# Mathematics

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember</td>
<td>Identify concepts and principles of mathematics, including differential equations and numerical methods.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td></td>
<td>(remember previously learned material)</td>
<td></td>
</tr>
<tr>
<td>2 – Comprehend</td>
<td>Explain concepts and principles of mathematics, including differential equations and numerical methods.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td></td>
<td>(grasp the meaning of learned material)</td>
<td></td>
</tr>
<tr>
<td>3 – Apply</td>
<td>Apply concepts and principles of mathematics, including differential equations and numerical methods.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td></td>
<td>(use learned material in new and concrete situations)</td>
<td></td>
</tr>
<tr>
<td>4 – Analyze</td>
<td>Select appropriate concepts and principles of mathematics to solve civil engineering problems.</td>
<td>Post-Graduate Education</td>
</tr>
<tr>
<td></td>
<td>(break down learned material into its component parts so that its organizational structure may be understood)</td>
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</tr>
<tr>
<td>5 – Synthesize</td>
<td>Develop mathematical models to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(put learned material together to form a new whole)</td>
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<tr>
<td>6 – Evaluate</td>
<td>Assess mathematical models used to solve civil engineering problems.</td>
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</tr>
<tr>
<td></td>
<td>(judge the value of learned material for a given purpose)</td>
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</tbody>
</table>

**Understanding the Outcome**

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. Since the 17th century mathematics has been an indispensable adjunct to the physical sciences and technology and is considered the underlying language of science and engineering. The principal branches of mathematics relevant to civil engineering are algebra, analysis, arithmetic, geometry, calculus, numerical analysis, optimization, probability, set theory, statistics, and trigonometry.

**Rationale**

All areas of civil engineering rely on mathematics for the performance of quantitative analysis of engineering systems. A technical core of knowledge and breadth of coverage in mathematics and the ability to apply this knowledge to analyze and solve engineering problems are essential skills for civil engineers. Mathematics has always been an integral part of engineering and has been part of the civil engineering BOK since its inception. Numerical analysis is included in recognition of its importance and broad use in analyzing and solving complex problems in civil engineering.
Level of Achievement

Mathematics is a foundational tool that is applied to analyze and solve civil engineering problems. Accordingly, for entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to “select concepts and principles of mathematics to solve civil engineering problems.”

Fulfillment of the Outcome

The basic knowledge, comprehension and application of mathematics required for civil engineering practice should be learned at the undergraduate level and should prepare students to apply it in subsequent engineering courses and in practice following graduation. Post-graduate education should bring civil engineers to the analysis level. Recognizing that the application of mathematics in practice can vary greatly, from indirect to direct application, the mathematics outcome is expected to be fulfilled through a combination of undergraduate and post-graduate education.
## Natural Sciences

<table>
<thead>
<tr>
<th>Level of Achievement</th>
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</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles of calculus-based physics, chemistry and at least one other area of the natural sciences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles of calculus-based physics, chemistry and at least one other area of the natural sciences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> concepts and principles of calculus-based physics, chemistry and at least one other area of the natural sciences, to solve civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> appropriate concepts and principles of natural sciences to solve civil engineering problems.</td>
<td>Post-Graduate Education</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> appropriate concepts and principles of natural sciences to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> solutions to civil engineering problems involving concepts and principles of natural sciences.</td>
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</tr>
</tbody>
</table>

### Understanding the Outcome

Underlying the professional role of the civil engineer as the master integrator and technical leader is a firm foundation in the natural sciences. Natural science is the knowledge of objects or processes observable in nature such as physical earth and life sciences, e.g. biology, physics, chemistry, as distinguished from the abstract or theoretical sciences such as mathematics or philosophy (Oxford English Dictionary.) It involves the description, prediction, and understanding of natural phenomena, based on empirical evidence from observation and experimentation. Physics and chemistry are two disciplines of the natural sciences that have historically served as basic foundations for civil engineering. Additional disciplines of natural science, including biology, ecology, geology, meteorology, and others are also important in various sub-disciplines of civil engineering.

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. The fundamentals of physics are mechanics and field theory. Mechanics is concerned with the equilibrium and motion of particles or bodies under the action of given forces. The physics of fields encompasses the origin, nature, and properties of gravitational, electromagnetic, nuclear, and other force fields. Taken together, mechanics and field theory constitute the most
fundamental approach to an understanding of natural phenomena that science offers. Physics is characterized by accurate instrumentation, precision of measurement, and the expression of its results in mathematical terms. Many areas of civil engineering rely on physics for understanding the underlying governing principles and for obtaining solutions to problems. A technical core of knowledge and breadth in coverage in physics, and the ability to apply it to solve engineering problems, are essential for civil engineers.

Chemistry is the science that deals with the properties, composition, and structure of substances (elements and compounds), the reactions and transformations they undergo, and the energy released or absorbed during those processes. Chemistry is concerned with atoms as building blocks, everything in the material world, and all living things. Branches of chemistry include inorganic, organic, physical, and analytical chemistry; biochemistry; electrochemistry; and geochemistry. Some areas of civil engineering, especially environmental engineering and construction materials, rely on chemistry for explaining phenomena and obtaining solutions to problems. A technical core of knowledge and breadth of coverage in chemistry is necessary for individuals to solve related problems in civil and environmental engineering.

Additional knowledge in at least one more area of natural science is required to provide well-rounded exposure in the sciences. Disciplines of natural science of particular relevance to civil engineering include, but are not limited to, biology, ecology, geology, and meteorology.

Rationale
A technical core of knowledge and breadth of coverage in the natural sciences and the ability to apply this knowledge to analyze and solve engineering problems are essential skills for civil engineers. Civil engineers must have the basic scientific literacy that will enable them to be conversant with technical issues pertaining to environmental systems, public health and safety, durability of construction materials, and other such subjects. With technological advances in science and their applications to civil engineering beyond physics and chemistry, study in an additional area of natural science is required to prepare the civil engineer of the future and to keep the profession relevant.

Level of Achievement
Natural science is foundational in the analysis and solution of civil engineering problems. Accordingly, for entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to “select concepts and principles of natural sciences to solve civil engineering problems.”

Fulfillment of the Outcome
The basic knowledge, comprehension and application of natural sciences required for civil engineering practice should be learned at the undergraduate level and should prepare students to apply it in subsequent engineering courses and in practice following graduation. Postgraduate education should bring civil engineers to the analysis level. The natural sciences
outcome is expected to be fulfilled through a combination of undergraduate and post-graduate education.
Social Sciences

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<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
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<tbody>
<tr>
<td>1 – Remember</td>
<td>Identify concepts and principles of social sciences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(remember previously learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Comprehend</td>
<td>Explain concepts and principles of social sciences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(grasp the meaning of learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – Apply</td>
<td>Apply concepts and principles of social sciences relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(use learned material in new and concrete situations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – Analyze</td>
<td>Select appropriate concepts and principles of social sciences to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>(break down learned material into its component parts so that its organizational structure may be understood)</td>
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<td></td>
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<tr>
<td>5 – Synthesize</td>
<td>Integrate appropriate concepts and principles of social sciences to solve civil engineering problems.</td>
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<tr>
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<tr>
<td>6 – Evaluate</td>
<td>Evaluate solutions to civil engineering problems involving concepts and principles of social sciences.</td>
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<tr>
<td>(judge the value of learned material for a given purpose)</td>
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</table>

**Understanding the Outcome**

The social sciences are the study of society and the manner in which people behave and influence the world around them (Economic and Social Research Council). Social science disciplines include, but are not limited to, anthropology, communication studies, economics, geography, law, linguistics, political science, sociology, and psychology. Social sciences are scientific, quantitative, analytical, and data-driven and use the scientific method, including both qualitative and quantitative methods. To be effective, civil engineers must work within a social framework. This outcome is intended to guide civil engineers in making connections between their technical education and their education in the social sciences. Effective delivery of engineering services depends critically upon these connections.

