PROJECT LEAD THE WAY
PLTW

# College-Level Recognition

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# Major Concepts and ABET, Inc.

## Major Concepts

Concepts are the principles, theories, and recurring themes important to a student's understanding of a course of study. Teachers use concepts to help students understand the "why" that supports what they are learning. In Project Lead The Way® curricula, each course, each unit and lesson have a listing of concepts that are directly related to the major topics of that unit or lesson. The following listing of concepts is consistent across all Project Lead The Way® curricula.

1. Individuals who accept the responsibility of continuous self-evaluation will benefit from personal growth, professional development and increased employability.
2. Individual contributions to group processes facilitate the solving of complex problems and the achievement of common goals.
3. Mathematics is the body of knowledge used to describe the scientific principles that happen naturally in the world, and technology is the application of these principles to produce products and services to benefit society.
4. Skillful researchers are proficient with the technologies and strategies used to gather, organize, document, and disseminate information.
5. The use of the design process to analyze and solve problems has greatly improved the quality of, and the speed at which, new products are created.
6. Project success is dependent on problem identification, planning, and the allocation of resources.
7. Consideration of the ethical, environmental, social, and economic impacts of the engineering design process is essential to being a responsible, involved citizen.
8. Critical thinking involves using a variety of established and original problem-solving techniques.
9. In order to solve complex problems, the use of systems which monitor and correct performance must be developed.
10. Understanding contemporary issues aids in determining the solutions to complex problems.

## ABET, Inc.

In addition, all Project Lead The Way® curricula are designed to align with the ABET, Inc. (formerly known as the Accreditation Board for Engineering and Technology Standards). ABET, Inc., is the recognized U.S. accreditor of college and university programs in applied science, computing, engineering, and technology. A listing of the Criterion 3: Program Outcomes and Assessment are used as guides through out the development of PLTW curricula.

Engineering programs must demonstrate that their students have attainment of ABET, Inc. requirements at the basic educational level for entry into engineering practice

a. an ability to apply knowledge of mathematics, science, and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. an ability to function on multi-disciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

# College-Level Recognition

# PTE

PROJECT LEAD THE WAY

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# IED

# IED Course Description

Introduction to Engineering Design™ (IED) is a high school level course that is appropriate for 9th or 10th grade students who are interested in design and engineering. The major focus of the IED course is to expose students to design process, research and analysis, teamwork, communication methods, global and human impacts, engineering standards, and technical documentation. IED gives students the opportunity to develop skills and understanding of course concepts through activity-, project-, and problem-based (APPB) learning. Used in combination with a teaming approach, APPB-learning challenges students to continually hone their interpersonal skills, creative abilities and understanding of the design process. It also allows students to develop strategies to enable and direct their own learning, which is the ultimate goal of education.

The course assumes no previous knowledge, but students should be concurrently enrolled in college preparatory mathematics and science. Students will employ engineering and scientific concepts in the solution of engineering design problems. In addition, students use a state of the 3D solid modeling design software package to help them design solutions to solve proposed problems. Students will develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges that increase in difficulty throughout the course. Students will also learn how to document their work, and communicate their solutions to their peers and members of the professional community.

Introduction to Engineering Design™ is one of three foundation courses in the Project Lead The Way® high school pre-engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Design Process
- Modeling
- Sketching
- Measurement, Statistics, and Applied Geometry
- Presentation Design and Delivery
- Engineering Drawing Standards
- CAD Solid Modeling
- Reverse Engineering
- Consumer Product Design Innovation
- Marketing
- Graphic Design
- Engineering Ethics

- Virtual Design Teams

# Introduction to Engineering Design Detailed Outline

## Unit 1: Design Process
## Time Days: 49 days

**Lesson 1.1: Introduction to a Design Process (11 days):**

**Concepts Addressed in Lesson:**

1. There are many design processes that guide professionals in developing solutions to problems.
2. A design process most used by engineers includes defining a problem, brainstorming, researching, identifying requirements, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing, refining, making, and communicating results.
3. Design teams use brainstorming techniques to generate large numbers of ideas in short time periods.
4. Engineers conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
5. A designer uses an engineer's notebook to chronologically document all aspects of a design project.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Apply engineering notebook standards and protocols when documenting their work during the school year.
- Identify and apply group brainstorming techniques and the rules associated with brainstorming.
- Research a product's history, develop a PowerPoint presentation, list chronologically the major innovations to a product, and present findings to a group.
- Use online and published works to research aspects of design problems.
- Identify the design process steps used in given scenarios and be able to list the steps, if any are missing.

**Lesson 1.2: Introduction to Technical Sketching and Drawing (11 days):**

**Concepts Addressed in Lesson:**

1. Engineers create sketches to quickly record, communicate, and investigate ideas.
2. Pictorials and tonal shading techniques are used in combination to give sketched objects a realistic look.
3. Designers use isometric, oblique, perspective, and multiview sketching to maintain an object's visual proportions.
4. A multiview projection is the most common method of communicating the shape and size of an object that is intended for manufacture.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify, sketch, and explain the function of points, construction lines, object lines, and hidden lines.
- Plot points on grid paper to aid in the creation of sketches and drawings.
- Explain the concepts of technical sketching and drawing.
- Sketch an isometric view of simple geometric solids.
- Explain how an oblique view of simple geometric solids differs from an isometric view.
- Sketch one-point, two-point, and three-point perspectives of simple geometric solids.
- Describe the concept of proportion as it relates to freehand sketching.
- Sketch multiview drawings of simple geometric solids.
- Determine the front view for a given object.

