STEM's Many Branches:

College Planning for Students Considering Majors in Science, Technology, Engineering, and Mathematics

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Why we wrote this guide

College can be a wonderful time to explore your interests, find out where you excel, and discover your ideal career. But for many students majoring in Science, Technology, Engineering, or Mathematics (STEM), college is a demanding path, and one that requires a lot of focus from the get-go. So, you may have some questions before deciding if STEM is for you.

Maybe you're interested in one or more of the STEM fields but aren't sure whether or not you should major in them. Maybe you're curious about what kind of career a STEM degree might lead to when you graduate. Or maybe you just want to get a better sense of what your life might be like during and after college if you pursue a STEM path. We wrote this guide to help answer those questions.

Why is STEM so complicated?

The career fields in Science, Technology, Engineering, and Mathematics (STEM) are vast, complex, and very interrelated. There's a lot of mystery surrounding what engineers, technologists, scientists, and mathematicians actually do. STEM professionals are partly responsible for this. Once you're trained to talk like a scientist or an engineer, it's hard to remember how to translate what you do to someone who isn't well-versed in science or engineering. These days, there's a real push for STEM professionals to share what they do with a broader audience. But it can still be really hard to sort out the differences. And when you're in high school, it can be difficult to figure out which subject you want to study in college and where your degree can take you after you graduate.

Who are we?

For nearly five years, **Abby van Geldern** worked for Rensselaer Polytechnic Institute (RPI), first as an assistant women's soccer coach and then as an admissions counselor. As an admissions counselor, she traveled to California, Western Massachusetts, and Pennsylvania to talk with high schoolers about their STEM interests and passions. Abby's had a lot of experience helping students decipher the differences between the STEM disciplines and explaining the benefits of going to a predominately tech institution.

A majority of Abby's time was spent reading and evaluating applications of students applying to RPI, recognizing how they might contribute to the campus beyond the classroom and assessing which majors might be the best fit.

Although Abby didn't inherit the STEM gene, she has surrounded herself with engineers from the very beginning (her dad is a mechanical engineer and her fiancé is a biomedical engineer). She loves connecting with students and supporting their passion projects.

Meredith Graham spent 12 years as an admissions officer and academic advisor for college students who were interested in studying the STEM fields. Before that, she majored in chemistry in college and spent two years working in research and development at a large consumer goods company (more on that later), but realized she liked talking about STEM work rather than doing STEM work.

After graduate school, Meredith worked at Purdue University, where she spent two years advising first-year engineering students, and then three years advising students majoring in mathematics, statistics, and actuarial science. She also did some recruiting for Purdue's College of Science. Those experiences led Meredith to Cornell University, where she spent seven years as an admissions officer for the College of Engineering. Purdue and Cornell are both recognized for their strong and rigorous STEM programs, and for good reason. During those 12 years, no matter where she was working, there was always one constant. At least once a week, Meredith had a conversation that went something like this:

> **Meredith:** *"So tell me a bit about your interest in STEM."*
> **Student:** *"Well, I'm good at math and science, so my [teacher/parent/counselor/friend/neighbor] told me I should be an engineer!"*

As counselors, we love when students hear about engineering from teachers, parents, friends, and neighbors—that's great news! But not all of these students are a great fit for engineering. Some are better equipped to become scientists, others mathematicians, and still others technologists. But how can students figure this out? We've spent a lot of time learning to help students discover which area is really the best fit for them, and we're now sharing that knowledge with you.

We've both seen a lot of overlap when it comes to what STEM professionals do in the workforce and the kinds of projects they work on; for example, finding a cure for cancer isn't limited to any one area of STEM. But when students are considering what to study in college and how to best prepare, there can be some big differences. In this guide, we'll share some "representative examples" that will help you get a sense of the differences and similarities within the STEM fields.

Beyond the fields themselves, this guide will also cover some essential skills and traits that successful STEM students share, as well as suggestions for how to prepare for a STEM major while you're still in high school. We'll also share some resources so that you can explore the STEM fields on your own.

Defining STEM

While there's a lot of overlap when it comes to career options for STEM majors (more on this later), the differences between college choices, applications, and curricula can be huge depending on which STEM field you pursue. Before you make a decision, it's helpful to first define and explore each of the individual fields.

It might seem most logical to define the fields in the order that they appear in the acronym—first covering Science, then Technology, then Engineering, and then Mathematics. Personally, though, we don't think that's the easiest approach. Because they are so interrelated, we believe the best way to understand what is unique to each field is by starting with Mathematics, then covering

Science, then explaining Engineering, and, finally, Technology. This is the order we'll be following in this next section.

Mathematics

Mathematics is unusual in some ways—it is its own field of study, yet it is also a primary foundation for the other STEM fields at the same time. Most students know "math" as the arithmetic, algebra, and geometry they learn in school. In truth, mathematics as a discipline is very abstract and complex and quite different from what most students study in high school. As Peter, a friend of Meredith's who is a college math professor, once explained to her, "You're asking questions about the properties of the abstract mathematical universe and somehow you relate it all to pictures or counting."

Higher-level mathematics can be tough to follow, but here are a few examples of math that's used in the real world:

- If you've seen the movie *Moneyball*, you've seen how statistics can be used to analyze a baseball player's performance to build a team that can win championships, and maybe even do it for less money. The movie is based on a true story, which makes it all the more interesting!
- How can we mathematically describe the way curly hair moves? The Pixar movie *Brave* needed an answer to this question in order to make Merida's red mane move and bounce like real hair. Mathematicians wrote computer code that illustrated that movement and

actually created an entirely new software package that could handle the math to make 1,500 strands and segments of hair move individually to look more realistic.
- A book called *The Mathematics of Marriage* describes how different advanced mathematical principles can be applied to relationships, and it includes a mathematical model of marital relations. (Yes, really.)

Here's another example (we're paraphrasing) that Meredith's friend Peter uses in one of his classes:

There are 52 cards in a standard deck of playing cards. When you start shuffling the cards, how many possible orders of cards are there? The answer is 52! (the exclamation mark stands for factorial). You can calculate the actual product by multiplying 52 x 51 x 50 x 49 x 48, continuing all the way down to number 1. You can tell pretty quickly that this number will be absolutely huge. If you wanted to actually list all of the different orderings of that deck of cards, it would take a supercomputer the size of Earth itself a trillion times the age of the universe. Start listing them now! (Just kidding.) You have to come up with a clever way to solve this problem without doing any direct calculations. If working to answer that question sounds really awesome to you, then mathematics might be your thing!

Later in this guide, we'll talk more about how you can figure out if you want to pursue the study of math itself, or if you want to use your interest in math to support your study and work in other areas.

Science

Science is really about discovering and describing the world we live in. It often focuses on answering the "how" and "why" questions of the world. Here are several examples:

- Why does acid turn mouse blood cells into mouse stem cells? How can we use this information to create human stem cells?
- What does the flu virus look like, and how can we use its shape and characteristics to make vaccines that will prevent future outbreaks?
- How do we find and identify other planets that are similar to Earth?
- How do we prove whether or not global warming exists?
- Why does the universe have more matter than anti-matter?

Scientific discovery is rooted in the scientific method, which students usually study in their K-12 science classes. It involves asking a question, creating and testing a hypothesis, and then analyzing the results of the test and drawing conclusions from those results. (This is different from the method typically used in engineering and technology, but more on that later.)

Folks who work in theoretical science (the "science only" side of things) are exploring knowledge for the sake of knowledge. There might be a specific use for it later on, but that's not the reason for the exploration. The exploration is about building knowledge, and there's often no way to know if or when that knowledge will have a practical application. Sir Alexander Fleming didn't set out to discover a revolutionary drug known as penicillin. He just noticed something unusual happening in his world and approached it in a curious and methodical way. That's good science.