**Rationale**

Civil engineers must be able to recognize and incorporate various aspects of social science considerations into the development, delivery, and evaluation of civil engineering projects. They must think open-mindedly and acknowledge the inputs and impacts from the social sciences perspective. They must also recognize and assess the assumptions, implications, and practical consequences of their work. Continued development of professional competence comes from lifelong learning, mentorship from senior engineers, and practical experience,
grounded on a firm foundation in, and recognition of, the importance of the social sciences and advances in them.

**Level of Achievement**
The formal education process at the undergraduate level must include study in social sciences in order for the student to develop an appreciation of their importance in the development of engineering solutions. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the application level and be able to “apply concepts and principles of social sciences relevant to civil engineering.”

**Fulfillment of the Outcome**
The foundational knowledge, understanding and application of the social sciences necessary for civil engineering practice should be learned at the undergraduate level. Students should be able to apply their understanding of the social sciences in subsequent engineering courses and in the practice of civil engineering following graduation. Recognizing that the application of social sciences in practice can be situational and vary by technical areas of practice, sectors of the engineering profession, and geographic areas of projects, the social sciences outcome is expected to be fulfilled entirely through undergraduate education. Examples of opportunities to demonstrate this ability at the undergraduate level include incorporating the application of social sciences in engineering courses as well as in a capstone or major design experience.
Humanities

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<th>Fulfilled Through</th>
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<tbody>
<tr>
<td>1 – Remember</td>
<td>Recognize relationships between the humanities and the professional practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(remember previously learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Comprehend</td>
<td>Explain relationships between the humanities and the professional practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(grasp the meaning of learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – Apply</td>
<td>Apply aspects of the humanities to the solution of civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(use learned material in new and concrete situations)</td>
<td></td>
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<tr>
<td>4 – Analyze</td>
<td>Illustrate aspects of the humanities in the solution of civil engineering problems.</td>
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<tr>
<td>(break down learned material into its component parts so that its organizational structure may be understood)</td>
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<tr>
<td>5 – Synthesize</td>
<td>Integrate aspects of the humanities into the solution of civil engineering problems.</td>
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<tr>
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<tr>
<td>6 – Evaluate</td>
<td>Assess the integration of the humanities into the solution of civil engineering problems.</td>
<td></td>
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</table>

**Understanding the Outcome**

The humanities can be defined as the study of the human aspects of the world, including how people process and document the human experience. The humanities include philosophy, history, literature, the visual and performing arts, language, and religion. This outcome is intended to define the importance of the humanities and its relationship to the practice of civil engineering. The understanding of humanities is critical to the delivery of civil engineering services to people and communities, and is supportive of the development of critical thinking skills.

**Rationale**

Humanities are similarly fundamental to a civil engineer’s ability to develop solutions that positively impact people and support community growth. Civil engineers must think open-mindedly within diverse systems of thought, recognizing and assessing, as need be, the assumptions, implications, and practical consequences of their work. To produce human-centered designs, civil engineers must be informed not only by mathematics and the natural and social sciences, but also by the humanities. To be effective, civil engineers must be critical thinkers and possess the ability to raise vital questions and problems and then formulate them clearly and appropriately. They must gather and assess relevant information, use abstract ideas to interpret the information effectively, and come to well-reasoned conclusions and solutions, testing them against relevant criteria and standards.
Ultimately, designing effective civil engineering solutions requires empathy on the part of civil engineers for the individuals and communities involved. Developing this needed empathy is facilitated and enhanced by studying the great works of literature, film, and other aspects of the humanities. (Ottino, J. M., & Morson, G. S. (2016). Building a bridge between engineering and the humanities. Chronicle of higher education.)

**Level of Achievement**

Some level of knowledge and appreciation of the humanities is fundamental to all citizens within society. Humanities are similarly fundamental to a civil engineer’s ability to develop solutions that positively impact people and support community growth. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the application level and be able to “apply aspects of the humanities to the solution of civil engineering problems.”

**Fulfillment of the Outcome**

The foundational knowledge, understanding, and application of the humanities necessary for civil engineering practice should be learned at the undergraduate level. Students should be able to apply their understanding of the humanities in subsequent engineering courses and in the practice of civil engineering following graduation. Recognizing that the application of humanities in practice can be situational and vary by technical areas of practice, sectors of the engineering profession, and geographic areas of a project, the humanities outcome is expected to be fulfilled entirely through undergraduate education.
# Materials Science

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles of materials science.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles of materials science.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> concepts and principles of materials science relevant to solve civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> appropriate concepts and principles of materials science to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Develop</strong> new applications in materials science to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> solutions to civil engineering problems involving new applications in materials science.</td>
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</tr>
</tbody>
</table>

## Understanding the Outcome

Civil engineering materials include, but are not limited to, concrete, asphalt, wood, steel, polymers, fibers, and soil. Civil engineers must be familiar with the properties and behaviors of these materials for selection of material type and to create appropriate specifications for their use.

## Rationale

Civil engineers are responsible for specifying appropriate materials in civil engineering projects. The civil engineer should have knowledge of how materials systems interact with the environment so that durable materials that can withstand aggressive environments can be specified as needed. This includes the understanding of materials at the macroscopic and microscopic levels, and the growing importance of recycling and reuse of materials and resources in a sustainable manner. A technical core of knowledge and breadth of coverage in materials science appropriate to civil engineering is necessary for individuals to solve a variety of civil engineering problems.

## Level of Achievement

Civil engineers are expected to identify and explain the concepts and principles of materials science, and then apply these principles and concepts to solve civil engineering problems. For entry into the practice of civil engineering at the professional level, all civil engineers should be
at the application level and be able to “apply concepts and principles of materials science relevant to solve civil engineering problems.”

**Fulfillment of the Outcome**

The basic knowledge, comprehension and application of materials science required for civil engineering practice should be learned at the undergraduate level and should prepare students to apply it in subsequent engineering courses and in practice following graduation. The materials science outcome is expected to be fulfilled entirely through undergraduate education.
Engineering Mechanics

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<th>Level of Achievement</th>
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<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles of statics, dynamics, mechanics of materials, and fluid mechanics.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles of statics, dynamics, mechanics of materials, and fluid mechanics.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> concepts and principles of statics, dynamics, mechanics of materials, and fluid mechanics to solve civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> appropriate concepts and principles of engineering mechanics to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Develop</strong> new applications in engineering mechanics to solve civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> solutions to civil engineering problems involving new applications in engineering mechanics.</td>
<td></td>
</tr>
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</table>

**Understanding the Outcome**

Engineering mechanics is the study of the behavior of systems under the action of forces. These systems include solids and fluids. Mechanics is subdivided according to the types of systems and phenomena involved. The Newtonian laws of classical mechanics can adequately describe those systems encountered in most civil engineering areas.

**Rationale**

Mechanics in civil engineering encompasses the mechanics of continuous and particulate solids subjected to load, and the mechanics of fluid flow through pipes, channels, and porous media. A technical core of knowledge and breadth of coverage in both solid and fluid mechanics, and the ability to apply it to solve civil engineering problems, are essential for civil engineers. Areas of civil engineering that rely on mechanics include, but are not limited to, structural engineering, geotechnical engineering, environmental engineering, and water resources engineering.

**Level of Achievement**

Engineering mechanics encompasses concepts and principles that are applied to solve civil engineering problems. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the application level and be able to “apply concepts and
principles of statics, dynamics, mechanics of materials, and fluid mechanics to solve civil engineering problems."

