Spring 2018

AME409: Senior Design Project

Department of Aerospace & Mechanical Engineering

University of Southern California

COURSE SYLLABUS

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Course Section:	28807D
Course Unit:	4 Units
Prerequisite:	Senior Standing
Class Hours:	Lecture & Lab/Workshop: Tuesdays 1:00pm - 4:50pm
Class Location:	RTH-105
Office Hours:	Tuesdays, 11am-12pm
Teaching Assistant:	Hristina Milojevic (milojevi@usc.edu)

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Course Description

This design course focuses on the development and configuration of innovative vehicles and alternative energy systems in the context of the rising energy cost and the increasing pressures for socially responsible engineering. The designer, in addition to having advanced technical skills, needs to understand the integration and interactive optimization of many subsystems, each operating coherently as part of an efficient whole. She/he must use fundamental relationships for critical parameters of weight, strength, power, performance etc., which are less specific, defined and detailed than those learned in other engineering classes. An integrative, holistic approach to the creation of a complete system is taught, as opposed to the reductive analyses associated with specialized disciplines.

The course consists of lectures on essential features of modern technology and interactive workshops, in which small student groups develop preliminary designs of the selected system for that year. For the final presentation the students are required to give a formal briefing to the class.

Course Objectives

Following objectives are set for the students of this class:

- Understand and apply an iterative, integrative and holistic design process.
- Create innovative solutions for assigned design problems
- Comprehend fundamental relationships of vehicle weight power, strength and performance.
- Understand teamwork and work effectively as a team member.
- Clarify and define requirements or a mission statement and develop a design that satisfies the requirements.
- Understand various approaches to reduce or eliminate vehicle emission.
- Analyze power requirement and design a power system to satisfy both power and emission needs.
- Calculate energy requirements and determine specifications of major vehicle components.
- Understand vehicle steering dynamics and design an adequate steering mechanism for desired performance.
- Understand vehicle rolling dynamics and design a suspension system for desired performance.

- Understand the importance of ergonomics in engineering design and address ergonomic issues in the design project

Prerequisite

Senior standing.

Course Structure:

The scope of this course covers five components, namely, introduction to engineering design, vehicle power system analysis and design, energy system design, automotive steering and suspension design, and packaging design and ergonomics. To make the learning process more effective and efficient, the course structure is designed to include the following modules.

Module 1: Introduction to Engineering Design

The goal of this module is to introduce basic concepts and processes of engineering design, including form, function behavior, and processes.

- Definition and scope of engineering design
- Engineering design processes
- Different phases of engineering design

Module 2: Vehicle Power System Analysis and Preliminary Design

Power system design is a fundamental part of vehicle design. This module starts from identifying customers, and discusses power requirements and solution development.

- Automotive design process
- Customer identification and style design
- Automotive aerodynamics and power required estimate
- Hybrid power systems
- Power available curve and power system design

Module 3: Energy System Analysis and Preliminary Design

To ensure sufficient range of operation, a vehicle must be equipped with sufficient source of energy. Based on the power system design, this module addresses various driving scenarios and discusses ways of providing energy to the vehicle system.

- Driving mission scenario analysis
- Energy required estimate

- Energy system design and layout
- Ways to improve energy efficiency through alternative powertrains

Module 4: Automotive Steering and Suspension Dynamics and Design

In addition to power and energy system issues mentioned above, this module introduces the basic concepts and analysis methods of automotive steering and suspension dynamics and discusses the ways to specify basic parameters of steering and suspension systems.

- Introduction of beam theory
- Automotive chassis systems
- Steering system dynamics and design
- Suspension system dynamics and design

Module 5: Packaging Design and Ergonomics

Packaging design is important because the driver and passengers sit inside the car. This module addresses the issues of packaging design and provides some guidance for seats layout and sightline design.

- Introduction to packing design and ergonomic issues
- Driver and passenger seats design
- Estimate of visual sightlines of the driver
- Weight schedule and vehicle cost estimate

Course Work

The class meets for four hours a week, of which 1 to 2 are lectures while the balance consists of workshop sessions in with students working in groups. Part of the course training involves a specific study of general methods of engineering design and problem solving, encouraging innovation and channeling creativity; the balance consists of the development of the preliminary design of an innovative vehicle.

Lectures:

Lectures will be 1 to 2 hours every week on Tuesdays. The instructor will present and discuss the basics of engineering design and fundamentals of automotive engineering and vehicle design, following the course structure described above. Participation of all students to the lecture sessions is strongly required.

Workshop:

The workshop sessions, 2 to 3 hours per week on Tuesdays after the lecture, are designed for students to complete their weekly work assignments. Students form groups of 5-6 people and discuss as a group in the workshop time. During the first half of the semester, students will work on their assignments and a midterm report as individuals. After the spring break, students will work as a group and submit work assignments and the final project report as a group.