Engineering & Technology

If science is about answering "why" and "how" questions, the engineering response to those questions is something along the lines of "Okay, so what?" Engineers use math and science as tools to solve problems and improve people's lives.

Once you learn about engineering, you start to see it everywhere.

- Lots of people know that designing and building cars involves engineering, but you might not realize that the roads on which cars drive, and the design of the intersections and timing of stoplights, are also the result of engineering.
- Disney World is essentially built on a swamp. It took great engineering to figure out how to build a multi-billion-dollar theme park on a swamp, and then to make sure that the swamp would not reclaim the park. And within the park itself are all sorts of engineering feats, from Fast Passes (which manage the traffic in lines) to the coasters and rides themselves. Plus, engineers have to figure out how to keep so much foot traffic and waste from damaging the swamp that's still there—and that's not easy.

- Most of us take clean water for granted—it's a well-established feat of engineering where the majority of us live. In developing areas of the world, though, it's a problem that many engineers are still working on.
- A lot of modern medical tools are based on good engineering. Scopes and monitors are the result of engineering. So are prosthetic limbs and dissolvable stitches.
- Your smartphone? Engineers made that.

One common misconception about engineering is that you have to love math and science to be an engineer. That's kind of like saying that someone becomes a chef because they love to chop vegetables. If you've ever watched *Top Chef*, you'll know what we mean. The chefs talk about the creativity involved in cooking, about having a passion for food, about wanting to nourish people and to create great-tasting and nutritious food. But in all of the episodes we've watched, we've never seen any of the chefs talk about their passion for chopping things as their primary reason for becoming a chef. For an engineer, math and science are like a chef's knives: primary tools that need to be used with a great deal of skill and proficiency, but tools that are really just the means to an end. If they love those tools, great! But it's not a requirement for the job.

Engineering vs. Technology

Technology is very closely related to engineering. The Accreditation Board for Engineering and Technology (ABET), describes the difference this way:

"Engineering programs often focus on theory and conceptual design, while engineering technology programs usually focus on application and implementation." (You can find that definition and more here.) Sometimes technology programs are called "Engineering Technology," and sometimes simply "Technology."

Because engineering and technology are so closely related, it can be hard to separate the pure engineering from the pure technology. The chart below showing typical entry-level job tasks (and is adapted from an image created by the American Society for Mechanical Engineers that is used occasionally on various college websites) might help:

Engineering Tasks	Technology Tasks
Theoretical Research	
Complex Design & Analysis	
Analysis	
Systems Integration	
Development & Design	Development & Design
Test & Evaluation	Test & Evaluation
Company Management	Company Management
Component Design	Component Design
	Manufacturing
	Production Engineering
	Operation, Service, & Maintenance
	Distribution & Sales
More Mathematical/Scientific Tasks ↑	*Less Mathematical/Scientific Tasks* ↓

Basically, engineers focus more on theories, ideas, and initial prototypes, while technologists focus more on the hands-on component of making things happen and improving and maintaining something once it has been created. An engineer will design a new car, while a technologist will "tweak" the design to improve it for future models. Again, this isn't an absolute—some engineers focus on the hands-on side and some technologists focus on the conceptual design—but it is a general distinction.

Instead of the scientific method, engineers and technologists use something called [the engineering design process](). Engineers and technologists identify and research a problem, brainstorm solutions within required parameters, choose the best solution, and then create a prototype to test and refine. If the original solution fails completely, they can go back and choose a different solution to prototype and refine. Just think about all of the different solutions people came up with to try to make human flight possible before the Wright Brothers found something that ultimately worked.

Curriculums: Engineering vs. Technology

When it comes to college classes, the curriculum in a typical engineering program has a very different focus than that of a typical technology curriculum. In both kinds of programs, students will get some theoretical and some hands-on study, but the emphasis will depend on the program. In college, engineering coursework emphasizes a lot of higher-level mathematics (typically 2-3 semesters of calculus along with linear algebra and differential equations) and requires more pure/theoretical science courses. An engineering student can also expect to take a calculus-based physics class or two. Technology coursework tends to focus more on math at the algebra and trigonometry level, along with applied calculus and other more applied courses. A technology student will typically take algebra-based physics classes rather than calculus-based ones.

Are you an engineer or a scientist?

For the remainder of this guide, we will be blending math and science under the “science” label, and combining engineering and technology under the “engineering” label. Since pure math and pure science are usually concerned with the same kinds of “why/how” questions, and engineering and technology are usually concerned with similar kinds of problem-solving and design issues, this is more or less a shortcut. We don't want to shortchange math or technology in this process, but we do want the rest of our guide to be easily understood. Where there are issues specific to math or technology, we will highlight them separately.

In some ways, the "science vs. engineering" question is an exaggerated distinction. Once you're out in the workforce, the tasks start to blend together in many cases, and there aren't a lot of real-world issues that involve only pure science or pure engineering. At this point, though, it's a vital distinction because a number of colleges will require students to make a choice during the application process. So here's the question. Do you want to be a scientist or an engineer? A mathematician or a technologist?

Math or…?

Students who are passionate about math often have a really tough time with this choice. Since mathematics is its own specific discipline but also a foundation for science, engineering and technology, it can be tough to make a decision about which STEM area to pursue at the outset.

A former mentor of Meredith's, Alan, used to pose the following question to students who were debating the "math vs. other STEM area" question: *Are you more interested in knowing how to make the calculus work to solve other problems, or are you more interested in the proofs of why the formulas/procedures in calculus are working?* Someone who likes math for the sake of math is probably going to be more engaged by pure and theoretical mathematical coursework and should therefore seriously look into a math major. However, students who want to make the math work so they can use it to solve other problems will probably find one of the other areas more appealing. This isn't a perfect solution, but it gets students thinking along the right lines. And it's not unusual for students who major in science or engineering to end up taking a lot of math courses, perhaps even to the point of a double major or dual degree. It's less typical, however, for students in technology, given the different math needs of most technology majors, as we described previously.

When Meredith was at Purdue, she worked with a student while she was advising engineering majors. Shortly after she made the switch to advising math majors, Meredith ended up working with this same student again when he changed his major from chemical engineering to mathematics. They talked about why he had made the change, and he told her that he finally realized he loved math for the sake of math. He found himself spending more time working the proofs in his advanced math classes than he was on his engineering calculations. And he worked them by *choice*, not because they were homework assignments. He just really loved what he saw as the beauty and elegance of math.

Science vs. Engineering

If you already know that you want to use math to help solve problems in other fields, now is the time to figure out where you want to focus your attention. As we mentioned earlier, science majors are generally more concerned with understanding how and why the world is the way it is, whereas engineering majors like to find and create solutions to problems in the world.

If you compare the scientific method with the engineering design process, you'll get a sense of the different approaches.

When you think about your interests, are you mostly curious about how and why things work the way they do and why our natural and physical world is the way it is? Or are you more interested in harnessing facts to create new solutions to problems in the world?

If you have a pretty clear internal answer to those two questions, then you probably have a good idea of whether you want to study science or engineering in college. When in doubt, look at a plan of study for a science major at a few different schools and compare it to a plan of study for an engineering major. Read the descriptions of the courses you'll take at those schools. If you have any "Oooh, that sounds so cool!" or "Ugh, that's not what I want to study!" moments, take notice—this might help solidify your decision.

During our time working in admissions, we had frequent conversations with students and families about the similarities and differences between chemistry and chemical engineering. This is a great example of an instance when reviewing the plans of study for each major made a huge difference. At most colleges, chemistry majors will take classes in organic, physical, analytical, and inorganic chemistry. Chemical engineers will also take organic chemistry, but then they'll study topics like heat and mass transfer, separation processes, and process dynamics and control. For most students, seeing those differences was a great first step toward determining which field was the best fit.