Fulfillment of the Outcome

The engineering mechanics capabilities required for the practice of civil engineering should be learned at the undergraduate level. Undergraduate civil engineering students should be prepared to apply mechanics knowledge in subsequent civil engineering courses and in practice. Acknowledging that the application of mechanics in practice can vary greatly, particularly in different areas of civil engineering, the engineering mechanics outcome is nonetheless expected to be fulfilled entirely through undergraduate education.
## Experimental Methods and Data Analysis

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<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> the procedures and equipment necessary to conduct experiments in at least two technical areas of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> the purpose, procedures, equipment, and practical applications of experiments of experiments in at least two technical areas of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Conduct</strong> experiments in at least two technical areas of civil engineering, and <strong>report</strong> the results.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> appropriate experiments, and <strong>analyze</strong> the results in the solution of civil engineering problems.</td>
<td>Post-Graduate Education</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Develop</strong> new experimental methods, and/or integrate the results of multiple experiments for the solution of civil engineering problems</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> new experimental methods and/or the results of multiple experiments for the solution of civil engineering problems.</td>
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</table>

### Understanding the Outcome

An experiment is a procedure carried out to determine something that is unknown, to evaluate a hypothesis, to demonstrate a fact, or to provide an insight into cause-and-effect. Experiments include those conducted in the field, the laboratory, or through virtual experimentation or numerical simulation. Methods are either prescribed in industry standards, or they may have to be developed based on the scientific method. Experiments should always include repeatable procedures and logical analysis of the results. Experimentation is not limited to physical procedures or operations, but may also be virtual in nature to include numerical simulations and analysis with existing data sets. Data analysis is a process for obtaining raw data and converting it into information useful for engineering decision-making.

Breadth of experience in experimentation and reporting results is required in at least two technical areas of civil engineering. The traditional technical areas of civil engineering include construction engineering; environmental engineering; geotechnical engineering; structural engineering; surveying, utilities and site development; transportation engineering; and water resources engineering. Other areas may be appropriate with well-reasoned justifications.
Rationale

Experimentation and data analysis are essential for many civil engineering projects including the characterization of and understanding the relationship between specific cause and effect, or evaluating a particular hypothesis. The need for experimentation and data analysis can arise during any phase of a project, including conceptual planning, detailed design, delivery, execution, or performance evaluation. Since engineering is based on scientific principles, experimentation in the course of civil engineering must adhere to the scientific method and be based on repeatable procedures and logical analysis of the results.

Level of Achievement

Civil engineers will be familiar with the purpose, procedures, equipment, and computational methods associated with standardized experiments and report results in at least two related technical areas of civil engineering. Civil engineers are also expected to have the ability to select appropriate experiments and analyze the resulting data. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to “select appropriate experiments and analyze the results in the solution of civil engineering problems.”

Fulfillment of the Outcome

Experimentation and data analysis is obtained through a combination of undergraduate education and post-graduate education. Standardized test methods and data reporting procedures are typically learned at the undergraduate level. Civil engineers will be able to conduct and report the results from common testing methods, which are typically taught as a part of undergraduate education in classroom and laboratory courses, in at least two technical areas. The ability to select appropriate test methods and provide more thorough interpretation and analysis of the results is typically gained through post-graduate education.
## Critical Thinking and Problem Solving

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<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify and define</strong> a complex problem, question or issue relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> the scope and context of a complex problem, question or issue relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Formulate</strong> a set of possible solutions to a complex problem, question or issue relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Analyze</strong> a set of possible solutions to a complex problem, question or issue relevant to civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Develop</strong> the most appropriate solution to a complex problem, question or issue relevant to civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> solutions to complex problems, questions or issues relevant to civil engineering.</td>
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</table>

### Understanding the Outcome

Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication as a means to recognize and solve problems. (adapted from the definition of critical thinking as accessed from [https://www.criticalthinking.org/pages/defining-critical-thinking/766 on January 27, 2018]).

An engineering problem is a problem that exists in any domain that can be solved by the application of engineering knowledge and skills and generic competencies (International Engineering Alliance, Graduate Attributes and Professional Competencies). In civil 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. The application of the engineering problem solving process to obtain the most appropriate solution requires critical thinking skills.

### Rationale

Critical thinking skills enable civil engineers to define, address, and solve ill-defined, complex and ambiguous problems. As members of a profession, civil engineers exercise discretionary judgement, which requires critical thinking. Through observation, experience, reflection, and
reasoning, civil engineers move from simply solving problems to creating the most appropriate solutions.

**Level of Achievement**

Critical thinking and problem solving are essential in the practice of civil engineering. Civil engineers must possess and continuously use critical thinking and problem solving skills. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and be able to “develop the most appropriate solution to a complex problem, question or issue relevant to civil engineering.”

**Fulfillment of the Outcome**

The critical thinking and problem solving outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. The foundation of critical thinking and problem solving should be learned at the undergraduate level. This includes properly identifying and defining problems, explaining the scope and context of problems and generating possible solutions. This is usually accomplished in upper-level courses and in a capstone design or culminating experience. Through mentored experience civil engineers should further refine these skills to progress from generating solutions to analyzing solutions and developing the most appropriate solutions to complex problems.
Project Management

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember</td>
<td><strong>Identify</strong> concepts and principles of project management.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(remember previously</td>
<td></td>
<td></td>
</tr>
<tr>
<td>learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Comprehend</td>
<td><strong>Explain</strong> concepts and principles of project management.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(grasp the meaning of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – Apply</td>
<td><strong>Formulate</strong> components of project management plans for complex civil engineering</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(use learned material</td>
<td>projects.</td>
<td></td>
</tr>
<tr>
<td>in new and concrete</td>
<td></td>
<td></td>
</tr>
<tr>
<td>situations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – Analyze</td>
<td><strong>Analyze</strong> components of project management plans for complex civil engineering</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>(break down learned</td>
<td>projects.</td>
<td></td>
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<tr>
<td>material into its</td>
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<tr>
<td>component parts so</td>
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<td>that its organizational</td>
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<td>structure may be</td>
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</tr>
<tr>
<td>understood)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 – Synthesize</td>
<td><strong>Integrate</strong> components into complete project management plans for complex civil</td>
<td></td>
</tr>
<tr>
<td>(put learned material</td>
<td>engineering projects.</td>
<td></td>
</tr>
<tr>
<td>together to form a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>new whole)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate</td>
<td><strong>Evaluate</strong> project management plans for complex civil engineering projects.</td>
<td></td>
</tr>
<tr>
<td>(judge the value of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>learned material for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a given purpose)</td>
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</tbody>
</table>

Understanding the Outcome

Project management within the practice of civil engineering can be defined as the disciplined application of specialized civil engineering knowledge, skills, tools, and techniques to civil engineering project activities, including project initiation, planning, execution, monitoring and controlling, and closing, to meet project requirements. There are standard components within a typical project management plan that are generally applicable regardless of the type of project. The standard components of a project management plan include, but are not limited to, statement of scope, critical path/success factors, deliverables, schedule, budget, quality control, human resources, communication, and risk management.

Rationale

Successful civil engineering projects rely on both technical and non-technical knowledge, skills, and attitudes, including knowledge and skills associated with project management. When projects are not managed well there can be significant additional costs. One report\(^1\) indicated nearly one-half of assessed projects went over budget and over half were completed behind schedule. Developing appropriate project management knowledge and skills benefit civil engineers and civil engineering projects through improved efficiencies and effectiveness.

Level of Achievement

Project management encompasses concepts and principles that are used to successfully initiate, plan, execute, monitor and control, and close complex civil engineering projects. For
entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to “analyze components of project management plans for complex civil engineering projects.”

**Fulfillment of the Outcome**

The project management outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. An understanding of the concepts and principles of project management and the ability to apply this understanding by formulating components of project management plans for complex civil engineering projects should be learned at the undergraduate level. The knowledge and skills gained through formal education needs to be further developed, completing the fulfillment of the project management outcome through mentored experience.

---

Engineering Economics

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td>Identify concepts and principles of engineering economics.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td>Explain concepts and principles of engineering economics.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td>Apply concepts and principles of engineering economics in the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td>Select appropriate concepts and principles of engineering economics for the practice of civil engineering.</td>
<td></td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td>Integrate engineering economics analyses in the practice of civil engineering.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td>Appraise the effectiveness of engineering economic analyses in the practice of civil engineering.</td>
<td></td>
</tr>
</tbody>
</table>

Understanding the Outcome

Engineering economics is defined as economics for application to engineering projects and includes the study of time value of money; cost, including incremental, average, sunk, and estimating; economic analyses; depreciation and taxes; discounted cash flows; type and breakdowns of costs, including fixed, variable, direct and indirect labor; accounting, including financial statements and overhead cost allocations; capital budgeting; financial risk identification; cost-benefit analysis; profit and loss; supply and demand; and net income, cash flow statements, and balance sheets. (U.S. Department of Labor)

Rationale

Civil engineers must hold the welfare of the public paramount and costs play a significant role in this regard. Successful civil engineering projects rely in part on the effective application of the concepts and principles of engineering economics. Developing appropriate knowledge and skills in engineering economics benefit civil engineers and civil engineering projects through improved efficiencies and effectiveness.

