Spring 2019

AME 503: Advanced Mechanical Design

Department of Aerospace & Mechanical Engineering

University of Southern California

COURSE SYLLABUS

Version: Rev. A

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Course Section:	28863D and 29033D
Course Unit:	3 Units
Prerequisite:	Senior Standing; AME 410 Recommended
Class Hours:	Thursday 6:40pm – 9:20pm
Class Location:	RTH-109 and DEN@Viterbi
Office Location:	VHE-418
Office Hours:	Thursday, 5:00pm (4:30) -6:20 pm
Teaching Assistant:	N/A
TA Email:	N/A
TA Office Location:	N/A
TA Office Hours:	N/A

Course Description and Objectives:

Mechanical engineering design is a critical skill for all mechanical engineers who will be developing products. In this course, products are not just defined as consumer goods, but rather any end results an engineer creates in the course of their work. Products may be internal or external to the company or organization. While there are both physical and non-physical products (such as digital), this course will focus on physical products.

The primary goal of this course is to aid mechanical engineers in the development of products. The topics covered for developing products can be placed in two categories: technical engineering design and engineering design theory. The merger of these two areas is engineering judgement. This course will focus on advancing engineering judgement for the development of mechanical systems. Specific goals are train the student to:

- To become customer centered, not design centered.
- Understand how take an abstract problem, and develop it into a product, through fundamental design theory approaches.
- Understand the basic physics relevant to mechanical design and mechanical systems.
- Develop the ability to take fundamental physics, and create simplified mathematically based models.
- Get a "hands-on" feel for how things work in mechanical systems.
- Add to your engineering judgment.
- Learn from the expertise of others in this class.

Course Structure:

Each lecture is divided into two halves. The first half will generally be technical and equation based. The second half will be applied theory, design theory, or hands on practice.

Throughout the lectures, the course can be further divided into three main themes. These are mixed throughout the course.

Engineering Design Theory:

Engineering design theory and methodology provides a framework within which to implement the design process. This course will specifically cover the Axiomatic and TRIZ design methods in detail. (AME 410, Design Theory and Methodology covers additional design methods, including design thinking and Systematic Design should that be of interest).

Technical Engineering Design:

Technical engineering design is the knowledge which develops "engineering judgment". This is also sometimes known as "best practices" or "Good Engineering Practice (GEP)". While a highly trained engineering judgement requires years of practice, this course will provide a

number of insights to help students develop their "engineering judgement". Hands-on practice is implemented to assimilate this "engineering judgement", although it is expected the material covered in the course will become of true value when working in industry.

Hands-on Practice:

This course is based on the theory that hands-on, experiential practice is essential for internalizing the course concepts. Therefore there will be a number of exercises throughout the class in the form of homework, group projects, individual projects and in class exercises. This will also involve examples in class.

Important Note: *The process of engineering design is not challenging in the traditional academic sense, where it can be hard to understand subjects technically. However, this class will be very challenging from an aspect of achieving quality designs, which is time consuming. Therefore, I recommend students expect that this course will take more time in preparation than other 3 hour courses. (Assume minimum of the full 9 hours/week in preparation). Compared to many other courses, this course will require greater "work ethic" than "book smarts" to be successful. However, what this means is that this is a course any engineering student can do well in.*

Course Work:

The course work includes class lectures, in-class exercises, homework, quizzes, tests, presentations, and individual and group projects (note, there are both minor and major group projects). Each are defined below.

Classroom Lectures: (not graded)

Weekly lectures will occur weekly. Students are required to complete reading assignments, indicated on the schedule page, before each lecture. Students are expected to make every effort to attend lectures in person or online real time, as a number of practice exercises will occur during lecture. Active participation in classroom discussion is required for all students in real-time attendance.

Class room lectures will follow the following format.

