Fall 2017

AME 503: Advanced Mechanical Design

Department of Aerospace & Mechanical Engineering

University of Southern California

COURSE SYLLABUS

Version: Rev. A

Instructor: Dr. Jonathan Sauder

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Course Section:	28863D and 29033D
Course Unit:	3 Units
Prerequisite:	Senior Standing; AME 410 Recommended
Class Hours:	Tuesdays 6:40pm – 9:20pm
Class Location:	RTH-109 and DEN@Viterbi
Office Hours:	Tuesdays, 5:00pm (4:30) -6:20 pm
Teaching Assistant:	Hao Ji
TA Email:	haoji@usc.edu
TA Office Location:	VHE 202
TA Office Hours:	Tues. 2-4pm, Thurs. 1-3 pm

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. This course will focus on the mastery of both. Specific goals are:

- To develop technical engineering design skills by developing engineering judgement by providing practical advice from experienced engineers, both via the instructor, text, and class. Engineering judgement will be developed from conceptual design, to detail design, to design for manufacture. To internalize this advice, this class will consist of hands on applications.

- To instruct students on how to execute the Axiomatic Design method. This method is useful when starting with an abstract problem statement and having an organized process to drive towards a solution.

- To instruct the students on how to execute the TRIZ design method. TRIZ is particularly useful for solving conflicts in a design.

- Mechanical engineering design, like many other engineering applications has no single "right" answer. In fact, any one person, including the instructor, only knows a small percentage of mechanical design techniques and procedures. As such, the students will be expected to actively participate and provide advice and lessons learned from their personal experiences.

Course Structure:

This course is divided into two main sections, conceptual design and detail design. The portion of the course covering conceptual design occurs during the first half of the class, prior to the midterm, and the portion on detail design occurs in the second half.

Throughout these two sections, 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.

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:

Weekly lectures will occur on Tuesdays. 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.

- Lecture Overview
- Engineering Insights (by students)
- Lecture on Technical Engineering Design
- Break
- Lecture on Design Theory
- Interactive Practice Session
- Class Conclusion/What Comes Next

In-Class Exercises:

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.

Homework:

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.

Quizzes:

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, and class presentations. The ability to take the quiz will automatically be removed before each class session, as answers to the quizzes will be discussed in class.

Exams (Midterm and Final):

An online midterm and final will occur in place of two of the quizzes. Exams may cover the material in each lecture, required readings, material on prior quizzes, and class presentations (including student tip and project presentations).

Engineering Tip Presentation:

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.

Minor Group Projects:

Two 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.

Product Dissection:

Student will need to dissect a commercially available product, and then label all parts on a dissection 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:

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. At the midterm, each student will submit a report and a presentation on their work.

Term (Team) Design Project:

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.

Assignment Submission Instructions:

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

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

- For Reports, submit .pdf files. For PowerPoint, submit .ppt or .pptx
- 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)

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.

Recommended Textbook:

A copy of an engineering machine/mechanical design textbook is highly recommended. You likely already have one from your prior classes, if you saved the textbook. If you do not have a general mechanical engineering design, I recommend the following. Any edition will work. This book will be useful as a reference in the class.

- *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.*

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*

Grading Requirements:

Students will be graded according to the following grading scheme:

Task:	Percentage:
Participation	5
Homework	15
Quizzes	15
Midterm Exam	5
Final Exam	10
Engineering Tip	4
Minor Group Projects	6
Product Dissection	4
Midterm Individual Project	16
Term Group Project	20

Details are as follows:

Participation: 5%

All students begin with a 5% 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 the online discussion boards once every 4 weeks. (by either creating a new post or responding to a post). These must be posted by week 4, 8, 12, and 16. Evidence of posts will be requested in the final exam.

Homework: 15%

Total six (6) homework assignments will constitute 15% of the overall grade, with each amounting to about 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 Tuesday at 11:59 PM**.

Quizzes: 15%

A total of twelve (13) quizzes will constitute 15% of the overall grade, each worth about 1.2%. Online quizzes will occur after each lecture, via Blackboard, and are due **before** the next class session (**due by Tuesdays at 5:30 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: 4%

Each student will present a tip they have found to be useful in engineering design. Tips may not overlap with those in the primary textbook, and may not have been presented before in lecture. 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: 6% (3% each)

Two minor group project will occur during the class, focused on presenting a specific assigned concept. More details will be provided at a later time.

Product Dissection: 4%

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.

Mid-term (Individual) Project: 20% (10% report, 10% 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.

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.

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. 5% of the class grade) on the final presentation, and 75% (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 participation to the team project, from 0 (no 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.

Up to 2% (on the project total score) is available for conducting focus group. You must document who attended the focus group, how you selected your participants, how long the focus group lasted, and what the results of the focus group were. You must also submit your questioning route plan.

Up to 2% (on the project total score) is available for conducting customer surveys for project. You must state how surveys informed your decisions, and provide a copy of the survey, along with the statistical results.

Up to 5% 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 1.05.

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: -15% of assignment grade
- 1-3 hours after deadline: -30% of assignment grade
- 3 hours to 1 day after deadline: -60% of assignment grade
- More than 1 day 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 Schedule

#	Date	Engineering Applications	Design Methods	Assignment Due	Readings	Test Due
1	**8/22**	Course Overview	Customer Needs			
2	**8/29**	Solving Technical Engineering Problems	Axiomatic Design Theory & AME410	Homework 1	Text: Sec. 1, 2, 14	Quiz 1
3	**9/5**	Engineering Structures: Design, Loadpaths	AX Design/Product Dissection Review	Product Dissection	Text:4,5,6, 12,13,17, 15, Handout 1	Quiz 2
4	**9/12**	Constraints of Structures and Mechanisms	Axiomatic Design: Examples	Homework 2	Text: 3 Handout 1	Quiz 3
5	**9/19**	Selection of Components and Bolted Joints	Brainstorming and Ideation	Minor Group Project A	Text: 10, 18	Quiz 4
6	**9/26**	Design Principles of Mechanisms	Axiomatic Design: Q&A, B&I	Homework 3	Text: 7, 8, 20	Quiz 5
7	**10/3**	Linkages	Sketching and Storyboards	Homework 4	Text: 9	Quiz 6
8	**10/10**	Bearings	Further B&I Methods	Minor Group Project B		Quiz 7
9	**10/17**	**Midterm Project Reviews**		Midterm Project Report/Review		Quiz 8
10	**10/24**	Gears	Prototyping		Text: 11	**Mid-term**
11	**10/31**	Belt/Chain Drive Systems	TRIZ Design Methods	Homework 5		Quiz 9
12	**11/7**	Electro/Mechanical Systems	TRIZ Design: An Example			Quiz 10
13	**11/14**	Design for Manufacture/ Tolerances	Intellectual Property	Homework 6	Text: 16, 19, 21, 22, 23, C	Quiz 11
14	**11/21**	Cool/Innovative Mechanisms	Your Engineering Career	Note: TG Week		Quiz 12
15	**11/28**	Materials	Collection of Resources/Q&A			Quiz 13
16	**12/5**	Study Day (No Class)				
	12/12 (7-9)	**Final Exam Period: Project Reviews**		Term Project Report/Review		**Final**