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, information systems, artificial intelligence, systems simulation, process planning, distribution systems, genetic algorithms, data mining, and location science, supply chain design, human factors, and reliability.

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 defend 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. However, direct admission to the program may be possible if special circumstances are met and granted. 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 is required. The required test scores for the GRE are: 161 for Quantitative and 153 for Verbal. *NOTE: The GRE requirement can be waived by recommendation of your potential advisor. Three letters of recommendation are required from persons who can attest to the applicant's academic and research aptitude. Ohio University’s Graduate College has additional requirements, which are the responsibility of the student to meet. Admission to the program is restricted to students with educational plans falling in one of the two specialty areas.

A maximum of eight (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. Transfer credit MUST

meet the University requirements for transfer at the graduate level. 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 12 credit hours of course work must be at the 6000 level or above, of which at least 3 credit hours must be at the 7000 level or above. All Plans of Study must include at least 60 credit hours, including at least 40 credit hours for the dissertation and 20 credit hours of course work above the M.S. degree (excluding ET6020). 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 the qualifying examination before earning 12 credit hours of course work applicable toward the Ph.D. degree, and a comprehensive examination no later than the end of four 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 https://www.ohio.edu/graduate/apply.

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 (RGSP) of the Russ College of Engineering and Technology. The graduate chairmen of the ME and ISE departments assist the Associate Dean of RGSP 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 RGSP, 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 RGSP 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 RGSP develop recruiting and promotional materials for the MSE Ph.D. program. The Associate Dean of RGSP 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 external committee members. The Associate Dean for RGSP 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.

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. A student's dissertation advisory committee should be formed and approved by the Russ College before the student completes three semesters of course work applicable toward the degree. When the dissertation committee is proposed, a recommendation should also be made regarding 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 RGSP 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 policies and procedures in this document. In addition to the periodic review of the Plan of Study by the respective program graduate chairmen, all members of the dissertation

advisory committee (except for the external representatives) and the respective graduate chairman must formally approve the Plan of Study by reviewing and signing at least by the time of completion of the Comprehensive Examination. The Associate Dean of RGSP 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 RGSP 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. Changes to the advisory committee is executed using the same form and process as is used to initially form the committee.

2.3 Role of External Dissertation Committee Members

Two dissertation committee members must be from outside of the ME and ISE departments and one committee member must be from outside of the Russ College (such as from Physics, Chemistry, Math, Business, or Biology). 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 Associate Dean of RGSP 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 preference for admission is students who has earned a Master of Science degree in the desired engineering field (i.e. Mechanical or Industrial Engineering.) Admission may be possible for students who have earned a Masters degree in 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 is also required. 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 RGSP 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 RGSP 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 must be earned after admission to the program. Of this, at least 20 credit hours must be formal course work and at least 40 credit hours must be dissertation.

4.1 Course Work

A minimum of 20 credit hours of formal course work is required. At least 12 credit hours must be at the 6000 level or higher, of which at least 3 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 six credit hours of doctoral coursework 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.

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.

Courses taken prior to admission into the Ph.D. program can satisfy the requirements of credit hours for the major areas and the core courses. However, credit cannot be given for courses used to satisfy prior degree requirements.

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 (https://www.catalogs.ohio.edu/index.php?catoid=64). 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 by the completion of the comprehensive examination. The Plan-of-Study approved at the comprehensive examination must be signed by the student's dissertation advisory committee (with the exception of the external representatives), the track coordinator, and the Associate Dean for RGSP.
After approval, changes can be made, but the student's dissertation advisory committee, the track coordinator, and the Associate Dean for RGSP 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 grade point average to remain in the program. Students failing to maintain a 3.0/4.0 average may petition the Associate Dean of RGSP to remain in the program for one additional semester, 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.

No more than six credit hours below B (3.0) and no credit hours of C+ (2.33) or below may be counted toward the MSE Ph.D. More than 6 credit hours less than B- (2.66) 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 12 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 12 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 20 credit hours required for the Ph.D. and, hence, will not count toward the 12 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 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.

