Michigan Technological University
Mobility Based Education & Training Mobile Laboratory

APS LABS

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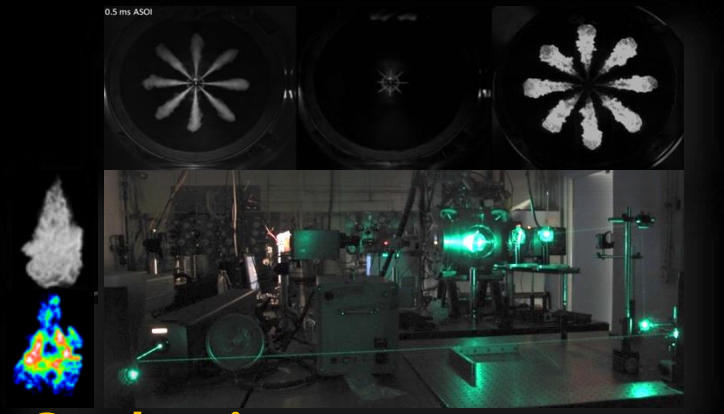
Advanced Power Systems (APS) LABS

A Tier 1 Interdisciplinary Research Center of experienced faculty and staff leveraging state of the art instrumentation and facilities to support industrial research gaining fundamental knowledge and developing engineering solutions.

CAV Technologies

Solar



Combustion

Education & Training

Powertrain

Waste-To-Fuel Generation

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APS LABS Education & Training

ABOUT US

The Michigan Tech APS Labs Education & Training division uses teaching methods that combine {theory, hands-on activities, and adult learning principles} to ensure learners understand and retain knowledge. We have built upon our hybrid electric vehicle engineering program - one of the first of its kind in the nation - to offer professional development and academic courses on campus, online, and (thanks to our one-of-a-kind Mobile Laboratory) on the road.

OPTIONS

- ✓ Hands-on Education
  - Courses (curriculum or short)
  - Professional Development
  - Seminars
- ✓ Outreach
  - Schools
  - Exhibits
  - Conferences
  - Community events
- ✓ Research Partnerships
- ✓ Demonstrations
  - Product/Technologies
  - Research

DELIVERY

Length: 20h (typical)

Hands-on time: 40-50%

Location: Customer's choice

Modality: In-Person / Hybrid / Online

Core Team

Dr. Jeremy Worm, PE
Director

Grant Ovist, MS.
Operations Manager

Dr. Vinicius Vinhaes
Training Manager

Support

- MTU Faculty
- APS Labs Staff
- Industry Partners

Mobile Laboratory

SAMPLE TOPICS

- High Voltage Safety
- Electrified Vehicle Components and Architectures
- Powertrain and Power Transfer
- Battery Chemistry and Application
- Charging and Regenerative Braking
- Controls & Diagnostics in Vehicle Systems
- CAN Communications

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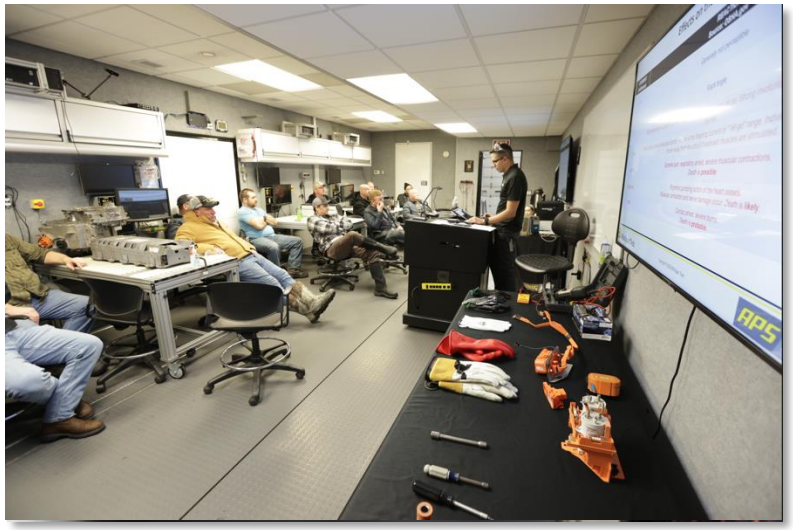
APS LABS Mobile Lab

