Guide to Graduate Study in the

Department of Mechanical and Aerospace Engineering

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1. OVERVIEW

The faculty in the Department of Mechanical and Aerospace Engineering offer graduate programs leading to the degrees of Master of Science (MS), Master of Science in Engineering (MSE) and Doctor of Philosophy (PhD) in Aerospace Engineering and Mechanical Engineering. All of the programs stress a sound foundation in technical fundamentals, communication, and professionalism. The Master's degree program prepares engineers for advanced industrial positions that require the ability to conduct research, project management, or product innovation or for advanced study. The Doctoral program emphasizes original research and provides students with a strong background for employment by government laboratories, industrial research laboratories, and academic institutions. The Department offers a broad-based curriculum in aerodynamics and fluid mechanics, design and manufacturing, heat transfer and energy systems, solid mechanics and dynamics, and system dynamics and control. Several interdisciplinary programs are also accessible. Modern computational and laboratory facilities are available to support timely research investigations.

The graduate program accommodates individual interests and encourages independent and innovative study. Students are part of a diverse intellectual community dedicated to advancing the state-of-the-art and practice of aerospace and mechanical engineering. The following sections provide information about program requirements, policies, and curriculum.

2. ADMISSIONS POLICY

It is the goal of the Department to achieve balance, to the extent possible, between domestic and international students. The Department will strive to achieve a representative population of under-represented groups as candidates for advanced degrees.

2.a. Admission Requirements

The Graduate College requires the applicant to submit a formal application, which contains basic personal and educational information, including an official transcript. The MAE Department also requires the following:

i) Graduate Record Examination. All applicants are required to take the Graduate Record Examination (GRE); the subject test in Engineering is highly recommended but not required.

ii) Area of Specialization. All applicants are required to indicate an area or areas of specialization as part of their application; this will allow matching the student's interests with those of the faculty. The incoming student is cautioned to understand that he or she will normally be expected to study in one of the areas of specialization he or she indicated on the application.

iii) Statement of Purpose. All applicants are required to submit a statement of career objectives. This statement should address the applicant's career goals and objectives and why the applicant wishes to pursue graduate studies.

iv) Letters of Recommendation. All applicants must submit three (3) letters of recommendation using the format specified by the MAE Department.

v) MS Students at ASU Continuing for the PhD. Upon completion of the MS program, a student may be admitted directly to the doctoral program upon the

recommendation of the student's advisory committee, the approval of the Department's Graduate Affairs Committee (GAC), the Department Chair and the Graduate College. PhD applicants are required to submit the title and abstract of their MS thesis.

vi) Admission of BS Students to the PhD Program. BS students are not admitted directly into the PhD program. Nevertheless, the MS degree can be bypassed as delineated in Section 8.

vii) Evaluation of Credentials. The MAE department policy does not allow for informal evaluation of prospective applicants' credentials; i.e., only fully-completed applications are processed.

2.b. Admission Standards/Guidelines

i) For graduates of accredited U.S. institutions, a minimum GPA of 3.00 (B) is a guideline. Some accounting for the strength of the applicant's institution is provided.

ii) For graduates of foreign institutions, GRE scores are used to assess the relative achievement and capabilities of candidates from a variety of institutions and with varying backgrounds. International students for whom English is a second language must have a minimum score of 213 (CBT), 550 (PBT) or 83 (iBT) in the TOEFL examination and participate, as appropriate, in the American Language and Cultural Program if pursuing a PhD Program.

iii) Under certain circumstances (e.g., an individual whose degree is in neither Aerospace nor Mechanical Engineering) the admitted student may be required to take background courses for which no graduate credit will be given.

