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- Transmission/Drivetrain
- General Management and Leadership
- Professional and Legal Issues
- Diesel Technology
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- Vehicle Dynamics
- Product Engineering Tools and Methods
- New! Accident Reconstruction

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SAE International is a global association committed to being the ultimate knowledge source for the mobility engineering professional. By uniting over 135,000 engineers and technical experts, we drive knowledge and expertise across a broad spectrum of industries. We act on two priorities: encouraging a lifetime of learning for mobility engineering professionals and setting the standards for industry engineering.

SAE International is the world’s leader in mobility engineering knowledge. Engineers and other professionals around the globe trust SAE to provide a broad, multi-sector source for information and solutions. The SAE International Professional Development program offers access to over 300 live online and classroom, and on demand learning opportunities—learning opportunities that supply the right content to help solve your specific challenges.
This resource guide is designed specifically to help companies address their learning needs through a variety of SAE Professional Development options.

Options
For 8 - 100+ employees, SAE works with companies like yours to design and deliver customized training at your site. Through SAE Corporate Learning Solutions you can:

• Select an existing SAE course for delivery at your site
• Subscribe to a single on demand course for one or many employees
• Purchase a corporate subscription to the entire library of over 50 on demand courses (more than 350 hours of content available)

• CUSTOMIZE A LEARNING EXPERIENCE TO ADDRESS YOUR SPECIFIC BUSINESS NEEDS.

Advantages
With as few as eight employees who have the same learning need, SAE Corporate Learning Solutions offers multiple advantages:

• **Variety** — Choose from a comprehensive course list of over 300 titles including classroom, online, and on demand offerings. Integrate these options for a blended solution.

• **Personalization** — If you can’t find the specific topic you need or if the course content does not exactly match your requirements, SAE will customize a training program to meet your needs.

• **Quality** — You are assured relevant and accurate training conducted by leading academic and industry instructors. SAE offers to you ONLY courses and instructors reviewed and approved by objective industry experts.

• **Convenience** — We schedule the instructor, supply the comprehensive course materials for each attendee, and coordinate other administrative details like instructor travel and accommodation or online connections.

• **Cost Effective** — The instructor comes to you! No staff travel expenses and no time away from the office=time and cost savings. Also, our extensive network and existing course list means we can offer you extremely competitive pricing!

• **Timeliness** — SAE International is the world’s leader in mobility engineering knowledge. Our programs are developed and refined to stay ahead of industry trends; and we offer only the most up-to-date and knowledgeable instructors.

What is included in a Corporate Learning Solutions Program?

• **Customization** — Most courses can be tailored to address your company’s specific business or training objectives. Often this involves incorporating company data, generating case problems, or developing completely new content.

• **Administrative Coordination** — SAE staff contracts with the instructor, supplies all course materials, and provides attendance and post-course evaluation forms. All you do is provide the facility and audio-visual equipment!

• **Pre-training Communication with the Instructor** — SAE arranges communication with the instructor and relevant company representatives to review the learning objectives and ensure understanding of the scheduled training. This is another opportunity to gear the program to your specific needs.

Contact SAE Corporate Learning:
1-724-772-8529 or corplearn@sae.org
Explore State Resources for Training Dollars

Often states and local economic development groups have grant dollars available for training. Contact your state’s Department of Labor or other groups in your area to research funds available for your organization.

For example, Michigan residents can visit www.michiganworks.org and enter their zip code to find local offices and Michigan Works! contacts in the area.

ACCREDITATIONS

The IACET CEU

SAE International is recognized as an Accredited Provider by the International Association for Continuing Education and Training (IACET). All SAE Professional Development seminars, e-Seminars, web seminars, and engineering academies meet eligibility requirements for IACET Continuing Education Units (CEUs) according to the ANSI/IACET 1-2013 Standard. To receive CEUs, attendees are required to be engaged in the entire course and demonstrate mastery of the learning objectives by successfully completing a knowledge assessment.

What determines the Corporate Learning Solutions cost?

- The length of the program (number of days or hours of learning contact time)
- The learning materials. Some courses include textbooks or other learning aids
- The number of attendees
- Any customization required
- The instructor’s travel expenses or connection fees

These variables are used to calculate a base fee, which is typically based on 10 attendees. The fee increases proportionally as more attendees are added. Companies are additionally responsible for instructor travel expenses or connection fees, transfer fees, and living expenses.

What amenities does your company provide?

- A suitable meeting room or classroom
- Audio-visual equipment and computers (if required)
- Refreshment breaks and meals (if desired)
- Information on local hotels and airports along with directions to your facility
- For online or on demand courses, participation can be accommodated through individual or group access

ACTAR Approved SAE Courses

Some SAE courses have been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for Continuing Education Units (CEUs). In addition, the ACTAR CEUs are also listed with the course description.

ACTAR approved courses feature the ACTAR icon.

Upon completion of any of these courses, accredited reconstructionists should contact ACTAR, 1-800-809-3818, to request CEUs. As an ACTAR approved course, the fee for the CEUs for each course is $5.00.

• Continuing Education Units — SAE awards Certificates of Completion with IACET approved Continuing Education Units (CEUs) to all attendees. One CEU is granted for every 10 learning contact hours.

• What determines the Corporate Learning Solutions cost?

• What amenities does your company provide?
A LEARNING FORMAT TO FIT EVERY NEED

SAE offers a variety of learning formats to accommodate diverse learning styles. Explore classroom, live and online, or on demand courses. Many courses are offered in multiple formats so be sure to watch for the icons that identify the format for each course.

Seminars or workshops available as similar live, online Web Seminars will feature both icons and the course description for the Web Seminar will be listed immediately following the classroom title.

Live, online or classroom courses that have a similar course offered on demand will include both icons – watch for those descriptions or notes on where to get additional information.

SEMINARS AND WORKSHOPS

SAE International offers over 200 seminar and classroom titles in 100 separate technology and business skill topics. These seminars and workshops range from one-to-three-days and are led by highly-qualified, industry or academic experts. SAE live, classroom courses are interactive and encourage skill-development and problem solving. Each course includes comprehensive course materials to assist the learner in implementing the knowledge gained in the course.

Additionally, we offer nearly all courses throughout the year at the SAE International Office in Troy, Michigan; or at sights across the US and the world including at SAE International Engineering Events.

ENGINEERING ACADEMY

SAE’s award-winning Engineering Academy format is an intensive “boot camp” experience that immerses attendees in a focused technology area. The Engineering Academy is a comprehensive training experience on core engineering topics. Multiple instructors team up to provide interactive lecture, discussion, and practice – all designed to aid learning and application.

The Engineering Academy is perfect for newly hired engineers or those changing technical disciplines who need to quickly develop a new skill set in order to become productive on the job. The Engineering Academy format earned the prestigious Award of Excellence from the American Society of Association Executives.

For a current schedule of upcoming Academies, visit training.sae.org/academies

SAE E-LEARNING

Learners can take advantage of the convenience and cost effectiveness offered by e-Learning from SAE. SAE maintains a growing menu of learning products delivered online. These programs are listed throughout the catalog. Look for the icons that denote live online or on demand.

Live, Online Courses

Informative and content-rich, SAE live, online courses are instructor-led programs delivered via the internet or internet and telephone. Schedules and budgets can make it difficult to attend a classroom offering so SAE has developed a web seminar format to deliver technical courses directly. Delivered in one or a series of 90 to 120-minute sessions, Web Seminars feature audio delivered by telephone or VoIP, web-based presentations, interactive question-and-answer, and course-specific online forums.
for posting of supplemental materials, networking and course activities. Comprehensive course materials are also provided in PDF format. CEU’s are awarded when course requirements have been met. Look for the live, online icon throughout the catalog.

**On Demand Courses**

Avoid travel expenses and time out of the office, and make learning fit into your schedule. Access on demand courses right from your PC through the internet. There are more than 50 courses with over 300 hours of content. Many of our on demand courses are based on classroom offerings or are replays of our most popular Web Seminars. We also provide short-courses designed to bring team members quickly up-to-speed on a specific subject. Look for the symbol in the course description to identify those titles that are delivered on demand.

Your company can subscribe to one title or the entire collection for just a few employees or for every employee. Please contact the Corporate Learning Solutions hotline, 1-724-772-8529 for additional information or to receive a proposal.

**On Demand courses INCLUDE:**

- Quick, short-duration courses on targeted topics
- Full length, self-paced courses based on our most popular instructor-led seminars
- Replays of recorded web seminars
- Courses on international standards, including ISO 9001, ISO 14001, ISO/TS 16949, and ISO 19011
- A portfolio of courses with a focus on metallurgy concepts and practices
- Powertrain and Global 8D courses produced by Ford Quality Office

There are varying equipment requirements for the different online or on demand options. Visit the webpage for each course to determine if your system meets the course equipment requirements.

**CATALOG KEY**

You will see the following icons alongside the course descriptions. These icons indicate:

- delivery formats available for the course
- the course is part of an SAE certificate
- that it is an ACTAR approved course

Many courses are available in multiple formats. See page X to get more information on the learning formats offered by SAE. In addition to finding courses that fit your technology need, look for courses with icons that fit the way you want to learn.

- Classroom – indicates the course is an instructor-led seminar or workshop offered in a classroom setting
- Live, Online – indicates the course is an instructor-led web seminar offered live and online via telephone and internet connection
- On Demand – indicates the course is available online anytime the participant would like to access the course through the internet
- Certificate – indicates the course is part of an SAE international curriculum-based, multi-course certificate. See a list of the multi-course certificates on page XII
- ACTAR logo – indicates the course is an ACTAR approved course. For more information on ACTAR and ACTAR accredited courses, see page IX
SAE CERTIFICATION & CERTIFICATE PROGRAMS

SAE CREDENTIALING - ELEVATING KNOWLEDGE

Show the industry the depth of your organization’s expertise. SAE offers focused topic-specific credentialing programs for engineers and other professionals in ground vehicle and aerospace. Shine a light on their knowledge and expertise through SAE Credentialing.

Your team can earn an SAE Certification by passing industry-created and vetted exams. Get more information at training.sae.org/credentialing

How does it work?

• Complete established eligibility requirements (typically educational background and work experience)
• Pass an industry-developed, vetted, and proctored exam that tests mastery of an industry-defined body of knowledge
• Earn your industry recognized credential endorsing your experience and knowledge of the technology, and establishing a solid foundation on which to build a successful career.

Certifications must be maintained over 3-year period of time by fulfilling established maintenance requirements.

Or, expand their knowledge and build your organization’s reputation as an expert through industry-advised Certificate of Competency programs.

How does it work?

• Complete a course in a focused content area
• Pass an industry-vetted exam that verifies your understanding of the material
• Earn a Certificate of Competency or Certificate of Mastery

SAE Certification or Certificate of Competency – how does it benefit the ENGINEER?

• Validates their mastery of industry-driven training and learning objectives or confirms mastery of an industry-generated body of knowledge
• Imparts international recognition of experience and skills
• Provides a portable credential that is recognized across industry
• Demonstrates their commitment to continued growth and improvement

What is the value to the ORGANIZATION?

• Recognizes the capabilities of your people and enhances your company’s credibility with the industry as a supplier OR OE through an independent assessment
• Contributes to the hiring and promotion process – quickly illustrates the capabilities and experience of potential new hires or those you’d like to advance
• Encourages employee commitment to growth and opportunity
• Supports the promotion of professional competence

SAE currently offers the following Credentialing Programs:

Vehicle Electrification (VE) Program: offering a Certificate of Competency and Certified Vehicle Electrification Professional (CVEP), Vehicle Electrification (VE) Certification is designed to validate a mastery of knowledge essential to VE safety and all major VE systems.

The Connected Vehicle Professional™ Program: designed for all engineering, technical, and industry professionals who touch the “connected vehicle”, the multi-course program provides the understanding of vehicle and infrastructure connectivity necessary to operate within the rapidly advancing field of Intelligent Transportation Systems (ITS) and Connected Vehicles.
EARN A CURRICULUM-BASED, MULTI-COURSE CERTIFICATE IN A SPECIFIC TECHNICAL AREA.

Intended to provide a guide towards deeper knowledge in a specific area, SAE’s multi-course certificates outline required courses that offer foundational knowledge of the subject. Some certificate programs also feature additional electives designed to broaden your exposure to more specific aspects of the technology studied.

In addition to the Continuing Education Units (CEUs) awarded, successful completion heightens your expertise within the field and earns you an SAE credential recognizing your achievement.

PLUS—completion of many of the multi-course certificate programs equates to graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S in Mechanical Engineering. Visit training.sae.org/collegecredit for more information.

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

NEW! Accident Reconstruction Certificate Program

Professionals become more proficient in the practice of vehicle crash/accident reconstruction by successfully completing this certificate program from SAE. Required courses guide one through crash reconstruction methods, vehicle dynamics, and event data recorder (EDR) technology then completion of three elective courses suit the individual’s specific technical interest area.

The following are required courses:

- **Vehicle Crash Reconstruction Methods** (I.D.# C1417)
- **Vehicle Dynamics for Passenger Cars and Light Trucks** (classroom I.D.# 99020 or on demand I.D.# PD130702ON) OR **Applied Vehicle Dynamics** (I.D.# C0414)
- **Applying Automotive EDR Data to Traffic Crash Reconstruction** (I.D.# C1210) OR **Accessing and Interpreting Heavy Vehicle Event Data Recorders** (I.D.# C1022)

Choose three electives:

- **Advanced Vehicle Dynamics for Passenger Cars and Light Trucks** (I.D.# C0415)
- **Chassis and Suspension Component Design for Passenger Cars and Light Trucks** (I.D.# 95025)
- **Hydraulic Brake Systems for Passenger Cars and Light Trucks** (I.D.# C0509)
- **High-Performance Brake Systems** (I.D.# C0718)
- **Introduction to Brake Control Systems: ABS, TCS, and ESC** (classroom I.D.# C0315 or on demand I.D.# PD130501ON)
- **Tire and Wheel Safety Issues** (I.D.# C0102)
- **The Tire as a Vehicle Component** (I.D.# C0101)
- **Injuries, Anatomy, Biomechanics & Federal Regulation** (I.D.# 85049)
- **Commercial Vehicle Braking Systems** (classroom I.D.# C023 or on demand I.D.# PD130611ON)
- **Introduction to Heavy Truck Tire, Steering, and Suspension Dynamics** (I.D.# C1209)
- **Fundamentals of Automotive All-Wheel Drive Systems** (I.D.# C0305)
- **Fundamentals of Heavy Truck Dynamics** (I.D.# C0837)
- **Applying Automotive EDR Data to Traffic Crash Reconstruction** (if not taken as a required course – I.D.# C1210)
- **Accessing and Interpreting Heavy Vehicle Event Data Recorders** (if not taken as a required course – I.D.# C1022)

Diesel Technology Certificate Program

This certificate equips engineers with a solid understanding of diesel engines, emissions and aftertreatment strategies, and related components including fuel injection and air management. The program requires completion of courses that address these areas and offers further depth through a menu of electives.

The required courses are:

- **Diesel Engine Technology** (classroom: I.D.# 93014 or on demand: I.D.# PD130812ON)
- **Common Rail Diesel Fuel Injection** (I.D.# C0920)
- **Turbocharging Internal Combustion Engines** (I.D.# C0314)

Choose one elective:

- **Diesel Engine Noise Control Web Seminar or Web Seminar RePlay** (I.D.# WB1041; PD331041ON)
- **Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems** (I.D.# C0235)
- **Exhaust Gas Recirculation (EGR) for Diesel Engines** (I.D.# C1214)
- **Selective Catalytic Reduction for Diesel Engines** (I.D.# C0913)
- **Variable Valve Actuation Design and Performance Impact on Advanced Powertrains** (I.D.# C1332)

Completion of the Diesel Engine Technology Engineering Academy can be used as a substitute for Diesel Engine Technology and one elective.
**General Management and Leadership Certificate Program**

This program focuses on four core management and leadership competencies: management capability, team leadership, project management, and finance providing a basis for growth into a leadership or management role.

All of the following courses are required:

- Managing Engineering & Technical Professionals (I.D.# C0608)
- Engineering Project Management (I.D.# 99003)
- Principles of Cost and Finance for Engineers (I.D.# C0828)
- Leading High Performance Teams (I.D.# C0410)

Attending the Engineering Management Academy serves as a substitute for Managing Engineering and Technical Professionals, and Leading High Performance Teams required courses.

**Product Engineering Tools and Methods Certificate Program**

This program focuses on the study, development, management and implementation of product engineering principles, methodologies and techniques. When used properly, these tools and methods become powerful productivity enhancers reducing product development time and cost through improved communication, documentation, problem-solving, and quality.

All of the following courses are required:

- Design of Experiments (DOE) for Engineers Web Seminar (I.D.# WB0932) OR classroom seminar - Design of Experiments for Engineers (DOE) (I.D.# C0406)
- Finite Element Analysis (FEA) for Design Engineers Web Seminar (I.D.# WB1241)
- Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) Web Seminar or Web Seminar RePlay (live, online: I.D.# WB0933; on demand I.D.# PD330933ON)
- Tolerance Stack-up Fundamentals Web Seminar or Web Seminar RePlay - (live, online: I.D.# C0842; on demand I.D.# PD330842ON)
- Root Cause Problem Solving: Methods and Tools Web Seminar or Web Seminar RePlay (live, online: I.D.# WB0931; on demand I.D.# PD330931ON)

Choose one elective:

- Accelerated Test Methods for Ground and Aerospace Vehicle Development (classroom: I.D.# C0316 or on demand: I.D.# PD330524ON)
- All three advanced web seminar/web seminar RePlay titles in the Geometric Dimensioning & Tolerancing Series (I.D.#s WB1319, WB1320, & WB1321)
- Design for Manufacturing & Assembly (DFM/DFA) (I.D.# 92047)
- Design Review Workshop (I.D.# C1306)
- Finite Element Analysis for Design Engineers - Hands-on FEA Workshop (I.D.# 93006)
- Introduction to Design Review Based on Failure Modes (DRBFM) Web Seminar or Web Seminar RePlay (live, online: I.D.# WB1047; on demand I.D.# PD331047ON)
- Introduction to Failure Mode and Effects Analysis for Product and Process (I.D.# C1201)
- Robust Design (I.D.# C1201)
- Statistical Tolerance Design (I.D.# 88033)
- Weibull-Log Normal Analysis Workshop (I.D.# 86034)

Additional elective courses

Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:

- Geometric Dimensioning & Tolerancing - classroom seminar (I.D.# C0133)
- Tolerance Stack-Up Analysis - classroom seminar (I.D.# C0022)

**Professional and Legal Issues Certificate Program**

This program focuses on legal and risk management issues critical for engineers to master to facilitate the successful design and deployment of products from a safety and reliability perspective.

All of the following courses are required:

- Patent Law for Engineers (I.D.# 88007)
- Product Liability and The Engineer (I.D.# 82001)
- The Role of the Expert Witness in Product Liability Litigation (I.D.# 92054)
- Program and Risk Management (I.D.# C0409)

**SI Engine Certificate Program**

This certificate is designed to familiarize engineers with key spark ignition engine components and technologies and how they function as a system. By completing the certificate, engineers can acquire fairly deep engine expertise and, at the same time, earn an SAE credential.

All of the following courses are required:

- Basics of Internal Combustion Engines (classroom: I.D.# C0103 or on demand: I.D.# PD330944ON)
- Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR (I.D.# C0613)
- Turbocharging Internal Combustion Engines (I.D.# C0314)
- Powertrain Selection for Fuel Economy and Acceleration Performance (I.D.# C2043)

Choose one elective:

- Gasoline Direction Injection (GDI) (I.D.# C1009)
- Combustion and Emissions for Engineers (I.D.# 97011)
- Automotive Heat Transfer (I.D.# C1230)
- Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems (I.D.# C0235)
- Piston Ring Design/Materials (I.D.# 86009)
- Compact Heat Exchangers for Automotive Applications (I.D.# 97002)
- Fundamentals of Automotive Fuel Delivery Systems (I.D.# C0203)
Variable Valve Actuation Design and Performance Impact on Advanced Powertrains (I.D.# C1332)

Additional elective courses
Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:

- Introduction to Commercial and Off-Road Vehicle Cooling Airflow Systems (classroom: I.D. #C0738; live online: I.D.# WB1240; or on demand: I.D. #PD331240ON)

Transmission/Drivetrain Certificate Program
This program familiarizes engineers with key drivetrain components and how those components function as a system. By completing the certificate, engineers can increase their expertise within the drivetrain body of knowledge and, at the same time, earn the SAE Certificate of Achievement

All of the following courses are required:

- A Familiarization of Drivetrain Components (classroom: I.D.# 98024 or on demand: I.D.# PD130555ON)
- Fundamentals of Automotive All-Wheel Drive Systems (classroom: I.D.# C0305 or on demand: I.D.# PD130556ON)
- Fundamentals of Modern Vehicle Transmissions (classroom: I.D.# 99018 or on demand: I.D.# PD130419ON)
- Introduction to Gears (I.D.# C0822)
- Powertrain Selection for Fuel Economy & Acceleration Performance (I.D. # C0243)

Additional elective courses
Courses no longer offered by SAE but eligible to be used as electives for this program, providing they were completed within seven years of the date the Certificate is requested, include:

- High-Performance Differentials, Axles, & Drivelines (I.D.# C1131)

Vehicle Dynamics Certificate Program
Designed to equip engineers with key vehicle dynamics and handling theory and application from a systems perspective, the objective of this program is for engineers to understand the interaction and performance balance between the major vehicle subsystems. The program design requires completion of fundamental and advanced-level vehicle dynamics theory and application courses with three elective courses that best suit an individual's interest areas or engineering emphasis.

All of the following courses are required:

- Vehicle Dynamics for Passenger Cars and Light Trucks (classroom: I.D.# 99020 or on demand: I.D.# PD130702ON) OR
- Fundamentals of Heavy Truck Dynamics (I.D.#C0837)
- Advanced Vehicle Dynamics for Passenger Cars and Light Trucks (I.D.#C0415)

Choose three from these electives:

- Applied Vehicle Dynamics (I.D.# C0414)
- Fundamentals of Steering Systems (I.D.# C0716)
- Introduction to Brake Control Systems: ABS, TCS, and ESC - (classroom: I.D. # C0315 or on demand: I.D.# PD130510ON)
- The Tire as a Vehicle Component (I.D.# C0101)
- Tire and Wheel Safety Issues (I.D.# C0102)
- Chassis & Suspension Component Design for Passenger Cars & Light Trucks (I.D.# 95025)
- Commercial Vehicle Braking Systems (I.D.# C0233)
- Heavy Vehicle Ride Comfort Engineering (I.D.# C0948)
- Hydraulic Brake Systems for Passenger Cars and Light Trucks (I.D.# C0509)
- High-Performance Brake Systems (I.D.# C0718)
- Fundamentals of Heavy Truck Dynamics (I.D.# C0837)
- Vehicle Dynamic Basics for Off-highway Trucks (I.D.# C1239)

Get more information on the curriculum-based, multi-course certificates at training.sae.org/credentialing/certificate/

Here's how you obtain your SAE Certificate
Once you complete all required courses in any of the certificate programs, contact SAE Customer Service, 1-877-606-7323 (or 1-724-776-4970 outside U.S. & Canada) or email: customerservice@sae.org and request your Certificate. Your SAE transcript will be reviewed to verify completion of required courses and your Certificate will be mailed to you within 30 days.

SAE Certificate Programs can also be conducted at your company site for groups of employees. For a price quote, call our Corporate Learning Solutions hotline, 1-724-772-8529.
MyLearn.sae.org houses information on all of SAE’s professional development opportunities including live classroom, live online, and on demand. Use MyLearn.sae.org to quickly locate learning solutions designed to meet the educational and training needs of technical professionals in your organization.

MyLearn.sae.org offers learners:

• Access to transcripts
• The option to plan and schedule training and to register or purchase any course
• Ability to enroll in certificate or certification programs
• A spot to check out what’s new in SAE professional development activities,
• And download a full catalog of programs

Visit MyLearn.sae.org and see how SAE International is the one-stop shop for your ongoing professional development needs!
BUILD YOUR SKILLS & KNOWLEDGE
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Stay current on the latest technology, increase your knowledge, and positively affect your organization’s bottom line with:

- Practical, useable industry knowledge delivered by respected and expert professionals
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- Customized onsite training designed for your organization’s specific needs

Build on your core education with fundamentals courses or specialize with technology-specific training - find the solution that fits your needs at SAE.

Plan Your Professional Development Now

training.sae.org
CHASSIS AND VEHICLE DYNAMICS

Includes vehicle and truck dynamics, ride and handling, tires, suspension, and braking systems.

VEHICLE DYNAMICS AND HANDLING

Advanced Vehicle Dynamics for Passenger Cars and Light Trucks

3 Days
I.D.# C0415

This interactive seminar will take you beyond the basics of passenger car and light truck vehicle dynamics by applying advanced theory, physical tests and CAE to the assessment of ride, braking, steering and handling performance. Governing state-space equations with transfer functions for primary ride and open loop handling will be developed & analyzed. Building on the analysis of the state space equations, common physical tests and their corresponding CAE solutions for steady state and transient vehicle events will be discussed. The “state-of-the-art” of vehicle dynamics CAE will be discussed. Common lab and vehicle tests and corresponding metrics used to assess chassis system and vehicle performance will be discussed in detail. Hands-on workshops using CARSIM™ vehicle dynamics simulation software will help reinforce the material. Significant time will also be dedicated to the use of design of experiments (DOE) as a tool to assist in the analysis and optimization of chassis systems for multiple vehicle responses.

Participants should bring a scientific calculator to participate in the classroom workshops.

Learning Objectives

By attending this seminar, you will be able to:

• Apply vehicle dynamics theory to practical evaluation and measurement
• Use governing state space equations and transfer functions to determine the effect of key parameters on primary ride and open loop handling
• Describe the current “state-of-the-art” of vehicle dynamics CAE
• Articulate various types of vehicle dynamics models
• Recognize kinematics and compliance (K&C) lab tests commonly used to quantify chassis system performance
• Identify and evaluate important K&C metrics used in vehicle dynamics development
• Identify and utilize important vehicle tests commonly used in industry to evaluate ride, steering and handling performance
• Relate chassis system characteristics to vehicle dynamic performance
• Utilize vehicle dynamics CAE software for the simulation of common physical lab and vehicle tests
• Apply design-of-experiments (DOE) to vehicle dynamics development

Who Should Attend

This seminar is designed for automotive engineers in the vehicle dynamics, chassis, suspension, steering and braking fields who work in product design, development, testing, simulation or research.

Prerequisites

Participants must have a working knowledge of the fundamentals of vehicle dynamics acquired through sufficient work experience or by participating in seminars such as the SAE seminars Vehicle Dynamics for Passenger Cars and Light Trucks (ID# 99020, page 7)
CHASSIS AND VEHICLE DYNAMICS

Topical Outline

DAY ONE
• Modeling Primary Ride Dynamics
  • 4-degree of freedom (DOF) primary ride model
  • 2-DOF primary ride model
• Modeling Vehicle Handling Dynamics
  • Developing the cornering compliance model
  • Developing the transfer function
• Introduction to Vehicle Dynamics CAE
  • Types of models
  • Strengths/Limitations
  • Commercial software packages
• Measurement and Simulation of Suspension Kinematics and Compliance (K&C)
  • Objectives of the K&C test
  • Definitions
  • Measurement equipment
  • Common tests
  • Simulation of the K&C test
• Measurement and Simulation of Primary Ride
  • Primary vs. Secondary Ride
  • Physical measurements
  • Common primary ride metrics
  • Olley Criteria for primary ride
  • Primary ride simulation
  • CarSim™ Exercise - Primary Ride Simulation

DAY TWO
• Measurement and Simulation of Acceleration and Braking
  • Steady state acceleration test and metrics
  • Steady state braking test and metrics
  • Simulation of steady state acceleration and braking
• Measurement and Simulation of Steering
  • On-center steering test and metrics
  • Low-g swept steer test and metrics
  • Simulation of steering tests
  • CarSim™ Exercise - Steering
• Measurement and Simulation of Open Loop Handling
  • Definition of open loop
  • Steady state open loop tests -- High-g swept steer
  • Transient open loop tests -- Step steer; Brake/throttle release in a turn; Fishhook; Sine with dwell
  • Simulation of open loop handling tests
  • CarSim™ Exercise - Open Loop Handling

DAY THREE
• Measurement and Simulation of Closed Loop Handling
  • Definition of closed loop
  • Steady state closed loop tests -- Constant radius
  • Transient closed loop tests -- Lane change; Slalom
  • Simulation of closed loop handling tests
  • CarSim™ Exercise - Closed Loop Handling

• Design of Experiments (DOE) Applied to Vehicle Dynamics Development
  • What is DOE
  • Why use DOE
  • Terminology
  • Types of DOE’s
  • Example - Screening DOE for primary ride
  • Example - Response Surface Method (RSM) DOE for Transient Handling
• Vehicle Dynamics Summary

Instructor: Richard Lundstrom and Timothy Drotar
Fee $1740 2.0 CEUs

Basic Tire Mechanics and Inspection
1 Day
I.D.# C1423

This course provides an introduction to basic tire mechanics, including materials, sidewall stampings, pressure, tread patterns, tire inspection and basic tire failure identification of passenger and light truck tires. Practical in nature and supplemented with samples and hands-on activities, the course will provide you with information that you can use immediately on-the-job and apply to your own vehicle. It serves as a good primer for the in-depth SAE Tire Forensic Analysis course.

Learning Objectives
By attending this seminar, you will be able to:
• Read the sidewall of a tire and explain all of the nomenclature
• Describe the various types of tread patterns and what they mean on a tire
• Describe what is inside the tire and how that relates to some of the sidewall stampings
• Photograph black objects and quickly inspect tires in the field
• Visualize and explain basic tire failures

Who Should Attend
This course is extremely helpful for Accident Reconstructionists, Law Enforcement and those with a thirst for knowledge on tires. The materials are basic in nature and not intended for individuals with substantial tire knowledge and is not intended to teach tire design.

Topical Outline
DAY ONE
• Tire Size
  • Service Description & tire size suffixes
  • Differences between LT and P type tires in load / pressure
  • Aspect ratio
Rim diameter and rim types
- Sidewall Stamping
  - UTQG
  - DOT code
  - DOT required stamping
- Inflation Pressure
- Load and Reserve Load
- Tire Terminology
- Tire Construction
  - Ply and plies
  - Belts
  - Tread
  - Overlay – the standing wave
  - Inner-liner
  - Bead and bead filler
  - Belt package types and casing construction layup
- Tire Types and Tread Patterns
  - All season, mud, all terrain, snow, summer
  - +1 concepts
  - Irregular wear
  - Wear bars
- Inspection and Photography in the Field
- Basic Failure Mode Identification

Instructor: Thomas Giapponi
Fee $790  .7 CEUs

Chassis & Suspension Component Design for Passenger Cars & Light Trucks
3 Days I.D.# 95025

Just as the chassis and suspension system provides an ideal framework for the automobile, this popular SAE seminar provides an informative framework for those involved in the design of these important systems. Emphasizing the fundamental principles that underlie rational development and design of suspension components and structures, this course covers the concepts, theories, designs and applications of automotive suspension systems.

Learning Objectives
By attending this seminar, you will be able to:
- Identify the types of suspensions and structures and their design differences from concept to prototype, theory to application; static and dynamic load conditions; and suspension modeling
- Describe the chassis design process and various suspension system interactions through demonstrations, video and audio devices and computer simulation
- Illustrate how an algorithm for a complete design cycle of the chassis works
- Explain the various chassis suspension analyses and designs that need to be performed and verified during development
- Recognize Magic Numbers in suspension design and the Suspension Design Factors (SDF)
- Analyze, predict, and evaluate the design parameters and performance characteristics for ride and handling quality control behavior of ground motor vehicles as a result of suspension design
- Reference a unique set of lecture notes related to suspension design

Who Should Attend
This seminar is designed primarily for engineers involved in vehicle ride, handling, chassis design, suspension, steering and brake design for passenger cars and light trucks.

Topical Outline
DAY ONE
- Survey
- General Overview
- Tires and Wheels
- Ride and Ride Design Criteria
- Handling and Handling Design Criteria
- Vehicle Dynamics Terminology

DAY TWO
- Roll Rates, Roll Motion
- Dynamic Transfer During Cornering
- Understeer Coefficient
- The Design of Springs, Stabilizer Bars, Shock Absorbers, Bushings, Control Arms
- Links, Semi-Active Damper, and Control Links
- Static Analysis and Design of Suspensions
- Suspension Terminology

DAY THREE
- Fore/Aft Dynamic Load Transfer Analysis
- Dive, Lift and Squat
- Steering Systems
- Active and Semi-Active Suspension
- CAD/Static, Dynamic and Proving Ground Testing
- Suspension Design Cycle
- Magic Number in Suspension Design
- Concluding Remarks

Instructor: Pinhas Barak
Fee $1730 2.0 CEUs
SAE MULTI-COURSE CERTIFICATE PROGRAMS
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

Intended to provide a guide towards deeper knowledge in a specific area, SAE’s multi-course certificates outline required courses that offer foundational knowledge of the subject. Some certificate programs also feature additional electives designed to broaden your exposure to more specific aspects of the technology studied.

training.sae.org/certificates

The Tire as a Vehicle Component
1 Day
I.D.# C0101

The principal functions of the pneumatic tire are to generate driving, braking, and cornering forces while safely carrying the vehicle load and providing adequate levels of ride comfort. This seminar explains how tire forces and moments are generated under different operating and service conditions and, in turn, demonstrates how these forces and moments influence various vehicle responses such as braking, handling, ride, and high-speed performance. The content focuses on the fundamentals of tire behavior in automobiles, trucks, and farm tractors, but also includes experimental and empirical results, when necessary.

The Pneumatic Tire, a 700-page E-book on CD, edited by Joseph Walter and Alan Gent, is included in the course material.

Learning Objectives
By attending this seminar, you will be able to:
• Explain the force and moment generating behavior of tires as related to construction, materials, and operating conditions
• Predict vehicle response based on tire characteristics using basic laws of mechanics supplemented by experimental results as necessary

Who Should Attend
This course is designed principally for technical professionals in the automobile, tire, and wheel industries and their suppliers. In addition, some case studies and examples involve truck, agriculture, and aircraft tires.

Topical Outline
• Introduction
  • Brief history of tires and wheels
  • Types of tires
  • Tire construction features

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Instructor: Joseph D. Walter
Fee $780 .7 CEUs

Tire Forensic Analysis
2 Days
I.D.# C1424

This course provides a detailed description of tire failure modes, their potential causes, identification, and the sometimes subtle nuances that go along with determination of tire failure. In addition, proper inspection techniques of tires will be discussed and samples will be available to reinforce the concepts learned. The book, Tire Forensic Investigation, authored by the instructor, is included with the course materials.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 13 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818 FREE, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.
CHASSIS AND VEHICLE DYNAMICS

Learning Objectives
By attending this seminar, you will be able to:
• Explain the methodologies of good tire inspection
• Describe tire failure causes
• Identify and determine root causes of tire failure

Who Should Attend
This course is extremely helpful for Accident Reconstructionists, Law Enforcement, Warranty investigators and individuals who need to be able to explore and explain tire failures.

Topical Outline
DAY ONE
• Belt Separation – Tread / Belt Detached
  • Identification
  • Working belt description
  • Reversion / bluing
  • Degradation of properties
  • Thick/Thin layering
  • Transition zones and identification of tear types
  • Road rash
• Belt Separation – Tread / Belt Intact
  • Identification
  • Working belt description
  • Reversion / bluing
  • Degradation of properties
  • Thick/Thin layering
  • Transition zones and identification of tear types
  • Road rash
• Belt Separation Locations and rate of growth
• Other Belt separation Types
  • Typical & non-typical
• Identification of Causes and Contributors to Belt Separation
  • Punctures, penetrations and repairs
  • Wire break types
  • Intra-car cass pressurization (ICP) – oxygen deterioration
  • Over-deflection identification
• Overlaying and Time
• Impact
  • No immediate failure – identification
  • Damage to casing and rubber components
  • Wheel impact identification
DAY TWO
• Ozone Deterioration
• Mounting / Demounting Damage
• Physiological Damage
• Snags, Gouges, Cuts, Tears, Abrasions
• Cutting and Chipping (C&C)
• Poor Tire Storage
• Vehicle Caused Conditions
• Non-Belt Separation Types
• Runflats
• Liner Conditions
• Wheel Conditions
  • Matching tire to wheel
  • Flange indicators of overdeflection
• Tire Location on the Vehicle
• Brassy Wire Failure
• Manufacturing Imprints
• Overlays
• Tire Examination

Instructor: Thomas Giapponi
Fee $1415 1.3 CEUs

Tire and Wheel Safety Issues
1 Day
I.D.# C0102

One of the most important safety critical components on cars, trucks, and aircraft is the pneumatic tire. Vehicle tires primarily control stopping distances on wet and dry roads or runways and strongly influence over-steer/under-steer behavior in handling maneuvers of cars and trucks. The inflated tire-wheel assembly also acts as a pressure vessel that releases a large amount of energy when catastrophically deflated. The tire can also serve as a fulcrum, both directly and indirectly, in contributing to vehicle rollover. This seminar covers these facets of tire safety phenomena. Engineering fundamentals are discussed and illustrated with numerous practical examples and case studies of current public interest. The Pneumatic Tire, edited by Joseph Walter and Alan Gent, is included in the course material.

Learning Objectives
After completing this seminar attendees will be able to:
• Describe the most important performance parameters and operating conditions of pneumatic tires related to safety.
• Use fundamental equations of engineering science to predict and/or explain tire-vehicle interactions related to safety.

Who Should Attend
This course is designed principally for technical professionals in the automobile, tire, and wheel industries and their suppliers. In addition, some case studies and examples involve truck, agriculture, and aircraft tires.
CHASSIS AND VEHICLE DYNAMICS

Instructor: Joseph D. Walter
Fee $780 .7 CEUs

Vehicle Dynamics for Passenger Cars and Light Trucks
3 Days
I.D.# 99020

A similar course is available on demand– Vehicle Dynamics for Passenger Cars and Light Trucks e-Seminar – see course info below.

This seminar will present an introduction to Vehicle Dynamics from a vehicle system perspective. The theory and applications are associated with the interaction and performance balance between the powertrain, brakes, steering, suspensions and wheel and tire vehicle subsystems. The role that vehicle dynamics can and should play in effective automotive chassis development and the information and technology flow from vehicle system to subsystem to piece-part is integrated into the presentation. Governing equations of motion are developed and solved for both steady and transient conditions. Manual and computer techniques for analysis and evaluation are presented. Vehicle system dynamic performance in the areas of drive-off, braking, directional control and rollover is emphasized. The dynamics of the powertrain, brakes, steering, suspension and wheel and tire subsystems and their interactions are examined along with the important role of structure and structural parameters related to vehicle dynamics. Physical experiments, applicable to vehicle dynamics are also introduced.

Attendees will receive the Bosch Automotive Handbook and The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler.

Learning Objectives
By attending this seminar, you will be able to:
• Summarize how vehicle dynamics is related to the voice of the customer
• Identify important vehicle system parameters useful for effective application of vehicle dynamics to chassis development
• List and explain parameters that effect vehicle performance relative to drive-off, braking, directional control and rollover
• Identify physical measurements needed to effectively apply vehicle dynamics to passenger cars and light trucks
• Define the value of vehicle dynamics simulation in the development and evaluation of vehicles
• Explain the balance required between ride, directional control and rollover and the essential process for this balance to be obtained for marketplace vehicles

Who Should Attend
Automotive engineers and quality professionals who work in product design, testing, quality, process or development will benefit from attending.

Topical Outline
DAY ONE
• The Role of Vehicle Dynamics in Passenger Car and Light Truck Product Development
• Vehicle Dynamics and the Voice of the Customer
  • Use of QFD to manage vehicle dynamics performance in drive-off, braking, ride and handling
  • Thinking systematically about automotive chassis design and development through the logic of vehicle dynamics
• Effective Metrics for Vehicle Dynamics
  • Vehicle system, subsystem and piece-part metrics used to link vehicle dynamics to vehicle system design and development: bounce frequencies, lateral acceleration gain, understeer gradient, roll gradient, roll stiffness, etc.
  • Tire Fundamentals: Tire Wheel System Anatomy and Architecture, Tire Axis System, Parameters and Characteristics

• Introduction
  • Vehicle accident statistics
  • The role of the tire in accident prevention/causation
  • Tire construction features
  • Tire failure modes
• Tire Grip and Related Phenomena
  • Tire-road friction characteristics; Tire braking forces
  • Factors influencing vehicle stopping distance
  • Combined braking and cornering
  • Hydroplaning
  • High speed behavior and standing waves
• Brake Performance
  • Front wheel/rear wheel lock-up
  • Braking efficiency
  • Anti-lock braking and other systems
• The Tire as a Pressure Vessel
  • Burst pressure
  • Energy release in punctured tires
  • Wheel issues
  • Tire and/or wheel case studies
• Over-steering Vehicles
  • Meaning of under-steer coefficient
  • The contribution of the tire
• Vehicle Rollover Analysis
  • History of rollover and rollover threshold
  • Tripping mechanisms
  • Tire effects
  • Operating conditions
  • Public policy issues

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Catalog Key Classroom Live, Online On Demand Certificate ACTAR approved
CHASSIS AND VEHICLE DYNAMICS

- Elementary Tire Patch Forces and Moments: Forces and Moments at the Tire Contact Patch During Steady Braking, Steady Cornering and Steady Drive-Off Maneuvers
- Acceleration (Drive-Off) Performance
  - Basic powertrain system anatomy and architecture
  - Power limited and traction limited drive-off including powertrain system dynamics required to produce vehicle motive force at the tire patch
  - Road load considerations: aerodynamic resistance, rolling resistance, grade resistance
  - Performance prediction in acceleration and fuel economy

DAY TWO
- Braking Performance
  - Basic brake system anatomy and architecture
  - Braking dynamics: braking forces, weight transfer, center of weight, brake force distribution, stability
  - Pedal force gain, brake proportioning, braking efficiency, anti-lock braking systems
  - Tire - road limitations
  - Federal requirements for braking performance
  - Brake system performance prediction
- Ride Fundamentals
  - Input excitation signals: road roughness, vehicle sources (tire/wheel system, driveline and engine)
  - Vehicle response properties: suspension isolation, tire vertical stiffness, spring rate ratio, suspension stiffness, ride rate, suspension damping, pitch and bounce frequencies
  - Quarter vehicle and pitch plane ride simulations
  - Ride performance prediction based on flat ride criteria

DAY THREE
- Cornering Fundamentals
  - Low speed turning
  - High speed cornering: tire forces, Bundorf bicycle model, understeer gradient, characteristic speed, lateral acceleration gain, yaw velocity gain, side-slip
  - Suspension effects on cornering: tire cornering stiffness, camber thrust, roll steer, lateral force compliance steer, aligning torque, lateral load transfer, steering system
  - Experimental methods for vehicle handling development
- Suspension Systems
  - Suspension system anatomy and suspension system performance requirements relative to drive-off, braking, ride and handling
  - Solid live axles, twist beam suspensions and independent suspensions
  - Side view pitch poles and pitch axis considerations: anti-squat and anti-dive suspension geometry, wheel travel and caster geometry
  - Role axis considerations: roll center location, roll axis geometry and location, wheel travel and toe geometry, wheel travel and camber geometry
- Steering Systems
  - Steering system anatomy, architecture and performance requirements
  - Steering geometry, wheel geometry, steering system forces and moments, steering ratio, steering compliance
  - Experimental methods for steering system performance evaluation and development
- Roll-Over Fundamentals
  - Vehicle system roll-over prevention requirements
  - Elementary and suspended vehicle simulations
  - Suspension system and steering system considerations

Instructor: Richard Lundstrom
Fee $1870 2.0 CEUs

Vehicle Dynamics for Passenger Cars and Light Trucks e-Seminar

15 Hours
I.D.# PD130702ON

A similar course is available as a live classroom seminar—Vehicle Dynamics for Passenger Cars and Light Trucks – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this four and a half hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This course offers more than fourteen hours of instruction and simulations divided into nineteen video modules; The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler; a coordinated handbook that includes a resource guide and SAE papers and paper collections.

View the complete course description and a video demo at training.sae.org/eseminars/vehicledynamics.

What You Will Receive:
- 90 Day access through MyLearn.sae.org
- Links to streaming video modules
- Course Handbook (downloadable .pdf's, subject to DRM)
- The Bosch Automotive Handbook (hardback)
- The book, The Automotive Chassis: Engineering Principles by Reimpell, Stoll and Betzler (eBook, downloadable through My Library)
- The SAE Papers (downloadable, .pdf's):
  - 970091
  - SP-355
CHASSIS AND VEHICLE DYNAMICS

- 760713
- 760710
- Online Pre-test (self-test, immediate results)
- Online Post-test (self-test, immediate results)
- CEUs/Certificate of Achievement (with satisfactory post-test score)

Instructor: Richard Lundstrom
Fee $695 1.5 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

SAE VEHICLE DYNAMICS CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Designed to equip you with key vehicle dynamics and handling theory and application from a systems perspective, the objective of this program is for you to understand the interaction and performance balance between the major vehicle subsystems. The program design requires completion of fundamental and advanced-level vehicle dynamics theory and application courses with three elective courses that best suit your specific interest areas or engineering emphasis. View the list of required and elective courses and more information on enrolling in this SAE certificate program--training.sae.org/certificate/vehicle_dynamics

BRAKES AND BRAKING SYSTEMS

Brake Friction Materials: Testing, Quality and Selection

1 Day
I.D.# C1020

The choice of brake friction materials varies per application, but each must have the appropriate coefficient of friction and be able to disperse large amounts of heat without adversely affecting braking performance. This seminar provides an introduction to brake lining raw materials and formulation, manufacturing, quality control and testing and covers the critical elements that must be reviewed before arriving at a lining selection decision. Different classes of friction material and their use will be defined.

Learning Objectives

By attending this seminar, you will be able to:
- Describe the principles of friction
- Define the basic elements of friction material formulations
- Identify the difference between OE and after-market friction materials
- Identify appropriate tests to distinguish the differences between friction materials
- Interpret friction material test results

Who Should Attend

Engineers and technicians working for friction material manufacturers, and suppliers to friction material industries, brake system designers, quality control auditors, product development engineers, application engineers, lab/bench/vehicle test technicians, managers/friction material sales and marketing will all gain valuable insight.

Topical Outline

- Principles of Friction Materials
- Lining Coefficient of Friction
- Formulation/Compounding Friction Material
- Manufacturing Friction Material
- General Asbestos/Non-asbestos Friction Material Characteristics
- Friction Material Testing
- Edge Code
- Bench & Vehicle Tests
- Wheel Dust Test

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CHASSIS AND VEHICLE DYNAMICS

- Government Regulations
- OE and After-market Friction Material Lining Selection
- Issues Facing Friction Material Industries
  - Copper in brake pads
  - CA intended regulations
- Workshop

Instructor: Mohammad Vakili
Fee $800 .65 CEUs

Brake Noise Problem Resolution
1 Day
I.D.# C0831
Brake noise is one of the highest ranked complaints of car owners. Grunts, groans, squeaks, and squels are common descriptions of the annoying problem which brake engineers spend many hours trying to resolve. Consumer expectations and the high cost of warranty repairs are pushing the optimization of brake NVH performance. This course will provide you with an overview of the various damping mechanisms and tools for analyzing and reducing brake noise. A significant component of this course is the inclusion of case studies which will demonstrate how brake noise squeal issues have been successfully resolved.

Learning Objectives
By attending this seminar, you will be able to:
- Describe the various brake shim damping mechanisms
- Compare the various brake shims available in the market place
- Describe the various tools available to reduce brake noise
- Utilize lessons learned in various brake noise problem case studies

Who Should Attend
The course is designed for a wide range of personnel from the brake test engineer who seeks to understand more about brake NVH to the experienced brake NVH/design engineer who wishes to know more about potential solutions. Anyone involved in the resolution of brake noise problems will find this course helpful.

Prerequisites
Participants should be familiar with brake hardware, basic terminology, and brake NVH measurement and testing. Previous attendance at the SAE seminars Hydraulic Brakes for Passenger Cars and Light Trucks (ID# C0509) and Brake, NVH, Measurement, and Testing (ID# C0802) or equivalent experience and knowledge are highly recommended.

Topical Outline
- Brief Review of Brake Noise
- Types of brake noises
- Frequency range
- Source/path/receiver
- Principles and Applications of Brake Shims
  - Damping
  - Role and purpose of brake shims
  - Different types of brake shims
  - Brake shims damping mechanisms
- Tools for Brake Noise Analysis/Reduction
  - Brake noise categorization
  - Solution strategy
  - Investigative tools -- Testing; Simulation
- Squeal
  - Brake pad design optimization
  - Pressure distribution optimization
  - Low frequency squeal
- Moan/Groan
  - After-stop noise program -- Problem identification; Transmission of the road to the lab; Measurement systems; Root cause analysis; Solution
- Questions and Answers Session

Instructor: Eric Denys
Fee $790 .7 CEUs

Brake System Balance for Passenger Cars and Light Trucks
6 Hours
I.D.# WB1413
Designing a brake system requires the ability to balance a multitude of parameters against the required tradeoffs of system weight, system cost, and system performance. Understanding the basic fundamentals of how each brake component attribute contributes to the overall Force vs Deceleration behavior of the vehicle is critical to the design and release of a safe, legal and optimized system for today’s vehicles. Brake balance also is a contributing factor to other chassis control and safety systems, such as regenerative braking, ABS, and electronic brake distribution (EBD).

In three-sessions, this web seminar will cover the fundamentals of the development of braking forces generated by the brake system and the theory and principals to properly balance a brake system in accordance with legal requirements. Brake balance modifiers will also be presented.
This live online course allows for a detailed presentation of this topic for those unable to participate in the longer and broader classroom seminar, Hydraulic Brake Systems for Passenger Cars and Light Trucks. It has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 6 Continuing Education Units (CEUs). Upon completion of this e-seminar, accredited reconstructionists should contact ACTAR, 1-800-809-3818 FREE, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives
By participating in this web seminar, you will be able to:
• Calculate the braking force on a vehicle from the installed brake components
• Determine the deceleration achieved by a vehicle for a given set of brake components
• Analyze and interpret the actual brake balance for a given vehicle and brake components
• Calculate the ideal brake forces required for a vehicle
• Evaluate tradeoffs between actual and ideal brake forces
• Calculate the impact of brake balance modifiers on vehicle braking performance

Who Should Attend
This course is designed for engineers interested in or responsible for: the specification, prediction and validation of braking system performance; brake component design by providing insight into the interaction of components and the contribution to system level performance metrics; the tuning and calibration of Chassis Control Systems including ABS, TCS, ESP, ROM and Regenerative Braking Systems. Practical experience in the design or validation of brake or chassis control systems is helpful in getting the most from this course.

Topical Outline
SESSION ONE
• Brake System Sizing – Brake Force Determination
  • Applicable legal requirements for a brake system
  • Derivation of brake input force vs. vehicle deceleration relationship

SESSION TWO
• Actual Brake Force Balance and Considerations
  • Derivation of actual brake force balance
  • Determination of special actual brake balance conditions (front only, rear only)

SESSION THREE
• Brake Balance Analysis
  • Derivation of ideal brake force balance for a vehicle
  • Tradeoff analysis between actual brake force and ideal brake forces
  • Utilizing brake balance modifiers to refine the brake system

Instructor: Thomas J. Hall
Fee $550 .6 CEUs

Commercial Vehicle Braking Systems
3 Days
I.D.# C0233

A similar course is available on demand – Commercial Vehicle Braking Systems e-Seminar – see course info below.

Increased public pressure to improve commercial truck safety and new stopping distance regulations have intensified the need to better understand the factors influencing heavy vehicle braking performance. To assist individuals and their organizations in preparing for these new truck braking standards, this seminar focuses attendees on understanding medium-duty hydraulic brake systems and heavy-duty air brake systems and how both systems’ performance can be predicted, maintained and optimized. The function and application of the major brake system components will be explained and attendees will discover how brakes, tires and roadways interact as a system. Federal braking regulations for both hydraulic and air brake vehicles will also be covered. Attendees will receive the text, Commercial Vehicle Braking Systems: Air Brakes, ABS and Beyond written by Leonard C. Buckman.

Learning Objectives
By attending this seminar, you will be able to:
• Design safe and efficient braking systems
• Test and measure braking performance
• Maintain and troubleshoot braking systems
• Comply with state and federal regulations on brakes
• Describe the brake implications of accident investigation

Who Should Attend
This seminar is designed for engineers and technicians who are involved in the design, development and testing of heavy vehicle brakes. Fleet personnel involved with safety and brake system specification and maintenance, driver-trainers, and truck accident investigators will also find this course of value.

Topical Outline
DAY ONE
• Medium Truck Hydraulic Brake Actuation Systems
• Heavy Truck, Bus & Trailer Air Actuation Systems
• Brake Actuation Components - Function, Advantages/Disadvantages, Applications
• Foundation Brakes - Cam, Wedge, Air Disc, Hydraulic Disc

DAY TWO
• Braking Performance Fundamentals
• Maintenance and its Impact on Performance
CHASSIS AND VEHICLE DYNAMICS

- Brake Force Distribution
- Heavy Vehicle Dynamics and Tire Characteristics
- Thermal Considerations
- Tractor - Trailer Brake Compatibility
- Truck & Tractor Air Antilock Braking Systems

DAY THREE
- Trailer Air Antilock Braking Systems
- Hydraulic Antilock Braking Systems
- Electronic Data Communication
- Automatic Traction Control Systems (ATC)
- Electronically Controlled Braking Systems (ECBS or “Brake-by-Wire”) 
- Electronic Stability Control and Roll Stability Control - Extended Applications of Electronics in Braking
- Brake Testing Procedures
- NHTSA and FMCSA Commercial Vehicle Brake Regulations

Instructor: Leonard C. Buckman
Fee $695 1.8 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

High-Performance Brake Systems

2 Days
I.D.# C0718

While most passenger car brake systems are quite robust and reliable under typical operating conditions, high-performance driving and/or racetrack operation generally require alternative design solutions to optimize consistency and longevity. Whether it is brake fluid fade, cracked rotor discs, chronic knockback, or insufficient brake pad life, the stresses of motorsports can pose unique challenges to even the very best brake system designs. Consequently, ceramic rotors, six-piston calipers, adjustable balance bars, and titanium backing plates have all made their way onto the high-performance brake system scene, but what is the right answer for your application?

This seminar has been designed to assist you in answering that very question. The day begins with a concise yet thorough analysis of brake system design factors relevant to all types and categories of high-performance vehicles. The principles of energy conversion, gain, balance, and deceleration are discussed and supported with straightforward mathematical models, allowing attendees to realize the compromises that must be considered when designing from a system perspective.

From selecting an appropriate brake pedal ratio through the calculation of caliper effective piston area, the second portion of the seminar dives into the details of brake system component design. Based upon the principles learned earlier in the day, attendees will quickly realize that just as with proper system design, brake system component design is an exercise in managing engineering trade-offs. As a result, the material presented will not disclose what components to choose as much as how to choose them.

Day two of the seminar concludes with a design exercise that will allow attendees to put into practice several of the key concepts learned throughout the seminar. Detailed course notes and illustrations are provided along with a copy of High-Performance Brake Systems: Design, Selection, and Installation for on-the-job reference.
Learning Objectives
By attending this seminar, you will be able to:
• Estimate brake system energy capacity
• Approximate brake system gain requirements
• Calculate vehicle deceleration
• Establish brake proportioning for ideal balance
• Determine pedal ratios, booster output, and hydraulic system gain
• Discuss the differences between brake fluid chemistries
• Specify brake caliper components
• Differentiate between brake pad friction materials
• Select rotor technologies for application-specific needs

Who Should Attend
This course has been developed for individuals involved in the specification, design, installation, maintenance, and performance of brake systems and their associated components in high-performance and/or racing applications; however, the fundamental principles and design considerations presented apply to all facets of brake system engineering. In addition to individuals involved directly in brake system design, this course can be valuable to those responsible for chassis design, suspension tuning, tire optimization, and overall vehicle dynamics in high-performance applications.

Topical Outline
DAY ONE
Module 1: Energy Conversion
• The Conservation of Energy
• Types of Energy
• Energy Transformation
• Calculating Brake System Temperatures

Module 2: Tires
• Brake Forces & Tire Slip
• The Mu-Slip Curve
• Calculating Maximum Deceleration

Module 3: Gain
• Gain & Force Distribution
• Brake Component Gain
• Brake System Gain
• Calculating Stopping Distance
• Compliance

Module 4: Brake Balance
• Brake Force and Corner Weight
• Static and Dynamic Weight Distribution
• Ideal Brake Balance
• Why Ideal Brake Balance Matters

Module 5: Apply System
• Brake Pedal Design & Function
• Brake Booster Design & Function
• Master Cylinder Design & Function
• Balance Bar Design & Function
• Proportioning Valve Design & Function

Module 6: Brake Fluid & Hoses
• Boiling Points and Water Adsorption
• DOT Ratings
• Hydraulic Circuit Design
• Brake Hose Design & Function

DAY TWO
Module 7: Calipers
• Caliper Design & Function
• Taper Wear and Piston Count
• Caliper Mounting
• Caliper Body Design
• Knockback

Module 8: Brake Pads
• Brake Pad Design & Function
• Brake Pad Fade
• Friction Material Categories & Chemistries
• Friction Mechanisms

Module 9: Rotors
• Rotor Design & Function
• Rotor Cooling
• Solid & Vented Rotors
• One-Piece & Two-Piece Rotors
• Cross-Drilled Rotors & Slotted Rotors

Module 10: Design Exercise
• Brake Force Analysis
• Deceleration Analysis
• Weight Transfer Analysis
• Brake Balance Analysis

Instructor: James Walker, Jr.
Fee $1335 1.3 CEUs
Hydraulic Brake Systems for Passenger Cars and Light Trucks

3 Days
I.D.# C0509

Hydraulic brake systems, one of the most important safety features on many road vehicles today, must meet manufacturer and customer requirements in addition to Federal Motor Vehicle Safety Standards. This course will analyze automotive braking from a system's perspective, emphasizing legal requirements as well as performance expectations such as pedal feel, stopping distance, fade and thermal management. Calculations necessary to predict brake balance and key system sizing variables that contribute to performance will be discussed. Major components of a brake system, including calipers, boosters, master cylinders, drum brakes, and park brakes will be presented in detail highlighting the many design variations. An overview of the chassis control components and operating principles will be presented with an emphasis on ABS, traction control and stability control.

Learning Objectives

By attending this seminar, you will be able to:
• Design a brake system in compliance with Federal Motor Vehicle Safety Standards
• Calculate the ideal brake balance for a vehicle under any loading condition
• Calculate the actual brake balance and brake output for a selected set of brake components and evaluate the effects of changing component parameters
• Determine the effects of variation in component parameters on the system performance
• Describe the basic function of major brake components
• Describe various chassis control systems and their role in vehicle safety
• Determine the appropriate design variation for a particular application

Who Should Attend

This course is designed for engineers interested in, or responsible for, the specification, prediction and validation of braking system performance. It will also benefit engineers responsible for brake component design by providing insight into the interaction of components and the contribution to system level performance metrics.

Topical Outline

DAY ONE
• System Level Requirements
  • Emphasis on FMVSS 135 and ECE 13 -- Effects of requirements on design; Tradeoffs with other system requirements; Partial system considerations; Loading conditions-

DAY TWO
• Workshop - The student will design a brake system for a vehicle of their choice and predict the performance to key system level targets
• Component Functional Review
  • Brake pedal assembly -- Variable ratio; Adjustable; Composite
  • Brake booster options -- Vacuum; Hydroboost; Active
  • Master cylinder
  • Fluid, pipes, and hoses
  • Proportioning and metering valves
  • Disc brakes -- Fixed; Floating; Multi-piston; Vented; 2-piece

DAY THREE
• Workshop - The student will determine the effects of component variation on their design from Day 2
• Anti-lock Braking Systems
  • Mechanization
  • Performance
  • Dynamic rear proportioning/electronic brake force distribution

Instructor: Thomas J. Hall
Fee $1700 2.0 CEUs
Introduction to Brake Control Systems: ABS, TCS, and ESC

2 Days
I.D.# C0315

A similar course is available on demand – Introduction to Brake Control Systems e-Seminar – see course info below.

Once reserved for high-end luxury vehicles, electronic brake control systems are quickly becoming standard equipment on even the most inexpensive cars and trucks. Today, nearly every new vehicle benefits from the optimized braking, enhanced acceleration, or improved stability that these systems provide. This comprehensive seminar introduces participants to the system-level design considerations, vehicle interface requirements, and inevitable performance compromises that must be addressed when implementing these technologies.

The seminar begins by defining the tire-road interface and analyzing fundamental vehicle dynamics. Following an in-depth study of system electronics, hydraulic hardware, and sensor requirements, the participants learn about the control strategies employed by anti-lock brakes (ABS), dynamic rear proportioning (DRP), traction control (TCS), and electronic stability control (ESC) with strong emphasis placed on vehicle dynamic response. The seminar concludes with a study of unique applications, a look forward to advanced brake control system integration, and an overview of Federal Motor Vehicle Safety Standard 126. Over 500 pages of detailed course notes and illustrations are provided for on-the-job reference.

Learning Objectives

By attending this seminar, you will be able to:
- Analyze brake system design parameters and their vehicle performance effects
- Evaluate the compromises between stability, steerability, and stopping distance
- Discern the discrete mechanical components required for ABS
- Specify fundamental ABS performance attributes
- Estimate dynamic brake balance and explain the benefits of DRP
- Reconcile TCS performance expectations vs. method of implementation
- Interpret ESC metrics and ultimate dynamic limitations
- Discuss opportunities for advanced brake control system integration
- Comprehend federal requirements for the performance of ESC

Who Should Attend

This course has been developed for engineers involved in all fields related to the design or development of vehicle dynamics, vehicle braking systems, powertrain systems, chassis systems, or suspension systems. In addition, this course can be valuable to those with component design responsibilities in brake, chassis, suspension, or tire disciplines.

Individuals new to the field of brake control systems will benefit most from the material; this introductory course is not intended for individuals with significant experience with brake control systems. In addition, please note that because of proprietary considerations this class does not provide details of algorithm design, algorithm performance, or algorithm application. Instead, the course places strong emphasis on vehicle dynamic responses.

Prerequisites

An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with vehicle brake and suspension systems is required.

Topical Outline

DAY ONE
- Tire-Road Interface Characteristics
  - Defining slip
  - Longitudinal mu-slip relationship
  - Longitudinal vs. lateral slip capacity
  - The friction circle
- Hydraulic Brake System Overview
  - What do braking systems do?
  - How does each component contribute?
  - What are the underlying fundamental relationships?
  - How does this apply to brake control systems?
- Stability, Steerability, Stopping Distance
  - Define stability, steerability, stopping distance
  - Illustrate with mu-slip curves
  - Illustrate with friction circle
- Mechanization of ABS
  - ECU functions and components
  - HCU functions and components
  - ABS hold, release, and apply functions
  - Diagnostics and warning lamp considerations
- ABS Sensor Overview
  - The role of sensors
  - Wheel speed sensors
  - Brake apply state sensors
  - Longitudinal accelerometers
- ABS Performance
  - ABS objectives and strategies
  - Basics of ABS wheel control
  - ABS performance on homogeneous surfaces
  - ABS performance under other conditions

DAY TWO
- DRP Performance
CHASSIS AND VEHICLE DYNAMICS

- Weight transfer and brake proportioning
- Proportioning valve design and performance
- DRP strategies, wheel control, and performance
- DRP benefits, design compromises, and limitations
- Mechanization of TCS and ESC
  - Additional ECU functions and components
  - Additional HCU functions and components
  - Pressure build sequence
- TCS and ESC Sensor Requirements
  - The role of sensors
  - Steering angle sensors
  - Brake pressure sensors
  - Lateral accelerometers and yaw rate sensors
- TCS Performance
  - TCS objectives and strategies
  - Basics of TCS wheel control
  - TCS performance under various conditions
  - Driveline architecture interactions
- ESC Performance
  - The physics of turning
  - ESC objectives and strategies
  - Basics of ESC wheel control
  - ESC performance
  - Driveline architecture
- Special Conditions and Considerations
  - 4x4 and off-road considerations
  - Racing and high-performance considerations
  - Impact of vehicle modifications
- Advanced Integration (handout only - no presentation)
  - Adaptive cruise control (ACC)
  - Panic brake assist (PBA)
  - Brake-by-wire (BBW)
- Federal Motor Vehicle Safety Standard 126
  - ESC definitional requirements
  - ESC dynamic performance test
  - Stability and responsiveness requirements
  - Industry rollout requirements
  - Federal Register preamble requirements
- Learning Assessment

Introduction to Brake Control Systems e-Seminar

9.5 Hours
I.D.# PD130501ON

A similar course is available as a classroom seminar—Introduction to Brake Control Systems—see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this nine and a half hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. The course is divided into 13 video modules, accompanied by a handbook.

View the complete course description and a video demo at training.sae.org/eseminars/brakecontrolsystems.

What You Will Receive:

- 90 Day access through MyLearn.sae.org
- Links to streaming video modules
- Course Handbook (downloadable .pdf’s, subject to DRM)
- Online Pre-test & Post-test (self-test, immediate results)
- CEUs/Certificate of Achievement (with satisfactory post-test score)

Instructor: James Walker, Jr.
Fee $535 1.0 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

Introduction to Brake Noise, Vibration, and Harshness

1 Day
I.D.# C1337

Brake Noise, Vibration, and Harshness (NVH) is recognized as one of the major problems currently faced by the automotive manufacturers and their suppliers, with customers warranty claims of more than $100 million per year for each manufacturer. With increasing consumer braking performance expectations, automotive OEM’s and suppliers need the ability to predict potential problems and identify solutions during the design phase before millions of dollars have been spent in design, prototyping, and manufacturing tooling. This seminar provides an introduction to brake NVH, including a concise summary of the various brake NVH problems, current lab and vehicle measurement techniques and SAE global
standards which are utilized to characterize the noise correctly in order to get the best option/solutions quickly. The information provided will serve as an excellent foundation for understanding and characterizing brake NVH issues and is an excellent primer to the SAE seminar Brake Noise Problem Resolution (ID# C0831, page 10), also taught by instructor Eric Denys.

Learning Objectives
By attending this seminar, you will be able to:
• Describe NVH and brake NVH
• Identify the various brake NVH problems
• Describe the components of a brake NVH dynamometer
• Configure and perform dyno and vehicle brake NVH tests measurements
• Utilize SAE J2521, the only international standard for brake NVH dynamometer evaluation
• Interpret basic noise and vibration data in the time and frequency domain
• Explain the premise behind various SAE Standards related to brake NVH

Who Should Attend
The information in this course is relevant to a wide audience, from the brake test technician who seeks to understand more about NVH and brake NVH, to the experienced brake NVH engineer who wishes to know more about the details of the tests performed and the meaning of the results. Brake development and brake component engineers who are not familiar with brake NVH will also find the course beneficial.

Topical Outline
• Basics of Noise and Vibration
  • Basic terminology
  • Spectral analysis
  • Modal analysis
  • Sound radiation
• Basics of Brake NVH
  • Different types of brake noise
  • Why do brakes make noise?
  • Source, path, and receiver description
• Basic Dynamometer Testing
  • Test set-up
  • SAE J2521 - Disc and Drum Brake Dynamometer Squeal Noise Matrix
  • Data analysis and reporting
• Vehicle Brake Testing
  • Basic instrumentation
  • Data analysis and reporting
  • SAE J2625 - Automotive Vehicle Brake Squeal Test Recommended Practice
  • Brake SAE NVH Standards Currently Released and Under Development
• SAE J2598 - Automotive Disc Brake Pad Natural Frequency and Damping Test
• SAE J2786 - Automotive Brake Noise and Vibration Nomenclature
• SAE J2933 - Verification of Brake Rotor Modal Nomenclature
• SAE J3001 - Brake Insulator Damping Measurement Procedure
• Introduction to Brake NVH Problem Resolution

Instructor: Eric Denys
Fee $770 .7 CEUs

Vehicle Braking Performance: Braking Confidence and Pedal Feel Fast Track
51 Minutes
I.D.# PD230912ON
Braking confidence and pedal feel are important braking performance attributes that should be optimized to achieve customer satisfaction with a vehicle's braking system. The relationship between the input force and travel provided by the driver to achieve the desired vehicle deceleration is as core to the vehicle personality or DNA as ride, handling, or driveability. This Fast Track will cover the main concepts and methods needed for tuning brake systems to desired pedal force and travel characteristics.

Major topics include:
• Introduction to Braking Confidence
• Input Force to Vehicle Deceleration Relationship
• Input Travel to Vehicle Deceleration Relationship
• Parametric Analysis
• Environmental Effects
• Emerging Trends Affecting Braking Confidence

Is this Fast Track for you?
The Vehicle Braking Performance: Braking Confidence and Pedal Feel Fast Track would be of value to anyone involved in the validation of a braking system, either in the development of the validation plan or the execution of the validation plan. This course would also be of value to those involved in vehicle marketing -- a detailed understanding of the metric's generation and contributing effects will insure that promotion and comparison is done in a qualified manner.

What You Will Receive
• Three months of on demand access to the 51 minute presentation
• Integrated knowledge checks to reinforce key concepts
Vehicle Braking Performance: Stopping Distance Fast Track

1 Hour
I.D.# PD230826ON

Stopping Distance is one of the most common metrics of a vehicle's braking performance and one of the most critical attributes of accident prevention and minimization. The measurements are used within the development of the vehicle and are a critical aspect of accident prevention, accident reconstruction, and overall occupant and pedestrian safety management. This one-hour online short course reviews the methods used to measure and report stopping distance and analyzes the associated formulations to determine the braking forces created by a wheel brake and necessary to achieve a desired distance. Vehicle and driver contributions to the overall stopping event are examined.

Major topics include:
• Calculation of Stopping Distance
• Common Procedures Used to Assess Stopping Distance
• Performance Metrics Compared to Target Avoidance
• Determination and Generation of Forces Necessary to Stop a Vehicle
• Contributions and Limitations

Is this Fast Track for you?
The Vehicle Braking Performance: Stopping Distance Fast Track would be of value to anyone involved in the validation of a braking system, either in the development of the validation plan or the execution of the validation plan. Those involved in accident reconstruction and accident prevention would benefit from an understanding of the techniques, principles, contributing factors and limitations of stopping performance to improved vehicle and road system design. This course would also be of value to those involved in vehicle marketing -- a detailed understanding of the metric's generation and contributing effects will insure that promotion and comparison is done in a qualified manner.

What You Will Receive
• Three months of on demand access to the 60 minute presentation
• Integrated knowledge checks to reinforce key concepts
• Proof of Participation

NEW! SAE ACCIDENT RECONSTRUCTION CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Become more proficient in the practice of vehicle crash/accident reconstruction by successfully completing this certificate program from SAE. Required courses guide you through crash reconstruction methods, vehicle dynamics, and event data recorder (EDR) technology. Then select three electives that suit your individual technical interest area. Completing the SAE Accident Reconstruction Certificate Program grants you eight credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems or Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. View the list of required and elective courses and more information on enrolling in this SAE certificate program--http://training.sae.org/credentialing/certificate/accident.htm
Includes electronics, vehicle electrification, modeling and simulation, data sensors, automotive lighting, and control systems.

**A Holistic Introduction to Commercial Telematics**

2 Days  
I.D.# C0947

The technical difficulty, time, and costs associated with deploying a successful telematics system are often underestimated. This seminar provides participants a comprehensive overview of the various technologies that make up a telematics system as a whole and provides the information necessary to help drive intelligent decisions that have long-term benefits.

This two-day seminar will begin with a review of the origins, technologies, and systems used in creating and operating modern-day telematics systems. The main technologies will be broken down into five categories, all of which are required to operate in unison in order for the system to be successful. This will include automotive technologies necessary to gain access to vehicle operating data, wireless technologies to establish communications, navigation technologies to introduce location, antennas that enable wireless, and data management to manage and make data useful. A series of practical examples will allow attendees the opportunity to work through each of the functional technologies and implement a simple telematics solution. The seminar will conclude with a discussion of the issues that drive a cost vs. buy decision on the specific elements in the telematics value chain, as well as various applications currently being deployed and the exploration of future applications within the telematics market. Attendees are encouraged to bring a laptop computer with a dual-boot Linux operating system installed.

**Learning Objectives**

By attending this seminar, you will be able to:

- Distinguish the various technologies used in telematics systems
- Assess the difficulty, time, and costs required to deploy a functional telematics solution
- Evaluate alternatives and make decisions on where to spend development dollars, and when to rely on outside resources
- Construct and demonstrate a simple telematics system
- Recognize the role current and future telematics technologies will play in our collective future

**Who Should Attend**

Engineers at all levels wanting to gain a better understanding of the fusion of technologies involved in telematics systems will benefit from this seminar. Also benefiting are OEMs looking for a competitive advantage and field data that will improve their product development system. Fleet operators looking to increase business productivity, better manage their assets, meet regulatory requirements more efficiently, and improve asset utilization will also benefit from the technical information presented.

**Topical Outline**

DAY ONE
- Telematics Overview
  - Definition
  - Historical Origins -- One size does not fit all
- Telematics Technologies
  - Overall System Architecture
• Automotive -- Vehicle Bus architecture; Protocols; Power requirements; Regulatory requirements; Proprietary barriers
• Wireless -- Providers/ISP’s; Terrestrial; GSM; CDMA; FM-RDS; WAN/PAN; 802.11; Zigbee; WiMax; Bluetooth; SATCOM; LEO; GEO
• Navigation -- GPS; Galileo; Everything Else
• Antennas -- The black magic
• Data Management -- Hosting/Servers; Databases; Scalability; NOC; Availability; Backup; Security; ASP
• Getting Started -- Basic System Architecture; Environment Setup; Powering up and getting familiar with the system

DAY TWO
• Practical Example #1
  • Vehicle Bus -- Standard messages; Capturing all data; Filtered messages; Capturing specific messages
• Practical Example #2
  • Navigation -- Capturing GPS stream; Combining GPS data with bus data
• Practical Example #3
  • Establishing network communications -- Basic communication setup; Terminal monitoring of network communication; Sending GPS/Bus data to server
• Practical Example #4
  • Send a formatted message to back-end application -- Display results on map
• Receive and decode formatted message from server -- Send specific vehicle bus data (request)
• Cost-Value / Cost-Performance
• Make vs. Buy: Hardware; Software; Back office
• Future Implications and Applications
  • Insurance -- Black Boxes; Usage based insurance
  • Safety & Security -- People; Products; RFID
  • Compliance/Regulation -- Intelligent highways; Sarbanes-Oxley
• Closing and Evaluation

Instructor: Emad Isaac
Fee $1335 1.3 CEUs

Acquiring and Analyzing Data from Sensors and In-Vehicle Networks

2 Days
I.D.# CO522

The acquisition of test data is required throughout the product’s life cycle - in prototype performance evaluation, reliability/durability testing, duty-cycle analysis, end of line testing, and service and aftermarket product areas. Both lab and on-road testing is needed for components, sub-systems and entire vehicles.

As in-vehicle networks become increasingly more sophisticated in terms of the number of controllers, the speed at which they communicate, and the number of parameters available, they are a virtual goldmine for the test engineer. If the data is already available on the vehicle network, the engineer may only need to add any missing sensors (or possibly none at all).

After reviewing the traditional approach of acquiring data directly from sensors, the course will focus on the newer approach of obtaining data from the in-vehicle network for both automotive and heavy duty vehicles. Attention is given to the complications of taking data from the in-vehicle network and how to overcome them, current trends and applications, wireless data acquisition (Wi-Fi and cellular), GPS, relevant technical standards, and how to simultaneously acquire network data with direct sensor measurements. Both PC-based and logger (flight recorder) data acquisition will also be covered. In addition, a practical guide for analysis and presentation techniques will be covered along with examples.

Learning Objectives

By attending this seminar, you will be able to:
• Explain what it takes to acquire data from both in-vehicle networks and sensors
• Compare and contrast acquiring data from both in-vehicle networks and directly from sensors
• Understand OBD-II, the CAN protocol and other common vehicle protocols
• Identify an unknown OBD-II network protocol
• Define the four database types that relate in-vehicle network messages to scaled engineering parameters
• Review vehicle messages and convert the messages to scaled engineering parameters using various automotive and heavy duty protocols and message types
• Demonstrate how sample rate has a major effect on your data beyond the obvious and show how to select the optimum sample rate
• List the four domains that are available to present your data to enhance understanding of the data
• Avoid common pitfalls of acquiring and analyzing good data
• Choose the best analysis techniques to better understand and present test data
• Compare benefits of acquiring data with a PC vs. a stand-alone data logger (without a PC in the vehicle)

Who Should Attend

Any engineer, scientist or technician who wants to learn the fundamentals to acquire and analyze test data will benefit from this course. Typical attendees include: R&D engineers, test engineers and technicians, fleet owners, government agencies, and aftermarket product developers. The assumption is that the in-vehicle network is working properly and the emphasis is on
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

how to maximize the information that can be obtained from the vehicle’s network.

Topical Outline

DAY ONE

• Acquiring Data Directly from Sensors
  • Sensor Inputs: Sensor overview, single-ended vs. differential inputs, proper ranging of the channels, zeroing offsets and signal conditioning.
  • Data Acquisition: Analog-to-digital converters (A/D), time and amplitude resolution, pre- and post-triggering, time synchronous averaging, sample rate, aliasing, frame length and number of frames in a data file.
• Frequency Domain
  • Analyzing data in the frequency domain with the Fast Fourier Transform (FFT) is a valuable tool to optimize sample rate, which affects many factors such as data quality (aliasing), time and frequency resolution, digital filtering, integration and differentiation. Analyzing and displaying the data in the revolution (angular) domain and order domain offer valuable insights into the data.
• In-Vehicle Data Acquisition
  • Comparison of in-vehicle data acquisition with sensor data acquisition.
  • Explanation of OBD-II and what it can and cannot do for you
  • Examination of files containing hex messages. Learn the steps required to convert to useful engineering parameters (e.g. engine RPM, wheel speed, ambient temperature). Message files will be shown from both heavy duty and automotive vehicles

DAY TWO

• In-Vehicle Data Acquisition - continued
  • Step-by-step procedure to acquire parametric data for both a PC and stand-alone loggers.
  • Explanation of why the database relating parameters and messages is the key and how to get this database information.
  • How to calculate fuel economy and fuel consumption from the in-vehicle network for automotive and heavy duty vehicles
  • Review of applicable standards and references.
  • How to identify unknown automotive protocols and learn about the various network protocols
  • Review of wireless data acquisition options, the advantages and disadvantages of them and the practical throughput rate for real-time data acquisition.
• Data Analysis Techniques
  • How to select the best numerical techniques and how to optimize their performance for digital filtering (including IIR and FIR filters), integration, differentiation, and correlation.
  • How combining logic, statistics and Z transform provides a powerful technique to find key points along a waveform.
  • Make decisions such as pass/fail or perform intelligent monitoring to store only the data of interest optimizing storage space and analysis time.
  • How to time correlate data taken from different sources, such as from the in-vehicle network and directly from sensors.

Instructor: Richard Walter
Fee $1415 1.3 CEUs

Automotive Lighting: Design and Technology

2 Days
I.D.# C0202

Since the invention of the automobile, lighting has been an important subsystem on all ground vehicles. Automotive lighting is vital to passenger safety, comfort and vehicle styling. The technology used in automotive lighting has rapidly expanded to make the lighting more value added, safer and pleasing to customers. This seminar provides broad information about automotive lighting systems with emphasis on lighting functions, effectiveness, and technologies. The intent is to assist attendees to gain sufficient knowledge about automotive lighting and its importance in overall vehicle design and development. Since only the exterior lighting devices on the ground vehicles are regulated by the federal and local governments, and standardized by the SAE Lighting Committee and the international communities, this course will only address automotive exterior lighting.