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 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. 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.

4.7 Comprehensive Examination

Following the completion of the majority of the course work as determined by an approved Plan of Study, but no later than four 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 for independent research.

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 RGSP.

5.0 ADMISSION TO CANDIDACY

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

(1) Passing 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 RGSP.

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. 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 research shall occur no sooner than nine months after the research proposal is presented and approved. The oral defense shall be scheduled and the Associate Dean for RGSP's office notified at least 14 calendar days prior to the date of the oral defense.

Approval of the oral defense 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. Approval of the dissertation document will not occur if it fails to pass the required academic honesty screening or fails to receive unanimous approval of the committee.

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:
https://www.ohio.edu/engineering/current/leadership-integrity/academic-integrity

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 RGSP 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 B1

Mechanical and Systems Engineering Ph.D. Program

Guidelines for Qualifying Exams - Industrial and Systems Engineering Track

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 four courses must be taken from the following list. (Variances granted by approval of graduate committee.) 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
5. Thermodynamics

Continuum Mechanics (Recommended courses: CE 6230, ME 5630 or ME 6630)

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 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:

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 course: ME 5460)

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. 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 (Recommended course: ME 5130)

Topics:

a. Conduction heat transfer, conduction equation, multi-dimension problems, steady and unsteady conduction
b. Convection: Thermal boundary layers, empirical correlations for Nu and St
c. 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)

Thermodynamics (Recommended courses: ME 5950)

Topics:

a. First law of thermodynamics, control volume approach
b. Maxwell relationship
c. Non ideal equations of state

Texts:

1. Cengel and Boles, Chapters 11-13

C.3 Comprehensive Exam

Purpose

The purpose of the comprehensive examination to evaluate the candidate's ability to develop independent research. While the qualifying exam test written knowledge, the comprehensive examination allows for both demonstration of written and oral comprehension skills ranging from technical knowledge to identification of knowledge gaps in an area of research, formulation of research objectives, and the ability to create a work plan to meet the stated objectives.

Procedure

The comprehensive examination takes place before the dissertation proposal. The candidate's primary advisor is responsible for formulating a suggested research question that is clearly not part of the candidate's dissertation work. This suggested question must be approved by the candidate's committee before presentation to the candidate. From this point forward, the candidate's primary advisor is no longer a part of the process. The graduate chair will assign an additional member to the candidate's committee to act at the "Exam Supervisor" to complete the process. This includes scheduling a time for the committee (minus the primary advisor) to meet at the end of the two week examination period.

Once the research question has been given to the candidate, a two-week clock starts in which the candidate must identify research objective(s) and formulate a research "proposal" including a work plant to address the question. This will take the form of both a written paper (less than 15 pages) and a presentation (less than 20 slides and 30 minutes.) The candidate must work with the graduate chair to ensure a viable room is available for the oral presentation three days after the delivery of the written proposal, which is due two weeks after question release. (The presentation should occur at seventeen days after the question release to the candidate.) The candidate must prepare not only for the presentation, but to defend the engineering principles behind the proposed work.

The candidate's doctoral committee will make up the majority of the comprehensive committee. However, for the purpose of the comprehensive, the committee will consist of only engineering faculty or faculty from other departments that are competent in the science of the topic area. Note that the non-engineering committee member(s) will not be replaced, therefore there will likely be fewer members on the comprehensive committee.

Passing the Examination

This committee will evaluate the research proposal and convey its decision and comments to the candidate no later than the end of the next workday. If either the oral or the written proposal is considered unsatisfactory by any committee member, the candidate will have failed. If the candidate fails, a written explanation for the assessment of the failing performance will be provided to the candidate, advisor, and graduate chair of Mechanical Engineering. Each candidate has two chances to pass the exam. The second attempt will consist of a new topic, and will begin with two weeks to prepare an oral proposal.

