

III. DOCTORAL DEGREES

1. Degrees Offered

Two doctoral degrees are available to graduate students in Biological Systems Engineering. Programs for the Doctor of Philosophy (Ph.D.) emphasize the science or research features of engineering and are intended to provide the student with abilities to assist with furtherance of the fundamental knowledge of engineering. Doctor of Engineering (D.E.) programs emphasize design, analysis, economics, management, and/or labor, and are intended to assist the student with training useful to the professional engineer.

2. Admission Requirements

Highly qualified students with or without a BS or MS degree in engineering may apply. However, students with a non-engineering BS degree need to meet additional prerequisites for admission and should make up deficiencies in engineering core and upper division courses as listed in #1b and c below. The application procedure will be as follows:

- Students who want to be considered for fellowships, should apply to the program by the published deadline by completing the standard doctoral application form (<http://gradstudies.ucdavis.edu/index.cfm>) and paying appropriate fees to be considered for potential fellowships and priority consideration. However, application will be accepted until May 31st, if the applicant does not expect to be considered for fellowships administered by UC Davis (i.e., applicant who is self-supporting or has other sources of support such as home country fellowship, international fellowship, Graduate Assistantship from the program etc.)
- Applicants will have a minimum undergraduate GPA of 3.0 or a graduate GPA of 3.25. Under some exceptional circumstances, students who only hold an undergraduate degree with a GPA below 3.0 may be conditionally admitted with a coursework only option for the purposes of demonstrating the ability to maintain a qualifying GPA at the graduate level prior to full admission.
- Applicants must take the GRE test.
- All students applying to the program will be required to submit three letters of recommendation.
- International applicants must take the TOFEL or IELTS test.
- Applicants are strongly encouraged to communicate with potential research advisers (major professors) prior to admission to the program.
- Students admitted to the doctoral program will be invited to the new student orientation in the Fall quarter, when the graduate adviser will explain all the degree requirements. The student will work with her/his major professor and constitute a course guidance committee in the first quarter of the program to plan the program of study. Students in

the doctoral program must submit the program of study to the Executive committee for approval by the end of the third academic quarter in residence.

- a) **Prerequisites:** In addition to the admission requirements stated above, applicants with non-engineering BS degree are expected to have passed with letter grades the following UC Davis equivalent science and mathematics courses:
- i. Differential and Integral Calculus (Calculus - MAT 21 A, B & C; Vector Calculus - MAT 21 D; Linear Algebra - MAT 22 A; Differential Equations - MAT 22B).
 - ii. Physics (Classical Physics - PHY 9A & B; Electricity and Magnetism - PHY 9C)
 - iii. Chemistry (General Chemistry - CHE 2A & B)
- b) **Deficiencies:** Non-engineering students must pass with letter grade any missing UC Davis equivalent engineering core and upper division engineering courses listed below during their MS program:
- i. Circuits 1: ENG 17
 - ii. Statics: ENG (35)
 - iii. Circuits: ENG 100
 - iv. Dynamics: ENG 102
 - v. Fluids: ENG 103/EBS 103
 - vi. Mechanics of materials: ENG 104
 - vii. Thermodynamics: ENG 105, and
 - viii. Two additional upper division courses in engineering.

Please visit <http://bae.engineering.ucdavis.edu/graduate/admission-requirements/for> more information.

- 2. Dissertation Plan:** Biological Systems Engineering Graduate Program offers Dissertation Plan B described under section 520 in the Davis Division Academic Senate Regulations: <http://gradstudies.ucdavis.edu/gradcouncil/C.4.%20Davis%20Division%20Reg%20520C%202008.pdf>

This plan requires a minimum of three members on the dissertation committee and an Exit Seminar or Public Presentation of the dissertation research. The Exit Seminar is scheduled after the student submits a rough draft to the Dissertation Committee on a date suitable to all members of the committee with the approval of the Graduate Adviser. The Thesis and Dissertation Presentation form can be found at the website: <http://bae.engineering.ucdavis.edu/graduate-forms/>

3. Course Requirements

Ph. D. - Core and Electives (49 units):

a) Core Courses (4 units)

- | | | |
|--------------|--|---------|
| (i) EBS 200: | Research methods in biological systems engineering | 2 units |
| (ii) EBS 290 | Seminar | 2 units |

b) Elective Courses (45 units). Note 8 of these 45 units have to meet Advanced Math and Advanced Experimental Design and Analysis requirements.

