Ph.D. in Integrated Engineering
Russ College of Engineering and Technology

Policies and Procedures

1.0 GENERAL

The Integrated Engineering Ph.D. (I.E. Ph.D.) program is an inter-disciplinary Ph.D. program with two specialization tracks:

(1) **Industrial and Systems Engineering**
(2) **Mechanical Engineering.**

An MS degree in engineering or a related field, e.g., chemistry, physics, or applied mathematics is required for admission. Admission to the program is restricted to those students whose educational plans fall within one of the two specialty areas.

An acceptable plan of study is developed on an individual basis by a 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. At least 12 credit hours at the 500 level or higher from any two departments in the Russ College of Engineering and Technology or 8 credit hours at the 500 level or higher from any three departments must be included on the plan of study. A minimum of 20 credit hours of the course work must be at the 600 level or above and at least 10 credit hours must be at the 700 level or above. All plans of study must include at least 90 credit hours, including at least 45 credit hours for the dissertation and 45 credit hours of course work, above the MS degree and must be approved by the student's dissertation advisory committee, the specialization track coordinator, and the chair of the Steering Committee.

Students must pass a 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 eight quarters of course work. Exceptions to the prescribed timeline may be considered on a case-by-case basis under extenuating circumstances only. The qualifying examination tests basic knowledge in mathematics, physics, and engineering subjects complimentary to the specialization track of study chosen by the student. The level of the topics covered by the qualifying exam is advanced undergraduate/beginning graduate and determines 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 Associate Dean for Research, Graduate Studies and Planning of the Russ

College of Engineering and Technology. 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.

The primary responsibility for seeing that these policies and procedures and the University policies and procedures are followed lies with the student.

2.0 PROGRAM ADMINISTRATION

Administration of the Integrated 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 I.E. Ph.D. Steering Committee and specialization track coordinators 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 one graduate faculty member from each of the five engineering departments. The dean appoints members of this committee with consideration of recommendations from the department or school chairs. Faculty serving on this committee must have full Graduate Faculty Status in the Russ College. At least three members of this committee are required to have experience directing Ph.D. dissertation work. The normal term for a faculty member on this committee is three years. The terms of the faculty on the SC are staggered to guarantee that three of the members have experience in carrying out the functions of the committee. 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. (This task is delegated to the track coordinators and the Associate Dean for RAGS in those cases that follow these guidelines.)
(4) See that quality is maintained
(5) Assist the Associate Dean of RAGS and the dissertation advisory committee in administering qualifying examinations.

The Associate Dean of RAGS selects two members of the SC to serve as specialization track coordinators. The duties of specialization track coordinators 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 I.E. 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 completion of the third quarter after the initiation of the I.E. Ph.D. program. The student's dissertation advisor must have research experience in the area in which the student has selected to specialize. The dissertation advisor must be a member of the graduate faculty in Russ College. The respective specialization track coordinator 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 track coordinator and the Associate Dean for RAGS approve all dissertation advisory committees and changes in the committee as justified.

The student and the dissertation advisor establish the student's plan of study under guidelines provided by the track coordinator and policies and procedures in this document. Except for the external representatives, all members of the dissertation advisory committee and the track coordinator 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 Integrated 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.

3.0 ADMISSION

All prospective students must apply through the normal application procedure of Ohio University. Application forms are available through the Office of Graduate Student Services (OGSS) or the Russ College of Engineering and Technology's Dean's Office or can be found on the web site of OGSS as follows: http://www.ohio.edu/graduate/. The application procedures of Ohio University must be followed precisely.

To be considered for admission to the I.E. Ph.D. program, an MS degree in engineering or a related field such as chemistry, physics, or applied mathematics is required, and the student's research and educational plans should fit within one of the two specialty tracks. Students must have excellent academic records, demonstrated skills in oral and written English, and an aptitude for research. In general, the GRE is required of all applicants.

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 have the basics 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 I.E. 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 I.E. 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 90 credit hours above the MS degree must be earned. Of this at least 45 credit hours must be formal course work, and at least 45 credit hours must be dissertation.

