

# ENGINEERING, PHD: BIOMEDICAL ENGINEERING

The Doctor of Philosophy, the highest degree offered by the University, is conferred in recognition of marked scholarship in a broad field of knowledge as well as distinguished critical or creative achievement within a special area of the general field (the special area being the subject of the doctoral dissertation). The Doctor of Philosophy (PhD) program in the College of Engineering and Applied Science (CEAS) is designed to meet the traditional high standards for such programs. The PhD in Engineering is administered by the CEAS Graduate Program Subcommittee (GPSC). Some aspects of the program are delegated to the CEAS Graduate Office and to the various departments of the College.

There are six major areas in the PhD program:

- Biomedical Engineering
- Civil Engineering
- Computer Science
- Electrical Engineering
- Industrial Engineering
- Materials Engineering
- Mechanical Engineering

Each major is flexible, allowing the student to develop a plan of studies tailored to meet individual needs. Evaluation of the study plan is based on its appropriateness as an engineering or computer science program, the availability within the University of appropriate course offerings, and the availability within the College of a faculty member who is qualified to serve as the student's major professor.

The PhD degree requires a minimum of 66 credits beyond the baccalaureate, including a dissertation. The student must also satisfy a residence requirement.

Many of the courses leading toward graduate degrees in CEAS are offered in the late afternoon or evening. So, students can complete much of their coursework on a part-time basis.

## Admission Requirements

### Application Deadlines

Application deadlines vary by program, please review the application deadline chart (<http://uwm.edu/graduateschool/program-deadlines/>) for specific programs. Other important dates and deadlines can be found by using the One Stop calendars (<https://uwm.edu/onestop/dates-and-deadlines/>).

### Admission

An applicant must meet Graduate School requirements (<http://uwm.edu/graduateschool/admission/>) plus these College requirements to be considered for admission to the program:

1. A bachelor's or master's degree:
  - a. Applicants holding a BS or MS degree in engineering or computer science, depending on the major area selected will generally be admitted without deficiencies.
  - b. Applicants holding BS or MS degrees from domains outside of engineering or computer science may be admitted with specific program-defined course deficiencies, provided that the deficiencies amount to no more than two courses. The student is

expected to satisfy deficiency requirements within three enrolled semesters. The deficiencies are monitored by the Graduate School and the individual graduate program unit. No course credits earned in making up deficiencies may be counted as program credits required for the degree. For the Engineering major areas, the BS or MS preparation generally must include mathematics equivalent to ELECENG 234 or MATH 234. For the Computer Science major area, the mathematics preparation must generally include mathematics equivalent to MATH 232. Otherwise, the made-up deficiencies must be sufficient to assure the Graduate Program Subcommittee that the applicant is able to proceed with advanced work directed toward the doctoral degree.

2. A minimum grade point average of 3.0 on the basis of 4.0, in the highest degree granted. An applicant with a master's degree in engineering or computer science having a GPA of less than 3.0, but at least equal to 2.75, may be admitted if substantial evidence can be submitted demonstrating that the applicant has the capacity to perform satisfactory doctoral work.
3. All applicants are required to submit a brief (1 or 2 page) statement describing their professional goals and at least two letters of reference.
4. The Graduate Record Examination (GRE) is required for all international and domestic applicants.
5. International students require proof of English language proficiency. Complete information is available at the UWM Center for International Education (<http://www.uwm.edu/Dept/CIE/>)
6. Applicants with a relevant master's degree who intend to complete an additional master's in engineering at UWM should announce their plans at the time of admission, and not later than the start of their second year into the PhD program.

### Reapplication

A student who receives a master's degree at UWM must formally apply for admission to the Graduate School as a doctoral student before continuing studies that will be credited toward the Doctor of Philosophy in Engineering.

## Credits and Courses

The minimum degree requirement is 66 graduate credits beyond the bachelor's degree. The minimum credit distribution of coursework to be undertaken must be as follows depending on the option selected.