3. FINANCIAL SUPPORT POLICY

The MAE Department will allocate a limited number of graduate assistantships each year. The following guidelines will be used to determine the recipients of this support.

i) All financial support will be based on merit. Criteria used to determine merit will be the applicant's GPA, GRE scores, letters of recommendation and statement of purpose.

ii) The decision as to whom will receive Department financial support (i.e., from the general departmental fund) will be determined by the Department's service needs (e.g., teaching assistants). All graduate students on Department support will be assigned appropriate teaching related duties. International students must pass the SPEAK test with a minimum score of 55 to be eligible for Departmental teaching assistantships.

iii) Assignments in teaching and research for incoming students will be predicated on the student's indicated area of specialization.

iv) The decision as to whom will receive support from research grants and contracts will reside with the principal investigator from whose funds the student will be paid.

v) Students making satisfactory progress (see Section 4), subject to the availability of funds, are eligible to receive a maximum of three semesters Departmental support as MS candidates and five semesters Departmental support as PhD candidates. Students pursuing the MSE degree are not eligible for Departmental support. Students on academic probation or new provisionally admitted students are not eligible for Departmental support.

vi) Students receiving financial aid must register for 12 hours of credit each semester; these hours may include research and dissertation credits. These students must also register for MAE 594 Graduate Research Conference. Note that an audited course does not count toward the 12 hours and requires a Petition to the Graduate College.

4. GRADUATE PROGRAMS

4.a. Graduate courses

Graduate course offerings in the MAE Department cover the classical areas, including aerodynamics and fluid mechanics, design and manufacturing, heat transfer and thermodynamics, solid mechanics and dynamics, and system dynamics and control as well as interdisciplinary topics in micro- and nano-technology and sustainability. A list of current course offerings in these areas is given in Appendix A. Students must also satisfy a mathematics requirement. Courses that may be used to satisfy this requirement are also listed in Appendix A.

Normally, a maximum of one 400 level class from Mathematics will count toward the course requirements of either the MS, MSE or the PhD degrees. Normally, a maximum of one 400 level class from the School of Engineering or from the Physical Sciences will count toward the course requirements of either the MS, MSE or the PhD degrees. Classes required for either the Mechanical Engineering or the Aerospace Engineering BS degrees are excluded.

Audited courses do not apply toward the degree program. In general MAE graduate students are not granted permission to audit a course until the student has filed a Program of Study (POS) and has completed all coursework on the POS.

4.b. Master of Science

The University requirements for the Master of Science (MS) degree are given in the Graduate Catalog. The MS is the Department's research master's degree; majors in Aerospace Engineering and Mechanical Engineering are available.

The student is encouraged to select an advisor as soon as possible but in no case later than the middle of the first semester in residence. The name of the student's advisor must be filed with the Department Office. A change of advisor requires approval of the Department Chair.

The advisor, in consultation with the student, will establish a Master of Science Program Committee (MSPC). The MSPC shall be composed of a minimum of three members from the ASU faculty with at least two being from MAE. Participation of individuals from institutions external to ASU is encouraged but these shall be non-voting members. The advisor shall serve as chair of the MSPC.

As soon as possible, but no later than the end of the student's first semester of residence, the student, in consultation with the MSPC, must file a program of study (POS) with the Department. The MSPC and the MAE Chair must approve changes to the POS.

The POS must be in accordance with Graduate College and MAE Department requirements. The candidate must complete at least 30 semester hours of course and research work distributed as follows:

1) At least twelve (12) hours course work in the candidate's major (research) area.

2) At least six (6) hours of mathematics.

3) At least six (6) hours of other graduate level course work outside the candidate's major (research) area; these must be restricted to mathematics, engineering and/or science.

4) At least six (6) hours of thesis (MAE 599).

Students are required to maintain a 3.0 GPA on the course work portion of their POS. In calculating the GPA, research and thesis grades cannot be included; whenever a C or lower is received the grade cannot be removed from the POS.

A final defense of the thesis will be administered by the MSPC.

4.c. Master of Science in Engineering

The University requirements for the Master of Science in Engineering (MSE) degree are given in the Graduate Catalog. This degree is the Department's professional degree; majors in Aerospace Engineering and Mechanical Engineering are offered. Only the non-thesis option is available in MAE. The requirements for selecting an advisor, forming a Master of Science in Engineering Program Committee (MSEPC) and establishing (and changing) a POS are the same as for the Master of Science degree.

