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PREFACE

Faculty members and staff of the Mechanical Engineering Department wish you a rewarding experience in your graduate study, and look forward to working with you during your enrollment here. For additional assistance, consult:

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I. DIRECTORY

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II. DEGREE PROGRAMS

Two degree programs are offered:

- Master of Science in Mechanical Engineering (M.S.)
- Doctor of Philosophy in Mechanical Engineering (Ph.D.)

Master of Science degrees have an option of Plan A, Plan B or Plan C. For both MS and PhD degrees, the program of study should be developed in consultation with one’s adviser. It is essential that an adviser be identified no later than the end of the second term of every student’s full-time enrollment.

Full-time graduate students in the Mechanical Engineering Department (including those on fellowship or assistantship support) are expected to complete their master’s degree in two years and to complete their doctoral degree in no more than five years (beyond the B.S. degree).

1. Credit requirements for MSME degrees

   a. Master’s degrees consist of the following minimum credits:
      i. Plan A MSME degrees: 10 thesis credits (ME 8777) and 20 graduate-level course credits taken on an A/F grade basis except as noted below. Courses must include:
         • At least 14 course credits of graduate coursework in mechanical engineering. Any ME5000- or ME8000-course is considered a mechanical engineering graduate course, except for independent research courses which do not count towards the credit requirement. Additional courses that meet the requirement for course credits in mechanical engineering are listed below:
         - AEM 8201 Fluid Mechanics I
         - AEM 8202 Fluid Mechanics II
         - AEM 5401 Intermediate Dynamics
         - AEM 5501 Continuum Mechanics
         - EE 5231 Linear Systems and Optimal Control
         - EE 8215 Nonlinear Systems
         • The remaining 6 credits should be graduate-level courses with significant scientific or engineering content, including courses in mechanical engineering. The six credits may be taken as a designated minor.
         • One research and professional ethics course (3 credit max) taken on an S/N grade basis.
         • Between 1 and 2 seminar credits taken on an S/N grade basis. Seminars may be taken in other departments but must have significant scientific or engineering content.
      ii. Plan B MSME degrees: 30 graduate-level course credits taken on an A/F grade basis with the exception of the seminar, ethics and Plan B project credits that are taken on an S/N grade basis. Courses must include:
         • At least 14 course credits of graduate coursework in mechanical engineering. Any ME5000- or ME8000-course is considered a mechanical engineering graduate course, except for independent research courses which do not count towards the credit requirement. Additional courses that meet the requirement for course credits in mechanical engineering are listed below:
         - AEM 8201 Fluid Mechanics I
         - AEM 8202 Fluid Mechanics II
• AEM 5401 Intermediate Dynamics
• AEM 5501 Continuum Mechanics
• EE 5231 Linear Systems and Optimal Control
• EE 8215 Nonlinear Systems

• The remaining 16 course credits should be graduate-level courses with significant scientific or engineering content, including courses in mechanical engineering. Six of these credits may be taken as a designated minor.
• One research and professional ethics course (3 credit max) taken on an S/N grade basis.
• Between 1 and 2 seminar credits taken on an S/N grade basis. Seminars may be taken in other departments but must have significant scientific or engineering content.
• No more than 4 Plan B Project credits selected from ME 8794 or ME 8951 and taken on an S/N grade basis.

iii. Plan C MSME degrees: 30 graduate-level course credits taken on an A/F grade basis with the exception of the seminar, ethics and independent study credits that are taken on an S/N grade basis. Courses must include:
• At least 24 course credits of graduate coursework in mechanical engineering. Any ME5000- or ME8000-course is considered a mechanical engineering graduate course, except for independent research courses which do not count towards the credit requirement. Additional courses that meet the requirement for course credits in mechanical engineering are listed below:
  • AEM 8201 Fluid Mechanics I
  • AEM 8202 Fluid Mechanics II
  • AEM 5401 Intermediate Dynamics
  • AEM 5501 Continuum Mechanics
  • EE 5231 Linear Systems and Optimal Control
  • EE 8215 Nonlinear Systems

• The remaining 6 credits should be graduate-level courses with significant scientific or engineering content, including courses in mechanical engineering. The six credits may be taken as a designated minor.
• One research and professional ethics course (3 credit max) taken on an S/N grade basis.
• Between 1 and 2 seminar credits taken on an S/N grade basis. Seminars may be taken in other departments but must have significant scientific or engineering content.
• No more than 4 credits of independent study (ME 8794) taken on an S/N grade basis.

b. No more than six 4000-level course credits may be used for graduate-level course credit. Only the following 4000-level courses are acceptable for programs of coursework:
  • AEM 4511 Mechanics of Composite Materials
  • AEM 4581 Mechanics of Solids
  • CHEM 4502 Physical Chemistry II
  • EE 4541 Digital Signal Processing
  • MATH 4512 Differential Equations with Applications
  • PHYS 4051 Methods of Experimental Physics I
  • PHYS 4101 Quantum Mechanics
  • PHYS 4201 Statistical and Thermal Physics
  • PHYS 4211 Introduction to Solid-State Physics
If a student wishes to include a different 4xxx-level course on his/her program, the adviser and the DGS must approve the course prior to enrollment. Approval will only be granted if a Degree Program Form is submitted.

c. Master’s Plan A thesis credits (ME 8777) may be taken at any time during the degree program.

d. At least 60% of the graduate-level course credits (not including thesis credits) must be taken at the University of Minnesota. A maximum of 12 graduate-level course credits taken as a non-degree or non-admitted student may be considered for inclusion once the student is admitted and enrolled in the graduate program.

e. The student must maintain a GPA of 2.80 or higher for courses in the degree program.

f. The plan for graduate course work must be approved by the adviser and the DGS.

2. Credit requirements for ME doctoral degrees

a. The doctoral degree course program is intended to provide the student with the necessary intellectual and professional foundation for their thesis project and their future career. The course program must be rigorous and must be appropriate for the proposed thesis. In addition, some faculty advisors will have suggestions for specific courses that the student should take to prepare for the thesis, consistent with the requirements listed below.

b. Doctoral degrees consist of the following minimum credits:

   i. 38 graduate-level course credits taken on an A/F basis except as noted. Courses must include:

   • At least 18 course credits of graduate coursework in mechanical engineering. Any ME5000- or ME8000-course is considered a mechanical engineering graduate course, except for independent research courses which do not count towards the credit requirement. Additional courses that meet the requirement for course credits in mechanical engineering are listed below:

   • AEM 8201 Fluid Mechanics I
   • AEM 8202 Fluid Mechanics II
   • AEM 5401 Intermediate Dynamics
   • AEM 5501 Continuum Mechanics
   • EE 5231 Linear Systems and Optimal Control
   • EE 8215 Nonlinear Systems

   • The remaining 20 course credits may be taken as additional grad-level courses with significant scientific or engineering content, including courses in mechanical engineering, and may include 12 credits in a designated minor.