Level of Achievement

Engineering economics encompasses concepts and principles used to analyze and evaluate economic and business aspects of civil engineering projects. For entry into professional practice, the practice of civil engineering at the professional level, all civil engineers should be
at the application level and be able to “apply concepts and principles of engineering economics in the practice of civil engineering.”

**Fulfillment of the Outcome**

The engineering economics outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. An understanding of the concepts and principles of engineering economics should be learned at the undergraduate level. The ability to apply the concepts and principles of engineering economics in the practice of civil engineering is expected to be fulfilled through mentored experience.
Risk and Uncertainty

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td>Identify concepts and principles of probability, statistics and risk relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td>Explain concepts and principles of probability, statistics and risk relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td>Apply concepts and principles of probability and statistics and determine risk relevant to civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td>Select appropriate concepts and principles of probability and statistics and analyze risk in complex civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td>Integrate risk analyses into the solutions to complex civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td>Assess the acceptability of the risks associated with solutions to complex civil engineering problems.</td>
<td></td>
</tr>
</tbody>
</table>

**Understanding the Outcome**

Risk may be defined as the most likely consequence of a particular hazard or vulnerability combined with the likelihood or probability of it occurring. Uncertainties are unavoidable in any engineering project and can be data-based (variability and quality of data) or knowledge-based (limited or incomplete information). To address issues related to risk and uncertainty in civil engineering projects, civil engineers need a firm grasp of concepts and principles of probability and statistics. Civil engineers must understand how to incorporate aspects of uncertainty such as vulnerability, fragility, hazards, and consequences of failure in the determination of risk. This is especially true when noting that the health, safety and welfare of the public is of paramount importance to all engineers.

**Rationale**

The fundamentals of probability and statistics, in combination with other mathematics, natural sciences, and engineering topics, are essential for modeling and quantifying risk and uncertainty in civil engineering problems. This includes the identification of major sources of uncertainties, determining their significance, and ultimately assessing probabilities and consequences of failure and risk. The fundamentals of probability and statistics must be applied so that the risk associated with civil engineering projects can be analyzed and, inasmuch as possible, be mitigated to safeguard the health, safety and welfare of the public.
Level of Achievement

The civil engineer must possess the ability to quantify uncertainties and analyze risks that are inherently a part of any complex project or design. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to both “select appropriate concepts and principles of probability and statistics” and “analyze risk in complex civil engineering problems.”

Fulfillment of the Outcome

A basic understanding of probability and statistics and the ability to apply this understanding to determine risk is appropriate as part of the undergraduate education of a civil engineer. However, in recognition that risk and uncertainty can be dependent on the specific type of complex civil engineering problems being solved and a greater depth of technical knowledge is needed, mentored experience is also necessary to fulfill the risk and uncertainty outcome.
Breadth in Civil Engineering Areas

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles related to at least four technical areas appropriate to the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles related to at least four technical areas appropriate to the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> concepts and principles to solve complex problems in at least four technical areas appropriate to the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Analyze</strong> complex problems that cross multiple technical areas appropriate to the practice of civil engineering</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> solutions to complex problems that involve multiple technical areas appropriate to the practice of civil engineering.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> solutions to complex problems that involve multiple technical areas appropriate to the practice of civil engineering.</td>
<td></td>
</tr>
</tbody>
</table>

**Understanding the Outcome**

Civil engineering is an inherently broad field encompassing a wide array of technical areas that contribute to infrastructure, public health, and safety. Most civil engineering problems draw upon ideas, concepts, and principles from across the discipline. Civil engineers must possess technical breadth and strong problem-solving ability in multiple technical areas of the civil engineering discipline. Traditional technical areas appropriate to civil engineering include construction engineering; environmental engineering; geotechnical engineering; structural engineering; surveying, utilities, and site development; transportation engineering; and water resources engineering. Other areas may include engineering disciplines where:

- ASCE has a institute or technical division in the technical area,
- ASCE publishes a journal in the technical area,
- ASCE sponsors a specialty conference in the technical area,
- there are civil engineering consulting firms that specialize in the technical area, or
- emerging areas with well-reasoned justifications.
Rationale

Application of knowledge in at least four technical areas appropriate to civil engineering is necessary to solve complex civil engineering problems. Possessing this breadth enables civil engineers to appreciate and relate to other engineers when working on complex civil engineering projects. Modern civil engineering practice requires the ability to analyze complex problems across more than one area of civil engineering.

Level of Achievement

This outcome requires breadth in at least four technical areas appropriate to civil engineering through the application level and breadth in at least two technical areas appropriate to civil engineering at the analysis level to address problems of a complex nature. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and be able to “analyze complex problems that cross multiple technical areas appropriate to the practice of civil engineering.”

Fulfillment of the Outcome

Breadth in civil engineering areas is obtained through a combination of undergraduate education and mentored experience. The ability to apply concepts and principles in four technical areas of civil engineering is typically achieved through undergraduate education. Civil engineers are expected to gain the ability to analyze complex problems that cross multiple technical areas appropriate to the practice of civil engineering through mentored experience.
# Design

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember</td>
<td><strong>Define</strong> engineering design and the engineering design process.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(remember previously learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 – Comprehend</td>
<td><strong>Explain</strong> engineering design and the engineering design process.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(grasp the meaning of learned material)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 – Apply</td>
<td><strong>Formulate</strong> a set of possible design solutions to complex civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>(use learned material in new and concrete situations)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 – Analyze</td>
<td><strong>Analyze</strong> a set of possible design solutions to complex civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>(break down learned material into its component parts so that its organizational structure may be understood)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 – Synthesize</td>
<td><strong>Develop</strong> the most appropriate sustainable design solution to complex civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>(put learned material together to form a new whole)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate</td>
<td><strong>Assess</strong> the most appropriate sustainable design solution to complex civil engineering problems.</td>
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<tr>
<td>(judge the value of learned material for a given purpose)</td>
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</tbody>
</table>

**Understanding the Outcome**

Design is a decision making process, often iterative, in which basic science, mathematics and engineering science are applied to convert resources optimally to meet a stated need. Such activities as problem definition, specifying requirements, the selection or development of design options, analysis, detailed design, performance prediction, implementation, observation, and testing are all parts of the engineering design process. Design problems are often ill-defined. Thus defining the scope and design objectives and identifying the constraints governing a particular problem are essential to the design process.

**Rationale**

"Science is about knowing; engineering is about doing."(1) Engineers combine science, math, technology, and creativity to create solutions to problems and develop products. In fact, the essence of civil engineering is the iterative process of designing, predicting performance, building, and testing. The design process is open-ended and involves a number of possible correct solutions, including innovative approaches. Thus successful design requires application fundamentals in basic science, math and engineering science, detailed knowledge of the design process, critical thinking, an appreciation of the uncertainties involved, and the use of engineering judgment.
Level of Achievement

Design encompasses fundamental concepts and principles used to solve problems with realistic constraints and standards. For entry into the practice of civil engineering at the professional level all civil engineers should be at the synthesis level. Such considerations as risk assessment, societal and environmental impact, standards, codes, regulations, safety, security, sustainability, constructability, and operability must be integrated at various stages of the design process. A breadth of technical knowledge in several recognized and/or emerging areas of the civil engineering discipline is necessary for understanding the relationship and interaction of different elements in a designed system or environment.