The POS must include at least 30 semester hours of course work distributed as follows:

1) At least fifteen (15) hours in the major area of interest.

2) At least six (6) hours of mathematics.

3) At least nine (9) hours of other graduate level course work outside the candidate's major (research) area; these may be in engineering, science, or other areas approved by the MSEPC.

Students are required to obtain a 3.0 GPA for the courses listed on their POS; whenever a C or lower is received, the grade cannot be removed from the POS.

A final comprehensive examination or applied project will be administered by the MSEPC. The purpose of this culminating event is to determine the student's ability to integrate the knowledge gained in his or her coursework.

4.d. Doctor of Philosophy (PhD)

The Doctor of Philosophy (PhD) degree is directed toward original research. The student is required to write and defend a dissertation that describes an original contribution within the chosen discipline. The research results should be suitable for publication in a reputable journal. The Department currently offers majors in Aerospace Engineering and Mechanical Engineering.

4.d.1 Selection of an Advisor

The student must select a faculty advisor with the selection being made no later than the end of the first semester in residence. The advisor's name must be filed with the Department Office. A change of advisor requires approval of the Department Chair.

4.d.2 Qualifying Criteria

A graduate student pursuing a PhD program of study in Aerospace or Mechanical Engineering, must complete within the first year of his/her graduate studies at ASU, three (3) 500-level (preferably core) courses in the major area and one (1) 500-level mathematics course with an average GPA of 3.25 or above. Specific qualifying course requirements for each major area are identified below.

Aerodynamics and Fluid Mechanics

Major: (i) MAE 571 Fluid Mechanics

(ii) MAE 561 Computational Fluid Dynamics

(iii) A choice of one of the following:

MAE 572 Advanced High Speed Flows

MAE 573 Viscous Flow

MAE 564 Advanced Aerodynamics

MAE 575 Turbulence

Mathematics: MAE 502 Partial Differential Equations in Engineering or the equivalent 500-level PDE course offered in the Mathematics Department

Design and Manufacturing

Major: (i) MAE 540 Advanced Product Design Methodology

(ii) MAE 544 Mechanical Design and Failure Prevention

(iii) A choice of one of the following:

MAE 541 CAD Tools for Engineers

MAE 598 Polymers and Composites (co-listed as MAE 455)

MAE 547 Mechanical Design and Control of Robots

Mathematics: MAE 501 Linear Algebra in Engineering

Heat Transfer and Thermodynamics

Following are the three PhD qualifying requirements:

1) Either MAE 589 Heat and Mass Transfer, MAE 581 Advanced Thermodynamics

2) Two of the following, that are different from 1) above:

MAE 504 Experimental Methods for Thermal and Fluid Processes
MAE 536 Combustion
MAE 586 Convection Heat Transfer
MAE 589 Heat and Mass Transfer
MAE 581 Advanced Thermodynamics
MAE 598 Nanoscale Heat Transfer

3) Mathematics: MAE 502 Partial Differential Equations in Engineering or the equivalent 500-level PDE course offered in the Mathematics Department

Solid Mechanics and Dynamics

Major: (i) MAE 510 Dynamics and Vibrations

(ii) MAE 520 Stress Analysis

(iii) A choice of one of the following:

MAE 515 Structural Dynamics

MAE 524 Theory of Elasticity

Mathematics: A choice of one of the following:

MAE 501 Linear Algebra in Engineering

MAE 502 Partial Differential Equations in Engineering

PHY 501 or PHY 502 Methods of Theoretical Physics or any 500-level course offered in the Mathematics Department

System Dynamics and Control

Major: (i) MAE 506 Advanced System Modeling, Dynamics, and Control

(ii) MAE 507 Optimal Control

(iii) MAE 510 Dynamics and Vibrations (required for PhD in Mechanical Engineering)

Mathematics: MAE 501 Linear Algebra in Engineering

Course substitutions are allowed only under unusual circumstances and require the approval of the GAC and Department Chair.

