Mechanical and Systems Engineering Ph.D.
Russ College of Engineering and Technology

Policies and Procedures

1.0 GENERAL

The Mechanical and Systems Engineering Ph.D. program is an interdisciplinary Ph.D. program with specialization tracks in Mechanical Engineering (ME) and Industrial and Systems Engineering (ISE). The Mechanical and Systems Engineering Ph.D. program prepares students for advanced engineering work in industry, government, or academia.

The ME track includes academic and research specialties in the areas of biomedical engineering, CAD/CAM, machine and automotive design, energy, manufacturing, materials and deformable solid body mechanics, robotics and rigid body mechanics, and thermo-fluid systems.

The ISE track includes specialization areas in manufacturing systems, manufacturing information systems, artificial intelligence, systems simulation, process planning, distribution systems, generic algorithms, data mining, and location science.

A minimum of 60 semester hours beyond the Master of Science (M.S.) degree is required. An interdisciplinary component, for which graduate coursework is taken outside the program track, is a general program requirement. In addition to general program requirements, specific track requirements must also be satisfied. Students must pass qualifying and comprehensive exams, as well as a successfully defending a doctoral dissertation. A minimum of 30 semester hours of dissertation and 30 semester hours of approved graduate coursework are required. A plan of study is approved by the student's dissertation advisory committee, the specialization track coordinator, and the chair of the program steering committee.

The basic requirement for admission is a Master of Science degree in engineering or a related field, i.e., chemistry, physics, or applied mathematics. Applicants holding degrees in closely related fields or from non-accredited engineering institutions may be required to compensate for deficiencies with additional coursework. The Graduate Record Exam (GRE) general test and Test of English as a Foreign Language (TOEFL) is required for applicants whose native language is not English. Three letters of recommendation are required from persons who can attest to the applicant's academic and research aptitude. Admission to the program is restricted to those students whose educational plans fall within one of the two specialty areas.

A maximum of 8 semester hours of graduate coursework, completed at another university, will be considered for credit towards degree completion. Such a request must be made in writing to the Russ College of Engineering and Technology, and will require approval by the Steering Committee and the student's dissertation advisory committee. Graduate courses
that were used to satisfy the requirements for another degree are not eligible for transfer. University residency requirements must be met as stated in the Ohio University Graduate Catalog. More than 8 semester hours will only be considered in exceptional situations.

A Plan of Study is developed on an individual basis with the student's advisor and dissertation advisory committee. Each Plan of Study must include the capstone synthesis course. In addition, students must include courses appropriate to the selected specialization track. A minimum of 15 credit hours of course work must be at the 6000 level or above, of which at least 6 credit hours must be at the 7000 level or above. All Plans of Study must include at least 60 credit hours, including at least 30 credit hours for the dissertation and 30 credit hours of course work above the M.S. degree. The plan must be approved by the student's advisor, dissertation committee, and the graduate chairman of either the ME or ISE department, depending on the track selected.

Students must pass two qualifying examination before earning 15 credit hours of course work applicable toward the Ph.D. degree, and a comprehensive examination no later than the end of 4 semesters of course work. Exceptions to the prescribed timeline may be considered on a case-by-case basis under extenuating circumstances only. The qualifying examinations encompass basic knowledge in mathematics, physics, and engineering subjects complimentary to the specialization track of study chosen by the student. The topics covered by the qualifying exam are at the advanced undergraduate and beginning graduate level and they determine the student's capability for advanced course work in engineering. The comprehensive examination measures the student's knowledge and integration of subject matter necessary for the successful completion of the dissertation. The student’s dissertation committee determines the format and content of the comprehensive exam.

Inquiries for admission into the program or requests for further information should be addressed to the graduate chairman of ME or ISE. University policies and general information regarding graduate studies are discussed in the Graduate Catalog of Ohio University that can be accessed at the following web site: http://www.ohio.edu/graduate/apply.cfm.

It is the responsibility of the Ph.D. candidate to ensure that these policies and procedures and those of the university are met.

