

GRADUATE PROGRAM GUIDE

Issued by

**THE GRADUATE STUDIES COMMITTEE
DEPARTMENT OF MECHANICAL ENGINEERING
THE OHIO STATE UNIVERSITY
201 West 19th Avenue
Columbus, OH 43210-1142**

**The Graduate Program Guide, including appendices, may be downloaded from the Mechanical Engineering website at:
<http://www.mecheng.osu.edu/files/grdguide.pdf>**

This guide lists policies, rules, and procedures relevant to the Graduate Program for the Department of Mechanical Engineering. The specific graduate degree programs covered in this document are the combined Bachelor of Science/Master of Science Program, the Master of Science Program, the Dual Master's Degree Program, and the Doctoral Program.

The Graduate School Handbook at <http://www.gradsch.ohio-state.edu/Depo/PDF/Handbook/Handbook.pdf> should be consulted for additional details on rules and regulations.

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Section I - Combined Bachelor of Science/Master of Science (BS/MS) Program

I.1 Purpose

The purpose of the combined program is to give gifted OSU undergraduate students an opportunity to apply as many as 15 credit hours from their undergraduate studies toward a Master of Science (MS) degree in Mechanical Engineering, thus reducing the amount of time normally required to complete the MS degree.

I.2 Eligibility

Students who are **current juniors** in the Department of Mechanical Engineering or related engineering disciplines, and have a **grade-point average of 3.5 or better** in all previous undergraduate courses taken at Ohio State, may apply. Undergraduate students from related disciplines are encouraged to apply for admission to the MS in Mechanical Engineering. They will be handled on a case-by-case basis.

I.3 Rules

To receive graduate credit hours, technical elective courses must meet the following requirements:

1. Technical electives must be courses taken at The Ohio State University **after** acceptance into the BS/MS Program.
2. No 500-level or lower mechanical engineering (ME) course may be included.
3. ME 693 and H783 cannot be included.
4. Other than ME 693, up to three 600-level ME courses, **excluding** Honors courses, may be included.
5. Up to nine credit hours of Honors 600-level ME courses may be included.
6. Any 700-level ME course (other than H783) may be included.
7. Relevant graduate courses in other subjects such as Mathematics (as allowed by the ME technical electives program) may be included; refer to the technical electives program for guidelines.
8. No more than 15 credits may be included.
9. The 15 credit hours of technical elective courses to be applied to the MS degree must be approved by ME BS/MS Advisor.

I.4 BS/MS Advisor

The BS/MS Advisor will be the first contact for potential undergraduates, and will advise and mentor BS/MS students (rank 4) until the completion of their BS degree.

Once enrolled in the BS/MS Program, students are encouraged to work with individual faculty in research and independent studies. Such faculty will serve as the Research Advisors. Further, each student (rank M) must find a faculty advisor for the MS degree program (by mutual consent) and submit the Notice of Advisor form, Appendix A.2.

The BS/MS Advisor will approve the technical electives to be applied toward both the BS and MS degrees. The BS/MS Advisor will honor the technical elective recommendations of the Research Advisor. **All BS/MS paperwork must be approved by the ME Graduate Studies Committee.**

The BS/MS Advisor may serve as the student's interim MS degree advisor for **no more than one quarter** beyond graduation with the BS degree. A research advisor must be selected promptly, and the Notice of Graduate Advisor (Appendix A.2) submitted.

The BS/MS Advisor will provide administrative guidance to the entire BS/MS Program. Accordingly, the BS/MS Advisor will:

1. be a member of both Graduate and Undergraduate Studies Committees given the combined nature of the program;
2. attend those meetings where decisions are likely to impact the combined BS/MS Program;
3. coordinate with all (such as Undergraduate and Graduate Program offices) to ensure that the students are making progress; and
4. be copied on relevant correspondence.

On a quarterly basis, the BS/MS Advisor will report to the ME Graduate Studies Committee on all matters pertaining to the BS/MS Program, including enrollment and funding. The term for the BS/MS Advisor will be one academic year (October 1st through September 30th), which may be renewed by the Graduate Studies Committee.

I.5 Admission Steps

Applicants must meet with the BS/MS Advisor to determine their eligibility and desired application dates. Applicants should then apply to the Graduate School and submit accompanying documents **at least 60 days** before planned entrance into the combined program. Students should time their applications such that admission to the BS/MS Program is approved **no more than four quarters** before completion of their BS degrees.

The required application steps are as follows:

- I.5.1 Apply to the Graduate School at http://www.gradadmissions.osu.edu/apply_online.htm
1. Under immediate degree objective: in the **Area of Specialization** field fill in **BS/MS**.
 2. *For questions related to the admissions process, application fee, or transcript submissions, please consult the Admissions website referenced above, or contact the Admissions Office by e-mail at domestic.grad@osu.edu, or by phone at (614) 292-9444.*
 3. *Please also visit the Mechanical Engineering "How to Apply" page at <http://www.mecheng.osu.edu/prospective-graduate-students/admission-information-requirements-deadlines-etc> and the "Frequently Asked Questions" page at <http://www.mecheng.osu.edu/prospective-graduate-students/frequently-asked-questions-faqs-regarding-admission>.*
- I.5.2 A completed College of Engineering BS/MS Degree Information Sheet available at Appendix A.1.1 of this guide or at <http://www.eng.ohio-state.edu/currentstudents/pdf/bsmsform-Eng.pdf>.
- I.5.3 Three letters of recommendation.

I.5.4 A one-page statement of purpose. (Also, state why you are interested in the BS/MS Program.)

Documents in Items I.5.2 through I.5.4 above must be submitted to the ME Graduate Program Office.

I.5.5 Procedures and Other Informational Items:

1. BS/MS applicants who commit to pursuing a PhD, apply by the January 1st deadline, and submit GRE scores, are eligible for multiple-year Graduate School Fellowships.

Notes:

- a) ***BS/MS students for whom MS is the final degree are not eligible for Graduate School Fellowships.***
 - b) ***This fellowship is payable during the PhD phase.***
2. Once admitted, BS/MS students are in the graduate program and are assessed graduate tuition.
 3. Rank 4 students will continue to be eligible for undergraduate scholarships until they obtain their undergraduate degrees.
 4. Rank 4 ***Mechanical Engineering students*** who choose the MS ***thesis option, and maintain a GPA of 3.50 or better***, will receive a scholarship to cover the difference between undergraduate and graduate tuition for ***up to four*** undergraduate quarters. Additional funding is also available to ME undergraduates, if their research advisor initiates it. Both sources of funding will cease when the BSME degree is conferred.
 5. Students must complete Appendix A.1.2 during the quarter of BS graduation that would transfer up to 15 credits to the MS degree. This form should be submitted to the ME Undergraduate Program Office and the BS/MS Advisor for certification ***before*** submitting to the ME Graduate Program Office.
 6. Upon receiving their undergraduate degrees, students are in the MS Program (rank M) and must meet all the requirements as detailed in the section of this guide titled “Master of Science Degree Program.”
 7. Once in the MS Program (rank M), students become eligible for graduate associateships. For further information, please refer to <http://www.mecheng.osu.edu/prospective-graduate-students/frequently-asked-questions-faqs-regarding-admission>.
 8. Students may also take additional graduate level courses (including 800-level courses in exceptional cases) ***for graduate credit only***. Check with the Graduate School for rules before enrolling in such a course. Report these courses using Appendix A.1.2.

Section II - Master of Science Degree Program

II.1 Selection of Thesis or Non-thesis Option

The MS **thesis option** is open to all entering MS students. The **thesis option** is **required** of all students supported by teaching, research, or administrative associateships, university fellowships, other fellowships and scholarships that provide a tuition authorization, and students who receive the BS/MS scholarship.

The **thesis option** requires a thesis that represents a maximum of 15 credit hours of ME 999 of the 45 credit hours required, and the **non-thesis option** requires a research paper that represents 3 credit hours of ME 993 of the 45 credit hours required. Where there is a choice, the option selected should be reported to the Department of Mechanical Engineering Graduate Program Office **by the end of the first quarter of enrollment**.

II.2 Advisor

The MS advisor must hold membership at the category M level or higher in the graduate program of the student (Section II.5.2.3, Graduate School Handbook) i.e., in Mechanical Engineering. The student is required to choose an advisor, through mutual consent, **by the last day of classes during the first quarter of enrollment**. A completed Notice of Graduate Advisor (Appendix A.2) must be submitted to the ME Graduate Program Office before the end of the quarter. University Fellows may take up to two quarters after entrance into the program to choose a faculty advisor. **Once Appendix A.2 has been submitted, changing an advisor requires a formal petition to the ME Graduate Studies Committee.**

II.3 Course Plan

In consultation with the advisor, each full-time MS student must submit the Graduate Program Approval Form (Course Plan; Appendix A.3) **by the fifth week of the second quarter of enrollment**. Part-time students must submit the form before 15 credit hours of graduate courses are accumulated. **Failure to submit a Course Plan may jeopardize further registration in the program.** The Graduate Program Approval form must be signed by the student's advisor before submission to the ME Graduate Program Office for Graduate Studies Committee approval. Once the Course Plan has been approved by the student's advisor and the ME Graduate Studies Committee, a revised Course Plan is required to substitute a previously-approved mathematics, engineering, or science course with a course that does not belong to these disciplines.

The following are some important considerations regarding the formulation of the Course Plan for both **thesis** and **non-thesis options**. These considerations are in addition to the Course Plan differences mentioned in the section of this guide entitled **Selection of Thesis or Non-thesis option** (ref. II.1).

II.3.1 A minimum of 45 credit hours, including course work and a satisfactory thesis or research paper, is required.

II.3.2 Thesis option:

1. There must be a minimum of 30 hours of letter-graded course credits (i.e., excluding ME 888, ME 993 or other individual study credits, audited course credits, or ME 999 which are graded S/U).

2. A minimum of 12 hours of course credits must be Mechanical Engineering courses.
3. A minimum of 12 hours of course credits must be at the 700 level or higher.
4. **Courses taken to fulfill the six-credit mathematics requirement cannot be double counted to meet other requirements.**
5. Unless used for mathematics credit, a single course **can** double count toward the ME and 700-level requirements.
6. After the 30 credit hour minimum course work requirement is fulfilled, the remaining 15 credits may be met using research (ME 999), or a combination of research (ME 999) and course work.

II.3.3 Non-thesis option:

1. There must be a minimum of 42 hours of letter-graded course credits (i.e., excluding ME 888, ME 993 or other individual study credits, audited course credits, or ME 999 which are graded S/U).
 2. A minimum of 18 hours of course credits must be Mechanical Engineering courses.
 3. A minimum of 18 hours of course credits must be at the 700 level or greater.
 4. **Courses taken to fulfill the six-credit mathematics requirement cannot be double counted to meet other requirements.**
 5. Unless used for mathematics credit, a single course **can** double count toward the ME and 700-level requirements.
 6. After the 42 credit hour minimum course work requirement is fulfilled, the remaining 3 credits must be taken as ME 993 to fulfill the research paper requirement.
- II.3.4 A minimum of six credit hours of level-approved Mathematics and Statistics Department courses must be included. Master's degree students may take **up to two** 500-level Mathematics Department courses **except Math 504 (History of Mathematics) and 568 (Introductory Linear Algebra)** to fulfill their mathematics requirement. **All Mathematics and Statistics Department 600-level and above letter-graded courses (i.e., not graded S/U) will count for mathematics credit.**
- II.3.5 **No 400-level course and no 500-level ME course may be included for graduate credit.** 500-level non-ME courses must be designated by the Graduate School as approved for graduate credit; such courses are denoted by "G" next to the course title in Course Offerings Bulletin.
- II.3.6 In addition to the basic 45-credit-hour requirement, **ME 888 (Mechanical Engineering Seminar) when offered, must be taken in each quarter of enrollment.** The ME 888 web page at <http://www.mecheng.osu.edu/graduate-students/me-888-seminars> should be consulted for specific rules for this course as well as quarterly seminar information. **Note: Part-time graduate students are exempt from the ME 888 requirement.**
- II.3.7 Those graduate students who do not have an ABET-accredited baccalaureate degree or equivalent in mechanical engineering will be required to take a number of background undergraduate courses in addition to the regular graduate courses. In consultation with the advisor, the list of background courses must be shown in the "Background" column of the Course Plan (Appendix A.3) and submitted to the Graduate Studies Committee for approval.
- II.3.8 The number of graduate course credit hours that may be transferred from another institution will be determined by the advisor and the Graduate Studies Committee. However, **no more than nine credit hours may be transferred, and the transfer must be sought no later than the second quarter of enrollment in the program.**

The Request for Transfer of Graduate Credit form (URL: <http://www.gradsch.ohio-state.edu/Depo/PDF/TransferCredit.pdf>) must be prepared by the student, verified by the advisor, and forwarded to the ME Graduate Program Office along with a copy of the student's transcript and a description of the course from the official bulletin that includes documentation that the course being transferred is a graduate level course. Upon approval by the Graduate Studies Committee, the petition will be forwarded to the Graduate School for final decision and notification to student.

II.3.9 To be in good standing in the Graduate School, a student must maintain a graduate cumulative point-hour ratio (CPHR) of 3.0 or better in all graduate credit courses, and must maintain reasonable progress toward degree requirements (Section II.4.1 Graduate School Handbook).

II.4 Course Load Requirements

II.4.1 Minimum registration required per quarter, including ME 888 (if applicable) and ME 999:

1. 15 credit hours for **supported students** i.e., students holding graduate associateships, university fellowships, or other fellowships and scholarships eligible for a fee authorization;
2. 15 credit hours for students on a **fourth¹ quarter fee authorization**;
3. 10 credit hours for **self-supported international² students** (Section II.2.1.1. Graduate School Handbook).
4. 9 credit hours for **full-time self-supported domestic students** (US citizens or permanent residents) during Autumn, Winter, Spring quarters, and 7 credit hours during Summer quarter.
5. 3 credit hours for **self-supported domestic students** in the quarter of expected graduation.

II.4.2 Maximum registration allowed by the Registrar's Office is 20 credit hours per quarter. Enrollment greater than 18 credits (excluding audited courses), must be approved by the student's advisor (Section II.2.1 Graduate School Handbook).

II.5 Thesis Plan

In consultation with the advisor, the student must submit a thesis plan (see Appendix A.4 for the form) to the Graduate Studies Committee for approval **by the tenth week of the second quarter**. Questions regarding the nature and contents of the MS thesis should be directed to the advisor.

II.6 Application to Graduate

The MS Application to Graduate is available online at <http://www.gradsch.ohio-state.edu/Depo/PDF/Master%27sGraduate.pdf>. In addition to the student's advisor, **at least one additional MS Committee member must be listed**. The completed form must be submitted to the ME Graduate Program Office **no later than the first Friday of the graduation quarter** for approval by the Graduate Studies Committee. An application to graduate may not be submitted until at least the minimum graduate credit hours for an MS degree have been earned by the student as delineated in the approved Course Plan. **During the**

¹According to University policy, students who have held GA appointments for three uninterrupted quarters are eligible for a fourth quarter fee authorization (tuition waiver) without being on appointment.

²The term "international" refers to students who hold F-1 visas.

quarter in which graduation is expected, unsupported domestic students must register for at least three credit hours, unsupported international students must register for the minimum required to maintain their visa status, and supported students and those receiving the fourth quarter waiver must register for fifteen credit hours.

II.7 Master's Examination

The student's MS Examination Committee consists of at least two members of the Department of Mechanical Engineering graduate faculty, including the student's advisor, with the advisor serving as chair. At least half of the members on the MS Examination Committee should be from the ME Department³.

II.7.1 Thesis option

1. The Master's examination is oral and emphasizes both an exposition and defense of the thesis investigation and a test of the candidate's knowledge of the course of study pursued. The examination is normally one hour in duration and should not exceed two hours. The examination may include a general presentation by the student open to visitors, followed by the actual thesis defense limited only to the MS Examination Committee and the student.
2. The committee's decision on the Master's examination is recorded on Graduate School's ***Master's Examination Report***, and acceptance of the thesis is indicated on the ***Thesis Approval Form***. Originals must be submitted to the Graduate School, ***and copies of the forms, along with a copy of the cover sheet of the Thesis, must be submitted to the Mechanical Engineering Graduate Program Office.***
3. The MS Examination Committee reports its recommendation on the student's admission to the Doctoral Program on the Mechanical Engineering MS Examination Committee Report (Appendix A.5).

II.7.2 Non-thesis option

1. The examination will include a written portion and may include an oral portion. The format of the examination will be selected by the student's advisor, consistent with the requirements stated in this guide and in Section II.5.2.6. of the Graduate School Handbook.
2. The written portion will be a minimum four-hour examination. It may either be a set of research problems, requiring the preparation of a formal paper, or a range of questions testing the candidate's broad knowledge of the course of study pursued.
3. The oral portion, if selected, will test the range of the candidate's knowledge of the course of study pursued and may include a presentation of the results of the formal research paper.
4. The committee's decision on the Master's examination is recorded on Graduate School's ***Master's Examination Report***. The original form must be submitted to the Graduate School, ***and a copy must be submitted to the Mechanical Engineering Graduate Program Office.***

³To add an external (non-OSU faculty) member to the Masters Committee, the student or the faculty advisor must submit a petition addressed to the Graduate School, including a brief rationale for the selection, and curriculum vitae of the external member. Upon approval by the ME Graduate Studies Committee, the documents are forwarded to the Graduate School for final decision and notification to student.

5. The MS Examination Committee reports its recommendation on the student's suitability for admission to the Doctoral Program on the Mechanical Engineering MS Examination Committee Report (Appendix A.5).

II.8 Time Limit

The entire work for the MS degree must be completed within a period of six calendar years.

II.9 Continuing toward a PhD Degree

Students planning to continue study toward a PhD degree should submit a Notification of Continuation form (Appendix A.6) to the ME Graduate Program Office **during the quarter in which they receive their MS degree**. The student's PhD advisor's signature is required on this form.

The student's MS Examination Committee must approve of the continuation toward a PhD degree in its Mechanical Engineering MS Examination Committee Report (Appendix A.5).

The student should take the Qualifying Examination no later than the first time it is offered after two quarters of registration in the Doctoral Program.

II.10 MS Program Checklist

II.10.1 First Quarter

1. Select the **thesis** or **non-thesis option**. (Students on fellowships or graduate associateships must select the **thesis option**.)
2. Choose an advisor and turn in Appendix A.2. (Note: University Fellows have time until the end of the second quarter).

II.10.2 Second Quarter

1. Complete and turn in the Course Plan by the fifth week of the quarter. (Course requirements depend upon whether the **thesis** or **non-thesis option** is selected.)
2. If the **thesis option** was selected, submit a thesis plan by the tenth week of the quarter.

II.10.3 Application to Graduate

Submit an Application to Graduate form to the ME Graduate Program Office **no later than the first Friday of the graduation quarter**.

II.10.4 Master's Examination

Consult with the advisor and the committee to schedule a date and time for the master's examination before the quarterly deadline set by the Graduate School.

1. For the **thesis option** there is an oral examination in the form of thesis exposition and defense. The advisor serves as the Chair of the MS Examination Committee, which consists of at least two Department of Mechanical Engineering graduate faculty members, including the advisor. At least half of the members on the MS Examination Committee should be from the ME Department.
2. For the **non-thesis option** the examination includes a written portion and may include an oral portion.
3. Obtain advisor's signature on the MS Examination Report (Appendix A.5).

II.10.5 Time Limit

The MS Program must be completed within six calendar years.

II.11 Additional Course Work

Credits accrued beyond what is specified in the MS course plan may be used toward doctoral degree requirements. However, only PhD-level appropriate courses are transferable. Graduate School's Transfer of Excess Master's Hours to the Doctoral Degree form (URL: <http://www.gradsch.ohio-state.edu/Depo/PDF/StatusBeyond.pdf>), along with student's transcript showing grade obtained in the course(s), must be submitted to the ME Graduate Program Office for Graduate Studies Committee approval.

Note: Level-approved Mathematics or Statistics Department course credits are eligible for transfer from MS to PhD only if a point-hour ratio of 3.50 or better has been obtained. For information on how to calculate the point-hour ratio, please refer to the "Course Credit" section of the OSU Course Offerings Bulletin at <http://www.ureg.ohio-state.edu/>.

II.12 Dual Master's Degree Program

Graduate School rules permit a student to pursue MS degrees from two graduate programs concurrently. ***A minimum of 50 percent of required coursework must be unique to each degree and may not be used for dual credit. The ME Graduate Studies Committee may establish a higher minimum.*** The "Program Plan for Dual Degree Students" form, available online at <http://www.gradsch.ohio-state.edu/Depo/PDF/DualDegree.pdf>, must be completed by the student after consulting with advisors from both programs, approved by each Graduate Studies Committee, and submitted to the Graduate School within one quarter of planning the integrated course of study.

Section III - Doctoral Degree Program

Two different plans can be used for earning a PhD

- 1. Enrollment from BS (BS-PhD track)** - The student begins to work toward a PhD degree directly after receiving a baccalaureate degree and being accepted as a PhD student. With this plan the student does not receive a master's degree. A student who starts in this program and later decides not to continue working toward a PhD can apply completed course and thesis work toward a master's degree.
- 2. Enrollment from MS (MS-PhD track)** - The student pursues a PhD degree after receiving an MS degree.

III.1 Advisor

The advisor of a doctoral student must hold membership at the Category P level in the graduate program of the student (Section II.6.4.4, Graduate School Handbook) i.e., in Mechanical Engineering. The doctoral student is strongly encouraged to choose an advisor, through mutual consent, **by the last day of classes in the first quarter of enrollment.** Thereupon, submit "Notice of Advisor" form (Appendix A.2). University Fellows may take up to two quarters after entrance into the program to choose a faculty advisor. **Once Appendix A.2 has been submitted, changing an advisor requires a formal petition to the ME Graduate Studies Committee.**

III.2 Qualifying Examination

The objective of the Qualifying Examination is to determine whether the student is qualified to enter or continue in the Doctoral Program. **The examination requires a comprehensive and in-depth understanding of undergraduate-level engineering principles and their application.**

The Qualifying Examination is given twice a year, during Winter and Summer quarters, and is administered by Department of Mechanical Engineering faculty members (the Qualifying Examination Committee) designated by the Graduate Studies Committee. **The student must take the examination no later than the first time it is offered after two quarters of registration in the Doctoral Program⁴.** If a student has not been formally admitted to the Doctoral Program, the results of this examination will be used as one factor in determining admission.

Each student must take the Qualifying Examination in three elective areas out of the eight areas listed below. One of these areas must be in the student's major research area. Each exam is a written three-hour exam.

III.2.1 **Design:** The examination covers fundamentals of mechanical design; failure modes; stress analysis and failure prevention principles; design of mechanical elements.

⁴Students admitted to the BS-PhD track **must** take the Qualifying Exam the first time it is offered after two quarters of enrollment in the Doctoral Program.

- III.2.2 **Mechanics of materials:** Static equilibrium analysis of simple structures and machines; stress-strain analysis of structural components under different load conditions; energy methods.
- III.2.3 **Dynamics and kinematics:** Dynamics of particles and rigid bodies; motion and force analysis of mechanisms.
- III.2.4 **System dynamics and vibrations:** Dynamic response of mechanical, fluid, thermal, and electrical elements; mechanical vibrations; frequency response and transfer functions; analytical methods for linear systems.
- III.2.5 **Measurements and controls:** Performance characteristics of motion, force, pressure, flow, and temperature transducers; data analysis; performance specifications for control systems; stability and error analysis techniques; controller concepts.
- III.2.6 **Fluid mechanics:** Integral balances; inviscid flows; viscous flows; turbulent flows; one-dimensional compressible flows.
- III.2.7 **Thermodynamics:** Conservation and balance principles; properties and property relations; nonreactive ideal-gas mixtures; combustion, thermochemistry, and chemical equilibrium.
- III.2.8 **Heat transfer:** Heat conduction; convection; radiation; multimode heat transfer.

More details about the Qualifying Examination can be found in Appendix B. Examiners in each subject area evaluate the performance of all students in that elected area and grade their performance as satisfactory or unsatisfactory. Admission to or continuation in the Doctoral Program is decided according to the following criteria:

1. A student must receive satisfactory grades in each of the three elected areas to continue in or be admitted to the Doctoral Program.
2. A student who receives three unsatisfactory grades on the first attempt will be denied admission to or further registration in the Doctoral Program.
3. A student must, at the next offering, retake only those parts of the examination in which an unsatisfactory grade was received to continue in the program.
4. No student may take any part of the Qualifying Examination more than twice.

The Qualifying Examination Committee reports each student's performance to the Graduate Studies Committee, which will communicate the results to the student and to the advisor. The decision on a student's qualifications to be admitted to or continue in the Doctoral Program is solely the responsibility of the Graduate Studies Committee, which may take other factors into consideration.

III.3 Doctoral Committee

The student and the advisor should select a Doctoral Committee, by the ***fifth week of the second quarter of registration*** in the Doctoral Program and submit the names of proposed committee members on the Graduate Program Approval Form (Appendix A.3). In addition to the advisor, the Doctoral Committee consists of three or more graduate faculty members, and is subject to Graduate Studies Committee approval.

At least half of the members on the Doctoral Committee should be from the ME Department. Additional⁵ faculty members may be added to the Doctoral Committee at the discretion of the Graduate Studies Committee. The duties of the Doctoral Committee members are to serve on the student's Advisory Committee, Candidacy Examination Committee, Dissertation Committee, and Final Oral Examination Committee. (See Section II.6 of the Graduate School Handbook for further details.) The Doctoral Committee also approves the Course Plan and the dissertation proposal before they are submitted to the ME Graduate Program Office for Graduate Studies Committee approval. The advisor for the doctoral student serves as the Chair for all committees.

III.4 Change of Advisor and Doctoral Committee

A student requesting to change an advisor may only do so by submitting a written petition (along with justifying reasons) to the Graduate Studies Committee. Only the advisor may request a change in the Doctoral Committee membership. Only the Graduate Studies Committee may approve changes in the Doctoral Committee membership.

III.5 Course Plan

After acceptance by the Doctoral Committee the student and the advisor must formulate and submit a Course Plan for the student's entire doctoral program (on the Graduate Program Approval Form, Appendix A.3) ***by the fifth week of the second quarter of registration*** in the Doctoral Program. ***Failure to comply with this requirement may jeopardize further registration in the program.***

As indicated previously under "Doctoral Degree Program", the PhD degree in Mechanical Engineering may be pursued either directly from the BS degree without obtaining an MS degree (BS-PhD track), or upon receiving the MS degree (MS-PhD track). Requirements for both PhD options include a ***total credit hour requirement*** specified by the Graduate School, and ***minimum course work*** required by the ME Graduate Program. After the minimum course work requirement is fulfilled, the total credit hour requirement may be met using research (ME 999), or a combination of research (ME 999) and course work.

Minimum course work requirements (excluding ME 888, ME 993 or other individual study credits, audited course credits, or ME 999) for the two options are as follows:

⁵To add an external (non-OSU faculty) member to the Doctoral Committee, the student or the faculty advisor must submit a petition addressed to the Graduate School, including a brief rationale for the selection, and curriculum vitae of the external member. Upon approval by the ME Graduate Studies Committee, the documents are forwarded to the Graduate School for final decision and notification to the student.

III.5.1 BS-PhD Track

1. **Total credit hours:** 135 graduate credit hours beyond the baccalaureate degree.
2. **Minimum course work:** 63 letter-graded course credits (i.e., excluding ME 888, ME 993 or other individual study credits, audited course credits, or ME 999 which are graded S/U) are required as follows:
 - a. 8 credit hours of PhD level math with a PHR of 3.50 or higher;
 - b. 6 credit hours of MS level math;
 - c. 8 credit hours of ME 700-level and above courses;
 - d. 15 credit hours of 700-level and above courses;
 - e. 15 credit hours of ME 600-level and above courses;
 - f. 11 credit hours of ME 700-level and above courses or non-ME 600-level and above courses, or a combination thereof;
 - g. 72 credit hours of ME 999, or a combination of ME 999 and ME or non-ME courses.

III.5.2 MS-PhD Track

1. **Total credit hours:** 90 graduate credit hours beyond the Master's degree.
2. **Minimum course work:** 27 letter-graded course credits (i.e., excluding ME 888, ME 993 or other individual study credits, audited course credits, or ME 999 which are graded S/U) are required as follows:
 - a. 8 credit hours of PhD level math with a PHR of 3.50 or higher;
 - b. 8 credit hours of ME 700-level and above courses;
 - c. 11 credit hours of ME 700-level and above courses or non-ME 600-level and above courses, or a combination thereof;
 - d. 63 credit hours of ME 999, or a combination of ME 999 and ME or non-ME courses.

III.6 Rules Common to Both BS-PhD and MS-PhD Tracks

III.6.1 ***Mathematics or Statistics Department 600-level or above letter-graded course (i.e., not graded S/U), may be applied to meet the eight-credit hour doctoral degree mathematics requirement.***

III.6.2 ***The mathematics requirement must be met prior to the Candidacy Examination.***

III.6.3 A doctoral student must obtain a point-hour ratio of 3.50 or better in courses taken to fulfill the eight-credit PhD-level math requirement.

Example: Course #1, credit hours (hrs): 5, grade: A, points*: $5 \times 4.00 = 20.00$; Course #2, hrs: 3, grade: B-, points: $3 \times 2.70 = 8.10$. Point-hour ratio = total points/total credit hours = $28.10/8 = 3.51$.

*Note: Per credit hour, A = 4.00 points, A- = 3.70, B+ = 3.30, B = 3.00, B- = 2.70, etc. For a detailed description of letter grade to grade point equivalencies and calculations of the point-hour ratio, please refer to the "Course Credit" section of the OSU Course Offerings Bulletin at <http://www.ureg.ohio-state.edu/>.

III.6.4 ***Courses taken to fulfill the eight-credit mathematics requirement cannot be double counted to meet other requirements.***

III.6.5 Until completion of the Candidacy Examination, ME 888 (Mechanical Engineering Seminar) must be taken in each quarter of enrollment in addition to the course work requirement. The ME 888 web page at <http://www.mecheng.osu.edu/graduate-students/me-888-seminars> should be consulted for specific rules for this course as well as quarterly seminar information. **Note: Part-time graduate students are exempt from ME 888.**

III.6.6 The number of course credit hours that can be transferred from another institution, **beyond** the usual transfer of 45 credit hours for an MS degree in mechanical engineering, will be determined by the student's Doctoral Committee and the ME Graduate Studies Committee. However, excluding OSU credit hours, **no more than nine credit hours may be transferred, and the transfer must be sought no later than the second quarter of enrollment in the program.**

The Request for Transfer of Graduate Credit (URL <http://www.gradsch.ohio-state.edu/Depo/PDF/TransferCredit.pdf>) must be prepared by the student, verified by the advisor, and forwarded to the ME Graduate Program Office along with a copy of the student's transcript and a description of the course from the official bulletin that includes documentation that the course being transferred is a graduate level course. Upon approval by the Graduate Studies Committee, the petition will be forwarded to the Graduate School for final decision and notification to student.

III.6.7 Once the coursework has been approved by the student's advisor and the ME Graduate Studies Committee, a revised Course Plan is required to substitute a previously-approved mathematics, engineering, or science course with a course that does not belong to these disciplines.

III.6.8 To be in good standing in the Graduate School, a student must maintain a graduate cumulative point-hour ratio (CPHR) of 3.0 or better in all graduate credit courses, and must maintain reasonable progress toward degree requirements (Section II.4.1, Graduate School Handbook).

III.7 Course Load Requirements

III.7.1 Minimum registration required per quarter, including ME 888 (if applicable) and ME 999:

1. 15 credit hours for **supported students** i.e., students holding graduate associateships, university fellowships, or other fellowships and scholarships eligible for a fee authorization;
2. 15 credit hours for students on a **fourth⁶ quarter fee authorization**;
3. 10 credit hours for **self-supported international⁷ students** (Section II.2.1.1. Graduate School Handbook).
4. 9 credit hours for **full-time self-supported domestic students** (US citizens or permanent residents) during Autumn, Winter, Spring quarters, and 7 credit hours during Summer quarter.
5. 3 credit hours for **self-supported domestic students** in the quarter of Candidacy, quarter of Final Oral Examination, and quarter of expected graduation.

⁶According to University policy, students who have held GA appointments for three *uninterrupted* quarters are eligible for a fourth quarter fee authorization (tuition waiver) without being on appointment.

⁷The term "international" refers to students who hold F-1 visas.

III.7.2 Maximum registration allowed by the Registrar's Office is 20 credit hours per quarter. Enrollment greater than 18 credits (excluding audited courses), must be approved by the student's advisor (Section II.2.1 Graduate School Handbook).

III.8 Candidacy Examination

The Candidacy Examination is a single examination consisting of a written portion and an oral portion. It may be taken **only after** satisfying the mathematics requirement but should be taken **within two years of passing the Qualifying Examination**. The objective of this examination is to test the student's knowledge of the field and related areas of study, capacity to undertake independent research, and ability to think and express ideas clearly. **No student is permitted to take the Candidacy Examination more than twice**. Section II.6.4 of the Graduate School Handbook should be consulted for additional details.

The Candidacy Examination Committee for first-time examinees consists of the four-member Doctoral Committee. For second-time examinees, the Candidacy Examination Committee also includes a representative of the Graduate School (GFR). All members of the Candidacy Examination Committee, including the GFR when applicable, are voting members.

III.8.1 Certification of Candidacy Eligibility

Before the student can take the Candidacy Examination, the **Notification of Doctoral Candidacy Examination** form, with the names of the Doctoral Committee members included, **should be submitted to the ME Graduate Program advisor for certification of the student's eligibility for Candidacy, three weeks prior to the Oral examination**. After certification, the Notification form will be submitted to the Graduate School by their **mandatory two-week notification deadline**. The *Notification of Doctoral Candidacy Examination* form is available online at http://www.gradsch.ohio-state.edu/Depo/PDF/Doc_Notify.pdf.

III.8.2 Written Portion of the Candidacy Examination

The written portion of the Candidacy Examination is administered and evaluated by the student's Doctoral Committee. It must include the preparation of a comprehensive dissertation proposal by the student. The dissertation proposal should be concise and precise and should include the following:

1. Title and abstract
2. Significance of the problem
3. Scope and objectives of the research
4. Literature review
5. Methodology
6. Expected results and conclusions
7. Expected contributions to the state of art or the literature

The Doctoral Committee is free to specify any reasonable length of dissertation proposal it feels appropriate. However, if the proposal is longer than the NSF format (15 pages), a short document effectively summarizing the full proposal is expected.

The dissertation proposal must be submitted to all members of the Doctoral Committee for evaluation.

The Doctoral Committee evaluates the written examination, including the dissertation proposal. The committee may ask the student to revise the proposal. An acceptable proposal is one that will result in a doctoral dissertation suitable for refereed journal publications.

If, based on evaluating the written examination, the Doctoral Committee members see no possibility for a satisfactory overall performance on the Candidacy Examination, the student may waive the right to take the oral examination. The Doctoral Committee may not, however, deny a student the opportunity to take the oral examination.

If the student decides to waive the right to take the oral examination, a written statement requesting the waiver must be presented to the Doctoral Committee. In such a case the Doctoral Committee records an unsatisfactory on the Candidacy Examination Report form and returns it to the Graduate School with a copy of the student's waiver request.

III.8.3 Oral Portion of the Candidacy Examination

The oral portion of the examination lasts approximately two hours and is normally held within one month of the written examination. It must be scheduled at least two weeks in advance, and the Graduate School must be notified of its proposed time and place by the advisor, using the Notification of Candidacy Examination form. The advisor is responsible for transmitting to every committee member the student's written portion of the general examination at least one week before the oral examination. A passing grade requires a unanimous vote of the committee.

Attendance at the oral portion of the Candidacy Examination is limited to the student and members of the Candidacy Examination Committee. Except when teleconferencing is involved, all members of the Candidacy Examination Committee must be present during the entire oral examination. ***According to Graduate School rules, oral presentation of any proposal or other prepared materials must be made prior to, or after, the oral examination. Questioning of the student should occupy the entire period of the examination.*** All committee members are expected to participate fully in the questioning during the course of the examination and in the discussion of and decision on the result of the Candidacy Examination.

1. The written portion of the Candidacy Examination, which necessarily includes the dissertation proposal, must be graded by the dissertation committee. For second-time Candidacy Examinations, the dissertation proposal must be graded by the dissertation committee before being sent to the Graduate Faculty Representative.
2. The student will make no formal or informal presentation during the two-hour oral examination period. Any use of prepared materials must be limited and only in response to a specific question.
3. The candidate should expect questions that probe for a comprehensive knowledge of the candidate's dissertation proposal, research area, and graduate coursework. The student should discuss the scope of the questioning with each member of the committee before the examination.
4. The candidate should submit the completed *Candidacy Examination Report* to the Graduate School after completion of the Oral Portion of the Candidacy Exam. A copy of the signed form ***must*** be submitted to the Mechanical Engineering Graduate Program Office.