Topic Selection

The topic selected should be in broadly the same field as the candidate's research, but not directly related to the dissertation topic or a simple derivation thereof. The candidate is expected to know and apply terminology and fundamental principles common to the core mechanical engineering curriculum, and to stretch beyond his/her dissertation research. The candidate should not be expected to learn a large amount of specialized terminology or new subject matter specifically for the comprehensive exam. The comprehensive exam should draw from specialized knowledge already familiar to the candidate.

Selection of the comprehensive exam topic is a critical task that requires an investment of time and effort from the candidate's primary advisor and his or her doctoral committee. All members should keep in mind the purpose of the comprehensive exam, the requirement that the research question NOT be aligned with the dissertation topic, and the interest of the department in maintaining a high quality graduate program. The department graduate chair will endeavor to rotate the Exam Supervisor role as much as possible. However, recognizing the potential for conflict with the candidate's advisor, untenured faculty will not be appointed Exam Supervisor.

Preparing the Proposal

The candidate is responsible for all preparation for the comprehensive exam, ***including fundamental science and engineering principles underlying the topic***. The candidate should review relevant literature to become familiar with the topic, identify a key question or knowledge gap, and then define a specific research objective and prepare a research proposal. The proposal should describe a research project that could be completed in 1–2 years.

A successful comprehensive exam solution has the following characteristics, most of which are common to any successful research proposal.

- It states a specific research objective.
- It explains the significance of the proposed research.

- References and summarizes only literature directly related to the proposed research
- ***It explains the science and engineering principles needed to perform the research***
- It describes the methods and equipment used.
- Presents a clear work plan with explicit discussion of variables to be tested, a reasonable range of values examined with justifications. A "test matrix" may be appropriate.
- It includes methods for quantifying uncertainties.
- It explains how the results will be evaluated and how you will determine whether the objective has been met.
- It includes a schedule for completion of the project.
- It includes a rough budget and budget justification for the project.
- The project description is not more than 15 pages long, 12 point font, double-spaced, with numbered pages.

The statement of the research objective is the most critical part of the proposal. In the examples below, the unacceptable objectives are too vague. They do not clearly identify the independent and dependent variables investigated. There is no way to tell when the objective has been met and the project is finished.

Unacceptable:
The objective of this research is . . .
- "To study catalytic converters."
- "To study how particle size affects catalytic converters."
- "To test metal-supported catalytic converters."
- "To model the operation of a catalytic converter."

Acceptable:
The objective of this research is . . .
- "To determine the relationship, if any, between active particle size and susceptibility of a metal-supported catalytic converter to poisoning by sulfur in the fuel."
- "To determine whether the choice of reactive element in the metal support affects the susceptibility of active metal particles in the catalytic converter to sintering."

It is often appropriate to state the objective as a hypothesis.

> "We hypothesize that the susceptibility of a metal-supported catalytic converter to poisoning by sulfur in the fuel is directly related to the surface area of the active particles, and, therefore, to the square of the average particle diameter."

The proposal must convey the significance of the research. How does this work differ from what has gone before? How will fulfilling the research objective benefit specialists in the field? How will it benefit humankind? What is the next step when this project is finished?

For an experimental project, the work and plan and discussion of analysis of data should show a command of the fundamentals of experimental design and statistics. Even when the project focuses on modeling rather than experimentation, uncertainties are important. Consider the third of the acceptable example objectives. It would be important to quantify the sensitivity of the

final model to changes in the thermal properties of the metal, the thermal properties of the gas, the flow rate of the gas, and the roughness of oxide the film.

The Ohio University Office of Research and Sponsored Programs (ORSP) has budget aid examples online. (Candidates should not contact ORSP staff directly for assistance in preparing a comprehensive exam solution.) Candidates should use an example for the National Science Foundation or the National Institutes of Health to prepare the budget. The committee will be satisfied with the right order-of-magnitude in each category (personnel, travel, materials and supplies, equipment, indirect costs, etc.).

The project description portion of the written proposal is not more than 15 pages long, 12 point font, double-spaced, with numbered pages. The 15 page limit does not include the cover page, abstract, budget, or list of references, but DOES include figures, tables, and appendices.