2.0 PROGRAM ADMINISTRATION

Administration of the Mechanical and Systems Engineering Ph.D. Program is delegated to the Associate Dean for Research, Graduate Studies, and Planning (RAGS) of the Russ College of Engineering and Technology. The graduate chairmen of the ME and ISE departments assist the Associate Dean of RAGS in administering the program. Final authority rests with the Dean of the Russ College of Engineering and Technology.

2.1 Steering Committee and Specialization Track Coordinators

The Steering Committee (SC) is composed of the graduate chairmen of the ME and ISE
departments. The Associate Dean of RAGS, who is responsible directly to the Dean of the Russ College, chairs the Steering Committee.

Functions of the Steering Committee are:

1. Set the direction for the program and establish program policies
2. Evaluate and recommend applicants for admission
3. Approve the dissertation advisory committees and Plans of Study of individual students
4. Ensure that quality and integrity are maintained
5. Assist the Associate Dean of RAGS and the dissertation advisory committee in administering qualifying and comprehensive examinations.

The duties of the ME and ISE chairmen are to develop guidelines for selecting courses for the track, approve programs of study, approve changes in programs of study, assist in administering qualifying and comprehensive exams, serve as initial advisors of new students who do not have a dissertation advisor, and help the Associate Dean of RAGS develop recruiting and promotional materials for the MSE Ph.D. program. The Associate Dean of RAGS consults with the Steering Committee in cases of exceptions to the Ph.D. program policies and guidelines.

2.2 Dissertation Advisory Committee

Each student must select a dissertation advisor no later than at the completion of the second semester after the initiation of the MSE Ph.D. program. The student's dissertation advisor must have research experience in the area that the student has selected to specialize. The dissertation advisor must be a member of the graduate faculty in the Russ College. The respective graduate chairman will advise students until they have selected a dissertation advisor.

The student's dissertation advisory committee, chaired by the student's dissertation advisor, consists of at least three graduate faculty members (including the dissertation advisor) from within the College and two representatives from outside the College. The Associate Dean for RAGS approves the external representatives based on recommendations from the student’s dissertation advisor. Each external representative must be a member of the graduate faculty of his or her college, or hold Associate Graduate Faculty status in the Russ College if the external representative is from an institution external to Ohio University. A student's dissertation advisory committee should be formed before the student completes three quarters of course work applicable toward the degree.

The dissertation advisory committee must have: (i) at least one member from each major department of study that the student has selected; and (ii) at least two members with previous experience in directing Ph.D. dissertations. When the dissertation committee is proposed, a recommendation can also be made regarding the external representatives. If recommendations have not been made or if the recommendations are not acceptable, the Associate Dean of RAGS will consult with the major advisor to select the external representatives. The external representatives must be approved before the student presents the research proposal to his/her dissertation committee. The graduate chairmen and the Associate Dean for RAGS approve all
The student and the dissertation advisor establish the student’s Plan of Study under guidelines provided by the policies and procedures in this document. Except for the external representatives, all members of the dissertation advisory committee and the respective graduate chairman must formally approve the Plan of Study by reviewing and signing. The Associate Dean of RAGS will give final approval of the Plan of Study by signing, if the Plan of Study adheres to the policies and guidelines of the Mechanical and Systems Engineering Ph.D. Program. In cases of exceptions to the guidelines or other special circumstances, the Associate Dean of RAGS will ask the Steering Committee to evaluate the Plan of Study and decide if exceptions are warranted. Changes in a Plan of Study must be submitted in a timely fashion and the approval process is the same as that for the original Plan.

The student's dissertation advisor oversees all aspects of the doctoral work and is directly responsible for quality control. The student and the dissertation advisor may periodically convene the dissertation advisory committee for the student to present progress reports and to seek advice and direction from the committee. If circumstances warrant, a student may petition for a change in the composition of the dissertation advisory committee. Approval of changes to the advisory committee is executed using the same form and process as is used to initially form the advisory committee.

2.3 Role of External Dissertation Committee Members

Two dissertation committee member must be from outside of the Russ College of Engineering and Technology (such as from Physics, Chemistry, Math, Business, or Biology). These faculty members must have graduate faculty status in his/her college. In special cases it may be possible to have a college representative from another University. If an external representative is from a college that does not specify graduate faculty status, the faculty member must be engaged in teaching graduate courses, advising graduate students and publishing research results.