(iii) Major:

ECH 259 or equivalent (Advanced engineering mathematics),
EBS 265 (Design and analysis of engineering experiments), and
other graduate and upper division courses in the major field 30 units

(iv) Minor: A minimum of 15 units of graduate and undergraduate courses in a particular field to enhance students breadth of knowledge. To achieve this breadth student typically takes 3 graduate and 2 upper division courses in a coherent subject (i.e., about 5 courses randomly selected from different areas will not constitute a minor) 15 units

c) **Summary:** Figure 5 succinctly summarizes our Ph. D. degree program requirements.

Note that course Guidance Committee, in concurrence with the student, may suggest ECH 140 (Mathematical methods in biochemical and chemical engineering), EAD 205A (mathematical methods), MAT 118A (Partial differential equations: Elementary methods), or (MAT 118 B (Partial differential equations: Eigenfunction expansions) as a substitution for ECH 259. Similarly, PLP 222 (Experimental approaches in plant pathology may be suggested as a substitution to EBS 265. However, EBS 265 and ECH 259 are the preferred courses and any recommended changes will have to be approved by the Executive Committee. Note also that any such changes may lead to a change in the total number of core units. However, such changes need to be compensated in major courses, which must total a minimum of 30 units including Advancement engineering mathematics and Design and analysis of engineering experiments or with their respective substitutions.

In selecting the courses, students should be very careful to make sure that in the major and minor fields, which amount to a total of 45 units, there are at least 30 graduate units of which at least 15 are engineering graduate units. Moreover, at least 23 units must be in engineering. Note that students holding a MS degree may be able to transfer up to 21 units from elsewhere. To be able to transfer these units students must provide an extended outline of the course (s) taken at other institutions. In any case, at least 24 units and core courses (EBS 200 and EBS 290) must be taken here at UC Davis to satisfy major and minor requirements. Figure 5 summarizes our Ph. D. degree course requirements succinctly.

D. Engr: Core and Electives (49 units)

Course requirements for D. Engr. is academically equivalent to Ph.D. program but emphasizes professional aspects of engineering rather than research. The student prepares for a qualifying examination in a major field of study and one **or** two minor fields. The major field area may include a wider range of subject matter than is customary in the Ph.D. program. As a consequence, the Doctor of Engineering candidate is not expected to probe into a single field of learning as deeply as the Ph.D. candidate. Minor fields should include courses outside engineering. Examples of minor fields are bioscience, business management, economics, international agricultural development, law, sociology, statistics, mathematics, political science, psychology and operations research. The area covered by the qualifying examination is thus broadened, and the minimum course work

required to prepare a student for the examination may exceed the 30 graduate units and an additional 15 upper division or graduate units suggested for the Ph.D. candidate.

a) Core courses (4 units)

- (i) EBS 200: Research methods in biological systems engineering 2 units
- (ii) EBS 290: Seminar 2 units

b) Elective courses (45 units)

- (iii) Major: A minimum of 30 units of graduate and upper division courses.
These courses should prepare the student to define and solve problems in recognized engineering area. These courses may come from physical sciences, mathematics, statistics, and engineering to provide knowledge necessary for practice high-level professional engineering performance
30 units
- (iv) Minor: A minimum of 15 units of graduate and undergraduate courses in particular field to enhance students breadth of knowledge. To achieve this breadth student typically takes 3 graduate and 2 upper division courses in a coherent subject (i.e., about 5 courses randomly selected from different areas)
15 units

c) Summary: Figure 6 succinctly summarizes our D. Engr. degree program requirements.