Learning Objectives

By attending this seminar, you will be able to:
• Describe various automotive lighting technologies
• Articulate the legal aspects and implications related to automotive lighting
• Examine safety measurements used with lighting functions and human factors costs
• Discuss the latest advancements in lighting technologies and trends in lighting styling

Who Should Attend

This seminar is of benefit to a wide audience, including: Automotive body engineers responsible for lighting and vehicle interface and integration; vehicle stylists who are interested in lighting effects on vehicle cosmetics; regulatory personnel involved with the legal specifications of automotive lighting; marketing specialists who are interested in customers’ preferences based on the relationship of human vision and lighting; and newcomers in the automotive industry who need to obtain a general overview of lighting.
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

Topical Outline
DAY ONE
• Introduction
• Fundamentals of Automotive Lighting
  • Light -- What is light; Definition of light; Types of light; Visible light; Generation of light
  • Light Measurements -- Basic concept; photometry and radiometry; Color of light; Terms of photometry; Photometry units comparison; Photometry and radiometry unit conversion; Photometry and radiometry calculations
• Lighting; Illumination Devices -- Functions of an illumination device; Types of illumination devices; Basic structure of illumination devices
• Classification of Automotive Lighting -- Forward lighting and signal lighting; Headlamps; Fog lamps (front and rear); Daytime running lamps; Stop & tail lamps; Turn signal lamps (front and rear); Other lamps
• Requirements for Automotive Lighting -- Regulations and industry standards; Performance; Testing
• Light Sources Used in Automotive Lighting
  • Basics of Light Source -- Incandescent; Discharge; Fluorescent; Solid-state; Electroluminescent; Light source comparison
  • Light Source Characteristics -- Light emitter geometry; Light output from a light source; Life; Light source operation and testing; Bulb accuracy levels
  • Types of Light Sources Used for Automotive Exterior Lighting -- Incandescent bulbs; Tungsten halogen bulbs; HID subsystem (burner, starter & ballast); Neon light source (emitter & ballast); LED source (LED package, circuit board & control device)
  • Major North America Automotive Light Source Suppliers -- Osram (OSI & OOS); Philips (including Lumileds); Others
• Automotive Lamp Photometry Design
  • Optical Design Principles -- Optics; Geometrical optics; Imaging optics; Non-imaging optics; Reflection; Refraction; Transmission; Dispersion
  • Light Control; Collections and Manipulations -- Light collectors; reflectors and lenses; Light manipulators (reflector optics, lens optics, diffusers, light guides and fiber optics, reflex); Etendue

DAY TWO
• Optical Design for Automotive Lamps -- Automotive lamp configurations; Optical design step 1; feasibility study; Optical design step 2; setup strategy; Optical design step 3; design optics; Optical design step 4; simulations; Other considerations; Light source selection; CAE for optical design and simulation
• Automotive Lamp System Configuration
• Automotive Lamp System Design Overview -- System level specifications; Vehicle interface
• Automotive Lamp Thermal Analysis -- Purpose; Heat transfer; Empirical database; CFD lamp thermal model
• Automotive Lamp Venting Analysis -- Understanding moisture; Moisture and condensation in a lamp; Venting analysis; Vent design
• Automotive Lamp System Analysis -- CAD tools used in automotive lamp design; Lamp thermal analysis; Lamp venting analysis; Lamp structural analysis; Lamp mold accuracy analysis; Lamp assembly analysis
• Human Factor Considerations -- What are human factors; Headlamp safety; seeing distance; Glare; Headlamp aiming issue; Headlamp mounting height issue; Headlamp lens issue; Signal detection; Lamp design for human factor optimizations
• New Automotive Lighting Technologies
  • Advanced Optical Structures for Automotive Lamps -- Combination of projector & free-form reflectors (P&F) headlamps
  • Improved projector modules
    • Dual-Function HID (Bi-Xenon) Lamps -- System; Reflector type dual-function HID lamp; Projector type dual-function HID lamp
    • Distributive Lighting System (DLS); a Remote Lighting System Using Fiber Optics -- System; DLS headlamp application; Other DLS applications
  • Adaptive Forward-lighting System (AFS); an Intelligent Lighting System -- System; Desired beam pattern variations; Driving and environment condition measurements; AFS design option I; add beam contributor(s); AFS design option II; rotate headlamps; AFS design option III; vary component(s) in the headlamp
  • Night Vision System -- System definition; Infrared and IR cameras; Types of night vision systems; Examples of night vision systems

Instructor: Jianzhong Jiao
Fee $1335 1.3 CEUs

Automotive Lighting: LED Applications

1 Day
I.D.# C0727

Lighting Emitting Diode (LED), a new generation semiconductor light source often referred to as Solid-State Lighting (SSL), has been broadly adopted in illumination, display, visualization, and other areas due to its higher efficacy and longer life. LEDs, first introduced for automotive interior applications such as indicators, expanded to exterior applications including center high mounted stop lamps and other automotive signal lighting devices. Today, LED technologies are being used for night vision, occupancy detection, and many other automotive application areas. This seminar is designed to provide the attendee with an overview of LEDs and their applications in automotive lighting and illumination.
Learning Objectives

By attending this seminar, you will be able to:

- Describe the basic LED configurations, characteristics, and classifications
- Assess LED and SSL technologies used in automotive applications
- Identify technical challenges and limitations of LEDs
- Select appropriate equipment for measurement of various conditions
- Evaluate LEDs for conformance to SAE standards
- Establish a basic design strategy for specific applications including forward lighting devices
- Manage a design activity to deal with thermal management

Who Should Attend

This seminar can be of benefit to a wide audience including LED automotive body and system engineers responsible for lighting and vehicle interface and integration; vehicle stylists who are interested in lighting effects on vehicle aesthetics and lighting developers and manufacturers; marketing specialists who are interested in customers’ preferences based on the relationship of human vision and lighting; and newcomers in the automotive industry who need to obtain a general overview of lighting.

Topical Outline

- Introduction
- LED - Definitions and Classifications
  - Types of LEDs
  - Basic LED characteristics
  - LED efficiency
  - Life and lumen maintenance
- LED Measurements and Standardization
  - Photometric measurements -- Light output measurements; Color of the light source; Measurements of LED life and lumen maintenance
  - Thermal measurements -- Thermal resistance and derating
  - Measurement equipment -- Photometric measurement and thermal management equipment
  - LED binning -- Luminous flux, voltage, and color bin
  - LED automotive lighting standards -- Signal lighting and forward lighting standards; Human factors evaluations for white LEDs
  - LED component standards -- Definitions; Industry trends
- LED Automotive Exterior Lighting Applications
  - LED lamp design basics
  - Photometric design requirements -- Basic design procedure; Design flow and optimization process
  - LED lighting system thermal and electronic design -- Why thermal management?; Effects of LED junction temperature; Cooling systems; LED bin selection; Electronic design - dual level lamps
- LED signal lighting design concepts and examples -- Direct lighting: with or without secondary optics; Indirect lighting: TIR - prism, light guide and light pipe
- LED headlamp design concepts and examples -- Comparison of light sources used for headlamps; Design restrictions and strategies
- LED Automotive Interior Applications -- Interior lighting basics (Types of interior lighting, Performance evaluations); LED applications (Backlight for display, Interior illumination, Occupancy detection)

Instructor:

Jianzhong Jiao

Fee $750 .7 CEUs

Automotive Lighting: Testing and Requirements

1 Day
I.D.# C0618

It has not been commonly known that automotive exterior lights are safety devices and must comply with governmental regulations. Since the 1930s, the SAE Lighting Standards Committee has been actively working with the automotive industry OEMs, lamp makers, tier-two suppliers, and human factor experts to develop automotive lighting standards. These standards have been widely used or referenced by the U.S. federal or state governments in establishing and enforcing the lighting regulations. This seminar emphasizes the safety importance of automotive lighting devices and provides important information on lighting functions, standards or regulations, testing and evaluations.

Learning Objectives

By attending this seminar, you will be able to:

- Describe the legal aspects and implications related to automotive lighting
- Search for and use the lighting related standards for all exterior lighting devices
- Establish or assist with lighting tests and evaluations

Who Should Attend

Automotive engineers and product development personnel who are responsible for lighting design, manufacturing, quality assurance, installation, vehicle interface and integration will benefit from attending this seminar. Regulatory personnel who are involved with the legal specifications of automotive lighting and law enforcement agencies or individuals responsible for lighting regulations will find the information valuable and relevant as will testing engineers or technicians who are responsible for evaluating and verifying the compliance of lighting standards and regulations.
3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at 1-724-772-8529
• Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org

Autonomous Vehicle Positioning Systems

1 Day
I.D.# C1026

This seminar addresses vehicle positioning and navigation systems. The first part of the seminar provides an overview of the Global Positioning System (GPS) since it is the main location technology enabler for automotive location-based applications. The following topics will be discussed: coordinate reference frames, satellite constellation, signal structure, ranging observables, ranging error sources, error mitigation techniques, position velocity and timing (PVT), accuracy and availability for different modes of positioning that include open-loop, differential GPS (DGPS), real-time kinematic GPS (RTK), GPS dead-reckoning, augmentation of GPS with wheel speed sensors, inertial measurement units and compasses. Sensor fusion using a Kalman filtering technique will be included. GPS accuracy and availability performance in automotive driving environments, GPS vehicle installations (antenna, RF cable and GPS receiver), and bench-level and vehicle-level methods to evaluate GPS will be covered. An introduction to automotive navigation systems will be presented. Topics such as map database sources, route guidance calculations, and graphical user interfaces will be covered.

Learning Objectives
By attending this seminar, you will be able to:
• Specify the performance of GPS receivers and navigation systems
• Evaluate the performance of GPS receivers and navigation systems
• Integrate the GPS with other sensors via a Kalman filter to improve navigation availability
• Select the appropriate implementation of a vehicle navigation system based on your application requirements

Who Should Attend
This course is appropriate for engineers or managers who want a better understanding of the technologies involved in vehicle to vehicle and vehicle to infrastructure applications. Those interested in wireless communications application to vehicular environments, vehicle positioning systems used for connected vehicles, vehicular software architectures and security, and vehicle system applications such as active safety as they apply to automotive/commercial vehicles will find this course useful.

Other professionals who will benefit from this course include: managers seeking to evaluate technology/regulation/standardization/business trends; fleet operators looking to increase business productivity, better manage their assets, meet regulatory requirements more efficiently, and improve asset utilization;
business stakeholders involved in controlling/exploiting data transmitted from/to vehicles; those involved with autonomous/unmanned vehicles; and professionals interested in the perspective that the mobility, data security, and safety aspects of connected vehicle systems can enhance the reliability and control of driver-assisted vehicles.

**Topical Outline**

- Overview of GPS and Navigation Systems
  - Coordinate reference frames
  - GPS Satellite Constellation
  - GPS signal structure
  - Code and carrier ranging observables
  - GPS ranging error sources and mitigation techniques
  - Position accuracy dependence on satellite geometry and range error
- GPS Modes of Positioning
  - Open Loop GPS positioning with C/A code
  - Differential GPS carrier phase positioning with C/A code
  - Kinematic GPS positioning with C/A code and/or L1/L2 carrier phase
  - GPS performance examples in typical automotive environments
- GPS/INS Integration for Vehicles
  - IMU modeling and vehicle dead-reckoning errors
  - Introduction to the Kalman filter
  - Ground vehicle dynamics
  - Ground vehicle models
  - Estimation of vehicle navigation states
  - Estimation of vehicle parameters
  - GPS/INS simulation examples
- GPS Integration with other sensors
  - Digital Compass
  - LIDAR
  - UWB
  - Wheel speed sensors
  - Application examples

**Instructor:** Daniel N. Aloi, Ph.D. and Ka C. Cheok, Ph.D.

**Fee:** $790 .7 CEUs

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**Control Systems Simplified**

2 Days

I.D.# C0525

The advent of digital computers and the availability of ever cheaper and faster micro processors have brought a tremendous amount of control system applications to the automotive industry in the last two decades. From engine and transmission systems, to virtually all chassis subsystems (brakes, suspensions, and steering), some level of computer control is present. Control systems theory is also being applied to comfort systems such as climate control and safety systems such as cruise control or collision mitigation systems.

This seminar begins by introducing the highly mathematical field of control systems focusing on what the classical control system tools do and how they can be applied to automotive systems. Dynamic systems, time/frequency responses, and stability margins are presented in an easy to understand format. Utilizing Matlab and Simulink, students will learn how simple computer models are generated. Other fundamental techniques in control design such as PID and lead-lag compensators will be presented as well as the basics of embedded control systems.

During this interactive seminar, attendees will utilize case studies to develop a simple control design for a closed loop system. And, with the aid of a simple positioning control experiment, students will learn the major components and issues found in many automotive control applications today.

**Learning Objectives**

By attending this seminar, you will be able to:

- Determine performance characteristics of open and closed loop systems such as time and frequency responses and stability margins
- Analyze compromises and select the best compromised solution between stability and closed loop performance metrics
- Model simple physical systems in MatLab/Simulink environment
- Analyze and design simple compensators in MatLab/Simulink environment
- Evaluate issues associated with digital control systems including effects of sampling time, word length, and throughput
- Explain the functions of various components found in today’s automotive embedded control systems including ECU I/O section, software/algorithms, power electronics, and sensors and actuators
- Communicate with control systems designers more effectively in terms of technical issues as well as toolsets, and functional needs
Who Should Attend
This introductory course is designed for individuals with little or no background in control systems. Engineers, managers, and technical managers with backgrounds in systems, mechanical, electrical, or industrial engineering who work with vehicle chassis (suspension/brakes/steering), powertrains, comfort systems, vehicle dynamics, sensors/actuators, and diagnostics will find the seminar beneficial. Test engineers and technicians, patent attorneys, and business executives may also find this course valuable.

Topical Outline
DAY ONE
• Background Information
  • Examples and block diagrams -- Open and closed loop systems
  • Dynamic systems (time and frequency domains)
  • Stability
  • Compromises of a closed loop system
• Model Development
  • Modeling philosophies
  • Case study -- Problem description; Governing equations; Create a model based on transfer function; Create a model based on Simulink blocks
• Model Analysis
  • Case study -- Simulation issues (numerical integration); Linear analysis - frequency domain; Nonlinear analysis - time domain
• Compensation (Controller Design) Methods
  • On-Off
  • Gain
  • PID
  • Lead-Lag
DAY TWO
• Control System Design
  • Case study -- Design philosophies; Time domain based design; Frequency domain based design
• Embedded Systems
  • Elements of embedded control systems
  • Experiment
  • Digital control
  • Implementation issues
• Design Implementation
  • Case Study -- Digital issues; Experiment; Sensors and estimation; Software architecture;
• Advanced Subjects
  • Nonlinear/adaptive control
  • Robust control
  • Trends, tools and references

Instructor: Farhad Bolourchi
Fee $1375 1.3 CEUs

Controller Area Network (CAN) for Vehicle Applications
2 Days
I.D.# C0120
A similar course is available on demand – Controller Area Network (CAN) for Vehicle Applications e-Seminar – see course info below.

The Controller Area Network has become the standard of choice for most automotive manufacturers. Approved for use as an ISO and EPA diagnostic network, its usage continues to grow. This seminar covers the theory and use of the CAN protocol, and its applications in the automotive industry.

Details on how the CAN protocol and other standards (J2411, J2284, J1939, ISO 11898, etc.) complement each other will be presented. Attendees will learn about CAN application layers; the latest J1939, J2284, J2411, and IDB standards, regulations, and implementation requirements; and details of device hardware and software interfaces. Also presented will be demonstrations using system development tools. The SAE standard, J1939 Recommended Practice for a Serial Control and Communications Vehicle Network, is included in the course materials.

Learning Objectives
By attending this seminar, you will be able to:
• Explain CAN protocol.
• Demonstrate how CAN is used in various automotive applications.
• Employ CAN-related standards and specifications.

Who Should Attend
This seminar is geared toward validation engineers, test engineers, embedded programmers, and those who are currently working (or will be in the future) with applications using CAN. Participants should have an undergraduate engineering degree.

Topical Outline
DAY ONE
• In-vehicle market overview
• General network topology overview
• CAN protocol; CAN controller programming
• CAN physical layers
• Overview of J2411, J2284, IDB, J1939, Diagnostics on CAN, etc.
DAY TWO
• J1939 in-depth review
• IDB in-depth review
• Demonstrations

Instructor: Mark Zachos
Fee $1415 1.3 CEUs

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Controller Area Network (CAN) for Vehicle Applications e-Seminar

10.5 Hours
I.D.# PD130557ON

A similar course is available as a classroom seminar—Controller Area Network (CAN) for Vehicle Applications—see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this 10.5 hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This course offers an introduction, six modules, and a Gryphon demonstration on video, accompanied by a handbook with exercises.

View the complete course description and online demo at training.sae.org/eseminars/can

What You Will Receive:
• 90 day access through MyLearn.sae.org
• Links to streaming video modules
• Course Handbook (Downloadable .pdf's subject to DRM)
• The SAE standards, J1939 Recommended Practice for a Serial Control and Communications Vehicle Network and J1939/71 Recommended Practice for Vehicle Application Layer (.pdf, downloadable)
• Online Pre-test & Post-test (self-test, immediate results)
• CEUs/Certificate of Achievement (with satisfactory post-test score)

Instructor: Mark Zachos
Fee $625 1.1 CEUs

Developing In-Vehicle User Interfaces: Design Principles and Techniques

1 Day
I.D.# C1341

The In-Vehicle user environment is transitioning from fixed dedicated features to an extensible connected interface that can dramatically increase complexity faced by the driver. This course will provide a systematic design method to develop intuitive and safe vehicle interface solutions. Participants will learn user interaction design steps, tools, and the team synergies required to develop an interface from concept to the final product. The course will use exercises to practice interface design, with example interfaces to cover lessons learned. Participants will learn key interaction elements and principles to build a robust and flexible interface.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the HMI user experience design flow from market research through hardware implementation
• Identify the range of usability issues specific to the vehicle environment and how they differ from desktop and mobile usability
• Articulate important human factors principles relevant to the automotive environment
• Utilize basic development tools and methods for interface design
• Explain how to integrate multiple user interfaces into a single unified interface

Who Should Attend
Those involved in vehicle user interaction systems (e.g., controls and displays for infotainment, navigation, smartphone integration, connectivity, HVAC, lights, etc.) in any functional role (e.g., product design, product development, product/market research and quality) will benefit from this seminar, including mechanical engineering, electrical engineering, software engineering, system engineering, product planning, research & development and design.

Topical Outline
• Understanding User Interaction Design Team and Collaboration
  • Key resources; Design process
• Human Factors Principles Important to Vehicle HMI Design
  • Memory
  • Perception
  • Information processing
• The User
  • Learning curve
  • Perceived complexity
  • Easy to use
• Techniques of HMI Design and Development
  • User Interactions; HMI interaction architecture
  • Developing HMI use cases
  • User testing
• HMI Design Tools and Documentation Methods
  • Interaction animation and models
  • Flow diagrams
  • Graphic development

Instructor: John Kosinski
Fee $780 .7 CEUs
Emissions-Related OBD Systems: A Design Overview

1 Day
I.D.# C0708

On-board diagnostics, required by governmental regulations, provide a means for reducing harmful pollutants into the environment. Since being mandated in 1996, the regulations have continued to evolve and require engineers to design systems that meet strict guidelines. This one day seminar is designed to provide an overview of the fundamental design objectives and the features needed to achieve those objectives for generic on-board diagnostics. The basic structure of an on-board diagnostic will be described along with the system definitions needed for successful implementation.

Please note that because of proprietary considerations, this class does not provide details of algorithm design, algorithm performance, or algorithm application. The class will cover general OBD algorithm designs and the features required to promote sound OBD system design.

Individuals desiring a more in-depth look at On-Board Diagnostics should consider attending SAE seminar Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems (ID# C0707).

Learning Objectives

By attending this seminar, you will be able to:

• Articulate the underlying design objectives of on-board diagnostic systems
• Apply the design features that all diagnostics need for successful implementation
• Apply basic design techniques to deal with variation
• Use a diagnostic design template in the development of an on-board diagnostic

Who Should Attend

This course is designed for engineers involved in either the design or control of on-board diagnostic systems for engines or transmissions. Individuals working in the heavy duty industry will find the information relevant, but should note that the examples will be based on spark ignition engines and light and medium duty regulations. In addition, engineers involved in engine and transmission hardware will benefit by obtaining a better understanding of the design of OBD systems. Engineers new to the area of OBD system design and engineers involved in the design of control systems wishing to obtain a better understanding of OBD requirements will also find the course valuable.

Prerequisites

An undergraduate engineering degree or a strong technical background is highly recommended. A basic knowledge of college algebra, college physics, and a familiarity with modern engine or transmission systems is required

Topical Outline

• Fundamental Design Objectives for OBD Systems
• Basic Design Features for OBD Systems
• Defining “Good” vs. “Bad” Systems
• Exercise: Defining Good vs. Defective Systems
• Anatomy of an On-Board Diagnostic
• Diagnostic Modeling
• Understanding and Dealing with Variation
  • Decision making processes
  • Design guidelines for Exponentially Weighted Moving Averages (EWMA)

Instructor: John Van Gilder
Fee $850 .7 CEUs

Fundamentals of Shielding Design for EMC Compliance

1 Day
I.D.# C0835

It is important for electronic and hardware engineers to not only be knowledgeable of a product’s intended function and performance, but also its ability to perform within electromagnetic compatibility (EMC) limits. This seminar introduces practical shielding theory, design fundamentals, and configurations, including shielding products, common and differential modes, electromagnetic fields, and enclosure shielding. A segment on enclosure testing is presented in conjunction with an aperture attenuation modeling program (which is used to model attenuation characteristics at various frequencies and aperture size prior to expensive FCC/CE compliance or MIL-STD 461 testing). Honeycomb vent panels, plating attenuation comparisons, and galvanic compatibility per MIL-STD 1250 will also be discussed. Although the concepts presented in this seminar may be applicable to the automotive industry, the examples and standards presented are primarily focused on military and commercial vehicle applications.

Learning Objectives

By attending this seminar, you will be able to:

• Identify the basic characteristics of Common and Differential Mode
• Recognize E/H, and Plane wave fields, Surface current and “Skin effect” based on increased frequency

Instructor: John Van Gilder
Fee $850 .7 CEUs
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

• Specify Galvanic compatibility of various metal plating
• Specify industry standard shielding products for EMC compliance
• Evaluate waveguide effect of EMI/RFI shielded honeycomb ventilation panels
• Analyze aperture attenuation modeling for EMC design

Who Should Attend
This seminar will benefit engineers requiring an understanding of their electronic product or system's electromagnetic impact on meeting commercial EMC and MIL-STD 461 requirements, as well as those engineers needing to incorporate shielding products into new or current product improvement designs.

Topical Outline
• EMC Fundamentals
  • Definitions
  • Maxwell equations
  • EMI and apertures
  • EMI environment and characteristics
• Practical Shielding Theory
  • Common / Differential modes
  • BLS Crosstalk / Radiated fields
  • Reciprocity
  • Emitter location effects
  • Partial shields
  • H, E, and PW fields
  • Shielding material testing
  • Absorption and reflection
• Shield Apertures
  • Skin depth
  • EM Leakage
  • Aperture calculation
  • Multiple apertures
  • RF current flow
• Aperture Attenuation Modeling Program
  • Aperture Calculations
  • PCB test data comparisons
  • Attenuation Modeling and Test Factor
• Honeycomb Vent Panels
  • Design - waveguide effect
  • Attenuation of various panels
  • Galvanic compatibility
  • EMC Shielding Products and Materials
  • Board Level Shields (BLS)
  • Gaskets (BeCu fingerstock, conductive fabric, conductive elastomer, wire mesh)
  • Ferrites Materials
  • RF Absorber
  • Shielding principles
• EMC Shielding Specifications and Applications
  • MIL-STD 461 / 464 test specifications

In-Vehicle Networking with LIN and FlexRay Applications

2 Days
I.D.# C0136

This two-day seminar covers the theory and practices of in-vehicle multiplex networking. Attendees learn about FlexRay and LIN SubBus, and other network standards. Attendees explore the latest OBD II regulations and implementation requirements, along with device hardware and software interfaces. Proprietary applications are discussed and system development tools are demonstrated.

Learning Objectives
By attending this seminar, you will be able to:
• Describe in-vehicle multiplex network architecture.
• Explain how multiplex networks are used in a wide range of automotive applications.
• Identify and use various standards and specifications related to in-vehicle networks.

Who Should Attend
Engineers who will be or currently are working with applications using multiplex networks, including validation engineers, embedded programmers, and test engineers.

Topical Outline
DAY ONE
• Introduction
• Overview of In-Vehicle Network Systems
  • On Board Diagnostics (OBD) Networks -- CARB, EPA, EURO
  • Control System Networks -- CAN Protocol
  • Deterministic System Networks -- FlexRay Protocol
  • Input/Output Device Networks -- LIN Protocol
• OBD Communications Specifications
  • SAE J1979
  • SAE J2012
  • SAE J1699-3
  • SAE J2534

Instructor: Michael J. Oliver
Fee $790 .7 CEUs
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

- SAE J1939-73
- ISO 15765-4
- ISO 14229
- CAN Bus Specifications
  - SAE J2284
  - ISO 15765
  - ISO 27145
  - SAE J1939

DAY 2
- FlexRay Networks
  - SAE, ISO, Other Specifications
  - Designing FlexRay Networks
  - Implementation of FlexRay Networks
- LIN SubBus
  - SAE J2602 Specification
  - LIN 2.x Specification
  - Designing LIN Networks
  - Implementation of LIN Networks
- Emerging Technology & Future Networks
  - Wireless
  - GbE
  - DSRC
- Vehicle Application Examples
  - LIN
  - FlexRay
- Session Review and Summary

Instructor: Mark Zachos
Fee $1415 1.3 CEUs

Mechatronics: Introduction, Modeling and Simulation

2 Days
I.D.# C0949

Modern engineering challenges and their solutions are often multidisciplinary in nature. Systems in today’s vehicles integrate mechanical, electronic, hydraulic, as well as various other components all working together in a synergistic manner. While progress is being made in lowering the barriers between traditional engineering disciplines and formal education programs, this seminar is designed to provide engineers with mechanical or electrical engineering backgrounds the knowledge to effectively interact with colleagues from the other discipline in an efficient and productive manner.

This two day seminar is designed for the engineer with little or no mechatronics systems experience and will begin with an introduction to mechatronics principles and components, including sensors, actuators, control strategies, and instrumentation.

The instructor will then guide the participants through the analysis, synthesis and design of mechatronics systems through the use of modeling and simulation tools. Emphasis will be given to a unified energy flow approach to model mechatronics systems that are comprised of multidisciplinary components. A key element of this seminar is the use of computer simulation exercises to enhance and reinforce the learning experience. The instructor will conduct modeling and simulation exercises for this class using commercial vehicle and automotive mechatronics systems examples. Attendees desiring a more direct hands-on learning experience are encouraged to bring a personal laptop computer with the demonstration version of the 20-sim modeling simulation software installed prior to arrival.

The text, *Mechatronic Modeling and Simulation Using Bond Graphs*, authored by Shuvra Das is included with the seminar.

**Learning Objectives**

By attending this seminar, you will be able to:

- Identify multidisciplinary principles and applications of mechatronics systems
- Apply appropriate use of sensors, actuators and mechanisms in mechatronics applications
- Implement a structured approach to modeling mechatronics systems
- Select and utilize appropriate software modeling tools
- Simulate system dynamic behavior for different input conditions
- Interpret simulation results to determine system behavior in physically meaningful terms
- Identify and overcome barriers that can interfere with collaborative work across engineering disciplines on mechatronics projects

**Who Should Attend**

Mechanical and electrical engineers needing to develop a fundamental understanding of the other discipline, especially in the context of the synergistic design of products that are multi-disciplinary in nature, will benefit most from this seminar. Also benefiting are engineers in leadership positions that require a fundamental understanding of mechatronics systems and how the engineering disciplines must work together to ensure efficiency and productivity.

**Topical Outline**

**DAY ONE**

- Introduction to Mechatronics
  - System dynamics
  - Components -- Mechanisms; Sensors; Actuators
  - Signal conditioning
  - Microcontrollers
  - Control strategies
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

• Introduction to Mechatronic Modeling and Simulation
  • Modeling techniques
  • Bond graphs as a modeling technique
  • Drawing of power flow diagrams (bond graphs) and their meaning
  • Generalized basic elements
  • Representation of systems in terms of basic elements
  • Deriving system models from bond graphs

DAY TWO
• Modeling of Electrical, Mechanical, and Magnetic Systems
  • Modeling basics
  • Use of software tools to draw the bond graph model
  • System types and their behavior
  • Simulation -- Results and interpretation

• Mechatronics Modeling Examples
  • Sensors, actuators and systems
  • Examples and cases from: Earth moving equipment; Automotive; Machine tools
  • Other mechatronics applications

• Course Assessment and Summary

Learning Objectives
By attending this seminar, you will be able to:
• Describe how on-board Connected Vehicles applications utilize multiple services
• Create a simple OSGi service or application
• Explain open versus closed loop Connected Vehicles applications
• Demonstrate how ASN.1 encoding can be used to packetize various data structures

Who Should Attend
This course is appropriate for engineers or managers who want a better understanding of the technologies involved in vehicle to vehicle and vehicle to infrastructure applications. Those interested in wireless communications application to vehicular environments, vehicle positioning systems used for connected vehicles, vehicular software architectures and security, and vehicle system applications such as active safety as they apply to automotive/commercial vehicles will find this course useful.

Other professionals who will benefit from this course include: managers seeking to evaluate technology/ regulation/standardization/business trends; fleet operators looking to increase business productivity, better manage their assets, meet regulatory requirements more efficiently, and improve asset utilization; business stakeholders involved in controlling/exploiting data transmitted from/to vehicles; those involved with autonomous/unmanned vehicles; and professionals interested in the perspective that the mobility, data security, and safety aspects of connected vehicle systems can enhance the reliability and control of driver-assisted vehicles.

Topical Outline
• Software architecture and security in the context of connected vehicles
  • Basic concepts of software architectural design
  • Basic concepts of security and related safety issues in connected vehicles
  • Security strategies and systems and an overview of existing wireless security
  • Automotive telematics (blending of GPS and wireless telecommunications, including existing examples such as GM’s ONSTAR)
  • Review of basic concepts of autonomous (driverless) vehicles
  • Local and short range communications for connected vehicles
  • Short-range wireless communication standards (e.g. Bluetooth, UWB, Zigbee)
  • Fundamentals of the OSGi (open services gateway initiative) Java-based middleware service platform for software development of wired and wireless networks
  • ASN1 (abstract syntax notation 1, used in the SAE J2735 standard) and similar type-length-value packetization techniques for transmitting data over networks

Software Architectures and Security for Connected Vehicular Systems
1 Day
I.D. # C1216

The connected vehicle of the future will contain features that fall into three mobile communication and vehicle sensing technology categories: telematics, autonomous systems, and local or short-range communication systems. Effective and safe functionality of these systems relies upon robust software and security protocols.

This class provides an overview of typical connected vehicle applications and services operating on-board the vehicle. The software systems, including protocols and packetization, are examined at an architectural level and not at a detailed programming level. A discussion at the architectural level provides a communication platform that can be used between a wide range of stakeholders (technical and non-technical). Important decisions that affect the detailed software design of applicable systems can subsequently be made earlier in the development process, and existing designs can be evaluated for usability in autonomous connected vehicles.

Instructor: Shuvra Das
Fee $1465 1.3 CEUs
**ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS**

- Propagation of traffic probe data through a network
  - IEEE 1609.2 security (based on IEEE 802.11) for WAVE (Wireless Access in Vehicular Environments) and DSRC (Dedicated Short Range Communications)
- End-to-end examples of vehicle-to-vehicle (VTV) and vehicle to infrastructure (VIT) interactions
- Existing systems/initiatives with applicability to connected vehicles
  - Open and closed loop software control techniques
  - Comparison of existing on-vehicle networking, e.g. Ethernet, CAN (Controller Area Network)
  - QNX real-time operating system
  - Existing vehicular and other mobility facilities/centers
  - Mobius software facilities for mobile/internet-based information distribution
- Connected Vehicle: DOT’s 5-year connected vehicle research initiative to allow connected vehicles to exchange real-time road and traffic information
- Utilization of on-board sensors and wireless communications for Connected Vehicles
- Genivi alliance to provide in-vehicle infotainment (e.g. in-vehicle internet)

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**Understanding and Using the SAE J2534-1 API to Access Vehicle Networks**

1 Day
I.D.# C0733

With the increase in vehicle electronics, the need to gather data from the vehicle has never been greater. From vehicle development, through vehicle test to vehicle validation, engineers are required to collect data from the vehicle’s network. The SAE J2534-1 API (Recommended Practice for Pass-Thru Vehicle Programming) gives engineers the tool to collect vehicle data from multiple network types including CAN, ISO15765, J1850, ISO9141 and Chrysler SCI, using standard J2534 interface devices. In addition, the aftermarket can access the vehicle’s OBDII information from the diagnostic connector. Using the SAE J2534-1 API, an engineer can write a single program that communicates on multiple protocols, uses an off-the-shelf interface device and is scaleable.

This course is designed to give you an understanding of the J2534-1 API, enabling you to create your own programs that accomplish your vehicle communication needs. In addition to learning how to use each of the J2534-1 functions, you will have the opportunity to write a program that collects messages off of the CAN vehicle bus and another program that reads trouble codes off of a J1850 vehicle.

Attendees will receive a copy of the SAE J2534-1 Recommended Practice for Pass-Thru Vehicle Programming.

**Learning Objectives**

By attending this seminar, you will be able to:
- Write programs that use the SAE J2534-1 compliant hardware to communicate with vehicles
- Reduce your dependency on proprietary vehicle communication hardware
- Increase your productivity by collecting the specific vehicle information you need when you need it
- Solve vehicle integration problems by capturing events from the vehicle network
- Protect your software investments by writing your application using a standard API

**Who Should Attend**

This seminar is designed for engineers involved with automotive design and development who need to write programs that interact with vehicles through the in-vehicle network. This includes engineers who validate OBDII, engineers developing and validating new electronic control modules, engineers writing reprogramming application, test engineers who log vehicle data, system integrators who need to validate system operation, and after-market engineers who add new functionality to vehicles. The seminar would also be helpful for people who develop end-of-line tests, service diagnostics or inspection and maintenance cells for vehicles.

**Topical Outline**

- What is the SAE J2534-1 PassThru API
  - Why use the SAE J2534-1 PassThru API
  - Overview of the SAE J2534-1 PassThru API
  - Overview of vehicle communication
  - History of the SAE J2534-1 PassThru API
  - Future of SAE J2534-1, J2534-2, J2534-3
- PassThru PC Setup
  - Using the registry to find devices
  - Loading the SAE J2534-1 DLL
- PassThru Open and Close
- PassThru Connect and Disconnect
  - PassThruConnect: protocols, connect flags, baudrates
  - PassThruDisconnect
- Lab 1: PassThru on the PC: Simple SAE J2534-1 Program
- PassThru Read Messages and Write Messages
  - The PassThru message structure
  - PassThruReadMsgs: read, loopback and indication messages
  - PassThruWriteMsgs
- PassThru Start Message Filter and Stop Message Filter

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Vehicle User Experience: Human Factors Principles and Techniques for Design, Research and Development

1 Day
I.D.# C1340

The automotive industry faces unprecedented growth in vehicle technologies and features that can dramatically affect the vehicle user experience. This course will provide an overview of principles and techniques for designing and developing vehicle interfaces which deliver optimal solutions while avoiding unintended consequences like driver distraction. Case studies and exercises will be used to identify best practices with key human factors design and research concepts that provide an intuitive, safe and effective user experience.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the range of user experience issues specific to the vehicle environment and understand how they are different from desktop and mobile usability
• Apply important human factors principles and techniques relevant to effective automotive user interface design
• Describe and use basic design and development tools and methods of interface design
• Understand how to assess the quality and applicability of specific research findings to your user experience design and development projects
• Perform research as efficiently and effectively as possible with available resources
• Describe and use basic measures and usability tests that can quickly reveal user experience issues early in the development process to avoid costly problems later on

Who Should Attend
Those involved in vehicle user interaction systems (e.g., controls and displays for infotainment, navigation, smartphone integration, connectivity, HVAC, lights, etc.) in any functional role (e.g., product design, product development, product/market research and quality) will benefit from this seminar, including mechanical engineering, electrical engineering, software engineering, system engineering, product planning, research & development and design.

Topical Outline
• The Vehicle User Experience
  • Special features of the vehicle context
  • User interfaces, user interaction and user experience
• Human Factors Principles for Vehicle User Experience Development
  • The cognitive and physical ergonomics distinction
  • Key concepts in attention, distraction, memory and perception
• Design Principles for Vehicle User Experience Development
  • Controls and Displays
  • Design Strategies
• Research Principles for Vehicle User Experience Development
  • Techniques, measures and methods for assessing user experience
  • Best practices in research
• Resources for Effective Vehicle Interface Design
  • Standards and best practices

Instructor: Michael Tschirhart
Fee $780 .7 CEUs
Wireless Communications in the Autonomous Connected Vehicle

1 Day
I.D.# C1025

Wireless communication is a key enabler for vehicle connectivity. This seminar provides participants with an engineering overview of the various technologies that comprise a wireless communication system as it relates to automotive and commercial vehicle applications. It is intended to develop the skill set necessary for an educated understanding of the challenges and opportunities related to Connected Vehicles and connected applications.

This lecture contains three sections:

Section One provides an immersion in the fundamentals of wireless communications. It begins with the physics of the technical challenges caused by propagation (e.g. multipath, Doppler spread) and interference that can impact the communication budget link. Then, it will introduce the basic mitigation techniques (wireless channel: models, capacity, modulation, detection, diversity) and their performance measured in terms of signal to noise ratio (SNR) and error probability.

Section Two addresses networking. It starts with the principles of wireless networks and reviews the TDMA and CDMA systems. It then discusses concepts related to Ad Hoc Networks including an overview of the Vehicular Area Network (VANET). It concludes with discussions on security issues and approaches relating to Mobile Ad Hoc Networks (MANET).

Section Three describes how wireless communications techniques can be applied in vehicle to infrastructure (V2I) and vehicle to vehicle (V2V). It provides details in the most recent developments of the Dedicated Short Range Communications (DSRC) technology as well as related standardization topics (IEEE 1609, IEEE 802.11p, and SAE J2735). Module Three concludes with insights about how the cellular 4G/LTE (Long Term Evolution) technology can be used to accelerate the development of V2X communications (where X can stand for I as in Infrastructure, V as in Vehicle, P as in Pedestrian, C as in Cyclist, etc.).

Learning Objectives

- Identify the key automotive/commercial vehicle wireless communications forums dealing with standardization/registration and business opportunities
- Recognize the role, both current and future, connected vehicle technologies will play in our collective future

Who Should Attend

This course is appropriate for engineers or managers who want a better understanding of the technologies involved in vehicle to vehicle and vehicle to infrastructure applications. Those interested in wireless communications application to vehicular environments, vehicle positioning systems used for connected vehicles, vehicular software architectures and security, and vehicle system applications such as active safety as they apply to automotive/commercial vehicles will find this course useful.

Other professionals who will benefit from this course include: managers seeking to evaluate technology/registration/standardization/business trends; fleet operators looking to increase business productivity, better manage their assets, meet regulatory requirements more efficiently, and improve asset utilization; business stakeholders involved in controlling/exploiting data transmitted from/to vehicles; those involved with autonomous/unmanned vehicles; and professionals interested in the perspective that the mobility, data security, and safety aspects of connected vehicle systems can enhance the reliability and control of driver-assisted vehicles.

Topical Outline

Fundamentals of Wireless Communication
- Technical Challenges
  - Math tools
  - Mobile radio propagation
- Mitigation Techniques
  - Channel capacity
  - Digital modulation and detection
  - Performance of digital modulation over wireless Channels
- Diversity
- Recent Advances
  - Multiple antennas and space-time communications
  - Ultra-WideBand (UWB) technology

Wireless Networks
- Cellular Networks
  - Principles
  - TDMA-based
  - CDMA-based
- Ad Hoc Networks
  - Characteristics of MANETs
  - Vehicular Area Network (VANET)
  - Security issues V2X Communications
**Vehicular Electrification**

**Hybrid and Electric Vehicles: Current Production, Future Strategies Web Seminar and Web Seminar RePlay**

2 Hours  
Web Seminar I.D.# CO906  
Web Seminar RePlay: I.D.# PD330906ON

Hybrids, and to a lesser extent, electric vehicles, have been on the road since 1997. Although just two hybrids were on the market in 2001, there are more than a dozen today, and the market is ramping up quickly, driven by fuel prices and constraints, environmental regulations, and customer demand. The commercial vehicle market is also rapidly embracing hybrid technology. This two-hour Web Seminar will highlight the passenger, light-duty, and heavy-duty hybrid and electric vehicles that are currently in production, offered for sale, or planned for near-term production. Asian, European, and North American manufacturers of hybrid and electric vehicles will be reviewed. Tier 1 suppliers of major hybrid and electric vehicle components will be covered as well.

**Learning Objectives**

By connecting with this web seminar, you will be able to:

- List the hybrid and electric vehicles that have been commercialized from 1997 to present

**Instructor:** Jack Rosebro  
Fee $270 .2 CEUs
Hybrid and Electric Vehicle Systems

2 Days
I.D.# C1504

Hybrid Electric Vehicle (HEV) and Battery Electric Vehicle (BEV) technology model offerings and production volumes continue to accelerate with each model year. Advanced technology vehicle populations are significantly increasing throughout the world, making it vital for engineers, technicians, and educators to have a thorough understanding of these technologies and systems. This two-day practical and applications based course will concentrate on architectures, operation, functions, and design considerations of the safety, power electronics, energy systems, and failure modes associated with HEV and BEV vehicles, providing an environment in which participants can acquire a solid systems and integration foundation for applying this content to vehicle/systems design.

Learning Objectives
By attending this seminar, you will be able to:
• Identify the different hybrid and electric vehicle (HEV) architectures
• Follow a procedure for safe interaction with high voltage
• Identify the components of HEV safety systems, controls, and diagnostics
• Consider the architectural options for controls and diagnostics
• Identify energy management components and functions
• Identify electric motor components and functions

Who Should Attend
This course is designed for engineers, scientists, and technicians who are involved with the design, development, manufacturing, or service of electrified vehicles or subsystems.

Topical Outline
• HEV/BEV Systems Operation Modes, Torque Production and Component Contributions
  • HEV
  • BEV
• High Voltage Safety – Personal Protection Equipment
  • High Voltage Safety Gloves
  • High Voltage Systems and Test Equipment
• HEV/BEV – Vehicle Safety Systems, Controls and Diagnostics
  • Battery Pack Manual Disconnect Systems
  • High Voltage Interlock Circuits
  • High Voltage Bus Active and Passive Discharge Circuits
  • Isolation Fault Detection Circuits
• Rechargeable Energy Management (Battery Pack) Systems, Controls and Diagnostics
  • Hardware Components
  • Overview of NiMH and Li-Ion Battery Technologies
  • Module/cell sensing systems (voltage, temp, air, etc.)
  • Experiences of field failures
  • Battery systems service considerations
  • Thermal Management Systems – Active and Passive Systems
  • Battery Pack/Module Testing
• HEV/BEV – Permanent Magnet (PM) and Induction Machine (IM) Electric Machine and Power Inverter Technologies
  • PM and IM Technologies
  • Electric machine construction and operation
  • Rotor position and speed sensing
  • PM-IM failure modes
  • On/off-board electric machine testing
• Power Inverter Technology and Electric Machine Control
  • Power electronics devices
  • Sensing circuits
  • Electric machine controls - torque and speed controls, wave shaping (sine wave, six-step), current regulation
  • Failure modes
  • Testing
• dc-dc Converter Systems
• Buck converter
• Buck/Boost converter
• Failure modes
• Testing

Instructor: Mark Quarto
Fee $1335 1.3 CEUs

Introduction to Hybrid and Electric Vehicle Battery Systems

2 Days
I.D.# C0626

Driven by the need for lower emissions, better fuel economy and higher efficiency, hybrid vehicles are appearing in many different configurations on today’s roadways. While the powertrain components such as the drive motor, motor controller and cooling system are somewhat familiar to the automotive industry, the battery systems are a relatively unfamiliar aspect. This seminar will introduce participants to the concepts of hybrid vehicles, their missions and the role of batteries in fulfilling those requirements. Battery topics including limitations, trends in hybrid development, customer wants and needs, battery system development timelines, comparison of electrochemistries and safety will be examined. Current offerings, cost factors, pack design considerations and testing will also be reviewed.
Students will have an opportunity to perform a battery pack analysis exercise using a real world application and are requested to bring a calculator to class.

**Learning Objectives**

By attending this seminar, you will be able to:

- Capture customer wants and expectations of the battery system
- Identify factors that drive power and energy requirements
- Determine test program structure
- Compare and contrast the newest relevant battery technologies
- Calculate estimates of electric range and quantify the assumptions
- Critically assess media claims of new battery discoveries

**Who Should Attend**

This seminar is primarily intended for vehicle systems engineers, battery system integration engineers, testing engineers, electrical engineers and thermal management engineers recently assigned to their roles or returning to hybrid or electric vehicle programs. It will also be beneficial to those involved in the specification, design, development, testing and planning of hybrid vehicle programs. Product planners and program managers will find the overview aspects helpful.

**Topical Outline**

**DAY ONE**

- Terminology, Definitions and Conventions
- Brief Review of the Hybrid Market
  - Market drivers and expectations
  - Market influences
  - Competing technologies
  - Customer expectations
- Review of Common Vehicle Product Offerings (battery descriptions, power, technology, size, architecture)
- Fundamentals
  - Fossil fuel vs. hybrid vs. electric
  - Source ragone plot
  - Efficiencies, weights
  - Cost of fuel (fossil vs. electrons)
- Role of Battery
  - ICE vs. electric systems
  - Energy vs. power
  - Expectations over vehicle lifetime
- Product Liability / FMEA
- Battery Development Cycle
  - You don’t know what you don’t know!
  - Why does it take so long and cost so much?
- Cost Factors
  - Scope of product: system vs. cells vs. sticks
  - $/kW vs. $/kWh
- System Considerations
- Electrochemistry Selection
- Safety
- Advance planning for safety tests
- Thermal runaway
- String configuration (series, parallel)
- Range Estimation (hybrid vs. electric)

**DAY TWO**

- Real-life Battery Analysis Exercise (using a contemporary vehicle as an example)
- Battery Pack Design Considerations
- Failure Modes
  - Wear-out
  - Power and energy degradation
  - High resistance / open circuit
  - Controller / signal malfunction
- Vehicle Trends
  - Plug-in hybrid
  - Battery electric
  - Demanding applications
  - Fuel cell hybrids
- Battery Trends
- Battery Warranty
- Battery Recycling

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**Plug-in Hybrids: Opportunities and Challenges Web Seminar and Web Seminar Replay**

**2 Hours**

Web Seminar: I.D.# C0905
Web Seminar RePlay: I.D.# PD330905ON

The path to commercialization of plug-in hybrids is likely to require complex interactions between OEMs, battery manufacturers, electric utilities, and government, yet the plug-in hybrid is a still-developing technology. How do plug-in hybrids (PHEVs) differ from conventional hybrids? What are the advantages and challenges for vehicle manufacturers, public utilities, energy and environmental concerns, and end-users? What is the current state of plug-in hybrid development? Those unfamiliar with PHEV or vehicle-to-grid (V2G) technology, yet whose job will be impacted by plug-in hybrid vehicles in the future, will benefit from this two-hour Web Seminar.

**Learning Objectives**

By connecting with this Web Seminar, you will be able to:

- Describe the relevant differences between plug-in hybrid (PHEV) and conventional hybrid vehicles
- Identify fundamental charge-discharge strategies
ELECTRICAL/ELECTRONICS AND ELECTRONIC SYSTEMS

- Explain the performance demands placed on PHEV energy storage systems and development trends in energy storage
- Recognize the enablers and barriers to mass commercialization of PHEVs
- Summarize infrastructure requirements as well as supply-side and demand-side incentives
- Explain the potential energy and emission benefits of PHEV and V2G synergies

Who Should Attend
This Web Seminar will benefit automotive and commercial vehicle industry professionals who want to understand the rapidly-changing development of plug-in hybrids, as well as proposed legislation that may affect that development, and surrounding infrastructure that will play a supporting role in PHEV commercialization.

Topical Outline
- Plug-in hybrid (PHEV) architectures
  - Gasoline-electric plug-in hybrids
  - Diesel-electric plug-in hybrids
  - Fuel cell plug-in hybrids
- Plug-in hybrid (PHEV) charge-discharge strategies
  - Series plug-in hybrids
  - Parallel plug-in hybrids
  - Series-parallel plug-in hybrids
  - Charge-sustaining (CD) strategies
  - Charge-depleting (CD) strategies
  - Blended charge-discharge strategies
- Plug-in hybrid (PHEV) energy storage systems
  - State of energy storage chemistries today
  - Influence of all-electric range
  - Influence of charge-discharge strategies
- State of plug-in hybrid development today
  - Conversion of existing hybrid vehicles
  - Passenger and light-duty vehicles
  - Heavy-duty vehicles
- Interaction between plug-in hybrids and the electrical grid
  - Charging considerations
  - Infrastructure considerations
  - PHEVs and grid demand
- Vehicle-to-grid (V2G)
  - How V2G works
  - State of V2G development today
  - What’s needed to enable large-scale commercialization V2G
- Government incentives toward development of PHEVs
  - Supply-side incentives
  - Demand-side incentives

Instructor: Jack Rosebro
Fee $270; .2 CEUs

CATALOG KEY
You will see the following icons alongside the course descriptions. These icons indicate:
- delivery formats available for the course
- the course is part of an SAE certificate
- that it is an ACTAR approved course

Many courses are available in multiple formats. See page X to get more information on the learning formats offered by SAE. In addition to finding courses that fit your technology need, look for courses with icons that fit the way you want to learn.

Classroom – indicates the course is an instructor-led seminar or workshop offered in a classroom setting

Live, Online – indicates the course is an instructor-led web seminar offered live and online via telephone and internet connection

On Demand – indicates the course is available online anytime the participant would like to access the course through the internet

Certificate – indicates the course is part of an SAE International curriculum-based, multi-course certificate. See a list of the multi-course certificates on page XII

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RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Introduction to Hybrid Powertrains Web Seminar
In this two-hour web seminar, energy storage systems, inverters, motor-generators, and DC-DC converters are explained, as well as design considerations for both light-duty and heavy-duty vehicle powertrains and developing trends such as plug-in, flywheel and hydraulic hybrids.
Read more about this course on page 139

Principles of Electric Drives
Industry professionals who are looking for a general understanding of the structure and components of vehicular electric drives will benefit from this course, which will cover theory, design, operation, and diagnostics of all major components used in electric drives (battery packs, inverters, motor-generators, DC-DC converters, and charging apparatus).
Read more about this course on page 140

Basic Hybrid and Electric Vehicle Safety
This 120-minute web seminar reviews safety concerns and precautions related to high-voltage circuits present in hybrid, plug-in hybrid, electric, and fuel cell hybrid vehicles.
Read more about this course on page 187

Overview and Impact of the Automotive Functional Safety Standard ISO 26262
This course provides background for reading and applying the standard and explains its scope, the major differences from the general safety standard IEC 61508, and how the scope changes with the introduction of new systems.
Read more about this course on page 189

Safe Handling of High Voltage Battery Systems
The battery system forms a key part of any of these vehicles and is probably the least understood. With practically no moving parts the battery systems show no visible or audible warning of any latent dangers. This seminar will introduce participants to the risks encountered in handling high voltage battery systems and their component parts.
Read more about this course on page 192
ENGINEERING TOOLS & METHODS

Includes design, engineering practices, test methods, problem solving, and data analysis.

Accelerated Test Methods for Ground and Aerospace Vehicle Development

2 Days
I.D.# C0316

A similar course is available on demand – Accelerated Test Methods for Ground and Aerospace Vehicle Development e-Seminar – see course info below.

Engineers and managers involved with product development are constantly challenged to reduce time to market, minimize warranty costs, and increase product quality. With less and less time for testing, the need for effective accelerated test procedures has never been greater. This course covers the benefits, limitations, processes, and applications of several proven accelerated test methods including accelerated reliability, step stress, FSLT (Full System Life Test), FMVT (Failure Mode Verification Testing), HALT (Highly Accelerated Life Testing), and HASS (Highly Accelerated Stress Screening). A combination of hands-on exercises, team activities, discussion, and lecture are used throughout the course. Participants will also receive a copy of the instructor’s book, Accelerated Testing and Validation Management, which includes numerous hands-on exercises and a CD with analytical spreadsheets. Attendees are requested to bring a calculator to the seminar.

Learning Objectives
By attending this seminar, you will be able to:
• Choose the accelerated test method for a given application
• Analyze accelerated testing results
• Explain how to accelerate one’s current test methods
• Explain how to accelerate one’s validation program
• Adjust accelerated test programs for business situations
• Describe how product development cycles can be reduced from 18 to 6 months

Who Should Attend
This seminar is designed for anyone involved in product design, life testing, reliability testing and validation for ground and aerospace vehicles, including reliability engineers, validation engineers, design engineers and their managers. Individuals who need to achieve shorter time to market or higher quality through custom test plans will find this course to be especially valuable. Purchasers or users of testing or engineering services will also find this course to be valuable. There are no prerequisites for this course although a technical background is helpful.

Topical Outline
• Statistical model for reliability testing
  • Fundamentals of a statistical reliability test
  • Effects of automotive supply chain on sample size and duration
  • Common pitfalls
  • Examine and solve two or three real life statistical data set problems
• Key Accelerated Tests, Terms, and Methods
  • Definitions: Information Goal, Basic Method, Limitations
  • Full System Life Test (FSLT); Step Stress
  • Accelerated Reliability Highly Accelerated Life Test (HALT)
  • Failure Mode Verification Test (FMVT) — Development; Warranty; Life Prediction
• Test Acceleration vs. Program Acceleration
  • Advantages of accelerating a full validation program compared to an individual test
  • Examples of time/cost saved on individual test acceleration
  • Examples of time/cost saved on program acceleration

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Hybrid Acceleration Methods
- Using information goals of individual test methods to combine and leverage tests
- Hands-on team exercise: combine test methods to solve a particular information need

Decision and selection process
- How to choose which method
- Considering position in supply chain
- Considering business model and product type
- Considering development phase
- Considering component, subsystem, and system level testing
- Hands on team exercise: selecting optimal testing solution for several scenarios

Instructor: Alexander (Alex) J. Porter
Fee $1405 1.3 CEUs

ANOVA for Design of Experiments
1 Day
I.D.# C0714
This seminar is suggested for product or process experts who have a need to utilize more detailed information concerning Design of Experiments analysis. It primarily addresses the subject of ANOVA, analysis of variance, which is a statistically based, objective decision-making tool. This is an advanced seminar that covers the fundamentals required to analyze orthogonal experiments, interpret, and recommend further action based on the analysis. Emphasis is placed on the analysis phase of the DOE process. The seminar covers DOE basic review, simple and complex ANOVA situations, process capability estimation, and a review of available computer software for experimental design and analysis.

Learning Objectives
By attending this seminar, you will be able to:
- perform ANOVA for DOE analysis
- interpret ANOVA results
- estimate process capability from ANOVA information

Who Should Attend
This seminar is designed for product and process design engineers, manufacturing engineers, quality engineers (control, assurance, or supplier), testing and development engineers, and technical managers who are interested in more comprehensive experimental analyses and information. Although, more statistical in nature, this seminar does not require a statistical education or background to comprehend the contents; only fundamental mathematical skills are necessary. This seminar is also very helpful in providing a statistical foundation for those seeking certification in quality engineering.

It is strongly recommended that the registrant attend a Basic Design of Experiments course or have experience with fractional factorial experiments based on orthogonal arrays before attending the ANOVA for Design of Experiments course.

Topical Outline
- Training Objectives
- Design of Experiments Process Flowchart
- Planning and Conducting Phase Review
- Analyzing and Interpreting Results
  - observation method review
  - column effects method review

Instructor: Alexander (Alex) J. Porter
Fee $595 1.0 CEU

Accelerated Test Methods for Ground and Aerospace Vehicle Development e-Seminar
10 Hours
I.D.# PDT30624ON
A similar course is available as a classroom seminar–Accelerated Test Methods for Ground and Aerospace Vehicle Development – see course info above.
This course offers more than 10 hours of instruction divided into fourteen modules; a coordinated handbook; and a copy of the instructor’s book, Accelerated Testing and Validation Management, which includes numerous hands-on exercises and a CD with analytical spreadsheets. Convenient, portable, and with core content from the instructor-led seminar (view description for classroom seminar above), the e-seminar program option offers new and alternative ways to receive the same instruction as the live classroom learning without the expense of travel and time away from the workplace.

View the complete course description and a video demo at training.sae.org/eseminars/atm.

What You Will Receive:
- 90 Day access through MyLearn.sae.org
- Links to streaming video modules
- Course Handbook (downloadable .pdf’s, subject to DRM)
- Online Pre-test & Post-test (self-test, immediate results)
- CEUs/Certificate of Achievement (with satisfactory post-test score)
Design and Process Failure Modes and Effects Analysis (FMEA)

2 Days
I.D.# C1510

This seminar covers the five types of FMEAs with emphasis on constructing Design and Process FMEAs. Each column of the FMEA document will be clearly explained using an actual FMEA example. The course covers various methods for identifying failure modes, effects and causes with special attention given to severity, occurrence, and detection tables and how to develop effective recommended actions strategies. Throughout the class, participants will be involved in exercises/actual projects that demonstrate and incorporate direct application of learned principles.

Learning Objectives

By attending this seminar, you will be able to:

• Describe the benefits, requirements and objectives of an FMEA
• Describe the five types of FMEAs and how to use them
• Develop and interpret a Design and Process FMEA form
• Identify and utilize various tools when performing an FMEA
• Describe the standard requirements/recommendations for an FMEA
• Select suitable projects and teams for completing an FMEA
• Complete a typical Design and Process FMEA form

Who Should Attend

This seminar is designed for core members of a Product Development Team such as project managers, product design, test, manufacturing, quality, reliability engineers and those responsible for assisting the PDT in design and development of product, manufacturing, assembly or services processes.

Instructor: Angelo Mago
Fee $1335 1.3 CEUs
Instructors Wanted...
To shape the future of mobility engineering, SAE International Professional Development is seeking experienced engineering professionals with industry and/or academic backgrounds to develop and teach live classroom or online courses; we are seeking expertise in a variety of topics including:

Classroom Seminar Topics
- Natural Gas Engines and Vehicles
- Sensors and Actuators
- Advances in SI Engines
- Small High-Efficiency Engine Design
- Electric Motors / Power Electronics
- Active Safety
- Heavy Duty Diesel OBD
- Heavy Duty High Voltage Systems
- Heavy Duty Hybrid
- Heavy Duty Electric Drive
- Diesel Emissions and Regulations
- Alternative Fuels and Energy Sources
- Strategies for Diesel Engine Downsizing
- Cyber Security
- V2V Technologies
- High Speed Digital Design for Rugged Applications
- Material Performance Data

Contact SAE Professional Development to explore how you can help to shape the future of industry.

Classroom Seminars contact Bev Longdon at Beverly.Longdon@sae.org

Online Web Seminars contact Sam Minehart at Sam.Minehart@sae.org.

Design for Manufacturing & Assembly

1 Day
I.D.# 95032

2 Days
I.D.# 92047

Design for Manufacturing and Assembly (DFM+A), pioneered by Boothroyd and Dewhurst, has been used by many companies around the world to develop creative product designs that use optimal manufacturing and assembly processes. Correctly applied, DFM+A analysis leads to significant reductions in production cost, without compromising product time-to-market goals, functionality, quality, serviceability, or other attributes. This seminar will include information on how DFM+A fits in with QFD, Concurrent Engineering, Robust Engineering, and other disciplines.

Each participant will receive and use the hard-bound authoritative reference textbook Product Design for Manufacture and Assembly, written by Geoffrey Boothroyd, Peter Dewhurst and Winston Knight.

Learning Objectives
Upon successful completion of this course, you will be able to:
- Perform Design for Assembly (DFA) Analysis using the BDI Manual (Worksheet) Method
- Perform DFM Analysis (manufacturing cost estimation)
- Apply Design for Service (DFS) Principles
- Reduce your company’s production costs by analyzing and eliminating the factors that greatly affect the time, cost, and quality of manufacturing, assembly and service processes
- Utilize effective analysis, brainstorming, and trade-off techniques for redesigning assemblies and subassemblies

Who Should Attend
You should attend if you are a product designer, product engineer, or manufacturing engineer. Individuals involved in a new or ongoing product development process will benefit by learning how to help synchronize and optimize fabrication and assembly activities. This course is most effective when attended by product development teams. However, this is not a requirement for attendance.

Topical Outline
- What is DFM+A
  - The history of DFM+A
  - The various “Design fors”
  - Why companies are using DFM+A
  - DFM+A success stories
  - DFM+A benefits
  - Key factors in ensuring DFM+A success
- DFA Good Design Principles
  - The Boothroyd Dewhurst Design for Manual Assembly Method
  - Using the manual handling and insertion tables
  - Determining theoretical minimum part count
  - Filling in the BDI DFA worksheet
  - Computing the DFA Index
- DFA Baseline Analysis Exercise (Pneumatic Piston)
- Redesign Project (Pneumatic Piston Assembly)
  - Developing design concepts
  - Identifying conservative and “stretch” designs
  - Selecting the best DFA concept
  - Analysis of redesign
  - Presentation of team results
- General Approach to Manufacturing Cost Estimation
  - Manufacturing cost drivers
  - Estimating piece cost
  - Cost calculation exercise
ENGINEERING TOOLS & METHODS

• BDI Design for Manufacture (DFM) Cost Estimation
  • Injection molding cost algorithms
  • Sample calculation
  • Exercise (analyzing part from pneumatic piston)
• Brief Design for Service (DFS) Overview
• DFM+A Workshop Checklist
• Institutionalizing DFM+A in Your Organization
  • How DFM+A fits in with other strategies
  • Lessons learned from other companies
  • Ideal workplace implementation plan

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Design of Experiments (DOE) for Engineers

2 Days
I.D.# C0406

A similar course is available as a live online Web Seminar – Design of Experiments (DOE) for Engineers Web Seminar – see course description below.

Design of Experiments (DOE) is a methodology that can be effective for general problem-solving, as well as for improving or optimizing product design and manufacturing processes. Specific applications of DOE include identifying proper design dimensions and tolerances, achieving robust designs, generating predictive math models that describe physical system behavior, and determining ideal manufacturing settings. This seminar utilizes hands-on activities to help you learn the criteria for running a DOE, the requirements and pre-work necessary prior to DOE execution, and how to select the appropriate designed experiment type to run.

You will experience setting up, running, and analyzing the results of simple-to-intermediate complexity, Full Factorial, Partial Factorial, and Response Surface experiments utilizing manual methods as well as a hands-on computer tool that facilitates experimental design and data analysis. You will also receive an overview of Robust DOE, including the Taguchi DOE Method.

Participants will be given information on how to receive, install and configure a fully-functional 30-day trial version of Minitab™ for their use in class, and/or for their personal evaluation. While some computers will be available, attendees are encouraged to bring a laptop computer and/or a calculator to the seminar to provide additional hands-on time.

Learning Objectives

By attending this seminar, you will be able to:

• Decide whether to run a DOE to solve a problem or optimize a system
• Set-Up a Full Factorial DOE Test Matrix, in both Randomized and Blocked forms
• Analyze and Interpret Full Factorial DOE Results using ANOVA, (when relevant) Regression, and Graphical methods Set-Up a Fractional (Partial) Factorial DOE, using the Confounding Principle
• Analyze and Interpret the results of a Fractional Factorial DOE
• Recognize the main principles and benefits of Robust Design DOE
• Decide when a Response Surface DOE should be run
• Select the appropriate Response Surface Design (either Plackett-Burman, Box-Behnken, Central Composite, or D-Optimal)
• Interpret Response Surface Outputs
• Utilize the MiniTab™ Software tool to analyze data

Who Should Attend

This seminar will benefit engineers, designers and quality professionals in research, design, development, testing and manufacturing who are interested or active in one or more of the applications listed above.

Topical Outline

• Icebreaker: Team Problem Solving Exercise Using Engineering Judgment
• What is DOE?
  • Types of Designed Experiments
  • Application Examples
  • Where DOE Fits in with Other Tools/Methods
• DOE Requirements: Before You Can Run an Experiment
  • Writing Problem and Objective Statements
  • Ensuring DOE is the Correct Tool
  • Selecting Response Variable(s) and Experimental Factors
  • Actual vs. Surrogate Responses
  • Attention to Experiment Logistics
  • Test Set-up and Data Collection Planning
  • Selecting and Evaluating a Gage
• Full Factorial Experiments
  • Introduction to Cube Plots for 3- or 4-factor 2-level Experiments
  • Experiment Set-Up
  • Factor Levels, Repetitions, and “Right-Sizing” the Experiment
  • Experiment Terms to Estimate (Main Effects and Interactions)
  • High-Level Significance Evaluation
• DOE Statistical Analysis
  • ANOVA Principles for Simple Full Factorial Experiments — Statistics Basics; Significance Test Methods; Effect of Non-Random Experiments; Estimating Significance Test “Power”; Confidence Intervals; Estimating Random Error
Design of Experiments (DOE) for Engineers

Web Seminar

12 Hours
I.D.# WB0932

A similar course is available as a classroom seminar – Design of Experiments (DOE) for Engineers— see course description above.

Design of Experiments (DOE) is a methodology effective for general problem-solving, as well as for improving or optimizing product design and manufacturing processes. Specific applications of DOE include, but are not limited to, identifying root causes to quality or production problems, identifying optimized design and process settings, achieving robust designs, and generating predictive math models that describe physical system behavior. This competency-based Web Seminar utilizes a blend of reading, discussion and hands-on to help you learn the requirements and pre-work necessary prior to DOE execution, how to select the appropriate designed experiment to run, DOE execution, and analysis of DOE results. You will experience setting up, running, and analyzing simple-to-intermediate complexity Full Factorial and Partial Factorial experiments both by hand and using computer software. You will also set-up and analyze Robust/Taguchi and Response Surface experiments utilizing computer software. Each participant will receive a 30 day Minitab™ product trial copy for use in the Web Seminar. Due to the nature of the Web Seminar format, each participant will be expected to dedicate approximately one hour to complete “homework” and/or short reading assignments in preparation for each session.

Learning Objectives

• Determine when DOE is the correct tool to solve a given problem or issue
• Select the appropriate DOE experiment type (DOE Goal) for a given application
• Set up simple Full Factorial DOEs by hand, using cube plots
• Set up and analyze any Full Factorial DOE using Minitab™
• Identify appropriate partial factorial design(s) based on one’s application
• Set-up and analyze Partial Factorial DOEs, simple Robust Design (Taguchi) DOEs, and simple Response Surface DOEs using Minitab™
• Recognize the structured process steps recommended when executing a DOE project

SAE PRODUCT ENGINEERING TOOLS AND METHODS CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program focuses on the study, development, management and implementation of product engineering principles, methodologies and techniques. When used properly, these tools and methods become powerful productivity enhancers and facilitate the reduction of product development time and cost. Complete this certificate and earn up to seven graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. For the complete list of required and elective courses and additional information on enrolling in this SAE certificate program, visit training.sae.org/certificate/engineering_tools.

Instructor: Kevin Zielinski
Fee $1395 1.3 CEUs
ENGINEERING TOOLS & METHODS

Who Should Attend
This Web Seminar will benefit engineers involved in product design and/or optimization; process design and/or optimization; quality improvement efforts such as defect elimination, warranty avoidance or similar initiatives; and technicians, analysts and managers who support engineers in these efforts. This course has no specific course prerequisites. However, participants are expected to have some math background, that includes elementary statistics. Since the course includes demonstration and hands-on use of Minitab™, participants should have some familiarity with Windows-based personal computer applications.

Topical Outline
Session 1
• Introduction
• What is DOE (with Initial Data Collection Exercise)
• Full Factorial Experiments using Cube Plots
  • Identifying main effect and interaction terms
  • Determining effects for all terms
• Estimating How Much Experiment Data is Enough
• Assignment for Session 2: Review of Web-Based Demo of Minitab™ - Full Factorial DOE Set-up and Analysis; and Reading, Overview of DOE Statistics
Session 2
• Set up and Analysis of a Full Factorial Experiment using Minitab™
• Minitab™'s DOE Results (High Level Overview of Minitab™ Outputs)
• Review of Methods for Determining ‘Significance’
• ANOVA and Regression Overview
• Assignment for Session 3: Hands-on Exercise in the use of Minitab™ using Simulator to Generate Data, and Reading on the Structured DOE Process
Session 2
• Review of Exercise Assigned at the End of the Session 2
• Review and Additional Information on DOE Statistics and Interpretation of DOE Output
• Best Practice: The Problem Solving Process
• Best Practice: The Structured DOE Process
• Assignment for Session 4: Reading on Overview of Confounding and Partial Experiments
Session 4
• The Confounding Principle and Partial Factorial Experiments
• How Confounded Occurs in a DOE, including Identity Usage and Resolution
• Setting up Partial Factorial Experiments using Minitab™
• Assignment for Session 5: Partial Factorial Exercise using Minitab™ and a Simulator to Generate Data for the DOE; Reading on Robust/Taguchi DOE
Session 5
• Review of Exercise Assigned at the End of the Session 4
• When Robust/Taguchi DOE is Appropriate
• How Robust/Taguchi DOE is Different
  • Two-Step Optimization Concept
  • Control vs. Noise
• Importance of Control-by-Noise Interactions
• Signal-to-Noise (S/N) and Loss Statistics
• Some Taguchi DOE Success Stories (incl. Set-up and Analysis in Minitab™)
• Demonstration of Minitab™ for Setting Up a Taguchi DOE
• Assignment for Session 6: Robust/DOE Exercise using Minitab™ and a Simulator to Generate Data for the DOE, Reading on Overview of Response Surface Methodology
Session 6
• Review of Exercise Assigned at the End of the Session 5
• When Response Surface DOE is Appropriate
  • How Response Surface DOE is Different
  • Box-Behnken Concepts (with Demonstration of Minitab™ Set-up)
  • Central-Composite Concepts (with Demonstration of Minitab™ Set-up)
• Class Exercise: Response Surface Set-up and Analysis
• High-level Overview of Other Designs/Application: Plackett-Burman and Mixture
• FAQ Review
• Summary

Instructor: Kevin Zielinski
Fee $835 1.2 CEUs

Design Review Workshop
1.5 Days
I.D.# C1306

In today’s highly competitive and liability minded environment, Design Reviews (DR) are a must for all major mobility industries such as Automotive, DOD, Aerospace, Agriculture, Recreation, Marine and Rail. While Design Reviews are becoming increasingly important in product liability litigation, they also serve as an effective way to transfer organizational best practices for specific concerns and issues.

This hands-on workshop describes how formal Design Reviews can be used in conjunction with other new product development methods to improve product designs by uncovering potential problems before they are discovered at a later stage of development or application when the costs of correction are much higher. A range of effective techniques for organizing and conducting Design Reviews will be presented. Participants will receive specific guidance and tools to assist them in tailoring

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Design Reviews to reflect their own organization’s requirements. Topics are applicable to a broad range of new product development programs, ranging from components to complete systems, for both OEMs and suppliers.

LEARN THEN DO -
In this workshop the attendee not only learns the essential elements of a robust Design Review process but also has the opportunity to apply these principles in the conduct of a mock Design Review. Participants will also experience some of the frequently encountered real-world issues that distract from accomplishing good results. During these “reviews” the attendee will experience each of the roles in a typical Design Review—leader, facilitator, recorder, and participant. An after-action review will be performed following each DR session to discuss positive outcomes and identify opportunities for improvement.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the relationship of the process to concurrent engineering and knowledge management
• Establish the requirements for a successful Design Review process
• Describe the types and timing of reviews
• Organize a typical Design Review
• Conduct a review and get positive results

Who Should Attend
The workshop is designed for individuals who are involved in the development of new products and who seek to improve that process. Product development team members including, but not limited to, directors, manager, project and program managers, design, development, process, product, quality, and application engineers will find the course valuable. It is aimed primarily at engineers and managers who will be facilitating or leading such reviews, but will also benefit manufacturing, marketing and purchasing personnel.

Topical Outline
DAY ONE
Design Review Process
• Why Design Reviews Should be Part of a Product Development Process
  • Market and quality drivers
  • Schedule and cost drivers
  • Litigation considerations
• Outline of the Design Review Process
  • Design reviews as part of an overall risk management process
  • What design reviews are and are not

Finite Element Analysis (FEA) for Design Engineers Web Seminar
12 Hours
I.D.# WB1241

The Finite Element Analysis (FEA) has been widely implemented by automotive companies and is used by design engineers as a tool during the product development process. Design engineers analyze their own designs while they are still in the form of easily modifiable CAD models to allow for quick turnaround times and to ensure prompt implementation of analysis results in the design process. While FEA software is readily available, successful use of FEA as a design tool still requires an understanding of FEA basics, familiarity with FEA process and commonly used modeling techniques, as well as an appreciation of inherent errors and their effect on the quality of results. When used properly, the FEA becomes a tremendous productivity tool, helping design engineers reduce product development time and cost. Misapplication of FEA however, may lead to erroneous design decisions, which are very expensive to correct later in the design process.
ENGINEERING TOOLS & METHODS

This six-session Web Seminar provides design engineers with the skills necessary for proper use of FEA in the design process and to ensure that this powerful tool is implemented in the most efficient and productive way. Participants will study different types of analyses typically performed, discuss common misconceptions and traps in the FEA, and review Implementation of Management of FEA in the design environment. The Web Seminar format will allow for some customization so problems of particular interest to participants and an exchange of FEA experiences may be discussed during the live sessions. Hands-on exercises focusing on the analysis of FEA errors and proper modeling techniques will be assigned.

The eBook, Engineering Analysis with SolidWorks® Simulation by Paul Kurowski, will also be included in the course materials. In-class, hands-on exercises and between-session assignments will provide an opportunity to put what is learned into practice.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Select preferable modeling approaches
• Analyze errors inherent to FEA results
• Identify FEA advantages and shortcomings
• Avoid mistakes and pitfalls in FEA
• Produce reliable results on time
• Request FEA analysis and use FEA results
• Provide effective FEA project management
• Ensure quality and cost-effectiveness of FEA projects

Who Should Attend
This course addresses the needs of design engineers who are not specialized analysts but need to use the Finite Element Analysis to analyze new product during the design process. Also non-specialist FEA users, R&D engineers and managers, project engineers, and product engineers will benefit from its coverage of different FEA formulations, tools for error analysis, common errors, traps and misconceptions, and an introduction to FEA project management.

Topical Outline
Session 1
• Fundamental Concepts in the FEA
• Finite Element Analysis Process
• Origins and Types of FEA Errors
• Finite Element Mesh
• In-class Exercises
Session 2
• Control of Discretization Error - Convergence Process
• Verification and Validation of FEA Results
• In-class Exercises
• Homework Assignment
Session 3
• Control of Modeling Error
• Types of Finite Elements Types of Boundary Conditions
• Useful Modeling Techniques
• In-class Exercises
• Homework Assignment
Session 4
• Modal Analysis
• Buckling Analysis
• In-class Exercises
• Homework Assignment
Session 5
• Nonlinear Geometry Analysis
• Nonlinear Material Analysis
• Contact Stress Analysis
• 2-3 in-class exercises
• Homework Assignment
Session 6
• Steady State Thermal Analysis
• Transient Thermal Analysis
• FEA Implementation
• FEA Project Management
• FEA Traps and Misconceptions
• Quiz in preparation to post-course learning assessment

Instructor: Paul Kurowski
Fee $870 1.2 CEUs

FMEA for Robust Design: What, Why, When and How Web Seminar
12 Hours
I.D.# WB1422

Failure Modes and Effects Analysis (FMEA) is an integral part of product design activity applicable to any type of product or service. It is a quantitative and qualitative step-by-step approach for identifying and analyzing all actual and potential points of failure in a design, product or service. A successful team-based FMEA activity can use their collective experience with similar products to dramatically improve not only product performance but also reduce manufacturing issues at both a component and system and processing level. This web seminar introduces the five basic types of FMEAs with emphasis on constructing a Design FMEA. Each column of the FMEA form is clearly explained using a typical FMEA example. This example can be a provided sample or a company sample provided candidate. The course covers various methods for clearly identifying product function at three levels, and associating distinct failure modes, effects and causes related to each function level. Special attention is given to Severity, Occurrence, and Detection and how to develop
Effective Risk Priority (RPN) strategies and Recommended Actions for significant RPNs.

All material is in conjunction with current industry standards.

**Learning Objectives**

Upon completion, the participant should have developed a completed FMEA and, thus, be able to understand and apply the following:

- Relating Product Development, Voice of the Customer (VOC) and the FMEA
- Why and when to use System and Design FMEAs
- The FMEA as a risk management technique
- The five types of FMEAs
- Organizing effective FMEA development teams and meetings
- The steps to generating a quality FMEA, including a column by column review of the Design FMEA form
- Basics of Root Cause Analysis
- Design Control techniques, Detection Strategy, Risk Priority strategies and Risk Ranking tables
- Assignment of recommended actions

**Who Should Attend**

The course is designed for individuals who are involved in the development of new products and who seek to improve that process. Product development team members including, but not limited to, project and program managers, design and development, process, product, quality, and application engineers will find the course valuable. It is aimed primarily at these managers and engineers who will be facilitating or leading such FMEA activities. Directors, marketing and purchasing personnel will also benefit by understanding why the FMEA process is important to developing a safe and effective product.

**Topical Outline**

Session 1
- FMEA Introduction
- Background and History
- The FMEA Standards - MIL-STD_1629, SAE J1739, AIAG
- Relationship of Design and Process FMEA in a design & manufacturing environment

Session 2
- Five Types of FMEAs

Session 3
- FMEA and Risk Management
- Defining Risk Management
- FMEA and Robust Design
- FMEA as part of Design to Cost
- FMEA as Product Liability Protection

Session 4
- Managing the FMEA Process
- Assembling the FMEA Team
- Facilitator Role during the FMEA Process

Session 5
- Column By Column Review of the FMEA - Part 1
- Header
- Item/Function - Primary, Secondary and Customer Satisfaction
- Failure Mode
- Effects and Severity
- Causes and Occurrence
- Controls and Detection

Session 6
- Column By Column Review of the FMEA - Part 2
- Calculating and Assessing RPN
- Risk Tables and RPN assignment strategies
- Recommended Actions
- Responsibility and Target Dates
- Verification

**Instructor:** Angelo E. Mago

**Fee:** $835 1.2 CEUs

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**Fundamentals of Statistical Process Control**

2 Days
I.D.# C0553

As competition for market share increases, so does the need to monitor processes and quality to ensure top-notch products. This hands-on seminar will provide you with the skills to apply and maintain statistical process control to assist your organization in the improvement of various processes to achieve higher percentage yield or higher quality products or services. Quality characteristics (process outputs to track), measurement systems, sampling strategies, types of control charts, construction of control charts, and control chart interpretation will be covered. The determination of the key process parameters and controlling them to provide consistent results will improve quality and lower costs, in particular, scrap and rework costs. Statistical theory and depth are kept to a minimum while you learn how to utilize the tools. Attendees will receive a copy of the Statistical Process Control Manual (SPC-3, 2nd Edition) by the Automotive Industries Action Group.

**Learning Objectives**

By attending this seminar, you will be able to:

- Describe the purpose and uses of SPC
- Select the best measurement system to use for a specific application
ENGINEERING TOOLS & METHODS

- Identify an appropriate process sampling strategy
- Determine the basic type of control chart to use
- Collect data and construct basic control charts
- Interpret control chart results

Who Should Attend

Quality managers, engineers, and technicians, project engineers, manufacturing engineers, technical specialists and anyone with responsibility for product or process control who want to apply SPC in the workplace should attend this seminar. Individuals seeking to attain the Certified Quality Engineering status within the American Society for Quality will find this course particularly helpful.

Topical Outline

DAY ONE
- Introduction
- Viewpoints and Determinants of Quality
- SPC: Part of a Product Quality System
- SPC philosophy: prevention versus detection
  - Process control system
  - Causes of variation: common and special
  - Reactions to causes of variation
  - Requirements and specifications
  - Control charts: SPC tools
  - Benefits of SPC
  - SPC implementation process
- Quality Characteristic Determination
  - Everything is a process
  - Process flowchart and functions
  - Quality characteristics generation -- intermediate/final; variable/attribute
  - Critical characteristics determination -- final customer requirements; subsequent process requirements
  - Process example
- Quantification (measurement) of Quality
  - Types of characteristics -- variable; attribute
  - Methods of measurement and measurement systems
  - Measurement system capability
- Sampling Strategy
  - Sample size
  - Sample frequency
  - Sample structure
- Quality Planning Workshop
- Basic Control Chart Types
  - Variable: X and R charts -- AIAG example; workshops
DAY TWO
- Basic Control Chart Types (continued)
  - workshops
  - process capability indices (Cp & Cpk)
- Attribute
  - np chart - number defective -- AIAG example; workshops
- c chart - number of defects -- AIAG example; workshops
- Basic Chart Interpretation
- Basic decision rules
- Process responses -- jumps, steps, shifts; trends; cycles
- Documented process changes

Instructor: Phillip J. Ross
Fee $1335 1.3 CEUs

Introduction to Design Review Based on Failure Modes (DRBFM) Web Seminar and Web Seminar RePlay

6 Hours
Web Seminar: I.D.# WB1047
Web Seminar RePlay: I.D.# PD331047ON

Design Review Based on Failure Modes (DRBFM) is a methodology focused on change management and continuous improvement. It centers on early prevention and engineering knowledge, eliminating time spent debating ranking systems, waiting for lead engineers to document and list their concerns, identifying what types of concerns are open for discussion and resolution, and brainstorming without any actionable closure.

This Web Seminar will explain all phases of the DRBFM methodology and provide details on how to accomplish the specific steps. With the Design Review Based on Failure Modes (DRBFM) and Design Review Based on Test Results (DRBTR) Process Guidebook that is bundled with the course, the instructor will provide specific information on each step. Formats, examples, notes and homework slides will be used to illustrate the defined steps of the new SAE J2886 DRBFM Recommended Practice. Similarities in content between DRBFM and FMEA will be discussed, however the focus will be on conducting DRBFM methodology.

This DRBFM web seminar will provide roles and responsibilities of management, design engineers, manufacturing engineers, facilitators and technical experts. Those interested in DRBFM will benefit from understanding the rationale behind this methodology and learn to guide teams through the paradigm shifts and mind set that are needed.

Learning Objectives

By connecting with this web seminar, you will be able to:
- Outline the fundamental steps of DRBFM methodology, including:
  - DRBFM Plan and analysis requirements
  - Necessary preparation feeding DRBFM analysis

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• The two phases of DRBFM analysis
• Documentation of design, validation and manufacturing actions
• Feedback loop into engineering knowledge documents
• Explain the intent and format of the DRBFM worksheets
• Predict what it takes to gain and maintain proficiency and consistent application of the methodology
• Find answers to most DRBFM questions

Who Should Attend
Product engineers, manufacturing engineers, quality engineers, supplier quality engineers, validation and test engineers, and facilitators, trainers and consultants in all industries. This Web Seminar will benefit beginning engineers, advanced and senior engineers and managers who must participate in FMEA’s and DRBFM.