1. Basic Requirements
   a. These members must be able and willing to assess the general "technical quality of the work" in comparison to the expectations for Ohio University graduate students and judge whether the work is "dissertation worthy". An external representative is not expected to have expertise in the technical content of the thesis, but to make sure that good research methods were used.
   b. These members must be able and willing to assess the general "quality of the document" in comparison to the expectations for Ohio University graduate students and judge whether the written document is of acceptable quality for a dissertation. The Introduction and Literature Search should be understandable to any educated reader, and the citations must meet an acceptable standard. An external representative is not expected to act as an editor, but rather as an assessor.

2. Basic Expectations
   a. The members are expected to read the dissertation proposal document and participate in the proposal defense (approximately 3-5 hour time
commitment).

b. The members are expected to read the dissertation document and participate in the final defense (6 to 10 hour time commitment).

The members are expected to notify the College’s Assistant Dean for research of any concerns with the dissertation advisor or the overall process.

3.0 ADMISSION

All prospective students must apply through the normal application procedure of Ohio University. Application information and forms can be found on the web site of the Graduate College as follows: http://www.ohio.edu/graduate/. The application procedures of Ohio University must be followed precisely.

The basic requirement for admission is a Master of Science degree in engineering or a related field, i.e., chemistry, physics, or applied mathematics. Applicants holding degrees in closely related fields or from non-accredited engineering institutions may be required to compensate for deficiencies with additional coursework. The Graduate Record Exam (GRE) general test and Test of English as a Foreign Language (TOEFL) is required for applicants whose native language is not English. Three letters of recommendation are required from persons who can attest to the applicant's academic and research aptitude. Admission to the program is restricted to those students whose educational plans fall within one of the two specialty areas.

The Steering Committee will have the final approval on admission in cases of exceptions to these guidelines, except as mentioned in the following paragraph. If the student applying for admission does not meet the basic requirements for pursuing graduate education in one of the specialization tracks, admission will be denied.

After following the admission process of Ohio University, a student may be admitted directly to the MSE Ph.D. program by the Associate Dean of RAGS under the following conditions: 1. A graduate faculty member of the Russ College requests in writing that the student be admitted. 2. In this request, the faculty member justifies that the student has the academic qualifications and aptitude for research to successfully complete the MSE Ph.D. program. 3. The faculty member states that he/she will be the dissertation advisor of the student. The Associate Dean for RAGS will review the case and may ask for advice from others. If the prospective student appears to be academically qualified and has an aptitude for research, admission will be granted. The faculty member who made the request automatically becomes the student’s dissertation advisor.

4.0 DEGREE REQUIREMENTS

At least 60 credit hours above the M.S. degree must be earned. Of this, at least 30 credit
hours must be formal course work and at least 30 credit hours must be dissertation.

4.1 Course Work

A minimum of 30 credit hours of formal course work above the M.S. degree is required. At least 15 credit hours must be at the 6000 level or higher, of which at least 6 credit hours must be at the 7000 level or higher.

Because the nature of this degree program is not a fixed curriculum but an integration of course work from at least two departments, it is necessary that the student develop an individualized Plan of Study that is appropriate for one of the two specialty areas: (1) Industrial and Systems Engineering or (2) Mechanical Engineering. The Plan of Study must include at least 9 credit hours of doctoral coursework from an engineering department outside the major track discipline. Students in both specialty tracks shall take the "capstone" synthesis course (ET 7990) after completion of a majority of the Ph.D. courses.

Courses taken by a graduate student at Ohio University prior to admission into the Ph.D. program can satisfy the requirements of credit hours for the major areas and the core courses. However, the student must still complete 30 credit hours of course work above that required for the M.S. degree.

Students are required to take the 1-credit hour ET 6020 Technical Writing Seminar. Students who satisfied this requirement while earning an M.S at Ohio University are not required to retake this course during the doctoral program.

