Career Explorations

Mc Graw Hill

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To the Student

Career Explorations

This book introduces you to the various industries and the variety of opportunities that exist in them. It will show you the steps you need to take to build a career in a field you are passionate about. It will also provide the opportunity to practice the skills that will help you succeed once you begin your career journey. These skills are needed in almost every job and are often called transferable skills, professional skills, employability skills, or soft skills.

Finding a job that interests you is the first step in managing your career. You will need to explore many job and career possibilities. What if your goals change? What if a shift in the labor market or the economy occurs? You may need, or want, to change jobs or even careers. By improving your transferable skills, such as speaking, writing, organizing, planning, and problem-solving, you will make yourself a more valuable employee and be able to cope with changes in the labor market. The more transferable skills you develop, the greater your chance of success at any job.

When considering a career, it is important to understand the realities of the industry. Which jobs have the strongest growth? Which offer good opportunities for advancement? Which jobs align most closely with your own abilities and interests? Are many jobs available in your area?

Keep these questions in mind as you read each chapter in this book. When you have finished, refer to them again to see how many you can answer. Do your answers make you more or less likely to want to work in a particular industry? If you feel an industry may be right for you, go to the online course to access more practice questions. Using real-world situations, they will help you begin preparing for any career in the industry you desire.

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Chapter 1 Exploring Your Future

Chapter Topics

1-1 Introducing Your Future

1-2 Building a Career

1-3 Education and Training

1-4 Trends

Essential Questions

By the end of the chapter, you will be able to answer the following questions:

- **1-1** How can you explore career options?
- **1-2** How can you match your skills and interests with the right job?
- **1-3** What training and education is needed for your career journey?
- **1-4** What are major trends in career journeys?

1-1 Introducing Your Future

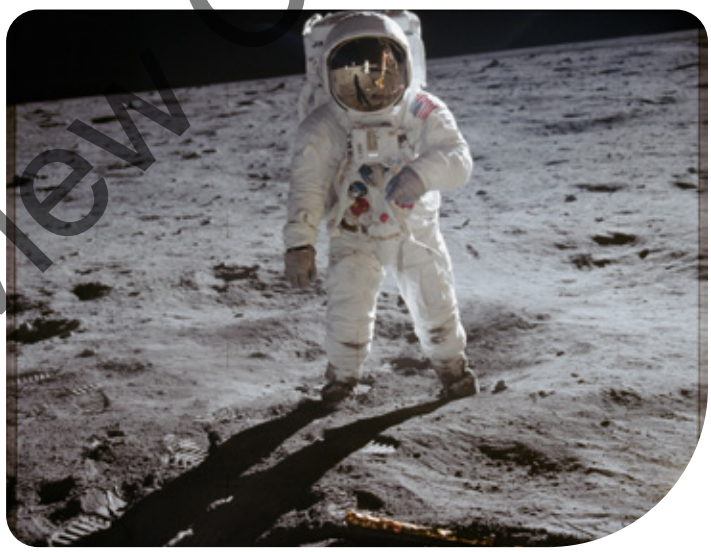
This textbook is about you. You may have access to the accompanying eBook and online materials, which are also about you. Many students have not deeply thought about their future career. Most students know of about a dozen possibilities out of the thousands of options. When you find an opportunity that fits your needs and allows them to contribute to others in a valuable way, they feel good about their career. This textbook will introduce you to possible future careers and guide you through the journey you will take after graduating high school.

1-1 Essential Question

As you read this section, keep this question in mind:

How can you explore career options?

Preparation



In 1969, *Apollo 11* carried three people to the moon. Two landed on the dusty, rocky surface and walked for the first time on a place different than the earth. Futurists optimistically projected that by the year 2000, humans would be living in orbit around the earth and the moon, and in bases on the moon. Other bold predictions included development of fusion, a limitless, clean, renewable energy source, and underwater cities. Which of these are realities today?

Instead of the advances mentioned above, we have found a way to communicate and connect globally—the Internet. We have video telephone calls. Medicine has advanced in many ways, such as finding treatments for diseases like AIDS and COVID-19 and understanding genetics down to the tiniest detail.

Industries with jobs that once were held exclusively by individuals with bachelor's degrees and beyond have opened to a broader workforce and offer many opportunities with medium- and high-paying salaries. These include occupations such as mechanical technician, paralegal, and nursing assistant. Occupations requiring hands-on attention to build and fix things, such as shipbuilding, automotive repair, and heavy machine operation, have continued to thrive. However, when considering their future, students often overlook these important

occupations. Most new jobs include the use of technologies that make work safer and more efficient.

Why is all this important to know? You are learning about and preparing for a world that does not yet exist! By the time you graduate high school, new industries and jobs will be created, while many old occupations will need fewer workers or disappear. It is simply not possible to accurately predict what the jobs of the 2030s, 2040s, and 2050s will be. What can you do about that?

Most occupations evolve. If you can find a field in which you are interested and prepare for success, you will find success as that field evolves. An important part of that preparation involves professional skills, sometimes referred to as soft skills or employability skills. Examples include communication, problem-solving, time management, and good personal and professional habits. Your professional skills comprise the most significant set of skills that predict and support your future success!

This program is designed to introduce you to the occupations of today. It will tell you about the variety of jobs in many fields and how to build careers in these fields. It will also provide opportunities to practice the skills that will help you succeed.

Exploring Your Career

Finding a job that interests you is the first step in managing your career. To be successful, however, you will need to explore many job and career possibilities. What if your goals change? What if a shift in the labor market or the economy occurs? You may need, or want, to change jobs or even careers.

When considering a career, it is important to know all you can about it. Which jobs project the greatest growth? Which offer opportunities for advancement? Which jobs align most closely with your own abilities and interests?

Keep these questions in mind as you explore each chapter in this book. Every chapter is designed to help you answer these questions. Do the answers make you more or less likely to want to work in a particular industry? If you feel an industry may be right for you, make note of that, and find out more about it. Share your thinking with your teacher and others and try to learn more about the realities of the industries and occupations that are of interest to you.

Also, sample some of the real-world scenarios included in each chapter. These practice questions provide a starting point from which you can get a glimpse at the work that is done in that industry. The questions focus on reading for information, decoding charts and graphs, and completing basic math in real-world scenarios. Do not worry if your reading and math skills are not perfect for each question or exercise. You have plenty of time left to learn more about reading and math!

Evaluating Career Choices

Choosing a career is challenging. Now is a good time to start thinking about what kind of career path you would like to follow. A well-chosen career can bring satisfaction and success in life.

Self-knowledge is the key to making wise career choices. The more you learn about your interests and strengths, the better quality of choices you will make. Also, while weaknesses are often areas for which you need more help, they can become strengths if you work on them. Friends, teachers, and family members may offer helpful suggestions for potential careers. However, you are ultimately in charge of making your own career decisions.

You may feel that your personality, the way you think and behave, is well suited to an industry or occupation. You should allow your interests to influence your career decisions. What activities do you most enjoy? In some cases, your aptitude, or ability in a certain area, will shape your career goals. Ask yourself what skills come naturally to you. Also, you should consider the growth you will experience between now and high school graduation.

Values are another factor to consider when selecting a career. Values are the principles and beliefs that you live by. You might value courage, independence, or creativity. Your values will shape all areas of your life. For example, if you value being a responsible family member, you might seek a job that allows for flextime and provides good vacation benefits.

Don't worry if you change your mind about your career path. This happens to many people. It often takes time to find the right path. You can always change your career path regardless of where you are in your chosen profession.

1-1 Essential Question Reflection

So, let us revisit our essential question:

How can you explore career options?

1-2 Building a Career

There may be several steps in your career journey before you reach your ultimate career goal. For example, science technicians usually start as trainees. In this entry-level position, your tasks might include monitoring experiments and maintaining lab equipment. With more experience, you might conduct research. In time you might become a supervisor. You would then oversee training technicians. Finally, if you continued your education, you might become a biologist or a chemist.

1-2 Essential Question

As you read this section, keep this question in mind:

How can you match your skills and interests with the right job?

Jobs

Finding a job is seldom easy, but finding a job in a new career field can be especially hard.

Changing Jobs

Many people jump from one career right into another. They may feel that their job does not match their skills or interests. They may believe the job does not offer enough room to advance. A new career can offer new opportunities.

If you find a job that you would like to pursue, spend time investigating the qualifications required. You might speak to someone who works in the industry. Learn everything you can to ensure the career cluster is right for you.

Look for ways to gain experience that will help you in your search. If the new career involves working with people, volunteer for tasks in which you will interact with people.

You should spend time networking or reaching out to people who can help in your job search. This may include family, friends, or colleagues from current or former jobs. Try to meet new people to expand your network. One good way to do this is to use online networking sites.

1-2 Essential Question Reflection

So, let us revisit our essential question:

How can you match your skills and interests with the right job?

Based on what you learned in this section, please answer this question in detail.

1-3 Education and Training

Each industry differs in how much training and education are needed to get started. As you build your career, more education and training may benefit you. You may acquire more skills, abilities, and knowledge. You also may attain more professional skills. College and a college degree are admirable and important goals but not always needed as starting points for many well-paying careers. Sometimes you may earn a degree while starting your career and earning money. Many employers even have tuition reimbursement programs and other ways to help you learn while you earn. The result is that you eventually have the education you need without the potentially crippling debt that a college education can entail.

1-3 Essential Question

As you read this section, keep this question in mind:

What training and education is needed for your career journey?

Preemployment Training

Preemployment training for jobs may involve completing one or more of the following:

- An apprenticeship or internship
- A certification or degree program at a technical or career school
- A degree program at a college or university

Apprenticeships

An apprenticeship is a way to gain real-life work experience. In an apprenticeship, an inexperienced worker learns by working alongside an expert. The apprenticeship may last up to five years. During this period, the apprentice receives very little pay. However, workers who have completed these programs are often well respected and well paid. For more information about apprenticeship opportunities, the U.S. Department of Labor's Office of Apprenticeship is an excellent source.

Internships

An internship is an opportunity to gain supervised practical experience in a field. Internships are usually shorter than apprenticeships. They may offer the opportunity to learn about various departments or jobs in an organization. An intern often receives little or no pay. However, completing an internship can improve your chances of getting a job.

Formal Training and Education Options

Formal training and education for your future career may include one of the following options:

- Technical or career school
- Associate degree
- Bachelor's degree
- Graduate degree
- On-the-job training
- Technical and soft skills

It is important to note that obtaining a high school diploma or equivalent is vital to being able to pursue the postsecondary (i.e., after high school) educational opportunities listed above. To address the needs of busy professionals, many schools now offer online programs.

Before choosing a postsecondary educational program, make sure that the program will prepare you for the job you want. Consider the length of the program and its rate of job placement. Find out whether the program is nationally accredited or state licensed. Consider the school's reputation in the field and the expertise of its faculty.

Technical and Career Schools

If you're interested in a position that requires some training, a technical school is a promising option. A technical school offers skills-oriented programs. For example, it may offer programs in electrical or mechanical engineering that could help you become a technician in one of those fields. In addition to certification programs, technical schools sometimes offer associate degree programs.

Career schools specialize in training for a certain career or group of related careers. They may specialize in business, computer technology, or environmental health. Career schools that meet state requirements receive special licenses to operate.

Associate Degree

An associate degree is an academic program of study taken at the undergraduate level at a junior or community college. Students who are interested in obtaining an associate degree must obtain a high school diploma or equivalent and complete an application.

It typically takes two years of full-time study to complete an associate degree. Cost for obtaining an associate degree is often much lower than a bachelor's or master's degree. Attending community college and earning an associate degree can be an affordable way to dip your toes into higher education before transferring to a four-year program.

Bachelor's Degree

A bachelor's degree is an undergraduate degree in which you study a subject of your choice at a university. Obtaining a bachelor's degree enhances your access to job opportunities, exposes you to new ideas and opinions, and boosts your earning potential. Bachelor's degrees typically take most students between four and five years of full-time study. To obtain a bachelor's degree, students must usually earn 120 credits. Most universities offer a wide variety of programs of study, including computer science, business, nursing, and English.

Graduate Degree

Postgraduate education occurs after earning a bachelor's degree. Most people who seek postgraduate education enroll in a master's or doctoral degree program at a university's graduate school. Having a master's or doctoral degree gives a job candidate an edge over candidates without advanced degrees.

On-the-Job Training

On-the-job training is on-site instruction in how to perform a particular job. It has two main advantages over other forms of training.

First, you are usually paid while you train. However, even if the job is not paid, you will be gaining knowledge and skill without paying tuition.

Second, the training is tailored to the job. When you complete the training, you'll feel comfortable in your position.

Even jobs requiring advanced education often have on-the-job training. Many companies provide continued training for even their most experienced workers.

Many paid apprenticeships qualify as on-the-job training, especially if they are sponsored by the company employing the apprentice.

1-3 Essential Question Reflection

So, let us revisit our essential question:

What training and education is needed for your career journey?

Based on what you learned in this section, answer this question in detail.

1-4 Trends

Industries, occupations, and jobs are constantly changing. Knowing about the trends and forces that produce these changes can help you make better decisions about your future path and preparation. Throughout the book, you will read about trends that affect the industry discussed in each chapter.

1-4 Essential Question

As you read this section, keep this question in mind:

What are major trends in career journeys?

Remote Work

Technology improvements have made working from home or other remote workplaces easier, effective, and efficient. Working remotely has several advantages for both workers and employers; however, it is not always possible.

Technology

What do you think of when you hear the word *technology*? Chances are, if you are like most people, something related to computers and the Internet is at the top of your list. However, there are other examples of technology. Improvements in sensors have made warehouses and factories much safer. Improvements in robotics have made it possible for people to reduce how often they put themselves in risky situations. As technology continues to evolve, it will change how and where we work.

Gig and Contract Work

The ability to work at any time from almost anywhere has helped millions of workers take on work in a way that was rare until 5 to 10 years ago. Working on a contract-by-contract basis, or "gig" work, is when someone does a certain job for a customer and is paid based on completing the task. The work may take a week, a few months, or several years. Some construction and artistic work has almost always been contracted. But today, everything from blog copywriting to audio creation is "gig" work.

1-4 Essential Question Reflection

So, let us revisit our essential question:

What are major trends in career journeys?

Based on what you learned in this section, answer this question in detail.

Chapter 2

Science, Technology, Engineering & Mathematics (STEM)

Essential Questions

By the end of the chapter, you will be able to answer the following questions:

- **2-1** What types of opportunities are available in STEM?
- **2-2** Which opportunities may be right for you?
- **2-3** How can I match my skills & interests with the right job?
- **2-4** What training & education is needed for a job in STEM?
- **2-5** What are typical work environments in STEM?
- **2-6** What factors affect trends in STEM?

