



**Texas Higher Education Coordinating Board**

***Making Opportunity Affordable in Texas:  
A Student-Centered Approach***



**Tuning of Chemical Engineering**

**Texas Higher Education Coordinating Board**

**Austin, Texas**

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# Tuning Oversight Council for Engineering Chemical Engineering Committee

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## Definition of Tuning

“Tuning” is a faculty-led pilot project designed to define what students must know, understand, and be able to demonstrate after completing a degree in a specific field, and to provide an indication of the knowledge, skills, and abilities students should achieve prior to graduation at different levels along the educational pipeline – in other words, a body of knowledge and skills for an academic discipline in terms of outcomes and levels of achievement of its graduates.

Tuning provides an expected level of competency achievement at each step along the process of becoming a professional: expectations at the beginning of pre-professional study, at the beginning of professional study, and at the transition to practice. It involves seeking input from students, recent graduates, and employers to establish criterion-referenced learning outcomes and competencies by degree level and subject areas. Through Tuning, students have a clear “picture” of what is expected and can efficiently plan their educational experience to achieve those expectations. The objective is not to standardize programs offered by different institutions but to better establish the quality and relevance of degrees in various academic disciplines.

An overview of Lumina Foundation for Education’s “Tuning USA” Initiative is available at: <http://www.luminafoundation.org/>; an overview of Tuning work to date in Texas is available at: <http://www.theccb.state.tx.us/tuningtexas>.

## Definition of Chemical Engineering

Chemical engineering is the profession in which knowledge of mathematics, chemistry, physics, biology, and other natural sciences gained by study, experience, and practice is applied with judgment to develop economic ways of using materials and energy for the benefit of humankind. The profession encompasses a broad spectrum of products and processes used to make them, using chemical, biological, or physical transformations in a safe, sustainable, and economical manner.

The lead society of this engineering discipline is the American Institute of Chemical Engineers (AIChE) with a webpage at <http://www.aiche.org> .

# Chemical Engineering Expertise Profile

The expertise profile shows 14 types of course work necessary for the completion of a baccalaureate degree in chemical engineering.