Work Assignment:

Throughout the semester, there will be weekly work assignments. Each work assignment has 2-5 analysis and/or design tasks, which are designed to help students (1) digest the knowledge learned from the lectures and (2) make progress on the design of their chosen vehicle.

Mid-Term Report:

Students will start their individual vehicle design from the third week. The design topic is a hybrid PZEV (Partial Zero Emissions Vehicle) for the Los Angeles basin, with alternative low emissions power systems for extended range. After the "Module 3" and right before the spring break, a Mid-Term Report – "Performance and Energy System Report" will be due as the design report of student's individual vehicle design. The report should provide a complete description of style design, power and energy systems design of a specific vehicle with advanced and hybrid powertrain. Completeness and correctness of the report and the merits of the vehicle design reported will be evaluated.

Team Project:

Teams of 4 to 6 people will be formed with each team developing a design aimed at their chosen specifications. The design topic is the same as the individual vehicle design. The team project effort will start right after the spring break. Students will perform an initial systems analysis and then, after review, revision and approval, complete the Preliminary Design of the vehicle, culminating in a formal engineering report "Final Project Report" covering the design of a specific vehicle from identifying customers in Module 2 to weight schedule and cost estimate in Module 5.

Course Materials

Course materials will be provided on the course blackboard or as handouts.

Grading Requirements

Students will be graded according to the following grading scheme:

Work Assignment: 35%

Total eleven (11) homework assignments will constitute 35% of the overall grade, with each amounting to 3.18%. Each work assignment has 2-5 analysis and/or design tasks. Students are encouraged to complete their work assignments during the workshop time.

Midterm Report: 35%

A midterm report is a formal engineering design report of a student's individual design. It is due on Friday of the week right before the spring break. Completeness and correctness of the report and the merits of the vehicle design reported will be evaluated.

Team project: 30%

Note that 30% of your semester grade is based on the results of your team design project, which is a team effort. All project work done by a team is first given a team grade. This team grade is then weighted for each student, based on confidential peer-evaluations by all team members at the end of the semester according to the following scheme.

Each student will be asked to fill out a questionnaire, which rate every team member (including him/herself) for the percentage participation to the team project, from 1 (10% participation) to 10 (100% participation). The evaluations are averaged in order to find each student's participation. The project grade of each student of a team will be weighted based on his or her percentage of participation.

Academic Integrity

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. SCampus, the Student Guidebook, (www.usc.edu/scampus or http://scampus.usc.edu) contains the University Student Conduct Code (see University Governance, Section 11.00), while the recommended sanctions are located in Appendix A. Academic integrity will be strongly enforced.

Students with Disabilities

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to the instructor as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. Website and contact information for DSP: http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html, (213) 740-0776 (Phone), (213) 740-6948 (TDD only), (213) 740-8216 (FAX), ability@usc.edu.

Emergency Preparedness/Course Continuity in a Crisis

In case of a declared emergency if travel to campus is not feasible, USC executive leadership will announce an electronic way for instructors to teach students in their residence halls or homes using a combination of Blackboard, teleconferencing, and other technologies.

Course Schedule

WK	Date	Lecture	Workshop	Work Due
1	1/9	• Course Introduction	WA#1: Explore Automobiles	.
2	1/16	• Automotive Design Process & 3-V Drawing	WA#2: 3-V Drawing	Exploration Report
3	1/23	• Powertrain System of Hybrid Vehicles	WA#3: Hybrid Power-train Configuration	3-V Drawing
4	1/30	• Power Required	WA#4: Power Required Curve	Hybrid Powertrain Configuration
5	2/6	• Maximum Power & Power Split	WA#5: Power Split	Power Required Curve
6	2/13	• Transmission Design & Power Available	WA#6: Power Available Curve	Power Split
7	2/20	• Energy Required & Mission Design	WA#7: Energy Required	Power Available Curve
8	2/27	• Energy System Layout • Efficiency Improvement	WA#8: Energy System Layout	Energy Required
9	3/6	• Energy System Recap • More about Battery	Q & A's	Energy System Study Report (Fri)
10	3/13	Spring Break, no class		
11	3/20	• Beam Theory & Automotive Chassis	WA#9: Project Planning	.
12	3/27	• Steering Dynamics	WA#10: Ackerman Angle	Project Planning
13	4/3	• Steering Geometry Design	WA#11: Steering Geometry Design	Ackerman Angle
14	4/10	• Suspension Geometry Design	WA#12: Suspension Geometry Design	Steering Geometry Design
15	4/17	• Ergonomics & Weight Schedule	WA#13: Ergo Design	Suspension Design
16	4/24	Project Briefing		
17	5/4	Final design report (PDF file) due 6pm by email		