

# Graduate Study Manual



## M.S. and Ph.D.

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<http://www.mae.okstate.edu>

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# Welcome Letter

Dear Student:

Welcome to the Oklahoma State University School of Mechanical and Aerospace Engineering (MAE) Graduate Program! You have joined a diverse, highly motivated group of faculty, staff, and students. The School of MAE includes scholars from across the world with a wide variety of background, skills, and ambitions. We anticipate your scholarship and determination will continue to add richness to our elite Program.

Please use this manual as a reference resource. This information has been compiled to provide a brief overview of Graduate requirements that will satisfy the University, Graduate College, Registrar, and the School of MAE.

As you pursue your degree, you will find that University and departmental information is continually being changed and updated. These updates are often posted on websites and bulletin boards outside offices such as the MAE office, the Graduate College, and the International Students and Scholars (ISS) office. Also, impending information is occasionally delivered to students through e-mail or postal mail. For this reason, it is imperative that your local contact information be kept up-to-date with both the School of MAE and the University.

The School of MAE will assist you in many areas of your Graduate studies. However, please be aware that, ultimately, it is your responsibility to know and satisfy all MAE, Graduate College, University, and Immigration and Naturalization Services (INS) requirements for attaining your degree.

Sincerely,



Afshin J. Ghajar, Ph.D., P.E.  
Regents Professor and Director of MAE Graduate Studies

# Admission Procedures

To qualify for admission to the Graduate Program in Mechanical and Aerospace Engineering (MAE), you must possess a degree from a recognized college or university and rank in the upper ten percentile of your class or have a “B” average in your studies. Master’s applicants must have a Bachelor’s degree in Engineering, and Doctoral applicants must have a Master’s degree in Engineering. As a Doctoral applicant, you must also have an advisor before you can be fully admitted. Your application will be distributed among MAE Faculty in your area(s) of interest, and if an appropriate Faculty member needs a Ph.D. student, he or she might choose to be your advisor.

The fastest and easiest way to apply to Oklahoma State University's Graduate Program is through the online application site. Please go to [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu) to submit your application. You must create a user account before you can apply.

The application fee and all of the following documents must be submitted directly to the Graduate College to receive admission consideration:

- TOEFL scores [Not required for OSU Graduates]
- GRE scores [Not required for OSU Graduates]
- One original transcript from each college or university attended (in English)
- Statement of Purpose clearly indicating one of the six areas of study you are interested in pursuing (Aerodynamics & Flight Dynamics, Applied Mechanics & Design, Biomechanics, Biofluid & Biomaterials, Dynamics & Control, Manufacturing & Materials, Thermal & Fluid Sciences)
- Resume
- Three letters of recommendation (typed on official institution or corporation letterhead) [Not required for OSU Graduates]

To expedite the processing of your application, please do not include copies of project reports or awards and certificates you have received. If you would like to highlight specific accomplishments, please include them in bulleted format in your resume. We suggest that international applicants submit their applications by March 1<sup>st</sup> for fall admission and August 1<sup>st</sup> for spring admission in order to receive their I-20's in a timely manner.

Upon acceptance, you will automatically be considered for a teaching assistantship. *Please do not correspond with our department about possible financial aid.* We will immediately mail an official letter (to the address listed on your Graduate application) if you have been awarded an assistantship. To receive a research assistantship the applicant must directly contact the MAE faculty in their area(s) of interest. Master’s students will not, generally, be offered a research assistantship until after demonstrating at least a semester of hard work, motivation, and research proficiency within coursework and the laboratory setting. Doctoral applicants are usually offered research assistantships at the same time the applicant is admitted to the MAE Graduate Program.

Your application materials will be collected at the Graduate College, processed, and then sent to the MAE department for further processing. The Graduate College will inform you if they have not received a necessary portion of your application within a reasonable amount of time. Once a decision has been made as to your admission, the Graduate College will immediately send you confirmation. Please do not correspond with the School of MAE regarding admission status - we cannot provide unofficial results.

# Graduate Faculty

Name	Education	Area(s) of Interest
Arena, A.S. Professor Member of Graduate Faculty	Ph.D., Notre Dame University M.S., Notre Dame University B.S., University of Arizona	Flight Dynamics/Control Aerodynamics Aircraft Performance
Chambers, F.W., P.E. Associate Professor Member Graduate Faculty	Ph.D., Purdue University M.S., University of Pennsylvania B.S., Purdue University	Fluid Mechanics Heat Transfer Acoustics
Cremaschi, L. Assistant Professor Member Graduate Faculty	Ph.D., University of Maryland M.S., Univ. of Modena & Reggio Emilia, Italy	Thermal Fluid Systems Energy System Optimization HVAC Systems & Equipment Micro-Refrigeration Systems & Pumps
Delahoussaye, R.D. Adjunct Associate Professor Assoc. Member Graduate Fac.	Ph.D., Oklahoma State University M.S., Georgia Tech. B.S., Louisiana Tech.	Computer-Aided Design Design Optimization Robotics, Mechanisms
Fisher, D.E. Professor Member Graduate Faculty	Ph.D., University of Illinois M.S., University of Illinois B.S., University of Illinois	Thermal/Fluid Systems Building Systems Simulation Energy Conservation
Ghajar, A.J., P.E. Regents Professor Member Graduate Faculty	Ph.D., Oklahoma State University M.S., Oklahoma State University B.S., Oklahoma State University	Heat Transfer in Two-Phase Flow Heat Transfer in Mini/Micro Channels Mixed Convection Heat Transfer Computational Heat Transfer
Good, J.K., P.E. Professor Member Graduate Faculty	Ph.D., Oklahoma State University M.M.E., Oklahoma State University B.S., Oklahoma State University	Web Mechanics, Machine Design Structures/Dynamics Experimental Stress Analysis
Hanan, J. Assistant Professor Member Graduate Faculty	Ph.D., California Inst. Of Technology M.S., California Inst. Of Technology B.S., Oklahoma Christian University	Materials Science Composites and Interfaces Data Reduction/Image Processing Non-Destructive Evaluation
Harimkar, S.P. Assistant Professor Member Graduate Faculty	Ph.D., University of Tennessee M.S., Indian Institute of Science B.S., Visvesvaraya National Institute of Technology	Laser Processing of Materials Surface Engineering Biomaterials Nanotechnology
Hoberock, L.L., P.E. Professor and Head Member Graduate Faculty	Ph.D., Purdue University M.S., Purdue University B.S., Univ. of Missouri-Rolla	Dynamics Systems & Controls Drilling Mechanics Robotics
Jacob, J.D., P.E. Associate Professor Member Graduate Faculty	Ph.D., Univ. of California – Berkeley M.S., Univ. of California – Berkeley B.S., University of Oklahoma	Aerodynamics Flow Control Vortex Dynamics Bio-Fluid Mechanics
Kalkan, K. Assistant Professor Member Graduate Faculty	Ph.D., Pennsylvania State University M.S., Pennsylvania State University B.S., Bogazici University, Turkey	Nanostructured Materials Nanodevices and Nanosensors Molecular Detection/Imaging Biomedical Monitoring
Komanduri, R. Regents Professor Member Graduate Faculty	Ph.D., Monash Univ., Australia M.E., Osmania University, India B.E., Osmania University, India	Manufacturing Processes Machining Tribology

For more information about each Professor's research area(s),  
go to <http://www.mae.okstate.edu/faculty.html> and click on the Professor's "Personal Page" link.  
See also <http://www.mae.okstate.edu/research/facilities.html>.

# Graduate Faculty

(Continued)

Name	Education	Area(s) of Interest
Lilley, D.G., P.E. Professor Member Graduate Faculty	D.Sc., Sheffield University, England Ph.D., Sheffield University, England M.S., Sheffield University, England B.S., Sheffield University, England	Combustion Heat Transfer Computational Fluid Dynamics Swirling Flows
Lucca, D.A. Regents Professor Member Graduate Faculty	Ph.D., Rensselaer Polytechnic M.S., Princeton University B.S., Cornell University	Ultra-Precision Machining Surface Mechanics Process Tribology
Maddalena, L. Professor Member Graduate Faculty	Ph.D., Virginia Tech M.S., Politecnico di Milano, Italy	Mixing, and Combustion in High Speed Flow Rocket Engines Heat Flux Measurements
Pagilla, P.R. Professor Member Graduate Faculty	Ph.D., Univ. of California-Berkeley M.S., Univ. of California-Berkeley B.S., Osmania University, India	Linear & Nonlinear Control Real-time Control Robotics, Mechatronics, Robotics
Rubenstein, D. Assistant Professor Member Graduate Faculty	Ph.D., Stony Brook University M.S., Stony Brook University B.E., Stony Brook University	Tissue Engineering Biofluid Flow Coagulation Cascade Nanofabrication
Sallam, K. Associate Professor Member Graduate Faculty	Ph.D., Univ. of Michigan-Ann Arbor M.S., Univ. of Michigan-Ann Arbor M.E., Cairo University, Egypt B.S., Cairo University, Egypt	Laser Diagnostics Atomization and Sprays Fluid Mechanics Nanotechnology
Singh, R.P. Associate Professor Member Graduate Faculty	Ph.D., University of Rhode Island M.S., University of Rhode Island B. Tech., Indian Inst. of Tech., Kanpur	Solid Mechanics Experimental Mechanics Advanced Materials
Spitler, J.D., P.E. Regents Professor Member Graduate Faculty	Ph.D., University of Illinois M.S., University of Illinois B.S., University of Illinois	Building Energy Analysis Thermal System Simulation Ground Source Heat Pumps
Yin, W. Assistant Professor Member Graduate Faculty	Ph.D., Stony Brook University M.S., University of Akron B.E., Tianjin University, China B.A., Tianjin University, China	Biofluid Flow Cell-Platelet Interactions Inflammatory Responses Multi-scale Modeling
Young, G.E., P.E. Professor Member Graduate Faculty	Ph.D., Univ. of California-Berkeley M.S., Univ. of California-Berkeley B.S., Univ. of California-Berkeley	Dynamic Systems & Controls Uncertain & Nonlinear Systems Real-Time Distributed Control

For more information about each Professor's research area(s),  
go to <http://www.mae.okstate.edu/faculty.html> and click on the Professor's "Personal Page" link.  
See also <http://www.mae.okstate.edu/research/facilities.html>.

# Master's Degree – Progress Sequence

Following is a calendar of requirements compiled from both the Graduate College and the School of Mechanical and Aerospace Engineering. Failure to comply with these requirements in a timely manner will result in an enrollment hold or delay of your graduation. Please adhere closely to the following steps:

## Week of Arrival

1. International Students: Report to International Students and Scholars office (076 Student Union) upon arrival.
2. Report to School of Mechanical and Aerospace Engineering. MAE Assistant to the Graduate Director will provide you with a New Student Information Packet.
3. Meet with MAE Graduate Director (or your pre-approved Advisor) to enroll for the upcoming semester.
4. If you have an assistantship, meet with the MAE Employment Secretary to complete payroll forms.
5. Enroll in courses either online or at the Registrar's Office.

## First Semester of Coursework

1. Select your permanent advisor. (See the "Graduate Faculty" section of this manual in addition to the Professors' Personal Pages at <http://www.mae.okstate.edu/faculty.html>.) Only Members or Associate Members of the Graduate Faculty can serve as principal advisors and assign MAE 5000 Theses and MAE 5010 Creative Component projects.
2. With your advisor, select Thesis or Creative Component option.

## Second Semester of Coursework

Submit original Plan of Study to Graduate College and a copy to the MAE Assistant to the Graduate Director before end of the semester. (Plan of Study can be downloaded from Graduate College website: [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu)) See the "Graduate Plan of Study – General Requirements" and "Master's Degree – Requirements" sections of this manual for guidelines.

## Semester of Graduation

1. Submit final/revised Plan of Study to the Graduate College and a copy to the MAE Assistant to the Graduate Director by the end of the second week of classes. All revisions must be approved and initialed by your Advisor.
2. File diploma application at Registrar's office.
3. Complete and submit Graduation Clearance Form to the Graduate College.
4. Complete requirements for Thesis or Creative Component option. (Go to the Academic Calendar on the Graduate College website to view deadlines for each stage of completion of Thesis option: [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu)) Creative Component must be defended prior to pre-finals week (two weeks before end of semester).
5. Students choosing the Thesis option must pay the electronic submission fee to the Bursar's office.
6. For the students that choose the Thesis option, the committee should complete the M.S. Assessment form and the M.S. Thesis Defense form at the time of your defense. The original Thesis Defense form should be submitted directly to the Graduate College, however, a copy of the Thesis Defense form along with the original Assessment Form should be submitted to the Graduate Academic Secretary. For the students that choose the Creative Component (Report) option, the committee should complete the M.S. Creative Component Assessment form and submit it directly to the Graduate Academic Secretary. Note that the results of the Creative Component Defense are also reported on the Assessment form and there is not a separate form for reporting the results.
7. Complete and return MAE Clearance Form to the Graduate Academic Secretary.

