

MAE3 Student Guide

Course Objective

MAE3 is an introductory design course, and design involves application of engineering theory to development of working machines. However, design requires much more than engineering theory. In real-world applications projects are always under time and cost constraints. Effective design requires creativity in developing new design solutions, managing risk, and effectively using resources and time. The best way to learn how to become a good designer is to go through the experience of a design process, which is what we do in MAE3. We recognize that technology is changing quickly, and it is essential to develop life long learning skills where one learns how to use new engineering tools and components. In MAE3 you will be challenged to use a wide range of resources, and use your creativity side by side with engineering theory.

The Design Process

A primary objective of MAE3 is to teach an effective way of managing the design process. Good designers do NOT start building the first design solution that comes to mind. Instead significant effort is spent in coming up with a wide range of design concepts, systematic risk reduction, application of engineering theory to verify feasibility, scheduling and allocation of tasks among team members, and designing parts for ease of fabrication and assembly. Throughout MAE3, each student and team will have to make decisions on how to proceed with their design. We will teach methods used by industry to effectively manage the design process, and deliver working machines on schedule.

Clock Project

The first project in MAE3 is a model clock project where each student designs their own pendulum with escapement wheel. The objective of the clock project is to learn important skills that will be used in the robot project. Each student will learn how to use AutoCad, create parts with the Lasercamm, and use the Design Studio machinery. We have purposefully designed the clock to have many features in it to illustrate different machine design methods including a range of fastening and coupling methods. In addition, the clock project includes a timing analysis using pendulum physics, comparing theory to actual performance, and documentation and report writing methods. The clock project is fun; each student designs their own pendulum and takes home a working device. However, don't forget to pay attention to the clock details and analysis used, since you will need to apply these approaches in the robot project and report.

Robot Project

The second and larger project in MAE3 is a team robot project, where engineering creativity is at the forefront. The robot project is a real design project in that it is truly open-ended with a wide range of viable design solutions, and each team must make their own design decisions. I encourage every student to embrace this project as a unique opportunity to challenge themselves as engineers and see what ideas they can come up, and with the implementation of these ideas. Each year I see a wide range of robots and detail designs that I did not envision. Whether you have significant shop experience or this is your first hands-on course, you will have an equal opportunity in coming up with winning designs.

Time Management

In any hardware design project it is possible to spend an infinite amount of time building and improving one's hardware, but this is neither desired nor efficient. In both industry and design classes, proper time management is necessary. Some key tips are:

- Do not wait till the last minute to get assignments done. It may be possible to cram in a regular homework assignment the night before it is due, but if you try this with hardware you will end up breaking parts and spending more than twice as long.
- Use your resources and ask for help. We have many tutors with office hours every weekday! Ask your classmates for suggestions and tips. Whether it be a software question or a fabrication challenge, you will likely learn some new material and avoid frustration.
- Work effectively as a team. The robot project is too time consuming to take it on as an individual project, the effort spent building up a good working relationship with your teammates will have a huge payoff.

Teamwork

In industry, engineering projects require teamwork, and this is a critical part of the MAE3 robot project. The foundation of good teamwork is based upon mutual respect, but also involves good communication, effective meetings, and written documentation of task assignments. In MAE3 we will go over effective teamwork techniques, but if you are experiencing team problems it is IMPORTANT that you contact your section tutor or course instructor early in the project. You will receive feedback from your teammates in an anonymous peer review midway through the robot project; pay close attention to this feedback. The peer review will also be implemented at the end of the project, and will become a component of the project's grade.

!!!!!!!!!!!!!! WARNING FOR STUDNTS WITH PRIOR DESIGN EXPERIENCE !!!!!!!!!!!!!!!