In selecting the courses, students should be very careful to make sure that in the major and minor fields, which amount to a total of 45 units, there are at least 30 graduate units of which at least 15 are engineering graduate units. Moreover, at least 23 units must be in engineering. Note that students holding a MS degree may be able to transfer up to 21 units from elsewhere. To be able to transfer these units students must provide an extended outline of the course (s) taken at other institutions. In any case, at least 24 units and core courses (EBS 200 and EBS 290) must be taken here at UC Davis to satisfy major and minor requirements. Figure 6 summarizes our D. Engr. degree course requirements succinctly.

4. Special requirements: None.

5. Committees:

- a) **Admission Committee:** The graduate admission adviser and staff adviser handle all application-related issues. Once the completed application, all supporting material, and the application fee have been received, the application will be submitted to the Admissions Committee. In consultation with the graduate program chair, the graduate admission adviser will make the admission recommendation and forward it to the Dean of the Office of Graduate Studies for final approval of admission
- b) **Course Guidance or Advising Committee:** Upon acceptance into the program, students are required to meet with an assigned major professor in their primary technical area of interest to formulate their proposed Program of Study. A Program of Study is a list of graded courses the student is expected to take to meet degree requirements. Course

Guidance Committee assists the student in developing this program of study. It should be signed by all three members of the course guidance committee before it is submitted to the Executive Committee. Doctoral students must submit their Program of Study to the Executive Committee for approval by the end of third quarter in residence (i.e, Spring quarter for students entering in Fall quarter).

- c) **Qualifying Examination Committee:** The student, in consultation with his/her major professor and Graduate Adviser, nominates five faculty to serve on the Examination Committee. At least one, but no more than two members, on the committee should be from outside the program. The major professor cannot serve on the QE committee. These nominations are submitted to the Office of Graduate Studies for formal appointment in accordance with Graduate Council policy. Students are encouraged to submit the form well in advance (4 to 6 weeks) of the proposed QE date . The QE cannot be taken until the committee appointment is approved by the Office of Graduate Studies. The QE Committee conducts the exam and submits results to the Office of Graduate Studies.
- d) **Dissertation Reading Committee:** This committee of three is nominated by the student in consultation with his/her major professor and submitted to the Graduate Adviser for approval. The composition of the committee is entered on the Advancement to Candidacy Form and are then submitted to the Office of Graduate Studies for formal appointment in accordance with Graduate Council policy. The role of the Dissertation Committee is to advise the doctoral student on the research topic and methods, and then to review the final completed dissertation for acceptance. The major professor acts as the chair of the committee. The Committee Chairperson should determine the desires of the individual members regarding assistance with the research and dissertation review at the time the dissertation committee is constituted. Students are expected to meet with the Chair of their dissertation committee regularly. Dissertation committee members are expected to read and comment on a dissertation within four weeks from its submission. This time limit policy does not apply to summer periods for faculty holding nine-month appointments. The student and faculty will coordinate a timeline for the student to present the thesis to the dissertation committee. This timeline must allow all dissertation committee members enough time to fulfill their responsibilities within the four-week deadline. Please note the Exit Presentation requirement listed in #2 above.

6. **Advising Structure and Mentoring:** The graduate adviser will go over the degree requirements with all admitted graduate students. For students entering in the Fall quarter, this is done as a part of EBS 200 course (Research methods in biological systems engineering) within the first couple of weeks of the quarter. For a student entering in other quarters (early or late admits), the Graduate Adviser will go over these requirements on an individual basis soon after arrival of the student. The Graduate Adviser and the staff adviser are available to discuss all matters pertinent to the graduate program. Students admitted to the Biological Systems Engineering Graduate Program work closely with their respective major professors. The **Mentoring Guidelines** can be found at