Chapter Topics

2-1 STEM Today

2-2 STEM Jobs

2-3 Building a Career in STEM

2-4 Education and Training for STEM Opportunities

2-5 Working Conditions in the STEM Industry

2-6 Trends in STEM

2-1 STEM Today

Throughout history, people have thought about the world around them. People have invented tools and designed structures to improve their lives. Technology and engineering apply science and math in practical ways to make these tools and structures. As a result, a person born today can expect to live past the age of 80!

Career opportunities in Science, Technology, Engineering, and Mathematics are valuable because they improve the quality of life for people. These fields together are often referred to as "STEM."

2-1 Essential Question

As you read this section, keep this question in mind:

What types of opportunities are available in STEM?

Science

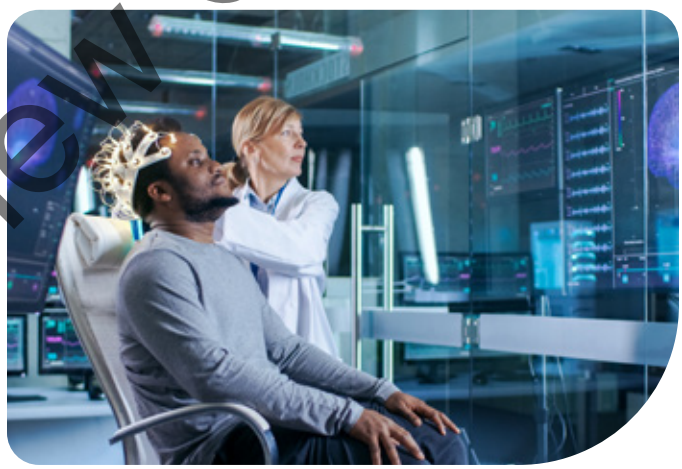
Science is the systematic study of the world. Scientists use the scientific method. They observe an aspect of the world and form a hypothesis, or an educated guess, that explains why something is the way it is. They then perform research experiments to test the hypothesis. They report the results to other scientists, who conduct their own tests. Only when many scientists have confirmed the findings does the hypothesis become a theory (a widely accepted explanation for why something happens). Science occupations are divided into three subcategories.

Table 2.1: Branches of Science

Category	Description	Examples of Occupations
Life Science	Focus on living things	Medical Researchers Geneticists Biologists Ecologists Environmental Scientists
Physical Science	Focus on nonliving things	Chemists Physicists Astronomers Geologists Meteorologists
Social Science	Focus on human behavior	Economists Psychologists

Life Science

Life sciences focus on the study of living things. This branch includes medical research, genetics, and biology. It also includes environmental science and ecology, the study of how organisms react with their physical environment.



Physical Science

Physical sciences deal mainly with studying nonliving things through chemistry, physics, astronomy, geology, and atmospheric science. Chemistry involves the makeup, structure, and behavior of substances. Physics deals with how objects interact with one another and with their surroundings. Astronomy examines the planets, stars, and other objects in space. Geology studies volcanoes, earthquakes, and the materials that make up Earth. Atmospheric science surveys the gases that surround Earth and includes the study of weather and climate.

Social Science

In the social sciences, the scientific method is used to study human behavior. This branch includes economists and psychologists. Economists study how humans produce and distribute goods and how they use wealth. Psychologists analyze the mental and emotional processes of humans.

Technology

Technology is the use of special tools or techniques to solve problems. Technology is closely related to science and engineering. For example, a scientist comes up with a theory about how hydrogen can be used to create energy. Then an engineer designs something that uses hydrogen to power motor vehicles. That invention, known as a hydrogen fuel cell, is an example of technology. Someone skilled in operating the tools of technology is called a technician. A laboratory technician uses equipment in a laboratory. Technicians often assist scientists and engineers with the more practical tasks involved their work.

Engineering

Engineering applies science and mathematics to the practical problems of designing and building new things. For example, aerospace engineers design aircraft. Robotics engineers design robots.

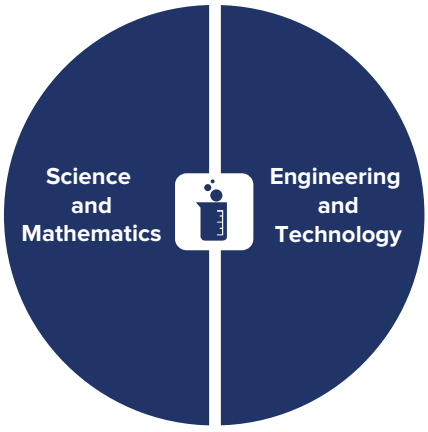
Mathematics

Mathematics examines the relationships between numbers. Theoretical mathematics studies the logic of mathematics; the fields of algebra and geometry, for example, are a part of theoretical mathematics. Applied mathematics uses mathematics to solve real-world problems.

Career Journeys in STEM

There are two major paths along which your journey in STEM might be shaped. People commonly move into and out of different paths. Each path contains a group of careers requiring similar skills as well as similar certifications or education. The paths are:

- Science and Math
- Engineering and Technology



Science and Math

This career path includes natural scientists, social scientists, and mathematicians. It also includes the researchers and lab technicians who collaborate with scientists.

Most natural scientists work in research and development. They usually specialize in a particular area. Botanists, for example, focus

on plant life. Zoologists focus on animals. Organic chemists study carbon-based compounds, which are the building blocks of life. Inorganic chemists focus on metals, salts, acids, and bases.

Some natural scientists work for colleges and universities. Others work for local, state, or federal government. For example, epidemiologists, who study diseases, may work for government health agencies. Meteorologists, who study and predict the weather, may work for the National Weather Service. Many life scientists and physical scientists work for private companies. An inorganic chemist, for instance, might help develop new fabrics for clothing manufacturers. Medical scientists often do research and development for drug companies.

Social scientists may work for colleges and universities, or they may work for private industries, the government, or nonprofit organizations. A political scientist, for instance, may work for a political research organization. A psychologist with special training may work with patients at hospitals or students in public schools.

Applied mathematicians often work for government agencies or businesses. A statistician, for example, might work for the US Department of Labor, gathering and interpreting data about jobs and job outlooks. Data scientists work for private companies or the government and develop useful insights from large amounts of data. In contrast, theoretical mathematicians usually work in universities.

Most scientists and mathematicians who do research at colleges and universities also teach. Some of them teach in places other than schools. An astronomer, for example, may explain the skies to visitors at a planetarium.

Scientists who work at colleges and universities often rely on grant money to support their research. That grant money may come from government programs or from private companies or organizations. A company seeking to produce fuel from crops, for example, may give grant money to a college biology department so scientists can conduct the needed research.

Engineering and Technology

This career path includes engineers and the technicians who assist them. There are many kinds of engineers. The three most common are civil engineers, mechanical engineers, and industrial engineers.

Civil engineers design and oversee the construction of roads, bridges, tunnels, dams, airports, water and sewage systems, and other public structures. Many specialize in a specific area, such as water resources or urban streets. Civil engineers are often employed by the architectural and engineering firms hired for government projects. Some are employed directly by government.

Mechanical engineers design tools, engines, and machinery. They are often employed by companies trying to develop new or better products. Mechanical

engineers may design anything from a bicycle to a life-support system needed in a hospital. Sometimes they work on power-producing machines such as electric generators and gas turbines. At other times, they work on machines such as refrigerators, elevators, and small power tools. Many mechanical engineers specialize in one type of design. For example, one mechanical engineer may specialize in designing car engines. Another may specialize in building robots.

Other types of engineers are less common, partly because their work is more specialized. A computer hardware engineer designs computers and related equipment. A petroleum engineer develops methods of extracting oil from the earth. A marine engineer designs and supervises the building of boats and ships.

Industrial engineers come up with ways to help people, machines, materials, and other resources work together to create a product or service.

Engineers are often assisted by engineering technicians. An industrial engineering technician, for instance, may work with an industrial engineer to formulate a more productive way for a company to distribute its goods.

STEM Future Outlook

The outlook for jobs in the STEM industry is better than average. It is especially good in the Science and Mathematics career path. The Bureau of Labor Statistics expects jobs in STEM to increase by about 33 percent from 2020 to 2030. That compares to only 8 percent growth in all job types. Competition for these jobs is expected to be strong. Since the jobs in this path will grow and pay well, many people will want these jobs. This means that candidates with the most experience or education—or both—are likely to land the best jobs.

Table 2.2: Employment in STEM Occupations, 2020 and Projected 2030

Occupation Category	Employment Change, 2020–30	Percent Employment Change, 2020–30	Median Annual Wage, 2021
Total, all occupations	11,879,900	7.7	$45,760
STEM occupations	1,074,500	10.5	$95,420
Non-STEM occupations	10,805,400	7.5	$40,120

Source: *U.S. Bureau of Labor Statistics*

In the Engineering and Technology career path, the job outlook is about average overall. However, prospects vary greatly, depending on the specific engineering area.

The best growth is expected to be in the life science and related engineering specialties, such as biomedical engineering. The nation's aging population will create a demand for new drugs and medical treatments. That, in turn, will result

in the demand for more medical research. The need to feed the world's rising population will increase job growth in areas such as agricultural and food sciences. The social sciences are expected to see higher-than-average job growth. Many of these jobs will be with nonprofit organizations that develop public policy.

Table 2.3: Job Forecast for a Sample of Occupations over the Next 10 Years

Occupation	Expected Growth Rate
Geographic Information Systems Technicians	5%–10%
Environmental Scientists and Specialists	5%–10%
Industrial Ecologists	5%–10%
Biological Technicians	5%–10%
Chemists	5%–10%
Surveyors	1%–5%
Blockchain Engineers	5%–10%
Computer and Information Scientists, Researchers	15% or more
Mechanical Engineers	5%–10%
Data Scientists	15% or more
Architectural Drafters	Little or no growth

Source: *O*NET Occupational Network Database*

2-1 Essential Question Reflection

So, let us revisit our essential question:

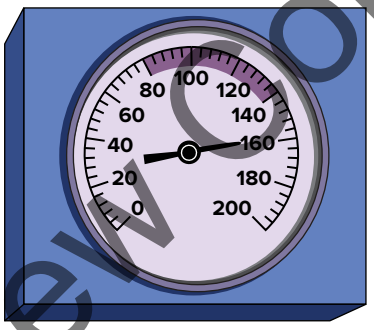
What types of opportunities are available in STEM?

Based on what you learned in this section, which path of STEM is the most interesting to you? Explain your answer.

Practice 2-1

Skills Practice

When reading workplace graphics and gauges, such as a diagram for a spacecraft, STEM workers must know what information to look for. The key information may be in one or more graphics. Workers must be able to sift through unimportant or distracting information to find what is needed. **Practice this skill!**



The above gauge measures pressure in pounds per square inch. Use the gauge to answer the two questions that follow.

1. As a water treatment plant operator, one of your jobs is to regularly check the pressure gauges on the 500-gallon water vessels. What is the current pressure for this water vessel?

A. 145 pounds per square inch

B. 150 pounds for square inch

C. 160 pounds per square inch

D. 165 pounds per square inch

E. 170 pounds per square inch

2. The shaded area indicates the ideal pressure range required for this water vessel to operate safely and properly. The pressure is currently too high. You want to lower the pressure. As the pressure lowers, at which point will you be back in a safe operating zone?

A. 140 pounds per square inch

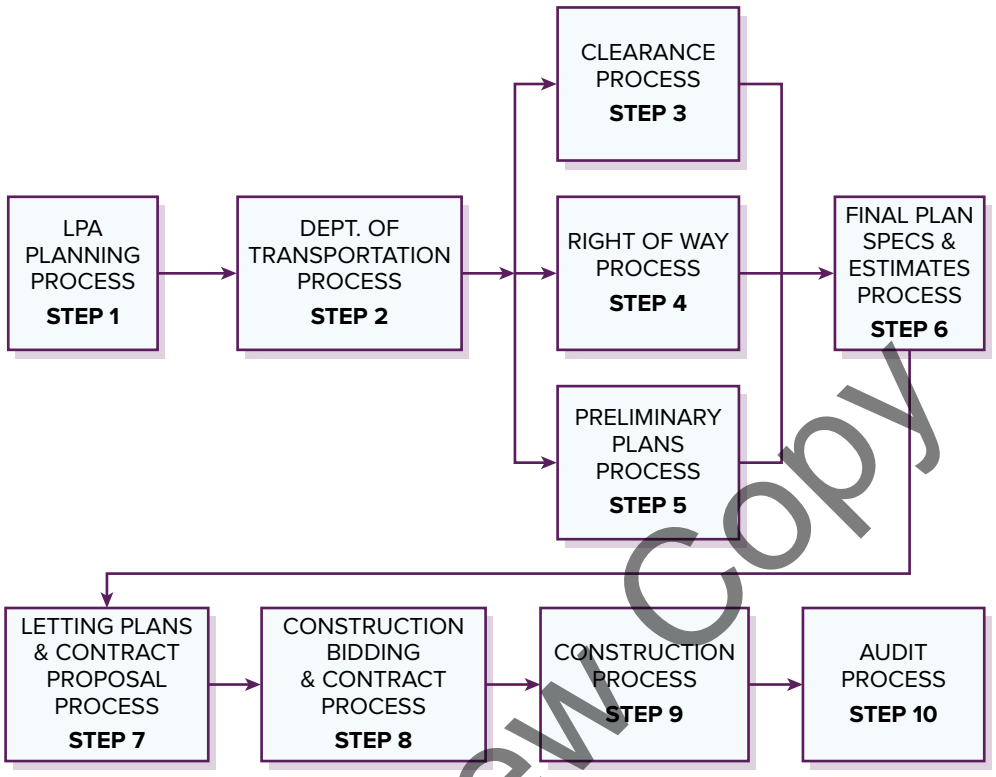
B. 155 pounds per square inch

C. 160 pounds per square inch

D. 185 pounds per square inch

E. 190 pounds per square inch

The chart below shows how different groups process information to get dollars from the U. S. government for a local project. Use the chart to answer the two questions that follow.



3. You are an entry-level transportation engineer working for your state Department of Transportation. You must refer to Local Public Agency (LPA) policy guidelines for any project using federal funds. According to your flow chart, which steps in the upcoming federal aid project occur simultaneously?