The Mobile Lab is the centerpiece of the Education & Training division

- Flexible classroom layout
- Gasoline, diesel, and electrified powertrain test cells
- Fleet of 30+ vehicles
- Benchtop instrumentation
- Rapid controls and hardware prototyping



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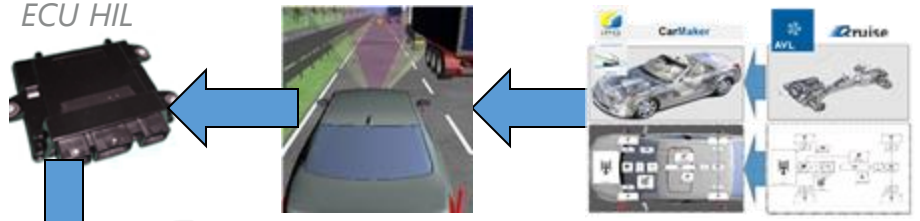
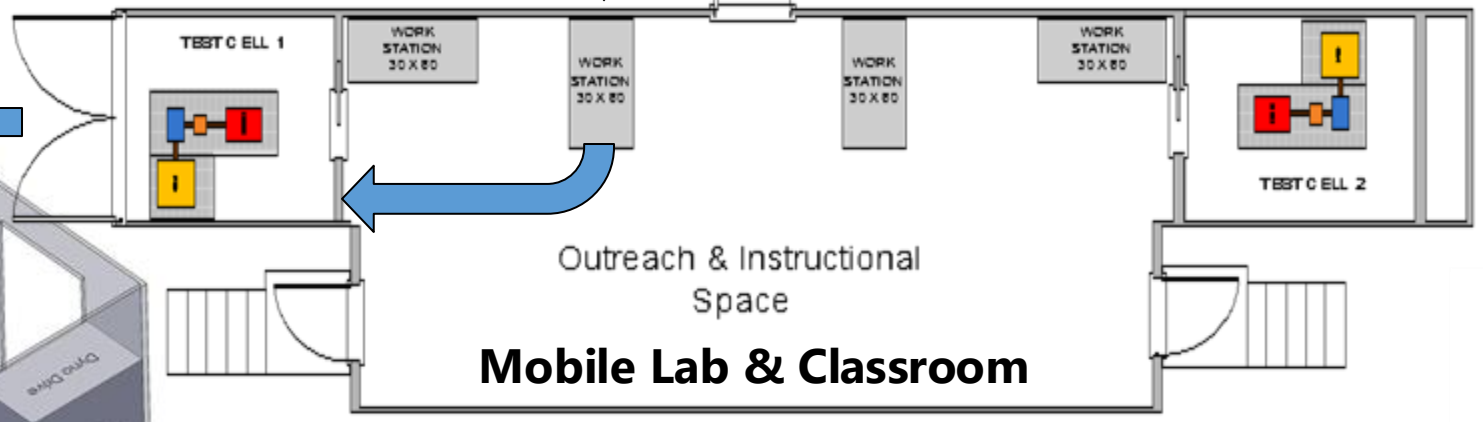
Mobile Laboratory – Learning Experience

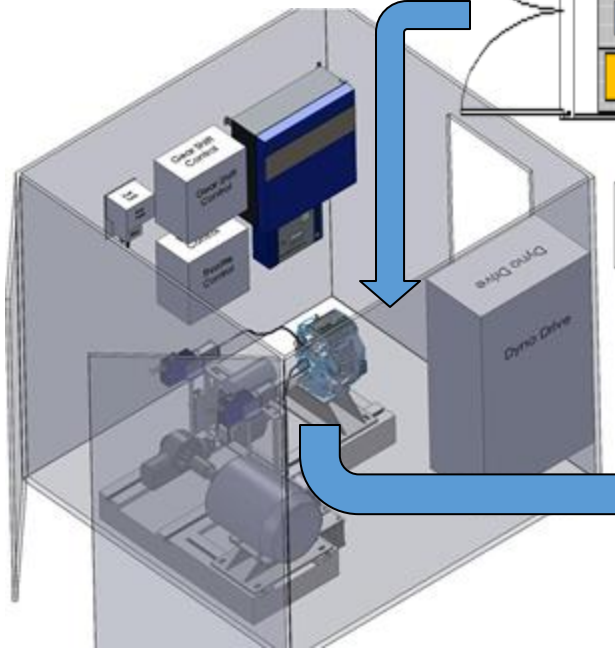
All aspects of the *Product Development Process* from analysis to validation

ECU HIL



Vehicle Simulation





Powertrain Component and System Testing
(Batteries, E-Machines, Engines, Drivetrain, etc.)