Fulfillment of the Outcome

The National Academy of Engineering recommends that the design process be introduced to students from the “earliest stages of the curriculum, including the first year.” (2) Fostering creative knowledge in students prepares them to handle a future of increasing complexity that relies on a multidisciplinary approach to solving problems. (3) The design component in the baccalaureate curriculum should involve application of the design process under a defined set of standards and constraints. Mentored experience should include opportunities to employ many or all aspects of the design process, including problem definition, project planning, scoping, the design objective, the development of design options, adherence to codes regulations and standards, economy, safety, constructability, operability, and sustainability. Experience at this level should include familiarity with interactions between planning, design, construction and operations and should take into account design life-cycle assessment.


## Technical Depth

<table>
<thead>
<tr>
<th>Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Define</strong> advanced concepts and principles related to a technical area appropriate to the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> advanced concepts and principles related to technical area appropriate to the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> advanced concepts and principles to solve complex problems in a technical area appropriate to the practice of civil engineering.</td>
<td>Post Graduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> appropriate advanced concepts and principles to solve complex problems in a technical area appropriate to the practice of civil engineering.</td>
<td>Post Graduate Education</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> advanced concepts and principles into the solutions of complex problems in a technical area appropriate to the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> advanced concepts and principles in the solutions to complex problems in a technical area appropriate to the practice of civil engineering.</td>
<td></td>
</tr>
</tbody>
</table>

**Understanding the Outcome**

Technical depth is required in the practice of civil engineering and involves the need for a deeper understanding within an area appropriate to the practice of civil engineering to meet the demand for detailed and expanded knowledge. Technical depth requires a deeper understanding of both theory and application in a given area than required for breadth in civil engineering areas. This deeper understanding involves advanced concepts and principles related to a technical area appropriate to the practice of civil engineering.

**Rationale**

The increasing complexity of engineering projects and growing volume of technical knowledge combined with the specialized nature of civil engineering practice requires civil engineers to develop a depth of expertise within a technical area. Technical depth may be reflected in emerging efforts for post-licensure credentialing in some areas of practice. Depth of specialized knowledge is one of the hallmarks of a learned profession such as civil engineering. (Ressler, 2011; Friedson, 2001)
Level of Achievement

Technical depth involves not only a deeper understanding of concepts and principles but also requires a higher level of achievement than expected for breadth in civil engineering areas. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and be able to “integrate advanced concepts and principles into the solutions of complex problems in a technical area appropriate to the practice of civil engineering.”

Fulfillment of the Outcome

Technical depth is obtained through a combination of undergraduate education, post-graduate education, and mentored experience. A substantial portion of this outcome is typically achieved through post-graduate education and culminates in the use of advanced knowledge in practice under mentored experience.


## Sustainability

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td>Identify concepts and principles of sustainability.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td>Explain concepts and principles of sustainability.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td>Apply concepts and principles of sustainability to the solution of civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td>Analyze the sustainable performance of civil engineering systems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td>Develop practices and requirements to achieve sustainable solutions to complex civil engineering problems.</td>
<td></td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td>Assess practices and requirements to achieve sustainable solutions to complex civil engineering problems.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affective Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td>Acknowledge the importance of sustainability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in an activity, attend to a task, and react to motivation)</td>
<td>Comply with the concepts and principles of sustainability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to a particular object, phenomenon, or behavior)</td>
<td>Value the benefits of sustainability in the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)</td>
<td>Integrate a commitment to sustainability principles in everyday practice.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is pervasive, consistent,</td>
<td>Advocate for principles of sustainability.</td>
<td></td>
</tr>
</tbody>
</table>
Understanding the Outcome

Sustainability for civil engineers is defined as “a set of economic, environmental and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality, or the availability of economic, environmental and social resources.” (ASCE Policy 418) The knowledge and skills needed to meet the requirements of sustainability are rooted in the foundational outcomes of natural sciences, social sciences, and the humanities. In order to effectively implement sustainability in civil engineering practice, all of the other outcomes in this Body of Knowledge are required.

Rationale

Civil engineers must be able to address the sustainability of a project during planning and to make environmental, economic, and social impacts understood by all stakeholders. Civil engineers are also responsible for addressing sustainability issues throughout the life-cycle of the project. Sustainability is part of the ASCE Code of Ethics and permeates all professional work of civil engineers.

Simply obtaining knowledge and skills may not guarantee they will be applied in practice. The application of the principles and concepts of sustainability requires a commitment to their importance to the civil engineering profession and society at large. Embracing sustainability in the development of a value system aids in situations where sustainability requires judgement that goes beyond the cognitive ability to monetize costs.

Level of Achievement

Cognitive Domain: Sustainability is critical to the civil engineering profession and civil engineers must be expected to be proficient in the application and analysis of principles of sustainability in all design work they perform. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and have the ability to “analyze the sustainable performance of civil engineering systems.”

Affective Domain: Civil engineers must also be expected to internalize and prioritize sustainability in all designs, decisions, and recommendations. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and have the ability to “integrate a commitment to sustainability principles in everyday practice.”

Fulfillment of the Outcome

Cognitive Domain: In the cognitive domain, the sustainability outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. Just as sustainability permeates the practice of civil engineering, its associated knowledge, skills, and attitudes must permeate the undergraduate experience. Undergraduate education should address the first two levels of the cognitive understanding of sustainability and ensure
graduates have the ability to identify and explain concepts and principles of sustainability. Mentored experience should build on and extend these fundamentals to extend the civil engineer’s ability to apply and analyze the sustainable performance of civil engineering systems.

Affective Domain: In the affective domain, the sustainability outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. While learning knowledge and skills of sustainable development, the undergraduate should develop attitudes that correspond to the first two levels of the affective domain. They should acknowledge the importance of sustainability and comply with its concepts and principles. Through the experience of working on civil engineering projects with mentors, civil engineers learn to value the benefits of sustainability in the practice of civil engineering. Ultimately, each individual civil engineer is responsible for integrating a commitment to sustainability principles in everyday practice through self-development and reflection.
## Communication

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles of effective communications for technical and non-technical audiences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles of effective communications for technical and non-technical audiences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Formulate</strong> effective communications for technical and non-technical audiences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Analyze</strong> effective communications for technical and non-technical audiences.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> different forms of effective communication for technical and non-technical audiences.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> the effectiveness of communication for technical and non-technical audiences.</td>
<td></td>
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<tbody>
<tr>
<td>1 – Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> the importance of effective and persuasive communication to technical and non-technical audiences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in an activity, attend to a task, and react to motivation)</td>
<td><strong>Practice</strong> effective and persuasive communication to technical and non-technical audiences.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to a particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> effective and persuasive communication to technical and non-technical audiences.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)</td>
<td><strong>Display</strong> effective and persuasive communication to technical and non-technical audiences.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is)</td>
<td><strong>Advocate</strong> for effective and persuasive communication to technical and non-technical audiences.</td>
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</tr>
</tbody>
</table>

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*CE BOK 3rd edition DRAFT March 2018 – Communication*
pervasive, consistent, predictable, and a defining characteristic

Understanding the Outcome
Civil engineers should be acquainted with the tools used to communicate their work. Forms of communication include but are not limited to listening, observing, reading, speaking, writing, non-verbal, visual, and graphical. The civil engineer must communicate effectively and persuasively with technical and nontechnical audiences in a variety of settings using formal and informal means.

Effective communication accurately conveys information clearly, correctly, and succinctly. Effective communication includes not only the skills to transmit information, but also to verify that the receiver has correctly understood the information. In a global setting, civil engineers must have sufficient knowledge of other cultures to effectively communicate the intended message.

Persuasive communication shapes, reinforces, or changes the response of the receiver. While all communication can persuade, it is important for civil engineers to know how to communicate in a manner intentionally designed to persuade others. Persuasive communication leads to a noticeable response and action by the receiver, not just an acknowledgement of the information presented. Not all communication by civil engineers is intended to be persuasive. Civil engineers can often communicate with the intent solely to transmit information. But when persuasion is needed, for example when asking for action from a city council, civil engineers must be knowledgeable and adept in the skills of persuasive communication.

Rationale
Proper communication is essential to the success of the civil engineer and his or her work. The focus of this outcome is on developing communication skills that are effective and persuasive. High performing civil engineers are better communicators and enjoy greater career success. Strong communication skills are key attributes associated with high-performing civil engineers who enjoy greater success.

