

AGRICULTURAL AND BIOLOGICAL ENGINEERING

Graduate Program Head	Suat Irmak
Program Code	ABENG
Campus(es)	University Park (Ph.D., M.S.)
Degrees Conferred	Doctor of Philosophy (Ph.D.) Master of Science (M.S.) Dual-Title Ph.D. and M.S. in Agricultural and Biological Engineering and International Agriculture and Development Dual-Title Ph.D. and M.S. in Agricultural and Biological Engineering and Operations Research
The Graduate Faculty	View (https://secure.gradsch.psu.edu/gpms/?searchType=fac&prog=ABENG)

Agricultural and Biological Engineering (ABENG) offers students the opportunity to gain expertise in several areas that relate to the world's most important sociotechnological and sustainability challenges including energy, environment, crop/food production and health. Specific focus areas include agricultural machinery, mechatronics, remote sensing, natural resources, water quality, climate change, fermentation, food production, food safety, biological and agricultural bioproducts, life cycle analysis and techno-economic analysis. The ABENG M.S. degree is research based and requires a thesis.

Excellent facilities, including equipment and instrumentation, are available for research. Extensive additional fabrication and characterization equipment and facilities are available through Penn State institutes and user facilities including the Institutes of the Environment and Energy, Huck Institutes of the Life Sciences, Materials Research Institute, Materials Characterization Laboratory, Nanofabrication Facility, Institute for CyberScience, PA Housing Research Center, Center for Food Manufacturing, USDA Pasture Systems and Watershed Management Research Lab, Mushroom Research and Demonstration Facility and a 1,500-acre agricultural research center for cooperative work with agronomic and horticultural production systems as well as animal production systems.

Admission Requirements

Applicants apply for admission to the program via the Graduate School application for admission (<https://gradschool.psu.edu/graduate-admissions/how-to-apply/>). Requirements listed here are in addition to Graduate Council policies listed under GCAC-300 Admissions Policies (<https://gradschool.psu.edu/graduate-education-policies/>).

An undergraduate major in engineering is normally a prerequisite to work in the major. Students without an undergraduate engineering degree will be considered for admission on a provisional basis (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/provisional-admission/>) pending the completion of a number of additional credits to be specified on an individual basis. These additional credits will not count towards the program degree requirements.

The language of instruction at Penn State is English. English proficiency test scores (TOEFL/IELTS) may be required for international applicants. See GCAC-305 Admission Requirements for International Students (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/gcac-305-admission-requirements-international-students/>) for more information.

All applicants must provide the department with official transcripts from all post-secondary institutions attended (<http://gradschool.psu.edu/prospective-students/how-to-apply/new-applicants/requirements-for-graduate-admission/>), as well as a statement of purpose written by the applicant, and at least three letters of recommendation. Admission into the Agricultural and Biological Engineering Graduate Program is based upon a thorough review of all applicant qualifications, and the best-qualified applicants will be accepted up to the number of students for which department resources are available. GRE scores will not be accepted.

Master of Science (M.S.)

Completion of an undergraduate degree in agricultural or biological engineering or in another related engineering discipline is required for direct admission to the Agricultural and Biological Engineering Graduate Program. Students need at least a 3.0 (4.0 base) junior/senior grade-point average to be considered for admission.

A student with an undergraduate degree in a non-engineering field can be admitted to the M.S. program on a provisional basis (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/provisional-admission/>), pending the completion of a number of additional credits to be specified on an individual basis. These additional credits will not count towards the M.S. degree requirements. The provisional status continues until completion of the engineering undergraduate requirements in mathematics, physics, engineering sciences and any additional required 400-level Biological Engineering courses. Upon completion of these preparatory courses with a minimum grade-point average of 3.0, the student will be admitted to the graduate program.

Doctor of Philosophy (Ph.D.)