Testing with Production and Configurable HEV's

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Mobile Lab Offerings

STEM Outreach

Mobile Lab at the USA Science and Engineering Festival

Women In Automotive Engineering Outreach

Outreach activities in Detroit with the Configurable Hybrid Electric Vehicle

Youth Outreach examples:
MTU Summer Youth Programs
Civil Air Patrol
Multiple Community Colleges
Multiple County Fairs
Girl Scouts
Heroes Alliance
Washington DC Science Festival

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Major Initiative Outreach

Mobile Lab at the Texas Motor Speedway for a Hybrid Electric Vehicle awareness event

Adult Outreach examples:
Multiple County Fairs
Heroes Alliance
Multiple Technical Colleges
Texas Motor Speedway
US Capitol for HEV Policymakers

Using the Mobile Lab to present a client's technology to a new customer base

Mobile Lab at the US Capital for an awareness event with Congress

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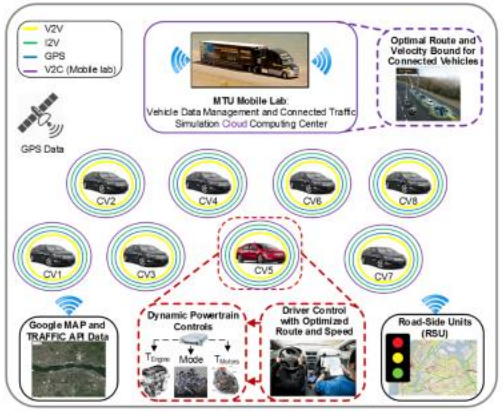
Field Research

CAV controls development for snowy conditions

CAV controls for railroad crossing safety



Mobile Command for NEXTCAR research

Field Research examples:
DoE Model Validation
DoE NEXTCAR I&II
DoE Multiple Vehicle Cohorts
Railroad Crossing Safety
MTU student group dyno testing

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Professional/Technical Training

NI technical training at a non-road OEM

Engine controls training at a Tier1

Tier1 engineers after an EV integration course

Electrified Vehicle training at an EV Retrofit Company

Diesel Calibration training at an OEM

Automotive OEMs
Tier 1 & 2 Automotive Suppliers
Offroad OEMS and Suppliers

Electrification Retrofit Suppliers
Data Acquisition Providers

Community Colleges
Engineering Society of Detroit
US Government Organizations

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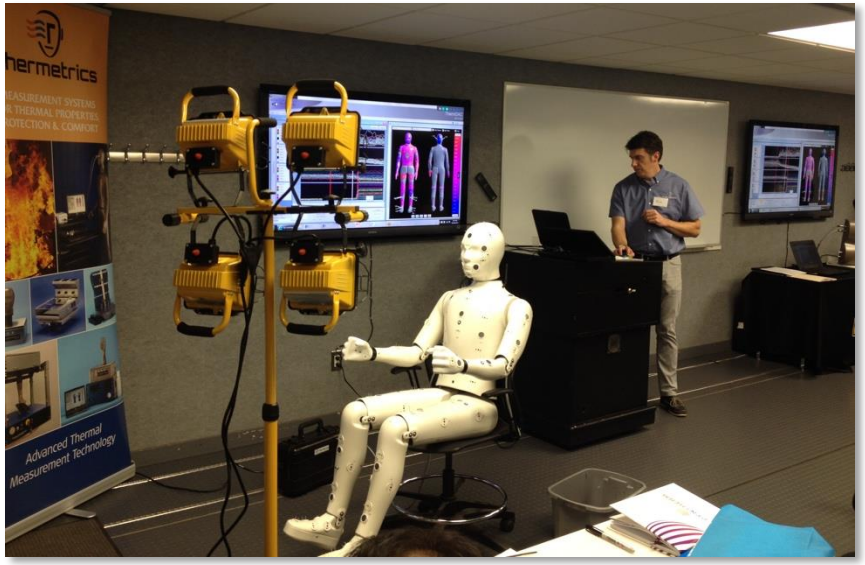