**\*Please see page 17-18 for the current Graduate College Academic Calendar that contains specific deadlines regarding document submission and graduation.**

# Master's Degree – Requirements

The minimal University requirements for the M.S. degree are determined by the Graduate College and can be found in the *University Catalog* (<http://prodosu.okstate.edu>). We, in MAE, have additional requirements in several areas. You have two options for completion of your Master's degree:

## Thesis

A total of 30 credit hours, which includes **24 hours of formal coursework** (regularly scheduled classes, not independent study) and **six hours of MAE 5000** (Thesis) are required for the Thesis Option, see table below.

## Creative Component

A total of 35 credit hours, which includes **33 hours of formal coursework** (regularly scheduled classes, not independent study) and **two hours of MAE 5010** (Creative Component) are required for the Creative Component Option, see table below.

## **Plan of Study**

Before you have completed 17 hours of coursework, you must file an original Plan of Study with the Graduate College. Download and complete a Plan of Study from the Graduate College website: [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu). Your Plan of Study is to be completed with the assistance of your Advisor. You are to collect the signature of your Advisor, two other faculty members, and the MAE Graduate Director, in the order indicated. MAE faculty should comprise a majority of the Committee.

General requirements and procedures are found in the “*Graduate Plan of Study – General Requirements*” section of this manual. MAE Graduate courses are listed on the “*Graduate Course Offerings*” sheet.

Your 30 (Thesis) or 35 (Creative Component) hours of coursework should satisfy the following:

	<b>Mathematics</b> (see “ <i>Graduate Plan of Study – General Requirements</i> ”)	<b>5000- and 6000-level Courses*</b> (see Course Offerings)	<b>Research Hours</b>	<b>(Optional) 4000-level MAE courses</b> (As needed, consult the MAE Graduate Director)
<b>Thesis Option</b>	6 hours	12 to 18 hours	MAE 5000 (6 hours)	6 hours or less of courses approved for Graduate credit (see Course Offerings)
<b>Creative Component Option</b>	6 hours	21 to 27 hours	MAE 5010 (2 hours)	6 hours or less of courses approved for Graduate credit (see Course Offerings)

\* At least 50% of the total required coursework credit hours, **exclusive of report or thesis hours** (ex: 50% of 24 hours for Thesis, and 50% of 33 hours for Creative Component) must be 5000- and 6000-level MAE courses (see Course Offerings).

When completed and signed, you should make two copies of your Plan of Study, for:

- The MAE Assistant to the Graduate Director (to be kept in your MAE student file).
- Your own records (Track revisions and file “Final Revised Copy” of your Study Plan.).

## **Final Examination**

An oral examination is required of all M.S. candidates. All candidates that are to be cleared for graduation in a given semester must be approved for graduation by a majority of the MAE Graduate Faculty. The MAE Graduate Director will poll the faculty and at his/her discretion may choose to call a faculty meeting (if dissent exists). At any faculty meeting, approval for graduation must be by a majority of the MAE Graduate Faculty in attendance.

### **Examining Committee**

The Examining Committee for all M.S. candidates will consist of at least three members of the Graduate Faculty, two of which must be members of the MAE faculty. The Examining Committee will be formed by the major Advisor, in consultation with the MAE Graduate Director. This committee is not necessarily the same faculty who will/have signed your Plan of Study. Any MAE Graduate Faculty has the right to be a voting member of any M.S. Examining Committee. You will be notified beforehand of the assigned Examining Committee, but should be aware that other faculty may participate and may choose to vote.

### **Form of Examination**

You must make a twenty- to thirty-minute presentation of your Thesis or Creative Component, answer questions in open session from the audience, and again later in closed session with the Committee. The Committee may also question you in regards to your understanding of general coursework, ensuring competency within your chosen area(s) of mechanical engineering. The total examination does not usually exceed two hours.

### **Result of Examination**

The Committee will deliberate in closed session at the end of the examination and may announce their recommendation immediately following. A majority vote suffices. *This recommendation must be confirmed by the MAE Graduate Faculty.* The recommendation will be one of the following: 1) pass, 2) retake the examination the following semester, or 3) fail. (The 'fail' recommendation will not be given before the student has had an opportunity to retake the examination.) You must make at least a "B" on your Thesis (MAE 5000) or Creative Component (MAE 5010). The Committee must also make a recommendation concerning study for the Ph.D. degree. Only the Thesis Option M.S. Candidates will be considered for recommendation for the Ph.D. degree.

### **M.S. Thesis or M.S. Creative Component Report Assessment Form**

This assessment was designed by the MAE Graduate Faculty to evaluate M.S. student's research ability and communication skills, both written and oral, upon completion of their M.S. Thesis defense or M.S. Creative Component defense. A copy of this form can be obtained from the Graduate Academic Secretary and should be returned back to her as well.

### **Procedure of Administration**

#### **Thesis Option**

- The OSU Graduate College specifies the correct format for Theses. Go to the Graduate College website for the *Graduate College Thesis Dissertation Manual*: [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu).
- You must follow the specific Thesis deadlines outlined in the OSU University Catalog in the Graduate College section. There are no exceptions to these dates.
- You must submit a final draft, signed by your major Advisor, and a copy of your abstract to each member of your Examining Committee and the Graduate College. You are responsible for obtaining necessary paperwork from the Graduate College and the MAE Assistant to the Graduate Director before your final examination. You must then submit the appropriate paperwork to the Graduate College and the School of MAE.
- Your major Advisor will schedule the examination. Exams will not be scheduled during pre-finals week through the date on which final grades are due for the semester.
- You must post a notice of the exam and send an e-mail notifying MAE Faculty and Assistant to the Graduate Director.
- After you have taken the oral examination and made all corrections recommended by your Committee, submit an electronic copy of the corrected thesis, an original signature page signed by all

of your committee members, and two copies of the abstract to the Graduate College as well as one paper copy of the corrected thesis to the School of MAE.

- You must pay the electronic submission fee to the Bursar's office.
- You should submit the M.S. Assessment form to the Graduate Academic Secretary.
- You must also submit the original thesis defense form to the Graduate College immediately following your defense along with a copy of this form to the Graduate Academic Secretary.

### **Creative Component Option**

- The formats for your Creative Component project and report are at the discretion of your Examining Committee.
- A final draft of the report must be submitted to all members of the Examining Committee one week prior to your exam. The draft must have the signature of your major Advisor indicating that s/he granted approval for distribution to the Committee.
- The report must be in an approved, professional format including a literature that provides an overview of the state of the art.
- Your major Advisor will schedule the examination. Exams will not be scheduled during pre-finals week through the date on which final grades are due for the semester.
- You must post a notice of the exam and send an e-mail notifying MAE Faculty and the Assistant to the Graduate Director.
- You should submit the M.S. Creative Component (Report) Assessment Form to the Graduate Academic secretary, following your committee's evaluation of the Master's Report Presentation. This form is filed with the department only and should not be submitted to the Graduate College.

### **Clearance Form**

The MAE Graduate Clearance Form will be provided to you at the approximate time of your final examination. If you choose to leave the MAE Graduate Program before completing your degree, the Clearance Form still *must* be completed before leaving the campus either when graduating or dropping out of school, or continuing on for your Ph.D. degree. ***It is your responsibility to complete and return the Clearance Form to the MAE Assistant to the Graduate Director. Failure to do so will result in a hold being placed on your graduation and/or your transcript.***

***It is your responsibility to ensure that all deadlines are strictly adhered to throughout the course of your Graduate Program.***

# Doctoral Degree – Progress Sequence

Prior to enrollment in your first semester of Graduate study at OSU, report to the MAE Graduate Director and your assigned Advisor.

## First Eleven Months of Coursework

- Consult with your Advisor regarding selection of your Advisory Committee.
- Enroll in only one (1) hour of MAE 6010 in your Advisor's section for preparation of your preliminary research problem.
- Develop a tentative Plan of Study with the assistance of the MAE Graduate Director and your Major Advisor. See the "*Graduate Plan of Study – General Requirements*" and "*Doctoral Degree – Requirements*" sections of this manual for guidelines.
- Schedule and complete your oral Preliminary Exam.
- Submit an approved copy of your Plan of Study to the Graduate College plus copies to your Major Advisor and MAE Graduate Director.
- Submit a signed Admission to Doctoral Candidacy Form to the Graduate College.

## Halfway Through Your Doctoral Studies

Schedule and take the Qualifying Examination. Sign the Application for Admission to Candidacy (from MAE Assistant to the Graduate Director)

## Semester of Graduation

- Complete your Dissertation.
- Submit a diploma application at the Registrar's office.
- Complete and submit a Graduation Clearance Form to the Graduate College.
- Not later than 6 weeks before the last day of classes, prepare a final draft copy of your Dissertation and submit it at least one week prior to the Examination, along with a copy of the abstract, to each member of your Committee and to the Graduate College. Your Advisor's signature of approval must accompany the copy submitted to the Graduate College.
- The final draft copy of your Dissertation, with one copy of the abstract, must be submitted to the Graduate College two weeks before your Final Oral Examination. The Examination will be administered no less than 4 weeks before the last day of classes. Your Committee will sign the Result of Final Examination Form and your Major Advisor will submit it to the Graduate College.
- No later than 2 weeks before the last day of classes, you must make changes to the Dissertation as required by the Examining Committee and by the Graduate College. Advisory Committee members will sign the signature page of the Dissertation. This signature page, an electronic copy of the Dissertation and two copies of the abstract shall be submitted to the Graduate College, which makes the final decision on acceptance of the Dissertation. It is suggested that the student also provide one paper copy of the corrected thesis to the School of MAE and one to their advisor.
- Pay the electronic submission fee to the Bursar's office.
- Complete and return the "MAE Graduate Clearance Form."

**\*Please see page 17-18 for the current Graduate College Academic Calendar that contains specific deadlines regarding document submission and graduation.**

# Doctoral Degree – Requirements

## **Advisory Committee**

You must select an Advisory Committee. Your Committee must consist of the following:

1. Major professor, or Committee Chairman who is usually the Thesis Advisor.  
The Committee Chairman must be a full member of the Graduate Faculty.
2. A mathematics, engineering (outside MAE), or science professor.
3. A minimum of two additional faculty members from schools or departments related to your field of study. MAE faculty should comprise a majority of the Committee.

## **Preliminary Examination**

### **Proposal**

After appointment of your Committee, your Advisor should call a meeting. The purpose of this initial meeting is to acquaint you with the Committee and begin the preliminary examination procedure. You should present a tentative subject to be used for your research proposal. This topic may be related to your Master's Thesis. It will not necessarily be your final dissertation topic. The intent of the MAE 6010 project and the Preliminary Examination is to demonstrate your ability to prepare a worthwhile research plan. Committee approval of the topic will allow you to promptly begin the proposal for submission and defense (to be completed by the end of the eleventh month in the Ph.D. Program).

### **Credit**

You should enroll in one hour of MAE 6010.

### **Examination**

The Preliminary Examination must be taken within eleven months of enrollment in the Ph.D. Program. The Examination will consist of one or more of the following options:

1. You are required to develop a research proposal. The proposal is expected to be approximately 50 pages (of quality content) in length. The Committee may ask any questions about the proposal as well as any engineering fundamentals, mathematics, or scientific areas covered by previous coursework as deemed necessary to evaluate and verify your potential for continuing in the Ph.D. Program. This proposal will typically be in your interest area, but may or may not be related to your Ph.D. Thesis. This type of Preliminary Examination is designed to determine your abilities to: 1) identify a problem, 2) search the literature, 3) define a theoretical, experimental, and/or computational approach, and 4) plan a research program.
2. As an alternative, or in addition to option 1 (additional if the Committee deems that, after not passing option 1, you should be given another opportunity to pass the Preliminary Examination), the Interviewing Committee may select the topic on which you are to write the proposal. Then, during the summer or between academic semesters, the Committee will provide you the topic two or three weeks before the proposal is due. During that two or three weeks, you are to work intensively and exclusively on this proposal, understanding the topic, searching the literature, carefully formulating the problem, and writing a potential research plan and/or solution procedure. At the conclusion of the two or three weeks, you will deliver your written document to the Committee. Two days later, you will orally present the proposal to the Committee. The proposal is expected to be approximately thirty pages (of quality content) in length. Similar to option 1, the Committee may ask any relevant questions about the proposal and/or coursework as deemed necessary to evaluate and verify your potential for continuing in the Ph.D. Program.