4.d.3 Program Committee

University regulations note the possibility of having two separate supervisory committees, a Program Committee and a Dissertation Committee. In the Department of MAE these will normally be one and the same and will be designated as the Program Committee (PC).

The advisor, in consultation with the student, will establish a PC, the purposes of which are to:

1) Approve the program of study (POS).

2) Provide guidance for the student's research.

3) Administer the comprehensive examination.

4) Administer the dissertation defense.

The PC shall consist of at least five ASU faculty with the majority being from MAE, but at least one being from outside the Department. Participation of individuals from institutions external to ASU is encouraged, but these shall be non-voting members. Furthermore, the PC should have the following character:

1) Advisor (PC Chair); must be from MAE.

2) Two or three additional faculty in the student's general area of research.

3) At least one faculty outside the student's general area of research (e.g., mathematics, physics or other Engineering disciplines).

A change in the PC requires approval of the Department Chair.

4.d.4 Program of Study

The student in consultation with his/her advisor and the PC must file a POS. The POS must meet general University requirements including residency and the need for rigorous fundamental knowledge of engineering principles. A minimum of 84 semester hours of credit, including six (6) hours of dissertation is required for the PhD degree. A minimum of 36 hours of this total must be formal graduate-level course work including four core courses completed after the BS. The PC for each student shall determine the content and total number of class hours on the POS subject to the following minimum requirements:

(1) At least eighteen (18) hours in the major area,

(2) At least nine (9) hours of mathematics,

(3) At least nine (9) hours of other graduate level course work outside the candidate's major (research) area; these must be restricted to mathematics, engineering and/or science.

(4) At least 12 hours of dissertation

(5) At least 42 hours of graduate level coursework and MAE 799 dissertation. These hours are “flexible” and may come from the Master’s Degree; on-line courses; or research. Note that a maximum of 30 hours may come from the Master’s Degree; the remaining 12 hours may come from on-line courses or research. MAE 594 cannot count in these hours. Up to six (6) hours of MAE 599 thesis hours may count toward the PhD (as part of the 30 hours Master’s credits).

There is a residency requirement for the PhD degree of 54 hours. Therefore, 54 of the total 84 hours must be taken on Arizona State University’s main campus AFTER admission to the PhD program.

Additional course work may be required to insure competence in a particular discipline area. Students are required to establish their PC and POS no later than the semester after successfully completing the qualifying criteria. The PC and the MAE Chair must approve any changes to the POS.

4.d.5 Comprehensive Examination

All students intending to earn the PhD degree are required to pass a comprehensive examination. The examination will be administered by the PC and consists of two parts:

1. Subject matter examination

The purpose of this portion of the examination is to determine a student's grasp of essential concepts relevant to the PhD degree in general and the student's ability to project beyond existing knowledge. Written and oral questions covering the student's graduate course work must be included.

2. Research proposal

The purpose of this portion of the examination is to evaluate a student's research acumen and ability to develop and present an original research proposal; and, equally as important, to advise the student in finalizing successful research goals and procedures. The formal written proposal containing the research goals, methodology, expected results and contributions of publishable quality will be defended orally before the entire committee.

The comprehensive examination is taken soon after completing the PhD qualifying requirements and at least one academic year prior to making the dissertation defense. Qualified PhD students should take the examination by their fifth semester as full-time students in the MAE PhD program and must pass the examination by the end of the sixth semester. Part-time students should apprise the MAE Chair of a timely schedule for exam completion.

4.d.6 Candidacy

PhD students achieve candidacy status in a letter from the Graduate College dean upon passing the comprehensive examination and successfully defending the dissertation prospectus.

4.d.7 Final Oral Examination

The dissertation defense is an oral examination administered by the PC in accordance with the Graduate College guidelines. The purpose of the examination is to evaluate the student's research efforts and written presentation (dissertation), and to determine if the candidate is worthy of receiving a PhD degree. The major area of emphasis of this examination is the student's research dissertation and the general areas of study related thereto. The final dissertation defense must be taken within five years of passing the comprehensive examination.