This technique also helps students understand the differences between engineering and technology. When Meredith was at Purdue, one of the students she was advising realized in the middle of his first semester as an engineering major that he wanted to study technology instead. He figured this out when he saw what his hallmates were doing in their technology classes and realized that he was more interested in working with them on their hands-on homework assignments than working on his own theoretical calculus homework. He took a serious look at the coursework ahead of him as an engineering major and then at what he could be doing in technology. It was a pretty clear-cut "Ooh!" vs. "Ugh!" moment for him, and he listened to the voice inside and made the necessary changes.

Real-World Science & Engineering

We've said this before, but it's worth repeating: there's a lot of overlap when you look at what scientists and engineers do once they're out in the workforce. Here are a few examples that show how things start to run together.

- Finding the cure for cancer involves folks across all STEM disciplines. A mathematician will model how a carcinogen moves through the air or water. A scientist will explore how that carcinogen triggers cancer in a living body. Once we know how the cancer is triggered, an engineer or a scientist (or maybe both) will see what math and science facts they can use to "turn off" the cancer—such as chemotherapy. An engineer or a scientist (or both) will identify chemotherapy drugs that work against this particular kind of cancer. An engineer will design a delivery system for that chemotherapy drug. A mathematician or scientist (or both) will model how the chemotherapy drug moves through the body to minimize damage to non-cancerous cells. An engineer or a technologist (or both) will continuously improve the chemotherapy delivery system.

- As mentioned earlier, Meredith's first job after college was in the research and development department for a large, well-known company. They were working with biodegradable plastic, and her team was made up of individuals from across the STEM fields who came together to try to figure out how this plastic could be used out in the marketplace. A mathematician used different models to describe how traditional plastic behaved at a variety of temperatures, and he worked to tweak the models so that they could also describe the behavior of the biodegradable plastic. A scientist (that was Meredith!) worked on exploring how the plastic actually behaved under different temperature and stress conditions. Other scientists were modifying how the plastic was made to see if it would behave differently when made differently. An engineer worked to figure out what this plastic could be used for and also made prototypes of things like plastic bags, travel-sized bottles, and plastic syringes. A technologist worked with the engineer to create and improve the equipment used to make the different prototypes.

We've laid both of these examples out to resemble something of a sequence, but you can probably tell that the work wasn't sequential. One person's results impacted the next and created new areas for scientific research or new problems that required engineering solutions. In the fields of science and engineering, everyone works together on a team to achieve breakthroughs. It's pretty exciting stuff.

Qualities of Good Scientists & Engineers
(And how to develop those qualities now)

There are a number of skills you need to hone if you want to succeed in the STEM fields. Yes, you need technical skills, but we're talking about the skills that go beyond just math and science.

Persistence

In high school science labs and math classes, students are asked to complete tasks where the outcomes are already well known by the teachers. In real life, things are quite a bit different. Folks in STEM are working to discover and build new knowledge to solve problems that have no existing solutions—there's no lab manual or answer key. Maybe you'll try something new and it won't work out the way you thought it might. So you tweak it and try it again. And again. And again. And again. And yet again. It can be very frustrating sometimes. But you have to keep trying, and eventually you'll get results. And it's SO exciting when you do!

You can practice being persistent in a lot of ways. If you're frustrated by a math problem, don't give up. Work on something else for a while, and then come back to it. If your jump shot isn't as strong as you'd like, don't give up. Practice your dribbling and your foul shots for a while, or walk away from the court for a bit and then come back to it. If there's a part of your piano recital piece you just can't get quite right, don't give up. Spend some time on a different piece or another activity entirely, and then come back to it. With persistence, you will improve.

Creativity

As we just mentioned, scientists and engineers spend a lot of time trying things, tweaking them, and trying them again. Sometimes the tweaks might be pretty obvious ideas, like turning up the heat a little, or changing an angle slightly. Sometimes, though, scientists have to look beyond the obvious and find inspiration in unexpected places. For example, Abby has a friend who was working on a new design for a coil stent and was suddenly inspired by her own tattoo of a four-leaf clover. Now she has a patent on that stent design. Another friend of Abby's studied ways to use spider silk in regenerative medicine during grad school. And a few years ago, NPR ran an article on a new surgical adhesive that was inspired by slugs. These might seem like unusual examples of STEM professionals finding inspiration, but that's what makes them creative!

Creativity probably isn't the first quality people think of when they consider STEM careers. But innovation and breakthroughs require creativity—it's just as vital as math and science skills. And that's what keeps STEM fields moving forward. An interest in art or music or theater doesn't detract from strength in math and science. It really adds to a student's potential in the STEM fields. If you love singing or drawing or acting, or you write music or do improv comedy, keep doing it! These activities can only enhance your skills in STEM.

Patience

Since real-life work as a scientist or an engineer doesn't always have a clear-cut path, you can't predict when you'll have a breakthrough. And a lot of scientific experiments and design processes simply can't be rushed. You'll spend a lot of time waiting for an experiment to run, or waiting to have a complete data set of your results, or waiting to see whether or not the computer code you've written will do what you want it to do, or whether or not your first prototype will work. And these processes all require patience.

We are so used to text messaging, Twitter, and overnight delivery from Amazon that it's tough to remember that not everything happens instantaneously. And it's hard to practice being patient. (Meredith admits she is not a particularly patient person, so she knows this from experience!) Earlier, we talked about persistence and sticking to a problem—your math problem, jump shot, and piano piece will all improve over time if you're persistent in your work. But none of them will improve instantaneously, and that's where patience and persistence go hand-in-hand. You have to allow time for the work you do to show results.

Teamwork

The stereotypical image of a scientist or engineer is usually some individual working alone in a lab or at a computer. Most people assume that STEM work is solitary, but this could not be further from the truth! Think of those real-world examples we shared earlier in the guide. STEM work is nearly always done as part of a team, where each individual's work relies on someone else's work and/or ideas. Sure, there are times when you might be alone in a lab or at a computer working on your own part of a project. But STEM work is far from a solitary endeavor.

In high school and in college, it can be very frustrating to work on a team. Maybe you care a lot about a particular project, but you've got a teammate who isn't pulling his own weight, so you're worried about the project's outcome. Maybe the person in charge of the team is insisting on doing it her way and won't listen to ideas from the group, even when they're good ideas. Maybe it just seems easier for you to do the whole thing yourself.

Being a good teammate is hard work, but there are a lot of places to practice this skill. The soccer team, student council, mission trip, or a part-time job can all offer you plenty of opportunities to be a valuable part of a team. You can practice being in charge of a team, listening to others' ideas, and bringing them all together. You can also practice giving other team members the opportunity to take the lead, asserting your ideas to the team leader, and trusting others to do their share—even if they don't do it the way you would have done it. And you can practice pulling your weight and meeting deadlines, even when the project is a low priority in your life. At some point, you'll need all of these skills in STEM careers—and beyond.

Tolerance for ambiguity

One of the most exciting things about science and engineering is that there aren't always clear-cut answers. On the other hand, one of the most frustrating things about science and engineering is that there aren't always clear-cut answers. In high school, there's a right way and a wrong way to do that math problem. There's a right way and a wrong way to run that physics experiment. In real-world STEM work, this is rarely the case. Yes, there are safety considerations, and you will need to be accurate and precise in your work in order to achieve accurate and precise results. And there are real-world limitations such as money…and gravity. But beyond that, a single problem or question can be approached using any number of different ideas or methods. Some approaches will yield great results, some will yield acceptable results, some will yield poor results, and some ultimately won't yield any results at all. You don't know which ones will work when you start out, though. You discover the best solutions through persistence, patience, creativity, and teamwork.

When Meredith was an academic advisor, this was a major challenge for a lot of students—they were so used to the "right way/wrong way" model that they got frustrated when their professor would suggest one approach to a problem or question, a teaching assistant would suggest a different approach, and a classmate would suggest an entirely different approach. Every fall, Meredith would have a handful of students tell her, "My T.A. doesn't know what she's doing. She can’t figure out how to solve the problem my professor assigned in class. She ignored what my professor showed us and started the problem a completely different way!”