MAE3 can be a time consuming, challenging, but a very rewarding class – which is good. But under some circumstances MAE3 can be an especially frustrating class if one has unresolved a teamwork problems – which is bad. The majority of teams work together well; there can be periods of debate but eventually the team members realize that it is necessary to work together effectively with mutual respect to get the job done. However, there have been cases of prolonged team conflict when a student with significant prior design experience gets teamed up with teammates with little design background. Such teams can succeed well, if mutual respect is present. Indeed, a winning team had a member with over 10 years industry

experience where the winning feature of the design was from a novice member encouraged on by the more experienced member. However, there have been cases where the experienced teammate has little patience, respect, or tolerance for their less experienced teammates. They may try to lead the team in a dictatorship fashion, which usually ends up blowing up towards week 9 or 10. Moreover, the team does not benefit from the full capabilities of all teammates. In real-world projects strong teams will have members with wide range of expertise and backgrounds, and winning design ideas come from both experienced and inexperienced members who see things in a new light. The bottom line is that a poorly functioning team will result in low grades all around. If you have significant prior design experience and take up a leadership role in your team, I will be looking to see how you bring out the best in all team members. If you are a new to design, I will be looking to see how you rise to the task and take upon yourself challenging tasks; I will not accept the excuse that a more experienced team member took the challenging design tasks from you.

Incorporating Analysis into Design

A key objective of MAE3 is application of analysis to your design. This will make your robot better, and will save you time by reducing the amount of trial and error needed to get your machine to work. More importantly, application of engineering theory is how real-world design is implemented. The truth is that one can build an MAE3 type robot without too much analysis, relying on just extensive trial and error; however in industry this is not possible since each trial can be expensive. Therefore, I challenge you to apply analysis wherever possible; try to predict robot performance before you build it, calculate the right gear size before trying endless variations, and choose your motors using power analysis. You will have to do the analysis anyway for your final report, so you might as well use it to help you design!

Oral and Written Communication

Effective communication is a critical engineering skill. In MAE3 you will need to communicate design ideas to your teammates, give an oral presentation to the instructor, and write a written report about a part of the robot you designed. One always gets better ideas when explaining their design to others and participating in peer critique. We will work on effective use of CAD, sketches, and clear documentation for communication.

Computer Aided Design (CAD)

CAD is an important engineering tool and you will spend many hours learning first 2D and then 3D CAD. It is especially exciting that we will use the Lasercamm rapid prototyping machine to transform 2D CAD drawings into actual hardware. 3D CAD will be used in your presentations to illustrate how your machine works, and some teams will build models in 3D before a machine is built to ensure that all parts fit together properly. However, MAE3 will just provide an introduction to CAD, and it is up to each student to pursue CAD in more depth depending upon their interests and career paths.

The MAE Design Studio

The Design Studio is a unique facility at UCSD. We have worked hard to create an environment where students can be creative, meet fellow engineering students, work in teams, and see their creations become a reality. This space is widely used, as we can have multiple courses and over 300 students using the Design Studio in a single quarter! To enable the facility to operate effectively we need your help in respecting your fellow students, the space, and the people who maintain and keep the facilities running. The Design Studio belongs to you; together lets make it the type of place we would like to work in.

Getting a Good Grade

While the ultimate objective of a course is the knowledge gained, the grade is an important factor. MAE3 is unique in that there are two large assignments (the clock and robot projects) but also many small assignments along the way. To get a good grade it is important to complete all assignments, which are necessary steps in the larger projects. A large portion of the grade is based on the projects' hardware and reports, where high marks are given for high quality work, creativity, and getting hardware to work. The final robot reports and robot hardware are graded by the course instructor. Since the robot project is a team effort a portion of your grade will depend upon the peer evaluation you receive from your teammates.

Beyond MAE3

One of the advantages of taking MAE3 early on at UCSD is that it opens a number of doors for enriching one's undergraduate education. Knowledge of CAD often gets one's foot in the door for industry internships. Knowing how to fabricate parts in the Design Studio makes one much more attractive for many research opportunities with faculty. I strongly encourage everyone to pursue either an industry internship or research project while pursuing their undergraduate degree.

Another objective of MAE3 is to make engineering theory more tangible. In MAE3 we show how the theory of basic physics can be applied to working machines. As you pursue more advanced engineering courses, my hope is that the MAE3 experience will make engineering theory easier to visualize and understand, whether it be Free Body Diagrams, dynamics, or continuum mechanics.

Finally, each engineering major has a senior capstone design project, and MAE3 can serve as a guide for effective implementation of the design process. In your future design projects I urge you to build upon your MAE3 experience and remember that your approach to the design process will be as important as the theoretical challenges in the project.