- Interview Question
- Lecture Overview
- Engineering Tips (by students)
- Lecture on Technical Engineering Design
- What Comes Next
- Break
- Lecture on Design Theory/Mechanical System Principles and/or Exercises
- Class Conclusion/Engineering Anecdote

In-Class Exercises: (not graded)

A variety of in-class exercises will occur to assist students in understanding and assimilating the material. Students will be divided into groups for these exercises, with several groups consisting of students physically present, and other consisting of the DEN students completing the exercises electronically. Groups for in-class exercises will be assigned at the beginning of the semester, and remain the same throughout the semester.

Online Participation: 4%

All students begin with a 4% participation score. Participation is measured by involvement on in-class exercises and lectures. If students are not actively involved in the class, or are distracting, the participation score may be reduced. **To maintain their participation score**, students must contribute to either the online discussion boards once every 2 weeks. (by either creating a new post or responding to a post). Each week, two students will be assigned to lead the discussion board, and each will be responsible for creating a new topic.

Homework: 24%

This course will contain regular homework assignments. Homework will consist of both traditional technical engineering problems as well as engineering design theory problems. Technical engineering design problems will be tradition text base problems with only on solution. Homework exercises for engineering design theory problems will be open ended and designed to accomplish work that will go into your midterm and final projects.

Total eight (8) homework assignments will constitute 24% of the overall grade, with each amounting to 3%. Each homework assignment will be centered on a design tasks or technical engineering design. Questions are usually open-ended. Thoughtfulness, clarity, conciseness and incisiveness are required. Homework is **due by the following Monday at 11:59 PM**, after the due date.

Quizzes: 13%

Online quizzes will occur after each lecture, via Blackboard, and are due **before** the next class session. Quizzes may cover the material in each lecture, required readings, class presentations and one question from the prior week's discussion board. (for example Quiz 2, which is posted after Lecture 2 about Lecture 2 will include a question about a discussion board post made between Lecture 1 and Lecture 2).

A total of thirteen (13) quizzes will constitute 13% of the overall grade, each worth 1%. Online quizzes will occur after each lecture, via Blackboard, and are due **before** the next class session (**due by Thursdays at 6:30 pm**). Questions will occur in random order, and once the student has proceeded to the next question, there is no going back. Please take the quiz in one setting on a reliable connection. Quizzes are open book, open note, open friend, open Google and online.

Midterm Exam: 5%

Exams may cover the material in each lecture, required readings, material on prior quizzes, and class presentations (including student tip and project presentations). Questions will occur in random order, and once the student has proceeded to the next question, there is no going back. Please take the quiz in one setting on a reliable connection, as the instructor will not be able to reset the exam. Exams are open book, open note, open friend, open Google and online.

Final Exam: 10%

Exams may cover the material in each lecture, required readings, material on prior quizzes, and class presentations (including student tip and project presentations). Questions will occur in random order, and once the student has proceeded to the next question, there is no going back. Please take the quiz in one setting on a reliable connection, as the instructor will not be able to reset the exam. Exams are open book, open note, open friend, open Google and online.

Engineering Tip: 3%

Starting with the third class, at the beginning of each class up to 3 students give a three minute presentation on a piece of engineering advice. The student is welcome to cover any type of engineering information, as long as it has not already be covered in class, or is not pulled from the primary textbook. This presentation should focus on explaining a new concept to students who are not familiar with it, and provide enough information so students can apply the information themselves.

Visual aids must be used (either Viewgraphs, prototypes, or product), the tips must last less than 3 minutes. Each student's presentation will be evaluated for enthusiasm, quality of visual aids, and foundation on engineering design principles. Every 30 seconds beyond 3 minutes will result in a 5% deduction of score.

Minor Group Projects: 4%

One minor group projects will occur in the first half of the class. The projects will focus on putting together small presentations of information. Each group project will have a unique team, comprised of DEN and on campus students. The goal of this minor project is to discuss a topic in detail with other students

Product Dissection: 3%

A product dissection board will be produced by dissecting a commercially available product. The product must have mechanisms (moving parts) in it, with at least one component discussed in class (gears, bearings, chain/belt drive, motors, or linkages). Grade will be based

completeness of the dissection (15 parts minimum), accuracy of the labeling, and complexity of the product. Pictures of dissection boards must be shared on the discussion board.