Meredith found that students could accept this ambiguity in other areas of life. It’s easy to understand why there are so many different plays in football, or why there are so many different recordings of *Beethoven’s Fifth Symphony* by different orchestras around the world—but in math and science, this was a revelation. Even if you complete your homework the “right way” (i.e. using the same method your teacher does), is there a different way to do that math problem and still get the same results? How about that physics experiment? If you start looking for these differences now, it’ll be that much easier when you start to run into multiple approaches and ambiguous experimental results in your college classes.

STEM, STEAM, & Innovation

There’s been a big push to integrate the arts into STEM over the past few years, so you’ve probably run across the acronym STEAM as well. Truth be told, Meredith is not a huge fan of the STEAM variation, and people often ask why. She worries that the STEAM acronym actually minimizes the importance of the arts, that they only exist in service to STEM rather than being vital on their own. A friend of hers who is a choir director recently said that “STEAM is kind of like saying that the only purpose for a person’s mouth is for kissing.” It's a funny comparison, but there is some truth in it.

The arts are a critical part of the human experience—in communicating, in living, in experiencing all that life has to offer—and she thinks it's just as important to celebrate the arts for the sake of the arts as it is to celebrate STEM.

Abby agrees with Meredith—to an extent. In her view, the arts should be honored and respected, but she recognizes the benefits of using art as a tool/resource in the STEM disciplines. When you're looking at products, buildings, and even technology, you expect to see aesthetics at work. Take bridges, for example. We don't marvel at the function of the Brooklyn Bridge, but rather the allure of the suspension system and the architectural detail of its arches. When Abby worked at Rensselaer Polytechnic Institute (RPI), she was fascinated by the School of Architecture's curriculum, which gave students the opportunity to focus solely on the creative process for their first two years of college. This course of study trained students to become designers and innovators before learning how to construct and build. By the time students graduated, they'd learned to harmonize design and construction together quite nicely. Need an example? Just look at George Ferris' (RPI Class of 1881) novel design of the Ferris wheel.

One thing we can agree on is that STEAM broadly emphasizes the importance of creativity and innovation in STEM. In a previous section of this guide, we talked about creativity and its application to STEM, but we believe the role of innovation deserves its own discussion.

While at RPI, Abby was particularly intrigued by the Design, Innovation, and Society (DIS) program, which integrates STEM with artistic, visual, and musical design with the aim of producing solutions to social problems. It's one of the most unique design programs in the US—successfully blending STEM and the arts, enabling students to find creative solutions to real-world problems.

A great example of this was a project inspired by RPI's "Change the World" innovation competition. A DIS student recognized the global need for reducing pollution caused by plastic water bottles. Despite easy access to reusable plastic water bottles, the number of discarded water bottles is still staggering. Inspired by an origami design, the student decided to redesign the reusable water bottle. He made one that was collapsible, making the bottle easier to pack and transport. You can see in his design video the integral relationship between STEM and the arts.

Another student, who was also an RPI baseball player, recognized the severity of concussions in his sport. Inspired by his own experience and struggles with concussions, he decided to redesign the baseball helmet with an ultrasonic sensor and an airbag system. The sensor would detect when a projectile was moving toward the helmet above a certain speed and activate the airbag before the object hit the helmet. His goal was to alleviate the pressure of impact and hopefully help athletes avoid concussions.

There are elements of the art/STEM interplay embedded in many STEM programs, but this RPI program is a wonderful illustration of the power and relevance of creativity, innovation, and the ways art and STEM subjects intersect.

Application considerations & picking a school

If you are fairly certain which STEM area you want to major in, choosing which colleges to apply to can be relatively easy. But for students who aren't as sure, this part can feel intimidating. At the end of this guide, there's an appendix that lists some well-known schools that require you to select a STEM major when you apply, and other schools that don't.

Schools that don't require a declared major when you apply

Some colleges don't require you to declare a major when you apply. These schools are ideal for students who have an interest in multiple areas within STEM, or who simply can't pick which area they want to focus on yet. If you decide to apply to schools like this, you'll want to make sure they offer the STEM majors that appeal to you the most. You should also take a closer look at the classes you'll be required to take to declare a specific STEM major and if the program has a minimum GPA requirement to be admitted as a major.

You may find that many of the smaller schools won't offer all the specialties in engineering and science that larger colleges do. Don't worry about this too much. Since the STEM fields work together, a solid education in a major that excites you (and at a school you love) will give you a strong STEM foundation. While you're in school, you can look for electives, internships, or activities that can give you experience in your specialized area of interest. Some students opt to work for a while before transitioning into their specialized field, while others decide to go on to graduate school.

When Meredith worked as a scientist, one of her labmates had also attended a small college. But while Meredith had majored in Chemistry, he had majored in Earth Science. They were working side-by-side and utilizing the same skills, but they had developed those skills in different majors at different small colleges. And there was another graduate, also from a small college, who worked down the hall from them in an analytical chemistry lab. She had studied biology in college. For all of them, developing their STEM skills and taking advantage of opportunities in college mattered more than the actual majors they selected.

Schools that require a declared major

Many larger colleges require you to choose a major when you apply. At a minimum, you'll need to decide on "engineering" or "science" or "technology," even if you don't have to choose "mechanical engineering" or "biology" or "electrical engineering technology" right off the bat.

When you're considering schools in this category, find out what steps you'll need to take if you decide to switch from science to engineering, or engineering to technology. It will also be helpful to ask the following questions: Is changing majors allowed? How often does it happen? Is there an advisor to guide students who want to make the change? Who decides whether or not you can make the change? How and when do they decide? Do you have to take certain classes or earn certain grades? Is there a website you can access to learn more before you even apply? Many schools allow students to switch between science and engineering, or engineering and technology, but the process can be complicated. That's why it's important to spend some time thinking about which area of STEM is the best fit before you apply.

If you're unsure about committing to a major, there are a few ways to get a better sense of your interests. You can read the descriptions of the classes you'll take in the different STEM majors you're considering and see which one sounds most interesting to you. (We have more suggestions for this process in Appendix C of this guide.) You can also check out a school's career services office to see what their STEM graduates go on to do. Additionally, you can use the resource list at the end of this guide to explore the STEM areas more fully. And finally, you can ask yourself the following questions that we covered earlier:

- Do you like understanding how math works for the sake of the math itself, or do you prefer applying the math to other kinds of problems? If it's the first part—you loved the proof of the Fundamental Theorem of Calculus—then take a look at majoring in math.
- Are you mostly curious about how and why our natural and physical world is the way it is, or are you more interested in harnessing facts about the world to solve problems? The first part is more of a science approach, and the second is more of an engineering approach.
- When you look at the scientific method and the engineering design process, does one of them appeal to you more than the other?

- Are you more interested in focusing on ideas, theories, and initial prototypes, or are you more interested in taking a prototype or existing item and tweaking it to improve it? Engineers usually fall into the first category, and technologists into the second.

When Meredith worked at Purdue, she read a profile of an alumnus who had graduated with his degree in materials engineering 10 years earlier. At the time the profile was written, he was working as an aeronautical engineer; his transferrable skills allowed him to cross-train and learn information that was new to him and critical to his new field. Meredith also advised a young math major at Purdue who, since graduating, has consistently landed jobs that focus more on engineering than math. These are both examples of students who chose schools that they loved and majors that excited them and have found success in the workforce.

You still might not be 100% clear on whether you would rather be an engineer or a scientist, and that's okay. Finding a school you love, pursuing a major you enjoy, and taking advantage of all the opportunities you'll find in college are the most important pieces of this puzzle. If you make those things your priority, everything else will likely fall right into place.

