**Spring 2022**

# AME 503: Advanced Mechanical Design

**Department of Aerospace & Mechanical Engineering**

**University of Southern California**

# COURSE SYLLABUS

**Version: Rev. 1**

**Instructor: Dr. Jonathan Sauder**

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| | |
|---|---|
| **Course Section:** | 28862R and 29053D |
| **Course Unit:** | 3 Units |
| **Prerequisite:** | Senior Standing;<br>AME 410 Recommended |
| **Class Hours:** | Thursday 6:40pm – 9:20pm |
| **Class Location:** | RTH-109 |
| **Office Location:** | TBD |
| **Office Hours:** | Thursday, 5:00pm (4:30) -6:20 pm |
| **Teaching Assistant:** | TBD |
| **TA Email:** | TBD |
| **TA Office Location:** | TBD |
| **TA Office Hours:** | TBD |

## Course Description and Objectives:

The goal of this class in short, is to be a stepping stone to becoming the best version of yourself as a mechanical system design engineer.

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, which is also referred to as "design rules of thumb".

Design is inherently abstract and ill defined. The goal of this class is to equip students with tools to perform excellent technical and functional design.

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.
- Be able to transfer customer needs to functions, and identify the critical functions and functional requirements a product must perform.
- 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.
- Build 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.

*All course work must be original work by the student alone, unless proper citations are provided. By the student alone, means the student must write/draw/create every element of the work themselves, not copying from other sources work.* ***Any questions with regards to what is permissible should be discussed with the instructor.***

Unless the student notifies the instructor, the instructor reserves the right to use any content the student submits in future classes (with credit/citation of course) as examples or to enhance the learning in the course.

**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
- 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: 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 either the online discussion boards once every week on average. (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 class period it is due in.

It is critical that the Homework is the students OWN work. While students may discuss the homework and homework approaches with each other, any material a student submits must be created by themselves, originally for this class. Students may not re-use other students spreadsheets, or reuse the example spreadsheets (note: reusing example spreadsheets will result in incorrect answers).

**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.

Tips will be posted on D2L after the students presentation, so students can find them as a reference. Also, the instructor may select some student's engineering tips in future lectures (with credit to the student of course) to aid in better understanding.

**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).

**Machine Investigation: 3%**

Look for a machine that is large, complex, and has many moving parts. It must be a product that you can physically touch or investigate. It can be your car, a vehicle, a piece of manufacturing equipment, etc. It may be more meaningful if it is related to your midterm project, but this is not required.

**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, which is determined by the rest of the fellow team members.**

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.

Up to 1% extra credit is available for submitting a provisional patent draft application along with your report.

Up to 3% extra credit is available for posting the design on a crowdsourcing website, like Kickstarter. The first 1% is provided for launching the campaign, 1% is available if the design achieves 100 backers, and the final 1% is available if the design achieves 500 backers (number of backers for extra credit is determined on the number of backers on the Sunday after the final exam)

**Summary of Grades:**

Students will be graded according to the following grading scheme:

| | |
|---|---|
| Participation | 5 |
| Homework | 24 |
| Quizzes | 13 |
| Midterm Exam | 5 |
| Final Exam | 10 |
| Engineering Tip | 3 |
| Product Dissection | 3 |
| Machine Investigation | 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. Download any files uploaded, to ensure the correct file was uploaded.

Follow the naming convention below for file names.

| **Task:** | **File Name:** |
|---|---|
| **Homework #** | Homework#_LastName_FirstName.xxx<br>(Homework1_Sauder_Jonathan.pdf) |
| **Engineering Tip** | Tip_LastName_FirstName.xxx<br>(Tip_Sauder_Jonathan.pdf) |
| **Minor Group Project** | Minor#_Group#.xxx<br>(Minor1_Group3.pdf) |
| **Midterm Ind. Project (Presentation)** | Midterm_P_LastName_FirstInitial.xxx<br>(Midterm_P_Sauder_J.pdf) |
| **Midterm Individual Project (Report)** | Midterm_R_LastName_FirstInitial.xxx<br>(Midterm_R_Sauder_J.pdf) |
| **Term Group Project (Presentation)** | Term_P_Group#.xxx<br>(Term_P_Group3.pdf) |
| **Term Group Project (Report)** | Term_R_Group#.xxx<br>(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: -20% of assignment grade
- 3 hours to 24 hours after deadline: -40% 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."

## Statement on Academic Conduct and Support Systems

### Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

NOTE: Even submitting your own work, which has been submitted to another class or previously published can be plagiarism.

### Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call

engemannshc.usc.edu/counseling

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 - 24/7 on call

http://www.suicidepreventionlifeline.org

Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call

https://engemannshc.usc.edu/rsvp/

Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)/Title IX - (213) 740-5086

https://equity.usc.edu/, http://titleix.usc.edu/

Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421

https://studentaffairs.usc.edu/bias-assessment-response-support/

Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776

http://dsp.usc.edu

Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710

https://studentaffairs.usc.edu/ssa/

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101

https://diversity.usc.edu/

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

http://dps.usc.edu/, http://emergency.usc.edu

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

http://dps.usc.edu Non-emergency assistance or information.

## 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 needed. 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/Required Materials:**

LEGO Simple Machines (9689)

Or

LEGO Simple & Powered Machines Set (9686)

**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 | 1/13 | Course Overview | Design Theory Basics & AME410 | | | |
| 2 | 1/20 | Stress, Strain, and Failure Theories | Design Theory Applied | | Text: Sec. 1, 2, 14 | Quiz 1 |
| 3 | 1/27 | Engineering Structures: Design and Loadpaths | Morphology, Brainstorming and Ideation | Homework 1 | Text:4,5,6, 12,13,17 | Quiz 2 |
| 4 | 2/3 | Constraints of Structures and Mechanisms | Sketching and Storyboards | Product Dissection 1 | Text: 3, Appx. A/B | Quiz 3 |
| 5 | 2/10 | Constraints of Structures and Mechanisms | Simple Machines/ COTS Parts | Homework 2 | Text: 9, 15, 18 | Quiz 4 |
| 6 | 2/17 | Springs | Design Principles of Mechanisms | Homework 3 | Text: 10 | Quiz 5 |
| 7 | 2/24 | Bolted Joints | TRIZ | Machine Investigation | Text: 7, 8, 20 | Quiz 6 |
| 8 | 3/3 | Bolted Joints & Lead Screws (cont.) | | Homework 4 | | Quiz 7 |
| 9 | 3/10 | **Midterm Project Reviews** | | Midterm Project | | Quiz 8 |
| | 3/17 | **SPRING BREAK (no class)** | | | | |
| 10 | 3/24 | Linkages | | Homework 5 | Text: 11 | **Mid-term** |
| 11 | 3/31 | Bearings | Prototyping | Term Project Summary (Optional) | | Quiz 12 |
| 12 | 4/7 | Gears | Gears | Homework 6 | | Quiz 13 |
| 13 | 4/14 | Gear Systems/ Motors /Belt/Chain Drive | Assemblies, Drawings & Tolerances | Homework 7 | | Quiz 14 |
| 14 | 4/21 | Materials & Manufacturing Processes | Intellectual Property | | Text: 16, 19, 21, 22, 23, Appx C | Quiz 15 |
| 15 | 4/28 | Topics in Mechanical System Design | Collection of Resources/Q&A | Homework 8 | | Quiz 16 |
| | 5/5 | Project Reviews | | Term Project Review/Report* | | **Final (Online)** |

*=Due Friday at 11:59 pm

‡Lecture is Remote