3. A series of written exams, taken over a two or three day time period, may be required of any student whom the Committee discovers to have a weak background in any area of previous coursework in engineering fundamentals, mathematics, or science. The Committee may have identified this weakness in background from informal interviews, examination of your transcripts, or through the formal Preliminary Examination process or option 1 or 2 above. One month in advance of these written exams, the Committee shall specify the coverage of the exams, what is considered to be a passing grade on these exams, and the rules for taking the exams (ex: allowance for open books and/or crib sheets, and length of time given).
4. A series of oral exams, taken over a two or three day time period, may be required of any student whom the Committee discovers to have a weak background in any area of previous coursework in engineering fundamentals, mathematics, or science. The same comments made with regard to written exams (in option 3 above) are applicable for oral exams, with regard to identification of weakness(es), potential breadth of exams, notice to the student, and Committee participation.

If the Committee gives you a second chance to pass the Preliminary Examination, by allowing you to take any one of options 1, 2, 3, or 4, and the Committee's assessment is that, as a result of that second chance, you do not receive an A or a B on the Preliminary Examination, there will be no third opportunity to take the Preliminary Examination. You will automatically be removed from the Ph.D. Program in the School of MAE.

#### **Objectives of the Examination**

1. Redirect candidates with poor prospects of success in the Ph.D. Program before the students have made large investments of time and resources.
2. Provide a focal point for the student's Committee to evaluate his/her potential and consider his/her Plan of Study.
3. Demonstrate the student's familiarity with literature, ability to organize a research proposal, competence in oral and written communication, and his/her understanding of engineering fundamentals, mathematics, and areas of science related to his/her chosen field of specialization.

#### **Grade**

A or B	Encouraged to continue Ph.D. Program
I	Conditional continuation in Ph.D. Program, with a reevaluation during the following semester under options 1 or 2, or with a reevaluation within a month under options 3 and/or 4
C, D, or F	Termination of Ph.D. Program

#### **Preliminary Examination Report**

The Committee will complete the "Preliminary Examination" results form and return to the Graduate Academic Secretary immediately following the defense.

#### **Length of Examination**

The oral exams of options 1 and 2 can last up to four hours in duration. The battery of written and oral exams of options 3 and 4 can be up to 12 hours each in duration.

#### **Overall Time Limit**

***The maximum time that a student can take to complete the Preliminary Examination is 16 months after enrollment in the Ph.D. Program.*** If the student has not passed the Examination within that time, the student will automatically be removed from the MAE Ph.D. Program.

## Plan of Study

- Your proposed plan should be organized with the assistance of the MAE Graduate Director and your Major Advisor prior to the Preliminary Examination. The proposed plan should be developed prior to enrollment in the second semester beyond the M.S. degree.
- Download a Plan of Study from the Graduate College website ([www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu)) and include the requirements listed within this section and the “*Graduate Plan of Study – General Requirements*” section of this manual. MAE Graduate courses are listed on the “*Graduate Course Offerings*” sheet.
- Upon successful completion of the Preliminary Examination, you must file an approved Plan of Study with the Graduate College. Your plan must be submitted to the Graduate College before you have completed 28 hours of coursework. A copy should be filed with the MAE Assistant to the Graduate Director.
- Changes to your Plan of Study may be made with the approval of your Ph.D. Committee when your interests or course offerings require such changes.

### Your Ph.D. Plan of Study must contain:

1. At least 60 hours of acceptable Graduate work beyond the M.S. Degree, not more than 30 hours of which can be research (MAE 6000).
2. At least 24 hours of 5000- and 6000-level coursework beyond the M.S. Degree.
3. MAE 5000- and 6000-level courses for at least 50% of Graduate coursework.
4. A minimum of 6 hours of mathematics beyond the requirements for the OSU M.S. Degree.

Your hours of Doctoral coursework must include the following:

<b>Mathematics</b> (see “ <i>Graduate Plan of Study – General Requirements</i> ”)	<b>5000- and 6000-level Courses</b> (see Course Offerings)	<b>Research Hours</b>
6 hours	24 to 30 hours (at least 50% of Graduate coursework must be MAE)	MAE 6000 (24-30 hours)

## Ph.D. Candidacy Form

To be admitted to candidacy, a doctoral student must have (1) an approved Plan of Study on file with the Graduate College and (2) satisfactorily completed the Preliminary Exam.

As part of fulfilling degree completion requirements, a Ph.D. student must successfully complete (grades of ‘SR’) at least 10 hours of dissertation (MAE 6000) coursework after being admitted to candidacy. If a student is admitted to candidacy prior to the end of the eighth week of a regular semester or prior to the end of the fourth week of an eight-week summer session, one-half of the dissertation credits taken that term can be counted toward this minimum hour requirement. It is recommended that this form is completed immediately following successful completion of the Preliminary Exam.

## Qualifying Examination

### Written Examinations

Optional [exercised by your Committee]; required when any member of your Advisory Committee or the MAE Graduate Committee deems necessary to:

- Remove all doubt as to significant weaknesses in a student’s academic qualifications.
- Evaluate a student’s qualification in an area with respect to other candidates.

### Oral Examination

Required; includes a defense of the proposed Thesis subject, scope, and strategy; establishes the student’s qualification to undertake his/her proposed research.

### Typewritten Prospectus

Required; a typewritten prospectus must be submitted to each member of your Committee. The prospectus must contain:

1. Definition of Thesis problem
2. Background and literature survey
3. Strategy for completion of Degree
4. Outline of proposed study

This prospectus should have greater depth and detail than the MAE 6010 proposal presented at the Preliminary Exam, and must contain partial analysis or some experiments and computations to prove the feasibility of the methods chosen. ***However, the Qualifying Exam must not be delayed until work is completed – it must be taken not less than six months before Dissertation Defense.***

### Report of Qualifying Examination

The Committee will complete the “Qualifying Examination” results form and it should be returned to the Graduate Academic Secretary.

### **Dissertation**

***Not later than six weeks before the last day of classes***, prepare a final draft copy of the dissertation and submit it at least one week prior to the Final Examination, with a copy of the abstract, to each member of the Committee and to the Graduate College (check the Graduate College website and *Graduate College Thesis Dissertation Handbook* at [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu) for exact draft and final copy due dates). The Advisor’s signature of approval must accompany the copy submitted to the Graduate College.

The final draft copy of the dissertation is to be submitted electronically to the Graduate College two weeks before the Final Examination results are due. An original signature page signed by all Committee members should also be turned in to the Graduate College at this time along with two signed copies of the abstract. All Committee members sign the Results of Final Exam Form. The examination must be administered ***no less than 4 weeks before the last day of classes.***

### Preparation of Dissertation

The preparation of the dissertation is the private business of each individual Graduate student. No departmental secretarial effort may be applied to this activity. This includes any verbal contact and/or discussion during office hours and rough drafting of preliminary dissertation copy. In the event that all or a part of any dissertation may be used for a project report, the project leader may wish to purchase masters and provide some drawing and/or photographic assistance from project funds. Extra copies of the project may be purchased directly from duplicating services from project funds.

### **Final Examination**

The final examination is used to determine the validity and significance of the research and whether you have demonstrated initiative and creative intelligence. **Note that the final defense should be scheduled no earlier than 6 months after successful completion of the Qualifying Examination and completion of 10 hours of MAE 6000 beyond filing the Admission to Doctoral Candidacy form.**

Your Final Oral Examination must be taken prior to the last week of classes. No oral exams will be given from one week before the end of classes through the date on which final grades are due for that semester. If you complete all requirements for your Thesis between semesters, you must enroll for 2 hours in the following semester (international students must retain full-time status).

### Implementation

You must present a formal oral presentation to interested Faculty and Graduate students in the presence of your Committee.

- In general, the presentation will be based on your technical paper draft.
- Visual aids should be used wherever possible.
- The presentation must not exceed 30 minutes.
- The formality of the presentation should be the same as would exist at a technical society meeting.

- You must post announcements of the oral exam, and notify Faculty by e-mail no less than three days prior to the Exam.

You will be expected to defend your thesis by answering questions from the audience and your Committee, typically for less than 90 minutes.

After the presentation and discussion period, you will meet with the Committee privately for deliberation and possible further questioning.

The Committee must make one of the following recommendations:

1. Recommend for graduation (possibly signing the Dissertation after typographical errors have been corrected).
2. Require revisions and/or additions to the work with a re-examination at a later date.
3. Reject from the Program.

A grade point average of 3.0 is required for coursework on the Plan of Study, as well as an average of 3.0 on the research (MAE 6000).

You must pay a \$50 electronic submission fee to the Bursar's office before submitting the final draft of your dissertation.

### **Deadlines**

1. Not later than 6 weeks before the last day of classes, prepare a final draft copy of your dissertation and submit it at least one week prior to the examination, along with a copy of the abstract, to each member of your Committee and to the Graduate College. The first page of the draft and abstract should be signed by the Major Advisor.
2. The final draft copy of your dissertation, with one copy of your abstract, will be submitted to the Graduate College two weeks before the Final Oral Examination. The examination must be administered no less than 4 weeks before the last day of classes. The Committee will sign the Results of Final Examination Form and your Major Advisor will submit it to the Graduate College.
3. No later than 2 weeks before the last day of classes, you must make final changes to your dissertation as required by your Examining Committee and the Graduate College. Advisory Committee members will sign the signature page of your dissertation. The dissertation shall be submitted electronically to the Graduate College, which makes the final decision on acceptance of the dissertation. You will submit two approved copies of the Abstract signed by your Major Advisor and the original signature page of your dissertation to the Graduate College.

### **Publications**

You are strongly encouraged by the School of MAE and the University to publish technical papers based on the research obtained through your Dissertation prior to your final defense.

# Graduate Plan of Study – General Requirements

The following general requirements pertain to both the M.S. and Ph.D. Plans of Study.

## Mathematics Requirement

Minimum of six credit hours of Mathematics. The following courses are approved:

MATH 4013, Engineering Mathematics; Calculus of Several Variables (prerequisites: MATH 2163, 3013)  
MATH 4023, Introduction to Modern Analysis (prerequisites: MATH 2163, 3013)  
MATH 4153, Advanced Calculus II (prerequisite: MATH 4143)  
MATH 4233, Engineering Mathematics; Intermediate Differential Equations (prerequisites: MATH 2233, 3013)  
MATH 4283, Complex Variables (prerequisite: MATH 4013)  
MATH 4553, Linear & Non-Linear Programming (prerequisites: MATH 2163, 3013)  
Any MATH 5000- or 6000-level course

MAE 5093, Numerical Engineering Analysis (prerequisite: Undergraduate course in computer programming and consent of instructor) may also be used to satisfy your mathematics requirement in the MAE graduate program. If MAE 5093 is used to satisfy your mathematics requirement, it will not also count as a MAE 5000-level course requirement.

You may partially satisfy the mathematics requirement by the following courses in computer science, statistics, or physics, if approved beforehand by your advisor and the MAE Graduate Director.

Courses that may be approved to partially satisfy the mathematics requirement are:

CS 5513, Numerical Analysis I (prerequisite: CS 4513)  
STAT 5053, Time Series Analysis (prerequisite: STAT 4043)  
STAT 5063, Multivariate Methods (prerequisites: STAT 4023, 4043, 5023)  
STAT 5133, Stochastic Processes (prerequisites: MATH 2233, 3013, STAT 5123)  
(Same course as MATH 5133 and IEM 5133)  
Any STAT 6000-level course  
PHYS 5453, Methods of Theoretical Physics (prerequisite: PHYS 3513)

Only those courses listed for Graduate credit in the OSU University Catalog (having an asterisk) and acceptable to the student's advisor can be used on the Study Plan. DO NOT take non-MAE or MATH courses without *prior* approval of your advisor and the MAE Graduate Director.

Your mathematics requirement may be waived by the MAE Graduate Director, if you have received prior credit for taking advanced mathematics courses as Undergraduate electives.

## Revisions to Plan of Study

Your major Advisor and the MAE Graduate Director must approve all changes to a student's Plan of Study *before* you enroll in any course not on your existing Plan of Study. (Documentation of prior approval must be initialed and dated by your major Advisor.) Approval WILL NOT be given retroactively.

## Withdrawing from a Course

You may withdraw from a course that is listed on your Plan of Study, with prior approval from both your major Advisor and the MAE Graduate Director. When doubt exists regarding your explanation, the issue will be brought before the MAE Graduate Faculty. International students are required, by INS rules, to carry a full load throughout each semester.

