Electric Vehicles

ELEC 5970/6970/6970-D01

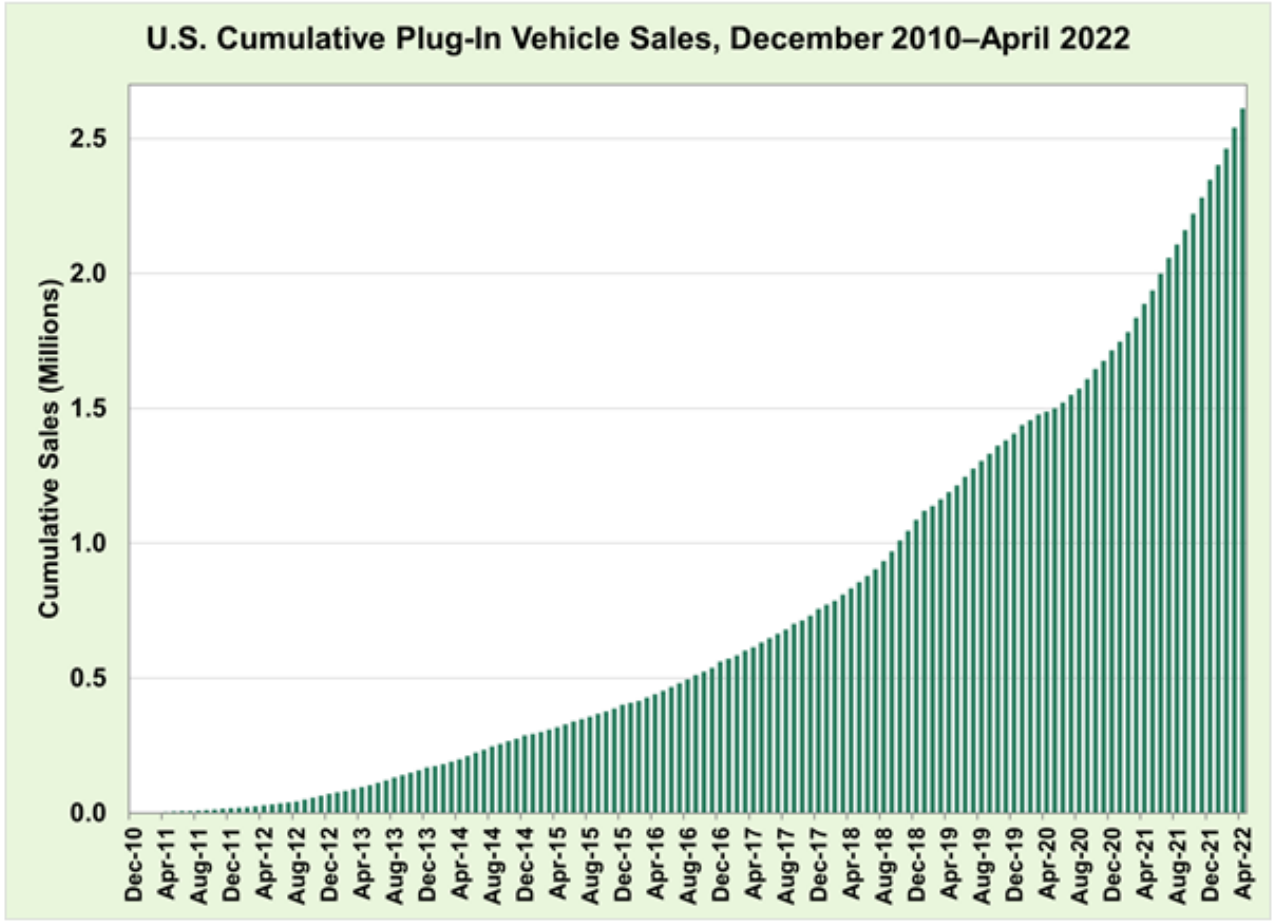
Course Outline and Overview

References:

- Iqbal Husain, ”Electric and Hybrid Vehicles, Design Fundamentals,” Third Edition, March 2021, CRC Press, Taylor & Francis Group, ISBN: 978-0429-49092-7

Top Commodity by Value Shipped Out of Each State, 2020

Cumulative Plug-in Vehicle Sales in the US Reached 2.6 million in April 2022



Note: Plug-in vehicles refers to both plug-in hybrid electric vehicles and all-electric vehicles.