<http://bae.engineering.ucdavis.edu/graduate/masters-students-guide/>

7. **Advancement to candidacy:** Before advancing to candidacy for a doctoral degree, a student must have satisfied all requirements set by the graduate program, must have maintained a minimum GPA of 3.0 in all coursework undertaken (except those courses graded S or U), and must have passed a Qualifying Examination before a committee appointed to administer that

examination. Normally, students who enter directly after a BS degree in Engineering, advance in three years. However, students who enter with a MS degree with substantial amount of units transferred (say 18 to 21) from their MS program, are expected to Advance to Candidacy in two years. Students with non-engineering BS degree may require an additional year to Advance to candidacy. The student must file the appropriate paperwork with the Office of Graduate Studies and pay the Candidacy Fee in order to be officially promoted to Ph.D. candidacy. Refer to the Graduate Council website for additional details regarding the Doctoral Qualifying Examination at <http://gradstudies.ucdavis.edu/gradcouncil/policiesall.html>.

8) Preliminary Examination, Qualifying Examination and Dissertation

a) Preliminary Examination: None.

b) Qualifying Examination:

(i) General Information

All students will complete all course requirements before taking their Qualifying Examination. Passing this exam makes the student eligible for advancement to candidacy. A student entering with a BS degree in engineering should take the qualifying examination within 9 quarters (excluding summer) and no later than 12 quarters (excluding summer) after admission to the Ph.D. program. Students with MS degree with significant number of units (18 to 21) transferred from their MS program, should take qualifying examination in 6 quarters (excluding summer) and no later than 9 quarters (excluding summer) after admission to the Ph. D. program. Students with non-engineering BS degree would be allowed an additional year for taking the qualifying examination.

The primary purpose of the Qualifying Examination (QE) is to validate that the student is academically qualified to conceptualize a research topic, undertake scholarly research and successfully produce the dissertation required for a doctoral degree. The QE must evaluate the student's command of the field, ensuring that the student has both breadth and depth of knowledge, and must not focus solely on the proposed dissertation research. In addition, the QE provides an opportunity for the committee to provide important guidance to the student regarding his or her chosen research topic.

(ii) Written Portion of the Exam – Dissertation Prospectus

At a minimum the written portion of the exam consists of a research proposal called the Dissertation Prospectus. The Prospectus should be provided to members of the qualifying examination committee at least 10 days before the oral portion of the exam.

The Prospectus is an independently prepared proposal of 10-12 pages describing the student's dissertation-specific research aims, hypotheses, progress to date, and experimental approach. Concepts within the research proposal can be discussed with others (such as the student's major professor and peers), but the writing of the proposal should be solely the student's work (i.e., no editorial assistance is allowed) as the proposal will serve as evidence of the student's proficiency in scientific writing.

The qualifying exam committee will be responsible for assessing that the student's writing proficiency is satisfactory before advancement to candidacy. Furthermore, the Prospectus will provide information that may be discussed during the oral exam.

(iii) Oral Portion of the Exam:

The oral portion of the qualifying exam will be 3 hours in length and is intended to demonstrate the student's critical thinking ability, powers of imagination and synthesis, and broad knowledge of the field of study. Typically, the examination will start off with student making a brief (20 to 25 minutes) presentation of the research prospectus. The committee may examine the student on various aspects of the prospectus to evaluate student's depth of understanding. This part of the examination will take approximately half of the allotted time. The second part of the examination will focus on student's breadth of knowledge in his/her chosen field (major and minor areas).

The committee will evaluate the student's general qualifications for a respected position as an educator or leader as well as the student's preparation in a special area of study based upon relevant portions of the student's previous academic record, performance on specific parts of the examination, and the student's potential for scholarly research as indicated during the examination.

(iv) Outcome of the Exam

The committee will reach a decision on the student's performance immediately after the oral exam. The committee, having reached a unanimous decision, shall inform the student of its decision to:

- "Pass" (no conditions may be appended to this decision),
- "Not Pass" (the Chair's report should specify whether the student is required to retake all or part of the examination, list any additional requirements, and state the exact timeline for completion of requirements to achieve a "Pass"), or
- "Fail".