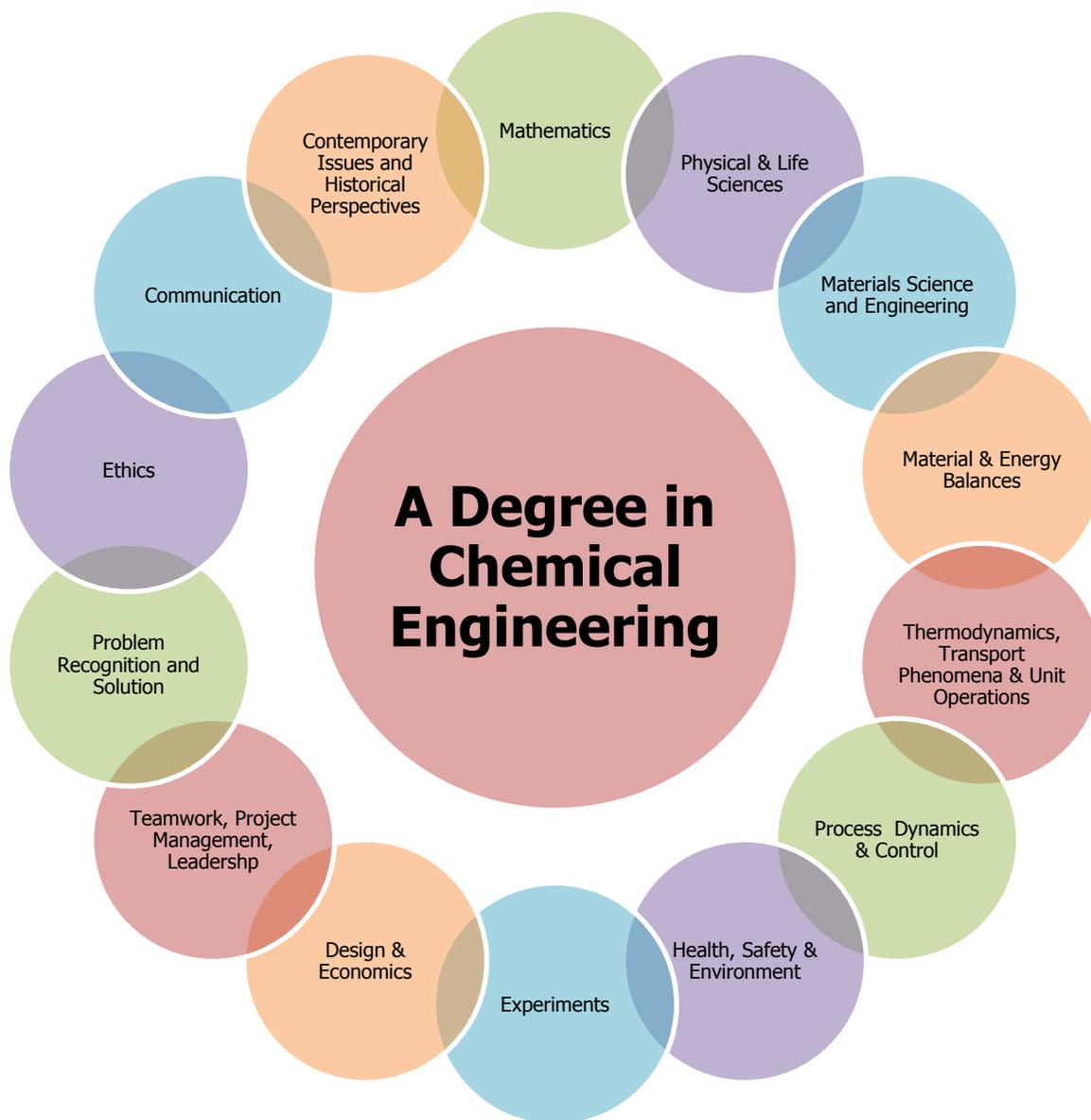


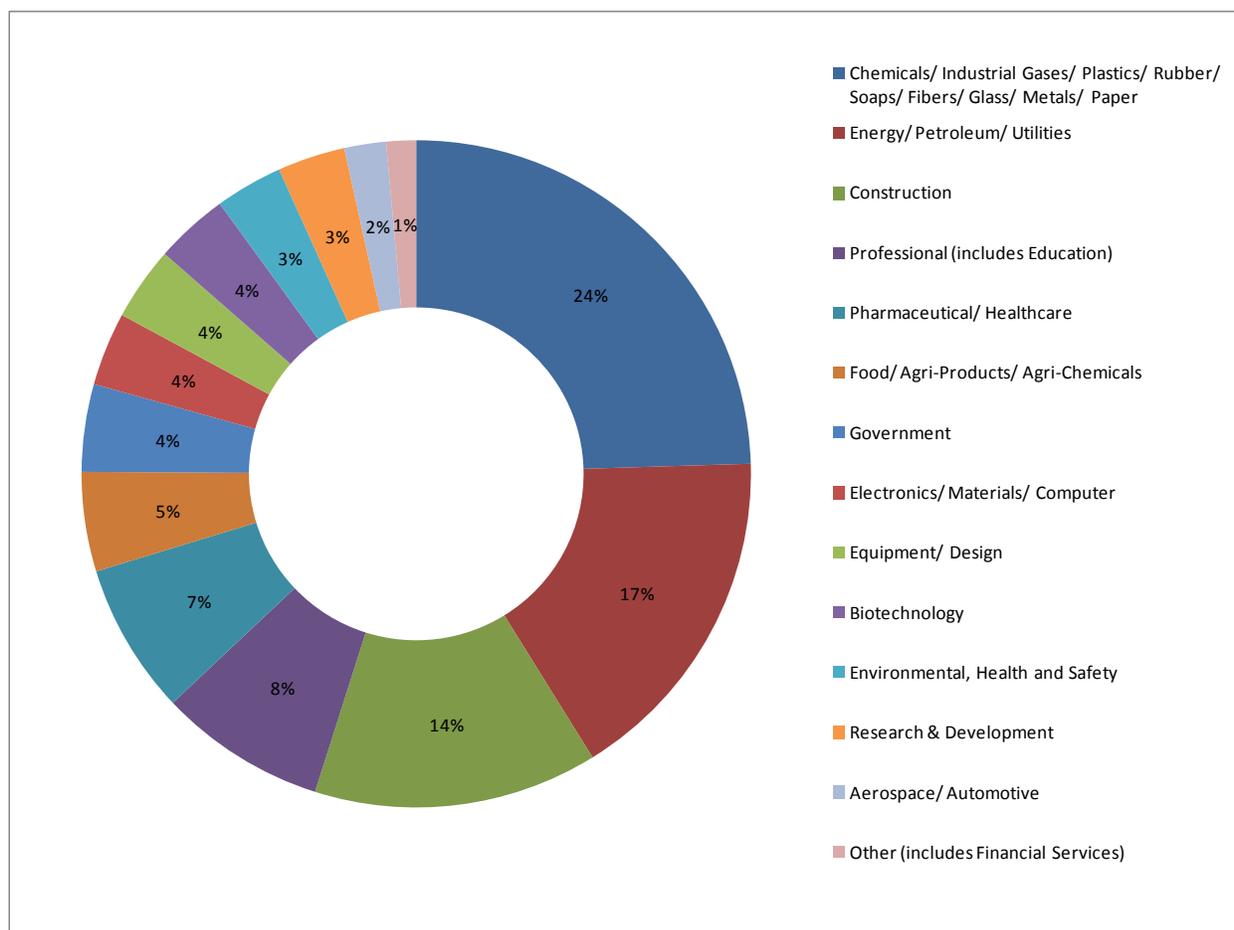
Figure 1. Course work necessary for the completion of a baccalaureate degree in chemical engineering