   • No more than 20 credits of supporting graduate courses offered in departments other than mechanical engineering. These courses must have substantial technical and/or scientific content and are normally offered in the College of Science and Engineering.

   • At least 12 8000-level course credits must be taken A/F. Seminar and ethics courses are excluded from this requirement.

   • One research and professional ethics course (3 credit max) taken on an S/N grade basis.

   • Between 2 and 3 seminar credits taken on an S/N grade basis.

c. No more than six 4000-level course credits may be used for graduate-level course credit. Only the following 4000-level courses are acceptable for programs of coursework:

   AEM 4511 Mechanics of Composite Materials
   AEM 4581 Mechanics of Solids
   CHEM 4502 Physical Chemistry II
   EE 4541 Digital Signal Processing
   MATH 4512 Differential Equations with Applications
   PHYS 4051 Methods of Experimental Physics I
If a student wishes to include a different 4xxx-level course on his/her program, the adviser and the DGS must approval the course prior to enrollment. Approval will only be granted if a Degree Program Form has been submitted.

- A minimum of 12 graduate course credits taken at the University of Minnesota. The number of course credits that can be transferred from another university will be determined on a case-by-case basis and must be approved by the adviser and DGS.
- A maximum of 12 graduate course credits taken as a non-degree or non-admitted student may be considered for inclusion in the course program once the student is enrolled in the graduate program.

ii. A minimum of 24 thesis credits (ME8888).

- Doctoral thesis or any other type of research credits earned at another university cannot be applied toward the thesis credit requirement.
- A thesis done at another university cannot be transferred to the University of Minnesota.
- Thesis credits may be taken only after successful completion of the Preliminary Oral Exam.

c. The student must maintain a GPA of 3.00 or higher for courses in the degree program.
d. The plan for graduate course work must be approved by the advisor and the DGS.

3. Minor credit requirements for students majoring in other fields

a. At least 6 credits in mechanical engineering are required for a master's minor in mechanical engineering.
b. At least 12 credits in mechanical engineering are required for a doctoral minor in mechanical engineering.
III. APPROVAL PROCESS STEPS IN DEGREE STUDY

Master of Science—Plans A, B and C (M.S.)

____ 1. Choose a research adviser for the Plan A and Plan B soon after beginning study. The adviser must be a member of the ME graduate faculty or an Affiliate Senior Member (see pages 1 and 2) and should be chosen no later than the end of the first semester of full-time graduate registration (or second semester of part-time graduate registration). Once an adviser has been chosen, notify the DGS assistant.

____ 2. Select research committee members in consultation with your adviser and in accordance with Graduate School Policy. The formal approval of the research committee requires online submission by the student at the following link:

http://www.grad.umn.edu/students/forms/masters/index.html

The committee member is due after one full-time academic semester or after completing 10 credits. Plan C students do not need to submit a committee.

____ 3. Complete the degree program form with adviser approval and submit it to the DGS Assistant. The form is due after one full-time academic semester or after completing 10 credits.

http://policy.umn.edu/forms/otr/otr198.pdf

Complete all blanks on the program form: courses, major/minor-related field, ethics seminar, calendar time taken, credits, etc. Attach a transcript.

If a student wants to change their approved degree program form, file a petition form, available at:

http://www.grad.umn.edu/current_students/forms/gs59.pdf

Return the petition form to ME 1120 for DGS approval.

____ 4. Complete the Plan A thesis or Plan B project. The Plan C does not have a project or thesis.

For a Plan B project, up to 4 credits of directed research (ME 8794) may be applied to the course requirements. Directed research credits are for ME 8794 only.

____ 5. Pick up the final oral exam form, and other graduation materials, including the application for degree, at the Graduate School office, 160 Williamson. Material can also be requested via the web at:

http://www.grad.umn.edu/current_students/forms/grad_packet/index.html

If circumstances require a change of a committee member, simply resubmit your new committee:

http://grad.umn.edu/students/forms/doctoral/index.html

Each student must have an approved degree program form on file with the Department and the Graduate School before he or she can execute this step.

The application for degree form must be submitted to the Student Services Office (STSS Building) by the first working day of one’s expected graduation month.
6. Schedule the final oral examination for the defense of the Plan A thesis or Plan B project. The Plan C does not have a final oral exam.

A final examination is required for all Plan A and Plan B MS candidates. The exam is oral, and is usually 90 minutes in length. It is conducted by a minimum of three members of the graduate faculty assigned at the time the degree program form is approved. At least two faculty members must be from the major field and one from the minor or supporting program area. The final oral for the master’s degree is conducted as a closed examination, attended only by the student and the examining committee.

It is the student’s responsibility to schedule the oral exam in consultation with their adviser and committee members.

This examination may relate to a combination of both thesis content (for Plan B programs, project and paper content) and technical course competence. The final presentation should be well-prepared and succinct, and one should allow examiners ample time for questions and comments on coursework. The formal presentation should be no more than 30 minutes in duration.

Be sure the committee is informed of impending examination, and schedule it to accommodate all examining members. For available rooms, please contact:

ME-reservations@me.umn.edu

File the approved final examination form with Graduate School (160 Williamson Hall). This form is due the last working day of one’s expected graduation month.

7. Complete final edit of the examined Plan B paper or Plan A thesis.

For Plan A, submission of one bound thesis (maroon binding with white lettering) to the DGS Assistant, ME 1120 and to one’s adviser(s) is required.

8. Check-out. To verify completion of graduate work for a degree and to provide control of inventory, keys, and office space, each student must complete a Departmental Check-out Form (available in ME 1120) prior to departure from the Department or prior to beginning another degree objective within the Department.
Doctor of Philosophy (Ph.D.)

_____ 1. Choose a research adviser soon after beginning study. The adviser must be a member of the ME graduate faculty or an Affiliate Senior Member (see pages 1 and 2) and should be chosen no later than the end of the first semester of full-time graduate registration (or second semester of part-time graduate registration). Once an adviser has been chosen, notify the DGS assistant.

_____ 2. Register and take the oral qualifying exams. The registration deadline for the exams is announced early in each semester. For students who enter the Ph.D. program after completion of an M.S. in mechanical engineering, these exams must be taken in the first semester upon admission to the Ph.D. program. For all other students, the exams must be taken by the second semester in the Ph.D. program.

_____ 3. Select research committee members in consultation with your adviser and within two semesters of passing the qualifying exams. To assign one’s committee for preliminary oral exam please submit selected committee members with the Graduate School at the following link:

http://grad.umn.edu/students/forms/doctoral/index.html

_____ 4. Complete the degree program form. This step must be approved before the written preliminary exam can be taken. The form is available at:

http://policy.umn.edu/forms/otr/otr198.pdf

Complete all blanks on the program: courses, major/minor-related field, calendar time taken, credits, etc. Thesis credits should be included in the course listings; however, they should not be added to the credit totals at the bottom of the program.