Civil engineers are more effective communicators when they value the need for accurate, succinct, and persuasive communication using appropriate forms. An appreciation of the receiver’s perspective is also essential for the communication to be effective and persuasive. This appreciation is particularly important when communicating with diverse stakeholders and communicating technical issues to non-technical audiences.

Level of Achievement

Cognitive Domain: When civil engineers present information, they integrate multiple forms of effective communication appropriate for the audience, such as listening, observing, speaking, writing, non-verbal, visual, and graphical. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and have the ability to
“integrate different forms of effective communication for technical and non-technical audiences.”

**Affective Domain:** Civil engineers recognize the importance of effective and persuasive communication as part of their value system for professional practice. The importance that the civil engineer attaches to communication should manifest itself in efforts to improve communication through self-development. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and have the ability to “display effective and persuasive communication to technical and nontechnical audiences.”

**Fulfillment of the Outcome**

**Cognitive Domain:** In the cognitive domain, the communications outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. The undergraduate experience provides many and varied opportunities to present and apply communication fundamentals. Communication can be taught and learned across the curriculum—that is, over many years of formal education and in most courses. Given the many and varied communication means, communication fundamentals and application can be woven into mathematics, science, and technical and professional practice courses as well as into humanities and social science courses. Examples include having students create graphics to explain complex systems or processes, write detailed laboratory reports for technical audiences and executive summaries for nontechnical audiences, research a topic and write a documented report, and make team presentations in capstone design courses. Such co- and extracurricular activities as cooperative education and active participation in campus organizations offer opportunities to communicate using various means in a variety of situations. In short, there are a plethora of opportunities for undergraduate civil engineering students to apply their communication skills and reach the application level.

Mentored experience should build on and extend these fundamentals to solidify the civil engineer’s communication skills. Engineering practice provides numerous “real-world” opportunities to analyze and synthesize communication knowledge and skills. The engineer should seek out and be encouraged by mentors to take on tasks and functions that involve ever more challenging communication. Examples of communication opportunities include drafting memoranda or reports for review by a more senior engineer, giving an internal presentation, speaking at local schools, serving on professional society committees, and making presentations at conferences and publishing the results. Mentored experience should play an integral role in helping the civil engineer reach the analysis and synthesis levels.

**Affective domain:** In the affective domain, the communications outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development.

At the undergraduate level, civil engineering students should acknowledge the importance of effective and persuasive communication and actively participate in communication activities. Mentored experience should help the civil engineer to place value on communication skills. Having gained a value for communication skills, through dedicated self-development engineers
should further develop their effective and persuasive communication skills and demonstrate the priority that civil engineers place on these skills.

# Teamwork and Leadership

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> concepts and principles of teamwork and leadership, including diversity and inclusion.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> concepts and principles of teamwork and leadership, including diversity and inclusion.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> concepts and principles of teamwork and leadership in the solutions of civil engineering problems.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Select</strong> concepts and principles of effective teamwork and leadership in the solutions of civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> concepts and principles of effective teamwork and leadership, including diversity and inclusion, into the solutions of civil engineering problems.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> the effectiveness of leaders and teams in the solution of civil engineering problems.</td>
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</tbody>
</table>

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<tbody>
<tr>
<td>1 – Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> the importance of teamwork, leadership, diversity and inclusion.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in an activity, attend to a task, and react to motivation)</td>
<td><strong>Practice</strong> concepts and principles of teamwork, leadership, diversity and inclusion.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to a particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> the need for teamwork, leadership, diversity and inclusion.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)</td>
<td><strong>Display</strong> effective teamwork and leadership, including support of diversity and inclusion.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is pervasive, consistent,</td>
<td><strong>Advocate for</strong> teamwork and leadership, diversity and inclusion.</td>
<td></td>
</tr>
</tbody>
</table>
predictable, and a defining characteristic)

**Understanding the Outcome**

Engineers frequently work in teams, either as team members or leaders. This requires an understanding of team formation and evolution, personality profiles, team dynamics, collaboration among diverse disciplines, problem solving, time management, and being able to foster and integrate diversity and inclusion of perspectives, cultural backgrounds, knowledge, and experience. [1]

In a broad sense leadership is developing and engaging others in a common vision, clearly planning and organizing resources, developing and maintaining trust, sharing perspectives, inspiring creativity, heightening motivation, and being sensitive to competing needs. Leadership is the art, science, and craft of influencing others to accomplish a task and improve the organization. Leaders can be assigned formal roles or can emerge without a formal role or position within a group.

Qualities and attributes of leaders include: vision, enthusiasm, industriousness, initiative, competence, commitment, selflessness, integrity, high ethical standards, adaptability, communication skills, discipline, agility, confidence, courage, curiosity, and persistence. [2] [3] [4]

Being able to function as a member of a team and leading of a team are two distinct, yet complementary, skill sets. A team composed of diverse individuals, e.g. race, ethnicity, gender, engineering discipline, or non-engineer, leads to better creativity and more diligence and hard work in the entire team. [5]

**Rationale**

Roles change with experience, project scope, and circumstances. Therefore, engineers must be able to function effectively on teams, and to understand and fulfill different roles including that of a leader. Engineers must be willing to lead when confronted with professional and/or ethical issues. Although technical competence and broad managerial skills will remain important, success in engineering will be more a result of leadership in applying that competence and those skills, rather than the competence and skills themselves. [6]

More often “employers are calling for graduates who are not merely expert in design and analysis but who possess the leadership skills to apply their technical expertise and to capitalize on emerging construction and information technologies, management models, and organizational structures.”[7] Many also argue that “an engineer is hired for his or her technical skills, fired for poor people skills, and promoted for leadership and management skills.”[8]

The NAE report *The Engineer of 2020: Visions of Engineering in the New Century* states that “engineers must understand the principles of leadership and be able to practice them as their careers advance.” [6] Clearly the acquisition of leadership skills and the art of practicing leadership are vital to the future of civil engineering. By the very nature of a profession that requires the attainment of strong analytical and rational decision-making skills, engineers are particularly well suited to assume leadership roles.
Level of Achievement

Cognitive Domain: Civil engineers must understand and be able to both function as a member of a team and lead. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and have the ability to “integrate concepts and principles of effective teamwork and leadership, including diversity and inclusion, into the solutions of civil engineering problems.”

Affective Domain: Civil engineers must also value, internalize, and prioritize teamwork and leadership in the practice of civil engineering. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and have the ability to “display effective teamwork and leadership, including support of diversity and inclusion.”

Fulfillment of the Outcome

Cognitive Domain: In the cognitive domain, the teamwork and leadership outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. Leadership can be taught and learned. Leadership principles include being technically competent, knowing oneself and seeking self-improvement, making sound and timely decisions, setting the example, seeking responsibility and taking responsibility for one’s actions, communicating with and developing subordinates both as individuals and as a team, and ensuring that the project is understood, supervised, and accomplished. The formal education process has the potential to make a significant impact on teaching leadership principles and developing leadership attributes. [7] Examples of leadership opportunities in the undergraduate program include leadership of design teams, leadership opportunities within capstone or culminating design experiences, and leadership within such organizations as ASCE’s student chapters, student competitions, civic organizations, honor societies, athletic teams, student government, and fraternities and sororities.

Civil engineers must continue to grow as valued team members and leaders through mentored experience. Mentors should encourage engineers to pursue development opportunities to enhance their professional skills, including interpersonal skills and leadership, through work experiences as well as professional development seminars.