## Chemical Engineering Employment Profile

*Chemical engineers have a variety of employment options. This variety is reflected in Figure 2, where various employment sectors as well as corresponding percentages are shown.*

Upon graduation with a Bachelor of Science degree, chemical engineers may immediately start their professional careers, or they may opt for a variety of choices to further their education, such as:

- graduate school in engineering, science, or business administration
  - doctoral degree (Ph.D.)
  - master's degree (M.S., M.Ch.E.)
- professional school
  - medicine
  - law



*Figure 2. Sectors of employment for chemical engineers. Percentages are for 2007 (Source: AIChE Centennial 1908–2008, Chapter 25, [http://www.aiche.org/uploadedFiles/About/Centennial/Books/100/AIChE\\_A\\_Century\\_of\\_Achievements\\_Chap25.pdf](http://www.aiche.org/uploadedFiles/About/Centennial/Books/100/AIChE_A_Century_of_Achievements_Chap25.pdf)).*

# Chemical Engineering Competency Table

The Chemical Engineering Tuning Committee has two sets of competency tables. The first table (**Error! Reference source not found.**) adopts the exact definitions stipulated in Criterion 3 Student Outcomes (a) to (k) in ABET Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2011-2012 Accreditation Cycle. The corresponding webpage is <http://www.abet.org>. The second table adopts the 11 learning outcomes specific for chemical engineering disciplines.

Both of the Chemical Engineering competency tables have four levels of learning outcomes:

1. Secondary education competencies (HS)
2. Pre-engineering competencies (LL)
3. Baccalaureate-level competencies (UL/BS)
4. Post-baccalaureate competencies (PB)

## Table 1. ABET Student Outcomes

1. an ability to apply knowledge of mathematics, science, and engineering
2. an ability to design and conduct experiments, as well as to analyze and interpret data
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4. an ability to function on multidisciplinary teams
5. an ability to identify, formulate, and solve engineering problems
6. an understanding of professional and ethical responsibility
7. an ability to communicate effectively
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
9. a recognition of the need for, and an ability to engage in, lifelong learning
10. a knowledge of contemporary issues
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

## Table 1. Chemical Engineering Competency Learning Outcomes

1. Mathematics, Science, and Engineering
2. Experiments
3. System Design
4. Multidisciplinary Teams
5. Engineering Problems
6. Professional and Ethical Responsibility
7. Communication
8. Global Impact of Engineering Solutions
9. Lifelong Learning
10. Contemporary Issues
11. Engineering Tools

# Chemical Engineering Key Competencies Profile

The key competencies profile is a schematic diagram that is derived from the competency table. It lists, for each learning outcome (columns), the required competency levels according to Bloom's taxonomy (rows) that have to be gained at each of four educational levels: namely, HS, LL, UL/BS, and PB.