Source: Argonne National Laboratory, Light Duty Electric Drive Vehicles Monthly Sales Update.

- Mass market plug-in vehicle sales began in the United States at the end of 2010 with just a few models available to consumers.
- As new plug-in models have been introduced and production volumes have increased, sales have accelerated accordingly.
- It took nearly eight years to reach one million cumulative sales but just two and a half more years to reach two million cumulative sales. Just 10 months after reaching two million in June 2021, cumulative sales climbed to 2.6 million as of April 2022.

Parts of the Course

- This course is divided into three parts. There will be one exam for each part
- Part 1 = 9~10 lectures with Exam 1 (50 minute)
- Part 2 = 9~10 lectures with Exam 2 (50 minute)
- Part 3 = 16 lectures with Exam 3 (150 minutes)
- Projects: Each project will be led a graduate student and will be supported by several undergraduate students.
- There will be project presentations at the end of the semester (approximately 3 presenters/50-min)

List of Topics

- This course is offered for the first time in the Fall 2022
- The list of planned topics is a plan we may have to modify in the progression of the course.
- Some chapters may be shortened, while others may be extended
- The topics listed here is the first draft and may be modified as necessary

This list of topics may be modified during the semester

	12:00 pm - 1:00 pm	MWF		Aug 16, 2022 - Dec 3, 2022
	Electric Vehicles - Fall 2022			
	ELEC 5970 - ELEC 6970			
Week	**Lecture #**	**Day**	**Date**	**Topics**
1	0	M	8/15/2022	No Class - Class officially starts on Tuesday 8/16/22
	1	W	8/17/2022	Course Outline and Overview
	2	F	8/19/2022	Introduction to Electric Transportation
2	3	M	8/22/2022	Introduction to Electric Transportation
	4	W	8/24/2022	Introduction to Electric Transportation
	5	F	8/26/2022	EV Mechanics
3	6	M	8/29/2022	EV Mechanics
	7	W	8/31/2022	Alternative Vehicles
	8	F	9/2/2022	Alternative Vehicles
4	8	M	9/5/2022	Labor Day
	9	W	9/7/2022	Alternative Vehicles
	10	F	9/9/2022	Review
5	11	M	9/12/2022	Exam1

This list of topics may be modified during the semester

	12:00 pm - 1:00 pm	MWF		Aug 16, 2022 - Dec 3, 2022
	Electric Vehicles - Fall 2022			
	ELEC 5970 - ELEC 6970			
Week	**Lecture #**	**Day**	**Date**	**Topics**
	12	W	9/14/2022	Battery Energy Storage
	13	F	9/16/2022	Battery Energy Storage
6	14	M	9/19/2022	Battery Energy Storage
	15	W	9/21/2022	Alternative Energy Storage
	16	F	9/23/2022	Alternative Energy Storage
7	17	M	9/26/2022	DC and AC Motors
	18	W	9/28/2022	DC and AC Motors
	19	F	9/30/2022	DC and AC Motors
8	20	M	10/3/2022	Mangetic Analysis
	21	W	10/5/2022	Mangetic Analysis
	22	F	10/7/2022	Fall Break (10/6-10/7)
9	23	M	10/10/2022	Review
	24	W	10/12/2022	Exam2

This list of topics may be modified during the semester

	12:00 pm 1:00 pm	MWF		Aug 16, 2022 - Dec 3, 2022
	Electric Vehicles - Fall 2022			
	25	F	10/14/2022	Power Electronics Converters
10	26	M	10/17/2022	Power Electronics Converters
	27	W	10/19/2022	Power Electronics Converters
	28	F	10/21/2022	Electric Motor Drives
11	29	M	10/24/2022	Electric Motor Drives
	30	W	10/26/2022	Electric Motor Drives
	31	F	10/28/2022	Electric Motor Drives
12	32	M	10/31/2022	AC Machine Controllers
	33	W	11/2/2022	AC Machine Controllers
	34	F	11/4/2022	Power Train
13	35	M	11/7/2022	Hybrid Electric Vehicle
	36	W	11/9/2022	Battery Charging Station
	37	F	11/11/2022	Battery Charging Station
14	38	M	11/14/2022	EV within Microgrids
	39	W	11/16/2022	EV within Microgrids
	40	F	11/18/2022	Review Exam
15	*40*	*M*	*11/21/2022*	*Thanksgiving Break*
	40	*W*	*11/23/2022*	*Thanksgiving Break*
	40	*F*	*11/25/2022*	*Thanksgiving Break*
16	*41*	*M*	*11/28/2022*	*Grad-Presentation*
	42	*W*	*11/30/2022*	*Grad-Presentation*
	43	*F*	*12/2/2022*	*Grad-Presentation - Last Day of the Class*
	44	*Tue*	*12/6/2022*	*Final Exam 12:00OPM-2:30PM (2.5 hours)*