A. Steps 1, 2, and 3

B. Steps 3, 4, and 5

C. Steps 2, 4, and 6

D. Steps 6, 7, and 8

E. Steps 8, 9, and 10

4. You typically help coordinate the bidding process. At which point will you become involved?

A. Step 3

B. Step 5

C. Step 6

D. Step 8

E. Step 9

To access more problems that will help you grow professional skills and are real-world examples in STEM, go online.

GO ONLINE

2-2 STEM Jobs

Many kinds of jobs are available in the STEM industry. Some workers conduct research to cure diseases, develop a new food product, or identify criminals. Others design a water treatment center or find ways to dispose of toxic material. Jobs are available in private companies, at colleges, in the government and military, and with nonprofit organizations. They are also available with local, state, and federal governments. Some workers in this field start their own business. Here are some industry jobs and the skills they require.

2-2 Essential Question

As you read this section, keep this question in mind:

Which opportunities may be right for you?

Occupation With the Most People Employed:

Maintenance and Repair Workers

- Maintain and fix objects that range in size from the width of a human hair to the largest buildings in the world
- Exciting opportunities in the future from repairing drones and robots to maintaining machines that are networked through small computer chips in them

Fast Facts:

Employment: 1.44 million in 2020, expected to grow to 1.56 million in 2030
Annual Openings: 152,000 – the size of a large city!
Median Annual Wage: $43,000
Education Needed: High school diploma
Other: Some on-the-job training

Fastest-Growing Occupations:

Wind Turbine Service Technicians

- Inspect, adjust, or repair large wind turbines (windmills)
- Diagnose and fix any problem that could cause the turbine to shut down unexpectedly

Fast Facts:

Employment: 6,900 in 2020, expected to grow to 11,700 in 2030

Did You Know: 1 out of 8 are self-employed

Education Needed: High school diploma and on-the-job training

Engineers in Advanced Systems

- Research, design, develop, and test parts and systems that apply to wind and solar energy, nanosystems, robotics, photonics, and mechatronics
- Engineers are on the cutting edge of products that are the result of applying science. They are responsible for making and testing the machines of today and of the future.

Fast Facts:

Employment: 1.72 million in 2020, expected to grow to 1.85 million in 2030

Median Annual Wage: $99,040

Education Needed: Master's degree

Occupation Where Most Work for Themselves:

Solar Cell Installers

- Assemble, install, or maintain solar energy systems on roofs or other structures in compliance with site assessment and schematics
- Measure, cut, assemble, and bolt structural framing and solar modules

Fast Facts:

Employment: 11,800 in 2020, expected to grow to 17,900 million in 2030
Percent Change in Employment: 52%
Median Annual Wage: $47,670
Education Needed: High school diploma
Did You Know: Solar energy is a form of energy that reduces carbon emissions.

Highest-Wage Occupation:

Physicists

- Conduct research into physical universe, develop theories from of observation and experiments, and devise ways to apply physical laws and theories
- Famous physicists include Albert Einstein and Isaac Newton.

Fast Facts:

Employment: 17,400 in 2020, expected to grow to 18,900 million in 2030
Percent Change in Employment: 8.8%
Median Annual Wage: $152,430
Education Needed: Doctoral degree
Did You Know: Physicists publish papers in journals and are critical to innovative advances, such as the James Webb telescope and electric vehicle development.

Great Job! – Associate Degree Needed:

Aerospace Engineering Technicians

- Operate, install, adjust, and maintain systems, consoles, simulators, and other data acquisition, test, and measurement instruments and equipment, which are used to launch, track, position, and evaluate air and space vehicles
- Technicians work alongside scientists and engineers and make their visions and concepts to reality.

Fast Facts:

Employment: 11,900 in 2020, expected to grow to 12,900 million in 2030

Median Annual Wage: $73,580

Education Needed: Associate degree

Did You Know: This is a "high-flying" occupation where the work you do eventually becomes part of making a vehicle fly.

Great Job! – High School Diploma Needed:

Nuclear Power Reactor Operators

- Operate or control nuclear reactors
- Move control rods, start and stop equipment, monitor and adjust controls, and record data in logs
- Implement emergency procedures when needed
- Respond to abnormalities, determine cause, and recommend corrective action

Fast Facts:

Employment: 5,300 in 2020

Median Annual Wage: $104,260

Education Needed: High school diploma, or equivalent

Did You Know: As technology becomes better and the need for energy generated from non–fossil fuels, nuclear power reactor operators will be needed worldwide.

2-2 Essential Question Reflection

So, let us revisit our essential question:

Which opportunities may be right for you?

Based on what you learned in this section, what 2 or 3 opportunities are the most interesting? Explain your answer.

Case Study: Environmental Science & Protection Technicians

Also called: Environmental Technicians, Laboratory Technicians, Public Health Sanitarians, Sanitarians

What do they do?

- Perform laboratory and field tests to monitor the environment and investigate sources of pollution, including those that affect health, under the direction of an environmental scientist, engineer, or other specialist
- Collect samples of gases, soil, water, and other materials for testing

What would you do?

- Discuss test results and analyses with customers
- Record test data and prepare reports, summaries, or charts that interpret test results
- Develop or implement programs for monitoring of environmental pollution or radiation

What do you need to know?

Arts and Humanities

English language

Math and Science

Biology

Arithmetic, algebra, geometry, calculus, or statistics

Safety and Government

Law and government

Public safety and security

Business

Customer service

What skills do you need?

Communication

Listen to others, do not interrupt, and ask good questions

Read work-related information

Problem Solving

Notice a problem and figure out the best way to solve it

People and Technology Systems

Think about the pros and cons of different options and pick the best one

Figure out how a system should work and how changes in the future affect it

What abilities must you be good at?

Verbal

Listen to and understand what people say

Read and understand what is written

Ideas and Logic

Notice when problems happen

Use rules to solve problems

Math

Add, subtract, multiply, or divide

Choose the right type of math to solve a problem

Visual Understanding

Quickly compare groups of letters, numbers, pictures, or other things

Who does well in this occupation?

People who like activities that include ideas, thinking, and figuring things out

People who do well at these jobs need:

Integrity

Dependability

Attention to detail

Analytical thinking

Initiative

Adaptability/flexibility

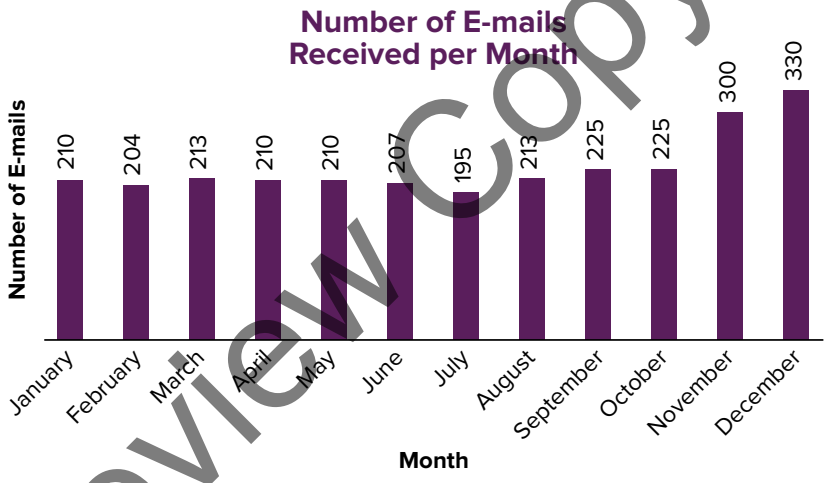
What educational level is needed?

- Bachelor's degree or associate degree

Practice 2-2

Skills Practice

STEM workers must sometimes analyze graphics to identify trends. They might search data for evidence that conditions have changed over time. Geodetic surveyors, for example, need to study data from satellite images to measure changes in the earth's surface. Being able to identify common trends from several pieces of data can be helpful in a variety of jobs in this industry. **Practice this skill!**



1. As an assistant in the science department at your college, you track e-mails that are received each month. Based on this graph, what trend can you identify?

A. The number of e-mails increased every month.

B. The number of e-mails received decreased every month.

C. The number of e-mails stayed consistent throughout the year.

D. The number of e-mails stayed relatively consistent but decreased in the last two months.

E. The number of e-mails stayed relatively consistent but increased in the last 2 months.

2. Based on this graph, which of the following general statements can you make?

A. There is a large increase in e-mails in the summer months.

B. There is a large increase in e-mails at the beginning of the year.

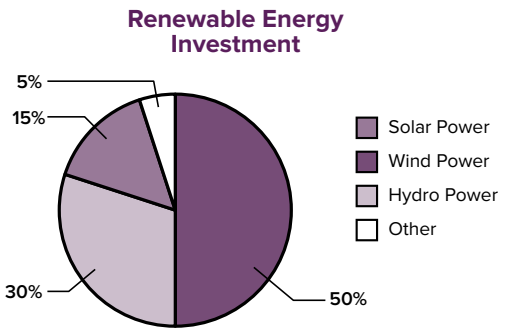
C. There is a large increase in e-mails every other month.

D. There is a large increase in e-mails at the end of the year.

E. There is a large increase in e-mails in July.

Skills Practice

When workers look at a graphic such as a diagram or a bar graph, they need to analyze and make sense of the information. It may be necessary to summarize the information or outline only the most important facts. For example, health and safety engineers may need to summarize graphics showing statistics on the hazards they find in a particular location. Being able to summarize allows workers to make sense of varying information. **Practice this skill!**



3. As an agricultural engineer, you have researched and created a graph showing the percentage of dollars invested in different forms of energy. How would you summarize the investment in energy sources from your chart?

A. From greatest to least, companies have invested the most in wind, hydro, other, and solar power, in that order.

B. From greatest to least, companies have invested the most in hydro, other, solar, and wind power, in that order.

C. From greatest to least, companies have invested the most in wind, hydro, solar, and other power, in that order.

D. From greatest to least, companies have invested the most in other, solar, wind, and hydro power, in that order.

E. From greatest to least, companies have invested in solar, wind, hydro, and other power, in that order.

4. Your team is considering designs for a machine that can work using any type of energy. The team is trying to get money to fund building the machine. You and your team think that the greater the investment amount, the better the chances that a type of energy will be best.

Based on the graph showing the percentage of investments in renewable energy sources, what is your recommendation to gain the most financial support?

A. You recommend solar power for the new machine.

B. You recommend hydro power for the new machine.

C. You recommend hydro and solar power for the new machine.

D. You recommend wind and hydro power for the new machine.

E. You recommend solar and other types of power for the new machine.

To access more problems that will help you grow professional skills and are real-world examples in STEM, go online.

GO ONLINE

2-3 Building a Career in STEM

Building a career in STEM can take many years. For example, a science technician usually starts as a trainee. Your tasks might include monitoring experiments and maintaining lab equipment. With more experience, you might conduct research. In time you might become a supervisor. You would then oversee training technicians. Finally, if you continued your education, you might become a biologist or a chemist.

Do not worry if you change your mind about your career path. This happens to many people. It often takes time to find the right path. You can always change your career path regardless of where you are in your chosen profession.

2-3 Essential Question

As you read this section, keep this question in mind:

How can I match my skills & interests with the right job?

Are You More Interested in Working With Data, People, or Things?

When planning your career path, consider what balance of data, people, and things you want in a career. Many online resources can help you determine opportunities that match your skills and interests.

Careers That Involve Working With Data

Examples include drawing up industrial blueprints, solving complex equations, analyzing population statistics, and writing a lab procedures manual. Meteorologists are another example of people who work with data.

Almost all jobs in STEM involve working with data. Engineers, for example, often run tests and then analyze the data when designing a new product or improving an old one. Actuaries assess risks by studying data. Meteorologists examine data to make predictions about the weather. Science technicians often perform calculations and record data from experiments.

Scientists of all kinds must carefully record, collect, and analyze data when performing experiments or making observations. They also work with data in the form of scientific principles and formulas. Mathematicians work almost exclusively with data in the form of numbers, formulas, and principles.

Careers That Involve Working With People

Examples of working with people in the STEM industry includes coordinating work teams, sharing theories with colleagues, teaching students, and working with a construction crew on a civil engineering project. All these activities require strong communications skills.

If you are a manager or part of a team of workers, you will spend much time working with other people. If you are employed at a university, you will interact with students, teaching assistants, and colleagues. As a scientist or mathematician, you are likely to consult with people in your field. You may benefit from attending conferences where you can share your findings.

Careers That Involve Working With Things

In STEM working with things might involve experimenting with chemicals or constructing engineering prototypes. It may mean working with tiny microchips or enormous telescopes.

Many careers in STEM involve extensive work with things. Botanists, for example, spend much of their day working with plants, plant samples, and laboratory equipment. Electrical engineers may use circuits, machines, or power-generating equipment. Hazardous materials technicians use air samplers, water samplers, and special equipment for removing physical waste.

2-3 Essential Question Reflection

So, let us revisit our essential question:

How can I match my skills & interests with the right job?

Based on what you learned in this section, please answer this question in detail.

2-4 Education and Training for STEM Opportunities

The STEM industry perhaps has mostly training-intensive jobs. Most jobs require a college degree.

2-4 Essential Question

As you read this section, keep this question in mind:

What training & education is needed for a job in STEM?

Training and Education for STEM

To get a job as a technician, you may need to complete a training program or earn a certificate. However, most higher-level jobs require a college degree.

Jobs Requiring Specific Training or Certification

Almost all jobs in STEM deal with complex problems. Virtually all of them require at least a high school diploma and some training, or education in a specific job skill or professional area, after high school. Additionally, most careers in this industry require a license or certification. These licenses are often required by government agencies and are obtained by passing an exam.

Many environmental services technician jobs only require special training after high school. To become a hazardous waste removal technician, you need a high school diploma and 40 hours of formal training on the job or at an EPA-approved school. The training requires completing a program in chemistry, environmental technology, and safe waste handling.

To become a nuclear power plant operator, you need a high school diploma plus experience in a nuclear power plant. You may also need to obtain a special license, depending on the state or area in which you wish to work. Preference is often given to graduates of the U.S. Navy's Nuclear Field Program. This intensive 18-month training program is open to high school graduates with a proven talent in math and science.

Radon measurement technicians are certified by the National Environmental Health Association (NEHA) or the National Radon Safety Board (NRSB). For certification, you must complete an approved 8- or 16-hour training course. You also must pass an exam.

Some jobs as lab assistants require a high school diploma along with special training and certification. Technical or vocational schools often offer this training. Lab assistants who wish to rise to the position of lab technician can continue their education and obtain an associate degree.