Affective Domain: In the affective domain, the teamwork and leadership outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. While learning to identify, explain and apply the concepts and principles of teamwork, the undergraduate should also acknowledge the importance of teamwork, leadership, and diversity and inclusion, and practice these concepts and principles. Through mentored experience civil engineers learn to value the need for teamwork, leadership, and diversity and inclusion, and through self-development and reflection, civil engineers should be able to display behaviors to effectively work in teams and lead.
References


# Lifelong Learning

<table>
<thead>
<tr>
<th>Cognitive Domain Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> the need for additional knowledge, skills, and attitudes to be acquired through self-directed learning.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> the need for additional knowledge, skills and attitudes to be acquired through self-directed learning.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Acquire</strong> new knowledge, skills and attitudes relevant to civil engineering through self-directed learning.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Analyze</strong> new knowledge, skills and attitudes relevant to civil engineering through self-directed learning.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> new knowledge, skills and attitudes relevant to civil engineering through self-directed learning.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Evaluate</strong> the effectiveness of the additional knowledge, skills and attitudes relevant to civil engineering through self-directed learning into civil engineering practice.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Affective Domain Level of Achievement</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1 – Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> the need for lifelong learning.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in an activity, attend to a task, and react to motivation)</td>
<td><strong>Participate</strong> in lifelong learning opportunities.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to a particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> lifelong learning in the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)</td>
<td><strong>Establish</strong> a lifelong learning plan to support one’s own professional development.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is)</td>
<td><strong>Advocate</strong> for lifelong learning in the practice of civil engineering.</td>
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</tr>
</tbody>
</table>
Understanding the Outcome

Lifelong learning is the ability and commitment to acquire knowledge, skills, and attitudes throughout one’s professional career. With respect to the cognitive domain, the levels of achievement focus on the knowledge and skills, whereas the affective domain addresses motivation and attitudes. The affective domain describes the value of and desire to acquire the knowledge, skills and attitudes to support lifelong learning.

Rationale

Given the ever-increasing quantity of technical and non-technical knowledge required of practicing civil engineers, the ability to engage in lifelong learning is essential. Knowledge, skills, and attitudes acquired at any point in time will not be sufficient for successful continued practice of civil engineering at the professional level spanning several decades. This outcome sets a foundation for the integration of and planning for lifelong learning required throughout a career.

Level of Achievement

Cognitive Domain: Lifelong learning is crucial to the civil engineering profession and civil engineers must be expected to be lifelong students with the ability to continuously learn across various topics. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and have the ability to “integrate new knowledge skills, and attitudes relevant to civil engineering through self-directed learning.”

Affective Domain: Civil engineers must also be expected to value and pursue lifelong learning necessary to advance their careers and develop as engineers and professionals to keep up with an ever-changing world. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and “establish a lifelong learning plan to support one’s own professional development.”

Fulfillment of the Outcome

Cognitive Domain: In the cognitive domain, the lifelong learning outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. Independent study projects and open-ended problems requiring additional knowledge that is not presented in a formal class setting are examples of ways to provide opportunities for self-directed learning in an undergraduate program. Civil engineers should engage in lifelong learning through additional formal education; continuing education; professional practice experience; and active involvement in professional societies, community service, coaching, mentoring, and other learning and growth activities.

Affective Domain: In the affective domain, the lifelong learning outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. Through their undergraduate experience, students should acknowledge the
need for lifelong learning and participate in lifelong learning opportunities. Opportunities include membership in ASCE other student organizations, attending professional development seminars, professional goal setting and career mapping activities. Mentors must demonstrate and be role models in valuing the importance of lifelong learning. They should encourage professional development to reinforce the valuing of continuing education and lifelong learning. Having internalized the value of lifelong learning through mentored experience, civil engineers must establish their own lifelong learning plan to support their own self-development and career advancement.
## Professional Attitudes

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<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> knowledge of professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Illustrate</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Mentored Experience</td>
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<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
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<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
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<td>1 – Receive (be aware of, willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in activity, attend to task, react to motivation)</td>
<td><strong>Practice</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
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<td>4 – Organize (sort values into priorities by contrasting different values, resolve conflicts between them, and creating a unique value system)</td>
<td><strong>Establish</strong> professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is pervasive, consistent, predictable, and a defining characteristic)</td>
<td><strong>Advocate</strong> for professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.</td>
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</tbody>
</table>
**Understanding the Outcome**

Attitudes can be described as learned predispositions to respond in a consistently favorable or unfavorable manner. Professional attitudes are the positive and constructive attitudes that a civil engineer should display. Professional attitudes encompass a range of elements including creativity, curiosity, flexibility, and dependability. Although neither specifically listed in the outcome statements nor required for every civil engineer, other professional attitudes that are not addressed elsewhere in this Body of Knowledge may include commitment, confidence, empathy, entrepreneurship, fairness, honesty, integrity, optimism, persistence, and respect.

Creativity is the ability to make new things or form new ideas and is needed to solve complex civil engineering problems that do not have obvious solutions. Curiosity is the urge to know about something and is essential for the civil engineer to gain new knowledge and to be more creative. Flexibility is the ability to change or be changed according to the situation and is critical for civil engineers to work within a diverse group and in an ever changing environment. Dependability is defined as the quality of being able to be counted on or relied upon and is an attitude civil engineers should display.

**Rationale**

Positive professional attitudes create a more effective and pleasant workplace and as Sir Winston Churchill stated “Attitude is a little thing that makes a big difference.” Perceptions of civil engineers may be enhanced by exhibiting positive attitudes, which may also lead to better career opportunities for civil engineers.

ASCE calls for civil engineers to be innovators and integrators of ideas and technology across the public, private, and academic sections. To achieve this vision, civil engineers must be creative, dependable, flexible, and curious about new ideas.

**Level of Achievement**

*Cognitive Domain*: Possessing and displaying the appropriate attitudes are essential to effectively work in the civil engineering profession. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the analysis level and have the ability to “illustrate professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.”

*Affective Domain*: Civil engineers must also be expected to internalize and prioritize the appropriate professional attitudes in practice of civil engineering. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and have the ability to “establish professional attitudes including creativity, curiosity, flexibility, and dependability in the practice of civil engineering.”
**Fulfillment of the Outcome**

*Cognitive Domain:* In the cognitive domain, the professional attitudes outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. The undergraduate experience should plant the seeds of professional attitudes and include education and basic practice in such skills and practices of creativity, curiosity, flexibility, and dependability. Mentored experience should build on and extend these fundamentals to further the civil engineer’s ability to apply and illustrate professional attitudes that enhance the practice of civil engineering.

*Affective Domain:* In the affective domain, the professional attitudes outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. While learning to identify and explain professional attitudes, the undergraduate should also acknowledge the importance of professional attitudes and begin to put them into practice. Through mentored experience civil engineers learn to value the benefits of professional attitudes in the practice of civil engineering. Ultimately, each individual civil engineer is responsible for integrating these professional attitudes in everyday practice through self-development and reflection.

References:

### Professional Responsibilities

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<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Illustrate</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Mentored Experience</td>
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<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Integrate</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Affective Level of Achievement</th>
<th>Demonstrated Ability</th>
<th>Fulfilled Through</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Receive (be aware of, willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in activity, attend to task, react to motivation)</td>
<td><strong>Examine</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolve conflicts between them, and creating a unique value system)</td>
<td><strong>Form judgements</strong> about professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
<td>Self-Developed</td>
</tr>
<tr>
<td>5 – Characterize (follow a value system that controls behavior that is pervasive, consistent, predictable, and a defining characteristic)</td>
<td><strong>Advocate for</strong> professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.</td>
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</tbody>
</table>
Understanding the Outcome

Professional responsibilities encompass a range of elements including safety, legal issues, licensure, credentialing, and innovation. Although neither specifically listed in the outcome statements nor required for every civil engineer, other professional responsibilities that are not addressed elsewhere in this Body of Knowledge may include history and heritage of the profession, cultural perspectives, public policy, and global perspectives.

The primary responsibility of a civil engineer is to ensure public safety, and to keep this goal at the forefront during engineering design. There is also a need to create and operate safe work environments, particularly in terms of construction site issues. There are important policies and regulations in place to help ensure the safety of construction activities (e.g. OSHA).

A civil engineer must be aware of the wide variety of legal and regulatory responsibilities that pertain to the practice of civil engineering, including regulations, standards, codes, contracts, and guidelines relevant to the jurisdiction, which can span federal, state, and local requirements.

It is important that civil engineers understand the process and importance of becoming a professionally licensed engineer (PE) and the responsibilities associated with licensed practice.