**Grade Point Average (GPA)**

You must make at least a 3.0 grade point average in the coursework listed on your Plan of Study, exclusive of Thesis and Creative Component hours.

Graduate students are expected to demonstrate a planned and orderly program for matriculation as indicated by enrollment. Even part-time students are expected to satisfactorily complete no less than six semester credit hours during each academic year.

You are also responsible for following additional regulations, as listed in the OSU University Catalog. These regulations cover such issues as maximum and minimum hours of enrollment, enrollment regulations for Teaching and Research Assistants, residence requirements, and time limits.

**Research Grades (effective August 18, 2008)**

At the end of each semester, MAE 5000/6000 courses will receive either a grade of "SR" (for Satisfactory Research) or "UR" (for Unsatisfactory Research). Only hours that have received a grade of "SR" can be used on a student's Plan of Study. Grades for research hours will not be calculated into the student's GPA.

A student who receives a research grade of "UR" will be subject to the following disciplinary actions:

- M.S.** – After three total hours of MAE 5000 resulting in a grade of "UR" the student will be placed on Academic Probation. Subsequently, after six total hours of MAE 5000 resulting in a grade of "UR" the student will be terminated from the MAE Graduate Program.
- Ph.D.** – Following the completion of the Preliminary Exam, a student earning six total hours of MAE 6000 resulting in a grade of "UR" will be placed on Academic Probation. Subsequently, after earning 12 total hours of MAE 6000 resulting in a grade of "UR", the student will be terminated from the MAE Graduate Program.

Creative Component hours can be assigned a grade of "R" until the final project is presented and graded. After the project is completed, the MAE 5010 hours will receive the appropriate letter grade corresponding to the quality of work as determined by the committee's assessment.

# Graduate College Academic Calendar

## Fall 2009 Semester

<b>Date</b>	<b>Event</b>
August 17, Monday	Class work begins
October 16, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
October 30, Friday	Last day to file a diploma application with the Registrar's office
October 30, Friday	Last day to file revised plan of study (if needed) and Graduation Clearance form to Graduate College
November 6, Friday	Admission to doctoral candidacy for Spring due in Graduate College (for students with approved plans of study dated before January, 2009)
November 20, Friday	Results of Thesis/Dissertation Defense Forms due in Graduate College
December 4, Friday	Online submission of electronic dissertation or thesis due
December 11, Friday	Class work ends
December 11, Friday	<b>Graduate Commencement</b>

## Spring 2010 Semester

<b>Date</b>	<b>Event</b>
January 11, Monday	Class work begins
January 29, Friday	Admission to doctoral candidacy for Summer due in Graduate College (for students with approved plans of study dated before January, 2009)
March 12, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
April 1, Thursday	Last day to file a diploma application with the Registrar's office
April 1, Thursday	Last day to file a revised plan of study (if needed) and Graduation Clearance Form to Graduate College
April 23, Friday	Results of Thesis/Dissertation Defense forms due in Graduate College
April 30, Friday	Online submission of electronic dissertation or thesis due
May 7, Friday	Class work ends
May 7, Friday	<b>Graduate Commencement</b>

## Summer 2010 Semester

<b>Date</b>	<b>Event</b>
June 7, Monday	Class work begins
June 18, Friday	Admission to doctoral candidacy for Fall due in Graduate College (for students with approved plans of study dated before January, 2009)
June 18, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
July 1, Thursday	Last day to file a diploma application with the Registrar's office
July 1, Thursday	Last day to file a revised plan of study (if needed) and Graduation Clearance Form to Graduate College
July 16, Friday	Results of Thesis/Dissertation Defense forms due in Graduate College
July 23, Friday	Online submission of electronic dissertation or thesis due
July 30, Friday	Class work ends

### **Fall 2010 Semester**

<b>Date</b>	<b>Event</b>
August 23, Monday	Class work begins
October 22, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
November 1, Monday	<i>Last day</i> to file a diploma application with the Registrar's office
November 1, Monday	<i>Last day</i> to file a revised plan of study (if needed) and Graduation Clearance Form to Graduate College
November 5, Friday	Admission to doctoral candidacy for Spring due in Graduate College (for students with approved plans of study dated before January, 2009)
December 3, Friday	Results of Thesis/Dissertation Defense Forms due in Graduate College
December 10, Friday	Online submission of electronic dissertation or thesis due
December 17, Friday	Class work ends
December 17, Friday	<b>Graduate Commencement</b>

### **Spring 2011 Semester**

<b>Date</b>	<b>Event</b>
January 10, Monday	Class work begins
January 28, Friday	Admission to doctoral candidacy for Summer due in Graduate College (for students with approved plans of study dated before January, 2009)
March 11, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
April 1, Friday	<i>Last day</i> to file a diploma application with the Registrar's office
April 1, Friday	<i>Last day</i> to file a revised plan of study (if needed) and Graduation Clearance Form to Graduate College
April 22, Friday	Results of Thesis/Dissertation Defense Forms due in Graduate College
April 29, Friday	Online submission of electronic dissertation or thesis due
May 6, Friday	Class work ends
May 6, Friday	<b>Graduate Commencement</b>

### **Summer 2011 Semester**

<b>Date</b>	<b>Event</b>
June 6, Monday	Class work begins
June 17, Friday	Admission to doctoral candidacy for Fall due in Graduate College (for students with approved plans of study dated before January, 2009)
June 17, Friday	FORMAT REVIEW DRAFT of dissertation or thesis due in Graduate College
July 1, Friday	<i>Last day</i> to file a diploma application with the Registrar's office
July 1, Friday	<i>Last day</i> to file a revised plan of study (if needed) and Graduation Clearance Form to Graduate College
July 15, Friday	Results of Thesis/Dissertation Defense Forms due in Graduate College
July 22, Friday	Online submission of electronic dissertation or thesis due
July 29, Friday	Class work ends

# Deviation From MAE Regulations – Procedure for Requests

The specific requirements of the MAE Faculty are designed to ensure a high quality educational Program. Almost all students find these requirements compatible with their goals and will have no difficulty in meeting these requirements. However, there may be a few circumstances where our educational Program would be enhanced by deviation from a MAE regulation. Consequently, the following philosophy and procedures are available for handling requests for deviations from standard regulations.

The underlying reason for granting any requested deviation from a MAE Graduate Program Regulation is enhancement of quality, effectiveness, or efficiency of the student's academic Program. In no case will a deviation be granted when the overall quality of the student's Program would be decreased by the action.

The procedure for processing and approving a request as recommended by the Graduate Advisory Committee includes the following:

1. The student must discuss the proposed action with both his/her major Advisor and the MAE Graduate Director to ensure that formal action is necessary.
2. The student must submit a written request to the MAE Graduate Director. The request must be explicit, thorough, and contain an endorsement of approval from the student's major Advisor (and Advisory Committee where appropriate). No further action will be taken unless the Advisor or Committee concurs that the request is appropriate and necessary. If it is appropriate, further written explanation or justification can be appended to the request by the faculty endorsing the request. In all subsequent Committee and Faculty meetings, the faculty members endorsing the request will be permitted to vote but they will be excluded from all debate. They will be permitted to answer informational questions at the direction of the chairman of the meeting.
3. The written documentation will be submitted to the MAE Graduate Director, who will bring the matter to the attention of the Graduate Advisory Committee. In a regular meeting, the Graduate Advisory Committee will consider the request and vote to recommend to the entire MAE Faculty that the request be either granted or denied. At this point, the request can be returned to the student only if the Graduate Advisory Committee needs additional information.
4. At a MAE Faculty Meeting, the recommendation of the Graduate Advisory Committee will be submitted as a formal motion. After appropriate discussion, a vote will be taken. Sixty percent or more of the faculty present must vote to approve the request before the deviation will be granted. Formal action of the Faculty Meeting will be the final action on the request.

# Financial Assistance

## Teaching Assistantships (TA)

A limited number of teaching assistantships are offered each semester. These assistantships are usually quarter-time or half-time. Quarter-time teaching assistantships require about ten hours of work per week; half-time assistantships require approximately twenty hours of work each week.

Most TA offers are made at the same time an applicant is admitted to the Graduate Program. Other students might receive TA assignments after demonstrating hard work and motivation for at least one semester.

Teaching Assistants can be assigned any of the following duties: lead discussion sections, assist in the laboratory, grade papers, hold office hours, and other miscellaneous activities.

To become a teaching assistant, international students must pass the Test of English Language Proficiency (TELP), Test of Spoken English (TSE) (or SPEAK, which is offered at OSU), and International Teaching Assistant (ITA) examinations. These tests ensure high quality instructors that are proficient in the English language. More information about these exams can be found at the OSU English Department website: <http://english.okstate.edu/ita/>.

## Teaching Assistants

The College of Engineering will strictly adhere to the rules set forth by Oklahoma State University regarding effective Oral Communication of persons employed in a teaching setting. The following policy was set forth in 2007 and will not be deviated from.

1. It is the Policy of Oklahoma State University that all persons employed as members of the faculty, as teaching assistants, or for any other assignments involving oral instruction shall be proficient in spoken English. Assignments with oral instruction include classroom and laboratory settings as well as any other assignment requiring oral communication between the instructor and student (e.g., discussion section, tutoring, etc.).
2. Each college will develop standards and procedures to ensure that all instructional staff are proficient in the use of English as a spoken language. The standards will include, as one means of demonstrating proficiency and achievement, a score of at least 50 on the OSU-administered SPEAK Test, at least a 50 on the Test of Spoken English (TSE), or at least 26 on the speaking section of the internet -based TOEFL (iBT).
3. Individuals appointed as graduate teaching assistants must, in addition to the requirements of item 2 above, successfully complete a two-session orientation workshop, and pass the OSU-administered International Teaching Assistant (ITA) Test. Students who:
  - a. pass the ITA are permitted to be employed in a classroom or laboratory setting.
  - b. make a "provisional pass" may be employed in an instructional setting subject to concurrent enrollment in GRAD 5990.
  - c. Do not meet the requirements of provisional pass may not be employed in an instruction setting. Further, they may retake the ITA examination only after passing the GRAD 5990 course.

## Research Assistantships (RA)

Many Graduate students are hired by professors to work on funded research projects. These students conduct research for faculty member(s), and are paid by the School of MAE.

Master's students will not, generally, be offered a research assistantship until after demonstrating at least a semester of hard work, motivation, and research proficiency within coursework and the laboratory setting. Doctoral applicants are usually offered research assistantships at the same time the applicant is admitted to the Graduate Program.

**Free Application for Federal Student Aid (FAFSA)**

Domestic (American) students should file a FAFSA application through the Office of Scholarships and Financial Aid each academic year. By doing so, these students become eligible for various sources of funding. The Office of Scholarships and Financial Aid can be accessed at: <http://www.okstate.edu/finaid/>.

**Office of Scholarships and Financial Aid**

Additional scholarships and forms of financial assistance are available through the OSU Office of Scholarships and Financial Aid, at <http://www.okstate.edu/finaid/>.

**Miscellaneous**

Recently-announced fellowships, on-campus positions, and miscellaneous job opportunities are posted on the bulletin board outside the MAE Office (218 Engineering North).

International students can be employed on-campus through such entities as libraries, the Student Union, etc.

# Online Resources

Oklahoma State University: [www.pio.okstate.edu](http://www.pio.okstate.edu)

- b. Links to all departments on the OSU campus
- c. Links to additional on-line resources
- d. Link to SIS – On-line course information and enrollment, *University Catalog*, etc.

School of Mechanical and Aerospace Engineering: [www.mae.okstate.edu](http://www.mae.okstate.edu)

- e. Faculty research, interests, and contact information
- f. Course syllabi, links, and additional information
- g. Undergraduate and Graduate Degree Information and links

Graduate College: [www.gradcollege.okstate.edu](http://www.gradcollege.okstate.edu)

- h. “Download Pages” – Plans of Study, *Thesis & Dissertation Manual*, etc.
- i. “Academic Calendar”
- j. Graduate Admissions
- k. Fees and expenses

Edmon Low Library: [www.library.okstate.edu](http://www.library.okstate.edu)

OSU Bursar: <http://bursar.okstate.edu>

International Students and Scholars Office: <http://osunet.okstate.edu/iss/>

- l. Orientation information
- m. International organizations
- n. Employment information

English Department: <http://english.okstate.edu/>

## Exams for International Students:

### o. **Test of English Language Proficiency (TELP)**

The TELP assesses the academic English skills necessary for students to function well in Graduate-level university classes. The exam includes a listening subtest and a reading-writing subtest. Students who score below 70 on either subtest are required to take ENGL 0003. You are exempt from the TELP exam if you made a score of at least a 600 pBT/250 cBT on the TOEFL and a TWE score of 5. Students who took the TOEFL iBT will not be required to take TELP. If you scored at least a 42 on the combined Reading and Listening portions, with at least a score of 20 in each section, you are not required to enroll in any remedial coursework. Students who score less than this on the Reading and Listening portions of the TOEFL (irrespective of the score on the Written portion) are required to enroll in ENGL 0003 in their **first semester**. Students who score at or above the minimum score(s) on the Reading and Listening portions of the TOEFL, but less than 22 on the Writing portion, are required to enroll in ENGL 4893 at some point in their studies. ENGL 4893 carries graduate credit but may not be used to satisfy degree requirements in the School of MAE.