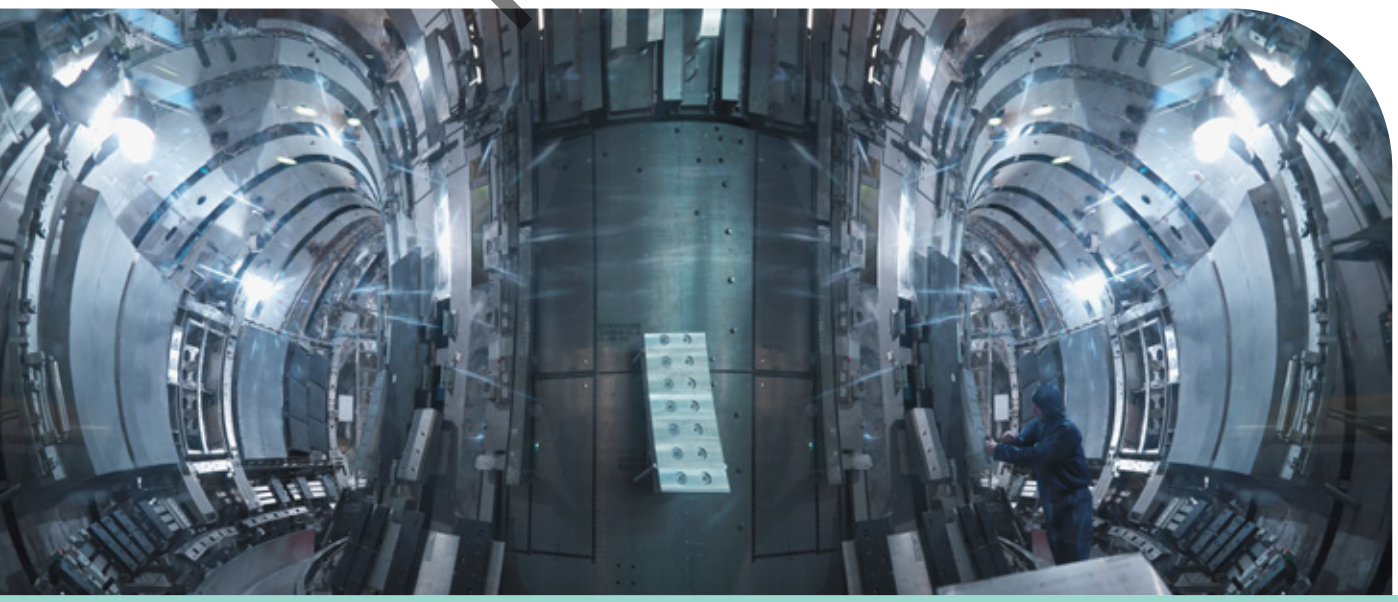
Jobs Requiring an Associate Degree

Not all jobs in the STEM industry require advanced degrees. Technicians and research assistants in several science and engineering fields may need only an associate degree. An associate degree is a degree awarded after two years of successful study.

Engineering technicians, for example, generally require only an associate degree. Many obtain their degree at community colleges or technical schools. Some receive their training in the armed forces. The U.S. Army, for example, offers training in technical engineering and pharmacy technology. Drafters, who make the detailed drawings used in building and manufacturing, may also receive training in the armed forces or at technical schools.

Jobs Requiring a Bachelor's, Master's, or Doctoral Degree

Most jobs in STEM require an advanced education. If you want to become a scientist, a mathematician, or an engineer, you will need at least a bachelor's degree in your field. Most scientists and mathematicians obtain a master's and often a doctoral degree. These advanced degrees lead to far more job opportunities and higher pay. For example, a master's or doctoral degree in physics could prepare you for work in the government space program or with an airplane manufacturer. Scientists and mathematicians who wish to conduct advanced research and publish their findings must obtain a doctoral degree.



Engineers whose work affects life, health, or property and engineers who work for the government must obtain a state license. To be licensed as a professional engineer, you generally need a bachelor's degree and four years of job experience. You must also pass a state exam. Engineers who work with nuclear materials must obtain a special license from the U.S. Nuclear Regulatory Commission (NRC).

Table 2.4: Education Required for STEM Jobs

Level of Education	Job Title
High school diploma & other training	Hazardous Material Remover Workers Nuclear Power Plant Operators Water Treatment Plant Operators Lead Sampling Technicians
Associate degree	Automotive Engineering Technicians Electrical Engineering Technicians Genetic Engineering Research Assistants Lab Assistants
Bachelor's, master's, or doctoral degree	Biochemical Engineers Electrical Engineers Wind Energy Engineers Archaeologists Chemists Environmental Scientists

STEM Skill Standards

Skills standards in the STEM industry vary considerably. Funding provided by the U.S. Department of Education has let several groups develop specific standards and programs for entry-level employees. For instance, beginning- to middle-level bioscience technical specialists must now meet specific requirements consisting of 34 integrated skills standards. For each standard, candidates are asked to demonstrate how they would handle a particular problem.

Standards have also been established for entry-level chemical lab technicians. These standards assess a candidate's mastery of math and statistics, computer skills, communication skills, workplace skills, and general laboratory skills. One general laboratory skill requires competency in handling lab equipment.

In some cases, mastery of specific skills leads to certification or licensing. This shows that the person has achieved a high level of competence in a field. Scientists are generally not licensed, but many engineers and technicians are. Employers and clients often value licenses, and many companies require that senior engineers be licensed.

License regulations for engineers vary from state to state. Most require that a candidate has a four-year engineering degree from a program approved by the state board and four years of qualifying engineering experience. Candidates must also pass exams on engineering fundamentals, principles, and practices.

Professional Skills

Communications Skills In the STEM industry, communication skills are necessary when giving instructions and explaining procedures. They are essential for scientists and mathematicians who teach students. They are also important for communicating with coworkers.

Listening Skills Listening skills are key to following instructions safely and precisely. They are very important in discussing ideas and information with colleagues. Good listening skills also help in understanding other ideas and viewpoints. They are essential to teachers when they interact with students.

Problem-Solving Skills Problem solving is key to many jobs in STEM. For example, an environmental engineer might try to design the best way to clean up a toxic spill. An industrial chemist might aim to figure out why a new formula for furniture polish leaves spots on the furniture. Problem solving requires creativity, logical thinking, and persistence.

Technology Skills The impact of technology on this industry is enormous. Many scientists and engineers work with new technologies such as fiber optics, lasers, and robots. They must be able to keep up with cutting-edge advances. Workers in this field must be able to use sophisticated lab equipment.

Decision-Making Skills STEM jobs often involve making important decisions. Civil engineers, for example, must decide on the safest, most practical ways to make improvements to infrastructure. Environmental engineers may need to decide on the best way to clean up a polluted site. Being able to gather and analyze

information quickly and to think clearly under pressure are very important skills for virtually all workers in this industry.

Organizing and Planning Skills
Engineering a product or conducting an experiment involves many steps. Organization and planning are crucial to the success of any project. Engineers and scientists often work on complex research projects that require long-term, far-sighted planning. The ability to organize teams, schedules, and processes is essential.

Teamwork Skills Scientists and engineers rarely work entirely on their own. They are required to work with various teams, departments, managers, colleagues, and sometimes customers to complete a job. Teamwork requires leadership skills, communication skills, and respect for the thoughts and feelings of others.

Social Skills Social interaction makes for a more enjoyable and productive work environment. It is also very important when working with students and colleagues at colleges and universities. Private consultants need effective social skills to help them obtain and work with clients. Social scientists need strong social skills when conducting studies in which they need to interview human subjects.

Adaptability Skills Change is a fact of life in the STEM industry. Job descriptions, work environments, and technologies are constantly changing. Workers must view change positively and be flexible.

2-4 Essential Question Reflection

So, let us revisit our essential question:

What training & education is needed for a job in STEM?

Based on what you learned in this section, please answer this question in detail.

Practice 2-4

Skills Practice

When reading documents, workers in the STEM industry need to be able to identify the main idea. The main idea tells what the document is about. They must also find details supporting the main idea. For example, as a biologist studying a particular animal, you may need to find the main ideas and details in research papers. Details provide more information that helps explain the main idea. **Practice this skill!**

As a conservation biology field assistant, you help protect sea turtle hatching areas. Your manager has given you information to distribute to residents and business owners around the beach. The following is the flyer they have given you:

LEARN TO SET UP LIGHTS FOR SEA TURTLES!

March 22, 3–5 p.m.

Turtle Beach Annex Building

Come participate in a special lighting workshop where you can learn how to set up safe lights for our sea turtle mothers and hatchlings in kind ways! We'll show you how artificial light affects sea turtles, which lights are the most turtle-friendly, and how to get ready for hatching season.

Please RSVP to Donna Smith by March 8.

You can also contact Donna for more information at dsmith@turtlebeachconservation.org or via phone at 555-3232 ext. 15.

Brought to you by the Turtle Beach Conservation Organization.

1. What is the main idea of this flyer?

A. Artificial lights hurt sea turtles.

B. People can attend a workshop to learn how to install lighting that is safe for turtles.

C. Residents must leave the beach during hatching season.

D. Mother turtles will not lay eggs if artificial light is around the beach.

E. Business owners should learn to be more turtle friendly.

2. One of the business owners you speak to has more questions about the workshop. What does the email suggest they should do to get more information?

A. Visit the Turtle Beach Annex Building.

B. Talk to other business owners in the area.

C. Find someone to talk to on Turtle Beach.

D. Call or e-mail Donna Smith.

E. Write a letter to the Turtle Beach Conservation Organization.

To access more problems that will help you grow professional skills and are real-world examples in STEM, go online.

2-5 Working Conditions in the STEM Industry

When choosing a career path, knowing what it is like to work in the industry is important. Understanding the work environment, hazards, and benefits of a job can help you make informed decisions.

2-5 Essential Question

As you read this section, keep this question in mind:

What are typical work environments in STEM?

Work Environment

Work environment refers to factors that affect workers' health and satisfaction on the job. These include the physical surroundings and the working hours. They also include the physical activities required to perform the job.

These volcanologists are ready for a fast exit as this volcano erupts. Volcanology is hazardous but exciting!

Physical Environment

People in STEM work in a variety of settings. Researchers, professors, and managers usually work in laboratories, classrooms, or offices. These worksites are generally clean, modern, well lit, and well equipped. Nevertheless, lab work can be hazardous, especially if it involves work with chemicals, biological agents, heat, or dangerous machinery.

Sometimes scientists and engineers need to work outdoors. Volcanologists study volcanoes and work in some of the most extreme conditions possible. Some environmental scientists or engineers gather information by taking water samples or monitoring animal populations. Some aerospace engineers go to test ranges or airstrips to observe tests of vehicle designs or electronic equipment. In these cases, engineers may have to work outdoors regardless of the weather conditions.

Some scientists and engineers must travel or live abroad to work. For example, mining engineers often work in parts of the world that are rich in certain minerals. Archaeologists must gather physical evidence in the regions of the world that they

specialize in. Sometimes the climate and living conditions in foreign lands present an increased risk of health problems or environmental dangers. The political climate may also present hazards. When working overseas, it is generally a good idea to keep in touch with the U.S. State Department and organizations such as American Citizens Abroad (ACA).

Work Hours

The work hours for careers in STEM vary greatly. Some experiments must be constantly monitored. Some workplaces must remain secure around the clock. For these reasons, many labs and other facilities rely on shift work. Shift work divides the day into blocks of time. Some workers start their shifts early in the morning. Others start late at night. In addition, many workers do not have weekends or holidays off. Science technicians, engineers, and power plant operators might all work shifts.

Most scientists, mathematicians, and engineers work 40 hours a week during standard working hours. However, they may need to work overtime to meet deadlines. Often, they face long evening and weekend hours when a project nears its deadline. For example, a deadline might require a satellite component to be finished by a certain date so that other specialists can plan how their components will fit together.

Because professionals, like scientists and engineers, are paid a salary, they are often not paid for overtime work. A salary is a fixed wage, usually set for a year. Workers who earn an hourly pay wage generally do earn overtime pay.

Some scientists, mathematicians, engineers, and technicians may work flextime. Flextime is a type of schedule that allows employees to choose the hours and days they work, if they work a standard total number of hours per week. For example, a worker who must put in 40 hours a week may choose to work ten hours on four days a week instead of eight hours on five days.

College professors have fixed schedules for teaching classes and for office hours when students meet with them. The time they spend doing their own research or examining student work is usually flexible. Nevertheless, professors may put in long hours to get their work done.

Essential Physical Activities

Workers in STEM are usually not required to be in excellent physical condition. However, those who work outdoors do need to be in good shape so they can tolerate various climates and rugged conditions. Many scientists work in laboratories or offices. They might be required to spend long periods of time on their feet. Those who work with microscopes and small tools, wiring, and other small items need good hand-eye coordination. Good vision is also a must for scientists who study minute objects or read thermometers, gauges, and meters.

Science and Mathematics

Life Scientists and Technicians

- Those who work in labs often stand for long periods of time.
- Some scientists make field trips that can involve strenuous activity.
- Those working with dangerous organisms or toxic substances must follow strict safety procedures.

Physical Scientists and Technicians

- Chemists may work outdoors gathering samples. They must follow safety procedures when working with potentially harmful chemicals.
- Physicists may need to travel and use special equipment for research.
- Hydrologists and geologists often work outdoors.
- Oceanographers may spend long periods at sea on research ships.

Social Scientists

- Archaeologists, anthropologists, sociologists, linguists, and geographers often work in the field gathering data or artifacts.
- Historians may spend long hours doing research in libraries.
- Psychologists sometimes work in clinics or hospitals.

Mathematicians

- Mathematicians may spend long hours working at computers or pouring over spreadsheets; this work can cause eyestrain.
- Statisticians may need to do field work gathering data.

Engineering and Technology

Engineers and Engineering Technicians

- Most work in offices, labs, or industrial plants.
- Those who work in labs or industrial plants are often on their feet for long periods.
- Some may be exposed to hazardous equipment, chemicals, or materials.
- Mining, geological, and petroleum engineers may work overseas.

Environmental Services Technicians

- Most work outdoors in all weather conditions, and they are exposed to noise, toxic substances, and unpleasant odors.
- Many do repetitive, physically demanding work.
- Waste and wastewater treatment plant operators must stoop, reach, and climb. They may work in hazardous conditions.
- Hazardous materials removers may do strenuous physical labor. They wear safety gear and follow safety rules to avoid toxic substances.
- Nuclear plant operators must comply with strict safety rules to avoid endangering themselves and others.

Source: *O*NET*

Some jobs in the STEM industry can be physically demanding. Hazardous materials technicians, for example, may need to shovel, lift heavy objects, crawl into tight spaces, or work on scaffolding.

