Engineering Ph.D.

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The Doctor of Philosophy in Engineering degree is offered through the Norm Asbjornson College of Engineering. The most current information on requirements for the degree can be found at: http://www.coe.montana.edu/grad/index.html (http://www.coe.montana.edu/grad/)

Candidates will be admitted to both the College of Engineering and The Graduate School under one of the options listed below:

Applied Mechanics

This option involves research in areas central to engineering mechanics including solid mechanics, fluid mechanics, thermal mechanics, geo-mechanics, and structures.

Coordinating Departments: Chemical and Biological Engineering, Civil Engineering, and Mechanical and Industrial Engineering. Typical Research Areas: solid mechanics, fluid mechanics, biomechanics, thermal sciences, structural mechanics.

Civil Engineering

This option involves research in geotechnical engineering, structural engineering, transportation engineering, environmental engineering and water resources engineering.

Coordinating Departments: Civil Engineering and Mechanical and Industrial Engineering. Typical Research Areas: geosynthetics, seismic response of structures and foundations, innovative structural materials, intelligent transportation systems, transportation operations, transportation planning, recycled pavements and base materials, fish passage and constructed wetlands.

Environmental Engineering

This option involves research in all areas of the environment including soil, water, and air, with emphasis on microbial interactions with natural and engineered systems.

Coordinating Departments: Chemical and Biological Engineering and Civil Engineering. Typical Research Areas: bioremediation, wetlands, water treatment, wastewater treatment, solid and hazardous waste treatment, biofilm engineering.

Industrial & Management Systems Engineering

This option involves research related to areas of Industrial Engineering.

Coordinating Department: Mechanical and Industrial Engineering. Typical Research Areas: human factors, service systems engineering, virtual reality, health care, ergonomics, usability engineering, data analytics, ambient intelligence, internet of things, time-series data mining, complex systems, decision analytics, multi-agent network systems, stochastic optimization, advanced manufacturing, digital manufacturing, and microfabrication.

Application and Admission

For information on how to apply to degrees in the Norm Asbjornson College of Engineering, please visit the graduate programs page on the college site (http://www.coe.montana.edu/grad/) where you can learn about application deadlines, test scores needed, funding opportunities and more.

Degrees Offered

- Ph.D. in Computer Science (http://catalog.montana.edu/graduate/engineering/computer-science/phd-computer-science/)
- Ph.D (http://catalog.montana.edu/graduate/engineering/electrical-computer-engineering/phd-electrical-computer-engineering-option/) in Electrical & Computer Engineering (http://catalog.montana.edu/graduate/engineering/electrical-computer-engineering/phd-electrical-computer-engineering-option/)
- Ph.D. in Chemical Engineering (http://catalog.montana.edu/graduate/engineering/engineering-phd/chemical-engineering/)
- Ph.D. in Mechanical Engineering (http://catalog.montana.edu/graduate/engineering/mechanical-industrial-engineering/phd-mechanical-engineering/)
- Ph.D. in Engineering with options in:
  - Applied Mechanics (p. 2)
  - Civil Engineering (p. 3)
  - Environmental Engineering (p. 3)
  - Industrial & Management Systems Engineering (p. 4)

Program Requirements

To satisfy the requirements for the Ph.D. in Engineering, the student will take a minimum of 60 credits beyond the bachelor's degree according to the table below. Different options within the Ph.D. in Engineering and individual graduate student committees may require additional coursework beyond the minimum requirements (see Declared Option Coursework section later in this document).

For students entering with a Masters degree, up to 24 graded credits may be applied (see below). However, the Scientific Communication and Proposal Development (ENGR 650) and Rsch & Mthds in Engineering (ENGR 610) requirements and a minimum of 13 additional graded course credits must still be taken at Montana State University. Depending on option requirements, students may have the option (with approval of the committee) of using some of their M.S. credits toward the advanced mathematics and numerical methods requirements.

ENGR 610	Rsch & Mthds in Engineering	3
ENGR 650	Scientific Communication and Proposal Development	2
Advanced Mathematics - see declared option coursework *		3
Numerical Methods - see declared option coursework *		3
Other Graded Courses - see declared option coursework		24
Dissertation		18
Additional Dissertation or Course credits		7
* Course content must be above and beyond that typically required for an undergraduate degree in the student's Ph.D. option area.		
** ENGR 650 should be taken the semester prior to scheduling the comprehensive exams as this seminar class helps the student to prepare the written proposal for their comprehensive.		
Total Credits		60

Credits applied from a prior Masters degree must:

- be graded course credits (e.g., not M.S. thesis or independent study credits),
- have a grade of B or higher (or equivalent), and
- be approved by the student's graduate committee.

Students are expected to attend the COE Seminar Series presentations.