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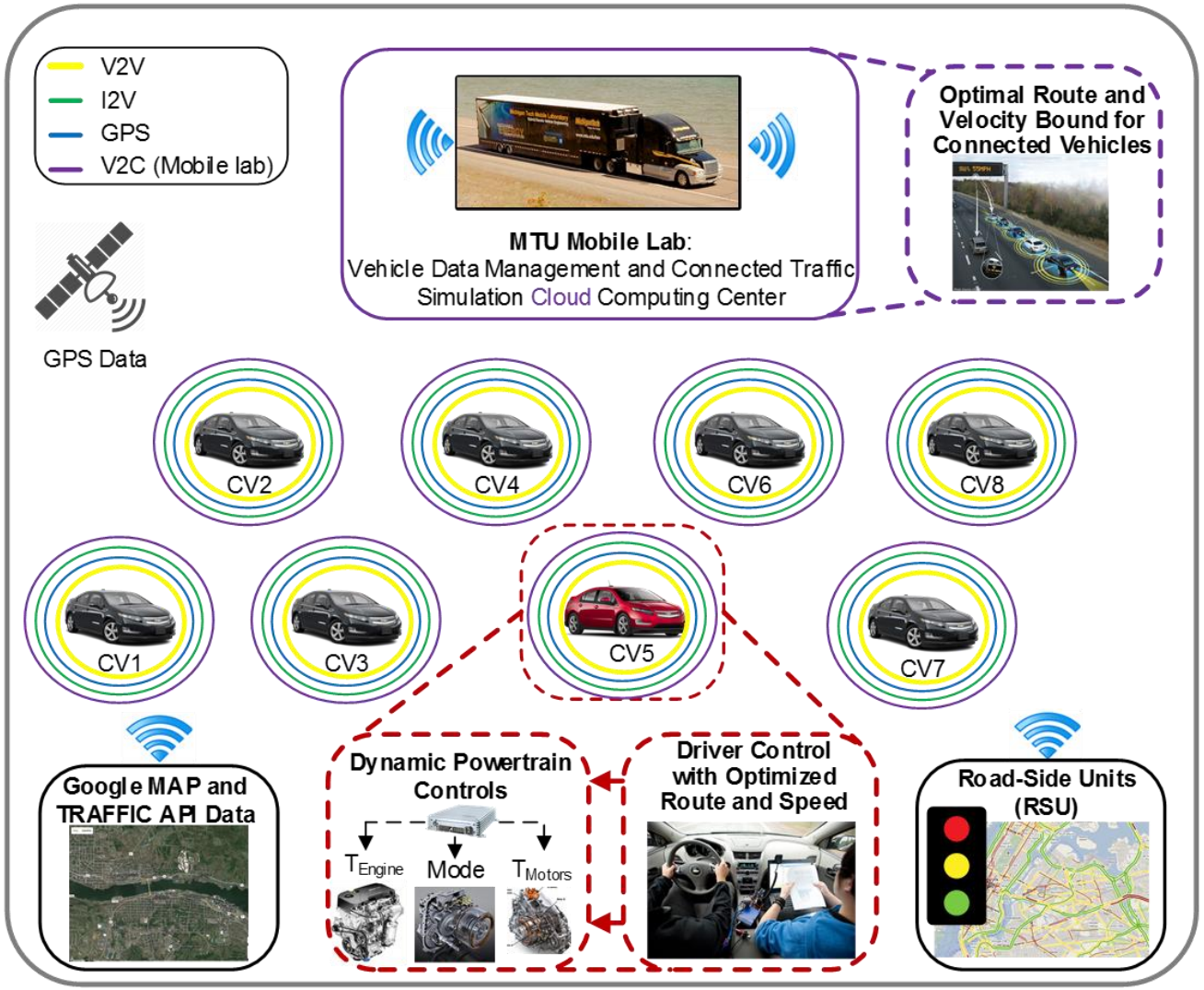

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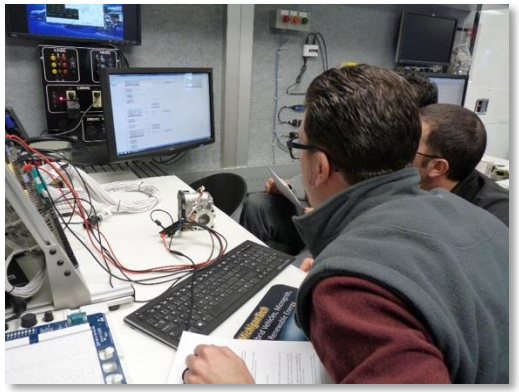

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Location Flexibility

Tier1 Auto Supplier World HQ

No need for your team to travel… we bring the classroom and lab to you!!