**Lesson 1.3: Measurement and Statistics (10 days):**

**Concepts Addressed in Lesson:**

1. Measurement systems were developed out of the need for standardization.
2. Engineers apply dimensions to drawings to communicate size information.
3. Manufactured parts are often created in different countries, where dimensional values are often converted from one standard unit to another.
4. The amount of variation that can be measured depends on the precision of the measuring tool.
5. Statistical analysis of measurements can help to verify the quality of a design or process.
6. Engineers use graphics to communicate patterns in recorded data.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Research and design a CD cover or book jacket on the origins of the measurement systems.
- Measure and record linear distances using a scale to a precision of 1/16 inch and 1 mm.
- Measure and record linear distances using a dial caliper to a precision of 0.001 inch.
- Add and subtract U.S. standard and metric linear measurements.
- Convert linear distance measurements from inches to millimeters and vice versa.
- Apply linear dimensions to a multiview drawing.
- Calculate the mean, mode, median, and range of a data set.
- Create a histogram of recorded measurements showing data elements or class intervals, and frequency.

**Lesson 1.4: Puzzle Cube (17 days):**

**Concepts Addressed in Lesson:**

1. Three-dimensional forms are derived from two-dimensional shapes.
2. The results of the design process are commonly displayed as a physical model.
3. Engineers develop models to communicate and evaluate possible solutions.
4. Geometric and numeric constraints are used to define the shape and size of objects in Computer Aided Design (CAD) modeling systems.
5. Engineers use CAD modeling systems to quickly generate and annotate working drawings.
6. Packaging not only protects a product, but contributes to that product's commercial success.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Brainstorm and sketch possible solutions to an existing design problem.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create simple extruded solid Computer Aided Design (CAD) models from dimensioned sketches.
- Generate dimensioned multiview drawings from simple CAD models.
- Measure and Fabricate parts for a functional prototype from the CAD multiview drawings.
- Assemble the product using the CAD modeling software.
- Test and evaluate the prototype and record results.
- Apply geometric and numeric constraints to CAD sketches.
- Identify the purpose of packaging in the design of consumer products.

# Unit 2: Design Exercises
# Time Days: 50 days

### Lesson 2.1: Geometric Shapes and Solids (10 days):

**Concepts Addressed in Lesson:**

1. Geometric shapes describe the two or three dimensional contours that characterize an object.
2. The properties of volume and surface area are common to all designed objects and provide useful information to the engineer.
3. CAD systems are used to increase productivity and reduce design costs.
4. Solid CAD models are the result of both additive and subtractive processes.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify common geometric shapes and forms by name.
- Calculate the area of simple geometric shapes.
- Calculate the surface area and volume of simple geometric forms.
- Identify and explain the various geometric relationships that exist between the elements of two-dimensional shapes and three-dimensional forms.
- Identify and define the axes, planes, and sign conventions associated with the Cartesian coordinate system.
- Apply geometric and numeric constraints to CAD sketches.
- Utilize sketch-based, work reference, and placed features to develop solid CAD models from dimensioned drawings.
- Explain how a given object's geometry is the result of sequential additive and subtractive processes.

### Lesson 2.2: Dimensions and Tolerances (9 days):

**Concepts Addressed in Lesson:**

1. Working drawings should contain only the dimensions that are necessary to build and inspect an object.
2. Object features require specialized dimensions and symbols to communicate technical information, such as size.
3. There is always a degree of variation between the actual manufactured object and its dimensioned drawing.
4. Engineers specify tolerances to indicate the amount of dimensional variation that may occur without adversely affecting an object's function.
5. Tolerances for mating part features are determined by the type of fit.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Explain the differences between size and location dimensions.
- Differentiate between datum dimensioning and chain dimensioning.
- Identify and dimension fillets, rounds, diameters, chamfers, holes, slots, and screw threads in orthographic projection drawings.
- Explain the rules that are associated with the application of dimensions to multiview drawings.
- Identify, sketch, and explain the difference between general tolerances, limit dimensions, unilateral, and bilateral tolerances.
- Differentiate between clearance and interference fits.

**Lesson 2.3: Advanced Modeling Skills (19 days):**

**Concepts Addressed in Lesson:**

1. Solid modeling programs allow the designer to create quality designs for production in far less time than traditional design methods.
2. Engineers use CAD models, assemblies, and animations to check for design problems, verify the functional qualities of a design, and communicate information to other professionals and clients.
3. Auxiliary views allow the engineer to communicate information about an object's inclined surfaces that appear foreshortened in basic multiview drawings.
4. Designers use sectional views to communicate an object's interior features that may be difficult to visualize from the outside.
5. As individual objects are assembled together, their degrees of freedom are systematically removed.
6. Engineers create mathematical formulas to establish geometric and functional relationships within their designs.
7. A title block provides the engineer and manufacturer with important information about an object and its creator.
8. A parts list and balloons are used to identify individual components in an assembly drawing.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Sketch and model an auxiliary view of a given object to communicate the true size and shape of its inclined surface.
- Describe the purpose and demonstrate the application of section lines and cutting plane lines in a section view drawing.
- Sketch a full and half section view of a given object to communicate its interior features.

- Identify algebraic relationships between the dimensional values of a given object.
- Apply assembly constraints to individual CAD models to create mechanical systems.
- Perform part manipulation during the creation of an assembly model.
- Explain how assembly constraints are used to systematically remove the degrees of freedom for a set of components in a given assembly.
- Create an exploded model of a given assembly.
- Determine ratios and apply algebraic formulas to animate multiple parts within an assembly model.
- Create and describe the purpose of the following items: exploded isometric assembly view, balloons, and parts list.