Frequently Made Mistakes

We know we just told you that everything will work out even if you're not 100% clear on what field of STEM you want to major in. But the more work you can do to clarify this for yourself, the better off you'll be. You can make sure to choose a college or university that offers the majors you are most interested in, and a school that is also a great fit for you in other ways as well. And there's no excuse for not making an effort—you've got the resources and the time!

Here are a few examples of folks who have learned this lesson the hard way:

- When Meredith was at Cornell, the application included an essay question specific to the applicant's interest in engineering. The admissions team wanted to make sure that the student knew something about engineering and that she could see herself as an engineer. Even if the applicant had just discovered engineering within the past year, she could still show the admissions team she understood engineering. The most disappointing and frustrating essays were from students who didn't seem to have any awareness of engineering. Those essays typically highlighted engineering clichés. The two most common were: *"I'm good at math and science and that's why I want to study engineering,"* and, *"I want to go to med school (or law school) and I hear a degree in engineering is a great foundation for that."* (There was also a healthy dose of: *"My parents say it's a great career choice,"* which didn't bode well when the student didn't show any engineering interest!) Students who fell back on these simplistic explanations while writing about their interest in engineering didn't help their applications. It was really hard to say yes to an applicant who didn't seem to have any idea of what engineering was really about—and students who wrote those kinds of essays were rarely admitted.

- While at Boston University, Meredith worked with students who were withdrawing from the university for any reason. She met with one student who was withdrawing after his first year because BU didn't offer his major of interest, which was civil engineering. Meredith assumed it was a new interest of his since he had chosen BU, but he said he'd always known that he wanted to be a civil engineer. He had no clear answer as to why he had chosen to attend a university that did not offer the major he was most interested in. As a result, he had to transfer schools to finish his bachelor's degree. Simple research would have saved him a lot of time, hassle, and heartache.
- When Abby was at RPI, the university offered majors in computer science, computer systems engineering, and information technology and web science. Each of those majors were housed in a different college on campus, and they all had their own entry point in admissions. The individual majors covered different—although overlapping and clearly related—content. Most students had a predominant interest in developing computer software, designing computer hardware, or bridging the gap between software and hardware. But every summer during new student orientation, a number of incoming students would realize they were in the "wrong" program for their interests—they wanted to work with hardware design but had applied to the more software-focused program, or they really wanted to be an IT and database administrator, but they were in a track that focused more on hardware design. It

> was horrible to see the look on these students' faces when they realized they were starting their college career in the "wrong" major. It was even more horrible when they saw the number of steps and amount of time it would take to change majors (it was rarely an option to switch programs on the spot). Sometimes it would take them an extra semester or even an extra year to get the classes they needed to transfer into the "right" major. Reading over the plans of study for these majors BEFORE applying would have saved those students a semester or a year, and also would have prevented them from feeling like they were already behind and scrambling to keep up.

Now, we're not trying to scare you by sharing these examples. None of the situations we listed were so permanent that they couldn't be shifted. It's our hope, though, that you'll be more thoughtful than those students, now that you're armed with a little knowledge and wisdom.

STEM & Employment

As you're probably aware, there's a lot of talk right now about STEM training and employment. The details differ depending on the source, but the general consensus is that STEM graduates are highly employable as a whole, and that we need people with a wide variety of backgrounds to be involved in STEM careers.

- The Brookings Institute released a study in 2013 called "The Hidden STEM Economy" that talks about high employability in STEM fields, even for graduates with two-year degrees and certificates.
- The National Association of Colleges and Employers (the professional association for college career counselors) regularly shows that students heading into STEM jobs will be at or near the top of the salary ranges for students right out of college.

Money isn't everything. And in our experience, STEM education is truly at its best when it's balanced with the study of the liberal arts and humanities. But in an age of rising college costs and questions about the return on an investment of college tuition, it helps to know that STEM education typically sets the stage for careers that are financially sustaining and provides opportunities for personal and professional growth. As always, students who are full participants in their education and take advantage of the opportunities their college offers will be in better shape come graduation than students who simply "exist" in a STEM curriculum. A student pursuing STEM education simply because of the potential for a large paycheck is no different from a student who pursues a highprestige college simply for the name. But there is a lot of room within STEM for people with a wide variety of skills and interests. You can steer your STEM education in many different directions. And we need people with a variety of backgrounds and interests to get involved (and stay involved) in STEM careers!

So, what's next?

So far, we've described each of the STEM fields and talked about how they are similar to and different from each other. We've also talked about the kinds of work that STEM professionals do and some of the qualities that will help you to be successful as a STEM student and, later on, as a STEM professional. But what can you do *now*?

Explore STEM

At the end of this guide, there is an appendix with a variety of online resources you can explore to learn more about STEM. Here are a few of our favorites:

- "STEM is Cool Video Contest" from Change The Equation: The videos on this playlist were produced as part of a contest a few years ago, and the winning videos are pretty fun tools that can help you learn a bit more about STEM. In particular, check out the videos from Activision, Dow, IBM, Intel, Raytheon, and SAS—we found them to be the most engaging and informative of the videos.

- "The Secret Life of Scientists and Engineers" from PBS: Each profile highlights a different scientist or engineer. Each person's area of science is featured (from neurobiologist to architectural engineer) and their "secret" is revealed (from NFL cheerleader to professional wrestler to stuntwoman). Each profile is broken down into short video clips, and they are wonderful profiles on the people, their science, and their lives.
- "Pathways to Science": Our favorite part of this site is the extensive list of summer programs—many of them **paid** programs—available to high school students who want some hands-on STEM experience before applying to college. It also includes tons of information on career paths for students interested in STEM.
- Sloane Career Cornerstone Center: This is a **very** information-dense site that doesn't have a lot of personality to it. However, the information is incredibly extensive and high quality. And it's free. If you are specifically interested in the differences between chemical engineering and chemistry, or if you want specific information on career paths for mathematicians, this is a great starting place.

Consider your high school classwork

No matter where students apply, admissions counselors will take a thorough look at the applicant's transcript. Some of our students are surprised by this—it really is about more than just your math and science coursework! If you think about the pieces of an application, however, the transcript is the most comprehensive picture of the student's last four years. Beyond grades, admissions officers can see what academic areas interest you, where you feel the most comfortable in the classroom, and how you’ve challenged yourself academically.

Why are these significant in the world of college admissions?
We’re so glad you asked!

When admissions counselors are reading thousands (yes, thousands) of applications for students interested in the STEM fields, it's easy for applicants to blend together. Most students who are planning to major in a STEM field will be enrolled in a rigorous math and science curriculum, but students can set themselves apart by choosing the courses that best match their interests.

If you're thinking about majoring in biology, you should take as many biology classes as you can. If your school offers an engineering elective and you're thinking about majoring in an engineering discipline, it makes sense to enroll in one—or all—of those courses (schedule permitting, of course). Course selection shows an admissions counselor that you're not only interested in a particular subject, but also at least somewhat experienced in that field.

Our biggest piece of advice is to have some fun with your course selection, especially in the places where your curriculum is more flexible. If your school offers them, feel free to take a "greengineering" course, a meteorology class, or even that game design elective (yes, these courses actually exist at some high schools).

There are a few courses that are non-negotiable if you are considering a STEM major in college. You'll generally be expected to have at least three years of science, including Biology, Chemistry, and a lab-based Physics course (preferably one that uses calculus). Students should also complete four years of math in the Calculus stream, so you need to get through Precalculus at an absolute minimum (but know that many STEM programs actually require you to have Calculus in high school in order to be admitted). Colleges have these requirements not simply to challenge students, but also to give them a strong math and science foundation before they start their college-level STEM curriculum.

We also want to remind students that English, foreign language, and History classes are just as important, so don't neglect them. Colleges love well-rounded students, so if you like history as much as math, feel free to dive deeper into both subjects. You may even find a unique connection between them—how else would you learn about both the scientific and the historical implications of the Tacoma Narrows bridge collapse?

