EE559 Electric Vehicle Development and Design (DRAFT)

A. COURSE INFORMATION

a. Meeting time: Thursday 6:00 – 9:30 pm
b. Meeting location: ECE 037
c. Instructor: Dr. Eric Cheng
d. Email: kwec@uw.edu
e. Office hours: Thursday 2:00- 6:00 pm, or other hours by appointment
f. TA name: TBD

B. COURSE INFORMATION:

Course description/course overview:

With the rapid development of electric vehicles (EVs) and the growing demand for zero-emission transportation, this course provides a comprehensive exploration of EV technology from a research, commercial, and academic perspective. The course begins with an overview of electric vehicles, highlighting their significance in the current automotive landscape. The course delves into the key components and design of the EV powertrain, focusing on crucial elements such as battery energy storage, chargers, and auxiliary components. Additionally, emerging electric vehicle technologies, including fuel cell technology, will be examined to provide students with a holistic understanding of EV advancements. Furthermore, the course covers the infrastructure required to support electric vehicles, including charging stations, grid integration, and the challenges associated with building a robust charging network. The societal impact of electric vehicles will also be explored, considering factors such as environmental benefits, urban planning, and the potential for transformative changes in transportation systems. Through a combination of lectures, case studies, and discussions, students will gain a comprehensive understanding of electric vehicles, enabling them to analyze the current state and future prospects of this rapidly evolving industry. The course aims to equip students with the basic knowledge and tools necessary to contribute to the development, implementation, and sustainable growth of electric vehicles in the broader societal context.

Learning objectives: By the end of the course, students will be able to:

- Acquire a comprehensive understanding of modern electric vehicles, including their key features, components, and operational principles.
- Analyze the development of electric vehicles from technological, environmental, and societal perspectives, considering factors such as advancements in battery technology, electric drivetrains, and their impact on sustainable transportation.

- Recognize the basic design principles of electric vehicles, including the integration of electric drivetrains, energy storage systems, and motor controllers.
- Evaluate the societal impact of electric vehicles, including changes in transportation infrastructure, energy consumption patterns, and the potential for enhanced urban mobility.

Course Outline:

1. **INTRODUCTION & ELECTRIC VEHICLE DEVELOPMENT**
    - History of Electric vehicles
    - Recent Development
    - Engineering Philosophy of EVs
2. **ELECTRIC VEHICLE SYSTEMS**
    - Different types of Electric vehicles
    - **Key parts and components of EVs**
    - **Drive Topologies**
    - **Multiple motor drive**
3. **ELECTRIC PROPULSION**
    - What is propulsion
    - The force equation
    - Power electronics for EVs
4. **ELECTRIC MOTORS FOR EV**
    - Common motors
    - Motor driver
    - Operation of basic motors
    - Motor control
5. **POWER TRAIN**
    - Structure of power train
    - EV configuration
    - Power conversion
6. **BATTERY AND ENERGY STORAGE**
    - Types of batteries
    - Types of Li-ion batteries
    - Other energy storage for EVs
    - Basic characteristics
7. **BATTERY MANAGEMENT SYSTEM (BMS)**
    - Structure of BMS
    - Sensors and estimation of the status
    - Cell balancing
8. **HYBRID ELECTRIC VEHICLE SYSTEMS**
    - Type of hybrid
    - Super-capacitor hybrid
    - Hydrogen vehicles
    - Other hybrid vehicles
9. **ELECTRIC VEHICLE INFRASTRUCTURE**

- Different levels of charger
- Vehicle to Grids
- Load management
- Dynamic charging
- Opportunity charging
- City planning and issues

10. **ELECTRIC VEHICLE CHARGING TECHNOLOGY**
    - On-board and off-board charger
    - Standard, medium and fast charger
    - Basic configuration and circuit

Course format

The course format consists of engaging lectures that cover the major topics in electric vehicles. Lecture materials will be provided, and while there is no required textbook, students will have access to a list of recommended reference books for further reading. The course includes four homework assignments, a mid-term test in Week 6, and a mini-project with eight topic options.