Hazards and Environmental Dangers

Eye injuries are a major concern in laboratories. Goggles are required to prevent damage from sharp objects or exposure to chemicals and extreme light. Showers and eye baths must be available to workers at risk for eye damage. Scientists, mathematicians, and engineers who often read gauges, dials, or detailed written material may suffer from eyestrain.

Scientists, engineers, and technicians may be exposed to chemicals or other substances that are dangerous to touch or breathe. For example, some lab workers risk skin injuries from acids or strong alkaline solutions. Safety shoes, gloves, and respirators must be available to all workers exposed to dangerous substances. Some workers, such as hazardous materials removers, may need to wear protective gear whenever they are on the job.

Because accidents happen on the job, safety must be a priority. Workers must follow all safety procedures. They must be especially careful with sharp tools, lab animals, explosions, broken lab glass, electricity, and hazardous or radioactive materials.

In addition to on-the-job-injuries, workers may face more chronic health problems. Over time, they may suffer from musculoskeletal disorders (MSDs). A musculoskeletal disorder is a chronic problem with the muscles, nerves, tendons, joins, cartilage, or spinal discs. One kind of MSD is a repetitive stress injury (RSI), an ailment that can develop when the same motions are performed repeatedly. Scientists, mathematicians, and engineers who spend many hours using a computer may suffer from repetitive stress injuries (RSIs) because they repeat the same motions hundreds of times a day.

The federal government helps protect workers by creating workplace safety standards and laws to help prevent accidents and job-related illnesses. The Occupational Safety and Health Administration (OSHA) is the government agency that sets most job safety standards and inspects job sites. Many states also run their own OSHA programs.

2-5 Essential Question Reflection

So, let us revisit our essential question:

What are typical work environments in STEM?

Based on what you learned in this section, please answer this question in detail.

2-6 Trends in STEM

Few industries change as rapidly as the STEM industry. New technology means new directions for research and new ways of conducting research. Changes in society create new demands on what scientists study and engineers design.

2-6 Essential Question

As you read this section, keep this question in mind:

What factors affect trends in STEM?

Technology in the STEM Industry

New technology and a commitment to use "green" products and processes are changing the STEM industry. Researchers today use the technology of the Internet and computer databases—rather than paper—to gather and store information. Many scientists are employed to find ways of improving the environment through renewable energy and sustainable design.

Artificial Intelligence and Sensor Technology

Artificial intelligence (AI) is the technology that develops computer programs to do human tasks. It has been applied extensively in aerospace engineering. NASA uses AI software to guide satellites and spacecraft. Computers react to changes in their surroundings and perform functions without aid from ground controllers.

A sensor can detect and record objects and movement. With sensor technology, machinery is "aware" of its surroundings. Some electric wheelchairs, for example, have been equipped with ultrasonic sensors that enable the wheelchair to avoid bumping into objects. The U.S. Defense Advanced Research Projects Agency (DARPA) is encouraging the development of biosensors that detect dangerous microorganisms, small living things that could be used in a terrorist attack.

Robotics, another AI application, is the technology of designing, building, and operating robots. A robot is made up of a small computer "brain," mechanical devices that enable movement, and sensors that allow the robot to respond to its surroundings. Today's robots are becoming much more adaptable. Carnegie Mellon University has successfully tested the navigation/sensor system of a robot helicopter. Such a craft may one day be able to evacuate soldiers or others in dangerous situations without putting pilots at risk.

Neuromorphic engineering copies structures in the human brain and nervous system to design computers and robots capable of sensing. This technology could eventually create computer systems that will recognize objects by sight.

Natural language processing (NLP) attempts to build computers that understand human language. Using NLP, computers may be able to translate or summarize texts or understand exactly what users are looking for when they conduct web searches.

Nanotechnology and Biotechnology

Nanotechnology is the ability to control matter at the level of individual atoms and molecules (the smallest pieces of matter) to build tiny devices. Physics, chemistry, and engineering all contribute to the field of nanotechnology. Nanotechnology can create computers the size of a single molecule. This technology has hundreds of applications. For example, a tiny layer of particles placed in household paint could be programmed to make the paint resistant to fires. A pill-sized camera swallowed by a patient can check for diseases. The use of nanotechnology in health and medicine is called nanomedicine.

Nanotechnology has produced the atomic force microscope (AFM). This tool helps scientists see tiny things in great detail. Biologists can use it to observe how cells interact.

DNA is the molecule that is the “blueprint” for a living organism. This tiny material is made up of genes that determine what an organism looks like and how it is different from other organisms. In 2003, the Human Genome Project completed its effort to identify and map all 25,000 genes in human DNA. The effort helped create the biotechnology industry, which uses DNA to improve, create, or modify living things. Biotechnology has led to the discovery of important drugs like human insulin and growth hormone. It is the basis of genetic engineering, which modifies foods and other organisms. Genetic engineering can develop crops that are resistant to insects.

Sustainability in STEM

Sustainability is a major trend in STEM today. It refers to economic activity that does not harm the environment. Examples of sustainable technology include renewable energy, green chemistry, and sustainable design.

Renewable Energy

Renewable energy is generated from natural sources that do not run out. It causes less pollution than energy from petroleum-based fuels like oil and gasoline. Many scientists and engineers are working to find the best forms of renewable energy and the best ways to use them. Solar energy systems engineers design and maintain systems that get energy from sunlight. Engineers in nanotechnology are working on less costly solar panels to help generate solar energy. Wind energy engineers design wind farms where wind is collected and used for energy. Wind resource analysts are helping them decide where to locate these wind farms.

Geoscientists work with engineers on two other types of renewable energy: geothermal energy and hydropower. Geothermal energy uses the heat inside the earth as an energy source. Hydropower is energy produced by moving water. Dams on rivers have long been a source of hydropower. Now efforts are being made to use the energy of the ocean waves.

Renewable energy also comes from biofuels, which are fuels produced from easy-to-grow plants, such as corn, and the waste materials of plants, like leftover cooking oil. Biofuels work well in motor vehicles, such as buses, boats, and trucks. The most widely used biofuels today are ethanol and biodiesel. Biological scientists continue to identify the best plants or plant products to use. Engineers continue to design new ways to use them.

Green Chemistry

One growing trend in the field of chemistry is green chemistry. The goal of green chemistry is to avoid products and processes that harm the environment. To achieve this goal, scientists work to design products that are less hazardous to people and the environment. They design products that take less energy or fewer materials to produce. Scientists look for ways to reuse or recycle chemicals or to treat existing chemicals to make them less hazardous. Finally, they work to ensure that chemicals are disposed of without doing harm to the environment.

Sustainable Design

Sustainable design focuses on the design and use of processes and products that lower the risk of harm to human health and the environment. It stresses the use of "green" chemistry, chemical products that are not harmful. It encourages the use of building materials from renewable sources. The American Society of Civil Engineers (ASCE) has set sustainable design as a goal for its members.

2-6 Essential Question Reflection

So, let us revisit our essential question:

What factors affect trends in STEM?

Based on what you learned in this section, please answer this question in detail.

Chapter 3 Manufacturing

Essential Questions

By the end of the chapter, you will be able to answer the following questions:

- **3-1** What types of opportunities are available in Manufacturing?
- **3-2** Which opportunities may be right for you?
- **3-3** How can I match my skills & interests with the right job?
- **3-4** What training & education is needed for a job in Manufacturing?
- **3-5** What are typical work environments in Manufacturing?
- **3-6** What factors affect trends in Manufacturing?

Chapter Topics

3-1 Manufacturing Today

3-2 Manufacturing Jobs

3-3 Building a Career in Manufacturing

3-4 Education and Training for Manufacturing Opportunities

3-5 Working Conditions in the Manufacturing Industry

3-6 Trends in Manufacturing

3-1 Manufacturing Today

Look around you. How much of what you see has been made by combining materials in creative, effective ways? The chair on which you sit, the walls around you, your phone, and even much of what you eat and drink have all been made. Manufacturing is the process of making products by hand or by machine. The term "production" sometimes means the same thing as "manufacturing." For example, apparel manufacturers produce the clothes you wear, and breakfast cereal is created at food processing plants. Manufactured products can be as simple as paper clips or as complicated as robots and computers. Manufacturers create their products by hand or by using highly specialized machinery that they purchase from other manufacturers.

The United States is the world's largest manufacturing economy. It produces products worth $1.6 trillion each year. The Manufacturing industry includes 18.6 million jobs. This is about one in every six jobs in the private sector, or private and non-government companies.

3-1 Essential Question

As you read this section, keep this question in mind:

What types of opportunities are available in Manufacturing?

Career Journeys in Manufacturing

There are six major paths along which your journey in Manufacturing might be shaped. Each field contains a group of careers requiring similar skills as well as similar certifications or education. These paths are:

- Production
- Manufacturing Production Process Development
- Maintenance, Installation, and Repair
- Quality Assurance
- Logistics and Inventory Control
- Health, Safety, and Environmental Assurance

Companies in the Manufacturing industry fall into three broad categories:

- **Producers** make and sell a product directly to the public or retail merchants.
- **Suppliers** are manufacturing businesses that make parts or components. They then sell these parts to other manufacturers.
- **Distributors** sell the products of suppliers.

Production

Workers in the Production path include people who work on the shop floor of manufacturing plants. These workers may use machines to make electronic parts. They may construct or assemble housing. They may weld metal, or they may print books.

Machinists use tools like lathes and grinders to produce precision metal parts. Foundry workers melt and mix metals and pour them into molds. Sheet metal workers shape and weld flat sheets of metal into large products, such as heating ducts and drainpipes. Tool and die makers create metal parts used to form all kinds of products, from wood furniture to ceramic bowls.

This path is not limited to making products. Hydroelectric plant technicians make sure their plants are running smoothly. Other workers operate chemical and nuclear plants. Millwrights install, move, and take apart heavy machinery. Boilermakers assemble, maintain, and repair boilers and other vessels that hold liquids and gases.

Workers in this path must be good at working with their hands. They often must be physically strong. They should have good problem-solving skills and be able to work well on their own. Many workers in this field take part in apprenticeships or train at community colleges.

Manufacturing Production Process Development

Employees in this career path supervise product design and the design of the manufacturing process itself. They make sure that products meet or exceed customer expectations. They also monitor the materials used to manufacture products.

A variety of engineering jobs are included in this path. These include design engineers, electronics engineers, and industrial engineers. Engineers design new products, using computers to analyze and test their designs.

There are a variety of other jobs in this path. Process improvement technicians work to find the most efficient processes for creating a product. Production

managers coordinate all the people and equipment involved in the production process. Precision inspectors, testers, and graders make sure the products meet required quality standards.

Workers in this path must have good problem-solving skills and mathematical abilities. They must exercise good judgment and have a detailed knowledge of the production process. Many jobs in this field require a bachelor's degree.

Maintenance, Installation, and Repair

This career path is wide-ranging. It includes all jobs involved with installing, maintaining, and repairing a broad range of devices. These devices can be small, such as cellular phones, computers, and home security systems. Or they can be large, such as nuclear power generators and satellites. This field is vital to every area of the Manufacturing industry.

Jobs in installation and maintenance require highly developed technical skills. These skills may be learned through apprenticeships, technical schools, community colleges, and on-the-job training. Workers in this career path need to understand electrical wiring and components. They must also be able to diagnose and repair complex systems.

Quality Assurance

Employees in the Quality Assurance path make sure that standards are met and procedures are followed. They are responsible for fulfilling the performance requirements that customers expect from various products and services. Some employees in this path monitor and maintain the quality of parts, while others inspect raw materials to see that they meet specifications. Still other employees measure and test products and parts to make sure they meet customer satisfaction.

Jobs in this career path include food science technicians, medical and health services managers, aerospace engineers, and managers of computer and information systems. Employees may have titles such as inspector, tester, sorter, sampler, and weigher.

Good communication skills are required in this path. A quality control systems manager, for instance, meets with the marketing and sales departments of a company to define client expectations. He or she supervises the tracking of test results and product defects. A manager in this field oversees supervisors, inspectors, and laboratory workers engaged in testing activities.

Logistics and Inventory Control

Employees in this path move products and materials around. Jobs in this field include storage and distribution managers, shipping and receiving clerks, cargo and freight agents, and transportation managers. Employees move raw materials to the production line, unload trucks with raw materials, and communicate with traffic managers. Organizational skills are very important in this path.

Logistics analysts, for example, work with data that tells whether a product is available, how well the production process is working, and how the product is being transported to the next location. They meet and communicate with management teams to make sure the materials required for production are available and not too expensive. People involved in logistics make sure deliveries are made on time and all orders are fulfilled. They keep track of inventory, the amount of the product available to be shipped. They also manage systems that make sure the price of a product considers the cost of producing and shipping it.

Health, Safety, and Environmental Assurance

Employees in this career path ensure the safe use of workplace equipment. They design and install safety procedures for new production processes. They carry out health and safety investigations. Many jobs in this path focus on preventing health problems. People in this path train other workers in health, safety, and environmental issues.

For example, environmental science and protection technicians often perform laboratory and field tests to monitor the impact of manufacturing firms on the environment. They investigate sources of pollution and other things that may endanger a person's health. Skills needed for this job include knowledge of biology, chemistry, computers, and public safety and security.

Manufacturing Future Outlook

Industry outlook refers to the projected job growth or decline in a particular industry. According to the Bureau of Labor Statistics, growth will be slow in the Manufacturing industry in the years up to 2030. The greatest growth will be in the areas of high-tech equipment and pharmaceuticals. Other areas will see declines.

Table 3.1: Job Forecast for a Sample of Manufacturing Occupations

Occupation	Expected Growth Rate
Welders, Cutters, Solderers, and Brazers	5%–10%
Purchasing Agents	–1% or lower
First-Line Supervisors	1%–5%
Machinists	5%–10%
Machine Tool Operators (CNC automated)	5%–10%
Industrial Production Managers	5%–10%
Power Plant Operators	–1% or lower
Telecommunications Equipment Installers	–1% or lower
Security and Fire Alarm Installers	15% or higher!
Medical Equipment Repairers	5%–10%
Inspectors, Testers, and Sorters	–1% or lower
Quality Control Systems Managers	5%–10%
Logistics Analysts	15% or higher!
Cargo and Freight Agents	5%–10%
Environmental Engineers	1%–5%
Health and Safety Engineers	5%–10%

3-1 Essential Question Reflection

So, let us revisit our essential question:

What types of opportunities are available in Manufacturing?

Based on what you learned in this section, which field of Manufacturing is the most interesting to you? Explain your answer.

