

PHARMACEUTICAL ENGINEERING, DOCTOR OF PHILOSOPHY (PH.D.) [COLLEGE OF ENGINEERING]

The Ph.D. in Pharmaceutical Engineering will prepare students to respond to current, emerging and future challenges in the discovery, development and production of pharmaceutical products. The program will prepare talent and leaders who can pursue careers in industry and regulatory and nonprofit agencies, as well as academic settings that deal with drug products. Students will engage in a rigorous and cross-disciplinary educational experience that includes foundational and research-area-specific course work; be empowered with the necessary tools to formulate and answer hypotheses-driven research questions in collaboration with mentors that have special expertise; engage in professional development opportunities to effectively promote and disseminate their work; and be immersed in a research and innovation environment of excellence.

Graduates will gain the necessary skills and scientific foundation to work in a team-based environment, seek entrepreneurial solutions, and effectively communicate concepts and results. The program will prepare students to work and innovate in areas that create medicines to improve human health including the pharmaceutical industry, medical nonprofits, universities and regulatory authorities.

Student learning outcomes

- Students will demonstrate the knowledge and understanding of core concepts and processes necessary for developing pharmaceutical drug products.
- Students will be able to identify and solve problems in health care that are relevant to pharmaceutical engineering.
- Students will be able to develop entrepreneurial approaches to pharmaceutical engineering that may lead to innovation in the health care field.
- Students will be able to demonstrate the ability to carry out independent and collaborative work.
- Students will be able to communicate scientific knowledge and discoveries.
- Students will be able to demonstrate the ability to teach and mentor.
- Students will be able to demonstrate the ability to plan and execute research projects.
- Students will be able to demonstrate that they understand and will participate in community engagement/outreach.

VCU Graduate Bulletin, VCU Graduate School and general academic policies and regulations for all graduate students in all graduate programs

The VCU Graduate Bulletin website documents the official admission and academic rules and regulations that govern graduate education for all graduate programs at the university. These policies are established by the graduate faculty of the university through their elected representatives to the University Graduate Council.

It is the responsibility of all graduate students, both on- and off-campus, to be familiar with the VCU Graduate Bulletin as well as the **Graduate School website** and academic regulations in individual school and department publications and on program websites. However, in all cases, the official policies and procedures of the University Graduate Council, as published on the VCU Graduate Bulletin and Graduate School websites, take precedence over individual program policies and guidelines.

Visit the academic regulations section for additional information on academic regulations for graduate students.

Degree candidacy requirements

A graduate student admitted to a program or concentration requiring a final research project, work of art, thesis or dissertation, must qualify for continuing master's or doctoral status according to the degree candidacy requirements of the student's graduate program. Admission to degree candidacy, if applicable, is a formal statement by the graduate student's faculty regarding the student's academic achievements and the student's readiness to proceed to the final research phase of the degree program.

Graduate students and program directors should refer to the following degree candidacy policy as published in the VCU Graduate Bulletin for complete information and instructions.

Visit the academic regulations section for additional information on degree candidacy requirements.

Graduation requirements

As graduate students approach the end of their academic programs and the final semester of matriculation, they must make formal application to graduate. No degrees will be conferred until the application to graduate has been finalized.

Graduate students and program directors should refer to the following graduation requirements as published in the Graduate Bulletin for a complete list of instructions and a graduation checklist.

Visit the academic regulations section for additional information on graduation requirements.

Apply online today. (<https://www.vcu.edu/admissions/apply/graduate/>)

Admission requirements

Degree:	Semester(s) of entry:	Deadline dates:	Test requirements:
Ph.D.	Fall	May 15	TOEFL or IELTS scores for non-native English speakers

In addition to the general admission requirements of the VCU Graduate School (<http://bulletin.vcu.edu/graduate/study/admission-graduate-study/admission-requirements/>), the following are also required:

- Applicants must have graduated with a bachelor's degree or master's degree (or equivalent professional program) from an accredited college or university, with a degree in a discipline that provides an appropriate background for graduate-level study in pharmaceutical engineering, including but not limited to pharmacy, (bio)chemistry, bioengineering, chemical engineering, materials science, mechanical engineering, biomedical engineering and molecular biology.