The program requirement for acceptance to graduate study toward a Ph.D. degree in Agricultural and Biological Engineering is an M.S. degree with research thesis in an engineering or science discipline with a B.S. degree from an engineering program. Outstanding students interested in direct admission from a B.S. engineering program to the Ph.D. Program should contact the Graduate Program Coordinator. Direct admission will be based on critical evaluation of the student's potential to conduct publishable research, academic record, statement of purpose, and reference letters. Students who apply directly to the Ph.D. program but are not qualified will be considered for admission into the M.S. program.

A student with an undergraduate degree in a non-engineering field can be admitted to the Ph.D. program on a provisional basis (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-300/provisional-admission/>), pending the completion of a number of additional credits to be specified on an individual basis. These additional credits will not count towards the Ph.D. degree requirements. The provisional status continues until completion of the engineering undergraduate requirements in mathematics, physics, engineering sciences and any additional required 400-level Biological Engineering courses. Upon completion of these preparatory courses with a minimum grade-point average of 3.0, the student will be admitted to the graduate program.

Degree Requirements

Master of science (M.S.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

A minimum of 30 credits at the 400, 500, 600, or 800 level is required, with at least 18 credits at the 500 and 600 level, combined. A minimum of 12 credits in course work (400, 500, and 800 series) must be completed in the major program (BE or ABE). A thesis is required and a minimum of 6 credits in thesis research (600 or 610) must be completed. The thesis must be accepted by the advisers, committee members, the head of the graduate program, and the Graduate School, and the student must pass a thesis defense.

Each M.S. program of study must meet the following requirements:

Code	Title	Credits
ABE 500	Research Methods	3
BRS 502	Human Behavior and ethics in Management and Technology (or other Ethics course from a list of approved courses maintained by the program office.)	3
One 500-level STAT course		3
ABE 590	Colloquium (1 credit per semester for 3 semesters)	3
Additional 400-level BE courses (limit 3 credits), 500-level or 800-level ABE courses		6
ABE 600	Thesis Research	6
Additional 400, 500, or 800-level courses or ABE 600 Thesis Research		6
Total Credits		30

In addition to the above listed course work requirements, every graduate student must fulfill the Scholarship and Research Integrity (SARI) requirement. SARI requirement consists of two parts: 1) completion of ABE 500 with a grade of B or better and 2) completion of online training program at: <http://www.research.psu.edu/training/sari/> (<http://www.research.psu.edu/training/sari/>) Responsible Conduct of Research (RCR) for Engineers. The online SARI requirement must be completed within one year from date of enrollment in the program of study. A copy of the completion certificate of the online SARI training program should be given to the Graduate Administrative Assistant. This will be placed in the student's department folder.

A minimum grade point average of 3.00 is required for graduation. Only grades of C or better are accepted for graduate credit. All courses must be approved by the Advisory Committee as having significance and value for the degree program. All requirements for M.S. degree, whether satisfied on this campus or elsewhere, must be met within eight years from the first semester of graduate study.

Doctor of Philosophy (Ph.D.)

Requirements listed here are in addition to Graduate Council policies listed under GCAC-600 Research Degree Policies. (<https://gradschool.psu.edu/graduate-education-policies/>)

Ph.D. degree requirements include successful completion of the following: approved graduate course work, a qualifying examination, English Competence requirements, a comprehensive examination, and a final oral examination (the dissertation defense). To earn the Ph.D. degree, doctoral candidates must write a dissertation that is accepted by

the Ph.D. committee, the head of the graduate program, and the Graduate School.

Each Ph.D. program of study, for students holding a masters level engineering degree, must meet the following requirements (courses taken previously do not have to be repeated, except ABE 590):

Code	Title	Credits
ABE 500	Research Methods (unless previously taken)	3
BRS 502	Human Behavior and ethics in Management and Technology (or other ethics course from a list of approved courses maintained by the program office, unless previously taken)	3
ABE 590	Colloquium (1 credit per semester for 4 semesters)	4
500 and/or 800-level ABE courses (excluding ABE 500, 590-596) ¹		6
EDCE 530	Teaching and Learning in Agricultural Science (B grade minimum) ²	3
ABE 602	Supervised Experience in College Teaching	1-3
Communications ²		3
Additional course work as approved by the Ph.D. Committee		

¹ One 500-level ABE course (3 credits) and one engineering graduate (500-level) course (3 credits) from the list of approved courses maintained by the program office fulfills this requirement.

