

How to Design Electric Vehicles (EVs)

Course Syllabus, IAP 2016 Non-Credit Course

Instructors

Ryan Chin, Managing Director & Research Scientist, MIT Media Lab, City Science Initiative
Lennon Rodgers, Research Scientist, MIT International Design Center
Sanjay Sarma, Professor of Mechanical Engineering, MIT Mechanical Engineering

Guest Instructors

Rick Chamberlain, Chief Technology Officer, Boston-Power Inc.
Eric Carlson, Senior Fellow, Boston-Power, Inc.
Craig Carlson, Executive Advisor, Parthenon EY

Course Description:

If you are interested in designing and building electric vehicles (EVs), then this IAP class is for you.

This hands-on course brings together industry experts, MIT faculty, staff, and students to present the basic building blocks to EVs including: battery systems, electric motors, motor controllers, and the overall vehicle systems integration. Each session will delve into practical engineering issues through interactive presentations by instructors and guest speakers. There will also be working sessions conducted by student mentors. The course will address the following questions:

- How to specify batteries, motor controllers, and motors to satisfy vehicle performance and efficiency goals
- How to integrate cooling, electrical, and communications systems that are crucial to the operation of EVs
- How to evaluate technology options
- How to make design decisions related to overall system and subsystem specification and selection

In addition to lectures, this year we will be offering three “hands-on” lab sessions in order for participants to apply lessons from the talks to practical in-class exercises that emphasize learning by doing and peer-to-peer collaboration.

The remaining sessions will focus on current market trends, cost challenges, competitive technologies, and future applications including urban mobility, EV infrastructure, energy storage for utilities, and the role of policy and incentives.

Schedule

Lectures – 9am to 12pm on January 19, 20, 21, 26, 27, 28 in E15-341

Labs – 9am to 4pm on January 22, 25, 29 in the International Design Center (IDC) in N52, 3rd floor

Enrollment – Advance sign-up required by Jan. 15th, 2016. Course size is limited to 40 (lecture) and 14 (labs). Students can sign up for both lecture and lab sessions. If the course is oversubscribed, a short essay will be required for selection. Sign-up for the course at this link: <http://goo.gl/forms/7LGMW16pOY>

Prerequisites – Permission of Instructor

Attendance – Participants welcome at individual sessions

Sponsors – Mechanical Engineering

Contacts

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Lectures

(1) Course Introduction and Batteries (Jan. 19)

This session will introduce the goals of the overall course; provide an overview of EV battery systems with a focus on Li-ion technology (history, cell chemistries and attributes, cell designs and components, performance metrics, cell dynamics and models, safety, battery management); and next generation battery chemistries.

Speakers: Ryan Chin, Rick Chamberlain, Eric Carlson

Guest Speakers: Betar Gallant, MIT Mechanical Engineering

(2) Controllers and Electric Motors (Jan. 20)

Led by guest speakers from Protean Electric, this session will focus on the design of controllers and electric motors. This session will also present a case study of building an electric motorcycle for the Isle of Man TT Zero race.

Speakers: Lennon Rodgers

Guest Speakers: Chris Hilton, CTO, Protean Electric

(3) Battery Pack Design (Jan. 21)

This session will focus on pack design with consideration of design requirements, the specification process and vehicle integration, packaging options from cell to module to pack, thermal management, current collection, safety (mitigation of cell failures), pack testing, and design for impact energy absorption and crashworthiness.

Guest Speakers:

Dale Robertson, Boston-Power, Inc.

Elham Sahraei, MIT Impact and Crashworthiness Laboratory

(4) Powertrain Integration (Jan 26)

This session will provide an automotive OEM perspective on overall vehicle integration for EVs.

Guest Speakers:

OEM (1) – Greg Hubbard, Senior Engineer for Chevy Bolt, General Motors (GM)

OEM (2) – Ford (TBC)

OEM (3) – Tesla (TBC)

(5) Applications and Markets (Jan. 27)

This session will cover trends and existing and future markets for traditional EVs, new urban vehicles, on-demand systems, and self-driving vehicles.

Speakers: Craig Carlson, Ryan Chin

Guest Speaker: Zipcar or Car2go (TBD)

(6) EV Infrastructure and MIT Student Clubs (Jan. 28)

This session will cover EV infrastructure including electric charging, vehicle-to-grid, second life EV battery re-use, and new markets (e.g., home energy management systems). This session will also introduce the EV ecosystem of MIT student research projects and clubs including Formula SAE, Electric Vehicle Team, Solar Car, etc.

Speakers: Ryan Chin, Lennon Rodgers

Guest Speakers:

Praveen Subramani, Energy Partnerships, NEST

Michael Lin, MIT Media Lab

Charles Guan, MIT-SUTD Collaboration (TBC)

Ivan Huang, MIT Campus EVs

Representatives from MIT EVT, Solar Car, Formula SAE

Labs (limited to 14 students)

All of the labs below will be a very hands-on introduction to topics related to electric vehicle engineering.

(1) Vehicle Systems Lab (Jan. 22)

- Main components of electric vehicles (e.g. motors, controller, high voltage, low voltage, contactors).
- Model and electric vehicle to estimate power and energy with application to range estimation.
- Sensors and microcontrollers to measure vehicle energy.
- Extra topics: PID speed controllers.

Instructor: Lennon Rodgers

(2) Battery Lab (Jan. 25)

The full day battery laboratory will be a more in-depth hands-on session of selected lecture topics. Key questions addressed will include:

- How to charge a lithium-ion cell? What are critical control parameters and metrics?
- How to verify manufacturer cell specifications?
- How to characterize continuous and pulse discharge performance and to use this data to develop a dynamic cell model?

Specific topics covered include:

- Laboratory safety while working with high voltage high power battery packs
- Battery test equipment and how to make measurements
- Charging and discharging (continuous and pulse) cells
- Data collection and analysis (extraction of key performance metrics)

Instructor: Eric Carlson, Lennon Rodgers, Dylan Urb

(3) Motor Lab (Jan. 29)

- Power electronics
- Tuning of electronics to motor characteristics
- Use of dynamometer

Instructor: Lennon Rodgers, Dylan Urb

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IAP 2015 Non-Credit Course Schedule

Lectures held in E15-341

Labs held in N52, third floor

Tuesday, January 19th

900 – 945am	Course Introduction – Ryan Chin and Sanjay Sarma
945 – 1100am	Battery Systems for EV's – Eric Carlson (Boston-Power, Inc)
1100 – 1115am	Break
1115 – 1200pm	Next Generation Battery Chemistries – Betar Gallant, MIT MechE

Wednesday, January 20nd

900—1030am	“Electric Motors and Controllers for EVs” – Chris Hilton (Protean Electric)
1030—1045am	Break
1045—1145am	“Electric Motorcycles at the Isle of Man” – Lennon Rodgers
1145—1200pm	End of day summary

Thursday, January 21th

900—1045am	“Pack Design” – Dale Robertson (Boston-Power, Inc)
1045—1100am	Break
1100—1200pm	“Pack Safety and Crashworthiness” – Elham Sahraei (MIT Impact and Crashworthiness Lab)

Friday, January 22nd (Vehicle Systems Lab Session)

900—1200pm	Introduction to motors, controllers, high/low voltage, contactors, range estimation
1200—100pm	Lunch Break
100—400pm	Sensors and microcontrollers (extra: PID speed controllers).

Monday, January 25th (Battery Lab Session)

900—1200pm	This session will involve: Battery Lab safety lecture, basic cell measurements, charging and discharging cells, and comparison of experimental data.
1200—100pm	Lunch Break
100—400pm	This session will focus on characterization of the transient characteristics of EV cells and how to use this data to estimate RC model parameters.

Tuesday, January 26th

900—1015am	“EV Integration at GM” – Greg Hubbard, Senior Engineer for Chevy Bolt, General Motors
1015—1030am	Break
1030—1145am	“EV Integration at Ford” – Speaker (TBD) from Ford Motor Company
1145—1200pm	End of day summary

Wednesday, January 27th

900—945am	“EV Market Trends” – Craig Carlson
945—1045am	“Shared, Autonomous, Electric Mobility for Cities” – Ryan Chin

1045—1100am Break
1100—1200pm “Shared EVs” – Speaker from Zipcar or Car2go

Thursday, January 28th

900—930am “Persuasive Electric Vehicle (PEV)” – Michael Lin, MIT Media Lab
930—1000am “MIT Campus EV Network” – Ivan Huang, MIT
1000—1045am MIT EV Clubs (Formula SAE, MIT EV Team, Solar Car)
1045—1100am Break
1100—1200pm “EV Infrastructure: V-to-G, second life battery use, and smart charging” – Praveen Subramani (Nest) via Video Conference.

Friday, January 29th (Motor Lab Session)

900—1200pm Morning session (topics TBC)
1200—100pm Lunch Break
100—400pm Afternoon session (topics TBC)