MMAE Guide to Graduate Studies

Illinois Institute of Technology

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Chapter 1

Introduction

This guide serves as a supplement to the IIT Graduate Bulletin[1] and the MMAE Department's web site for faculty and students of the Mechanical, Materials and Aerospace Engineering (MMAE) Department. Students should refer to Graduate College forms and Graduate College deadlines, and see the Graduate Student Handbook for general policies. For information on co-terminal bachelors and masters degree programs and accelerated masters programs (AMPs), see the AMP website. Faculty should refer to Graduate College forms for faculty. These resources should be consulted for degree requirements; Graduate College deadlines, forms, and procedures; course descriptions; etc. It is the student's responsibility, with guidance from his/her adviser, to be sure that all procedures are followed and deadlines met. For your reference, this guide addresses issues specific to the MMAE Department and is available on the MMAE departmental web site.

Contacts:

Department Chair:	Prof. Lou Cattafesta
Associate Chair for Graduate Studies:	Prof. Ankit Srivastava

The Chairman of the Department, in consultation with the faculty, appoints faculty members to serve on the Graduate Studies Committee (GSC), who oversee the graduate programs within the department and can make recommendations to the full departmental faculty, who have final jurisdiction over the programs. The Graduate Studies Committee Chair leads the Committee and handles the day-to-day obligations of the graduate studies program.

[1] Blue text in the electronic version of this PDF document provides links to the specified resources or information within this document or on the IIT or MMAE web sites.

1.1 MMAE Graduate Programs

The MMAE Department offers graduate programs in Mechanical and Aerospace Engineering (MAE), Materials Science and Engineering (MSE), and Manufacturing Engineering (MFG). The degrees that the department offers are summarized below.

Mechanical and Aerospace Engineering (MAE)

- Master of Science in Mechanical and Aerospace Engineering
- Master of Mechanical and Aerospace Engineering
- Doctor of Philosophy in Mechanical and Aerospace Engineering

Materials Science and Engineering (MSE)

- Master of Science in Materials Science and Engineering
- Master of Materials Science and Engineering
- Doctor of Philosophy in Materials Science and Engineering

Manufacturing Engineering (MFG)

- Master of Science in Manufacturing Engineering
- Master of Manufacturing Engineering

The master of science degrees include course-only or thesis options. For information on co-terminal bachelors and masters degree programs and accelerated masters programs (AMPs), see the AMP website. For additional interdisciplinary degrees offered by the Armour College of Engineering see Armour College of Engineering Graduate Programs.

1.2 Advising Procedures

All new graduate students are assigned an advisor at the time of admission who will assist in the selection of courses. MS with thesis and PhD students are encouraged to find a permanent research advisor as soon as possible. All graduate students are advised to update their mailing addresses, email addresses, and/or telephone numbers on myIIT so that IIT has accurate contact information.

Students registering for either of the following research and thesis credit hours require an online registration override from their research adviser prior to registering:

- MMAE 591 Research and Thesis for MS Degree
- MMAE 691 Research and Thesis for PhD Degree

Students registering for either of the following project credit hours require an online registration override from the corresponding instructor prior to registering:

- MMAE 594 Project for Masters of Engineering Degree
- MMAE 597 Special Topics

1.3 Financial Assistance Policy

The Mechanical, Materials, and Aerospace Engineering Department has a limited number of teaching assistantships (TA) available to graduate students in the department who show high potential for success in the programs and have the necessary teaching skills. Applications are sought near the end of each semester for the following term. The Department Chair, in consultation with the Chair of the Graduate Studies Committee, awards these assistantships to the most qualified students for a certain period of time during their degree programs. In order to make these awards to as many deserving students as possible, teaching assistantships are awarded for a maximum number of semesters as follows:

- MS with thesis students: 2 semesters
- PhD students: 4 semesters

Master of engineering and non-thesis master of science students are not eligible for teaching assistantships. The availability of these assistantships is dependent upon funding and the needs of the department. Students are encouraged to pursue a research assistantship (RA) as early as possible in their program. RA positions are available to full-time Master of Science with thesis and Doctor of Philosophy degree students and are awarded by individual faculty members.