If a unanimous decision takes the form of "Not Pass" or "Fail", the Chair of the QE committee must include in its report a specific statement, agreed to by all members of the committee, explaining its decision and must inform the student of its decision. In the event that the committee is unable to reach a unanimous decision, the outcome will be resolved through the Dean of Graduate Studies as well as the Graduate Council, in accordance with the procedures detailed in the Graduate Advisers Handbook GS-202. If the committee decision results in a "Not Pass", the student may attempt the QE one additional time; the QE report must list the specific conditions and timing for the second exam. After a second examination, a vote of "Not Pass" is unacceptable; only "Pass" or "Fail" is recognized. Only one retake of the qualifying examination is allowed. Should the student receive a "Fail" on the first or second attempt at the exam, the student will be recommended for disqualification from the program to the Dean of the Office of Graduate Studies.

c) The Dissertation

(i) Exit Seminar:

Biological Systems Engineering Graduate Program follows Dissertation Plan B and requires an exit seminar. As listed in # 2 above, the Exit Seminar is scheduled after the student submits a rough draft to the Dissertation Committee on a date suitable to all members of the committee with the approval of the Graduate Adviser. The Thesis and Dissertation Presentation form can be found at the website: <http://bae.engineering.ucdavis.edu/graduate-forms/>. Scheduling of the Exit Seminar is the responsibility of the student.

(ii) Dissertation: General Requirements

Filing of a Ph.D. dissertation with the Office of Graduate Studies is normally the last requirement satisfied by the candidate. The deadlines for completing this requirement are listed each quarter in the campus General Catalog (available online at the website of the Office of the Registrar or from the Bookstore). A candidate must be a registered student or in Filing Fee status at the time of filing a dissertation, with the exception of the summer period between the end of the Spring Quarter and the beginning of Fall Quarter. The Ph.D. Dissertation will be prepared, submitted and filed according to regulations instituted by the Office of Graduate Studies <http://gradstudies.ucdavis.edu/students/filing.html>. Satisfaction of this requirement must be verified by the Dissertation Committee Chair.

(iii)Dissertation:

The research conducted by the student must be of such character as to show ability to pursue independent research. The dissertation reports a scholarly piece of work of publishable quality that solves a significant scientific problem in the field and is carried out under the supervision of a member of program while the student is enrolled in the program. The chair of the dissertation committee must be a member of the program and must be immediately involved with the planning and execution of the work related to the dissertation.

Students should meet regularly with their dissertation committee. The dissertation must be submitted to each member of the dissertation committee at least one month before the student expects to make requested revisions; committee members are expected to respond within 4 weeks, not including summer months for nine month faculty. Informing committee members of progress as writing proceeds helps the members to plan to read the dissertation and provide feedback within this time frame. The dissertation must be approved and signed by the dissertation committee before it is submitted to Graduate Studies for final approval.

9. Normative time to degree: Normative time to degree is 5 years for those entering the program with a BS degree in Engineering. A student with a MS degree may require one year less to complete all degree requirements (i.e., 4 years) as s/he is able to transfer several units (up to 22) from his/her MS program. An additional year may be needed for a student who enters with a non-engineering degree to makeup the deficiencies listed in #2C.

10. Typical timeline and sequence of events: The following degree checklist provides various milestones:

Ph. D. Degree (For students entering with BS degree in Engineering):

Year	Fall	Winter	Spring	Summer
One	200 (2 units) + ECH 259 (4 units) + 1 unit of 290 C + 299 (5 units) Select guidance committee	8 units of graduate or upper division courses + 290C (1 unit) + 299 (3 units)	265 (5 units) + 3 units of graduate or upper division courses + 290C (1 unit) + 299 (3 units) Submit Program of study.	Conduct Research

