Course Syllabus, Fall 2015

Course Number: ECE 5330/EVE 5430/AET 5330
Title: Modeling and Control of Power Electronics and Electric Vehicle Powertrains
Credit hours: 4 (Lecture)

Course Description: This course will introduce basic methodologies for modeling, dynamic analysis, control system design, system coordination for electric vehicle powertrains. Course design projects will be required to develop design experience in the process of modeling, control design, and simulation involving batteries, power electronics, and electric machines.

Instructor: Le Yi Wang, Professor
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Office Hours: Tuesdays, 2:00-3:00 PM or by appointment
Class Time: Tuesdays and Thursdays 5:30-7:20 PM

Goals: To develop competence in analysis and design of control systems for electric vehicle powertrains.

Learning Objectives: At the end of this course, students will be able to:
1. Describe the basic principles of electric vehicle powertrains, including batteries, basic power electronic components and topologies, power converters, and electric machines
2. Derive the models of electric vehicle powertrain components and systems.
3. Analyze stability and performance of a control system for power electronic converters
4. Design controllers for electric vehicle powertrains

Textbooks and References:

This class will cover topics from a variety of sources, rather than a single textbook. Lecture notes will be distributed. The following books are some sample reference books for this class.

On Electric Vehicle Powertrains

On Power Electronics
Introduction to Power Electronics, Daniel W. Hart, Prentice Hall, 1997

On Control Theory

Prerequisite By Topics:
1. Topics in ECE 4470 for basic control concepts, analysis and design methods of control systems
2. Topics in ECE 5410 for power electronics

Main Contents:
Part I: EV Powertrain, Modeling and Control Basics
1. Introduction to EV Powertrains:
   Principles of EV/HEV powertrains, and their performance
2. System Modeling Fundamentals:
Mathematics background reviews, basic modeling methods

3. Power Electronics and Electric Machines: Overview:
   Power circuits, rectifiers and converters, electric machines, performance measures in power electronics

4. Modeling of Powertrains:
   Models of battery, power electronic, motor systems for control design

Midterm Exam: Topics in Part I
Design Project 1: Power Electronic and Motor System Modeling and Simulation

Part II: Control of Power Electronic and Electric machines

5. Control Fundamentals:
   Feedback control, stability, time domain analysis, frequency domain analysis, control design methods, simulation

6. Converter Dynamics and Control:
   Buck converter, boost converter, buck-boost converter, inverters

7. Control of Electric Machines

Final Exam: Topics in Part II
Design Project 2: Integrated Control System Design

Grade Distribution:
1. Homework Assignments: 20%
2. Exam 1: 20%
3. Design Project 1: 15%
4. Exam 2: 25%
5. Design Project 2: 20%

Grading Curves:
A = 95-100, A- = 90-94, B+ = 85-89, B = 80-84, B- = 75-79,
C+ = 70-74, C = 65-69, C- = 60-64, F = 0-59
(Note: No grades “D” or “E” for graduate courses)

Homework:
Homework assignments are an important part of the course and must be completed individually.
Homework deadlines will be specified on the class schedule and will be enforced.

Exams:
1. The midterm exam will be arranged in regular class meeting time. The final exam will be scheduled based on the Wayne State Exam Schedule.
2. No makeup exams will be administered.
3. A student who misses an exam due to illness or jury duty must provide written proofs to the instructor.
4. Students may only use calculators that do not include high-level computational programs (such as Matlab, Mathcad, symbolic math software, etc). No laptop computers are allowed during exams.

Extra Credits: No extra-credit projects will be given.

Outcome Coverage:
(a) An ability to apply math, science and engineering knowledge. The exams and projects require direct applications of mathematical, scientific, and engineering knowledge to successfully complete the course. This requires performing various circuit analysis methods, modeling
techniques, control theory, and computer simulation in derivation, calculation, and design decisions.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data. Students will apply modeling and control methodologies to design controllers for power converters, and conduct computer simulations using several software packages to evaluate and validate design concepts and performance.

(c) An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. Design projects require students to analyze system structure, develop models, and design control strategies to meet described specifications. Design problems have many possible solutions; and design specifications have multiple objectives to satisfy within realistic constraints such as power rating and transient response behavior.

(e) Identify, formulate and solve engineering problems. The course is primarily oriented toward modeling and control systems for electric vehicle powertrains. Students must identify the system, formulate a system model, and design a valid control system for the application.

(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context. Students taking the course will realize the broad applicability of modeling and control theory to electrical vehicle systems and their applications to alternative energy power sources. Economic and social consequences of alternative energy systems will be discussed in the class.

Student Code Of Conduct:

Cheating is defined by the University as “intentionally using or attempting to use, or intentionally providing or attempting to provide, unauthorized materials, information, or assistance in any academic exercise.” This includes any group efforts on assignments or exams unless specifically approved by the professor for that assignment/exam. Cheating in any form will be prosecuted according to the University regulations and will result in a severe penalty. It is your responsibility to protect your work from unauthorized copying.

Deferred Grades:

A grade of "I" will only be assigned if a student IS NOT currently failing the course and if there is NOT a substantial amount of work to be completed. An "I" grade MUST be made up within one year of assignment of the grade. Assignment of an “I” grade will be at the sole discretion of the instructor.

Blackboard:

Blackboard will be used throughout the course for communication among students and the instructors. Homework assignments, course handouts, and reference materials will be posted on Blackboard for the student to download. In order to use the system, you must log on through Pipeline. Please activate your Wayne State email address, and forward emails to your regular email address if you wish. This will be the address with which the instructor communicates with you.

Withdrawal Policy:

Please consult the current policy of the University and College of Engineering.