**Lesson 2.4: Advanced Designs (12 days):**

**Concepts Addressed in Lesson:**

1. Design solutions can be created as an individual or in teams.
2. Engineers use design briefs to explain the problem, identify solution expectations, and establish project constraints.
3. Teamwork requires constant communication to achieve the goal at hand.
4. Engineers conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.
5. Engineers use a design process to create solutions to existing problems.
6. Engineers use CAD modeling systems to quickly generate and annotate working drawings.
7. Fluid Power Concepts could be used to enhance design solutions.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision making matrix.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create solid computer-aided design (CAD) models of each part from dimensioned sketches using a variety of methods.
- Apply geometric numeric and parametric constraints to form CAD modeled parts.
- Generate dimensioned multiview drawings from simple CAD modeled parts.
- Assemble the product using the CAD modeling software.
- Explain what constraints are and why they are included in a design brief.

- Create a three-fold brochure marketing the designed solution for the chosen problem, such as a consumer product, a dispensing system, a new form of control system, or extend a product design to meet a new requirement.
- Explain the concept of fluid power, and the difference between hydraulic and pneumatic power systems.

# Unit 3: Reverse Engineering
# Time Days: 43 days

**Lesson 3.1: Visual Analysis (8 Days):**

**Concepts Addressed in Lesson:**

1. Visual design principles and elements constitute an aesthetic vocabulary that is used to describe any object independent of its formal title, structural, and functional qualities.
2. Tangible design elements are manipulated according to conceptual design principles.
3. Aesthetic appeal results from the interplay between design principles and elements.
4. Though distinctly different, a design's visual characteristics are influenced by its structural and functional requirements.
5. Visual appeal influences a design's commercial success.
6. Graphic designers are concerned with developing visual messages that make people in a target audience respond in a predictable and favorable manner.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify visual design elements within a given object.
- Explain how visual design principles were used to manipulate design elements within a given object.
- Explain what aesthetics is, and how it contributes to a design's commercial success.
- Identify the purpose of packaging in the design of consumer products.
- Identify visual design principles and elements that are present within marketing ads.
- Identify the intent of a given marketing ad and demographics of the target consumer group for which it was intended.

**Lesson 3.2: Functional Analysis (4 Days):**

**Concepts Addressed in Lesson:**

1. Mechanisms use simple machines to move loads through the input of applied effort forces.
2. Engineers perform reverse engineering on products to study their visual, functional, and structural qualities.
3. Through observation and analysis, a product's function can be divided into a sequence of operations.
4. Products operate as systems, with identifiable inputs and outputs.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the reasons why engineers perform reverse engineering on products.
- Describe the function of a given manufactured object as a sequence of operations through visual analysis and inspection (prior to dissection).

**Lesson 3.3: Structural Analysis (15 Days):**

**Concepts Addressed in Lesson:**

1. Objects are held together by means of joinery, fasteners, or adhesives.
2. Precision measurement tools and techniques are used to accurately record an object's geometry.
3. Operational conditions, material properties, and manufacturing methods help engineers determine the material makeup of a design.
4. Engineers use reference sources and computer-aided design (CAD) systems to calculate the mass properties of designed objects.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Describe the differences between joinery, fasteners, and adhesives.
- Identify the types of structural connections that exist in a given object.
- Use dial calipers to precisely measure outside and inside diameter, hole depth, and object thickness.
- Identify a given object's material type.
- Identify material processing methods that are used to manufacture the components of a given commercial product.
- Assign a density value to a material, and apply it to a given solid CAD model.
- Perform computer analysis to determine mass, volume, and surface area of a given object.

### Lesson 3.4: Product Improvement By Design (16 Days):

**Concepts Addressed in Lesson:**

1. Engineers analyze designs to identify shortcomings and opportunities for innovation.
2. Design teams use brainstorming techniques to generate large numbers of ideas in short time periods.
3. Engineers use decision matrices to help make design decisions that are based on analysis and logic.
4. Engineers spend a great deal of time writing technical reports to explain project information to various audiences.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Write design briefs that focus on product innovation.
- Identify group brainstorming techniques and the rules associated with brainstorming.
- Use decision matrices to make design decisions.
- Explain the difference between invention and innovation.

## Unit 4: Open-Ended Design Problems
## Time: 33 Days

### Lesson 4.1: Engineering Design Ethics (8 Days):

**Concepts Addressed in Lesson:**

1. The material of a product, how the material is prepared for use, its durability, and ease of recycling all impact a product's design, marketability, and life expectancy.
2. All products made, regardless of material type, may have both positive and negative impacts.
3. In addition to economics and resources, manufacturers must consider human and global impacts of various manufacturing process options.
4. Laws and guidelines have been established to protect humans and the global environment.
5. A conscious effort by product designers and engineers to investigate the recyclable uses of materials will play a vital role in the future of landfills and the environment.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create a brainstorming list of different products made from common materials that are used daily.
- Research and construct a product impact timeline presentation of a product from the brainstorming list and present how the product may be recycled and used to make other products after its lifecycle is complete.
- Identify the five steps of a product's lifecycle and investigate and propose recyclable uses for the material once the lifecycle of the product is complete.

**Lesson 4.2: Design Teams (25 Days):**

**Concepts Addressed in Lesson:**

1. Teams of people can accomplish more than one individual working alone.
2. Design teams establish group norms through brainstorming and consensus to regulate proper and acceptable behavior by and between team members.
3. Engineers develop Gantt charts to plan, manage, and control a design team's actions on projects that have definite beginning and end dates.
4. Virtual teams rely on communications other than face-to-face contact to work effectively to solve problems.
5. Each team member's strengths are a support mechanism for the other team members' weaknesses.
6. Conflict between team members is a normal occurrence, and can be addressed using formal conflict resolution strategies.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Explain why teams of people are used to solve problems.
- Identify group norms that allow a virtual design team to function efficiently.
- Establish file management and file revision protocols to ensure the integrity of current information.
- Use internet resources, such as email, to communicate with a virtual design team member throughout a design challenge.
- Identify strategies for addressing and solving conflicts that occur between team members.
- Create a Gantt chart to manage the various phases of their design challenge.