## Chemical Engineering Key Competencies Profile

Lumina Foundation Grant Chemical Engineering Committee

Evaluations	G	UL	G	G	UL	G	G	G	G	G	G
Synthesis	UL	UL	UL	G	UL	G	G	G	G	UL	G
Analysis	UL	UL	UL	G	UL	UL	UL	UL	G	UL	UL
Application	UL	UL	UL	UL	LL	UL	LL	UL	UL	LL	LL
Comprehension	LL	LL	UL	UL	LL	UL	HS	LL	LL	LL	LL
Knowledge	HS	HS	LL	LL	HS	LL	HS	HS	HS	HS	LL
	Mathematics, Science & Engineering	Experiments	System Design	Multidisciplinary Tasks	Engineering Problems	Professional & Ethical Responsibility	Communication	Global Impact of Engineering Solutions	Life-Long Learning	Contemporary Issues	Engineering Tools

G	graduate-level competencies
UL	Upper-level competencies
LL	Lower-level competencies
HS	secondary education competencies

The six competency levels according to Bloom's taxonomy are:

1. knowledge,
2. comprehension,
3. application,
4. analysis,
5. synthesis, and
6. evaluation.

The level of response for each of the Bloom's taxonomy levels are described through active verbs, for example ([http://www.teach-nology.com/worksheets/time\\_savers/bloom/](http://www.teach-nology.com/worksheets/time_savers/bloom/)):

<b>Knowledge</b>	count, define, describe, draw, find, identify, label, list, match, name, quote, recall, recite, sequence, tell, write
<b>Comprehension</b>	conclude, demonstrate, discuss, explain, generalize, identify, illustrate, interpret, paraphrase, predict, report, restate, review, summarize, tell
<b>Application</b>	apply, change, choose, compute, dramatize, interview, prepare, produce, role-play, select, show, transfer, use
<b>Analysis</b>	analyze, characterize, classify, compare, contrast, debate, deduce, diagram, differentiate, discriminate, distinguish, examine, outline, relate, research, separate,
<b>Synthesis</b>	compose, construct, create, design, develop, integrate, invent, make, organize, perform, plan, produce, propose, rewrite
<b>Evaluation</b>	appraise, argue, assess, choose, conclude, critic, decide, evaluate, judge, justify, predict, prioritize, prove, rank, rate, select

**The following pages contain the Learning Outcome Descriptions for Chemical Engineering:**

## Mathematics, Sciences, and Engineering

Mathematics deals with the science of structure, order, and relation that has evolved from counting, measuring, and describing the shapes of objects. It uses logical reasoning and quantitative calculation, and is considered the underlying language of science. The principal branches of mathematics relevant to chemical engineering are arithmetic, geometry, algebra, trigonometry, analysis, calculus, differential equations, numerical methods, linear algebra, probability and statistics, and optimization.

The chemical engineer must possess a thorough grounding in the basic sciences, including chemistry, physics, and biology; and sufficient knowledge in the application of these basic sciences to enable graduates to design, analyze, and control chemical, physical, and biological processes.

The science of chemistry deals with the properties of matter, and the transformations and interactions of matter and energy. Since a primary role of the chemical engineer is to apply fundamental chemical knowledge to produce useful products on a large scale, thorough knowledge of chemistry is essential.

Physics is concerned with understanding the structure of the natural world and explaining natural phenomena in a fundamental way in terms of elementary principles and laws. Many areas of chemical engineering rely on physics for understanding governing principles and for obtaining solutions to problems.

Additional breadth in such science disciplines as biology, microbiology, and ecology will be required to prepare the

chemical engineer of the future. Chemical engineers should have the basic scientific literacy that will enable them to be conversant on technical issues pertaining to biomedical systems, drugs and pharmaceuticals, public health and safety, and environmental science, as well as traditional subject areas.

The chemical engineering graduate solves problems in mathematics, calculus-based physics, chemistry, and additional areas of natural science through differential equations and *applies* this knowledge to the solution of engineering problems. The mathematics, chemistry, physics, and breadth in natural sciences required for chemical engineering practice must be learned at the undergraduate level and should prepare students for subsequent courses in engineering and engineering practice.

Mathematics, Science, & Engineering			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Define key concepts and factual information using algebra, trigonometry, and algebra-based physics and chemistry.	Explain key concepts and problem-solving processes using mathematics through differential equations, calculus-based physics, chemistry.	Solve chemical engineering problems using differential equations, calculus-based physics, chemistry, statistics.	Resolve a complex chemical engineering problem into components to determine its relevant mathematical and scientific principles, then apply that knowledge accordingly.

## Experiments

Experimentation can be defined as performing “an operation or procedure carried out under controlled conditions in order to discover an unknown effect or law, to test or establish a hypothesis, or to illustrate a known law.”