4.1 Course Work

A minimum of 45 credit hours of formal course work above the MS degree is required. At least 20 credit hours must be at the 600 level or higher, of which at least 10 credit hours must

be at the 700 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. An acceptable plan of study must include a significant amount of doctoral course work from a minimum of two engineering departments, with a minimum of 12 credit hours from each. If three or more departments are included as major discipline areas, a minimum of 8 credit hours from each must be earned. Students in both specialties shall take the "**capstone"** synthesis course (ET 799) 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 45 credit hours of course work above that required for the MS degree.

Students are required to take for the 1-credit hour ET 602 Technical Writing Seminar. Students that satisfied this requirement while earning a Masters degree at Ohio University are not required to retake this course during the doctoral program.

4.2 Academic Credit for Course Work at Other Universities

Graduate work completed at another university, up to 12 quarter credit hours, will be considered by the Steering Committee and the student's dissertation advisory committee in the development of the student's program of study, provided the course work was not used to satisfy the requirements for another degree. University residency requirements must be met as stated in the Ohio University Graduate Catalog. More than 12 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 quarter of entry into the I. E. Ph.D. program. A completed final plan of study must be on file in the Dean's office prior to completion of three quarters 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 course work 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 I.E. Ph.D. More than 9 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 June). The exam 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 course work will not be counted toward the 45 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. Part A covers math and physics topics, and Part B covers topics from the specialty area that has been chosen by the student according to his/her research interest. Both parts of the qualifying examination test basic knowledge at the advanced undergraduate/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 & B will be evaluated by the faculty who administer the exam in regard 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 Scholarly Discipline

The scholarly discipline requirement may be satisfied by any one of the following:

(1) A demonstrated reading ability in a non-native language, including English
(2) A demonstrated proficiency in statistical analysis or computer science
(3) Other special abilities that are currently accepted by the University.

The student's dissertation committee decides how the scholarly discipline will be satisfied, e.g., taking and passing a language reading exam, performing research that is not related to the dissertation that is followed up with a written report and oral presentation, taking a course, etc. If the student takes a course to satisfy the scholarly discipline, the course cannot be used to satisfy the course requirements of the I.E. Ph.D. program.

It is the student's responsibility to see that his/her dissertation committee formally notifies the Office of the Associate Dean of RAGS on how the scholarly discipline was satisfied. This must be done prior to the oral presentation of his/her research proposal.

4.7 Comprehensive Examination

Following the completion of the majority of the course work, as determined by an approved plan of study, but no later than eight quarters into the I. E. 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.

4.8 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) Satisfying the scholarly discipline requirement
(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

A written dissertation must be prepared describing the student's completed research work. The format of the dissertation must follow that given in the Ohio University "Style Manual" and the Russ College "Guidelines for the Format and Presentation of Theses and Dissertations". The student is personally responsible for 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 three quarters 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 advisors, both 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/plagiarism/

7.0 TIME LIMIT

The maximum time allowed from the date of taking the first course in the program of study at Ohio University until completion of the doctorate degree is seven calendar years. The Associate Dean of RAGS has the authority to grant a one-quarter 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-quarter extension, the student can apply for readmission to the I.E. Ph.D. Program. The I.E. Ph.D. Steering Committee determines if readmission is justified and sets the terms and conditions for the student to complete the degree.

Tuition Scholarship support cannot be provided to any student who has received such support for more than 18 quarters at Ohio University. Tuition support is limited to 15 quarters for a student who has completed a master's degree at another university (see Graduate Catalog - section on Financial Support: time limits). This does NOT include summer quarters. This constraint does not apply to financial assistance provided in the form of service stipends through research grants or other funding sources.

Appendix A

Qualifying Exam — Part A

Mathematics and Physics

Specific subjects included: material normally covered in first year physics courses (classical physics equivalent to the Ohio University Physics 250 series) and first year math courses (calculus equivalent to the Ohio University Math 263 series)

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

Integrated Engineering PhD 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 student's PhD Committee and student considering the potential dissertation PhD 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 3 or 4 in each topic.

5. Exams are open notes and books.

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 Integrated PhD Steering Committee if he/she fails the exam in the second trial.