1.4 MMAE Seminar

Registration in the departmental seminar course, MMAE 593, is required for all graduate students enrolled in a degree with a thesis requirement. This includes all PhD students and Master of Science students pursuing the thesis option. The seminar is a no fee, no credit class, but registration and attendance is mandatory. The seminar is a pass/fail class and will be graded on attendance. A student will receive a passing grade if he/she attends a minimum of 80 percent of the seminars offered in that semester. For degree completion, students must pass the seminar "K" times, where "K" is an integer greater than (n+1)/2, and n is the number of semesters a student is enrolled as a full-time graduate student. Thesis students must register for the seminar every semester that they are full-time graduate students. Students pursuing master of engineering (including co-terminal and AMP students) and course-only master of science degree programs are encouraged to attend the seminars, but they are not required to attend the seminar for graduation requirements.

Chapter 2

Master of Science (MS) and Master of Engineering (MEng)

2.1 Overview

Students with bachelors degrees in mechanical engineering, materials science and engineering, aerospace engineering, or other related fields are eligible to apply for masters degrees in the MMAE Department. Once admitted, the student's advisor will help the student formulate a program of study that includes 30 credit hours for the Master of Engineering (MEng) degrees or 32 credit hours for the Master of Science (MS) degrees. The Master of Engineering degrees are course-only programs that may include an optional project. The Master of Science degrees have a course-only option as well as one that includes research and a thesis. See the IIT Graduate Bulletin for specific course requirements for the masters degrees available in the MMAE Department.

2.1.1 Mechanical and Aerospace Engineering (MAE)

All MAE students are expected to demonstrate proficiency in engineering analysis, normally accomplished by taking one or two courses, and one of the five major areas within mechanical and aerospace engineering. The five major areas of study are fluid dynamics; thermal sciences; solids and structures; design and manufacturing; and dynamics and control. Master of science students are required to take the core course for their chosen major area and a set of electives. Master of engineering students are required to take an engineering analysis course, one course that emphasizes numerical methods, the core course in their major area, and electives, which may include core courses from other areas. The core courses corresponding to the five major areas are:

- Fluid Dynamics: MMAE 510 Fundamentals of Fluid Mechanics
- Thermal Sciences: MMAE 525 Fundamentals of Heat Transfer
- Solids and Structures: MMAE 530 Advanced Mechanics of Solids
- Dynamics and Controls: MMAE 541 Advanced Dynamics
- Design and Manufacturing: MMAE 545 Advanced CAD/CAM

The approved MMAE courses that emphasize numerical methods are:

- MMAE 451 Finite Element Methods in Engineering
- MMAE 500 Data-Driven Modeling
- MMAE 517 Computational Fluid Dynamics
- MMAE 532 Advanced Finite Element Methods
- MMAE 544 Design Optimization
- MMAE 570 Computational Methods in Materials Science and Engineering

Courses offered by other departments with an emphasis in numerical methods can also be used to satisfy the numerical requirement. Such requests will be considered on a case-by-case basis by the GSC.

2.1.2 Materials Science and Engineering (MSE)

Masters students in MSE must complete six (for MS) or seven (for MEng) designated materials science and engineering courses. The remaining credit hours are fulfilled by elective courses and/or thesis research.

2.1.3 Manufacturing Engineering (MFG)

All manufacturing engineering students are expected to complete a series of required courses. Students must select either a mechanical and aerospace (MAE) or a materials science and engineering (MSE) emphasis. Students are required to take additional courses depending on their area of emphasis. The remaining credit hours must be fulfilled by elective courses approved by the adviser.

2.2 MS and MEng Degree Completion

2.2.1 All Masters Students

Within two weeks of the start of the intended graduation semester, the student files a Form G527, Application for Graduation, with the Graduate Academic Affairs Office. After the application is filed, the Graduate College provides a form entitled, "The Sequence of Events and Deadlines," applicable to that

semester that articulates the necessary steps and corresponding deadlines for completion of the degree. Note that students must be registered for a minimum of one credit hour in the semester in which they graduate, including the summer semester.