4.2 Academic Credit for Course Work at Other Universities

A maximum of 8 semester credit hours of graduate coursework, completed at another university, will be considered for credit towards degree completion. Such a request must be made in writing to the Russ College of Engineering and Technology, and will require approval by the Steering Committee and the student's dissertation advisory committee. Graduate courses that were used to satisfy the requirements for another degree are not eligible for transfer. University residency requirements must be met as stated in the Ohio University Graduate Catalog. More than 8 credit hours will be considered only in exceptional situations.

4.3 Approval and Modification of Plan of Study

A preliminary Plan of Study shall be on file in the Dean’s office no later than the end of the first semester of entry into the MSE Ph.D. program. A final Plan of Study must be on file in the Dean's office prior to completion of two semesters of formal course work applicable toward the degree. Both the preliminary and final Plans-of-Study must be approved and signed by the student's dissertation advisory committee (with the exception of the external representatives), the track coordinator, and the Associate Dean for RAGS.

After approval, changes can be made, but the student's dissertation advisory committee,
the track coordinator, and the Associate Dean for RAGS must approve the changes. The Plan of Study is to be updated, reviewed, and approved by the dissertation advisory committee at the completion of the comprehensive examination. The dissertation advisory committee may require that additional coursework be added to the program of study if the comprehensive exam reveals weaknesses that may preclude the student from successfully completing his/her dissertation research. The updated and approved Plan of Study is to be submitted to the Dean's office, along with the results of the comprehensive examination.

If a student needs to take remedial courses for any reason, these courses must be included in the Plan of Study and so identified as not applicable toward degree requirements.

4.4 Academic Standards

A student must maintain a 3.0/4.0 average to remain in the program. Students failing to maintain a 3.0/4.0 average may petition the Associate Dean of RAGS to remain in the program for one additional quarter, during which the student's average must be corrected to at least 3.0/4.0. Only one such petition is allowed during the entire degree program. Exceptions to this must be approved by the Steering Committee.

No more than six credit hours below B and no credit hours of C or below may be counted toward the MSE Ph.D. More than 6 credit hours less than B will automatically drop the student from the program.

4.5 Qualifying Examination

The student must demonstrate mastery of the necessary fundamentals to pursue the Ph.D. degree by taking and passing the Ph.D. qualifying examination. The student must pass the qualifying exam in no more than two attempts. This examination will be offered twice a year (December and May or June). The first exam attempt must be taken prior to earning 15 credit hours of formal course work applicable toward the degree. If the student fails to do so, it will be counted as a "Fail of the Qualifying Examination". If for some exceptional reason a student fails to take the qualifying examination before earning 15 credit hours, he/she must take it at the next offering. In cases where remedial courses are required, the student will petition the chair of the Steering Committee requesting a delay in taking the exam and listing the remedial courses needed. Remedial coursework will not be counted toward the 30 credit hours required for the Ph.D. and, hence, will not count toward the 15 credit hours mentioned above. The student's advisor must endorse the petition.

The subject areas of this examination include those that are deemed necessary to pursue study at the advanced graduate level in preparation for performing research in one of the two specialty areas. The exam is a two-part exam. The Part A exam covers math and physics topics, and the Part B exam covers topics from the student’s specialty track. Both parts of the qualifying examination test basic knowledge at the advanced undergraduate and beginning graduate level.
Part A. Common areas for all students (See Appendix A for details.):

(1) Mathematics
(2) Physics

Part B. The student shall also select one of the following specialty areas for examination:

(1) Industrial and Systems Engineering (See Appendix B for details.)
(2) Mechanical Engineering (See Appendix C for details.)

The results from both Parts A and B will be evaluated by the faculty who administer the exam in regards to the following: (i) a decision on pass/fail, (ii) recommendations for remedial course work, and (iii) a recommendation for a second (final) attempt.

Part B of the exam should be taken within one quarter after taking Part A. Because the results of this exam will be used to formulate or modify the student's Plan of Study, it is strongly recommended that the student take the qualifying examination as early as possible.