Beyond taking the "right" courses, admissions officers want to see that you've challenged yourself academically. Now, we want to be very clear here: every student has a different capacity for academic rigor, and we recognize that. We don't want students enrolling in every AP offered to them simply to demonstrate rigor. Instead, students should challenge themselves in the subjects they're most comfortable and confident. If your freshman math course was a breeze, talk with your school counselor about jumping into the honors course sophomore year. If you can do physics problems in your sleep, you might want to take AP Physics C senior year. We encourage each of our students to talk with their school counselors and current teachers to determine the appropriate course level for them. Trust their guidance. They've seen how you work in your classes and can make strong and specific recommendations for you. The last thing you want is to bite off more than you can chew. Success in your classes is just as important as the level of the class—and sometimes even more important.

As college counselors, a common question we hear is: "What should I do if my school doesn't offer [*insert course title here]*?" We understand that some students may be confined by what their schools offer, but when you're passionate about a subject, you can find ways to pursue it outside of school, too. We've seen students enroll in courses at a local community college or take classes through a virtual high school. For example, Abby had a student who really wanted to learn how to code, but she wasn't able to enroll in classes through her high school, so she decided to enroll in several edX courses. With the help of online instruction and her individual persistence, Abby's student learned four computer languages in one summer.

If you're preparing for the STEM track, make sure you get through Precalculus and stick with the Calculus stream of math courses as long as you can. Take three years of lab science in high school, especially Biology, Chemistry, and Physics. And choose challenging and interesting courses for your language, humanities, and elective courses.

Below, we've highlighted a few ways students can progress throughout their math and science curricula while continuing to challenge themselves each year. We used some high school course catalogs (from schools near Collegewise offices across the US) to show you a few possibilities. We recognize that every school is different, so what your school offers might look completely different.

	9th Grade	10th Grade	11th Grade	12th Grade
MA High School Curriculum	Physics	Chemistry	Biology	Science Elective
	Honors Physics	Honors Chemistry	AP Biology	AP Science Elective
OH High School Curriculum	Physical Science	Biology	Chemistry	Physics
	Biology	AP Chemistry or AP Biology	AP Biology or AP Physics I & II	AP Physics C
CA High School Curriculum	Biology	Chemistry	Physics	Science Elective
	Honors Biology	Honors Chemistry	AP Physics I & II	AP Science Elective

Here are some possible math progression sequences (depending on the level where you begin and what your high school offers):

9th Grade	10th Grade	11th Grade	12th Grade
Geometry	Algebra 2	Trig & Analysis	Foundations of Calculus
Honors Geometry	Honors Algebra 2	Honors/Advanced Precalculus	AP Calculus AB
Honors Alegbra 2	Honors/Advanced Precalculus	AP Calculus AB	AP Calculus BC
Honors/Advanced Precalculus	AP Calculus AB	AP Calculus BC	Multivariable Calculus

Develop the “five qualities”

So you’ve explored STEM and considered your high school coursework. You’re well on your way to getting yourself ready to pursue a STEM major at college. What else should you be doing now? Work on developing **the five personal qualities** we discussed earlier.

At Collegewise, we believe that students should get to know themselves and pursue their own interests—there’s no “magic formula” for college applications. Find out what you want to pursue and get involved. There are a number of STEM-specific activities available at many high schools, such as FIRST Robotics and Science Olympiad, but don’t worry if your school doesn’t offer those. Playing soccer, working a part-time job, volunteering at a food pantry, and singing in the choir all provide great opportunities for developing *persistence, creativity, patience, teamwork,* and *tolerance for ambiguity.*

Find the right college for you

As college counselors who make a living helping both STEM and non-STEM majors find the right schools for them, we have one piece of advice we share with everyone: Unless you apply to a binding, Early Decision school, remember that for now, you’re just applying. You don’t decide which school you’ll actually attend until May of your senior year.

The fact that there is a difference between applying to a college and actually deciding to attend that college is a powerful realization for many students. For example:

- You can apply as a Math major at some schools and undeclared at others.
- You can apply to a few schools that have absolutely nothing to do with STEM programs.
- You can apply to a rigorous engineering program at one school and a psychology program at another.
- You can apply to some schools that are big and others that are small; some that are close and others that are far away; some that have football teams and some that don't (and the list goes on).

We're not suggesting that you should be so unfocused that you apply to 40 colleges—that's always a bad idea! But don't force a focus that isn't there yet. For now, you're just researching and applying. You'll get much more focused once you decide which college you'll attend. And a lot can change in just a few months of your senior year.

Final Thoughts

College is a time to try new things, to learn, and to explore. You might go to college and decide not to major in STEM after all, or you might decide to switch from math to engineering, or science to technology. That's totally normal. If you just make sure you're being true to yourself and making the most of the opportunities you have at your high school and your college, you'll build a remarkable college experience, post-college life, and career for yourself.

Appendix A: The Application Process

A sampling of schools that do (and do not) require students to declare Engineering during the application process. Our amazing Collegewise colleague, Arun, put this list together for some of his students and families a few years ago. Many thanks to him for letting us include it in this guide!

The first table includes some highly ranked universities (listed alphabetically) that ask students to declare Engineering when they apply. Typically, the application will be reviewed from the perspective of whether or not the student has the preparation, background, and interest to be successful as an engineering student and later as an engineer. Remember, this is **not** a comprehensive list of all schools that require you to declare your engineering interest upon application, and you should always confirm this information with the university itself!

"Yes, I'm an engineer!"

Carnegie Mellon University	Penn (University of Pennsylvania)
Cornell University	Purdue University
Columbia University	Rice University
Duke University	USC (University of Southern California)
Johns Hopkins University	Vanderbilt University
Lehigh University	Washington University in St. Louis
Northwestern University	Yale University

The second table is a list of some highly ranked universities (again, listed alphabetically) that do **not** require students to declare Engineering when they apply. Essentially, these schools are admitting students in general. They typically review applications with a focus on broad preparedness for the university rather than a specific program in particular. Many of these universities still ask you to provide some information on what major you think you're most interested in, and they might even ask you to write a bit more about your interest, but an expression of interest at these schools is **not** binding. However, you should always confirm this information with the university itself.

"Maybe I'm an engineer, maybe I'm not!"

Brown University	MIT
Caltech	University of Notre Dame
Case Western Reserve University	Princeton University
Dartmouth College	RPI (Rensselaer Polytechnic Institute)
Harvard University	Stanford University

Appendix B: Resources

Here's a list of some of our favorite “exploring STEM” resources. We’ve also included links that appear earlier in the guide so you can have them all in one place. They're sorted into two categories: our all-time favorites for STEM exploration, and a few other noteworthy links.

http://www.pbs.org/wgbh/nova/blogs/secretlife/video-profiles/

We seriously love this web series. Hearing about the STEM content from each expert is fascinating, and we love that you can see how to be a STEM professional and still have a really awesome life outside of the lab.

http://www.pathwaystoscience.org/K12.aspx

Pathways to Science has all kinds of information on summer programs for high school students. If you’re looking to explore some STEM goodness during the summer, this is a great resource!

http://www.careercornerstone.org/index.htm

Sloane Career Cornerstone Center has the most extensive information across all STEM disciplines of any links included here. Yes, it’s a little on the dry side, but the content is so valuable that it’s totally worth it.

http://www.engineergirl.org/
https://tryengineering.org
These two sites are engineering-specific with a little technology thrown in, but they do a great job of helping students and families understand the power of engineering as well as the engineering "cool factor." We promise that's not an oxymoron!

https://www.youtube.com/playlist?list=PL89DD3B60747CDBC3
This is the link to the "STEM is Cool Video Contest" from earlier in the guide. Definitely check out the videos from Activision, Dow, IBM, Intel, Raytheon, and SAS—we think they're the most engaging and informative.