Chemical engineers frequently design and conduct field and laboratory studies, gather data, create numerical simulations and other models, and then analyze and interpret the results. Individuals should be familiar with the purpose, procedures, equipment, and practical applications of experiments spanning more than one of the technical areas of chemical engineering. They should be able to conduct experiments, report results, and analyze results in accordance with the applicable standards in or across more than one technical area. In this context, experiments may include field and laboratory studies, virtual experiments, and numerical simulations.

*The chemical engineering graduate analyzes the results of experiments and evaluates the accuracy of the results within the known boundaries of the tests and materials in or across more than one of the technical areas of chemical engineering.*

Experiments			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Identify the procedures, phenomena and measurable parameters, and equipment to conduct chemical engineering experiments.	Explain the procedures, phenomena and measurable parameters, and equipment to conduct chemical engineering experiments.	Conduct chemical engineering experiments according to established procedures and report the results.  Conduct chemical engineering experiments according to established procedures, and analyze and interpret the results.  Design chemical engineering experiments to investigate a phenomenon, conduct the experiment, and analyze and interpret the results.	Evaluate the effectiveness of an experiment and its value for solving a chemical engineering problem.

## Design

Design is an iterative process that is often creative and involves discovery and the acquisition of knowledge. Such activities as problem definition, the selection or development of design options, analysis, detailed design, performance prediction, implementation, observation, and testing are parts of the engineering design process.

Design problems are often ill-defined, so defining the scope and design objectives and identifying the constraints governing a particular problem are essential to the design process. The design process is open-ended and involves a number of likely correct solutions, including innovative approaches. Successful design requires critical thinking, an appreciation of the uncertainties involved, and the use of engineering judgment. Consideration of risk assessment, societal and environmental impact, standards, codes, regulations, safety, security, sustainability, constructability, and operability are integrated at various stages of the design process.

*The chemical engineering graduate designs a system or process to meet desired needs within such realistic constraints as economic, environmental, social, political, ethical, health and safety, constructability, and sustainability.*

<b>Design</b>			
<b>Secondary Education Competencies in Chemical Engineering</b>	<b>Lower-Level Chemical Engineering Competencies</b>	<b>Upper-Level Chemical Engineering Competencies</b>	<b>Graduate-level Chemical Engineering Competencies</b>
No competency expected.	Describe designs for chemical or allied/related systems or processes that incorporate economic, environmental, social, political, ethical, health and safety, and sustainability considerations.	<p>Summarize and explain crucial issues and regulations in designs of chemical or allied/related systems or processes with considerations for economic, environmental, social, political, ethical, health and safety, and sustainability issues.</p> <p>Apply a particular engineering solution with the compliance of realistic economic, environmental, social, political, ethical, health and safety, and sustainability constraints.</p> <p>Break down into unit operations and processes of the design to illustrate the practicality and function of the chemical or allied/related system or process with the consideration of economic, environmental, social, political, ethical, health and safety, and sustainability needs.</p> <p>Write a cohesive research proposal to clarify, demonstrate, and justify the development and optimization of a chemical or allied/related system or process with the consideration of economic, environmental, social, political, ethical, health and safety, and sustainability needs.</p>	Judge and appraise the value of different design options for chemical or allied/related system or process with the consideration of economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability needs.

## Multidisciplinary Teamwork

Chemical engineers must be able to function as members of a team. This cooperation requires understanding team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, and time management; and being able to foster and integrate diverse perspectives, knowledge, and experiences.

A chemical engineer will eventually work within two different types of teams. The first is intra-disciplinary and consists of members from within the chemical engineering sub-discipline—for example, a process engineer working with an optimization/integration specialist. The second is multidisciplinary and is a team composed of members of different professions—for example, chemical engineers working with finance experts to finance plant construction. Multidisciplinary also includes a team consisting of members from different engineering sub-disciplines—sometimes referred to as a cross-disciplinary team—for example, chemical engineers working with petroleum, mechanical, and/or electrical engineers.