2.2.2 MS with Thesis Students

MS with thesis students should submit Form G300 prior to the final oral examination to schedule the exam. The examination committee consists of at least three faculty members whose purpose it is to evaluate the student's thesis and carry out the examination. The committee includes the student's advisor, and one of the three faculty members must be a departmental representative from a discipline different than the student's major area of study. At least one week prior to the final oral defense, the student distributes copies of the thesis draft to the thesis committee members. His/her adviser then emails all MMAE faculty members announcing the place and time of the examination. The email should include an abstract of the thesis. It is the student's responsibility to ensure that the email is sent on time. Failure to do so may result in rescheduling of the examination.

The MS oral examination is conducted by the student's MS Advisory Committee but shall be open to the public without restriction. However, the student's MS Advisory Committee appointed to conduct the examination may continue the defense and deliberate the candidate's performance and prepare its report in private. The results of the oral examination are reported to the Graduate College on Form G309 by the student's adviser in the presence of all members of the PhD Advisory Committee, and should be returned to the Graduate College within 72 hours after the final oral exam. Form G309 will be provided to the advisor by the Graduate College. The student is responsible for obtaining approval from all committee members of the final thesis on Form G501, Final Thesis Approval.

Chapter 3

Doctor of Philosophy (PhD)

3.1 Overview

Although it is possible to apply directly to the PhD program upon receipt of a bachelors degree, the majority of those entering the PhD program will have already completed a Master of Science or Master of Engineering degree. Students who have earned a masters degree from IIT and wish to pursue a doctorate must reapply to the Graduate College through the Graduate Admissions Office. Typically, all of the work done towards a masters degree in the same field will apply toward satisfying the requirements for the PhD. Students who wish to transfer a masters degree in a different field should be prepared to provide course descriptions and/or syllabi to the GSC. The GSC will evaluate the student's transcripts and supporting documentation to determine how many credits should be transferred and which course requirements have been met by transfer courses.

The student's thesis adviser will help the student formulate an overall plan of study, including course work and a plan of research. The program of study must include a total of 72 credit hours, of which up to 32 credit hours may be from a completed MS degree. See the IIT Graduate Bulletin for specific course requirements for the PhD degrees in mechanical and aerospace engineering (MAE) and materials science and engineering (MSE).

3.2 PhD Qualifying Exam

Students who are admitted to the MMAE PhD program must pass a qualifying examination administered by the department in order to be admitted to candidacy for the PhD degree; each student has two attempts to pass the exam. The examination evaluates the student's academic background in order to determine their potential for achieving a doctorate. It also encourages doctoral students to develop and maintain a solid knowledge of fundamentals across a broad set of areas in their chosen discipline.

3.2.1 MAE Exam

The PhD qualifying exam for MAE students is administered by the MMAE PhD Qualifying Exam Committee. Students are required to take the exam during their third semester of study in the PhD program, which allows students to complete the necessary coursework during their first two semesters. Requests to delay the qualifying exam beyond the third semester owing to special circumstances must be made via petition to the MMAE Graduate Studies Committee.

The PhD qualifying examination for MAE students consists of a series of oral exams in three subject areas, including Engineering Analysis, the student's major area, and a second area. The scope of each exam is based on the material from the following courses:

- Engineering Analysis: MMAE 501, Engineering Analysis I
- Fluid Mechanics: MMAE 510, Fundamentals of Fluid Mechanics
- Thermal Sciences: MMAE 525, Fundamentals of Heat Transfer
- Solid Mechanics: MMAE 530, Advanced Mechanics of Solids and undergraduate strength of materials
- Dynamics and Controls: MMAE 541, Advanced Dynamics and undergraduate dynamics and control systems

MAE students should submit the PhD Qualifying Exam Registration Form to the Chair of PhD Qualifying Exam Committee at least four weeks before the exam week. The exam will be offered during the second week of September and the third week of January as a series of subject-area oral exams. The oral exams allow for assessment of a broad range of topics within a subject area at both the conceptual and problem-solving levels. In addition, the oral exams serve to prepare students to present and defend their research. The exams will be scheduled for all subject areas by the Chair of the PhD Qualifying Exam Committee typically within a one-week timeframe. Each oral exam will be conducted separately and last approximately 45 minutes per subject per student and be scheduled at one hour intervals. At least two subject-area faculty and one faculty member outside the area of the examination must be present at each oral exam session; these three will conduct the exam and determine the pass/fail outcome for each oral exam. The exams are open to all faculty, including the student's research advisor, for observation.