Appendix B2
Integrated Engineering PhD 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 PhD and MS level course work. It is the student's responsibility to provide MS plan of study and PhD 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. Oral examination is limited to 1.5 hr. It will start with a presentation of the student's answer 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 Oral Examination. The result 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 Integrated PhD 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 Oral Examination.

3. The result 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 Integrated PhD Steering Committee if he/she fails the exam in the second trial.

Appendix C
Integrated Engineering Ph.D. Program
Mechanical Engineering Track

C.1 Additional Course Requirements

At least 6 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 513	Conduction, Convection and Radiation (4 hrs.)
ME 514	Convection (4 hrs.)
ME 546	Potential Flow Theory (4 hrs.)
ME 595	Introduction to Kinetic Theory and Statistical Thermodynamics (4 hrs.)
ME 633	Numerical Heat Transfer and Fluid Flow (4 hrs.)
ChE 642	Transport Phenomena (4 hrs.)

Group B:

ME 510	Advanced Vibrations (4 hrs.)
ME 601	Advanced System Analysis and Control (3 hrs.)
ME 604	Mechanics and Control of Multi-Degree-of-Freedom-Systems (3 hrs.)
ME 605	Dynamics: Theory and Applications (4 hrs.)
ME 663	Mechanical Behavior of Engineering Materials (4 hrs.)
ME 785	Plasticity: Theory and Application (4 hrs.)
CE 523	Continuum Mechanics (4 hrs.)

Recommended courses at the 700 level for ME students include ME 704, ME 705, ME 712, ME 720, ME 731, ME 733, ME 751, ME 760, ME 762, ME 776, ME 784, ME 797, ISE 709, ISE 710, CE 723, CE 730. The list of approved courses at the 700 level is updated periodically; therefore students should consult their dissertation advisory committee in selecting these courses.

Students are also strongly encouraged to include courses from the following list in their plan of study: ME 522, ME 529, ME 535, ME 555, ME 557, ME 560, ME 562, ME 563, ME 576, ME 596, ME 597, ME 636, ISE 560, ISE 626, ISE 640, ISE 642, ISE 660, ISE 689, CE 520, CE 527, CE 625, ChE620/632.

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 523 or ME 663)

Topics:

a. 3-dimensional stress and strain tensors
b. Hydrostatic and deviator stress tensor components
c. Transformation of stress and strain axes
d. Principal stresses and strains
e. Isotropic elasticity (Hooke's Law)
f. Anisotropic elasticity (compliance and stiffness matrices)
g. Tresca and von Mises yield criteria
h. Power-law strain hardening

Texts:

1. M. Lasi, D. Rubin, E. Krempl, Introduction to Continuum Mechanics (3rd Edition), Pergamon Press, 1993, Chapters 3 – 5
2. W.F. Hosford, Mechanical Behavior of Materials, Cambridge University Press, 2005, Chapters 1 – 6
3. G.E. Dieter, Mechanical Metallurgy, 3rd Edition, McGraw-Hill, 1986, Chapters 2 – 3

Controls (Recommended course ME 601)

For the Mechanical Engineering Controls portion of the I.E. 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:

a. Linear algebra
b. Modeling of engineering systems
c. State-space description of dynamical systems
d. Solution of state-space equations
e. Shaping dynamic response
f. Controllability and observability
g. Canonical realizations
h. Stability
i. Design of linear state-feedback controllers and observers

Texts:

1. Ogata, Modern Control Engineering, Prentice-Hall
2. Friedland, Control Systems Design, McGraw-Hill
3. Brogan, Modern Control Theory, Prentice-Hall
4. Dorf and Bishop, Modern Control Systems, Prentice-Hall

Fluid Mechanics (Recommended courses: ME 546, ME 514)

Topics:

a. Governing equations: Mass conservation/continuity, and momentum equations

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

Texts:

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

Heat Transfer and Thermodynamics (Recommended courses: ME 595, ME 328, ME 412, ME 513) 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. Heat Transfer by Alan Chapman (Chapters 1, 3, 4, 6 – 9, 11)
2. Heat Transfer by J. P. Holman (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 I.E. 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.