III.9 Application to Graduate

Students must submit an Application to Graduate form (URL: <http://www.gradsch.ohio-state.edu/Depo/PDF/DoctoralGraduate.pdf>) to the ME Graduate Program Office **by the first Friday of the graduation quarter. During the quarter in which graduation is expected, unsupported domestic students must register for at least three credit hours, unsupported international students must register for the minimum required to maintain their visa status, and supported students and those receiving the fourth quarter waiver must register for fifteen credit hours.**

III.10 Dissertation Draft Approval

A complete, typed dissertation draft must be submitted to the Doctoral Committee (which also serves as the Dissertation Committee) for approval. The *Doctoral Draft Approval/Notice of Final Oral Examination* form (URL: http://www.gradsch.ohio-state.edu/Depo/PDF/Doc_Oral.pdf), with signatures, must be submitted to the Graduate School no later than two weeks before the date of the Final Oral Examination.

III.11 Final Oral Examination

The Final Oral Examination normally lasts two hours. The advisor schedules the examination by completing the notification form. The Final Oral Examination Committee, with the advisor as the Chair, also includes the following faculty members:

1. The student's Doctoral Committee, which also serves as the Dissertation Committee
2. A representative appointed at its discretion by the Graduate Studies Committee
3. The Graduate School Representative (GFR)

All members of the committee, including the Graduate School Representative, are voting members. The student must submit the signed **Final Dissertation Approval** form and the **Final Oral Examination Report** to the Graduate School. **Copies of the signed forms along with a copy of the cover sheet of the Dissertation must be submitted to the Mechanical Engineering Graduate Program Office.**

III.12 Time Limit

A student must successfully complete a dissertation and final oral examination within five calendar years after completing the Candidacy Examination. Failure to do so results in cancellation of Candidacy (Refer to Section II.6.8.1., Graduate School Handbook, for additional details). A student who has not completed his or her dissertation and final oral examination within four calendar years after the Candidacy Examination must submit to the Doctoral Committee documentation of the progress to date, the work remaining, and a schedule. This document must be approved by the Doctoral Committee and forwarded to the Graduate Studies Committee for action.

III.13 Doctoral Program Checklist

III.13.1 First Quarter

Choose an advisor and turn in Appendix A.2. (Note: University Fellows have time until the end of the second quarter).

III.13.2 Second Quarter

1. Along with the advisor, select a Doctoral Committee and submit the names to the Graduate Studies Committee by the fifth week of the quarter.
2. Submit a Course Plan by the fifth week of the quarter.

III.13.3 Qualifying Examination

1. Take the Qualifying Examination in three elective areas out of the eight areas listed earlier in this guide. One of the examination subjects must be in the student's major research area.
2. Take the examination ***no later than*** the first time it is offered after two quarters of registration in the Doctoral Program.

III.13.4 Candidacy Examination

In consultation with the advisor, take the Candidacy Examination when

1. the mathematics requirement has been completed, and
2. course requirements have been completed or nearly completed.

III.13.5 Application to Graduate

Prior to applying to graduate, a student must have course and dissertation plans approved by the Doctoral Committee. Submit an Application to Graduate to the ME Graduate Program Office ***by the first Friday of the quarter in which graduation is expected.***

III.13.6 Dissertation Draft Approval

1. Have a draft of the dissertation approved by the Dissertation Committee.
2. Forward the approval form to the Graduate School **at least two weeks before** the Final Oral Examination.

III.13.7 Final Oral Examination

Inform all Department of Mechanical Engineering faculty members and graduate students one week in advance.

III.13.8 Time Limit

1. The Doctoral dissertation must be submitted to the Graduate School within five years of being admitted to Candidacy.
2. If the final oral examination is not completed within four calendar years after the Candidacy Examination, the student must submit a progress report to the Dissertation Committee. The Dissertation Committee forwards the document to the Graduate Studies Committee.

Appendix A - Forms to be Completed by the Graduate Student

Completed forms must be submitted to the ME Graduate Program Office for obtaining Graduate Studies Committee Approval

A.1 BS/MS Program

A.1.1. College of Engineering Combined BS/MS Degree Information Sheet

Note: The College of Engineering “Combined BS/MS Degree Information sheet” may be downloaded from:

<http://www.eng.ohio-state.edu/currentstudents/pdf/bsmsform-Eng.pdf>.

When: BS/MS application process

A.1.2. BS/MS Program Courses

When: During the BS degree graduating quarter (Rank 4)

The ME Undergraduate Office will submit this form to the ME Graduate Program Office

A.2 Notice of Graduate Advisor

When:

For BS/MS Students: No later than the end of first quarter (Rank M) beyond the completion of the BS degree

For MS/PhD Students: By the last day of classes in their first quarter in the ME Graduate Program. (Note: University Fellows have time until the end of the second quarter).

A.3 Graduate Program Approval Form (Course Plan)

When: By the fifth week of student’s second quarter in the ME Graduate Program

A.4 Form for Graduate Studies Committee Approval of Master’s Thesis Plan

When: By the tenth week of a student’s second quarter in the ME Graduate Program

A.5 Mechanical Engineering MS Examination Committee Report

When: Submitted by the MS Examination Committee after the MS Examination

A.6 Notification of Continuation toward a PhD Degree Form

When: After the MS Examination

Student Information

Student name:	
SSN:	
E-mail:	
Phone:	
CPHR in all previous undergraduate coursework:	
Student signature:	
Date:	

Undergraduate Program Information (steps 1 and 2 only)

Undergraduate major program:	
Expected BS graduation quarter:	
Undergraduate advisor:	
Undergraduate advisor signature: (see note below)	
Date:	

Signature of undergraduate advisor confirms that courses the student has checked on page 1 as counting toward the BS degree, or toward both the BS and MS degrees, will count toward the BS degree.

Graduate Program Information

Graduate major program:	
Combined BS/MS enrollment quarter:	
Expected MS graduation quarter:	
Graduate Studies Committee Chair:	
Graduate Studies Committee Chair signature: (see note below)	
Date:	

Signature of Graduate Studies Committee Chair confirms that the student has been admitted to the Combined BS/MS Degree Program, and that the courses the student has checked on page 1 as counting toward the MS degree, or toward both the BS and MS degrees, will satisfy the course requirements for the MS degree.

For Administrative Use Only

College of Engineering Processing

College of Engineering coordinator for BS/MS signature:	
Date:	

Graduate School Approval

Graduate School coordinator for BS/MS signature:	
Date:	

APPENDIX A.1.2

**BS/MS Program Courses and Transfer of Credits
to the MS Degree Program**

Note: Undergraduates must submit this form during the graduating quarter of the BS degree (no later than the 7th week).

Name: _____

OSU lastname.#: _____ Phone: _____

Campus Location (Bldg./Room): _____

Graduating Quarter (BS Degree): _____

A. List of Technical Electives to be Applied toward the MS Degree (refer to the rules.)

COURSE #	TITLE	QTR/YR	CREDITS	GRADES
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

TOTAL (not to exceed 15 credits): _____

B. List of Graduate Courses Taken but not Applied toward BS Degree (Refer to the Graduate School rules)

COURSE #	TITLE	QTR/YR	CREDITS	GRADES
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

C. Plans for the MS Degree

Area of Interest: _____

MS Advisor: _____

Financial Support: _____

Signatures:

Student Undergraduate Office BS/MS Advisor

ME Graduate Program Chair

Date: _____

ME Graduate Program Processing:

___ Send to Graduate School (Graduation Services) to apply courses towards graduate GPA

___ Make a copy for ME Graduate Program records

APPENDIX A.3



DEPARTMENT OF MECHANICAL ENGINEERING
Graduate Program Approval Form (Course Plan)

Date: _____

Student's name _____
Last First Middle

OSU lastname.#: _____

Campus Location (Bldg./Room): _____ Phone: _____

Degree sought: MS _____ MS _____ PhD _____
Thesis Non Thesis

Student's advisor _____

First enrolled in current degree program: Quarter _____ Year _____

Scholarship, fellowship, assistantships currently in effect _____

Degree(s) held: Undergraduate _____ School _____ Year _____ GPA _____/4.00
Graduate _____ School _____ Year _____ GPA _____/4.00

Major in undergraduate study _____

Area of Study and Specialization (be precise) _____

Doctoral Students Only:

Major in MS degree _____

MS Thesis title _____

List the probable dissertation topic _____

List at least three graduate faculty, other than the advisor, suitable for the student's Doctoral Committee.