Topical Outline
Session 1
• DRBFM Procedure, Forms, Planning and Preparation
  • Process Guide and Workbook Overview
  • Scope and Purpose
  • Process Map - General Requirements
  • Planning - Formats, examples, homework
  • Planning Results and Output
  • Preparation - Formats, examples, homework
  • Preparation Results and Linkage with DRBFM Format
  • Definition of Change Section
Session 2
• DRBFM - Forum 1, Design Review, Action Results and Follow Up
  • DRBFM Forum 1 - Engineer analysis
  • Change Point definition
  • Identification of concerns
  • Identification of causes and influences on the vehicle
  • Identification of effects
  • Identification of severity/priority
  • Actions to gain engineering knowledge - evidence
Session 3
• DRBFM - Forum 2, Design Review, Action Results and Follow Up
  • DRBFM Forum 2 - Design Review introduction
  • Change Point overview
  • Identification of additional concerns
  • Identification of additional causes and influences on the product
  • Identification of effects
  • Identification of severity/priority
  • Actions taken to eliminate concerns
  • Design actions to gain engineering knowledge - evidence
  • Validation actions to gain evidence of reliability
  • Manufacturing, assembly, and supplier actions

• Action results and feedback to design guidelines
• Roles and responsibilities

Instructor: Bill Haughey
Fee $615 .6 CEUs

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Introduction to Failure Mode and Effects Analysis for Product and Process

2 Days
I.D.# C1201

Failure Mode and Effects Analysis (FMEA) is a systematic method for preventing failure through the discovery and mitigation of potential failure modes and their cause mechanisms. Actions are developed in a team environment and address each high: severity, occurrence or detection ranking indicated by the analysis. Completed FMEA actions result in improved product performance, reduced warranty and increased product quality. This course assists team members to apply severity, occurrence and detection rankings consistently and efficiently and explores, in detail, the linkage of the Design FMEA and the Process FMEA through special characteristics development and product and process design collaboration. The relationships between FMEA and other popular tools, including Fault Tree Analysis (FTA), Design Verification Plan and Report (DVP&R) and Control Plans is discussed. Participants can expect dynamic “hands-on” activities with in-class Design and Process FMEA creation, facilitation skill development and risk analysis best practices. Instruction and clarification will be provided for relevant portions of the SAE J1739 standard, Potential Failure Mode and Effects Analysis in Design (Design FMEA), Potential Failure Mode and Effects Analysis in Manufacturing and Assembly Processes (Process FMEA), a copy of which will be included with the course materials.

Learning Objectives

Upon completion of this seminar, attendees will be able to:
• List the benefits, requirements, and objectives of an FMEA
• Demonstrate the steps used in developing an FMEA
• Follow the methodology to efficiently create an FMEA
• Describe other tools used in, or related to the FMEA
• Identify corrective actions resulting from proper FMEA development
• Identify and classify the levels of risk requiring corrective action
• Show the links between Design and Process FMEA
• Demonstrate the FMEA’s role in developing Special Characteristics and Design and Process Controls
• Summarize the objectives of the SAE standard J1739
ENGINEERING TOOLS & METHODS

Who Should Attend
This seminar is designed for engineers involved with manufacturing, product design, reliability, testing, quality, development, logistics/support, product assurance/design assurance, materials, and their management or anyone responsible for the design and development of manufacturing, assembly or service processes in the completion of a Design or Process FMEA.

Topical Outline
DAY ONE
• Pretest - Set baseline of knowledge and determine Voice of the Customer (participants) wants needs and desires
• FMEA Process Overview
  • Introductions and course objectives
  • The history and purpose of FMEA
  • SAE J1739 introduction
  • FMEA - where it fits in the product development process
  • System/Subsystem/component Design FMEA
  • Manufacturing and Assembly Process FMEA
  • Machinery and Equipment FMEA (Logistics Support)
• FMEA Development Methodology
  • Design FMEA development methodology - the three path model
  • Failure Mode Avoidance FMA /FPA Failure Prevention Analysis
  • Team structure and rules for efficiency - cross functional teams
• The Links between Design and Process FMEA
  • Special characteristics (critical and significant)
  • Collaboration on special characteristics
  • Characteristics as inputs to PFMEA
• Workshop 1: Review product and processes to be performed
• Practical Application of the Design FMEA Technique
  • Robustness Tools: Interface Analysis/Boundary (BLOCK) Diagrams; Parameter Diagram (P Diagram)
• Workshop 2: Construct Boundary/Block Diagrams and P Diagrams
• Review of Days Activities and Q&A
DAY TWO
• Methodology and Hands-on Experience
• Path 1: Functions/Failure Modes/Effects of Failure/Severity
  • Severity ranking guidelines
  • Actions for high severity (9,10)
  • Workshop 3: Path 1 Exercise
• Path 2: Causes/prevention controls/occurrence
  • Occurrence ranking guidelines
  • Inputs to FTA (Fault Tree Analysis)
  • Actions to eliminate and/or reduce cause probability
  • Workshop 4: Path 2 Exercise
• Path 3: Test and verification methods
  • Detection ranking guidelines
  • Links to DVP&R

Instructor: Lee D. Dawson
Fee $1395 1.3 CEUs

Reverse Engineering: Technology of Reinvention

2 Days
I.D.# C0559

During the past decade reverse engineering has become a common and acceptable practice utilized by many original equipment manufacturers and suppliers. This course focuses on the application of modern technologies used to decode the design details and manufacturing processes of an existing part in the absence of the original design data. It emphasizes the real-life practice of reverse engineering in the aerospace industry from both scientific and legal points of view. Attendees will learn the applicability and limitations of reverse engineering through case studies and hands-on exercises.

Various measurement instruments, ranging from traditional micrometers to computer-aided laser probes, will be compared for their merits and shortcomings. The statistics of dimensional measurements and the acceptable tolerance of variations, with emphasis on industrial standards in real-life practice will be discussed. Material identification, manufacturing process verification and the system compatibility of the subject part to
be reverse engineered will be covered in substantial detail. In addition, the materials specifications will be exemplified as useful supporting documents for substantiation data.

Note: Participants should bring a calculator for in-class exercises.

**Learning Objectives**

By attending this seminar, you will be able to:

- Define the critical elements of reverse engineering
- List the measurements and analyses required to duplicate/reproduce an OEM part by reverse engineering
- Recognize if an OEM part can be duplicated/reproduced by reverse engineering
- Judge if a “duplicated” part will meet the design functionality of the OEM part
- Evaluate the feasibility of a reverse engineering proposal/project
- Describe and implement a process to duplicate/reproduce a part by reverse engineering

**Who Should Attend**

This seminar is designed to assist individuals in various industries including, but not limited to, automotive, aerospace, off-highway, motorsports and parts brokerage firms. Corporate senior executives, engineering managers, engineers, technicians, government inspectors, sales managers, salespersons, lawyers and legal counselors will find the course relevant and informative.

**Topical Outline**

**DAY ONE**

- Introduction
  - Historical background
  - Reverse engineering vs. machine design
  - Three basic requirements: form, fit and function
- Geometrical Form
  - Dimensional measurement
  - Precision instruments of measurement
  - Tolerance
  - Virtual exercise of geometrical modeling
- Material and Process Identification
  - Chemical composition identification
  - Manufacturing process verification
  - Materials specification substantiation
  - Machining process identification
- Data Process and Analysis
  - Statistical analysis
  - Statistical exercise
  - Case study of statistical confidence
  - Reliability

**DAY TWO**

- Demonstration and Exercise
  - Demonstration of scanning
  - Hands-on exercise of reverse engineering
  - Case study
- Regulations and Certifications
  - Government regulations
  - Industrial standards Certification requirements
- Fit and Function
  - System compatibility
  - Critical performance
  - Vendor substantiation
  - Safety and damage tolerance
- Acceptance and Legality
  - Evolving industry trends
  - Moral and legal issues
  - Examples – legal precedents

**Instructor:** Wego Wang

**Fee:** $1335 1.3 CEUs

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**Robust Design**

2 Days  
I.D.# C1231

Engineers are taught to create designs that meet customer specifications. When creating these designs, the focus is usually on the nominal values rather than variation. Robustness refers to creating designs that are insensitive to variability in the inputs. Much of the literature on robustness is dedicated to experimental techniques, particularly Taguchi techniques, which advocate using experiments with replications to estimate variation. This course presents mathematical formulas based on derivatives to determine system variation based on input variation and knowledge of the engineering function. If the function is unknown, experimental techniques are presented to efficiently estimate a function.

The concept of designing for both nominal values and variability is expanded to multiple outputs and designing to minimizing costs. Traditionally, if the output variation is too large to meet requirements, the tolerances (variation) of the inputs are reduced. Using the approach presented in this course, the equations presented can be used to identify the contribution of each of the inputs to the output variation. The variation of the components with the largest contribution can be reduced which will reduce output variation. At the same time, the variation of the components contributing the least to the variation of the output can be increased which will reduce costs. A system of equations can be created that will allow an optimization routine to create a design optimized for total cost including the cost of poor quality and component cost.

Participants should bring a laptop computer for in-class exercises.
ENGINEERING TOOLS & METHODS

Learning Objectives
By attending this seminar, you will be able to:
• Create designs that have a minimal sensitivity to input variation
• Reduce design costs
• Determine which design parameters have the largest impact on variation
• Optimize designs with multiple outputs

Who Should Attend
This course is relevant to design and manufacturing engineers, researchers and those interested in cost reduction. This methodology can link manufacturing to engineering design and help design engineering solve manufacturing problems.

Topical Outline
DAY ONE
• Basics of Variation - unique problems facing engineers; small sample sizes and the inability to obtain random samples; techniques for overcoming these problems
• Distributions
• Normal, Lognormal, and Weibull Process Capability
  • Measuring process capability
  • Process capability indices
  • Estimating process capability for design inputs
• Robustness Concept
  • Statistical bias that results from input variation in a non-linear system
  • Modeling output variation
  • Circuit exercise
  • Projectile exercises
• Simulation
  • Determining the variability of the inputs
  • Random number generators
  • Verification & validation
  • Simulation modeling
DAY TWO
• Minimizing the Variance of a Single Output
  • Polynomial exercise
• Identifying Critical Parameters
  • Ranking the contribution to the output variation
  • Identifying parameters that are constrained
  • Pipe flow exercise
• How to Model and Optimize Multiple Outputs
  • Combustion exercise
• Adding Cost to the Design Model
  • Minimizing the total system cost including component, scrap and process costs
  • Electronics exercise

Instructor: Bryan Dodson
Fee $1385 1.3 CEUs

Simplified Taguchi/DOE Methods
2 Days
I.D.# 96017

Companies realize that they need to do more with less which means we need to use the most efficient and effective methods. This seminar blends the philosophy of Taguchi with the simple graphical methods of Box, Hunter, & Hunter to give a powerful set of DOE tools.

Wide use of Design of Experiments or DOE methods has been hindered by complications in planning a DOE to handle interactions and by analysis complexity of ANOVA. A Preferred Columns Method simplifies planning so engineers can assign factors to an array in minutes. Graphical methods allow quality professionals to distinguish large (active) factors from small terms and portray these findings to broad audiences. By simplifying DOE’s, road blocks are removed so that more people can begin using these highly productive methods.

Learning Objectives
By attending this seminar, you will be able to:
• Explain Taguchi’s Quality Philosophy of Closeness to Target
• Plan efficient factorial experiments using the Preferred Columns Method
• Compare data sets with dual or multiple stem and leaf plots
• Analyze the data using simple graphical methods such as dot plots and probability plots

Who Should Attend
This seminar will be most beneficial to engineers and quality professionals who work in product design, manufacturing, testing, reliability, quality, process, or development.

Topical Outline
• Taguchi Loss Function
• Comparison of Two Means
  • Dual stem & leaf plots
  • Exceedances test
  • Graphical T-test for differences
• One-Factor Experiments
  • Multiple stem & leaf plots
  • Graphical F-test for multiple comparisons
• Two-Factor Experiments
  • Response plots to see effects and interactions
  • Graphical F-tests to compare averages
• Full Factorials
  • Math model behind factorial experiments
  • Independent factors vs. interactions
  • Randomizing the runs
  • Planning Fractional Factorials Measurement system that
uses continuous data
• How to select factors for a DOE
• Confounding patterns and resolution
• Preferred Columns Method to set up a fractional factorial
• Data sheets
• Customizing for a 4-level factor
• Analyzing Fractional Factorials
  • Column effects table
  • Quantifying the noise of repeats
  • Dot plots with error distributions
  • Interaction plots
  • Prediction model
  • Cube plot
  • Probability plot of column effects

Who Should Attend
This course applies to anyone making product or process assessment or changes and will help them to make effective decisions concerning those situations. Product design managers and engineers, process design managers and engineers, and quality managers and engineers will particularly benefit from this course. Individuals seeking to attain the Certified Quality Engineering status within the American Society for Quality will find this course particularly helpful.

Topical Outline
DAY ONE
• Introduction
  • Training objectives
  • Statistical resources
• Concept of variation
  • Common development questions
  • Histograms
  • Descriptive statistics
• Distribution Models
  • Continuous
  • Discrete
  • Applications
• Model Selection
  • Empirical distribution functions
  • Cumulative distribution functions
  • Normal probability paper
  • Small sample sizes and median ranks
  • Tests for normality
DAY TWO
• Parametric Evaluations and Tests
  • Normal and log-normal data -- Z confidence intervals and tests; t confidence intervals and tests; Chi-Square confidence intervals and tests; K factor confidence intervals; F tests;
DAY THREE
• Parametric Evaluations and Tests (continued) -- analysis of variance
  • Weibull distribution, confidence intervals and tests
  • Exponential distribution tests
  • Poisson distribution applications
  • Binomial distribution applications
  • Hypergeometric applications
• Nonparametric Tests
  • Sign tests, Run tests, and Rank tests

Learning Objectives
By attending this seminar, you will be able to:
• Select the proper distribution model
• Determine valid sample sizes
• Design valid tests of comparison
• Make effective decisions at stated confidence levels

Instructor: Phillip J. Ross
Fee $1700 2.0 CEUs
Vibration Analysis Using Finite Element Analysis (FEA)

12 Hours
I.D.# WB1401

Finite Element Analysis (FEA) has been used by engineers as a design tool in new product development since the early 1990’s. Until recently, most FEA applications have been limited to static analysis due to the cost and complexity of advanced types of analyses. Progress in the commercial FEA software and in computing hardware has now made it practical to use advanced types as an everyday design tool of design engineers. In addition, competitive pressures and quality requirements demand a more in-depth understanding of product behavior under real life loading conditions. This course will enable participants to expand the scope of FEA to vibration analysis to simulate product behavior under those conditions. This six-session web seminar introduces vibration analysis performed with Finite Element Analysis (FEA). By considering time-dependent loads and inertial and damping effects, vibration analysis allows for a more in-depth product simulation thus reducing product development cost and time. The course reviews basic concepts of vibration analysis and illustrates how they are implemented in FEA to simulate product behavior. The most common types of vibration analysis such as modal, time response, and frequency response will be covered.

All topics are illustrated using FEA software, SolidWorks® Simulation, for which participants will be provided a student license and opportunity to practice skills learned. Acquired skills, however, will not be software specific and no prior exposure to FEA software is required.

Learning Objectives
By participating in this web seminar, you will be able to:
• Evaluate the importance of dynamic effects in product simulation
• Analyze inertial and damping effects in structural response
• Perform modal analysis, time response analysis and frequency response analysis
• Apply proper FEA modeling techniques to model system vibration
• Use vibration analysis as a design tool

Who Should Attend
The course will be of interest to design, R&D, project, and product engineers who already use Finite Element Analysis (FEA) as a design tool and would like to explore if and how vibration analysis with FEA may benefit the design process. It builds on participants’ experience with static FEA and on knowledge of mechanical vibrations common to any mechanical engineer.

Topical Outline
Session 1
• Structure vs. Mechanism
• Simulation Process with the FEA
• Verification and Validation of FEA Results
• Discrete and Distributed Systems
• Mode of Vibration
• Modal Analysis
• Eigenvalues and eigenvectors
• In-class Exercises/Homework Assignment

Session 2
• Modal Analysis
• Convergence of Frequencies
• Rigid Body Modes
• Properties of Lower and Higher Modes
• Modes of Vibration of Single Degree of Freedom Oscillator (1DOF) and Two Degrees of Freedom Oscillator (2DOF)
• In-class Exercises/Homework Assignment

Session 3
• Modal Analysis
• Modeling Techniques in Modal Analysis
• Modes Separation
• Modal Analysis as a Tool to Find “Weak Spots”
• Modal Analysis as a Diagnostic Tool
• In-class Exercises/Homework Assignment

Session 4
• Modal Analysis with Pre-Stress
• Buckling Analysis
• Analogies between Modal Analysis and Buckling Analysis
• Modes of Vibration
• Modal Superposition Method
• In-class Exercises/Homework Assignment

Session 5
• Time Response Analysis
• Load Excitation and Base Excitation
• Impulse Load
• Static vs. Dynamic Response
• Time Response of a 1DOF and 2DOF Systems Time Response of a Distributed System
• In-class Exercises/Homework Assignment

Session 6
• Frequency Response Analysis
• Steady State Harmonic Response
• Force and Base Excitation
• Resonance
• Modal Damping
• Frequency Response of a 1DOF and 2DOF Systems
• Frequency Response of a Distributed System
• Linear vs. Non-linear Vibration Analysis
• Summary for Post-Course Learning Assessment
Instructor: Paul Kurowski
Fee $870 1.2 CEUs

Tolerance Stack-up Fundamentals Web Seminar and Web Seminar RePlay

6 Hours
Web Seminar: I.D.# C0842
Web Seminar RePlay: I.D.# PD330842ON

Analysis of tolerance stacks varies widely. This Web Seminar introduces the basic tools to create a common methodology for tolerance stack-ups, and ensure seamless documentation. Participants will create 1-D tolerance stacks for parts and assemblies that use geometric dimensioning and tolerancing using a tolerance stack spreadsheet. This simple, manual spreadsheet method produces an easily interpreted and checked documentation trail, and is easily adaptable to common electronic spreadsheet programs. Multiple examples will be provided to assist engineers in applying tolerance stack-up fundamentals to Y14.5 issues.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Perform and develop a tolerance stack-up analysis
• Correctly enter geometric feature control frame data into a tolerance stack
• Apply a common step-by-step methodology to tolerance stack analysis

Who Should Attend
Engineers familiar with concepts and practices contained within Y14.5 and who are looking for a fundamental step-by-step process for getting geometric dimensioning and tolerancing (GD&T) into a tolerance stack will benefit from this course. A basic understanding of GD&T symbols and concepts is required.

Topical Outline
Session 1
• Introduction and review
  • Introduction and tolerancing review
  • Tolerancing strategies
  • Review of GD&T

Session 2
• Stack fundamentals
  • How to identify the stack path The two-column stack spreadsheet
  • Entering dimensions into the spreadsheet
  • Examples with coordinate dimensions

Session 3
• Factoring GD&T into a Stack

Instructor: John-Paul Belanger
Fee $640 .8 CEUs

Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) Web Seminar and Web Seminar RePlay

16 Hours
Web Seminar: I.D.# WB0933
Web Seminar RePlay: PD330933ON

Geometric dimensioning and tolerancing (GD&T) is used as a symbolic way of showing specific tolerances on drawings. GD&T is a valuable tool that effectively communicates the design intent to manufacturing and inspection. It is governed by the technical standard ASME Y14.5M-2009. This course introduces participants to the GD&T system, providing a working knowledge of the correct interpretation and application of each symbol, general rules, the datum system, and ‘bonus’ tolerance and highlighting some of the changes in the updated Y14.5 standard. The material is reinforced with many practice exercises.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Explain the benefits of geometric tolerancing
• Identify datum features and determine their order of precedence
• Identify and interpret each of the characteristic symbols
• Describe the material condition modifiers and how “bonus” tolerance occurs
• Correctly interpret GD&T feature control frames, and explain the impact on manufacturing and inspection

Who Should Attend
This course is ideal for anyone who has a need to apply or interpret geometric tolerances on a product print. Product engineers, manufacturing engineers, CAD designers, quality inspectors, and other engineering and manufacturing personnel will all benefit from a better understanding of design requirements; improved communication with customers and suppliers; and improving designs by taking advantage of bonus tolerance and other GD&T
ENGINEERING TOOLS & METHODS

benefits. Participants should have an understanding of basic blueprint reading.

Topical Outline
Session 1
• Why Use GD&T?
  • Review of traditional dimensioning
  • Benefits of GD&T
  • Technical standards
  • Definitions
  • Basic dimensions
  • How to read the feature control frame
Session 2
• Rules and the Form Symbols
  • Rule #1: Size controls form
  • Rule #2: Assume RFS
  • Flatness
  • Surface straightness
  • Circularity
  • Cylindricity
Session 3
• Bonus Tolerance
  • GD&T applied to a feature of size
  • Bonus and the MMC modifier
  • Virtual condition
  • Gaging and inspection of GD&T
Session 4
• Datums
  • Datum vs. datum feature
  • The datum reference frame
  • Primary, secondary, and tertiary datums
Session 5
• Profile and Orientation
  • General definition of profile
  • Profile of a line
  • Profile of a surface
  • Use of datums with profile
  • Perpendicularity; Angularity
  • Parallelism
Session 6
• Position Tolerance I
  • True position; Position tolerance RFS
  • Using MMC or LMC
  • The “boundary” concept
  • The pitch diameter rule
Session 7
• Position Tolerance II
  • Projected tolerance zone
  • Inspecting parts for position
  • Calculating tolerance values

Advanced GD&T Competencies: Composite Positioning Web Seminar and Web Seminar RePlay
1.5 Hours
Web Seminar: I.D.# WB1321
Web Seminar RePlay: I.D.# PD331321ON

While the basics of position are covered in a standard Geometric Dimensioning & Tolerancing (GD&T) course, and sometimes a lone example of composite position is given, those discussions often overlook the variations allowed that enable more accurate control based on part function. This advanced Web Seminar will clarify the proper use of “double-decker” position controls in GD&T. There are two distinct types: composite position (one symbol) and two single-segment position controls (two symbols). These are commonly used to locate patterns of features (bolt circles, etc.), but they are rarely taught in any depth. In this course, participants will learn the difference in showing one vs. two position symbols and the importance of the datum references in understanding each meaning, per the ASME Y14.5-2009 standard. Many samples will be shown of the proper tolerancing of patterns of holes and pins that use each method. Examples and exercises will be provided to allow participants to practice several calculations. Learning these advanced techniques will permit better communication of part and assembly requirements between designers and manufacturers.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Explain composite positioning tolerancing
• Explain two single-segment tolerancing
• Apply the appropriate callout based on functional requirements
• Describe gages for each and calculate gage sizes

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel,
and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Profile of a Surface And Advanced GD&T Competencies: Datum Usage Web Seminars - page 59

**Prerequisites**

For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing Web Seminar is a recommended prerequisite. See course description on page 57

**Topical Outline**

- Brief review of position and bonus tolerance
- Explanation of composite tolerancing
- The need to control orientation vs. location
- Adding secondary and tertiary datums to the lower tolerance
- Two single-segment position tolerancing
- Functional gaging and CMM gaging perspectives

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<tr>
<th>Instructor:</th>
<th>John-Paul Belanger</th>
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**Advanced GD&T Competencies: Datum Usage Web Seminar and Web Seminar RePlay**

1.5 Hours

Web Seminar: I.D.# WB1319
Web Seminar RePlay: I.D.# PD331319ON

Standard Geometric Dimensioning & Tolerancing courses cover the basics of datums but can overlook the variations that enable usage in complex ways. This advanced Web Seminar details the proper use of datums, showing their full potential to make your drawings as effective as possible. Most people who use GD&T are familiar with traditional datums derived from flat surfaces, and have adequate knowledge of the principle of establishing 3-2-1 contact points. Participants learn to select, identify, simulate, and describe datums and datum features for special uses such as irregular shapes, flexible parts, and datum referencing that use the maximum material modifier. Web Seminar also covers are several new modifiers and options given in the ASME Y14.5-2009 standard. Learning these advanced techniques will allow designers to better communicate certain requirements.

**Learning Objectives**

By connecting with this Web Seminar, you will be able to:
- Explain the difference between a datum and a datum feature
- Select appropriate datums for irregularly shaped parts such as body or interior panels
- Properly simulate given datums
- Explain effects of a modified datum on a geometric tolerance
- Interpret new datum tools such as translation and custom degrees of freedom

**Who Should Attend**

This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Composite Positioning and Advanced GD&T Competencies: Profile of a Surface Web Seminars. See course descriptions on pages 58 and 59.

**Prerequisites**

For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing Web Seminar is a recommended prerequisite. See the course description on page 57.

**Topical Outline**

- Brief review of traditional datum usage
- Selecting datums: surface vs. feature of size
- Use of the MMB modifier (formerly MMC)
- Using a pattern as a single datum
- The new translation modifier
- Applying the “M” modifier to a surface
- Customized degrees of freedom
- Irregular feature of size datums
- Moveable datum targets

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**Advanced GD&T Competencies: Profile of a Surface Web Seminar and Web Seminar RePlay**

1.5 Hours

Web Seminar I.D.# WB1320
Web Seminar RePlay: I.D.# PD331320ON

Basic Geometric Dimensioning & Tolerancing courses cover profile but often ignore the variations allowed with these symbols that enable usage in complex ways. This advanced Web Seminar clarifies the proper use of the profile tolerances in GD&T and uncover the nuances of these two symbols. Profile of a surface is arguably the most powerful GD&T symbol, so its full potential is explored. It can be used to control size, form, orientation, and location and its relationship to datums can be varied. Learning these advanced techniques allow designers to better communicate certain requirements. The examples given in the
ENGINEERING TOOLS & METHODS

course will also illustrate several of the new options for profile that were introduced in the ASME Y14.5-2009 standard.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Explain when profile tolerances require a datum reference
• Determine which aspects of GD&T a given profile tolerance controls
• Interpret unilateral, bilateral, and nonuniform tolerances
• Describe how to properly measure profile tolerances

Who Should Attend
This advanced-level course is intended for designers, product engineers, manufacturing engineers, manufacturing personnel, and quality/gaging inspectors with a basic knowledge of GD&T concepts. It is a companion to the Advanced GD&T Competencies: Datum Usage and Advanced GD&T Competencies: Composite Positioning Web Seminars. See course descriptions on page 58 and 59.

Prerequisites
For those new to GD&T, the Fundamentals of Geometric Dimensioning & Tolerancing Web Seminar is a recommended prerequisite. See course description on page 57

Topical Outline
• Review of profile of a surface and profile of a line
• Using profile without datums
• All around and all over
• Locating a profile zone with tolerated dimensions
• Using the MMB modifier with profile
• Composite profile
• The “U” modifier
• Nonuniform tolerancing

Instructor: John-Paul Belanger
Fee $215 .15 CEUs

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A seasoned training company founded by globally recognized GD&T expert Alex Krulikowksi, ETI offers an array of training products designed to train industry engineers at all levels of GD&T usage. High-quality learning products including classroom and digital courses, text books and reference guides, and job resources all meant to produce the world’s best GD&T practitioners. All ETI instructors are ASME certified and mentored by Alex Krulikowski.

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Course titles exclusively from ETI include:

• Engineering Drawing Requirements
• Executive Overview of GD&T
• GD&T for Manufacturing (ASME Y14.5-2009)
• GD&T Overview (ASME Y14.5M-1994)
• Intro to Statistical Tolerance Stacks
• Solid Model Tolerancing (ASME Y14.41)
• System Approach to Component Tolerancing

For more information visit www.etinews.com or contact sales@etinews.com

Engineering Drawing Requirements

1 Day
I.D.# ET2701

Providing you have a basic understanding of engineering drawings, this course teaches how to correctly interpret engineering drawings. It will improve a student’s understanding of print reading and result in more effective communication on the job.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on practical application of print interpretation providing a better understanding of the view representation, dimensions, tolerances, and symbols used.

Learning Objectives

By attending this class, you will be able to:
• Describe the types of engineering drawings
• Recognize common drawing formats
• Explain line conventions and lettering used on drawings
• Recognize types of drawing views
• Recognize the section views on drawings
• Describe dimensioning and tolerancing practices on drawings
• Explain surface texture standards and symbols
• Describe how weld symbols are used on drawings
• Recognize the symbols and conventions used on electronic diagrams

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/ professionals. Attendees should have a basic understanding of engineering drawings prior to enrollment.

Topical Outline

• Engineering Drawings
  • Engineering drawings
  • CAD
  • The purpose and importance of engineering drawings
  • Standards used on engineering drawings
  • Types of engineering drawings
  • Layout, detail, assembly, control, and diagram drawings
• Drawing Formats
  • Drawing sheet sizes
  • Drawing zones
  • Title and revisions blocks
  • Angle of projection
  • Engineering drawing units
  • Parts lists
  • General, local, and flag notes
  • Drawing scale
  • Multi-sheet drawings
Engineering Tools & Methods

- Line Conventions and Lettering
  - Line types on drawings
  - The functions represented by line types
  - Hierarchy of line types
  - Lettering
- Drawing Views
  - Orthographic projection
  - Projection systems
  - Single view and multiview drawings
  - Detail, auxiliary, and assembly views
- Section Views
  - Section views
  - Eight types of section views
  - Conventional vs. true geometry
  - Revolution of features
  - Sectioning of assemblies
- Dimensioning and Tolerancing
  - Practices for metric and English unit dimensions
  - Expressing tolerance
  - General tolerances
  - Definitions
  - Implied and coaxial relationships
  - General symbols and abbreviations
  - Thread, gear, and spline representation and specifications
  - GD&T standards and symbols
  - Uses of GD&T
- Surface Texture
  - Surface texture standards
  - Definition of surface texture
  - ASME surface texture symbols
- Weld Symbols
  - Weld specifications
  - Common weld types
  - Common weld joints
- Electric and Electronic Diagrams
  - Components on electrical and electronic diagrams
  - Cables and conduits on electrical and electronic diagrams
  - Wiring conventions and terminal conventions
  - The types of electrical and electronic diagrams

Solid Model Tolerancing (Based on ASME Y14.41)

1 Day
I.D.# ET2501

Providing you have a basic understanding of Y14.5 Dimensioning and Tolerancing practices, this course explains the fundamental definitions, concepts, and methods from the ASME Y14.41 Standard on Digital Product Definition Data Practices.

Utilizing the expertise of world-renowned GD&T expert and former Chairman of the Y14.41 Committee, Alex Krulikowski, the course focuses on understanding the benefits of a math-based product development process.

Learning Objectives
By attending this class, you will be able to:
- Explain the benefits of a math-based product development process (PDP)
- Describe the history, basic information, and definitions from the Y14.41 standard
- Explain how to create product definition data sets
- Describe data set requirements
- List drawing model data set requirements
- Explain various requirements that apply to annotated model data sets
- List the requirements when using the annotated model method
- Recognize the gaps, issues, and challenges of implementing a math-based PDP

Who Should Attend
This course is valuable for designers, engineers, and managers who are considering implementation of a math-based product development process. Attendees should have a basic understanding of Y14.5 Dimensioning and Tolerancing practices.

Topical Outline
- The Product Development Process
  - The characteristics of current PDP’s
  - Problems with current PDP’s
- What a math-based PDP is
  - The benefits of math-based PDP’s
  - The role of standards in implementing math-based PDP’s
- General Information on the ASME Y14.41 Standard
  - The history of the Y14.41 standard
  - Basic information about Y14.41
  - Y14.41 terms

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information
0.7 CEUs

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The Data Set Concept
- The data set concept explained
- Two methods in the standard for creating product definition data sets
- Common Requirements for Data Sets
- Data set and design model requirements that apply to both the annotated model data set and drawing data set
- Display management requirements
- Reasons for model value query
- Requirements for resolved, basic, and size dimensions

Requirements for the Drawing Data Set Method
- The data set requirements that apply to the drawing data set method
- General method requirements for drawing data set method
- The requirements for work coordinate systems in orthographic and axonometric views
- The requirements for specifying section views, dimensions in axonometric views, datums, and geometric tolerances

Requirements for the Annotated Model Method
- The data requirements that apply to annotated model data sets
- The design model requirements for the annotated model method
- The requirements for views, annotation, query, and notes on annotated models

Tolerancing Using the Annotated Model Method
- The requirements for plus-minus tolerances
- The requirements for datum applications
- The requirements for displaying geometric tolerances

Gaps, Issues, and Challenges of Implementing a Math-Based Development Process
- The benefits of the Y14.41 standard
- The major questions that companies need to answer to implement a math-based development process
- The gaps and issues when trying to achieve a math-based product development process

Fundamentals of GD&T (Based on ASME Y14.5M-1994)
1 Day
I.D.# ET2601

This subject is offered as a one, two, three, or four-day course.

Providing you have a basic understanding of mechanical drawings, this course teaches the terms, rules, symbols, and concepts of GD&T as prescribed in the ASME Y14.5M-1994 Standard. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course offers an in-depth explanation of geometric symbols, including each symbol’s requirements, tolerance zones, and limitations. It also includes a comparison of GD&T to coordinate tolerancing; an explanation of tolerance zones; Rules #1 and #2; form and orientation controls; tolerance of position; runout and profile controls. Newly acquired learning is reinforced throughout the class with more than 300 practice problems.

Learning Objectives
By attending this class, you will be able to:
- Describe engineering drawings: importance, drawing conventions, dimensions and tolerances, standards
- Explain why geometric tolerancing is superior to coordinate tolerancing
- Describe the key terms used in geometric tolerancing
- Recognize the modifiers and symbols used in GD&T
- Explain the rules used in GD&T
- Describe the concepts of basic dimensions, worst-case boundary, virtual condition, inner and outer boundary, and bonus tolerance
- Interpret the various types of tolerances (flatness, straightness, circularity, cylindricity, perpendicularity, angularity, parallelism, position, concentricity, symmetry, runout, and profile)
- Describe the datum system
- Interpret applications of datum targets, feature of size datum specifications (RFS & MMC)
- Describe the fundamental concepts of tolerance of position
- Interpret tolerance of position special applications

Who Should Attend
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Attendees should have completed ETI’s Engineering Drawing Requirements course or equivalent.
ENGINEERING TOOLS & METHODS

Topical Outline

- Introduction
  - Engineering drawings
  - GD&T/coordinate dimensioning comparison
  - Eight key GD&T terms
- Terminology
  - GD&T modifiers and symbols
  - Rule #1 and Rule #2
  - Basic dimensions, virtual condition, bonus tolerance
- Form Controls
  - Flatness
  - Straightness
  - Circularity
  - Cylindricity
- Datums
  - The datum system (planar datums)
  - Interpreting datum targets
  - Feature of size datum specifications (RFS)
  - Feature of size datum specifications (MMC)
- Orientation Controls
  - Perpendicularity
  - Angularity
  - Parallelism
- Tolerance of Position Controls
  - Definitions, conventions, advantages, basic theories
  - RFS and MMC tolerance of position applications
  - Cartoon gages for tolerance of position (MMC) applications
  - Tolerance of position special applications
  - Calculating distances on parts dimensioned with tolerance of position
  - Fixed and floating fastener formulas
- Concentricity / Symmetry Controls
  - Concentricity
  - Symmetry
- Runout Controls
  - Circular runout
  - Total runout
- Profile Controls
  - Profile tolerancing
  - Profile of a surface
  - Profile of a line

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information
1.3 CEUs

Fundamentals of GD&T for Inspectors (Y14.5M-1994, Y14.5.1, and Y14.43 Standards)

1 Day
I.D.# ET2503

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches an introduction to how to inspect GD&T requirements.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an explanation of the geometric symbols, rules, and concepts, the datum system, and how to inspect GD&T requirements using tools from the four categories of inspection tools. The scope of the course does not include how to use the various inspection tools.

Learning Objectives

By attending this class, you will be able to:
- Describe inspection and engineering drawings
- Explain key terms used in GD&T and how they affect interpretation and inspection
- Recognize the modifiers and symbols used in geometric tolerancing
- Interpret and inspect Rule #1, Rule #2, flatness, straightness, circularity, cylindricity, perpendicularity, angularity, parallelism, concentricity, symmetry, circular and total runout
- Explain the concepts of basic dimensions, virtual condition, inner and outer boundary and bonus tolerance and their effects on inspection
- Interpret and simulate planar datums and datum targets for inspection
- Interpret and inspect feature of size datums RFS and MMC
- Explain the fundamental concepts of tolerance of position: definitions, conventions, advantages and interpretations and their effects on inspection
- Interpret and inspect tolerance of position RFS, MMC, and special applications
- Describe functional gages for tolerance of position (MMC) applications
- Explain profile tolerancing
- Interpret and inspect profile of a surface and profile of a line applications

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/ professionals.
Attendees should have completed ETI’s Engineering Drawing Requirements course or equivalent prior to enrollment.

**Topical Outline**

- **Inspection**
  - Quality parts and quality drawings
  - Inspection, importance, components, and the characteristics of an expert inspector
  - Sources of variation
  - Categories of inspection tools

- **The Engineering Drawing**
  - Engineering drawings, communication, and drawing errors
  - Dimension, tolerance, limit tolerance, plus-minus tolerance
  - Metric unit dimensions on drawings
  - Interpreting dimensional limits
  - ASME Y14.5M-1994 and the fundamental dimensioning rules

- **Key Terms and Their Effect on Interpretation and Inspection**
  - Feature, feature of size, cylindrical feature of size, planar feature of size
  - Actual local size, actual mating envelope of external and internal feature of size
  - Maximum and least material condition of a feature of size
  - Non-feature of size dimensions and regardless of feature size

- **Modifiers and Symbols**
  - Modifiers, geometric characteristic symbols, and controls
  - Radius and controlled radius

- **Feature control frame Interpreting and Inspecting Rule #1 and Rule #2**
  - Rule #1, envelope boundary, size dimension, overriding, and exceptions
  - Rule #1 effects on the interrelationship between features of size
  - Inspecting a feature of size controlled by Rule #1
  - Rule #2

- **Basic Concepts**
  - Basic dimensions, virtual condition and uses in inspection
  - Inner, outer, worst-case boundary, and virtual condition of a feature of size
  - Geometric tolerance applied to feature or feature of size
  - Bonus tolerance calculations
  - MMC and LMC modifiers and inspection

- **Interpreting and Inspecting Flatness**
  - Flatness, flatness tolerance zone, location, and inspection
  - Rule #1 as an indirect flatness control
  - Legal flatness specification
  - Establishing a reference plane for flatness

- **Interpreting and Inspecting Straightness**
  - Straightness, straightness tolerance zone, and Rule #1 as indirect straightness control
  - Legal straightness specification

- **Inspecting straightness applied to a surface**
- **Determining if a straightness control is applied to a surface or a feature of size**

- **Interpreting and Inspecting Circularity**
  - Circlearity, circlearity tolerance zone, and inspection
  - Rule #1 as an indirect circlearity control
  - Legal circlearity specification

- **Interpreting and Inspecting Cylindricity**
  - Cylindricity, cylindricity tolerance zone, and inspection
  - Rule #1 as an indirect cylindricity control
  - Legal cylindricity specification

- **Interpreting and Simulating Planar Datums for Inspection**
  - True geometric counterpart, datum feature simulator, and simulated datum
  - Datum feature symbol, planar datums, datum reference frame
  - Choosing datum features and what controls their orientation
  - Six degrees of part freedom in space and the 3-2-1 Rule
  - Datum-related and non-datum-related dimensions
  - Datum reference frame for a part with inclined datum features
  - Coplanar datum features and simulation for inspection

- **Interpreting and Simulating Datum Targets for Inspection**
  - Datum targets, specification, requirements, and the datum target symbol
  - Basic dimensions used to locate datum targets
  - Point, line, and area datum targets
  - Simulated gage for a point, line, and area datum target applications
  - Simulating datum targets for inspection

- **Interpreting and Inspecting Feature of Size Datums (RFS)**
  - Datum that results from a feature of size datum feature
  - Specifying an axis or center plane as a datum
  - How feature of size datum references communicate size condition
  - Datum feature simulators and coaxial datum features

- **Interpreting and Inspecting Feature of Size Datums (MMC)**
  - Referencing a feature of size datum at MMC
  - Special-case feature of size datums
  - Datum shift and datum application
  - Datum feature simulator – external / internal feature of size datum feature (MMC primary), MMC primary and secondary virtual condition
  - Datum axis for a pattern of features of size (MMC secondary)
  - Datum reference sequence and part to gage setup
  - Simulating datum features of size MMC for inspection

- **Interpreting and Inspecting Perpendicularity**
  - Perpendicularity tolerance on implied right angles, tolerance zone shapes
ENGINEERING TOOLS & METHODS

- Perpendicularity of a surface and the surface flatness
- Multiple datum references with a perpendicularity control
- Perpendicularity of the axis/center plane of a feature of size
- Perpendicularity control and worst-case boundary of a feature of size
- Gage for verifying perpendicularity at MMC
- Indirect perpendicularity controls, legal perpendicularity specification; inspection

- Interpreting and Inspecting Angularity
  - Angularity, tolerance zone, and inspection
  - Angularity of a surface and the surface flatness
  - Angularity control and the worst-case boundary of a feature of size
  - Angularity of the axis/center plane of a feature of size
  - Indirect angularity controls, legal angularity specification

- Interpreting and Inspecting Parallelism
  - Controlling parallelism when no symbol is shown
  - Parallelism, tolerance zone shapes, applied to a surface, and inspection
  - Parallelism of a surface and the flatness of the surface
  - Controlling the parallelism of the axis/center plane of a feature of size
  - Parallelism control and the worst-case boundary of a feature of size
  - Tangent plane modifier with a parallelism control
  - Indirect parallelism controls, legal parallelism specification

- The fundamental Concepts of Tolerance of Position: Definitions, Conventions, Advantages and Interpretations and Their Effects on Inspection
  - True position
  - Tolerance of position control, advantages, use of MMC modifier
  - Implied basic relationships
  - Virtual condition boundary and axis interpretation

- Interpreting and Inspecting Tolerance of Position RFS and MMC Applications
  - Tolerance of position control (RFS), tolerance zone, and tolerance zone shapes
  - Worst-case boundary of a feature of size controlled with tolerance of position at RFS
  - MMC modifier used in a tolerance of position application
  - Tolerance zone in tolerance of position (MMC) applications
  - Bonus tolerance available for a tolerance of position application
  - Datum shift available in a coaxial diameter tolerance of position application
  - Legal tolerance of position specification, inspection

- Functional Gages for Tolerance of Position (MMC) Applications
  - Functional and cartoon gages and benefits
  - Cartoon gage for a tolerance of position application

- Interpreting and Inspecting Tolerance of Position Special Applications
  - Interpreting position - applied to non-parallel holes and not perpendicular to the datum axis, a bi-directional position application, applied to elongated holes, with the projected tolerance zone modifier, in a symmetrical relationship, with the LMC modifier
  - Inspecting a projected tolerance zone
  - Bonus tolerance in an LMC application
  - Position used to control the spacing and orientation of a hole pattern
  - M multiple single-segment position control and zero tolerance at MMC dimensioning

- Interpreting and Inspecting Concentricity
  - Concentricity, tolerance zone, median point, application, and inspection
  - Concentricity compared to total runout and tolerance of position (RFS)
  - Legal concentricity specification

- Interpreting and Inspecting Symmetry
  - Symmetry, tolerance zone, application, and inspection
  - Differences between symmetry and tolerance of position
  - Legal symmetry control specification

- Interpreting and Inspecting Circular Runout
  - Specifying datum axis for a runout application
  - Circular runout, tolerance zone (dia.), composite control, inspection
  - Amount of axis offset from a circular runout callout
  - Worst-case boundary in a circular runout application
  - Legal circular runout control specification

- Interpreting and Inspecting Total Runout
  - Total runout, tolerance zone (dia.), composite control, inspection
  - Amount of axis offset from a total runout callout
  - Worst-case boundary in a total runout application
  - Legal total runout control specification and circular vs. total runout
  - Distances on a part that uses runout

- Profile Tolerancing
  - Profile tolerancing with or without datum references and true profile
  - Part characteristics that profile can affect, tolerance zone coverage, advantages
  - Bilateral and unilateral profile tolerance zones, between and all around symbols

- Interpreting and Inspecting Profile of a Surface Applications
  - Tolerance zone for profile applied to planar and coplanar surfaces
  - Multiple single-segment profile application
  - Legal profile of a surface specification, inspection
ENGINEERING TOOLS & METHODS

- Interpreting and Inspecting Profile of a Line Applications
  - Profile of a line used in a multiple single-segment control
  - Used with a coordinate tolerance
  - Inspecting profile of a line

Instructor: This course is taught by one of ETI's approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information

1.3 CEUs

Topical Outline

- Importance of statistical stacks
  - The three assumptions that apply to Worst-case tolerance stacks
  - The two laws of probability that apply to statistical stacks
  - Two common probability distribution curves used in statistical stacks
  - The probability of an assembly of six parts with uniform distributions reaching extreme limits
  - The probability of an assembly of six parts with normal distributions reaching extreme limits

- Statistical stacks terminology
  - Statistics and data
  - Uniform and normal frequency distributions
  - Range, mean, and deviation
  - Variance and standard deviation
  - Specification limits
  - Standard normal curve and the Empirical Rule
  - A Z score and parts per million rejects
  - Control limits
  - How CP and CPK relate to a normal distribution
  - The difference between dependent and independent variables

- Common statistical tolerance stacks methods
  - What a statistical tolerance stack is
  - The Realistic Predicted Limits (RPL) method its assumptions
  - The Root Sum of Squares (RSS) method and its assumptions
  - The Motorola Six Sigma Root Sum of Squares (DRSS) method and its assumptions
  - The Monte Carlo Simulation method and its assumptions
  - The formulas for and results of using the different statistical stack methods
  - Three benefits of statistical stacks
  - Two common reasons why statistical stacks are done

- The ETI statistical stack form
  - How to complete the ETI statistical stack form
  - The four stack consequences that must be considered when doing statistical stacks

- The RPL statistical stack method
  - The formula for calculating the RPL factor
  - A qualified dimension used in the RPL method
  - How to do the RPL method using the ETI statistical stacks form
  - The advantages and disadvantages of the RPL method
  - Calculating a statistical stacks using the RPL method

Introduction to Statistical Tolerance Stacks

1 Day
I.D.# ET2055

Providing you have an understanding of tolerance stacks, this course teaches an introduction to statistical tolerance stacks, a crucial skill in today’s competitive workplace.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course includes a brief overview of several terms used in statistical stacks. It explains four methods for applying statistics to tolerance stacks and covers precautions about when and how to use statistics in stacks. Newly acquired learning is reinforced throughout the class with stacks that allow the student to practice applying statistical methods.

Learning Objectives

By attending this class, you will be able to:
- Define the terminology used with statistical tolerance stacks
- Describe common statistical tolerance stacks methods
- Calculate statistical tolerance stacks using the RSS method
- Calculate statistical tolerance stacks using the realistic method
- Apply the RPL method to statistical tolerance stacks
- Apply the Monte Carlo method to tolerance stacks
- Describe precautions needed when using statistical tolerance stacks

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Please be aware that this is not an introductory course. Students should have completed ETI’s Tolerance Stacks Using GD&T course or equivalent prior to enrollment.
### Engineering Tools & Methods

- The Six Sigma DRSS statistical method
  - The derivation of the standard RSS statistical stack formula
  - The seven steps in calculating a RSS statistical stack
  - Calculating a stack using the RSS method with a safety (Bender) factor applied
  - The Motorola Six Sigma RSS formula and its advantages
  - The Dynamic RSS (DRSS) formula and its advantages
  - The eight steps in calculating a DRSS statistical stack
  - How to do a DRSS stack using the ETI statistical stack form
  - How to interpret the stack results shown on the ETI statistical stack form
  - How to adjust a statistical stack to handle dependent variables (bonus & shift)
  - Statistical stack results before and after adjusting for dependent variables
- The Monte Carlo statistical simulation method
  - Simulation and Monte Carlo simulation
  - The parameters used in a Monte Carlo simulation
  - List common distributions used in a Monte Carlo simulation stack
  - The minimum number of trials that should be used in a Monte Carlo simulation stack
  - Available software that can perform Monte Carlo simulations
  - How a Monte Carlo simulation works
  - How to do a Monte Carlo simulation using the ETI stack form with RiskAMP plug-in
- Statistical tolerance stacks precautions
  - The guidelines for determining when a statistical stack should be done
  - The seven assumptions of RSS statistical tolerance stacks
  - The four precautions to reduce risk of using statistical tolerance stacks
  - Why the ST symbol from Y14.5 should be used on a drawing that specifies statistical tolerances
  - How the ST is used on a drawing to indicated a tolerance is based on statistical methods
  - The benefits of using the ST symbol on product drawings
- DRSS and RPL statistical stack calculations
  - Calculating statistical tolerance stacks
  - Making adjustments for bonus and shift
  - Calculating a stack using the DRSS and RPL methods
  - Using CPK values in a statistical stack

### GD&T for Manufacturing (ASME Y14.5-2009 Standard)

**1 Day**

I.D.# ET2726

Providing you have an understanding of GD&T fundamentals, this course teaches an introduction to geometric dimensioning and tolerancing and its impact on the manufacturing process.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on the basic requirements of engineering drawings, size dimensions, form tolerances, and the datum system, as well as the impact of tolerancing requirements on production.

### Learning Objectives

By attending this class, you will be able to:

- Understand the basic facts about engineering drawings
- Recognize the types of dimensions and tolerances used on engineering drawings
- Explain the basic concepts and requirements of size dimensions
- Answer five basic questions for interpreting form tolerances
- Describe the basic concepts of the datum system and planar datums
- Answer five basic questions for interpreting orientation, position, runout, and profile of a surface tolerances
- Explain the purpose and limitations of in-process inspection methods
- Assess the GD&T on a typical drawing and determine the impact to manufacturing

### Who Should Attend

This course is designed for product engineers, designers, checkers, and engineering managers, and supplier quality engineers. Attendees should have completed ETI’s Engineering Drawing Requirements course or equivalent prior to enrollment.

### Topical Outline

- Engineering Drawings
  - Engineering drawing purposes
  - Relationship between drawings and part function
  - Applicable standards on drawings
  - Why drawings are legal documents
  - Fundamental tolerancing rules
- Dimensions and Tolerances
  - Geometry attributes of a part
  - General dimensioning symbols
  - General notes, flag notes, and local notes;
  - The 14 major GD&T symbols
  - The feature control frame

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**Instructor:** This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

**Fee**

Contact ETI for pricing information

No CEUs are offered for this course

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Applications of GD&T (Based on Y14.5M-1994 & Y14.5-2009)

2 Days
I.D.# ET2512

Providing you have an understanding of GD&T fundamentals, this course teaches the thought processes involved in assigning GD&T to components. It will change the way many engineers think about part tolerancing.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on what constitutes good and poor drawing practices, common dimensioning methods used in industry, using GD&T to communicate system functions on component dimensions, and the logic of how to apply GD&T to components. Newly acquired learning is reinforced when students perform a design function analysis on a part assembly provided by your company, then specify GD&T on assembly components during the workshop. (This is optional in case of concerns over drawings and privacy.)

Learning Objectives

Attendees will learn how to do a design functional analysis on an assembly and use this information to assign dimensions and tolerances. They will also learn how to select datum features and how to fully define component surfaces using GD&T. Establishing tolerance values is not covered. The students will work in teams and actually create GD&T tolerance mark-ups of their company parts in the workshop.
ENGINEERING TOOLS & METHODS

By attending this class, you will be able to:

• Describe the importance of technically correct drawings
• List three major areas that affect the creation and interpretation of technically correct drawings
• Explain the common approaches to part tolerancing
• Identify and specify datum features based on the fit and functional requirements of the part
• Use GD&T to communicate functional requirements of a component
• Describe how to specify nonfunctional dimensions
• Explain the five-step approach to functionally dimensioning a component
• Apply the five-step method to functionally dimensioning a component to your company product

Who Should Attend

This course is designed for product engineers, designers, checkers, and engineering managers, and supplier quality engineers. Please be aware that this is not an introductory course. Attendees should have completed 16 hours of formalized classroom training in GD&T or ETI’s Fundamentals of GD&T course, experience interpreting or applying GD&T in an industrial setting, and working knowledge of the ASME Y14.5-2009 Standard.

Topical Outline

• Importance of technically correct drawings
• Principles and guidelines for making technically correct drawings
• Common approaches to part tolerancing
• Specifying datums based on mounting and performing features
• Using GD&T to describe functional relationships on a component
• Specifying secondary (nonfunctional) dimensions
• The five-step approach to functionally dimensioning a component
• Applying the five-step approach to functionally dimensioning a component

Instructor:

This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee

Contact ETI for pricing information

1.3 CEUs are offered for this course

Functional Gaging and Measurement (ASME Y14.43, Y14.5, Y14.5.1, B89.3.1, B89.7.2, and B89.7.3 Standards)

2 Days

I.D.# ET8200

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course is an introduction to functional gaging design and teaches how to verify part dimensional requirements using functional gages and other measurement methods.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an explanation of metrology, the roles of the metrologist and inspector, measurement uncertainty, inspection tools, functional gages, inspection planning and reporting, and simulating datums. The scope of this course does not include measurement systems analysis or sampling strategies.

Learning Objectives

By attending this class, you will be able to:

• Describe the functions of inspection in an organization
• Define what measurement uncertainty is.
• Explain the basic operating principles, strengths, and weaknesses of the three major categories of inspection tools
• List the types, uses, and tolerance methods for attribute gages
• Explain attribute gage design fundamentals
• Develop a measurement / inspection plan
• Describe the purpose and content of an inspection report
• Inspect and report size dimensions
• Describe the basic concepts of datums related to inspection
• Understand how to simulate datums for inspection
• Verify flatness, straightness, circularity, cylindricity, orientation, position, runout, profile of a surface, and profile of a line tolerance requirements

Who Should Attend

This workshop is a valuable tool for individuals who inspect parts, create inspection plans, or approve inspection methods. Typical attendees include CMM operators, inspectors, gage designers, manufacturing engineers, technicians, supplier quality engineers.

Prerequisites

Please be aware that this is not an introductory course. In order to understand the course content, you should have:

1. Completed 16 hours of formalized classroom training in GD&T
2. Experience interpreting or applying GD&T in an industrial setting
3. Have a working knowledge of the ASME Y14.5-2009 Standard

A certificate from the GD&T Trainer: Fundamentals 2009 or ETI’s Fundamentals of GD&T course is acceptable.

**Topical Outline**

- Inspection in an Organization
  - Quality; the purpose and contents of a quality manual
  - Metrology and the roles of a metrologist
  - Importance and types of inspection, roles of inspector
- Introduction to Measurement Uncertainty
  - Terms, importance, and major contributors
  - Using calipers for size measurements
  - Type A, type B, combined, and expanded uncertainties
  - Measurement uncertainty standards and major contributors
  - Decision rule, requirements, and factors that affect the choice of a decision rule
  - Guard band, simple acceptance, and simple rejection
  - Pros and cons of measurement uncertainty decision rules
  - Uncertainty calculator software
- Three Major Categories of Inspection Equipment
  - Three categories, types, and pros and cons of inspection tools
  - Attribute and variables gages and data, operating principles
  - Common sources of attribute and variables gage errors
  - Operating principles of algorithmic measurement
  - Common sources of CMM errors
- Attribute Gaging Concepts
  - Supporting Y14.5 concepts, common types, uses
  - Basic concept of functional gages
  - Options for gaging tolerance policies
  - Y14.43 recommendations and cost effects
  - The five gagemakers’ tolerance classes
- Attribute Gaging Design Fundamentals
  - Design constraints of functional gages
  - Considerations for workpiece distortion during gaging
  - In-process, final acceptance, and referee gages
  - Calculating gage pin size using absolute, tolerant, and optimistic tolerancing policies
  - Gage tolerance accumulation
  - How RMB datum references affect gage design
- Benefits of RMB Datum Feature Simulation
  - Permitted departure from MMC and LMC principles of a gage design
  - Measurement/Inspection Plan
  - Dimensional measurement plan (DMP) purposes, contents, and importance
  - Eight inputs to a DMP
  - Classification of dimensional characteristics
  - Seven steps to creating a DMP
- Inspection Reporting
  - Inspection reports, requirements, standards for reporting
  - Common methods for indicating inspection numbers
  - Mark up a drawing to number the dimensions for inspection
  - Non-conformance report and contents
- Inspecting and Reporting Size Dimensions
  - Y14.5 requirements for a feature of size
  - Relationship between Rule #1 and a size dimension
  - Inspecting MMC size limits
  - Minimum CMM probe points
  - Rule #1 MMC boundary, actual local size inspection
  - Reporting MMC & LMC size inspection results
- Datums Related to Inspection
  - Y14.5 requirements
  - Effects of datum sequence on inspection
  - Y14.5.1 candidate datum set concept
- Simulating Datums for Inspection
  - Simulate datum planes using a fixture, datum reference frame with a functional fixture
  - Effects of datum reference frame simulation with a fixture on inspection
  - Simulating datum planes and a datum reference frame using a CMM
  - Simulating a datum axis (RMB) on a functional fixture and using a CMM
  - Simulating a datum axis (MBM) on a fixture
  - How a functional gage accounts for datum shift
  - How a CMM simulates datum shift (MBM)
- Verifying Flatness Tolerance Requirements
  - Y14.5 requirements
  - Applied to a surface: verification using variable and algorithmic measurement
  - At MMC: verification with attribute measurement
  - Dimensional measurement planning and inspection reporting
- Verifying Straightness Tolerance Requirements
  - Y14.5 requirements
  - Applied to a surface: verification using variable and algorithmic measurement
  - Applied to a feature of size at MMC with attribute and variable measurement
  - Dimensional measurement planning and inspection
- Verifying Circularity and Cylindricity Tolerance Requirements
  - Circularly and cylindricity tolerance Y14.5 requirements
  - Circularity: inspecting using variable and algorithmic measurement
  - B89.3.1 circularity verification and filtering requirements
  - Cylindricity: verification using variable measurement and a CMM
  - Dimensional measurement planning, inspection
ENGINEERING TOOLS & METHODS

• Verifying Orientation Tolerance Requirements
  • Y14.5 requirements for an angular dimension, perpendicularity tolerance applied to a surface and feature of size (RFS and MMC)
  • Angular tolerance verification and sources of uncertainty
  • Perpendicularity tolerance applied to a surface verification using variable and algorithmic measurement, sources of uncertainty
  • Perpendicularity tolerance of a feature of size MMC verification using attribute measurement, RFS verification using variable measurement, sources of uncertainty
  • Perpendicularity tolerance applied to a feature of size RFS & MMC verification using algorithmic measurement, sources of uncertainty
  • Perpendicularity tolerance: inspection planning and reporting
• Verifying Position Tolerance Requirements
  • Y14.5 requirements for a position tolerance (RFS and MMC)
  • Position tolerance (MMC) verification using an attribute gage, sources of uncertainty
  • Position tolerance (RFS) verification using variable measurement, sources of uncertainty
  • Applied at RFS & MMC using algorithmic measurement, sources of uncertainty
  • Inspection planning and reporting
• Verifying Circular and Total Runout Tolerance Requirements
  • Y14.5 requirements
  • Applied to a diameter: verification using a variable and algorithmic measurement methods, sources of uncertainty
  • Inspection planning and reporting
• Verifying Profile of a Surface and Profile of a Line Tolerance Requirements
  • Controlling parallelism when no symbol is shown
  • Y14.5 requirements of profile of a surface and line tolerances
  • Verification using an attribute, variable, and algorithmic measurement methods, sources of uncertainty
  • Inspection planning and reporting

| Instructor: | This course is taught by one of ETI's approved instructors, each of whom has been vetted and mentored by Alex Krulikowski |
| Fee | Contact ETI for pricing information
1.3 CEUs are offered for this course |

Advanced Concepts of GD&T (Based on Y14.5M-1994)

2 days
I.D.# ET2411

This course is offered in a 2-day, 20-hour, and 3-day format.

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches the advanced concepts of GD&T as prescribed in the ASME Y14.5M-1994 Standard.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an in-depth explanation of advanced GD&T topics like composite tolerancing, tolerance analysis, datum selection, non-rigid part dimensioning, and many more key dimensioning topics, including the system approach for part dimensioning.

Learning Objectives

By attending this class, you will be able to:
• Explain the importance of product design and functional dimensioning
• Define the terms “feature” and “feature of size”
• Recognize which dimensioning standards apply to an engineering drawing
• Explain the fundamentals of drawing interpretation and how to handle substandard drawings
• Recognize the difference between a rigid and a flexible (non-rigid) part
• State the requirements for tolerancing parts measured in the restrained state
• Identify the two special considerations for datum usage on restrained (non-rigid parts
• Calculate advanced applications of form controls
• Describe uses, advantages, misconceptions, and common errors of the datum system
• List nine common datum feature types
• Describe advanced datum target concepts
• Explain how to specify / interpret specialized datum feature applications
• Describe modifier usage in tolerance of position applications
• Describe the effects of simultaneous and separate requirements with tolerance of position
• Explain composite position tolerancing and multiple single-segment position tolerancing
• Interpret tolerance of position applications with a conical tolerance zone
• Explain composite profile tolerancing and multiple
single-segment profile tolerancing
- Describe profile applications

**Who Should Attend**
This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Please be aware that this is not an introductory course. In order to understand the course content, attendees should have completed ETI’s GD&T Fundamentals course or equivalent.

**Topical Outline (3-day format)**
- GD&T Fundamentals Review
  - GD&T skills survey
  - GD&T fundamentals for further study
- Importance of Product Design
  - Product design effects on costs
  - Consequences of drawing errors
  - Advantages of GD&T
- Functional Dimensioning
  - The purpose of tolerances
  - The importance of specifying proper tolerances
  - The importance of a common tolerancing approach
  - Tolerancing principles and benefits
- Interpretation of Feature
  - The terms “element,” “gap,” and “interruption”
  - Y14.5 definition of feature and types
  - Regular, element, complex, and interrupted feature; sub-feature
- Interpretation of Feature of Size
  - The terms “opposed,” “fully opposed,” “partially opposed, "size dimension," and "cylindrical”
  - Importance of distinguishing between a feature and feature of size
  - The definition of feature of size from Y14.5
  - Requirements and categories of a feature of size
  - Identifying and interpreting a complete, interrupted, partial, and bounded feature of size
- Applicable Drawing Standards
  - Determining on which standards an engineering drawing is based
  - Clarifying a drawing when no dimensioning standard is referenced
  - Reducing confusion on dimensioning standards
- Drawing Interpretation
  - Interpreting an engineering drawing
  - Drawing title block, revision column, general drawing notes
  - Fundamental rules that affect drawing interpretation
  - Surface coating and heat treat
  - Geometric controls and a valid datum system
- Misconceptions on measuring parts that use the datum system
- Controlling characteristics for each part feature
- Proper uses for coordinate tolerancing
- Specification / interpretation
- Using Substandard Drawings
  - Categories of substandard drawing specifications Steps for dealing with substandard drawings
  - Things not to do when using a substandard drawing
- Rigid/Non-Rigid Parts Definitions
  - Free state; Restricted state
  - Rigid part; Non-rigid part and part feature
- Tolerancing Non-Rigid Parts
  - Tolerancing a non-rigid (restrained) part
  - Roles of a restraint note
  - Determining restraining conditions on non-rigid parts
  - Requirements that need to be addressed in a restraint note
  - The difference between a general note and a local restraint note
  - When a free state symbol should be used
  - Areas that need special attention when inspecting a non-rigid part
- Restricted Part Datum Usage
  - How to use datum targets to support, orient, and locate a restrained part in the datum reference frame
  - How datum shift occurs on a restrained part
- Form Controls
  - Calculating the flatness tolerance value for a gasketed joint application
  - Calculating the cylindricity tolerance value in a support application
  - Calculating the straightness tolerance value in an assembly application
  - Overriding Rule #1 to limit flatness on a thin part
- The Datum System
  - When to use the datum system.
  - Advantages of the datum system.
  - Common misconceptions about the datum system.
  - Common errors in datum usage
- Datum Feature Types
  - Common datum feature types
  - When each datum feature type is typically used
  - Degrees of freedom restrained when each datum feature type is used
  - The datum feature simulator for the datum features referenced in a geometric tolerance
- Datum Targets
  - Reducing the impact that using datum targets has on functional dimensioning
  - Application requirements
  - Applications where datum targets should be used
  - Specifying fixed and movable datum targets
3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at 1-724-772-8529
• Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information
CEUs vary based on course length

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**ENGINEERING TOOLS & METHODS**

- Special datum target types
- Dimensioning a simulated gage for datum target applications
- Specialized Datum Applications
  - Specifying a screw thread as a datum feature and interpreting application
  - Specifying a gear or spline feature as a datum feature and interpreting application
  - Temporary and permanent datum features
  - Major disadvantage of temporary datum features
- Tolerance of Position Usage
  - When to use a tolerance of position control
  - Loss function curve, customer robust dimension, and customer sensitive dimension
  - Tolerance of position control and material condition used
- Simultaneous and Separate Requirements
  - Simultaneous and separate requirements, effects and where they apply
  - Tolerance of position at MMC simultaneous requirement
  - Tolerance of position controls as separate requirements
  - One exception to the simultaneous requirement
- Composite Position Tolerancing
  - Rules, advantages, and when to use it
  - “FRITZ” and “PLTZF”
  - Tolerance of position composite application
- Multiple Single-Segment Tolerance of Position Tolerancing
  - Rules, advantages, and when to use it
  - Tolerance of position vs. composite tolerance of position
- Conical Tolerance Zones
  - A conical tolerance zone and advantage of use
  - Specifying a conical tolerance zone in a tolerance of position application
  - When to use tolerance of position with a conical tolerance zone
- Profile Tolerances
  - Myths about profile controls
  - When to use a profile control
  - The four characteristics profile can control
  - Converting coordinate tolerances into profile callouts
  - The profile datum rule
- Profile and Simultaneous Requirements
  - Simultaneous requirement applied to profile
  - Profile controls with separate requirements
- Composite Profile Tolerancing
  - Composite profile tolerancing, rules, and advantages
  - Interpreting a composite profile application
- Multiple Single-Segment Profile Tolerancing
  - Rules, advantages, interpretation, when to use it
  - Profile vs. a composite profile tolerance

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**Tolerance Stacks Using GD&T**

2 Days
I.D.# ET2421

This subject is offered in a 2-day, 20-hour, 3, or 4-day format.

Providing you have an understanding of geometric tolerancing fundamentals and advanced concepts, this course teaches how to calculate tolerance stacks, a crucial skill in today’s competitive workplace.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course offers an in-depth explanation of how to use tolerance stacks to establish part tolerances, analyze design, create process designs, and how to use geometric tolerances in stacks.

**Learning Objectives**

By attending this class, you will be able to:
- Explain the importance of tolerance stacks
- Explain the concepts of virtual condition
- Describe a tolerance stack
- Recognize part stacks using coordinate tolerancing
- Calculate assembly stacks using coordinate tolerancing
- Recognize the symbols and modifiers used in geometric dimensioning and tolerancing
- Explain how to assemble stacks
- Calculate part stacks using profile, position (RFS, bonus, & shift), and multiple geometric tolerances
- Calculate assembly stacks using profile, position, and multiple geometric tolerances

**Who Should Attend**

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. This is not an introductory course. In order to understand the course content, attendees should have completed ETI’s GD&T Fundamentals and Advanced Concepts courses or equivalent.
ISO Geometrical Tolerancing (Based on ISO 1101:2004 and related standards)

2 Days
I.D.# ET7103

This subject is offered in a 2, 3, or 4-day format.

Providing you have a basic understanding of mechanical drawings, this course teaches how to use engineering drawings that use the International Standards Organization (ISO) standards. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, this course teaches proper recognition of requirements for standard-compliant drawings and geometrical tolerances based on the ISO standards. The course combines information from dozens of ISO standards into a logical understandable topic.

Learning Objectives

By attending this class, you will be able to:

- Describe the ISO standards system on technical drawings
- Recognize ISO drawing practices
- Explain the structure of GPS and the domains of features
- Recognize the symbols used in geometrical tolerancing
- Describe linear size and size conditions
- Explain the principle of independency and the envelope requirement
- Explain geometrical tolerancing concepts: MMR, LMR, RPR, virtual conditions, and collective requirements
- Describe the ISO 286 system of limits and fits
- Describe the datum system (planar datums)
- Interpret datum target and size datum specifications
- Interpret the flatness, straightness, roundness, cylindricity, perpendicularity, angularity, and parallelism tolerances
- Explain the fundamental concepts of position tolerances
- Interpret the position tolerance at MMR and special applications
- Interpret the coaxiality, concentricity, symmetry, circular and total run-out tolerances
- Interpret the profile any surface and profile any line tolerances
- Explain the ISO system for general tolerances
- Interpret work piece edge specifications
- Interpret surface texture and surface imperfection requirements

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee Contact ETI for pricing information
CEUs vary based on course length

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ENGINEERING TOOLS & METHODS

Attendees should have completed ETI’s Engineering Drawing Requirements course or equivalent prior to enrollment.

Topical Outline
• ISO Standards and Drawing Conventions
  • The ISO standards system used on technical drawings
  • ISO drawing practices
• GPS Basics
  • Modifiers and symbols used in geometrical tolerancing
  • Fundamental ISO geometrical tolerancing concepts
  • Feature types and levels
  • Linear size and material conditions
  • Independency and envelope principles
  • Key geometrical tolerancing concepts: maximum, least, and reciprocity requirement; virtual condition; bonus tolerance
• Limits and Fits
  • The ISO 286 system of limits and fits
• The Datum System
  • The datum system (planar datums)
  • Datum target specifications
  • Datum specifications
• Form Controls
  • Flatness
  • Straightness
  • Roundness
  • Cylindricity
• Orientation Controls
  • Perpendicularity
  • Angularity
• Location Controls
  • Position
  • Position tolerance RFS, MMR, and LMR
  • Concentricity
  • Symmetry
• Location Controls
  • Circular run-out
  • Total run-out
  • Profile tolerance
  • Profile any surface tolerance
  • Profile any line tolerance
• General Tolerances
  • ISO system for general tolerances for linear and angular dimensions
  • ISO system for general tolerances for geometrical tolerances (ISO 2768-2)
• Workpiece Edges
  • Interpret workpiece edge specifications
• Surface Texture and Surface Imperfections
  • Surface texture and surface imperfection requirements
• ISO/ASME Comparison
  • Major differences between the tolerancing standards

Instructor: This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee: Contact ETI for pricing information

1.3 CEUs are offered for this course

ASME Y14.5 1994-2009 Comparison

1 Day
I.D.# ET8000

Providing you have a basic understanding of geometric dimensioning and tolerancing fundamentals, this course teaches the significant revisions, additions, and deletions prescribed in the new ASME Y14.5-2009 Standard. Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course offers an in-depth cross-examination and comparison of features in the 2009 and 1994 ASME Standards.

Newly acquired learning is reinforced throughout the class with numerous practice problems, and a set of comprehensive comparison charts that highlight itemized changes in the standard are included in the workshop price.

Learning Objectives

The one-day ASME Y14.5-2009 Comparison Workshop will teach you about the pertinent changes made to the Y14.5 standard. You’ll learn how the subject matter has been reorganized, and about new sections that have been created for profile, orientation, and form.

By attending this class, you will be able to:
• Recognize forty new or revised terms
• Explain the revisions and additions to the fundamental rules
• Describe twelve new or revised modifying symbols
• Recognize the revisions and new symbols for datum specifications
• Describe new geometric symbols and specifications
• Describe the revisions and new additions to 3D digital data sets
• Summarize the major changes in the standard
• Describe considerations for implementing the new standard

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals.
Topical Outline

24 revised terms in ASME Y14.5-2009
16 new terms in ASME Y14.5-2009
Revised and new modifying symbols
The datum system
Revisions to geometric symbols
3-D digital data sets
Summary of major changes
Implementing a new standard

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information

Fundamentals of GD&T (Based on ASME Y14.5-2009)

2 Days
I.D.# ET1150

This course is offered in multiple length formats. Contact ETI to determine which course length best suits your specific need.

This course is offered in multiple length formats. Contact ETI to determine which course length best suits your specific need.

Providing you have a basic understanding of mechanical drawings, this course teaches the terms, rules, symbols, and concepts of GD&T as prescribed in the ASME Y14.5-2009 Standard.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, Fundamentals of GD&T offers an in-depth explanation of geometric tolerancing symbols, their tolerance zones, applicable modifiers, common applications, and limitations. The class includes a comparison of GD&T to coordinate tolerancing; Rules #1 and #2; form and orientation controls; tolerance of position; runout and profile controls.

Learning Objectives

By attending this class, you will be able to:
• Explain the importance of standards on engineering drawings
• Describe the types of dimensions, tolerances, and notes
• Explain why geometric tolerancing is superior to coordinate tolerancing
• Interpret the general dimensioning symbols

Who Should Attend

This course is valuable for individuals who create or interpret engineering drawings, product and gage designers; process, product, and manufacturing engineers; supplier quality engineers/professionals; CMM operators; buyers/purchasers; checkers; inspectors; technicians; and sales engineers/professionals. Attendees should have completed ETI’s Engineering Drawing Requirements course or equivalent prior to enrollment.

Topical Outline

Introduction
• Drawing standards
• Dimensions, tolerances, and notes
• Coordinate tolerancing and GD&T
• General dimensioning symbols

Fundamentals
• Key GD&T terms
• Symbols and modifiers
• GD&T rules
• GD&T concepts

Form
• Flatness tolerance
• Straightness tolerance
• Circularity tolerance; Cylindricity tolerance

Datum System
• Datum system
• Datum targets
• Size datum features (RMB)
• Size datum features (MMB)

Orientation
• Perpendicularity tolerance
• Parallelism tolerance
• Angularity tolerance

Position
• Position tolerance introduction
• Position tolerance - RFS and MMC
• Position tolerance - special applications
• Position tolerance - calculations

Runout, Concentricity, Symmetry
• Circular and total runout tolerances
ASME to ISO Standards Comparison

1 Day
I.D.# ET2025

Providing you have a basic understanding of Y14.5 Dimensioning and Tolerancing practices, this course explains the major differences between the ASME and ISO standards in a concise, easily understood manner.

Utilizing the expertise of world-renowned GD&T expert Alex Krulikowski, the course focuses on how the standards compare when dealing with symbols, feature control frames, tolerances, form controls, datums, and more.

Learning Objectives

By attending this class, you will be able to:
• Explain how ASME and ISO standards are developed
• Recognize the advantages and cautions of using ASME and ISO standards
• List the major differences in technical drawing presentation
• Recognize the major differences between ASME and ISO geometric tolerancing terms and symbols
• Recognize the major differences between ASME and ISO datum systems
• Identify the differences in ASME and ISO drawings

Who Should Attend

This course is valuable for individuals who work with ISO standards on drawings, designers, engineers, inspectors, and machinists. All attendees should have a basic understanding of Y14.5 Dimensioning and Tolerancing practices prior to enrolling in this course.

Topical Outline

• Introduction
• Standards and Technical Drawings
  • Importance of standards
• ASME and ISO organizations
• Stages of standard development
• Major differences in scope of standards
• Advantages and Cautions
  • Why each standard should be used
  • ISO GPS concept
  • Three domains of ISO specifications
  • Comparing ASME and ISO GPS systems
  • Five cautions when using ASME standards
  • Six cautions when using ISO standards
• Technical Drawing Presentation Differences
  • Technical drawing standards
  • Items that are the same in both standards
  • View projection methods
  • Dimensioning termination and presentation methods
  • Dimensioning symbols
  • Angular tolerance interpretation
  • Workpiece edge requirements and general tolerance specification
• Size dimensions and limits and fits expressions
• Surface texture is specification
• Tolerancing Term Differences
  • Feature and feature of size
  • Envelope requirement and independency principle
  • Eight major terms
  • Bonus tolerance and collective requirement
• Datum System Differences
  • Datum specifications
  • Datum interpretations
  • Candidate and single solution datums
  • Datum target specifications
• Geometric Tolerancing Symbol Differences
  • Specification / use for each geometric tolerance symbol
  • Interpretation for each geometrical tolerance
  • Specification / use for modifiers and symbols
• ASME and ISO Drawing Differences
  • Applicable standards
  • Drawing symbol differences
  • Geometrical tolerance specification and interpretation differences

Instructor:
This course is taught by one of ETI’s approved instructors, each of whom has been vetted and mentored by Alex Krulikowski

Fee
Contact ETI for pricing information

1.3 CEUs are offered for this course
**RELATED TRAINING SOLUTIONS**

Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

**Developing In-Vehicle User Interfaces: Design Principles and Techniques**
Participants will learn user interaction design steps, tools, and the team synergies required to develop an interface from concept to the final product.
Read more about this course on page 27

**Vehicle User Experience: Human Factors Principles and Techniques for Design, Research and Development**
This course will provide an overview of principles and techniques for designing and developing vehicle interfaces which deliver optimal solutions while avoiding unintended consequences like driver distraction.
Read more about this course on page 33

**Root Cause Problem Solving: Methods and Tools**
This proven 8-step approach to problem solving will help improve operational and financial performance by identifying causes and implementing solutions to significant or recurring problems.
Read more about this course on page 86

**Creating and Managing a Product Compliance Program**
You will learn best practices in creating a compliance program for your products and markets, and how to use this program at all stages of product development and production.
Read more about this course on page 165

**Fault Tree/Success Tree Analysis**
Sharpen your skills with this no-nonsense program that will show you practical ways to implement popular tools in your product/process design, manufacturing, reliability assurance and safety operations.
Read more about this course on page 167

**Introduction to Weibull Engineering Fast Track**
Weibull Analysis is popular worldwide as the best method for predicting modeling variability and failure of designs, products, and systems. In this introductory short course, instructor Wes Fulton will provide a solid overview of Weibull Engineering capabilities.
Read more about this course on page 168

**Weibull-Log Normal Analysis Workshop**
New and advanced Weibull techniques are a significant improvement over the original Weibull approach. This workshop, originally developed by Dr. Bob Abernethy, presents case studies in addition to the latest techniques in SuperSMITH® Weibull for risk forecasts with renewal and optimal component replacement.
Read more about this course on page 175
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MANAGEMENT AND LEADERSHIP

Includes effective leadership, strategic thinking, team building, management, and effective decision making.

Effective Decision-Making: A Methodology Approach

1 Day
I.D.# C1354

Effective decision making is critical to maximizing profit/minimizing expenses, return on capital spending, and operational efficiency. To understand the impact of decisions that affect the enterprise, professionals at every level must secure and integrate relevant cross-functional information. Register for this seminar and learn skills needed to base decision making on solid business knowledge and sound financial principles instead of on emotion or “your gut.” The instructor walks you through the tenets of structured decision-making and teaches a step-by-step approach to make practical, effective decisions.

Learning Objectives

By attending this seminar, you will be able to:
• Define the decision boundaries and expectations for decision outcomes
• Select the optimal methodology for decision making
• Select the best decision-making criteria in making project decisions and allocating capital budgets
• Determine the lowest enterprise costs in raising capital through debt and equity offerings
• Analyze make-buy, buy-lease, replacement and other alternative enterprise decisions based on the best financial strategies
• Articulate the financial sensitivity of project decisions and the use of decision tools for integrating cross-functional business requirements
• Develop an effective decision-making structure for your unique specific project criteria and your organization

Who Should Attend

This seminar will benefit individuals having responsibilities in engineering, business, finance, marketing, purchasing, manufacturing, research, and program management. In addition, local government leaders and individuals in non-profits may benefit from these decision-making case studies in determining business decisions including which projects and grants should be supported. A group from the same organization may find it advantageous to attend together.

Topical Outline

• Decision Boundaries and Expectations
  • Region & Functions Impacted
  • Time Frame of Decision
  • Outcomes
  • Plan B
• Decision-Making Principles
  • Evolution
  • Terminology
  • Types
  • Stages
• Financial Principles
  • Time Value of Money, Interest & Inflation
  • Worth (Present Value, Future Value, etc.)
  • Financial Decision Methods (NPV, IRR, Payback Period, etc.)
• Case Studies
• Decision-Making Criteria
  • Market Demographics
  • Product or Service Position/Leadership, Parity
  • Financials & Price/Margin/Cost Reduction
  • Quality/Customer Satisfaction
  • Change in Business Direction/Vision
  • Personnel/Job Creation
MANAGEMENT AND LEADERSHIP

- Cost Impact & Enterprise Decisions
  - Cost of Capital: Equity & Debt, Revenue Sources
  - Cost of Ownership: Depreciation, Accelerated Cost Recovery
  - Influence of Tax Obligations
  - Case Studies
- Alternative Financial Decisions for the Enterprise (Principles & Case Studies)
  - Make/Buy
  - Buy/Lease
  - Replace/Repair
  - Investments of Unequal Life
- Sensitivity & Scenario Analysis & Decisions (Case Studies)
- Decision-Making Methodology
  - Matrix Priority Rating System
  - Case Study by Attendees

Instructor: James Masiak
Fee $780  .7 CEUs

SAE GENERAL MANAGEMENT AND LEADERSHIP CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program focuses on four core management and leadership competencies: management capability, team leadership, project management, and finance providing a basis for growth into a leadership or management role. View the list of required and elective courses and more information on enrolling in this SAE certificate program: training.sae.org/certificate/management_leadership

Leading High Performance Teams
2 Days
I.D.# C0410

Product development is organizationally a complex undertaking that requires effective coordination within a company and between companies. During product development, teams are confronted with a number of ongoing organizational challenges and there is a high potential for conflict between participants in the process.

This course addresses teamwork and other “soft-side” factors that largely determine whether product development programs are successfully completed on schedule. The content is relevant for both OEMs and suppliers.

Learning Objectives
By attending this seminar, you will be able to:
- Explain the importance of effectively managing ‘soft-side’ issues that cause problems and delays during product development programs
- Employ successful practices of chartering and launching teams
- Implement techniques to successfully lead and facilitate effective teams
- Effectively troubleshoot problems on a team and employ techniques to remain productive
- Implement proven tips for conducting effective team meetings

Who Should Attend
Engineers and business people involved in various product development team activities will find the subject matter practical and useful. The content is of particular value to professionals from engineering, manufacturing, purchasing, quality, marketing, and finance functions in ground vehicle OEMs and suppliers.

Topical Outline
- Designing High Performance Team
  - Characteristics of effective teams
  - Systems aspects of team design
  - Addressing systemic variables
  - Identifying key stakeholders
  - Establishing the team’s charter
- Leadership and Group Dynamics
  - Responsibilities of the team leader
  - Understanding human behavior in groups
  - Motivating team members
  - Establishing a productive team culture
  - Developing team support
  - Productive and destructive team roles
  - Effective communications
  - Influence of personality styles
MANAGEMENT AND LEADERSHIP

• Launching the Team
  • Stages of team development
  • Pre-meeting considerations
  • Selecting the team
  • Common reasons meetings fail
  • Managing the first team interface
  • Establishing group norms
  • Structuring the agenda
• Making Sound Decisions
  • Situational analysis: problems, decisions and polarities
  • Common errors in decision making
  • Essential steps in the decision process
  • Quality and acceptance factors in decision making
  • When to use and avoid group consensus
  • Identifying the decision makers
  • Facilitating consensus decisions
• Flawless Facilitation
  • Recognizing and defusing common group problems
  • Managing conflict and providing feedback
  • Mind mapping, story boarding and other techniques
  • Making work assignments
  • Assessing group performance
  • Concluding the meeting
• Avoid the most common errors that supervisors and managers make
• Describe the evolution of management thought, and utilize the latest proven concepts for improving the performance of people in complex organizations
• Explain the issues that drive the psychology of effective leadership and develop greater emotional intelligence
• Implement strategies to enhance your skills in meeting management, coaching, and performance review that are essential in today’s professional workplace

Who Should Attend
Engineers and technical professionals who are either recently promoted into a management position, or have some experience as a manager but would like to learn how to become more effective will benefit from attending this workshop. The concepts and skills developed during this interactive experience will be of interest to those involved in product development, manufacturing, service, or quality engineering, and all related technical activities in automotive, aerospace, manufacturing, and off-highway industries.

TOPICAL OUTLINE

DAY ONE
• The Management Perspective - How Managers Earn Their Keep
  • The value proposition of management
  • The “Peter Principle” and how to avoid this trap
  • Understanding the most important errors that managers commonly make - and how to steer clear of major supervisory pitfalls
  • Why people usually struggle to cooperate, and how you can reduce this
• What You Need to Know about Today’s Workforce
  • The evolution of leadership thought, and why recent events have significantly changed effective leadership methods
  • Understanding what leadership is really about
  • Why teamwork and cooperation are necessary in modern corporate structures
  • How you can generate consistent focus and daily commitment among technical and engineering professionals
  • Playing “The Tower Game” - applying focus and commitment
• The Psychology of Successful Modern Leadership
  • Process centered leadership: getting sustained results
  • Task and relationship balances
  • Why “Output Leadership” is ineffective and counter-productive
  • Different kinds of team models - and which is most effective
  • How to reduce the influence of “bad” politics in an organization through constructive decision making processes

Managing Engineering & Technical Professionals

3 Days
I.D.# C0608

In the fast paced and competitive environment of today’s global economy, the work of technical professionals is often the difference between success and failure in an organization. Providing leadership for engineers is uniquely challenging, and the transition from working engineer to first-line technical supervisor is one of the most difficult career challenges that an engineer may face. First-time engineering supervisors and mid-level managers who wish to sharpen their skills and learn new techniques for guiding, coaching, and motivating working engineers, technicians, and designers will find this seminar valuable. A mix of lecture and attention-grabbing exercises are used to develop intense and lasting learning results.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the basic value proposition of management: what managers bring to an organization that makes them worthwhile

Instructor: Joseph Doyle
Fee $1335 1.3 CEUs
MANAGEMENT AND LEADERSHIP

DAY TWO

• The Psychology of Change
  • Why change is often stressful
  • Five stages of change
  • How to make change exciting and interesting
• Emotional Intelligence: Building an Effective Leadership Style
  • Why “emotional intelligence” is important - the research results
  • The five elements of emotional leadership
  • How to practice and develop greater emotional intelligence
  • Solving typical meeting problems with emotional intelligence
• Coaching in Supervision
  • Building trust
  • Coaching roles
  • Improving communication for constructive coaching
• Using Meeting Time Effectively
  • Five key issues for successful meetings
  • How teamwork breaks down in meetings, and how to correct this

DAY THREE

• Dealing with Practical Issues
  • Dealing with difficult people
  • Learning how to delegate effectively
• Basic Negotiation Principles
  • Soft & hard negotiating approaches
  • Win-win negotiation
  • Positions, interests, & goals
• How to Make Performance Reviews Constructive
  • Legal requirements
  • Style issues
  • 360 reviews

Instructor: Eric Timmis
Fee $1850 2.0 CEUs

This web seminar will tell you what you need to know about U.S. patent litigation and will provide in-depth insights into the practical realities of patent disputes in the U.S. You will learn what’s involved in a patent case, including the issues that the patent owner has to prove, e.g., infringement, and the issues the accused infringer has to prove, e.g., invalidity. You will increase your awareness of the role of the judge and the jury in patent cases and you will hear about the increasing use of alternative dispute resolution mechanisms, such as mediation, to resolve patent disputes. Among other topics, this course also will increase your appreciation for the time it typically takes to go from the filing of a case to trial, and the fees and expenses associated with the case.

Learning Objectives

By connecting with this Web Seminar, you will be able to:
• Obtain an overview of U.S. patent litigation
• Explain the basic legal principles for liability and damages in patent cases
• Gain insights into how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Anticipate the scope of discovery in, and/or business disruption arising from, a U.S. patent case
• Peek into the future of potential patent law reform

Who Should Attend

This course is geared toward executives, in-house counsel, in-house patent agents, and senior managers across industries, such as automotive and aerospace. Participants may be both U.S. and non-U.S. -- anyone who needs help in understanding what to expect and what the realities are should they become involved in U.S. patent litigation.

Topical Outline

Session 1
• Overview of Patent Litigation
  • Issues the patent-owner has to prove
  • Issue the accused infringer has to prove
• What is the Scope of Discovery?
  • Documents, including e-documents
  • Depositions
  • Third parties (e.g. customers, suppliers)
  • Confidentiality of discovery materials
• Who Decides Liability and Damages?
  • Jury
  • Judge
  • Mediator/Arbitrator

Session 2
• How Long Does it Take from Filing to Trial?
  • District Courts
  • ITC

Patent Litigation in the U.S.: What You Need to Know

4 Hours
Web Seminar: I.D.# WB0940

In today’s economic environment, patents have become an increasingly important asset for both individuals and corporations. More and more, individuals and corporations, including those in the automotive and aerospace industries, are recognizing that revenue can be generated from their patent rights, whether those rights consist of a single patent, a family of patents or an entire portfolio. Indeed, some companies do not make or sell products; their entire revenue is derived from the licensing of their patents. Suffice it to say, licensing revenue has become a significant source of value in the global intellectual property economy.
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MANAGEMENT AND LEADERSHIP

- How Much Does it Cost?
  - Fees and expenses
  - Contingency fees
  - Recovery of fees and expenses
- What Changes are on the Horizon?
  - Supreme Court
  - Patent law reform

Instructor: William Cory Spence
Fee $425 .4 CEUs

Root Cause Problem Solving: Methods and Tools Web Seminar and Web Seminar RePlay

8 Hours
Web Seminar: I.D.# WB0931
Web Seminar RePlay: I.D.# PD330931ON

Tough times require searching for things that we can change and making them better. But so often problems are solved with ‘band-aids’ and not root cause solutions. This approach is getting too expensive and at best only helps companies tread water. To combat these issues and adopt a fresh approach, teams can use the methods and tools of Root Cause Problem Solving to first view problems as opportunities for improvement, identify root causes and implement solutions to prevent recurrence. Benefits include improved quality and customer satisfaction, reduced operation costs, and greater employee knowledge of work processes.

This proven 8-step approach to problem solving will help improve operational and financial performance by identifying causes and implementing solutions to significant or recurring problems. This approach to problem solving is used by many major automotive manufacturers.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
- Describe the 8-Step Problem Solving Methodology
- Define the difference between Symptom and Root Cause
- Use tools and techniques to solve problems
- Evaluate effectiveness of problems solving efforts
- Describe the role of problem solving in continuous improvement
- Write an action plan to apply problem solving to a specific concern

Who Should Attend
This course is applicable to those directly working in or responsible for performance improvement of any definable, repetitive process, e.g. manufacturing, design, logistics, purchasing, sales, or distribution, including:
- Manufacturing managers, supervisors and team leaders
- Manufacturing engineers
- Design engineers
- Quality engineers and technicians
- Technical managers
- Project team leaders
- Problem solving and quality improvement facilitators
- Anyone whose role includes problem solving; therefore all supervisors and lead personnel

Topical Outline
Session 1
- Overview
  - Following a process approach
  - What is a problem?
  - Inhibitors to effective problem solving
  - 8-step problem solving process overview
  - Step 1: See the Problem as an Opportunity
    - Framing the problem solving effort
    - Identifying team member; Team roles
- Step 2: Describe the Problem
  - Symptoms vs. Causes
  - Methods for describing the problem
  - Using and charting data
  - Problem Is/Is-Not analysis

Session 2
- Step 3: Implement Containment
  - Protect the Customer
- Step 4: Recognize Potential Root Causes
  - Identifying possible causes; Process Maps
  - Cause-Effect diagrams
  - 5-Why tool

Session 3
- Step 5: Design Solution
  - Solutions that don’t work
  - Process Controls and Error Proofing
  - Standardized Work
- Step 6: Implement Permanent Corrective Actions
  - Plan the work
  - Complete system changes
  - Verify effectiveness

Session 4
- Step 7: Prevent Recurrence
  - Was the problem eliminated?
  - Layered audits

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Strategic Leadership
3 Days - I.D.# C0620

As a strategic leader, it is your responsibility to ensure that your organization is moving in the right direction. Executives and high-level managers must have the practical insight necessary to address competitive business challenges. Each segment of this three day course is designed to impart simple, but powerful lessons that will equip participants to more fully engage in strategic discussions, ask pertinent questions, facilitate critical decisions and shape high performing organizations. In addition, the course provides students with a personal leadership profile that illustrates their strengths and potential limitations. Participative exercises assist emerging executives with practical and effective methods of gaining organizational credibility and avoiding common errors in strategic leadership.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the role and responsibilities of strategic leadership
• Manage the critical factors that drive the success and failure of business strategies
• Anticipate the longer term impact of strategic initiatives
• Attain credibility and support as you assume the helm of a new operation
• Avoid common errors made by leaders in transitioning to higher levels of responsibility
• Select the most effective approaches when framing strategic decisions
• Think strategically and systemically as you plan organizational change
• Influence the emergence of a more positive and functional corporate culture
• Eliminate turf battles, dropped balls and organizational duplication of effort
• Analyze and correct dysfunctional organizational dynamics
• Manage the strengths and limitations of your personal leadership style

Who Should Attend
This seminar is designed for executives, senior level managers, and engineering managers or technical specialists who are called upon to formulate or provide input into strategic decisions and business strategies.

Topical Outline
• Introduction to Strategic Leadership
  • What exactly do we mean by leadership?
  • Who is and is not a leader?
  • At what point do we become leaders?
  • Critical elements of leadership support
  • Managing versus leading - is there really a difference?
  • Critical factors in assessing leadership performance
  • The relationship between leadership, strategy, human behavior, decision-making and organizational systems
• Understanding the Human Dimension
  • Similarities between animal behavior and human behavior
  • Influence of brain structure on human behavior
  • Creating long term employee motivation
  • Rules of thumb for predicting human behavior in organizations
  • Recognizing the symptoms of pathological leadership
  • Managing and defusing dysfunctional behavior
• Assuming the Helm
  • Managing the transition to a new workgroup
  • Common and avoidable errors of leadership
  • Developing and maintaining the support of your workgroup
  • Simple, but effective steps to improve workgroup performance
• Shaping Corporate Culture
  • Understanding the critical components of corporate culture
  • Forming productive organizational norms
  • How leaders contribute to dysfunctional cultures
  • Establishing a high performance work environment
• Creating Organizations that Work
  • Creating an organizational charter
  • Selecting an effective management team
  • Thinking systemically
  • Importance of managing image and expectations
  • Creating meaningful performance indicators
  • Eliminating turf battles and duplication
  • Limitations on the application of common systems
• Facilitating Strategic Decisions
  • Critical distinctions between problems, decisions and polarities
  • How to properly frame a decision
  • Selecting the decision makers
  • Common errors in decision making process
  • Essential elements of effective decision making process
  • Knowing when the decision has been made
• The Leader’s Role in Creating Effective Strategies
  • What exactly is a strategy?
  • Why business strategies fail

Instructor: Murray Sittsamer
Fee $640 .8 CEUs
MANAGEMENT AND LEADERSHIP

- Internal and external considerations
- What constitutes effective strategy?
- Anticipating the impact of adaptive responses
- Framing strategic initiatives
- Barriers to strategy implementation

- Leading Strategic Change
  - Planning a change initiative
  - Critical variables in organizational change
  - The leader’s role in fostering change
  - Anticipating and dealing with resistance
  - Culture as a barrier to change

- Political Reality versus Dysfunctional Idealism
  - Gaining credibility in executive circles
  - Sources of leadership power
  - How power is gained and lost
  - The importance of building networks and relationships
  - How to avoid getting derailed

- Lessons of History for Strategic Leaders

- Developing a Leadership Profile
  - Charting your personal leadership profile
  - Identifying your leadership assets and liabilities
  - Creating a plan of action

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Instructor: Joseph Doyle
Fee $1740 2.0 CEUs

Success Strategies for Women in Industry and Business

1 Day
I.D.# C1202

It is a well-known fact that the number of women in science, engineering and business fields is growing, yet men continue to outnumber women, especially at the upper levels of these professions. Many women appear to encounter a series of challenges at early or midcareer stages that contribute to them leaving their careers prematurely due to feelings of isolation, an unsupportive work environment, extreme work schedules, and unclear rules about advancement and success.

This program serves as a unique opportunity to obtain both formal and informal mentoring tips from a successful woman engineer who spent over 25 years in the petrochemical/specialty chemical industry. She has seen and has experienced significant changes in the number of professional women active in the technical/scientific field and is convinced that more positive change can happen in the future.

This seminar will provide detailed guidance, based on real life examples, on how female professionals can become proactive in creating career opportunities via self-assessment, self-motivation, an objective view of one’s own abilities, and continuous steps in self-improvement. The program will take participants beyond theory to case studies and real life examples exemplifying potential for immediate use.

**Learning Objectives**

By attending this seminar, you will be able to:

- Identify obstacles and common challenges that hold you back in your career
- Develop and utilize critical communication skills
- Develop focused and well defined criteria for professional progress
- Define your professional relationships with clear boundaries and respect
- Create a flexible career plan
- Handle criticism and difficult situations with composure

**Who Should Attend**

This seminar will benefit professional women who want to positively impact their careers. Recent engineering graduates, as well as experienced female engineers and/or scientists having responsibilities in research, design, product and process development, manufacturing, quality, information technology, sales/marketing, and management will learn skills to help them navigate these male-dominated fields. Additionally, individuals currently working in non-engineering disciplines, including general management, human resources, academia, business, and law as well as current engineering students, will also benefit from this unique perspective.

**Topical Outline**

- Course Motivation: Why are you here?
- Historical Perspective - Women in Engineering and Scientific Professions
  - Dr. Ewa Bardasz - personal story
  - Survey data - status of women professionals: tenure, promotions, salary trends, recognitions, etc
- Case Study #1: What holds you back in your career?
  - Common Challenges
- Case Study #2: Career Goals: Success Defining Questions
  - Work Climate Changes
- Definition of Professional Success
  - Technical know-how
  - Leadership skills
- Refining Critical Verbal Communication Skills
  - Presentations/ public speaking
  - Negotiations/ conflict communications
  - Getting your points across
  - How to speak up without coming across as too aggressive
MANAGEMENT AND LEADERSHIP

• How to find balance between “being too nice” and “coming on too strong”
• How you can say “no” without feeling guilty
• Case Study #3: How can you successfully negotiate with a group of aggressive men?
• Refining Critical Written Communication Skills
  • Reports, technical papers
  • Email, social media
• Networking
• Behaviors and Relationships
  • Handling emotions at work
  • Mentors/Advisors - pros and cons
• Work-Life Balance
• Key Resources
  • Professional organizations
  • Community activities
• Reflections and Final Thoughts
• Take Away Message
• Case Study #4: What will I do next?

Instructor: Ewa Bardasz
Fee $595 .7 CEUs

CATALOG KEY
You will see the following icons alongside the course descriptions. These icons indicate:
• delivery formats available for the course
• the course is part of an SAE certificate
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Many courses are available in multiple formats. See page X to get more information on the learning formats offered by SAE. In addition to finding courses that fit your technology need, look for courses with icons that fit the way you want to learn.

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RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Engineering Project Management
Project Management and Advanced Product Quality Planning (APQP) are two critical techniques used in product development in the mobility industry today. This seminar will bring these techniques together in an easy to understand format that goes beyond the typical concept of constructing timelines and project planning, by exploring not only the AIAG APQP process, but also specific aspects of PM processes. Students will gain a solid foundation in the essential principles of Project Management and APQP. Read more about this course on page 166
MATERIALS AND MANUFACTURING

Includes manufacturing, parts and components, and assembly; as well as materials including plastics, alloys, and metals.

MANUFACTURING

Automotive Plastics: Principles of Materials & Process Selection

2 Days
I.D.# C0135

Plastic - any class of synthetically-produced organic compounds capable of being molded and hardened into a specific shape or form. This course is designed to offer a basic understanding of plastics and plastic processing. Using plastics can be simple, but there is much more behind producing high performance plastic parts. This seminar will walk you through the molding process, provide a comprehensive look at the variables in the manufacturing mix, and review characteristics of typical automotive plastics such as PP, PVC, ABS, and more. This seminar will also cover troubleshooting molding mistakes and alternative processes, and review the selection of an application’s appropriate plastic material. Material presented is both an excellent foundation for further development and an extensive update for those already working in the field.

Learning Objectives
At the completion of this seminar, attendees will be able to:

• Demonstrate an understanding of typical automotive plastics and primary and application-specific plastics processing methods
• Recognize key plastics terminology and parameters related to plastics
• Explain alternative molding processes
• Prevent or reduce molding mistakes
• Understand the molding cycle
• Troubleshoot the processing operation

Who Should Attend
This seminar is designed for those who are new to automotive plastics, as well as those who have some experience. The program will benefit product designers, process engineers, purchasing agents, project engineers, manufacturing engineers, material engineers, and sales and marketing professionals.

Topical Outline

DAY ONE
• Introduction to Injection Molding
  • Process description
  • Product description
  • Business overview
• The Injection Molding Machine
  • Clamp systems
  • Plastication unit
  • Screw
  • Controls
• The Molding Cycle
  • Pressure in process
  • Velocity generation, including mold filling, mold packing, cooling, ejection, material melting and material handling.

DAY TWO
• Typical Injection Molding Mistakes
MATERIALS AND MANUFACTURING

- Melt temperature
- Material drying
- Contamination
- Over packing
- Incomplete fill
- Oversized machines
- Undersized machines
- Temperature control
- Mold(s)
- Function
  - Forming
  - Cooling
- Basic Design Requirements
  - Clamp slots
  - Ejection “hole”
  - Support
  - “Seal-off”

Learning Objectives
By attending this seminar, you will be able to:
- Describe the basic electrochemical concepts of various corrosion processes
- Articulate and utilize corrosion prevention strategies and estimate corrosion behavior of materials and components
- Describe the role of ion-diffusion, crystal structure, and grain size on corrosion of metals and alloys
- Design and engineer corrosion resistive components for different industries
- Define methods of corrosion protection and interpret corrosivity maps
- Perform standard corrosion tests, in-depth analyses of test results
- Define anodic/cathodic protections and coatings specifications for various components
- Formulate corrosion prevention coatings materials for metallic and non-metallic structures

Who Should Attend
This course is designed for engineers working in automotive, commercial vehicle, off-road, aerospace, marine, rail, energy sectors, electronics and related industries who are interested in corrosion and corrosion prevention. Engineers working for chemical companies on the production of corrosion resistive materials and chemicals and scientists working for government and national laboratories working in the area of conservation, national infrastructures, and advanced energy technologies, as well as academicians will benefit from this course.

Topical Outline
DAY ONE
- Fundamentals of Corrosion and Corrosion Prevention
  - Overview of corrosion problems and their economic impacts
  - Basic electrochemical principles of corrosion and corrosion prevention
  - Types of corrosion and role of electromotive force, ion diffusion, crystal structure, and grain size
  - Corrosion of composite materials and impact of combined cyclic loading and corrosion
  - Standard corrosion tests, and recent software and hardware for corrosion testing
- Mechanisms and Prevention of Corrosion
  - Automotive components
  - Aerospace components
  - Marine and underwater infrastructures
  - Electronics and energy related systems
- Corrosion Engineering and Coating Technologies
  - Design principles to minimize corrosion
  - Passive and active coating technologies

Instructor: Robert G. Speirs
Fee $1335 1.3 CEUs

Corrosion Engineering and Prevention
2 Days
I.D.# C1217

The transportation industry, including motor vehicles, aircraft, rail, marine, commercial, off-road and defense vehicles, as well as infrastructures, energy sectors, raw materials, manufacturing, health and food industries all experience significant issues with corrosion resulting in billions of dollars of loss each year. Corrosion education and prevention is essential to improve and increase the service life of parts and components - possibly impacting the economy of various industries and nations.

The focus of this course is on the fundamentals of corrosion engineering and corrosion prevention of metallic and alloy structures as well as on non-metallic composites and hybrid materials. Recent challenges and opportunities in corrosion of advanced composites used in the automotive, aerospace, and marine industries as well as for underground structures for oil, gas, geothermal and tidal wave technologies will also be included. Different types of corrosion, methods of corrosion protection and prevention, optimum engineering design of corrosion resistance parts and components, standard corrosion tests, responsibilities of corrosion engineers, and a process for setting-up an advanced corrosion laboratory will be discussed. This course also covers most traditional and non-traditional tests for corrosion studies, including real-time characterization techniques and analysis of corrosion phenomenon and corrosion monitoring principles.
MATERIALS AND MANUFACTURING

DAY TWO
- Surface Coating Technologies for Corrosion Prevention
  - In-situ surface coating and coating optimization
  - Anodic and cathodic protections and engineering principles
  - Application of metal oxides, carbides, nitrides and composite coating
- Supply and Manufacturing of Corrosion Prevention Materials
  - Inorganic base coating materials and their applications
  - Organic based coating materials and mode of operation
  - Composite coatings and their applications in auto and aerospace industries
- Corrosion and Corrosion Prevention of EVs and HEVs with Batteries, Supercapacitors and Fuel Cells
  - Corrosion prevention and role of high voltage, electromagnetic sources
  - Corrosion in fuel cells and component design to optimize corrosion
  - Corrosion in renewable alternative energy sectors

Instructor: Gholam-Abbas Nazri
Fee $1295 1.3 CEUs

Introduction to Advanced High Strength Steel Applications and Manufacturing

2 Days
I.D.# C1416

Advanced High Strength Steels (AHSS) are now commonly used in automotive body structural applications. The high strength of this grade classification is attractive to help reduce mass in the automotive body through reduction in thickness. Strength also supports improvements in safety requirements so that mass increases are minimized. In some specific grades of AHSS, energy absorption is possible in addition to the high strength. This course will review the definition and properties of AHSS and cover several common applications in automotive body structures. In addition, key manufacturing areas including stamping and welding will be addressed to demonstrate the increased challenges as compared to lower strength steel grades. Troubleshooting of typical engineering and production problems will round out the seminar leaving attendees with tools to help design more robust engineering solutions to AHSS applications.

Learning Objectives
By attending this seminar, you will be able to:
- Define AHSS grades and describe general properties of AHSS
- Identify potential applications for AHSS
- Describe key manufacturing processing issues
- Assimilate tools for trouble shooting part issues

Who Should Attend
This course is designed for Automotive Body Engineers, Die Engineers, Designers, Manufacturing Plant Personnel, New Hires in the Steel Industry, Supervisors, Planners, and others who would like to decrease vehicle weight through the use of AHSS.

Topical Outline
DAY 1
- Background/Overview of AHSS
  - Definition
  - Types of AHSS
  - Typical chemistry and properties
  - Comparison to High Strength Low Alloy (HSLA) Steels
  - Thermo-mechanical processing
  - Coatings
  - Material call-outs
  - Availability of grades/gauges/coatings/coil widths
  - Coil tolerances
- Product Applications and Design Considerations
  - Typical automotive body and chassis applications
  - Crash performance advantages
  - Design for manufacturability

Day Two
- Stamping
  - Formability; Springback
  - Effect of material variation
  - Press tonnage
  - Edge fracture
  - Lubrication
- Stamping Tooling
  - Die design standards
  - Die materials and surface treatments
  - Die maintenance
- Die Try-Out
  - Proof tooling
  - Trouble shooting; Lessons learned
- Roll Forming
- Assembly
  - Joining/welding
  - Other assembly considerations
- Case Studies

Instructor: Jody N. Hall
Fee $1325 1.3 CEUs
Metal Forming

2 Days  
I.D.# 85012

This seminar covers metal forming and related manufacturing processes, emphasizing practical applications. From forged or P/M connecting rods to tailor-welded blank forming, metal parts are integral to the automotive industry. As a high value adding category of manufacturing, metal forming is increasingly important to the core competency of automobile manufacturers and suppliers. A thorough survey of metal forming processes and metal forming mechanics will be performed, including bulk deformation, sheet-metal, and powder metallurgy operations. Design considerations are fully integrated into the course and are presented with every process. A large number of real-world case studies are presented to the attendees to emphasize course content. Attendees will receive a copy of the book Manufacturing Engineering Technology, co-written by instructor Steven R. Schmid.

Learning Objectives

By attending this seminar, you will be able to:
• Identify the unique characteristics of metals that lead to plastic deformation as a processing strategy
• Explain the processes involved in metal forming mechanics, materials, and tribology
• Analyze the interrelationships between various factors that influence the quality of manufactured products
• Describe sheet metal characteristics and forming
• Describe the wide variety of processes used to shape and deform metals, including forging, rolling and extrusion; sheet metal forming, shearing and stamping; powder metallurgy processes and assorted other processes

Who Should Attend

This course is designed for engineers who are involved in metal forming and other related manufacturing processes.

Topical Outline

DAY ONE
• Overview of Solid Mechanics and Materials Science Topics of Importance to Metal Forming
• Tribology of Metal Forming: Friction, Lubrication and Wear
• Bulk Deformation Processes
  • Forging: open die and closed-die (impression) forging; machinery description and capabilities; forging process layout and die design; heading, coining, piercing and upsetting operations; swaging
  • Rolling: flat rolling process, including Orowan model; control of product quality including surface finish and gage control; rolling equipment and capabilities; shape rolling; ring rolling
• Extrusion and drawing: direct, indirect and hydrostatic extrusion; cold and hot extrusion; die design; defects in extrusion; drawing equipment and mechanics; limiting drawing ratio

DAY TWO
• Sheet Metal Forming Processes
  • Sheet metal shearing: mechanics of shearing, burr formation, blanking operations, fine blanking
  • Sheet metal bending: types of bending operations and equipment; springback calculation and control; tube bending
  • Sheet forming operations: deep drawing and ironing; stretch forming; bulging, rubber forming and hydroforming; roll forming of sheet; spinning; incremental forming; explosive, peen and other specialty forming processes; stamping operations and die design
  • Sheet metal formability: limiting drawing ratio for deep drawing; sheet metal formability; forming-limit diagrams
• Powder Metallurgy Processes
  • Compaction through pressing, cold and hot isostatic pressing and metal injection molding; sintering mechanics and processes; coining and finishing

Instructor: Steven R. Schmid
Fee $1415 1.3 CEUs

Automotive Glazing Materials

2 Days  
I.D.# 99002

Automotive glazing materials affect the total automotive system. This seminar presents an overview of different automotive glazing materials and covers a wide range of topics including history, manufacturing, testing, and safety. The chemical, physical, and design issues related to various glazing materials (annealed, laminated, tempered, glass-plastic, and plastic) are covered in depth.

Attendees will receive a copy of SAE Standard J673 Automotive Safety Glasses as part of the course material.
Learning Objectives
By attending this seminar, you will be able to:
• Describe the evolution of glazing materials in the automotive industry
• Contrast the safety characteristics of various products and how they perform in normal usage and in accidents
• Explain how safety glazing materials are regulated and certified
• Describe the production processes used to make laminated and tempered glass
• Avoid problems by optimizing the performance and failure modes of the different glazing materials
• Describe the physical and chemical characteristics of the different products
• Summarize glass manufacturing procedures, processing, handling, installation, and usage to disposal
• List the important characteristics of tempered, laminated glass, and plastic glazing
• Articulate how glazing materials affect the total automotive system
• Explain when and why specialty products are used and how they are manufactured
• Discuss future trends and technical innovations

Who Should Attend
This seminar is designed for transportation, safety and glass engineers and others who work on or with automotive or similar glazing products. Individuals who need either general information on glazing or details on specific glazing topics, such as legal, safety, marketing, performance and manufacturing issues will benefit from this seminar.

Topical Outline
• Introduction
  • Laminated glass; Tempered glass
  • History of automotive glass
  • Automotive safety glass regulations
• Glass
  • Chemistry
  • Surface properties
  • Ceramic paint and silver
  • Stress; Breakage
  • Physical properties
  • Manufacturing process
• Glass Processing
  • Inspection
  • Cutting; Break-out
  • Grinding and seaming
  • Washing; Printing; Bending
• Laminated Glass - The Windshield
  • History
  • Production process: glass bending; windshield interlayer; and windshield production
  • Safety
  • Testing and weathering
  • Windshield issues
  • Encapsulation and adhesion
  • Packaging and shipping
  • Installation
  • Replacement, repair, disposal and warranties
  • Design considerations
  • Specialty windshields: heated, HUD, and solar control
• Tempered Glass
  • Production process
  • Testing and evaluation
  • Safety: legal requirements; testing; and performance
  • Design considerations
  • Encapsulation and adhesion
  • Installation: movable and stationary
  • Warranty
• Tempered vs. Laminated Glass
  • History
  • Legal Requirements
  • Safety: testing and performance
  • Design considerations
  • Ejection
  • Security
• Specialty Glazing Materials
  • Plastic; Glass-Plastic
  • Roof glass
  • Truck and van glazing materials
  • Bullet resistant glass
  • Photochromic; Electrochromic
  • Hydrophobic
  • Coatings
  • Off-highway glazing materials
• The Replacement Market
  • Finding the glass
  • Tinting materials: transmittance; reflectance; and performance
  • Windshield installation: sealant and procedure
  • Legal requirements
  • Windshield repair
  • Anti-theft

Instructor: Siegfried H. Herliczek
Fee $1435 1.3 CEUs
Laminated Glass: Design Considerations for Vehicle Door Systems Fast Track

40 Minutes
I.D.# PD130810ON

The evolution in glass technology creates both opportunities and challenges which must be understood by today’s automotive designers and engineers for successful implementation. Because laminated glass has different structural properties than tempered glass, this 40 minute online short course will provide an overview of best practices for integration of the product into vehicle door systems based upon extensive testing and field experience.

Major topics include:
• Overview of Laminated Glazing
• Laminated Glazing Selection Criteria
• Automotive Glass Strength Characterization
• Static Stresses and Door Design Considerations
• Dynamic Stresses from Door Slam
• Laminated Glass Performance and Analysis Techniques
• Summary of Laminated Glazing Benefits

Is this Fast Track for you?
This online short course was developed for engineers and those in the automobile supply chain involved in all disciplines related to the design or development of glass. It is designed to provide a technology overview that is relevant to those who simply want an introduction to laminated glass, while providing sufficient technical detail on best practices to benefit seasoned glazing engineers.

What You Will Receive
• Three months of on demand access to the 40 minute presentation
• Integrated knowledge checks to reinforce key concepts
• Proof of Participation

Instructors: Peter Dishart & DeWitt W. Lampman
Fee $79

Material Selection and Testing for Plastics

2 Days
I.D.# C0134

Today’s necessity for quickly delivering products to market limits product development time and leaves less room for error and ‘re-dos.’ With so many plastic materials available, it is crucial that those involved in product design understand resin properties and how they affect part design and manufacturability. To help you make the best plastic choices the first time, this seminar provides an overview of polymer chemistry, explains the methods for testing properties of plastics and presents a method of systematic selection that will optimize your plastics material selection process.

Learning Objectives
At the conclusion of this seminar, attendees will be able to:
• Understand the properties of plastic materials
• Know what types of instruments are used in testing
• Demonstrate methods used to test the properties of plastic materials
• Possess the technical background necessary to select the optimum resin for a given application
• Apply measurements to the standards and specifications so the material and design meet an application’s service requirements

Who Should Attend
This seminar will benefit product and part designers, engineers, engineering managers and those involved in the development of plastic parts. Specifically designed to enhance on-the-job effectiveness for professionals at all levels of plastics part development, this course will provide an invaluable foundation for selecting plastic materials and understanding their capabilities and limitations.

Topical Outline
DAY ONE
• Introduction to Plastic Materials
  • Definitions
  • Thermoset vs. thermoplastics
  • Good (and bad) characteristics
  • General properties
  • Brief history
  • Economic “position” (commodity vs engineering vs specialty)
• Plastics-General Overview
  • Materials form; Shipment sizes
  • Pre-compounded vs blended
  • Drying/storing
  • Handling
  • Grades and lots
  • Regrinding and reuse
• Polymer Chemistry Introduction/Review
  • Molecular weight
  • Distribution, dispersity index
  • Morphology
  • Molecular configuration
• Process Related Property Variations
  • Drying; Shrinking
  • Rheology
Surface Texture: Specification and Control
1 Day
I.D.# C1110

Surface texture is one of the most important topics in today’s world of design, development and performance. As tolerances are shrinking and performance demands are increasing, surface texture is rapidly becoming one of the most important aspects of engine and vehicle performance. Every moving component on a vehicle or engine is influenced by surface texture in one or more of the following ways: vibration, sealing, adhesion, traction, emissions, safety, durability, wear/failure analysis. Many of the industry’s top warranty issues (leaks, noise, vibration, etc.) are a direct result of surface texture implications. Rather than focus on the theories of surface texture, this course will focus on the applications of these concepts to automotive applications - thereby giving the attendees tools that they can immediately use as they solve automotive problems such as cylinder bores and emissions control, crankshafts, camshafts and early engine failures, brakes and NVH, wheel bearings and vibration, gaskets and sealing, bearings and durability, pistons and durability, and shaft straightness and vibration.

**Learning Objectives**

By attending this seminar, you will be able to:
- Communicate clear descriptions of surface texture in reports and product documentation
- Recognize roughness and waviness impacts on components
- Recognize measurement errors and avoid misinterpretations of results
- Specify surface texture according to ISO 1302
- Identify and specify functional wavelength regimes for surface texture

**Who Should Attend**

This topic bridges all fields within the automotive industry and is designed for engineers and technicians involved in: the specification of mechanical systems and components; failure analysis and warranty; quality control and measurement functions, manufacturing and process development. The areas of interest could include: sealing, sliding, cosmetic appearance, friction, leakage and more.

**Topical Outline**

- The Language of Surfaces
  - Roughness
  - Waviness
  - Form
- The Measurement of Surfaces
  - Describing Wavelength Regimes
  - Separating roughness from waviness
  - Distortions that can occur in the data and how to deal with them
  - Choosing the right filter cutoff
- Surface Texture Interactions with other Tolerances like GD&T
- Parameters
- Specifying Surface Texture

**Instructor:** Mark Malburg

Fee $790  .7 CEUs
Principles of Metallurgy

4 Hours
I.D.# PD261322ON

This on demand course teaches the basic microscopic structures present inside of metals, how these structures and metal composition influence metal strength, and how these structures can be modified using common manufacturing processes to obtain specific mechanical properties. Several examples are presented to demonstrate how common alloying and manufacturing methods are used to modify the microscopic structures and properties of metals. It includes twelve modules followed by a quiz.

Major topics include:
• Composition
• Microscopic structures
• Crystal defects
• Diffusion
• Cold Working
• Annealing
• Solid Solution strengthening
• Precipitation Strengthening Heat Treatment
• Steel and Steel Heat Treating

Is this Metallurgy On Demand Course for You?
This course is targeted towards design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds.

What You Will Receive
• Three months (from date of purchase) of on demand access to the four hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course workbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $225

Corrosion of Metals

5 Hours
I.D.# PD261328ON

This online course teaches about corrosion of metals. The physics of corrosion is explored as a background for the discussion of seven common types of corrosion (uniform, galvanic, crevice, pitting, intergranular, stress corrosion cracking, and dealloying). Students will learn why and how corrosion occurs and methods for controlling corrosion. It includes eleven modules followed by a quiz.

Major topics include:
• Introduction to electrochemical corrosion
• Aqueous corrosion
• Uniform corrosion
• Galvanic corrosion
• Crevice corrosion
• Pitting corrosion
• Intergranular corrosion
• Stress corrosion cracking
• Dealloying

Is this Metallurgy On Demand Course for You?
This course is targeted to design engineers, manufacturing engineers, and quality engineers. It is suggested that, as a prerequisite, you either take our Principles of Metallurgy online course (I.D.# PD261322, page 97) or have basic knowledge of the following topics: grains, grain boundaries, crystal lattice, substitutional solid solution, diffusion, phases, precipitation, precipitation hardening, microstructure, tensile testing.

What You Will Receive
• Three months of on demand access (from date of purchase) to the five hour presentation
• Integrated knowledge checks to reinforce key concepts
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $290

Corrosion of Metals: Chemistry of Corrosion

1 Hour
I.D.# PD261334ON

This on demand course covers the fundamental mechanisms involved in the aqueous (water based chemicals) corrosion of metals. The factors that influence the inherent corrosion behav-
ior of a metal and the factors that influence metal corrosion rate will be discussed. The course takes one hour to complete.

**Major topics include:**
- Parts of an electrochemical corrosion cell
- Corrosion reactions
- Factors that influence the corrosion behavior of a metal
- Factors that influence the corrosion rate of a metal

**Is this Metallurgy On Demand Course for You?**
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you should be familiar with chemistry concepts such as ions, electrons, and chemical reactions.

**What You Will Receive**
- Three months (from date of purchase) of on demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

**Author:** Industrial Metallurgists, LLC

**Fee $70**

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**Corrosion of Metals: Uniform Corrosion**

1 Hour  
I.D.# PD261335ON

This on demand course teaches about uniform corrosion of metals. Participants will learn why and how uniform corrosion occurs and methods for controlling it. References of textbooks and handbooks for more information are also provided. The course content can be completed in one hour.

**Major topics include:**
- Uniform corrosion mechanism
- Why uniform corrosion occurs
- Appearance of uniform corrosion
- Methods for controlling uniform corrosion

**Is this Metallurgy On Demand Course for You?**
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested you have knowledge of the concepts covered in our Corrosion of Metals: Chemistry of Corrosion online course (I.D.# PD261334ON, page 97).

**What You Will Receive**
- Three months (from date of purchase) of on demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

**Author:** Industrial Metallurgists, LLC

**Fee $70**

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**Corrosion of Metals: Galvanic Corrosion**

1 Hour  
I.D.# PD261336ON

This on demand course teaches why and how galvanic corrosion occurs and methods for controlling galvanic corrosion. The course content can be completed in one hour.

**Major topics include:**
- Galvanic corrosion cell components
- Factors that influence galvanic corrosion rate
- Galvanic series and its use
- Methods to control galvanic corrosion

**Is this Metallurgy On Demand Course for You?**
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that you have knowledge of the concepts covered in our Corrosion of Metals: Chemistry of Corrosion online course (I.D.# PD261334ON, page 97).

**What You Will Receive**
- Three months (from date of purchase) of on demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

**Author:** Industrial Metallurgists, LLC

**Fee $70**
MATERIALS AND MANUFACTURING

SAE MULTI-COURSE CERTIFICATE PROGRAMS
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

Intended to provide a guide towards deeper knowledge in a specific area, SAE’s multi-course certificates outline required courses that offer foundational knowledge of the subject. Some certificate programs also feature additional electives designed to broaden your exposure to more specific aspects of the technology studied. PLUS—completion of many of the multi-course certificate programs equates to graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S in Mechanical Engineering. Visit training.sae.org/collegecredit for more information.

SAE offers these multi-course certificate programs:
• Transmission/Drivetrain
• General Management and Leadership
• Professional and Legal Issues
• Diesel Technology
• SI Engine
• Vehicle Dynamics
• Product Engineering Tools and Methods
• New! Accident Reconstruction

Visit training.sae.org/credentialing/certificate for more information.

Failure Analysis of Metals
5 Hours
I.D.# PD261505ON

Quickly getting to the bottom of a metal failure is critical for preventing future failures, keeping customers happy, and keeping manufacturing lines running. This course will teach you how to perform failure analysis of fracture, corrosion, and manufacturing failures.

Major topics include:
• The relationship between failure analysis and root cause analysis
• How to select, collect, handle, and prepare samples for failure analysis
• The background information required to determine failure mechanism and root cause
• The common techniques used for failure analysis and the data obtained
• Which metallurgical analyses are appropriate for specific failures
• How to determine fracture mode based on the appearance of a fracture surface
• How to perform a failure analysis on fracture, corrosion, and manufacturing failures
• The categories of failure root causes for specific failures

Is this Metallurgy On Demand Course for You?
This course is targeted towards design, manufacturing, supplier quality and quality control engineers, sales people and purchasing agents with technical backgrounds.

What You Will Receive
• Three months (from date of purchase) of on demand access to the approximately 5-hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course workbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $290

Hardness Testing
30 Minutes
I.D.# PD261331ON

This on demand course focuses on Rockwell and Brinell hardness testing and Vickers and Knoop microhardness testing. Participants will learn about how the tests are performed, test sample requirements, test parameter selection, and testing requirements. The course can be completed in 30 minutes.

Major topics include:
• Rockwell hardness testing
• Brinell hardness testing
• Knoop and Vickers microhardness sample preparation and testing

Is this Metallurgy On Demand Course for You?
This on demand course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Corrosion of Metals: Chemistry of Corrosion online course (I.D.# PD261334ON, page 97).

What You Will Receive
• Three months (from date of purchase) of on demand access to the thirty minute presentation
MATERIALS AND MANUFACTURING

- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Metallurgy of Precipitation Strengthening

2 Hours
I.D.# PD261329ON

This on demand course teaches about the microscopic changes that take place in a precipitation strengthened alloy and their effects on the properties of the alloy. The effects of the different heat treating steps (solution treatment, quench, and aging) and heat treatment process parameters (solution treatment temperature and time, quench rate, and aging temperature and time) on the alloy microstructure and the effects on alloy strength are discussed. The course is divided into five modules followed by a quiz.

Major topics include:
- Phase diagrams
- Precipitation strengthening heat treatment
- Heat treatment details
- Quality control and course review

Is this Metallurgy On Demand Course for You?
This course is targeted to design, manufacturing, and quality engineers. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Principles of Metallurgy (I.D.# PD261322, page 97) online course.

What You Will Receive
- Three months (from date of purchase) of on demand access to the two hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $39

Metallurgy of Steel Case Hardening

1 Hour
I.D.# PD261333ON

This on demand course discusses common steel case hardening processes and how they are used to modify the surface layers of steels to obtain specific mechanical properties. Participants will learn about the process parameters and how they affect case composition, depth, microstructure, and properties. The course takes one hour to complete.

Major topics include:
- Carburizing
- Carbonitriding
- Nitriding
- Nitrocarburizing Flame hardening; Induction hardening

Is this Metallurgy On Demand Course for You?
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Principles of Metallurgy (I.D.# PD261322, page 97) and Metallurgy of Steel: Principles (I.D. PD261326ON, page 101) or knowledge of the concepts covered in those courses.

What You Will Receive
- Three months (from date of purchase) of on demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Course workbook (.pdf, downloadable)
- Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $70

Metallurgy of Steel Heat Treating

5 Hours
ID # PD261327ON

This on demand course teaches about common heat treating processes and how they are used to modify the microstructure of steels to obtain specific mechanical properties. You will learn about the metallurgy of steel, the effects of heat treating temperature and cooling rate on microstructure properties, and the effects of the interaction between heat treating process parameters and steel composition on steel microstructure and strength. It includes eleven modules followed by a quiz.

Author: Industrial Metallurgists, LLC
Fee $125
MATERIALS AND MANUFACTURING

Major topics include:
• Introduction
• Metallurgy of Steel
• Steel Phase Diagram
• Phase Transformations in Steel
• Annealing and Normalizing
• Through Hardening
• Case Hardening

Is this Metallurgy On Demand Course for You?
This course is targeted to design engineers, manufacturing engineers, quality engineers, and sourcing specialists. It is suggested that, as a prerequisite, you either take our Principles of Metallurgy (I.D.# PD261322, page 97) online course or have basic knowledge of the following topics: solid solution, substitution, interstitial, diffusion, effects of process temperature and time on diffusion and metallurgical changes, metallurgical phase, grain, grain boundary, precipitates and precipitation, tensile testing, and hardness testing.

What You Will Receive
• Three months (from date of purchase) of on demand access to the five hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course workbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $290

Metallurgy of Steel Through Hardening
1 Hour
I.D.# PD261330ON
This on demand course teaches about the metallurgy of the following steel through hardening processes: quench and temper, martempering, and austempering. Participants will learn about the effects of heat treating temperature and cooling rate on steel microstructure and properties, and the effects of the interaction between heat treating process parameters and steel composition on through hardened steel microstructure and strength. This course takes one hour to complete.

Major topics include:
• Quench and temper
• Steel hardenability
• Common problems associated with quenching (distortion, cracking, retained austenite)
• Martempering; Austempering

Is this Metallurgy On Demand Course for You?
This course is targeted to design, manufacturing, and quality engineers, and sales people and purchasing agents with technical backgrounds. It is suggested that, as a prerequisite, you have knowledge of the concepts covered in our Principles of Metallurgy online course. (I.D.# PD261322, page 97).

What You Will Receive
• Three months (from date of purchase) of on demand access to the one hour presentation
• Integrated knowledge checks to reinforce key concepts
• Course workbook (.pdf, downloadable)
• Proof of Participation (Transcript)

Author: Industrial Metallurgists, LLC
Fee $70

Metallurgy of Steel: Principles
3 Hours
I.D.# PD261326ON
This on demand course teaches the phases and microstructures that form in steels, their effects on steel properties, the microstructure changes that occur when steel is heated and cooled, and the effects of carbon content and cooling rate on the microstructures that form. Also, how to read the iron-carbon phase diagram will be discussed. All this information is applicable to understanding the effects of steel heat treating processes and heat treating process parameters on the microstructure and properties of heat treated plain carbon, low-alloy, and tool steels. The course is divided into six modules followed by a quiz.

Major topics include:
• Steel types and designations
• Metallurgical phases that form in steel and their effects on properties
• Steel phase diagram
• Metallurgical changes in carbon steel during cooling
• Metallurgical changes in carbon steel during heating
• Course Review

Is this Metallurgy On Demand Course for You?
This on demand course is targeted to design, manufacturing, and quality engineers, and sourcing specialists. It is suggested that, as a prerequisite, you have basic knowledge of solid solution, substitutions, interstitials, diffusion, effects of process temperature and time on diffusion and metallurgical changes, metallurgical phases, grains, grain boundaries, dislocations or the concepts covered in our Principles of Metallurgy online course. (I.D.# PD261322, page 97).
Tensile Testing

Duration: 25 Minutes
I.D.# PD261308ON

This on demand course teaches about tensile testing of metals with a focus on how the testing is performed and tensile properties are measured. It includes one module followed by a quiz.

**Major Topics Include:**
- How a tensile test is performed
- Tensile specimen shape
- Calculation of stress and strain
- Stress and strain curve
- How to determine elastic modulus, yield strength, tensile strength, and elongation from a stress-strain curve

**Is this Metallurgy On Demand Course for You?**

This course is targeted towards design, manufacturing, supplier quality and quality control engineers, sales people and purchasing agents with technical backgrounds.

**What You Will Receive**
- Three months (from date of purchase) of on demand access to the 25-minute presentation
- Course handbook (downloadable, .pdf’s)
- Integrated knowledge checks to reinforce key concepts
- Proof of Participation (Transcript)

**Author:** Industrial Metallurgists, LLC

**Fee:** $39
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

**Design for Manufacturing & Assembly (DFM/DFA)**
Design for Manufacturing and Assembly (DFM+A), pioneered by Boothroyd and Dewhurst, has been used by many companies around the world to develop creative product designs that use optimal manufacturing and assembly processes. Correctly applied, DFM+A analysis leads to significant reductions in production cost, without compromising product time-to-market goals, functionality, quality, serviceability, or other attributes. In this two-day seminar, you will not only learn the Boothroyd Dewhurst Method, you will actually apply it to your own product design!

Read more about this course on page 43

**Sound Package Materials for Vehicle Noise Control**
The two day seminar starts with the fundamentals of NVH and sound quality related to sound package materials and discusses the importance of various noise sources that impact the development of sound package treatments in a vehicle.

Read more about this course on page 109

**Vehicle Sound Package Materials**
This four-session web seminar provides a detailed understanding of the source – path-receiver relationship for developing appropriate sound package treatments in vehicles, including automobiles, commercial vehicles, and other transportation devices.

Read more about this course on page 109
NOISE, VIBRATION AND HARSHNESS

Includes acoustics, engine noise control, sound package materials, vibration, and harshness.

Acoustic Fundamentals for Solving Noise and Vibration Problems Web Seminar and Web Seminar RePlay

6 Hours
Web Seminar: I.D.# WB1309
Web Seminar RePlay: PD331309ON

This course provides an introduction to the characteristics of sound waves, human perception of sound, sound and vibration measurements, measurement facilities, and various noise sources and noise control principles. It will include an overview of sound pressure, power, intensity, decibels, and frequencies. Practical examples will be used to familiarize participants with the acoustic fundamentals for solving noise and vibration problems and the associated solution principles.

Learning Objectives
By connecting with this web seminar, you will be able to:
• Discuss the differences of various acoustic terminologies that are important to solve noise and vibration problems
• Define a relationship between sound pressure, sound power, and sound intensity
• Associate decibel to both sound and vibration
• Prepare effective acoustic specifications encompassing all variables that affect noise and vibration
• Select correct instrumentation for noise and vibration measurements recognizing the challenges of measurements
• Define the source-path-receiver relationship
• Determine the steps of noise and vibration source identification process for a given application
• Employ different noise control options to address specific noise and vibration issues

Who Should Attend
This fundamental Web Seminar will be especially valuable for technical staff, engineers, and managers with limited experience in noise and vibration. It is designed to be suitable for all areas of the mobility industry. An Associate degree in the field of science or technology is recommended; BS degree is preferred.

Topical Outline
Session 1
• Introduction
  • Waves
  • Pressure, power, intensity
  • Frequency
  • Human perception of sound
• Decibels
  • What is decibel
  • Addition and subtraction of decibels
  • Background noise
  • Linear averaging/spatial averaging
• Frequency
  • Frequency Analysis
  • Linear and logarithmic frequency
  • Filters
Session 2
• Human Perception of Sound
  • Equal Loudness contours
  • Frequency weighting of sound
  • Loudness, loudness level, articulation index
• Instrumentation and Facilities
  • Transducers
  • Spectrum analyzers
  • Anechoic/hemi-anechoic room
  • Reverberation room
• Sound power measurements
• Source-path-receiver relationship

Session 3
• Various Noise Sources
  • Product noise
  • Community Noise
  • Industrial noise
  • Vehicle noise
  • Aircraft noise
• Noise Control Principles
  • Sound package materials
  • Absorber, barrier, damper, isolator
  • Mufflers, resonators
  • Active and passive noise control

Introduction to Contemporary Muffler Design Techniques

.5 Days
I.D.# C1352

Most muffler design in the automotive industry is accomplished by using “cut-and-try” methods that rely on what has worked in the past and/or extensive full-scale testing on engines for validation. New computer software aimed at muffler design can shorten the design cycle and yield more effective results.

This four hour seminar provides an introduction to the behavior of mufflers and silencers including a description of the two-port approach to muffler design. This seminar covers the acoustic simulation of muffler and silencer systems and the use of experimental methods to measure muffler performance. Following a review of basic muffler concepts and definitions, this seminar will focus on meeting design objectives such as insertion loss with a specified back pressure requirement. This seminar will show how modern software such as SIDLAB can be used to model both the acoustics and flow in achieving the design objective and the role that 1D engine simulations can play in providing important input. The final topic will cover optimizing muffler design to meet a specified design objective with a specified space constraint. The main focus is on IC-engine intake and exhaust systems, but most of the information is also applicable to any pipe or duct system.

Learning Objectives
By attending this seminar, you will be able to:
• Explain the underlying principles of mufflers and silencers
• Gain insight into muffler and silencer design concepts using contemporary software
• Understand experimental methods for measuring muffler and silencer performance
NOISE, VIBRATION AND HARSHNESS TECHNOLOGY

Who Should Attend
This course is designed for engineers and technical managers seeking an understanding of the principles of muffler design and an introduction to the use of muffler and silencer design software. In addition, other personnel from companies that design, purchase, or manufacture muffler or silencer systems will also benefit from the information presented in this seminar.

Topical Outline
• Overview of Engine Exhaust and Intake Systems  
  • Definitions: TL, IL, etc.  
  • Performance measures for intake and exhaust systems  
• Engine Exhaust and Intake Systems Measurement Methods  
  • Measurement of TL  
  • Measurement of IL  
• Design Approach for Exhaust and Intake Systems  
  • Two-port method for modeling  
  • Typical results for muffler system design  
• Software for Engine Exhaust and Intake Modeling Design  
  • Optimization to meet a specific design objective  
  • Examples of muffler system design

Instructors: Andrew F. Seybert
Fee $395 .4 CEUs

Introduction to NVH Aspects of Hybrid and Electric Vehicles
1 Day
I.D.# C1128

The influx of different hybrid and electric vehicle configurations has brought about unique NVH challenges from a variety of sources. NVH refinement is an important aspect of powertrain development and the vehicle integration process. While developing the NVH behavior of the vehicle is critical to satisfy customer expectations, it is also important to consider the influence of reduced exterior noise levels on pedestrian safety. This seminar introduces participants to basic NVH principles and unique NVH challenges encountered in the development of HEV, ReEV, and EV including engine start/stop behavior, electric motor whine, driveline NVH, body structure, influence of noise from accessories, and sound quality development, as well as potential countermeasures.

Learning Objectives
Upon completion of this seminar, you will be able to:
• Articulate the basic principles of NVH  
• Describe the relative importance of powertrain noise, wind noise, and road noise in the vehicle’s interior  
• Identify the key sub-components of powertrain noise and means to control them  
• Explain the key NVH issues specific to electrified vehicles and means to develop appropriate countermeasures  
• Identify key metrics available to assess the NVH performance of electrified vehicles  
• Develop an awareness of advanced NVH methodologies available to design the sound character of electrified vehicles

Who Should Attend
This seminar has been developed for engineers involved in all fields related to the design or development of electrified vehicles. Individuals involved with component design/release responsibilities in ICE, electric motor, transmissions, powertrain mounts, vehicle body, and chassis areas will find this course helpful.

Topical Outline
• Automotive NVH Fundamentals  
  • Fundamentals of noise, vibration, and sound quality  
  • Vehicle NVH  
  • Powertrain-induced interior noise  
  • Engine noise  
  • Transmission noise  
  • Driveline noise  
  • Intake noise  
  • Exhaust noise  
  • Road-induced noise  
  • Wind noise  
  • Vehicle interior noise simulation for powertrain-induced noise  
  • Vehicle interior noise simulation for road-induced noise  
  • Vehicle sound quality  
  • Vehicle exterior noise simulation  
• HEV, ReEV, PHEV, and EV NVH  
  • HEV, ReEV, PHEV, and EV architecture definition  
  • “Road Map” for vehicle NVH development of HEV, ReEV, PHEV, and EV  
  • ICE start/stop noise using case study examples  
  • ICE start/stop vibration using case study examples  
  • Active control for start/stop refinement using case study examples  
  • Motor NVH using case study examples  
  • HEV/EV driveline NVH using case study examples  
  • Power electronics noise  
  • Accessory noise  
  • Application of powertrain-induced vehicle interior noise simulation  
  • Application of road-induced vehicle interior noise simulation  
  • Sound character of EV using case study examples
Practical NVH Signal Processing Methods

2 Days  
I.D.# CO431

Signal processing has become a critical tool in optimizing vehicle noise. This seminar will help you to understand the foundation common to all NVH data acquisition equipment including digitizing, windows, aliasing, averaging techniques, and common analysis functions such as the power spectrum, transfer function and coherence. Fundamental concepts such as filtering, modulation, convolution, and correlation, as well as specialized techniques used in rotating machinery such as adaptive re-sampling and order tracking, will be covered. The seminar will also cover multi-input multi-output (MIMO) signal processing, array based solutions for force identification, source and path characterization and data visualization. Brief introductions to emerging concepts will also be explored and computer demonstrations, physical experiments and case studies will be used to illustrate applied, real-world problems.

Learning Objectives

By attending this seminar, you will be able to:
• Explain the fundamental controls typical in modern spectrum analysis tools
• Interpret NVH data and judge its relevance to physical phenomena
• Extract new types of useful information from NVH data
• Implement new signal processing techniques

Who Should Attend

NVH technicians, engineers and managers who want to understand how NVH data is produced and interpreted will find this seminar valuable. The material is presented at a level suitable for beginners, but offers the more experienced practitioners new insight into the concepts presented through the illustrations and demonstrations that are included.

Topical Outline

• Properties of the FFT
  • Sampling and digitizing
  • Aliasing and filters
  • Leakage and windows
  • Averaging techniques

• Autopower, crosspower and coherence
• Transmissibility and isolation
• Measuring and interpreting the transfer function
• Rotating Machinery Basics
  • What is an order?
  • Rotation synchronous data acquisition methods
  • AM and FM modulation effects
  • FIR, IIR and re-sampling filters
  • Up-sampling down-sampling and adaptive re-sampling
• Time Frequency Methods
  • Short time Fourier transform
  • Gabor expansion and Gabor transform
  • Orthogonality, invertability and the dual function relationship
  • Gabor order tracking
  • Introduction to wavelets
• Fundamentals of Multi-Input-Multi-Output (MIMO) System Analysis
  • Review of Single-Input-Single-Output (SISO) systems
  • Introduction to Single-Input-Multiple-Output (SIMO) systems
  • Partial correlation concepts
  • Coherent output power
  • Statistical errors in basic estimates
  • Conditioned spectral analysis
• Forces and Sources in MIMO Systems
  • Least squares solution techniques
  • Force estimation technique Conditioned Source Analysis (CSA)
  • Case history: transfer path analysis
  • Case history: model correlation and updating
• Introduction to Data Classification and Pattern Recognition
  • Techniques for building and analyzing feature vectors
  • Recognition engines: neural networks and hidden Markov models
  • Applications: machine noise recognition, vision based gear mesh quality
SAE ENGINEERING ACADEMIES

Immersive training covering core engineering topics. Cost-effective and time-efficient educational programs taught by experts dedicated to helping the industry.

- Engineering Management
- Diesel Engine Technology
- Vehicle Noise Control
- Hybrid and Electric Vehicle
- Automotive Composites Technology

training.sae.org/academies
Sound Package Materials for Vehicle Noise Control

2 Days
I.D.# 92032

A similar course is available as a live, online web seminar - Vehicle Sound Package Materials – see course description below. The sound package materials for vehicle noise control seminar provides a detailed and thorough analysis of three different classes of acoustical materials - namely absorbers, barriers, and dampers, how they are different from each other, and acoustical properties that materials should possess for optimum vehicle noise control. The seminar addresses new advances in acoustical materials, primarily in absorption materials that impact the vehicle acoustics. The seminar covers ways to evaluate the acoustical performance of these materials using different test methods, including material, component, and vehicle level measurements. The two day seminar starts with the fundamentals of NVH and sound quality related to sound package materials and discusses the importance of various noise sources that impact the development of sound package treatments in a vehicle.

Learning Objectives
By attending in this seminar, you will be able to:
- Identify various descriptors that are used in NVH and sound quality while working with sound package materials
- Recognize various noise sources and paths in a vehicle
- Identify three different classes of acoustical materials
- Describe ways that acoustical materials work and how they differ from each other
- Road map for vehicle sound package development
- Distinguish test methods used to evaluate the acoustical performance of material

Who Should Attend
Designed for OEM or supplier employees responsible for various noise activities, such as design, evaluation, trouble-shooting, procuring, supplying, and/or manufacturing noise control treatments and parts, this seminar will also benefit those with responsibilities including the areas of manufacturing, design, engineering, process, noise and release engineering, supervision or management. Attendees should have an undergraduate engineering degree and/or a working knowledge of noise control and automotive acoustics.

Topical Outline
- Fundamentals of NVH and Sound Quality
  - Defining acoustical performance of acoustical parts
  - Definition of terms
  - Human response to sound
- Various noise and vibration instrumentation
- Vehicles Noise Sources and Solutions
  - The noise system
  - Vehicle noise sources
  - Road and wind noise
- Miscellaneous noise sources
  - Noise control solution - source, path, receiver
  - Noise control system using sound package materials
- Materials for Vehicle Noise Control
  - Absorber, including case studies and test methods
  - Barrier, including case studies and test methods and the effect of holes
  - Damper, including case studies and test methods
  - Isolator
- Different Automotive Measurements
  - Vehicle
  - Component
  - Material

Instructor: Pranab Saha
Fee $1375 1.3 CEUs

Vehicle Sound Package Materials Web Seminar and Web Seminar RePlay

8 Hours
Web Seminar: I.D.# WB1204
Web Seminar RePlay: I.D.# PD331204ON

A similar course is available as a classroom seminar - Sound Package Materials for Vehicle Noise Control – see course description above.

This four-session web seminar provides a detailed understanding of the source – path-receiver relationship for developing appropriate sound package treatments in vehicles, including automobiles, commercial vehicles, and other transportation devices. The course provides a detailed overview of absorption, attenuation (barrier), and damping materials and how to evaluate their performances on material, component, and vehicle level applications. A significant part of this course is the case studies that demonstrate how properly designed sound package materials successfully address vehicle noise issues.

Learning Objectives
By participating in this web seminar, you will be able to:
- Identify various descriptors that are used in acoustics while working with sound package materials
- Identify three fundamentally different sound package materials that are used in the industry
NOISE, VIBRATION AND HARSHNESS TECHNOLOGY

• Explain how these materials work and how to improve their performance
• Describe how various measurements are made and why they are necessary on a material level, component level, and vehicle level
• Prescribe appropriate sound package materials for specific NVH issues
• Construct proper protocols for combining different sound package materials for different components so that the final vehicle meets the required acoustic target

Who Should Attend
This web seminar will be especially valuable for those new to the vehicle sound package area and those interested in how absorbers, barriers, and dampers work, how they are different from each other, how they interact with each other in an application, and what one needs to be aware of while making measurements so the results are meaningful. The course is also designed for OEM or supplier engineers and those in roles involved with design, evaluation, trouble-shooting, procuring, releasing, supplying, and/or manufacturing noise control materials and parts for passenger cars and light trucks, heavy trucks, off-highway vehicles, farm machinery, and other transportation systems including aircraft, watercraft and rail transit.

Topical Outline
• Vehicle Noise Sources and Solutions
  • The noise system – sources
  • Ranking noise paths
  • Source-path-receiver relationship
  • The noise control system using sound package materials
  • Calculating Onboard Energy Storage Needs
  • Sound Package Material – Absorber
    • Application
    • Primary function
    • Effect of various parameters
  • Sound Package Material – Absorber (cont’d)
    • How it works
    • How to improve performance
    • Case studies
    • Measurements
• Sound Package Material – Barrier
  • Application
  • Primary function
  • How it works
  • How to improve performance
  • Case studies
  • Measurements
• Sound Package Material – Damper
  • Application
  • Primary function
  • How it works
  • How to improve performance
• Case studies
• Measurements
• Component and Vehicle Level Noise Measurements

Instructor: Pranab Saha
Fee $640 .8 CEUs

SAE MULTI-COURSE CERTIFICATE PROGRAMS
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate.

Intended to provide a guide towards deeper knowledge in a specific area, SAE’s multi-course certificates outline required courses that offer foundational knowledge of the subject. Some certificate programs also feature additional electives designed to broaden your exposure to more specific aspects of the technology studied. PLUS—completion of many of the multi-course certificate programs equates to graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S in Mechanical Engineering. Visit training.sae.org/collegecredit for more information.

SAE offers these multi-course certificate programs:
• Transmission/Drivetrain
• General Management and Leadership
• Professional and Legal Issues
• Diesel Technology
• SI Engine
• Vehicle Dynamics
• Product Engineering Tools and Methods
Visit training.sae.org/credentialing/certificate for more information
NOISE, VIBRATION AND HARSHNESS TECHNOLOGY

RELATED TRAINING SOLUTIONS
Explore these courses related to noise, vibration, and harshness listed in other sections of this resource guide.

Brake Noise Problem Resolution
This course will provide you with an overview of the various damping mechanisms and tools for analyzing and reducing brake noise. A significant component of this course is the inclusion of case studies which will demonstrate how brake noise squeal issues have been successfully resolved.

Read more about this course on page 10

Introduction to Brake Noise, Vibration, and Harshness
This seminar provides an introduction to brake NVH, including a concise summary of the various brake NVH problems, current lab and vehicle measurement techniques and SAE global standards which are utilized to characterize the noise correctly in order to get the best option/solutions quickly.

Read more about this course on page 16

Vibration Analysis Using Finite Element Analysis (FEA) Web Seminar
This web seminar introduces vibration analysis performed with Finite Element Analysis (FEA). The course reviews basic concepts of vibration analysis and illustrates how they are implemented in FEA to simulate product behavior. The most common types of vibration analysis such as modal, time response, and frequency response are covered.

Read more about this course on page 56
POWER AND PROPULSION

Includes vehicle powertrain and its various components, internal combustion systems and their emissions control, hybrid and electric vehicles, and fuels.

POWERTRAIN AND DRIVETRAINS

A Familiarization of Drivetrain Components

2 Days
I.D.# 98024

A similar course is available on demand – A Familiarization of Drivetrain Components e-Seminar – see course info below.

An efficient, robust, and quiet running drivetrain is as essential to customer satisfaction as styling and interior creature comforts. In this seminar, you will be exposed to various methods that can be used to accomplish this goal. Designed to help you visualize both individual components and the entire drivetrain system - without reference to complicated equations - this seminar focuses on the terms, functions, nomenclature, operating characteristics and effect on vehicle performance for each of the drivetrain components. Attendees will receive an introduction to the various components of the drivetrain, including the clutch or torque converter, manual or automatic transmission, driveshaft, axle, wheel ends, and brakes.

This course also provides insight into: the structure and function of each component; vehicle integration; and related noise, vibration and harshness issues. You will be equipped to evaluate the space requirements, mounting needs, clearances required, and effect on vehicle response for each component.


Learning Objectives

By attending this seminar, you will be able to:

• Discuss both practical and technical aspects of smoothing clutch operation by incorporating cushion and torsional dampers.
• Compare different types of transmission synchronizers, automatic transmission torque converters, hydraulic clutch operation and epicyclic gear trains.
• Describe the interaction of gear ratios and vehicle performance as related to engine horsepower and torque curves.
• Explain phasing and mounting of propeller shafts as related to torsional excitation and secondary couple loads
• Review different types of differentials.
• Compare common misconceptions of limited slip devices to their actual performance.
• Recognize four-wheel drive systems and the need for an inter-axle differential.
• Appraise electronic control of torque through braking and clutching devices.
• Evaluate the total drivetrain package as a system.

Who Should Attend

This seminar is intended for engineers now working with passenger car, sport utility, truck, bus, industrial, and off-highway vehicles who have had minimal prior experience with the total drivetrain.

3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at 1-724-772-8529
• Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org
Topical Outline

DAY ONE
• Clutch (dry/wet)
• Pressure Plate (Cover)
  • Direct pressure
  • Indirect pressure
  • Belleville
  • Over center springs
• Disc
  • Hub
  • Facing support member
• Torsional damper -- damper springs; co-axial damper springs; damper friction devices
• Facings - Organic; Ceramic/metallic; cushion types
• Linkage Hydraulic
  • Cable
  • Mechanical
• Transmission
• Automatic
  • Hydraulically controlled
  • Electronically controlled
  • Planetary or epicyclical gearing
  • Hydraulic multi-disc clutches
• Torque Converters
  • Impeller
  • Turbine
  • Stator
  • Lock-up clutch
• Manual
  • Synchronized
  • Non-Synchronized
  • Electronically shifted
  • Gear rattle
• Propshaft
• Cardan Joints
  • Torsional excitation -- cancellation (two or more joints)
  • Secondary couple
• Constant Velocity Joints
  • Rzeppa type
  • Others
• Axle
  • Rigid -- Semi-float; Full-float; Carrier type; Banjo type
• Steering
  • Independent
• Gearing -- Spiral bevel; Hypoid
• Differentials
  • Two pinion; Four pinion
  • Limited slips
  • Full locking
  • Plate types -- spring loading of plates; springs between side gears and plates; springs between gears; gear loading of plates

DAY TWO
• Axle (continued from Day One)
• Transfer Case
• Full Time
  • The requirement for a differential -- bevel differential; planetary differential
• Part Time
  • Two-wheel drive; Locked four-wheel drive
• Wheel Ends
  • Independent
  • Live vs. Dead Spindle
  • Bearing architectures
• Brakes
  • Disc; Drum
  • Hydraulics
  • Master Cylinder, Proportioning valve
  • Electronic Control of Brakes and Torque
  • Anti-Lock Brake Systems

Instructor: Joseph Palazzolo
Fee $1465 1.3 CEUs

A Familiarization of Drivetrain Components e-Seminar

5.25 Hours
I.D.# PD130555ON

A similar course is available as a classroom seminar — A Familiarization of Drivetrain Components — see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this five and a quarter hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This is divided into seven video modules and a coordinated handbook.

View the complete description and a video demo at training.sae.org/eseminars/drivetraincomponents.

What You Will Receive:
• 90 Day access
• through MyLearn.sae.org
• Links to streaming video modules
• Course Handbook (downloadable .pdf’s, subject to DRM)
Power and Propulsion

- Online Pre-test (self-test, immediate results)
- Online Post-test (self-test, immediate results)
- CEUs/Certificate of Achievement (with satisfactory post-test score)

Instructor: Joseph Palazzolo
Fee $295 .5 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

Fundamentals of Automotive All-Wheel Drive Systems

1 Day
I.D.# C0305

A similar course is available on demand – Fundamentals of Automotive All-Wheel Drive Systems e-Seminar – see course info below.

This seminar provides an introduction to the fundamental concepts and evolution of passenger car and light truck 4x4/all-wheel drive (AWD) systems including the nomenclature utilized to describe these systems. Basic power transfer unit and transfer case design parameters, component application to system function, the future of AWD systems, and emerging technologies that may enable future systems are covered.

Students with limited experience with the total drivetrain should consider participation in A Familiarization of Drivetrain Components. See course description on page 112.

Learning Objectives

By attending this seminar, you will be able to:
- Identify front wheel drive and rear wheel drive vehicle architectures
- Identify part time, full time, and on demand all-wheel drive systems
- Explain the benefits of all-wheel drive over two-wheel drive
- Quantify all wheel drive traction and mobility benefits
- Describe auxiliary axle disconnect systems
- Explain basic vehicle dynamics performance and the effect of AWD on performance
- Identify couplers vs. biasing devices and their basic function
- Describe the differences between mechanical and electrical implementation in AWD systems
- Describe basic control strategies and logic
- Discuss advanced propulsion concepts and systems

Who Should Attend

This seminar is designed for engineers (working with passenger cars, light trucks, and SUVs) who need to master AWD component, and the function and effect of those components. Engineers new to the 4WD/AWD field, as well as managers, marketing personnel, purchasing professionals and others interested in all-wheel drive fundamentals will benefit from this seminar.

Topical Outline

- Front wheel drive and rear wheel drive vehicle architectures
  - Engine layout - Transverse vs. longitudinal
  - Transmission layout - Transaxle vs. longitudinal
  - Axle layout - Independent vs. beam
  - Powerflow - typical power transmission arrangements
- Part time, full time, and on demand all wheel drive systems
  - Modes of operation
  - Performance benefits
  - Usage profiles
  - Twin systems
- Benefits of all-wheel drive as compared to two-wheel drive
  - Performance
  - Weight
  - Packaging
- Quantifying all-wheel drive traction and mobility benefits
  - Vehicle dynamics
  - Stability Acceleration
- Auxiliary axle disconnect systems--Function; Design
- Basic vehicle dynamics performance and the effect of AWD on performance
  - Oversteer; Understeer; Neutralsteer
  - Traction Effects; Stability Effects
- Couplers vs. biasing devices
  - Functions of couplers
  - Functions of biasing devices
- Types - mechanical, electrical, speed sensing, torque sensing
- Mechanical vs. electrical implementation in AWD systems
  - Active control
  - Passive control
- Effects of AWD driveline configuration on NVH and weight
  - Consequences of axle ratio selection
  - Halfshaft and propshaft options
- Basic control strategies and logic
- Advanced propulsion concepts and systems
  - Active differentials
  - Independent wheel control
  - Hybrid electric all-wheel drive

Instructor: Joseph Palazzolo
Fee $800 .7 CEUs
Fundamentals of Automotive All-Wheel Drive Systems e-Seminar

4.5 Hours
I.D.# PD130556ON

A similar course is available as a classroom seminar—Fundamentals of Automotive All-Wheel Drive Systems – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this 4.5-hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. It is an excellent follow-up to SAE’s A Familiarization of Drivetrain Components e-Seminar (which is designed for those who have limited experience with the total drivetrain).

View the complete description and a video demo for this course at training.sae.org/eseminars/awdsystems

Instructor: Joseph Palazzolo
Fee $265 .5 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

Fundamentals of Gear Design and Application

2 Days
I.D.# CO223

Through informative discussions and detailed explanations, this seminar will provide a solid and fundamental understanding of gear geometry, types and arrangements, and design principles. Starting with the basic definitions of gears, conjugate motion, and the Laws of Gearing, those attending will be given the tools needed to understand the inter-relation and coordinated motion operating within gear pairs and multi-gear trains. Basic gear system design process and gear measurement and inspection techniques will also be explained. In addition, the fundamentals of understanding the step-wise process of working through the iterative design process required to generate a gear pair will be reviewed, and attendees will also briefly discuss the steps and issues involved in design refinement and some manufacturing considerations. Also, an explanation of basic gear measurement techniques, how measurement equipment and test machines implement these techniques, and how to interpret the results from these basic measurements will be covered.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the “Law of Gearing,” conjugate action and specifically, involute profiles
• Review the various definitions and terms used in gearing
• Identify the function and operation of all gear arrangements
• Appraise preliminary design considerations and the gear system design process
• Explain practical gear measurement and inspection techniques, tools and equipment
• Recognize “Best Practices” in regards to gear system design
• Discuss some of the new and automated gear design systems

Who Should Attend
The intended audience for this seminar is powertrain engineers, engineering directors and managers, component suppliers, vehicle platform powertrain development specialists, and those involved in the design and application of geared systems and assemblies. This seminar will appeal to anyone who is interested in gears, gear systems, design development or measurement and inspection techniques. More specifically, anyone responsible for the following will benefit:
• Mechanical power transmission system design, development, durability assessment and application
• Application and development of geared systems technologies
• Management of transmission designers and manufacturers
• Supply of components and sub-systems to mechanical power transmission system manufacturers

Prerequisites
Attendees should have an undergraduate engineering degree to attend this program. This seminar is intended for powertrain engineers, engineering directors and managers, component suppliers, vehicle platform powertrain development specialists, and those involved in the design and application of geared systems and assemblies.

Topical Outline
DAY ONE
• Principles of Gears
  • Purpose of gears
  • Basic concepts -- Law of gearing; common tooth forms
  • Classification of gears
  • Definitions and terms used in gearing
  • Velocity ratio
  • Pitch surfaces
• Gear Tooth Action
  • Conjugacy
  • Profile curves
  • Surface of action
  • Profile sliding
POWER AND PROPULSION

- Gear Geometry and Nomenclature
  - Principle of planes
  - Tooth nomenclature; Blank nomenclature
- Gear Arrangements
  - Simple gear train;
  - Compound gear train -- ratios
  - Epicyclic -- configurations (solar, planetary, star); ratios;
  - Tooth number selection and build requirements; application
- Preliminary Design Considerations
  - Gear type selection
  - Preliminary estimate of size
  - Stress formulations
  - Gear Drawing Data

DAY TWO
- Gear System Design Process
  - Calculation of gear tooth data
  - Gear rating practice
- Gear Design Process
  - Layout
  - Root geometry
  - Backlash
- Gear Measurement and Inspection
  - Dimension over pins; Pin diameter
  - Modify pin diameter and dimension over pins
  - Pin contact point
  - Charts - involute; lead; red liner
  - Dimension sheet
- Gear Design Systems and Best Practices
  - Common proportions
  - Interchangeability
  - Tooling considerations
  - Mounting considerations
  - Best practices
  - Application

Instructor: William Mark McVea
Fee $1365 1.3 CEUs

Fundamentals of Modern Vehicle Transmissions

3 Days
I.D.# 99018

A similar course is available on demand – Fundamentals of Modern Vehicle Transmissions e-Seminar – see course info below.

Starting with a look at the transmission’s primary function -- to couple the engine to the driveline and provide torque ratios between the two -- this updated and expanded seminar covers the latest transmission systems designed to achieve the most efficient engine operation. Current designs, the components and sub-systems used, their functional modes, how they operate, and the inter-relationships will be discussed.

A manual transmission display will be used to explain ratios and how they function within the driveline. Automatic transmission design will illustrate the concept of automatic control and hydro-mechanics theory and implementation. Attendees will have the opportunity to supplement these theoretical concepts with practical, “hands-on” experience using the various transmission models and components provided. Mechatronics, toroidal transmission functions, and the future of the automatic transmission will also be discussed.

Continuously Variable Transmission (CVT) systems, which represent a fundamental shift in the way power is transmitted from the primary source to the remainder of the driveline will be the focus of in-depth coverage on the third day of this seminar.

Learning Objectives
By attending this seminar, you will be able to:
- Explain the development, operational aspects and design principles of passenger vehicle and light truck transmission systems, their major components and sub-systems
- Describe the operational parameters and inter-relationships of each of the sub-systems
- Apply basic design synthesis and analysis techniques for each of the major components and sub-systems
- Compare and contrast ‘stepless’ to ‘stepped’ transmission technology
- Identify and describe the function and operation of all major components and sub-systems by participating in hands-on demonstrations
- Recognize the limitations, technological trends, and potential new products under consideration
- Summarize the direction of new passenger car transmission designs and systems

Who Should Attend
This seminar is intended for anyone not familiar with the operational theories or functional principles of modern vehicle transmission systems. As the material covered is targeted at a number of design and engineering disciplines, attendees should have a minimum of two years design experience in the automotive powertrain field, or preferably a B.S. in engineering or related field.

Topical Outline
DAY ONE
- Overview of Mechanical Power Transmission in a Passenger Vehicle and Light Truck -- Manual transmission; automatic transmission; continuously variable transmission (CVT)
- Theory, Function and Operation of Manual Transmission -- Design; main components; common configurations
- Vehicle Powertrain Requirements and Specifications Assessment
- Shift Strategy Analysis and Control System Implementation
- Components and Sub-systems -- Shifters, clutches, synchronizers, gears, shafts
- Basic Gear Theory and Application Development
- Powerflow Analysis
- Synchronizer Operation and Analysis
- Lubrication and Cooling Requirements Review

DAY TWO
- Development and Layout of the “Automatic” Transmission -- Front-wheel drive; rear-wheel drive; four-wheel drive
- Functionality -- Torque converter operation; gear systems; gear design considerations; type; layout; NVH (Noise, Vibration and Harshness); epicyclic powerflow
- Extension of Gear Theory to Epicyclic Gear-trains
- Design and Operation of Clutches and Bands
- Application of One-Way/Over-Riding Clutches
- Powerflow Analysis of Torque Converters, Epicyclic Gear Sets
- Review of Shift Strategy
- Implementation of Shift Strategy Through Hydro-Mechanical Control Systems
- Simple Shift Model Analysis
- Lubrication and Cooling Requirements Review

DAY THREE
- CVT Design and Operation -- Theory and function; typical layout; main components
- Technological Development of the CVT
- Basic Theory of Friction Drives
- Toroidal Drive Technology -- Theory of operation; main components; benefits and limitation of the technology
- Functionality and Characteristics of CVT Components, Sub-systems -- Gearbox housing; variators; forward clutch; converter housing; input shaft; selector shift valve; differential; output shaft; mechatronic control unit; belt/push chain
- CVT Power-Flow -- Torque converter; primary variator; secondary variator; output shaft
- Mechatronics -- Theory and operation; general implementation; CVT application
- CVT Manufacturing -- Considerations; major manufacturers; future CVT development
- Future Technologies -- “Manualized” automatics, automated manuals; DCT, SSCT, DSCT

Instructor: William Mark McVea
Fee $1770 2.0 CEUs

Fundamentals of Modern Vehicle Transmissions e-Seminar
14 Hours
I.D.# PD130419ON
A similar course is available as a classroom seminar--Fundamentals of Modern Vehicle Transmissions -- see course info above.
Convenient, portable, and with core content from the instructor-led seminar (view seminar description above), this 14 hour e-seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace.

The course is divided into nine video modules, accompanied by a handbook.

View the complete course description and video demo at training.sae.org/eseminars/fmvtrans

What You Will Receive:
- 90 Day access
- through MyLearn.sae.org
- Links to streaming video modules
- Course Handbook (downloadable .pdf’s, subject to DRM)
- Online Pre-test (self-test, immediate results)
- Online Post-test (self-test, immediate results)
- CEUs/Certificate of Achievement (with satisfactory post-test score)

Instructor: William Mark McVea
Fee $695 1.4 CEUs

Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.

High-Performance Differentials, Axles, & Drivelines
2 Days
I.D.# CI113
Every automobile has a differential and most have axles, yet the exact function of these is not common knowledge. This comprehensive seminar introduces participants to the function and interfaces of axles and their individual components. As we modify cars for street performance or all out race applications, it is important to know the trade-offs in the drivetrain system. The theory and practice of axle systems is introduced along with

Catalog Key Classroom Live, Online On Demand Certificate ACTAR approved
a hands-on style approach to repairing and modifying axles for high performance applications. For this hands-on approach, actual hardware will be reviewed in an informal setting.

The seminar begins by defining the axle fundamentals and operation followed by an in-depth review of original equipment axles, differentials, torque bias, hypoid gears, and rebuild steps. The different manufacturing and service techniques required for different gear architectures is also reviewed. The seminar concludes with a unique applications-specific workshop and industry trends discussion. Upon completion of the seminar, attendees will have a working knowledge of axles, hypoid gearing, and differentials (open and limited slip), along with typical performance enthusiast modifications for race teams and weekend warriors.

The book, "High-Performance Differentials, Axles, and Drive-lines," by Joseph Palazzolo is included in the course materials.

**Learning Objectives**

By attending this seminar, you will be able to:

- Identify vehicle specific axle types
- Evaluate the differences between open and limited slip differential (LSD)
- Distinguish between the different torque transfer characteristics of the different LSD technologies
- Identify how to correctly set and adjust bearing preload and hypoid contact patterns
- Describe how to assemble and disassemble a differential
- Explain the steps to set-up a new gear set and bearings
- Recognize the difference required between typical passenger car applications and high-performance, race style axles

**Who Should Attend**

This seminar is intended for automotive engineers and mechanics who are working in the driveline area. This also includes performance shop mechanics and race teams that are modifying axles for specific on and off-road applications. Any performance-minded amateur, professional racer, or race team would also benefit from attending this seminar.

**Topical Outline**

- Axle Fundamentals
  - Lube flow
  - Venting
  - Housing reaction loads
- Axle housing types
  - Beam axles - Banjo / Salisbury
  - Independent axles
  - Quick change axles
  - Axle tubes
  - Axle shaft retention methods
  - Common axle identification
- Axle rebuild
  - Common axle problems
  - Axle disassembly; Axle Reassembly
  - Component inspection
- Differentials
  - Theory and practice of open differential
  - Factory installed limited slip differentials
  - Torque bias ratio explanation
  - Teardown and rebuild process
  - Review preload and friction modifier
- Aftermarket differentials
  - Review advantages and disadvantages of the following:
    - Open differentials; Locking differentials
    - Limited slip differentials
    - Spool and mini-spools
    - Helical differentials
    - Viscous control differentials
    - Torque Vectoring
- Hypoid Ring and Pinion Gears
  - Gearing fundamentals
  - Spiral bevel review
  - Hypoid
  - Review face milling vs. face hobbing
  - Review how to correctly set-up gear set
  - Review correct contact pattern
  - Importance of bearing preload and how to set
  - Break-in procedure
  - Tire size, speedometer accuracy
- Axle Shafts
  - Primary function; Materials
  - Spline details
- Driveshafts
  - Driveshaft considerations
  - Universal joint: Replacement; Sizes; Retention methods
  - Pinion angle

**Instructor:** Joseph Palazzolo

**Fee:** $1385 1.3 CEUs

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**Introduction to Powertrain Calibration**

**Engineering Web Seminar**

5 Hours  
I.D.# WB1346

Driven by the need for lower emissions, better fuel economy and improved drive quality, optimized powertrain calibrations are required for the many different vehicle configurations on today's roadways. While powertrain components such as the internal combustion engine, transmission, and hybrid electric powertrain
are somewhat familiar to the automotive industry, the control theory, calibrations and system interactions between these components are a relatively unfamiliar aspect.

This Web Seminar will introduce participants to the concepts behind optimized powertrain calibrations and how they impact fuel consumption, exhaust emissions, and vehicle performance. Participants will also gain exposure to the role that the calibration plays in the system level interactions of the various powertrain components.

Each participant will be asked to view the recording from the one-hour SAE Vehicle/Powertrain Calibration Engineering: What Is It and Why Is It For You? Telephone/Webcast as a course requirement.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
• Describe the role of calibration in powertrain and vehicle performance
• Identify the fundamental requirements that drive powertrain calibration development
• List the major international regulatory agencies
• Identify the driving factors for complexity of powertrain systems
• Identify the powertrain system interactions that are influenced by calibration
• Recognize tools used in the development of powertrain calibrations
• Diagram the high level calibration process flow

Who Should Attend
This Web Seminar is intended for anyone who would like a better understanding of powertrain calibration and how it influences vehicle performance and drivability. Engineering students with an automotive interest through automotive professionals will gain insight into the calibration process and its system impact. It will also be beneficial to those involved in the specification, design, development, testing and planning of vehicles and powertrains. Product planners and program managers will find the overview aspects helpful.

Topical Outline
Session 1
Requirements, Boundary Conditions and Complexity
• Fundamental requirements driving powertrain calibration
  • Regulations
  • Vehicle Requirements: Environmental requirements
• Overview of the factors driving complexity in powertrain calibration systems
  • Global requirements
  • Fuels
  • Product hardware

Calibration Functional Objectives
• Overview of some basic powertrain calibration tasks including base engine, transmission, OBD, aftertreatment, vehicle driveability
• Base Engine Calibrations
  • Steady state models (air charge, exh backpressure, knock thresholds)
  • Single point optimizations (spark, AFR, VVT, EGR, FUP, etc.)
  • Simple transients
• In-vehicle validation of dyno cals
  • Steady state correlation
  • Transient conditions
  • Knock behavior and fuel sensitivity
• Vehicle-specific Calibrations
  • Pedal progression
  • Drive/shift quality
  • Emissions
  • Performance
• Location-Specific Calibrations
  • Customer expectation of “normal” behavior in all climates
  • Hot weather (component protection)
  • Cold Weather (Emissions, startability, drive quality)
• Altitude (Emissions, startability, drive quality, performance)

Session 2
• Systems - How they interact
  • What is a powertrain system?
  • Powertrain subsystem calibration and interactions (engine, aftertreatment, transmission, hybrid, control)
• Overview of some basic powertrain components and their effects on the overall system
• Communication between systems and components
• The calibration engineer’s role in the overall development process as the bridge between hardware and controls
• Calibration Tasks
  • Testing environments for calibration engineers including simulations, engine test cells, powertrain test cells, chassis dynamometer test cells and test track/field testing
  • Tools of the trade - industry standard tools and specialized tools that calibration engineers use
  • Using test data to create a calibration including modeling, optimization and table generation

Instructor: Julian Blair, Greg Banish, Talus Park, Chi Binh La
Fee $425 .5 CEUs
Powertrain Selection for Fuel Economy and Acceleration Performance

2 Days
I.D.# C0243

Developing vehicles that achieve optimum fuel economy and acceleration performance is critical to the success of any automotive company, yet many practicing engineers have not received formal training on the broad range of factors which influence vehicle performance. This seminar provides this fundamental understanding through the development of mathematical models that describe the relevant physics and through the hands-on application of automotive test equipment. Attendees will also be introduced to software used to predict vehicle performance.

The course begins with a discussion of the road load forces that act on the automobile (aerodynamic, rolling resistance, and gravitational) followed by a review of pertinent engine characteristics. This background information is then used to show how appropriate gear ratios for a vehicle transmission are selected and to develop models for predicting acceleration performance and fuel economy. The models form the basis for the computer software used to predict vehicle performance. Participants will also use an in-vehicle accelerometer, GPS fifth-wheel, and an OBDII scanner to measure vehicle performance.

Learning Objectives

By attending this seminar, you will be able to:

• Explain the basic operation of the components in an automotive powertrain
• Calculate road loads on a motor vehicle

• Select appropriate gear ratios for a given engine/chassis combination
• Predict the effect of gear selection, body design, and weight on the fuel economy of a vehicle
• Explain and utilize the mathematical models for predicting the acceleration of an automobile
• Explain and utilize the mathematical models for predicting the fuel economy of an automobile
• Use computer software for predicting vehicle fuel economy and performance

Who Should Attend

As this seminar is designed for automotive engineers involved in the design and development of automotive powertrains (with special value for entry-level engineers and others seeking to develop a fundamental understanding), attendees should have a degree in mechanical engineering or a related field, be able to apply Newton’s second law of motion, and be familiar with spreadsheets and simple computer programming concepts.

Topical Outline

DAY ONE

• Course Introduction/Powertrain Configuration
  • Powertrain layout: front-wheel drive, rear-wheel drive, four-wheel drive
  • Powertrain components: engine, clutch/torque converter, transmission, drive shaft, differential, tires
• Road Load Forces and Power
  • Vehicle freebody diagram
  • Aerodynamic forces
  • Rolling resistance forces
  • Gravity forces
• Vehicle Coastdown Test
  • Theory behind coastdown test
  • GPS fifth-wheel
  • SAE Recommended Practice J1263
• Vehicle Ttractive Effort
  • Characterization of internal combustion engines
  • Characterization of pneumatic tires
• Drivetrain Selection
  • Vehicle design criteria
  • Selection of top gear & low gear ratio
  • Selection of intermediate gear ratios

DAY TWO

• Analysis of Power and Torque Flow in Drivetrain Components
  • Clutches
  • Standard & planetary gear sets
  • Axles and differentials
• Manual transmissions; Automatic transmissions
• Torque Converters
• Acceleration Performance Prediction
  • Vehicle acceleration modeling
Powertrain Controls (PTC) - Ford On Demand Course

6 Hours
I.D.# PD111013ON

The Ford Powertrain Controls (PTC) on demand course introduces the critical role the powertrain controls system plays in providing excellent vehicle performance, fuel economy, driveability, and emissions. The course describes the powertrain controls system components, including sensors and actuators. The information is presented from a functional, interface diagram, and p-diagram perspective, to enable reliable and robust powertrain operation.

This 6-hour on demand course is intended to stimulate systems interaction thinking by emphasizing powertrain controls interactions with internal and external interfaces and to help you understand powertrain control systems, prevent late design changes, reduce warranty costs, and improve customer satisfaction.

Major topics include:
- Powertrain Controls Overview
- Powertrain Controls Hardware
- Powertrain Controls Software/Calibration and Diagnostics
- Powertrain Controls Reliability and Robustness
- Powertrain Controls Interfaces
- Sensors and Actuators
- Powertrain Controls Modes of Operation

Is this SAE/Ford On Demand Course for you?
This course is geared toward powertrain, product development, quality, and manufacturing engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

What You Will Receive
- Three months of on demand access to the six hour course
- Proof of Participation

Fee $215
Powertrain As-Installed Stationary Subsystems (PAISS) - Ford On Demand Course

12 Hours
I.D.# PD111015ON

Powertrain as-installed subsystems have a common fundamental function to perform in harmony, enabling the engine to power the vehicle and/or accessories. There is a need to avoid issues such as idle roughness and to realize these are system interaction issues. For example, modal alignment affects idle roughness, and improving idle roughness can affect fuel economy.

This 12-hour Ford On Demand Course discusses hardware design, function, and major interfaces of powertrain as-installed stationary subsystems. It also discusses Design Verification System (DVS) metrics/performance requirements for each subsystem and how each subsystem affects other subsystems.

Major topics include:
- Accelerator Controls
- Air Induction
- Engine and Transmission Cooling
- Exhaust
- Fuel
- Powerplant Mounts

Is this SAE/Ford On Demand Course for you?
This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

What You Will Receive
- Four months of on demand access to the six hour course
- Proof of Participation

Fee $395

Powertrain Driveability - Ford On Demand Course

3 Hours
I.D.# PD111016ON

Driveability is the result of a system’s interaction between the powertrain, the vehicle, and the customer. Driveability concerns can arise in any mode of operation and have a common factor that all are the result of a change in engine/torque speed. Driveability is a key customer-driven Powertrain attribute. Improving driveability is critical to improving customer satisfaction and competitiveness of vehicles.

All Powertrain Product Development engineers must know how their area of subsystem responsibility could affect vehicle Driveability. This 3-hour Ford On Demand Course will provide knowledge of driveability fundamentals. With this knowledge, you can better determine actions to improve the customer’s perception of driveability.

Major topics include:
- The Customer’s Perspective
- Systems and Interfaces that Impact Driveability
- Evaluating a Vehicle’s Driveability Performance

Is this SAE/Ford On Demand Course for you?
This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

What You Will Receive
- Three months of on demand access to the three hour course
- Proof of Participation

Fee $115

Powertrain Performance Feel - Ford On Demand Course

3.5 Hours
I.D.# PD111017ON

In addition to NVH, Driveability, and Shift Quality, Performance Feel is among the four Powertrain attributes that directly influence customer satisfaction. It is defined in terms of the availability of power to the end customer and is the customer perception of performance that includes the effects of vehicle acceleration, accelerator control characteristics, shift character, and sound quality.

This 3.5-hour Ford On Demand Course is intended to increase the awareness of vehicle Performance Feel issues, target setting process, and the interactions and controls that affect Performance Feel.

Major topics include:
- Performance Feel from the Customer’s Perspective
- Performance Feel from an Engineering Perspective
- Metrics and Targets of Performance Feel
- Performance Feel Design Considerations

3 ways to get a no-obligation price quote to bring a course to your company • Call SAE Corporate Learning at 1-724-772-8529 • Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org
Is this SAE/Ford On Demand Course for you?
This course is geared toward powertrain, product development, quality, and manufacturing engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

What You Will Receive
- Three months of on demand access to the 3.5 hour course
- Proof of Participation

Fee $125

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Advanced Diesel Particulate Filtration Systems
2 Days
I.D.# C0502

As diesel emissions regulations have become more and more stringent, diesel particulate filters (DPF) have become possibly the most important and complex diesel aftertreatment device. This seminar covers many DPF-related topics using fundamentals from various branches of applied sciences such as porous media, filtration and materials sciences and will provide the student with both a theoretical as well as an applications-oriented approach to enhance the design and reliability of aftertreatment platforms. Structure, geometry, composition, performance, applications and optimizations of DPFs are some of the main topics covered in this advanced level seminar. Computer simulation techniques for analysis and optimization of DPF performance are also demonstrated.

Learning Objectives
By attending this seminar, you will be able to:
- Discuss fundamental, moderate and advanced topics on DPF structure, geometry, composition, performance, applications and optimizations
- Formulate porosity, permeability, inertial loss coefficient, flow resistance descriptors, different particulate transport modes (diffusional, interceptive), etc. to develop models for predicting backpressure of DPF
- Recognize different modes of particulate filtration regimes in DPF
- Select, design, utilize and optimize DPF for various light duty and heavy duty aftertreatment applications
- Predict, via modeling and simulations, various important DPF performance features (backpressure, peak regeneration temperature, etc.) as well as to analyze their failure modes and thus enhance the reliability of diesel exhaust aftertreatment platform designs

Who Should Attend
This seminar is designed for engineers, scientists, investigators and consultants involved in researching, developing, applications, designing or optimizing diesel exhaust aftertreatment components and systems. Individuals from technical and regulatory institutions as well as individuals from OEMs, suppliers, emissions service companies, research facilities and universities will gain modern knowledge of diesel filter performance.

Prerequisites
Students should have some technical insight into the performance of exhaust emission aftertreatment. Attendees with science or technology background (mechanical/chemical engineering, chemistry, physics) will benefit substantially from this seminar.

Topical Outline
DAY ONE
Porous Media Basics for Diesel Particulate Filters
- Pore space and structure definitions (definitions of relevant length scales, derivation of “pore metrics” such as correlation lengths, lineal path distributions.)
- Simplified representations of structures (unit cell models based on granular, cylindrical and composite collectors.)
- Flow resistance descriptors (Darcy permeability, Forchheimer coefficient, inertial loss coefficient as functions of wall micro-geometry, cell density, wall thickness, plug length)

Filtration Concepts for Diesel Particulate Filters
- Particle transport and deposition phenomena -- Condensed vs. vapor phases in diesel exhaust; Diesel fractal soot aggregate basics; Diffusional transport; Thermophoretic transport; Direct interception mechanism; Inertial transport mechanism; Other phenomena (electrical effects, sticking, entrainment by exhaust flow)
- Continuum filtration theory -- Deep-bed filtration regime; Cake filtration regime reconstruction of filter media
- True-to-the-geometry representations (digital reconstruction of filter media, micro-flow simulation with Lattice-based techniques and discrete particle dynamics. Examples applied to granular ceramic extruded filters, sintered metal filters, foam filters and fibrous textile filters.)
**POWER AND PROPULSION**

**Diesel Filter Types: Materials and Configurations in Practice**
- **Materials aspects**
  - Ceramics (oxide based): Cordierite, Mullite, other (Tialite/Aluminum Titanate, etc.); Non-oxide based: Recrystalized Silicon Carbide (R-SiC), Siliconized Silicon Carbide (Si-SiC), Silicon Nitride
  - Metallics (high temperature alloys) -- Sintered grains and fibers
- **Configurations**
  - Wall-flow honeycombs (square, triangular, symmetric vs. asymmetric channels.)
  - Pleated, foiled (sheet-based) designs
  - Fibrous, textile cartridges
  - Foam-based designs
  - Flow-through particulate collectors

**DAY TWO**

**Applications, Performance Optimization and Modeling of Diesel Particulate Filters**
- Filter backpressure/particulate loading -- Porosity, permeability, pore structure issues; Role of catalyst coatings; Filter size effects (length, diameter, cell density, wall thickness); Microstructure of soot deposits (physical and chemical properties); Soot deposition conditions and role on soot structure: Steady state, transients, cycles; Modeling aspects
- **Filter Regeneration**
  - Soot reactivity and structure -- Oxidation mechanisms (thermal, catalytic, NO2); Kinetic descriptions
  - Types of regeneration technologies -- Raising exhaust temperature by post-injection and/or by exhaust-port injection in combination with DOxC; Fuel borne additive-assisted regeneration; Catalyst coating-assisted regeneration; Reactive species-assisted regeneration (NO2-assisted, non-thermal plasma, etc.)
  - Simulation Techniques for Diesel Particulate Filters -- Brief history of DPF performance modeling; Backpressure -- Theory, insights and lessons; Modeling: demonstrations, validations; Regeneration -- Theory, insights and lessons; Modeling: demonstrations, validations
- **Ash Effects** -- Ash production, transport, deposition and thermal history; Ash effects on filter thermal management, catalyst activities, and filter sizing

**Automotive Heat Transfer**

2 Days
I.D.# CI230

Heat transfer affects the performance, emissions and durability of the engine as well as the design, packaging, material choice and fatigue life of vehicle components. This course covers the broad range of heat transfer considerations that arise during the design and development of the engine and the vehicle with a primary focus on computational models and experimental validation covering the flow of heat from its origin in the engine cylinders and its transfer via multiple paths through engine components. Specifically, the course will cover heat transfer design considerations related to the following: engine cooling and lubrication systems as well as bay-to-bay breathing; exhaust system and after-treatment components; tail pipe gas temperatures, as well as thermal interactions between the engine and its exhaust system with the components in the vehicle under-hood and under-body; turbochargers; passenger cabin HVAC system, including windshield de-icing; battery cooling; and heat exchangers and challenges associated with predicting thermal mechanical fatigue life of components.

**Learning Objectives**

By attending this seminar, you will be able to:
- Formulate solutions to heat transfer problems to optimize component design for durability and cost
- Make more reliable predictions of engine in-cylinder heat transfer rates (and therefore thermal stresses and fatigue life) for engine components, namely, the cylinder head, piston, cylinder liner, valves and ports
- Optimize design decisions for above engine components by improving trade-offs between material choices, design, durability, packaging, heat flow map and cost
- Specify thermal boundary conditions for under-hood and under-body CFD models early in a vehicle development program when only high level engine and performance metrics have been defined.
- Predict energy losses due to bay-to-bay breathing
- Describe techniques to facilitate thermal management of exhaust aftertreatment devices (DOC, SOC, particulate filters) and tail pipe exit gas temperatures for diesel vehicles

**Who Should Attend**

This course will be valuable to engine and vehicle engineers dealing with heat transfer issues. Specifically thermal and structural analysis engineers will learn best practices for making reliable analysis predictions. Hardware release engineers will gain a better appreciation of the limits and capabilities of the analysis and measurement technologies that drive their decisions. Supervisory and managerial persons with the responsibility for solving thermal problems that arise during sub-system design.

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Instructor: Athanasios Konstandopoulos & Mansour Masoudi

Fee $1375 1.3 CEUs
and development will gain a better appreciation of the uncertainties and trade-offs behind the thermal decisions for which they are ultimately responsible. Vehicle thermal engineers will gain knowledge to assist them in making design and packaging decisions in the early stages of vehicle development. This unique course will give in-depth insights into thermal considerations spanning the entire vehicle, providing subsystem specialists with an overall perspective of the other vehicle system issues and constraints with which they may not be familiar.

Topical Outline

• Introduction
  • Engine and exhaust components
  • Heat transfer CFD
• Engine In-Cylinder Heat Transfer
  • Benchmark in-cylinder measurements
  • Interaction of heat transfer with combustion
  • Zero & multi-dimensional modeling
  • Standard and modified wall functions
  • Low Reynolds Number Model
  • Heat transfer coefficients
  • Validation with measurements
• Engine Component and Sub-System Heat Transfer
  • Overview
  • Piston, liner, head and valve temperatures
  • Bay-to-bay breathing
  • Engine cooling system considerations
  • Engine lubrication system considerations
• Exhaust System Heat Transfer
  • Interaction with under-hood components
  • Design decisions early in a vehicle program
  • Turbochargers
  • After treatment devices
  • Tail pipe gas temperatures
  • Materials, properties and temperatures
  • Thermo-mechanical fatigue
• Heating, Ventilation and Air Conditioning
  • Passenger compartment human comfort
  • Energy transactions and heat transfer parameters
  • Energy balances
  • Air management
  • Refrigeration considerations
  • Windshield de-icing
• Heat Exchangers
• Battery Cooling
• Best Practices and Challenges
  • Best practices for heat transfer modeling
  • Challenges in simulation and measurement

Instructor: Raj P. Ranganathan
Fee $1275 1.3 CEUs

Catalytic NOx Control Technologies for Diesel and GDI Engines Web Seminar

6 Hours  
I.D.# WB1237

Lean burn engines (diesel and GDI) boast higher fuel economy and cleaner emissions than conventionally tuned engines while producing equivalent power. They employ higher combustion chamber compression ratios, significant air intake swirl and precise lean-metered direct fuel injection. The downfall of lean-burn technology, however, is increased exhaust NOx emissions (due to higher heat and cylinder pressure) and a somewhat narrower RPM power-band (due to slower burn rates of lean mixtures). Removal of NOx from exhausts is a critical need for emission standards and ambient ozone requirements. This three session Web Seminar will examine the various catalytic processes for lean burn applications, including Selective Catalytic NOx Reduction (SCR), NOx Trap Technologies (i.e. LNT, NSR), and the combination of SCR, NOx Trap and Hydrocarbon NOx Reduction (LNC). It will focus in on SCR NOx fundamentals, equipping participants with the basic concepts for NOx control and important design parameters for SCR NOx catalyst. The course will examine the system design for SCR in diesel applications including passenger cars and heavy duty trucks, including SCR catalysts, SCR integration with diesel particulate filter, key sensor development-catalyst durability issues and urea control.

Learning Objectives

By connecting with this Web Seminar, you will be able to:
• Define NOx catalysis and identify key acronyms
• Describe in-use issues
• Cite key elements in NOx catalyst design for diesel applications
• Define SCR design for passenger cars and heavy duty applications
• Identify available sensors for SCR catalyst performance monitoring
• Determine where lean NOx traps may be appropriate versus SCR NOx control

Who Should Attend

This Web Seminar will be especially valuable for mechanical, metallurgical and chemical engineers, materials scientists, and chemists involved in the design, operation and calibration of a NOx emission control system for both mobile and stationary source applications, such as automobiles, trucks, buses, ships, locomotives, stationary engines, small engines, etc. It will also help the newly hired engineer assigned to an emission control team, the seasoned veteran who just transferred to the emission control group, sales people responsible for emission controls, plant managers concerned about meeting new regulations with catalytic controls, and regulators now involved in transmission technologies. Participants should have a basic familiarity with automotive emissions for gasoline engines, diesel engines or...
off-road applications.

**Topical Outline**

Session 1
Lean NOx Catalysis
- NOx reduction catalytic approaches
- Lean NOx reduction fundamentals
- Hydrocarbon NOx reduction (LNC)
- NOx traps technologies (LNT, NSR or NAC)
- SCR Catalytic NOx reduction (ammonia based)
- Combination SCR/NOx traps

Session 2
SCR NOx Catalyst
- SCR NOx catalytic approaches (Vanadia and Zeolite)
- Performance characteristics of SCR NOx catalysts (Vanadia and Zeolite)
- Comparison of commercial issues with lean NOx traps and SCR

Session 3
SCR Catalyst Design Mobile Applications
- Passenger cars
- Heavy duty systems
- Auxiliary equipment design
- Sensor performance
- Catalyst durability

**Instructor:** Ronald Heck

**Fee:** $550 .6 CEUs

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**Combustion and Emissions for Engineers**

**3 Days**
**I.D.# 97011**

Public awareness regarding pollutants and their adverse health effects has created an urgent need for engineers to better understand the combustion process as well as the pollutants formed as by-products of that process. To effectively contribute to emission control strategies and design and develop emission control systems and components, a good understanding of the physical and mathematical principles of the combustion process is necessary. This seminar will bring issues related to combustion and emissions “down to earth,” relying less on mathematical terms and more on physical explanations and analogies.

**Learning Objectives**

By attending this seminar, you will be able to:
- Identify and describe the important processes in combustion and emission
- Identify the formation mechanisms and reduction strategies of pollutant species in combustion systems
- Recognize the effects of engine design and operating conditions on combustion and emission
- Explain the technology and the logic behind after-treatment of pollutants
- Identify the underlying laws and principles used in combustion and emission black-boxed computer programs
- Explain the role chemical kinetics plays in the design of low-emission combustion systems
- Identify design trade-offs between increasing engine performance and maintaining low emission characteristics

**Who Should Attend**

Engineers working on the design of combustion engine components, software development and application for modeling of thermal-fluid, combustion and emissions processes, and those working on the reduction of harmful pollutants emissions will find this course valuable.

**Topical Outline**

**DAY ONE**
- Air Composition
- Concept of “Complete Combustion”
- A/F & Stoichiometric (A/F) ST, and (Equivalence Ratio)
- Lean, Rich, Stoichiometric Mixture
- First and Second Law and Applications in Combustion Systems
- Adiabatic Flame Temperature, Heat of Reaction (or Heating Value) and Their Usage
- Thermodynamic and Chemical Equilibrium
- Demonstration Applications of Equilibrium Using Computer Simulation (SuperState)

**DAY TWO**
- Chemical Kinetics
  - General concept and rate of reaction (RR)
  - Classifying reactions
  - Reaction Between Gas Molecules and a Solid Surface
  - Physical absorption, chemisorption, and heterogenous catalysts
  - Nature of catalysis reaction
  - Arrhenius equation and activation energy
  - Analysis of data for complex reaction
  - General characteristics of catalysis
- Explosion
  - Simplified generalized kinetic model (slow reaction and explosion)
  - Explosion and flammability limits
  - Mechanism of H2O2 Reaction
  - Oxidation of CO
  - Explosion Limits of Hydrocarbons (HC)
  - Experimental combustion characteristics
  - Methane and Paraffin oxidations
  - Demonstration applications of chemical kinetics using
SuperState
• Autoignition and Induction Time Using SuperState
• Flame and its Propagation
  • Laminar flame structure
  • Laminar flame speed (Sl)
  • Flammability limits
  • Quenching distance dr
  • Flame stabilization
DAY THREE
• Combustion in SI Engines
  • Simple thermodynamic analysis of SI engine combustion
  • Flame and unburned gas motions
  • Mass fraction burned and heat release analysis
  • Combustion process characterization
  • Flame structure, speed, and effects of various parameters on burning rate
  • Sl turbulence & turbulent flame
  • Cyclic variability, partial burning & misfire
• Pollutant Formation and Control
  • Nature of problem SI & CI
  • NO and NO2 formation kinetics and reduction
  • CO kinetics and reduction
  • Unburned Hydrocarbon (UHC) emission and reduction
  • Effects of design and operating parameters on HC and NOx
  • Demonstration Applications of Pollution Effects Using SuperState -- Minor species; Lean-burn engine
• Exhaust Gas Treatments
  • Options
  • Catalytic converters
  • Thermal reactors
• Typical Engine Emission Results
• Emission Measurements
• FTP Emission Standards

Instructor: Bruce Chehroudi
Fee $1800 2.0 CEUs

Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems

3 Days
I.D.# C0707

On-board diagnosis of engine and transmission systems has been mandated by government regulation for light and medium vehicles since the 1996 model year. The regulations specify many of the detailed features that on-board diagnostics must exhibit. In addition, the penalties for not meeting the requirements or providing in-field remedies can be very expensive. This course is designed to provide a fundamental understanding of how and why OBD systems function and the technical features that a diagnostic should have in order to ensure compliant and successful implementation.

Fundamental design objectives and features needed to achieve those objectives for generic on-board diagnostics will be covered. The course will also include a review of the California Air Resources OBD II regulation, providing students with a firm foundation for reading and understanding the requirements, including the in-use rate portion of the regulations and how to properly calculate and output the required rate information. Relationships between the regulation and various SAE and ISO recommended practices will be reviewed. The course will also explore the relationship of the OBD system with the underlying control system.

Note that because of proprietary considerations, this class does not provide details of algorithm design, algorithm performance, or algorithm application. The class will cover general OBD algorithm designs and the features required to promote sound OBD system design.

Learning Objectives
By attending this seminar, you will be able to:
• Articulate the underlying design objectives of on-board diagnostic systems
• Use the latest California Air Resources Board On-Board Diagnostic Regulation for Light and Medium Vehicles to find and apply OBD requirements
• Apply the design features that all diagnostics need for successful implementation
• Design diagnostics to comprehend variation
• Successfully implement algorithms to track in-use rates in accordance with the CARB OBD II Regulation
• Use SAE J1979 to implement generic scan tool support in diagnostic design
• Implement OBD design requirements in control system design
Who Should Attend
This course is designed for engineers involved in either the design or control of on-board diagnostic systems for engines or transmissions for light and medium duty on-road vehicles. Individuals working in the heavy duty industry may also find the information interesting, but should note that the examples will be geared towards spark ignition engines and light and medium duty regulations. In addition, engineers involved in engine and transmission hardware will benefit by obtaining a better understanding of the design of OBD systems. Engineers new to the area of OBD system design and engineers involved in the design of control systems wishing to obtain a better understanding of OBD requirements will also find the course valuable.

Topical Outline
• Fundamental Design Objectives for OBD Systems
• Basic Design Features for OBD Systems
• Exercise: “Customers” and their OBD Requirements
• Overview of the World Wide OBD Regulatory Structure
• California Air Resources Board (CARB) Regulatory Process
• How to use the CARB Light/Medium Regulation
  • Malfunction and diagnostic system requirements
  • Enforcement of malfunction and diagnostic system requirements
• CARB Regulation - an in-depth look at:
  • In-use rates
  • Comprehensive component requirements
• Introduction to a Diagnostic Design Process (Box, Graves, Bisgaard, Van Gilder, et al)
• Defining “Good” vs. “Bad” Systems
• Exercise: Defining Good vs. Defective Systems
• Anatomy of an On-Board Diagnostic
• Diagnostic Modeling
• Exercise: Induction System Modeling
• Understanding and Dealing with Variation
• Decision making processes
• Design guidelines for Exponentially Weighted Moving Averages (EWMA)

DAY THREE
• SAE J1979 - An Overview
• Exercise: Finding Information in J1979
• System Design for Diagnosability
• Overview of Regulatory Requirements Related to OBD
  • In-use Enforcement
  • Emissions warranty
• OBD Certification Process
• The Relationship between the Control and OBD System Design

Instructor:  John Van Gilder
Fee $1820  2.0  CEUs

Evaporative and Refueling Emission Control
2 Days
I.D.# C0928

All gasoline powered vehicles and equipment create exhaust and evaporative and refueling emissions. Unlike exhaust emissions, which occur only when the engine is operating, evaporative emissions (evap emissions) occur all the time. Controlling evap emissions to PZEV levels is as challenging as controlling exhaust emissions. It becomes even more important in the case of plug-in hybrid electric vehicles (PHEV) and extended range electric vehicles (EREV) which generate evaporative fuel vapors, but have no place to burn/consume the vapors when the engine does not operate for extended periods of time. Constantly changing evaporative regulations including new test procedures for accommodating future EREVs and PHEVs vehicle evap systems, new test fuels to reflect changing commercial gasolines, identifying and controlling new sources of fuel vapor emissions, etc., require that individuals working in this area have a solid understanding of both regulatory and system design issues for evap emissions control.

This comprehensive seminar introduces the participants to the principles of gasoline evaporative fuel vapor generation (diurnal, hot soak, running loss, and refueling) from the vehicle fuel tank, fuel vapor storage in activated carbon canisters, and fuel vapor desorption and consumption in engine combustion. The seminar begins with an analysis of gasoline and gasoline/ethanol blends and estimation of their vapor pressures and vapor generation. In-depth analysis of various vapor generations as a function of fuel properties (ethanol content, Reid Vapor Pressure, etc.) and ambient conditions will be presented. Activated carbon canister design, OBD II leak detection, hydrocarbon permeation, and CARB and EPA evaporative test procedures will also be covered. Participants will have the opportunity to apply the knowledge gained by designing a sample evaporative and refueling emissions control system in class.

Participants are asked to bring a calculator for use in classroom exercises.

Learning Objectives
By attending the seminar, you will be able to:
• Identify various sources of evaporative fuel vapor emissions
• Predict the effects of ethanol on evaporative emissions
• Estimate diurnal and refueling vapor generation
• Analyze the differences in the test procedures: U.S., Europe, and Asia
• Explain activated carbon canister operation: loading, purging, vapor redistribution, and back-purge
• Identify potential solutions to induction hydrocarbon emissions
• Estimate the effect of altitude on evaporative emissions
POWER AND PROPULSION

Who Should Attend
This course is designed for engineers in all fields related to the design and development of evaporative and refueling emission control systems including platform fuel system design engineers for fuel tanks, onboard refueling vapor recovery systems, evaporative emission control canisters, fuel vapor lines, vapor purge lines, purge and vent valves, etc. Air induction system design engineers dealing with induction hydrocarbon adsorbers, powertrain fuel delivery design engineers responsible for canister purge vapors, powertrain calibration engineers responsible for evaporative canister purge and evaporative emission diagnostics, and environmental engineers who deal with state and federal emission regulations, will all find the seminar valuable.

Topical Outline

DAY ONE
• Introduction
  • Evaporative and refueling emission control system
  • Why and how to control fuel vapor emissions
• Fuel and Fuel Vapor Pressure
  • Hydrocarbon fuels
  • Oxygenated fuels and non-ideal solutions
  • Estimation of vapor pressures of ideal (hydrocarbon fuels) and non-ideal solutions (oxygenated fuels)
  • Flexible Fuel Vehicles (FFV) and fuel commingling
  • Vapor pressure and boiling point estimation
• Fuel Vapor Generation
  • Diurnal, hot-soak, running loss
  • Refueling - liquid seal and mechanical seal, hot tank/cold dispersed fuel, cold tank/hot dispersed fuel, RVP, air entrainment and vapor recirculation, etc.
  • Effect of altitude on vapor generation and fuel boiling in running loss test
  • Effect of oxygenates on fuel vapor generation and fuel boiling in running loss test

DAY TWO
• Carbon Canisters
  • Adsorbents and isotherms
  • Activated carbons
  • Adsorption/desorption phenomena
  • Canister vapor loading, purging, redistribution, and back-purge
  • Canister design
• Evaporative and Refueling Emission Control System Design
  • Test procedures - EPA & CARB 3-day test, EPA-ORVR, EPA & CARB 2-day test, ECE and other global EVAP test procedures, etc.
  • Canister sizing - determine optimum size
  • Purge air volume requirement
• Miscellaneous Evaporative Emission Control Topics
  • Hybrid and plug-in hybrid evaporative emission control
  • Pressurized/sealed and bladder fuel tank for evaporative emission control
  • Evap OBD II leak detection
  • Permeation losses - effects of materials, temperature, fuel composition, etc.

Instructor: Sam Reddy
Fee $1325 1.3 CEUs

Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems
1 Day
I.D.# C0235

Exhaust Flow Performance and Pressure Drop of Exhaust Components and Systems

1 Day
I.D.# C0235

Designing more efficient and robust emission control components and exhaust systems results in more efficient performance, reduced backpressure and fuel penalty, and higher conversion efficiency. This course will help you to understand the motion of exhaust flow in both gasoline and diesel emission control components including flow-through and wall-flow devices such as catalytic converters, NOx adsorsers, diesel oxidation catalysts, diesel particulate filters as well as flow through the overall exhaust system. Discussions will also cover: flow recirculation in inlet cones, flow maldistribution and its effect on conversion efficiency in flow throughs, non-uniform particulate deposit in diesel filters, and roots of non-uniformity in flow distribution due to exhaust system design such as bends.

Learning Objectives
By attending this seminar, you will be able to:
• Describe how exhaust stream is distributed in flow-throughs in gasoline or in diesel emission components and in wall-flow components (catalytic converters, NOx adsorbers, DOC, diesel particulate filters), including in inlet cones, exit cones, bends, elbows, flow constrictions, and in other components of an exhaust system
• Design exhaust systems yielding higher conversion efficiency, lower backpressure, faster light-off, and optimal performance
• Design diesel particulate filter systems yielding more uniform soot distribution in filters, thus lowering both filter backpressure and its peak regeneration temperature
• Describe connections between flow distribution and thermal performance such as light-off and radial and axial temperature gradients

Who Should Attend
This seminar is intended for engineers, managers, designers, researchers and technical associates who wish to gain deeper insight into developments and optimization of exhaust systems
and components. This also includes professionals involved with catalyst and emission components and exhaust sensors.

**Topical Outline**

- Flow-throughs (e.g., catalytic converters or NOx adsorbers)
  - The basics: flow distribution; roots of and various contributors to pressure drop; effect of geometry; effect of surface area, length and diameter; role of catalyst; etc.
  - How to optimize the performance
  - How to measure the pressure drop

- Wall-flows (e.g., diesel particulate filters)
  - The basics: flow distribution; roots of and various contributors to pressure drop; effect of geometry such as wall thickness, cell density, plugs, and aspect ratio; transport and deposit of particulate in filters and its effect on the filter performance; role of exhaust flow on regeneration
  - How to optimize the performance
  - How to measure the pressure drop

- Inlet and exit cones: flow recirculation in cones and its effect on backpressure and performance (e.g., conversion efficiency, particulate deposit, light-off, etc.)

- Similar analysis of other exhaust system components such as pipes, bends, elbows, and constrictions and expansions in the path of the exhaust flow

**Instructor:** Mansour Masoudi

**Fee:** $780 .7 CEUs

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**Exhaust Gas Recirculation (EGR) for Diesel Engines**

2 Days

I.D.# C1214

Meeting the requirements of heavy-duty engine emissions regulations is a challenge for all engine manufacturers. Since the introduction of Exhaust Gas Recirculation (EGR) in medium and heavy-duty diesel engines, these systems have become more sophisticated and tightly integrated with emission control systems.

This 2-day seminar will explore the advantages and disadvantages of EGR and the most effective implementation of various EGR systems. This seminar will begin by defining EGR and why it is used in diesel engines, along with an explanation of the mechanisms by which EGR is able to reduce NOx. This seminar will then move into implementation of EGR systems and examples of these systems on medium and heavy-duty diesel engines. In addition, the impact of EGR on various engine components will be discussed and will include EGR coolers, valves and piping.

Finally, a section will be devoted to the comparison between EGR and SCR and their future roles in reducing NOx emissions, as well as their impact on fuel efficiency and CO2 emissions. Emphasized in this comparison is the use of EGR in novel combustion systems and its ability to reduce emissions in-cylinder.

**Learning Objectives**

By attending this seminar you will be able to:

- Define EGR
- Recognize the different types of EGR systems used in diesel engines
- Evaluate the overall advantages and disadvantages of EGR systems in diesel engines
- Identify the impact of EGR on the combustion process
- Identify the impact of EGR on NOx and PM emissions
- Compare and evaluate EGR and SCR systems as a means to meeting emissions regulations

**Who Should Attend**

This seminar is designed for engineers and managers working in diesel combustion and emissions control technologies.

**Topical Outline**

**DAY ONE**

- Fundamentals of Exhaust Gas Recirculation
  - Defining EGR; Purpose of EGR
  - How EGR works
  - Why EGR is used in diesel engines
  - Types of EGR Systems and Implementation
  - HPL EGR
Ignition Issues and Their Impact on Engine Performance, Efficiency and Emission

2 Days
I.D.# C0131

Improved understanding and control of ignition and thereby combustion are critical in dealing with the problems of pollutants formation, engine performance, and fuel economy. This seminar will provide you with basic knowledge and recent advances in combustion-initiation (ignition) issues to more intelligently evaluate and harness their potentials. Thermodynamic and fluid mechanical properties of the unburned charge near the spark plug and at the time of ignition strongly affect the quality of the combustion and therefore the emission of the pollutants from the engine. Furthermore, a weak ignition limits engine performance and drivability. The so-called cyclic variability, which affects and bounds the lean and knock limits of an engine design is to a great degree influenced by the ignition system. Equally important, the ignition system can and is being used to provide local in-cylinder information on air-fuel ratio, misfire, knock, and mass fraction burned in each individual cylinder. Hence, great potential exists for applications of this information for individual cylinder control strategy to attain a more fuel efficient and environmentally compatible engine.

Learning Objectives

By attending this seminar, you will be able to:
• Describe the important processes in ignition and its relation to engine performance, efficiency, and emission
• Explain the combustion process in internal combustion engines
• Apply ignition strategies for reduction of engine pollutants
• Recognize the effects of ignition system design and engine operating conditions on combustion and emission
• Describe the technology and the logic behind the current and future ignition-based engine diagnostics
• Assist in the design of critical components such as combustion chambers and exhaust systems
• Identify key design components of an ignition system for optimum combustion chamber design and low engine emission of pollutants

Who Should Attend

This seminar will be especially valuable for engineers, technical and project managers, researchers, and academicians involved in ignition and combustion/emission aspects of the combustion engines. Currently, the design strategy of many components in these engines is affected by combustion and emission control measures to meet customer’s, federal and local government’s demands and regulations. Therefore, engineers working on the design of components for high efficiency and performance
of combustion engines as well as those directly and indirectly involved in ignition and emission reduction strategies will highly benefit from this seminar.

**Topical Outline**

**DAY ONE**
- A Concise Background on Combustion in Spark Ignited (SI) Engines
  - Cylinder pressure traces
  - MBT and ignition timing
  - Flame propagation issues
  - Combustion characterization
  - Cyclic variability
- Ignition Fundamentals
- Spark Ignition
  - Function of ignition system
  - Commonly used ignition systems
  - What determines the amount of ignition energy
- Four Phases of Spark Ignition
  - Pre-breakdown, breakdown, arc, and glow discharge

**DAY TWO**
- Effects of Some Key Parameters on Combustion, Emission and Performance
  - Higher power and/or energy
  - Longer duration discharge
  - Multiple spark plugs
  - Different spark plug designs
- Alternative Ignition Methods
  - Corona ignition system
  - Plasma-jet ignition system
  - Flame-jet ignition system
  - Activated radical (AR) ignition
  - Others
- Diagnostic and Control Opportunities
  - Use of spark voltage for monitoring combustion
  - Spark spectroscopy
  - Ionization measurement for engine health monitoring & diagnostics
- Ignition Systems for Highly Diluted Mixtures
- Conclusions

**Instructor:** Bruce Chehroudi

**Fee $1335 1.3 CEUs**

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**Selective Catalytic Reduction for Diesel Engines**

2 Days
I.D.# C0913

Stringent requirements of reduced NOx emission limits in the US have presented engineers and technical staff with numerous challenges. Several in-cylinder technical solutions have been developed for diesel engines to meet 2010 emission standards. These technologies have been optimized and have yielded impressive engine-out results in their ability to reduce emissions to extremely low levels. However, current and state-of-the-art in-cylinder solutions have fallen short of achieving the limits imposed on diesel emissions for 2010. To help meet emissions requirements, the catalyst industry has developed exhaust emission reduction technologies with impressive levels of performance. These technologies include hydrocarbon selective catalytic reduction (SCR), NOx absorber catalysts, and urea SCR.

This seminar will begin with an explanation of NOx formation in diesel engines and in-cylinder methods for reducing these emissions. The aftertreatment systems for NOx reduction will be explained and the advantages and disadvantages of these emission reduction technologies will be discussed.

In this two-day seminar, the primary focus is on urea SCR and its technology will be fully examined. The important chemical reactions and methods for improving SCR performance by encouraging desirable reactions and avoiding undesirable reactions are explained. Additionally, the components and control of a urea SCR system are detailed and the necessary sensors for its control are described. The SAE paper *Laboratory Testing of Urea-SCR Formulations to Meet Tier 2 Bin 5 Emissions* is included in the course materials.

**Learning Objectives**

By attending this seminar you will be able to:
- Identify how NOx is formed in diesel engines
- Identify the in-cylinder means for reducing NOx
- Evaluate NOx aftertreatment technologies for diesel exhaust.
- Describe the characteristic of selectivity in catalytic aftertreatment
- Apply selectivity to urea SCR
- Describe the features and components of a complete urea SCR system
- Learn how to optimize the control of a urea SCR
- Distinguish the differences between various catalytic SCR formulations
POWER AND PROPULSION

Who Should Attend
This seminar will benefit engineers and technical staff who are
developing urea aftertreatment systems for diesel engines,
including catalyst engineers who supply NOx aftertreatment sys-
tems to the diesel industry. Also benefitting will be suppliers of
other NOx reducing technologies, such as EGR components and
fuel injection systems, as well as on-highway and off-highway
diesel engine technical staff.

Prerequisites
Attendees should have knowledge of how a diesel engine op-
erates, including its 4-stroke operation. Additionally, attendees
should have basic knowledge of the emission formation mecha-
nism in internal combustion engines.

Topical Outline
DAY ONE
• Introduction
  • On-Highway diesel emission regulations
  • Non-Road diesel emission regulations
  • Passenger car diesel emission regulations
  • Light- Truck diesel emission regulations
  • EURO IV Regulations
  • EURO V Regulations
  • NOx regulations in Japan
  • Drivers for controlling NOx
• NOx Formation in Diesel Engines
  • Diffusion combustion model
  • The Zeldovich Mechanism
  • Pressure/Crank angle diagram
  • Heat release rate
• In-Cylinder Means for NOx Reduction
  • Injection timing retard
  • Multiple injections/combustion cycle
  • Charge air cooling
  • Exhaust gas recirculation
• NOx Afttreatment Systems for Diesel Engines
  • Lean NOx Catalysts (LNC), DeNOx Catalysts, HC SCR
  • Lean NOx Trap (LNT), NOx Adsorber Catalyst (NAC also
    NAK), and NOx Storage Reduction (NSR)
  • Selective Catalytic Reduction (SCR) using urea reductant
  • Derivatives: Ammonium Carbamate, Combination LNT/SCR
• Urea SCR Technology
  • Chemical reactions
  • Advantages/Disadvantages of the urea SCR system
  • Notable demonstration
DAY TWO
• Components of the Urea SCR System
  • Catalyst -- Extruded substrate; Coated substrate
  • Catalyst Type -- Vanadia/Titania/Tungsten; Iron Zeolite; Copper Zeolite
  • Catalyst volume and space velocity considerations
  • Urea injection system -- Air-Assist systems; Airless systems
  • NOx sensors
  • Urea specifications and suppliers
• System Calibration and Control Considerations
  • Effect of NH3/NO
  • Effect of NO2/NO
  • Ammonia slip
  • Exhaust architecture
• Regulatory and Market Considerations
  • Urea Infrastructure -- Bottles; Dispensers; Co-Fueling
  • End-user and urea refills
  • The Japanese experience
  • The European experience
  • Plans for USA manufacturers
  • Commercial vehicle market projections
• Urea Production and Distribution
  • The A.D. Little Report
  • The European experience
  • Passenger car diesel emission regulations
  • Light-Truck diesel emission regulations
• SCR Options and Configurations for Future NOx Limits
  • On-Highway heavy-duty diesels
  • Non-Road diesel engines
  • Passenger car diesels
  • Light-Truck diesels
  • Cold weather operation
• Closing and Evaluations

Instructor: Magdi Khair
Fee: $1375 1.3 CEUs

SAE SI ENGINE CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course
titles that are part of an SAE multi-course certificate
program.
Designed to familiarize you with key spark ignition engine
components and technologies and how they function as
a system, completing this certificate delivers a fairly deep
level of engine expertise and, at the same time, an SAE
credential. Complete the SI Engine Certificate and earn
seven or eight graduate credits towards the SAE/Kettering
University 20-credit Certificate in Automotive Systems and
Kettering’s 40-credit M.S. in Mechanical Engineering. Visit
training.sae.org/collegecredit. View the list of required and
elective courses and additional information on enrolling in
this SAE certificate program:
training.sae.org/certificate/siengine
HYBRID AND ELECTRIC VEHICLES

Energy Efficient Motor Drives and Power Electronics for EV, HEV, and PHEV Applications

4 Days
I.D.# C1045

Electric motor drives have emerged as one of the differentiating technologies in electric vehicles (EV), hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV). As a result, it is critical for engineers and technical decision-makers to understand the various energy-efficient motor drive technologies and how to apply them. Likewise, power electronics is one of the key technologies enabling the shift from conventional gasoline/diesel engine powered vehicles to electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs). Of particular importance are the power electronics converters used in EVs, HEVs, and PHEVs, which include rectifiers, unidirectional and bidirectional DC-DC converters, inverters, and battery chargers.

The first two days of this seminar begins with an introduction to the principle of power electronics followed by a thorough coverage of various converters. The unique aspects of power converters in EVs, HEVs, and PHEVs are addressed, including vehicle to grid technology and battery chargers. Distinctive characteristics of the operation of EV converters, such as uncontrolled rectification of permanent magnet motors, are covered in detail. Modeling and simulation of different power converters are demonstrated with hands on examples and hardware-in-the-loop concepts are briefly covered.

The second two-day module begins by defining energy-efficient motors and EV/HEV/PHEV motors. Following an in-depth study of induction motor drives, permanent magnet (PM) brushless motor drives, and switched reluctance (SR) motor drives, attendees will understand the core motor drive technology for EVs, HEVs and PHEVs. The course concludes with information on in-wheel motors, emerging motor technologies, and electric variable transmission (EVT) motor systems.

Learning Objectives

By attending this seminar, you will be able to:
- Identify energy-efficient motors
- Identify EV/HEV/PHEV motors
- Explain the differences between induction, brushless, and SR motor drives for EVs/HEVs/PHEVs
- Explain the differences between various in-wheel motors
- Identify a sound methodology for sizing EV/HEV/PHEV motors
- Describe how to approach finite element and thermal analyses of motors
- Describe EVT motor systems and various emerging motor technologies
- Explain the basic principle of power electronics and the operation principle of different converters
- Describe the uniqueness of EV/HEV/PHEV power converters
- Identify the appropriate power converter topology for different powertrain applications
- Identify passive components for power converters
- Model power converter circuits used in an EV/HEV/PHEV
- Select the semiconductor devices for major power converters in an EV/HEV/PHEV
- Describe vehicle to grid and battery charger technology
- Explain the implementation principle of hardware in the loop tools
- Identify emerging power electronics technologies

Who Should Attend

This course is designed for those who work in engineering, marketing, or manufacturing of powertrain systems or other electrical and mechanical aspects of EVs, HEVs, and PHEVs. In addition, this course can be valuable to those involved in renewable energy or transportation systems that utilize electric motors. Individuals new to the field of power electronics, electric motors and drives will benefit most from the material. This course is not intended for individuals with significant experience with power electronics or motor drives.

Prerequisites

An undergraduate degree in engineering or a strong technical background is highly recommended. Attendees should have taken an undergraduate or graduate course in basic electric circuits and/or basic electric machines, basic electric circuits, and basic electronics or be familiar with resources such as:
- Electric Circuits: J David Irwin: Basic Engineering Circuit Analysis, John Wiley & Sons
- Electronic Circuits (chapter 1 to 5 of Sedra and Kenneth C. Smith, Microelectronic Circuits, Oxford University Press

Topical Outline

DAY ONE
- Introduction to Power Electronics
- Modeling of power electronics
Fundamentals of Hybrid and Electric Vehicles

2.5 Days
I.D.# C1232

Electric and hybrid vehicles are still relatively new products and are undergoing developmental refinements as the technology moves towards maturity. There are challenges related to the fundamentals of the technologies, the availability of various materials and sub-systems, cost targets and customer demands. The technology is complex and multi-disciplinary involving system integration of diverse components. This course will cover the interdisciplinary aspects of electric and hybrid vehicles where engineers of various disciplines have to work together to develop the system. The fundamentals, design philosophies for electric and hybrid vehicles, component selection and sizing, and modeling and control strategies will be covered. Existing electric and hybrid vehicle models such as Nissan Leaf, Ford Focus, Tesla Roadster, Chevy Volt, Toyota Prius, Chevy Malibu, Ford Fusion etc. will be used as case studies. Participants will learn about the future trends in battery, power electronics and motor drive technologies.

Learning Objectives
By attending this seminar, you will be able to:
• Describe the pros and cons of different types of EVs and HEVs
• Perform basic designs of EV and HEV systems using series, parallel and series-parallel architectures
• Size an EV or HEV powertrain
• Size components for EVs or HEVs, including electric motors, power electronics and energy sources
• Develop specifications for EV/HEV systems and components
• Define the testing procedures for EVs and HEVs
• Discuss the emerging technologies, engineering challenges, and development trends in EVs and HEVs

Who Should Attend
This fundamental overview course is designed to provide an introduction to electric and hybrid vehicles for engineers in electrical, mechanical, chemical, automotive, and other related fields who are interested in the EV/HEV design, development, modeling, manufacture and marketing.

Topical Outline
DAY ONE
• Introduction to EVs and HEVs
  • Why electric vehicles and hybrid electric vehicles?
  • Environmental impact
  • Well-to-wheel efficiency analysis
  • How HEVs achieve improved powertrain efficiency/fuel economy and reduced pollutions
  • Interdisciplinary nature of EVs and HEVs
  • Future of EVs and HEVs
  • Opportunities in EVs and HEVs
• Vehicle Fundamentals
  • Roadway fundamentals
  • Tractive force and power requirements
  • Tire-road force mechanics
  • Powertrain component sizing
  • Energy storage requirements
  • Vehicle performance: acceleration, gradeability, maximum speed, fuel economy
• Electric Vehicles/Electric Power Transmission Path
  • Components of electric drivetrain
  • EV powertrain sizing example
  • Hybrid Vehicles /System Architectures
• Series, parallel, series-parallel HEVs: relative advantages, disadvantages
• Charge sustaining and charge depleting hybrids
• Mild, power and energy hybrids
• Plug-in electric vehicles

• HEV Powertrain Sizing Example
  • Component sizing and calculations
  • Mass analysis and packaging
  • Series HEV design example
  • Parallel HEV design example
  • Series-parallel HEV design example

• HEV Control Strategies
  • Vehicle supervisory controller
  • Mode control strategies (series, parallel or series-parallel options)
  • Modal control strategy (series, parallel and series-parallel controls)
  • Regenerative control
  • Power-split control strategy

• EV/HEV Modeling and Simulation
  • Vehicle and sub-system models
  • Modeling and simulation platform
  • Modeling examples using Matlab/Simulink
  • Commercial packages for simulation
  • Vehicle performance and analysis

DAY TWO
• Energy Storage Systems
  • Batteries: lead acid, nickel-metal hydride and Li-ion batteries
  • Ultracapacitors
  • Fuel cells
  • Compressed air
  • Hybridization of energy source
  • Battery management systems

• Electrical Machines and Drives
  • Fundamentals of electric motor drives
  • Sizing of electric motors for EV and HEV
  • AC and DC electric machines
  • Induction motor drives
  • Permanent Magnet (PM) synchronous motor drives
  • Interior PM motor drives
  • PM brushless DC motor drives
  • Switched reluctance motor drives

• Power Semiconductors and Electronics
  • Power semiconductors in hybrid-electric powertrains
  • DC-DC converters
  • Battery chargers
  • Wireless power transfer

• High Voltage System
  • Safety issues
  • System example schematics

• Motor Drive System Modeling and Simulation
  • PM motor drive simulation

• Induction motor drive simulation

DAY THREE (ends at 12:30 PM)
• Controls and Communications
  • Microcontrollers and DSPs for controls and communication
  • In-vehicle communications network
  • Controller Area Network (CAN)
  • Advanced communications protocols

• Current EVs and HEVs
  • Nissan Leaf
  • Tesla Roadster
  • Ford Focus
  • Chevy Volt
  • Toyota Prius
  • Toyota Camry
  • Ford Fusion

• Special Topics
  • Off-road vehicles
  • Auxiliary Systems for EV/HEVs
  • Electromagnetic compatibility (EMC) issues
  • Thermal management
  • System integration issues
  • After sales: reliability and servicing

• Emerging Technologies
  • Non rare-earth machine technologies
  • Post silicon devices: Silicon Carbide and Gallium Nitride
  • Vehicle-to-grid technologies
  • Smartgrid technologies

Instructor: Iqbal Husain and Yilmaz Sozer
Fee $1670 1.7 CEUs

Fundamentals of Hybrid Electric Vehicles
3 Days
I.D.# C0511

One of the fastest growing automotive fields, hybrid electric vehicles (HEVs), presents both opportunities and challenges. HEVs are more fuel-efficient and environmentally friendly compared to conventional vehicles. Optimizing the power intake in HEVs allows the engine operation to be kept within the range designed for best fuel economy and lowest emission, while the motor/generator system either provides additional power input, or generates electricity using the excessive power from the engine. It also recovers the kinetic energy during braking or coasting. These advantages have attracted worldwide development interests for HEVs in the automotive industry. Global sales of hybrid vehicles continue to grow.

The challenges presented in HEVs include power electronics, electric motors and generators, batteries, power management,
thermal management, and system integration. Additional challenges related to after-sales issues include reliability, gracefully degradable operation, and servicing.

This three-day seminar will cover the fundamentals of HEV. In an easy-to-understand format, the course will explain the engineering philosophy of HEVs, the component selection and design, modeling, and control of HEVs. Some existing HEV models such as the Toyota Prius, Honda Civic, Mercury Mariner, Saturn VUE and Camry will be used as case studies.

**Learning Objectives**

By attending this seminar, you will be able to:

- Describe the pros and cons of different types of HEVs
- Implement fundamental HEV design parameters
- Develop specifications for HEV systems and components
- Perform basic design of HEV systems, using parallel, series, or complex topologies
- Develop models and perform simulations of HEVs; simulate the fuel economy and emissions of HEVs
- Size a HEV powertrain
- Size HEV components, including motors, energy sources and motor controllers
- Calculate the regenerative braking performance of a HEV
- Describe the testing procedures for HEVs
- Compare and contrast hydraulic hybrid and electric hybrid systems
- Discuss the emerging technologies, engineering challenges, and development trends in HEVs

**Who Should Attend**

This fundamental overview course is designed to provide an introduction to HEVs for engineers in electrical, mechanical, automotive and other related fields who are involved or interested in HEV development, design, modeling, manufacturing and marketing.

**Topical Outline**

**DAY ONE**

- Introduction to Hybrid Electric Vehicles
  - Environmental impacts of HEVs
  - Interdisciplinary nature of HEVs
  - Configuration of HEVs, parallel, series and complex HEVs
  - State-of-the art HEVs
  - HEVs vs. diesel engine vehicles
  - The future of HEVs
  - Opportunities in HEVs
- HEV Fundamentals
  - Vehicle resistances
  - Traction and slip ratio models
  - Vehicle dynamics
- Transmission: gear transmission, CVT and planetary gear systems
- Vehicle performance: maximum speed, gradeability and acceleration
- Fuel economy and improvement
- Braking performance
- Sizing of HEV powertrains
- Vehicle modeling
- Power management
- Vehicle control
- HEV Modeling and Simulation
  - Vehicle model
  - Modeling and simulation basics
  - Vehicle performance
  - Modeling examples using ADVISOR
- Power Electronics
  - The need for power electronics in HEVs
  - Overview of power electronics circuits in HEV powertrains
  - Fundamentals of power electronics
  - Bidirectional DC/DC converter
  - Inverter and motor control
  - Regenerative braking and rectification

**DAY TWO**

- Series HEV Powertrain Design
  - Concepts of hybridization
  - Hybrid architecture
  - Series hybrid configuration and functionality
  - Operation patterns, advantages
  - Control strategies
  - Power management
  - Sizing of major components
  - Design examples
  - Modeling of series HEVs
- Parallel HEV Powertrain Design
  - Parallel architecture and operation modes
  - Torque coupling
  - Speed coupling
  - Torque and speed coupled architecture
  - Control strategies and power management
  - Design example and modeling using ADVISOR
  - Mild hybrid and micro hybrid
  - Complex hybrid
  - Plug-in hybrid
- Electric Propulsion Systems
  - Fundamentals of electric motor drives
  - DC motor drives
  - Induction motor drives
  - Permanent magnet synchronous motor drives
  - Brushless DC PM motor drives
  - Switch reluctance motor drives
  - Sizing of electric motors and power electronics in HEVs
Introduction to Hydraulic Hybrid Systems for Road Vehicles

2 Days
I.D.# C0833

Considerable attention has been given to the design and efficiencies of electric hybrid propulsion systems and energy storage technologies. Although they draw much less attention, hydraulic hybrid propulsion and regenerative braking systems for road vehicles are a cost effective alternative to electric systems and have relevance to important sectors of the passenger and commercial vehicle markets.

In this two-day seminar, hydraulic hybrid vehicle systems and their potential will be examined using model based evaluations. This will include an evaluation and comparison of hybrid configurations as well as the introduction of components used in these hydraulic hybrid systems. Also provided will be details on how hydraulic systems are designed and integrated into vehicles, including interactions with braking systems and various other vehicle systems. Recent developments in hydraulic machines and an update on the component technology needed to implement these solutions will also be presented.

Learning Objectives
By attending this seminar, you will be able to:
• Identify the fundamentals of parallel and series hydraulic hybrid vehicle transmission systems and components
• Evaluate the applicability of such systems to particular vehicle applications
• Identify how hydraulic hybrid system components can be integrated into the vehicle
• Recognize the interactions with other vehicle systems (e.g. engine, transmission, ABS, foundation brakes) and integration of controls

Who Should Attend
This course will benefit individuals new to hydraulic hybrid systems as well as engineers and designers involved in all areas related to the design and development of vehicle powertrain systems. Also benefiting will be individuals interested in the interaction of this hybrid system with braking systems and engine controls.

Topical Outline
DAY ONE
• Introduction and Overview
  • Objectives
  • Course outline and scope
• Hybrid Vehicle Systems - Outline and Comparisons
Basic information on hybrids is scattered among information sources, and is often difficult to synthesize. In this two-hour Web Seminar, energy storage systems, inverters, motor-generators, and DC-DC converters are explained, as well as design considerations for both light-duty and heavy-duty vehicle powertrains and developing trends such as plug-in, flywheel and hydraulic hybrids.

**Learning Objectives**

By connecting with this Web Seminar, you will be able to:

- Describe the efficiency improvements that hybrid vehicles achieve with respect to conventional vehicles
- Identify common components of hybrid powertrains
- Recognize basic layouts utilized in light, medium, and heavy-duty hybrid vehicle powertrains
- Compare the advantages and disadvantages of different hybrid architectures
- Summarize hybrid powertrain applications that are on the market today
- Explain upcoming HEV developments

**Who Should Attend**

This course is designed for the engineer, manager, or marketing professional who needs a quick overview of the design and manufacture of hybrid vehicle powertrains. Industry professionals who want a broad yet concise overview of the technological aspects of current and upcoming hybrid powertrains will benefit. Anyone who is unfamiliar with basic hybrid technology, yet whose job will be impacted by hybrid vehicles in the future, will benefit from this Web Seminar. A basic understanding of road vehicle construction and operation will be helpful.

**Topical Outline**

- Types of hybrids
  - Gasoline-electric hybrids (HEV)
  - Diesel-electric hybrids (HEV)
  - Hydraulic hybrids (HH)
- Hybrid-electric powertrain components
  - Energy storage systems
  - Motor controllers; Motor-generators
  - DC-DC converters
  - Safety interlocks and circuits
  - Ancillary systems
- Series hybrid architectures
  - Advantages and disadvantages of series hybrids
  - Upcoming commercialization of series hybrids
- Parallel hybrid architectures

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**Introduction to Hybrid Powertrains**

**Web Seminar and Web Seminar RePlay**

2 Hours
Web Seminar: I.D.# C0903
Web Seminar Recording: PD330903ON

Hybrid powertrains have been on the market for more than a decade and have become one of the most successful alternative powertrains available today. More than a million hybrids are sold globally per year, primarily in Japan and the US. Some OEMs estimate that up to 80% of their light-duty vehicles may require some level of hybridization to meet upcoming CAFE regulations in the United States. Hybrids are also starting to make inroads into markets in Europe, and have recently been introduced to Chinese and Indian markets, among others.
**POWER AND PROPULSION**

- Engine-assist systems; Through-the-road systems
- Series-parallel hybrid architectures
  - Power-split hybrids
  - GM “two-mode” hybrids
- Plug-in Hybrids
  - Advantages and disadvantages of PHEVs
  - Early PHEV conversions
  - Commercialization of PHEVs
  - Design considerations for PHEVs
- Hybrid vehicle trends and developments
  - Effects on IC engine development
  - Research and development trends
- Identify the different design configurations and requirements of electric drives in hybrids, plug-in hybrids, fuel cell hybrids, and battery electric vehicles
- Classify different types of battery packs, inverters, motors, and DC-DC converters
- Analyze the design and construction of a given electric powertrain, and evaluate its particular attributes and drawbacks
- Assess fault detection and protection strategies and circuits as well as on-board diagnostic requirements
- Appraise technical limitations of electric drive components, as well as design and technological trends that may address such limitations

**Who Should Attend**

Powertrain engineers, electrical engineers, project planners, project managers, technical writers, safety officers, component specialists, component suppliers, and anyone else who is professionally impacted by the development of electric vehicle technology will be able to use this information to help them transition to working with electric drives. Participants should have a basic knowledge of electric circuits. This is an introductory Web Seminar; a mechanical or electrical engineering degree is helpful but not necessary.

**Topical Outline**

**Session 1**

- Battery Packs, Capacitors, and Energy Management
  - Calculating Onboard Energy Storage Needs
  - Battery Chemistries and Lithium-Ion Sub-Chemistries
  - Electrolytic Double Layer Capacitors
  - Combination Systems (Hybrid Battery-Capacitor Systems)
  - Battery Pack Performance
  - Integrating an Energy Storage System into the Chassis
  - System Relays and Power-on Sequences
  - Battery Management Systems and Communication with the CAN Bus
  - Thermal Management Systems and Considerations
  - System Degradation
  - Onboard Charging Strategies
  - Failure and Diagnostic Modes
  - Recycling and Recovery of Battery Cell Material

**Session 2**

- External Charge-Discharge Systems and DC-DC Converters
  - Charging Systems for Electric Vehicles
  - Inductive and Conductive Charging
  - Charger-to-Vehicle Communication
  - Power Supply Considerations
  - Vehicle-to-Grid Systems
  - Switching Power Supplies and DC-DC Converters
  - Packing and Thermal Management of DC-DC Converters
  - Failure and Diagnostic Modes
  - Power Requirements of Drive-By-Wire Systems

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**Instructor:** Jack Rosebro

**Fee:** $270 \( \approx .2 \) CEUs

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**Principles of Electric Drives Web Seminar**

8 Hours

I.D.# WB0941

Electric drives are found in hybrid, plug-in hybrid, and hydrogen fuel cell vehicles, as well as battery electric vehicles. More than two million hybrid vehicles worldwide utilize electric drive components, and battery technology has matured enough to enable major manufacturers to develop light-duty and commercial electric vehicles for mass production and sale beginning in 2010-2012. It is also likely that many conventional vehicles will incorporate some form of idle-stop or stop-start system comprised of a low-output electric drive, as an integral part of efforts to meet U.S. CAFE fuel economy standards and EU CO₂ emission requirements.

Industry professionals who are looking for a general understanding of the structure and components of vehicular electric drives will benefit from this course, which will cover theory, design, operation, and diagnostics of all major components used in electric drives (battery packs, inverters, motor-generators, DC-DC converters, and charging apparatus) as applied to all forms of vehicles, including charge-sustaining hybrids, plug-in hybrids, fuel cell hybrids, and battery electric vehicles. Battery chemistry, charging systems, power conversion, switching techniques, and traction motor construction will be discussed in detail.

**Learning Objectives**

- Explain the design, function, and interactions of all major components of a typical electric vehicle powertrain
- Describe the operation, attributes, and behavior of battery packs, inverters, motor-generators, on-board and off-board charging systems, and DC-DC converters across all ranges of performance

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Session 3
Inverters and Fundamentals of Power Electronics
- Power Transistors And Switching Operation
- Basic Motor Control Producing AC Waves from a DC Supply
- Capacitors in Inverters
- Pulse-Width Modulation
- PWM Inefficiencies
- Overmodulation and Six-Step Control
- Space-Vector Modulation
- Boost Converters
- Thermal Management of Inverters
- Circuit Protection
- Failure and Diagnostic Modes
- Upcoming Power Electronics Developments and Enhancements

Session 4
Synchronous and Asynchronous Motor-Generators
- Flux Linkages and Rotating Magnetic Fields
- Rotor and Stator Construction
- Torque Production, Motor-Generator Types
  - Permanent-Magnet
  - Induction; Reluctance
  - Enhanced Lundell Motor-Generators
- Operation in Motor, Generator, and High-Speed Modes
- Field-Weakening
- Choosing a Motor-Generator, Thermal Management of Motor-Generators
- EMF Considerations
- Failure Modes and Diagnostic Strategies

Instructor: Jack Rosebro
Fee $640 .8 CEUs

Common Rail Diesel Fuel Injection
1 Day
I.D.# C0920
The improved efficiencies of the modern diesel engine have led to its increased use within the mobility industry. The vast majority of these diesel engines employ a high-pressure common rail fuel injection system to increase the engine's fuel-saving potential, emissions reduction, and overall performance. This one-day seminar will begin with a review of the basic principles of diesel engines and fuel injection systems. Diesel and alternative fuels will be discussed, followed by current and emerging diesel engine applications. The majority of the day will be dedicated to the common rail system itself, beginning with a comprehensive overview of the complete system. The instructor will then introduce the main subsystems, including hydraulics and controls. Finally, the subsystems will then be broken-down into their respective components.

Learning Objectives
By attending this seminar you will be able to:
- Identify the basic principles of diesel engines and diesel fuel injection
- Distinguish the main properties of diesel and diesel alternative fuels
- Compare and evaluate various diesel engine applications
- Describe the main systems and sub-systems of common rail diesel fuel injection and how these systems interact
- Identify the main design features of the common rail components
- Discuss basic common rail control strategies

Who Should Attend
This course will benefit engineers and other individuals involved in the design, application, and service of common rail diesel engines utilized in passenger cars, light/medium/heavy-duty trucks, and off-highway vehicles, including marine and farm machinery.

Topical Outline
- Basic Principles of Diesel Engines
- Basic Principles of Diesel Fuel Injection
- Diesel and Alternative Fuels
- Applications -- Passenger car; Light-duty; Heavy-duty; Off-highway; Pressure history
- Common Rail System Overview
  - Low-pressure system
  - High-pressure system
  - Controls
- Hydraulic Components
  - Pumps -- Radial piston; Inline piston
  - Rails
  - Injectors -- Solenoid; Piezo
  - Nozzles
  - Control valves -- Pressure control valve; Metering unit; Pressure relief valve
  - High-pressure lines
- Controls
  - Overview
  - Requirements
POWER AND PROPULSION

- Functions
- Components
- ECU
- Sensors
- Actuators
- Diesel Engine Overview
- Seminar Summary

Instructor: Vincent Piacenti
Fee $780 .7 CEUs

Diesel Engine Technology

2 Days
I.D.# 93014

A similar course is available on demand – Diesel Engine Technology e-Seminar – see course info below.

As diesel engines become more popular, a fundamental knowledge of diesel technology is critical for anyone involved in the diesel engine support industry. This course will explain the fundamental technology of diesel engines starting with a short but thorough introduction of the diesel combustion cycle, and continue with aspects of engine design, emission control design, and more. An overview of developing technologies for the future with a comprehensive section on exhaust aftertreatment is also included.

The text, Diesel Emissions and Their Control, authored by Magdi Khair and W. Addy Majewski is included with the seminar.

Learning Objectives

By attending this seminar, you will be able to:
- Summarize the technological advances in modern diesel engines
- Evaluate the sources of emissions from diesel engines and the influence of engine component design on curbing these emissions
- Explain diesel exhaust aftertreatment systems and their effectiveness in reducing emissions
- Recognize the importance of fuel injection parameters to performance and emission control

Who Should Attend

You should attend this seminar if you are involved in diesel engine support industries such as catalytic converters, lube oils, gaskets, and turbocharger suppliers, and if you are not well versed with diesel engines although they play a major role in your career’s survival.
POWER AND PROPULSION

• Desired injection flexibility
• Operation differences between HEUI-A & HEUI-B
• The HEUI-B injection system
• HEUI-A and HEUI-B injectors
• Air Management - Supercharging & Turbocharging
  • The purpose of air charging
  • Methods of air charging
  • Supercharger drives
  • Types of superchargers
  • Schematic representation of supercharger types
  • Sample performance map of a supercharger
  • Photographs of two centrifugal superchargers
  • Sample performance map of a centrifugal supercharger
  • Types of turbochargers
  • Schematic representation of a turbocharging system
  • Exhaust and charge airflow through a fixed geometry turbocharger
  • Anatomy of a turbocharger
  • Energy conversion in a turbocharger
  • The importance of A/R in a turbocharger design
  • Cutaway in a modern turbocharger
  • Sample performance map of a turbocharger
  • Waste-gated turbocharger
  • Variable geometry turbocharger
  • Combination system - wave charging
  • Turbocompounding
  • Sequential turbocharging
• Emissions Formation in Diesel Engines
  • Hydrocarbon
  • Carbon monoxide
  • Nitrogen oxides
  • Particulate matter
  • Smoke
• Emission Standards
  • Europe
  • North America
• Steps Towards the Modern Diesel Engine
  • Injection
  • Combustion
  • Induction
  • Oil consumption
  • Engine electronics
  • Other design parameters
• Current and Future Technologies
  • Exhaust gas recirculation
  • Multiple injections
  • Auxiliary emission control devices (aftertreatment)
  • Fuels and emulsions

Diesel Engine Technology e-Seminar

13 Hours
I.D.# PD130812ON

A similar course is available as a classroom seminar—Diesel Engine Technology – see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this nearly 13 hour e-Seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. The course is divided into an introduction and eight modules.

View the complete description and a demo for this course at training.sae.org/eseminars/det

What You Will Receive:
• 90 Day access through MyLearn.sae.org
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• Course Handbook (downloadable .pdf’s, subject to DRM)
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• CEUs/Certifi cate of Achievement (with satisfactory post-test score)

Instructor: Magdi Khair
Fee $645 1.3 CEUs

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SAE DIESEL TECHNOLOGY CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Designed to equip you with a solid understanding of diesel engines, emissions and aftertreatment strategies, and related components, the program requires completion of courses that address these areas and then facilitates further depth in aftertreatment technologies through a menu of electives. Complete the Diesel Technology Certificate and earn eight graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. View the list of required and elective courses and more information on enrolling in this SAE certificate program: training.sae.org/certificate/dieseltech.
Engine Failure Investigation and Analysis

2 Days
I.D.# C1344

Engines can and do experience failures in the field in a variety of equipment, vehicles, and applications. On occasion, a single vehicle type or equipment family will even experience multiple engine failures leading to the inevitable need to determine what the most likely cause of one or all of those failures was. This comprehensive seminar introduces participants to the methods and techniques used to determine the most likely cause of an individual engine or group of engine failures in the field.

The seminar begins with a review of engine design architecture and operating cycles, integration of the engine into the vehicle itself, and finally customer duty cycles and operating environments. Special emphasis is placed on the number and type of subsystems that not only exist within the engine (diesel and gasoline) but are used to integrate the engine into the overall vehicle package. Following this review, participants learn about failure types, investigation techniques, inspection methods, and how to analyze the available evidence using their own knowledge of engine and vehicle operating characteristics to determine the most likely cause of an engine(s) failure. The seminar concludes with a review of actual engine failure case studies that were investigated and resolved using the same process and methods taught during the course.

Learning Objectives

By attending this seminar, you will be able to:
• Analyze engine failure claim narratives
• Analyze and interpret engine and/or vehicle warranty data
• Determine what physical evidence to gather and review when investigating an engine failure claim(s)
• Evaluate the physical evidence associated with an engine failure claim(s)
• Reconcile the physical evidence with the narrative and warranty evidence
• Determine the most likely cause of engine failure based on the available evidence

Who Should Attend

This course has been developed for engineers and technical professionals in all fields related to the investigation, analysis, and root cause determination of engine failures in various types of vehicles and equipment used in both on road and off road applications. In addition, this course can be valuable to individuals involved with handling and processing customer warranty and insurance claims for engine related issues.

Individuals directly involved in the investigation of engine failure and failure related issues will benefit most from this material. Please note that this course is not intended to provide an in depth discussion of individual component failure modes within the engine. The focus of the course is the process used to gather and analyze the information and evidence necessary to make a determination as to the cause of an engine failure in the field.

Prerequisites

• Professional technical certification or 2 year technical degree is highly recommended
• Bachelor’s degree in Mechanical Engineering is recommended
• A basic knowledge of and familiarity with engine operation, design, and vehicle installations is required
• A basic knowledge of vehicle operational environments and duty cycles is recommended

Topical Outline

DAY ONE
• Engine Design Overview
  • Operating Cycles - compression ignition and spark ignition
  • Architecture
  • Subsystems - Turbo/supercharger, oil supply, cooling, emissions
  • Subsystem crossover and interaction
• Vehicle Integration and Packaging
  • Mounting
  • Fuel supply
  • Air supply
  • Emissions
  • Cooling
  • Controls
• Operational Profile
  • Climate
  • Environment
  • Duty Cycle
  • Operator Specific Habits
• General Failure Classification
  • Thermal
  • Lubrication
  • Fuel/Air Combustion
  • Mechanical
  • Diesel Runaway
• Failure Points
  • Joints and Gaskets
  • Vehicle Systems
  • Subsystems and Components
  • Evidence and Indicators

DAY TWO
• Investigation
  • Reviewing the claim
  • Service history/fleet maintenance
• Warranty histories
• Data mining
• Peer group comparisons
• Manufacturing related history
• Analysis
  • Customer Duty Cycle vs. Manufacturer intent
  • Manufacturer specifications and process’s
  • Analysis without inspecting the failed engines
  • Vehicle package and integration review
  • Developing a conclusion
• Case Studies
  • Single engine
  • Multiple engines
  • Turbo Diesel engines

Instructor: Robert (Skip) Kuhn
Fee $1325 1.3 CEUs

Gasoline Direct Injection (GDI) Engines
3 Days  I.D.# C1009

The quest for more efficient, smarter, and environmentally cleaner liquid-fueled spark ignition (SI) reciprocating engines is more alive and intense now than ever before. GDI SI engines have overcome many of the original limitations and are now becoming commonplace. This seminar will provide a comprehensive overview of GDI engines. Mixture preparation and the combustion process, with an emphasis on strategies for both homogenous and stratified charge operation and control, including issues related to the direct injection of gasoline into the combustion chamber, and fuel injection system requirements for optimal spray characteristics will be explored. Emission of pollutants, fuel economy and effects of some key design and operating parameters will also be covered. The seminar concludes with an overview of a select list of production and prototype GDI engines.

Learning Objectives
Upon completion of this seminar, you will be able to:
• Describe the rationale behind the GDI engine operation
• Analyze the important processes in GDI engines
• Explain liquid atomization, sprays, and injector requirements for successful GDI operation
• Utilize the technology and the logic behind gasoline direct injection
• Estimate and predict effects of key engine design and operating conditions on performance, combustion, and emission in GDI engines
• Communicate effectively with engineers working on fuel injection, combustion and emission aspects of the GDI engine in your firm or with customers
• Effectively contribute to the design of critical components such as combustion chambers, injectors, and emission reduction strategies
• Explain and utilize trade-offs between increasing engine performance and maintaining low emission characteristics

Who Should Attend
This seminar will be especially valuable for engineers, technical and project managers, researchers, and academicians. Engineers working on the design of components for high efficiency and performance of GDI engines as well as those directly and indirectly involved in mixture preparation and emission reduction of harmful pollutants from these engines will highly benefit from this course. Environmental engineers desiring to expand their understanding of fuel spray formation, combustion and emissions from GDI engines will benefit, as well as, engineers active in the development and application of software for the modeling and design of combustion chambers, fuel spray dynamics, combustion and emission issues.

Topical Outline
DAY ONE
• Combustion Systems
  • Relative position of spark plug and fuel injector
  • How to achieve homogeneous and stratified charge -- spray-, wall-, and air-guided combustion systems
• Fuel Injection System
  • Fuel injection system requirements
  • Fuel injector requirements and classification
• Fuel Spray Characteristics
  • Spray atomization requirements
  • Sac spray consideration
  • After-injection
  • Fuel spray penetration and cone angle
  • Split injection; Sprays characteristics of injectors
  • Effects of ambient pressure (density) on spray
  • Spray characterization (GDI)
DAY TWO
• Mixture Formation
  • In-cylinder flow characteristics and GDI combustion
  • Fuel-air mixing process
  • Spray-wall interactions
  • Cold start and wall wetting issues
• Combustion Process and Control Strategies
• Engine Operating Modes and Fuel Injection Strategies
  • Early-injection, late-injection, stoichiometric operation
  • Operating mode transition
• Split Injection Strategy
  • Two-stage, split, and post injection
• Combustion characteristics
  • Homogeneous-charge and stratified-charge combustion
High Performance Engine Design and Development

1 Day
I.D.# C0725

Ever since Beau de Rochas patented the four stroke cycle in 1862, engineers have pursued the development of high performance engines for road and racing applications at an accelerated pace. While this course will not cover such ancient history, it will focus on engine design and development advances over the last 40 years from “BC to AD” (“Before Cosworth to After Duckworth”), covering the concepts and designs behind the modern racing engines for series including Formula One, Indy Cars, the IRL, and NASCAR.

This course will help you determine how to design a championship-winning racing engine including many of the key calculations that support the pursuit of power. Attention to detail on every aspect of engine design is emphasized with focus on applying simple math, physics, and even plain old common sense, rather than relying heavily on sophisticated software.

The course begins with a review of the major advances in engine design, then explores the design of the engine’s primary systems and structures including oil systems, cam drive systems, water systems, inlet systems, exhaust systems, cylinder heads, cylinder blocks, and sumps. It will then explore how combustion works and how to analyze the major parameters involved in burning different fuels. This will be followed by the design and optimization of inlet and exhaust systems and applying mathematics via simple Excel spreadsheets to determine the key factors for cam design, port design, inlet and exhaust tuning, and turbocharger/supercharger matching for those formulae that permit the use of boost to increase the inlet pressure. The day concludes with a discussion and opportunities to continue design exercises that will allow attendees to put into practice several of the key concepts learned throughout the seminar.

Detailed course notes and illustrations are provided along with example calculations to enable the attendee to calculate the key parameters required in the design and development of racing engines.

Learning Objectives

By attending this seminar, you will be able to:

- Describe the key parameters and choices facing the high performance engine designer
- Consider a variety of tips and solutions which can be applied by both design and development engineers to enhance the performance of competition engines
- Select “the least worse design solution” for any particular problem
- Summarize the major advances in engine design over the past 40 years

Who Should Attend

This course is for individuals with a thirst to improve their understanding of what makes a racing engine a championship winner. It can be valuable to those responsible for engine design, component design, and overall engine performance calculations or those who are merely interested in the subject.

Topical Outline

- Engines from BC to AD A brief outline of racing engine history covering the design and development of several famous racing engines to highlight how fundamentally different approaches to design and manufacturing can generate championship winning engines for various classes of racing
- Detailed Design of Engine Systems
  - How does a modern racing engine work and why?
  - Review of fundamental systems of the modern racing engine
- Engine Structures
  - Designing from the inside out, focusing on performance design
  - Adding the structures to integrate the load paths through-
Homogeneous Charge Compression Ignition Engines

2 Days
I.D.# C1010

The potential benefits of the Homogeneous Charge Compression Ignition (HCCI) engine are numerous and have the potential to combine some of the best features of the Compression Ignition engine with that of the Spark Ignition engine. These benefits include overall engine efficiencies available with compression ignition and the substantially lower emissions of PM and NOx available with spark ignition systems. However, the commercial viability and wide-spread use of the HCCI engine has been slow to materialize due to significant technical challenges.

This two day seminar will provide attendees a comprehensive overview of the benefits of HCCI combustion and the main challenges to its acceptance and use in vehicles. Current technologies will be examined along with recent developments in HCCI engines. The characteristics of several commercial engines that use HCCI combustion during a portion of their operating range and the future directions for HCCI research will also be examined.

Learning Objectives
By attending this seminar, you will be able to:
- Evaluate the benefits of HCCI combustion
- Identify the primary challenges in the development of commercially viable HCCI engines
- Identify recent developments in HCCI technology
- Describe the characteristics of several commercial engines that use HCCI combustion during a portion of their operating range
- Evaluate current research being performed and with support from governmental agencies
- Assess the potential and future direction of HCCI technology

Who Should Attend
This course is designed for engineers, technicians, managers, and students that are associated with engine design. In addition, personnel in the transportation industry that are involved in the research of advanced low pollutant emission technologies and high thermal efficiency engine concepts will benefit from this seminar.

Topical Outline
- Introduction and HCCI Overview
  - What is Homogeneous Charge Compression Ignition?
  - HCCI and other low temperature combustion strategies
  - HCCI for diesel engines -- Advantages; Limitations
  - HCCI for gasoline engines -- Advantages; Limitations
  - The importance of R&D in HCCI
- Benefits and Challenges
  - Benefits -- Efficient; Fuel flexibility; Lower emissions
  - Challenges -- Controlling ignition timing over a range of speeds and loads; Extending the Operating Range to High Loads; Cold-Start Capability; Hydrocarbon and Carbon Monoxide Emissions
- Developments in HCCI for Diesel Engines
  - Fundamental understanding
  - Advancements in speed and load control
  - Results using different fuels
  - Early applications of HCCI technology
- Developments in HCCI for Gasoline Engines
  - Fundamental understanding
  - Advancements in speed and load control
  - Results using different fuels
  - Early applications of HCCI technology
- Future Directions
  - Ignition Timing Control
  - Low Temperature Combustion Strategies
  - Combustion Rate Control for High-Load Operation
  - Cold-Start
  - Emission Control
  - Exhaust Aftertreatment
  - Transient Operation
  - Dynamic Predictive Control and Mode Transitioning
  - Advanced Control Systems
  - High Pressure and Low Pressure EGR Applications
POWER AND PROPULSION

- Valve Train Development
- Fuel Injection System Development
- Multi-Cylinder Effects
- Combustion Modeling

Instructor:  Gerald J. Micklow
Fee $1335  1.3 CEUs

Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR

3 Days
I.D.# C0613

Societal and regulatory demands to lower emissions and increase engine-operating efficiencies have forced engine designers to adopt new technologies and control strategies. This has resulted in dramatic evolutions of the technology of internal combustion engines and their support systems in recent years. These operational management strategies have evolved into more robust control systems and sensory packages, which in turn has driven the need for more accurate and specific information being communicated between the various systems found within a modern automobile.

This seminar will expose you to the emerging technologies in engine design and operation that can significantly improve operational efficiencies. The fundamental science and implementation technology of the various internal combustion engine systems will be presented. Attendees will learn how the Engine Control Module (ECM) uses information related to the operational status to implement real-time running efficiency of the engine. You will also learn how the ECM effects changes in the operation of the engine through the control systems that manage its operation. With this understanding, you will be able to derive your own set of improvement criteria that could be made to address the limitations of current engine technology.

Learning Objectives
By attending this seminar, you will be able to:
- List the typical sensors, the sensory information they collect and describe the use of that information as it addresses improved fuel economy and reduced combustion emissions
- Describe the significance, technology, and application of:
  - Direct Injection (DI) of both gasoline and diesel fuels
  - Homogeneous Charge Compression Ignition (HCCI)
  - Displacement on Demand (DoD) Systems
  - Variable Cam Timing (VCT) and Variable Valve Timing (VVT)
  - Variable Compression Ratio (VCR) engine designs
- Explain the fundamental physics of the various technologies
- Specify the operational parameters and inter-relationships of each of the sub-systems of the enabling hardware
- Describe the basic design synthesis and analysis techniques for each of the major operational improvement technologies

Who Should Attend
This intermediate level seminar is appropriate for a number of design and engineering disciplines including, but not limited to: design engineers and engineering managers, automotive engine designers, component suppliers, engine test and development engineers, design services managers, and others who require the technological knowledge to perform their respective job functions.

Prerequisites
Individuals should have a practical understanding of current internal combustion technology and systems such as that covered in the SAE seminar The Basics of Internal Combustion Engines (ID# C0103, page 152), or its equivalent. An undergraduate engineering degree, or a strong technical background, is highly recommended. Basic knowledge of algebra and physics is essential.

Topical Outline

DAY ONE
- Operation of ECM and Sensor Systems
  - Information requirements
  - Use and distribution of collected information
  - Control theories and implementation of fuel management strategies
- Direct Injection (DI) of Both Gasoline and Diesel Fuels
  - Overview and historical perspective of DI technologies -- Gasoline; Diesel; DI hardware review
  - Potential and proven benefits of DI -- Theory; Aspects of gasoline combustion; Aspects of diesel combustion; Engine hardware development
- Homogeneous Charge Compression Ignition (HCCI) Technologies
  - Overview and historical perspective of HCCI technologies
  - Hardware review
  - Gasoline based HCCI -- Theory; Aspects of gasoline combustion; Engine development
  - Diesel based HCCI -- Theory; Premixed HCCI; Historical direct inject systems; Current technology direct inject systems; Water injection systems for HCCI control
  - The chemistry of HCCI -- Alternative fuels; Fuel blends; Fuel additives
  - HCCI control -- Operating range extension; Key parameters for control; Control strategies
- Kinetics of HCCI combustion

DAY TWO
- Displacement on Demand (DoD) Systems
POWER AND PROPULSION

- Theoretical improvements to engine system performance and efficiency
- Historical mechanisms to implement DoD systems
- Modern approaches to DoD systems
- Variable Cam and Valve Timing (VCT, VVT)
  - General theory and potential system benefits of varying valve timing
  - Variable cam timing or phasing -- Benefits associated with VCT; Mechanisms to implement VCT; Modern approaches to VCT systems
  - Variable valve timing -- Benefits associated with VVT; Mechanisms to implement VVT systems; Modern approaches to VVT systems

DAY THREE
- Variable Compression Ratio (VCR) Engine Designs
  - Theoretical improvements to engine system performance and efficiency
  - Mechanisms to implement VCR technology
  - Modern approaches to VCR systems
- General Discussion
  - Use of alternate fuels
  - Implementing dual-fuel engines
  - Engines designed to run multiple fuels (not dual-fuels)
  - Control strategies for implementing and combining above technologies
  - Emerging technologies; New technologies

Instructor: William Mark McVea
Fee $1700 2.0 CEUs

Instructor: Harold E. McCormick
Fee $1285 1.3 CEUs

Piston Ring Design/Materials

The purpose of this course is to provide an overview of the factors in the cylinder kit assembly of natural gas, gasoline, and diesel engines that affect oil consumption, ring and cylinder bore wear, and blow-by. This course includes background and the evolution of designs and materials currently employed in modern engines as well as providing an overview of computer models, designs, and material systems that can be utilized to optimize the performance of new engines. An overview of the trends in materials and designs employed in U.S., European and Japanese engines will be presented.

Learning Objectives
By attending this seminar, you will be able to:
- Describe the function of each ring and its interaction with other components within the cylinder kit to provide oil consumption and blow-by control
- Identify available computer models and instrumentation that is available to predict and measure the function of each of the components in the cylinder kit on oil consumption and blow-by control
- Compare the base systems and facing material systems and the trade-offs associated with each of the material systems, i.e., wear rate, scuff resistance, etc.

Who Should Attend
If you are an engineer associated with engine design and development and interested in understanding the function and design considerations within the cylinder kit system, you would benefit from attending.

Topical Outline
- Evolution of piston ring designs/materials -- diesel engines
- Evolution of piston ring designs/materials -- gasoline engines
- Outline of Nomenclature & Ring Design Methodology, including Referencing to Various Published Standards i.e. -- SAE, DIN, ISO
- Systems Parameters & Their Interaction with Piston Rings to Cause Variations in Performance
  - Cylinder bore geometry; Cylinder bore finish
  - Piston design; Power density; Operating speed; Engine lubricants
- Typical Procedures/Equipment Employed to Measure Dimension Properties of Piston Rings
- Developed Models Aiding in Cylinder Kit Design
- Determining the Effect of Design Parameters on Oil Consumption, Ring Function, Cylinder Bore Distortion, Friction & Wear Rates -- Unique test set-up procedures and their utilization

Practical Race Car Data Acquisition: RPM and Speed Analysis Fast Track

Two of the most important and commonly used components in racing data acquisition today are engine RPM and speed analysis. These two channels of data give race teams and engineers critical information that can be used every day to help quantify changes in both the driver and the race vehicle. This 80-minute, on demand short course focuses on race car data acquisition, highlighting cornering speeds, engine acceleration rates, gear selection, engine RPM curves, shift times, throttle on/off, engine acceleration, wheel spin, brake lock, cornering speed, ignition cutout and much more. Whether you are a weekend racer or a professional data acquisition engineer, you will find the components of this course fundamental to successful data analysis in the real world. From hardware installation to software interpre-
POWER AND PROPULSION

This course will give you confidence and additional insight into these key pieces of data analysis.

**Major topics include:**
- Introduction
- Set-up for Acquiring Engine RPM Data
- Acquiring and Analyzing Engine RPM Data
- Interpreting RPM Results
- Set-up for Acquiring Speed/MPH Data
- Interpreting Speed/MPH Results
- Alternative Analysis Strategies

**Is this Fast Track for you?**

*The Practical Race Car Data Acquisition: RPM and Speed Analysis Fast Track* is designed for the racer - from the professional road racer to the weekend racer - or the engineer who is incorporating data acquisition into their race team strategy and want to maximize the abilities of their system as quickly as possible. This course does not require any pre-requisite, as the content will unfold from the basics, up to the more advanced features of these important data acquisition sensors. The knowledge gained in this course can be applied the next day at any level of racing without any additional training or experience.

**What You Will Receive**
- Three months of on demand access to the 80 minute presentation
- Integrated knowledge checks to reinforce key concepts
- Proof of Participation

**Instructor:** Dave Scaler

**Fee:** $149

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**Race Engine Calibration for Optimal Performance**

1 Day  
I.D.# C0602

A similar course is available on demand – *Race Engine Calibration for Optimal Performance e-Seminar – see course info below.*

The engine control module (ECM, or on-board computer) is the tool used to control the fuel injection rate, fuel injection timing, ignition timing, rate of exhaust gas recirculation (EGR), and other functions. The task of “programming” the ECM is much easier for a race engine than for a production engine because the calibration engineer does not need to be concerned about emissions: EGR, keeping the exhaust catalyst “happy”, etc. This course provides a practical introduction to ECMs, including the uses for the various sensors. It also covers the specific methods used to incorporate the various sensor signals into the ECM’s control systems for the fuel injection rate, fuel injection timing, and ignition timing. Background information will include an understanding of the desired air/fuel ratio and optimum ignition timing. While examples are tailored around the application of the ECM to Formula SAE race engines, this course is useful for improving any engineer’s understanding of the functions of the ECM for other types of race engines as well as production engines.

**Learning Objectives**

By attending this seminar, you will be able to:
- Describe the functions of the crank position sensor, cam position sensor, intake air temperature sensor, manifold air pressure sensor, mass air flow sensor, exhaust “oxygen” or lambda sensor, throttle position sensor, engine coolant temperature sensor, and knock sensor
- Explain how the ECM controls the fuel injection rate, fuel injection timing, and ignition timing
- Interpret base look-up tables, multipliers, and adders
- Develop base look-up tables, multipliers, and adders

**Who Should Attend**

Anyone interested in engine calibration/programming the on-board computer, especially for race engines. At a minimum, classification as at least a junior in a curriculum leading to a BS degree in engineering or experience in engine development is necessary background for taking this course.

**Online Bonus Segments**

Attendees will have the opportunity to access online bonus segments after the seminar. Segments will contain presentations by representatives of Ricardo and Performance Electronics, Ltd.

**Online Segment by Ricardo in Brief:**

Throughout this seminar, Prof. Matthews discusses how an accurate engine modeling code can be used to simplify the effort required to generate the base look-up tables. In this segment, Steve Rawnsley of Ricardo discusses their WAVE engine modeling code, an example of a state-of-the-art engine modeling program that can be used to simplify engine calibration. Seminar attendees will be given information to contact Ricardo Software if they desire a WAVE product evaluation.

**Online Segment by Performance Electronics, Ltd. in Brief:**

The seminar is focused on learning how to program an aftermarket Engine Control Module (ECM) to obtain optimal performance from a race engine. In this segment, Brian Lewis of Performance Electronics, Ltd., discusses their aftermarket ECM. He discusses how various aspects of their ECM are to be used given the background from Prof. Matthews’ discussion.
**POWER AND PROPULSION**

**Topical Outline**

- Basic engine theory
  - Relationships between torque, brake specific fuel consumption, engine design parameters, engine operating conditions, and four fundamental efficiencies (volumetric, combustion, indicated thermal, and mechanical)
  - Effects of fuel/air equivalence ratio
  - Effects of load
  - Effects of engine speed
  - MBT and LBT
- Goals for race engines
- Goals for production engines
- Correction factors
- Engine sensors--the need for and use of:
  - Crank position sensor
  - Cam position sensor
  - Intake air temperature sensor
  - Manifold air pressure sensor
  - Mass air flow sensor (if used)
  - Exhaust “oxygen” or lambda sensor
  - Throttle position sensor
  - Engine coolant temperature sensor
  - Knock sensor
- Air/fuel ratio control
  - Base pulse width look-up table for speed-density systems
  - Benefits of MAF systems
  - Multipliers
- Ignition timing control
  - Base ignition timing look-up table
  - Adders
- The Calibration Process
  - Explain why the calibration process must be an iterative procedure to obtain the proper ignition timing and fuel injection pulse width for every “cell” in the two base tables
  - Explain that generating the base pulse width table requires few experiments
  - Explain how to embed the “load” multiplier for pulse width
  - Generate the “start” multiplier, or the “crank” and “warm-up” multipliers if your ECM has this option
  - Calculate the intake air temperature multiplier
  - Discuss how to experimentally generate the battery voltage multiplier using an injector test stand
  - Explain why the auto companies take thousands of data points to get MBT timing as accurate as possible in the base table, and why your race team will benefit from an equal effort
  - Discuss the issues or dangers (from the engine durability perspective) involved in generating MBT accurately
  - Discuss the problem that is encountered when trying to find MBT at low load and two techniques that can be used to overcome this problem
- Explain how to safely identify the Knock Limited Spark Advance regime of engine operation
- Recognize how to determine the values for the ignition timing adders

**Conclusions**

- List things you should look for in an after-market ECM
- Concisely review how to generate the base pulse width look-up table, the pulse width multipliers, the ignition timing look-up table, and the ignition timing adders

**Instructor:** Ronald D. Matthews

**Fee:** $790 .7 CEUs

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**Race Engine Calibration for Optimal Performance e-Seminar**

7 Hours
I.D.#PD130701ON

A similar course is available as a classroom seminar—Race Engine Calibration for Optimal Performance – see course info above.

The engine control module (ECM, or on-board computer) is the tool used to control the fuel injection rate, fuel injection timing, ignition timing, rate of exhaust gas recirculation (EGR), and other functions. In this course, the instructor provides a practical introduction to ECMs, including the uses for the various sensors. He discusses the specific methods used to incorporate the various sensor signals into the ECM’s control systems for the fuel injection rate, fuel injection timing, and ignition timing. Background information includes an understanding of the desired air/fuel ratio and optimum ignition timing. While examples are tailored around the application of the ECM to Formula SAE race engines, this e-Seminar is useful for improving any engineer’s understanding of the functions of the ECM for other types of race engines as well as production engines.

Convenient, portable, and with core content from the instructor-led seminar (course I.D.# C0602), this e-Seminar option offers an alternative way to receive the same instruction without the expense of travel and time away from the workplace. This course offers six video modules; more than two hours of bonus material and software demonstrations; and a glossary of acronyms, accompanied by a handbook.

View the complete course description and a video demo at training.sae.org/eseminars/raceenginecalibration.

**What You Will Receive:**

- 90 Day access through MyLearn.sae.org
- Links to streaming video modules (4.5 hour course, 2.5 hours of bonus material)
- Course Handbook (downloadable .pdf’s, subject to DRM)
POWER AND PROPULSION

• Online Pre-test (self-test, immediate results)
• Online Post-test (self-test, immediate results)
• CEUs/Certificate of Achievement (with satisfactory post-test score)

**Instructor:** Ronald D. Matthews

**Fee** $750 .7 CEUs

*Quantity discounts and Site License options are available – call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote.*

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### The Basics of Internal Combustion Engines

**2 Days**  
I.D.# C0103

*A similar course is available on demand – The Basics of Internal Combustion Engines e-Seminar – see course info below.*

In your profession, an educated understanding of internal combustion engines is required, not optional. This two-day technology survey seminar covers the most relevant topics - ranging from the chemistry of combustion to the kinematics of internal components of the modern internal combustion engine - for maximum comprehension. Attendees will gain a practical, hands-on approach to the basics of the most common designs of internal combustion engines, as they apply to the gaseous cycles, thermodynamics and heat transfer to the major components, and the design theories that embody these concepts.

#### Learning Objectives

By attending this seminar, you will be able to:

- Discuss in detail the basic functioning and component interaction in a modern internal combustion engine, specifically; two and four-stroke cycles as they relate to reciprocating and rotary engine designs
- Describe the general thermodynamic concepts governing the operation of an internal combustion engine and its various cycles
- Compare the principle operational differences of the various fuels used in internal combustion engines, their availability, and understand the applicability of each
- Discuss the function and operation of all major components and systems within a modern internal combustion engine; identify the operational principles behind the timing and working relationships among all internal components, and articulate the importance of this inter-relationship
- Recognize the limitations of the current designs and implementations of the modern internal combustion engine
- Perform a basic assessment and evaluation of new, cutting-edge designs and new powertrain initiatives as they apply to the mobility industry

#### Who Should Attend

Designed for powertrain engineers, component suppliers, vehicle platform powertrain development specialists, and those involved in the application, design and discussion of engines. It is recommended that seminar attendees have an undergraduate engineering degree.

#### Topical Outline

**DAY ONE**

- Fundamental Operating Procedures
  - Open circuit
  - Closed circuit
  - Internal combustion
  - External combustion
  - Spark ignition
  - Compression ignition

- Engine Technology
  - 2-stroke
  - 4-stroke
  - Pistons, connecting rods and crankshaft
  - Valvetrain, camshaft and timing gear
  -Engine block, cylinder and head geometry
  - Manifold, surface finish, track length
  - Fuel systems, carburetors, fuel injection
  - Turbo- and super-charger
  - Ignition, timing and spark advance

- Fuel Delivery Systems
  - Air intake systems
  - Fuel delivery
  - The problem of part throttle operation
  - Intake manifold design and tuning
  - Turbo-charging
  - Super-charging
  - Introduction to emissions
  - Fuel management and control theory
  - Fuel injection
  - ECU operation
  - Sensors and instrumentation

- Valve Train
  - Operation
  - Arrangement -- Push-rod; Single overhead cam shaft (SOHC) design; Dual-overhead cam shaft (DOHC) design
  - Camshaft function and design considerations
  - Valve timing
  - Valve-train design considerations

**DAY TWO**

- Component and Event Timing
  - Valve actuation timing
  - Valve timing diagram
The Basics of Internal Combustion Engines  
**e-Seminar**

10 Hours  
I.D.# PD130944ON

A similar course is available as a classroom seminar—*The Basics of Internal Combustion Engines*—see course info above.

Convenient, portable, and with core content from the instructor-led seminar (content and description similar to the preceding classroom counterpart), this more than ten hour e-seminar option offers an alternative way to receive the same instruction as the live classroom learning without the expense of travel and time away from the workplace. The course offers ten video modules accompanied by a handbook.

View the complete course description and a video demo at training.sae.org/eseminars/ic_engines

**What You Will Receive:**
- 90 Day access through MyLearn.sae.org  
- Links to streaming video modules  
- Course Handbook (downloadable .pdf’s, subject to DRM)  
- Online Pre- & Post-test (self-test, immediate results)  
- CEUs/Certificate of Achievement (with satisfactory post-test score)

**Instructor:** William Mark McVea  
**Fee** $565 1.0 CEUs

Quantity discounts and Site License options are available—call SAE Corporate Learning Solutions hotline at 724-772-8529 for a quote

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Turbocharging Internal Combustion Engines

**3 Days**  
I.D.# C0314

The need to control emissions and maintain fuel economy is driving the use of advanced turbocharging technology in both diesel and gasoline engines. As the use of diesel engines in passenger car gasoline and diesel engines increases, a greater focus on advanced turbocharging technology is emerging in an effort to reap the benefits obtained from turbocharging and engine downsizing.

This seminar covers the basic concepts of turbocharging of gasoline and diesel engines (light and heavy duty), including turbocharger matching and charge air and EGR cooling, as well as associated controls. The limitations and future possibilities of...
today’s systems will be covered, as well as details on how emerging technologies will impact engine/vehicle performance. The seminar’s primary focus is on the turbocharger-engine interface (subjects such as matching, benefits, limitations, and new technologies) rather than detailed turbocharger aerodynamics and design. Advanced technologies such as variable geometry and multi-stage turbocharging, high and low pressure loop EGR systems, assisted turbocharging and turbocompounding are discussed. Students will have the opportunity to perform hands-on exercises to gain an appreciation of parametric effects in a wide range of engines.

**Participants are expected to bring a laptop computer, with Excel, to the seminar for class exercises.**

**Learning Objectives**

By attending this seminar, you will be able to:

- Describe the thermodynamic principles governing the turbocharging of internal combustion engines
- Articulate the critical contribution of turbocharging to modern day diesel engine performance and emission control
- Determine the possible benefits of turbocharging for specific gasoline and heavy and light duty diesel engine applications
- Estimate the appropriate turbocharger characteristics for specific applications based on engine system requirements
- Describe the limitations of current technologies and evaluate new technologies and their possible role in meeting future engine/vehicle system challenges
- Apply the basic principles of matching turbocharger with engine and optimizing overall system for desired performance and emissions

**Who Should Attend**

This seminar is designed for engineers, managers, and other technical personnel from OEM and support industries concerned with the design and development of optimized diesel and spark ignition engine systems, including performance, fuel economy and emissions for passenger car, light truck and heavy duty engines. Some background in thermodynamics, IC engine performance and emissions will be helpful. Individuals who need more background should consider attending the SAE seminars *Diesel Engine Technology* (ID# 93014, page 142) or *The Basics of Internal Combustion Engines* (ID# C0103, page 152).

**Topical Outline**

**DAY ONE**

- Engine-Turbocharger Basics
  - Overview
  - Impact of charge density
  - Pumping loop and thermodynamics effects
  - Gas exchange/air flow and performance characteristics -- Engine; Turbocharger; Engine/turbocharger interaction
  - Turbocharger Design Features

  - Overview
  - Compressor side components and features
  - Turbine side components and features
  - Other significant turbocharger design requirements
  - Charge and EGR cooler features
  - Durability - thermal stress, materials, high and low cycle fatigue
  - Cooling, bearings, lubrication and sealing
  - Noise considerations

  - Free-floating, Wastegate, Variable Area or Variable Geometry Turbochargers and Controls
  - Compressor and Turbine Aerodynamics
    - Aerodynamic design features
    - Figures of merit for aero performance
    - Performance maps and their impact on engine characteristics
    - Methodology to evaluate the performance of compressors and turbines

**DAY TWO**

- Engine Air and EGR Flow Requirements
  - Power density and efficiency considerations
  - Emissions control considerations
- Turbocharger Matching
  - Matching principles with and without EGR
  - Single and multi-stage turbo matching
- Turbocharger Selection Based on Engine System Requirement
- Transient Response Considerations
- Basic Spreadsheet Tools for Engine and Turbocharger Parametric Explorations
  - Hands-on exercises for turbocharger and engine performance calculations
  - Hands-on parametric studies using simple calculation tools

**DAY THREE**

- Impact of Turbocharging on Gasoline and Diesel Engine Performance and Emissions
- Charge (Air and EGR) Cooling Systems
- Advanced Concepts in Turbocharging including Design Features of Advanced Concepts
  - Advanced versions of variable geometry turbocharging
  - High temperature and high strength materials
  - Two-stage turbocharging, series, parallel and sequential
  - Exhaust gas recirculation systems to minimize impact on efficiency
- Turbocompounding
- Electrically (and hydraulically) assisted turbocharging
- Impact on emissions control in diesel and gasoline engines
- Cold start emissions issues, catalyst temperature for diesel and gasoline
- Turbocharger response issues

**Instructor:** Kevin Hoag & Roy J. Primus

**Fee:** $1850 2.0 CEUs
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- Diesel Engine Technology
- Vehicle Noise Control
- Hybrid and Electric Vehicle
- Automotive Composites Technology

training.sae.org/academies
Turbocharging for Fuel Economy and Emissions Web Seminar and Web Seminar Recording

4 Hours
Web Seminar: I.D.# WB1018
Web Seminar Recording: I.D.# PD331018ON

Turbocharging is already a key part of heavy duty diesel engine technology. However, the need to meet emissions regulations is rapidly driving the use of turbo diesel and turbo gasoline engines for passenger vehicles. Turbocharged diesel engines improve the fuel economy of baseline gasoline engine powered passenger vehicles by 30-50%. Turbocharging is critical for diesel engine performance and for emissions control through a well-designed exhaust gas recirculation (EGR) system. In gasoline engines, turbocharging enables downsizing which improves fuel economy by 5-20%.

This Web Seminar will explore turbocharging for gasoline and diesel (heavy and light duty) engines, including the fundamentals of turbocharging, design features, performance measures, and matching and selection criteria. It will discuss the interaction between turbocharging and engine systems and the impact on performance, fuel economy, and emissions. Developments in turbocharging technology such as variable geometry mechanisms, two-stage and sequential (series & parallel) turbocharging, EGR including low pressure loop, high pressure loop and mixed mode systems and novel turbocharging systems will be described using figures and data.

Learning Objectives
By connecting with this Web Seminar, you will be able to:
- Identify the basics of how a turbocharger works, how to measure the appropriateness of a turbocharger, and how to select and match a turbocharger to the needs of your powertrain
- Estimate the impact of turbocharging on performance and emissions
- Anticipate potential issues such as packaging, noise, driveability, reliability, and durability
- List the latest developments in turbocharging technology, their impact on engine performance and emissions, and the use of turbocharging world-wide

Who Should Attend
This course will be beneficial to powertrain development engineers, component development engineers, engineering managers, product planners, service engineers, and those developing product strategy. Heavy duty diesel engine development engineers may find the course helpful by increasing their knowledge of turbocharging and EGR systems.

Variable Valve Actuation: Design and Performance Impact on Advanced Powertrains

2 Days
I.D.# C1332

Engine valvetrain systems have become more capable and increasingly more compact in the quest to improve efficiency. The developments parallel the advancements in other key engine components such as fuel injection or spark systems, turbocharging, aftertreatment, base engine and controls. While the gasoline sector has seen a steady rise in the adoption of Variable Valve Actuation (VVA), Diesel systems have lagged behind and only a few systems have been produced. The level of VVA activity however in the Diesel sector is beginning to increase as tighter regulations of CO2 emissions approach. Valve control plays a strong role in a number of key areas: turbocharger systems, allowing for better optimization matching across wide engine operating flows; enabling advanced combustion strategies where control over the charge mass and temperature are important; and cold start, where valve timing can be extremely effective for engine warm up compared with other strategies that rely on additional fueling.

This seminar will cover the range of Variable Valve Actuation technologies present in the market, their operation principles, and their effect on engine performance. Both gasoline and Diesel applications will be covered including how they impact the in-cylinder combustion as well as the aftertreatment. Participants will have the opportunity to perform hands-on exercises.
to examine the effects of the engine valve profiles on performance and are asked to bring a laptop computer, with Excel, to the seminar for class exercises.

Learning Objectives
By attending this seminar, you will be able to:
• Describe and differentiate the variable valve actuation technologies present in the automotive industry
• Describe the defining features of each of these technologies, their requirements for engine design layouts, required actuators, lube oil, and need for control and ECU interface
• Apply basic tools to gage the thermodynamic impact effected by varying the valve profiles: impact on pumping efficiency, resulting charge mass trapped in cylinder, estimated bulk and adiabatic flame temperatures
• Articulate the contribution of valve timing and control over the engine performance and aftertreatment in modern engines in the context of today’s emissions standards
• Describe the limitations of current technologies towards more efficient and cleaner engines and the future role of valve actuation and its integration aspects with other advanced powertrain components

Who Should Attend
This seminar is designed for engineers, managers, and other technical personnel from OEMs and support industries concerned with the design and development of optimized diesel and spark ignition engine systems, including calibration, performance, fuel economy and emissions for passenger car, light truck and heavy duty engines. It will be particularly interesting to Diesel engineers who will likely adopt some of the technologies developed in the gasoline sector for further improvements in emissions control and gains in fuel economy. It will be also of interest to combustion researchers as VVA will play a strong enabling role to exploring advanced combustion strategies.

Prerequisites
Some background in thermodynamics, IC engine performance and emissions will be helpful. Individuals who need more background should consider attending the SAE seminar The Basics of Internal Combustion Engines (I.D.# C0103). See the course description on page 152.

Topical Outline
DAY ONE
• Motivation and Objectives
  • Near and long term landscape
  • Fuel Economy, performance and emission standards
  • Key engine technologies
  • Overview of VVA landscape
  • VVA Timeline
  • Efficiency improvements and synergies with other technologies
  • Industry trends and benchmarking
• Basic Engine Definitions
  • Work, fuel consumption, efficiency, exhaust gas recirculation (EGR)
  • Class exercise: engine performance calculator sheet
  • Thermodynamics and chemistry
  • Class exercise: EGR and valve timing effects on combustion
• Variable Valve Actuation Designs
  • Valvetrain overview: lift, timing, valve overlap
  • Cam phasing, cam switching, continuous variable lift
  • Lost motion systems including cylinder cut-off
  • Camless systems, electro-hydraulic, fully electro-magnetic
  • Case study: continuously variable valve system design
  • VVA Case Studies and Impact on Gasoline Engine Performance
    • Continuously variable valve system on gasoline engine
    • Atkinson cycle with a hybrid plugin powertrain
    • Miller Cycle

DAY TWO
• VVA Case Studies and Impact on Diesel Engine Performance
  • Loss motion system to enable LTC on a MD Diesel engine
  • Electro-hydraulic system on HD Diesel engine
• Engine Brake Systems
  • System description and competitive advantages
  • Class exercise: hydraulic layout of brake system
• Transient Performance
  • Response
  • Engine warm-up strategies
  • Gas exchange interactions (turbochargers)
• Modeling and Controls
  • Physical modeling of air system
  • Integration of multiple actuator systems
  • Enhancing combustion stability
• Future Trends
  • Enabling roles of VVA in advanced combustion engines
  • Stretched efficiency concepts

Instructor: William de Ojeda
Fee $1315 2.0 CEUs
Alternative Fuels: Impact on SI and CI Fuel Systems, Distribution and Storage

2 Days
I.D.# C0729

Microbial contamination and material compatibility present significant issues for alternative fuels, causing costly operational problems for suppliers, distributors and end-users. Fouling, corrosion, sulphide spoilage and increased water content can lead to filter plugging, blocking of fuel lines and injectors and consequently cause excessive wear and failure of engines and systems components. This course is a primer for those professionals who desire to learn how new fuel and fuel blends could potentially impact the operation and reliability of engines powered by oxygenated gasoline, desulfurized diesel fuel and biodiesel fuel blends. Attendees will learn the basics about fuel chemistries, material compatibility and how the increased susceptibility to water and microorganisms can affect equipment operation and reliability.

Learning Objectives
By attending this seminar, you will be able to:
• Explain the events that have shaped our current fuel policies
• Compare the differences between petroleum and biomass fuel chemistries
• Detect fuel and potential system material compatibility issues
• Describe how fuel systems could potentially be at greater risk for problems due to the presence of microorganisms
• Detect and remediate problems associated with microbial contamination of fuels
• Improve the overall operational reliability of power systems that utilize diesel and biodiesel fuels

Who Should Attend
This seminar is appropriate for fuel systems design engineers, fuel quality managers in refinery, pipeline and terminal operations, engine fuel quality managers, and maintenance technicians.

Topical Outline
DAY ONE
• Fuels

DAY TWO
• Remediation of Microorganisms
  • Microbial pesticides approved for use in fuels
  • USEPA regulations governing the sale of microbial pesticides
  • Characteristics of an efficacious microbial pesticide
  • Methods for treating storage and distribution systems
• Surveillance and Testing
  • Benefits of a routine surveillance program
  • Developing a surveillance program

Instructor: Ed English & Howard Chesneau
Fee $1435 1.3 CEUs

Fundamentals of Automotive Fuel Delivery Systems

2 Days
I.D.# C0303

The key to a vehicle’s overall operation is the superior, quality design of its major moving subsystems. Automotive gasoline and diesel fuel delivery systems in particular must be virtually malfunction free for all components for the entire vehicle.
prescribed service life. Fuel systems must be robust and precise enough to store and deliver the appropriate amount of fuel to power the engine. These stringent requirements necessitate a basic understanding of the subsystem working principles, functionalities and interrelated components.

This course provides a basic yet thorough examination of technical issues involved in automotive gasoline and diesel fuel delivery. Participants will acquire a fundamental understanding of the current technology and requirement guidelines and apply some of the principles through an in-class project and exercises. Examples of frequently encountered technical issues of fuel delivery systems shall also be discussed. The course is designed to encourage discussion, insights, and possible solutions into the engineering problems encountered in the gasoline and diesel fuel delivery systems and components.

Learning Objectives

By attending this seminar, you will be able to:
• Organize, differentiate and interpret the fundamental concepts, features and applications of fuel delivery systems
• Describe general gasoline and diesel fuel delivery system functionality
• Compare and differentiate individual components comprising the subsystem
• Identify interconnections of system components
• Apply general gasoline and diesel fuel system requirement guidelines

Who Should Attend

You should attend if you are an engineer or engineering manager involved in design, research, testing or implementation of automotive fuel delivery systems. Engine designers, suppliers of fuels and fuel delivery system components, and polymer engineers may benefit as well.

Topical Outline

• Introduction
  • Overview
  • General expectations
• Fundamental Fuel Delivery Systems
  • SI engine fuel delivery systems -- Gasoline; Alternative fuel
  • GDI engine fuel delivery systems -- for stratified; homogeneous; mixed combustion mode
  • Diesel engine fuel delivery systems -- Conventional unit injector system; Electronic controlled intensifier systems; High pressure common rail systems
  • Fuel Cell -- Solid oxide fuel cell; Proton exchange fuel cell
  • Advanced fuel delivery system concept -- Variable valve lifting; Cylinder deactivation
• Fuel Types & Properties
• Fuel Delivery Subsystem Working Principles
• Delivery modules -- Return systems; Returnless; Mechanical returnless fuel delivery system (MRFS); Electronic returnless fuel delivery system (ERFS)
• Fuel pump assemblies -- PFI pumps; GDI high pressure pumps; and diesel high pressure common rail (HPCR) pumps
• Injector assemblies -- PFI injectors; GDI injectors; HEUI injectors; unit injectors; Diesel HPCR injectors and their electronic driving mechanism
• Injection types -- Multi-point injection (MPI); Sequential multi-point injection (SMPI); Direct injection (DI); Common rail diesel injection (single injection event; Multiple injection events; Rate shaping); Homogeneous charge compression injection (HCCI) for gasoline and diesel
• Fuel pressure regulation -- mechanical and electronic
• Onboard refilling vapor recovery system (ORVR) and vapor management
• Fuel level indication mechanism -- contact; non contact
• Fuel filtration -- Pump/module inlet filtration; Inline filtration; Integrated filtration system; lifetime filters; filtration efficiency; beta value; and dirt capacity
• Fuel delivery metering -- High pressure end; Inlet metering
• Fuel Delivery System OEM and Government Regulatory General Requirements
  • Functionality requirements
  • FTP highway and urban cycles
  • Durability requirements
  • Safety requirements
  • Permeation requirements
  • Contamination life requirements
  • Static charge and abatement techniques
• Fuel Delivery System and Components Evaluation and Testing Methods
  • Fuel tank; Fuel lines
  • Delivery module
  • Pump
  • Injector
  • Regulator
  • ORVR valve
  • Fuel level gauge; Fuel filter
  • Vapor canister
  • Fuel delivery driver module
  • Leak testing
  • Electrical static discharge testing
  • Permeation testing
• Summary

Instructor: Dr. Xiaojian Tao
Fee $1335 1.3 CEUs
Improving Fuel Efficiency with Engine Oils

2 Days
I.D.# C0914

Improving vehicular fuel efficiency is of paramount importance to the global economy. Governmental regulations, climate change and associated health concerns, as well as the drive towards energy independence, have created a technical need to achieve greater fuel efficiency. While vehicle manufacturers are focusing efforts on improved combustion strategies, smaller displacement engines, weight reduction, low friction surfaces, etc., the research involved in developing fuel efficient engine oils has been less publicized. This seminar will highlight the role of lubricants in improving fuel efficiency and provide strategies for selecting the best oil for a given application.

The course begins with a brief overview of the fuel consumption regulations and global perspective of passenger car lubricants and diesel oil specifications in North America, Europe and Asia. Limitations and advantages of various methods to measure fuel consumption in a variety of bench tests, dyno tests and actual vehicles will be presented. Fundamentals of fluid lubrication regimes, as well as detailed aspects of oil formulations which have significant effects on reduction in mechanical friction, such as base oil selection, viscosity grade choice and impact of friction modifiers, will be covered. The performance characteristics of fresh oil versus used oil and lubrication of coated surfaces will also be discussed. Finally, the impact of various emission control devices on overall diesel fuel consumption will be described.

Learning Objectives

By attending this seminar, you will be able to:
- Describe the effects of mechanical friction on engine efficiency
- Summarize the pros and cons of various test methodologies used to measure engine friction
- Articulate the limitations in various fuel consumption test methodologies
- Select oils based on frictional control performance
- Describe the role of oil degradation on fuel economy and engine wear
- Evaluate lubricant interactions with low friction surfaces

Who Should Attend

This seminar is designed for engineers, scientists, investigators and consultants involved in designing or optimizing mobile or stationary powertrains. Individuals interested in understanding the role of engine oils in reducing fuel consumption will find the seminar beneficial. Automotive decision makers will also benefit by gaining an understanding of the limitations of fuel economy testing methods.

Topical Outline

DAY ONE
- Reducing Fuel Consumption
  - Regulations - N. American, Europe and Asia
  - GHG emissions and climate change
  - Petroleum based fuels - availability
  - Biofuels - availability and global trends
- Fundamentals of Engine Friction
  - Gasoline engine; Diesel engine
- Methodology - Part 1: How to Measure Engine Friction
  - Examples of bench tests
  - Examples of engine tests
- Methodology - Part 2: How to Measure Fuel Consumption in Real Life Conditions
  - Gasoline vehicles; Diesel trucks
DAY TWO
- Fuel Economy Derived Lubricant Specifications
  - N. America - API specifications
  - United Europe - OEM specifications
  - Japan - OEM specifications
- Lubrication Fundamentals
  - Lubrication regimes
  - Stribeck curve
- Lubricant Components - Effects on Fuel Consumption
  - Base oils
  - Viscosity grades
  - Friction modifiers
- Fuel Economy Retention
  - Impact of used oil on fuel consumption vs. engine wear protection
- Lubrication of Low Friction Surfaces
  - Coatings
  - Engineered surfaces
- Impact of Diesel Emission Control Devices on Overall Fuel Consumption

Instructor: Ewa Bardasz
Fee $1325 1.3 CEUs

Liquid Atomization, Sprays, and Fuel Injection

3 Days
I.D.# 98019

Liquid fuel atomization and spray formation is the heart of the majority of stationary and mobile power generation machines that we rely on. This seminar focuses on the process of liquid atomization and spray formation and how it relates to fuel injection systems and emission of pollutants in modern engines. The
seminar begins with background coverage of terminology, the purposes of liquid atomization and spray formation, and different designs of atomizers and nozzles employed in various industries. The focus is then directed to gasoline and diesel fuel injections, injector designs, and performance requirements for optimum engine operation with lowest possible emission of harmful pollutants. Based on the idea that knowledge of technical practices and advances in one area (i.e. diesel fuel injection) is beneficial to engineers in other areas (gasoline direct injection, rocket engines), this seminar takes an interdisciplinary approach. Attendees will understand the technology and logic behind different injector designs, and gain the knowledge to judge, adapt and transfer technology advances from one discipline to another.

Learning Objectives
• By attending this seminar, you will be able to: Explain important terminology commonly used in atomization and sprays
• Describe important processes in atomization and spray formation
• Articulate the effects of injection system design and operating conditions on engine performance, combustion, and emission of pollutants
• Describe different injector designs and the rationale for the use of each
• Define the role the injection system plays in combustion and emission and how it is used to provide guidance in design of low-emission combustion systems
• Implement appropriate design concepts and logic in the design of critical components such as intake valves and induction systems
• Evaluate future trends and technology developments in fuel injection

Who Should Attend
Automotive and aerospace engineers, technical and project managers, researchers and academicians will benefit by attending this seminar. Automotive engineers working on the design of combustion engine components, reduction of harmful pollutants emissions, software development and application for modeling of thermal-fluid, combustions and emissions and engineers and managers directly involved in fuel injection systems will also benefit. Aerospace engineers involved in the design of gas turbine or rocket engines’ combustion chambers will benefit as well.

Topical Outline
DAY ONE
• Description of the Atomization Process
• Disintegration of the Liquid Jets
  • Rayleigh criterion (no viscosity)
  • Weber’s criterion (effects of viscosity)
  • Ohnesorge criterion for atomization (Ohnesorge Number)
  • Rayleigh, first and second wind-induced breakup and atomization regimes
• Influence of some parameters -- jet velocity profile; nozzle length-to-diameter ratio; ambient pressure
• Disintegration of liquid sheets
• Drop breakup in air flow, turbulent flow, and viscous flow
• Types of Atomizers: Pressure, Air-Assist, Air-Blast, Effervescent, Electrostatic, Ultrasonic, Diesel Injector and Gasoline-Fueled Injectors
• Drop Size Distribution and Measurements
  • Graphical and mathematical representation of drop size distribution
  • Averaged diameter and representative diameters
  • Measurement techniques -- patternation; drop size measurements and spray characterization
  • Mechanical methods -- drop collection on slides; molten-wax and frozen-drop approach; cascade impactors; electrical; charged-wire and hot-wire methods; optical methods; imaging - photography and holography; single-particle light scattering (Phase Doppler Particle Analyzer, etc.); diffraction size analyzer
• Drop evaporation

DAY TWO
• Diesel Fuel Spray, Injector and Injection System
  • Fuel injection system -- pumps: in-line injection, distributor-type injection, single-barrel injection, and unit injector & unit pumps; injector designs: nozzle holder, nozzles, others
  • Overall spray structure
  • Liquid fuel atomization
  • Spray angle
  • Intact core length
  • Spray evaporation
  • Ignition delay
  • Mixing-controlled combustion
  • HC emission mechanisms in diesel engines and its relation to fuel injection
  • Soot formation and fuel sprays
  • Advanced topics (details of split injection, common-rail injection, interacting-sprays injection, ultra-high pressure fuel injection, effects on performance and emissions, and others)

DAY THREE
• Gasoline Port Fuel Injectors and Injection System
  • Multipoint port injection system -- classes of gasoline port injectors: low pressure, medium pressure, high pressure, air-assisted, swirl, heated vaporizing, ultrasonic, and electrostatic; key requirements of gasoline port injectors; deposit considerations
  • Single-point throttle body injection system
  • Feedback system
  • Effects of injection parameters on engine performance and emission: injection timing, spray targeting, spray momentum, mean drop size, pulse-to-pulse variability, and others
• Flow of Fuel and Air in Intake Manifolds
Modern Fluids for Crankcase Engines: An Overview

2 Days
I.D.# C0704

Lubricating fluids are the lifeblood of modern engines, performing numerous vital functions from reducing system friction, temperature, and fuel consumption to minimizing tailpipe emissions. This comprehensive seminar covers the latest developments in lubricating fluids technologies and explores the relationships between lubricating fluids and emissions, after-treatment devices, bio-fuels, and fuel economy. Fundamentals of crankcase lubrication, including the properties and performance requirements of global base stocks and lubricants will be covered. The seminar will further explore the need for lubricating systems to possess thermal and oxidative stability sufficient to withstand the rigors of low-heat-rejection, high performance diesel engines or other modern engines equipped with various emission control devices. Case studies will be utilized to demonstrate the existence of overlapping phenomena aimed at extending oil life and protecting key mechanical components.

Learning Objectives

By attending this seminar, you will be able to:
- Describe how various classes of additives commonly used in crankcase lubricants impact:
  - wear of bearings, pistons, and piston rings
  - friction and fuel consumption
  - corrosion
  - piston cleanliness
  - swelling of seals
  - hydraulic media in fuel systems, such as hydraulically-actuated electronically-controlled unit injector system (HEUI).
- Recognize the limitations and technical trends in new base stocks and additive technologies
- Compare performance characteristics of lubricants designed for passenger cars manufactured in N. America, Europe or Japan
- Identify key lubricant requirements for protecting heavy duty diesel engines
- Select and optimize fluids for various light duty and heavy duty after-treatment applications
- Recognize differences between API, ACEA, and ILSAC lubricant categories

Who Should Attend

This seminar is designed for engineers, scientists, investigators and consultants involved in designing or optimizing mobile or stationary powertrains. Individuals interested in understanding the role of crankcase fluids in extending useful life of the overall systems, minimizing emissions and reducing fuel consumption will find the seminar beneficial.

Topical Outline

DAY ONE

- Introduction to Engine Lubricant Formulations
  - What are motor oils?
  - Standardized tests of new oils (SAE J300)
  - Used oils testing
- Lubrication Fundamentals
  - Functions of a lubricant
  - Friction
  - Lubrication regimes (Steinbeck Curve)
  - Wear modes
  - Viscosity
- Base Oils
  - Classes of crude oils
  - Conventional refining processes
  - Base oil categories
  - Affect of base oils on performance of engine oils
- Additives
  - Composition of motor oils - historical perspective
  - Lubricant additives industry
  - Engine oil additives -- Dispersants and dispersant VI improvers; Detergents and overbased detergents; Oxidation inhibitors; Wear inhibitors; Rust inhibitors; Friction reducers; Viscosity improvers; Factors promoting wear and deposits formation; Dispersion of particles in diesel and gasoline engine oils

DAY TWO

- Global Lubricant Specifications
  - Classification of motor oil by performance category
  - API service categories
  - Development of a new diesel engine oil category: PC10
  - Motor oil classifications- API doughnut
  - ACEA European oil specifications for gasoline and diesel engines
- Extended Service Intervals (ESI)
  - Maintenance intervals and engine life
  - Effect on lubricant formulations
- Fuel Economy
Motor Fuel: Technology, Performance, Testing, and Specifications

3 Days
I.D.# 98003

Fuel composition has had to change with the advent of more stringent emission regulations. Reformulated gasoline (RFG), for example, is vastly different from gasoline of even ten years ago. Tightening regulations on diesel emissions will dramatically change both diesel fuel and engine design. This three-day seminar will review the fundamentals of motor fuels, combustion and motor power generation. The primary content of the course provides a basic introduction to the technology, performance, evaluation, and specifications of current gasoline, diesel, and turbine fuels. The first day of the course begins with a brief review of the evolution of motor fuel through 100 years of performance and specification.

Learning Objectives
By attending this seminar, you will be able to:
• Describe how fuel compositional variables affect engine performance
• Interpret test data to determine if fuel meets required specifications and regulations
• Determine the purpose and mode of action of performance additives
• List the important processes in motor fuel
• Communicate effectively with others working with motor fuels
• Have a working knowledge of motor fuel composition, properties, and performance -- a necessity for engine designers, and fuel and additive formulators.

Who Should Attend
This course is intended for engine design engineers who need a basic understanding of the fundamental performance properties of motor fuels and additives. The course is also intended for formulators who need to understand the relationships of fuel performance and composition to properly design fuels and additives to meet current and future needs. Engine testing personnel; petroleum company employees; Federal, State, and Local Regulatory personnel, laboratory supervisors; and fuel marketing personnel would also benefit.

Topical Outline
• Introduction and History of Motor Fuels
• Overview of Motor Gasoline
  • Gasoline composition, chemistry, production, blending
  • Spark ignition engine and effect of fuel quality on performance
  • Gasoline volatility and combustion
  • Influence of composition on storage stability and engine deposit formation
• Oxygenated Blend Components and Emissions
• Gasoline Specifications
• Overview of Diesel Fuel
  • Diesel composition, chemistry, production, blending
  • Diesel engine and effect of fuel quality on performance
  • Fuel characteristics influencing combustion and emissions
  • Low temperature and other fuel characteristics
• Fuel additives
• Alternative Fuels, Future Trends, and Directions
• Diesel Specifications
• Gaseous Fuels for Engines
  • Natural gas combustion, performance, and emissions
  • LPG combustion, performance, and emissions
  • Alternative fuels, future trends, and directions
• Racing Fuels
  • General considerations
  • Hydrocarbon fuels; Alcohol fuels; Special fuels
• Future Trends in Fuels
  • Alternative fuels
  • Future trends and directions
POWER AND PROPULSION

RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Emissions-Related OBD Systems: A Design Overview
This one day seminar is designed to provide an overview of the fundamental design objectives and the features needed to achieve those objectives for generic on-board diagnostics.
Read more about this course on page 28

Hybrid and Electric Vehicles: Current Production, Future Strategies
This two-hour web seminar will highlight the passenger, light-duty, and heavy-duty hybrid and electric vehicles that are currently in production, offered for sale, or planned for near-term production.
Read more about this course on page 35

Introduction to Hybrid and Electric Vehicle Battery Systems
Driven by the need for lower emissions, better fuel economy and higher efficiency, hybrid vehicles are appearing in many different configurations on today’s roadways. This seminar will introduce participants to the concepts of hybrid vehicles, their missions and the role of batteries in fulfilling those requirements.
Read more about this course on page 36

Hybrid and Electric Vehicle Systems
This two-day practical and applications based course will concentrate on architectures, operation, functions, and design considerations of the safety, power electronics, energy systems, and failure modes associated with HEV and BEV vehicles, providing an environment in which participants can acquire a solid systems and integration foundation for applying this content to vehicle/systems design.
Read more about this course on page 36

Plug-in Hybrids: Opportunities and Challenges
What are the advantages and challenges for vehicle manufacturers, public utilities, energy and environmental concerns, and end-users? What is the current state of plug-in hybrid development? This Web Seminar explores these questions and more.
Read more about this course on page 37
Creating and Managing a Product Compliance Program

2 Days
I.D.# C1213

Around the world, and more often than not, government bodies require formal certification of products. As product developers expand into new markets, they will be confronted with new standards, regulations, and customer expectations that may require new compliance processes. A properly run compliance program improves your product’s quality and safety, broadens your product’s market, ensures compliance with regulations and laws, and helps provide protection from future product liability issues.

This two-day seminar presents a process development methodology that can be used repeatedly as new compliance requirements emerge. You will learn best practices in creating a compliance program for your products and markets, and how to use this program at all stages of product development and production. Sample spreadsheets will be used to demonstrate tailoring the program to your product, your markets, and your organization. A properly managed compliance program simplifies the certification or approval of your product, and ensures that you regularly apply and document good engineering practices for product safety and reliability.

Learning Objectives
By attending this training program you will be able to:
• Summarize how a formal compliance program adds value to your goods and services
• Develop a compliance checklist
• Identify effective strategies for researching compliance requirements
• Describe how to manage the ongoing compliance process
• Explain the importance of documenting compliance and retaining records

Who Should Attend
This seminar is designed for managers with implementation authority for product safety and compliance: product development engineers, designers and managers; new business development managers; risk managers and compliance or certification managers. Companies considering expanding or modifying their product line, or attempting to enter new export markets, will especially benefit. Suppliers who are involved in product development and compliance, regulatory agency representatives, industry safety organization representatives, and corporate compliance lawyers will also benefit.

Topical Outline
DAY ONE
• Introduction to Compliance
  • What do we mean by compliance
  • The 3 basic forms of compliance
  • Why we need to show compliance: Legal requirements in different countries; Commercial advantages; Product liability risks
  • What is a formal compliance program
• Creating a compliance checklist - getting started
  • An introduction to the compliance process
  • Defining your markets in terms of compliance requirements
  • Finding applicable regulations, standards, and guidelines
  • Documenting best practices in the compliance checklist
DAY TWO
• Completing the compliance checklist
  • Extracting relevant requirements from the regulations, standards and guidelines
  • Selecting methods of compliance
Learning Objectives
By attending this seminar you will be able to:

- Define the importance of each of the ten (10) Bodies of Project Management Knowledge and the essential components of APQP by Phase (includes the newest Knowledge Area – Stakeholder Management)
- Recognize the minimum essential elements of a Robust Project Plan
- Properly evaluate and differentiate between Statement of Requirement, Statement of Work and Work Breakdown structures
- Apply the different timeline methodologies: Milestone, Gantt, Network (PERT) and Critical Path
- Utilize different types of meeting and conflict resolution strategies, formulate an effective meeting summary and action list, and conduct an actual Design Review
- Recognize the pitfalls common to most mobility projects due to Voice of the Customer (VOC) collection, current U.S. and international legislation and directives, improper application of limited resources, and others.
- Beyond the Checklist! - Advanced techniques for Risk Management

Who Should Attend
New Project Managers, Lead or Design Release Engineers, Project Managers requiring refresher training or desire to learn how to properly apply more advanced project management techniques. Other individuals involved with projects will benefit by attending. The course is best suited for individuals in any of the mobility industry sectors such as automotive, truck, recreational, farming, and mining, to include DOD mobility contracts. Attendees should be familiar with how projects are currently managed in their company so they may ask questions relating to their specific problem areas.

Topical Outline

- The Project Management Process
  - Definition, outline and overview of the differences between 4th and 5th editions
  - Project constraints
  - The ten (10) bodies of Project Management Knowledge
  - Project Management and ISO
- Project Plan Life Cycle
  - Three types of life cycles: Product, Project, Project Management
  - Comparison of project management and the automotive APQP process
  - Major elements of each APQP phase
- Project Management Techniques
  - Principles of Integration Management
  - Managing project Stakeholders and Sponsors

Instructor: R.W. (Bill) Walker
Fee $1325 1.3 CEUs

Engineering Project Management

2 Days
I.D.# 99003

Project Management and Advanced Product Quality Planning (APQP) are two critical techniques used in product development in the mobility industry today. This seminar will bring these techniques together in an easy to understand format that goes beyond the typical concept of constructing timelines and project planning, by exploring not only the AIAG APQP process, but also specific aspects of PM processes. Students will gain a solid foundation in the essential principles of Project Management and APQP.

Students will immediately apply learned skills by taking a sample project through all phases of the Project Plan using actual industry documents. Realistic issues, problems and time constraints are introduced throughout the exercise to stimulate actual project concerns. Each workshop exercise uses documents specific to the particular areas of study such as Statement of Requirements and Statement of Work, Timeline development and reacting to changing situations such as time crash. Discussion of the major milestones of typical OEM APQP processes, to include PPAP. The workshop is structured so that students must operate in teams and the time constraints allow students to see firsthand the effects of improper delegation of work assignments.

Fault Tree/Success Tree Analysis

1 Day
I.D.# 92028

Sharpen your skills with this no-nonsense program that will show you practical ways to implement popular tools in your product/process design, manufacturing, reliability assurance and safety operations. Fault Tree/Success Tree analysis are proven devices for improving the design of a product or process by revealing logical failure paths and appropriate actions for implementing design changes or controls.

Learning Objectives

By attending this seminar, you will be able to:
• Define Fault Tree and Success Tree Analysis
• Identify the terminology and methodology used in Fault Tree/Success Tree Analysis
• Compare the benefits of Fault Tree/Success Tree Analysis to the product/process design and development process
• Appraise Fault Tree/Success Tree Analysis in relation to other tools
• Demonstrate Qualitative and Quantitative Analysis using the Fault Tree/Success Tree approach

Who Should Attend

You will profit from this detailed seminar if you...
• Are a product/process design or development engineer
• Are involved in manufacturing/process/industrial engineering
• Are a quality/reliability engineer
• Have product/process assurance responsibility
• Are a safety or service engineer
• Manage any of the above
• You and your company want to observe new automotive supplier quality requirements

Topical Outline

• Exposure to Fault Tree Analysis - Basic Concepts
• Uncovering Basic Elements of a Fault Tree
• Focusing on Fault Tree Construction
• Tackle Boolean Algebra and its Application to Fault Tree Analysis
• Zero in on Success Tree/RFT Concepts
• Reveal the Relationship between Fault Tree/Success Tree Analysis
• Mastering Block Diagrams
• Reliability Prediction Using Fault Tree/Success Tree Analysis

Instructor: E. Harold Vannoy
Fee $790 .7 CEUs

Instructor: Angelo E. Mago
Fee $1565 1.3 CEUs
**Global 8D - Ford On Demand Course**

12 Hours  
I.D.# PD111012ON

Global 8D (G8D) is a disciplined process developed by Ford Motor Company to help product development and manufacturing engineers identify and solve problems. Solving problems results in efficient, as well as effective, resolution to ‘root causes’ of customer satisfaction issues, and helps reduce warranty costs. With this 12-hour on demand course, you will learn the methods and tools used to complete each step in the Ford Global 8D find-and-fix problem-solving process, including steps to define the problem, verify the root cause and escape point, and prevent occurrence.

**Major topics include:**
- Global 8D Overview
- Prepare for Global 8D and Establish the Team
- Describe the Problem and Find the Root Cause
- Choose and Implement a Permanent Corrective Action (PCA)
- Complete the Global 8D

**Is this SAE/- Ford On Demand Course for you?**

This course is geared toward quality, manufacturing, and product development engineers. It is recommended that you have an engineering degree and experience in the automotive engineering field.

**What You Will Receive**
- Four months of on demand access to the 12-hour course
- Proof of Participation

**Fee $395**

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**Introduction to Advanced Product Quality Planning (APQP) Fast Track**

1 Hour  
I.D.# PD230908ON

To become a preferred supplier in the automotive industry, organizations must demonstrate high-level engineering and organizational capabilities that will meet customers’ needs today and tomorrow. Because the outcome of a product development project may determine whether or not an organization procures a purchase order or contract from a global automotive customer, the Introduction to Advanced Product Quality Planning Fast Track will address an overview of the best practices / methodologies for planning and managing the successful launch of a new product.

**Major topics include:**
- What is APQP?
- What is the purpose of APQP?
- Understanding how APQP integrates into the automotive supply chain
- APQP - A master plan for new product development
- Summary of APQP benefits

**Is this Fast Track for You?**

Participants in the one hour Introduction to Advanced Product Quality Planning (APQP) Fast Track will gain a ‘common-sense’ perspective for successful new product launches and what needs to be done to comply with automotive customer specific requirements. You will also understand how to apply the concepts of “front-end” planning (via the APQP process) that will result in continual improvement of products and services for both the customer and the supplying organization. This course is relevant to individuals with limited or general knowledge of the APQP process and some experience with introducing new products or new manufacturing processes.

**What You Will Receive**
- Three months of on demand access to the one hour presentation
- Integrated knowledge checks to reinforce key concepts
- Proof of Participation

**Instructor:** Larry Bissell  
**Fee $110**

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**Introduction to Weibull Engineering Fast Track**

80 Minutes  
I.D.# PD230946ON

The Weibull engineering technique is the starting point for solving most issues related to product reliability, maintainability, supportability, quality, safety, test planning, and cost control. Weibull Analysis is popular worldwide as the best method for predicting modeling variability and failure of designs, products, and systems. In this 80-minute, introductory short course, instructor Wes Fulton will provide a solid overview of Weibull Engineering capabilities. This Fast Track should be considered a prerequisite for participation in a Weibull project or for attending additional SAE training that covers advanced Weibull applications.

**Major topics include:**
- Introduction and Background
- Basic Weibull Plotting and Interpretation

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• Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

- Case Studies of Successful Weibull Applications
- Overview of Weibull Extensions
- Course Summary

Is this Fast Track for You?

The Introduction to Weibull Engineering Fast Track is designed for the engineer - from automotive, aerospace, electrical, biomedical, and nuclear. This course does not require any pre-requisite, as the content will unfold from the basics, up to the more advanced features of this valuable analysis tool. The knowledge gained in this course can serve as a prerequisite to more advanced Weibull projects.

What You Will Receive

- Three months of on demand access to the 80 minute presentation
- Integrated knowledge checks to reinforce key concepts
- Proof of Participation

Instructor: Wes Fulton
Fee $152

Managing Programs and Associated Risks

2 Days
I.D.# C0409

This course presents a proven eight-step method for program planning and control, including: definition of customers’ requirements, roles of the program team, determination and flowcharting of program tasks, scheduling and costing, quality aspects of critical tasks, and risk management. Easy to grasp, each of the eight steps evolve from common-sense questions that should be answered for any program, regardless of size or complexity.

With shortened development cycles and greater reliance on information in programs, this course emphasizes the value of communication within a program team, between the team and functional areas, and between the team and the program customer. Since the appropriateness of communication vehicles vary depending on purpose and audience, alternative modes of communication and change control are discussed.

Learning Objectives

By attending this seminar, you will be able to:
- Explain the eight-step method for program planning and control
- Implement the eight-step method to improve program outcomes as measured by cost, schedule and quality
- Make plans and progress visible to team members and to the program customer
- Explain the eight-step method for program planning and control
- Implement the eight-step method to improve program outcomes as measured by cost, schedule and quality
- Make plans and progress visible to team members and to the program customer

Who Should Attend

Engineers and business people involved in various product development team activities will find the subject matter practical and useful. The content is of particular value to professionals from engineering, manufacturing, purchasing, quality, marketing, and finance functions in ground vehicle OEMs and suppliers.

Topical Outline

- Program and risk management overview
- Process approach to planning programs
- Competition drives us to perform better
- Why programs sometimes fail
- Reference materials and website
- Defining program outcomes and measurables
- Building quality and performance targets into program planning
- Financial impact of poor planning
- Roles and responsibilities of project team members
- Design reviews
- Product performance measurement
- Program/project metrics
- Team formation and task planning
- Team development
- Roles and responsibilities
- Matrix management; Meeting management
- Scheduling work
- Critical Path calculation
- Fast tracking
- Developing a baseline schedule
- Gantt chart creation
- Software tools for scheduling & program management
- Resource planning
- Resource planning (quantity, skills, resource conflicts, anticipating needs)
- Adding contingencies
- Constraint management
- Risk Management
- Proactive assessment and mitigation of risks
- Types of risk
- Failure mode and effects analysis applied to programs/projects
- Optimizing work performance
- Spheres of influence and control
- Cause-effect diagrams
- Assessing critical information flows
- Managing human performance
- Responsibility matrix (RASIC)
- Project initiation
- Establishing a war room
- Authorization to begin
- Meeting management
- Tracking program performance
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

Patent Law for Engineers

1 Day
I.D.# 88007
This information-packed seminar focuses on the intricacies of patents, patent infringement litigation and patent licensing. Attendees will explore the important subjects of obtaining U.S. and foreign patents, maintaining U.S. and foreign patent rights, enforcing patent rights, defending against patent rights asserted by competitors, and licensing patent rights for revenue. After this seminar, you will effectively understand patents and ways to protect your company’s valuable inventions. Your new knowledge will help your company maintain and enhance its position in the marketplace.

Learning Objectives
By attending this seminar, you will be able to:
• Obtain an overview of U.S. patent litigation
• Understand the basic legal principles for liability and damages in patent cases
• Gain insights into how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Anticipate the scope of discovery in, and/or business disruption arising from, a U.S. patent case
• Peek into the future of potential patent law reform

Who Should Attend
Participants should have a mid- to upper-level managerial role. Research and development, in-house legal staff members such as in-house lawyers, patent agents, or patent liaisons will especially benefit.

Topical Outline

- Overview of Patent Litigation
- Issues the Patent-Owner Has to Prove
- Issues the Accused Infringer Has to Prove
- Who Decides Liability and Damages
  - Jury
  - Judge
  - Mediator/Arbitrator
- How Long Does It Take From Filing to Trial
  - District Courts
  - ITC
- How Much Does It Cost
  - Fees and expenses
  - Contingency Fees
  - Recovery of fees and expenses
- What is the Scope of Discovery
  - Documents, including e-documents
  - Depositors
  - Third parties (e.g. customers, suppliers)
  - Confidentiality of discovery materials
- What Changes are on the Horizon
  - Supreme Court
  - Patent law reform

Instructor: William Cory Spence
Fee $800 .7 CEUs

Patent Litigation in the U.S.: What You Need to Know Web Seminar and Web Seminar RePlay

4 Hours
Web Seminar: I.D.# WB0940
Web Seminar RePlay: I.D.# PD330940ON
In today’s economic environment, patents have become an increasingly important asset for both individuals and corporations. More and more, individuals and corporations, including those in the automotive and aerospace industries, are recognizing that revenue can be generated from their patent rights, whether those rights consist of a single patent, a family of patents or an entire portfolio. Indeed, some companies do not make or sell products; their entire revenue is derived from the licensing of their patents. Suffice it to say, licensing revenue has become a significant source of value in the global intellectual property economy.

This web seminar will tell you what you need to know about U.S. patent litigation and will provide in-depth insights into the practical realities of patent disputes in the U.S. You will learn what’s involved in a patent case, including the issues that the patent owner has to prove, e.g. infringement, and the issues

Instructor: William Cory Spence
Fee $800 .7 CEUs

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the accused infringer has to prove, e.g., invalidity. You will increase your awareness of the role of the judge and the jury in patent cases and you will hear about the increasing use of alternative dispute resolution mechanisms, such as mediation, to resolve patent disputes. Among other topics, this course also will increase your appreciation for the time it typically takes to go from the filing of a case to trial, and the fees and expenses associated with the case.

Learning Objectives
By connecting with this web seminar, you will be able to:
• Obtain an overview of U.S. patent litigation
• Explain the basic legal principles for liability and damages in patent cases
• Gain insights into how patent disputes are resolved
• Predict the fees and expenses associated with bringing and/or defending a patent case in the U.S.
• Anticipate the scope of discovery in, and/or business disruption arising from, a U.S. patent case
• Peek into the future of potential patent law reform

Who Should Attend
This course is geared toward executives, in-house counsel, in-house patent agents, and senior managers across industries, such as automotive and aerospace. Participants may be both U.S. and non-U.S. -- anyone who needs help in understanding what to expect and what the realities are should they become involved in U.S. patent litigation.

Topical Outline
Session 1
• Overview of Patent Litigation
  • Issues the patent-owner has to prove
  • Issue the accused infringer has to prove
• What is the Scope of Discovery?
  • Documents, including e-documents
  • Depositions
  • Third parties (e.g. customers, suppliers)
  • Confidentiality of discovery materials
• Who Decides Liability and Damages?
  • Jury; Judge; Mediator/Arbitrator
Session 2
• How Long Does it Take from Filing to Trial?
  • District Courts
  • ITC
• How Much Does it Cost?
  • Fees and expenses
  • Contingency fees
  • Recovery of fees and expenses
• What Changes are on the Horizon?
  • Supreme Court
  • Patent law reform

Patent Litigation Risk Management Toolkit
4 Hours
I.D.# WB1525
In recent years, total annual United States patent grants have increased to over 300,000, while patent infringement lawsuit filings have exceeded 6,000 per year. Only a small fraction of granted patents ever end up in litigation. Of the many causes for the disparity is the growing awareness and sensitivity of companies to patent infringement risk management practices. This course addresses a number of those practices (and tools for implementing the practices), placing them into context, and providing a practical overview for how to implement them to help reduce the prospect of patent infringement litigation.

Participants will receive a basic working knowledge of various common, but most misunderstood, practices for reducing the risk of patent infringement litigation. The course will teach the role and significance of patent claims, address pragmatic record keeping practices, reveal ways to monitor competitive patent filings, explain common practical pitfalls in analyzing a patent landscape, and illustrate alternative ways that risk can be managed (e.g., by use of contracts).

Learning Objectives
By participating in this web seminar, you will be able to:
• Identify causes why many companies end up in litigation
• Discover ways to help avoid poor patent litigation outcomes
• Expand existing practices to help avoid the risk of litigation in the first place

Who Should Attend
Small to mid-size company CFO’s, as well as technology officers, engineering managers, patent liaisons, and in-house counsel for companies of all sizes will benefit from this course. These people will typically have at least five years of industry experience, and some may have two or three decades of experience.

This course complements the Patent Litigation in the U.S.: What You Need to Know web seminar, which focuses on what engineers and business managers need to know to effectively manage patent procurement, patent infringement litigation, and patent licensing.
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

Topical Outline

Session 1
• Infringement: The Theme that Brings Us Together?
  • Patent statistics
  • Glossary of terms
  • Infringement and its consequences
• Hypothetical Case: Fact Review
  • The market generally
  • The patent landscape for the market
  • The product sought for market entry
  • Perspective
• The Tools in the Kit: For the Market Entrant and Existing Participants
  • Internal policies and practices
  • Prior art
  • Contracts
  • Patent applications/patents
  • Design arounds
• Internal Policies and Practices
  • Intellectual property policy of company
  • Confidentiality obligations
  • IP Ownership obligations
  • Invention disclosures
  • Patent searches and competitive patent watches
  • Product clearance
  • Archiving internal activities
  • Sending and receiving accusations of infringement
• The Role of Prior Art in Defining Boundaries in the World of Patents
  • Patents and non-patent literature
  • First inventor to file
  • Public accessibility requirement
  • Public use
  • Possible relevance of prior invention activities

Session 2
• Contracts
  • Employment agreements
  • Nondisclosure agreements
  • Joint development agreements
  • License agreements
• Patent Applications/Patents
  • Overview of patents
  • Utilitarian features
  • Ornamental features
  • International filings
  • Continuation/Divisional/Broadening Reissue Applications
• Design Arounds
  • Lawful
  • Precautions
• Toolkit Laboratories
  • The marketplace

• Patent Offices
• The Courts
• Comparison of proceedings in Patent Offices and Courts

Instructor:  Eric Dobrusin
Fee $425 .4 CEUs

Principles of Cost and Finance for Engineers

3 Days
I.D.# C0828

In today’s corporate environment of shrinking budgets, required structural cost reductions, sharing of global designs/services, and pricing pressures, it is critical that engineers possess a working knowledge of engineering economics principles. To fully understand the economic viability of engineering decisions, engineers need to find the appropriate balance between design alternatives, resulting costs, and impact on their enterprise. This seminar introduces participants to the cost, finance and economic concepts and their applications to products and services. This three-day course provides you with practical information normally obtained through university level economics and business management courses and will help you to maximize efficiencies from both an engineering and business perspective.

Note: Attendees are requested to bring with them a business or scientific calculator capable of doing exponential calculations.

Learning Objectives
By attending this seminar, you will be able to:
• Understand the hierarchy of economics, finance and cost in making financial decisions
• Review financial statements and ratios in assessing the financial state of a business
• Select the best decision-making criteria in making project decisions and allocating capital
• Implement a benchmarking plan to establish a competitive market position
• Determine the enterprise costs of raising capital through debt and equity offerings
• Analyze make-buy and buy-lease options and other alternative decisions based on the best financial strategies
• Understand the financial sensitivity of project decisions and the use of decision tools for integrating business requirements
• Determine and optimize all costs in the production process
• Select the optimum cost accounting strategy and inventory plan
• Identify the appropriate cost estimation methodology for metallic, electronic & plastic components
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

• Select cost control alternatives from marketing, engineering, commercial & geographic options

Who Should Attend
This seminar will benefit engineers having responsibilities in manufacturing, maintenance, research, design, product and process development, program and project management, troubleshooting, and materials management. Additionally, individuals in non-engineering disciplines, including marketing and general management, will benefit from an introduction to the engineering perspective.

Topical Outline
DAY ONE - Principles of Economics & Finance
• Process & Responsibility for Determining Cost
• Economics, Finance & Cost Principles
  • Macroeconomics and Growth
  • Microeconomics, Supply & Demand
  • International Economics & Comparative Advantage
  • Finance & Accounting: Corporate
• Finance
  • Financial Statements & GAAP
  • Financial Analysis & Ratios, Case Analysis
  • Capital Sources & Allocation
• Time Value of Money and Decision Making
  • Interest: simple and compounded
  • Inflation
  • Worth: present and future values
• Decision Making
  • Net Present Value, Payback Period
  • AAR, Internal Rate of Return, Profitability Index
  • Case Analysis
• Benchmarking Module
DAY TWO - Cost Impact & Enterprise Decisions
• Cost Impact on the Enterprise
  • Cost of capital, cost of equity and debt, WACC, Case Analysis
  • Cost of Ownership, Depreciation; Accelerated cost recovery; Depletion
  • The influence on tax obligations
• Alternative Financial Decisions Using Case Analysis
  • Make-Buy; Buy-Lease
  • Repair-Replace
  • Investments of Unequal Life
• Sensitivity & Scenario Analysis
• Matrix Priority Rating Systems
DAY THREE - Cost Management
• Production Cost Relationships
  • Break-even Point
  • Marginal Costing
• Elements of the Production Process
  • Pricing influences -- Quality; Competition
  • Elasticity of Demand
• Cost Principles & Definition
  • Accounting, Opportunity, Estimating
  • Fixed, Variable, Cost Function, Transfer Pricing
  • Economies of Scale
• Managerial & Cost Accounting
  • Cost Volume Profit Analyses
  • Standard Costing
  • Throughput Costing & Case Analysis
  • Activity-based
• Inventory Management
  • Types
  • Accounting
• Cost Estimating Methodology
  • Activity-based costing
  • Cost analysis process examples (metallic, electronic, plastic)
• Cost Control Alternatives
  • Marketing & content evaluation
  • Engineering & redesign (DFSS, DFMA, VE, Benchmarking)
  • Commercial Decisions (Purchasing, Economies of Scale)
  • Regions of manufacture & transportation

Instructor: James Masiak
Fee $1720 2.0 CEUs

Product Liability and The Engineer
1.5 Days
I.D.# 82001

In the past few decades, product liability law has dramatically changed the manufacturer’s outlook in the design and manufacture of product. The concept of safety and reliability has been altered from a purely engineering/manufacturing concept to a legal/manufacturing approach. This new approach requires an understanding of legal concepts as related to the manufacturing and design process. The engineer’s role has shifted to include a safety audit analysis to minimize the existence of a product defect and/or to defend the product in a way that is responsive to the legal concerns. An overnight assignment will be made by the instructor. It will consist of problems drawn from actual cases and a group project that examines the design, instructions, and warnings of a product.

Learning Objectives
By attending this seminar, you will be able to:
• Relate legal concepts as they apply to the manufacturing/design process
• Use safety audit analysis techniques to minimize or eliminate product defects during design, thus reducing product liability
• Discuss defense of product from a legal perspective
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

• Recognize the importance of potential liability as it relates to the manufacturer

Who Should Attend
Persons responsible for product design, including managers and designers; corporate risk managers; persons responsible for developing and approving product instructions and warnings; marketing personnel; production and quality assurance managers and personnel; personnel responsible for product safety and those persons, including lawyers, who oversee and manage product liability issues.

Topical Outline
• Legal Concepts
  • Negligence: elements, defenses
  • Strict liability: section 402A (elements, defenses)
  • Warranties: express, implied
• Analysis of Defect
  • Meaning of unreasonable danger
  • Production defect
  • Design defect
  • Defect by words
• Designing for Reasonable Safety
  • Products’ use, users & environment
  • Product safety audit
• The Role of Standards in Design
• Warnings
  • Guidelines for design & warnings
  • Functions & use
• Problem Analysis by Participants
• Review of a Product Design by Participants

Instructor: Charles F. Seyboldt
Fee $1325 1.0 CEUs

SAE PRODUCT ENGINEERING TOOLS AND METHODS CERTIFICATE PROGRAM
Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

This program focuses on the study, development, management and implementation of product engineering principles, methodologies and techniques. When used properly, these tools and methods become powerful productivity enhancers and facilitate the reduction of product development time and cost. Complete this certificate and earn up to seven graduate credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems and Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. For the complete list of required and elective courses and additional information on enrolling in this SAE certificate program, visit training.sae.org/certificate/engineering_tools.

The Role of the Expert Witness in Product Liability Litigation
1.5 Days
I.D.# 92054

According to the Federal Rules of Evidence, an expert witness is anyone who can assist the trier of fact (the jury) in understanding any issue in dispute at trial. The witness’ ability to give this assistance can be derived from any specialized training, education, background, or experience. To be effective in providing this assistance, however, requires that the expert witness understand the true role that he or she is to play both before and at the trial.

This seminar will address the critical issues that every person who may be, has been, or is, an expert witness must understand to assist both the attorney and the product manufacturer, regardless of which side the expert serves.

Learning Objectives
By attending this seminar, you will be able to:
• Employ the risk/utility balancing process necessary for effectively addressing the issue of design defect
• Recognize the critical elements that govern the interaction between human behavior and product behavior
• Apply the technical/legal elements that will enhance your effectiveness as an expert witness

Who Should Attend
This seminar is intended for anyone who is or may become an expert witness in product liability litigation. In-house experts typically have engineering, engineering management or field
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

Technician responsibilities. In addition, insurers, risk managers, corporate product safety personnel, attorneys and those who manage product liability litigation will benefit from insight into selecting and using expert services and witnesses more effectively and efficiently.

**Topical Outline**

(Day two ends at 1:00 p.m.)
- The Legal Framework of Negligence and Strict Liability
- The Relationship Between the Attorney and the Potential Expert Witness
- Investigation of an Accident Years After an Occurrence
- Developing the Background Necessary to Understand the Product and its Environment
- Understanding How to Allege or Refute the Existence of a Product Defect
- Analyzing the Role of Human Behavior and its Relationship to the Cause of an Accident
- Guidelines for Effective Presentation Before Trial and on the Witness Stand
- The seminar will also include overnight problem assignments and a demonstration of direct and cross-examination of an expert witness.

**Instructor:** Charles F. Seyboldt
**Fee:** $1325 1.0 CEUs

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**Weibull-Log Normal Analysis Workshop**

3 Days  I.D.# 86034

RMS (Reliability-Maintainability-Safety-Supportability) engineering is emerging as the newest discipline in product development due to new credible, accurate, quantitative methods. Weibull Analysis is foremost among these new tools. New and advanced Weibull techniques are a significant improvement over the original Weibull approach. This workshop, originally developed by Dr. Bob Abernethy, presents special methods developed for these data problems, such as Weibayes, with actual case studies in addition to the latest techniques in SuperSMITH® Weibull for risk forecasts with renewal and optimal component replacement. Class work is used to reinforce key concepts, lectures are based on actual case studies, and personal computers and hands-on experiments are used to analyze dozens of Weibull & Log Normal problems. Students will be fully capable of performing basic and advanced RMS Engineering analysis with their own software on completion of the workshop. Attendees must bring a laptop to this course.


Optional Weibull Introduction—to accelerate your learning in this Workshop, you may want to complete the SAE Fast Track, Introduction to Weibull Engineering (I.D.# PD230946ON, page 168). This highly recommended overview of Weibull engineering can improve your retention prior to taking the workshop or provide a great review afterwards.

**Learning Objectives**

By attending this seminar, you will be able to:
- Analyze design, development, production, and service failures
- Model product lifetime and reliability
- Evaluate calibration and maintainability plans
- Analyze inspection data
- Reduce test substantiation, time and costs

**Who Should Attend**

An engineering undergraduate degree in any discipline would be beneficial. Engineers responsible for reliability, safety, supportability, maintainability, materials, warranties, life cycle cost, design, structures, instrumentation and logistics will find these Weibull techniques extremely useful.

**Topical Outline**

**DAY ONE - Undergraduate Weibull Analysis**
- Background, Development & Introduction - 23-Minute Video Short Course
- How to do Weibull Analysis
- Interpretation of Good Weibulls - 2 & 3 Parameter
- Are two Weibull datasets significantly different?
- Interpretation of Bad Weibulls
- Risk and Failure Forecasting Case Studies
- Weibull Experiments (Wire Rupture, Torsion, LCF, Accelerated Testing), Classwork Problems and Solutions
- Log Normal Analysis
- Optimal Replacement Intervals, Block Replacement

**DAY TWO - Postgraduate Weibull Analysis**
- Maximum Likelihood Weibull Theory and Application
- WeiBayes Analysis
- Dauser Shift, Warranty Analysis
- Rank Regression vs. Maximum Likelihood
- Extremely Small Samples Analysis
- One Failure Weibull Case Study
- An Introduction to SuperSMITH® Software, Features, Input, Analysis, Output
- Summary of Weibull Methods
- Class Work Problems
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

- Experimental Wire Data Distribution Analysis
- Playtime With SuperSMITH® Tutorial
- DAY THREE - Confidence Intervals and System Models
- Confidence Intervals, “The Good, The Bad and The Complicated”
- Comparing Designs
- The Binomial & Poisson
- Crow-AMSAA Reliability Growth Modeling - Useful Technology for Tracking Development Testing and Any Significant Event to be Managed
- The Exponential Related to the Poisson and the Weibull
- Kaplan-Meier Survival Analysis
- Crow-AMSAA Employed for Analyzing Renewal-Repairable Systems
- System Models
- Classwork
- Complete Playtime With SuperSMITH®
- Ph.D. Oral Examination

Instructor: Wes Fulton
Fee $2220 2.0 CEUs

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CALISO ONLINE COURSES

Good Laboratory Practices (GLP) Training – CALISO On Demand Course
8 Hours
I.D.# GLP

GLP refers to a Quality Systems of management controls for laboratories and research organizations to ensure the consistency and reliability and reproducibility of results. The original regulatory enforcement was first published by FDA and then a few years later by EPA. It is also outlined in the Organization for Economic Co-operation and Development (OECD) Principles of GLP in 1992 and has since been added to many national regulations. Your company, and all who partake in the daily activities of running a laboratory or a research and testing center, will benefit from this course. This 8-hour GLP (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Major topics include:
- Scope
- Definitions

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently get a comprehensive training of GOOD LABORATORY PRACTICES (GLP)
- Want to improve your CV and career opportunities with qualifications in quality assurance

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $185.95 0.8 CEU

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ISO 9001 Overview – CALISO On Demand Course
4 Hours
I.D.# ISO9001OVERVIEW

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001 standard, because it is business and management oriented, can be applied to any activity. It is the most widely used quality management standard in the world. This four-hour ISO 9001 overview is particularly adapted for training top management on the high level requirements.

Major topics include:
- General Requirements of ISO 9001
- Management Responsibility
- Resource Management
- Product Realization (summary)
- Measurement, Analysis and Improvement

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently get a comprehensive overview of ISO 9001:2008
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

- Want to improve your CV and career opportunities with qualifications in ISO 9001
- Want to upgrade your expertise from auditing ISO 9001:2000 to ISO 9001:2008
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $159.95  0.4 CEUs

ISO 9001:2008 Training – CALISO Online Course
8 Hours
I.D.# ISO9001TRAINING

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. This eight-hour ISO 9001 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

Major topics include:
- General Requirements of ISO 9001
- ISO 9001 Vocabulary
- Management Responsibility
- Resource Management
- Product Realization
- Measurement, Analysis and Improvement

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently get a comprehensive training of ISO 9001:2008
- Want to improve your CV and career opportunities with qualifications in quality assurance
- Want to upgrade your expertise from ISO 9001:2000 to ISO 9001:2008

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95  0.8 CEUs

ISO 9001:2008 Auditor Training – CALISO On Demand Course
8 Hours
I.D.# ISO9001AUDITOR

ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in the daily activities of running the business will benefit from taking ISO 9001 training. The eight-hour (.8 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
- General Requirements of ISO 19011
- Auditing techniques
- QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to lead an ISO 9001:2008 audit
- Want to quickly and efficiently be trained on ISO 9001 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to be a lead auditor to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing ISO 9001:2000 to ISO 9001:2008
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95  0.8 CEUs
ISO 9001:2008 Lead Auditor – CALISO
On Demand Course

22 Hours
I.D.# ISO-9001-2015-LEAD-AUDITOR-TRAINING

As described in the previous ISO 9001 Overview description, ISO 9001 is a quality management standard developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the audit activities of running the business will benefit from taking ISO 14001 Auditor training. The 22-hour (2.2 CEU) ISO 9001 Auditor course provides training on the standard itself and on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
• General Requirements of ISO 9001
• Management Responsibility
• Resource Management
• Product Realization
• Measurement, Analysis and Improvement
• General Requirements of ISO 19011
• Auditing techniques
• QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to conduct an ISO 9001:2008 audit
• Want to quickly and efficiently be trained on ISO 9001 (the standard), and ISO 9000 (the vocabulary for the standard)
• Want to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes

Fee: $355.95 2.2 CEUs

ISO 9001 Business Strategy – CALISO
On Demand Course

I.D.#BSI

This is the ideal course for the CEO, Executive, other senior management team member, or corporate development department (strategy) staff who must design the vision for the company and chart the course and strategy for the management team to follow. This course was designed by expert partner-level management consultants with an average 15-years of experience with the top tier global strategic management consulting firms as consultants to Fortune 500 companies and financial institutions.

Major topics include:
• Vision, what does it do and how important is it?
• Selecting market segments where the company will compete
• Understanding market segments and capturing with tactical strategy and brand
• Figuring out the capabilities the company needs to have to win
• Enabling the needed set of capabilities at your company
• Performance metrics and aligning the firm to successfully execute the strategy

This SAE/CALISO course is for you if you:
• Are an employee or manager and want to quickly and efficiently become familiar with business strategy for implementation
• Want to understand Business Strategy in order to knowledgeably assess and contract Business Strategy services from a management consulting firm
• Want to improve your CV and career opportunities with Business Strategy knowledge and qualifications
• Are interested in learning world-class best practice methodology which will help increase your value to your company and help you think strategically
• Need to develop a competitive strategy for your company
• If the vision and strategy for your company is unclear or possibly in need of further enhancement
• Are uncertain that you have the correct organization design, processes, technology, and performance metrics needed to successfully execute the company’s business strategy
• Are restructuring or implementing quality programs but, so far, have not seen desired results
• Noticed that legacy processes, policies, and organization structures at your company don’t change although they seem inadequate, out of date, or inconsistent with the business strategy

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes.
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $219.95 1.2 CEUs

ISO 9001:2015 Overview – CALISO
On Demand Course

4 Hours
I.D.# ISO-9001-2015-OVERVIEW

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• Process Approach
• Risk-based Thinking
• General Requirements of ISO 9001:2015
• Context of the organization
• Leadership
• Planning
• Support
• Performance Evaluation
• Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive overview of ISO 9001:2015
• Want to improve your CV and career opportunities with qualifications in ISO 9001
• Want to upgrade your expertise from auditing ISO 9001:2008 to ISO 9001:2015
• Do NOT have time to allocate a full day to take an ISO 9001:2015 overview class

Fee: $199.95 0.4 CEUs

ISO 9001:2015 Training – CALISO
On Demand Course

10 Hours
I.D.# ISO-9001-2015-TRAINING

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• Process Approach
• Risk-based Thinking
• General Requirements of ISO 9001:2015
  • Section 4. Context of the organization
  • Section 5. Leadership
  • Section 6. Planning
  • Section 7. Support
  • Section 9. Performance Evaluation
  • Section 10. Improvement

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently get a comprehensive training of ISO 9001:2015
• Want to improve your CV and career opportunities with qualifications in quality assurance
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

• Want to upgrade your expertise from ISO 9001:2008 to ISO 9001:2015
• Do NOT have time to allocate a 2 full days to take an ISO 9001:2015 class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos at certain stages of the course delivery, and on-going quizzes are incorporated throughout the course to reinforce learning and retention and gauge your understanding of a topic before you move forward. Convenient and portable, this course provides instruction without the expense of travel and time away from the workplace. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes, or in a final exam provided for trainees with a score inferior of 70%. You can take this course using a laptop or PC with an internet connection, at your own pace, and at times convenient to you.

Fee: $269.95   0.8 CEUs

ISO 9001:2015 Auditor Training – CALISO
On Demand Course

1.8 Hours
I.D.# ISO-9001-2015-AUDITOR

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• General Requirements of ISO 19011
• Auditing techniques
• QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
• Want to quickly and efficiently learn how to lead an ISO 9001:2015 audit
• Want to quickly and efficiently be trained on ISO 9001:2015 (the standard), and ISO 9000 (the vocabulary for the standard)

Fee: $299.95   0.8 CEUs

ISO 9001:2015 Lead Auditor – CALISO
On Demand Course

32 Hours
I.D.# ISO-9001-2015-LEAD-AUDITOR

ISO 9001:2015 is a quality management standard developed by the International Organization for Standardization (ISO). The ISO 9001:2015 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products is not like producing food products or offering consulting services; yet the ISO 9001:2015 standard, because it is business and management oriented can be applied to any activity. It is the most widely used quality management standard in the world.

Major topics include:
• General Requirements of ISO 9001:2015
• Management Responsibility
• Resource Management
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

- Product Realization
- Measurement, Analysis and Improvement
- General Requirements of ISO 19011
- Auditing techniques
- QMS Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to conduct an ISO 9001:2015 audit
- Want to quickly and efficiently be trained on ISO 9001:2015 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Do NOT have time to allocate a 2-5 days to take an ISO 9001:2015 Lead Auditor class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently get a comprehensive training of ISO 14001:2004
- Want to improve your CV and career opportunities with qualifications in EMS
- Do NOT have time to allocate two full days to take an environmental management class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

Fee: $399.95 2.2 CEUs

ISO 14001:2004 Auditor Training – CALISO On Demand Course

8 Hours
I.D.#ISO14001AUDITOR

ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). The ISO 14001 standard is generic and can be used for any organization, whether it provides physical products or services. The requirements must be carefully interpreted to make sense within a particular organization. Developing automotive products and the environmental impact of this activity is not like producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world.

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to conduct an ISO 9001:2015 audit
- Want to quickly and efficiently be trained on ISO 9001:2015 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Do NOT have time to allocate a 2-5 days to take an ISO 9001:2015 Lead Auditor class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently get a comprehensive training of ISO 14001:2004
- Want to improve your CV and career opportunities with qualifications in EMS
- Do NOT have time to allocate two full days to take an environmental management class
- Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

Fee: $219.95 0.8 CEUs

ISO 14001:2004 Training – CALISO On Demand Course

8 Hours
I.D.#ISO14001
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

producing food products or offering consulting services; yet the ISO 14001 standard, because it is business and management oriented can be applied to any activity. It is the most widely used EMS standard in the world. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 14001 training. This eight-hour (.8 CEU) ISO 14001 Auditor course provides training on the standards and how to conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:

• General Requirements of ISO 19011
• Auditing Techniques
• EMS Auditing Case Studies

This SAE/CALISO course is for you if you:

• Want to quickly and efficiently learn how to lead an ISO 14001:2004 audit
• Want to quickly and efficiently be trained on ISO 14001 (the standard) and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first and second party audits
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002
• Do NOT have time to allocate two full days to take an ISO 14001 auditor class
• Want to train more of your staff on auditing economically and without having to immobilize them in a class for a full day

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $229.95 .8 CEUs

ISO 14001:2004 Lead Auditor – CALISO On Demand Course

22 Hours
I.D.#ISO14001LEADAUDITOR

As described in the previous ISO 14001 course description, ISO 14001 is an environmental management standard (EMS) developed by the International Organization for Standardization (ISO). Your company and all who partake in planning, leading and conducting the EMS audit activities of your business and managing its environmental program will benefit from taking ISO 14001 training. The 22-hour (2.2 CEU) ISO 14001 Lead Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:

• General Requirements of ISO 14001
• ISO 14001 Vocabulary
• Environmental Policy
• Planning
• Implementation and Operation
• Checking
• Management Review
• General Requirements of ISO 19011
• Auditing Techniques
• EMS Auditing Case Studies

This SAE/CALISO course is for you if you:

• Want to quickly and efficiently learn how to lead an ISO 14001:2004 audit
• Want to quickly and efficiently be trained on ISO 14001 (the standard), and ISO 14000 (the vocabulary for the standard)
• Want to be a lead auditor to conduct internal audits and supplier audits for your company
• Want to improve your CV and career opportunities with qualifications in EMS and leading first part and second party audits
• Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $319.95 2.2 CEUs

ISO/TS 16949:2009 Training – CALISO On Demand Course

8 Hours
I.D.# ISO16949

The ISO/TS16949 is an ISO technical specification for the automotive industry aiming to the development of a quality management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain. The requirements must be carefully interpreted to make sense within a particular organization.
Your company and all who partake in the daily activities of running the business will benefit from taking ISO/TS 16949 training. This eight-hour ISO/TS 16949 (.8 CEU) overview is particularly adapted for training all levels of an organization on the requirements of this standard.

**Major topics include:**
- General Requirements of ISO 16949
- ISO 16949 Vocabulary
- Management Responsibility
- Resource Management
- Product Realization
- Measurement, Analysis and Improvement

**This SAE/CALISO course is for you if you:**
- Want to quickly and efficiently get a comprehensive training of ISO 16949:2009
- Want to improve your CV and career opportunities with qualifications in quality assurance
- Want to upgrade your expertise from QS 9000 to ISO 16949:2009

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

**Fee:** $229.95 0.8 CEUs

**ISO/TS 16949:2009 Auditor Training – CALISO On Demand Course**

8 Hours

I.D.# ISO16949AUDITOR

The ISO/TS16949 is an ISO technical specification for the automotive industry aiming to the development of a quality management system that provides for continual improvement, emphasizing defect prevention and the reduction of variation and waste in the supply chain. The requirements must be carefully interpreted to make sense within a particular organization. Your company and all who partake in the QMS and supplier audit activities will benefit from taking ISO/TS 16949 training. The eight-hour (.8 CEU) ISO/TS 16949 Auditor course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

**Major topics include:**
- General Requirements of ISO 19011
- Auditing techniques
- QMS Automotive Auditing Case Studies

**This SAE/CALISO course is for you if you:**
- Want to quickly and efficiently learn how to lead an ISO/TS 16949:2009 audit
- Want to quickly and efficiently be trained on ISO/TS 16949 (the standard), and ISO 9000 (the vocabulary for the standard)
- Want to be a lead auditor to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing QS 9000 to ISO/TS 16949:2009
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

**Fee:** $239.95 0.8 CEU

**ISO/TS 16949:2009 Lead Auditor Training – CALISO On Demand Course**

22 Hours

I.D.# TS16949LEADAUDITOR

The ISO/TS16949 is an ISO technical specification which forms the requirements or application of ISO 9001 for automotive production and relevant service part organizations. It is essentially ISO 9001 with additional automotive specific requirements and is required by most major automotive manufacturers. Once your company implements processes and procedures that comply with the requirements listed in ISO/TS 16949, you can be audited by a third party organization called a Registrar, which will certify your organization to this standard.

This lead auditor course provides management representatives, QA managers or supervisors and others not only the information needed to conduct an audit for ISO/TS 16949, but also to organize, implement and lead it. All audit teams need a leader, and the body of knowledge of this course covers all of the lead auditing aspects.
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

Major topics include:
- Statistical Process Control (SPC)
- APQP/CP: Advanced Product Quality Planning and Control Plans
- PPAP: Product Part Approval Process
- FMEA: Failure Mode and Effects Analysis
- MSA: Measurement Systems Analysis

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to lead an ISO/TS 16949:2009 audit
- Want to quickly and efficiently be trained on the TS 16949 specification
- Want to be a lead auditor to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing with ISO 19011:2002 to ISO 19011:2011

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $369.95 2.2 CEUs

4 Hours I.D.#ISO19

ISO 19011 is a guideline developed by the International Organization for Standardization (ISO). The ISO 19011 standard is generic and can be used for auditing any type of management standard: quality, environmental, health and safety and others. Your company and all who partake in the daily activities of running the business will benefit from taking ISO 19011 training for its auditing activities. The four-hour (.4 CEU) ISO 19011 course is the most comprehensive training on the subject. It provides training on the standard itself but also on how to lead or conduct internal audits and supplier audits using ISO 19011, the guideline standard on how to audit management systems.

Major topics include:
- General Requirements of ISO 19011
- Auditing techniques
- Auditing Case Studies

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently learn how to audit management systems
- Want to be a lead auditor to conduct internal audits and supplier audits for your company
- Want to improve your CV and career opportunities with qualifications in quality assurance and leading 1st part audits
- Want to upgrade your expertise from auditing with ISO 10011-1 to ISO 19011:2002

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $169.95 .4 CEUs

Sarbanes-Oxley (SOX) Training – CALISO On Demand Course
4 Hours I.D.#SOX

This is the ideal course for employees or managers who want to get a comprehensive training on Sarbanes-Oxley (SOX) compliance requirements, practical applications, and how ISO 9001 business management methodologies can be used, applied and combined to implement Sarbanes-Oxley. This is the ideal course for individuals who you want improve their résumé and career opportunities in SOX, by adding this course to the education or training section of your CV.

Major topics include:
- Sarbanes-Oxley, what is it?
- Sarbanes-Oxley (SOX) Certification Requirements
- Sarbanes-Oxley Section 302 - a big concern; Section 906 - the biggest concern
- What’s a CEO to do? How to most easily implement SOX without the CEO having to do everything?
- Minimal levels of SOX compliance, Risk Analysis
- How to avoid defrauding of the auditors by the business
- Whistle blower program
- What to do if something is already wrong (non-compliance)?
- Top steps to Sarbanes-Oxley compliance

This SAE/CALISO course is for you if you:
- Want to quickly and efficiently become familiar with Sarbanes-Oxley to understand, implement Sarbanes-Oxley compliance as an employee or a manager
PRODUCT DEVELOPMENT/QUALITY ASSURANCE

- Want to understand Sarbanes-Oxley compliance in order to knowledgeably assess and contract Sarbanes-Oxley services
- Want to improve your CV and career opportunities with Sarbanes-Oxley knowledge and qualifications
- Want to protect your company from financial fraud and related legal, criminal and financial liability

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $269.95 .4 CEUs

Six Sigma Overview – CALISO
On Demand Course

8 Hours
I.D.#SIGMA

Six-Sigma is a systematic way to improve a product, process and/or service. This is the ideal course for employees or managers who want to get a basic training on Six-Sigma concepts, methodology and techniques.

Six-Sigma methodology can be used for any size organization, whether it provides physical products (i.e. hardware or software) or services. Developing and maintaining profitable products and services require continuous improvement in numerous key areas such as quality, performance and efficiency. Six-Sigma techniques can help any company achieve these goals.

This is the ideal course for individuals who you want improve their résumé and career opportunities in Six-Sigma, by adding this industry-wide recognized course to the education or training section of your CV.

The course covers Six-Sigma process improvement techniques; it is a stepping stone for Six Sigma Green and Black-belt certifications.

Major topics include:
- Six-Sigma, what is it?
- Six-Sigma, why use it?
- International quality standards and Six-Sigma
- Six-Sigma Core Concepts, How to use Six-Sigma
- Six-Sigma application example and Case Study “JFS”
- Another Case Study “BBB”
- Top steps to Six-Sigma
- Sigma Table, Spread Sheet Tips

This SAE/CALISO course is for you if you:

- Want to quickly and efficiently become familiar with Six-Sigma to understand and launch Six-Sigma projects as an employee or a manager
- Want to improve your CV and career opportunities with Six-Sigma knowledge and qualifications
- Want to systematically improve the profitability and customer satisfaction of your product or service by improving numerous key areas such as quality, performance and efficiency

This is an internet-delivered course featuring graphical presentation screens with text-based instruction, videos, and on-going quizzes to reinforce learning and retention and gauge your understanding of a topic before you move forward. An online training certificate will be issued upon successful completion of the course and obtaining 70% or above on the final average of the ongoing quizzes.

Fee: $159.95 .8 CEUs

RELATED TRAINING SOLUTIONS

Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

Accelerated Test Methods for Ground and Aerospace Vehicle Development

This course covers the benefits, limitations, processes, and applications of several proven accelerated test methods including accelerated reliability, step stress, FSLT (Full System Life Test), FMVT® (Failure Mode Verification Testing), HALT (Highly Accelerated Life Testing), and HASS (Highly Accelerated Stress Screening).

Read more about this course on page 40

Robust Design

Robustness refers to creating designs that are insensitive to variability in the inputs. This course presents mathematical formulas based on derivatives to determine system variation based on input variation and knowledge of the engineering function. If the function is unknown, experimental techniques are presented to efficiently estimate a function.

Read more about this course on page 53
SAFETY AND ACCIDENT RECONSTRUCTION

Includes vehicle impact, accident reconstruction, occupant safety, and safety standards.

Applying Automotive EDR Data to Traffic Crash Reconstruction

3 Days
I.D.# C1210

EDR’s are not new, but are becoming more prevalent in part due to a new federal regulation. 49 CFR, Part 563, which affects vehicles produced after September 30, 2012, will result in a standardized and publicly available EDR in 90% of new vehicles. Accident Reconstructionists frequently have trouble reconciling EDR data with other data sources, and improvements in ABS technology result in fewer tire marks visible at the scene of crashes to allow calculation of pre-crash speeds without an EDR.

This course will provide the participant with the skills necessary to analyze EDR data that has already been imaged, apply it to crash reconstruction, and reconcile it with calculations using other data sources. The course will enable the participant to analyze any current and future EDR data set without regard to manufacturer. The class presents the generic analysis step by step, then groups EDR’s into manufacturer-specific families and their data limitations, and works case studies that highlight targeted key learning objectives. The student will also learn key points to satisfy court Frye and Daubert requirements for EDR data to be admissible, and suggest methods to present EDR data that will communicate the data understandably to attorneys and lay juries.

Learning Objectives

By attending this seminar, you will be able to:

- Describe EDR sensor operation, recording interval and duration, resolution, accuracy, and time latency and articulate the limitations of applying the data to crash analysis.
- Calculate min and max speeds prior to loss of control or braking, and at impact based on the last accurate EDR pre-crash speed data point.
- Evaluate EDR vs. actual ground speed for specific vehicle operational conditions and vehicle equipment modifications.
- Calculate speed at impact and closing speeds by combining EDR Delta V data with normally collected scene and vehicle data such as post crash travel distance, departure angle, drag factor, and vehicle weights. Apply data to inline rear end, head on, and angular collisions.
- Reconcile EDR data with other physical evidence and combine to narrow speed ranges.
- Use time-distance and overlay EDR data on scene maps/diagrams to show where critical driving inputs were made vs. inputs required to avoid collisions.

Who Should Attend

This course is a must for anyone involved in the investigation and analysis of passenger car and light truck crashes who needs to understand the types of event data that are available, the limitations of that data, and how to apply it to a collision reconstruction and reconcile it with data from other sources. In addition, this course can be valuable to insurance adjusters and claims managers, and attorneys handling automotive collisions. Engineers designing EDR’s to meet part 563 regulations may also benefit from understanding how the data they store will be used. New analysts requiring training, as well as experienced analysts who require information on changing technology and federal regulations will find this course relevant and timely.

Topical Outline

DAY ONE

- Overview
  - Case Study - vision of success

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• Fill out the online quote request at www.sae.org/corplearning • Email us at Corplearn@sae.org
SAFETY AND ACCIDENT RECONSTRUCTION

• Overview - EDR data availability by manufacturer by model and model year
• 49 CFR Part 563 EDR regulation timing and contents
• EDR Data Analysis
  • Rules of recording and data limitations - Is this recording from my crash, and which of my multiple events is this recording(s) from?
  • Speed data accuracy
  • Speed at impact drills
  • Accelerator pedal release and brake application
  • Using Delta V to obtain closing speed and impact speed
  • Delta V data accuracy

DAY TWO
• GM EDR families - data availability and limitations, and case studies
  • Using Longitudinal Delta V to get speed at impact in angular collisions
  • Using speed data in critical speed yaw single vehicle crashes; transforming speed vs time into speed vs. distance to impact
  • Reconciling EDR data to scene evidence and evaluating uncertainty in inline collisions
  • Multiple events - which event is my recording from?
• Ford EDR families - data availability and limitations, and case studies
  • Ford PCM - evaluating when criminal or negligent behavior occurs, transforming speed vs time data to speed vs distance and overlaying on map to evaluate sight lines
  • Ford ACM - using Delta V in inline collisions and stability control system longitudinal acceleration data to determine real time drag factor

DAY THREE
• Chrysler EDR families - data availability and limitations, and case studies
  • Using acceleration data to calculate Delta V
  • Using yaw angle data to sub-topic
• Toyota EDR families - data availability and limitations, and case studies
  • Using RPM and Delta V to determine speed when actual speed is above data limitation
  • Data latency
• Honda, Mazda, and other manufacturer EDR families (to the extent they are known at the time of the class)
• EDR data admissibility technical foundation

Basic Hybrid and Electric Vehicle Safety
Web Seminar and Web Seminar RePlay

2 Hours
Web Seminar: I.D.# C0904
Web Seminar RePlay: I.D.# PD330904ON

High-voltage, high-current energy storage systems and electrical circuits in many current and future alternative-propulsion powertrains present unique challenges to the automotive industry. Care must be taken to minimize risk to all who come into contact with the vehicle throughout its development and life cycle, including powertrain developers, assembly line workers, service technicians, vehicle occupants, and first responders. Significant risk to life and limb can arise from technical issues surrounding these vehicles.

This 120-minute Web Seminar reviews safety concerns and precautions related to high-voltage circuits present in hybrid, plug-in hybrid, electric, and fuel cell hybrid vehicles. HV circuits are discussed in general to provide an understanding of “where the risk lies”. The effects of electrical current on the human body are summarized and existing protective measures, along with the standards that govern such measures, are described. Specific issues related to vehicle development, service, and operation are explained, along with onboard fault detection systems used to protect individuals from electrical injury. A general understanding of electrical and mechanical engineering is helpful, but is not required.

Learning Objectives

By participating in this web seminar, you will be able to:
• Describe component functions and locations in a typical high-voltage powertrain as well as the onboard safety systems associated with such components
• Explain the general effects of electric current on the human body
• Know which national and international safety standards apply to high-voltage vehicle circuits
• Summarize HV safety working issues that may be present during a vehicle’s development, assembly, service, and operation
• Identify general issues associated with extrication of occupants from vehicles with high-voltage powertrains

Who Should Attend

Light and heavy duty engineers and technicians who work directly with high-voltage vehicle circuits in hybrid, plug-in hybrid electric, and/or fuel cell hybrid vehicles, as well as component suppliers, safety officers and/or personnel who plan to develop high-voltage safety programs or procedures, will benefit from this Web Seminar.

Instructor: Richard R. Ruth
Fee $1650 2.0 CEUs
SAFETY AND ACCIDENT RECONSTRUCTION

Topical Outline

- General high-voltage electrical safety issues in vehicles
  - Issues with energy storage systems
  - Issues with motor controllers
  - Issues with motor-generators
  - Issues with DC-DC converters
  - Relationship between high-voltage (HV) bus and 12V bus
  - Gasoline-electric hybrids (HEV)
- Electrical injury
  - Effects of electrical energy on the human body
  - Electrical resistance of the human body
  - “Let-go” current
  - Common electrical accidents
- Industry protection against electrical injury
  - Standards and regulations organizations
  - Personal protective equipment
- On-board vehicle protection against electrical injury
  - Insulation and insulation breakdown
  - Fusing and interlocks
  - Ground-fault protection systems
  - Discharge and isolation circuits
- Powertrain development issues
  - Working with prototype battery packs
  - Working in powertrain test cells
- Service and repair issues
  - Hazards associated with routine maintenance
  - Hazards associated with HV component diagnosis and repair
  - General industry safety procedures
- Vehicle occupant and first responder issues
  - Protective measures for vehicle occupants
  - Hazards associated with vehicle occupant

Instructor: Jack Rosebro
Fee $270 .2 CEUs

Driver Distraction from Electronic Devices: Insights and Implications Web Seminar and Web Seminar RePlay

4 Hours
Web Seminar: I.D.# WBI140
Web Seminar RePlay: I.D.# PD331140ON

Although many have an idea of what the term “driver distraction” means, there is no common definition within the research community. Additionally, there are many studies that have investigated the topic, but with varying and sometimes conflicting results. What should be made of these discrepancies?

This four-hour Web Seminar will provide an overview of driver distraction (predominantly electronic devices): the problem; how to define it; the current state of research and how to critically evaluate that research to make informed decisions; and the effectiveness of state laws and fleet policies to reduce it. The conclusion of the course will summarize strategies, techniques, and technologies that have been shown to be effective in reducing distracted driving from electronic devices.

Learning Objectives

By connecting with this web seminar, you will be able to:

- Weigh the extent of the driver distraction problem
- Define driver distraction
- Critically examine the current state of driver distraction research
- Identify the strengths and limitations of various research approaches that assess driver distraction from electronic devices
- Recognize the difference between various forms of distraction (cognitive, auditory, visual, manual)
- Assess the effectiveness of policy efforts to reduce driver distraction from electronic devices
- Explain that all cell phone “tasks” do not have equal risk
- Determine effective strategies, techniques, and technologies for minimizing distracted driving

Who Should Attend

This course is intended for all those interested in being equipped to critically examine the current state of research in driver distraction. Although the course is aimed at driver distraction from electronic devices, the results pertain to driver distraction in general. Vehicle manufacturers, OEMs, and cell phone providers and manufacturers will be able to use the information presented in this Web Seminar to develop engineering solutions in this area. Government and driving advocate officials will be able to use the information presented in this Web Seminar to design and deliver informed policy decisions regarding driver distraction. Transportation safety researchers will learn about the latest research in this area as well as future research needs.

Topical Outline

Session 1

- Overview of Driver Distraction Problem
  - Statistics (crashes, injuries, fatalities, monetary burden)
- Forms of Distraction
  - Cognitive
  - Visual
  - Auditory
  - Manual
- Definition of Driver Distraction
- Overview of Methods to Assess Driver Distraction
SAFETY AND ACCIDENT RECONSTRUCTION

Session 2
• Possible Reasons for Discrepancies
  • Driver Choice
  • Self-regulation
  • Arousal
• Effectiveness of Policy Efforts to Reduce Driver Distraction from Electronic Devices
• Research Needs/Next Steps
• Minimizing Distracted Driving from Electronic Devices (what works, what shows promise, what doesn’t work)
• Summary

Instructor: Jeffrey Hickman
Fee $425 .4 CEUs

Injuries, Anatomy, Biomechanics & Federal Regulation

3 Days
I.D.# 85049

Safety continues to be one of the most important factors in motor vehicle design, manufacture and marketing. This seminar provides a comprehensive overview of these critical automotive safety considerations: injury and anatomy; human tolerance and biomechanics; occupant protection; testing; and federal legislation. The knowledge shared at this seminar will enable attendees to be more aware of safety considerations and to better understand and interact with safety experts.

Learning Objectives
By attending in this seminar, you will be able to:
• Recognize the significance of various injuries, how to rank order and quantitatively compare their severity, and how to access overall severity of multiple injuries.
• Assess the significance of various test results, know their basis and how to interpret them.
• Identify the biomechanical and legal basis of safety regulations and their changes (especially FMVSS 208 and 214).
• Describe the different measuring capabilities of various test dummies including Hybrid III test dummies.
• Contrast the difference between impact and deceleration injuries for various body regions and explain the “third collision,” which takes place within the vehicle.

Who Should Attend
This seminar is designed for all professionals - technical or managerial - who are involved either directly or indirectly with vehicle safety performance. An engineering undergraduate degree in any discipline would be beneficial.

Topical Outline
• Introduction & Background
• Next Generation Restraint Systems
• Injury Scales -- Abbreviated Injury Scale (AIS); Injury Severity Score (ISS); Trauma Score; Harm; Injury Priority Rating (IPR), Functional Capacity Index (FCI)
• Diagnostic Images of Injuries -- Plain Film X-rays, CT, MRI
• The Role of Alcohol
• Anatomy, Injuries and Tolerance Parameters (By Body Region) -- Head & Neck; Spine; Chest; Abdomen; Pelvis and Lower Extremities
• Test Devices: Basic Differences and Measuring Capabilities for Front and Side Impact Tests
• FMVSS 201, 208, 214 and NCAP and LINCAP -- Current & Proposed Injury Criteria and their Biomechanical Basis
• Regulatory Process -- Federal Rulemaking Process and NHTSA -- Legal Authorizations and Restrictions
• Assessing Pre-existing Conditions and Previous Injury
• Older Drivers - Special Needs

Instructor: Jeffrey A. Pike
Fee $1690 2.0 CEUs

Overview and Impact of the Automotive Functional Safety Standard ISO 26262
Web Seminar and Web Seminar RePlay

4.5 Hours
Web Seminar: I.D.# WB1134
Web Seminar RePlay: I.D.# PD331134ON

ISO 26262: Road Vehicle - Functional Safety is now becoming a condition of compliance for doing business in the automotive sector. The Scope states: “ISO 26262 is intended to be applied to safety-related systems that include one or more electrical and/or electronic (E/E) systems and that are installed in series production passenger cars with a maximum gross vehicle mass up to 3,500 kg...”

This course provides background for reading and applying the standard and explains its scope, the major differences from the general safety standard IEC 61508, and how the scope changes with the introduction of new systems. The vocabulary of the standard is used to enable participants to engage in the context of the standard and a selected list of acronyms is provided as reference. An overview of all parts of the standard is provided and its impact is explained, without lengthy examples requiring days of workshop attendance.
SAFETY AND ACCIDENT RECONSTRUCTION

Learning Objectives
By connecting with this web seminar, you will be able to use the standard to:
• Determine if and how the scope of ISO 26262 applies to your system or component
• Plan a Safety Case based on ISO 26262
• Prepare or reply to Development Interface Agreement compliant to ISO 26262
• Determine the safety goals and Automotive Safety Integrity Level (ASIL)
• Determine the HW requirements based on ASIL
• Determine the SW requirements based on ASIL

Who Should Attend
This Web Seminar would be especially valuable for engineers and managers that desire an overview of the standard’s content, without attending a multi-day workshop or following lengthy technical examples in order to become skilled practitioners. This includes those involved in product development for vehicle manufacturers or suppliers whose products contain electronics or software; engineering quality professionals including SPICE, CMMI, and internal process assessment; attorneys involved in Product Liability; and supplier quality engineers. Web Seminar participants should have an engineering degree. Knowledge of automotive product development and electronics or software is helpful. It is recommended that you have a copy of the ISO 26262 Standard, but it is not required. However, the standard is required for application after the course is completed.

Topical Outline
Session 1
• Motivation for Creating ISO 26262
  • Pre-standard work of France and Germany
  • U.S. involvement and resulting changes to the standard
  • National Academy of Science expectations
• Differences to IEC 61508, the General Safety Standard Previously Used
  • Comparison
  • Impact on Automotive Development
• Overview of the ISO 26262
  • Planning
  • System
Session 2
• Overview of the ISO 26262 (cont’d)
  • Hardware/Software
  • Operations
  • Supporting Processes
  • ASIL-oriented and Safety-oriented Analyses

Instructor: Joseph D. Miller
Fee $425 .45 CEUs

Reconstruction and Analysis of Rollover Crashes of Light Vehicles

1 Day
I.D.# C1502

The field of vehicular accident reconstruction has become increasingly specialized. For automotive engineers involved in crash reconstruction and analysis, a knowledge of basic accident reconstruction principles and techniques is essential, but often insufficient to answer the sophisticated questions posed by design engineers, regulators, and lawyers. This seminar takes participants beyond the basics of accident reconstruction to physical models and analysis techniques that are unique to the reconstruction of single-vehicle rollover crashes.

The seminar begins by defining rollover and discussing the common characteristics and phases of single-vehicle rollover crashes and the common types of physical evidence deposited on the roadway and the vehicle during a rollover crash. Participants will learn how to use this physical evidence to reconstruct the motion the vehicle experienced during the crash as well as the techniques and methods available for analyzing each phase of a single-vehicle rollover crash.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 7 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818 FREE, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives
By attending in this seminar, you will be able to:
• Name common characteristics and phases of rollover crashes
• Identify and document common types of physical evidence from rollover crashes
• Use physical evidence to reconstruct the motion of a vehicle involved in a rollover crash
• Estimate the rate at which a vehicle will decelerate during each phase of a rollover crash
• Calculate the speed a vehicle was traveling during each phase of a rollover crash
• Determine what steering and braking inputs a driver utilized before a rollover
• Quantify the forces applied to a vehicle when it impacts the ground during a rollover

Who Should Attend
This course is designed for engineers or others with a strong background in college physics and algebra, who are involved in the investigation and reconstruction of vehicular crashes. Indi
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viduals with a strong background in crash reconstruction, but new to or inexperienced in the specialized area of rollover crash reconstruction, will benefit the most from the course material.

Topical Outline

- General Characteristics of Rollover Crashes
  - Test methods and characteristics; field relevance
- Physical Evidence from Rollover Crashes
  - Scene evidence and documentation - photogrammetry to locate evidence
  - Vehicle evidence and documentation
- Analysis Methods – Rollover Phase
  - Average deceleration rates - dependence on surface and vehicle type?
  - Non-constant deceleration models
  - Evaluating roll motion from physical evidence – glass; scratch patterns; rim gouges
  - Typical rollover characteristics - # of rolls v. rollover distance; typical roll velocity curves
  - Roof-to-ground impact model - testing and validation
- Simulation - PC-crash; HVE; validation considerations of simulation software
- Analysis Methods – Trip Phase
  - Physical evidence
  - Analytical Models – equations; static stability factor; increasing the complexity and accuracy; estimating the center of gravity height; estimating the roll moment of inertia; trip duration
- Simulation
  - PC-crash
  - HVE
  - Validation considerations of simulation software
- Analysis Methods – Pre-Trip Phase (Loss-of-Control)
  - Tire marks
  - Striations and their meaning - uncertainty and sensitivity analysis
  - Calculating speed loss
  - Is the critical speed equation applicable?
  - Testing - validation of striation analysis; validation of speed loss equations

Reconstruction and Analysis of Motorcycle Crashes

1 Day
I.D.# C1506

The reconstruction and analysis of motorcycle crashes requires a specialized set of skills and knowledge beyond those required for typical four wheel vehicles. This seminar takes participants beyond the basics of crash reconstruction to physical models and analysis techniques that are unique to the reconstruction of motorcycle crashes, providing learners with a comprehensive summary of applicable reconstruction techniques. In addition, case studies will be utilized throughout the course to further explore crash causation, configuration, kinematics, dynamics, and handling characteristics, focusing on pre-crash, impact and post impact analysis.

This course has been approved by the Accreditation Commission for Traffic Accident Reconstruction (ACTAR) for 7 Continuing Education Units (CEUs). Upon completion of this seminar, accredited reconstructionists should contact ACTAR, 800-809-3818 FREE, to request CEUs. As an ACTAR approved course, the fee for CEUs is reduced to $5.00.

Learning Objectives

By attending in this seminar, you will be able to:

- Identify motorcycle crash causation from field studies
- Identify pertinent engineering design parameters affecting motorcycle dynamics
- Describe motorcycle motions both in plane and cornering
- Describe common characteristics and phases of motorcycle crashes
- Identify, document, and analyze common types of vehicle and roadway evidence pertinent to motorcycle crashes
- Use physical evidence to reconstruct the motion of a motorcycle involved in a crash
- Estimate the rate at which a motorcycle decelerates during each phase of a crash
- Calculate the speed a motorcycle travels during each phase of a crash sequence
- Evaluate the steering and braking inputs a rider used before a crash
- Identify factors leading to a single vehicle motorcycle crash

Who Should Attend

This course is designed for engineers or other professionals with a strong background in crash reconstruction, but new to or inexperienced in the specialized area of motorcycle crash reconstruction.

Instructor: Nathan Rose
Fee $790 .7 CEUs
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Topical Outline

- Introduction
- Motorcycle Crash Characteristics
  - CDC Data, GES / NASS, NHTSA data, Hurt Report, Thai Report, MAIDS Report
- Motorcycle Performance and Design
  - Motorcycle types – dirt, sport, touring, cruiser
  - Configuration - engine types, frame types, rake / trail, fork offset, C.G. location, wheel radius, suspension travel, clearance, technologies: ABS/TCS/ESC, tire types - multi-compound, multi-surface (DOT), knobbie, sport, touring
  - Rectilinear Motion - steady state motion, aerodynamic forces, braking / accelerating
  - Cornering - countersteer, lean angle, steady state, understeer/oversteer, roll motion, gyroscopic effects
- Motorcycle Inspection
  - Damage, mechanical, and tire documentation
- Scene Information
  - Scene inspection and evidence, tire marks, roadway evidence
- Analysis Methodology - Motorcycle Single Vehicle Crashes
  - Terrain effects (edges, potholes, ridges)
  - Instabilities - high side crashes, kick back (lift off roadway), chattering, low side crashes, weave/wobble
  - Rider inputs leading to crashes
- Analysis Methodologies - Pre-Crash Phase
  - Front braking, rear braking, overbraking, sliding
- Analysis Methodology - Motorcycle Crash Phase
  - Motorcycle crash tests - ISO 13232, UCLA (Severy), IMMA, JARI, SAE, KEVA
  - Crash configuration
  - Crash partner energy calculation; narrow object crash analysis of vehicles
  - Motorcycle crash energy calculation
  - Component evaluation and/or testing
  - Computer simulation – SMAC, PC- Crash
- Analysis Methodology - Motorcycle Post-Crash Phase
  - Motorcycle trajectory, sliding vs tumbling, sliding characteristics

Instructor: Stein Husher & Michael Varat
Fee $790 .8 CEUs

Safe Handling of High Voltage Battery Systems

1 Day
I.D.# C1019

Electric and hybrid vehicles are becoming more visible on today's roadways and the automotive companies are working hard to make these vehicles as transparent as possible to enhance consumer acceptance. The battery system forms a key part of any of these vehicles and is probably the least understood. With practically no moving parts the battery systems show no visible or audible warning of any latent dangers. This seminar will introduce participants to the risks encountered in handling high voltage battery systems and their component parts. With the understanding of these risks, the seminar will then address how to raise risk awareness and then methods of dealing with those risks. The outcome of this seminar should be improved avoidance of personal injury, reduced risk of reputation loss and product liability actions and reduced risk of loss of property and time.

Students will have an opportunity to participate in a real world battery handling case study scenario in which they will identify solutions for potential risk situations.

Learning Objectives

By attending this seminar, you will be able to:
- Identify the handling risks of the battery system
- Respect the risks and work with them
- Develop a safety program to manage the risks

Who Should Attend

This seminar is primarily intended for vehicle and battery engineers, battery system integration engineers, battery testing engineers, safety systems engineers, electrical engineers and thermal management engineers recently assigned to their roles or returning to hybrid or electric vehicle programs. It will also be beneficial to those involved in the specification, design, development, testing and planning of hybrid vehicle programs. Prototype shop staff will find the safety protocol aspects helpful.

Prerequisites

SAE course Introduction to Hybrid and Electric Vehicle Battery Systems (C0626, page 36), is recommended as a prerequisite. Material presented will be practical in nature and is based on selected fundamentals of chemistry, materials science, electrical and mechanical engineering. An undergraduate degree in electrical, mechanical or chemical engineering will assist in gaining maximum benefit from the material presented. Experience or training in battery electrochemistry is helpful, but not essential.
SAFETY AND ACCIDENT RECONSTRUCTION

Topical Outline

• High Voltage Batteries
  • Electrochemical energy
  • Construction aspects and controls
  • DC vs AC
  • Lithium Ion aspects
• Risks of HV Batteries
  • Team exercise: identifying the risks
  • Risk drivers
  • Hazards classifications
  • Cell vs pack level
• Risk Management
  • Abuse prevention
  • Best practices, design measures, error proofing
  • Prevention & warnings
  • Claims vs. test data
  • Housekeeping
  • Containment
• High Voltage Issues in Engineering and Manufacturing Environments
  • Avoidance of internal dangers from handling
  • What can go wrong in different environments
  • MSDS
  • Special tools
  • Handling of ‘failed’ batteries or cells
  • Dealing with an incident - team exercise

Side Impact Occupant Safety and CAE

2 Days
I.D.# C0717

Side impact crashes account for approximately twenty-six percent of all motor vehicle fatal crashes, second only to frontal crashes, according to a report by the National Highway Transportation and Safety Administration (NHTSA). While car companies and suppliers continue to develop new technologies that make vehicles safer, NHTSA rolled out updated safety regulations (FMVSS 214) based on new research studies, making vehicle safety design more and more complex.

This seminar is designed to familiarize participants with the engineering principles behind vehicle and restraint designs for occupant safety. Students will learn the mechanics of side crashes and how vehicle structures, restraint systems, and interiors affect occupant safety. Students will also be exposed to system, subsystem and component level CAE and testing tools used in the simulation of side impacts. Accident crash statistics, biomechanics, government regulations and public domain frontal safety tests will also be covered. A combination of hands-on activities, including computer simulations, discussion, and lecture are used throughout the course. A camera that takes slow-motion movies at up to 1,000 frames per second is employed to capture the miniature Side Impact Crash Demo Test kit on day one, which enables the registrants to thoroughly analyze the crash impact.

Learning Objectives

By attending this seminar, attendees will be able to:
• Explain side impact and how the vehicle structure, door trim and side airbags affect occupant responses
• Describe different dummy types and what injury metrics are used to evaluate occupant injuries
• Interpret FMVSS 214 regulations and public domain safety evaluations such as LINCAP and IIHS safety rating systems
• Describe system, sub-system and component level CAE and testing tools that are used to assist in design decisions
• Evaluate the relative effect of door intrusion and restraint system characteristics
• Select correct data filtering to process crash test data

Who Should Attend

This course is designed for engineers who are new to the field of occupant protection in side impacts as well as those individuals who require knowledge regarding IIHS side impact ratings and the FMVSS 214 regulation. This course will also be of interest to engineers who deal with side impact issues or are involved in designs of side impact related components, such as airbags, door trim, side.

NEW! SAE ACCIDENT RECONSTRUCTION CERTIFICATE PROGRAM

Watch for the certificate icon to indicate course titles that are part of an SAE multi-course certificate program.

Become more proficient in the practice of vehicle crash/accident reconstruction by successfully completing this certificate program from SAE. Required courses guide you through crash reconstruction methods, vehicle dynamics, and event data recorder (EDR) technology. Then select three electives that suit your individual technical interest area. Completing the SAE Accident Reconstruction Certificate Program grants you eight credits towards the SAE/Kettering University 20-credit Certificate in Automotive Systems or Kettering’s 40-credit M.S. in Mechanical Engineering. Visit training.sae.org/collegecredit for more information. View the list of required and elective courses and more information on enrolling in this SAE certificate program--http://training.sae.org/credentialing/certificate/accident.htm
SAFETY AND ACCIDENT RECONSTRUCTION

Topical Outline

DAY ONE
• Vehicle Crash Safety Introduction
  • Crash injury and fatality data from the U.S.
  • Distribution of different crash types
  • Active safety and passive safety
  • Trend of crash safety ratings
• Vehicle Side Impact Test Modes
  • Moving deformable barrier impact
  • Pole impact
• Biomechanics
• Test Dummies and Injury Metrics
  • SID/HIII; SID IIs & SID IIs-FRG
  • ES-2 & ES-2re
  • BioSID & WorldSID
• U.S. Regulatory Requirements
  • FMVSS 214, 201, 301
• U.S. Public Domain Tests and Performance Ratings
  • LINCAP; IIHS
• European Regulatory Requirements
• Euro-NCAP and Performance Ratings in Other Markets
• Test Data Processing
  • Filtering and SAE J211 guidelines
  • HIC, TTI
  • Numerical integration, differentiation, occupant relative travel
  • Hands-on in computer lab: test data processing
• Hands-on Computer Exercises
  • Simulations Using Simplified Models
  • Crash Data Processing
DAY TWO
• Side Impact Mechanics
  • Vehicle structure
  • Door trim
  • Thoracic and pelvic bolsters
  • Inflatable devices for impact protection
• Restraint System for Side Impact
  • Thorax bag; Shoulder bag
  • Thorax-head combo bag; Thorax-pelvis combo bag
  • Seat mounted and door mounted side airbags
  • Inflatable curtain
  • Inflatable shoulder belt / lap belt
• Crash Sensors
  • G-based sensors; Pressure sensors
• Vehicle Crash Computer Modeling (CAE)
  • Vehicle CAE model
  • Occupant CAE model
  • Crash Barrier CAE models
• Component and Sub-system Crash Development Tools
  • Sled tests
  • Sub-system level FEA

Vehicle Crash Reconstruction Methods

3 Days
I.D.# C1417

Automotive crash reconstruction is a process carried out with the specific purpose of estimating in both a qualitative and quantitative manner how a crash occurred. Reconstructions are based on data collected during the crash and physical evidence gathered during a crash investigation. To some extent, testimonial evidence is also used. Whether a crash is between two vehicles, a vehicle and pedestrian or a vehicle and a barrier, specific crash segments, classified as pre-impact, impact and post-impact motion often are reconstructed separately. Each of the segments is analyzed using established engineering, scientific and mathematical principles and based on the physical evidence. Not only must each method be well established, but it must be selected so its coverage corresponds to the conditions of the physical conditions. Three main factors - human, vehicle and environment are taken into account during a reconstruction.

This seminar is devoted to the exposition, use and limitations of the engineering, scientific and mathematical principles and methods used to reconstruct vehicle crashes. The primary objective is to help the attendees achieve a high level of understanding of these methods. The course covers a wide range of topics including vehicle acceleration/deceleration, impact mechanics, Event Data Recorder (EDR) and Engine Control Module (ECM) technology, tire mechanics, vehicle-pedestrian impacts and topics from vehicle dynamics. Most of the calculations can be carried out using commonly available spreadsheet technology.
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VCRware, a commercially available software based in Microsoft Excel and written by the instructors, will be provided to the attendees for class exercise use during the seminar. Attendees should bring a Windows-based laptop equipped with Excel 2003 or later. Attendees will also receive a copy of the instructors’ book, Vehicle Accident Analysis and Reconstruction Methods, published by SAE International, 2011.

Learning Objectives
By attending this seminar, attendees will be able to:

• Describe the basic mechanics of collisions, including the differences between normal and tangential contact/interaction effects, restitution, energy loss, ΔV, PDOF, common velocity conditions and other topics.
• Articulate the differences between point mass and rigid body impact analysis and when each can be applied, and should not be applied.
• Recognize the critical differences between methods described in the field of Crash Reconstruction such as "Conservation of Linear Momentum" and "Planar Impact Mechanics", the assumptions and limitations behind these methods and when and how they should, and should not, be used.
• Formulate and solve impact problems to reconstruct crashes with Event Data Recorder (EDR) and/or Engine Control Module (ECM) data and use spreadsheet optimization technology to turn a crash analysis into a reconstruction.
• Combine pedestrian and vehicle motion to reconstruct pedestrian collisions including situations where the point of impact is unknown.
• Use planar photogrammetry to determine unknown points and paths from photographs and site measurements.
• Describe tire forces and tire mechanics for braking/accelerating and steering including Antilock Braking System (ABS) operation.

Who Should Attend
This course is well-suited for persons just beginning to work in the area of crash reconstruction as well as persons already in the field who want to establish a more firm foundation in current crash reconstruction technology.

Topical Outline
DAY ONE

• Straight-Line Motion
  • Equations of motion of two-axle vehicles including pitch motion and load transfer due to braking acceleration
  • Values of the frictional drag coefficient, f , (“drag factor”) of light vehicles and heavy trucks
• Point Mass Collisions (COLM, Conservation of Linear Momentum)
  • Basic concepts and simple applications of impact theory: impulse, momentum, velocity change, ΔV, energy loss, normal & tangential impulses (and the impulse ratio)

• Planar Impact Mechanics (PIM)
  • Thorough coverage of the system equations and solution equations of impulse and momentum for the collision of two vehicles including rotational inertia and angular momentum which are essential for the analysis and reconstruction of crashes using EDR data
• Class exercises using VCRware software

DAY TWO

• Crush and Tangential Energy Loss
  • Introduction to the concepts of crush measurements (CRASH3) to compute collision energy loss and its relationship to crash vehicle ΔV
• Event Data Recorder (EDR) Technology
  • Introduction to the general characteristics of EDRs: driver and vehicle state data (settings), time intervals, pre-crash data, crash acceleration & ΔV
  • Crash Reconstruction using EDR Data, Planar Impact Mechanics and Spreadsheet Optimization Techniques
  • Use of Planar Impact Mechanics for analysis & reconstruction of crashes
  • Class exercises using VCRware software
• Frontal Vehicle-Pedestrian Collisions
  • Introduction to and derivation of the equations of the Han-Brach pedestrian impact model and other pedestrian impact models, both empirical models and mechanics models
  • Class exercises using VCRware software

DAY THREE

• Planar Photogrammetry
  • Determination of road surface markings from photographs and site measurements
• Mechanics and Modeling of Tire Forces
  • Description of longitudinal tire forces (braking/acceleration)
  • Lateral tire forces (steering/cornering) and tire forces under combined braking and steering
• Friction ellipse
  • Modeling of tire forces using the Bakker-Nyborg-Pacejka (BNP) equations and the modified Nicolas-Comstock equations
  • Antilock braking principles
• Critical Speed from Tire Yaw Marks
• Description and measurement of yaw marks and reconstruction of vehicle speed at the beginning of yaw marks
• Articulated Vehicle Impact
• Concepts of impulse and momentum applied to crashes between articulated vehicles (such as tractor semitrailers) and other articulated vehicles, barriers or single vehicles
• Topics from Vehicle Dynamics
• Discussion of the bicycle model of a two-axle vehicle along with concepts of oversteer and understeer

Instructor: R. Matthew Brach and Raymond M. Brach
Fee $1830 2.0 CEUs
SAFETY AND ACCIDENT RECONSTRUCTION

Vehicle Frontal Crash Occupant Safety and CAE

2 Days
I.D.# C0621

Car companies and suppliers continue to develop new technologies that make vehicles safer and regulatory agencies continue to update safety regulations based on new research studies, making vehicle safety design more and more complex. This seminar covers the mechanics of frontal crashes and how vehicle structures, vehicle restraint systems, and vehicle interiors affect occupant safety. It also describes details of how CAE tools work in the simulation of frontal crashes. The goal of the course is to familiarize participants with engineering principles behind vehicle and restraint designs for occupant safety. Accident crash statistics, biomechanics, government regulations and public domain frontal safety tests will be reviewed briefly. Students will also be exposed to Madymo, one of the major occupant CAE tools. The basic inner workings of the tool, such as rigid body dynamics, joints, contact, airbag and seatbelt modeling, and modeling techniques will be shared with the class. The class also offers participants opportunities to do hands-on computer analysis as well as simplified hands-on crash tests, where students can learn first-hand how vehicle pulses and restraint design affect occupant response. A camera that takes slow-motion movies at up to 1,000 frames per second is employed to capture the miniature Side Impact Crash Demo Test kit, which enables the registrants to thoroughly analyze the crash impact.

Learning Objectives

By attending this seminar, you will be able to:
• Explain frontal crashes and how vehicle structure and restraint systems affect occupant responses
• Describe how restraint components function in crashes and protect occupants
• Carry out calculations of injury metrics using test or CAE results as input
• Describe the occupant CAE tool, Madymo, and how it works
• Explain assumptions and limitations of CAE models
• Evaluate the relative effect of crash pulse, and restraint system characteristics
• Analyze and evaluate crash pulses
• Describe FMVSS 208 and NCAP requirements and metrics
• Explain the use of different dummies and their limitations

Who Should Attend

This course is designed for engineers who are either new to the field of automotive safety or familiar with only certain aspects of automotive safety. It can help engineers, for example, who design a specific component in a vehicle to understand how it works in vehicle crashes, how its characteristics affect occupant response and how it relates to other components in the vehicle.

Topical Outline
DAY ONE
• Vehicle Crash Safety Introduction
  • U.S. crash injury and fatality data
  • Distribution of different crash types
  • Active and passive safety
• Vehicle Frontal Crash Modes
  • Frontal rigid, offset deformable and angular barriers
  • Out of position tests, driver and passenger
  • HYGE and Servo sled tests; Component tests
• Biomechanics - Human Anatomy and AIS Injury Scale
• Brief Overview of Frontal Test Dummies and Injury Metrics
• Frontal Crash Mechanics
  • Crash pulse, front loaded, rear loaded
  • Class Project using Excel: calculate vehicle velocity and crush from pulse; get maximum crush, time to zero velocity; pulse comparison, front-loaded and rear loaded pulses
  • Intrusions
    • Occupant to restraint gaps and restraint characteristics
    • Belted vs. unbelted occupant
    • Class project: determining occupant responses
  • Airbag quickness and stiffness
  • Belt slack, pretension, EMR
  • Driver vs. passenger
  • Typical crash event
  • 5th percentile female submarining
• Crash Sensor - Airbag & Pretensioner Firing & Non-firing Conditions; Sensor Tests
DAY TWO
• Brief Review of U.S. and European Regulations and Public Domain Safety Ratings
• Numerical Data Processing
  • Filtering and SAE J211 guidelines
  • HIC, Nij, Cumdur, V*C calculations
  • Numerical integration, differentiation, occupant relative travel
• Vehicle Crash Computer Modeling (CAE)
  • Vehicle structure CAE, finite element method
  • Occupant CAE, rigid body dynamics
  • CAE assumptions and limitations
  • DABLIT - Component Test for Driver Airbag
• DOE and Optimization
• Restraint System
  • Airbag, inflator, single & dual stage
  • Crash sensor, Restraint Control Module (RCM)
  • Seatbelt, D-rings
  • Retractors, torsion bars
  • Buckle and retractor pretensioners
  • Steering column stroke; Steering wheel lower and upper rims
  • Knee bolster
• Real World Crashes - Safety for the Aging Population; Crash Severity Distribution

Instructor: Stephen Kang
Fee $1365 1.3 CEUs
SAFETY AND ACCIDENT RECONSTRUCTION

RELATED TRAINING SOLUTIONS
Some of our courses apply to more than one technology category. Consider these related courses described in other sections of this resource guide.

**Tire Forensic Analysis**
This seminar provides a detailed description of tire failure modes, their potential causes, identification, and the sometimes subtle nuances that go along with determination of tire failure.
Read more about this course on page 5

**Tire and Wheel Safety Issues**
In this seminar engineering fundamentals are discussed and illustrated with numerous practical examples and case studies of current public interest.
Read more about this course on page 6

**Acquiring and Analyzing Data from Sensors and In-Vehicle Networks**
After reviewing the traditional approach of acquiring data directly from sensors, the course will focus on the newer approach of obtaining data from the in-vehicle network for both automotive and heavy duty vehicles. Attention is given to the complications of taking data from the in-vehicle network and how to overcome them.
Read more about this course on page 20

**Developing In-Vehicle User Interfaces: Design Principles and Techniques**
This course will provide a systematic design method to develop intuitive and safe vehicle interface solutions. Participants will learn user interaction design steps, tools, and the team synergies required to develop an interface from concept to the final product.
Read more about this course on page 27

**Vehicle User Experience: Human Factors Principles and Techniques for Design, Research and Development**
The automotive industry faces unprecedented growth in vehicle technologies and features that can dramatically affect the vehicle user experience. This course will provide an overview of principles and techniques for designing and developing vehicle interfaces which deliver optimal solutions while avoiding unintended consequences like driver distraction
Read more about this course on page 33

**Product Liability and The Engineer**
The concept of safety and reliability has been altered from a purely engineering/manufacturing concept to a legal/manufacturing approach. This new approach requires an understanding of legal concepts as related to the manufacturing and design process.
Read more about this course on page 173

**The Role of the Expert Witness in Product Liability Litigation**
This seminar will address the critical issues that every person who may be, has been, or is, an expert witness must understand to assist both the attorney and the product manufacturer, regardless of which side the expert serves.
Read more about this course on page 174
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Akingbehin, Kiumi
Kiumi Akingbehin, Ph.D is a Professor of Computer and Information Science at University of Michigan-Dearborn. He has Ph.D. and MA degrees in Computer Science. He also has a MS in Nuclear Engineering and a BS in Electrical Engineering. He has been employed at University of Michigan-Dearborn since 1986. His other employers include GM, NASA, AT&T Bell Labs, IBM, and Unisys. His areas of research interest include wired and wireless networks, real-time software engineering, embedded systems, vehicular communications, and web technologies. He has published over 150 papers in his areas of interest.

Albright, Michael F.
Michael F. Albright is co-founder and General Manager of Signal.X Technologies LLC, a firm specializing in NVH engineering and custom test &amp; measurement application development. His past positions include Business Development Manager for the NVH consulting group of LMS North America, Management and Project Engineering positions at the Roush Anatrol Division of Roush Industries, Inc, and Civilian engineering for the U.S. Navy. With experience predominantly in the automotive industry, Mr. Albright has addressed a very diverse range of noise and vibration control issues including powertrain NVH, vehicle NVH, brake noise, engine accessory noise, driveline NVH, test procedure and facility development, test/CAE hybrid simulation methods, as well as a host of manufacturing quality issues. Mr. Albright holds a B.S. in mechanical engineering from University of Cincinnati and an M.S. in mechanical engineering from Purdue University.

Aloi, Daniel N.
Daniel N. Aloi, Ph.D., is an Associate Professor of Engineering and the Interim Chair at the Electrical & Computer Engineering Department, Oakland University, Rochester, MI. He received his B.S., M.S. and Ph.D. degrees in electrical engineering from Ohio University in 1992, 1996 and 1999, respectively. He has been employed at Oakland University since January 2002. Dr. Aloi was a Sr. Project Engineer at OnStar, Inc. (2000 - 2001) and a Visiting Assistant Professor at Ohio University (1999 - 2000). His research areas include applied electromagnetics and various areas of the global positioning system (GPS) in the automotive and aviation industries. Dr. Aloi has attracted in excess of $2.0M dollars in external funding as PI, authored over 45 technical papers and obtained 5 patents. He is an Associate Editor for the IEEE Transactions on Aerospace and Electronic Systems in the area of navigation and for the SAE International "Journal on Passenger Vehicles: Electrical and Electronic Systems. He has also served as a key technical advisor to the Federal Aviation Administration’s Satellite Program Office in regards to the Local Area Augmentation System, which is a proposed GPS-based landing for commercial aircraft.

Banish, Greg
Greg Banish is a mechanical engineer and motorsports enthusiast. He currently works as the powertrain development manager for Roush/SLP, leading calibration and development of emissions legal high performance vehicle packages. After studying for a bachelor’s degree in Mechanical Engineering at GM Engineering & Management Institute (Kettering University), he wrote his thesis on vehicle instrumentation and measurement. Putting this education to practical use, he founded his own performance shop outside of Detroit. Greg later worked for SiemensVDO and General Motors, and Ford Motor Company as a calibration engineer on programs ranging from direct injection turbocharged engines to hybrids. He is a member of SAE International and SEMA and has authored two books and several instructional DVDs on aftermarket EFI calibration. With thousands aftermarket calibrations performed, he has worked with a wide variety of engines and control systems in addition to his OEM calibration work.

Barak, Pinhas
A professor of mechanical engineering, Dr. Pinhas Barak specializes in vehicle systems dynamics and suspension design, active and semi-active suspension systems, chassis and vehicle design systems, mechanical control systems, and vibrations. He recently established the Vehicular Dynamics Design Center at Kettering University. Dr. Barak is a member of SAE International, ASME, ASEE and SIAM, with more than 25 years of industrial experience in automotive engineering. He also received the SAE International Outstanding Faculty Advisor Award in 1993. Dr. Barak received both a B.S.C. and an M.S.C. in mechanical engineering from Wayne State University.

Bardasz, Ewa
Dr. Ewa A. Bardasz is a Fellow at The Lubrizol Corporation, where she is currently responsible for overseeing technical activities related to lubricating novel combustion hardware, aftertreatment systems and emissions. She is experienced in the areas of crankcase lubrication, corrosion inhibition, engine testing and exhaust emissions control. Dr. Bardasz holds over 25 patents, has published multiple technical and scientific papers, authored chapters for technical books and is a frequent invited speaker at conferences throughout the U.S. and Europe. She is the recipient of the SAE International 2002 Award for Research on Automotive Lubricants, and 2009 SAE International International
Environmental Excellence in Transportation Award. Dr. Bardasz is a Fellow of SAE International and a Fellow of the Society of Tribologists and Lubrication Engineers (STLE) where she is also on the Board of Directors. Dr. Bardasz obtained a M.Sc. in Chemical Engineering from Warsaw Technical University and a PhD in Chemical Engineering from Case Institute of Technology.

Baseley, Simon
Simon J. Baseley was the Director of Engineering Strategy and Program Management within the Intelligent Hydraulic Drive Group at Bosch Rexroth Corporation until he retired in July 2011. He currently works part time at the University of Michigan as a Visiting Research Investigator in the Automotive Lab. Mr. Baseley was also a Director of the Intelligent Hydraulic Drive Products for the Dana Corporation, where he worked to develop and promote applications for hydraulic drive systems for vehicles and the Director of Advanced Engineering for Hobourn Automotive Ltd. where he formulated and executed new hydraulic pump applications and directed the applied research initiatives in fluid flow and noise suppression. Mr. Baseley also has extensive experience within the aerospace industry, previously serving as Chief Design Engineer for Rolls-Royce Ltd. An active member of SAE International, Mr. Baseley has written several papers on noise related research and hydraulic hybrid systems. He holds eight patents related to hydraulic pumps and hybrid systems. Mr. Baseley, formally educated in the U.K., received a B.S. in Mechanical Engineering from the University of Nottingham and a M.S. in Aircraft Propulsion from Cranfield University.

Belanger, John-Paul
John-Paul Belanger is president of Geometric Learning Systems, a consulting firm specializing in geometric dimensioning and tolerancing (G D & T). For over ten years, he has trained people throughout North America and Europe in the proper interpretation and application of G D & T per the Y14.5 standard by using practical examples. Mr. Belanger is certified by the American Society of Mechanical Engineers as a Senior G D & T Professional, and has worked with a wide range of companies in the automotive, aerospace, electronic, and other industries to apply tolerances and perform stack calculations. He holds a B.S. in aerospace engineering from the University of Michigan specializing in aircraft design and safety.

Bissell, Larry E.
Larry Bissell is a renowned and well respected international trainer, consultant, and auditor specializing in automotive supply chain management, supplier development, business management systems, business excellence, and continual improvement for all size automotive companies. Mr. Bissell is recognized as an authority on global supply chain requirements and global supplier development, particularly regarding the stringent requirements of automotive OEM’s within the United States. His expertise, abilities, and techniques are designed and structured for automotive supplier organizations that wish to participate in the automotive global supply chain market. Mr. Bissell has over 30 years of industrial experience and has been directly involved in over 1000 highly successful management system audits and client consultations within the ISO 9001, QS-9000, and ISO/TS 16949:2002 arenas.

Blair, Julian
Julian Blair is the Calibration Process Lead of Engine Development, Calibration and Verification for General Motors. Named to this position in January 2013, Julian leads the Global Calibration Process Technical Resource Board with the charter of streamlining GM calibrations tools to enable the benefits of common process. Previously, Julian was a Calibration Specialist on V6 passenger car applications for a number of engine calibration areas namely: Torque Modeling and Control, Spark and Dilution Control, Electronic Throttle Control, and Fuel Control. He also held positions of Lead Engine Calibrator, Test Automation Engineer and Test Technology Engineer in the GM Engine Development Dynamometer Laboratory. Julian joined GM’s engineering team in 2001 after graduating from Tennessee State University with a Bachelor’s and Master’s degrees in Mechanical Engineering. He is also a licensed and registered Professional Engineer in the State of Michigan.

Bolourchi, Farhad
Dr. Bolourchi is currently a staff research engineer II with Nexteer Automotive Innovation Center where he designs algorithms for advanced chassis systems. Farhad helped develop Delphi’s first electric power steering system, for which he received the company’s highest technical award, the “Boss Kettering”. Dr. Bolourchi previously worked for Hughes Aircraft Company and gained valuable experience in both missile systems controls and automotive applications. He was also a part time faculty member at the University of California - Davis and Sacramento State University. Farhad received GM’s President Honors award in 1998, and was inducted to Delphi’s Hall of Fame in 1999. He has numerous publications and patents related to control systems and automotive applications. Dr. Bolourchi has a B.S. in Mechanical Engineering from Northeastern University, a M.S. in Mechanical Engineering and a Ph.D in Nonlinear Control Systems from the University of California - Davis.

Brach, R. Matthew
Matt is currently a Senior Managing Consultant for Engineering Systems, Inc. (ESI). His area of specialization includes vehicle impact analysis and dynamics and automotive crash reconstruction for both light and heavy vehicles. Matt has worked for Brach Engineering, Lawrence Technological University, Exponent Corporation, Ford Motor Company and MPC Products. He is a member of SAE International, American Society of Mechanical Engineers (ASME), National Association of Professional Accident Reconstruction Specialists (NAPARS), and the Institute of Electrical and Electronics Engineers (IEEE). He has a B.S. in Electrical Engineering from the University of Notre Dame, an M.S. in Mechanical Engineering from the University of Illinois-Chicago, and a Ph.D. in Mechanical Engineering from Michigan State University.

Brach, Raymond
Ray is a Consultant for Engineering Systems, Inc. (ESI) and Professor Emeritus, University of Notre Dame. His areas of specialization include, vibrations, acoustics, and noise, mechanical engineering design, ground vehicle dynamics, applied mathematics and statistics, solid mechanics, mechanical impact dynamics, vehicle collision analysis, and crash reconstruction. He has authored and co-authored three technical books on the topics of mechanical impact, scientific uncertainty, and vehicle crash reconstruction. He is a member of SAE International, Acoustical Society of America (ASA), American Society of Mechanical Engineers (ASME), Institute of Noise Control Engineering (INCE), National Association of Professional Accident Reconstruction Specialists (NAPARS), and Tau Beta Pi, Sigma Xi, and Pi Tau Sigma.

Buckman, Leonard
Leonard Buckman is president of Buckman Consulting Services, Inc., a firm with OEM and brake supplier clients in North America, Japan and Europe. Previously, he worked at Ford Motor Company as a brake specialist, heading up all heavy truck brake system design actions necessary for the initial implementation of FMVSS 121; at Rockwell International, serving as Chief Brake Engineer, Director of Worldwide Brake Engineering & Product Planning, and Vice President of Brake and Axle Product Management; and at Meritor WABCO VCS as President and General Manager. Mr. Buckman has a unique perspective because of his experience as a brake specialist both at a major truck OEM and at major suppliers of worldwide brakes and brake systems. He was selected
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by the U.S. Secretary of Transportation to serve as the commercial
vehicle brake specialist on the 1999 DOT Vehicle Safety Planning Group
and has twice received the SAE International Distinguished Speaker
Award. Mr. Buckman is a registered Professional Engineer and holds
a B.S. in engineering physics from Michigan Technological University.
He also completed post-graduate work in engineering mechanics and
mechanical engineering at Wayne State University and the University of
Michigan, respectively.

Chau, K. T.
K. T. Chau received his B.Sc.(Eng.) degree with 1st Class Honors, M.Phil.
degree and Ph.D. degree all in Electrical & Electronic Engineering from
The University of Hong Kong. He joined the alma mater in 1995, and
currently serves as Professor and Director of the International Research
Center for Electric Vehicles. He is a Chartered Engineer and Fellow of the
IET. At present, he serves as Co-Editor of the Journal of Asian Electric
Vehicles. Professor Chau has published over 300 refereed technical
papers, co-authored a monograph “Modern Electric Vehicle Technology”,
and wrote two book chapters. Professor Chau has received many awards:
including the Chang Jiang Chair Professorship by the China’s Ministry
of Education; the Environmental Excellence in Transportation Award
for Education, Training and Public Awareness by SAE International; the
Award for Innovative Excellence in Teaching, Learning and Technology at
the International Conference on College Teaching and Learning; and the
University Teaching Fellow Award by The University of Hong Kong.

Chehroudi, Bruce
Dr. Chehroudi is Chief Scientist and Group Leader at Advanced Technology
Consultants. His previous positions include: Principal Scientist at Air
Force Research Laboratory (AFRL/ERC), Chief Scientist at Raytheon STX
(formerly Hughes Aircraft STX), Professor of Mechanical Engineering, and
Research Staff Member at Princeton University. He specializes in fluid
mechanics and heat transfer, laser optical diagnostics, internal combustion
gas engine, gas turbine and rocket engines, structure of sprays, gas turbine
engines, combustion, fuel injection issues and emission of pollutants. Dr.
Chehroudi is an AIAA Associate Fellow, a member of Ta Beta Pi and the
recipient of several SAE International awards including the Arch T. Colwell
Merit Award, the Ralph R. Teetor Award, Forest R. McFarland Award in
recognition of his efforts and leadership in contributions to Professional
Development. He has taught courses in the areas of internal combustion
gas engines, thermodynamics, thermophysics of gas flows, combustion, and
measurement system, and has more than 150 publications and over 200
presentations in conferences, national and international journals. Dr.
Chehroudi has a Ph.D from Princeton University.

Cheok, Ka C.
Ka C. Cheok, Ph.D. is a Professor of Engineering at the Electrical &
Computer Engineering Department, Oakland University, Rochester, MI.
He conducts theoretical and experimental research in driver’s assistance
systems, navigation and guidance for autonomous unmanned vehicle
systems and mobile robots, UWB tracking of multiple robots and assets.
His work focuses on transition of R&D in intelligent systems, heuristics
search, fuzzy logic, neural network and optimal control and estimation
techniques into practical applications to smart mechatronics systems for
the automotive and defense industries. Dr. Cheok has published over 40
technical journal articles and 100 conference papers. He is an Associate
Editor for three technical journals and an organizer for the annual
Intelligent Ground Vehicle Competition, and has served as a consultant
Member on the US Army Science Board.

Chesneau, Howard
Mr. Chesneau is the President of Fuel Quality Services, Inc. A recognized
expert on fuel-related issues, he has over thirty years of experience in fuel
additives, distillate fuel problems, fuel filtration, and tank remediation.
Additionally, Mr. Chesneau has extensive knowledge and field experience in
the area of microbial contamination and detection. Mr. Chesneau is on the
IASH Board of Directors and is the past Chairman of the SAE International
Atlanta Section. He is an active member of other professional
organizations including SAE International, IATA, and ASTM. He currently
serves on the IATA Working Group on Microbial Contamination, the ASTM
Committee dealing with fuel from middle distillates to heavy oils, the
ASTM Committee establishing specifications for biodiesel, and the ASTM
Committee on jet fuel. In addition to his committee and working group
activities, Mr. Chesneau has authored and co-authored many articles
on the subject of fuel storage and handling that have been published in
various trade magazines. Mr. Chesneau served as a commissioned officer
in the US Army and holds a B.S. degree from the University of Florida.

Das, Shuvra
Dr. Shuvra Das is Professor of Mechanical Engineering and the Associate
Dean for Research and Outreach for the College of Engineering and
Science at University of Detroit Mercy. His research and teaching
interests include engineering mechanics, computational mechanics using
finite and boundary element methods, modeling and simulation, inverse
problems, mechatronics, modeling and simulation of mechatronics
systems, condition based health monitoring of engineering systems, etc.
Dr. Das, author of the text “Mechatronic Modeling and Simulation
Using Bond Graphs”, has over fifty conference and journal publications
and has received several awards, including the Best Teacher award from
the North Central section of ASEE and the Junior Achievement award at
University of Detroit Mercy. Dr. Das received his Ph.D. and M.S. degrees
in Engineering Mechanics from Iowa State University. In addition, he
received his B.Tech (Hons.) in Mechanical Engineering from the Indian
Institute of Technology in Kharagpur, India.

Davis, Gregory
Dr. Gregory Davis is a Professor of Mechanical Engineering at Kettering
University where he teaches courses in the Automotive and Thermal
Science disciplines. He also serves as Director of the Automotive Engine
Research Laboratory, and faculty advisor to the Clean Snowmobile
Challenge Project. At Kettering, Dr. Hoff team-teaches a graduate/
undergraduate course on the fundamentals of automotive powertrains
with Dr. Craig Hoff; and they are co-authors of the text “Introduction to
Automotive Powertrains”.

Dawson, Lee D.
Mr. Dawson has over 35 years of experience in Quality and Reliability
engineering, President and CEO of Quality-One International since 1986.
Mr. Dawson has previously held engineering and training positions at
Ford Motor Company, and Wickes Manufacturing. As CEO of Quality-
One, Mr. Dawson has consulted with hundreds of companies and trained
thousands of quality and engineering professionals in Failure Mode and
Effects and Analysis (FMEA) and Advanced Product Quality Planning
(APQP). He periodically teaches these and other related quality and
reliability courses for several colleges and universities in the US, Canada,
and Australia and speaks at engineering related functions. Mr. Dawson
has written and collaborated on several technical books and manuals
including “Murphy’s Law Overruled (FMEA in Design, Process and
Service)”, Ford Design Institute FMEA Handbook and AIAE Effective
Error Proofing CQI-18. He has participated, written and presented
numerous technical papers at ASQ, ASM and other professional
organizations. Mr. Dawson has a B.S. in Metallurgical Engineering from
Penn State University and is a Certified Quality Engineer (CQE), Certified
Reliability Engineer (CRE) and is a Master Black Belt in the practice of
Six Sigma.

de Ojeda, William
William de Ojeda, PhD, PE, is the Engineering Director of WM
International. He is responsible for the development of specialized fuel
injection, air management and controls systems for automotive and
Deng, Zhibing

Dr. Zhibing Deng is currently a senior engineer specializing in side impact safety at Ford Motor Company. He has in-depth knowledge of side impact development, including setting targets for key vehicle components, developing and applying component/subsystem test methodologies, and implementing actual designs of vehicle components in achieving side impact performance targets. His work experience includes rear impact development and CAE support in front impact, roof crush and interior head impact. Prior to joining Ford, Dr. Deng was an Assistant Professor at South China University of Technology. He is a recipient of the Henry Ford Technology Award in 2005. Dr. Deng received a B.S. in Computational Mathematics and an M.S. in Applied Mathematics in China and a M.S. in Mechanical Engineering, M.A. in Statistics and Ph.D. in Applied Mathematics all from Wayne State University.

Denys, Eric

Eric Denys is currently the Vice President of Global OE Brake and AM Integration at Wolverine Advanced Materials. He previously worked for Material Sciences Corporation and Federal-Mogul. Throughout his career, Mr. Denys has lead teams to achieve best-in-class in brake squeal on numerous vehicle lines and he is the recipient of the 2001 Ford Global Customer Satisfaction Award for his work on high mileage brake squeal reduction. His work has been published in numerous national and international papers, and in an SAE International book on Disc Brake Squeal. Eric is a 6 Sigma Black Belt and is currently the chairman of the SAE International Brake NVH Standards Committee. He received a B.S. in Mathematics from the Jean-Bart University, France and a M.Sc. in Mechanical Engineering from the University of Technology of Compiègne, France and an MBA from the University Of Michigan.

Dishart, Peter

Peter T. Dishart manages the laminated glass business of PPG Industries Inc. He holds B.S. and M.S. degrees in mechanical engineering as well as an MBA. Dishart is a member of SAE International and has served on the Glazing Committee. He is currently President of the Enhanced Protective Glass Automotive Association (EPGAA), an industry organization dedicated to laminated glass.

Dobrusin, Eric M.

Eric M. Dobrusin is a shareholder in the Dobrusin Law Firm, PC in metropolitan area of Detroit, Michigan, where he concentrates his practice in intellectual property law. He is a member of the Michigan Bar and is registered to practice before the United States Patent and Trademark Office. Mr. Dobrusin previously served as the Executive Director of the National Patent Board, and he has served as an ADR Neutral and a Special Master in IP litigation disputes. Mr. Dobrusin has presented talks and authored articles on a variety of intellectual property topics. He also has co-authored the books, “Intelligent Property Culture: Strategies to Foster Successful Patent and Trade Secret Practices in Everyday Business” and “Intelligent Property Litigation: Pretrial Practice, Third Edition”. Mr. Dobrusin has earned recognition as a SuperLawyer®, Best Lawyers® in America (2014 Patent Law Lawyer of the Year for Detroit), dBusiness Magazine Top Lawyers in Metro Detroit, Leading Lawyers, and Managing Intellectual Property Magazine IP Stars. In 2013, he was recognized by the Michigan Lawyers Weekly publication as among its “Leaders in the Law”. Mr. Dobrusin received a B.S. degree in materials and metallurgical engineering from the University of Michigan and a J.D. degree from Wayne State University Law School.

Dodson, Bryan

Dr. Dodson is currently the Executive Engineer for SKF. Dr. Dodson has held the positions of Senior Director Corporate Quality & Continuous Improvement for Collins & Aikman and Associate Director of Quality & Reliability Engineering with global responsibility for Visteon. Dr. Dodson has authored several books including: “The Reliability Engineering Handbook”, “Practical Accelerated Testing”, and “Weibull Analysis: with Software”. Dr. Dodson has also developed several software packages including; the Training Pro Interactive Study Guides, the Reliability & Maintenance Analyst, and Measurement Assurance. Dr. Dodson served as Chair of the committee that created the International Quality Federation’s Six Sigma Exam and also developed the software that delivers this state of the art exam. Dr. Dodson has published numerous articles in technical journals and teaches several courses for technical societies and as an adjunct faculty member at universities. A Fellow of SAE International and ASQ, Dr. Dodson holds a B.S. in Petroleum Engineering, an M.S. in Industrial Engineering, an M.B.A., and a Doctor of Business Administration. In addition, he is a Certified Quality Engineer (CQE), a Certified Reliability Engineer (CRE), a Six Sigma Master Black Belt, and a licensed Professional Engineer in Michigan.

Doyle, Joseph

Joseph Doyle is the principal of Strategic Insights, a Michigan-based consulting firm, specializing in executive leadership. In his thirty-years with GM, he held a variety of management positions including: Internal Business Consultant with General Motors University, Senior Research Manager with the Corporate Organization Research and Development Activity, Manager of the Corporate Executive Development Activity, and Lead Consultant with the Corporate Strategy and Decision Support Activity. Prior to joining General Motors, Mr. Doyle held positions with the U.S. Public Health Service, Ford Motor Company and the Management and Organization Development Department of General Motors Institute (now Kettering University). Dr. Doyle served as a teaching fellow for the Hartwick Leadership Institute and was a member of the advisory council for the Academy of Management Executive Magazine. He was a member of the Advisory Board for the Institute for Management Studies as well as member of the National Research Committee for the American Society for Training and Development. Dr. Doyle has served as an adjunct professor and lecturer at the University of Michigan Dearborn’s School of Business, taught Engineering Administration at the University of Detroit’s Graduate School of Engineering and Business Strategy at Oakland University’s School of Business Administration. He holds a B.S. in Mathematics and Physical Science from Eastern Michigan University, a M.Ed. in Educational Evaluation and Research from Wayne State University and a Ph.D. in Organizational Behavior from the University of Michigan.

Drotar, Timothy

Timothy Drotar is currently a product development engineer at Ford Motor Company where he specializes in chassis systems and vehicle dynamics for passenger cars and light trucks. He also has developed engineering training in suspension and steering. Previously, he worked for Saturn Corporation in product engineering. Tim is a member of the Course Industry Advisor Board for Chassis Systems Design at Kettering University, and a member of SAE International and SCCA. He holds a B.S. in Mechanical Engineering from Lawrence Technological University.
and a M.S. in Mechanical Engineering from the University of Michigan.

English, Ed
Mr. English is Vice President & Technical Director for Fuel Quality Services, Inc. where he oversees all aspects directly related to the research, development, and deployment of chemicals, antimicrobials and detection equipment for use in the various stages of the petroleum and biomass fuels industry from the refinery to the end user. He is also responsible for evaluating regulatory and industry issues, compliance with federal and state regulations, formulating policy and implementing programs to address regulatory and industry issues, and performing technical reviews and program audits. Mr. English previously worked in the nuclear power industry. He is nationally recognized for his knowledge and expertise in the area of microbial contamination of fuels, alternative fuels, and materials compatibility and has been an invited speaker for such organizations as the EPA, FAA, CALCUPA, NEIWPCCC, PEI, NISTM, and SAE International, DuPont, and Biofuels Americas. Mr. English is also an active member of numerous professional organizations including SAE International, IASH, IATA, and ASTM. He has a B.S. in Chemistry from the University of Florida and two years post-baccalaureate work from the University of Miami.

Fulton, Wes
Mr. Wes Fulton is the Founder and CEO of Fulton Findings. Prior, he was a program engineer/manager for AiResearch Los Angeles Division, Allied-Signal Aerospace Corporation. As a program engineer for aircraft actuation projects he had engineering and management responsibility for the Indigenous Defensive Fighter (IDF) leading edge flap actuation system (LEFAS) development and production, the Rockwell/MBB X-31A LEFAS flight test program, and the F-16 Fighting Falcon LEFAS production and deployment support. He co-patented a multi-fuseable shaft (high performance drive train device). Additionally, Mr. Fulton has over 20 years of programming experience as a private programmer and developed SuperSMITH™, Visual, WeibullSMITH™, LogNormSMITH™, Normal+SMITH™, Visual+SMITH™, BiWeibullSMITH™, and MonteCarloSMITH™ analysis software. He received his B.S.M.E. from Georgia Tech and his M.S.M.E. from California State University at Long Beach.

Giapponi, Thomas
Mr. Giapponi’s professional career spans the Armstrong Rubber Company and Pirelli Tire North America in the capacities of Tire Design Engineer, Manager Medium/Heavy Truck Tires, Manager Light Truck and Passenger Car Tire Engineering, Director of Tire Engineering and Director of Tire Testing. He directed Pirelli’s North American R&D and Quality as the Director of R&D, Technical Director and Director of Quality in the market. In 2001 Mr. Giapponi started TRGtech Tire Consulting LLC which performs tire forensic investigations, tire patent defense, and tire forensic training. Mr. Giapponi received his Bachelor of Science in Engineering from Purdue University and is a registered P.E. in Connecticut.

Goddard, Geoff
Geoff Goddard is Professor in Motorsport Engineering Design and Head of the Vehicle Engineering Research Group in the School of Technology at Oxford Brookes University in the UK. Following a position in the gas turbine industry as a Rolls Royce University Apprentice, he joined Cosworth Engineering in 1970 and was later promoted to Chief Designer by Keith Duckworth. The engines he designed made the Cosworth name synonymous with winning including the F1 World Championship as well as World Sportscar, World Touring Car, and World Rallycar championships.

In 1995, he joined TWR as Director of Engine Design responsible for the design and development of engines for clients including Aston Martin DB7, Volvo, Ducati, Renault, SAAB, Audi, GM, Ford, Nissan, and the Oldsmobile Aurora. While working in these companies, he led the open design-led structure favoured by Duckworth, which allowed a free-flow of information across the boundaries of all technical areas, enabling design engineers to expand their knowledge and vision at an incredible pace. This was demonstrated by the winning results, making Cosworth the best post-graduate university in the world. By joining Oxford Brookes University, he brought some of this vision to their engineering courses and helped initiate new MSc courses in Racing Engine Design and Motorsport Engineering. He has also underpinned PhD research programmes for FI clients and industrial programmes covering advanced combustion research into future fuels, nano-particle additives, and various championship winning racing programmes. Geoff’s external activities include Director of Geoff Goddard Engines Ltd consulting on engines, Ambassador for EEMS, the British Government’s Energy Efficient Motor Sport body, and co-chair for the SAE International Motorsport Conference Engine and Drivetrain Panels.

Govindswamy, Kiran
Kiran Govindswamy is currently the Director of NVH, Driveline and Vehicle Integration at the North American Technical Center of FEV, Inc. where he is responsible for automotive NVH, structural dynamics, acoustics, transmissions, driveline systems, and full vehicle integration. He is a member of SAE International, serves on the SAE International NVH Conference Committee, and contributes regularly to several automotive publications focusing on vehicle driveline systems and NVH. His educational background includes a Bachelor’s Degree in Mechanical Engineering from the College of Engineering Pune, India and Master’s and Doctoral Degrees from the Pennsylvania State University.

Hall, Jody N.
Dr. Jody Hall is currently the Vice President, Automotive Market for the Steel Market Development Institute. Prior to that she was the Technical Integration Engineer for the Body Manufacturing Engineering Center at General Motors in North America where she was responsible for new steel applications and specifications for all stamped steel body components. Jody’s experiences in manufacturing at General Motors ranged from research and development of new materials and manufacturing processes to solving production problems. Her background includes engine and transmission components, body sheet metal, stamping die design and construction, plant floor data management, and manufacturing strategic planning. She was also GM’s manufacturing representative to the Auto/Steel Partnership Joint Policy Council for fourteen years. Dr. Hall is the recipient of numerous professional awards including the University of Michigan College of Engineering Alumni Merit Award in 2007, the Auto/Steel Partnership Instrumental Change Award in 2007, the GM Die Engineering Services Award for Leadership in 2005, the UASCAR Special Recognition Award for Outstanding Contributions in 2004, and the GM Chairman’s Honors Award in 2001. Dr. Hall has a B.S. in Materials & Metallurgical Engineering, and a M.S. and Ph.D. in Materials Science and Engineering from the University of Michigan.

Hall, Thomas J.
Thomas J. Hall currently owns and manages MaxG Technology LLC, a technical consulting and training company, specializing in Vehicle Braking and Stability technology for the transportation industry, formerly the Chief Engineer for Global Brake Systems - General Motors for the Robert Bosch Chassis Systems Division. Prior to that, he was the Engineering Manager for System Design and Validation at ITT Automotive, Continental Teves. His experience also includes development of ABS, TCS and Stability Control Systems, responsibility for application of system engineering principles and process to the brake industry and development and promotion of brake system proposals and advance braking technologies. Mr. Hall has a B.S. in mechanical engineering from the University of Michigan and a Master of Science in
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Finance from Walsh College.

**Haughey, Bill**

Bill Haughey is a respected consultant and instructor in the areas of Failure Modes Effects Analysis, Design for Manufacturability and Assembly, Design Review Based on Failure Modes, Design Review Based on Test Results, and other GD3 methodologies. He is a current member of the issuing committee of the SAE International J1739 FMEA standard. SAE International Automotive Quality and Process Improvement Committee; the SAE International Automotive Electronic Systems Reliability Standards Committee; and the AIAF FMEA Fourth Edition Recommended Practice Committee. Mr. Haughey was recently approved to lead the development of a new SAE International DRBFM Recommended Practice (J2886). Mr. Haughey formerly worked for GM, where he held various managerial, manufacturing, and engineering positions including Process Lead and Supervisor for FMEA and DFMA. While at GM, Mr. Haughey also supported Tatsuhiko Yoshimura in the global implementation of the GD3 (DRBFM) methodology. Yoshimura considers Mr. Haughey to be a subject matter expert in the GD3 methodologies, including DRBFM and DRBTR. Mr. Haughey received a B.S. degree from the University of Michigan and M.S. from Central Michigan University, and has the following certifications: Black Belt in GD3 (DRBFM and DRBTR); Master Design for Manufacturability and Assembly Engineer; and Certified Internal Auditor.

**Heck, Ronald**

Dr. Ron Heck is currently an independent consultant. Prior to that, Ron was a research manager responsible for developing catalyst technology for Engelhard Corporation. He has worked on the development of catalytic processes in SCR NOx, NSCR NOx, automotive catalyst, diesel catalyst, PremAir™ catalyst systems, hydrogenation technology, ozone abatement, volatile organic compound abatement, ammonia oxidation, chemical feedstock purification and chemical synthesis. Ron is a member of American Men and Women of Science and Who’s Who in Technology Today. He is an SAE International Fellow and a recipient of the SAE International Forest R. McFarland. He was a co-instructor for courses for SAE International in automotive emission control catalysis and diesel emission control catalysis. He was a member of the Scientific Advisory Board of the Strategic Environmental R&D Program for environmental studies in the Department of Defense. Ron has been involved in over 80 publications in commercial applications of catalysts and holds 36 U.S. patents on catalytic processes. He is the co-author of the book with Dr. Farrauto entitled “Catalytic Air Pollution Control: Commercial Technology” and is the former co-editor of the NewsBrief section of Applied Catalysis B: Environmental. Ron and his former research team from Engelhard received the 2004 Thomas Alva Edison Patent Award from R&D Council of New Jersey for the invention of close coupled catalyst technology for ultra low emission gasoline vehicles. Ron received his B.S. in Chemical Engineering and his Ph.D. from the University of Maryland.

**Herliczek, Siegfried H.**

Dr. Siegfried H. Herliczek, a consultant specializing in glass, has worked on glass products for automotive, aircraft, and architectural applications including tempered, laminated, and specialty products. He has extensive experience in research and development and has worked at Union Carbide Corporation, Libbey-Owens-Ford, and Pilkington Glass. Dr. Herliczek has written numerous papers, presented glass seminars in several countries, and received 15 glass-related patents. He is a member of SAE International, ACS, and SPE. Dr. Herliczek earned a B.S. from the University of Massachusetts and a Ph.D. in chemistry from Northeastern University.

**Hickman, Jeffrey**

Dr. Jeffrey Hickman is a Group Leader at the Virginia Tech Transportation Institute. His primary areas of research include community-wide applications of behavior-based safety, self-management, and organizational culture change techniques, assessing driver behavior, fatigue, work/rest cycles, and driver distraction in commercial motor operations. These research projects include competitive research awards from the FMCSA, NHTSA, Mine Health and Safety Administration, National Transportation Research Center, Inc., Transportation Research Board, Canadian Council of Motor Transport Administrators, and the AAA Foundation for Traffic Safety. He has over 60 presentations, 30 scientific publications and technical reports, scientific reviews for the National Institute for Occupational Safety and Health, and currently serves as a reviewer for the Journal of Occupational Health Psychology, Accident Analysis and Prevention, and Journal of Organizational Behavior Management. Dr. Hickman is also the President of Hickman Management Solutions. He has significant experience in the design, delivery, and implementation of targeted solutions for organizations looking to improve safety, productivity, and performance.

**Hoag, Kevin**

Kevin Hoag is an Institute Engineer in the Engine, Emissions, and Vehicle Research Division at Southwest Research Institute, and has more than 35 years of engineering experience in diesel and spark-ignition engine development. Before joining Southwest Research he held engineering management positions with Cummins, Inc., and was most recently Associate Director of the Engine Research Center at the University of Wisconsin. He continues to teach in Wisconsin's Master of Engineering in Engine Systems program. Kevin holds bachelors and masters degrees in mechanical engineering from the University of Wisconsin. He is the author of two books, “Skill Development for Engineers” (IEE Press, 2001), and “Vehicular Engine Design” (Springer-Verlag, 2005, 2015).

**Hoff, Craig J.**

Dr. Craig J. Hoff is an Associate Professor of Mechanical Engineering at Kettering University, teaching the areas of thermal and mechanical design, with applications in automotive engineering and biomedical engineering. His research interests include loop heat pipes, electronic and vehicle thermal management, and alternative automotive powertrains. Dr. Hoff is the faculty advisor to the Kettering Formula SAE International racecar team and is the Chair of SAE International’s Scholarship Committee. He is the co-author, with Dr. Gregory Davis, of the textbook “Introduction to Automotive Powertrains.”

**Husain, Iqbal**

Dr. Iqbal Husain is currently a Distinguished Professor in the Electrical & Computer Engineering Department at North Carolina State University. Prior, he served as a faculty member at the University of Akron, Ohio for many years, was a visiting Professor at Oregon State University, and also lectured at Texas A&M University. Professor Husain’s research interests are in the areas of control and modeling of electrical drives, design of electric machines, development of power conditioning circuits, microinverters for distributed power generation, inverter controls for grid synchronization, and modeling of electric and hybrid vehicle systems. He has worked extensively on the development of SR and PM motor drives for various automotive and industrial applications. Dr. Husain is currently the Co-Director of the Advanced Transportation Energy Center (ATEC) and a faculty member of the NSF Future Renewable Electric Energy Delivery and Management (FREEDM) systems center at North Carolina State. He is the General Co-Chair for Energy Conversion Congress & Expo (ECCE) 2012 in Raleigh, NC, the chairman of the IEEE-IAS Transportation Systems Committee, and the past chairman of the IEEE-IAS Electric Machines Committee. Dr. Husain received the 2006 SAE International Vincent Bendix Automotive Electronics Engineering Award, the 2004 College of Engineering Outstanding Researcher Award, the 2000 IEEE Third Millennium Medal, the 1998 IEEE-IAS Outstanding Young
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**Member award, and several IEEE-IAS prize paper awards. Dr. Husain is an IEEE Fellow and a Distinguished Lecturer for IEEE-IAS during 2012-13. He received a B.Sc. from Bangladesh University of Engineering and Technology, and a M.S. and Ph.D. from Texas A&M University.**

**Husher, Stein**
Stein E. Husher is currently a principal scientist engaged in crash reconstruction at KEVA Engineering, LLC. He has been working and conducting research in the field of Accident Reconstruction for over 30 years. An avid street motorcycle rider himself, Mr. Husher has reconstructed hundreds of motorcycle crashes. He has published numerous technical papers related to accident reconstruction, including motorcycle crashes and serves on SAE International and ISO committees. He holds a Bachelor’s degree in Mathematics and a Master’s degree in Mechanical Engineering.

**Issac, Emad**
Emad S. Isaac is Senior Vice President and Chief Technology Officer at Rand McNally, a company specializing in geospatial information, education, navigation, and fleet management technologies. Mr. Isaac’s prior experience includes over 20 years of broad responsibilities in automotive, commercial vehicle electronics, wireless communications, systems, and embedded technologies industries. Previously, he was CTO for a U.S.-based electronics development and manufacturing services company. Mr. Isaac was also a Distinguished Member of Motorola’s Technical Staff as Lead Systems Architect for Motorola’s Telematics Group he served on the Motorola Patent Committee, led several corporate wide innovation initiatives, identified new standards and standard bodies for regional and global Telecommunications. In addition, Mr. Isaac served as vice-chairman for the SAE International J1939 committee. Mr. Isaac holds several key patents and is a dedicated advocate of various projects and school programs that inspire children in the areas of Math, Science, and Engineering. Mr. Isaac holds two BS degrees in Applied Physics and Mechanical Engineering from McGill University. He also holds a MS in Biomechanics from the University of Arizona, as well as a Master of Engineering Management degree from Northwestern University.

**Jiang, Yuxiang**
Mr. Jiang is currently Chief Engineer-Powertrain at the Commercial Vehicle Technical Center of SAIC Motor Corporation Limited. Previously, Mr. Jiang was Chief Engineer in the Engine Tech Center at Foton Motor Company Research Institute. Mr. Jiang also held the position of Project Manager-Powertrain Control and Advanced Engineering at Ford Motor Company in Dearborn, Michigan. Additionally, he was Project Manager in the Powertrain Control Center at General Motors Corporation at the Milford Proving Grounds in Michigan. Mr. Jiang received his B.S. and M.S. in Thermal-Automatic Engineering from Tsinghua University, Beijing and his Ph.D. in Mechanical Engineering from the University of Illinois, Chicago, Illinois. In addition, Mr. Jiang holds an M.B.A. in Business Administration from the University of Michigan.

**Jiao, Jianzhong**
Dr. Jianzhong Jiao is an internationally recognized lighting expert for light sources and lighting products design, technology development, testing, industry standards and government regulations. Dr. Jiao has been actively involved in professional and industry organizations and standardization activities. He is the Chairman of the SAE International Lighting Committee, past Chairman of the Next Generation Lighting Industry Alliance (NGLIA), Chairman of the NEMA SSL Section Technical Committee, and active member of IESNA Committees, ANSI-NEMA SSL Working Groups, UL LED Standard Technical Panel, as well as member of CIE, SPIE, IET and other organizations. Dr. Jiao is an SAE International Fellow, and has received several industry awards. Dr. Jiao holds a Ph.D. degree in Electrical Engineering from Northwestern University, a M.S. degree in Applied Physics, and a B.S. degree in Mechanical Engineering. He is titled to 9 U.S. Patents and has over 20 technical publications. Dr. Jiao currently serves as the Director of Regulations and Emerging Technologies at OSRAM Opto Semiconductors Inc. He also served as an adjunct professor teaching physics and electrical engineering courses at Purdue University and Lawrence Technological University. He has been teaching for SAE International since 2003.

**Johnston, Paul**
Paul Johnston is Senior Director of Compression and Braking at Meritor WABCO and is responsible for application engineering, product planning and new product development. Previously at ArvinMeritor, Johnston was Senior Director of the North American Foundation Brake Business Unit and Worldwide Director of Product Engineering for the CVS Worldwide Braking Division. He has over 38 years of experience in commercial vehicle air and hydraulic braking systems and products. A member of SAE International, Mr. Johnston was the recipient of the 2007 SAE International Award for Outstanding Technical Committee Service. Mr. Johnston is active in the Truck & Bus Council, Truck & Bus Brake Committee, and related subcommittees to develop new brake products and system recommended practices. Mr. Johnston’s experience includes that of Chairman and member of the Heavy Duty Brake Manufacturers Council. He has been involved in the Technology & Maintenance Council and the Commercial Vehicle Safety Alliance regarding technical products and commercial vehicle practices. Mr. Johnston received a B.S. in Mechanical Engineering from Ohio Northern University, a M.S. in Mechanical Engineering from Cleveland State University, and a M.B.A. from Baldwin Wallace College.

**Kang, Stephen**
Dr. Stephen Kang is currently a Technical Specialist in the Safety Core and Strategy Department of Ford Motor Company where he is responsible for developing safety methods such as component test methods, CAE methods and best practices. He was responsible for developing a truck program from beginning to production launch, and for meeting safety requirements. Dr. Kang has conducted occupant safety and CAE trainings; designed and conducted extensive dynamic component tests; established several Ford internal component design requirements and is responsible for the establishment of an Occupant CAE database at Ford. Dr. Kang is the recipient of the Henry Ford Technology Award in 2005. He serves as an Advisory Board Member for TNO North America and is a certified six-sigma black belt. Dr. Kang has a Ph.D. in Biomechanics from Wayne State University.

**Khair, Magdi**
Dr. Khair is a consultant at Magdiesel Technologies. He has recently retired from Watlow Electric where he was Chief Technologist in Watlow’s Diesel Emission Space. He was previously an Institute Engineer at Southwest Research Institute. He had prior assignments at Allied Signal Automotive Catalyst, Ford New Holland, Ford Tractor Operations, Bendix Diesel Operations, and the Chrysler Corporation. Dr. Khair has an extensive background in diesel aftertreatment, stratified charge, and gas turbine engines since 1970. He was involved with developing emission control systems to help diesel and alternative combustion engines meet future regulated limits. He is the co-author of “Diesel Emissions and Their Control”, and continues to present seminars in diesel engine technology, selective catalytic reduction for diesel engines, and exhaust gas recirculation. Dr. Khair holds a B.S. in Automotive Engineering from Cairo, Egypt, a M.S. in Thermodynamics from the University of Birmingham, England, a MBA from Michigan State University USA, and a Ph.D. in Engineering Management from Warren National University. Dr. Khair holds 20 US patents in the areas of fuel injection, turbocharging, exhaust gas recirculation and filtration, and diesel aftertreatment systems.
Kipers, Kenneth
Dr. Kenneth Kipers has over 25 years of experience in additive synthesis, fuels, formulation, field testing, and customer service, is a Certified Lubrication Specialist and is currently involved in the consulting and training field specializing in fuels and lubricants. He is an adjunct professor at Richland College in Dallas and an instructor for Dale Carnegie courses, as well. Dr. Kipers has been an expert witness in many cases involving gasoline, diesel, and aviation fuels. He is also an active member of ACS, SAE International, and STLE. Dr. Kipers received a B.S. from San Diego State University and a Ph.D. in physical organic chemistry from the University of California-Los Angeles.

Konstandopoulos, Athanasios
Dr. Athanasios G. Konstandopoulos, recipient of the 2006 Descartes Laureate, is the founder and head of the Aerosol and Particle Technology Laboratory (APTL), a well-known European diesel emission control laboratory at the Chemical Process Engineering Research Institute (CPERI/CERTH) in Thessaloniki, Greece. In 2006, he was elected as Director of CPERI and member of the Board of Directors of the National Centre for Research and Technology-Hellas (CERTH). Since 2006, he has also been a member of the faculty of Chemical Engineering at Aristotle University in Thessaloniki. Dr. Konstandopoulos is a specialist in combustion aerosols and nanoparticles and he has extensive research and engineering consulting experience in the design, modeling, and testing of diesel particulate filter systems and monolithic reactors. Dr. Konstandopoulos, an SAE International Fellow, has authored more than 70 scientific and technical papers and is a frequent invited speaker at conferences throughout the U.S. and Europe. His educational accomplishments include a Diploma in Mechanical Engineering from Aristotle University of Thessaloniki, an M.S. in Mechanical Engineering from Michigan Technological University and an M.S., MPhil and a Ph.D. in Chemical Engineering from Yale University. Dr. Konstandopoulos is the Editor-in-Chief of the journal “Emission Control Science and Technology”.

Kosinski, John
John Kosinski is a User Interaction Technical Professional at Visteon Corporation with over 25 years of user interaction design experience ranging from automated test and machine tool equipment to emergency vehicle and in-vehicle infotainment systems. He holds multiple patents in controls and user interfaces and brings extensive experience in systems, hardware and software engineering, graphic design and human factors applied to the development of innovative user interface solutions.

Kuhn, Robert (Skip)
Mr. Kuhn is currently a Managing Engineer for JP Research where he manages a technical consultancy for a variety of clients including automotive OEM’s and suppliers. Prior to becoming a consultant, Mr. Kuhn worked for both Ford and Chrysler in a variety of positions that included engine related projects including single failures, multiple failures, class action suits, and individual engine operational and reliability issues, as well as engine testing and development, fleet testing of prototype engines, vehicle chassis and engine packaging, and overall vehicle platform development including engine systems. He holds a B.S. in Mechanical Engineering from Carnegie Mellon University and an M.S. in Automotive Systems Engineering from the University of Michigan Dearborn and is also a licensed Professional Engineer in the State of Michigan.

Kurowski, Paul
Dr. Paul Kurowski is a professor in the Department of Mechanical and Materials Engineering at the University of Western Ontario in London, Ontario. His teaching experience includes finite element analysis, machine design, mechanics of materials, kinematics and dynamics of machines, mechanical vibration and product development. He is also the President of Design Generator Inc., a consulting firm specializing in product development, design analysis and training in Computer Aided Engineering methods. Dr. Kurowski has published multiple technical papers and taught professional development seminars for SAE International, the American Society of Mechanical Engineers, the Association of Professional Engineers of Ontario, the Parametric Technology Corp. (PTC), Rand Worldwide, SolidWorks Corp. and other companies and professional organizations. He contributes regularly to several engineering publications focusing on the implementation of CAE methods into the product development process. He is a member of SAE International and the Association of Professional Engineers of Ontario. Dr. Kurowski obtained his M.Sc. and Ph.D. in Applied Mechanics from Warsaw Technical University and completed postdoctoral work at Kyoto University.

La, Chi Binh
Chi Binh La has over 15 years of experience in engine development covering NVH, mechanical development and calibration, as well as analysis and simulation. In 2012, he joined IAV where he is responsible for the strategic vision and profitable growth of the business unit. Technically the business unit is responsible for the development of gasoline and alternative fueled engines including base engine calibration to vehicle drivability, emissions and OBD. Chi Binh holds a Bachelor’s Degree in Mechanical Engineering from University of Waterloo and a Master’s Degree in Engine Systems from University of Wisconsin.

Lampman, Dewitt W.
Dewitt Lampman is a Staff Engineer with PPG Glass Research, where he has been in the Automotive OEM Process and Product Development Division since 1973. Mr. Lampman was a major contributor to the development of thin laminated sidelites, where he was involved with developing product specifications and process capability requirements for production, and conducting modeling and stress level measurements on vehicles to define glass and door design specifications, having worked with four automobile manufacturers in these areas. To date, Mr. Lampman holds seven U. S. Patents. Mr. Lampman graduated with a B.S. degree in Ceramic Engineering from Alfred University, Alfred, NY.

Lundstrom, Richard
Dr. Richard Lundstrom is an independent research and project engineer specializing in dynamic system engineering, automotive chassis development, and application of the science of improvement. He formerly taught Chassis Design, Systems Analysis and Mechanical Control Systems at Kettering University, where he also previously served as team leader for the annual Kettering Industry Symposium. In addition, Dr. Lundstrom taught several mechanical engineering courses, developed Vehicle Dynamics and Thermal System Design courses, and founded and directed the Vehicle Dynamics Lab at Lawrence Tech. He worked as a product engineer with Ford Motor Company and developed and taught a Fundamentals of Vehicle Design course. Dr. Lundstrom is a member of SAE International, ASME, ASQ, ASEAl and SCCA. He received a B.S. in Mechanical Engineering from the University of Illinois, a M.S. from the University of Michigan and a Ph.D. from Oakland University.

Mago, Angelo E.
Angelo Mago is senior consultant and owner of ATM Consulting, Inc., which provides customized training and consulting services to a varied design and manufacturing supplier community in the areas of Design to Cost, Quality Assurance, Document Management, Supplier Development and Management, and Customer Management. He has over 25 years of experience in product design, quality assurance, and project management working in both the Governmental and Commercial mobility industry. DOD experience includes serving in the US Army TACOM Program Office in the MI Abrams and Bradley Program Management offices and Plant Manager for the Depot Repair Facility in Mannheim Germany. Commercially Mr. Mago has worked as the Senior Supplier Quality Engineer for GM Truck.
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Group responsible for NAO and off-shore supplier ISO qualification, Product Development, and PPAP qualification and approval. Through ATM Consulting, Mr. Mago has played a lead role in deploying a PM and APQP environment for both large and small companies. He is a recipient of the SAE International Forest R. McFarland Award for distinction in professional development/education. He has a B.S. in Mechanical Engineering from Florida Institute of Technology.

Malburg, Mark
Dr. Malburg is the president of Digital Metrology Solutions, Inc where he provides dimensional and surface metrology consultation and develops analysis and control algorithms, software and custom instrumentation. He is also the president and chief software architect of Verified Technologies – the creators of the award-winning BrakeView® system for the measurement of rotating components and is an adjunct associate professor of engineering at the University of North Carolina at Charlotte. He is currently a member of the ASME B46.1 “Surface Texture” standards committee, a member of the B89 committees for “Roundness”, “Straightness” and “Flatness”, and is a United States Subject Matter Expert for several ISO committees under ISO/TC213 for surface and form metrology. Dr. Mark Malburg holds a B.S. and M.S. in Mechanical Engineering from Michigan Technological University. His graduate work at Michigan Tech addressed the characterization of plateau-honed surfaces and the approach he developed was later adopted as an International Standard. He completed his Ph.D. at the University of Warwick researching problems in instrument correlation in surface metrology applications.

Masiak, James
Mr. Masiak is currently a Principal of Technology Highway, LLC, responsible for Technology Development and Commercialization processes. Prior to this, Jim worked for General Motors for more than 25 years where he was responsible for the implementation of business and engineering processes, including the implementation of an enhanced engineering product cost management process within GM North America, the alignment of cross functional organizational initiatives, and development of an engineering resource allocation plan for GM Regions. Mr. Masiak was also responsible for the development and implementation of specific global engineering and business strategies across all of General Motors International Operations. He received a B.S. in Mechanical Engineering from Wayne State University, a M.S. in Mechanical Engineering from the Massachusetts Institute of Technology, and a M.B.A. from Michigan State University’s Executive Management Program.

Masoudi, Mansour
Dr. Mansour Masoudi is the founder of Emissol LLC, an emission control (aftertreatment) company specializing in various automotive powertrain technologies, Research and Development (R&D) with a core specialty in emission reduction and aftertreatment technologies. Throughout his career, he has carried out various responsibilities working on gasoline and Diesel emission control components and systems, including substrate and catalyst technologies, spray injection (fuel, DEF), aftertreatment system design and optimization, testing and validation. He formerly held technology, product and R&D responsibilities at Corning Inc. (Senior Product Engineer), Delphi Corp. (Staff Project Engineer), Bosch Diesel Systems (Senior Engineer), Bosch Emission Systems (Manager, Aftertreatment Systems) and at Paccar (Manager, Advanced Powertrain Technology). He has a Ph.D. in Mechanical and Aerospace engineering, M.S. in Mechanical Engineering and MS. in management. Dr. Masoudi is the Editor-in-Chief of the journal “Emission Control Science and Technology”.

Masrur, Abul
Dr. Masrur is currently with the US Army RDECOM-TARDEC (Research Development and Engineering Command), in the Ground Vehicle Power and Mobility Department within TARDEC, where he is involved in vehicular electric power system architecture concept design, modeling and simulation, electric power management, and military applications. He previously worked with the Scientific Research Labs of Ford Motor Company where he was involved in research and development related to simulation and control for electric drives for electric and hybrid electric vehicles and power electronics, advanced automotive electric energy management, electric active suspension systems for automobiles, automotive multiplexing systems, electric power assist steering, and automotive radar applications, including the Computer Aided Engineering development and simulations for such applications. Dr. Masrur has authored more than sixty publications and has co-authored eight U.S. patents and is the recipient of SAE International’s Environmental Excellence in Transportation Award in Education, Training and Public Awareness. He has a B.S. in Electrical Engineering from Bangladesh Engineering University, a M.S. in Computer Engineering from Wayne State University, a M.Eng. in Electrical Engineering from the University of Detroit and a Ph.D. in Electrical Engineering from Texas A&M University.

Matthews, Ronald D.
Professor Ron Matthews, currently serving as a member of the SAE International Board of Directors, is Head of the General Motors Foundation Engines Research Laboratory on the campus of the University of Texas at Austin. He has been actively involved in engines research for 35 years, including engine control systems since the initial introduction of on-board computers. Dr. Matthews, a Fellow of SAE International, founded the Formula SAE competition in 1981 and has been the Faculty Advisor for a Formula SAE team each year since. He has been author or co-author on over 200 technical papers and reports, mostly in the field of engines.

McCormick, Harold E.
Harold McCormick is currently President of C-K Engineering Inc., an engineering firm specializing in providing analysis instrumentation gauging and other consulting services for engine and lubricant manufacturers. He was formerly Director of Engineering, Ramsey Plant TRW-Valve Division, with ongoing responsibility for research and product engineering. He has also completed 57 graduate hours in Applied Mechanics and Metallurgy at St. Louis University. His experience has involved directing substantial work to develop models/test procedures and test fixtures that can be utilized to predict wear in severe wear applications such as piston rings, engine exhaust and valve seats as well as severe dry sliding wear applications. He holds more than 40 U.S. patents and has authored or co-authored numerous technical papers for SAE International as well as other automotive engineering organizations. Mr. McCormick holds a B.S. in Mechanical Engineering from University of Missouri-Rolla and an M.B.A. from St. Louis University.

McVea, William Mark
Dr. William Mark McVea, P.E., is currently Chief Technology Officer for Torvec, Inc., an industry leader in the design and development of patented powertrain engineering technology used primarily in the automotive industry. He is also President and Principal Engineer of KBE+, Inc. where Dr. McVea and his team design and develop complete powertrains for automotive and off-highway vehicles. His prior positions include Professor of Vehicle Dynamics and Powertrain Sciences in the Mechanical Engineering Department at the Rochester Institute of Technology and adjunct professor at Purdue University in their Automotive Sciences Department. He was also formerly a manager of the CAE group within a tier-one powertrain supplier to global automotive markets, a consulting engineer in vehicle dynamics with Gear Consultants, Inc., and a project manager of traction systems for off-highway vehicles with Clark-Hurth International. Dr. McVea has published extensively on the topics of transmission systems, automated
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design assistant systems, knowledge systems and knowledge based engineering in general. He also holds or is listed as co-inventor on numerous patents related to mechanical power transmissions. Dr. McVea holds a B.S. in Mechanical Engineering from the Rochester Institute of Technology, a Ph.D. in Design Engineering from Purdue University and is a licensed Professional Engineer.

Mi, Chris
Dr. Mi is currently an Associate Professor at the University of Michigan - Dearborn, and Chief Technical Office of 1Power Solutions, Inc. His teaching and research interests are in the areas of power electronics, hybrid electric vehicles, electric machines and drives, and renewable energy and control. At 1Power Solutions, Inc., he is responsible for the powertrain electronics, plug-in hybrid electric vehicle battery management systems, energy engineering solutions, and technical strategy. Prior to that, he worked with General Electric as an Electrical Engineer responsible for the design and development of large electric motors and generators. In addition, Dr. Mi has also worked in China for the Rare-Earth Permanent Magnet Machine Institute of Northwestern Polytechnical University and the Xi’an Petroleum Institute and was a visiting scientist at the University of Toronto. Dr. Mi is the recipient of many awards including the Government Special Allowance (China), Technical Innovation Award (China), the Distinguished Teaching Award from the University of Michigan - Dearborn, and SAE International’s Environmental Excellence in Transportation Award in Education, Training and Public Awareness and has published more than 80 papers. Dr. Mi received a B.S. and M.S. in Electrical Engineering from Northwestern Polytechnical University, Xi’an, Shaanxi, China, and a Ph.D in Electrical Engineering from the University of Toronto, Canada.

Micklow, Gerald J.
Gerald Micklow, Ph.D. PE is currently a full professor of Engineering at East Carolina University and is a licensed engineer in the state of North Carolina. For nearly three decades, Dr. Micklow has been actively involved in the design and evaluation of advanced power producing systems. Dr. Micklow’s research over the years has been heavily funded by NASA, the National Science Foundation, the Department of Energy, the Federal Aviation Administration, Argonne National Labs and others with the majority of the work being related to fuel injection and low pollutant emission combustion systems for aircraft and on-road and off-road automotive/trucking/machinery applications. Dr. Micklow has received numerous awards from NASA including being inducted into the NASA/U.S. Space Foundation Innovative Technology Hall of Fame in 2000 and receiving the NASA Space Act Award for work performed on the Space Shuttle in 2002. In addition, Dr. Micklow’s industry experience includes eight years of designing advanced aircraft and missile configurations where he maintained top-secret security clearances. With well over 60 engineering publications, Dr. Micklow received both a B.S. and M.S. in Aerospace Engineering from Pennsylvania State University and a Ph.D. in Mechanical Engineering from Virginia Polytechnic Institute and State University.

Miller, Joseph D.
Since 2005, Joe Miller has served as the chairman of the United States Technical Advisory Group to ISO TC22/SG3/WG16, which is developing ISO 26262: Road Vehicles - Functional Safety. This was recognized by the SAE International Technical Standards Board Outstanding Contribution Award. He is the Chief Engineer of Systems Safety at TRW Automotive responsible for the systems safety process. Prior to this, he has managed systems engineering, manufacturing planning, and program control for electric steering. He has also engineered communication, avionics, infrared, and radar systems, as well as and thick and thin film components. Joe has 20 US patents, a Master of Engineering (EE) and a Master of Business Administration.

Nazri, Gholam-Abbas
Dr. Nazri is currently the technical director of new technologies at Frontier Applied Sciences and Technologies, LLC. and is also an adjunct professor of Physics and Chemistry at Wayne State University, Oakland University, and University of Windsor, Canada. Dr. Nazri began his career as a Research Scientist at General Motors Global Research and Development Center after two years of postdoctoral fellowships at the Lawrence Berkeley National Laboratory. He also served as a visiting Professor at the University of Pierre and Marie Curie, Paris France, Institute of Condense Matter Chemistry at Bordeaux France, and Institute of Materials at Nantes, France. He is an active organizer of symposia on advanced batteries and is on the International Science Advisory Board of several Lithium Battery Meetings and Conferences. Dr. Nazri has published over 100 scientific papers, 12 proceedings volumes, two text books on science and technology of lithium batteries, and is the holder of 15 U.S. patents. His research interests are in the area of materials for advance batteries for transportation applications, supercapacitors, solid-state hydrogen storage materials, electrochemical catalysis, synthesis of novel materials, and advanced analytical techniques for real time study of electrochemical systems. Dr. Nazri received his Ph.D. in Physical Chemistry from the Center for Electrochemical Sciences, Case Western Reserve University.

Oliver, Michael J.
Michael J. Oliver is Vice President of Electrical / EMC Engineering at MAJR Products Corporation, where he is responsible for customer EMC design and consulting and new product development. He is also the company’s ISO-9001:2000 management representative. An expert in EMI/RFI shielding technology, he has experience in electronics, military shelter electrical systems, and high power antenna/radome design. His experience also includes the design and testing of aerospace antennas, shielding of military shelter electrical systems, and discrete EMC shielding components. Mr. Oliver has expertise in open and anechoic chamber radiated testing to military standards and has utilized various antennas and radiated test systems. In addition, he has written numerous technical papers and publications on electromagnetic shielding components, product testing and design, and military antenna/ radome test methodology standards. Mr. Oliver is the founder and currently serves as Chairman of the IEEE Pittsburgh EMC Chapter. He is Co-Chairman of the SAE International AE4 Electromagnetic Compatibility Committee, and a member of the IEEE EMC Standards Advisory Coordination Committee (SACCom). Mr. Oliver has three patents (one pending) on EMC shielding-thermal management devices and he received a B.S. in Electrical Engineering Technology from Gannon University.

Palazzolo, Joseph
Joe Palazzolo is Chief Engineer – eDrive Systems at GKN Driveline. He is responsible for managing the mechanical design and development of new automotive gearboxes, torque transfer devices, concepts, and industrialization into production applications. His prior professional experience spans the majority of vehicle powertrain systems, including overall chassis design and validation, all-wheel systems design and development, power transfer unit and transfer case design, and torque management device development. Joe has been privileged to contribute while working at Carron and Company, Visteon Corporation, Warn Industries, Magna Powertrain, and Ford Motor Company. Mr. Palazzolo maintains the ASE certified Master Technician and Undercar Specialist certifications, has chaired the SAE International All-Wheel Drive Standards Committee, and has been an active SAE International member since 1990. Mr. Palazzolo was a recipient of the SAE International Forest R. McFarland Award for distinction in professional development and education in 2007. In 2010, he achieved the SAE International Master Instructor designation and continues to maintain this in his three seminars that he has been teaching globally since 1999. In 2013,
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his technical and professional accomplishments to the industry were recognized by reaching the membership grade of SAE International Fellow. Mr. Palazzolo is the award winning author of “High-Performance Differentials, Axles & Drivelines”. He furthered his authoring with his second text on “How to Rebuild the Ford 8.8 and 9 inch Axles”. He finalized three chapters featured in the “Automotive Engineering Encyclopedia”, released in 2014. His scope of work has been inclusive of the entire vehicle but also focused on competitive, high-performance drivetrain systems. He holds a Bachelor’s degree in Mechanical Engineering from Cleveland State University and a Masters degree in Automotive Engineering from Lawrence Technological University. He has received numerous patents for his work and creativity in advancing mobility systems.

Park, Talus
Talus Park is the Calibration Skill Team Leader at AVL Powertrain Engineering based in Plymouth, Michigan. He is responsible for diesel and gasoline engine calibration, transmission calibration as well as certification services throughout North America. His team is focused on utilizing innovative tools and methods to deliver high quality calibration projects with maximum efficiency. Mr. Park has over twelve years of experience in the transportation industry focused on calibration. He earned both his Bachelor’s and Master’s degrees in mechanical engineering from West Virginia University.

Piacenti, Vincent
Mr. Piacenti is Senior Manager at Robert Bosch LLC in Farmington Hills, Michigan and is responsible for Diesel Fuel Injection Hydraulic Systems Integration for North American diesel-engine applications. This encompasses simulation, adaptation and testing of high-speed, high-pressure fuel injection systems, concentrating on Common-Rail systems, both solenoid-valve and Piezo. Included is research of alternate fuels for diesel engine applications. Experienced in all types of diesel fuel injection and various gasoline systems, Mr. Piacenti is a contributing author to the Springer Handbook for Mechanical Engineers. Mr. Piacenti holds a B.S. in Mechanical Engineering and has been with Bosch for over thirty years, seven of which were at the Bosch Headquarters for Diesel Fuel Injection in Stuttgart, Germany.

Pike, Jeffrey A.
Jeffrey A. Pike is President, Biomechanics Consulting, Inc. and Adjunct Professor, Biomedical Engineering, Wayne State University. He previously held the position of Senior Technical Specialist, Occupant Injury/Biomechanics, Ford Motor Company, from which he recently retired. He has extensive professional experience in biomechanics, injury mechanisms and causation, occupant protection, testing, regulatory requirements and regulatory process and medical records review. Mr. Pike has organized and presented at numerous technical forums, including sessions at two White House Conferences as well as SAE International Symposia on Vehicle Rollovers, Occupant Protection and Lower Limb Injuries. He has also taught SAE International regulatory and forensics seminars for 21 years and has been a guest lecturer at MIT, the Medical College of Wisconsin, the University of Michigan, Harvard Medical School, and the University of Virginia. Mr. Pike is an SAE International Fellow and received the Forest R. McFarland Award in 2004 for his contributions to SAE International professional development activities. His publications include technical papers, book chapters and principal author of two textbooks published by SAE International: “Automotive Safety: Anatomy, Injury, Testing and Regulation and Neck Injury: The Use of X-Rays, CT’s and MRI’s to Study Crash-Related Injury Mechanisms”. His educational background includes studies at Polytechnic Institute of Brooklyn, New York University and the University of Michigan.

Porter, Alexander (Alex) J.
Alexander J. Porter is the Chief Engineer for Programs, Performance, and Durability for Intertek, and has been with the company since 1992. Since 1996, he has been developing accelerated testing methods for mechanical components and systems. Mr. Porter has three patents relating to accelerated testing equipment and has authored over 40 articles and technical papers on accelerated testing. Alex is the author of the book “Accelerated Testing and Validation” (Elsevier 2004). His work in the past has included implementation of FEA in a laboratory setting and development of a thermal management system for an advanced data acquisition package developed by NASA’s Dryden Flight Research Facility. Alex is a member of SAE International and IEEE. He holds a B.S. in aircraft engineering and an M.S. in mechanical engineering, both from Western Michigan University.

Primus, Roy J.
Roy J. Primus is a Senior Principal Engineer in the Combustion Systems Organization at the General Electric Global Research Center. Prior to joining GE Global Research, Mr. Primus was an Executive Director at the Technical Center of Cummins, Inc. He has been conducting reciprocating engine design and development for over 38 years. Mr. Primus’ areas of expertise include diesel engine performance development, emissions control, thermodynamic system modeling and air handling system design and analysis. He holds a Master of Science degree in Mechanical Engineering and a Bachelor of Science degree in Mathematics from Rose-Hulman Institute of Technology. He has authored over 25 technical publications and holds 25 patents on reciprocating engine systems and technology. Mr. Primus is a Fellow of SAE International and an Assistant Adjunct Professor for the University of Wisconsin Master of Engineering in Engine Systems distance learning program.

Quarto, Mark
Dr. Mark Quarto is currently the Chief Technology Officer (CTO) for Automotive Research and Design, LLC where he is responsible for the design/development of diagnostic test equipment and software, technical education and training programs, and technology innovations focused on hybrid and electric vehicle propulsion and energy management systems. Dr. Quarto previously worked within the General Motors Company as an Engineer and Engineering Group Manager in Advanced Powertrain Technology Systems / Global Aftermarket Engineering where he was responsible for the management and development of control and diagnostics systems and service solutions. He also served as the Service Training Development Manager and Resident Service School Instructor. In addition to his accomplishments and experiences while working at General Motors, Mark has served as a Chief Engineer, Senior Consultant, Author, and Subject Matter expert in Hybrid, Electric, and Fuel Cell Technologies. Dr. Quarto has a Bachelor’s Degree in Electrical Engineering from LaSalle University specializing in Power Electronics; a Bachelor’s Degree in Automotive Technology from Ferris State University; Master’s Degree in Technical Education from Ferris State University specializing in electric and hybrid propulsion systems; and a Doctorate in Technical Education from Nova Southeastern University, specializing in designing and developing learning systems for hybrid/electric vehicles and high voltage energy and propulsion systems.

Rakouth, Heri
Heri Rakouth, Ph.D., is Manager, Technology Exploration at the Innovation and Technology Office (ITO) of Delphi Corp. in Troy, MI. In this capacity, he coordinates technology innovation activities across three out of the five divisions of Delphi. He spearheaded cross-sectional efforts that have led to the build of the telematics business development team for the aftermarket and the launch of the V2X proof of concept project currently implemented for the Land Transport Authority of Singapore. Dr. Rakouth has about 30 years experience in both aerospace/defense telecommunications and automotive electronics industries. He has held various responsibilities at
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Thomson CSF/Thales and Renault in France as product engineer and technical manager before joining Delphi in 1996. Dr. Rakouth is also an adjunct professor at Oakland University teaching undergraduate and graduate classes in Power Electronics and Wireless Communications. Dr. Rakouth has published over 20 IEEE or equivalent technical papers and tens of classified and non-classified reports. He holds several U.S. and European patents. He holds MS and PhD degrees in Electrical Engineering, from the University of Pierre and Marie Curie (UPMC) of Paris, an MBA from Saginaw Valley State University, and an MS in Manufacturing Management from Kettering University.

Ranganathan, Raj P.
Dr. Raj Ranganathan is well known for his expertise in heat transfer. Prior to his current position, he was a Director at CD-Adapco. In addition, Dr. Ranganathan worked for General Motors and Caterpillar in the U.S. primarily in gasoline and diesel engines. He received GM’s highest award for innovation, the 2007 “Boss Kettering” Award. He has been associated with SAE International for 20 years and received the Forest McFarland Award in 2006. Raj has co-authored over 40 papers, patents, patents pending and proprietary research reports. Dr. Ranganathan received both a M.S. and Ph.D. in Mechanical Engineering with specialization in the area of heat transfer from Purdue University.

Reddy, Sam
Dr. Reddy is the owner of Evaporative Emissions Consulting, Inc., which was formed in 2009 after Sam’s retirement from General Motors R&D Center. He has 30 years of experience in fuels and fuel vapor emission control research and development. Dr. Reddy has been working on evaporative emission research and development with significant research in the area of diesel fuel cold temperature wax plugging problems and diesel fuel stability. He holds twenty six U.S. patents and has authored ten SAE International papers in the same field. Dr. Reddy obtained his B.S. CHE from Osmania University in India, M.S. CHE from UCLA, and Ph.D. CHE from the University of Michigan and is a licensed engineer in the state of Michigan.

Reinhart, Thomas
Thomas Reinhart is a Program Manager for NVH in the Engine, Emissions, and Vehicle Research division of Southwest Research Institute. Previous roles include Senior Manager for NVH at Visteon Chassis Systems, where Mr. Reinhart was responsible for the NVH analysis and development of axles, driveshafts, and power steering systems. From 2001 to 2004, he was NVH Program Manager at Roush Industries, Inc. where he was responsible for NVH testing and development of diesel and gasoline engines, as well as transmissions, axles and accessories. Diesel fuel system noise was a special focus of this work. Prior to Roush, he was Director of Noise & Vibration Technology at Cummins, Inc. Mr. Reinhart has been involved in solving noise and vibration issues in engines, as well as in a wide variety of engine applications, including pickup trucks, heavy duty trucks, construction equipment, and marine. Mr. Reinhart has developed noise reduction features for diesel engines, four of which have been patented. He has published 15 technical papers on Powertrain NVH topics. Mr. Reinhart received his B.S. and M.S. in mechanical engineering from Purdue University. He also spent a year studying automotive engineering at the Technical University of Hannover, Germany. His master’s thesis focused on the application of acoustic intensity measurements to diesel engines.

Rose, Nathan
Mr. Rose is currently a Director and Principal Engineer focusing on vehicular accident reconstruction at Kineticorp, LLC, a Denver-based forensic engineering firm that he helped found in 2005. He has been working and conducting research in the field of accident reconstruction for more than 16 years. Mr. Rose has published numerous technical papers and articles related to accident reconstruction and has conducted extensive research and testing related to rollover crashes. He has reconstructed hundreds of rollover crashes. Mr. Rose holds a B.S. in Civil Engineering and a M.S. in Mechanical Engineering.

Rosebro, Jack
Jack Rosebro has taught hybrid, plug-in hybrid, and electric vehicle technology to a wide variety of automotive industry professionals for the past ten years. Since 2006, he has developed and delivered curriculum for Perfect Sky, Inc. throughout the US and Canada. He also consults to community colleges that are integrating hybrid and electric vehicle technology into their curricula. Jack writes about hybrid technology, regulatory issues, and sustainable mobility for Green Car Congress, and is a frequent speaker at industry conferences. Previously, Jack developed and taught courses on hybrid and electric vehicles, air/fuel systems, OBD-II self-diagnostic systems, and emission control systems. He received his M.Sc. in Engineering from Blekinge Institute of Technology in Sweden.

Roslund, Jerry L.
Dr. Jerry Roslund is an independent consultant specializing in the Design of Experiments (DOE) and Reliability Methods. Prior to retiring from GM, he provided leadership as a GM Technical Fellow for Statistical Methods and Reliability and as a Validation Technical Integration Engineer at GM North America Vehicle Engineering. Specifically, Dr. Roslund conducted seminars on the Key Aspects of Quality, Reliability and Durability (QRD), Weibull Analysis, and Design of Experiments (DOE) for leaders and engineers within both GM and GM Suppliers. Dr. Roslund joined General Motors at Detroit Diesel Allison, transferred to Saturn, and retired from GM in 2007. Dr. Roslund spent 24 years at General Motors solving problems using statistical methods and providing in-house consulting on a daily basis. He also developed numerous course textbooks and conducted over 200 seminars providing a wealth of experience and a vast number of case studies. Dr. Roslund is a member of SAE International, ASQ, and the Society of Reliability Engineers. He received his B.S. degree in Mechanical Engineering from the University of Nebraska, M.S.M.E. from Cleveland State University, and Ph.D. in Systems Engineering from Oakland University.

Ross, Phillip J.
Phillip J. Ross is President of Quality Services International, Inc., a consulting firm specializing in quality and statistical training. He has accumulated over 4500 hours of classroom instruction teaching courses in quality, design, tools, and manufacturing processes and problem solving in the United States, Great Britain, Holland, Japan, and Singapore. Prior to his consulting business, Mr. Ross worked for General Motors in automotive powertrain design and development and automobile manufacturing and assembly. He first worked with Allison Transmission Division in product design/development and then with Saturn Corporation in the manufacturing and assembly aspects. Mr. Ross was involved in the design phase of many transmission components and systems, developed statistical/quality methods and training, and performed process development. He also performed process development for lost foam casting, painting, molding, and others while at Saturn. Mr. Ross is the author of the book “Taguchi Techniques for Quality Engineering” which has sold over 35,000 copies worldwide, has had articles published in “Quality Progress” by ASQ and in “Target” by AME and is the holder of three patents on product design. Mr. Ross received a B.S. in mechanical engineering from General Motors Institute, and is an ASQ Fellow and Certified Quality Engineer.

Ruth, Richard R.
Mr. Ruth is currently president of Ruth Consulting LLC which specializes in passenger car and light truck Event Data Recorders and restraint systems performance in crashes. He has 10 published papers on EDR...
accuracy and assists civil attorneys and prosecutors in Frye and Daubert hearings to get EDR data admitted in court. He has taught over 30 classes in EDR imaging and data analysis to law enforcement and private reconstructionists, and is a regular speaker at national and regional crash reconstruction conferences. He is a beta tester for new releases of the Bosch Crash Data Retrieval system. Mr. Ruth is a member of the SAE International J1698 Event Data Recorder Committee, and a member of ISO’s EDR related TC22/SC12/WG7, and a former member of the ASTM 4150 group that developed an EDR procedure. Prior to consulting, Mr. Ruth worked 33 years for Ford Motor Company, and during his last 10 years managed the engineers who did field investigations of safety system performance in real world crashes including EDR imaging and analysis, and championed the release of Ford EDR data to the Bosch Crash Data Retrieval system, personally writing some of the data limitations. He handled law enforcement requests for EDR readout assistance, was a member of Ford’s EDR policy committee, was Ford’s representative to the SAE International EDR standards committee, and helped shape Ford and Auto Alliance responses to NHTSA on Part 563 EDR legislation. Mr. Ruth has a B.S. in Electrical Engineering from Michigan Technological University and an M.B.A. from the University of Michigan Ross Business School, and is a registered professional engineer.

Saha, Pranab
Pranab Saha is the principal consultant and co-founder of Kolano and Saha Engineers, Inc., an independent professional engineering and consulting company in acoustics, noise and vibration control. A well-known authority on automotive noise control and body interior systems, Dr. Saha has directed and participated nationally and internationally in numerous advanced noise control engineering programs and training seminars for various OEMs and suppliers in India, Mexico, and USA. Dr. Saha is currently the Chair of the SAE International Engineering Meetings Board, a Professional Development Instructor, and the Lead Faculty Member of the SAE International Vehicle Interior Noise Academy. He is also the past-chairman of the SAE International Acoustical Materials Committee and has helped develop several standards in acoustics. Dr. Saha is an active member of ASA, ASME, ESD, INCE, NSPE, SAE International, and a contributing editor of Sound and Vibration publication. He has presented technical papers, organized and chaired numerous technical sessions sponsored by SAE International and other professional organizations. Dr. Saha has also won several awards presented by the SAE International and the Michigan Society of Professional Engineers (MSPE) and has been named an SAE Master Instructor. Dr. Saha holds a B.S. in Mechanical Engineering from the University of Calcutta, a M.S. in Engineering Sciences from the University of Florida and a Ph.D. in Mechanical Engineering (Acoustics Specialty) from the Georgia Institute of Technology.

Scaler, Dave
Dave Scaler is the owner of AdvantageMotorsports.com, a company that performs engineering and analysis in the field of racing data acquisition and produces data logger hardware, software and sensors for racers around the world. Celebrating his 25th year in the racing industry, Dave has worked as a race mechanic, engine builder, race engineer, and race team manager for Road Racing, Oval Track, Drag Racing and Bonneville teams. Dave has taught Data Acquisition seminars all over the US, and his practical, real-world training style has been well received in all forms of motorsports venues.

Schmid, Steven R.
Dr. Schmid is an Associate Professor at the University of Notre Dame, where he conducts research and teaches courses in manufacturing, metal forming, tribology and design. Prior to joining academia, Dr. Schmid was a project engineer at Triodyne, Inc., a consulting firm specializing in machine and manufacturing/product consulting with a special emphasis on safety. As such, he has visited hundreds of manufacturing facilities as diverse as sugar cane plants in Hawaii to battery factories in Vermont, and has been a consultant to industry and government. He is a past recipient of the Society of Manufacturing Engineers John T. Parsons Outstanding Young Manufacturing Engineer Award, has won numerous teaching awards, and was named a Kaneb Center Teaching Faculty Fellow at the University of Notre Dame in 2003. Dr. Schmid has organized numerous conferences, and has written over 80 technical papers and eight books and book chapters. He holds a Professional Engineer’s license and is a Certified Manufacturing Engineer. Dr. Schmid is a graduate of the Illinois Institute of Technology and Northwestern University.

Seybert, Andrew F.
Andrew F. Seybert, Ph.D., P.E., is President of Spectronics, Inc. and Professor Emeritus of Mechanical Engineering at the University of Kentucky. His research specialization is acoustics and vibrations. Dr. Seybert is a Fellow of the Acoustical Society of America, the American Society of Mechanical Engineers, and the International Institute of Acoustics and Vibration. Dr. Seybert is a Founding Member of the International Institute of Acoustics and Vibration. Dr. Seybert is a registered Professional Engineer in the states of Kentucky and Ohio. He has been active in SAE International professional development and other NVH activities for many years and is the recipient of the SAE International’s Lloyd L. Withrow Distinguished Speaker Award. Dr. Seybert received his B.S. in Mechanical Engineering from the University of Cincinnati and the M.S. and Ph.D. in Mechanical Engineering from Purdue University.

Seyboldt, Charles F.
Mr. Charles Seyboldt has degrees in Mechanical Engineering and Law. He has over 15 years of experience in the transportation industry, having engineering responsibilities covering a broad range of product and manufacturing technologies. He is a registered Professional Engineer and a registered patent agent.

Sittsamer, Murray
Murray Sittsamer of The Luminous Group has over 26 years’ experience in operations management, strategic planning, new process launches, financial analysis, quality systems and process improvement. During the past 12 years, Murray has focused his work on supporting automotive OEMs and suppliers with their quality and productivity improvement efforts, especially in the areas of Advanced Product Quality Planning (APQP), Failure Mode and Effects Analysis (FMEA), variation reduction and Problem Solving. Before entering the consulting field in 1994, Murray served as director of distribution support and quality systems for Gelman Sciences. While there, he led a successful 15-month effort to obtain ISO 9000 quality system registration and had the role of project manager for a highly publicized groundwater contamination dispute. Murray holds a Master of Science in Industrial Administration from Carnegie Mellon University. He earned his undergraduate degree in industrial engineering from the University of Pittsburgh.

Sozer, Yilmaz
Dr. Sozer is on the faculty of the Electrical and Computer Engineering Department at the University of Akron where he is developing a research and teaching program on Alternative Energy Systems. He works in the areas of control and modeling of electrical drives, alternative energy systems, design of electric machines, integrated and belt-driven starter/alternator systems, high-power isolated DC/DC converter systems, large industrial static power conversion systems that interface energy storage and distributed generation sources with the electric utility. Dr. Sozer previously worked at Advanced Energy Conversion and developed expertise in all aspects of electronic power conversion and its control. He has been involved in IEEE activities which support power electronics.
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Tao, Xiaojian
Dr. Xiaojian Tao is Manager of Advanced Fuel Delivery and Contamination Research at the Southwest Research Institute (SwRI). His work primarily focuses on automotive fuel delivery systems and system contamination sensitivity. Dr. Tao has conducted extensive testing and research on fuel and component compatibility for OEM auto-makers and also assisted in developing key life testing procedures for fuel pumps, fuel delivery modules and many other associated components. With the help of his staff, he developed a prototype electronic controlled variable valve lifting mechanism and a fast acting fuel injection system for flexible fuels. Dr. Tao has assisted the automobile industry in revising existing fuel delivery procedures and establishing new ones. He has also successfully established mathematical models for these fuel delivery systems using nonlinear stochastic system theory. He then utilized these models to investigate the physics essentials of the interactions among contaminants, additive packages, fuels and fuel delivery system components. Dr. Tao has authored and co-authored numerous technical publications in related fields. He is a graduate of the Mechanical and Aerospace Engineering Department at Oklahoma State University.

Timmis, Eric
Eric Timmis is the owner of BusinessAsAContactSport.com, a training and consulting company dedicated to business process improvement, focusing on value and quality management implementation, program/project management training, and the integration of strategic partnership relationships between departments and organizations. Mr. Timmis has over thirty years of diversified experience across several industries, which includes the delivery of value engineering facilitation services to Ford Motor Co. and its supplier community and training for Eaton Corporation’s, Product Development Group. He is also a recognized speaker at various national conferences. Eric received a B.Sc. in Civil Engineering from the University of Birmingham in England and is a member of the Institution of Civil Engineers.

Tschirhart, Michael
Michael Tschirhart is a Human Factors Technical Fellow and Human-Machine Interaction (HMI) R&D Manager at Visteon Corporation where he is responsible for the development of advanced HMI product concepts and intellectual property, and directing global advanced user research activities. Dr. Tschirhart joined Visteon Corporation in 2000 and has since held leadership roles in marketing, research and advanced product development. Prior to Visteon, he held positions in market research, organizational development and process improvement at Ford Motor Company. He is a certified Six Sigma Master Black Belt and holds a master’s degree in Statistics and a doctorate in Cognitive Psychology, both from the University of Michigan. He has taught at the College for Creative Studies in Detroit and the Ross School of Business at the University of Michigan in Ann Arbor.

Vakili, Mohammad
Mr. Vakili is currently a consultant in the friction material industry. Throughout his career he has held numerous positions including the Vice President of Technology & International for Fritec; Director & VP of Technical Services in the friction material industries and various related industries including Wagner Automotive, HKM, ITT, and Continental. He has traveled extensively around the world and visited most “who’s who” of the friction manufacturing industries in order to select the best suitable products for a given OE or OES application. Mr. Vakili recently was a co-publisher of a research work on Automotive Wheel Dust Evaluation & Testing with Ford Motor Co. and Link Engineering. He has been a speaker and chairperson at the SAE International Brake Colloquium, FMSI, and BCM and has taught a course in “Friction Material Topics” for Continental Automotive System employees in the U.S. and Europe. A member of AIChE and SAE International, Mr. Vakili has a B.S. and M.S. in Chemical Engineering from the University of Massachusetts.

Van Gilder, John
John Van Gilder is currently a Technical Fellow, OBD II Development, in the General Motors Powertrain Group where he is responsible for implementing statistical techniques in OBD design, model based onboard diagnostic design, development of OBD requirements for new powertrain systems, and in-use assessment of OBD systems. Prior to that, Mr. Van Gilder was a Product Assurance Engineer at Delphi where he focused on improving design and manufacturing process...
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reliability, including implementation of quality tools such as design of experiments, quality function deployment, statistical process control, etc. for spark plugs and exhaust oxygen sensors. Mr. Van Gilder was also a Commissioned Officer in the United States Navy working in materials research and development. He has organized and presented at numerous SAE International OBD and Powertrain Controls technical meetings. Mr. Van Gilder has a B.S.E. in Engineering Physics from the University of Michigan, a M.S.E. in Nuclear Engineering from the Bettis Atomic Power Laboratory and a M.S.E. in Reliability Engineering from Kettering University and is a Professional Engineer in the state of Michigan.

Vannoy, E. Harold
Mr. Vannoy operates a consulting business specializing in product design assurance, process design assurance and reliability engineering. He earned a B.S. and M.S. in Electrical Engr. from the Univ. of Missouri-Rolla; studied probability and statistics at Purdue Univ.; and studied reliability engr. at the Univ. of Arizona. He is a Registered Professional Engineer in the state of Indiana, a Certified Reliability Engineer and a member of Eta Kappa Nu. He is also a member of SAE International, SRE, IEEE, and ASQ. Mr. Vannoy was inducted into the Univ. of Missouri-Rolla Academy of Electrical Engineering for his contributions to the reliability of automotive electrical and electronic systems. He began his career with General Motors Delco Electronics Div., establishing a product assurance group for computer systems. From there he served as supervisor of reliability and service activities at GM Emission Control System Center; supervisor of electrical and electronic groups in the Reliability Engrg. Dept. for Cadillac Motor Car Div; and as Mgr. of Product Assurance at AC Spark Plug Div. Mr. Vannoy has presented papers at ASQ, IIE, GM Product Engineering Technical Conf., Penn State Univ. Quality Assurance Seminar Series, Reliability and Maintainability Symposium, SRE, Univ. of Arizona Reliability Engrg. Management Inst., the Univ. of Arizona Reliability Testing Inst. and SAE International. He serves on the SAE International Reliability Comm. and has established reliability engineering courses with several universities.

Varat, Michael S.
Michael S. Varat is currently a principal scientist engaged in crash reconstruction at KEVA Engineering, LLC. He has been working and conducting research in the field of Accident Reconstruction for over 25 years. Mr. Varat has published numerous technical papers related to accident reconstruction, including motorcycle crashes and serves on SAE International and ASTM committees. He is an avid motorcycle rider (both dirt and street) and has reconstructed hundreds of motorcycle crashes. Mr. Varat holds a Bachelor’s degree in Mechanical Engineering.

Walker, R. W. (Bill)
Bill Walker is the owner and principal engineer at Walker Technical Services providing consulting services in design, testing, and certification for manufacturers and operators of aerospace and mobile equipment throughout North America, Europe, and Asia. Mr. Walker has almost four decades of experience in test engineering, regulatory compliance engineering, and product safety engineering. Mr. Walker held the position of Manager of Safety and Compliance at John Deere Forestry, Inc., overseeing safety engineering, regulatory compliance, product liability management, intellectual property management, and standards development activities for the world-wide manufacturer of advanced forestry equipment. Additionally, Mr. Walker held the positions of Manager of Testing at Diamond Aircraft Industries, Director of Engineering, Manager of Flight Testing, and Test Engineer at Eurocopter Canada, Ltd. He is currently a member of SAE International MTC4 (forestry machinery), ISO TC23/SC15 (Forestry Machinery), TC23/SC3 (Safety and comfort of the operator), and TC23/SC14 (Operator Controls, Operations Symbols and other displays, and Operator Manuals). He has also served on Canadian Standards Association Technical Committees on Mobile Forestry Machines and Rollover Protective Structures. Mr. Walker received a B.Sc. Aerospace Engineering from Northrop University and M.A.Sc. in Aerospace Engineering from the University of Toronto Institute for Aerospace Studies.

Walker, Jr., James
James Walker, Jr. is a Principal Engineer specializing in chassis, brake, and electronic brake control systems at Carr Engineering, Inc. His prior professional experience includes brake control system development, design, release, and application engineering at Kelsey-Hayes, Saturn Corporation, General Motors, Bosch, Ford Motor Company, and Delphi. Mr. Walker created scR motorsports consulting in 1997, and subsequently competed in seven years of SCCA Club Racing in the Showroom Stock and Improved Touring categories. Through scR motorsports, he has been actively serving as an industry advisor to Kettering University in the fields of brake system design and brake control systems. Since 2001, he has served as a brake control system consultant for StopTech, a manufacturer of high-performance racing brake systems. In addition to providing freelance material to multiple automotive publications focusing on chassis and brake technology, Mr. Walker is the author of the book “High-Performance Brake Systems: Design, Selection, and Installation”. In 2005, he was presented with the SAE International Forest R. McFarland Award for distinction in professional development and education and in 2010 he was designated an SAE International Master Instructor. He obtained his B.S.M.E. in 1994 from GM Engineering & Management Institute.

Walter, Joseph D.
Dr. Joseph D. Walter is presently on the faculty of The University of Akron's College of Engineering as an adjunct professor where he teaches graduate and undergraduate courses in both the Mechanical and Civil Engineering Departments. Prior to joining academia, Dr. Walter was managing director of Bridgestone-Firestone's Technical Center Europe located in Rome, Italy, and served on the Board of Directors of Bridgestone-Firestone Europe located in Brussels, Belgium. He has served as a mechanical engineering evaluator for the Accreditation Board for Engineering and Technology, ABET, and has also served on the original Committee of the National Academy of Sciences that addressed the future fuel economy (CAFE) goals for the nation, which is detailed in the 1992 book: “Automotive Fuel Economy-How Far Should We Go?” Dr. Walter received his Ph.D. from Virginia Tech and an MBA from The University of Akron. He is a member of several professional organizations, including SAE International and the Rubber Division of the American Chemical Society.

Walter, Richard
Richard Walter is the President and Founder of HEM Data Corporation. A pioneer in PC-based data acquisition and analysis, he has acquired data from in-vehicle networks since they were mandated in 1996. Mr. Walter previously worked at the Bendix Research Laboratories where he was awarded five patents for automotive inventions and gained valuable testing experience. He taught at Lawrence Technological University and has conducted numerous seminars and training sessions. He has had several articles and papers published in engineering journals including SAE International and Sensors Magazine. Mr. Walter is a member of SAE International, ASME and The Vibration Institute and is a registered professional engineer in Michigan. Mr. Walter has a B.S. in mechanical engineering from the University of Detroit, an M.S. in mechanical engineering from Wayne State University and an M.E.M. in engineering management from the University of Detroit.
Wang, Wego
Dr. Wang is an aerospace engineer in the Engine Certification Office of the Federal Aviation Administration, where he serves as the focal point for Parts Manufacturer Approval. He has been a technical instructor and a researcher in mechanical engineering and materials science for more than twenty years. Dr. Wang taught at Northeastern University and is currently an adjunct faculty at Boston University and the University of Massachusetts - Lowell. Dr. Wang authored or co-authored over 40 technical/professional articles, and presented lectures/reports at numerous seminars/conferences. He is on the executive committee of ASM International Boston Chapter and was the 2005-06 Chairman of the Chapter. He also served on the executive committee of TMS Boston Section, where he was president from 1993-95. Dr. Wang has a B.S. in Mechanical Engineering from National Cheng - Kung University, a M.S. in Mechanical Engineering from National Taiwan University, and a M.S. and Sc.D. in Materials Science and Engineering from Massachusetts Institute of Technology.

Wine, Mark
Mark Wine is a senior development engineer at Drew Technologies Inc. which is a manufacturer of J2534-1 devices. His work includes developing and supporting the J2534-1 compliant CarDAQ and Mongoose family of products. Mr. Wine has over 25 years of experience in product and software development including 10 years developing vehicle communication products. Most recently, Mr. Wine has been working with GM and Allison Transmission on advanced J2534-1 applications. Prior to working in automotive, Mr. Wine delivered product training and technical support throughout Asia. He has a B.S. in Electrical Engineering from Montana State University.

Zachos, Mark
Mark Zachos is currently an adjunct professor at the University of Michigan. He is the President of Dearborn Group, Inc. and has more than twenty years of networking experience. Mr. Zachos participates in many SAE International and ISO multiplexing committees, including the following: J1850, J1939, J2284, J2411, and J2367. He holds a B.S. and an M.S. in engineering from the University of Michigan.

Zielinski, Kevin
Kevin Zielinski currently owns and operates Red Cedar Media LLC, a training and corporate communications consulting, design, development and delivery company based in Michigan. Previously, Kevin was Senior Applications Specialist for EDS (including General Motors/EDS and Hewlett Packard/EDS) specializing in technical training delivery, training consulting, courseware design and development, and e-Learning. He has designed, developed and delivered over 40 lecture- and web-based courses attended by General Motors and EDS employees worldwide. Mr. Zielinski has also served as Adjunct Professor for the Wayne State University College of Engineering and WSLI/Focus:Hope for many years. His areas of expertise include: e-Learning design and development, Quality Tools and Methods (Design of Six Sigma, Robust Engineering, Design of Experiments (DOE), Statistical Tolerancing and GD&T); Design for Manufacturing and Assembly (DFMA); Engineering Economics; and Plant Floor Throughput Improvement. He has been an instructor for SAE International Professional Development since 1990, and is a recipient of SAE International’s Forest R. McFarland Award (April 2005). He holds a bachelor’s and master’s degree in engineering from Wayne State University.

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- Material Performance Data

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Classroom Seminars contact Bev Longdon at Beverly.Longdon@sae.org.

Online Web Seminars contact Sam Minehart at Sam.Minehart@sae.org.
Norwalk, California – Cerritos College
Jan 25-26 ARP4754A and the Guidelines for Development of Civil Aircraft and Systems – I.D.# C1118
Jan 25-27 Gasoline Direct Injection (GDI) Engines – I.D.# C1009
Jan 27-28 Understanding the FAA Parts Manufacturer Approval Process – I.D.# C1324
Jan 28-29 ARP4761 and the Safety Assessment Process for Civil Airborne Systems – I.D.# C1245

Live, Online
Jan 25-Feb 5 Design of Experiments (DOE) for Engineers – I.D.# WB0932

Warrendale, Pennsylvania – SAE International Office
Feb 18-19 Engineering Project Management – I.D.# 99003
Feb 2-4 Diesel Engine Noise Control – I.D.# WB104
Feb 29-Mar 16 Fundamentals of Geometric Dimensioning & Tolerancing (GD&T) – I.D.# WB0933

Troy, Michigan – SAE International Professional Engineering Education Center
Mar 3-4 Product Liability & The Engineer – I.D.# 82001
Mar 7-8 Material Selection & Testing for Plastics – I.D.# C0134
Mar 7-9 Combustion & Emissions for Engineers – I.D.# 97011
Mar 9-11 Advanced Vehicle Dynamics for Passenger Cars and Light Trucks – I.D.# C0415
Mar 14-15 Modern Fluids for Crankcase Engines: An Overview – I.D.# C0704
Mar 14-15 Selective Catalytic Reduction for Diesel Engines – I.D.# C0913
Mar 16-17 Acquiring and Analyzing Data from Sensors and In-Vehicle Networks – I.D.# C0522
Mar 16-17 Engine Failure Investigation and Analysis – I.D.# C1344
Mar 21 Brake Noise Problem Resolution – I.D.# C0831
Mar 21-22 Introduction to Advanced High Strength Steel Applications and Manufacturing – I.D.# C1416
Mar 21-23 Internal Combustion Systems: HCCI, DoD, VCT/VVT, DI and VCR – I.D.# C0613
Mar 23-24 Vehicle Frontal Crash Occupant Safety and CAE – I.D.# C0621
Mar 29-30 A Familiarization of Drivetrain Components – I.D.# 98024
Mar 31 Fundamentals of All-Wheel Drive Systems – I.D.# C0305
Mar 31-Apr 1 Evaporative and Refueling Emission Control – I.D.# C0928

Tysons, Virginia – LMI
Mar 14-15 Design for Manufacturing & Assembly (DFM/ DFA) – I.D.# 92047
Mar 14-15 Understanding the FAA Aircraft Certification Process – I.D.# C0821
Mar 16-17 Aircraft Cabin Safety and Interior Crashworthiness – I.D.# C0926
Mar 16-17 Introduction to Failure Mode and Effects Analysis for Product and Process – I.D.# C1201

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<td>Leading High Performance Teams</td>
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<td>Engine Failure Investigation and Analysis</td>
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<td>Scottsdale, Arizona</td>
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PROFESSIONAL DEVELOPMENT SCHEDULE

Nov 17-18  Introduction to Hybrid and Electric Vehicle Battery Systems – I.D.# C0626
Nov 21-23  Chassis & Suspension Component Design for Passenger Cars & Light Trucks95025
Nov 21-23  Principles of Cost and Finance for Engineers – I.D.# C0828
Nov 29-30  Leading High Performance Teams – I.D.# C0410
Nov 30-Dec 2 Applying Automotive EDR Data to Traffic Crash Reconstruction – I.D.# C1210

Nov 14-16  Applied Vehicle Dynamics – I.D.# C0414

Tysons, Virginia – LMI
Nov 14-16  AS9100C Internal Auditor Training – I.D.# C1120
Nov 16-17  Managing Programs and Associated Risks – I.D.# C0409
Nov 16-18  Designing On-Board Diagnostics for Light and Medium Duty Emissions Control Systems – I.D.# C0707

Nov 14-18  Engineering Management Academy – I.D.# ACAD09

Live, Online
Nov 1-10  Principles of Electric Drives – I.D.# WB0941
Nov 2-4  Driver Distraction from Electronic Devices: Insights and Implications – I.D.# WB1140
Nov 14-18  Introduction to Design Review Based on Failure Modes (DRBFM) – I.D.# WB1047
Nov 15-17  Overview and Impact of the Automotive Functional Safety Standard ISO 26262 – I.D.# WB1134
Nov 29-Dec 6  Acoustic Fundamentals for Solving Noise and Vibration Problems – I.D.# WB1309
Nov 30-Dec 2 Turbocharging for Fuel Economy and Emissions – I.D.# WB1018

Troy, Michigan – SAE International Troy Office
Nov 14-18  Design Review Workshop – I.D.# C1306
Dec 1-2  Understanding the FAA Parts Manufacturer Approval Process – I.D.# C1324
Dec 5  Introduction to Heavy Truck Tire, Steering, and Suspension Dynamics – I.D.# C1209
Dec 5-7  Managing Engineering and Technical Professionals – I.D.# C0608
Dec 12-13  Engineering Project Management – I.D.# 99003

Norwalk, California – Cerritos College
Dec 1  Reconstruction and Analysis of Rollover Crashes of Light Vehicles – I.D.# C1502
Dec 5-6  Introduction to DO-178C – I.D.# C1410
Dec 5-7  Weibull-Log Normal Analysis Workshop – I.D.# 86034
Dec 7  Reconstruction and Analysis of Motorcycle Crashes – I.D.# C1506

Live, Online
Dec 5-16  Vibration Analysis Using Finite Element Analysis (FEA) – I.D.# WB1401
Dec 6-15  Tolerance Stack-up Fundamentals – I.D.# C0842

Troy, Michigan – SAE International Professional Engineering Education Center
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