4.6 Comprehensive Examination

Following the completion of the majority of the course work as determined by an approved Plan of Study, but no later than 4 semesters into the MSE Ph.D. program, the student is required to pass a comprehensive examination. This exam must be passed in no more than two attempts. This examination will test the student's knowledge of the advanced level (Ph.D.) course work and his/her ability to integrate knowledge from courses and ability for independent research in the specialty track.

The student’s dissertation advisory committee will decide the format of the examination in accordance with the respective department guidelines. (Typically, the comprehensive examination is a written examination followed shortly by an oral examination.) The examination is prepared and administered by the student's dissertation advisory committee. The student must consult with the dissertation advisory committee to schedule the exam. At the conclusion of the comprehensive examination, the student’s Plan of Study is reviewed. If the dissertation advisory committee detects a weakness in the student’s ability, the committee can add additional course work to the student’s program of study. An updated and approved Plan of Study is submitted to the Dean's office, along with the results of the comprehensive examination, by the student’s dissertation advisor.

4.7 Review of Research Proposal

Within six months of the successful completion of the comprehensive examination, the student must deliver an oral presentation of his/her proposal for dissertation research. A written version of the research proposal must be submitted to the dissertation advisory committee for review at least 14 calendar days before the oral review takes place.

The oral presentation is intended to evaluate the student's plan and ability to carry out
his/her proposed dissertation research. The student should be prepared to answer questions regarding his/her research proposal, his/her major area of specialization, and general background. The dissertation committee and the track coordinator must approve the proposal. The student’s dissertation advisor is responsible for seeing that the “Research Proposal Approval” form is submitted to the Office of the Associate Dean for RAGS.

5.0 ADMISSION TO CANDIDACY

Students are admitted to candidacy for the Ph.D. degree after:

1. Passing both parts of the qualifying exam
2. Satisfactorily completing the Comprehensive Examination
3. Approval of research proposal
4. Filing results of comprehensive exam and research proposal approval form in the Office of the Associate Dean of RAGS.

A student is not permitted to schedule the oral defense of the dissertation until all requirements for admission to candidacy have been met.

6.0 DISSERTATION

Students must adhere to all university dissertation guidelines with regard to format, submission procedures and deadlines. This information is provided on the following website: http://www.ohio.edu/graduate/etd.cfm. The thesis and dissertation submission form, the oral defense forms, and the deadlines for thesis oral defenses are also obtained through this website. The student is personally responsible for academic honesty, good literary style, proper grammar, and accurate spelling. Members of the dissertation advisory committee have the right to refuse to review the technical content of the dissertation if it does not meet accepted standards of English construction.

The completed dissertation, in "final" form, must be in the hands of each of the dissertation advisory committee members at least 14 calendar days prior to the oral defense. ("Final" form in this context refers to dissertation quality; the dissertation advisory committee may still require changes in the content of the dissertation).

The oral defense of the dissertation shall occur no sooner than two semesters after the quarter in which the research proposal is presented and approved. The oral defense shall be scheduled and the Associate Dean for RAGS’s office notified at least 14 calendar days prior to the date of the oral defense. The dissertation must be approved and accepted in writing (using the appropriate form) by the dissertation advisory committee including the external representatives.

Approval by the advisory committee will not occur if the dissertation advisor, either of
the external representatives, or any two of the advisory committee members do not approve the dissertation or if it fails to pass the required academic honesty screening.

6.1 Academic Honesty

The dissertation must pass academic honesty screening. The student must submit the dissertation to the Associate Dean for Research and Graduate Studies with a signed “Statement of Originality”.

Information on the Russ College’s policy on academic honesty may be found at:

http://www.ohio.edu/engineering/integrity/resources/thesis.cfm

7.0 TIME LIMIT

The maximum time allowed, from the official Ohio University program start date to completion of the doctorate degree is seven calendar years. The Associate Dean of RAGS has the authority to grant a one-semester extension with a written request from the student that is endorsed by the student’s major advisor. If all the requirements cannot be completed with a one-semester extension, the student can apply for readmission to the MSE Ph.D. Program. The MSE Ph.D. Steering Committee determines if readmission is justified and sets the terms and conditions for the student to complete the degree.
Appendix A

Qualifying Exam — Part A

Mathematics and Physics

Specific subjects include material normally covered in first year physics courses (classical physics equivalent to Ohio University’s first year calculus-based physics course) and first year engineering calculus math courses.