Note for Students Entering Without a Prior Degree in Engineering

If a student enters the Ph.D. program without a prior degree in engineering from an accredited program and is interested in pursuing registration as a professional engineer, they should consult with their department head and major professor to determine what coursework and other experiences may be needed to ensure they are on a pathway to seek licensure. These requirements vary with discipline and the state where licensure is sought.

Examination Requirements

General information about forms required for completion of examinations can be found on The Graduate School (http://www.montana.edu/gradschool/current-grad.html)'s website.

Ph.D. candidates within the Norm Asbjornson College of Engineering at Montana State University must pass a qualifying examination, a comprehensive examination, and a defense of dissertation. The general rules governing these follow. Options may have more specific requirements; see the specifics under option requirements below.

Ph.D. Qualifying Examination

The purpose of the qualifying examination is to determine whether the student has sufficiently mastered the core topics within their chosen area of study. It will be a written examination on undergraduate engineering topics determined by the student's chosen Ph.D. option area and administered by that option's committee.

Each Ph.D. Option Committee will offer a qualifying examination annually to students in that option. The qualifying examination will be completed within three semesters but typically within two semesters of full admission (matriculation) into the Ph.D. program. Failure to take the examination in that time period may result in suspension of Ph.D. candidate status, including stipend. The committee will document the results of the examination in a letter to the student, and in the student's file.

Ph.D. Comprehensive Examination

The purpose of the Ph.D. comprehensive examination is to determine whether the student is ready for independent research in their chosen area of study. The comprehensive examination is administered by the student's graduate committee (including the Graduate Representative assigned by The Graduate School), and must be completed within two years after passing the qualifying examination. It is also recommended that the student has taken 2/3 of their graded coursework. In addition, students should have completed ENGR 650 prior to taking the exam; the course is designed to assist the student in preparing their proposal.

The Ph.D. comprehensive examination is comprised of:

- A written proposal for the student's Ph.D. dissertation, and
- An oral presentation of the proposal and oral examination.

The candidate will prepare a written proposal associated with the research topic for the Ph.D. dissertation, in a format designated by the Ph.D. Option. The successful proposal will include a significant literature review, preliminary research to date, and the research proposed to complete the Ph.D. The written proposal will be presented to the student's graduate committee in advance of the oral presentation, by a date agreed to by the student and graduate committee.

The student will then present the dissertation proposal as a public research seminar that has been advertised to the College of Engineering. This will be followed by a closed-session oral examination by the student's graduate committee on:

- the candidate's current and proposed research;
- the candidate's graduate level understanding of option specific engineering principles; and
- additional topics relevant to the proposed research, including fundamentals of other disciplines drawn upon in the research.

The student's graduate committee will inform the student of the results of the comprehensive examination immediately following the oral examination and committee deliberation, and will document the results on the appropriate form filed with The Graduate School. A student not passing the comprehensive will have one opportunity to retake the comprehensive after a span of six months has passed. Failure to pass the examination on the second attempt is grounds for dismissal from the Ph.D. program.

There may be additional requirements for these exams specified in the option requirements.

Dissertation Defense

The dissertation defense will consist of two parts: an open seminar of the research results and a closed session with the student's committee and the graduate representative. Written notification of the results within one week of the defense must be delivered to The Graduate School and the student. Committee members must approve the dissertation, along with the Department Head, and Vice Provost for Graduate Education. Deadline for the dissertation approval is 14 working days before the end of the term for a given semester.

If failure occurs at the first attempt, a second defense must be held. At least six months must elapse before the second examination takes place, with the time period not to exceed nine months. Failure of the second exam will result in suspension from the program.

Graduation Application

An application to graduate is prepared by the student, approved by the major professor, and submitted to The Graduate School through the student's academic department. Applications are due to The Graduate School September 20th for a Fall Semester graduation, February 5th for a Spring Semester graduation and June 10th for Summer semester graduation.

Declared Option Requirements

Applied Mechanics

Requirements include:

EM 510	Elastic & Inelastic Analysis I	3
EM 525	Continuum Mechanics	3
EMEC 530	Advanced Fluid Mechanics I	3
EM 560	Finite Elem Analys in Engr	3

The remaining credits are to be established by the student and the major professor in consultation with the student's graduate committee.

Qualifying Examination:

The qualifying examination is a requirement for all Ph.D. students in the Department. The purpose of the qualifying examination is to determine whether the student has sufficiently mastered the core topics within their chosen area of study. The exam will be an evaluation of undergraduate and graduate engineering topics relevant to the student's chosen Ph.D. option area and administered by that student's graduate committee.

The diversity of backgrounds of students pursuing the Ph.D. option requires that the qualifying examination format and subject be responsive to individual backgrounds. The qualifying exam will adhere to the following general guidelines.