Credentials include a variety of licenses and certifications that relate to civil engineering, recognizing various types and levels of professional expertise. Credentialing requires a specialized knowledge and an expectation of additional professional responsibilities.

Innovation is an essential part of engineering as engineers create what has not previously existed. Innovation stems from creative thinking. Creative thinking includes the capacity to combine or synthesize existing ideas and expertise in original ways. Those who are innovative and creative often employ divergent thinking, and are willing to take risks.

Rationale

Each problem that a civil engineer faces is unique, due to a combination of technical, safety, historical, environmental, political, and cultural issues. In addition to technical competence, civil engineers are expected to understand and consider a plethora of design, construction and operational constraints which fall under the umbrella of professional responsibility. Civil engineers are expected to have the ability to recognize and discharge their professional responsibilities in engineering situations and make informed judgements, considering the impact of engineering solutions in a global, economic, environmental, societal, and historical context. Determining appropriate solutions to complex problems requires innovation, adherence to standards, and consideration of many non-technical factors.

Level of Achievement

Cognitive Domain: Civil engineers must understand and be able to integrate various professional issues and responsibilities into the practice of civil engineering. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and have the ability to "integrate professional responsibilities relevant to the
practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.”

**Affective Domain**: Civil engineers must also value, internalize, and prioritize the various professional responsibilities in practice of civil engineering. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the organize level and have the ability to “form judgements about professional responsibilities relevant to the practice of civil engineering, including safety, legal issues, licensure, credentialing, and innovation.”

**Fulfillment of the Outcome**

**Cognitive Domain**: In the cognitive domain, the professional responsibilities outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. The undergraduate experience should include education on safety, legal issues, licensure, credentialing, and innovation, and may include such topics as history and heritage of the profession, cultural perspectives, public policy, and global perspectives. This is usually accomplished through professional development seminars during a capstone or culminating design experience, through other in-course exercises and discussions. Civil engineers face many of these issues and responsibilities in practice and further development to include the application, illustration, and integration of professional responsibilities in practice occurs through mentored experience.

**Affective Domain**: In the affective domain, the professional responsibilities outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. While learning to identify and explain the professional responsibilities of a civil engineer, the undergraduate should also acknowledge the importance of professional responsibilities in the practice of civil engineering and examine these responsibilities as they pertain to civil engineering. Through mentored experience civil engineers learn to value these professional responsibilities and through self-development and reflection, civil engineers should be able to resolve conflicts among them and form judgments about them.
Ethical Responsibilities

<table>
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<tbody>
<tr>
<td>1 – Remember (remember previously learned material)</td>
<td><strong>Identify</strong> the ethical responsibilities of a civil engineer in accordance with the ASCE Code of Ethics and statutory requirements.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Comprehend (grasp the meaning of learned material)</td>
<td><strong>Explain</strong> the ethical responsibilities of a civil engineer in accordance with the ASCE Code of Ethics and statutory requirements.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Apply (use learned material in new and concrete situations)</td>
<td><strong>Apply</strong> appropriate ethical requirements to a situation involving conflicting ethical interests.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Analyze (break down learned material into its component parts so that its organizational structure may be understood)</td>
<td><strong>Analyze</strong> ethical dilemmas involving conflicting ethical interests to determine possible courses of action.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>5 – Synthesize (put learned material together to form a new whole)</td>
<td><strong>Develop</strong> courses of action to ethical dilemmas in complex situations involving multiple conflicting interests.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>6 – Evaluate (judge the value of learned material for a given purpose)</td>
<td><strong>Assess</strong> ethical dilemmas in a complex situation involving multiple conflicting interests.</td>
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<tr>
<td>1 – Receive (be aware of, be willing to receive, and be attentive to a particular phenomenon or behavior)</td>
<td><strong>Acknowledge</strong> the importance of ethical behavior in the practice of civil engineering.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>2 – Respond (actively participate in an activity, attend to a task, and react to motivation)</td>
<td><strong>Comply</strong> with the ASCE Code of Ethics and statutory requirements.</td>
<td>Undergraduate Education</td>
</tr>
<tr>
<td>3 – Value (attach value to a particular object, phenomenon, or behavior)</td>
<td><strong>Value</strong> ethical behavior in the practice of civil engineering.</td>
<td>Mentored Experience</td>
</tr>
<tr>
<td>4 – Organize (sort values into priorities by contrasting different values, resolving conflicts between them, and creating a unique value system)</td>
<td><strong>Adhere to</strong> ethical behavior in accordance with the ASCE Code of Ethics and statutory requirements.</td>
<td>Mentored Experience</td>
</tr>
</tbody>
</table>
5 – Characterize (follow a value system that controls behavior that is pervasive, consistent, predictable, and a defining characteristic)

| **Advocate for** ethical behavior in the practice of civil engineering. | Self-Development |

**Understanding the Outcome**

Civil engineers in professional practice have a privileged position in society and have a responsibility to hold paramount the health, safety, and welfare of the public. They must exhibit high levels of honesty, integrity, and fairness, and must continually guard against conflicts of interest, either real or perceived. Ethical practice is the means to gain and maintain the public trust.

Civil engineers are subject to the ASCE Code of Ethics. They are sometimes also subject to other ethical guidelines, such as the NSPE Code of Ethics, state jurisdictional standards of conduct, and clients’ or employers’ codes of ethics that may differ from the ASCE Code of Ethics. Students may also be subject to codes of ethics at universities and colleges.

With respect to the cognitive domain, the levels of achievement focus on the knowledge and skills, whereas the affective domain addresses motivation and attitudes. The affective domain describes the value of and desire to acquire the knowledge, skills, and attitudes to support ethical responsibilities and behavior.

**Rationale**

Civil engineers are expected to uphold and advance the integrity, honor, and dignity of the engineering profession by practicing in compliance with the ASCE Code of Ethics and other applicable codes. Civil engineers are expected to have the ability to recognize ethical responsibilities in engineering situations and make informed judgements, considering the impact of engineering solutions in a global, economic, environmental and societal context. To advocate for ethical behavior within the profession, civil engineers must internalize the value of ethical behavior.

**Level of Achievement**

*Cognitive Domain:* Ethical responsibilities are essential in the practice of civil engineering and civil engineers must be able to appropriately address ethical issues. For entry into the practice of civil engineering at the professional level, all civil engineers should be at the synthesis level and have the ability to “develop courses of action to ethical dilemmas in complex situations involving multiple conflicting interests.”

*Affective Domain:* Civil engineers must also value, internalize, and display ethical behavior, and be expected to internalize and prioritize the appropriate professional attitudes in the practice of civil engineering. For entry into the practice of civil engineering at the professional level, all
civil engineers should be at the characterize level and have the ability to “advocate for ethical behavior in the practice of civil engineering.”

**Fulfillment of the Outcome**

*Cognitive Domain*: In the cognitive domain, the ethical responsibilities outcome is expected to be fulfilled through a combination of undergraduate education and mentored experience. The undergraduate experience should include an introduction to ethical practices, the ASCE Code of Ethics, and the importance of statutory requirements. This is usually accomplished through professional development seminars during a capstone or culminating design experience, through other in-course exercises and discussions, or even sometimes through entire courses on engineering ethics. When faced with ethical dilemmas in practice, civil engineers should reach out for guidance from senior engineers. Mentored experience should build on the undergraduate education and experiences to further the civil engineer’s ability to apply appropriate ethical requirements and analyze ethical dilemmas to develop courses of action to address ethical dilemmas in complex situations.

*Affective Domain*: In the affective domain, the ethical responsibilities outcome is expected to be fulfilled through a combination of undergraduate education, mentored experience, and self-development. While learning to identify and explain the ethical responsibilities of a civil engineer, the undergraduate should also acknowledge the importance of ethical behavior in the practice of civil engineering and comply with the ASCE Code of Ethics. Through mentored experience civil engineers learn to value ethical behavior and adhere to ethical standards. Advocating for ethical behavior in the practice of civil engineering essentially comes from self-development and an internalization of the requirements and benefits of ethical behavior.