ELEC 5970/6970/6970-D02 – ELECTRIC VEHICLES

Bulletin Data: **ELEC 5970 – ELECTRIC VEHICLES (3)** LEC. 3. Pr., ELEC 3600, ELEC 3700.
ELEC 6970/6970-D00 – ELECTRIC VEHICLES (3) LEC. 3.

Textbook: **Electric and Hybrid Vehicles, Design Fundamentals**, Iqbal Husain, Third Edition, March 2021, Published by CRC Press, Taylor & Francis Group, ISBN:978-0429-49092-7.

References: None

Coordinator: Eduard Muljadi, Professor of Electrical & Computer Engineering

Course Goals: To learn and understand:

1. The design and principles of electric and hybrid vehicles
2. The characteristics of vehicle components and subsystems.
3. The major issues related to electric and hybrid vehicle design and development

Prerequisites by topic:

1. Electric circuit analysis
2. Basic power concepts
3. Basic electronic devices

Topics (44 class meetings/50 minutes each):

1. Introduction to Electric Transportations	(4 classes)
2. Electric Vehicle Mechanics	(2 classes)
3. Alternative Vehicles	(3 classes)
4. Battery and Energy Storage	(3 classes)
5. Alternative Energy Storage	(2 classes)
6. DC and AC Motors	(3 classes)
7. Magnetic Analysis	(2 classes)
8. Power Electronics Converters	(3 classes)
9. Electric Drives	(4 classes)
10. AC Machine Controllers, Power Train, and Hybrid EV	(4 classes)
11. Battery Charging and EV Grid Integration	(4 classes)
12. Final Project Presentations	(3 classes)
13. Exams and review	(6 classes)

Typical method for evaluating student performance:

	ELEC 5970	ELEC 6970/6970-D00
1. Homework	20%	10%
2. Exams 1 & 2	40%	40%
3. Project	10%	20%
4. Final exam	30%	30%

Computer usage: Students are expected to utilize tools such as PSCAD, Mathcad, and Matlab/Simulink for both homework and projects.Other more specialized tools may be used for specific project applications.

Justification for Graduate Credit in ELEC 6970: Graduate students are challenged with a more intensive design project and are also expected to prepare more in-depth project reports which may include formatting according to IEEE publication requirements. Formal presentations of these more in-depth projects may also be required in the classroom environment.

Primary student outcomes related to the course ELEC 5970:

Graduates will have achieved and demonstrated

(1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.

(2) An ability to apply engineering design to produce solutions that meet specified needs with consideration for public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.

Prepared by: Eduard Muljadi Date: 4/3/22

Typical method for evaluating student performance:

GRADING:	Undergrad	Graduate
Homework/Quizzes	20%	10%
Exam 1	20%	20%
Exam 2	20%	20%
Final	30%	30%
Project	10%	20%
Total	100%	100%

	Low	High
A =	90.0%	100.0%
B =	80.0%	< 90%
C =	70.0%	< 80%
D =	60.0%	< 70%
F =	Below	60%

Project for Electric Vehicles class

Part 1: Due Monday, October 10, 2022, You are expected to write a brief description of the project. The description must include the project title, the abstract, and the outline of the final report your planned project. The description in words does not have to be extreme detail but should indicate the background, the issues, and the goal of the project. The point of this Part 1 is to describe the problem in words, so minimize the use of equations in the description.

- **Grad students: Proposal of your Project.** I will post the proposal on Canvas. Each grad student must mentor at least one undergraduate student intern (from our class) but no more than two UG students. As a hiring manager for the student interns, you are entitled to interview the student interns and ask the student interns to support your project. Your final score for the project will be:
  - a) 50% from your presentation, i.e., the average of scores given by all the students in class;
  - b) 50% of the score from your report (from me, the instructor).