# IED National Science Education Standards Grades 9-12 Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • Systems, order, and organization | √ | √ | √ | √ |
| • Evidence, models, and explanation | √ | √ | √ | √ |
| • Change, constancy, and measurement | √ | √ | √ | √ |
| • Evolution and equilibrium | | | √ | |
| • Form and function | √ | √ | √ | √ |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities necessary to do scientific inquiry | √ | √ | √ | √ |
| • Understandings about scientific inquiry | **x** | √ | √ | √ |
| ***NSES* Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Structure of atoms | | | | |
| • Structure and properties of matter | | | | |
| • Chemical reactions | | | | |
| • Motions and forces | | | | |
| • Conservation of energy and increase in disorder | | | | |
| • Interactions of energy and matter | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • The cell | | | | |
| • Molecular basis of heredity | | | | |
| • Biological evolution | | | | |
| • Interdependence of organisms | | | | |
| • Matter, energy, and organization in living systems | | | | |
| • Behavior of organisms | | | | |
| ***NSES* Content Standard D: Earth and Space Science** As a result of | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Energy in the earth system | | | | |
| • Geochemical cycles | | | | |
| • Origin and evolution of the earth system | | | | |
| • Origin and evolution of the universe | | | | |
| ***NSES* Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities of technological design | √ | √ | √ | √ |
| • Understandings about science and technology | √ | √ | √ | √ |
| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Personal and community health | | | | |
| • Population growth | | | | |
| • Natural resources | | | | √ |
| • Environmental quality | | | | √ |
| • Natural and human-induced hazards | | | | √ |
| • Science and technology in local, national, and global challenges | ● | | | √ |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Science as a human endeavor | **x** | | | **x** |
| • Nature of scientific knowledge | | | | |
| • Historical perspectives | **x** | | | |

**Table 1.** Comparison of *National Science Education Standards* (*NSES*) and PLTW – Introduction to Engineering Design™.

Source: National Research Council (NRC) *National Science Education Standards*.

# IED Standards for Technological Literacy Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | |
| **K-2** | **A.** The natural world and human-made world are different. | | | | |
| | **B.** All people use tools and techniques to help them do things. | | | | |
| **3-5** | **C.** Things that are found in nature differ from things that are human-made in how they are produced and used. | | | | |
| | **D.** Tools, materials, and skills are used to make things and carry out tasks. | | | | |
| | **E.** Creative thinking and economic and cultural influences shape technological development. | | | | |
| **6-8** | **F.** New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. | √ | √ | √ | √ |
| | **G.** The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative. | ● | **x** | √ | √ |
| | **H.** Technology is closely linked to creativity, which has resulted in innovation. | **x** | **x** | √ | √ |
| | **I.** Corporations can often create demand for a product by bringing it onto the market and advertising it. | **x** | | ● | √ |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | | | | |
| | **K.** The rate of technological development and diffusion is increasing rapidly. | | | | √ |
| | **L.** Inventions and innovations are the results of specific, goal-directed research. | **x** | **x** | | √ |
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | ● | | ● | √ |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|---|
| of technology. | | | | | |
| **K-2** | **A.** Some systems are found in nature, and some are made by humans. | | | | |
| | **B.** Systems have parts or components that work together to accomplish a goal. | | | | |
| | **C.** Tools are simple objects that help humans complete tasks. | | | | |
| | **D.** Different materials are used in making things. | | | | |
| | **E.** People plan in order to get things done. | | | | |
| **3-5** | **F.** A subsystem is a system that operates as a part of another system. | | | | |
| | **G.** When parts of a system are missing, it may not work as planned. | | | | |
| | **H.** Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. | | | | |
| | **I.** Tools are used to design, make, use, and assess technology. | | | | |
| | **J.** Materials have many different properties. | | | | |
| | **K.** Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing. | | | | |
| | **L.** Requirements are the limits to designing or making a product or system. | | | | |
| **6-8** | **M.** Technological systems include input, processes, output, and, at times, feedback. | | | √ | |
| | **N.** Systems thinking involves considering how every part relates to others. | | **x** | ● | √ |
| | **O.** An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. | | | √ | |
| | **P.** Technological systems can be connected to one another. | | | | |
| | **Q.** Malfunctions of any part of a system may affect the function and quality of the system. | | | **x** | √ |
| | **R.** Requirements are the parameters placed on the development of a product or system. | ● | | | √ |
| | **S.** Trade-off is a decision process recognizing the need for careful compromises among competing factors. | | ● | | √ |
| | **T.** Different technologies involve different sets of processes. | | | | |
| | **U.** Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability. | | | | |
| | **V.** Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. | | | ● | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | | | | √ |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | | | | |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | | ● | | ● |
| | **Z.** Selecting resources involves trade-offs between competing values, | | | | √ |

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| | such as availability, cost, desirability, and waste. | | | | |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | **x** | √ | √ | √ |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | | | | |
| | **CC.** New technologies create new processes. | | | ● | ● |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | | | |
| | **EE.** Management is the process of planning, organizing, and controlling work. | | | | √ |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | | | | |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | |
| **K-2** | **A.** The study of technology uses many of the same ideas and skills as other subjects. | | | | |
| **3-5** | **B.** Technologies are often combined. | | | | |
| | **C.** Various relationships exist between technology and other fields of study. | | | | |
| **6-8** | **D.** Technological systems often interact with one another. | | | | |
| | **E.** A product, system, or environment developed for one setting may be applied to another setting. | | | | |
| | **F.** Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. | √ | √ | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | | ● | √ | ● |
| | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | **x** | **x** | | **x** |
| | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | | | | |
| | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | √ | √ | | |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | |
| **K-2** | **A.** The use of tools and machines can be helpful or harmful. | | | | |
| **3-5** | **B.** When using technology, results can be good or bad. | | | | |
| | **C.** The use of technology can have unintended consequences. | | | | |
| **6-8** | **D.** The use of technology affects humans in various ways, including their | | | √ | |