ME8794 and master’s thesis credits may not be applied towards a Ph.D. degree.

If circumstances require a change of a committee member, simply resubmit your new committee:

http://grad.umn.edu/students/forms/doctoral/index.html

To change an approved degree program form, file a petition form, available at:

http://www.grad.umn.edu/current_students/forms/gs59.pdf

Return the petition form to ME 1120 for DGS approval.

_____ 5. Complete written preliminary exam. After passing the oral qualifying examinations, the written preliminary examination must be taken within two semesters. It is recommended that students submit the written document to the examination committee by the 8th week of the semester. The written examination must be passed prior to scheduling the preliminary oral examination.

Submit the preliminary written exam report to the DGS Assistant, ME 1120, asserting passing quality.

For doctoral candidates who have not completed an MS degree in Mechanical Engineering, it is permissible to submit the written preliminary exam document in lieu of a plan B MS project report if your adviser approves this procedure. If all other requirements have been satisfied for the MS Plan B

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1 Extensions will only be granted in exceptional circumstances with approval of the adviser(s) and the Director of Graduate Studies. Requests for exceptions must be submitted in writing to the DGS. The request should document the extenuating circumstances that justify an extension.
(including a completed Degree Program Form) and with advisor consent, the Plan B MS final exam can be scheduled concurrently with the preliminary oral exam.

6. Schedule oral preliminary exam after passing the written preliminary exam. Schedule this exam at least one week in advance (http://www.grad.umn.edu/current_students/prelimschedule/). Rooms may be scheduled via email at:

ME-reservations@me.umn.edu

Submit the oral preliminary examination form to 160 Williamson Hall.

If the defense of a Plan B MS is done at the same time as the doctoral preliminary oral exam, obtain signatures on the forms for the Plan B final exam as well as the PhD preliminary exam at the conclusion of the exam.

7. To assign one’s committee for final exam please submit selected committee members with the Graduate School at the following link:

http://grad.umn.edu/students/forms/docto ral/index.html

8. Pick up Reviewers Report Form, and other graduation materials at the Graduate School, 160 Williamson. Graduation material can also be requested via the web at:

http://www.grad.umn.edu/current_students/forms/grad_packet/index.html

The application for degree form must be picked up from the Graduate School. Submit this form to the Student Services Office (STSS Building) by the first working day of one’s expected graduation month.

9. Submit Thesis to reviewers (check with reviewers to ascertain their required reading time frame—usually a minimum of 2 weeks).

10. Submit the signed Thesis Reviewers Report form to 160 Williamson at least one week before scheduled final oral examination.

11. Schedule the final oral exam at least two weeks in advance at:

http://www.grad.umn.edu/current_students/finalschedule/

(The Graduate School will pass the final oral examination report to each student’s committee chairperson). A minimum of 4 committee members are required to serve on the final examining committee (three from the major and one from outside).

12. File final oral exam report (Graduate School, 160 Williamson Hall).

13. Edit examined Thesis if required.

14. Distribute Thesis and check out

The submission of one bound thesis (black binding with white lettering) to the DGS Assistant, ME 1120 and to one’s adviser(s) is required. To verify completion of graduate work for a degree and to provide control of inventory, keys, and office space, each student must complete a Departmental Check-out Form (available in ME 1120) prior to departure from the Department or prior to beginning another degree objective within the Department.
IV. DOCTORAL EXAMINATION PROCEDURES

Ph.D. candidates in mechanical engineering must pass the following “qualifying” and “preliminary” examinations:

- Oral “qualifying” examinations in three subject areas
- A written preliminary examination that will be constituted by the Ph.D. thesis proposal.
- An oral preliminary examination that will consist of a presentation on the proposed research, followed by questioning that is focused on material and course work related to the proposed research.

**Oral Qualifying Exams**

After entering the Ph.D. program, but before taking the written Ph.D. preliminary exam, students will be required to take three oral qualifying exams.

**Timing**

For students who enter the Ph.D. program after completion of an M.S. in mechanical engineering, the oral exam must be taken in the first semester upon admission. For all other students, the exam must be taken by the second semester in the Ph.D. program. There will be an announcement each semester with the exact dates of the exam and the deadline for registration.

**Length of exams**

Normally, exams will be 30 minutes long. However, exams may be extended up to 60 minutes at the discretion of the examiners.

**Choice of subjects**

The subjects of the three exams must be selected from six core subjects. Descriptions of the level and content of the exams in each of these core subject areas follow below. The subjects are:

- Fluid mechanics
- Heat transfer
- Machine design
- Solid mechanics
- System dynamics and control
- Thermodynamics

**Examining committees**

The committee for each oral exam will consist of two members of the ME graduate faculty. The adviser cannot be on the committee.

**Evaluation of exams**

Immediately following every examination, each examiner will independently grade the student’s performance on a 10-point scale. After all students have completed the qualifying examinations, the ME Graduate Faculty will make final decisions regarding pass, fail with retake (at most one retake allowed) or fail without retake. If the result is fail with retake, then the student must retake the entire qualifying examination, i.e. he/she must take three exams again, though not necessarily the same three. Retake of the exams must occur during the oral qualifying exam week of the following semester. For cases where a student performs poorly on a retake of the oral qualifying exams, the adviser’s input will be considered before making the decision whether to fail the student and terminate him or her from the Ph.D. program.
Ph.D. Oral Qualifying Examination in Fluid Mechanics

Background
The qualifying examination in fluid mechanics will be used to assess the candidate’s understanding of fluid mechanics at an advanced undergraduate level. The successful candidate will demonstrate a working knowledge of hydrostatics, conservation of mass, conservation of linear momentum, conservation of energy, Lagrangian and Eulerian descriptions (frames of reference) as well as similitude and the Buckingham Pi theorem. These subject areas are present in the vast majority of undergraduate fluid mechanics courses/programs, and are the minimum required to enter a graduate-level course in fluid dynamics. Students should demonstrate a systematic approach to fluid systems analysis.

Topics that may be covered
- Hydrostatics (thermodynamics approach and force balances)
- Fluid kinematics, acceleration, Eulerian and Lagrangian descriptions
- System and Control Volume analysis, Reynolds transport theorem
- Incompressible Bernoulli equation and Euler’s equation, understanding their advantages and limitations
- General motion of a fluid element; differential analysis of a fluid element
- Conservation of mass, momentum, and energy
- Buckingham’s Pi theorem, dimensional analysis, similitude
- Viscous flows, e.g. pipe flows; planar Couette flow; lubrication; thin films; venturis, orifice plates, obstruction meters
- Boundary layers—laminar and turbulent: both fundamental understanding and appreciation for the role of boundary layers in external and internal flows; developing flows; lift and drag
- Understanding of important dimensionless groups in fluid mechanics, including Reynolds number, Mach number, Weber number, Froude or Richardson number, etc.