*The chemical engineering graduate functions effectively as a member of an intra-disciplinary team. At the undergraduate level, the focus is primarily on working as members of an intra-disciplinary team—that is, a team within the chemical engineering sub-discipline. Examples of opportunities for students to work in teams include design projects and laboratory exercises within a course and during a capstone design experience.*

Multidisciplinary Teams			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
No competency expected.	Identify and list the key characteristics of effective teams.	Describe and explain the factors that affect the ability of single-discipline and multidisciplinary teams to function effectively. Implement effective teamwork practices in intradisciplinary (single-discipline) teams.	Function as a member of a team, or implement effective teamwork practices in both intradisciplinary and multidisciplinary teams. Function as a member of a team, or implement effective teamwork practices and strategies for dealing with non-cooperative team members in both intradisciplinary and multidisciplinary teams. Evaluate the composition, organization, and performance of an intradisciplinary or multidisciplinary team.

## Problem Recognition and Solution

Chemical engineering problem solving consists of identifying engineering problems, obtaining background knowledge, understanding existing requirements and/ or constraints, articulating the problem through technical communication, formulating alternative solutions—both routine and creative—and recommending feasible solutions.

Appropriate techniques and tools—including information technology, contemporary analysis and design methods, and design codes and standards to complement knowledge of fundamental concepts—are required to solve engineering problems. Problem solving also involves the ability to select the appropriate tools as a method to promote or increase the future learning ability of individuals.

*The chemical engineering graduate develops* problem statements and *solves* well-defined fundamental chemical engineering problems by *applying* appropriate techniques and tools. Chemical engineers should be familiar with factual information related to engineering problem recognition and problem-solving processes. Additionally, chemical engineers should be able to explain key concepts related to engineering problem recognition, articulation, and solving.

Problem Recognition and Solution			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Describe and state the physical and chemical laws that govern chemical engineering problems.	Identify the correct chemical and physical laws applicable to a specific chemical engineering problem.	Solve chemical engineering problems using standard mathematical, graphical, and computer simulation techniques.  Analyze a complex chemical engineering problem to simplify and subdivide it into parts that can be solved with appropriate engineering techniques.	Develop new methods for solving chemical engineering problems.

## Professional and Ethical Responsibility

Chemical engineers in professional practice have a privileged position in society, affording the profession exclusivity in the design of a wide variety of chemical processes, including, among others, petroleum and gas processing systems, petrochemical and specialty chemical production, food processing, pharmaceutical production, and semiconductor processing. This position requires each of its members to adhere to a doctrine of professionalism and ethical responsibility. This doctrine is set forth in the American Institute of Chemical Engineers' (AIChE) Code of Ethics and Sexual Harassment Policy. The first item states that chemical engineers "...shall hold paramount the safety, health, and welfare of the public...." By meeting this responsibility, which puts the public interest above all else, the profession earns society's trust.

Chemical engineers aspire to be "entrusted by society to create a sustainable world and enhance the global quality of life." Therefore, current and future chemical engineers, whether employed in public or private organizations or self-employed, will increasingly hold privileged and responsible positions.

*The chemical engineering graduate analyzes a situation involving multiple conflicting professional and ethical interests to determine an appropriate course of action. The undergraduate experience should introduce and illustrate the impact of the chemical engineer's work on society and the environment. This experience naturally leads to the*

importance of meeting such professional responsibilities as maintaining competency and the need for ethical behavior.

Professional and Ethical Responsibility			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
No competency expected.	Identify the professional codes of ethics/conduct and define ethical concepts.	Explain ethical concepts in a personal and professional context.  Apply ethical concepts to determine a professional response to a hypothetical situation.  Analyze the possible implications and ramifications of ethics in engineering decision making.	Integrate the responsibility for ethical decision making with the associated risks and costs to the individual, company, and society.

## Communication

Within the scope of their practice, chemical engineers use calculations, graphics, and text—all of which are integral to a typically complex analysis or design process. Effective conduct and implementation of the results of this sophisticated work requires that chemical engineers communicate the essence of their expectations, findings, and recommendations. In numerous surveys conducted by universities or industry, communication skill is the one competence that is frequently at the top of the list among areas where recent graduates have significant room to grow. Means of communication are oral (speaking and listening) and written (presenting and comprehending text or visuals). The chemical engineer must communicate effectively with both technical and nontechnical individuals and audiences in a variety of settings. Use of the means of communication by chemical engineers requires an understanding of communication within professional practice. While personal charisma may underlie “great communicators,” the fundamentals of effective communication (such as understanding the expectations of the target audience; use of text and/or visuals in reports or presentations; speaking in front of an audience; exchanging information in a team) are teachable and should be acquired during formal education. Pre-licensure experience should build on these fundamentals to solidify the chemical engineer’s communication skills.

Communication			
Secondary Education Competencies in Chemical Engineering	Lower Level Chemical Engineering Competencies	Upper Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Identify the main forms of communication important to the engineering profession. Understand the advantages and disadvantages of different forms of communication used to present a specific concept.	Apply an appropriate form of communication and technique to present and discuss an engineering problem and its solution.	Analyze and select the best form of communication and technique to present and discuss a specific engineering problem with its solution.	Prepare and present an effective presentation on an engineering subject. Evaluate the quality and content of any form of engineering communication.

## Global Impact of Engineering Solutions

In today's engineering practice, the chemical engineering graduate must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. In general, chemical engineering students get this type of broad education through core undergraduate curriculum which includes engineering economics, computer science, and other requirements for subsequent engineering courses.

Among other topics, an understanding of industrial chemistry and engineering is also required for the treatment of hazardous wastes and degradation of waste and byproducts produced in various chemical engineering systems. Chemical engineering includes elements of chemistry and engineering, as well as integration of components into a complete system.

*The chemical engineering graduate* draws upon a broad education and global perspective to explain the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems and explains the impact of engineering solutions on the economy, environment, political landscape, and society.

Global Impact of Engineering Solutions			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Identify general impacts of engineering solutions in global, economic, environmental, and societal contexts.	Explain key impacts of engineering solutions in global, economic, environmental, and societal contexts.	Ascertain the impacts of engineering solutions in global, economic, environmental, and societal contexts.	Analyze the pros and cons of impacts of engineering solutions in global, economic, environmental, and societal contexts. Integrate the possible and probable impacts of engineering solutions in global, economic, environmental, and societal contexts. Evaluate multiple options and determine the optimum solution based on the impacts of engineering solutions in global, economic, environmental, and societal contexts.

## Lifelong Learning

To be effective, professional chemical engineers should constantly update their knowledge in engineering and related fields. In today's ever-evolving world, chemical engineers must realize the need for and develop ability and skill in lifelong learning. The tutorial materials available on the internet and different media should be utilized along with continued education and training seminars. Conferences of different professional engineering societies and organizations are also important venues for disseminating and updating current issues and techniques in engineering fields.

*The chemical engineering graduate must appreciate the importance of lifelong learning. The habit and skill can be taught and learned across the engineering curriculum—that is, over years of formal education and in most courses.*

Lifelong Learning			
Secondary Education Competencies in Chemical Engineering	Lower Level Chemical Engineering Competencies	Upper Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Define the evolution of knowledge and the demand for staying abreast of new developments in engineering.	Articulate and defend the importance of continued professional development related to the discipline.	Find professional development opportunities to keep abreast of developments in the discipline.	Analyze expositions of new developments in the discipline to isolate the important aspects.  Integrate professional development in the discipline into their practices to keep their work consistent with the best information available to them.  Identify professional development opportunities for subordinates that will help them keep abreast of developments in the discipline.

## Contemporary Issues and Historical Perspectives

To be effective, professional chemical engineers should draw upon their broad education to analyze the impacts of historical and contemporary issues on engineering and analyze the impact of engineering on the world. The engineering design cycle illustrates the dual nature of this outcome. In defining, formulating, and solving an engineering problem, engineers must consider the impacts of historical events and contemporary issues.

Examples of contemporary issues that could impact engineering include the multicultural globalization of engineering practice; raising the quality of life around the world; the importance of sustainability; the growing diversity of society; and the technical, environmental, societal, political, legal, aesthetic, economic, and financial implications of engineering projects. When generating and comparing alternatives and assessing performance, engineers must also consider the impact that engineering solutions have on the economy, environment, political landscape, and society.

The chemical engineering graduate draws upon a broad education; explains the impact of historical and contemporary issues on the identification, formulation, and solution of engineering problems; and explains the impact of engineering solutions on the economy, environment, political landscape, and society.

Contemporary Issues and Historical Perspectives			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper- Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Define current engineering related issues or problems and be aware of emerging technologies and engineering fields (e.g., nanotechnology, biomedical, renewable energy, etc.).	Explain the key concepts that are related to current engineering issues as well as emerging engineering fields and technologies.	Apply basic problem- solving skills to current engineering problems and key aspects of emerging engineering fields and technologies.	Analyze and integrate the key concepts related to current engineering issues as well as emerging engineering fields and technologies. Develop new technologies and apply them to current engineering issues; develop new technologies within emerging engineering fields. Evaluate the validity of solutions being applied to current engineering problems; evaluate the validity of new technologies from emerging engineering fields.