A few helpful guidelines for product dissection are:

1) Remove all batteries/cut off power cord of product, at least 24 hours before dissecting to ensure discharge of power.
2) Dissect a product by first removing all parts held in place by screws.
3) Next carefully release plastic snap tabs, or cut welded plastic joints. Do not pry things apart in a way that can hurt yourself.
4) When coming across capacitors, place screw driver across them to discharge them.
5) As you are taking things apart, how does the product accomplish its functions?
6) What are the flows of energy, signal/information, and materials through the system?
    a. I would recommend avoiding vacuum sweepers (they are nasty).

Mid-term (Individual) Project: 14% (7% report, 7% presentation)

This class emphasizes the importance of learning by doing. The best way to understand the methods is to practice. Each individual student will work on an individual design project, to begin the product development process. The midterm project consists of the midterm presentation and midterm report (both due at the midterm). Both are weighted equally. The midterm report will be the slide package for the midterm presentation, with some additional content required.

Term (Team) Design Project: 20% (15% report, 5% presentation)

This class emphasizes the importance of learning by doing. The best way to understand the methods is to practice. The term project will begin at the midterm, and continue through the end of the class. The goal is to develop a conceptual product by the end of the course. Teams may have a minimum of 2 members, and a maximum of 8 members, and must be combined of at least one DEN and one on campus student. However, **no more** than 2 DEN students may be on one team.

As the size of the project teams may vary, different amounts of work are expected for the various team sizes. The table below illustrates expected outcomes:

Team Size:	Expected Output:
2	2
3	2.75
4	3.5
5	4
6	4.5
7	5.25
8	6

The final project is based ~25% (i.e. 7% of the class grade) on the final presentation, and ~66% (i.e. 15% of the class grade) on the final report. Part of the final report grade will included demonstration of a prototype, which will be shown after the final presentation.

Note that 20% of your semester grade is based on the results of your design project, which is a team effort. All project work done by the 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 each team member contributed to the project. 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.**

Up to 2% extra credit is available for working in a team of 5 or more students, which will be calculated by multiplying the final project score by 1.02.

Summary of Grades:

Students will be graded according to the following grading scheme:

Participation	4
Homework	24
Quizzes	13
Midterm Exam	5
Final Exam	10
Engineering Tip	3
Minor Group Project	4
Product Dissection	3
Midterm Individual Project	14
Term Group Project	20

Assignment Submission Instructions:

Quizzes and tests are on Desire 2 Learn (D2L).

Reports, presentations, homework should be uploaded to the D2L folder.

- For Reports and Homework, submit .pdf files. For Presentations, submit .ppt, .pptx, or .pdf files
- Allow time for uploading files. Do no wait until the last minute to upload files. I would recommend uploading drafts early and often, as for assignments, multiple submissions are accepted. Only the most recent submission will be graded.
- I would recommend double checking submissions on all tests, quizzes, and assignments.

Follow the naming convention below for file names.

Task:	**File Name:**
Homework #	Homework#_LastName_FirstName.xxx (Homework1_Sauder_Jonathan.pdf)
Engineering Tip	Tip_LastName_FirstName.xxx (Tip_Sauder_Jonathan.pdf)
Minor Group Projects	Minor#_Group#.xxx (Minor1_Group3.pdf)
Midterm Ind. Project (Presentation)	Midterm_P_LastName_FirstInitial.xxx (Midterm_P_Sauder_J.pdf)
Midterm Individual Project (Report)	Midterm_R_LastName_FirstInitial.xxx (Midterm_R_Sauder_J.pdf)
Term Group Project (Presentation)	Term_P_Group#.xxx (Term_P_Group3.pdf)
Term Group Project (Report)	Term_R_Group#.xxx (Term_R_Group3.pdf)

Late Assignments:

Late Assignments are accepted, but with the following deductions. Do not wait until the last minute to upload. Unless there an emergency (in which case exceptions will be made) late assignments will have the following grades.