Practice 3-1

Skills Practice

The details in workplace documents are not always clearly stated. For example, a help wanted ad for a machine repairer might ask for related experience. People applying need to identify what would qualify as related experience and determine whether they have that experience. It may sometimes be necessary to infer, or make a logical guess, when a detail is suggested rather than stated. **Practice this skill!**

WAREHOUSE AND OPERATIONS SPECIALIST

Description

Responsibilities include keeping accurate records on warehouse inventory, truck loading and unloading (manually and using a forklift), and primary shipping/receiving. Forklift driving certificate may be required.

Primary Responsibilities

- Operate equipment and/or a forklift safely and efficiently
- Track, receive, and store incoming items efficiently using established procedures and automated devices including barcode scanners
- Maintain accurate, complete records of incoming, outgoing, and stored product including partial cases of returned product

Desired Experience

- Experience in high-speed warehouse or shipping environment
- Forklift driving experience or certificate
- Experience in tracking and managing inventory
- Computer experience including using spreadsheets, proprietary applications, and hand-held devices such as barcode scanners

Use the above job posting for a Warehouse and Operations Specialist to answer the questions that follow.

1. As a warehouse and operations specialist, you are interested in applying for this job. Which one of the following jobs listed on your resume should you highlight because it relates directly to the type of experience the employer is looking for?

A. restaurant busser; cleaned tables and refilled beverages

B. theme park operator; operated a roller coaster

C. cafeteria cashier; rang up customers' orders

D. stock clerk; used a barcode scanner to check inventory levels

E. fry cook; managed the fryer

2. You also have additional skills and achievements listed on your resume. According to the job description's list of desired experience, which of the following should you highlight?

A. your forklift driving certificate

B. your experience as a telemarketer

C. your experience as a clothing store sales clerk

D. your certificate to teach cooking classes

E. your Employee of the Month award at a fast-food restaurant

To access more problems that will help you grow professional skills and are real-world examples in Manufacturing, go online.

3-2 Manufacturing Jobs

The field of Manufacturing contains jobs that represent a variety of skills and abilities. You might find yourself working at an auto plant assembling cars, or you might work in a lab creating robots. Here are some common industry jobs and the skills they require.

3-2 Essential Question

As you read this section, keep this question in mind:

Which opportunities may be right for you?

Occupation With the Most People Employed:

Supervisors

- Directly supervise and coordinate the activities of production and operating workers
- Keep records of employees' attendance and hours worked
- Inspect materials, products, or equipment to detect defects or malfunctions

Fast Facts:

Employment: 616,000 in 2020, expected to grow slightly to 640,000 in 2030
Annual Openings: 63,000
Median Annual Wage: $61,790
Education Needed: High school diploma

Great Job! – Associate Degree Needed:

Drafters

- Prepare detailed working diagrams of objects requiring assembly
- Sometimes called CAD Designer (Computer Aided Design Designer), CAD Operator (Computer Aided Design Operator), Design Drafter, Drafter

Fast Facts:

Employment: Approximately 100,000
Median Annual Wage: $61,000
Education Needed: Associate degree
Did You Know: This is a "high flying" occupation, where the work you do eventually becomes part of making a vehicle fly.

Great Job! – High School Diploma Needed:

Mapping Technicians

- Perform mapping duties, usually under supervision
- Obtain data used for construction, mapmaking, boundary location, mining, or other purposes
- May calculate mapmaking information and create maps from source data

Fast Facts:

Employment: 54,800

Median Annual Wage: $46,910

Education Needed: High school diploma, or equivalent

Did You Know: In this field you contribute to everything from weather maps to map apps used by drivers!

3-2 Essential Question Reflection

So, let us revisit our essential question:

Which opportunities may be right for you?

Based on what you learned in this section, please answer this question in detail.

Case Study: Computer Numerically Controlled (CNC) Programmers

What do they do?

- Develop programs to control machining or processing of materials by automatic machine tools, equipment, or systems
- Set up, operate, or maintain equipment

What would you do?

- Write programs in the language of a machine's controller and store programs on media, such as punch tapes, magnetic tapes, or disks
- Determine the sequence of machine operations and select the proper cutting tools needed to machine workpieces into the desired shapes
- Revise programs or tapes to eliminate errors and retest programs to check that problems have been solved

What do you need to know?

Engineering and Technology
Computers and electronics
Mechanical

Math and Science
Arithmetic, algebra, geometry, calculus, or statistics

Manufactured or Agricultural Goods
Manufacture and distribution of products

Arts and Humanities
English language

What skills do you need?

Basic Skills

Keep track of how well people and/or groups are doing in order to make improvements

Figure out how to use new ideas or things

Problem Solving

Notice a problem and figure out the best way to solve it

People and Technology Systems

Figure out how a system should work and how changes in the future will affect it

Think about the pros and cons of different options and pick the best one

What abilities must you be good at?

Math

Choose the right type of math to solve a problem

Add, subtract, multiply, or divide

Ideas and Logic

Order or arrange things

Notice when problems happen

Visual Understanding

Quickly compare groups of letters, numbers, pictures, or other things

See hidden patterns

Verbal

Listen and understand what people say

Who does well in this occupation?

People interested in this work like activities that include data, detail, and regular routines

People who do well at these jobs need:

Attention to detail

Independence

Analytical thinking

Dependability

Integrity

Achievement/effort

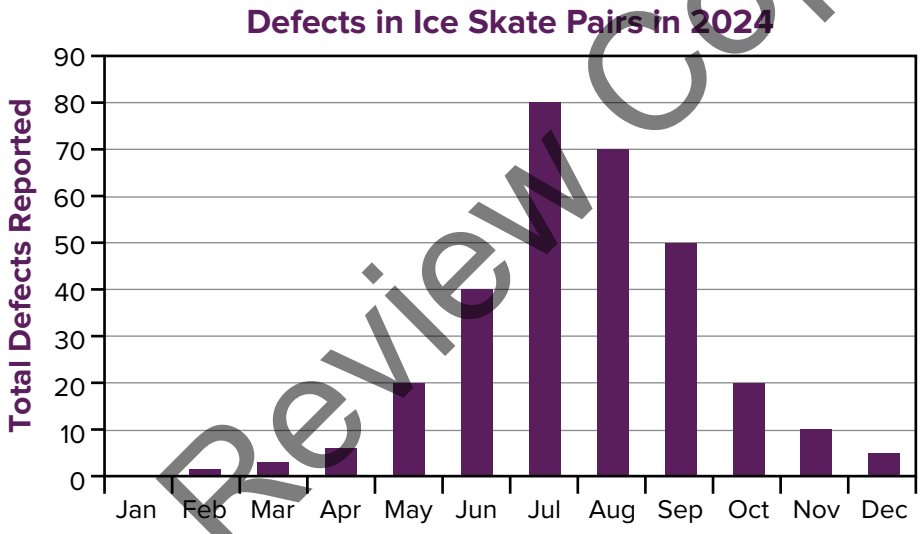
What educational level is needed?

- High school diploma, or equivalent
- Certificate, can be obtained during or after high school

Practice 3-2

Skills Practice

Manufacturing workers must sometimes analyze graphics to identify trends. They might search for data that has increased or decreased over time. An industrial safety and health engineer might analyze tables of accident statistics in a factory over several years. Being able to identify common trends from several pieces of data can help with a variety of jobs in this industry. **Practice this skill!**



Use the chart above to answer the questions that follow.

1. As a shift manager in a production plant that makes ice skates, you have received the defect report for your shift's production over the past year. In what month were the defects at their highest point?

A. January

B. March

C. April

D. June

E. July

2. By how much did the defect rate change between May and June?

A. It doubled.

B. It was reduced by half.

C. It stayed the same.

D. It fell slightly.

E. There were no defects in June.

To access more problems that will help you grow professional skills and are real-world examples in Manufacturing, go online.

GO ONLINE

3-3 Building a Career in Manufacturing

Once you have found a field that interests you, look ahead and consider your overall career path and where you should start. For example, many robotics engineers begin their career as an apprentice. After a few years, their responsibility might increase to include designing and managing projects. Robotics engineers with significant experience generally become more involved with clients and upper-level executives. Some senior-level engineers might even start their own companies.

3-3 Essential Question

As you read this section, keep this question in mind:

How can I match my skills & interests with the right job?

Are You More Interested in Working With Data, People, or Things?

Environmental engineers, for example, work mainly with data. Labor relations managers work primarily with people. Welders work mostly with things. When planning your career path, consider what balance of data, people, and things you want in a career.

Careers That Involve Working With Data

Examples of working with data include preparing financial statements and drawing up budgets, making measurements and calculations, and scheduling the steps needed to manufacture a product.

Many Manufacturing jobs focus on data. Machinists and tool and die makers review blueprints before calculating where and how to cut into something. Engineers may be called upon to design new products or improve existing ones. This requires conducting research, running tests, and collecting and analyzing data. Engineers may also perform calculations and make projections based on collected data.

Some managers in Manufacturing also need to work with data. A production manager, for instance, may need to study spreadsheets that display rates of production to determine whether a particular procedure is efficient and cost-effective.

Careers That Involve Working With People

Examples of working with people include training employees, mediating conflicts among coworkers, negotiating prices with suppliers, and advising customers. All these activities involve strong communication skills.

Many Manufacturing jobs enable you to spend a great deal of time working with others. Production managers or supervisors must effectively supervise and lead teams of workers. Assemblers rely heavily on teamwork, which requires the ability to follow directions and communicate ideas to other members.

Careers That Involve Working With Things

Examples of working with things include setting up and operating machinery, driving a forklift, and welding metal. For instance, someone who works with machinery might start, stop, and observe the operations and actions of equipment. A tender (a worker who attends to machines) may need to adjust materials or controls of a machine. He or she may change guides, adjust timers and temperature gauges, turn valves to allow the flow of materials, and flip switches in response to lights.

This carpenter is using a plane. Carpenters spend much of their time working with tools and machines.

Setting up requires preparing machines or equipment for operation by planning the order of the steps. Employees with this focus adjust the positions of parts or materials, set controls, and verify the accuracy of machine capabilities. These employees evaluate the properties of materials. They use tools, equipment, and work aids such as precision gauges and measuring instruments. This job requires experience and good independent judgment.

Most careers in Manufacturing involve working primarily with things. For example, welders, assemblers, and machinists spend a majority of their day working with tools, machines, and other equipment.

Working with things, though, may occur in a wide variety of settings. For instance, boiler tenders are responsible for handling and monitoring large equipment. Boiler tenders work in a variety of Manufacturing industries. Some, for example, are employed at plants that produce lumber, paper, chemicals, iron, or steel. Others work at public facilities, such as schools or government buildings.

3-3 Essential Question Reflection

So, let us revisit our essential question:

How can I match my skills & interests with the right job?

Based on what you learned in this section, please answer this question in detail.

3-4 Education and Training for Manufacturing Opportunities

Jobs in the Manufacturing industry require varying levels of education. Many jobs in the industry require little or no formal training. For others, it is necessary to have specific education and experience.

3-4 Essential Question

As you read this section, keep this question in mind:

What training & education is needed for a job in Manufacturing?

Training and Education in Manufacturing

The level of training necessary to succeed in the Manufacturing industry varies by career. Jobs can be categorized into three groups—jobs requiring little or no training, jobs requiring some training, and jobs requiring advanced training.

Jobs Requiring Little or No Training

Positions such as precision assembler, machine tool operator, and hand packer usually require little previous training. The training for jobs such as these, and similar on-the-floor production jobs, is usually provided by your employer when you are hired.

However, getting a high school education or the equivalent is important. Many employers look for workers who earned solid grades in high school. Failing to complete high school may hurt your chances of advancing in your field.

Jobs Requiring Some Training or Certification

Many jobs in Manufacturing require some specialized training. If you are interested in working as a welder, electrician, machinist, or mechanical drafter, you will need to pursue specialized degrees or certifications.

You can complete apprenticeships to prepare for many of the more skilled trades in Manufacturing. Technical colleges offer programs in such fields as electronics servicing, mechanical drafting, and electronic engineering technology. Some programs will provide you with an associate degree upon completion.

Drafting, as well as many other Manufacturing roles, may require a specialized credential.

Trade organizations, or organizations representing a specific industry or type of job, often offer certification programs. These programs provide training for a specific occupation. Specialized certification exists in a wide variety of Manufacturing careers, including occupations in plastics and welding. These programs might require a minimum number of hours on the job and a minimum score on a standardized test.

Earning an associate degree or a nationally recognized certification can help you prosper in your field. For more information about such programs, contact trade organizations or community colleges and technical schools in your area.

Jobs Requiring Advanced Training

Jobs in Manufacturing that require extensive training usually involve business management, science, or engineering. Such jobs generally require at least a bachelor's degree. Some may require study at the master's or doctoral level.

Manufacturing professionals who work in scientific or engineering positions often need extensive schooling. The Manufacturing industry has a wide variety of scientific and engineering jobs.

For example, the aerospace industry employs many physicists. Most physicists have doctoral degrees in physics. Other Manufacturing fields, such as drug manufacturers, employ chemists with degrees in chemistry.

Table 3.2: Training Required for Manufacturing Jobs

Level of Training	Job Title
Little or No Training	Boiler Tenders Cooling and Freezing Equipment Operators Machine Tool Operators Shipping Clerks
Some Training	Boilermakers Computer Technicians Machinists Patternmakers Quality Control Technicians Tool and Die Makers
Advanced Training	Computer Engineers Industrial Engineers Mechanical Engineers Robotics Engineers Technicians

The Manufacturing industry also employs many engineers, particularly in the automotive and aerospace industries. To become an engineer, you must have at least a bachelor's degree in engineering. Common types of engineers in Manufacturing include mechanical, chemical, electrical, and civil engineers. Many engineers eventually pursue advanced degrees (master's or doctoral degrees) in their fields. Some companies hire technicians who have high school diplomas and some college training, usually less than two years. Many of these companies then pay for the employee to finish college and earn their degree.

Manufacturing Skill Standards

The Manufacturing Skill Standards Council (MSSC) represents individuals and organizations from the Manufacturing industry. These include labor unions, companies, educators, and public interest groups. Members of the council have worked together to create a set of core knowledge and skills. The standards stress the importance of specific job skills. They also emphasize general workplace skills. The standards call for knowledge in 17 academic areas, such as math, science, computer technology, and writing. The standards also define three main technical areas: safety procedures, the manufacturing process, and business policies and procedures.