Here are a few other noteworthy links:
https://www.societyforscience.org
The Society for Science & the Public is an organization dedicated to expanding STEM education. You might not know their name, but you've probably heard of international science and engineering fairs sponsored by Westinghouse, Intel, or Regeneron . The Society for Science & the Public is the group responsible for launching those fairs. Visit their site to find information about affiliated college fairs in your area, including fairs in more than 70 different countries.

https://www.sciencedaily.com
A great online resource to learn about current research in pure/theoretical STEM areas, such as quantum physics and robotics, as well as in applied and interdisciplinary STEM areas, including psychology and medicine. Most of the articles are written so that someone who isn't already a STEM pro can understand them, making it a great resource for everyone.

Appendix C: Plans of Study

We've included a couple of excerpts from several plans of study for you to compare and contrast. (Links to the actual plans of study are included if you want to read more.) These plans of study are specific to their institutions, and we chose them because we think they are pretty easy to follow and understand. That means you'll be able to see some of the similarities and differences pretty clearly among the STEM disciplines. The fine details will vary with each college, but the major-specific themes we're illustrating will tend to be similar across colleges.

Side-By-Side Required Courses in the Major

Rochester Institute of Technology (RIT): Electrical Engineering Technology vs. Electrical Engineering

The list starts with the lower-level courses at the top, while the more advanced courses are at the bottom. We also want to point out that there are many more required courses for each of the plans of study—these are just the courses that make up the core of each of those majors.

RIT: Electrical Engineering Technology
RIT: Electrical Engineering

Technology	**Engineering**
DC Circuits	Digital Systems 1
Digital Fundamentals	Computational Problem Solving for Engineers
AC Circuits	Circuits 1
Computational Problem Solving	Semiconductor Devices
Electronics 1	Circuits 2
Digital Systems Design	Digital Systems 2
Electronics 2	Electromagnetic Fields & Transmission Lines
Microcontroller Systems	Linear Systems
Electrical Machines &Transformers	Digital Electronics
Signals Systems & Transforms	Embedded Systems Design
Digital Signal Processing	Classical Control
Design & Innovation	Analog Electronics
Control Systems	Mechatronics
Transmission Lines	

In the two columns above, you'll see some overlap with terms that are similar or even the same, particularly digital systems and computational problem solving. The classes in the two columns cover similar content but are completely different classes—one for the Technology majors and one for the Engineering majors. Here are the two descriptions for Digital Systems Design and Digital Systems 1, straight from the RIT catalog.

> *CPET 231—Digital Systems Design (2 credits, lecture only)*
> This course covers the design and simulation of digital circuits using modern digital design techniques. Using a hardware description language, students will design, synthesize and analyze finite state machines and combinational, sequential and arithmetic logic circuits. Topics will include: design for synthesis, verification techniques, memory circuits, programmable logic devices, and implementation technologies.

> *EEEE 120—Digital Systems 1 (3 credits, lab and lecture)*
> This course introduces the student to the basic components and methodologies used in digital systems design. It is usually the student's first exposure to engineering design. The laboratory component consists of small design, implement, and debug projects. The complexity of these projects increases steadily throughout the quarter, starting with circuits of a few gates, until small systems containing several tens of gates and memory elements. Topics include: Boolean algebra, synthesis and analysis of combinational logic circuits, arithmetic circuits, memory elements, synthesis and analysis of sequential logic circuits, finite state machines, and data transfers.

Now, we know that these two descriptions are pretty opaque for someone who doesn't already know a lot about digital systems (even we couldn't explain much about what is taught in these courses!) But it's still pretty obvious that although they have similar names and cover some similar topics, they're pretty different courses in content and scope. When you start to dig into the content of each course bit-by-bit, you'll get a better sense of what the similarities and differences are between the majors you're exploring. That's how you'll start to pinpoint your own interests.

Side-By-Side Coursework for Freshmen & Sophomores

Carnegie Mellon: Chemical Engineering vs. Chemistry

As we mentioned earlier, students with an interest in chemistry and chemical engineering usually find looking at the plans of study to be particularly helpful.

Carnegie Mellon: Chemical Engineering
Carnegie Mellon: Chemistry

Chemical Engineering—Fall Courses 1st Year	**Chemistry—Fall Courses 1st Year**
Differential & Integral Calculus	Introduction to Modern Chemistry
Designated Writing/Expression Course	Differential & Integral Calculus
Computing @ Carnegie Mellon	Physics I for Science Students
Introduction to Chemical Engineering	Interpretation & Argument
Introduction to Modern Chemistry I	Computing @ Carnegie Mellon

Chemical Engineering—Spring Courses 1st Year	Chemistry—Spring Courses 1st Year
Integration & Approximation	Integration & Approximation
Introductory Engineering Elective (other than Chemical Engineering)	Modern Chemistry II
Physics for Engineering Students I	H&SS Distribution Course I
General Education Course	Physics I for Science Students

There are a lot of similarities in the first year. Students in both programs are taking math, physics, and chemistry—although with slightly different perspectives and emphases. (Reading the course descriptions for each class will give you more details on the differences. Just follow the links to the course catalog!)

Sophomore year, things start to split off between science and engineering:

Chemical Engineering—Fall Courses 2nd Year	Chemistry—Fall Courses 2nd Year
Calculus in Three Dimensions	Undergraduate Seminar I
Thermodynamics	Modern Organic Chemistry
Sophomore Chemical Engineering Seminar	Lab I: Introduction to Chemical Analysis
Modern Chemistry II	Physics II for Biological Sciences & Chemistry Students
Computer Science/Physics II	H&SS Distribution Course 2
General Education Course	

Chemical Engineering—Spring Courses 2nd Year	Chemistry—Spring Courses 2nd Year
Fluid Mechanics	Undergraduate Seminar II: Safety & Environmental Issues for Chemists
Mathematical Methods of Chemical Engineering	Professional Communication Skills in Chemistry
Lab I: Introduction to Chemical Analysis	Modern Organic Chemistry II
Physics II/Computer Science	Lab II: Organic Synthesis & Analysis
General Education Course	Inorganic Chemistry
Experiential Learning	H&SS Distribution Course 3

At this point, you can see that the curricular paths are starting to diverge. This kind of split is highlighted clearly in most science vs. engineering curricula.

Side-By-Side First-Year Math vs. Engineering

Purdue University Core Mathematics vs. First-Year Engineering

https://www.science.purdue.edu/Current_Students/majors/index.html
https://engineering.purdue.edu/ENE/Academics/FirstYear/FYEPOS

When you examine these two curricula side-by-side, the math major looks like a walk in the park compared to the engineering major. We promise you—it isn't. But at least on this campus, there is much more flexibility when it comes to the math major's schedule and requirements in the first year when compared to the first year of an engineering major. And that's not terribly unusual. (Remember when we said that lots of students major in math and a science, or math and engineering, at the same time? This will help you see why!)

Core Mathematics	First-Year Engineering
Calculus I Option	Calculus I
Calculus II Option	Calculus II
Language I	Physics I
Language II	General Chemistry I
Computing Option	Science Selective (Chemistry II or CS)
English I	Transforming Ideas into Innovation I
Free Elective	Transforming Ideas into Innovation II
Free Elective	Oral or Written Communication Course I
Free Elective	Oral or Written Communication Course II
Free Elective	

You can repeat this process with any college or major you're considering, and we definitely encourage you to dig into them!

Appendix D: Summer Planning Ideas

As college counselors, we're often asked how our students can gain more exposure to and/or experience in the STEM fields when course loads are full and so many hours are already allocated to extracurricular activities. Summer is the perfect opportunity to take advantage of your free time and begin to explore or dive deeper into a STEM discipline. You'll be surprised at how many opportunities are actually available for high school students (and even students much younger). It would be nearly impossible to list all of the opportunities in this guide, so instead we've decided it would be more useful to explain the different options for summer experiences and give you a few examples of each. Collegewise also offers a terrific resource: our Summer Planning Guide.