- 1 second to 5 minutes after deadline: -5% of assignment grade
- 5 minutes to 1 hour after deadline: -10% of assignment grade
- 1-3 hours after deadline: -25% of assignment grade
- 3 hours to 24 hours after deadline: -50% of assignment grade

- 24 to 48 hours after deadline: -60% of assignment grade
- More than 2 days after deadline: -80% of assignment grade
- More than 1 week after deadline: -90% of assignment grade

Please note that all emergency situations will require documentation (doctors note, police report, etc.). Losing internet access or power outages do not classify as an emergency. (be sure to submit before the deadline to account for things like internet outages)

Academic Integrity:

"The Viterbi School of Engineering adheres to the University's policies and procedures governing academic integrity as described in SCampus. Students are expected to be aware of and to observe the academic integrity standards described in SCampus, and to expect those standards to be enforced in this course."

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.

Course Materials:

There are required and optional textbooks for this course. Additional handouts and reading materials may be provided on the Course Blackboard Website when needed.

Required Primary Textbook:

- *James Skakoon," The Elements of Mechanical Design", ASME Press 2008*

NOTE: You must finish reading the assigned pages before the class of the assigned date.

- *Budynas, Richard G., J K. Nisbett, and Joseph E. Shigley. "Shigley's mechanical engineering design". 10th Edition New York, NY: McGraw-Hill Education, 2015. Print.*

A copy of an engineering machine/mechanical design textbook is need. You likely already have one from your prior classes, if you saved the textbook. If so, you may use that book instead of the above. Please also note that any version of Shigley's is acceptable.

Please note that this textbook has been published online at. However, if you download it without purchasing a copying of the text book, you are likely in violation of copy right laws.

I've included it only in case you find an electronic copy easier to search through for specific terms or to notate.

https://eclass.teicrete.gr/modules/document/file.php/TM114/shigley-machine-design-.pdf

Optional Secondary Textbooks:

- *Suh, N.P.: "Axiomatic Design - Advances and Applications", Oxford University Press*
- *Pahl, G. & Beitz, W.: "Engineering Design - A Systematic Approach", 2nd Ed. Springer*

Course Schedule

#	Date	1st Half	2nd Half	Assignment Due	Readings	Test Due
1	1/10	Course Overview	Customer Needs			
2	1/17	Stress, Strain, and Failure Theories	Solving Engineering Problems		Text: Sec. 1, 2, 14	Quiz 1
3	1/24	Engineering Structures: Design and Loadpaths	Design Theory Basics & AME410	Homework 1 (Design)	Text:4,5,6, 12,13,17,	Quiz 2
4	1/31	Constraints of Structures and Mechanisms	Morphology, Brainstorming and Ideation	Product Dissection	Text: 3, Appx. A/B	Quiz 3
5	2/7	Springs and Components	Simple Machines	Homework 2 (Design)	Text: 10, 15, 18	Quiz 4
6	2/14	Bolted Joints	Sketching and Storyboards	Minor Group Project	Text: 9	Quiz 5
7	2/21	Bolted Joints & Lead Screws (cont.)	Design Principles of Mechanisms	Homework 3 (Technical)	Text: 7, 8, 20	Quiz 6
8	2/28	**Midterm Project Reviews**		Midterm Project Slides		Quiz 7
9	3/6	Linkages		Homework 4 (Technical)	Text: 11	Quiz 8
10	3/14	**Spring Break**				
11	3/21	Bearings	Prototyping	Homework 5 (Technical)		**Mid-term**
12	3/28	Gears	Gears	Term Project Summary (Optional)		Quiz 11
13	4/4	Belt/Chain Drive Systems Motors	Intellectual Property	Homework 6 (Technical)		Quiz 12
14	4/11	Tolerances/Materials		Homework 7 (Technical)	Text: 16, 19, 21, 22, 23, Appx C	Quiz 13
15	4/18	Design for Manufacture	Collection of Resources/Q&A			Quiz 14
16	4/25	Technical Topics in Engineering Design	Course Summary	Homework 8 (Technical)*		Quiz 15
	5/2 (7-9)	**Project Reviews (Final Exam Period)**		Term Project Report/Review		**Final**

*=Due Friday at 11:59 pm