² B- does not mean this requirement.

Except as specified above, no particular course levels, total number of courses or total credits are required by the department. The Dissertation committee will determine the minimum requirements in such supporting areas as mathematics, engineering, agricultural/biological sciences, and physical sciences. The candidate is expected to develop a program of study and submit it to the Dissertation Committee for consideration and approval.

In addition to the above listed course work requirements, every graduate student must fulfill the Scholarship and Research integrity (SARI) requirement. SARI requirement consists of two parts: 1) completion of ABE 500 with a grade of B or better, and 2) completion of online training program at <http://www.research.psu.edu/training/sari-> Responsible Conduct of Research (RCR) for Engineers. The online SARI requirement must be completed within one year from date of enrollment in the program of study. A copy of the completion certificate of the online training program should be given to the Graduate Administrative Assistant. This will be placed in the student's department folder.

It is expected that each Ph.D. student not holding an M.S. engineering degree will satisfy the intent of the M.S. degree coursework requirements specified elsewhere in this document. Research credits (ABE 600) are in addition to coursework credits.

All requirements for a Ph.D. degree must be completed within eight years after passing the Qualifying Examination.

A Ph.D. candidate is not required to have a minor field of study. However, if the student selects a minor field, the minor must consist of not fewer than 15 graduate credits above and beyond any credits used for a master's minor. The coursework must be distinct from the student's primary academic and research focus regardless of the course abbreviation/prefix. All credits must be approved by the graduate major program and graduate minor program heads. The minor must meet Graduate Council policy requirements listed under GCAC-611 Minor –

Research Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/>).

Dual-titles

Dual-Title M.S. and Ph.D. in Agricultural and Biological Engineering and International Agriculture and Development

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/>).

Graduate students with research and educational interests in international education may apply to the dual-title program in Agricultural and Biological Engineering and International Agriculture and Development. The goal of the dual-title program in ABENG and INTAD is to enable graduate students from ABENG to acquire the knowledge and skills of their primary area of specialization in ABENG, while at the same time gaining the perspective and methods needed for work in the international agriculture. Graduate study in this program seeks to prepare students to assume leadership roles in science, engineering, outreach, and project management anywhere in the world. Students acquire a broad perspective on how to apply their research findings in the context of the broader international community. Thus, the dual-title will allow students to master their field of specialization from an international perspective so that they can effectively engage in agricultural development activities within various countries and regions.

Admission Requirements

Students must apply and be admitted to the graduate program in ABENG and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the INTAD dual-title program. Refer to the Admission Requirements section of the INTAD Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/>). Doctoral students must be admitted into the dual-title degree program in INTAD prior to taking the qualifying examination in their primary graduate program.

Degree Requirements for the Dual-Title M.S.

To qualify for the dual-title degree, students must satisfy the degree requirements for the M.S. degree, listed on the Degree Requirements tab. In addition, students must complete the degree requirements for the dual-title M.S. in INTAD, listed on the INTAD Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/>). Up to 6 credits of INTAD approved courses can be applied to fulfilling ABENG program requirements. Final course selection must be approved by the student's advisory committee.

Degree Requirements for the Dual-Title Ph.D.

To qualify for the dual-title degree, students must satisfy the degree requirements for the Ph.D. degree, listed on the Degree Requirements tab. In addition, students must complete the degree requirements for the dual-title Ph.D. in INTAD, listed on the INTAD Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/international-agriculture-development/>). Some courses may satisfy both ABENG program requirements and those of the INTAD program. Up to 6 credits of INTAD approved courses can be applied to fulfilling ABENG program requirements. Final course selection must be approved by the student's Ph.D. committee.

