

2019-20

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**Independent Work/Senior Thesis
Department of Mechanical and Aerospace Engineering**



**PRINCETON
UNIVERSITY**

Overview

The Department of Mechanical and Aerospace Engineering requires at least one semester (MAE 439, MAE 440) of independent work, which ***must*** be completed in senior year, and strongly encourages a two-term senior year project (MAE 444) or thesis (MAE 442). All projects must include elements of engineering design (*engineering design is the process of devising a system, component, or process to meet desired needs*).

There are four avenues available to choose independent work projects: student initiated, faculty inspired research, societal projects*, or competitions. A faculty member must serve as project adviser, and it is up to the students, in consultation with the faculty coordinating the independent work courses, to enlist a faculty member as a project adviser before submitting for approval an independent work proposal. Students have ample flexibility in choosing a topic, with the only caveat that projects must have clearly defined mechanical or aerospace engineering content. Most students have historically developed their projects in conjunction with faculty inspired research, or student initiated ideas. Nevertheless, MAE has an excellent history of participation in national design competitions organized by the professional societies.

* *Check with individual faculty for projects of this kind.*

Each year-long course requires an interim preliminary design review (PDR) presentation in front of the faculty during January, a final written report to the adviser and a poster presentation to the faculty at the end of spring term. One additional reader, assigned by the faculty in charge of the independent work program, also evaluates each final report.

Group projects are encouraged when the scope of the work is broad enough. Team efforts may be graded either individually, with separate reports on independent aspects of the project from each member, or collectively, with one group report and a single grade assigned to each member. Only individual reports may qualify as a Senior Thesis. One term independent work may be carried out either individually or in teams.

This grading process in place for independent work aims at ensuring equity of evaluation of the student work across the broad range of projects. The final grade is assigned by the faculty in charge of the program based on a composite evaluation of the written report by the adviser and reader, and the poster presentation grade taken as an average of the faculty attending. Written reports are graded on originality, completeness, and technical quality, quality of design, scholarship, and writing quality.

At the beginning of each term, a memo detailing the independent work program and containing all the relevant deadlines is posted on the BlackBoard site. Additionally, the faculty coordinator holds a mandatory meeting with the students to explain the program and answer questions students may have. Please read this guide before your first class meeting. This way you can prepare any questions you have for me about Independent Work.

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Key Dates

The following are very important dates you should keep in mind. Please remember that the University determines many of these deadlines. ***Failure to meet these deadlines will result in a grade penalty or refusal to accept your proposal and/or reports.***

	Fall '19	Spring '20
<i>Mandatory Meeting Senior Class</i>	Tues, Sept. 17 <i>12:30, Friend center Convocation</i> <i>Room 113 with Lunch</i>	
<i>All Proposals due</i>	Tues, Oct. 1	Mon, Feb. 17
<i>Marshall & McKinzie fund proposals</i>	Tues, Oct. 8	Fri, Feb. 28
<i>Supplemental fund proposals</i>	Mon, Nov. 4	Mon, Mar. 23
<i>IW written reports due</i> <i>(MAE 339, 339D, 340, 340D, 439, 440)</i>	Tues, Jan. 7 '20*	Tues, May 5*
<i>Poster Session</i> <i>One-semester projects</i> <i>(MAE 339, 339D, 439)</i>	Mon, Jan. 13 '20 <i>J223 Faculty Lounge</i> <i>10 – 11 am w/Breakfast</i>	
<i>Preliminary Design Review (PDR)</i> <i>Year-Long thesis or project</i> <i>(MAE 442 or 444)</i>	Mon, Jan. 13 '20 <i>J223 Faculty Lounge</i> <i>12 – 5 pm w/Lunch</i>	
<i>Spring final report due</i> <i>(MAE 442, 444)</i>		Wed, Apr. 29**
<i>Posters due to Drop Box</i>		Fri, May 1 by 4 pm
<i>Poster Session:</i> <i>One-semester projects (MAE 340, 340D, 440)</i> <i>and</i> <i>Year-long thesis or project (MAE 442, 444)</i>		Wed, May 6 <i>Friend Center Convocation</i> <i>Room 113</i> <i>Set up 12:30 – 1:30 pm</i> <i>Session 1:30 – 3:30 pm</i> <i>with light Lunch & Snacks</i>
<i>Oral Presentations for Senior Awards</i>		Mon, May 11 <i>J223 Faculty Lounge</i> <i>12 noon – 2:00 pm</i> <i>with Lunch</i>

****University Deadline***

*****University Deadline for Senior Thesis is Monday, May 4.***

****&** (Absolutely no extensions may be granted beyond these dates without the approval of your Residential College Dean/Dean of the College)***

What To Do (Seniors)

For those of you planning on doing only one term of independent work, you should be enrolled in one of the following courses:

- MAE 439 Independent Work (Fall)
- MAE 440 Independent Work (Spring)

Each of these courses will have the following requirements:

- a proposal approved by your adviser
 - a written report to your adviser and reader and an electronic copy to the Undergraduate Office (Jo Ann Love) at the end of the term
 - a poster presentation to the faculty at the end of the term
- These courses are open to Seniors only. You should only enroll if you are doing one semester of independent work.¹*

If you are a senior planning on doing a full year thesis or project you will not enroll in a course in the Fall (you will be allowed to take 3 courses²). In the Spring you must enroll in one of the following courses:

- MAE 442 Senior Thesis (individual effort)
- MAE 444 Senior Project (team or group effort)

Each of these courses will have the following requirements:

- a proposal approved by your adviser
 - a preliminary design review (PDR) presentation to the faculty in January
 - a final written report to your adviser and reader and an electronic copy uploaded to Thesis Central at the end of Spring term**
 - a poster presentation at the end of Spring term**
- ** See report and presentation format document*

Group projects are encouraged when the scope of work is broad enough. This is particularly true of the many student design competitions available. Students interested in doing a team project should enroll in Senior Project in the Spring. Team efforts may be graded either individually, with separate reports on independent aspects of the project from each member, or collectively, with one group report and a single grade assigned to each member. To avoid

¹ Note that some **SENIOR** students will enroll in 439 in the fall with the intent of doing only a single semester project. However, they may find that the scope is more than expected and they want to extend it to a full year. In that event, it is possible to drop 439 (within the drop period), write a progress report instead of final report, and enroll in the spring in one of the full year courses either 442 or 444. For **Juniors and Sophomores**: If you wish to extend your one semester Independent Work project (MAE 339/339D) from fall into spring semester, you should enroll in MAE 340/340D in Spring. You will prepare a written report and present a poster at the end of each term. You will receive a final grade for Fall semester and a final grade for Spring semester. Please be reminded that MAE 339/D or MAE 340/D will not fulfill your senior independent work, senior thesis or senior project requirement.

² For seniors - If you are enrolled in three courses only in fall semester you must enroll in a year-long senior thesis or senior project course in Spring semester. You will not be allowed to drop down to a one semester project in Spring without incurring a failure for fall semester. In other words, you are committed. In Spring you must enroll in three courses plus senior thesis or senior project (which count as two courses). Therefore your senior year course load will be 3 in fall, 5 in spring as opposed to 4 in fall, 4 in spring. For seniors selecting the 3 courses in fall option, there are NO exceptions to this rule even if your total number of courses will exceed 36.

confusion, decide early in the term with your adviser and co-members how your group wishes to be graded.

Only individual reports may qualify as a Senior Thesis, which is normally completed at the end of individual projects. One term independent work may be done either individually or in teams.

Although you have enrolled in one of two class sessions, there will not be a required bi-weekly class. Rather, there will be meetings scheduled if needed.

Note that one mandatory meeting will take place on Tuesday, September 17, 12:30 to 1:30 pm, Friend Convocation Room #113. Lunch served.

What To Do (Juniors)

For those of you planning on complete junior independent work, you should be enrolled in one of the following courses:

- MAE 339 Independent Work or MAE 339D Independent Work with Design (Fall)
 - MAE 440 Independent Work or MAE 340D Independent Work with Design (Spring)
- These courses do not satisfy the department's Independent Work/Senior Thesis/Senior Project requirement.*

Each of these courses will have the following requirements:

- a proposal approved by your adviser
- a written report to your adviser and reader and an electronic copy to the Undergraduate Office (Jo Ann Love) at the end of the term
- a poster presentation to the faculty at the end of the term

Although you have enrolled in one of two class sessions, there will not be a required bi-weekly class. Rather, there may be meetings scheduled if needed.

Note that one mandatory meeting will take place on Tuesday, September 17, 12:30 to 1:30 pm, Friend Convocation Room #113. Lunch served.

Choosing a Topic

You should spend the first few weeks of the term determining the topic for your work. The faculty is your greatest resource in this effort! Please see as many professors as you can to discuss any and all areas that interest you. Their doors are always open and they have exciting projects they wish to share with undergraduates, whether or not they have listed some in the handout.

There are four avenues currently available to you for your independent work projects: student initiated, faculty inspired research, competitions, and projects of benefit to society. None of these are better or worse than others and you will not be evaluated on your choice of topic – only on the quality of your work. However, keep in mind that some projects may be more involved than others. Whichever way you go, remember that you must have a faculty member as an adviser for any project as well as a faculty reader (you choose your adviser but the

reader will be assigned to you closer to the report deadline). It is up to you to find a faculty member willing to take you on before you submit your independent work proposal.