- The qualifying exam will be administered during a time period of mutual agreement between the student, advisor and graduate committee.
- The exam may be an oral exam, a written exam or a combination exam with both oral and written components. The format of the exam will be defined by the advisor and the gradate committee at least four weeks prior to the qualifying exam date. Exam format will be communicated to the candidate in writing and approved by the Department Head.
- The topic areas included on the exam will be defined by the advisor and the gradate committee at least four weeks prior to the qualifying exam date. Exam content will be communicated to the candidate in writing and approved by the Department Head.

The qualifying examination will be completed when between 24 and 36 credit hours of graduate work have been completed. The qualifying exam must be completed no more than 4 semesters after admission into the Ph.D. program. Failure to take the examination in that time period may result in suspension from the Ph.D. program.

There must be a minimum of one semester between the qualifying and comprehensive exams. The student must be registered when the qualifying examination is taken. Upon successful completion of the qualifying examination, the student officially becomes a candidate for the Ph.D. degree.

The student will only have two opportunities to pass the qualifying examination. If failure occurs at the first attempt, at least one semester must elapse before the second examination takes place. Failure of the second exam will result in suspension from the program.

Students may apply for a Ph.D. qualifying exam waiver if they have completed a Master of Science comprehensive exam in a similar discipline to the focus area of the proposed Ph.D. program of study.

Comprehensive Examination: In the Applied Mechanics Option there are two distinct oral examinations: one associated with the Dissertation Proposal and a separate one pertaining to the candidate's graduate level understanding of Engineering Mechanics principles.

Civil Engineering

Students must meet the overall requirements for the Ph.D. in Engineering. The student's committee may require additional credits of study based on the student's background and needs. Specific course selections will be determined by the student and his/her committee to support the student's area of study. Up to 24 graded course credits can be applied from an M.S. Degree in meeting the Ph.D. credit requirements, at the discretion of the student's Ph.D. committee.

Qualifying Examination

The qualifying examination is a requirement for all Ph.D. students in the Department. The purpose of the qualifying examination is to determine whether the student has sufficiently mastered the core topics within their chosen area of study. The exam will be an evaluation of undergraduate and graduate engineering topics relevant to the student's chosen Ph.D. option area and administered by that student's graduate committee.

The diversity of backgrounds of students pursuing the Ph.D. option requires that the qualifying examination format and subject be responsive to individual backgrounds. The qualifying exam will adhere to the following general guidelines.

- The qualifying exam will be administered during a time period of mutual agreement between the student, advisor and graduate committee.
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- The topic areas included on the exam will be defined by the advisor and the gradate committee at least four weeks prior to the qualifying exam date. Exam content will be communicated to the candidate in writing and approved by the Department Head.

The qualifying examination will be completed when between 24 and 36 credit hours of graduate work have been completed. The qualifying exam must be completed no more than 4 semesters after admission into the Ph.D. program. Failure to take the examination in that time period may result in suspension from the Ph.D. program.

There must be a minimum of one semester between the qualifying and comprehensive exams. The student must be registered when the qualifying examination is taken. Upon successful completion of the qualifying examination, the student officially becomes a candidate for the Ph.D. degree.

The student will only have two opportunities to pass the qualifying examination. If failure occurs at the first attempt, at least one semester must elapse before the second examination takes place. Failure of the second exam will result in suspension from the program.

Students may apply for a Ph.D. qualifying exam waiver if they have completed a Master of Science comprehensive exam in a similar discipline to the focus area of the proposed Ph.D. program of study.

Comprehensive Examination: The proposal should be in the NSF format, in compliance with the current year's grant proposal guidelines (gpg) at www.nsf.gov (http://www.nsf.gov/) unless otherwise agreed to by the student's committee. A public oral seminar of 30 to 40 minutes plus 10 minutes of public questions, on the research to date and proposed research to complete the Ph.D., will be given by the Ph.D. candidate. This will be followed by a closed-session oral examination of up to 2 hours administered by the student's Ph.D. committee. A written exam on graduate level environmental engineering topics may be required of graduate students who have a GPA in graduate coursework of less than 3.5.

Environmental Engineering

Of the credits in the Option Coursework noted above, 12 credits from the following subset of courses are required, with no more than 6 credits at the

400 level. Equivalent courses from prior MS degrees may be used to satisfy this requirement.

EENV 441	Natural Treatment Systems	3
EENV 443	Air Pollution Control	3
EENV 445	Hazardous Waste Treatment	3
EENV 534	Environmental Engineering Investigation	3
EENV 562	Water Treatment Process/Design	3
EENV 563	Wastewater Treat Proc/Design	3
ECIV 529	Groundwater Contamination	3
EBIO 566	Fundamentals of Biofilm Engr	3

The remaining credits are to be established by the student and the major professor in consultation with the student's graduate committee.