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from ABENG and must include at least one Graduate Faculty member from the INTAD program. Faculty members who hold appointments in both programs' Graduate Faculty may service in a combined role. There will be a single qualifying examination, containing elements of both ABENG and INTAD. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed on semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of an ABENG and INTAD dual-title Ph.D. student must include at least one member of the INTAD Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may service in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in INTAD, the member of the committee representing INTAD must be appointed as co-chair. The INTAD representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in ABENG and INTAD. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Dual-Title M.S. and Ph.D. in Agricultural and Biological Engineering and Operations Research

Requirements listed here are in addition to requirements listed in GCAC-208 Dual-Title Graduate Degree Programs (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-200/gcac-208-dual-titles/>).

Graduate students with interests in operations research may apply to the dual-title program in Agricultural and Biological Engineering and Operations Research. The goal of the dual-title program in ABENG and Operations Research is to enable graduate students from ABENG to acquire the knowledge and skills of their primary area of specialization in ABENG, while at the same time gaining the perspective and methods needed for work systems analysis and modeling. Graduate study in this program seeks to prepare students to utilize the tools, techniques, and methodology of operations research, while maintaining a close association with areas of application. Operations research is the analysis—usually involving mathematical treatment—of a process, problem, or operation to determine its purpose and effectiveness and to gain maximum efficiency.

Admission Requirements

Students must apply and be admitted to the graduate program in ABENG and The Graduate School before they can apply for admission to the dual-title degree program. After admission to their primary program, students must apply for admission to and meet the admissions requirements of the OR dual-title program. Refer to the Admission Requirements section of the OR Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research/>). Doctoral students must be admitted into the dual-title degree program in OR prior to taking the qualifying examination in their primary graduate program.

Degree Requirements for the Dual-Title M.S.

To qualify for the dual-title degree, students must satisfy the degree requirements for the M.S. degree, listed on the Degree Requirements tab. In addition, students must complete the degree requirements for the dual-title M.S. in OR, listed on the OR Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research/>). Up to 6 credits of OR approved courses can be applied to fulfilling ABENG program requirements. Final course selection must be approved by the student's advisory committee.

Degree Requirements for the Dual-Title Ph.D.

To qualify for the dual-title degree, students must satisfy the degree requirements for the Ph.D. degree, listed on the Degree Requirements tab. In addition, students must complete the degree requirements for the dual-title Ph.D. in OR, listed on the OR Bulletin page (<http://bulletins.psu.edu/graduate/programs/majors/operations-research/>). Some courses may satisfy both ABENG program requirements and those of the OR program. Up to 6 credits of OR approved courses can be applied to fulfilling ABENG program requirements. Final course selection must be approved by the student's Ph.D. committee.

The qualifying examination committee for the dual-title Ph.D. degree will be composed of Graduate Faculty from ABENG and must include at least one Graduate Faculty member from the OR program. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. There will be a single qualifying examination, containing elements of both ABENG and OR. Dual-title graduate degree students may require an additional semester to fulfill requirements for both areas of study and, therefore, the qualifying examination may be delayed on semester beyond the normal period allowable.

In addition to the general Graduate Council requirements for Ph.D. committees (<http://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/phd-dissertation-committee-formation/>), the Ph.D. committee of an ABENG and OR dual-title Ph.D. student must include at least one member of the OR Graduate Faculty. Faculty members who hold appointments in both programs' Graduate Faculty may serve in a combined role. If the chair of the Ph.D. committee is not also a member of the Graduate Faculty in OR, the member of the committee representing OR must be appointed as co-chair. The OR representative on the student's Ph.D. committee will develop questions for and participate in the evaluation of the comprehensive examination.

Students in the dual-title program are required to write and orally defend a dissertation on a topic that is approved in advance by their Ph.D. committee and reflects their original research and education in ABENG and OR. Upon completion of the doctoral dissertation, the candidate must pass a final oral examination (the dissertation defense) to earn the Ph.D. degree. The dissertation must be accepted by the Ph.D. committee, the head of the graduate program, and the Graduate School.