Format: ten questions (five each in math and physics), closed book, single 8.5” x 11” sheet written on both sides with any notes of the student’s choosing.

Length: four hours
Appendix B1

Mechanical and Systems Engineering Ph.D. Program

Industrial and Systems Engineering Track
Guidelines for Qualifying Exams Part B

1. Every candidate takes Probability and Statistics as their first topic.

2. The student’s advisor selects the second topic in consultation with the student’s Ph.D. Committee and the student, considering the potential dissertation Ph.D. area and the student’s preparation (Operations Research, Manufacturing, Simulation, Production, Artificial Intelligence, Information Systems, Human Factors or any other relevant area).

3. The Departmental Graduate Committee determines who will prepare and correct the exams.

4. Total duration for both topics is 2 hours. The students will choose 2 questions out of 3 or 4 in each topic.

5. The use of open notes and books is permitted during exams.

6. The passing grade is 70 and higher out of 100 points.

7. The student gets a second chance if he/she fails the exam in the first trial. The student can appeal to the Mechanical and Systems Engineering Ph.D. Steering Committee if he/she fails the exam in the second trial.
Appendix B2
Mechanical and Systems Engineering Ph.D. Program

Industrial and Systems Engineering Track
Guidelines for Comprehensive Examination

There are two options:

Option I
1. Each engineering college member of the dissertation advisory committee will prepare 2 questions considering primarily the student’s Ph.D. and M.S. level course work. It is the student’s responsibility to provide an M.S. Plan of Study and Ph.D. Plan of Study to the committee members.

2. The student will pick and answer three questions in two weeks. The emphasis is on testing the student’s knowledge on the advanced level courses and his/her ability to integrate knowledge from courses.

3. The questions will be given on a Monday and the answers will be due the Friday of the following week. The committee will schedule the Oral Examination the week after. The Oral Examination is limited to 1.5 hrs. It will start with a presentation of the student’s answers and more discussions/questions will follow. This procedure is limited to 30 minutes per question.

4. All members of the dissertation committee will vote at the end of the Oral Examination. The results will be satisfactory or unsatisfactory based on the majority vote. If unsatisfactory, the student will get a second chance with a new set of questions subject to the same timeline. A failure in the second trial may lead to recommendation for dismissal from the program by the dissertation advisory committee. The student can appeal to the Mechanical and Systems Engineering Ph.D. Steering Committee if he/she fails the exam in the second trial.

Option II
1. The dissertation advisor will ask a single question and the student will have four weeks to answer the question.

2. The committee will schedule the Oral Examination and all members of the dissertation committee will vote at the end of the Oral Examination.

3. The results will be satisfactory or unsatisfactory based on the majority vote. If unsatisfactory, the student will get a second chance with a new topic subject to the same timeline. A failure in the second trial may lead to recommendation for dismissal from the program by the dissertation advisory committee. The student can appeal to the Mechanical and Systems Engineering Ph.D. Steering Committee if he/she fails the exam in the second trial.
Appendix C
Mechanical and Systems Engineering Ph.D. Program
Mechanical Engineering Track

C.1 Additional Course Requirements
At least 4 courses must be taken from the following list. A minimum of two courses must be taken from each sub-group (A and B).

Group A:
- ME 5130 Conduction, Convection and Radiation (3 hrs.)
- ME 5460 Potential Flow Theory (3 hrs.)
- ME 5950 Introduction to Kinetic Theory and Statistical Thermodynamics (3 hrs.)
- ME 7330 Numerical Heat Transfer and Fluid Flow (3 hrs.)
- ChE 6400 Transport Phenomena (3 hrs.)

Group B:
- ME 5630 Mechanics of Materials (3 hrs.)
- ME 6010 Advanced System Analysis and Control (3 hrs.)
- ME 6040 Mechanics and Control of Multi-Degree-of-Freedom-Systems (3 hrs.)
- ME 6050 Intermediate Dynamics (3 hrs.)
- ME 6100 Advanced Vibrations (3 hrs.)
- ME 6630 Advanced Mechanics of Materials (3 hrs.)
- ME 7850 Plasticity: Theory and Application (3 hrs.)
- CE 6230 Continuum Mechanics (3 hrs.)