Project for Electric Vehicles class

- **Undergraduate students:** Project Team Members and the Mentor
- Undergraduate students will apply for an internship with a graduate project based on the proposed projects posted on Canvas. As a potential intern, you have to apply to the Graduate Students (e.g. hiring manager), and, ask them to be your mentor for the project. It is expected that the graduate student will explain in detail about their project to you so that you understand very well during the final presentation.
- Your score will be:
  - a) 50% from the average scores of your mentors' presentation
  - b) 50% from your mentors indicating your contribution and participation in the project.

Project for Electric Vehicles class

Part 2: Due Monday, November 14, 2022 (PowerPoint Presentation Due). For the online student, we will provide the Zoom link for the presentation. The presentation should include the solution/implementation of the project, shows an example of a formulation, as do the various case studies you are studying. You should add to the material turned in for Part 1 so that the description and detailed formulation are all in one document. This final report should include a detailed formulation using equations to precisely, mathematically describe the problem. Make sure to be explicit about the variables and the equations describing the problem formation, including the objectives and constraints.

Project for Electric Vehicles class

Part 3: Final Presentation There are 12 graduate students and there are 7 undergraduate students in this class.

Graduate students will present their presentations. Each presenter is given a 10-minute-presentation and 2-minute-Q&A, or a total of 12 minutes per person.

The presentations are scheduled as follows:

- The 1st set of presentations on Monday, 11/28, 2022 (Project 1, Project 2, Project 3,Project 4)
- The 2nd set of presentations on Wed. 11/30, 2022 (Project 5, Project 6, Project 7, Project 8)
- The third set of presentations on Fri. 12/2, 2022 (Project 9, Project 10, Project 11, Project 12)

Graduate Project Final Reports (due December 2, 2022)

The final reports are due on the last day of the class, Friday, December 2, 2022.

Project Presentation Scoring

All students (Undergraduate and Graduate Students) must fill up this form)

Project -Electric Vehicles - ELEC 5970/6970/6970-D002 (Fall 2022)

Record Number	Student Name	Scores (1-10 points for each category)				
Monday		1	2	3	4	5
1						
2						
3						
Wednesday		1	2	3	4	5
1						
2						
3						
Friday		1	2	3	4	5
1						
2						

Project Presentation Scoring

Numerical Scoring for Electric Vehicles class

Ref: Technical Paper Review Guidelines for Numerical Scoring

Score each quality on the scale of 0 to 10, thus, 0-2 is poor, 3-5 is below average or fair; 6-8 is above average or good; 9-10 is excellent or outstanding.

Presentation (50 points) – To be scored by all students

1. *Electric Vehicles Interests (10 points):* Is the Topic of the presentation related to the Electric Vehicles field?
2. *Importance (10 points):* Is the subject important or trivial? Is it timely? Does it contribute something of value to the understanding of the Electric Vehicles field for those less expert than the audience? Is it too limited in scope?
3. *Reference value (10 points):* Does the work/project have a permanent reference value?
4. *Clarity of the Presentation (10 points):* Is the presentation clearly presented?
5. *Originality (10 points):* Affirmative answers to this question should lead to a high score on this point. Does it present a new concept, design or product? Does it bring together known facts to reveal new meaning? Does it report research extending the range of application of material or designs or practice? Does it significantly correct or redefine current practice? If the project presented is a survey of the state of the art, does it display originality in its selection and evaluation of previously (known) published material? Does it reveal an area in which progress is delayed for the want of new materials or information?

Internship Scoring

Each graduate student must fill up this form for the final score of your intern/s.

Each graduate student can only take a maximum of four undergraduate student interns

Electric Vehicles in Electrical Power Systems ELEC 5970/6970/D02

Mentor/ Manager	Name of the Student Intern	Scores (1-10 points for each category)				
	Number of Interns = 3	1	2	3	4	5
Grad Student 1	Undergradate Student 1					
	Undergradate Student 2					
	Undergradate Student 3					
	Number of Interns = 3	1	2	3	4	5
Grad Student 2	Undergradate Student 1					
	Undergradate Student 2					
	Undergradate Student 3					
	Number of Interns = 3	1	2	3	4	5
Grad Student 3	Undergradate Student 1					
	Undergradate Student 2					
	Undergradate Student 3					

Score each quality on the scale of 0 to 10, thus, 0-2 is poor, 3-5 is below average or fair; 6-8 is above average or good; 9-10 is excellent or outstanding.