Relevant courses (at the University of Minnesota)
- ME 3332, Thermal Sciences II (essential)
- ME 5341, Thermal Design (beneficial)
- ME 5344, Thermodynamics of Fluid Flow (beneficial)

Suggested references
Ph.D. Oral Qualifying Examination in Heat Transfer

Background
The qualifying examination in heat transfer will be used to assess the candidate’s understanding of heat transfer at an advanced undergraduate level. The successful candidate will demonstrate a working knowledge of the macroscopic and physical basis of the three primary modes of heat transfer: conduction, convection and thermal radiation. Demonstration is required of an ability to analytically apply the Fourier law of conduction and Newton’s law of cooling, to determine heat transfer rates in steady and transient situations in both one and two dimensions. Familiarity (not memorization) with widely used empirical correlations for forced and free convection is expected. For thermal radiation, candidates are expected to be able to compute heat transfer rates via thermal radiation in enclosures with non-participating gases. Candidates must also demonstrate the ability to conceptualize a thermal systems component or processing involving heat transfer to meet a desired need or engineering objective.

Topics that may be covered
- Thermodynamic foundation of heat transfer; heat transfer defined; Fourier’s law of heat transfer by conduction; thermal conductivity
- Steady thermal conduction in one and two dimensions; planar systems, cylindrical systems, spherical systems; overall heat transfer coefficient; insulation & R-values; critical thickness of insulation
- Steady conduction-convection systems; fins & thermal contact resistance; conduction in two dimensions; unsteady heat transfer; lumped system analysis; Heisler charts
- Convection fundamentals; thermal boundary layer concepts; laminar and turbulent flat plate boundary layers; energy equation in two dimensions; Newton’s law of cooling
- Empirical relationships for engineering systems under forced convection: pipe flows, flow across cylinders, spheres, tube banks
- Fundamentals and empirical relationships for natural convection systems
- Solid understanding of important dimensionless groups in heat transfer, including Reynolds number, Prandtl number, Nusselt number, Biot number, Grashof number, etc.
- Radiation heat transfer fundamentals; physical mechanisms; radiation properties; shape factors; radiation networks

Relevant courses (at the University of Minnesota)
- ME 3333, Thermal Sciences III (essential)
- ME 4331, Thermal Engineering Laboratory (beneficial)
- ME 5341, Thermal Design (beneficial)

Suggested references
Ph.D. Oral Qualifying Examination in Machine Design

Background
The machine design qualifying exam covers topics on basic solid mechanics, energy methods, failure theories, kinematics, dynamics, and machine elements. Most mechanical engineering programs address these topics in undergraduate or beginning graduate level courses in machine design and mechanisms. A detailed list of potential topics addressed in this exam is provided below. Courses where these topics are addressed at the University of Minnesota are also provided, as well as textbooks that are recommended for preparing for this exam.

Topics that may be covered
- Beam analysis; column buckling
- Energy methods: Castigliano’s theorem
- Static failure theories; fatigue analysis
- Degrees of freedom
- Displacement analysis: graphical & analytical displacement analysis; analysis of the four-bar linkage (& slider-crank); Grashof’s criteria
- Velocity analysis: general velocity equation; velocity polygons; instant centers; analytical velocity analysis; mechanical advantage; transmission angle
- Acceleration analysis: general acceleration equation; acceleration polygons; analytical acceleration analysis
- Mechanism dynamics: free body diagrams; parallel axis theorem; Newton’s second law; D’Alembert’s principle; work, energy and power; impulse and momentum; spring-mass-damper systems; friction
- Gears: the involute profile; types of gears; simple gear trains; planetary gear trains; tooth forces
- Machine element design, selection and analysis: shafts, bearings, bolts, screws, springs

Relevant Courses (at the University of Minnesota)
- AEM 2021, Statics and Dynamics, or AEM 2012, Dynamics
- ME 3221 & 3222, Design & Manufacturing I & II
- ME 3281, System Dynamics & Control

Suggested references
Ph.D. Oral Qualifying Examination in Solid Mechanics

Background
This examination is intended to assess both mastery of subject matter and ability to apply basic concepts in the analysis of mechanical systems. The general exam content is the description of loads, deformations, strains and stresses in deformable bodies subjected to complex loading, as studied in a course on the mechanics of materials and used in numerical stress analysis.

The typical solid mechanics content of undergraduate mechanical engineering curricula culminates with a course on deformable body mechanics. Prerequisite knowledge for the determination of structural loads and reactions for use in deformable body analyses is provided in courses on statics and dynamics.

As numerical methods are a basic skill in engineering analysis, there is a numerical simulation component of the examination. The emphasis of the finite element stress analysis part of the examination is the creation and use of numerical models that accurately represent reality, not a review of the basic formulation of finite elements and solution procedures.

Topics that may be covered

Analytical and numerical analyses
- Description of 2-dimensional and 3-dimensional elastic stress states
- Elastic stress-strain relations in 2-dimensions and 3-dimensions
- Determination of internal reaction forces, moments, torques
- Compatibility of deformations
- Determination of stresses in structures

Complex mechanical structures requiring 3-dimensional analysis
- Combined stresses
- Stress transformations: equations, graphical representation (Mohr circle representation); determination of stress state at arbitrary orientation; principal stresses, principal strains, maximum shear stress
- Useful, special stress states (e.g., plane stress, plane strain)

Finite element modeling
- Accurate representation of reality
- 2-D vs. 3-D models, boundary conditions, applied loading
- Choice of element type
- Mesh refinement
- Evaluation of results

Relevant courses (at the University of Minnesota)
- AEM 3031, Deformable Body Mechanics
- ME 5221, Computer-Assisted Product Realization
- ME 5228, Introduction to Finite Element Modeling, Analysis, and Design
- ME 5241, Computer-Aided Engineering

Suggested references
Finite Element Modeling for Stress Analysis, R. D. Cook
ANSYS: Release 10.0 Documentation - , Introduction: Basis Analysis Guide, Chapter 1, Getting Started with ANSYS, Tutorials related to Structural Analysis
Ph.D. Oral Qualifying Examination in System Dynamics and Control

Background
The system dynamics and control exam covers modeling, analysis and design as detailed below. Background for the system dynamics and control exam is contained in standard courses on system dynamics and control found in virtually all mechanical engineering departments. References below are to texts that cover the expected background.

Topics that may be covered

- Formulation of models of mechanical, electrical, fluid, thermal and mixed energy domain systems.
- Identification of energy sources, energy storage elements, energy dissipative elements and energy transforming elements. Model simplifications including lumping, linearizing nonlinear elements and neglecting small effects. Models in state-variable or input-output form.
- Design of SISO (single input, single output) feedback control system for a linear time-invariant system.
- Transient response specifications such as rise time, settling time and peak overshoot. PID (proportional plus integral plus derivative) control. Lead-lag and lag-lead control. System “type.” Final value theorem to find steady-state errors to standard (step, ramp, etc.) inputs in command and disturbance. Controller design using root locus. Stability analysis using the Routh-Hurwitz method. Design of a control system using frequency response. Gain margin, phase margin and bandwidth.