Minor

A graduate minor is available in any approved graduate major or dual-title program. The default requirements for a graduate minor are stated in Graduate Council policies listed under GCAC-600 Research Degree Policies (<https://gradschool.psu.edu/graduate-education-policies/>) and GCAC-700 Professional Degree Policies (<https://gradschool.psu.edu/graduate-education-policies/>), depending on the type of degree the student is pursuing:

- GCAC-611 Minor - Research Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-611-minor-research-doctorate/>)
- GCAC-641 Minor - Research Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-600/gcac-641-minor-research-masters/>)
- GCAC-709 Minor - Professional Doctorate (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-709-professional-doctoral-minor/>)
- GCAC-741 Minor - Professional Master's (<https://gradschool.psu.edu/graduate-education-policies/gcac/gcac-700/gcac-741-masters-minor-professional/>)

Student Aid

Graduate assistantships available to students in this program and other forms of student aid are described in the Tuition & Funding (<https://gradschool.psu.edu/graduate-funding/>) section of The Graduate School's website. Students on graduate assistantships must adhere to the course load limits (<https://gradschool.psu.edu/graduate-education-policies/gsad/gsad-900/gsad-901-graduate-assistants/>) set by The Graduate School.

Courses

Graduate courses carry numbers from 500 to 699 and 800 to 899. Advanced undergraduate courses numbered between 400 and 499 may be used to meet some graduate degree requirements when taken by graduate students. Courses below the 400 level may not. A graduate student may register for or audit these courses in order to make up deficiencies or to fill in gaps in previous education but not to meet requirements for an advanced degree.

Agricultural and Biological Engineering (ABE) Course List (<https://bulletins.psu.edu/university-course-descriptions/graduate/abe/>)

Learning Outcomes

Master of Science (M.S.)

1. **KNOW:** Graduates will be able to demonstrate mastery of core principles and methods of agricultural and biological engineering professional practice and in-depth mastery of a subfield.
2. **THINK:** Graduates will be able to critically and creatively conceptualize and evaluate engineering problem formulations, analyses, and solutions.
3. **APPLY/CREATE:** Graduates will demonstrate proficiency in engineering problem formulation, planning, organization and implementation of appropriate methods of analyses and solutions.
4. **COMMUNICATE:** Graduates will be able to effectively communicate technical knowledge, including ideas, data analysis, findings, or decision justification in written and oral presentation appropriate to the audience.
5. **PROFESSIONAL PRACTICE:** Graduates will demonstrate knowledge of, and ability to, practice the professional standards of engineering and professional behavior. Graduates will demonstrate a knowledge of ethics, equity, diversity and inclusivity and the application of these concepts and principles to the profession and to relevant social issues.

Doctor of Philosophy (Ph.D.)

1. **KNOW:** Graduates will demonstrate a deep knowledge of principles and methodologies of agricultural and biological engineering which

may include the foundational mathematics, physics, chemistry, biology, engineering or communications.

2. **CREATE:** Graduates will be able to create new knowledge and develop new solutions to agricultural and biological engineering problems by developing an understanding of the scientific and engineering literature and engaging in scientific research.
3. **APPLY:** Graduates will be able to apply knowledge of the principles and methodologies of agricultural and biological engineering to the process of creating new knowledge and conducting original scientific research in the field of agricultural and biological engineering.
4. **THINK:** Graduates will be able to independently analyze and critique motivations for conducting research, the research process, research results, and the implications of research and its results to our world.
5. **COMMUNICATE:** Graduates will be able to actively listen, convey accurately and clearly ideas and results both orally and in writing, and engage in positive, effective deliberation.
6. **PROFESSIONAL PRACTICE:** Graduates will be prepared to become leaders in our society by being able to apply technical skills for effective decision making in agricultural and biological engineering fields. Graduates will demonstrate a knowledge of ethics, equity, diversity and inclusivity and the application of these concepts and principles to the profession and to relevant social issues.

Contact

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Director of Graduate Studies (DGS) or Professor-in-Charge (PIC)	Ali Demirci
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Program Website	View (http://abe.psu.edu/ graduateprograms/)