Category:

#1 Understand the Project Goal/s

#2 Attitude (willingness to perform tasks requested)

#3 Contribution to the Presentation

#4 Contribution to the Final Report

#5 At the end of the internship, if your company approve of your proposed budget, will you hire your intern?

Two Questions from each Project

- Each Project shall submit two questions and the corresponding answers about your project.
- These questions (at least one of the two) will be included in the final exam.

For Each Project Leader (Graduate Student):	
Your Name	
Question1:	
Correct answer to Question 1	
Question 2:	
Correct answer to Question 2	

Schedule and Office Hours

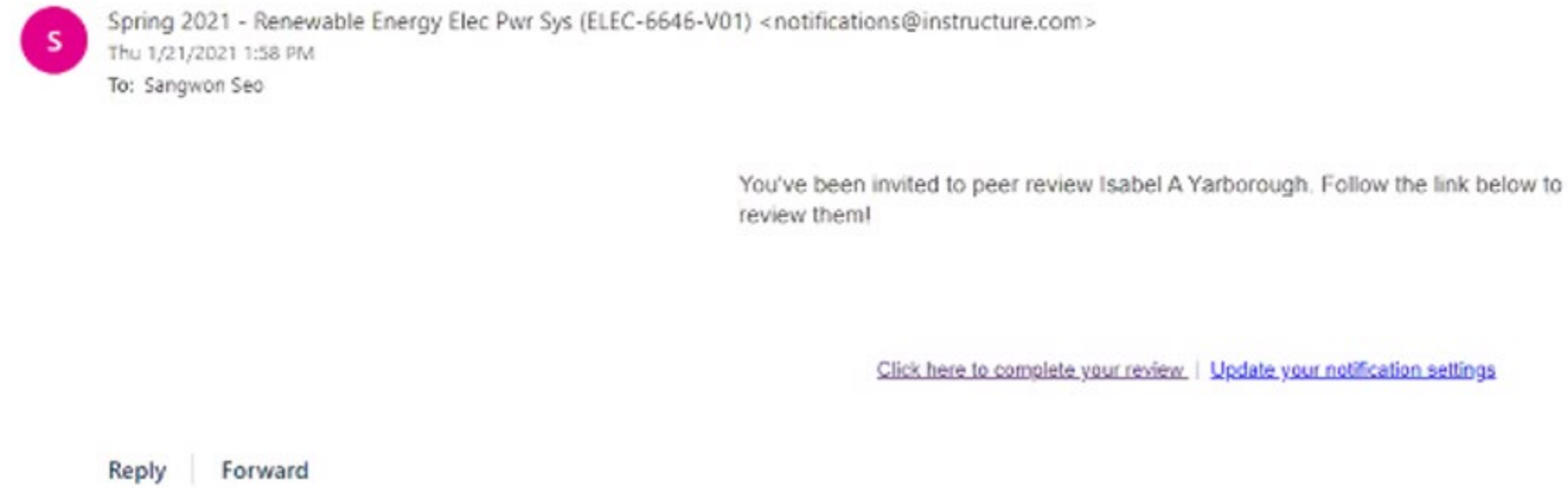
- Office hours will be through Zoom web-conference MF 11:00AM – 11:50AM and W 10:00 AM – 10:50 AM
- Zoom link will be provided
- The instructor will wait for the first twenty minutes, if no one shows up during office hour, the Zoom link will be closed.

Muljadi - Semester: Fall 2022					
Time	Monday	Tuesday	Wednesday	Thursday	Friday
8:00				Advising	
9:00	PElectronics		PElectronics	Advising	PElectronics
10:00			Office Hr.	Advising	
11:00	Office Hr.			Advising	Office Hr.
12:00	E.Vehicles		E.Vehicles		E.Vehicles
13:00					
14:00					
Class Room	TBD		TBD		TBD

Peer Review

- You will have opportunity to perform Peer Review for your classmates' homework
- This process will help you learn the correct/incorrect/different ways in solving homework problems and learn from someone else work.

As a peer reviewer, you get an email like this:



Your Name (as a reviewer)

Peer Review

The page to start your review: