

Answers to Frequently Asked Questions for Engineering Advisors at Liberal Arts Colleges

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1. What is ABET certification and what engineering fields require this certification to get a job in engineering?

- a) What is ABET and what does this agency do?

ABET stands for Accreditation Board for Engineering and Technology and is a non-profit, non-governmental agency that accredits college and university programs in applied science, computing, and engineering.

<http://www.abet.org/>

- b) Why is ABET accreditation important?

ABET accreditation certifies that a program meets certain standards, set by ABET, to adequately prepare its graduates to enter certain fields in science, engineering, and technology. The ABET program prepares students for an engineering licensure exam that is required to perform some engineering jobs. Furthermore, on the job market companies looking to hire engineers will generally expect applicants to have an ABET accredited degree, though individuals with non-ABET accredited degrees can apply. Some “Tech” companies insist on ABET degrees for engineer level positions, and allow other degrees for technician level positions.

- c) Do all applied science, engineering, and technology jobs require that students pursuing work in these fields have an ABET accredited degree?

No. If a student were wishing to become a practicing engineer (as opposed to one in research or in academia) in the US, especially in some areas of civil, electrical, mechanical, chemical or structural engineering, then becoming licensed would be important, since contractual work for governments (e.g., public utilities and building bridges or other structures for town, county, state, or federal governments) usually involves licensed engineers. Licensure is required for any activity involving public safety in order to “sign” docs (i.e. take responsibility).

To qualify for the licensing exams, one generally needs to have earned an undergraduate engineering degree from an ABET-accredited program. Obtaining a BA in, say, physics and then a PhD in engineering would not ordinarily qualify one to sit for the licensing exams.

- d) To clarify, if students plan to pursue work in civil, mechanical, chemical or structural engineering, then they should get an ABET-accredited degree?

Not necessarily. It depends on the type of work they want to do. If they want to do work that requires contract work for governmental agencies then there is a good chance they will need an ABET-accredited degree. If they want to go into R&D and/or are not interested in building structures (e.g., bridges, buildings, etc.) or products that are government regulated, then they do not need an ABET accredited degree. Even if a student does not become a professional licensed engineer (P.E.), having an ABET accredited degree can imply a standard of validity in the eyes of some employers and some graduate programs.

2. What does it mean to be a professional licensed engineer (P.E.) and what does this have to do with licensure exams?

a) What is a professional licensed engineer (P.E.) and who needs this certification?

A professional licensed engineer is an engineer who has met requirements in three areas as required by a state's licensing board. These three areas are education, experience, and examinations and these requirements vary by state.

A P.E. is a very specific certification and is not required for most forms of engineering or engineering jobs. P.E. certification is not required for engineers doing research or teaching, however P.E. certification is required for working on state-funded projects, especially ones that involve significant public safety such as buildings, bridges, energy production, and the like that must be completed to state codes.

Only about 20% of those who complete ABET accredited BS degrees eventually become P.E.'s. Although this is partially because some individuals fail the F.E. or the P.E. exam, in actuality many simply do not pursue P.E. licensure because it is not needed for what they want to do.

b) Why is professional licensure important for some engineers?

Professional licensure is the way that the state protects the public by enforcing certain standards that restrict the practice of engineering in specific areas of public concern to individuals who have met certain requirements. Since the licensure for engineering in the U.S. is regulated by the state, it is important for students to check the licensure requirements in the state or territory in where they want to practice.

c) How are the requirements for a P.E. met?

i. *The education requirement is met by earning an ABET accredited degree. Normally students enrolled in the last year of an ABET accredited engineering program will take the Fundamentals of Engineering (F.E.) exam. Those who pass the exam are sometimes designated "Engineer In Training" or "Engineer Intern," depending on their state's licensure board's approach to recognizing those who are partway through the licensure process. Opportunities to assist students preparing for the F.E. exam are often provided by the ABET accredited school that they attend. The experience requirement is met by providing work experience and professional references. The examinations requirement is met by taking appropriate licensing exams.*

ii. *In order to qualify to take the licensure exam, typically one needs an ABET accredited degree. However there are a few states that allow students with an engineering technology, physics, math, or chemistry degree, or without any degree at all to take the licensure exam, provided the individual meets certain experience requirements. For more information on the requirements for taking the licensure exam, please see <http://ppi2pass.com/faqs/qualifying-to-take-the-licensing-exams>.*

d) Where can I find additional information about licensure?

*National Council of Examiners for Engineering and Surveying (<http://ncees.org/>)
PPI: Exam Review Materials for Engineers and Building Professionals
(<http://ppi2pass.com/faqs/qualifying-to-take-the-licensing-exams>)*

3. What are pathways for students from liberal arts institutions to pursue engineering after completing their undergraduate degree and what are the pros and cons of these different pathways?

a) What are the three common pathways for students into engineering?

i. Pathway 1

Many liberal arts colleges have partnerships with one or more universities that allow students to obtain a degree from their liberal arts college and an ABET accredited engineering degree from the partner university. These programs are commonly called 3-2, 4-2, or dual-degree engineering programs. This is the presumed pathway into engineering for most entering students. This pathway works well for some students and provides a direct pathway to licensure.

ii. Pathway 2

The most common (actual) pathway into engineering is for students to complete their B.A. at the liberal arts college with a science, computer science, or math major related to their engineering interest and then to pursue an M.S. or Ph.D. in engineering at the university of their choice. This pathway may not allow for an easy P.E. licensure.

iii. Pathway 3

Students can also apply directly to engineering jobs after completing their B.A. in a related science, computer science, or math field. This is the most difficult pathway, but is possible.

b) What are the advantages and disadvantages of the 3-2, 4-2, and dual degree engineering programs?

i. What are these partnership engineering programs?

These programs allow students to obtain a B.A. degree from a liberal arts college in 3 or 4 years and a B.S. degree in engineering from the partner university in 2 years (and occasionally 1 year). In the initial 3 or 4 years, students must complete their home institution's distribution requirements, their major, and the course and GPA pre-requisites of the partnership institution. For some partner institutions, students must also apply to be admitted to the program. The most common forms of these partnership programs are 3-2 and 4-2 arrangements.

There are other versions of these programs that specifically address some of the disadvantages (see Section 3biii) of these partnership programs. For example the Dartmouth 2-1-1-1 program is structured like an abroad program so that students spend their junior year at Dartmouth, return to their home institution for their senior year, and then complete their B.S. degree after completion of their B.A. degree. In addition to the traditional 3/4-2 program, Washington University also offers a 3-3 program that allows students to earn a B.A., B.S., and M.S. by the completion of the program.

ii. What are the advantages of these partnership engineering programs?

There are three main advantages of these partnership engineering programs. First, students who start their studies at liberal arts colleges often have additional exposure to key value-added skills that enhance their ability to become exceptional engineers, particularly in areas of writing, communication, creativity, and lateral thinking. Second, many of these programs offer students guaranteed admission if they meet all of the requirements of the program. That said, because of the enrollment pressures this guarantee puts on the partner university, the partner universities are either raising the requirements to make it harder for applicants to receive guaranteed admission or they are offering preferred admission instead of guaranteed admission. Third, and most important, is that the B.S. degree is an ABET accredited degree, which is required for practicing some forms of engineering (see Section 1 on ABET accreditation).

iii. What are the disadvantages of these partnership engineering programs?

The main disadvantage is related to the extra time and expense required if students wish to pursue an M.S. degree in engineering. Since many engineering M.S. programs do not require an undergraduate degree in engineering, the dual degree B.A./B.S. programs add an extra 1-2 years (~7-8 years total) of schooling and financial aid compared to completing the B.A. degree and going straight into an M.S. program (~6 years total). This is where programs like the Washington University 3-3 program is attractive, since this program allows you to get an ABET accredited engineering degree and an M.S. degree in six years.

A second key disadvantage is the limitations dual-degree programs place on students' studies at college. A primary reason to attend a liberal arts college is to have the freedom of course offerings and curricular requirements to pursue a diverse course of study. A dual degree program puts significant constraints on the types of classes one can take in order to complete all requirements for both institutions in 5-6 years. The dual degree program can also constrain one's ability to participate in study abroad and sports.

A third potential disadvantage is related to financial aid. Students may not receive the same financial aid package as at their home institution as the partner institution's financial aid process is completely separate from the undergraduate institution. Additionally, governmental-based financial aid is only available to students for four years, so it is common for less aid to be available to students in their fifth (and sixth) years of undergraduate study.

Further, the partner school may not have expertise in the particular sub-area of engineering a student is interested in. Finally students who pursue the 3-2 program do not graduate with their friends at their home institution, a common concern among students who build strong relationships with their peers. Thus the 4-2 program can be more attractive or a program like the Dartmouth 2-1-1-1 program that allows students to return to their home institution for their senior year.

c) What are the advantages and disadvantages of students completing their B.A. and then pursuing an M.S. (or Ph.D.) in engineering?

i. Is it possible to be accepted to a graduate program with B.A. in science or math?

Yes.

ii. What are the advantages of the B.A./M.S. approach?

Students like the fact that they graduate with their peers, they can take full advantage of the liberal arts environment (i.e., more electives, study abroad, sports eligibility, etc.), and they can apply to an M.S. or Ph.D. program that most closely matches their specific interests. This approach requires less time and financial aid to obtain an M.S. or Ph.D. compared to most partner engineering programs. It is important to consider that while graduate school can be expensive, many engineering Ph.D. programs and certain M.S. programs provide financial assistance in the form of research and/or teaching assistantships, such that students pay no tuition and receive a stipend sufficient to cover the typical cost of living during graduate school.

iii. What are the disadvantages of the B.A./M.S. approach?

If the engineering work that a student wants to pursue requires an ABET degree and/or specific credentialing exams then the student may not be able to pursue such work without extra time and expense. (See Section 1 on ABET and credentialing exams.) It may be harder to gain admission to certain graduate schools without a B.S. in engineering, although many are open to admitting students with a B.A. in science or math."

- d) What are the advantages and disadvantages of going straight into an entry-level engineering position?
- i. What are the advantages of getting a job in engineering?
This allows the student to get first-hand experience working in the engineering field to better decide if they like it and/or if they want a graduate degree in engineering. Occasionally jobs will offer co-op programs that allow students to work towards a graduate degree with financial compensation to pay for the degree or a modified work schedule while working for the company.
 - ii. What are the disadvantages of getting a job in engineering?
It can be extremely challenging to obtain a job in engineering without an engineering degree. Many job listings do not advertise that they are willing to consider an applicant with a related science, computer science, or math degree, so the student must be willing to apply for jobs they are interested in regardless of the stated degree requirement. Additionally, students applying to these positions must be adept at effectively communicating their skills in engineering terms and skillfully writing their resume for an engineering position. This requires carefully translating a student's skills and experiences into engineering language that shows that the student has met the requirements stated in the job description. Close work with a campus career center, alumni networks, and personal networks can help facilitate finding and applying for these positions.

Another challenge for students directly entering the workforce is that engineers approach problems differently than scientists. Engineers must make a product work reliably in a way that scientists are not trained to do (e.g., tolerance analyses). This does not mean that students with a science or math degree cannot perform engineering jobs, rather it means that these students must be aware of the difference and seek training to facilitate the transition. Some companies are willing to pay for this training provided the student brings other valuable skills.

4. If a student wants to pursue engineering after attending a liberal arts institution, but does not want to pursue a dual-degree program, what coursework do they need?

- a) What should they major in?
Although students typically major in physics, chemistry, or computer science, it is also possible to pursue engineering with biology and math degrees. Students should choose a major closely related to the type of engineering they are interested in pursuing.

Engineering Area of Interest	Liberal Arts Major
<i>Biomedical Engineering</i>	<i>Biology and/or Physics</i>
<i>Chemical Engineering</i>	<i>Chemistry</i>
<i>Computer Engineering</i>	<i>Computer Science and/or Math</i>
<i>Electrical Engineering</i>	<i>Physics/Computer Science</i>
<i>Environmental Engineering</i>	<i>Physics/Chemistry</i>
<i>Mechanical Engineering</i>	<i>Physics</i>

Further, students are encouraged to take additional courses outside of their major to supplement their knowledge and skills. This is particularly true for interdisciplinary engineering fields like biomedical engineering and environmental engineering. For example, a student interested in biomedical engineering can either major in physics and take a lot of biology coursework or major in biology and take a lot of physics coursework. A student interested in environmental engineering could major in physics and take additional coursework in biology, geology and chemistry. Moreover, ABET-accredited undergraduate programs generally require a full complement of math and science courses. So students should try to take as many of these as possible. (See Section 4b.)

- b) What additional coursework should a student take beyond their major requirements?

Students interested in interdisciplinary engineering fields, should take subject courses outside of their major that are relevant to their area of interest. See 2a for examples of engineering fields and related academic departments where students might consider doing coursework.

Although not necessarily required to pursuing engineering, students should consider coursework that expands their engineering skill set if these skills are not already developed in their major. (Note these skills can also be acquired via extra-curricular clubs as well.)

Desirable Engineering Skills	Sample Coursework
Technical Skills	
<i>Desirable Engineering Skills</i>	<i>Sample Coursework</i>
<i>Computer Programming</i>	<i>Introduction to Computer Science</i>
<i>Laboratory Skills (e.g., basic error analysis, graphical analysis, etc.)</i>	<i>Introductory and/or intermediate experimental physics and chemistry courses</i>
<i>Basic Circuit Design</i>	<i>Introductory electricity and magnetism course with lab (depends on the curriculum), Analog Electronics and/or Digital Electronics Course</i>
<i>Equipment Assembly</i>	<i>Intermediate Experimental Physics Courses</i>
<i>Machining, technical drawings, and/or CAD software</i>	<i>Intermediate Experimental Physics Courses, certain art courses (i.e., courses that use a machine shop or maker space)</i>
Soft Skills	
<i>Decision-making, argument analysis, risk, probability</i>	<i>Critical thinking, informal logic</i>
<i>Cost-Benefit Analysis</i>	<i>Microeconomics</i>
<i>Ethical Reasoning</i>	<i>Ethics, applied ethics courses (e.g., bioethics, environmental ethics)</i>
<i>Engineering in context</i>	<i>Courses that look at the relationship between science/technology and society (e.g., science and politics, computers and society, history of science, etc.)</i>
<i>Creative thinking</i>	<i>Music composition, creative writing, studio design</i>
<i>Sustainability</i>	<i>Related coursework can be found in environmental studies, humanities, and social science department.</i>
<i>Tolerance for ambiguity</i>	<i>Courses in English, art history, or other areas where there are no “correct” interpretations</i>

Since ABET-accredited undergraduate programs generally require a full complement of math and science courses, students planning to pursue engineering without a dual degree program are strongly encouraged to take math through multivariate Calculus, two semesters of introductory physics with lab, a general chemistry course with lab, and an introductory computer science course.

If the students' liberal arts college is nearby to an institution that offers engineering, and cross-registration is possible, students should also strongly consider taking at least a few introductory engineering courses at that institution, to help the students ensure that their anticipated interest in engineering is accurate, and to demonstrate to future graduate schools or employers that they have a capacity to do well in engineering classes. Students who are not near to an institution that offers engineering sometimes take this coursework in a different location through summer school near an employment or internship opportunity.

- c) Are students required to take additional coursework in order to pursue engineering after completing their undergraduate degree?

Not necessarily. Some master's or PhD programs will add one or more undergraduate courses to students' graduate coursework if the program feels that this knowledge is essential background for their degree.

If the student is planning to go directly into the workforce, missing important field-specific coursework can be problematic even if the student feels capable of teaching themselves the material. If the student has other skills that make them a very attractive candidate, the student may be able to negotiate taking a course or attending a training to gain the desired missing skills.

Coursework in economics or computer programming will likely not be required by a graduate program. It would be expected that the student could pick up this knowledge on their own if this is needed. However with current technology trends, some knowledge of computer programming is strongly encouraged for any technology-related degree.

5. Are there particular issues to be aware of with regard to international students?

Historically dual degree engineering programs have been a popular option for international students. Normally the same standards as domestic students must be met to be admitted. One limitation is that some specific school-sponsored engineering internships or co-ops, such as working for a government contractor like Boeing, may be restricted to domestic students. Also, international students are not eligible for federal financial aid at their liberal arts school or the engineering school. It is possible there will be more limitations on need-based financial aid for international students, but this varies. Consult the specific engineering school for more information.

Another consideration is that ABET accreditation does not have the same importance for international students. If there plan is to return home and practice engineering, they should find out under what circumstances they will be able to transfer the engineering degrees back home.

6. How do I understand what engineers, in different engineering fields, really do?

This is a very difficult question since one can do a wide variety of jobs/research with the background from any number of degrees. For example, one could approach environmental engineering work from an electrical engineering, mechanical engineering, environmental engineering, chemical engineering, etc. academic background. The best way to figure out what different engineering fields really do is to identify someone (professional or research) doing what you are interested in and ask them about their path and the academic preparation of people that do similar work. Alumni, family, friends, neighbors, are also excellent resources.

Additionally, here is a list of other resources that may be helpful:

- *Engineering Your Future: A Comprehensive Introduction to Engineering* by William C. Oakes, Les L. Leone
- Websites:
 - <http://tryengineering.org/become-an-engineer>
 - <http://www.careercornerstone.org/engineering/engineering.htm>
 - <http://www.nacme.org/types-of-engineering>
 - <http://educatingengineers.com/career-specialties>