- International applicants for whom English is not their native language must demonstrate language competency by achieving a minimum 100 points in TOEFL (BT). A bachelor's or graduate degree from an accredited U.S. institution along with an interview from a faculty member will be accepted in lieu of such an examination.
- Applicants must present a current resume or curriculum vita.
- Applicants must present transcripts (translated and validated if from abroad) from their bachelor's degree program and from any/all graduate programs the candidate may have attended.

Note: The GRE is not required but students are encouraged to submit their scores as additional evidence of their qualifications. Competitive scores are greater than 300 for combined Quantitative and Verbal and 4.0 Analytical score. The GRE cannot be used in place of other admissions requirements.

Transfer credits will be allowed. Students with an advanced degree (M.S. or equivalent professional program) from an accredited college or university, with a degree in a discipline related to pharmaceutical engineering, including but not limited to pharmacy, chemistry, bioengineering, chemical engineering, materials science, mechanical engineering, biomedical engineering and molecular biology, may petition to transfer up to nine credits of elective courses. If the students have produced a thesis during their advanced studies, they may be eligible to transfer another nine credits of research.

Curriculum requirements

The degree program has three entry points:

- B.S. entry point that will require a minimum of 83 credits to graduate
- M.S. without a thesis entry point that will require a minimum of 74 credits to graduate
- M.S. with a thesis entry point that will require a minimum of 63 credits to graduate

Regardless of the credits to degree, all students must satisfy common curriculum elements, including 12 credits of core courses. All of the courses in the curriculum ensure that students receive the necessary didactic instruction that will enable them to excel in the development of cutting-edge research in pharmaceutical engineering. The curriculum is highly flexible and consists of a combination of core courses, research area elective courses, electives and directed research. Students will develop a dissertation under the supervision of a faculty member, thus offering another opportunity for students to delve into a specific area while at the same time developing professional skills.

Curriculum for students entering with a B.S. degree

Course	Title	Hours
Core courses		
OVPR 601	Scientific Integrity	1
PESC 605	Advanced Topics in Pharmaceutical Engineering I	3
PESC 607	Advanced Topics in Pharmaceutical Engineering II	3
PESC 609	Pharmaceutical Engineering Laboratory I	1
PESC 690	Pharmaceutical Engineering Seminar (.5-credit course taken six times)	3

PESC 709	Pharmaceutical Engineering Laboratory II	1
Research area elective courses		
Select nine credits in consultation with the adviser and approved by the program directors.		9
Electives		
Select nine credits in consultation with the adviser.		9
Research		
PESC 697	Directed Research in Pharmaceutical Engineering	53
Total Hours		83

The minimum total of graduate credit hours required for this degree is 83.

Curriculum for students entering with a non-thesis M.S. degree

Course	Title	Hours
Core courses		
OVPR 601	Scientific Integrity	1
PESC 605	Advanced Topics in Pharmaceutical Engineering I	3
PESC 607	Advanced Topics in Pharmaceutical Engineering II	3
PESC 609	Pharmaceutical Engineering Laboratory I	1
PESC 690	Pharmaceutical Engineering Seminar (.5-credit course taken six times)	3
PESC 709	Pharmaceutical Engineering Laboratory II	1
Research area elective courses		
Select nine credits in consultation with the adviser and approved by the program directors		9
Electives		
Select nine credits in consultation with the adviser.		9
Research		
PESC 697	Directed Research in Pharmaceutical Engineering	44
Total Hours		74

The minimum total of graduate credit hours required for this degree is 74.

Curriculum for students entering with an M.S. degree with thesis

Course	Title	Hours
Core courses		
OVPR 601	Scientific Integrity	1
PESC 605	Advanced Topics in Pharmaceutical Engineering I	3
PESC 607	Advanced Topics in Pharmaceutical Engineering II	3
PESC 609	Pharmaceutical Engineering Laboratory I	1
PESC 690	Pharmaceutical Engineering Seminar (.5-credit course taken six times)	3

PESC 709	Pharmaceutical Engineering Laboratory II	1
Research area elective courses		
Select nine credits in consultation with the adviser and approved by the program directors		9
Electives		
Select nine credits in consultation with the adviser.		9
Research		
PESC 697	Directed Research in Pharmaceutical Engineering	33
Total Hours		63

The minimum total of graduate credit hours required for this degree is 63.