The Mobile Lab is self contained and can be set up anywhere accessible by a Class 8 tractor-trailer combination

- Customer site
- Tour of multiple sites
- Destination event
- Michigan Tech APS LABS
  (discounts are available for this option)

Symposium Courses on Chicago's Navy Pier

Customizable Subjects

Content is tailored to the learner needs.

For example, the topic of **Electrified Propulsion Systems** has been delivered to multiple audiences including:

- Design Engineers
  - Component and subsystem fundamentals
  - CAE Methods
  - Controls and Calibration
- System Engineers
  - System interactions and considerations
  - Digital communication protocols
  - Engineering process and tools
- Technicians
  - Component identification
  - HV safety and Service considerations
  - Onboard Diagnostics
- Engineering Sales Support
  - EV familiarity
  - Component and system functionality
  - Diagnostics and Troubleshooting

Professional Development Subjects

- Over 30 course titles available in systems and sub-system areas
  - ✓ Vehicle Systems (Electrification, Integration, CAV, etc.)
  - ✓ Electric Machines & Power Electronics
  - ✓ Control Systems
  - ✓ Instrumentation, Testing, & Signal Processing
  - ✓ Engines
  - ✓ Transmission & Driveline
  - ✓ Energy Storage
  - ✓ Distributed Power
  - ✓ Engineering Refreshers
  - ✓ Custom Courses Available Upon Request

Checking DAQ prior to testing

Developing throttle body controls

Professional Development Examples

Topical Area	Hands-On Professional Development Course Title
Engineering Process & Tools	Instrumentation & Experimental Methods
	Advanced Powertrain Instrumentation
	Introduction to Digital Signal Processing
	Advanced Digital Signal Processing
	Using Labview
	Design for Six Sigma
Vehicle Systems	Electrified Propulsion Systems
	Modeling and Synthesis of Electrified Vehicles
	Vehicle Dynamics
	Vehicle Weight Reduction
	Automotive Cyber Security
	Autonomous Vehicles
	V2X; Connected Vehicles
	Automotive Systems
Energy Storage	High Voltage Safety
	Battery Engineering
Electric Machines & Power Electronics	Electric Machines
	Power Electronics
Engines	SI Engine Fundamentals
	SI Engine Control Systems
	Diesel Engine Fundamentals
	Diesel Engine Management Systems, Emissions, and Aftertreatment
	Turbocharger Systems (Emphasis on SI or CI)
	Powertrain Calibration (Emphasis on SI or CI)
	1D Engine Simulation
Driveline	Fundamentals of Transmission & Driveline Systems
	Transmission System Calibration & Control
Control Systems	Embedded Control System Design
	Model Based Control System Design
	Optimization of Control Systems Using Matlab / Simulink
	Nonlinear Control System Analysis and Design
Distributed Power Systems	Smart Microgrid Systems

(1) Engineering Refresher courses available in any subject area (i.e. thermodynamics, design, etc.)
(2) Custom courses available upon request

Calibrating a Diesel Powered Bus

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Recent & Current Developments

Course Updates

- Some of our courses, have roots going back as far as 2009
- We have always done “Model Year Updates” on a regular basis, but are also completing a significant upgrade in many courses
  - Adding new vehicles to keep the fleet current
  - Added PMAC test apparatus to the Mobile Lab Test Cells
  - Updated Teaching Aids & Teardown Sub-Systems representative of current production
  - Purchasing & Integrating COTS Trainers

EV High-Voltage Safety Trainer

Tesla Drive Unit

Course Updates

- We are also creating new courses to meet needs
  - Split some pre-existing courses to target specific audiences
    - xEV now has 3 distinct versions: Engineers, Technicians, Executives
  - New courses developed recently / currently
    - HV / xEV for First Responders
    - Systems Engineering (very significant update)
    - ADAS & Autonomous Systems

ADAS Trainer

New Partnerships & Opportunities

50 / 50 Cost Split on Courses for members of MEDC's Talent Action Team

New Partnerships & Opportunities

- Partnership with Michigan Tech Global Campus
  - Increase awareness of and access to our courses
  - Streamline payment
  - Adding asynchronous online options

Michigan Technological University
GLOBAL CAMPUS

https://www.mtu.edu/globalcampus/

Thank you!