### p. **SPEAK or Test of Spoken English (TSE)**

The purpose of the SPEAK and TSE tests is to determine the spoken language proficiency of speakers of English as a Second Language (ESL). The Test of Spoken English (TSE) can be taken through Educational Testing Services (ETS) at any time in most countries. A score of 50 is required to pass the TSE exam. The SPEAK exam, which is offered on the OSU campus a week prior to the beginning of each semester, can be substituted for the TSE. The 30-minute SPEAK exam is evaluated for at least two of the following categories: pronunciation, grammar, fluency, and comprehensibility.

### q. **International Teaching Assistant Exam (ITA)**

Once you have passed the TSE or SPEAK test, you have the opportunity to take the ITA exam. The ITA is a 5-minute presentation on an engineering topic that evaluates the presenter’s pronunciation, grammar, visual aids, presentation skills, and ability to understand and answer questions posed by members of the audience.

***A student must pass all three exams to become a teaching assistant in the School of MAE.***

# SIS – OSU Online Information

To access SIS, go to:

1. <http://prodosu.okstate.edu/>
2. Or go to: <http://pio.okstate.edu> and click on “Student Info. System” (SIS)

## SIS Options

- **Admission**
- **University Catalog**
- **Available Courses**

To view up-to-date online course schedules:

1. Click on “Available Courses”
2. Select the Academic Term
3. Select desired department
4. Select desired course.

- **Financial Aid**
- **Request OSU Information**
- **LOGIN**

To view and/or change your personal and enrollment information:

1. Click on “LOGIN” (on left side of page)
2. Enter your Student ID and PIN number
3. Select the desired information from the following categories:
  - ♦ Student Records
  - ♦ Personal Information
  - ♦ Registration and Schedule
  - ♦ Course Catalog
  - ♦ Available Course Sections
  - ♦ Scholarships and Financial Aid

# Graduate Course Offerings

	<b>COURSE No.</b>	<b>COURSE TITLE</b>	<b>PREREQUISITES</b>	<b>FA</b>	<b>SP</b>	<b>SU</b>
<b>AERODYNAMICS &amp; FLIGHT DYNAMICS</b>	MAE 4223+	Aerospace Engineering Laboratory	MAE 3113, 3253, 4283		X	
	MAE 4283+	Aerospace Vehicle Stability & Control	MAE 3253,3723, ENSC 2123	X		
	MAE 4513+	Aerospace Structures I	MAE 3223, 3403	X		
	MAE 5913	Advanced Aerodynamics	MAE 3233 or equivalent	X		
	MAE 5923	Guidance & Control of Aerospace Vehicles	MAE 4053 or ECEN 4413 or equivalent			Z
	MAE 5933	Aeroelasticity	Graduate standing or consent of instructor		Y	
	MAE 5943	Unsteady Aerodynamics & Aeroacoustics	ENSC 3233 or equivalent		Y	
	MAE 5953	Aerospace Systems Engineering I	MAE 3253			Z
<b>THERMAL &amp; FLUIDS SCIENCES</b>	MAE 4243 +	Gas Power Systems	ENSC 3233	X		
	MAE 4263 +	Vapor Power Systems	MAE 3223, 3233		X	
	MAE 4273 +	Experimental Fluid Dynamics	MAE 3113, ENSC 3233	X		
	MAE 4703 +	Design of Indoor Environmental Systems	MAE 3223, 3233	X		
	MAE 4713 +	Thermal Systems Design, Simul., & Optim.	MAE 3233, 3223, ENSC 3233; Co-Requisite: MAE 3403			X
	MAE 5233 #	Viscous Fluid Dynamics	ENSC 3233	X		
	MAE 5243 #	Micro Flows	Graduate standing or consent of instructor			X
	MAE 5253 #	Multiphase Flow	Graduate standing	X		
	MAE 5263	Combustion	MAE 3233	AA	AA	
	MAE 5633	Advanced Thermal Systems	MAE 3223, 3233, ENSC 3233	Z		
	MAE 5653	Refrigeration	MAE 3223		Y	
	MAE 5803	Advanced Thermodynamics I	MAE 3223		Z	
	MAE 5813	Intermediate Heat Transfer	MAE 3233 or equivalent		Z	
	MAE 5823	Radiation Heat Transfer	MAE 3233 or equiv. & grad. standing or consent of inst.	Y		
	MAE 5843	Conduction Heat Transfer	ENSC 3233	X		
	MAE 5853	Computational Heat Transfer	MAE 3233, graduate standing, & knowledge of FORTRAN			AA
	MAE 5863	Bldg Heat Transfer & Simulation	MAE 3223, 3233, ENSC 3233		Z	
	MAE 5873	Advanced Indoor Environmental Systems	MAE 4703		Y	
	MAE 6233	Turbulent Fluid Dynamics	MAE 5233		X	
	MAE 6263 #	Computational Fluid Dynamics	MAE 5233		X	
MAE 6823	Advanced Radiative Transfer	MAE 5823	AA	AA		
MAE 6843	Convection Heat Transfer	MAE 5233 or equivalent		Y		
<b>APPLIED MECHANICS &amp; DESIGN</b>	MAE 4333 +	Mechanical Metallurgy	ENSC 3313		X	
	MAE 4353 +	Mechanical Design II	MAE 3033, 3323, 3403		X	
	MAE 4363 +	Experimental Methods in Design	MAE 3113, 3323		X	
	MAE 5093 #, *	Numerical Engineering Analysis	Undergrad. course in comp. prog. & consent of instructor			X
	MAE 5403	Computer-Aided Analysis and Design	Undergrad. course in comp. prog. & consent of instructor	AA	AA	
	MAE 5503	Advanced Composites	ENSC 2113, 2143 & consent of instructor	X		
	MAE 5533	Analysis of Structural Systems	MAE 3323		Z	
	MAE 5553	Fatigue and Fracture Mechanics	MAE 4333 or consent of instructor	AA	AA	
	MAE 5563	Finite Element Methods	Graduate standing or consent of instructor	X		
	MAE 5573 #	Continuum Mechanics	Consent of instructor	X		
	MAE 5593 #	Theory of Viscoelasticity	Consent of instructor		Y	
	MAE 5663	Advanced Finite Element Analysis	MAE 5563 or consent of instructor		X	
	MAE 5673	Mechanics of Fracture, Contact & Friction	Graduate standing or consent of instructor	AA	AA	
MAE 5743	Geometric Modeling for Design & Manuf.	C programming or consent of instructor	AA	AA		

### ATTENTION OSU-TULSA GRADUATE STUDENTS

Please be advised the majority of MAE Graduate courses will be offered on the Stillwater campus. Occasionally we will offer courses at OSU-Tulsa; however, there is no set schedule for them at this time. Please contact the MAE Graduate Director for further information.

AA = As available  
 X = Every term (as shown above)  
 Y = Even year term  
 Z = Odd year term

\* = Can be used as a MATH course in MAE graduate programs  
 + = Approved for Graduate credit  
 # = Option for Specialization in Biomechanics/Biofluids/Biomaterials

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(Continued on next page)

# Graduate Course Offerings

	<b>COURSE No.</b>	<b>COURSE TITLE</b>	<b>PREREQUISITES</b>	<b>FA</b>	<b>SP</b>	<b>SU</b>
<b>MANUFACTURING &amp; MATERIALS</b>	MAE 4313 +	Adv. Processing of Engineered Materials	ENSC 3313		X	
	MAE 5113	Diffra. for Nondestructive Material Eval.	Graduate standing or consent of instructor	Z		
	MAE 5123	Adv. Material Removal Processes	ENSC 3313, MAE 3123 & grad. standing or consent of inst.	Z		
	MAE 5133 #	Mechanical Behavior of Materials	ENSC 3313 or equivalent		Z	
	MAE 5143	Tribology	Graduate standing or consent of instructor	AA	AA	
	MAE 5153	Precision Engineering I	Graduate standing or consent of instructor	AA	AA	
	MAE 5543 #	Modern Materials	ENSC 3313	Y		
	MAE 5583	Corrosion Engineering	ENSC 3313	X		
	MAE 5683#	Advanced Materials Science I	ENSC 3313 or equivalent		X	
	MAE 5993	Microstructural Mechanics	Graduate Standing or consent of instructor	Y		
	MAE 6123	Non-Traditional Machining	MAE 3123, 5123 & graduate standing or consent of inst.	AA	AA	
	MAE 6133	Surface Mechanics	Consent of instructor		Y	
MAE 6143	Thermal Analysis of Manuf. Processes	Graduate standing or consent of instructor	AA	AA		
<b>DYNAMICS &amp; CONTROL</b>	MAE 4053 +	Automatic Control Sys. (X List ECEN 4413)	MAE 3723 or ECEN 3723	X		
	MAE 4063 +	Mechanical Vibrations	MAE 3723		X	
	MAE 4733 +	Mechatronics Design	MAE 3113, 3403	X		
	MAE 5073	Advanced Mechanical Vibrations	MAE 4063 or consent of instructor	AA	AA	
	MAE 5083	Engineering Acoustics	Graduate standing or consent of instructor	AA	AA	
	MAE 5413	Optimal Control (X List ECEN 5413)	MAE 5713 or ECEN 5713	AA		AA
	MAE 5433	Robotics, Kinematics, Dynamics & Control	MAE 4053 or ECEN 4413 or consent of instructor		Y	
	MAE 5463	Nonlinear System Analysis and Control	MAE 4053 or ECEN 4413	X		
	MAE 5473	Digital Control Systems	MAE 4053 or ECEN 4413	X		
	MAE 5483	Digital Data Acquisition & Control	Undergraduate course in programming		X	
	MAE 5513	Stochastic Systems (X List ECEN 5513)	MAE 4053 or 4063 or ECEN 3513 & 4503, or STAT 4033	X		
	MAE 5523	Estimation Theory (X List ECEN 5523)	MAE 5513 or ECEN 5513		Z	
	MAE 5703	Optimization (X List CHE 5703)	Graduate standing	X		
	MAE 5713	Linear Systems (X List ECEN 5713)	Graduate standing or consent of instructor		X	
	MAE 5733	Neural Networks (X List ECEN 5733)	Graduate standing		X	
	MAE 5773	Intelligent Systems (X List ECEN 5773)	MAE 5733 or ECEN 5733	Y		
	MAE 6423	System Identification (X List ECEN 6423)	MAE 5473 or 5713 or ECEN 5473 or ECEN 5713	Y		
	MAE 6453	Adaptive Control (X List ECEN 6453)	MAE 5473 or 5713, or ECEN 5473 or ECEN 5713	Z		
MAE 6463	Advances in Nonlinear Control	MAE 5463 or ECEN 5463	AA	AA		
MAE 6483	Robust Multivariable Control Systems	MAE 5713 or ECEN 5713		Z		
<b>BIOMECHANICS, BIOFLUID &amp; BIOMATERIALS</b>	MAE 4623 +,#	Biomechanics	MATH 2163, ENSC 2143, 3233		X	
	MAE 5003 #	Advanced Biomaterials Science & Eng.	Graduate standing or consent of instructor		X	
	MAE 5013 #	Physiological System Analysis for Engrs.	Graduate standing or consent of instructor	X		
	MAE 5033 #	Adv. Biomedical Engr. (X List CHE 5293)	Consent of instructor	X		

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# Course Descriptions

An asterisk (\*) following the four-digit number indicates the course is approved for graduate credit.

## **ENSC 2113**

### **Statics**

Prerequisites: MATH 2144 and either PHYS 1114 or 2014. Resultants of force systems, static equilibrium of rigid bodies, statics of structures, and fluid statics. Shear and moment diagrams.

## **ENSC 2123**

### **Elementary Dynamics**

Prerequisite: ENSC 2113. Kinematics and kinetics of particles, systems of particles, and rigid bodies from a Newtonian viewpoint using vector algebra and calculus. Work-energy and impulse-momentum principles. Planar and three-dimensional kinetics and kinematics of rigid bodies.