Degree requirements

Research adviser

Qualified students will be admitted to the Ph.D. program in pharmaceutical engineering upon selection by a pharmaceutical engineering graduate faculty member who is willing to serve as their major research adviser. In the event of admission without an adviser assignment, students will meet with all eligible graduate faculty and then select an adviser by the end of the first semester. The adviser is responsible for providing the student guidance and counsel essential to scholarly development. The dissertation project will be designed by the student in consultation with the adviser. The student will be responsible for conducting research and promoting the work through peer-reviewed publications and presentations.

The graduate student advisory committee

An advisory committee will be appointed shortly after (within the first year of study) the adviser has been selected and approved. The advisory committee serves as both an examining and consultative body. Together the adviser and the student will select the advisory committee members, which will need to be approved by the pharmaceutical engineering program directors. The advisory committee will consist of at least three graduate faculty members besides the adviser. The faculty members will have expertise in areas related to the student's dissertation work. One of the committee members must be from a program outside pharmaceutical engineering. The advisory committee will work with the adviser in guiding the student through the graduate program; the committee must meet formally once a year to ensure timely progress toward degree completion. The body of experimental work to be incorporated into the dissertation is subject to approval by the membership of the advisory committee, which will conduct the comprehensive (candidacy) exams, qualifying exam and final oral defense examinations.

Admission to candidacy for Ph.D. degree

Students are admitted to candidacy based on completing required course work, the examinations described below and the recommendation of the adviser, advisory committee and the co-directors of the pharmaceutical engineering program. Advancement to candidacy should take place prior to initiating the third academic year in the program.

Part I – Qualifying examination

The qualifying examination consists of a combined written/oral examination to be taken prior to the second year in the program, and after clearing didactic core sequence and laboratories. A majority "pass" from the advisory committee is required for the student to advance. In case the student is not successful in the first iteration, a second examination with the same format will be automatically scheduled for the end of

the following semester. Failing a second attempt will result in removal from the program. The written qualifying examination will consist of questions related to core classes and laboratory work, with the format to be determined by the faculty preparing the exams, which are the same as those administering the courses.

Part II – Written comprehensive examination

The written comprehensive examination is taken after successful completion of the qualifying examination. Comprehensive exams are administered to the Ph.D. student based on research proposals. The research proposal should follow the R21 (NIH) format exactly, including budget and other requirements. The topic of the proposal must be related to the student's doctoral dissertation project and agreed upon with the adviser, particularly the aims of the proposal. The student's advisory committee will evaluate the written proposal and will grade as pass/fail.

Oral comprehensive examination

After passing the written comprehensive examination(s), the student is eligible for the oral comprehensive examination, which is conducted by the advisory committee and is chaired by the student's adviser. The oral examination is administered to assess the ability of the candidate to integrate information and display an appropriate mastery of problem-solving capabilities. This is to be a defense of their written exam and can include questions related to general concepts in pharmaceutical engineering as well as those pertaining to the proposed work. Written and oral comprehensive exams must be taken by the end of the second year of study.

Final Ph.D. examination and oral defense

The final examination requires the student to write a dissertation based on their research and defend it in an oral examination. On completion of their research, and in agreement with the adviser, the student shall prepare a written dissertation describing the completed research using the format approved by the Graduate School and submit it to the pharmaceutical engineering graduate program committee for approval. The student's advisory committee will select an appropriate external examiner to review the written dissertation and attend the dissertation defense. The oral defense of the dissertation under the direction of the student's advisory committee will be open to all faculty members and other graduate students; it will examine the student's project, intellectual context, and the underlying fundamental knowledge or contribution to science.

Following the defense, all committee members and the external examiner will vote on the acceptability of the dissertation. A student can pass the oral defense, signifying that the committee has accepted the dissertation project, with no more than one negative vote. If the outcome is negative, the final oral defense may be retaken with the approval of the directors of the pharmaceutical engineering program. Upon successful completion of the defense and dissertation, the student may apply for graduation from VCU with the degree of Ph.D. in Pharmaceutical Engineering.

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