***** Note: Approval signatures required on the next page *****

APPENDIX A.4

The Ohio State University
Department of Mechanical Engineering (ME)

Graduate Studies Committee Approval of Master's Thesis Plan

Date: _____

This form is to be prepared and signed by the faculty member directing the Master's thesis, and is to be submitted to the Mechanical Engineering Graduate Program Office.

Student's name: _____
Last First Middle

OSU lastname.#: _____

Campus Location (Bldg./Room): _____ Phone: _____

Student's Advisor: _____

Thesis subject programmed for _____ quarters of study and _____ ME 999 credit hours

Title of proposed subject investigation: _____

The proposed investigation is related basically to the fields of: _____

Please append a research abstract explaining the objectives and expected results of the investigation.

If unusual instruments, facilities, or large amounts of computer time are required, please state them clearly at the end of the abstract.

MS Advisor Approval

I have reviewed the thesis plan submitted with this form, and, in my opinion, its successful execution is likely to result in a thesis which contributes to knowledge of importance sufficient to warrant its publication.

Date: _____ Advisor: _____
NAME SIGNATURE

Recommendations of the ME Graduate Studies Committee: _____

Approved by: _____
Signature: Chair, ME Graduate Studies Committee Date

ME Graduate Program Processing:

___ Update Current Student Database

APPENDIX A.5

Mechanical Engineering MS Examination Committee Report

Note to the Advisor:

- (i.) Please have the MS Examination Committee complete this form even if the student indicates no interest in continuing study towards the PhD degree.
- (ii.) Please submit the completed form to the ME Graduate Program Office.

Based upon the evaluation of the student's thesis as well as an evaluation of the student's performance on the MS Examination, the undersigned Examination Committee recommends that:

Student Name: **Last** **First** **Middle**

OSU lastname.#: _____

Campus Location (Bldg./Room): _____ **Phone:** _____

be not be (check one) permitted to continue graduate work towards the PhD degree.

NOTE: If the committee is undecided or has reservations about the student's ability to work independently on a PhD level dissertation topic, please check this space _____ and comment below.

Advisor Name and Signature

Name and Signature

Name and Signature

Date: _____

COMMENTS:

APPENDIX A.6

**NOTIFICATION OF CONTINUATION
TOWARD A PHD DEGREE**

Students who have received their MS degrees or are in the process of doing so, and intend to subsequently work toward a PhD in Mechanical Engineering, must submit this form to the Mechanical Engineering Graduate Program Office for Graduate Studies Committee approval prior to the start of the PhD Program.

Date: _____

Student's name _____
Last First Middle

OSU lastname.#: _____

Campus Location (Bldg./Room): _____ Telephone: _____

Residence Address: _____ Telephone: _____

PhD Research Advisor: _____

Signature of PhD Advisor

Date:

To continue toward a PhD degree, the student's MS Examination Committee must approve of this continuation on the Mechanical Engineering MS Examination Committee Report (Appendix A.5).

Appendix B

QUALIFYING EXAMINATION ELECTIVE AREAS

1. Design

The examination covers the material taught in ME 561, ME 562, and ME 563. The subject matter on which the student will be examined consists of:

I. Fundamentals of Machine Elements

- a) Safety factor, critical section, static equilibrium, free body diagram
- b) Shear and moment diagrams, Mohr's circle, octahedral stresses, plain strain
- c) Torsion, bending, and transverse shear
- d) Singularity functions, method of superposition, Castigliano's theorem
- e) Stress concentration, fracture toughness, failure prediction
- f) Fatigue, modified endurance limit, cumulative damage
- g) Impact stresses and deformation
- h) Properties of solid materials, lubrication, friction, and wear principles

II. Design of Mechanical Elements

- a) Screws, fasteners and connections
- b) Welded joints
- c) Mechanical springs
- d) Rolling element bearings
- e) Gears (spurs, helical and bevel)
- f) Shafting and associated parts
- g) Clutches, brakes, couplings and flywheels
- h) Hydrodynamic bearings
- i) Flexible machine elements (belts, ropes, and chains)

The following texts are recommended:

Shigley, J.E. and Mischke C.R. (1989) *Mechanical Engineering Design*, McGraw-Hill, New York

Collins, J.A. (2003) *Mechanical Design of Machine Elements*, 1st Edition, John Wiley

2. Dynamics and Kinematics

The examination covers the material taught in ME 430 (formerly EM 430) and ME 553. The subject matter on which the student will be examined consists of:

I. Dynamics:

- a) Kinematics of particles
 1. Rectilinear and plane curvilinear motion in different coordinate systems.
- b) Kinetics of particles.
 1. Newton's second law
 2. Work/energy
 3. Impulse/momentum
- c) Kinetics of systems of particles.
 1. Newton's second law, work/energy and impulse/momentum
- d) Rigid body kinematics
 1. Absolute and relative motion
 2. Instantaneous center
 3. Motion relative to rotating axes

- e) Rigid body kinetics
 1. General equations of motion for translation, fixed axis rotation and general motion
 2. Angular momentum
 3. Work/energy relations
 4. Impulse/momentum equations

II. Planar Linkages

- a) Degrees of freedom and mobility in linkages
- b) Linkages with fixed and moving sliders
- c) Graphical and analytical methods for velocities and accelerations
- d) Instant centers

III. Gear Kinematics

- a) Gear train analysis when rotation axes are fixed
- b) Planetary gear train analyses

IV. Mechanism Force Analysis

- a) Analytical approaches to static and dynamic force analyses
- b) Energy methods
- c) Inertial forces and shaking forces

The following texts are recommended:

Meriam, L.L. and Kraige L.G. *Engineering Mechanics-Dynamics*, any edition,
John Wiley & Sons, New York.

Waldron, K.J. and Kinzel, G.L. (2004) *Kinematics, Dynamics and Design of Machinery*,
John Wiley & Sons, New York.

3. Fluid Mechanics

The examination will cover the topics covered in ME 503 and ME 504, and some introductory material in one-dimensional compressible flow. In the following outline, material in the first two sections is discussed ME 503, the next three sections in ME 504 (the last section also in the first few weeks of ME 701).