## **ENSC 2143**

### **Strength of Materials**

Prerequisite: ENSC 2113. Bending moments, deformation and displacement in elastic and plastic deformable bodies. Axial, torsional and shear loads. Buckling stress transformations and combined loads.

## **ENSC 2213**

### **Thermodynamics**

Prerequisites: CHEM 1314, 1414 or 1515, MATH 2144, PHYS 2014. Properties of substances and principles governing changes in form of energy. First and second laws.

## **ENSC 2613**

### **Introduction to Electrical Science**

Prerequisites: MATH 2153 and PHYS 2114. Elements of electrical engineering; AC and DC circuits, mesh and node formulation of network equations, steady-state response to sinusoids, energy, power and power factor.

## **ENSC 3213**

### **Computer Based Systems in Engineering**

Prerequisite: CS 1113 or ENSC 1412 and sophomore or higher standing. A comprehensive introduction to technology and application of microprocessors, concepts of computer and computation, interfacing and communication, data acquisition and representation. Applications of general-purpose and embedded processors in various disciplines of engineering and engineering problem solving.

## **ENSC 3233**

### **Fluid Mechanics**

Prerequisites: ENSC 2113, MATH 2153. The study of fluid properties, statics, conservation equations, dimensional analysis and similitude, viscous flow in ducts, inviscid flow, boundary layer theory, open channel flow, turbomachinery and fluid measurement techniques.

## **ENSC 3313**

### **Materials Science**

Prerequisite: CHEM 1314 or 1414 or 1515. Introductory level. Relationship between structure and properties of materials and engineering applications. Atomic, microscopic and macroscopic properties.

## **MAE 3013**

### **Mechanical and Aerospace Engineering Analysis**

Prerequisites: MATH 2233, ENSC 2123, 2143, 2213, 2613, 3233. Setup and solution of equations which govern mechanical engineering systems. Application and solution of the governing equations to describe the steady state, transient, or harmonic behavior of dynamics, thermodynamics, mechanics, heat transfer and circuit problems. Behavior will be described with linear sets of equations, differential equations, and partial differential equations. Solutions of these equations may be simplified by using complex numbers, Fourier and Laplace transforms. In some cases only numerical solutions will be feasible.

**MAE 3033****Engineering Design**

Lab 2. Prerequisite: ENGR 1332. Design methodology and practice. Design process, with emphasis on the broad range of technical, economic, and societal factors considered in design decision-making. Designing and building a machine to participate in a design competition.

**MAE 3113****Measurements and Instrumentation**

Lab 4. Prerequisites: ENSC 2123 and ENSC 2613. Application of basic electronic laboratory measurement equipment. Selection and testing of transducers for measurement of displacement, time frequency, velocity, pressure, force, temperature, flow-rate, and vibration, for machine design applications. Considerations of accuracy, uncertainty and repeatability. Design projects involving the use of analog and digital integrated circuits and construction of prototype sensors. Practice in the use of signal processing, including digital filtering and applications of Fast Fourier Transform theory. Practice in the use of computer-based data acquisition systems. Preparation of formal reports, including the presentation of plots, figures and tables.

**MAE 3123****Manufacturing Processes**

Prerequisites: ENSC 2143 and 3313 or equivalent. An introduction to manufacturing processes including the fundamental processes of casting, forging, rolling, extrusion, drawing and metal cutting. Quantitative relationships to identify important parameters which influence a given process.

**MAE 3223****Thermodynamics II**

Prerequisite: ENSC 2213. A continuation of ENSC 2213. Irreversibility and availability, power cycles, refrigeration cycles, mixtures and solutions, chemical reactions, phase and chemical equilibrium, and introduction to compressible flow.

**MAE 3233****Heat Transfer**

Prerequisite: ENSC 3233. Mechanisms of heat transfer. Steady and transient conduction, free and forced convection, heat exchanger design and analysis, radiation and multiphase behavior. Numerical methods, dimensional analysis and boundary layer theory.

**MAE 3253****Applied Aerodynamics and Performance**

Prerequisites: ENSC 3233, MATH 2233. Relevant fluid properties; standard atmospheres; mathematical models of flows about bodies. Characteristic parameters of airfoils and wings. Thin airfoil theory and flows about finite wings. Boundary layers. Propeller theory. Supersonic and hypersonic flows about wings and lifting bodies. Drag polars. Power required for level flight. Rate of climb and descent. Steady turns. Maximum range and endurance. Design applications.

**MAE 3293****Compressible Fluid Flow**

Prerequisites: ENSC 2213, 3233, MATH 2233. Gas flows in one and two dimensions. Basic thermodynamic and dynamic equations. Nozzle and duct flows, choking, plane and oblique shock waves, Prandtl-Meyer expansions, rocket propulsion, frictional high-velocity flows and heat addition effects. Two-dimensional ideal fluid flow, stream function, velocity potential, linearized flows and method of characteristics.

**MAE 3323****Mechanical Design I**

Prerequisites: ENSC 2113, 2143. Introduction to the design process. Consideration of reliability, factors of safety, product liability, and economics. Use of codes, standards, and other design resources. Design stress analysis of mechanical components such as beams, rings, cylinders, and shafts. Analysis of stiffness and deflection of straight and curved beams, columns, and links. Consideration of failure theories for various types of engineering materials. Application of fatigue analyses in the design process.

**MAE 3403****Computer Methods in Analysis and Design**

Prerequisite: ENGR 1412. Application of computer methods in the design, analysis, and simulation of mechanical, thermal and fluid systems. Linear algebra and numerical methods. Applied statistics.

**MAE 3723****Systems I**

Prerequisites: ENSC 2123, 2613 and MATH 2233. Physical and mathematical modeling of electrical and mechanical dynamic systems. Transient response of first- and second-order systems. Laplace transform technique for solving differential equations; transfer functions, frequency response and resonance. (Same course as ECEN 3723)

**MAE 4010\*****Mechanical Engineering Projects**

1-6 credits, max 6, Lab variable. Prerequisite: Consent of instructor. Special projects and independent study in mechanical engineering.

**MAE 4053\*****Automatic Control Systems**

Prerequisite: MAE 3723 or ECEN 3723. Properties of feedback control systems, mathematical models of basic components, state-variable models of feedback systems, design specifications of control systems, time-domain analysis, stability, stability robustness, transform analysis, frequency domain techniques, root-locus, design of single-input-single-output systems and compensation techniques for engineering systems. (Same course as ECEN 4413\*)

**MAE 4063\*****Mechanical Vibrations**

Prerequisites: MAE 3723. Lumped parameter analysis of multi-mode vibrating systems. Analysis techniques including classical analytical methods, matrix methods and numerical methods. Selection and design of vibration isolation systems. Selection of vibration instrumentation. Machine dynamics, including balancing, whirl, nonlinear effects, and self-excited vibrations.

**MAE 4223\*****Aerospace Engineering Laboratory**

Lab 6. Prerequisites: MAE 3113, MAE 3253, MAE 4283. Experimental study of aerospace principles including topics in aeronautics and astronautics. State-of-the-art instrumentation, diagnostics, and computerized data acquisition equipment and techniques applied to experiments including application of low speed wind tunnel testing techniques, rocket propulsion and control-jet experiments, fundamentals of supersonic nozzles, and flight test evaluation of performance, stability, control, and handling qualities of a propeller-driven airplane.

**MAE 4243\*****Gas Power Systems**

Prerequisite: ENSC 3233. Power and propulsion engines utilizing a gas as the working fluid. Thermodynamic and dynamic equations of one-dimensional compressible flow, including shock waves. Design and analysis of overall aircraft engine systems and individual components of the aircraft engine, as well as engine component matching, using design software packages. Centrifugal and axial flow turbines and compressors.

**MAE 4263\*****Vapor Power Systems**

Prerequisites: MAE 3223, MAE 3233. Vapor power cycles, combustion processes applied to power production, power plants, and auxiliary systems associated with power plants. Overall design of power plants as well as component design. Power system economics and loan analysis. Extensive use of software design and analysis packages.

**MAE 4273\*****Experimental Fluid Dynamics**

Lab 3. Prerequisites: MAE 3113 and ENSC 3233. Experimental study of basic and applied fluid dynamics systems with comparisons to analytical predictions. Fluid dynamics instrumentation, digital data acquisition and processing, design of facilities and experiments, technical report writing and design project with experimental verification.

**MAE 4283\*****Aerospace Vehicle Stability and Control**

Prerequisites: MAE 3253, MAE 3723, ENSC 2123. Motion and control of aerospace vehicles. Derivation of equations of motion for aircraft and spacecraft. Aerodynamic stability derivatives. Static and dynamic aircraft stability and control. Handling qualities. Satellite orbital and attitude dynamics. Satellite attitude control. Design experience for stability and control in aeronautical and astronautical vehicles.

**MAE 4313\*****Advanced Processing of Engineered Materials**

Prerequisite: ENSC 3313. Introduction of novel processing methods for a range of engineered materials, such as electro-slag remelting, vacuum melting, melting to remove tramp elements, precision casting, sintering, hot-pressing, directional solidification, mechanical alloying, liquid infiltration, net-shaped finishing, superplastic forming, sol-gel processing, float glass process, tape laying, microwave processing, laser processing, CVD and PVD, sputtering, ion plating, ultraprecision machining and grinding, polishing and lapping, multilayer coatings, Czochralski single crystal growth, processing of nanocrystalline materials, engineered surfaces and surface modification, and layer processing for electronic materials.

**MAE 4333\*****Mechanical Metallurgy**

Lab 2. Prerequisite: ENSC 3313. Mechanical deformation processes and strengthening mechanisms in engineering materials. Material failure modes including creep, fatigue, stress corrosion, ductile and brittle fractures.

**MAE 4344\*****Design Projects**

Lab 4. Prerequisites: MAE 3033, MAE 3113, MAE 3323. Students work in small teams on a semester-long design project sponsored by a company, agency, or individual. Team members work with mentors from sponsors and with faculty members in fields related to their topics. Presentations on safety, patent law, product liability, report writing, oral presentations, scheduling and ideation. Oral presentations, progress reports, and a professional log book documenting personal activity and contributions.

**MAE 4353\*****Mechanical Design II**

Prerequisites: MAE 3033, MAE 3323 and MAE 3403. Design of power transmission systems, including belts, chains and gears. Selection and application of hydraulic and pneumatic components in machine design applications. Selection of electric motors, actuators, encoders, and related electromechanical components. Design practice in the form of short projects integrating segments of the course. (Same course as BAE 4353\*)

**MAE 4354\*****Aerospace Systems Design for Mechanical Engineers**

Lab 8. Prerequisites: MAE 3033, MAE 3113 and MAE 3323. Multidisciplinary design of aerospace vehicles. Multidisciplinary teams that work on a semester-long project that includes the design, construction, and a flight test of an aerospace vehicle optimized for a given set of requirements. Teamwork, leadership and presentation skills emphasized. Students from all appropriate disciplines who wish to participate in this course are encouraged to do so by enrolling in MAE 4010.

**MAE 4363\*****Experimental Methods in Design**

Lab 6. Prerequisites: MAE 3113 and MAE 3323. Laboratory techniques for the experimental analysis of vibration, stress, force and motion. Projects involve the use of strain gages, brittle lacquer techniques, reflection and transmission polariscopes, load cells and accelerometers.

**MAE 4374\*****Aerospace Systems Design**

Lab 8. Prerequisites: MAE 4243, MAE 4283, MAE 4513. Multidisciplinary design of aerospace vehicles. Multidisciplinary teams that work on a semester-long project that includes the design, construction, and a flight test of an aerospace vehicle optimized for a given set of requirements. Teamwork, leadership and presentation skills emphasized. Students from all appropriate disciplines who wish to participate in this course are encouraged to do so by enrolling in MAE 4010.

**MAE 4383\*****Nanotechnology for Engineers**

Prerequisites: MATH 2163, CHEM 1414 or 1515, PHYS 2114. Size and shape dependence of material properties at the nanoscale. Top-down and bottom-up nanofabrication and self-assembly. Interaction, functionalization, binding, and immobilization of nanostructures. Properties applications and synthesis of well-studied building blocks; quantum dots (semiconductor nanocrystals), carbon nanostructures (nanotubes and fullerenes), semiconductor nanowires, metal nanoparticles and nanowire. Supramolecular structures, nanophase films, and nanocomposites. Characterization of nanostructures.

**MAE 4513\*****Aerospace Structures I**

Prerequisites: MAE 3323 and 3403. Design and analysis of flight structures. Topics from two and three-dimensional elasticity. Behavior of composite materials. Stress and deflection analysis of thin-skinned stiffened structures. Introduction to the finite element method and its applicability in the design process.

**MAE 4623\*****Biomechanics**

Prerequisites: MATH 2163, ENSC 2143, ENSC 3233. To introduce non-bioengineering students to the field of biomechanics. This class will serve as a foundation for further biomechanics investigation at senior undergraduate and graduate level. At the end of this class students will be able to apply engineering principles to describe the mechanical properties of biological systems.

**MAE 4703\*****Design of Indoor Environmental Systems**

Prerequisites: MAE 3223, MAE 3233. Design of heating, ventilating and air conditioning systems. Calculation of heating and cooling loads.

**MAE 4713\*****Thermal Systems Design, Simulation and Optimization**

Prerequisites: MAE 3233, MAE 3223; ENSC 3233; Co-requisite: MAE 3403. Design, modeling, simulation and optimization of thermal systems. Analysis and modeling of components such as fans, pumps, ducts, pipes, fittings, heat exchangers, compressors, thermal storage equipment.

**MAE 4733\*****Mechatronics Design**

Prerequisites: MAE 3113 and 3403. Design of mechanical and electrical components, including sensors and actuators into an integrated environment using microcontrollers. Software design using an easy-to-program microcontroller embodies the importance of software implementation into the overall engineering system. Design practice with given design projects to build up skills plus an open-ended term design project of the student's choosing.

**MAE 5000\*****Thesis**

1-6 credits, max 6. A student studying for a master's degree who elects to write a thesis must enroll in this course.

**MAE 5003\*****Advanced Biomaterials Science and Engineering**

Prerequisites: Graduate standing or consent of instructor. Engineering issues that are implicit in understanding the interactions of living tissue and processed materials will be introduced. Emphasis is on identifying the processes in which cells interact with surfaces and particulate matter and the outcome of these interactions. Highlighted biological responses will include inflammation and coagulation. Also, biomaterial issues related to drug delivery and tissue engineering will be discussed. (Same course CHE 5003)

**MAE 5010\*****Mechanical Engineering Projects**

1-12 credits, max 12. Project in research or design selected by the student, or assigned by the instructor. A student who wishes to complete a master's degree under Plan III must enroll in this course.

**MAE 5013\*****Basic Physiology and Physiological System Analysis for Engineers**

Prerequisite: Graduate standing or consent of instructor. The goals of this class are: 1) to introduce the basic physiology concepts used widely in biomedical engineering research; 2) to introduce and develop engineering concepts and approaches for quantitative analysis of physiological systems. Engineering principles will be applied to study mechanical properties of various tissue and organ systems under normal and diseased conditions. Knowledge obtained from this class can help engineers to apply engineering principles to the design and development of medical devices for disease treatments. (Same course as CHE 5013)

**MAE 5030\*****Engineering Practice**

1-12 credits, max 12. Prerequisites: Senior or graduate standing and consent of instructor. Solution of real-life engineering design and development problems in an actual or simulated industrial environment. Activities include application of design and testing procedures, economic evaluation and periodic oral and written reporting on one or more assigned problems. Activities must be approved in advance by the adviser.

**MAE 5033\*****Advanced Biomedical Engineering**

Prerequisite: Consent of instructor. Principles and engineering analysis of biomedical processes. Artificial organs, biomaterials, tissue engineering, transport in biological systems, biomedical imaging and drug delivery systems. (Same course as CHE 5293)

**MAE 5073\*****Advanced Mechanical Vibrations**

Prerequisite: MAE 4063 or consent of instructor. Analysis of nonlinear vibrations, classical analysis of continuous systems and numerical methods.

**MAE 5083\*****Engineering Acoustics**

Prerequisite: Graduate standing or consent of instructor. Acoustical analysis and measurement techniques, with emphasis on design applications for noise and vibration control in machinery and in buildings.

**MAE 5093\*****Numerical Engineering Analysis**

Prerequisites: Undergraduate course in computer programming and consent of professor. Practical digital methods for obtaining steady-state and transient solutions to lumped and distributed mechanical, fluid and thermal problems.

**MAE 5113\*****Diffraction for Non-destructive Materials Evaluation**

Prerequisite: Graduate standing or consent of instructor. Introduction to crystallography and diffraction with an emphasis on X-ray diffraction, some exposure to Neutron diffraction. Applications will focus on mechanical properties measurements. New methods will be surveyed with an emphasis on current research.

**MAE 5123\*****Metal Cutting**

Prerequisites: ENSC 3313, MAE 3123 and graduate standing or consent of instructor. Understanding the fundamental principles and practice (mechanics and material aspects) of machining and grinding of materials. Historical aspects; physics of metal cutting, mechanics of machining (orthogonal and oblique); shear stress and shear strain in machining, dynamometry; tool materials, tool wear, tool life, and machinability; vibrations in machining; thermal aspects of machining, cutting fluids; economics; surface finish accuracy and surface integrity, and grinding.

**MAE 5133\*****Mechanical Behavior of Materials**

Prerequisite: ENSC 3313 or equivalent. A unified approach to the behavior and response of engineering materials to applied loads. Mechanical and metallurgical fundamentals of deformation processes. Spatial scales of atomic physics, micromechanics and continuum mechanics.

**MAE 5143\*****Tribology**

Prerequisite: Graduate standing or consent of instructor. The principles of tribology. Definition of tribology, contact of solids, surface topography, real area of contact, friction of various materials, basic mechanisms of friction, mechanisms of wear (adhesion, abrasion, fatigue, erosion, and fretting), hardness of solids, frictional heating and surface temperatures, material properties that influence surface interactions, surface roughness measurement, surface integrity residual stresses and subsurface deformation, application of tribology to manufacturing, wear resistant materials, wear-resistant coatings, experimental methods in tribology, surface analytical tools in tribology, scanning tunneling microscopy/atomic force microscopy, wear monitoring and wear prevention, and systems approach to tribology.

**MAE 5153\*****Precision Engineering I**

Prerequisite: Graduate standing or consent of instructor. An integrated approach to underlying engineering principles governing product and process designs requiring accuracies typically better than 1 part in 10<sup>6</sup>. Design and control of precision machines and instruments, dimensional and surface metrology, scanning probe microscopy, ultra-precision machining and grinding, and precision assembly.

**MAE 5233\*****Viscous Fluid Dynamics**

Prerequisite: ENSC 3233. The dynamics of viscous flow over external surfaces, inside channels, and in free shear layers. Boundary layer solutions. Theory of similarity. Approximation methods.

**MAE 5243\*****Micro Flows**

Prerequisite: Graduate standing or consent of instructor. Fundamentals and simulation of micro flows including governing equation, slip models, shear- and pressure-driven micro flows. Thermal effects in micro scales. Applications; MEMS and micro propulsion. Numerical methods for continuum simulation and atomistic simulation.

**MAE 5253\*****Multiphase Flow**

Prerequisite: Graduate standing. Theory, methods and practical experience for studying complex transient multiphase flows: basic concepts and definition, dynamics of bubbles, drops and rigid particles, gas-liquid transport in ducts, fluid-solid transport in ducts, aerosol and spray systems, foam, fluidization, particle separation systems multiphase flow in porous media, breakup of liquid sheets and jets, modeling, advanced experimental techniques for multiphase flow.

**MAE 5263\*****Combustion**

Prerequisite: MAE 3233. Theory, design and performance of combustion systems. Fundamentals of aerothermochemistry fluid dynamics, heat transfer and combustion. Laminar and turbulent flows. Diffusion and premixed flames. Pollutant reduction. Numerical simulation and solution.

**MAE 5403\*****Computer-aided Analysis and Design**

Prerequisites: Undergraduate course in computer programming and consent of professor. Theory, application and implementation of digital-computer-oriented algorithms for the synthesis, simulation, analysis and design of engineering systems. Advanced FORTRAN methods for optimization, simulation and data analysis. Implementation of these methods uses program libraries, batch processing, remote terminals and graphic display units.

**MAE 5413\*****Optimal Control**

Prerequisite: MAE 5713 or ECEN 5713. Optimal control theory for modern systems design. Specification of optimum performance indices. Dynamic programming, calculus of variations and Pontryagin's minimum principle. Iterative numerical techniques for trajectory optimization. (Same course as ECEN 5413\*)

**MAE 5433\*****Robotics, Kinematics, Dynamics and Control**

Prerequisite: MAE 4053 or ECEN 4413 or consent of instructor. Kinematic and dynamic analysis of robot manipulators. Inverse kinematics, motion planning and trajectory generation. Industrial practice in robot servo control. Dynamics and control in the presence of constraints. Actuators and sensors. Force sensors and vision systems. Robotic force control and its applications in industry. Passivity based control algorithms. Advanced control techniques for motion and force control. (Same course as ECEN 5433\*)

**MAE 5463\*****Nonlinear System Analysis and Control**

Prerequisite: MAE 4053 or ECEN 4413. Failure of superposition of effects; phase-plane analysis; limit-cycles; Lyapunov stability; hyperstability and input-output stability; controllability and observability of nonlinear systems; feedback linearization; robust nonlinear control system design. (Same course as ECEN 5463\*)

**MAE 5473\*****Digital Control Systems**

Prerequisite: MAE 4053 or ECEN 4413. Input output and state space representations of linear discrete-time systems. Approximate methods in discrete-time representation. Stability methods. Controllability, observability, state estimation, and parameter identification. Design and analysis of feedback control system using frequency-domain and state-space methods. Introduction to optimal control. (Same course as ECEN 5473\*)

**MAE 5483\*****Digital Data Acquisition and Control**

Prerequisite: Undergraduate course in programming. Use of microcomputers operating in real-time applied to engineering systems for data acquisition and control, use of analog to digital, digital to analog, and digital input/output, synchronous and asynchronous programming. Competence in the engineering use of microcomputers through lectures and laboratory applications. (Same course as ECEN 5483\*)

**MAE 5503\*****Mechanics of Advanced Composites for Structural Design**

Prerequisites: ENSC 2113, ENSC 2143 or consent of instructor. Basic principles governing the micro-mechanics of a lamina, and the macro-mechanics of a laminate are discussed in detail. Analysis of continuous fiber, short-fiber, and woven-fiber polymer matrix composites. A computer program for a analysis and design of composite laminates is developed.

**MAE 5513\*****Stochastic Systems**

Prerequisites: ECEN 3513 and 4503 or STAT 4033 or MAE 4053 or MAE 4063 or consent of instructor. Theory and applications involving probability, random variables, functions of random variables, and stochastic processes, including Gaussian and Markov processes. Correlation, power spectral density, and non-stationary random processes. Response of linear systems to stochastic processes. State-space formulation and covariance analysis. (Same course as ECEN 5513\*)

**MAE 5523\*****Estimation Theory**

Prerequisite: MAE 5513 or ECEN 5513. Stochastic model development, parameter estimation and state estimation. The linear model, model order determination, least squares, estimation, maximum likelihood estimation, Bayesian estimation. Gaussian random vectors, estimation in linear and Gaussian models, state estimation, the Kalman filter, prediction and smoothing. (Same course as ECEN 5523\*)

**MAE 5533\*****Analysis of Structural Systems**

Prerequisite: MAE 3323. Computer-oriented matrix methods in the analysis of linear structural systems; energy principles; matrix equations for static and dynamic analyses of elastic systems; stability.

**MAE 5543\*****Modern Materials**

Prerequisite: ENSC 3313. Properties, applications and recent innovations of structural engineering materials. Metals, ceramics, polymers and composites considered.

**MAE 5553\*****Fatigue and Fracture Mechanics**

Prerequisite: MAE 4333 or consent of instructor. Fracture processes in engineering materials including design considerations, failure avoidance and predictability. Fatigue processes and high-strength, toughness-limited materials.

**MAE 5563\*****Finite Element Methods**

Prerequisite: Graduate standing or consent of instructor. Introduction to the finite element method in mechanical engineering. Numerical and mathematical formulations including an introduction to variational methods. Computer applications in solid mechanics, heat transfer and fluid mechanics.

**MAE 5573\*****Continuum Mechanics**

Prerequisite: Consent of instructor. Principles governing the mechanics of continua. Kinematics of deformation, including the Lagrangian and Eulerian descriptions. Development of stress and strain tensors. Conservation principles to derive field equations describing solid and fluid mechanics. Application to problems in linear elasticity and viscous fluid flow.

**MAE 5583\*****Corrosion Engineering**

Lab 2. Prerequisite: ENSC 3313. Modern theory of corrosion and its applications in preventing or controlling corrosion damage economically and safely in service.