Contact

Jeremy Worm, Ph.D., P.E.
Associate Director – Advanced Power Systems Research Center
906-487-2686
jjworm@mtu.edu

Grant Ovist, M.S.
Advanced Power Systems Research Center
Operations Manager – Education & Training
906-487-1213
gjovist@mtu.edu

Vinicius Bonfochi Vinhaes, Ph.D.
Advanced Power Systems Research Center
Training & Curriculum Development Manager
906-487-1213
vbvinhae@mtu.edu

Professional Development Short Course Example

Electrified Propulsion System
Course Breakdown

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Electrified Propulsion System Breakdown

TOPIC	LEARNING OBJECTIVES	HANDS-ON LAB EXAMPLES
High Voltage Safety	- High voltage in the human body - HV risk mitigation - HEV safety components and systems	- Examples of HV safety devices and components - MSD removal from a battery pack - Verification of zero voltage - Isolation resistance checks
xEV Components and Architectures	- Motivation for Electrified Powertrain - Overview of the components and systems of light-duty and heavy-duty xEVs - Description of Basic functionality - Vehicle system considerations with xEV operation	- Examine and discuss components - Identify components in-situ on multiple electrified vehicles - Operate a short drive route to experience the differences in architecture

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Electrified Propulsion System Breakdown

TOPIC	LEARNING OBJECTIVES	HANDS-ON LAB EXAMPLES
Electrified Propulsion Systems	<u>eMachines</u> - Advantages and disadvantages of each type - Control fundamentals - Operating and practical limits - Losses and efficiencies <u>Power Electronics</u> - Overview of HEV components - Voltage conversion methods and losses - Control types and PWM <u>IC Engines & Emissions</u> - Operation Fundamentals and integration w/ electrified powertrain - Emissions and Regulatory Standards - Understand the impact of eliminating the ICE	- Disassemble and inspect a hybrid drive unit - Observe the components and integration - Run an eMachine in a dynamometer test cell - Calculate the eMachine and Power Electronics efficiency - Tear down an ICE - Observe the effect of changes to ICE control calibrations - Observe the control strategy differences between vehicles
Battery Basics	- Overview of battery types, chemistries, and components - Calculate the tradeoffs between mass and energy, compare to ICE sources - Implementation considerations (cell/module/pack scaling, aging, cooling, structure, safety) - Charging and cell balancing - Current and Power limitations	- Test a 48V battery pack during a discharge cycle - Calculate the battery internal resistance - Disassemble a HV battery pack - Observe the components and integration - Calculate the battery pack parameters based on vehicle requirements

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Electrified Propulsion System Breakdown

TOPIC	LEARNING OBJECTIVES	HANDS-ON LAB EXAMPLES
Regenerative Braking Basics	- Kinetic energy to potential energy conversion - Use of eMachine for regenerative braking - Integration considerations	- Potential energy calculation - Collect vehicle data under various deceleration modes - Calculate regen rates from vehicle data - Compare across modes and vehicles
Controls and Diagnostics in EV Systems	- Control System Basics - Regulatory requirements - Diagnostic types - Offboard reporting - Implementation considerations - Case studies	- Investigate implementation of OBD Mode requests - Use OBD tools to pinpoint a fault and observe DTCs - Observe system response and default action to various faults - Correct a fault using knowledge of the EV systems
CAN Communication Basics	- Analog to Digital conversion of sensor data - CAN physical layer and message structure - Regulatory requirements - Methods for reading CAN messages	- Intercept raw CAN data using BUS sniffing - Creating a PID request and decode response - Send Mode 1 and Mode 22 requests using CAN software - Collect vehicle data and assess the performance of several powertrain architectures over a city and highway drive cycle