Acceptable Resources for Candidates to Use in Preparing Comprehensive Exam Solutions
The candidate may consult the university writing center or the Ohio Program for Intensive English for assistance with language and grammar. No other candidates, staff, or faculty should review the candidate's proposal before it is evaluated by the candidate's committee. The candidate is encouraged to consult a style guide or technical writing guide. The candidate may read proposals written by other candidates, staff, or faculty. The candidate may use any literature or other resource in the public domain, including the peer-reviewed (preferred) and popular literature and web-based resources. Citations should contain sufficient information to allow the reader to find the original source material.

The candidate may draw on many resources, but *must* produce an original research proposal. Plagiarism will result in automatic failure. A candidate with *any* question about whether his/her work might constitute plagiarism should bring the source material and the proposal in progress to the Exam Supervisor for an opinion. International candidates in particular are cautioned that standards for plagiarism enforced in their home countries may be different from the prevalent standard in engineering and science research in the U.S. If the candidate's committee assesses that the solution includes plagiarized material, the candidate will automatically fail the comprehensive exam, even if a "pass" decision was previously rendered.

Comprehensive Exam Assessment Guidelines
A successful comprehensive exam solution has the following characteristics, most of which are common to any successful research proposal.

- It states a specific research objective.
  - The objective is specific, not vague.
  - The objective clearly identifies the independent and dependent variables (factors and responses).
  - The objective reflects a higher motivation than simple data collection.
- It explains the significance of the proposed research.
  - It is clear how this work differs from what has gone before.
  - It is clear how meeting the objective will benefit specialists in the field and/or humankind.
- It references and summarizes only literature directly related to the proposed research and its

significance.
    - Discussion of prior work is organized to show relationship to the proposed work.
    - Discussion of prior work shows relevant limitations or weaknesses as well as strengths.
- It provides a summary of the science and engineering principles used in the research
- It describes the methods and equipment to be used.
    - Descriptions are understandable to engineers who are not experts in the particular techniques.
    - Descriptions focus on the type, precision, and accuracy of the information obtained.
- It shows what variables will be tested, a reasonable range of values to be examined, and justification for the choices. A "test matrix" may or may not be appropriate.
    - Independent variables (factors) are clearly identified.
    - Dependent variables (responses) are clearly identified.
    - The reasons for investigating each of the factors and responses are clearly described.
- It is clear why or how each of the factors is expected to influence the responses.
- It is clear that the factors and responses selected are sufficient to meet the objective.
- It is clear that the factors and responses selected are reasonable for the resources allocated.
    - The range of values to be tested for each factor is stated.
    - The reason for selecting each range of values is clearly described.
- Limits dependent on common industrial practice, equipment or instrument limitations, safety considerations, etc. are stated.
- It is clear that the range investigated is sufficient to meet the objective.
- It is clear that the range investigated is reasonable given the time and resources allocated.
- It includes methods for quantifying uncertainties.
    - Measurements or assumptions likely to make the largest contribution to the uncertainty are identified.
    - Specific methods or techniques for quantifying uncertainties are identified. A broad statement such as "replicate measurements will be made to check accuracy" is not sufficient.
    - It is clear that the data to be collected or the tests to be run or the model to be developed is consistent with the proposed methods or techniques for quantifying uncertainty.
- It explains how the results will be evaluated and how to determine whether the objective has been met.
    - Specific methods, techniques, or procedures for evaluating results are stated.
    - The data to be collected or the tests to be run or the model to be developed are consistent with the proposed methods or techniques for evaluating results.
    - The methods or techniques for evaluating results are clearly related to the objective.
    - The methods or techniques for evaluating results completely address the objective.
- It includes a schedule for completion of the project.
    - The schedule is consistent with the amount of work to be done, the time required to complete each task, and a typical 40-hour workweek.
- It includes a rough budget for the project.
    - The budget reasonably estimates personnel, travel, materials and supplies, equipment, and indirect (overhead) costs.
- The project description, including figures and tables and appendices, (excluding cover page, budget, and reference list) does not exceed 15 pages.