Code	Title	Credits
Select 21 credits in the major area of concentration		21
Select 9 credits in an approved minor area		9
Select 6 credits in mathematics and/or quantitative methods		6
Select 18 credits of doctoral thesis		18
Select 9 credits of approved electives		9
Select 3 credits of CEAS Graduate Seminar (each department has its own section of this course, numbered 700)		3
Total Credits		66

The 6-credit requirement in mathematics and/or quantitative methods may be met by satisfactorily completing certain courses specified by the GPSC or by taking the minor in mathematics. When such courses also count for either the major or the minor area, the remaining credits may be taken as approved electives.

The student must achieve a 3.0 GPA separately in each of the following areas: the major area, the minor area, and the quantitative methods area.

The major area of concentration must be in one of the seven areas approved for the PhD degree in the College. These areas are:

- Biomedical Engineering
- Civil Engineering
- Computer Science
- Electrical Engineering
- Industrial Engineering
- Materials Engineering
- Mechanical Engineering

The minor is normally in another area offered in the College or in the physical sciences or mathematics or in management sciences. Consideration of any other area as a minor requires the prior approval of the GPSC.

A minimum of 26 credits, excluding doctoral thesis, must be at the 700 level or higher.

A minimum of 33 credits, including doctoral thesis, must be completed while enrolled at UWM in the PhD degree program. For students entering with a relevant master's degree who intend to complete a second master's and a PhD in Engineering at UWM, a minimum of 27 credits, including doctoral thesis, must be completed while enrolled in the doctoral program.

Students entering the program without a prior applicable master's degree are limited to a total maximum transfer of 9 credits for courses taken elsewhere. Independent study courses (699 and 999) may be included in the minimum course credit requirements provided GPSC approval has been obtained prior to registration in such course. Typically no more than six credits of independent study are allowed in the PhD program. Guidelines on acceptable independent study courses are available in the CEAS Graduate Studies Office.

The GPSC or the major department may require candidates to complete certain courses as part of the requirement for the specific major or to meet the mathematics and/or quantitative methods requirement.

## Biomedical Engineering Concentration

Students will complete:

- A minimum of 15 credits of graduate courses from the following list and any new graduate courses that Biomedical Engineering Program introduces in the future with BME coding; and
- At least 18 credits of doctoral thesis (BME 998).

Only one credit of BME 999 will be counted towards this requirement.

Code	Title	Credits
<b>Qualifying Courses</b>		<b>15</b>
BME 705	Rehabilitation Robotics	
BME 720	Machine Perception	
BME 733	Sensors and Systems	
BME 890	Special Topics:	
BME 999	Advanced Independent Study	
COMPSCI/ELECENG 710	Artificial Intelligence	

COMPSCI/ELECENG 711	Introduction to Machine Learning	
COMPSCI/ELECENG 712	Image Processing	
ELECENG/MECHENG 701	Advanced Linear System Analysis	
ELECENG/MECHENG 718	Nonlinear Control Systems	
ELECENG 737	Medical Imaging Signals and Systems	
ELECENG 765	Introduction to Fourier Optics and Optical Signal Processing	
ELECENG 810	Advanced Digital Signal Processing	
MECHENG 715	Numerical Methods in Engineering	
<b>Doctoral Thesis</b>		<b>18</b>
BME 998	Doctoral Thesis	

## Additional Requirements

### Major Professor as Advisor

The Graduate School requires that the student must have a major professor to advise, supervise, and approve the program of study before registering for courses. The GPSC or its delegates will assign the incoming student to an initial Program Advisor at the time of admission. Prior to the completion of 12 credits (9 credits for part-time students), the student must select a major professor who will be the student's thesis advisor. The student, in consultation with the major professor, develops a proposed program of studies which is submitted to the Graduate Program Subcommittee for approval. For subsequent changes, the student must file a revised program of study for approval.

### Foreign Language

There is no foreign language requirement for the degree.

### Residence

The program residence requirement is satisfied either by completing 8 or more graduate credits in two consecutive semesters, exclusive of summer sessions, or by completing 6 or more graduate credits in each of three consecutive semesters, exclusive of summer sessions.

### Qualifying Examination

Each student in the program must take and pass a Qualifying Examination to demonstrate that the student is qualified for doctoral-level work. The Qualifying Examination is a written exam and is structured in two parts: Part 1 and Part 2. The examination is offered twice a year during the regular academic year. The content of the examination varies among the major areas of the PhD in Engineering program.