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| | | safety, comfort, choices, and attitudes about technology's development and use. | | | | |
| | **E.** | Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. | | | | |
| | **F.** | The development and use of technology poses ethical issues. | | | | |
| | **G.** | Economic, political, and cultural issues are influenced by the development and use of technology. | | | | |
| **9-12** | **H.** | Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | | | | √ |
| | **I.** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | | ● | √ | √ |
| | **J.** | Ethical considerations are important in the development, selection, and use of technologies. | | | ● | √ |
| | **K.** | The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | | | | √ |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | |
| **K-2** | **A.** | Some materials can be reused and/or recycled. | | | | |
| **3-5** | **B.** | Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment. | | | | |
| | **C.** | The use of technology affects the environment in good and bad ways. | | | | |
| **6-8** | **D.** | The management of waste produced by technological systems is an important societal issue. | | | | |
| | **E.** | Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. | | | | |
| | **F.** | Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. | | | | |
| **9-12** | **G.** | Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | | | |
| | **H.** | When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | | √ | √ |
| | **I.** | With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | | | √ |
| | **J.** | The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | ● | | | √ |
| | **K.** | Humans devise technologies to reduce the negative consequences of other technologies. | | | | √ |

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| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | | | √ |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | |
| **K-2** | **A.** Products are made to meet individual needs and wants. | | | | |
| **3-5** | **B.** Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes. | | | | |
| | **C.** Individual, family, community, and economic concerns may expand or limit the development of technologies. | | | | |
| **6-8** | **D.** Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. | | | | |
| | **E.** The use of inventions and innovations has led to changes in society and the creation of new needs and wants. | | √ | | √ |
| | **F.** Social and cultural priorities and values are reflected in technological devices. | | | | |
| | **G.** Meeting societal expectations is the driving force behind the acceptance and use of products and systems. | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. | | | | |
| | **I.** The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | | √ | |
| | **J.** A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | | √ | √ |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | |
| **K-2** | **A.** The way people live and work has changed throughout history because of technology. | | | | |
| **3-5** | **B.** People have made tools to provide food, to make clothing, and to protect themselves. | | | | |
| **6-8** | **C.** Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements. | | | | |
| | **D.** The specialization of function has been at the heart of many technological improvements. | | | | |
| | **E.** The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships. | √ | | | |
| | **F.** In the past, an invention or innovation was not usually developed with the knowledge of science. | | | √ | |
| **9-12** | **G.** Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | | | √ | |
| | **H.** The evolution of civilization has been directly affected by, and has in | | | | |

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| | turn affected, the development and use of tools and materials. | | | | |
| | **I.** Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | | | | |
| | **J.** Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | | | | |
| | **K.** The Iron Age was defined by the use of iron and steel as the primary materials for tools. | | | | |
| | **L.** The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | | | |
| | **M.** The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | | | |
| | **N.** The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | | | |
| | **O.** The Information Age places emphasis on the processing and exchange of information. | | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | |
| **K-2** | **A.** Everyone can design solutions to a problem. | | | | |
| | **B.** Design is a creative process. | | | | |
| **3-5** | **C.** The design process is a purposeful method of planning practical solutions to problems. | | | | |
| | **D.** Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. | | | | |
| **6-8** | **E.** Design is a creative planning process that leads to useful products and systems. | **X** | **x** | √ | √ |
| | **F.** There is no perfect design. | | | √ | |
| | **G.** Requirements for a design are made up of criteria and constraints | √ | √ | √ | √ |
| **9-12** | **H.** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | √ | √ | √ | √ |
| | **I.** Design problems are seldom presented in a clearly defined form. | | | √ | |
| | **J.** The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | **X** | √ | √ | √ |
| | **K.** Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | **X** | **x** | √ | √ |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | |

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|---|---|---|---|---|---|
| **K-2** | **A.** The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. | | | | |
| | **B.** Expressing ideas to others verbally and through sketches and models is an important part of the design process | | | | |
| **3-5** | **C.** The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results. | | | | |
| | **D.** When designing an object, it is important to be creative and consider all ideas. | | | | |
| | **E.** Models are used to communicate and test design ideas and processes. | | | | |
| **6-8** | **F.** Design involves a set of steps, which can be performed in different sequences and repeated as needed. | √ | √ | √ | √ |
| | **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. | √ | √ | √ | √ |
| | **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. | | √ | √ | |
| **9-12** | **I.** Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | | | √ | √ |
| | **J.** Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | √ | √ | √ | √ |
| | **K.** A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | √ | √ | | √ |
| | **L.** The process of engineering design takes into account a number of factors. | | | | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | |
| **K-2** | **A.** Asking questions and making observations helps a person to figure out how things work. | | | | |
| | **B.** All products and systems are subject to failure. Many products and systems, however, can be fixed. | | | | |
| **3-5** | **C.** Troubleshooting is a way of finding out why something does not work so that it can be fixed. | | | | |
| | **D.** Invention and innovation are creative ways to turn ideas into real things. | | | | |
| | **E.** The process of experimentation, which is common in science, can also be used to solve technological problems. | | | | |
| **6-8** | **F.** Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. | | | | √ |
| | **G.** Invention is a process of turning ideas and imagination into devices and systems. | √ | | √ | √ |