The student will receive a letter from the Chair of the PhD Qualifying Exam Committee that describes the outcome of the overall exam at the end of the entire examination period. This outcome will be determined as follows depending on whether it is the student's first or second attempt at taking the qualifying examination.

First Attempt: Take all three subject areas (Engineering Analysis, major area, second area)

- Pass 0 of 3 subject areas ⇒ Retake oral exam in 3 failed subject areas at the next opportunity.
- Pass 1 of 3 subject areas ⇒ Retake oral exam in 2 failed subject areas at the next opportunity.
- Pass 2 of 3 subject areas ⇒ Retake oral exam in 1 failed subject areas at the next opportunity.
- Pass 3 of 3 subject areas ⇒ Pass PhD Qualifying Examination.

Second Attempt: Let n equal the number of failed subject areas in the first attempt

- Pass less than n subject areas ⇒ Failed PhD Qualifying Examination
- Pass n of n subject areas ⇒ Pass PhD Qualifying Examination.

3.2.2 MSE Exam

The PhD qualifying examination for MSE students consists of an oral exam administered by a committee of MSE faculty. The level of the exam will assess basic materials science and engineering concepts at the undergraduate level. A written research exam is also required where students submit a critical review of a published paper or research topic. Students are required to take the exam within their first three semesters of study in the PhD program.

3.3 PhD Advisory Committee

The purpose of the Thesis Advisory Committee is to assist the student in the satisfactory and timely progression of the thesis research and to evaluate the comprehensive and final oral examinations. The committee is nominated by the student in consultation with his or her adviser using Form G301A in preparation for the Comprehensive Exam. Upon approval by the Department Chair, Form G301A is submitted to the Graduate College.

The MAE student's PhD Advisory Committee must consist of at least four full-time IIT (tenured or tenure track) faculty members as follows:

- the student's adviser, who acts as committee chair
- one representative from the student's major area
- one representative from outside the student's major area but in the MAE program
- one representative from outside the MAE program

The PhD Advisory Committee for MSE students must consist of at least four full-time IIT (tenured or tenure track) faculty members as follows:

- the student's adviser, who acts as committee chair
- two tenured or tenure-track professors of materials engineering
- one representative from outside the MSE program

Non-tenured or tenure-track IIT faculty, or scientists from outside IIT, may serve as additional non-voting committee members with approval of the Department.

3.4 PhD Comprehensive Exam

Whereas the purpose of the PhD qualifying examination is to asses a student's technical background in the topical areas related to their degree program, the objective of the comprehensive examination is to determine the student's level of competency in conducting research in the area of his/her thesis. According to Graduate College guidelines, the comprehensive examination must be conducted at least one year before the PhD defense examination.

The MMAE version of the comprehensive exam consists of a written and oral thesis proposal. The student must submit a brief written thesis proposal to the PhD committee prior to the oral comprehensive examination. During the comprehensive examination, the student is expected to present his/her thesis proposal. The approval of the proposal will be based on a satisfactory oral presentation to the committee and evaluation of the written proposal.

The suggested Comprehensive Exam timeline is as follows:

1. Student submits written dissertation proposal to PhD committee approximately two weeks prior to the oral exam.
2. Oral exam dissertation proposal presentation. (At the committee's discretion, the oral exam on the written topic and the thesis proposal may be conducted on separate days).

The results of the Comprehensive Examination are reported to the Graduate College on Form G309 by the student's adviser in the presence of all members of the Comprehensive Examination Committee, and should be returned to the Graduate College within 48 hours after the completion of the exam. Form G309 will be provided to the advisor by the Graduate College.

3.5 PhD Thesis Review and Defense Exam

Within two weeks of the start of the intended graduation semester, the student files a Form G527, Application for Graduation, with the Graduate Academic Affairs Office. After the application is filed, the Graduate College provides a form entitled, "The Sequence of Events and Deadlines," applicable to that

semester that articulates the necessary steps and corresponding deadlines for completion of the degree. Note that students must be registered for a minimum of one credit hour in the semester in which they graduate, including the summer semester.