**MAE 5593\*****Theory of Viscoelasticity**

Prerequisite: Consent of instructor. Advanced stress analysis in solids exhibiting time-dependent behavior. Material characterization and thermodynamic foundation of the constitutive behavior of time-dependent materials such as polymers, solid propellants and metals near their melting points; time-temperature; superposition principle for thermo-rheologically simple materials; correspondence principle for linearly viscoelastic and associated linearly elastic solutions; integral formulation for quasistatic boundary value problems; treatment of time-varying boundary conditions such as moving boundaries and moving loads; linearly viscoelastic stress waves and approximate methods of linearly viscoelastic stress analysis.

**MAE 5633\*****Advanced Thermal Systems**

Prerequisites: MAE 3223, MAE 3233, ENSC 3233. Analysis, design, simulation and optimization of thermal systems. Engineering applications to HVAC systems, refrigeration systems, ground-source heat pump systems.

**MAE 5653\*****Refrigeration**

Prerequisite: MAE 3223. Thermal engineering or refrigeration and heat pump systems, vapor compression systems, absorption refrigeration cycles, cryogenics, compressors, heat exchangers, refrigerant control devices, laboratory simulators and measurements, socio-economic and environmental impact of systems and refrigerants.

**MAE 5663\*****Advanced Finite Element Analysis**

Prerequisite: MAE 5563 or consent of instructor. Development of three-dimensional isoparametric solid elements using Lagrange and serendipity family of elements, solution of three-dimensional thermoelasticity problems, linear time dependent problems, variational formulation and computer implementation of structural dynamics analysis using implicitly operators, implementation of three-dimensional diffusion and heat transfer analysis, solution of a nonlinear system of equations, and finite element analysis using commercial software packages.

**MAE 5673\*****Mechanics of Fracture, Contact and Friction**

Prerequisite: Graduate standing or consent of instructor. Rigorous derivation and presentation of the equations of fracture mechanics, contact and friction. Equations of solid mechanics and mathematical preliminaries, elastic stress field near a crack tip, stress intensity factors, fracture toughness, Griffith solution and J-integral, elastic-plastic fracture, fatigue, Dugdale model and cohesive zone laws, experimental techniques in fracture mechanics, contact mechanics, friction modeling. More advanced topics and projects will be chosen from interfacial crack growth, subsonic and intersonic dynamic fracture, rate- and state-dependent friction laws, fracture and friction at the small scales (nanomechanics), and finite-element analysis using commercial packages.

**MAE 5683\*****Advanced Materials Science I**

Notions of energy, entropy, equilibrium, macrostates, and microstates and their relation to material processes and properties. Deriving material properties from equations of state: Maxwell relations. Statistical thermodynamics: predicting material properties from microstates. Partition function. Phase transformations. Thermodynamics of surfaces and defects. Electrochemistry.

**MAE 5703\*****Optimization Applications**

Prerequisite: Graduate standing. A survey of various methods of unconstrained and constrained linear and non-linear optimization. Applications of these methodologies using hand-worked examples and available software packages. Intended for engineering and science students. (Same course as CHE 5703\*, ECEN 5703\* & IEM 5023\*)

**MAE 5713\*****Linear Systems**

Prerequisite: Graduate standing or consent of instructor. Introduction to the fundamental theory of finite-dimensional linear systems with emphasis on the state-space representation. Mathematical representations of systems; linear dynamic solutions; controllability, observability, and stability; linearization and realization theory; and state feedback and state observer. (Same course as ECEN 5713\*)

**MAE 5733\*****Neural Networks**

Prerequisite: Graduate standing. Introduction to mathematical analysis of networks and learning rules, and on the application of neural networks to certain engineering problems image and signal processing and control systems. (Same course as CHE 5733\* & ECEN 5733\*)

**MAE 5743\*****Geometric Modeling for Design and Manufacturing**

Prerequisite: C programming or consent of instructor. Application of parametric geometry for engineering design and manufacturing. Representation of curves, surfaces and solids. Analytic and relational properties. Fundamentals of solid modeling.

**MAE 5773\*****Intelligent Systems**

Prerequisite: MAE 5733 or ECEN 5733. Introduction to the state-of-the art intelligent control and system successfully deployed to industrial and defense applications. Emerging intelligent algorithms (e.g., bottom-up, top-down, semiotics); reinforcement learning and hybrid systems; and case studies and design projects. (Same course as ECEN 5773\*)

**MAE 5803\*****Advanced Thermodynamics I**

Prerequisite: MAE 3223. A rigorous examination of the fundamental principles of engineering thermodynamics; the First Law, the pure substance, flow processes, Second Law availability, properties of substances, thermochemistry, mixtures and equilibrium.

**MAE 5813\*****Intermediate Heat Transfer**

Prerequisites: MAE 3233 or equivalent Continuation of the topics covered in the undergraduate heat transfer course (MAE 3233) with the addition of mass transfer. This course covers problems of heat and mass transfer in greater depth and complexity than is done in the undergraduate heat transfer course and incorporates the subjects that are not included or are treated lightly in that course. Analysis will be given greater emphasis than the use of correlations.

**MAE 5823\*****Radiation Heat Transfer**

Prerequisites: MAE 3233 or equivalent and graduate standing or consent of instructor. The mechanism of the transfer of energy by thermal radiation; radiant properties of materials, energy transfer prediction methods and solar energy topics.

**MAE 5843\*****Conduction Heat Transfer**

Prerequisite: ENSC 3233. Advanced heat transfer analysis and design, with primary emphasis on conduction.

**MAE 5853\*****Computational Heat Transfer**

Prerequisite: MAE 3233, graduate standing, knowledge of FORTRAN. Computational techniques for the solution of two-dimensional heat transfer, fluid flow and related processes in problems of practical interest. A general-purpose computer program used to demonstrate the capabilities of the numerical method through a wide variety of engineering problems.

**MAE 5863\*****Building Heat Transfer and Simulation**

Prerequisites: MAE 3223, MAE 3233, ENSC 3233. Conduction, convection and radiation heat transfer applied to building thermal simulation. Solar radiation.

**MAE 5873\*****Advanced Indoor Environmental System**

Prerequisite: MAE 4703. Heating, air-conditioning, ventilation and refrigeration systems. System and component analysis, design and simulation.

**MAE 5913\*****Advanced Aerodynamics**

Prerequisite: ENSC 3233 or equivalent. Aerodynamics of the subsonic, transonic, supersonic, and hypersonic flow regimes. Derivation of governing equations and fundamental principles. Analytical and computational analysis methods. Recent developments.

**MAE 5923\*****Guidance and Control of Aerospace Vehicles**

Prerequisite: MAE 4053 or ECEN 4413 or equivalent. Navigation, guidance and attitude control of aircraft, launch vehicles and spacecraft. Inertial navigation mechanizations and error analysis. Stability augmentation systems.

**MAE 5933\*****Aeroelasticity**

Prerequisite: Graduate standing or consent of instructor. Interaction between fluid dynamic, inertial and elastic forces. Development of analytical and computational methods for analysis. Application to a broad range of problems in engineering.

**MAE 5943\*****Unsteady Aerodynamics and Aeroacoustics**

Prerequisite: ENSC 3233 or equivalent. Development of governing fluid dynamic equations for unsteady flows; linear unsteady aerodynamics for isolated and cascaded lifting surfaces; acoustics in moving media; three-dimensional duct acoustics; sound generation from isolated airfoils, cascaded airfoils, rotor-stator interactions, multiple pure-tone sources, propellers and jets.

**MAE 5953\*****Aerospace Systems Engineering**

Prerequisite: MAE 3253 or equivalent. Aircraft and spacecraft design from a systems perspective, covering basic systems engineering, cost and weight estimation, basic vehicle performance and trade study analysis, safety and reliability, lifecycle analysis, subsystem integration, risk analysis and management, system realization, and multi-disciplinary optimization (MDO). Additional topics include requirements identification and development, and program planning and control.

**MAE 5993\*****Microstructural Mechanics**

Prerequisite: Graduate standing or consent of instructor. Build a framework to understand the various microstructures of materials with their respective roles in controlling mechanical properties. Grain size, orientation, surface facets, compositional gradients, and second or multiple phases, in combination with the three-dimensional arrangement of the various types of imperfections, together constitute the microstructure of a material. An emphasis will be placed on new research areas and exposure to methods for controlling and probing microstructures.

**MAE 6000\*****Research and Thesis**

1-15 credits, max 30. Prerequisites: Consent of the head or the graduate committee of the School and approval by the student's advisory committee. Independent research under the direct supervision of a member of the graduate faculty. For students pursuing study beyond the level of the MS degree.

**MAE 6010\*****Advanced Study**

1-12 credits, max 12. Prerequisites: Approval of the student's advisory committee. Study and investigation under the supervision of a member of the faculty along lines of interest well advanced of and supported by the 5000-series courses.

**MAE 6123\*****Non-traditional Machining**

Prerequisites: MAE 3123, MAE 5123 and graduate standing or consent of instructor. Rationale for non-traditional machining; various non-traditional machining processes, including electro-discharge machining, electro-chemical machining, plasma arc-, microwave-, and laser assisted processing, waterjet (abrasive) cutting, ultrasonic machining, chemical machining, thermal assisted processing and electron beam machining.

**MAE 6133\*****Surface Mechanics**

Prerequisite: Consent of instructor. Models and solutions basic to surface studies. Equations of continuum mechanics, thermal field solutions at sliding interfaces, elasticity, plasticity. Applications of solution techniques to surface, surface layer and interface phenomena.

**MAE 6143\*****Thermal Analysis of Manufacturing Processes**

Prerequisites: Graduate standing and consent of instructor. Thermal analysis of various moving heat source problems encountered in a variety of manufacturing processes, including machining, grinding, polishing, casting, welding, energy beam cutting and other tribological applications such as meshing of gears, cams, bearings. Analysis of both transient and steady state conditions.

**MAE 6233\*****Turbulent Fluid Dynamics**

Prerequisites: MAE 5233. Isotropic turbulence, turbulent wakes and jets, bound turbulent shear flows, transition, hydrodynamic stability and integral calculation methods for turbulent boundary layers.

**MAE 6263\*****Computational Fluid Dynamics**

Prerequisite: MAE 5233. Stream function-vorticity and pressure-velocity simulations of incompressible and compressible flows. Temperature and concentration solutions. Applications to various external and internal flow problems.

**MAE 6423\*****System Identification**

Prerequisite: MAE 5473 or MAE 5713 or ECEN 5473 or ECEN 5713. Linear and nonlinear system modeling of random systems. Models of linear time-invariant systems, nonparametric methods and preliminary model development, parameter estimation methods, convergence and consistency, asymptotic distributions of parameter estimates, nonlinear modeling. (Same course as ECEN 6423\*)

**MAE 6453\*****Adaptive Control**

Prerequisite: MAE 5473 or ECEN 5473 or ECEN 5713 or MAE 5713. Analysis and design of control techniques which modify their performance to adapt to changes in system operation. Review of systems analysis techniques, including state variable representations, linearization, discretization, covariance analysis, stability, and linear quadratic gaussian design. On-line parameter estimation, model reference adaptive systems, self-tuning regulators, stable adaptive systems. (Same course as ECEN 6453\*)

**MAE 6463\*****Advances in Nonlinear Control**

Prerequisite: MAE 5463 or ECEN 5463. Introduction to vector fields and Lie algebra; controllability and observability of nonlinear systems; local decompositions; input-output and state-space representation on non-linear systems; feedback linearization; controlled invariance and distribution; control of Hamiltonian systems. (Same course as ECEN 6463\*)

**MAE 6483\*****Robust Multivariable Control Systems**

Prerequisite: MAE 5713 or ECEN 5713. Introduction to multivariable systems: SISO robustness vs. MIMO robustness; multivariable system poles and zeros; MIMO transfer functions; multivariable frequency response analysis; multivariable Nyquist theorem; performance specifications; stability of feedback systems; linear fractional transformations (LFT's); parameterization of all stabilizing controllers; structured singular value; algebraic ricatti equations; H<sub>2</sub> optimal control; H-∞ controller design. (Same course as ECEN 6483\*)

**MAE 6823\*****Advanced Radiative Transfer**

Prerequisite: MAE 5823. Radiative energy transfer within participating media and among real surfaces. Anisotropic scattering, emission, refractive index effects, and wavelength-dependent analysis. Current solution techniques—approximate and exact. Relationship of electric fields to radiative transfer. Combined radiation with conduction and/or convection. A project concerned with a unique radiative transfer problem.

**MAE 6843\*****Convection Heat Transfer**

Prerequisite: MAE 5233 or equivalent. Advanced convective heat transfer in laminar and turbulent flows over external surfaces and inside channels. Heat transfer at high velocities, free convection boundary layers, and mass transfer.