5. MILESTONES AND TIMELINE

5.a. MS Degree

i. Select advisor – middle of first semester.
ii. File Program of Study – end of first semester.
iii. Apply for graduation – must be completed at least 12 weeks before the end of the intended semester of graduation[1].
iv. Submit thesis for format approval – must be completed at least 15 business days before the last day to defend a thesis[1].
v. Submit Master's Defense Schedule Form (http://www.asu.edu/graduate/forms) a minimum of ten business days before defense date (consult 10-day calendar).[1]
vi. Hold oral defense of thesis – must be completed by the last day to defend a thesis date [1].
vii. Submit thesis to ASU Bookstore – must be completed at least 2 weeks before the end of the intended semester of graduation[1]. Three copies (2 for ASU library; 1 for MAE library).
viii. Commencement date – See academic calendar.

Maximum time limit – Oral defense of thesis must be held within six (6) consecutive years.

NOTE: MS students must maintain consecutive semester enrollment. If a student does not register for at least one credit hour during a semester, an application for re-admission to the MS degree program is required.

5.b. PhD Degree

i. Select advisor – end of first semester.
ii. Complete qualifying course requirements – within the first year.
iii. File Program of Study – No later than one semester after completing qualifying criteria.
iv. Complete comprehensive examinations – before completion of fifth semester.
v. Apply for graduation – must be completed at least 12 weeks before the end of the intended semester of graduation[1].
vi. Submit dissertation for format approval – must be completed at least 15 business days before the last day to defend a thesis[1].

[1] See Graduate Academic Advisor for deadlines

vii. Submit Doctoral Defense Schedule Form (http://www.asu.edu/graduate/forms) a minimum of ten business days before defense date (consult 10-day calendar).[1]
viii. Hold oral defense of dissertation – must be completed at least 2 weeks before the end of the intended semester of graduation[1].
ix. Submit dissertation to ASU Bookstore – must be completed at least 2 weeks before the end of the intended semester of graduation[1]. Three copies (2 for ASU library; 1 for MAE library).
x. Commencement date – See academic calendar.

Maximum time limit – Oral defense of dissertation must be held within ten (10) years. Additionally, the oral defense must be held within five (5) years of passing the comprehensive examinations.

NOTE: Doctoral students must maintain consecutive semester enrollment or have an approved petition for leave of absence on file. If a student does not register for a minimum of one credit hour during a semester an application as a new PhD student must be filed. If re-admitted to the degree program the student may forfeit some previously taken courses.

6. SATISFACTORY STANDING

All MS and MSE students must maintain a GPA of 3.00 and all PhD students a GPA of 3.25 in course work approved under their program of study to maintain good standing. Ira A. Fulton School of Engineering guidelines on retention are to be strictly enforced; see Appendix B. Note that MAE requirements for PhD students are more stringent than those of the Ira A. Fulton School of Engineering.

7. GRADUATE STUDENT ADVISING

For initial advising, incoming students will report to the MAE Vice-Chair of Graduate Programs who will arrange for a temporary advisor based on the student's stated area of interest. In any event, unless a particular faculty member on a research grant or contract is directly supporting an incoming student, in which case that faculty person will be the advisor, the initial advisor should be considered temporary until such time as a permanent advisor is designated.

8. ADMISSION TO PhD PROGRAM WITHOUT MS

A highly qualified graduate student may be permitted to bypass the MS and proceed directly to the PhD program. To qualify, the student must have completed at least 9 hours of approved graduate work at ASU in good standing and must be nominated by his or her research advisor.

The GAC will consider a request for a MS student to take the PhD qualifying course work and pursue the above degree path after receiving the following:

- A letter of intent from the student.
- A letter of nomination from the student's research advisor.
- Other appropriate supporting materials.

Approval of the request requires a majority vote of the GAC and the approval of the Department Chair and the Graduate College. A student, who has qualified to bypass the MS degree, may return to the MS program upon his or her request.