C.2 Part “B” Qualifying Exam
This is a closed-book exam. For each topic, the student is allowed one sheet of paper (8½"×11", both sides) with any formula needed for the topic, but not with any solved problems. The equation page for each topic must be attached (i.e., stapled) to that part of the exam when it is completed by the student. Students must attempt at least 3 topics and thus are allowed 3 equation sheets. For the exam, students are required to use a scientific calculator provided by the Department. This can be checked-out from the Department one week prior to the exam.

Exam Topics:
1. Continuum Mechanics
2. Controls
3. Fluid Mechanics
4. Heat Transfer and Thermodynamics

Continuum Mechanics (Recommended courses: CE 6230, ME 5630 or ME 6630)
Topics:
- 3-dimensional stress and strain tensors
- Hydrostatic and deviator stress tensor components
- Transformation of stress and strain axes
- Principal stresses and strains
- Isotropic elasticity (Hooke’s Law)
- Anisotropic elasticity (compliance and stiffness matrices)
- Tresca and von Mises yield criteria
h. Power-law strain hardening

Texts:

Controls (Recommended course ME 6010)
For the Mechanical Engineering Controls portion of the MSE Ph.D. qualifying examination, the subject is analysis and design for linear, multiple-input, multiple-output (MIMO) engineering systems, expressed in state-space form.

Topics:
- Linear algebra
- Modeling of engineering systems
- State-space description of dynamical systems
- Solution of state-space equations
- Shaping dynamic response
- Controllability and observability
- Canonical realizations
- Stability
- Design of linear state-feedback controllers and observers

Texts:
4. Dorf and Bishop, *Modern Control Systems*, Prentice-Hall

Fluid Mechanics (Recommended course: ME 5460)

Topics:
- Governing equations: Mass conservation/continuity, and momentum equations
- Inviscid Flow: Two-dimensional potential flow, stream function, Bernoulli equation, complex potential and complex velocity, source, sink and vortex flow
- Viscous flow: Governing equations, mass conservation, momentum equations
- Laminar boundary layer flows, laminar duct flow, natural convection
- Dimensionless parameters and their significance (Re, St, Ra, Gr)
- Turbulent flows and empirical correlations for turbulent flow

Texts:
1. I. G. Currie, *Fundamental Mechanics Fluids*, (Chapters: 1, 3, 4, 7, 9, 10)
2. Adrian Bejan, *Convection Heat Transfer*, (the fluid mechanics sections of chapters 1-4, 7)

Heat Transfer and Thermodynamics (Recommended courses: ME 5950, ME 5130) Students can answer either the heat transfer or the thermodynamics problem.

Topics:
a. First law of thermodynamics, control volume approach for uniform state, uniform flow process
b. Conduction heat transfer, conduction equation, multi-dimension problems, steady and unsteady conduction
c. Convection: Thermal boundary layers, empirical correlations for Nu and St
d. Radiation: Shape factor, radiation shields, radiation network

Texts:
1. Alan Chapman, Heat Transfer, (Chapters 1, 3, 4, 6 – 9, 11)
2. J. P. Holman, Heat Transfer, (Chapters 1 – 8)

C.3 Comprehensive Exam
The dissertation advisor or a committee member (in coordination with the entire dissertation committee) will prepare a question or formulate a small project unrelated to the student’s dissertation topic. The time for the student to complete this task and prepare a presentation will be established by the dissertation committee. An oral examination will be scheduled at the time that the topic or question is assigned. At the end of the oral examination, each dissertation committee member will vote to either pass or fail the student. It is expected that a unanimous consensus will be achieved; however, if it is not, then a majority vote will decide pass or fail. If the student does not pass, then a new topic and timeline will be established. A failure in the second attempt will result in dismissal from the MSE Ph.D. program. At the time of the comprehensive exam, the student is required to distribute his/her Plan of Study for review and approval by the committee.