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| | **H.** Some technological problems are best solved through experimentation. | √ | **x** | **x** | **x** |
| **9-12** | **I.** Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | √ | | √ | √ |
| | **J.** Technological problems must be researched before they can be solved. | | | √ | √ |
| | **K.** Not all problems are technological, and not every problem can be solved using technology. | | | √ | |
| | **L.** Many technological problems require a multidisciplinary approach. | | | | |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | |
| **K-2** | **A.** Brainstorm people's needs and wants and pick some problem that can be solved through the design process. | | | | |
| | **B.** Build or construct an object using the design process. | | | | |
| | **C.** Investigate how things are made and how they can be improved. | | | | |
| **3-5** | **D.** Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem. | | | | |
| | **E.** The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many. | | | | |
| | **F.** Test and evaluate the solutions for the design problem. | | | | |
| | **G.** Improve the design solutions. | | | | |
| **6-8** | **H.** Apply a design process to solve problems in and beyond the laboratory-classroom. | √ | **X** | | |
| | **I.** Specify criteria and constraints for the design. | √ | √ | √ | √ |
| | **J.** Make two-dimensional and three-dimensional representations of the designed solution. | √ | √ | √ | √ |
| | **K.** Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. | √ | | | √ |
| | **L.** Make a product or system and document the solution. | √ | | √ | √ |
| **9-12** | **M.** Identify the design problem to solve and decide whether or not to address it. | | | √ | √ |
| | **N.** Identify criteria and constraints and determine how these will affect the design process. | √ | | √ | √ |
| | **O.** Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | | | | √ |
| | **P.** Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. | | √ | | √ |

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| | **Q.** Develop and produce a product or system using a design process. | √ | | √ | √ |
| | **R.** Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | √ | √ | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | |
| **K-2** | **A.** Discover how things work. | | | | |
| | **B.** Use hand tools correctly and safely and be able to name them correctly. | | | | |
| | **C.** Recognize and use everyday symbols. | | | | |
| **3-5** | **D.** Follow step-by-step directions to assemble a product. | | | | |
| | **E.** Select and safely use tools, products, and systems for specific tasks. | | | | |
| | **F.** Use computers to access and organize information. | | | | |
| | **G.** Use common symbols, such as numbers and words, to communicate key ideas. | | | | |
| **6-8** | **H.** Use information provided in manuals, protocols, or by experienced people to see and understand how things work. | | | | √ |
| | **I.** Use tools, materials, and machines safely to diagnose, adjust, and repair systems. | | | | |
| | **J.** Use computers and calculators in various applications. | **X** | √ | √ | √ |
| | **K.** Operate and maintain systems in order to achieve a given purpose. | | | | √ |
| **9-12** | **L.** Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | | √ | | √ |
| | **M.** Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | | | | |
| | **N.** Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | | | | |
| | **O.** Operate systems so that they function in the way they were designed. | | | | |
| | **P.** Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | √ | √ | √ | √ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | |
| **K-2** | **A.** Collect information about everyday products and systems by asking questions. | | | | |
| | **B.** Determine if the human use of a product or system creates positive or negative results. | | | | |
| **3-5** | **C.** Compare, contrast, and classify collected information in order to identify patterns. | | | | |

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| | **D.** Investigate and assess the influence of a specific technology on the individual, family, community, and environment. | | | | |
| | **E.** Examine the trade-offs of using a product or system and decide when it could be used. | | | | |
| **6-8** | **F.** Design and use instruments to gather data. | | | | |
| | **G.** Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology. | | | | |
| | **H.** Identify trends and monitor potential consequences of technological development. | | | √ | |
| | **I.** Interpret and evaluate the accuracy of the information obtained and determine if it is useful. | | | | √ |
| **9-12** | **J.** Collect information and evaluate its quality. | | | | |
| | **K.** Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | | √ | |
| | **L.** Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | | |
| | **M.** Design forecasting to evaluate the results of altering natural systems. | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | |
| **K-2** | **A.** Vaccinations protect people from getting certain diseases. | | | | |
| | **B.** Medicine helps sick people get better. | | | | |
| | **C.** There are many products designed specifically to help people take care of themselves. | | | | |
| **3-5** | **D.** Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing. | | | | |
| | **E.** Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility. | | | | |
| | **F.** Many tools and devices have been designed to help provide clues about health and to provide a safe environment. | | | | |
| **6-8** | **G.** Advances and innovations in medical technologies are used to improve healthcare. | | | | |
| | **H.** Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety. | | | | |
| | **I.** The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced. | | | | |

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| | **J.** Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups. | | | | |
| **9-12** | **K.** Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | |
| | **L.** Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | |
| | **M.** The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | |
| **K-2** | **A.** The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources. | | | | |
| | **B.** There are many different tools necessary to control and make up the parts of an ecosystem. | | | | |
| **3-5** | **C.** Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals. | | | | |
| | **D.** Most agricultural waste can be recycled. | | | | |
| | **E.** Many processes used in agriculture require different procedures, products, or systems. | | | | |
| **6-8** | **F.** Technological advances in agriculture directly affect the time and number of people required to produce food for a large population. | | | | |
| | **G.** A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals. | | | | |
| | **H.** Biotechnology applies the principles of biology to create commercial products or processes. | | | | |
| | **I.** Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment. | | | | |
| | **J.** The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food. | | | | |
| **9-12** | **K.** Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | |
| | **L.** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | |

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| | **M.** Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | |
| | **N.** The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | |
| **K-2** | **A.** Energy comes in many forms. | | | | |
| | **B.** Energy should not be wasted. | | | | |
| **3-5** | **C.** Energy comes in different forms. | | | | |
| | **D.** Tools, machines, products, and systems use energy in order to do work. | | | | |
| **6-8** | **E.** Energy is the capacity to do work. | | | | |
| | **F.** Energy can be used to do work, using many processes. | | | | |
| | **G.** Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done. | | | | |
| | **H.** Power systems are used to drive and provide propulsion to other technological products and systems. | | | | |
| | **I.** Much of the energy used in our environment is not used efficiently. | | | | |
| **9-12** | **J.** Energy cannot be created or destroyed; however, it can be converted from one form to another. | | | | |
| | **K.** Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | | | |
| | **L.** It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | |
| | **M.** Energy resources can be renewable or nonrenewable. | | | | |
| | **N.** Power systems must have a source of energy, a process, and loads. | | | | |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | | | | | |
| **K-2** | **A.** Information is data that has been organized. | | | | |
| | **B.** Technology enables people to communicate by sending and receiving information over a distance. | | | | |
| | **C.** People use symbols when they communicate by technology. | | | | |
| **3-5** | **D.** The processing of information through the use of technology can be used to help humans make decisions and solve problems. | | | | |
| | **E.** Information can be acquired and sent through a variety of technological sources, including print and electronic media. | | | | |
| | **F.** Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|---|
| | **G.** Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. | | | | |
| 6-8 | **H.** Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. | | | | √ |
| 6-8 | **I.** Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. | | | | |
| 6-8 | **J.** The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. | √ | | | √ |
| 6-8 | **K.** The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas. | √ | √ | | √ |
| 9-12 | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | | |
| 9-12 | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | | | | √ |
| 9-12 | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | | | √ | √ |
| 9-12 | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | | | |
| 9-12 | **P.** There are many ways to communicate information, such as graphic and electronic means. | √ | | | √ |
| 9-12 | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | √ | √ | √ | √ |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | |
| K-2 | **A.** A transportation system has many parts that work together to help people travel. | | | | |
| K-2 | **B.** Vehicles move people or goods from one place to another in water, air, or space and on land. | | | | |
| K-2 | **C.** Transportation vehicles need to be cared for to prolong their use. | | | | |
| 3-5 | **D.** The use of transportation allows people and goods to be moved from place to place. | | | | |
| 3-5 | **E.** A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. | | | | |
| 6-8 | **F.** Transporting people and goods involves a combination of individuals and vehicles. | | | | |
| 6-8 | **G.** Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|---|
| | **H.** Governmental regulations often influence the design and operation of transportation systems. | | | | |
| | **I.** Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently. | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | |
| **K-2** | **A.** Manufacturing systems produce products in quantity. | | | | |
| | **B.** Manufactured products are designed. | | | | |
| **3-5** | **C.** Processing systems convert natural materials into products. | | | | |
| | **D.** Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products. | | | | |
| | **E.** Manufacturing enterprises exist because of a consumption of goods. | | | | |
| **6-8** | **F.** Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them. | | ● | | |
| | **G.** Manufactured goods may be classified as durable or non-durable. | | | | |
| | **H.** The manufacturing process includes the designing, development, making, and servicing of products and systems. | | | | |
| | **I.** Chemical technologies are used to modify or alter chemical substances. | | | | |
| | **J.** Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining. | | | | |
| | **K.** Marketing a product involves informing the public about it as well as assisting in selling and distributing it. | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | ● | | |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|---|
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | ● | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | ● | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | | | |
| ***STL*** **Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | |
| **K-2** | **A.** People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools. | | | | |
| | **B.** The type of structure determines how the parts are put together. | | | | |
| **3-5** | **C.** Modern communities are usually planned according to guidelines. | | | | |
| | **D.** Structures need to be maintained. | | | | |
| | **E.** Many systems are used in buildings. | | | | |
| **6-8** | **F.** The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. | | | | |
| | **G.** Structures rest on a foundation. | | | | |
| | **H.** Some structures are temporary, while others are permanent. | | | | |
| | **I.** Buildings generally contain a variety of subsystems. | | | | |
| **9-12** | **J.** Infrastructure is the underlying base or basic framework of a system. | | | | |
| | **K.** Structures are constructed using a variety of processes and procedures. | | | | |
| | **L.** The design of structures includes a number of requirements. | | | | |
| | **M.** Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | |
| | **N.** Structures can include prefabricated materials. | | | | |

**Table 1.** Comparison of *Standards for Technological Literacy* (*STL*) and **Introduction to Engineering Design.**

Source: International Technology Education Association's (ITEA) ***Standards for Technological Literacy: Content for the Study of Technology***.

# IED Standards for the English Language Arts Matrix

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and nonprint texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | | | √ | |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | ● | ● | ● | **x** |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | √ | √ | **x** | √ |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | **x** | **x** | √ | √ |
| ***SELA* Standard 7:** Students conduct research on issues and | √ | ● | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | √ | √ | √ | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | **x** | **x** | √ | **x** |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ |

**Table 1.** Comparison of *Standards for the English Language Arts* (*SELA*) and **Introduction to Engineering Design™**

Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# IED Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | √ | √ | √ | √ |
| • understand meanings of operations and how they relate to one another; | √ | √ | √ | √ |
| • compute fluently and make reasonable estimates | √ | √ | √ | √ |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions; | √ | √ | | |
| • represent and analyze mathematical situations and structures using algebraic symbols; | √ | √ | √ | |
| • use mathematical models to represent and understand quantitative relationships; | √ | √ | √ | √ |
| • analyze change in various contexts. | | √ | √ | |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | √ | √ | √ | **X** |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | √ | √ | √ | √ |
| • apply transformations and use symmetry to analyze mathematical situations; | √ | √ | √ | √ |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | √ | √ | √ | √ |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | √ | √ | √ | √ |
| • apply appropriate techniques, tools, and formulas to determine | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| measurements. | | | | |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | √ | **x** | √ | √ |
| • select and use appropriate statistical methods to analyze data; | | | | |
| • develop and evaluate inferences and predictions that are based on data; | | | √ | |
| • understand and apply basic concepts of probability. | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving; | | | √ | √ |
| • solve problems that arise in mathematics and in other contexts; | **X** | √ | √ | √ |
| • apply and adapt a variety of appropriate strategies to solve problems; | **X** | √ | √ | √ |
| • monitor and reflect on the process of mathematical problem solving. | | | | |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | |
| • make and investigate mathematical conjectures; | | | | |
| • develop and evaluate mathematical arguments and proofs; | | | | |
| • select and use various types of reasoning and methods of proof. | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication; | √ | √ | √ | √ |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | √ | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | **X** | | √ | √ |
| • use the language of mathematics to express mathematical ideas precisely | **X** | | √ | |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas; | √ | | √ | √ |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | | √ | √ | √ |
| • recognize and apply mathematics in contexts outside of mathematics. | | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Introduction to Design | Unit 2: Design Solutions | Unit 3: Reverse Engineering | Unit 4: Design Problems |
|---|---|---|---|---|
| • select, apply, and translate among mathematical representations to solve problems; | √ | √ | √ | √ |
| • use representations to model and interpret physical, social, and mathematical phenomena. | √ | √ | √ | √ |