Relevant courses (at the University of Minnesota)

- ME 3281, System Dynamics and Control
- ME 5281, Analog and Digital Control Systems

Suggested references
R. H. Cannon, Jr., Dynamics of Physical Systems
C.M. Close, D.K. Frederick and J. C. Newell, Modeling and Analysis of Dynamic Systems
R. C. Dorf and R. H. Bishop, Modern Control Systems
G.F. Franklin, J.D. Powell and A. Emami-Naeini, Feedback Control of Dynamic Systems
K. Ogata, Modern Control Engineering
K. Ogata, System Dynamics
Ph.D. Oral Qualifying Examination in Thermodynamics

Background
The qualifying examination in thermodynamics will be used to assess the candidate’s understanding of thermodynamics at an advanced undergraduate level. The successful candidate will demonstrate a working knowledge of conservation of mass, the first and second laws of thermodynamics, and property relationships of single and two-phase fluids. The exam will assess the knowledge of these topics in the context of engineering systems, such as pumps, compressors, turbines, nozzles, mixing chambers and valves, using open and closed thermodynamic systems.

Topics covered
- Concept of system, system boundaries, mass and energy transfer across system boundaries, and other interactions of system with surroundings
- Conservation of mass and energy
- Thermodynamic properties (density, p-v-T relations, specific heats, internal energy, enthalpy, entropy)
- Ideal gases
- Second law of thermodynamics and its consequences: concept of efficiency, Carnot efficiency, irreversibility,
- definition of entropy, entropy balance, isentropic and non-isentropic processes
- Analysis of power and refrigeration cycles
- Gas vapor mixtures: Dalton’s law, mixture specific heats, psychrometrics, mixture properties
- Thermodynamics of reacting flows: combustion, adiabatic flame temperature, enthalpy of combustion,
- enthalpy of formation, chemical equilibrium

Relevant courses (at the University of Minnesota)
- ME 3331, Thermal Sciences I (essential)
- ME 5103, Thermal Environmental Engineering (beneficial)
- ME 5344, Thermodynamics of Fluid Flow (beneficial)
- ME 5446, Combustion (beneficial)
- ME 5461, IC Engines (beneficial)
- ME 5462, Gas Turbines (beneficial)

Suggested references
Written Preliminary Examination

The Ph.D. preliminary written examination is a research proposal prepared by the student that provides suitable motivation for the proposed doctoral research, a summary of accomplishments, and a detailed research plan of thesis research.

Timing
After passing the oral qualifying examinations, the student must take the written preliminary examination within two semesters\(^2\). It is recommended that students submit the written document to the examination committee by the 8th week of the semester. The written examination must be passed prior to scheduling the preliminary oral examination.

Examination Committee
The examination committee for the written preliminary examination consists of the student’s adviser(s) and at least two additional members of the mechanical engineering graduate faculty. Selection of the examination committee is at the discretion of the student with approval of the adviser(s). Normally, members of the preliminary written examination committee will continue to serve on the oral and final examination committees and should be listed on the approved Degree Program Form.

Evaluation
The written examination will be evaluated on the basis of the scientific and technical comprehension, the quality of the research plan, and the ability to communicate clearly and effectively.

A two-week reading period is required for evaluation of the written examination. The committee members must indicate their assessment of the examination at the conclusion of the two week reading period on the preliminary written examination assessment form at:

http://www.me.umn.edu/education/graduate/current/forms.shtml.

Scoring options are pass, revise, or fail.

If one or more members of the committee score “revise” or “fail”, the examination committee must meet within two weeks to decide what revisions are required. The adviser(s) must summarize the deficiencies of the examination and provide requirements for revision to the student in writing within one week of the meeting of the examination committee.

If revisions are required, the student must submit a revised thesis proposal to the committee within one semester, or an earlier date if specified by the committee. A two-week reading period is required for reevaluation of the revised written proposal. A “pass” of the revised written preliminary examination by two of the three members of the examination committee constitutes a passing grade. (If there are four committee members, three of four must approve the revision.) Students who do not receive a passing grade after revision will be terminated from the Ph.D. program.

Format
Students are expected to write the thesis proposal independently in consultation with the faculty adviser(s). The research adviser(s) should be consulted during the process of formulating and preparing the research proposal.

The proposal must be legible, and conform to the following requirements:

a. The font size should be easy to read. Please use Times New Roman or Computer Modern Family at 11 point character font or larger, Arial, Courier New, or Palatino Linotype at a font size of 10 points or larger.

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\(^2\) Extensions will only be granted in exceptional circumstances with approval of the adviser(s) and the Director of Graduate Studies. Requests for exceptions must be submitted in writing to the DGS. The request should document the extenuating circumstances that justify an extension.
A font size of 10 points or less may be used for mathematical formulas or equations, figure, table or diagram captions and when using a Symbol font to insert Greek letters or special characters. It is cautioned, however, that the text must still be readable. Figure captions can have a different font style, such as Arial, to help offset them from the main text.

d. Margins, in all directions, must be at least an inch.

e. Page limits and line spacing requirements apply. See below.

Failure to follow these formatting guidelines will be grounds for the student’s committee to request a revision of the proposal.

**Content**

The proposal must contain the following sections:

a. **Cover Page.** The cover page must contain the title of the proposal, student’s name, adviser(s)’s name, and the names of the student’s committee members, including which ones will serve as readers. The submission date should also be included.

b. **Project Summary.** The Project Summary is a one page, single-spaced summary of the proposed activity. The Project Summary should be a self-contained description of the proposed research. It should include a statement of objectives and methods to be employed. It must address the scientific and/or technical merit of the project, for example, the influence that the results might have on the direction, progress and thinking in relevant scientific or engineering fields. It must also address the appropriateness of the proposed methods, and the logic and feasibility of the research approach.

The Project Summary should be informative to persons working in the same or related fields and, insofar as possible, understandable to a scientifically or technically literate lay reader.

c. **Project Description.** The Project Description is a 30 page (maximum), double-spaced proposal that describes the thesis project. It should include motivation and objectives, background, proposed research, preliminary results, and conclusion. The organization of the document is up to the student, in consultation with the adviser(s). Figures and tables are included in the 30 page limit.

The *motivation and objectives* section should provide a context for the proposed work as well as specific objectives and expected significance of the PhD thesis. It should contain a brief overview of the proposed work in relation to the present state of knowledge in the field and to work in progress by others.

The *background* section should include a critical review of the relevant literature. It should indicate the current state of understanding of the proposed research topic. The review should emphasize how the prior work relates to the proposed study. It should address the significance and limitations of the cited work. If any figures are taken from another publication or a website, they must be referenced explicitly in the caption.

The *proposed research* section is the key element of the proposal and should comprise no less than half the page limit set for the project description. This section should outline the plan of work, including the activities to be undertaken, and a description of experimental and/or computational methods and procedures. It should address the following questions.

- What will you do?
- How will you achieve your objectives?
- Why is your strategy an appropriate one to pursue?

The proposed research section should complete the arguments developed earlier and present initial ideas on how to solve the problems posed. Avoid repetitions and digressions. It should relate the proposed activities to the
project objectives and provide expected outcomes, including how the proposed research, if successful, will contribute to a greater understanding of the topical area. An assessment of risk should be provided with the proposed research as well as a contingency plan in case a particular research avenue proves inexpedient in some manner. It should present a reasoned path from where the student begins to where they want to be at the end of the research.

The preliminary results section should provide an overview of completed work including its significance.

The conclusion section should provide a concise summary of what will be known when the research has been completed that we do not know now. It must present the scientific and/or technical merit of the project.

d. References. Reference information is required. Each reference must include the names of all authors (in the same sequence in which they appear in the publication), the article and journal title, book title, volume number, page numbers, and year of publication. Proposers must be especially careful to follow accepted scholarly practices in providing citations for source materials, including websites, relied upon when preparing any section of the proposal. There is no page limitation for the references, but this section must include cited references only. References should be single-spaced, but a blank line between each individual reference is preferred.

e. Biosketch. A Biosketch of not more than 1 page, single-spaced should be provided. The biosketch should be written in a narrative format and it should include a summary of previous education, including institutions attended, and research experiences.

f. A copy of your approved Degree Program Form.
**Oral Preliminary Examination**

The oral preliminary exam will consist of a seminar presented by the student on his/her proposed research, followed by questions from the examining committee concerning the proposed research and related material.

**Timing**

The oral preliminary exam should be taken as soon as possible after the student has passed the written preliminary exam, preferably the same semester.

**Examining committees**

The examining committee will be the same as for the written preliminary exam, with the addition of at least one member from the minor or supporting program.

**Form of exam**

The exam will consist of an oral presentation by the student on his/her proposed research, and of questioning by the committee about the proposed research. The length of the presentation should be approximately 30 minutes, if it were not interrupted by questioning. The total length of the exam should not exceed two hours.

The exam emphasizes the following:

- understanding of research topic
- ability to formulate a hypothesis or research plan
- demonstration of independence and creativity in solving problems
- ability to think logically
- ability to communicate
- ability to adequately respond to critical questioning by faculty
- demonstration of fluency with the basic concepts that apply to the selected research area

Contents of visual aids used in any presentation, including slides, overheads, etc., must be the student’s work, or must be appropriately attributed.

The adviser(s) cannot take any role in presenting the material to the rest of the committee or interpreting and responding to questions.

It is up to the committee to decide whether to allow anyone other than committee members to attend the presentation portion of the oral preliminary examination. Under normal circumstances, this examination is closed to the public.

The examination is immediately followed by a deliberation of the committee on whether the student passed, passed with reservations, or failed. Voting complies with Graduate School policies:

“The outcome of the examination, with all committee members present and voting, is recorded in one of three ways: pass, pass with reservations, or fail. The voting proportions necessary for these decisions are as follows: if the committee consists of four members, a favorable verdict for passing consists of either a unanimous vote or 3-1; if the committee consists of five members, a favorable verdict for passing consists of either a unanimous vote or a vote of 4-1; if the committee consists of six members, a unanimous vote or a vote of 5-1 or 4-2 is needed. Candidates who do not earn committee votes in these proportions fail the examination. If, in order to achieve the minimum number of votes to reach a verdict of pass, any vote of pass with reservations is included, then the outcome will be recorded as pass with reservations. A vote to pass the student with reservations still constitutes a passing vote.”

The following procedures applies if the committee decides that the student has PASSED THE EXAMINATION WITH RESERVATIONS:
“...the student is informed immediately, but the committee is permitted one week in which to convey its reservations to the student in writing, informing the student of the steps that must be taken to remove them. A copy of this letter must be sent to the Graduate School. When the student has satisfied the committee’s reservations, a second letter informing the student and the Graduate School that the reservations have been removed and that the student may proceed toward the degree is also required. Both letters should be written by the committee chair. The final oral examination may not be scheduled until the Graduate School has received a copy of the letter indicating that the reservations have been removed.

“If the committee members disagree as to whether the reservations have been satisfactorily removed, the committee chair asks for another vote, the results of which are subject to the same voting proportions as the initial vote. If the student is unable to satisfy the committee’s reservations, his or her doctoral candidacy and graduate student status may be terminated.”

It is within the prerogative of the preliminary oral examining committee to decide on additional steps required to remove those reservations. If the committee so chooses, the student can retake part(s) of the oral preliminary exam, but only one repetition is allowed. The committee will specify the format and the date for that exam. This examination will be held as soon as possible.
Final Thesis Examining Committee

The final thesis examining committee is assigned within three months after the successful completion of the doctoral preliminary exams. To assign one’s committee for final exam please submit selected committee members with the Graduate School at the following link:

http://grad.umn.edu/students/forms/doctrinal/index.html

The committee will normally consist of faculty members who served on the Preliminary Oral Examination committee. The final oral examining committee requires at least four members: the adviser(s) and at least two other members of the mechanical engineering graduate faculty, and at least member with graduate faculty membership in the minor or supporting program.
VI. FINANCIAL SUPPORT

Financial support opportunities available to students include:

- Fellowships
- Research Assistantships
- Teaching Assistantships

In general these forms of support provide a regular stipend, waiver of all or part of tuition and fees, and a health insurance and benefit package.

Fellowships

All students who apply for admission to the Mechanical Engineering Department by the December 15 deadline will automatically be considered, on a competitive basis, for pre-awards (i.e., awards offered in advance of a student's enrollment) of financial support, often through a combination of fellowship and assistantship. Students who enroll without a pre-award are eligible for research and/or teaching assistantships, which can be obtained at any time during one's academic program. International students should contact the office of International Student and Scholar Services (ISSS) for counseling, advising, financial aid, career and immigration status services. Fellowships are offered on a competitive basis and require excellent academic records for consideration.

For current graduate students, a number of Fellowships are available on a competitive basis. Consult the Graduate Student Advising Office in Mechanical Engineering and online for opportunities at the University of Minnesota and external Fellowships at:

http://www.grad.umn.edu/fellowships/

This booklet does not present the full range of Fellowship opportunities available at the University of Minnesota.

Research Assistantships

Research assistantships (RAs) are appointments from faculty members who hold research contracts and grants. These appointments usually materialize through direct discussions with individual faculty. Please see individual faculty web pages for more information on research topics. The faculty member providing support will serve as a student's academic adviser. Appointments vary, depending on the availability of funds and the academic progress of the student. Research appointments are made at any time in the calendar year depending on funding and other factors. Teaching and Research Assistantships may be held concurrently. Stipend rates are set by the Mechanical Engineering Graduate Faculty. Ph.D. candidates will receive an increase in their stipend once they pass their preliminary oral examination and complete 24 credits of thesis registration. The stipend is increased by 10%, or up to the maximum rate the University may set, whichever is lower.

