

# FAQ about U.S Ph.D. Programs for Electrical Engineering Students

## 1) What is a Ph.D. degree ?

The Ph.D. ("Philosophiae Doctor", or Doctor of Philosophy) degree is the highest academic degree granted by U.S. universities in the fields of engineering, natural sciences, mathematics, statistics, and computer science. In addition, Ph.D. degrees are also awarded in humanities and in the social sciences. Holding a Ph.D. degree or equivalent is a normal requirement in the United States for any person who wishes to pursue a career in university teaching and advanced research (in both academia and industry).

The Ph.D. degree falls under the category of "research degrees", meaning the core of any Ph.D. program is original research done by the doctoral candidate under the supervision of one or sometimes two faculty advisors. For doctoral degrees in engineering, Ph.D. level research usually requires proposing a new solution to one or more problems that were either previously unsolved or solved in a way that compares unfavorably to the new proposed solution.

## 2) What are the requirements for admission to a Ph.D. program in engineering in United States ?

Initial admission to a U.S. Ph.D. program in engineering usually requires that the applicant hold a Master of Science (M.S.) or equivalent degree first, although some schools may accept applicants who hold a Bachelor of Science (B.S.) or equivalent degree only. In the latter case, the admitted student may be required to get a master's degree first from the school that is admitting him/her before he/she can continue pursuing the doctoral degree. Applicants are not required to have majored in engineering, but engineering majors usually have a higher probability of success in the admissions process.

Admission decisions are made based on a multitude of different criteria, among them: (1) academic record, including undergraduate school transcripts and, most importantly, evidence of research experience/potential; (2) letters of recommendation; (3) a personal statement of research interests and goals; and (4) standardized test scores. All international applicants whose first language is not English are required to take the Test of English as a Foreign Language (TOEFL). With the notable exception of MIT, all top U.S. Engineering schools also require that Ph.D. applicants (both domestic and international) take the Graduate Record Examination (GRE) General Test which consists of the verbal, quantitative, and analytical writing sections. In addition to the GRE General Test, a number of specific advanced GRE Subject Tests may be taken in several areas (e.g. computer science, mathematics, and physics), but most top engineering schools do not require or recommend subject tests.

The top engineering schools usually set mandatory minimum scores in the TOEFL and the GRE General Test, but, beyond that, standardized tests play a minor role in the admission process, with evidence of research accomplishments and/or potential being the most important factor in deciding whether a candidate will be admitted or not. Admission to the the top 10 Ph.D. programs in engineering in the United States is highly competitive, particularly for international students, and only a small percentage of applicants are successful.

### **3) Once I am admitted, what are the requirements to graduate from a Ph.D. program in electrical engineering in the US ?**

Initial admission to a Ph.D. program in the US does not automatically imply admission to Ph.D. degree candidacy. Instead, the admitted student must fulfill certain requirements first before being elevated to candidacy status.

In the field of Electrical Engineering (EE), the actual overall requirements for obtaining a U.S. Ph.D. degree vary from school to school, but usual requirements that are common to most programs include:

a) Taking a prescribed number of graduate-level courses in Electrical Engineering and/or related areas. Some schools have course breadth requirements under which the student must take a mandatory number of courses outside his/her main area of research interest within Electrical Engineering. A minimum GPA (grade point average) is generally required for the ensemble of graduate courses taken by the student.

b) Passing a Ph.D. Qualifying Exam (Qual). Depending on the school, the Qual format may vary from one or more comprehensive written exams covering several undergraduate and graduate subjects, to one or more comprehensive oral exams aimed at evaluating the candidate's breadth of knowledge in EE basics at both undergraduate and graduate levels. In some schools, the Qual may be a combination of both written and oral exams and, sometimes, it may also include a research seminar and the submission of a short survey paper to evaluate the candidate's writing and presentation skills. The Qual must be normally taken in the early stages of the Ph.D. program, usually some time between the end of the first and the end of the third semester depending on the school. Candidates are allowed to take the Qual at most twice. Failure to pass the exam after two attempts normally implies that the student be evicted from the Ph.D. program. The percentage of EE students failing the Qual twice is relatively high in several top Ph.D. programs.

c) Writing and, in most cases, presenting a Ph.D. Thesis Proposal which must be accepted by a proposal committee. The thesis proposal is normally due by the end of the fifth semester, but the actual timing varies depending on the school. Like the Qual, the proposal can be submitted at most twice.

d) Writing a complete Ph.D. thesis which must represent an **original and significant**

contribution to existing knowledge in the field to which the work is related. The thesis must be presented by the candidate before a thesis committee in a final oral public exam, which is aimed at evaluating the relevance, consistency and originality of the work, as well as the candidate's depth of understanding of his/her research. Results arising from or related to the Ph.D. thesis are expected to be submitted for publication in peer-reviewed journals and conference proceedings.

In addition,

e) Several schools (e.g. CMU, UC Berkeley, MIT) also require that the student complete one or two semesters of teaching internship before he/she can receive a Ph.D. degree. This requirement aims at ensuring that the Ph.D. student will also acquire teaching, mentoring and advising skills that are particularly relevant to candidates who want to pursue careers in academia.

f) In some schools (e.g. CMU), Ph.D. candidates must demonstrate evidence of steady progress in order to remain in the program. Progress may be demonstrated by fulfilling a given degree requirement (e.g. the Qual, the Proposal, the teaching internship, etc...) and/or by submission and publication of papers in peer-reviewed journals or conference proceedings. A candidate's progress is generally evaluated by his/her thesis advisor and reviewed by a collegiate faculty committee every semester. Candidates who do not show steady progress may be placed under probation or, eventually, may be evicted from the program.

Official admission to candidacy is usually granted in most Ph.D. programs after the student completes the required coursework and passes the Ph.D. Qualifying Exam. In some institutions however, candidacy status is only granted after acceptance of the Thesis Proposal, which, in turn, can only occur after approval in the Qualifying Exam.

#### **4) How long does it take to get a Ph.D. degree in engineering in the U.S. ?**

Most students normally take 4 years beyond the master's to complete a Ph.D degree in engineering in the United States. It is not unusual though for students to need up to 5 years of post-master's full-time dedication to obtain a Ph.D degree. The actual length of the program depends greatly on the expectation you yourself and your advisor set for your doctoral research and the level of the original contribution to existing knowledge you set as your goal. It is not uncommon also for certain advisors in the US not to allow their students to present their theses before they publish or at least submit a minimum number of papers to selective peer-reviewed international journals.

### **5) How much does it cost to pursue a Ph.D. degree in the US ?**

Unlike in Brazil or some European countries, all US colleges and universities, both public and private, charge tuition and other fees for both undergraduate and graduate programs. The actual cost of a 4 or 5-year Ph.D. education however varies greatly depending on the school you enroll at.

Private schools and universities (e.g. Stanford, MIT, CMU, or Princeton), are typically very expensive by Brazilian standards, with the total cost of tuition and school fees currently in the range of 25,000-30,000 US dollars/year. State universities (e.g. the University of California at Berkeley, the University of Illinois at Urbana-Champaign, or the University of Michigan at Ann Arbor) usually charge modest tuition/fees (typically between 3,000-8,000 dollars/year) if you happen to be a state resident. Unfortunately, foreign students who are not permanent residents of the US (i.e., who do not hold a so-called “Green Card”) cannot qualify for state residency and must pay full tuition, which may be as high as 15,000-20,000 US dollars/year in some state universities. In addition, any student living in the US will need a certain annual income for housing and other basic living expenses. The actual required amount depends largely on the city the student lives in, but should be at least around 15,000 US dollars/year for modest living in a moderately inexpensive city.

Fortunately though, most Ph.D. students (both international and domestic) in the top US schools are awarded research assistantships (RAs) upon admission to graduate school. Research assistantships are paid from research grants one’s advisor receives from federal research funding agencies (e.g. NSF, DARPA, NIH), other local state government agencies, or, more rarely, corporations in the private sector. RAs generally cover full tuition and school fees and also provide a monthly stipend for ordinary living expenses. The stipend again varies greatly in amount depending on the city one lives in, and is taxable at both the federal and state levels, even when the student is not a US citizen or permanent resident. Students who do not get research grants from their advisors are usually required to work as part-time instructors in the university to support themselves.

Brazilian students in the US differ somewhat from their American and international counterparts in the sense that most of them do not rely on funding from their own advisors, but are instead funded through scholarships from Brazilian federal agencies such as CAPES or CNPq. Brazilian federal scholarships cover full tuition and medical insurance (the latter only up to a maximum annual amount) and provide a modest monthly stipend for subsistence (currently 1,100 US dollars/month), which is not subject to US taxes. All foreign students in the US are required by immigration law to have health insurance.

## **6) How does the academic calendar in the US differ from the academic calendar in Brazil ?**

The normal school year in the US is divided into two 4-month terms : the fall term, which runs from late August/early September to mid-December, and the winter/spring term, which begins in mid-January and ends normally in mid-May. In addition, there is a summer term between June and August. Classes are normally offered in the fall and winter/spring, although a few classes may be also offered in the summer. Ph.D. students who are full-time residents in the program normally enroll for all terms in the academic year (including the summer) and spend most of their time concentrating on research and/or fulfilling a certain degree requirement. Depending on their needs, they may however take or audit additional classes beyond the minimum required for graduation which they normally take in the first year of the program.

There is a winter break between mid-December and the beginning of the second term when most Ph.D. students go home for the holidays. Like in Brazil, there is also a mid-semester week break both in the fall and the spring, which, for Ph.D. students, means only extra time to do research. Other noteworthy holidays in the US (when restaurants and stores do close) include Independence Day (July 4th) and the Thanksgiving Day (the 4th Thursday of November). Note that Election Day in the U.S. (always the first Tuesday of November) is not a holiday (people vote during work breaks or when they are going home from work).

## **7) What is a bachelor's degree ?**

The lowest academic degree awarded by a U.S. university is the bachelor's degree granted upon the completion of a 4-year post-secondary school program with a concentration in at least one major field of study. Students who have majored in natural sciences (e.g. physics, chemistry), mathematics, statistics, computer science or engineering are usually awarded the "Bachelor of Science" (B.S.) degree. Students majoring on humanities and social sciences are usually awarded the "Bachelor of Arts" (B.A.) degree. Certain majors such as economics may lead to either B.A. or B.S. degrees depending on the program and the school awarding the degree. U.S. bachelor's degrees are highly flexible allowing double majors or majors with minors in different areas of study.

For the purpose of admission to graduate school, most US universities consider a 5-year "Diploma de Engenheiro" from a top Brazilian school or university as equivalent to a 4-year US B.S. degree.

**8) What kind of master's degrees are awarded by US universities and what is the difference between a master's and a doctoral degree ?**

A prescribed course of studies, typically lasting between one and two years beyond the B.S. or B.A. degrees, may lead to a "Master of Science" (M.S.) or "Master of Arts" (M.A.) degree depending on the field of study. Awarding of an M.S. or M.A. degree in the United States usually requires taking a certain number of graduate-level courses in one major and possibly several minor areas of concentration. In addition, many M.S. programs also require that the student complete a research project culminating in a final report presented to a faculty committee. M.S. projects in engineering usually involve the application of existing theory or methods to a particular problem and, in general, do not represent a new contribution to current knowledge in the area.

Students holding a B.S. or B.A. degree who are interested in non-research graduate studies focusing on specific professional training have the option of seeking a professional master's degree such as e.g. the degrees of Master of Engineering (M.Eng.), Master in Business Administration (M.B.A.), or Master of Fine Arts (MFA). The main difference between, let's say, the M.S. and a professional master's degree is that the former is viewed as an intermediate step leading to a possible Ph.D. degree in the future, whereas the latter is normally seen as a terminal degree preparing professionals for non-research related work in business and industry.

Admission to a M.S. program in the US follows roughly the same criteria as admission to Ph.D. programs being based on school transcripts, letters of recommendation, and standardized test scores. In several engineering schools, the M.S. and Ph.D. programs are highly integrated, and Ph.D. students that are admitted without a master's are required to obtain a M.S. degree first before continuing their doctoral studies. U.S. universities usually consider a Brazilian "Mestre em Ciências" or "Mestre em Engenharia Elétrica" degrees as equivalent to an American M.S. degree for admission purposes into a Ph.D. program.

**9) Is there any other doctoral degree awarded in the US besides the Ph.D. degree ?**

Yes. A small number of schools, e.g. MIT, still award the Sc.D. ("Scientiae Doctor") degree, which is basically equivalent to a Ph.D. degree in natural sciences or engineering. Students who already hold a bachelor's degree from a 4-year college or university may be awarded the M.D. ("Medicinae Doctor") degree upon completion of an additional 4-year Medical School program. The equivalent degrees in dentistry and veterinary medicine, also requiring 4 years of study beyond the bachelor's, are respectively the D.M.D. ("Dentariae Medicinae Doctor") and the D.V.M. degrees. The Th.D. ("Theologiae Doctor") or D.D. ("Doctor of Divinity") degrees are the equivalent of a Ph.D. degree in the field of theology. A number of honorary doctoral degrees also exist, e.g. the Litt. D. ("Litterarum Doctor")

or "Doctor of Letters") degree.

**10) What is the difference between the J.D., LL.B., and LL.D. degrees ?**

Professional training in Law in the United States also follows a peculiar model. Students who hold a bachelor's degree from a 4-year college or university and are interested in pursuing a legal career must apply for admission in a 3-year Law School program, upon completion of which they will be awarded a J.D. ("Juris Doctor") degree. Despite its name, the J.D. is not a doctoral degree, being instead an initial law degree equivalent to the old LL.B. ("Legum Baccalaureus") degree. A few J.Ds continue their legal studies at a postgraduate level to obtain an LL.M. ("Legum Magister" or "Master of Laws") degree or, eventually, a LL.D. ("Legum Doctor") or S.J.D. "Scientiae Juris Doctor") degree which are the final equivalents of a Ph.D. degree in law.

**11) What other standardized tests besides the GRE are taken by individuals applying to graduate studies in the US ?**

Individuals seeking admission to an MBA program must take the GMAT ("Graduate Management Admission Test"). Students applying to Law School must take the LSAT ("Law School Admission Test"). Medical School-bound students are required to take the MCAT ("Medical College Admission Test").

**12) What are the legal immigration requirements for international students in the US?**

That question should be directed to a specialized immigration lawyer. Roughly speaking though, international students who are enrolled full-time in a degree program will typically enter the US under an F-1 student visa and will be in possession of an I-20 form that must be periodically certified by a school official in order for the student to maintain his/her immigration status. Some students, including nowadays CNPq/CAPES-funded Brazilian students, will enter the US under a J-1 exchange visitor visa and will be in possession of an IAP-66 form.

International students who do not hold a "Green Card are **not** permanent residents of the US and are not allowed to seek employment in the country, with the possible exception of part-time employment within the educational institution he or she is attending. F-1 visa holders are allowed one year of legal employment under the "practical training" category following graduation. After that one-year grace period expires, they must obtain a temporary work (H-1) visa or leave the country. J-1 visa holders from certain countries, including Brazil, are required to return to their home countries upon graduation and fulfill a two-year home country residency requirement before they can apply for a work permit or permanent

residency in the United States.