Two	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	Conduct Research
Three	5 units of upper graduate or upper division courses + 1 unit of 290C + 6 units of 299	4 units of graduate or upper division courses + 1 unit of 290 C+ 7 units of 299	1 unit of 290C + 11 units of 299 Prepare for Qualifying Exam (QE)	Take QE and Advance to candidacy
Four	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	Conduct Research
Five	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	Present Exit Seminar and submit the dissertation

D. Engr. Degree (For students entering with BS degree in Engineering):

Year	Fall	Winter	Spring	Summer
One	200 (2 units) + 4 units of Graduate or upper division courses + 1 unit of 290 C + 299 (5 units) Select guidance committee	8 units of graduate or upper division courses + 290C (1 unit) + 299 (3 units)	8 units of graduate or upper division courses + 290C (1 unit) + 299 (3 units) Submit Program of study.	Pursue engineering project
Two	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	6 units of graduate or upper division courses + 1 unit of 290C + 5 units of 299.	Pursue engineering project
Three	5 units of upper graduate or upper division courses + 1 unit of 290C + 6 units of 299	4 units of graduate or upper division courses + 1 unit of 290 C+ 7 units of 299	1 nit of 290C + 11 units of 299 Prepare for Qualifying Exam (QE)	Pursue the Engineering project, Take QE and Advance to

				candidacy.
Four	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	Pursue engineering project
Five	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	1 unit of 290 C + 11 units of 299	Present Exit Seminar and submit the dissertation

11. Sources of Funding: Almost all doctoral students in Biological Systems Engineering Graduate Program are employed as Graduate Student Researchers (GSR), or Teaching Assistants (TA), or hold fellowships such as Biological Systems Engineering Fellowship, University Fellowships, or External Fellowships. These assistantships and fellowships are very competitive.

12. PELP and Filing Fee Status: The planned educational leave program (PELP) is available to students to suspend their program of studies for good cause (i.e. illness, temporary departure from the University for employment or research away from campus, financial problems, personal problems). Students on PELP may leave the campus and be guaranteed the right to return later to resume academic work. The minimum duration of PELP is one quarter and maximum duration is three quarters.

Additional information about PELP (Planned Educational Leave), In Absentia (reduced fees when researching out of state), and Filing Fee status can be found in the Graduate Student Guide: <http://www.gradstudies.ucdavis.edu/publications/>

Ph.D. Program of Study:

Minimum Required Total (49)*	EBS 200 Research Methods (2)					
	EBS 290 Seminar (2)					
	Courses exclusive of EBS 200, EBS 290, 290C and 299 (45) Must meet these criteria:	Minor (15)	UCD or elsewhere (21)	Engr. and Other Courses (22)	Grad or Upper Div. Undergrad as needed to meet 45 unit minimum (15)	
		Major (30)			Minimum units taken at UCD (24)	Engr. Courses (23)
			Graduate Engineering Units (15)			
290C, 299 Research (variable)						

Note: Requires demonstration of skills in advanced engineering mathematics and experimental design. May require at least one course in the life sciences depending on background. Also requires qualifying examination, doctoral research dissertation, and public presentation of research (exit seminar) for completion of degree. *(minimum number of course units except as noted).

Figure 5. Course requirements for Ph.D. degree

D. Engr. Program of Study:

Minimum Required Total (30)*	EBS 200 Research Methods (2)	
	EBS 290 Seminar (1)	
	Courses exclusive of EBS 200, EBS 290, 290C and 299 (17) Must meet these criteria:	Graduate or Upper Division Undergraduate Courses not required for EBS BS degree (5)
		Graduate Engineering Courses (12)
290C, 299 Research (minimum of 6 units required) plus other Graduate or Upper Division Undergraduate Courses as needed to meet the required 30 unit minimum total		

Note: Requires written dissertation and public presentation of research (exit seminar) for completion of degree. May require at least one course in the life sciences depending on background. *(minimum number of course units except as noted).

Figure 6. Course requirements for D.E. degree