(a) Student Initiated Work

Some of you may already have ideas or inventions you wish to pursue. These may be interests you brought with you to Princeton, ideas that emerged out of your sophomore or junior lab work, or something that came to you in the shower this morning. The only restrictions on your topic are that it has clearly defined mechanical or aerospace engineering content and that you are able to find a faculty member willing to advise you (or your group). There have been many original and interesting projects in the past and if you have an interest in pursuing your own ideas I encourage you to review some past reports and discuss your ideas with the faculty.

(b) Faculty Inspired Research

The faculty members of the Department have a myriad of interests and research opportunities. This is an excellent way to participate in an exciting project and learn what academic research is like. The faculty members are always thrilled to discuss their research interests with students. A list of faculty interests and sample projects are on the blackboard web site. If any of these interest you, seek out the professor and discuss it. Note that most students have historically developed their projects this way.

(c) Competitions

There are also numerous student competitions sponsored by professional organizations around the Country, which may be of interest to you. MAE has an excellent history of participation in these competitions with many successes. Limited funding may be found to send some successful projects to the national competition in the Spring or Summer. Most competitions involve teams of 3 or 4 students, so keep that in mind. Many have monetary prizes for the winner.

If you are interested in this type of project, I encourage you to explore the Web to discover what opportunities are available. For instance, ASME and AIAA have websites devoted to listing various national competitions. We also try to email to you announcements as they become available.

Be forewarned – while these projects can be great fun and rewarding, *they are very competitive and often involve a tremendous amount of work* with many late nights in the shop. Balance your time accordingly. The deadlines approach quickly, so stay on top of it!

(d) Projects of Benefit to Society

For projects of this kind check with: individual faculty; Program for Community-engaged Scholarship ProCES <https://proces.princeton.edu/>; and Office of Sustainability (Campus as Lab) <https://sustain.princeton.edu/lab>

Proposals

Your proposal is due by the end of the third week of the term. **It must be signed by your adviser before being submitted or your adviser must send their approval via email to Prof. Martinelli and Jo Ann Love.** The proposal should be a short, one or two-page work plan explaining the objectives of your project and how you plan to accomplish them by the

end of the term. It must be sufficiently detailed to allow us to determine whether the project is adequate in scope and content.

The proposal should include the title of your project, your name and class, the course name and number, and the date. It is particularly important that you indicate if you are enrolled in the one term independent work courses or whether you are planning a full year project. It should also specify the adviser for your project. We will assign second readers toward the end of the term. Note that it is allowable to have advisers outside the Department as long as your proposal shows adequate mechanical or aerospace content to your project. In that event, your reader must be an MAE faculty member.

The body of the proposal should clearly and concisely describe your project. Be specific about the scope of the proposed work, how you expect it to fit within the time constraints, and what the objectives of the project are. Try to limit the amount of background material to only what you feel is necessary. If you expect to be making any purchases, please include your best estimate at a budget. A schedule of meetings with your adviser would also be worthwhile.

Financial Support and Other Resources

There are resources available to help you in completing your independent work project. Rooms C131 and a portion of J209 have been outfitted as an undergraduate design center and independent work lab. They are equipped with workstations, PCs, audio visual capability, and lab benches. Most software packages you will need are installed (Matlab, Pro-E, Lab View, etc). You will be expected to use these facilities for your lab work unless you have made other arrangements with your adviser. The other undergraduate lab facilities are **not** available for independent work unless you have explicit permission from the responsible faculty or staff (Prof. Littman, Prof. Martinelli, Mike Vocaturo, Glenn Northey, or Jon Prevost). We will assign one professional technical staff member to each project. He will be your primary point of contact for technical issues relating to equipment, testing etc. For those students working in a faculty members' research laboratory, your point of contact will be the research lab. Together with your faculty adviser, they will provide you with the necessary support for your project.

We recognize that many projects may involve costs outside the ability of students. The Department has made available \$200 for each student per semester to spend on independent work. Thus, a group of 5 has \$1000 available in a semester. Note that there are two restrictions on spending this money:

- 1) The Department will **not** pay for **any** travel expenses, regardless of distance (except possibly for travel to national competitions).
- 2) Students are responsible for all materials & services relating to production of their report (we do not require binding). We will order posters in bulk and will cover the cost of your poster.

For projects requiring funds above the Departmental allotment, there are other sources available. For projects in established research programs, the faculty may choose to support the work. The Department also offers the John Marshall II Memorial Prize fund and the

McKinzie prize fund in the fall and spring. The award provides financial support for independent work. Applications and deadlines are announced early in the fall term. There are also a variety of other funds available both within and outside the Department. For example, in the past, the Princeton Environmental Institute has offered thesis support and the School of Engineering through Dean Bogucki's office and the Keller Center. Additionally, students may search for funding through the University's Student Activities Funding Engine (SAFE) portal at: www.princeton.edu/studentfunding/

Finally, after midterms the Department will accept proposals for integrative funds. Note that your advisers must sign the funding proposals before your submission. Your proposal must include as detailed a budget as possible for how you intend to spend the money requested.