PhD students should submit Form G301B prior to the final oral examination, i.e. the PhD defense, to schedule the exam. At least one week prior to the final oral defense, the student distributes copies of the thesis draft to the thesis committee members. His/her adviser then emails all MMAE faculty members announcing the place and time of the examination. The email should include an abstract of the thesis. It is the student's responsibility to ensure that the email is sent on time. Failure to do so may result in rescheduling of the examination.

The PhD final oral defense is conducted by the student's PhD Advisory Committee but shall be open to the public without restriction. However, the student's PhD Advisory Committee appointed to conduct the examination may continue the defense and deliberate the candidate's performance and prepare its report in private. The results of the Defense Examination are reported to the Graduate College on Form G309 by the student's adviser in the presence of all members of the PhD Advisory Committee and should be returned to the Graduate College within 72 hours after the final oral exam. Form G309 will be provided to the advisor by the Graduate College. The student is responsible for obtaining approval from all committee members of the final thesis on Form G501, Final Thesis Approval.

Chapter 4

MMAE Courses

4.1 Engineering Analysis Courses

The pre-approved engineering analysis courses are:

MMAE 501	Engineering Analysis I
MMAE 502	Engineering Analysis II
MMAE 503	Advanced Engineering Analysis
MMAE 508	Perturbation Methods
MMAE 509	Introduction to Continuum Mechanics
MATH 512	Partial Differential Equations
MATH 515	Ordinary Differential Equations and Dynamical Systems
MATH 522	Mathematical Modeling
MATH 535	Optimization I
MATH 544	Stochastic Dynamics
MATH 545	Stochastic Partial Differential Equations
MATH 553	Discrete Applied Mathematics I
CHE 530	Advanced Process Control
ECE 505	Applied Optimization for Engineers
ECE 511	Analysis of Random Signals
ECE 531	Linear Systems Theory
ECE 533	Robust Control
ECE 567	Statistical Signal Processing

4.2 Courses Listed by Major Area

The MMAE graduate programs have six different areas of study: Fluid Dynamics, Thermal Sciences, Solids and Structures, Design and Manufacturing, Dynamics and Control, and Materials Science and Engineering. In this section, the core and non-core courses in each major area are listed in tabular form. The core course(s) in each area of study is marked in red italics.

4.2.1 Fluid Dynamics

MMAE 510	*Fundamentals of Fluid Mechanics*
MMAE 511	Compressible Flows
MMAE 512	Viscous Flows
MMAE 513	Turbulent Flows
MMAE 514	Stability of Viscous Flows
MMAE 515	Engineering Acoustics
MMAE 516	Advanced Experimental Methods in Fluids
MMAE 517	Computational Fluid Mechanics
MMAE 518	Spectral Methods in Computational Fluid Mechanics

Other relevant courses

MMAE 509	Introduction to Continuum Mechanics
MMAE 508	Perturbation Methods
MMAE 525	Fundamentals of Heat Transfer
MMAE 527	Heat Transfer: Convection and Radiation
CHE 536	Computational Techniques in Engineering
CHE 551	Fluid Dynamics

4.2.2 Thermal Sciences

MMAE 433	Design of Thermal Systems
MMAE 520	Advanced Thermodynamics
MMAE 522	Nuclear, Fossil-Fuel, and Sustainable Energy Systems
MMAE 523	Fundamentals of Power Generation
MMAE 524	Fundamentals of Combustion
MMAE 525	*Fundamentals of Heat Transfer*
MMAE 526	Heat Transfer: Conduction
MMAE 527	Heat Transfer: Convection and Radiation

Other relevant courses

MMAE 509	Introduction to Continuum Mechanics
MMAE 508	Perturbation Methods
MMAE 510	Fundamentals of Fluid Mechanics
MMAE 512	Viscous Flows
MMAE 513	Turbulent Flows
MMAE 514	Stability of Viscous Flows
MMAE 516	Advanced Experimental Methods in Fluids
MMAE 517	Computational Fluid Mechanics
CHE 501	Transport Phenomena
CHE 503	Chemical Engineering Thermodynamics
CHE 505	Fluid Properties
CHE 512	Heat Transfer
CHE 518	Mass Transfer
CHE 541	Renewable Energy Technologies
CHE 543	Energy, Environment and Economics
CHE 542	Fluid and Gas-Solid Flow

4.2.3 Solids and Structures

MMAE 451	Finite Element Methods in Engineering
MMAE 529	Theory of Plasticity
MMAE 530	*Advanced Mechanics of Solids*
MMAE 531	Theory of Elasticity
MMAE 532	Advanced Finite Element Methods
MMAE 533	Fatigue and Fracture Mechanics
MMAE 535	Wave Propagation
MMAE 536	Experimental Solid Mechanics

Other relevant courses

MMAE 509	Introduction to Continuum Mechanics
MMAE 508	Perturbation Methods
MMAE 570	Computational Methods in Materials Processing
MMAE 578	Fiber Composites
CHE 580	Biomaterials

4.2.4 Dynamics and Control

MMAE 539	Robotic Motion Planning
MMAE 540	Robotics
MMAE 541	*Advanced Dynamics*
MMAE 542	Applied Dynamical Systems
MMAE 543	Modern Control Systems
MMAE 549	Optimal Control
MMAE 550	Optimal State Estimation
MMAE 551	Experimental Mechatronics
MMAE 552	Introduction to the Space Environment
MMAE 555	Introduction to Navigation Systems

Other relevant courses

MMAE 508	Perturbation Methods
MMAE 544	Design Optimization
MMAE 560	Statistical Process and Quality Control
ECE 505	Applied Optimization for Engineers
ECE 511	Analysis of Random Signals
ECE 513	Communication Engineering Fundamentals
ECE 531	Linear System Theory
ECE 533	Robust Control
ECE 535	Discrete Time Systems
ECE 537	Optimal Feedback Control
ECE 567	Statistical Signal Processing
ECE 569	Digital Signal Processing
BME 511	Physiological Control Systems and Modeling

4.2.5 Design and Manufacturing

MMAE 445	CAD/CAM with Numerical Control
MMAE 534	Product Design and Innovation
MMAE 544	Design Optimization
MMAE 545	*Advanced CAD/CAM*
MMAE 546	Advanced Manufacturing Engineering
MMAE 547	Computer Integrated Manufacturing – Technologies
MMAE 556	Nano Manufacturing
MMAE 557	Computer Integrated Manufacturing – Systems
MMAE 560	Statistical Process and Quality Control
MMAE 585	Engineering Optics and Laser-Based Manufacturing
MMAE 587	Introduction to Digital Manufacturing
MMAE 588	Additive Manufacturing
MMAE 589	Applications in Reliability Engineering I
MMAE 590	Applications in Reliability Engineering II

Other relevant courses

MMAE 433	Design of Thermal Systems
MMAE 540	Robotics
MMAE 551	Experimental Mechatronics

4.2.6 Materials Science and Engineering

MMAE 468	Introduction to Ceramic Materials
MMAE 470	Introduction to Polymer Science
MMAE 472	Advance Aerospace Materials
MMAE 520	Advanced Thermodynamics
MMAE 554	Electrical, Magnetic and Optical Properties of Materials
MMAE 561	Solidification and Crystal Growth
MMAE 562	Design of Modern Alloys
MMAE 563	Advanced Mechanical Metallurgy
MMAE 564	Dislocation and Strength Mechanisms
MMAE 565	Materials Laboratory
MMAE 566	Problems in High Temperature Materials
MMAE 567	Fracture Mechanisms
MMAE 568	Diffusion
MMAE 569	Advanced Physical Metallurgy
MMAE 570	Computational Methods in Materials Science and Engineering
MMAE 572	Crystallography and Crystal Defect
MMAE 576	Materials and Process Selection
MMAE 578	Fiber Composites
MMAE 579	Advanced Materials Processing

Other relevant courses

MMAE 451	Finite Element Methods in Engineering
MMAE 525	Fundamentals of Heat Transfer
MMAE 530	Advanced Mechanics of Solids
MMAE 532	Advanced Finite Element Methods
MMAE 533	Fatigue and Fracture Mechanics
CHE 580	Biomaterials