Camps & programs

The experiences that are typically easiest to find are camps or non-academic opportunities. These are usually introductory programs into a STEM field, open to all students regardless of their grade level or experience. These programs typically require registrations rather than a formal application. This type of opportunity is a great first step if you're looking for exposure to computer science, engineering, lab sciences, or theoretical math and want to gain some experience before committing to a more selective or specialized program.

Examples of STEM Camps & Programs				
Name	*Subject*	*Locations*	*Age*	*Gender*
iD Tech Camp	Computer Science	Various	7-17	Co-ed
Discover Engineering Camp	Engineering	IL	14-16	Co-ed
PopHealth *Experience*	Science – Public Health	MA	12-16	Co-ed

Pre-college programs

At the end of the spring semester, college students clear out of their dorms and head home for the summer, leaving rather desolate campuses. Colleges have taken advantage of the empty space and opened their doors to high school students eager to have a taste of college life. These programs are what we call pre-college programs.

The pre-college program is exactly what it sounds like: students live in dorms, eat in dining halls, and attend classes taught by college professors. This is a great way for high school students to learn what it's like to live on a college campus, and most pre-college programs will offer course topics you can't find in your high school curriculum, such as: Summer@Brown's "Hiding in Plain Sight: An Introduction to the Art of Cryptography"; Harvard's "All Things Squishy: Physics of Soft Materials"; or University of Rochester's "What's Up Doc? Exploring the Pre-Med Experience."

These programs usually require an application process, so students should be prepared to write an essay or multiple essays, ask a teacher for a recommendation, and submit their transcript and test scores (if available). Some pre-college programs offer college credit, but the price might be a little higher than other summer programs you are considering. By attending a pre-college program, students show they are ready for college-level work and can enter college with a few credits under their belt. (But please don't feel pressured to pay the extra money for college credit—your experience on campus and in the classroom will be just as valuable as the credit itself.)

Examples of STEM Pre-College Programs

Name	*Subject*	*Locations*	*Age*	*Gender*
Summer@Brown	STEM	RI	14-17	Co-ed
Frontiers WPI Pre-College Experience	Engineering	MA	14-17	Co-ed
Boston University High School Honors Program	Science	MA	16-18	Co-ed
Santa Clara University's Young Scholars Program	Engineering	CA	14-18	Co-ed

Research & internship opportunities

If you are a rising senior, it's very possible that you've spent your previous summers attending camps and pre-college programs, so this is the year you'll want to kick your experience up a notch. Maybe you've narrowed your interests to a specific STEM topic or you'd like to explore what a potential career path would look like—this is where research and internship opportunities come in handy. *(Please note that while some students are ready to dive into research and internship opportunities prior to the summer before their senior year, we've found that there can be age limitations due to FDA regulations or work permits. If you find an opportunity with some leniency around age requirements, then by all means go for it, but the younger you are, the tougher it can be!)*

Students can find research and internship opportunities in a number of ways. Maybe a member of your family has a career in a field you are interested in, or a parent of a friend of yours has offered you a research gig over the summer. Regardless of how you obtain the internship, make the most of your time in the lab or in the field. Ask the people around you questions and learn about how they got to where they are today. And be as hands-on as you can, absorbing knowledge about the environment you're in and the work you're doing.

Getting early exposure to a field that you might work in someday can be extremely valuable. It can validate your interests, which can make writing those, "What academic subject excites you?" supplements much easier. You might even learn that this isn't actually what you had in mind at all. Whether your experience is a positive or negative one, there is so much value in discovering your interests (and even areas you *aren't* interested in) and saving yourself time and energy down the road.

Research and internship opportunities typically take a little more initiative to obtain, but the table below lists some programs for students who are interested in a formal position. You can always start at local hospitals and colleges, or even ask your STEM teachers at school—it's very likely they have friends in the industry who might be able to help you out!

Examples of STEM Research & Internship Opportunities				
Name	*Subject*	*Locations*	*Age*	*Gender*
Massachusetts Life Sciences Center (MLSC) High School Apprenticeship Challenge	Internship /Research	MA	16-17	Co-ed
Northeastern University's Young Scholars Program	Research	MA	14-17	Co-ed
COSMOS	Research	CA	13-18	Co-ed
Summer Discovery	Internship	Various	15-18	Co-ed

Alternative summer opportunities

We totally understand that camps, pre-college programs, and research experiences can be tough on the bank account. What if we told you that you can actually make money during your summer experience rather than spend money? We've seen several students put their STEM savviness to work.

Abby had a student who was pretty advanced in his coding skills, so rather than taking another programming course, he decided to work for a computer repair store. He really enjoyed the experience because he faced a new challenge every day and learned new tricks of the trade from his coworkers.

Meredith had a student who found an internship at a biotech company where she spent the summer learning about and running sandwich assays on breast cancer markers in tissue samples. It was this experience that convinced her she definitely wanted to study engineering, not science, once she was in college—she said she spent as much time learning how to adapt and troubleshoot the assays themselves as she did running the tissue samples.

Beyond job opportunities in the STEM fields, there are also a number of volunteer opportunities, which can give you valuable insight while you support and empower others. In the past, we've seen students mentor younger FIRST or Vex Robotic teams; volunteer at hospitals as patient escorts; help design and run science workshops; and prepare food for the penguins, fish, and seals at the local aquarium. Every volunteer experience is valuable in some way, so get creative and don't be afraid to reach out to organizations that don't have a formal volunteer program.

Another way our students engage with STEM disciplines is through what we call "passion projects." Some students are so eager and enthusiastic about a topic, issue, or project that they decide to pursue that idea independently.

Abby had a student who created an Arduino hydroponic farming system so she could learn a new programming language and explore her passion for environmental science. The student spent the whole summer coding and building a sustainable system that she then donated to a middle-school classroom to educate students about urban farming.

Meredith had a student who was intrigued by electric bicycles. He spent the summer reading and learning everything he could to design and create an efficient and effective e-bike.

Another Collegewise counselor had a student memorize as many digits of pi as he could.

The options are endless when it comes to passion projects, so have fun, get creative, and dive deeper into a topic you are excited about.

A few summer resources

Searching for summer opportunities can sometimes feel as daunting as de-bugging 1,000 lines of code, so we wanted to give you some starting points.

This list includes a few summer program databases that have streamlined and centralized the research process. Each database should have a range of camps, pre-college programs, and research/internship opportunities for students of all ages and abilities. Remember—there is no right or wrong way to spend your summer. Decide what you'd like to accomplish and then find an opportunity that will get you to your goals. And remember to have some fun (it is summer, after all)!

Databases

Johns Hopkins Center for Talented Youth

BostonTechMom®

MIT Admissions Summer Programs

American Mathematical Society's Math Camps & Programs for Students

Pathways to Science

About the Authors

Meredith Graham earned a degree in Chemistry from the College of Wooster and served as an associate director of admissions in Cornell University's College of Engineering. She is currently the director of Collegewise – Columbus, Ohio.

Abby van Geldern served as a former admissions counselor at Rensselaer Polytechnic Institute, which took her all over the West and East coasts to talk with high schoolers about their STEM interests and passions. She has helped students decipher the differences between STEM disciplines and given them a better understanding of the benefits of going to a predominately tech institution. She is currently the director of Collegewise Newton.

Want more?

Collegewise is a private college counseling company that holds two beliefs: (1) the college admissions process should be an exciting, adventurous time for every family, and (2) accurate, helpful college information should be made available to everyone. So even though we are private counselors who work with families who can afford to hire us, we also enjoy working with anyone who is interested and willing to listen, whether we're writing, speaking, or teaching. If you'd like to learn more about how we can help your family or your students enjoy a more successful, less stressful college admissions process, please **contact us**.

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