How to Order – Important!

The MAE Business Center will be placing your orders for independent work. See the Independent Work Blackboard site for instructions on how to place an order.

Safety

(a) Use of E-Quad Courtyard for Testing Projects

If you need to use the E-Quad courtyard to test your project you must obtain permission at least one week in advance (no ifs, ands, or buts). You may request several dates on one form but the first testing date must be at least one week in advance. These are not MAE rules they are the School of Engineering's rules. Please follow them or you may not be allowed to test. You will also need to arrange for a safety officer to be present in addition to your faculty adviser. The form to request permission is posted on the blackboard site for Independent Work: MAE-IW_F2020 Independent Work. <https://blackboard.princeton.edu/webapps/login/>

(b) Laboratory Safety Training

All students must have completed laboratory safety training to work in any faculty member's research laboratory or undergraduate teaching laboratories. If you have not received lab safety training, please complete the online modules and schedule to attend the final session offered in a classroom. Be sure to sign in or swipe your ID card so that there is a record of your attendance. <http://web.princeton.edu/sites/ehs/LabPage/training.htm> Click on Laboratory and Research on the bar above, then Training for Laboratory Personnel, then General Laboratory Safety, Click on Employee Learning Center. Log in with your NET ID and password and to enter the Employee Learning Center, Click on Training by Department, Laboratory Safety, Click on the plus to view the modules.

(c) Flying Policy

<http://drones.princeton.edu/> Information is also available on the IW Blackboard Site under Course Materials "sUAVPolicy, Procedures, Permission, How & Where to Fly".

Grading Policy and Presentation Guidelines

Students enrolled in Fall one-semester independent work (339, 339D, or 439) or Spring one-semester independent work (340, 340D, or 440) will submit a final report at the end of the

respective term. They will also present their work to the faculty at a poster session in either January (fall project) or May (spring project).

The final grade is a composite of grades on your written report by the adviser and reader and the oral presentation grade taken as an average of the faculty attending (with the highest and lowest grades dropped). The weightings are as follows:

- Adviser: 50%
- Reader: 25%
- Poster: 25%

Note that you will not be graded on the originality of your invention or on how your research changed the world. You will be graded on your clarity of thought, quality of work, scholarship, and effectiveness of presentation.

Year-long Senior Thesis and Senior Project students (MAE 442 and MAE 444) will give an oral presentation which is a preliminary design review (PDR) in front of the faculty in January. At the end of spring term you will hand in a final written thesis (or project) to your adviser and reader and give an oral presentation (poster session) to the faculty. The final grade is a composite of grade based on the written report by the adviser and reader and the oral presentation grade taken as an average of the faculty attending (with the highest and lowest grades dropped). The weightings are as follows:

- PDR: 15%
- Adviser 45%
- Reader: 20%
- Poster: 20%

(a) Written Grades

Your written report will be graded on originality, completeness, technical quality, scholarship, writing quality, and design. (Those students enrolled in MAE 339 or MAE 340 will not be graded on design). Also on the blackboard site are the grading sheets handed to your advisers and readers with your reports. These grading sheets explain each of the criteria and how they are weighted.

(b) Poster Grades

Your poster will be graded on knowledge, technical quality, presentation quality, ability to propose future directions, and quality of question responses. A sample scoring sheet is posted on the blackboard site. Faculty members attending the poster session will be assigned to certain posters and asked to submit scores. The overall grade on the poster will be found by averaging the scores for each faculty member and input from your adviser.

Lastly, seniors will be judged and nominated for the prestigious Donald Janssen Dike Award and John Marshall II Memorial Award. Following the poster presentation, the faculty will nominate a few of the top projects as finalists for the competition. The selected students will be required to deliver a public oral presentation of their work the following Monday. Awardees will receive a cash prize and a Certificate of Accomplishment. As noted earlier, the top senior thesis (written work) will also be awarded the McKinzie Prize (for students enrolled in senior thesis only). All of these prizes are announced and awarded on Class Day.

Oral Presentations for Senior Awards Guidelines

Please keep in mind the following guidelines for the length of your presentations:

All presentations (whether an individual, group or team project) will be 10 minutes in length. Following your presentation we will allow two questions from the audience.

Final Thoughts

Please don't be overwhelmed by the details in this memo. Independent work is supposed to be a fun and exciting culmination of your studies. I assure you, it will be the highlight of your MAE experience. I, Jo Ann, and Theresa will also be sure to send out reminders to you, as the important deadlines approach.

Remember that I am here to help you. I encourage all of you to discuss your ideas with me before submitting your proposals, and feel free to stop by any time with questions or concerns.

Have fun!

Gigi