The MSSC has developed skill standards for jobs in the six Manufacturing career paths. These are Production; Manufacturing Production Process Development; Maintenance, Installation, and Repair; Quality Assurance; Logistics and Inventory Control; and Health, Safety, and Environmental Assurance. These standards outline how work should be performed. The standards also define the level of knowledge and skill required for specific careers.

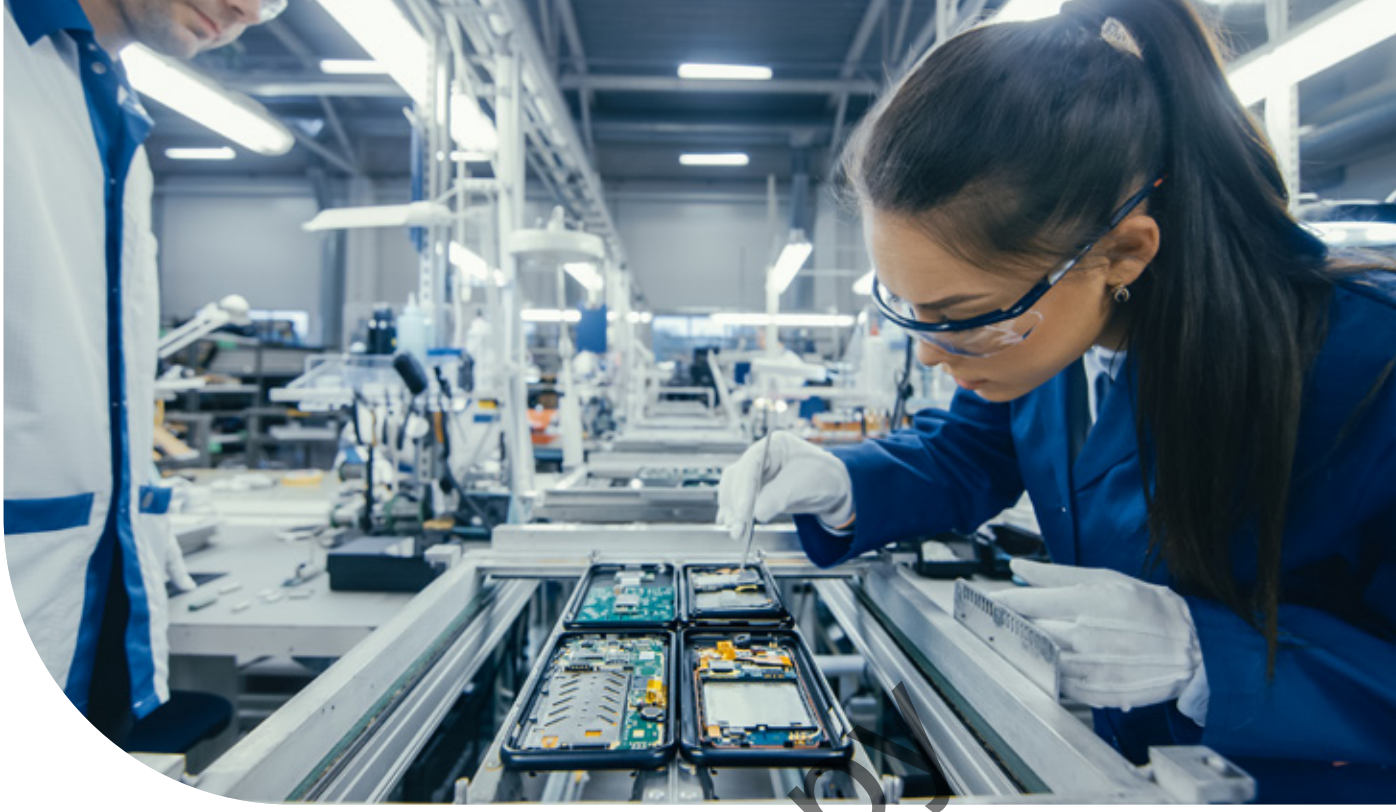
Professional Skills

Communication Skills In Manufacturing, workers need good communication skills when offering instruction to the people they manage or when bringing problems to management's attention. Good communication is also needed to develop good, productive relationships with coworkers.

Listening Skills Listening is the foundation of learning. Active listening skills are vital to effective communication. Listening skills are essential for following instructions safely and precisely. In the Manufacturing industry, this is necessary to ensure a safe working environment. Good listening skills also help colleagues understand each other's ideas and points of view.

Problem-Solving Skills Employers value workers who can spot problems and take action to find solutions. Solving problems requires creativity and self-reliance. A production supervisor, for example, may need to solve complex problems occurring on the production line or between departments. Maintenance, Installation, and Repair workers confront a broad range of problems almost every day. They must identify problems and then evaluate potential solutions. The same is true for employees in the Logistics and Quality Assurance career paths.

Technology Skills Technology has an ever-increasing impact on production processes. Many plants now use computer automation instead of human workers to produce items more quickly and efficiently. Line workers, such as assemblers, may be required to run computer programs and operate high-tech machinery.



Decision-Making Skills Time is of the essence in Manufacturing. The ability to gather and analyze information rapidly, and to think clearly under pressure, is key to this industry. A boiler tender, for example, might be faced with an equipment breakdown or problem during a night shift that will require him or her to make effective decisions quickly. Employees in the Health, Safety, and Environmental Assurance path must make important decisions daily to ensure a safe work environment.

Organizing and Planning Skills Because manufacturing involves so many steps, organization is crucial. Planning requires the ability to set goals and to visualize the sequence of steps leading up to those goals. Robotics engineers, for example, might be called on to develop new products on a deadline. They would then have to make a plan and organize different departments, teams, and processes to make sure the deadline is met.

Teamwork Skills Teamwork is key in Manufacturing. For example, a successful manufacturing firm brings hundreds, perhaps even thousands, of products to market. To do so, producers must work with maintenance and repair employees, logisticians, quality assurance workers, and health and safety inspectors. Good communication is one of the most important foundations of teamwork.

Social Skills In a production factory, workers might interact with individuals from various levels of the company, from apprentices to managers. They should keep an open mind and use the opportunity to learn from others. Some studies have shown that between 80 to 85 percent of a person's success in the workplace is due to the person's social skills. These skills build an excellent foundation for advancement opportunities.

Adaptability Skills In Manufacturing, job descriptions, work environments, and production processes are constantly changing because of technological innovation. Workers should keep an open mind and be ready to acquire new skills. Remember that for every firm in the Manufacturing industry, the image of being on the cutting edge is highly desirable.

3-4 Essential Question Reflection

So, let us revisit our essential question:

What training & education is needed for a job in Manufacturing?

Based on what you learned in this section, please answer this question in detail.

Practice 3-4

Skills Practice

Some jobs in the Manufacturing industry require workers to calculate costs and discounts. A plumber, for example, needs to be able to calculate a mark-up that will bring in a profit while being acceptable to the client. **Practice this skill!**

1. As a manager at a paper recycling facility, you buy recycled cardboard boxes. Your supplier offers 1,000 boxes (minimum purchase) at $0.50 a box plus a 7% sales tax. How much do you end up paying for the recycled cardboard boxes?

A. $515

B. $520

C. $525

D. $530

E. $535

2. You are a quality assurance assistant working in a semiconductor manufacturing plant. The supervisor just announced the introduction of a new line, using an innovative method of manufacturing semiconductors. To learn more about the new technology about to be introduced, you order a book from an online vendor. The book costs $30. Shipping is 3% of your purchase, but sales tax is free. How much do you end up paying for the book?

A. $29.25

B. $29.50

C. $30.25

D. $30.90

E. $32.75

To access more problems that will help you grown professional skills and are real-world examples in Manufacturing, go online.

GO ONLINE

3-5 Working Conditions in the Manufacturing Industry

Understanding the work environment, hazards, and benefits of Manufacturing jobs can help you make informed decisions about your future career path.

3-5 Essential Question

As you read this section, keep this question in mind:

What are typical work environments in Manufacturing?

Work Environment

There are many factors that can impact work environments in the Manufacturing industry, including workers' satisfaction, health, and the physical activities they are asked to perform on a daily basis. It is important to consider these factors before accepting an opportunity in the Manufacturing industry.

Physical Environment

Some jobs require workers to spend long days on their feet in noisy factories. Other jobs require them to handle chemicals and toxic substances. Most factory buildings are clean and have good lighting and ventilation. Some factories even have outdoor facilities.

In the aerospace, apparel, pharmaceutical, electronics, automotive, textile, and computer industries, employees usually enjoy a reasonably pleasant work environment. In every industry, however, production workers confront greater environmental stresses than administrators and engineers do. Workers in the iron and steel industries, for example, are often exposed to intense heat and noise. In glassmaking, which requires the use of high temperatures and heavy machinery, there is the risk of cuts and burns.

Production

- Workers are sometimes exposed to high noise levels, and heavy lifting may be required in some jobs.
- Part-time work is unusual.
- In chemical plants, split, weekend, and night shifts are common, but pay is usually higher for non-traditional hours.
- Many food industry production jobs involve repetitive, physically demanding work.

Manufacturing Production Process Development

- In the computer industry, research and development (R&D) personnel may work long hours of overtime.
- Many food manufacturing plants have redesigned equipment and increased the use of job rotation.
- In textiles, travel is an important part of the job for many managers and designers.

Maintenance, Installation, and Repair

- In steel mills, computer-controlled machinery helps to move iron and steel through the production processes, reducing the need for heavy labor.

Quality Assurance

- In pharmaceuticals, the danger of contamination means that there is rigorous attention needed in keeping plants and equipment clean.
- In food manufacturing, managers and employees must comply with numerous government standards and regulations.

Logistics & Inventory Control

- In motor vehicle manufacturing, overtime is especially common during periods of peak demand.

Health, Safety, & Environmental Assurance

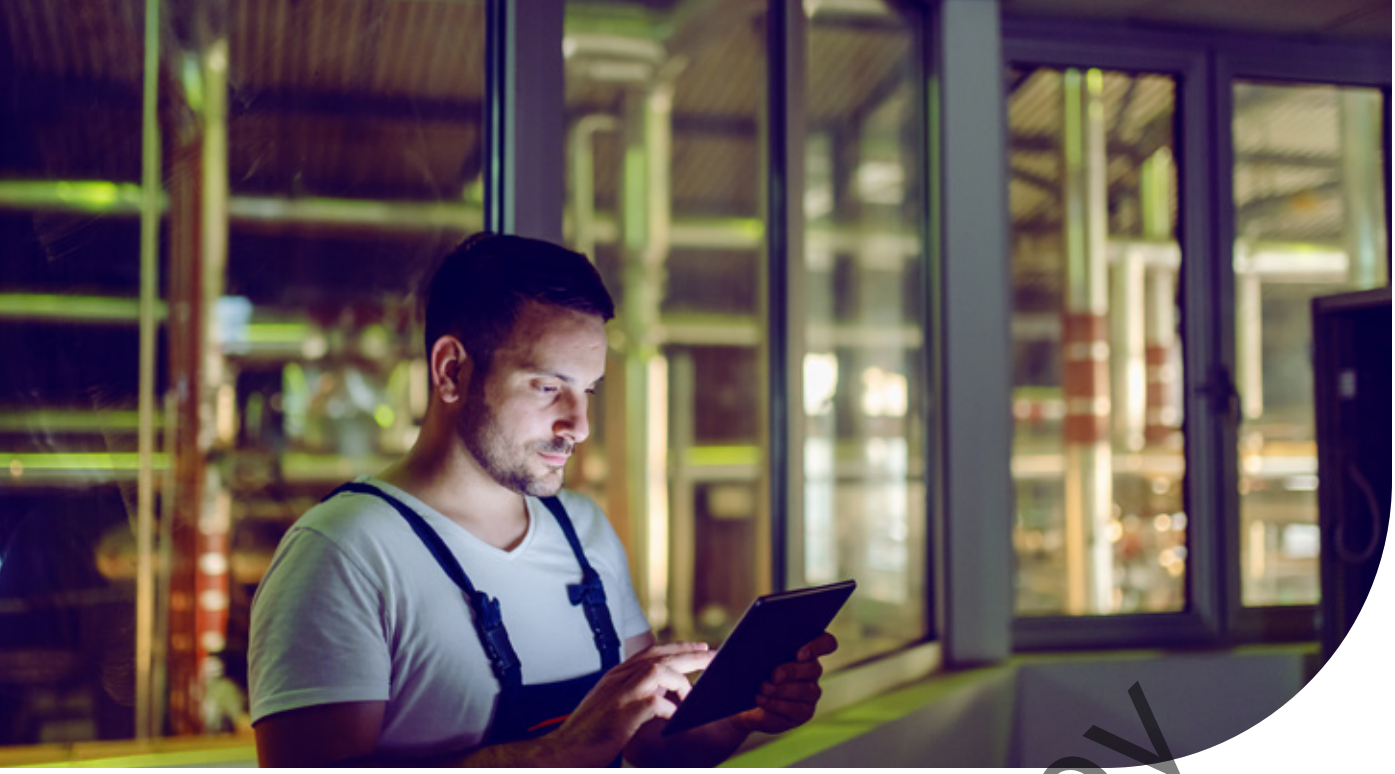
- Environmental engineers and health and safety engineers spend much of their time in offices working on plans and safety reports.
- Engineers may travel on-site to inspect facilities and machinery. In some cases, they may spend time near hazardous materials and situations to find ways to reduce the hazard's impact and improve safety.

Source: *U.S. Department of Labor*

Work Hours

The work hours of jobs in Manufacturing vary greatly. Because the equipment in many manufacturing plants requires 24-hour supervision, shift work is vital in this industry. Shift work divides the day into blocks of time, generally eight hours. Shift work allows Manufacturing companies to operate around the clock. It also allows workers to select hours to meet their needs. Shift work is common for assemblers, boiler tenders, quality control inspectors, and production supervisors.

Flextime is a trend affecting all industries, including Manufacturing. Flextime allows workers to choose the hours and days they work. However, employees must maintain a standard total number of hours per week. Workers may adjust their hours to suit their personal needs. One employee may choose to work ten hours only four days a week, for example. Another employee may work six and one-half hours six days a week. Flextime is especially important for workers who have young children or other family commitments.



Machinists, tool and die makers, and precision assemblers typically work eight-hour shifts. Although they do most of their work during standard working hours, they may need to work overtime to meet production demands. Most welding technicians work 40 hours per week, although opportunities for overtime are usually available. Boiler tenders also generally work 40 hours per week. However, because boilers operate around the clock, most boiler tenders are required to work some nights, weekends, and holidays.

