



Sloan Career Cornerstone Center

Chemical Engineering Overview

The Field - Preparation - Day in the Life - Industries - Earnings - Employment - Professional Development - Career Path Forecast - Professional Organizations

The Field

It would take too long to list all the products that are impacted by chemical engineers, but knowing what industries employ them may help you comprehend the scope of their work. Chemical engineers work in manufacturing, pharmaceuticals, healthcare, design and construction, pulp and paper, petrochemicals, food processing, specialty chemicals, polymers, biotechnology, and environmental health and safety industries, among others. Within these industries, chemical engineers rely on their knowledge of mathematics and science, particularly chemistry, to overcome technical problems safely and economically. And, of course, they draw upon and apply their engineering knowledge to solve any technical challenges they encounter. Don't make the mistake of thinking that chemical engineers only make things, though. Their expertise is also applied in the area of law, education, publishing, finance, and medicine, as well as many other fields that require technical training.



Specifically, chemical engineers improve food processing techniques, and methods of producing fertilizers, to increase the quantity and quality of available food. They also construct the synthetic fibers that make our clothes more comfortable and water resistant; they develop methods to mass-produce drugs, making them more affordable; and they create safer, more efficient methods of refining petroleum products, making energy and chemical sources more productive and cost effective. They also develop solutions to environmental problems, such as pollution control and remediation. And yes, they process chemicals, which are used to make or improve just about everything you see around you.

Chemical engineers face many of the same challenges that other professionals face, and they meet these challenges by applying their technical knowledge, communication and teamwork skills, the most up-to-date practices available, and hard work. Benefits include financial reward, recognition within industry and society, and the gratification that comes from working with the processes of nature to meet the needs of society.

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Preparation

A bachelor's degree in engineering is required for almost all entry-level chemical engineering jobs. Preparation for a career in chemical engineering begins as an undergraduate, but is not limited to course work. Employers value a range of capabilities which you can develop as you acquire technical competence in the classroom. You may also want to explore the possibility of a transfer program or a graduate degree.

► Undergraduate Courses

The core curriculum of a chemical engineering program serves a dual purpose: it provides technical information and instills a thought process unique to the engineering discipline. This sample curriculum is based on the required courses for chemical engineering students in an accredited university program, and is from the Academic Advising Guide to Chemical Engineering at Virginia Tech. This can be a guide for what to expect in your curriculum, but you should always select classes in consultation with a faculty advisor.

- First Year: General Chemistry (with lab); Calculus I and II; Introduction to Engineering; English; Algebra; Statistics; Vector Geometry; Electives
- Second Year: Organic Chemistry; Multivariable Calculus; Mass and Energy Balances; Physics; Statistics; Ordinary Partial Differential Equations; Physical Chemistry; Separation Processes; Mechanics of Deformable Bodies; Elective
- Third Year: Transport Operations; Thermodynamics; Process, Measurements and Controls; Physical Chemistry (with lab); Chemical Process Modeling; Chemical Reactor Analysis and Design; Elective Summer: Chemical Engineering Lab
- Fourth Year: Process and Plant Design; Separation Processes; Process Materials; Elective



► Accredited Programs

Those interested in a career in Chemical Engineering should consider reviewing engineering programs that are accredited by ABET Inc. ABET accreditation is based on an evaluation of an engineering program's student achievement, program improvement, faculty, curricular content, facilities, and institutional commitment. The following is a current list of all universities offering accredited degree programs in Chemical Engineering.

- | | |
|---|---|
| <ul style="list-style-type: none">• The University of Akron• The University of Alabama in Huntsville• The University of Alabama• Arizona State University• University of Arizona• University of Arkansas• Auburn University• Brigham Young University• Brown University• Bucknell University• California Institute of Technology | <ul style="list-style-type: none">• Missouri University of Science and Technology• University of Missouri-Columbia• Montana State University - Bozeman• University of Nebraska-Lincoln• University of Nevada-Reno• University of New Hampshire• University of New Haven• New Jersey Institute of Technology• New Mexico Institute of Mining and Technology |
|---|---|

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- California State Polytechnic University, Pomona
- California State University, Long Beach
- University of California, Berkeley
- University of California, Davis
- University of California, Irvine
- University of California, Los Angeles
- University of California, Riverside
- University of California, San Diego
- University of California, Santa Barbara
- Carnegie Mellon University
- Case Western Reserve University
- Christian Brothers University
- University of Cincinnati
- Clarkson University
- Clemson University
- Cleveland State University
- University of Colorado at Boulder
- Colorado School of Mines
- Colorado State University
- Columbia University
- University of Connecticut
- The Cooper Union
- Cornell University
- University of Dayton
- University of Delaware
- Drexel University
- Florida A & M University/Florida State University (FAMU-FSU)
- Florida Institute of Technology
- University of Florida
- Georgia Institute of Technology
- Hampton University
- University of Houston
- Howard University
- University of Idaho
- University of Illinois at Chicago
- University of Illinois at Urbana-Champaign
- Illinois Institute of Technology
- Iowa State University
- University of Iowa
- The Johns Hopkins University
- Kansas State University
- The University of Kansas
- University of Kentucky (Extended Campus-Paducah)
- University of Kentucky
- Lafayette College
- Lamar University
- Lehigh University
- University of Louisiana at Lafayette
- Louisiana State University and A&M College
- Louisiana Tech University
- University of Louisville
- University of Maine
- Manhattan College

- New Mexico State University
- University of New Mexico
- State University of New York at Buffalo
- City University of New York, City College
- North Carolina Agricultural and Technical State University
- North Carolina State University at Raleigh
- University of North Dakota
- Northeastern University
- Northwestern University
- University of Notre Dame
- The Ohio State University
- Ohio University
- Oklahoma State University
- The University of Oklahoma
- Oregon State University
- Pennsylvania State University
- University of Pennsylvania
- University of Pittsburgh
- Polytechnic University
- Prairie View A & M University
- Princeton University
- University of Puerto Rico, Mayaguez Campus
- Purdue University at West Lafayette
- Rensselaer Polytechnic Institute
- University of Rhode Island
- Rice University
- University of Rochester
- Rose-Hulman Institute of Technology
- Rowan University
- Rutgers, The State University of New Jersey
- San Jose State University
- University of South Alabama
- University of South Carolina
- South Dakota School of Mines and Technology
- University of South Florida
- University of Southern California
- Stanford University
- Stevens Institute of Technology
- Syracuse University
- University of Tennessee at Knoxville
- Tennessee Technological University
- Texas A & M University
- Texas A & M University - Kingsville
- University of Texas at Austin
- Texas Tech University
- The University of Toledo
- Tri-State University
- Tufts University
- Tulane University
- The University of Tulsa
- Tuskegee University
- University of Utah
- Vanderbilt University
- Villanova University

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- University of Maryland Baltimore County
- University of Maryland College Park
- University of Massachusetts Amherst
- Massachusetts Institute of Technology
- University of Massachusetts Lowell
- Michigan State University
- Michigan Technological University
- University of Michigan
- University of Minnesota Duluth
- University of Minnesota-Twin Cities
- Mississippi State University
- University of Mississippi

- Virginia Commonwealth University
- Virginia Polytechnic Institute and State University
- University of Virginia
- Washington State University
- Washington University
- University of Washington
- Wayne State University
- West Virginia University
- West Virginia University Institute of Technology
- Western Michigan University
- Widener University
- University of Wisconsin-Madison
- Worcester Polytechnic Institute
- University of Wyoming
- Yale University
- Youngstown State University

Electives

Employers usually look to hire candidates who have demonstrated success both within their core program and in a diverse range of elective courses. Within a chemical engineering program, students are generally required to take 31 credits (approximately 13 courses) of electives. Focus on becoming as well-rounded as possible by taking a variety of humanities courses, and try to include communication and business courses whenever possible. The following are skills and competencies you will need in a career; linked with possible courses you could take to acquire them.



Computer Literacy

Computers are used every day for communications, simulations, budgeting, monitoring controls, and word processing.

Courses to Consider: Computer Programming, Computer Science

Bilingual Ability

The marketplace is increasingly global, with a need for people who are fluent in more than one language.

Courses to Consider: Foreign Languages, Study Abroad

Communication Skills

Engineering involves working with others and communicating so that others understand and support your ideas.

Courses to Consider: Speech, Writing, English, Debate, Journalism, Acting, Film, Literature

Management / Finance

Many decisions an engineer makes have business consequences. Understanding business objectives will help you become more effective. Courses to Consider: Marketing, Management, Economics, Accounting, Business, Finance

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International Awareness

Working in a global market requires an understanding of the cultural, geographic, economic, and environmental factors that influence decisions. Courses to Consider: Foreign Language / Literature, History, Political Science, Religious Studies, Economics, Study Abroad

Respect for Diversity

Engineers regularly work in group settings. Being able to interact effectively, professionally, and respectfully with others will make you a more capable team player.

Courses to Consider: Psychology, Philosophy, Sociology, Ethnic Studies, Women's Studies, Art, History, Literature, Religious Studies

Technical Skills

Chemical engineers work with engineers from other disciplines. Having an understanding of their work and area of expertise will strengthen your relationships with them.

Courses to Consider: Mathematics, Chemistry, Biology, Geology, Mechanical or Electrical Engineering Courses

Activities

Extracurricular activities allow you to develop a well-rounded knowledge and skill base. Social, service, academic, athletic, and professional groups and activities provide opportunities to network and improve leadership, organization, and communication skills. There are a variety of organizations you might consider joining.

Co-ops / Internships

Many employers expect candidates to have some type of experience and are more likely to give second interviews and job offers to students with an internship or co-op on their resumes.

Transfer Programs

You can enter an engineering program by transferring from a Junior College or by enrolling in a 3+2 program. Junior College students need to ensure that they are taking courses that will prepare them for a chemical engineering curriculum. 3+2 programs allow students to take three years of coursework at a liberal arts school then transfer for two years of study at a school with a chemical engineering program.

Graduate / Professional School

Chemical engineering skills and training make transitioning into graduate programs in business, law, medicine, and other sciences easier. Work with professors, mentors, and contacts to determine if a graduate degree fits your future. Graduate and professional schools look at undergraduate GPA along with standardized exam scores, extracurricular activities, awards and honors, work experience, and letters of recommendation, among other factors. They may require an interview. Many resources are available to help with this process.

Day In The Life

Although your career will evolve over the years, the first choices you make are significant. It's difficult to approach decisions about your future without adequate information. All chemical engineers do not wear hard hats, nor do they work solely in chemical plants. Spend some time exploring the many possibilities available to chemical engineers.

Typical Functions

Although the specific responsibilities of chemical engineers vary among industries -- and even within companies -- it's possible to categorize them in general terms. Titles such as "Process Engineer" and "Design Engineer" describe positions in most industries, whatever type of work, process, equipment, or product is involved. Typical functions include:

Attorney

Specializes in intellectual property law, patent law, technology transfer, environmental compliance, and safety issues. Patent attorneys obtain patents for clients and monitor the marketplace for possible patent infringements.

Biomedical Specialist

Works alongside physicians to develop systems that track critical chemical processes in the body. Biomedical specialists may be involved in the design of artificial organs, such as hearts and lungs.

Computer Applications and Technology Engineer

Designs instrumentation and programs systems to control certain processes. Automation engineers may develop ways to monitor a series of interactive steps in chemical, petroleum, or biotechnology facilities.

Consultant

Works for many different customers and brings specialized knowledge to individual projects. Consultants in a construction company may work with teams of engineers to design and construct an expansion for a pharmaceutical company. Most consultants have several years of professional experience.

Process Design Engineer

Designs manufacturing facilities and the equipment and materials used inside. Process design engineers work with teams of engineers to develop new or improved processes to meet a company's production needs.

Environmental Engineer

Develops techniques to recover usable materials, and reduce waste created during manufacture of a product. Environmental engineers design air pollution control and wastewater treatment systems, waste storage and treatment facilities, and soil and groundwater clean-up systems. They also may be responsible for monitoring all systems in a facility for compliance with environmental regulations.

Technical Manager

Responsible for the engineering staff and programs at a facility. Manages people, research programs, and daily operations of the engineering functions. Technical managers may oversee R&D. With plant managers, they may plan and implement the funding and expansion programs necessary to develop a new product.

Business Coordinator

Develops budgets and capital projections for a facility or process. Business coordinators work closely with production and design team members to determine the exact needs of a new process, then plan the capital needs necessary to implement the program.

Plant Process Engineer

Provides technical support to staff and troubleshoots processes in a production facility to keep a plant running efficiently. Plant process engineers work closely with equipment operators to get feedback on the operations of each process and determine how to avoid shut-downs. They may also be involved with design work for improving methods of production.

Process Safety Engineer

Designs and maintains plants and processes that are safer for workers and communities. Process safety engineers may conduct safety analyses of new and existing equipment, and train employees on how to operate a new piece of equipment safely.

Product Engineer

Follows the production cycle of a particular product to ensure it is meeting specification. Product engineers may work with marketing and R&D to ensure that a product will meet the needs of customers, then see the product through production. They may work on new products or variations of existing products.

Manufacturing Production Engineer

Responsible for the day-to-day operation of a specific manufacturing process. Manufacturing production engineers work directly with operators to ensure that a particular product is made according to specifications.

Professor

Instructs students and conducts research. Professors may teach several classes in chemical engineering, be members of university committees, and conduct research using government, corporate, or private funding.

Project Engineer

Oversees the design and construction of specific processes in a facility. After construction, they may assist in equipment testing, operator training, and plant start-up.

Project Manager

Oversees the overall design and construction of a facility, then manages ongoing operations. Project managers may manage a group of project engineers during the design and construction of a new facility.

Quality Control Engineer

Monitors the manufacture of product to ensure that quality standards are maintained. Quality control engineers may bring samples of a product in from a field test, or from a normal application, and test them to determine how specific properties -- such as strength, color, and weatherability -- change over time.

Regulatory Affairs Engineer

Researches, develops, and monitors policies and procedures to ensure the proper handling of chemicals and chemical components. Chemical engineers in regulatory affairs may be government employees who study the environmental impact of a new chemical, then recommend appropriate guidelines for the chemical's use.

Research and Development Engineer

Seeks out new and more efficient ways of using and producing existing products. Explores and develops new processes and products and determines their usefulness and applicability. Chemical engineers working in R&D may work with chemists and other engineers to develop a new process or new product that will better meet customer needs.

Sales and Marketing Engineer

Assists customers in solving production and process problems by providing products and services to meet their specific needs. Chemical engineers in sales use their technical knowledge to sell chemicals, equipment, and other products, and provide follow-up services and training, where needed.

Technical Services Engineer

Works with customers, usually on-site, to solve production problems caused by a process or machine. Chemical engineers working in technical services may represent the manufacturer of a machine to determine why it is not performing as designed. They often must understand the other steps in the production process to determine if there is a breakdown in another area.

Alternatives

Because of their training and skills, chemical engineers make strong candidates for jobs not traditionally associated with chemical engineering: sales, technical writing, law, insurance, real estate, publishing, finance, technical services, and government.

Even within the "typical" industries, many engineers are surprised (and often pleased) to learn that their responsibilities regularly include management, marketing, packaging, distribution, strategic planning, training, and computer programming.

Industries

A variety of industries employ chemical engineers, representing a diverse range of products, employers, and services.

Chemical Process Industries

The focus of companies in this industry is on the development, extraction, isolation, combination, and use of chemicals and chemical by-products. Chemical engineers design and operate processes and systems to combine, transport, separate, handle, recycle, and store them. This industry consists of several specialty areas: Agricultural Chemicals; Catalysts; Specialty Chemicals; Industrial Gases; Paints, Varnishes, Lacquers, Pigments, and Inks; Petrochemicals; Petroleum Products; Plastics, Synthetic Resins, and Composites; Polymers; Pulp and Paper; Rubber and Rubber Products; Soaps, Detergents, Perfumes, Fats, Oils, and Cosmetics; and Synthetic Fibers, Textiles, and Films.

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Biotechnology

This area uses living cells, materials produced by cells, and biological techniques developed through research to create products for use in other industries. This field has produced antibiotics, insulin, interferon, artificial organs, recombinant DNA, techniques for waste reduction and recycling, and hybrid plants that are insect resistant. Chemical engineers develop and design the processes to grow, handle, and harvest living organisms and their by-products.

Design and Construction

This field works with other industry sectors to design and build facilities, specify machinery, and design and troubleshoot processes that allow companies to operate safe and efficient plants. Chemical engineers are involved with process design and project management and work closely with other engineering disciplines.

Electronics

Chemical engineers in the electronics industry are involved with material development and production, process control equipment design, and the manufacturing of microchips and intricate circuitry. Chemical engineers have contributed to the industry by producing components that better dissipate heat and operate faster.

Environmental Safety & Health

Every process involving use and manipulation of raw materials produces some by-products. Chemical engineers minimize the production of by-products (or find an appropriate use for them) through process monitoring and control, as well as by designing more efficient processes. Chemical engineers are involved in waste treatment and disposal and process safety and loss prevention

Food and Beverages

This industry includes the handling, processing, preparing, packaging, and preserving of food and beverages. Chemical engineers formulate new products to meet consumer demand, change ingredients to improve flavor, adapt handling processes to ensure more consistent texture, and freeze-dry products or design aseptic packaging to enable a longer shelf life.

Fuels

This industry comprises petroleum and petroleum products production and refining, as well as nuclear and synthetic fuels. Typically known for their work in refineries, chemical engineers are also involved in developing alternative energy sources, working on production processes, environmental monitoring, research and development, and process safety.

Advanced Materials

Several industries (most notably aerospace, automotive, glass, ceramics, electronics, refractories, metals, metallurgical products, minerals processing, and photographic products) employ chemical engineers to help develop materials. Chemical engineers manipulate the weight, strength, heat transfer, reflectivity, and purity of substances to produce materials with unique properties.

Other

The technical training received by chemical engineers makes them well suited for positions in business, finance, insurance, law, publishing, education, and government. Chemical engineers manage, analyze, and insure businesses in the chemical process industries. U.S. government employers include the Environmental Protection Agency, the Department of Energy, the U.S. Navy, NASA, the Nuclear Regulatory Commission, and the Department of Agriculture.

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Earnings

You may believe that money will be the determinant as you examine potential careers. It's possible to make general assumptions about salary as it relates to experience levels and the nature of the employer. As you'll probably discover, compensation comes in many forms and it's important that you be able to evaluate each of them clearly.



Salary Data

Entry-level salaries vary based on your areas of expertise, experience, education, supervisory responsibility, accountability for projects, and the geographic location, size, and industry of the employer. According to a 2007 Salary Survey by the National Association of Colleges and Employers, bachelor's degree chemical engineering graduates, typically one of the highest paid majors reported in Salary Survey, saw their average offer climb by 5.6 percent over last year at this time to \$59,707.

According to the U.S. Department of Labor, Bureau of Labor Statistics, the median income for chemical engineers is \$78,860. The lowest 10% earned \$50,060. The highest 10% earned \$118,670.

In terms of starting salaries, the average starting salary for chemical engineers who have earned a Bachelor's degree is \$59,361, while those with a Master's were offered \$68,561. Ph.D. chemical engineers received average starting salaries of \$73,667.

Employment

Chemical engineers hold about 30,000 jobs in the United States. This represents 2% of the 1.5 million jobs held by engineers in the U.S. Employment opportunities exist in many places because virtually all products require input from chemical engineers. They troubleshoot processes in Texas, write software in California, design cars in Michigan, manage production in New Jersey, analyze financial markets in New York, write documentation in Tennessee, teach in Kansas, and litigate patents in Washington, D.C.



► International Experience

While most U.S. chemical engineering students are employed in the U.S. following graduation, taking advantage of overseas study and employment could enhance your career. Foreign work assignments offer the most practical way to gain international experience, although exchange and study abroad programs do exist for chemical engineering students. There are things to consider before you decide to study or work abroad.

► Transitions

After graduation, starting a new job may involve moving to a new city or geographic location. Before accepting an offer, look at the personal and financial aspects involved. Consider the distance from your family and friends, and access to interesting recreational activities, in addition to the social, demographic, and economic profile of the new area. Factors like the cost of living, tax rates, the housing market, and climate are also important to consider. Enjoying where you live can make a good job even better.



► Distribution

Some areas of the country have higher concentrations of chemical engineering employees than others. AIChE US Membership by Region:

- Northeast – 25%
- Mid-West – 21%
- Southwest – 19%
- Southeast – 12%
- West – 11%
- Mid-Atlantic – 7%
- Plains – 3%
- Mountain – 2%

Professional Development

Learning is a life-long endeavor. Advances in technology are constantly changing chemical engineers' tools--it's been estimated that the half-life of an engineer's technical skills ranges from three to seven years. Actively pursuing professional development opportunities in and out of the work environment can expand your abilities and career options.

Advancement

You, not your company, are responsible for maximizing your career advancement opportunities. Take advantage of on-the-job or cross-department training programs, participate in a mentor program, and get involved with special projects and task force activities. Volunteer with a local organization or school, read industry and professional publications, and participate in professional associations. Always keep current on the job market and trends.

Mentors

One of the most effective ways to learn about a profession is to speak with someone already working in your field of interest. This might include a chemical engineering faculty member, a family friend or family member who is employed as a chemical engineer, a chemical engineer employed by a local company, alumni of your college or university, or a contact made through a professional society, such as AIChE. Finding a mentor to talk with, ask questions of, and network through, can be effectively done as early as high school. A mentor could:

- tell you about his/her job responsibilities
- answer questions about his/her work or industry
- help you find a summer internship or job opening
- provide input on your projects
- give you exposure to the workplace
- introduce you to other professionals in the field
- make you aware of resources you may not have access to at school
- guide you in developing skills and qualities that employees seek

Networking

Networking is the single best way to find a job and is a valuable professional development tool. Networking is a two-way street that can put you in touch with possible mentors, employers, summer internship providers, graduate school professors, and peer professionals; but you must also be ready, and actively look, to return the favor.

Networking is communicating with the purpose of achieving a career-related goal. It is not asking for a job. It is asking for advice and suggestions on areas that may include employment opportunities. Look out for possible contacts and remember to reciprocate when the time comes.

Licensing

A professional engineer's license is required of all engineering-related expert witnesses in legal proceedings, faculty members at some state universities, for advancement to senior engineering positions by some government agencies and industry employers, and consultants in private practice. It can also add credibility to a manufacturer's work.

Becoming registered as a professional engineer has advantages, but the process requires additional tests and takes at least four years. You should understand the benefits of licensure, and should you decide it is important, begin working toward it as soon as possible. The Principles and Practice of Engineering exam can be taken after four years of experience. The exam tests the engineer's ability to apply his or her education and experience to the solution of engineering problems.

Success

Defining success and happiness is best left to you. Starting early to determine what is important, however, will enable you to put yourself into a successful position. What you do, where you live, who you work with, your work environment, how much money you make, possibilities to advance, opportunities to travel--these are issues to consider seriously. Be honest with yourself, then work toward putting yourself in a successful situation.

Technology

There is an increased reliance on technology in the workplace. Gaining as much experience as possible with the latest equipment and practices will help you stand out while job hunting. Some of the more common technologies used in the workplace:

- Spreadsheets
- Word Processing
- Simulation Software
- Communications (e-mail, intranet)
- Drafting Software (CAD)
- Process monitoring software

Career Path Forecast

According to the U.S. Department of Labor, Bureau of Labor Statistics, chemical engineers are expected to have employment growth of 8 percent over the projections decade of 2006-2016. This is about as fast as the average for all occupations. Although overall employment in the chemical manufacturing industry is expected to decline, chemical companies will continue to research and develop new chemicals and more efficient processes to increase output of existing chemicals.

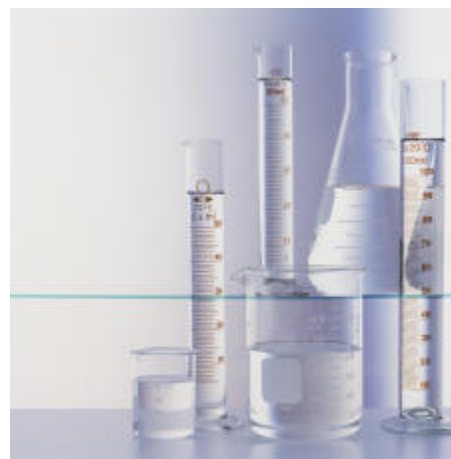


Among manufacturing industries, pharmaceuticals may provide the best opportunities for jobseekers. However, most employment growth for chemical engineers will be in service-providing industries such as professional, scientific, and technical services, particularly for research in energy and the developing fields of biotechnology and nanotechnology.



Professional Organizations

Professional organizations and associations provide a wide range of resources for planning and navigating a career in chemical engineering. These groups can play a key role in your development and keep you abreast of what is happening in your industry. Associations promote the interests of their members and provide a network of contacts that can help you find jobs and move your career forward. They can offer a variety of services including job referral services, continuing education courses, insurance, travel benefits, periodicals, and meeting and conference opportunities. The following is a partial list of professional associations serving chemical engineers and employers. A broader list of professional associations is also available by [clicking here](#).



► **American Institute of Chemical Engineers (www.aiche.org)**

AIChE is the world's leading organization for chemical engineering professionals, with more than 40,000 members from 93 countries. Divisions and forums provide programming for AIChE's technical meetings, and awards and recognition to outstanding chemical engineers in their area of expertise.

► **National Organization of Black Chemists and Chemical Engineers (www.nobcche.org)**

The mission of NOBCChE is to build an eminent community of scientists and engineers by increasing the number of minorities in these fields.