Teaching Assistantships

Teaching Assistantships (TA) are available each academic semester for graduate students to assist in departmental course instruction. The assignments naturally require demonstrated expertise in the course subject matter to which the student is assigned. Teaching assistant responsibilities vary with course assignments and may involve grading, recitation lecture, laboratory, homework problem solution, office hour consultation, or a mix of these duties. The teaching assistant is not ultimately responsible for course grades -- that is a faculty responsibility.

Appointment Scope

The number of teaching and research assistantships fluctuates with enrollment and availability of grant funds. There is no deadline to be accepted for an assistantship; however, for incoming students it is advisable to apply
for admission to the Graduate School early as TA offers are made only to those students who have received admission.

Whereas teaching assistantships are typically one semester in duration, after which a new assignment can be made, it is possible to hold simultaneous teaching and research assistantships within any academic semester. If simultaneous appointments are made, then each is typically a 25% appointment. Appointments are occasionally combined at other than 25% levels to total 50% overall. Maximum appointments to teaching assistantship and/or research assistantship positions are 50%, except in unusual cases where graduate students who have qualified for doctoral candidacy may receive 75% appointments if a distinct service need exists.

Teaching and Research Assistantships are financial aid academic appointments reserved for graduate students. If you accept an offer of financial aid, you are entering into a contract, which cannot be terminated unless both parties consent, in writing, to terminate the contract.

**The TA Appointment Process**

Teaching Assistant appointments are made several weeks prior to the onset of a new semester. The Associate Department Head consults with course instructors for recommendations when assigning teaching assistantships. The Associate Department Head will notify the student of the TA appointment.

Students must register in the semester in which they hold teaching assistantships (except during summer sessions providing they were registered the preceding spring semester). Teaching appointments hold no guarantee for continuation beyond one academic semester.

Incoming and current graduate students interested in teaching assistantships are advised to contact individual course instructors to discuss specific TA responsibilities and qualifications. A list of courses and course instructors for the current semester can be obtained from the ME Advising office, ME 1120.

**TA Application**

TA applications are accepted June - September for the Fall semester and November - December for the Spring semester. The application process is online at:

[http://www.me.umn.edu/education/graduate/ta/ta_page.shtml](http://www.me.umn.edu/education/graduate/ta/ta_page.shtml)
VII. REGISTRATION

Registration Steps—New Students

1. Obtain student I.D. card.

2. All new international students - check in with the International Student & Scholar Services Office, 190 Hubert H. Humphrey Center, West Bank.

3. Consult with Director of Graduate Studies or provisional advisers to establish first semester’s courses.

4. Follow the registration procedures on One Stop: http://www.onestop.umn.edu/registrar/registration/index.html

Registration Steps—Current Students

Register at One Stop in the Science Teaching and Students Services (STSS) building or on-line through the Student Access System (onestop.umn.edu), according to the registration queue published in the Class Schedule. Class Schedules are available through the Web via: https://webapps-prd.oit.umn.edu/courseinfo/classschedule_selectsubject.jsp?institution=UMNTC&searchTerm=UMNTC

- Students are charged a late fee if they register after classes begin and may only register after the first week of the semester with special permission.

- Students must register every Fall and Spring term to maintain active graduate status. If a student has not registered, they must apply for readmission and must register before they can resume work on a master or doctoral thesis or on master Plan B paper, take written or oral examinations, or file for graduation. The Department reserves the right to reject a readmission application based on academic performance and other factors.

- The University requires that graduate students holding appointments as teaching assistants, research assistants, and administrative Fellows register for at least 6 credits during each term which he or she holds an appointment of greater than 12.5%. (This rule does not apply to summer terms if you were registered the preceding spring quarter.) Each student should check to make sure they satisfy other criteria for full-time status (i.e., some student loan deferrals may require 7-credit registration) that may apply to financial aid.

- Doctoral students must register for 24 doctoral thesis credits (ME/IE 8888) at the University of Minnesota beginning the semester after they have passed the preliminary oral examination. The requirement of 24 doctoral thesis credits cannot be reduced by transfer of master’s thesis credits, or thesis credits taken at another institution.

- Students are permitted to register for thesis credits during the current semester if they have passed the preliminary oral examination and if the signed report form is delivered to 160 Williamson Hall no later than 1 p.m. on the last day of registration for that semester. We strongly urge you not to wait until the last minute to bring the signed report to the Graduate School.
Registration –Special Categories

Curricular Practical Training (CPT)
Curricular Practical Training (CPT) is work authorization that allows a student to work in a job related to his/her field. ISSS offers CPT/OPT Workshops; it is highly recommended that students attend a workshop before applying for CPT.

To sign up for CPT students need to first pick up a CPT Student Request and Academic Adviser Verification form from ISSS. Students should register for ME 8001 for CPT. In order to register for ME 8001 students will need a magic number which will be issued after all paperwork is completed and signed by their advisor, and pending DGS approval. CPT should only be taken over the summer and should not hinder the student’s ability towards continued progress towards degree.

If the student is nearing completion of their degree the student should not apply for CPT, but rather OPT (see ISSS website). If a student applies for CPT near the end of his/her degree or multiple times it may not be approved by the DGS.

GRAD 0999
GRAD 0999 is a zero credit/no fee class that will maintain a student’s active status with the Graduate School. However, it will not maintain fulltime status for anything else such as a paid appointment (RA or TA), visa status, or deferred student loans. International students can get a waiver from ISSS to register for GRAD 0999, but must check with ISSS before registering.

Once all degree requirements have been completed, but active status needs to be maintained to graduate, GRAD 0999 can be registered for. After a student’s second registration for GRAD 0999 a hold will be placed on their record. If a student is making continuous progress towards their degree a permission number may be granted for additional registrations of GRAD 0999. If continuous progress in not being made, a Leave of Absence should be considered.

Leave of Absence (LOA)
Graduate students are expected to maintain active status through continuous registration from the time they matriculate until their graduation. Students who are not able to maintain active status are strongly encouraged to consult with the DGS, their advisor, and student advising office to determine whether requesting a leave of absence is the most appropriate course of action.

In order to apply for a leave of LOA a student must complete the LOA form and have it signed by their advisor. Then, submit the completed form to the student advising office for the signature of the DGS. A student may request a leave for up to 2 academic years.

Once the student returns from the LOA they need to contact the student advising office for matriculating back into the Graduate Program. It is necessary that the student returns by the date specified on the LOA form, or earlier. One the student matriculates back into the program, it will be like they never left and there is no readmission fee necessary.
VIII. CHANGE OF STATUS

A Change of Status form must be filed with the Graduate School, 309 Johnston Hall, if one or more of the following Criteria are met:

- Student has completed M.S. and has interest in pursuing a Ph.D.
- Student would like to change major or add a second major
- Student has not registered in the Graduate School within the past fall or spring term.