Many workers in Manufacturing must deal with tight deadlines. A deadline might require that a specific number of cars be produced for a certain launch date, for example. This deadline would affect production supervisors, assemblers, and line workers. Manufacturing engineers and robotics engineers often face tight deadlines when developing new and innovative products.

Essential Physical Activities

Production workers in Manufacturing must be in good physical shape to withstand the demands of their jobs. Heavy lifting and the operation of powerful equipment is required for most production jobs. It is vital that workers be trained to handle heavy equipment properly. Although some production jobs are not strenuous, most workers are required to stand, walk, stoop, bend, or climb ladders regularly during the day.

Good vision is a must for production workers who must test products by color. Good eyesight is also necessary for the accurate reading of thermometers, gauges, charts, and meters.

Manufacturing workers should be skilled with their hands. Many assembly-line workers handle small pieces and parts and detailed machinery. Machinists and precision assemblers must have good hand-eye coordination to work with the machinery and components.

Hazards and Environmental Dangers

Because accidents can happen on any job, safety must be a priority. The federal government protects individual workers on the job through agencies such as the Occupational Safety and Health Administration (OSHA). These agencies create safety standards and laws that help prevent accidents. They also ensure that accident victims are helped. OSHA certification credentials require sitting through a 10-hour or 30-hour course and are usually needed for a person to be present on a jobsite. These credentials may be earned while you are in high school and may be taken remotely.

Injuries and Illnesses

Many Manufacturing jobs involve operating heavy equipment and machinery that can be dangerous if improperly used. Proper training and common sense are therefore necessary for tasks involving machinery. Workers must follow all safety procedures. They should take advantage of breaks in line work to rest tired muscles. They should also vary their tasks when possible. They should notify managers if they feel pain or stiffness.

Another job hazard is eye injuries. Goggles are necessary during exposure to chemicals, extremely bright lights, and sharp pieces. Workers who focus on very detailed machinery, such as tool and die makers, may suffer from eyestrain.

Developments in ergonomics are helping to create a healthier work environment. Ergonomics is the study of creating and adjusting work equipment and practices to make workplaces safer and more comfortable. Ergonomically correct production lines, for example, are set at a comfortable height. Workers can maintain a healthy and appropriate stance and posture. Ergonomic workstations can be adjusted to accommodate workers of different heights.

3-5 Essential Question Reflection

So, let us revisit our essential question:

What are typical work environments in Manufacturing?

Based on what you learned in this section, please answer this question in detail.

3-6 Trends in Manufacturing

Manufacturing is constantly evolving. People's needs for products change. Advances in technology continue to improve Manufacturing.

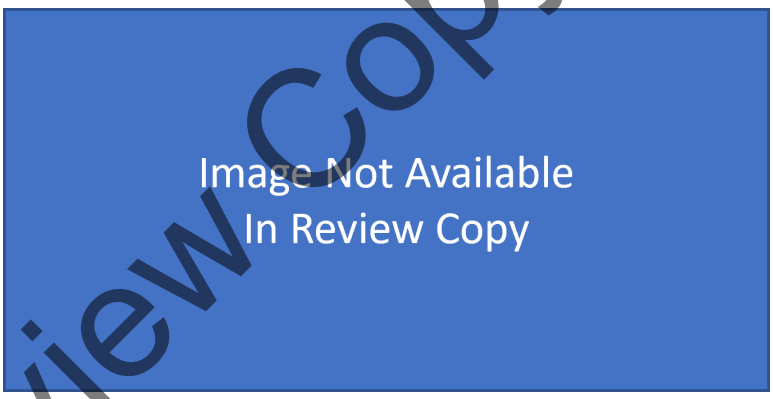
3-6 Essential Question

As you read this section, keep this question in mind:

What factors affect trends in Manufacturing?

Technology in Manufacturing

Technology continues to make Manufacturing more efficient and safe. Improvements have occurred so often that today's manufacturing machines and processes are referred to as "advanced manufacturing," "clean manufacturing," or "manufacturing 4.0." Companies that once dealt with suppliers in person or by telephone now use e-mail and websites to make purchases. Manufacturers also use the Internet to participate in online auctions. These auctions allow companies to bid on parts, products, or services over the Internet.



Hi-tech manufacturing uses strict safety and cleanliness practices to produce many different things. Here you can see a silicon "wafer" used in the computer chip industry as it reflects a glowing rainbow of color.

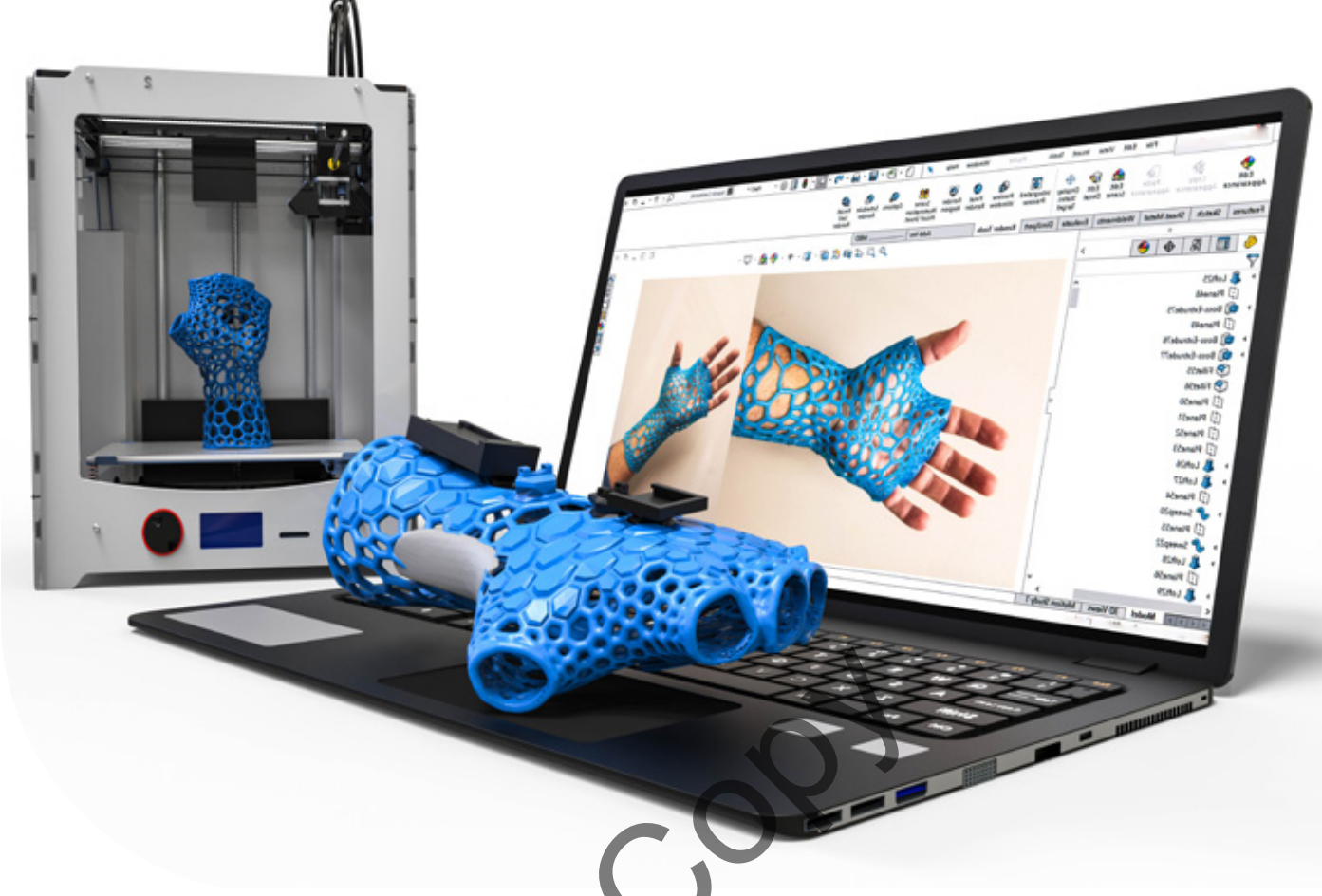
Computer Numerical Control (CNC) and Manufacturing

An example of the rapid changes in Manufacturing is the use of programmable machine tools. Imagine using simple programming to tell a machine what to make. This is referred to as "computer numerical control" or "CNC" manufacturing. Machines may be programmed to cut three-dimensional (3D) shapes out of wood, metal, stone, plastic, and many other materials.

3D Printing

Imagine making a house anywhere, anytime. 3D printing has made this a reality. 3D printing uses portable machines to cut all the objects needed to make a home into the right shapes. All people need to do is put the objects together in the right way.

This technology exists for mobile and at-home manufacturing of a vast number of products. As this technology improves and becomes more mobile, only the available materials will limit the possibilities. The photo in this section shows the



representation of a fingerless glove on the computer. That "recipe," a specific program that tells where to cut a block of material, is sent to the printer, which looks like a small kiln or microwave oven. A block of the needed material, in this case a plastic, is placed in the printer. The printer then cuts and shapes the material like a sculptor, and the glove is produced.

Automation

Robotics is the technology used in designing, constructing, and operating robots. It is perhaps the most useful development in computer-aided manufacturing. Creating and programming robots to perform production tasks is an example of automation. Automation is the operation and control of machinery by electronic devices. Robots can be programmed to do a wide range of jobs, such as spotwelding parts of an automobile frame.

The automotive industry is one of the biggest users of robots. However, other areas of Manufacturing are introducing robots into production processes as well. These include the aerospace, electronics, food processing, and pharmaceutical industries. For example, robotic devices have been used by NASA to collect and analyze soil samples on distant planets. The International Federation of Robotics predicts that worldwide sales of industrial robots may near the 500,000 mark in 2024, more than five times as many as in 2013. Some critics argue that robots are taking jobs away from people. However, robots are essential in performing jobs that are too dangerous for people to do.

Just-in-Time Production

Another benefit of technology is a just-in-time (JIT) inventory system. This system allows parts and raw materials to be delivered to production plants just before they are needed. A computer keeps track of supplies. Orders are placed when necessary items run low in stock. JIT decreases the inventory that a plant must maintain. This, in turn, saves money. JIT also cuts down on overstock, or having too much inventory. Successful just-in-time manufacturing depends on frequent communication between manufacturer and supplier.

Computer technology is also changing manufacturing strategies. The traditional manufacturing strategy, known as "push manufacturing," is to produce as much inventory as possible. Plants using this strategy often create an oversupply of products. Today, many companies are switching to "pull manufacturing." In this strategy, products are created in response to consumer demand. "Pull manufacturing" offers better responsiveness to special orders.

Contemporary Issues in Manufacturing

Manufacturers are always searching for the best way to get the job done. New methods are constantly being tested to produce goods that use environmentally safe processes. In addition, manufacturers want to reduce waste. They are also discovering that outsourcing, or sending jobs to other companies, often overseas, helps to improve production in a variety of ways.

Green Manufacturing

Green manufacturing emphasizes conserving resources and minimizing pollution and waste. The Manufacturing industry generates more waste than any other

industry. A growing number of environmental laws, as well as increasing consumer demand for environmentally sound products and processes, are creating new challenges for many companies.

The goal of green manufacturing is to create no waste at all. In some cases, remanufacturing can accomplish this. *Remanufacturing* is the process of taking apart, cleaning, repairing, and putting back together products for reuse. Instead of going to landfills or having their parts melted down for raw materials, products like vending machines and photocopiers are rebuilt and resold.

Outsourcing in Manufacturing

Outsourcing is the process of turning over control of certain tasks or duties to other companies. The contracting company specifies the desired result but does not specify how the result should be achieved. For example, an automobile factory might outsource the production of axles. The factory does not specify which machines, part numbers, or brands the outsource company should use. Instead, the contractor depends on the outsourced company to complete the job in the most cost-effective and efficient manner. Many large electronics manufacturers practice outsourcing. Companies must do a great deal of research before choosing the right outsource firm.

Companies that outsource must maintain a close relationship with the outsource company. The two firms must work toward a common goal. Outsourcing relationships work best when the partner companies share similar values, goals, and expectations.

3-6 Essential Question Reflection

So, let us revisit our essential question:

What factors affect trends in Manufacturing?

Based on what you learned in this section, please answer this question in detail.

Career Fields and Paths

A **career field** is a grouping of jobs and industries based on common characteristics. A **career path** is an area of focus within a career field. You can explore each of the following career fields and paths in McGraw-Hill's *Career Explorations*.

Agriculture, Food, & Natural Resources
Food Products and Processing Systems
Plant Systems
Animal Systems
Power, Structural & Technical Systems
Natural Resources Systems
Environmental Service Systems
Agribusiness Systems

Architecture & Construction
Design/Pre-Construction
Construction
Maintenance/Operations

Arts & Media
Audio and Video Technology and Film
Printing Technology
Visual Arts
Performing Arts
Journalism and Broadcasting
Telecommunications

Business Management & Administration
General Management
Business Information Management
Human Resources Management
Operations Management
Administrative Support

Education & Training
Administration and Administrative Support
Professional Support Services
Teaching/Training

Finance
Securities & Investments
Business Finance
Accounting
Insurance
Banking Services

Government & Public Administration
Governance
National Security
Foreign Service
Planning
Revenue and Taxation
Regulation
Public Management and Administration

Health Science
Therapeutic Services
Diagnostic Services
Health Informatics
Support Services
Biotechnology Research and Development

Hospitality & Tourism
Restaurants and Food/Beverage Services
Lodging
Travel & Tourism
Recreation, Amusement & Attractions

Human Services
Early Childhood Development & Services
Counseling & Mental Health Services
Family & Community Services
Personal Care Services
Consumer Services

Information Technology (IT)
Network Systems
Information Support and Services
Web and Digital Communications
Programming and Software Development

Law, Public Safety, Corrections, & Security
Correction Services
Emergency and Fire Management Services
Security & Protective Services
Law Enforcement Services
Legal Services

Manufacturing
Production
Manufacturing Production Process Development
Maintenance, Installation & Repair
Quality Assurance
Logistics & Inventory Control
Health, Safety and Environmental Assurance

Marketing
Marketing Management
Professional Sales
Merchandising
Marketing Communications
Marketing Research

Science, Technology, Engineering, & Mathematics (STEM)
Engineering and Technology
Science and Math

Transportation, Distribution, & Logistics
Transportation Operations
Logistics Planning and Management Services
Warehousing and Distribution Center Operations
Facility and Mobile Equipment Maintenance
Transportation Systems/Infrastructure Planning, Management and Regulation
Health, Safety and Environmental Management
Sales and Service