Students entering with only a bachelor's degree or with a master's degree in an area unrelated to their major area may take the Qualifying Examination for the first time after earning 12 credits of graduate work at UWM and must successfully pass the exam before earning 30 credits of graduate work at UWM.

Students admitted after completing an appropriate master's degree must take this examination no later than the semester immediately after 18 credits of graduate work have been earned at UWM.

A student may take the Qualifying Examination twice. On the first attempt, the student must attempt both Part 1 and Part 2 of the examination.

- If the student passes both parts, then the student has passed the entire examination and will be permitted to proceed toward the Doctor of Philosophy degree.
- If the student fails both parts, then the student must take the entire exam again at its next offering.
- If a student passes only one of the two parts, then the student must take the examination again at its next offering, but may choose to take only the part of the examination that was not passed on the first attempt.
- If a passing grade is not obtained on the second attempt of the Qualifying Examination, the student will not be permitted to proceed toward the Doctor of Philosophy degree.

A student who fails the qualifying exam twice is subject to dismissal from the PhD in Engineering program. A student may appeal the failure and dismissal within 30 days of being notified of the failure. If the student does not appeal or the appeal is not granted, the College will recommend to the Graduate School that the student be dismissed. A student who is dismissed from the PhD in Engineering program because of failing the qualifying exam may not be enrolled in the PhD in Engineering program for a complete calendar year. This does not preclude the student from being enrolled in any other degree program offered by the University. A student who wishes to re-enroll in the program after a calendar year has passed must apply as any other student would, including payment of fees. A student readmitted after having failed the qualifying exam twice must take the qualifying exam in the first semester of matriculation and this will count as the student's first attempt at the exam. The student may appeal this requirement prior to the first scheduled day of classes. If the student fails the qualifying exam on this first attempt, the student is permitted the customary second attempt as described above. All appeals must be in writing and directed to the CEAS Associate Dean for Academic Affairs.

### **Doctoral Program Committee**

The Doctoral Program Committee is proposed by the major professor in consultation with the student and the department. The Committee must include at least five graduate faculty (three from major area, one from minor area, and one from any area, including the major and minor areas). The last member may be a person from outside the University (such as another university, a research laboratory, or a relevant industrial partner), provided that person meets Graduate School requirements. The Committee may have more than five members, provided that the majority of the Committee members are from the student's major field.

### **Doctoral Preliminary Examination**

A student is admitted to candidacy only after successful completion of the doctoral preliminary examination conducted by the Doctoral Program Committee. This examination, which normally is oral, must be taken before the completion of 48 credits of graduate work toward the Doctor of Philosophy degree in Engineering and should be taken within the first seven years in the program. Prior to the examination, the student must present a proposal for a doctoral dissertation project. The examination may cover both graduate course material and items related to the proposed dissertation project.

### **Dissertation and Dissertator Status**

The student must carry out a creative effort in the major area under the supervision of the major professor and report the results in an acceptable dissertation. The effort of the student and the major professor to produce the dissertation is reflected in the PhD in Engineering program requirement that the student complete at least 18 credits of doctoral thesis.

After the student has successfully completed all degree requirements except the dissertation, the student may enter Dissertator Status. Achieving Dissertator Status requires successful completion of the Doctoral Preliminary Examination and prior approval of the student's advisor, the Doctoral Program Committee, and the GPSC of a dissertation proposal that outlines the scope of the project, the research method, and the goals to be achieved. Any proposal that may involve a financial commitment by the University also must be approved by the Office of the Dean. After having achieved Dissertator Status, the student must continue to register for 3 credits of doctoral thesis per semester during the academic year until the dissertation is completed.

### **Dissertation Defense**

The final examination, which is oral, consists of a defense of the dissertation project. The doctoral defense examination may only be taken after all coursework and other requirements have been completed. The student must have Dissertator Status at the time of the defense.

### **Time Limit**

All degree requirements must be completed within ten years from the date of initial enrollment in the doctoral program.

For additional information see the Graduate School PhD requirements (<http://uwm.edu/graduateschool/doctoral-requirements/>).