IX. MAIL, MAILBOXES

Each full-time graduate student who is on appointment by the Mechanical Engineering Department is given a mailbox upon check-in. Students are automatically assigned a mailbox by the payroll office.

Postings are distributed through mailboxes and electronic mailboxes. If a departmental email account has not been assigned, please see section XV Computing Facilities.

The department supplies building and room keys by having the faculty member responsible for the laboratory area contact keys@me.umn.edu. Requested keys can be picked up in Mechanical Engineering 1120.

X. STUDENT SHOP

The Student Shop, 180 ME, is a facility available to Mechanical Engineering students for bench work and basic and precision machining. All users of the shop are required to view a series of shop training videos, which cover safety, lathes, and milling machines. General rules and information about the student shop can be obtained by contacting the student shop foreman (see http://www.me.umn.edu/intranet/services.shtml.)

XI. COMPUTING FACILITIES

Two major computer facilities are available for graduate students within the Mechanical Engineering Department:

- The Institute of Technology Instructional Computing Labs (ITICC)
- The Mechanical Engineering Department Computing Labs.

There are also two main departmental computing labs which are accessible to graduate students - ME 10 and ME 472. Accounts for these facilities are requested by printing out a New Account Request Form from http://www.menet.umn.edu and submitting it to the ME Net Office in ME 152. Users must also pick up an access card in 1120 M.E. A deposit check for $20.00, payable to the University of Minnesota, and U-card are required to obtain an access card.
All workstations and personal computers are networked into the campus-wide network. From the network, the workstations have access to other computing resources, such as the supercomputer facilities of the Minnesota Supercomputer Center. Access the ME Webpage for an up-to-date list of accessible facilities.

Graduate students obtain accounts for using the labs of the Institute of Technology Instructional Computing Committee (ITICC) by paying the semester ITICC computing fee. The fee-payment procedure is described in the Class Schedule.

All software available in the Mechanical Engineering and ITICC labs is strictly limited to academic usage only. The software may be used for coursework and research directly attributed to your graduate program only. The software cannot be used for consulting under any circumstances. No licensed software may be copied or removed from the labs.
Sample Graduate Degree Plan

University of Minnesota

Graduate Degree Plan

Directions: Use this form to declare your degree plan. Review your major's manual handbook and consult with your faculty advisor and Director of Graduate Studies (DGS) to ensure your plan fulfills minimum graduate education and program requirements. Obtain original signatures from your faculty advisor, co-advisor (if applicable), major field DGS, and minor field DGS (if applicable) indicating their approval and submit to your graduate program office. Follow the guidelines presented in your degree program to design your course of study. A copy of your plan will be sent to your University email in order to help you prepare your course of study.

Special instructions for M.D., M.D., M.B.A., M.S., M.N., D.N.E., M.S.E., M.S., M.B., M.P.H., and M.S. students who wish to declare a minor:
- If you are pursuing a Grad degree and are taking a Grad minor, the number of credits in the minor field must be the same as in the major field.
- If you are pursuing an M.S. degree and are taking a Grad minor, the number of credits in the minor field must be the same as in the major field.
- If you are pursuing a Grad degree and are taking a minor, the minor must be approved by the college of the major field.
- If you are pursuing an M.S. degree and are taking a minor, the minor must be approved by the college of the major field.

To ensure privacy online, open in Adobe Reader (free at Adobe.com). Please add the required signature(s) in blue or black ink.

PART 1. Student Information

University: 1234567
University email: x.500
Name: Last

PART 2. Degree Information

Major: Mechanical Engineering
Minor (if declared): 
Language Requirement (if required): 

If Master's Degree (check one):
- Plan A
- Plan B

If Doctoral Degree (check one):
- Plan A
- Plan B

PART 3. Transfer Coursework

<table>
<thead>
<tr>
<th>Term</th>
<th>Major</th>
<th>Other</th>
<th>Course Title</th>
<th>Number of semester credits</th>
<th>Grade</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall 2019</td>
<td>x</td>
<td>x</td>
<td>AE 700</td>
<td>3</td>
<td>B</td>
<td>Transfer Institute</td>
</tr>
<tr>
<td>Spring 2019</td>
<td>x</td>
<td>x</td>
<td>ME 555</td>
<td>3</td>
<td>A</td>
<td>Transfer Institute</td>
</tr>
</tbody>
</table>

Transfer Credits
Include any transfer work taken at another institution.
### PART 4. University of Minnesota coursework

List University of Minnesota coursework required by your graduate program in chronological order, beginning with earliest term and year. Do not include the following: xxxx-8777, xxxx-8899, xxxx-8666, Grad 999, xxxx-8333, or xxxx-8444, coursework not applied to the degree.

**NOTE:** Course type “other” refers to outside of major or other minor field coursework.

A course cannot be used to meet both “major” and “other” course requirements.

<table>
<thead>
<tr>
<th>Term and year</th>
<th>Check one</th>
<th>Department &amp; course number</th>
<th>Course title</th>
<th>Number of semester credits</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
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<td>ME 6341</td>
<td>Conduction</td>
<td>3</td>
<td>A+</td>
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<tr>
<td>F-W 2011</td>
<td>x</td>
<td>AEM 8201</td>
<td>Fluids II</td>
<td>3</td>
<td>A</td>
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<td>Spring 2012</td>
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<td>AEM 8202</td>
<td>Fluids II</td>
<td>3</td>
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<tr>
<td>Spring 2012</td>
<td>x</td>
<td>ME 8773</td>
<td>Graduate Seminar</td>
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<tr>
<td>Fall 2012</td>
<td>x</td>
<td>ME 8543</td>
<td>Radiation</td>
<td>3</td>
<td>B</td>
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<td>Fall 2012</td>
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<td>ME 8381</td>
<td>Molecular Gas Dynamics</td>
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<td>A</td>
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<td>Thermal Design</td>
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<td>B+</td>
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<tr>
<td>Spring 2012</td>
<td>x</td>
<td>AEM 3521</td>
<td>Feedback Control</td>
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<td>A</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Departmental Ethics</td>
<td>0</td>
<td>P</td>
</tr>
</tbody>
</table>

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### Ethics Class
List Departmental Ethics Class

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### PART 5. Course totals (transfer and UMN coursework)

Major course credit total

Other/minor course credit total

Total course credit total

### PART 6. Approval

Adviser signature

Date

Co-adviser signature

Date

DGS (major field) signature

Date

DGS (minor field) signature

Date

Adviser signature

Office use only (notes)

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**Adviser Signature**

This is required before Submitting to ME 1120

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**DGS Signature**

The DGS will approve if All requirements are met

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**DGS Signature for minor**

If you declare a minor, obtain signature of minor field DGS before submitting