## Engineering Tools

The curriculum must prepare graduates to apply techniques, skills, and engineering tools appropriate to generate feasible solutions to problems. The curriculum must include instruction in information technology, process simulation, and process control design.

Chemical engineers apply basic scientific knowledge to design, analyze, and control chemical, physical, and biological processes. To accomplish this, chemical engineers use information technology, modeling software, and libraries of physical data to find optimal solutions and integrate systems. The chemical engineering graduate must be familiar with current information and technology in an effort to resolve chemical engineering problems. The exposure and training of these experimental and modeling toolsets are implemented throughout the engineering curriculum—that is, over years of formal education and training.

Engineering Tools			
Secondary Education Competencies in Chemical Engineering	Lower-Level Chemical Engineering Competencies	Upper-Level Chemical Engineering Competencies	Graduate-level Chemical Engineering Competencies
Identify engineering toolsets, including both computer-based applications and traditional problem-solving techniques and skills.	Determine appropriate problem-solving strategies by comparing available problem-solving techniques, skills, and tools.	Use appropriate problem-solving strategies to solve engineering problems.	Analyze complex problems and solve these problems using multiple tools, techniques, and skills in an appropriate and accurate manner.

# Community College Program of Study for Transfer to a Chemical Engineering Program

## FRESHMAN YEAR

First Semester (Fall)		Second Semester (Spring)	
Course	SCH	Course	SCH
MATH 2413 Calculus I	4	MATH 2414 Calculus II	4
CHEM 1311 General Chemistry I	3	PHYS 2325 University Physics I	3
CHEM 1111 Chemistry I Laboratory	1	PHYS 2125 University Physics I Laboratory	1
ENGR 1201 Introduction to Engineering <sup>2</sup>	2	CHEM 1312 General Chemistry II	3
XXXX ##### Texas Core Curriculum Requirement	3	CHEM 1112 Chemistry II Laboratory	1
XXXX ##### Texas Core Curriculum Requirement	3	XXXX ##### Technical or Texas Core Curr. Requirement <sup>4</sup>	3
		XXXX ##### Texas Core Curriculum Requirement	3
		Semester Credit Hours	18

## SOPHOMORE YEAR

First Semester (Fall)		Second Semester (Spring)	
Course	SCH	Course	SCH
MATH 2415 Multi-Variable Calculus (Calculus III) <sup>3</sup>	4	MATH 2320 Differential Equations	3
PHYS 2326 University Physics II	3	CHEM 2325 Organic Chemistry II	3
PHYS 2126 University Physics II Laboratory	1	CHEM 2125 Organic Chemistry II Laboratory	1
CHEM 2323 Organic Chemistry I	3	ENGR ##### Thermodynamics I	3
		XXXX ##### Technical or Texas Core Curr. Requirement <sup>4</sup>	4
CHEM 2123 Organic Chemistry I Laboratory	1	XXXX ##### Texas Core Curriculum Requirement	3
ENGR ##### Stoichiometry/Mass Balance	3		
XXXX ##### Texas Core Curriculum Requirement	3	Semester Credit Hours	17
		Semester Credit Hours	18

### Notes:

- 1 Texas Common Course Numbers are used for all TCCN-numbered courses.
- 2 This is a 1 hr course for some chemical engineering programs.
- 3 Most chemical engineering programs will accept the course MATH 2415/2515 for transfer credit and as applicable to the chemical engineering major, while some will accept the course for transfer credit only. The student is advised to check with the school to which he or she intends to transfer for specific applicability of this course to the chemical engineering major.
- 4 Some chemical engineering programs will accept the courses ENGR 2304 (programming), ENGR 2305/2105 (electrical circuits with laboratory) or ENGR 2303 or 2403 (statics & dynamics) for transfer credit and as applicable to the chemical engineering major, while some will accept the courses for transfer credit only. The student is advised to check with the school to which he or she intends to transfer for specific applicability of these courses to the chemical engineering major and the requisite number of credit hours for the course.
- 5 Some chemical engineering programs require a separate introductory course on computing, while others incorporate the same material into other lower-level courses.

## Prerequisite Flowchart for Chemical Engineering