Qualifying Examination:

The qualifying examination is a requirement for all Ph.D. students in the Department. The purpose of the qualifying examination is to determine whether the student has sufficiently mastered the core topics within their chosen area of study. The exam will be an evaluation of undergraduate and graduate engineering topics relevant to the student's chosen Ph.D. option area and administered by that student's graduate committee.

The diversity of backgrounds of students pursuing the Ph.D. option requires that the qualifying examination format and subject be responsive to individual backgrounds. The qualifying exam will adhere to the following general guidelines.

- The qualifying exam will be administered during a time period of mutual agreement between the student, advisor and graduate committee.
- The exam may be an oral exam, a written exam or a combination exam with both oral and written components. The format of the exam will be defined by the advisor and the gradate committee at least four weeks prior to the qualifying exam date. Exam format will be communicated to the candidate in writing and approved by the Department Head.
- The topic areas included on the exam will be defined by the advisor and the gradate committee at least four weeks prior to the qualifying exam date. Exam content will be communicated to the candidate in writing and approved by the Department Head.

The qualifying examination will be completed when between 24 and 36 credit hours of graduate work have been completed. The qualifying exam must be completed no more than 4 semesters after admission into the Ph.D. program. Failure to take the examination in that time period may result in suspension from the Ph.D. program.

There must be a minimum of one semester between the qualifying and comprehensive exams. The student must be registered when the qualifying examination is taken. Upon successful completion of the qualifying examination, the student officially becomes a candidate for the Ph.D. degree.

The student will only have two opportunities to pass the qualifying examination. If failure occurs at the first attempt, at least one semester must elapse before the second examination takes place. Failure of the second exam will result in suspension from the program.

Students may apply for a Ph.D. qualifying exam waiver if they have completed a Master of Science comprehensive exam in a similar discipline to the focus area of the proposed Ph.D. program of study.

Comprehensive Examination: The proposal should be in the NSF format, in compliance with the current year's grant proposal guidelines (gpg) at www.nsf.gov unless otherwise agreed to by the student's committee. A public oral seminar of 30 to 40 minutes plus 10 minutes of public questions, on the research to date and proposed research to complete the Ph.D., will be given by the Ph.D. candidate. This will be followed by a closed-session oral examination of up to 2 hours administered by the student's Ph.D. committee. A written exam on graduate level environmental engineering topics may be required of graduate students who have a GPA in graduate coursework of less than 3.5.

Industrial Engineering

The requirements for the IE Option of the Ph.D. in Engineering degree are summarized below:

ENGR 610	Rsch & Mthds in Engineering	3
ENGR 650	Scientific Communication and Proposal Development	2
Advanced Mathematics: EGEN 505, EIND 554, or EIND 557		3
Numerical Methods: EGEN 506, EIND 558, or EIND 509		3
EIND 5XX Courses		15 Minimum
EIND 4XX*, Other 4XX/5XX*, EIND 592		12-16
Dissertation: EIND 690		18 Minimum
TOTAL CREDITS		60 Minimum

*The total number of 400-level course credits taken must comply with Graduate School policies.

EIND 490, EIND 492, EIND 499, EIND 575 and EIND 590 cannot be used towards the PhD course requirements. EIND 592 may be counted as an EIND 4XX level course. Double counting is not allowed; that is, each course can be applied only to fulfill one requirement. Other courses may qualify pending approval in writing from the student's graduate committee.

Qualifying Examination: The exam will be administered on the second Tuesday in February of the Spring semester. Students will be examined on the following three Industrial Engineering topics: engineering probability & statistics (e.g. EIND 354), work design & analysis (e.g. EIND 313), and engineering economy (e.g. EGEN 325). Additionally, students will choose from one of the following Industrial Engineering topics: principles of operations research (e.g. EIND 364), ergonomics and human factors engineering (e.g. EIND 413), or engineering management & ethics (EIND 300). The exam will be 5 hours duration in an open book, open notes format. Each problem set will be graded by the faculty member who most recently taught the course. The results will be analyzed by the Industrial Engineering Ph.D. Option Coordinator, and each candidate will receive a grade of Pass (P), Fail (F) or Remediate (R). Students will not be given the test back in order to protect the questions from dissemination. In cases where remediation in certain topic areas is required, the Ph.D. advisor will develop a problem-solving-based plan with the Ph.D. candidate to prepare for a retest on the identified topic areas. The retest must occur prior to the next fall semester and will be overseen by the Ph.D. Advisor.

Comprehensive Examination: The public research seminar will include 40 minutes for the student's presentation and 10 minutes for questions from the audience. This will be followed immediately by a closed-session oral examination of 45-90 minutes by the student's Ph.D. committee and additional remediation may be required at this point.