I. Integral Balances

- a) Mass balance
- b) Momentum balance
- c) Moment of Momentum balance
- d) Energy balance

II. Inviscid Flows

- a) Bernoulli Equation
- b) Potential Flows

III. Viscous Flows

- a) Parallel flows. Fundamentals of lubrication
- b) Boundary layer theory

IV. Turbulent Flows

- a) Equations for the mean motion. Reynolds stresses.
- b) Pipe flow
- c) Skin friction and form drag

V. One-dimensional Compressible Flow

- a) Isentropic flow with area change
- b) Effect of friction on a flow in a duct of constant area
- c) Effect of heat transfer on a flow in a duct of constant area
- d) Normal shocks

The following texts are recommended as a guide for preparation:

R. Fox and A. McDonald, *Introduction to Fluid Mechanics*, John Wiley, 1992, Fourth Edition.

I. Shames, *Fluid Mechanics*, McGraw-Hill, 1982. Second Edition.

F. White, *Fluid Mechanics*, McGraw-Hill, 1994, Third Edition

R. Sabersky, A. Acosta and E. Hauptmann, *Fluid Flow*, MacMillan, 1989, Third Edition

Munson, Young, Okiishi, *Fundamentals of Fluid Mechanics*, John Wiley, 2006, Fifth Edition

4. Heat Transfer

The examination in heat transfer will cover the material taught in ME 510. The emphasis will be placed on student's ability to apply the fundamentals to the formulation of original heat transfer problems and to proceed with the solution. The subject matter on which the student will be examined will include:

I. Conduction

- a) Ability to apply balance of mass and energy to conduction
- b) Steady 1-D, 2-D, and 3-D conduction
- c) Heat transfer from extended surfaces
- d) Conduction in moving media
- e) Unsteady lumped systems
- f) Formulation of unsteady distributed systems (1-D, 2-D, and 3-D)
- g) Heisler charts

II. Convection

- a) Ability to apply balance of mass, momentum, and energy to convection
- b) Laminar and turbulent forced convection in internal and external flows
- c) Thermal and momentum boundary layers in forced convection
- d) Thermal and momentum boundary layers in natural convection
- e) Use of heat transfer correlations in forced and natural convection

III. Radiation

- a) Fundamental physics of thermal radiation
- b) View factors and their algebra
- c) Radiation exchange between gray-diffuse surfaces

IV. Multimode heat transfer

The following texts are recommended as a guide for preparation:

V.S. Arpaci, A. Selamet, and S.-H. Kao, *Introduction to Heat Transfer*, Second Print, Prentice Hall, New Jersey, 2000.

F.P. Incropera and D.P. DeWitt, *Introduction to Heat Transfer*, Fifth Edition, J. Wiley, New York, 2006.

J.P. Holman, *Heat Transfer*, Ninth Edition, McGraw-Hill, New York, 2001.

F. Kreith and MS Bohn, *Principles of Heat Transfer*, Sixth Edition, Harper & Row, New York, 2000.

5. Measurements and Controls

The examination in Measurements and Controls will cover material found in the courses ME 570 and 571. A table of Laplace Transforms will be provided. The subject matter covered includes:

I. Measurements

- a) Static and Dynamic Performance Characteristics of Measuring Devices
- b) Data and Error Analysis; Elementary Probability and Statistics
- c) Motion, Force, Pressure, Flow and Temperature Measurements

II. Controls

- a) Time and Frequency Domain Performance Specifications for Linear Continuous-Time Feedback Control Systems
- b) Stability Analysis Techniques-Routh-Hurwitz Criterion, Nyquist Criterion, Root-Locus Methods
- c) Basic Compensators: Proportional, Integral, and Derivative Controllers, and Lead and Lag Compensators

Relevant parts of the following texts or equivalents are recommended for study:

Measurements

E.O. Doebelin, *Measurement Systems, Application and Design*, McGraw-Hill Book Company, Fifth Edition, 2004.

Control Systems

G. Franklin, J.D. Powell, A. Emami-Naeini, *Feedback Control of Dynamic Systems*, 3rd Edition, Addison-Wesley, 1994.

R.C. Dorf, R.H. Bishop, *Modern Control Systems*, 7th Ed. Addison-Wesley, 1995

N.S. Nise, *Control Systems Engineering*, 4th Edition, John Wiley, 2004.

6. Mechanics of Materials

The examination in mechanics will cover the material taught in ME 410 (formerly EM 400) and ME 420 (formerly EM 440). The subject matter on which the student will be examined will consist of:

I. Statics

- a) Particle equilibrium
- b) Rigid body equilibrium
- c) Structural analysis: trusses, frames, and machines
- d) Internal forces and moments
- e) Friction
- f) Centroids and moments of inertia

II. Strength of Materials

- a) Stress
- b) Strains
- c) Mechanical properties of materials
- d) Axial load
- e) Torsion
- f) Beam bending and transverse shear
- g) Combined loading
- h) Stress and strain transformations
- i) Deflection of beams and shafts
- j) Buckling of columns
- k) Energy methods

The following texts are suggested:

Hibbeler, R.C., *Engineering Mechanics, Statics*, any edition, Prentice Hall

Hibbeler, R.C., *Mechanics of Materials*, any edition, Prentice Hall.

Beer, Johnston, Eisenberg, *Vector Mechanics for Engineers*, 3rd Edition, McGraw Hill, 1998

7. System Dynamics and Vibrations

The examination in System Dynamics and Vibrations will cover material found in the courses ME481, 482 and sections of 650. The subject matter covered includes:

1. System Dynamics

- a) Solution Methods for Ordinary Linear Differential Equations; Linearization Techniques
- b) System Elements - Mechanical, Electrical, Fluid and Thermal
- c) Fourier Analysis
- d) Frequency Response and Transfer Functions of First, Second and Higher Order Systems
- e) Lumped Parameter Models of Hydraulic Pumps and Motors, Motors, and Generators

II. Mechanical Vibrations

- a) Single degree of freedom systems:
 - free and forced response to general excitations
 - frequency response
 - damping models
 - vibration isolation
- b) Multiple degree of freedom systems:
 - natural frequencies and vibration modes of MDOF systems
 - free and forced response using modal analysis

Relevant parts of the following texts or equivalents are recommended for study:

Systems Dynamics

W.J, Palm III, *System Dynamics*, McGraw-Hill, 2005.

G. Rizzoni, *Principles and Applications of Electrical Engineering, Part III: Electro Mechanical Systems* (Chapters 15-17), McGraw-Hill, 2004.

Vibrations

D.J. Inman, *Engineering Vibration*, 2nd edition, 2001, Prentice-Hall.

W. E. Boyce and R. C. DiPrima, *Elementary Differential Equations and Boundary Value Problems*, 6th (1997), 7th (2001), or 8th edition (2004), Wiley.

8. Thermodynamics

The examination in thermodynamics will cover the material taught in ME 501 and ME 502. In the following outline, topics I and II are discussed in ME 501 and topics III-V are discussed in ME 502.

I. Conservation and Balance Principles

- a) Conservation of mass principle
- b) Energy balance for closed and open systems
- c) Entropy balance for closed and open systems
- d) Applications of balance principles to engineering devices

II. Properties and Property Relations

- a) Entropy, thermodynamic temperature scales
- b) Gibbs equations
- c) Use of “steam” tables and similar compilations
- d) Generalized compressibility charts
- e) Ideal gas model, ideal gas tables

III. Application to Power and Refrigeration Systems

- a) Rankine cycle with reheat and regeneration systems
- b) Brayton cycle
- c) Otto, Diesel and Dual cycles
- d) Vapor-compression refrigeration and heat pump systems

IV. Nonreactive Ideal Gas Mixtures

- a) Dalton mixture model and its use in mixing processes
- b) Air water vapor mixtures, Psychrometric chart

V. Combustion and Thermochemistry

- a) Application of conservation of mass, the first law, and the second law to reacting systems. Stoichiometry
- b) Enthalpy of formation. Heating values. Adiabatic-combustion temperature.
- c) Third law of thermodynamics. Absolute entropy. Entropy production in reacting mixtures.

The following texts are recommended as a guide for preparation:

M. Moran and H. Shapiro, *Fundamentals of Engineering Thermodynamics*, Fifth Edition, J. Wiley, 2004.

M. Moran, *Availability Analysis: A Guide to Efficient Energy Use*. ASME Press, 1989.

R. Sonntag, C. Borgnakke, G.J. Van Wylen, *Fundamentals of Thermodynamics*, Fifth Edition, J. Wiley, 1998.