9. GRADUATE COURSE OFFERINGS (Appendix A)

Aerodynamics and Fluid Mechanics:

MAE 561 Computational Fluid Dynamics

MAE 564 Advanced Aerodynamics

MAE 566 Rotary-Wing Aerodynamics

MAE 571 Fluid Mechanics

MAE 572 Advanced High Speed Flows

MAE 573 Viscous Flow

MAE 575 Turbulence

Design and Manufacturing:

MAE 540 Advanced Product Design Methodology

MAE 541 CAD Tools for Engineers

MAE 544 Mechanical Design and Failure Prevention

MAE 546 CAD/CAM Applications in MAE

MAE 547 Mechanical Design and Control of Robots

Heat Transfer and Thermodynamics:

MAE 504 Experimental Methods in Thermal and Fluid Processes

MAE 536 Combustion

MAE 581 Advanced Thermodynamics

MAE 585 Conduction Heat Transfer

MAE 586 Convection Heat Transfer

MAE 587 Radiation Heat Transfer

MAE 589 Heat and Mass Transfer

Solid Mechanics and Dynamics:

MAE 510 Dynamics and Vibrations

MAE 512 Random Vibrations

MAE 515 Structural Dynamics

MAE 520 Stress Analysis

MAE 521 Structural Optimization

MAE 523 Fracture Mechanics

MAE 524 Theory of Elasticity

MAE 527 Finite Elements for Engineers

MAE 557 Mechanics of Composite Materials

System Dynamics and Control:

MAE 506 Advanced System Modeling, Dynamics and Control

MAE 507 Optimal Control

MAE 510 Dynamics and Vibrations

EEE 581 Filtering of Stochastic Processes

EEE 582 Linear System Theory

EEE 585 Digital Control Systems

EEE 586 Nonlinear Control Systems

EEE 587 Optimal Control Systems

Mathematics Electives:

MAT 400 or 500 Level Courses

STP 500 Level Courses

MAE 501 Linear Algebra in Engineering

MAE 502 Partial Differential Equations in Engineering

PHY 501, 502 Methods of Theoretical Physics

EEE 550 Transform Theory and Appl.

STP 421 Probability

STP 425 Stochastic Processes

MAE 505 Perturbation Methods

IEE 500 Engineering Statistics (also referenced as IEE 485)

Note: STP 420 will not count toward any MAE graduate degree

10. MAE Academic Standards (Appendix B)

Policy for Maintaining Academic Satisfactory Progress

A student who has been admitted to an MS or MSE degree program in Mechanical or Aerospace Engineering, with either regular or provisional admission status, must maintain a 3.0 or higher grade point average (GPA) as stated below. A student who has been admitted to a PhD degree program in Mechanical or Aerospace Engineering, with either regular or provisional admission status, must maintain a 3.25 or higher grade point average (GPA) as stated below.

1. In all work taken for graduate credit (courses numbered 500 or higher);
2. In the coursework in the student's approved program of study, and
3. In all post baccalaureate coursework taken at ASU (overall GPA).

A. A student will be placed on academic probation if:

- One or more of the student's GPAs listed above falls below 3.0 (MS) or 3.25 (PhD) respectively;
- Or the student receives a grade of D or E in a course at the 400 level or above;

Students will be notified by mail when placed on academic probation.

B. A student will return to academic good standing by obtaining a minimum 3.0 (MS), or 3.25 (PhD) in the GPAs listed above by the time the next nine hours are completed. Coursework such as research and dissertation registration that are for Z or Y grade cannot be included in these nine hours.

C. A student may be recommended for dismissal from a graduate program if:

- The student fails to increase all of the GPAs listed above to a minimum of 3.0 (MS) or 3.25 (PhD) by the time he/she completes the next nine credit hours as defined in section B;
- Or the student receives a grade of D or E while on academic probation for any reason;
- Or a provisionally admitted student fails to meet the required provision(s) of admission.

A student may appeal actions concerning dismissal by petitioning the departmental unit in which they are enrolled.