The mini-project involves class presentations, which are scheduled to begin in week 4. Following the presentation, students are required to finalize their reports and submit them by week 10. This format ensures a comprehensive understanding of electric vehicles through lectures, assessments, and hands-on project work.

Prerequisite

There is no prerequisite, however, it is expected that you have an undergraduate qualification in engineering or science and knowledge of electric circuits.

C. ASSIGNMENT

Assignment weighting:

Homework :	*4 Assignments each 10%*
Mid-term test:	*Open-book, open-note 20%*
Miniproject :	35% (Report and presentation)
Participation:	5%

<u>Miniprojects</u>

Students will form groups to present their mini-projects in class. They will conduct research, perform surveys on their chosen topic, and create a PowerPoint presentation along with a final report for both their representation and submission. Dedicated class hours will be allocated to allow students to deliver their presentations effectively.

List of Miniprojects:

1. Comparison of EVs - Tesla, GM Bolt, Leaf, Jaguar, BYD, etc.
2. Analysis of Hybrid & Fuel cell EV: e.g. Prius; Honda FC car; comparison between EV, hybrid & FC; etc.
3. Examination of Electric Propulsion : e.g. Motor drive; In-wheel motor, high power motors, 4-wheel; drive, etc.
4. Analysis of commercial and special EVs - Trucks, bike, bus, trolley car, skateboard, etc.
5. Examination of Battery Technology: - Graphene battery; super capacitor, cells arrangement, battery swapping,
6. Auxiliary System examples: electric A/C; ABS braking; regenerative braking, power steering etc.
7. Analysis of the Charging system for EVs: high power charging standards; inductive charging; payment method, etc.
8. Town planning due to Electric Vehicles: EV car hire; EV sharing, solar charging, hyperloop, etc.

D. OTHER INFORMATION

Illness

If you are feeling unwell, particularly if you have a fever, it is important to prioritize your health and well-being by staying home and getting the rest you need. In the event that you become ill during a presentation or a Mid-term exam, please make sure to promptly inform the instructor by sending an email notification.

Academic Integrity

Instances of academic misconduct include submitting someone else's work as your own, committing plagiarism by copying portions of another person's words from published or electronic sources without proper acknowledgement, and consulting unauthorized solution keys. Breaching academic integrity carries serious consequences, with a penalty of a zero for the specific work in question on the first offense, and repeated offenses may result in a failing grade for the entire course. It is important to note that the use of AI-generated answers is also strictly prohibited. Upholding academic integrity ensures fairness, honesty, and ethical standards within the educational community.

Rubrics and further information

Miniproject: Presentation skills, the technical content of reports, and the overall impact will be evaluated. While each group may have the same topic, it is expected that their content, focus, and presentation approach will differ.

Homework: All problems must be supported with an appropriate amount of work. This typically entails demonstrating sufficient steps to showcase that the student has diligently worked through each aspect of the problem. Answers lacking supporting work will not be credited.

Mid-term exam: It covers the course materials leading up to the Mid-term exam. The quiz is conducted in an in-person format during class. It is an open-book and open-note quiz, allowing students to refer to their own notes, the instructor's notes, text/reference books, and information within the UW systems. No other materials are permitted, and the use of computers or internet access for external sources is not allowed.

E. REFERENCES

1. K. T. Chau, Electric Vehicle Machines and Drives: Design, Analysis and Application, Wiley, 2015.
2. Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamentals, New York: RC Press, 2003
3. Per Enge, Nick Enge, Stephen Zoepf, Electric Vehicle Engineering, McGraw Hill, 1st Edition, 2020.
4. L.A.Kumar, S.A.Alexander, “Power Converters for Electric Vehicles”, 1st Edition, Kindle Edition, 2020.
5. C.T.Rim, C.Mi, “Wireless Power Transfer for Electric Vehicles and Mobile Devices”, Wiley – IEEE, 1st Edition, Kindle Edition, 2017.
6. Hanky Sjafri. “Introduction to Self-Driving Vehicle Technology”, Chapman & Hall/CRC Artificial Intelligence and Robotics Series, 2019.