# Hybrid and Electric Vehicles

INTEGRATIVE SYSTEMS + DESIGN
UNIVERSITY of MICHIGAN ▪ COLLEGE of ENGINEERING

PRINCIPLES, APPLICATIONS, AND FUTURE TECHNOLOGIES

## The Latest Research-Based Findings on Clean Vehicle Technologies

This short course covers all key topics in hybrid vehicles including modeling and control, batteries, battery management systems, motors and power electronics, and EMC.

Learn more and register for upcoming courses at:
**isd.engin.umich.edu/HybridVehicles**


# Course Content that's More Than Theory

**This five-day short course emphasizes the delivery of concepts and examples that have been successfully implemented in laboratories and/or on prototype vehicles.**

Unlike other courses on HEV, this course extends the scope beyond regular passenger vehicles through the inclusion of topics which show the benefits of hybridization in various possible arenas of vehicular applications in general. It also tries to provide a scientific process for management decision-making by removing any subjectivity, in terms of whether hybridization is beneficial or not in a particular situation.

## Who Should Attend

Engineers and managers who are involved in the design and development of hybrid vehicles, and/or their key components.

## 6 Modules

Take them all, or just one. The choice is up to you

**Model-Based Approach for Hybrid Vehicle Design and Analysis**
Professor Huei Peng, U-M
7 HOURS

**Battery Fundamentals**
Professor Don Siegel, U-M
7 HOURS

**Battery Management Systems for Electric Drive Vehicles**
Professor Chris Mi, U-M
3.5 HOURS

**Power Electronics for Electric Drive Vehicles**
Professor Chris Mi, U-M
7 HOURS

**Military and Non-Automotive Applications of HEVs**
Abul Masrur
3.5 HOURS

**EMC of Hybrid and Electric Vehicles**
James Muccioli
7 HOURS

# Program Instructors

## Dr. Huei Peng

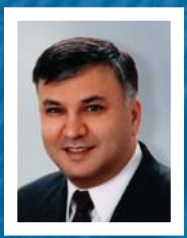
is a professor of Mechanical Engineering at the University of Michigan–Ann Arbor. His research interests include modeling and control of hybrid vehicles, fuel cell vehicles, and advanced power-train techniques.

## Dr. Chris Mi

is an associate professor of Electrical and Computer Engineering and director of DTE Power Electronics Laboratory at the University of Michigan–Dearborn. His research interests are in power electronics, electric machines, and their applications in HEVs and renewable energy systems.

## Dr. Don Siegel

is an assistant professor of Mechanical Engineering at the University of Michigan. His research interests include development of high-capacity materials and systems for energy storage applications, computational materials science, multi-scale modeling and more.



## James Mucciolli

has extensive experience in EMC design, analysis, and testing. His background includes over twenty years of specialized EMC systems experience at X2Y Attenuators, DaimlerChrysler, and United Technologies.

## Dr. M. Abul Masrur

is presently with the US Army RDECOM-TARDEC (R&D)* where he has been involved in research related to hybrid electric vehicles, vehicular electric power system architecture concept design and development, electric power management, and artificial intelligence based fault diagnostics in electric drives. He is also an Adjunct Professor in the University of Detroit Mercy where he has been teaching courses related to Advanced Electric and Hybrid Vehicles.

* This course instruction is presented by Dr. M. Abul Masrur in a personal/individual capacity, and nothing presented in this course should be construed as an endorsement of any of the statements, or of any products or other materials discussed or mentioned in this course, in one way or the other, by any of the organizations indicated above with which the author is or has been affiliated. The materials discussed and presented are merely for factual information.

# Program Components

## Model-Based Approach for Hybrid Vehicle Design and Analysis

- Introduction, Background
- Modeling of Hybrid Electric Vehicles
- Hybrid Vehicle Integration/Analysis
- Split Hybrid Electric Modeling and Control

## Introduction to Electrical Energy Storage (or Battery Fundamentals)

- Introductory Material
- Key Components of Batteries and Their Properties
- Thermodynamics and Kinetics of Battery Operation
- Battery Chemistries Overview
- Li-ion Batteries
- Models of Battery Operation
- Li-ion Degradation Mechanisms
- Advanced Batteries
- Ultra-capacitors

## Power Electronics for Electric Drive Vehicles

- Automobile Electrification
- Introduction to Power Electronics
- Modeling of Power Electronics
- Rectifiers (AC-DC)
- Unidirectional DC-DC Converters
- Bidirectional DC-DC Converter
- Power Electronics Building Blocks
- Thermal Issues in Power Electronics
- Hardware in the Loop
- Isolated DC-DC Converter
- Inverters
- Introduction to Motor Drive
- Battery Chargers
- Vehicle to Grid (V2G)
- Emerging and Future Technologies
- Learning Assessment

## Battery Management Systems for Electric Drive Vehicles

- Batteries for EV, HEV, and PHEV
- Functions of BMS
- Current, Voltage, Temperature Monitoring Circuit
- SOC Calculation and Calibration
- Cell Balancing
- Battery Sizing and Pack Design Example
- Thermal Management
- SOH—Concepts, Method, Impedance Measurements
- Power Supply for BMS
- Battery Chargers—Contact, Inductive, and Wireless
- V2G Scenarios and V2G Charger
- Relay and Contact Control Circuit
- Battery Charge Algorithms
- Battery Safety
- Future Technologies in BMS

## Hybrid and Electric Vehicle Special Topics

**Off Road HEV, Hydraulic Hybrid, and Non-Automotive Applications**

- Off Road HEV Overview
- Hydraulic Versus Electric HV
- Non-Automotive Applications
- Deployment Decision Making Process for HEV for Different Types of Vehicles

**Military Applications of HEV**

- Benefits
- Ground Vehicle Applications
- Architecture—Series, Parallel, Complex
- Non-automotive applications in military
- Ruggedness issues
- Vehicles which are most benefitted

**Diagnostics, Prognostics, Reliability, and NVH of HEV**

- What is Involved
- System Health Quantification
- Reliability of HEV
- EMC Issues
- Noise Vibration Harshness Issues (NVH) —Electromechanical and Others
- End of Life Issues

## EMC System Engineering Approach to Hybrid and Electric Vehicles

- EMC System Engineering of a Vehicle Architecture
- Battery System Testing Challenges
- Grounding Principles for Hybrid and Electric Vehicle Systems Shielding
- EMC System Engineering Verification and Validation Model

# Program Details

## Group Discount

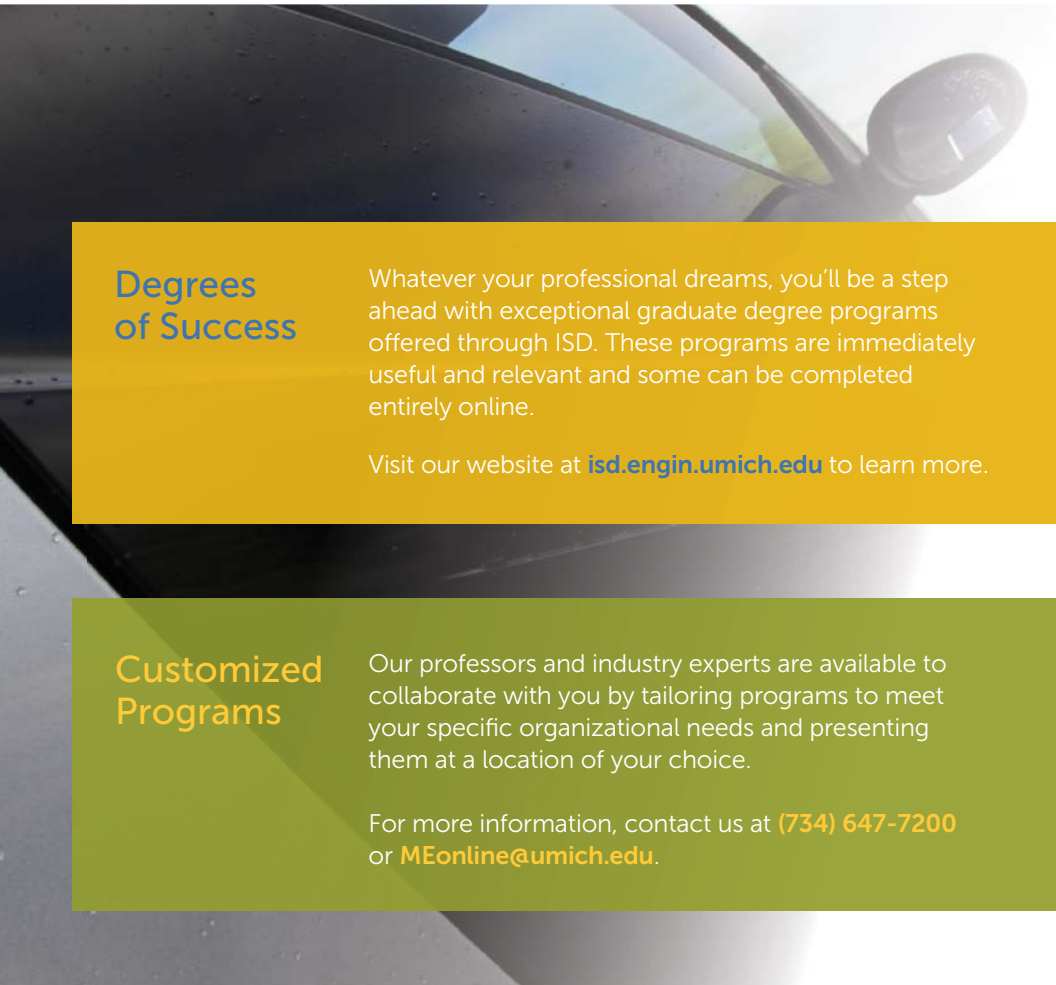
Registration of five or more individuals qualifies an organization for a group discount on the cost of the full five-day program. Call (734) 647-7200 or email MEonline@umich.edu to learn more.

## Register Today!

For upcoming public offerings, visit our Hybrid and Electric Vehicle program web page at isd.engin.umich.edu/HybridVehicle send an email to MEonline@umich.edu or call (734) 647-7200.

# Upcoming Program Dates

Contact us for the next available public offering of this program by calling (734) 647-7200 or sending an email to MEonline@umich.edu.



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# About Michigan Engineering and Integrative Systems + Design

**The University of Michigan's College of Engineering** was founded in 1853. Today, Michigan Engineering and its academic departments rank in the top ten in their respective areas (U.S. News and World Report). The faculty's ongoing research and industry consultation in engineering contribute to Michigan's strength and impact on professional development. Michigan Engineering's total research expenditures for fiscal 2012 exceeded $190 million, placing it in the forefront of collegiate engineering research in the U.S.

**Integrative Systems + Design (ISD)** (formerly known as Interdisciplinary Professional Programs), a division of Michigan Engineering, offers credit courses to students on campus and at locations around the world. Recognized as a global leader in online education in addition to offering on campus programs, ISD provides lifelong learning to technical professionals, and has served more than 100,000 with intensive short courses, conferences, professional certifications, and online advanced degree and certification programs.

ISD responds to the needs of industry, healthcare, government, the military, and non-profit organizations with specialized education programs.

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