**Table 1.** Comparison of *Principles and Standards for School Mathematics* (*PSSM*) and **Introduction to Engineering Design™**

Source: National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics*.

PROJECT LEAD THE WAY PLTW

# POE

# Principles Of Engineering Course Description

Principles Of Engineering (POE) is a high school-level survey course of engineering. The course exposes students to some of the major concepts that they will encounter in a postsecondary engineering course of study. Students have an opportunity to investigate engineering and high tech career POE gives students the opportunity to develop skills and understanding of course concepts through activity-, project-, and problem-based (APPB) learning. Used in combination with a teaming approach, APPB learning challenges students to continually hone their interpersonal skills, creative abilities, and problem solving skills based upon engineering concepts. It also allows students to develop strategies to enable and direct their own learning, which is the ultimate goal of education.

To be successful in POE, students should be concurrently enrolled in college preparatory mathematics and science. Students will employ engineering and scientific concepts in the solution of engineering design problems. Students will develop problem-solving skills and apply their knowledge of research and design to create solutions to various challenges. Students will also learn how to document their work and communicate their solutions to their peers and members of the professional community.

Principles Of Engineering is the second of three foundation courses in the Project Lead The Way high school engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Mechanisms
- Energy Sources
- Energy Applications
- Machine Control
- Fluid Power
- Statics
- Material Properties
- Material Testing
- Statistics
- Kinematics

# Principles Of Engineering Detailed Outline

## Unit 1 Energy and Power
## Time Days: 49 days

**Lesson 1.1 Mechanisms** (15 days):
**Concepts Addressed in Lesson:**

1. Engineers and engineering technologists apply math, science, and discipline-specific skills to solve problems.
2. Engineering and engineering technology careers offer creative job opportunities for individuals with a wide variety of backgrounds and goals.
3. Technical communication can be accomplished in oral, written, and visual forms and must be organized in a clear and concise manner.
4. Most mechanisms are composed of gears, sprockets, pulley systems, and simple machines.
5. Mechanisms are used to redirect energy within a system by manipulating force, speed, and distance.
6. Mechanical advantage ratios mathematically evaluate input work versus output work of mechanisms.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Differentiate between engineering and engineering technology.
- Conduct a professional interview and reflect on it in writing.
- Identify and differentiate among different engineering disciplines.
- Measure forces and distances related to mechanisms.
- Distinguish between the six simple machines, their attributes, and components.
- Calculate mechanical advantage and drive ratios of mechanisms.
- Design, create, and test gear, pulley, and sprocket systems.
- Calculate work and power in mechanical systems.
- Determine efficiency in a mechanical system.
- Design, create, test, and evaluate a compound machine design.

## Lesson 1.2 Energy Sources (11 days):

**Concepts Addressed in Lesson:**

1. Energy source classifications include nonrenewable, renewable, and inexhaustible.
2. Energy source processes include harnessing, storing, transporting, and converting.
3. Energy often needs to be converted from one form to another to meet the needs of a given system.
4. An understanding of work, energy, and power is required to determine system efficiency.
5. An understanding of the basics of electricity requires the understanding of three fundamental concepts of voltage, current, and resistance.
6. The atomic structure of a material determines whether it is a conductor, an insulator, or a semiconductor.

**Performance Objectives Addressed in Lesson**:

It is expected that students will:

- Identify and categorize energy sources as nonrenewable, renewable, or inexhaustible.
- Create and deliver a presentation to explain a specific energy source.
- Summarize and reflect upon information collected during a visit to a local utility company.
- Define the possible types of power conversion.
- Calculate work and power.
- Demonstrate the correct use of a digital multimeter.
- Calculate power in a system that converts energy from electrical to mechanical.
- Determine efficiency of a system that converts an electrical input to a mechanical output.
- Calculate circuit resistance, current, and voltage using Ohm's law.
- Understand the advantages and disadvantages of parallel and series circuit design in an application.

## Lesson 1.3 Energy Applications (10 days):

**Concepts Addressed in Lesson:**

1. Energy management is focused on efficient and accessible energy use.
2. System energy requirements must be understood in order to select the proper energy source.

3. Energy systems can include multiple energy sources that can be combined to convert energy into useful forms.
4. Hydrogen fuel cells create electricity and heat through an electrochemical process that converts hydrogen and oxygen into water.
5. Solar cells convert light energy into electricity by using photons to create electron flow.
6. Thermodynamics is the study of the effects of work, thermo energy, and energy on a system.
7. Thermo energy can transfer via convection, conduction, or radiation.
8. Material conductivity, resistance, and energy transfer can be calculated.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Test and apply the relationship between voltage, current, and resistance relating to a photovoltaic cell and a hydrogen fuel cell.
- Experiment with a solar hydrogen system to produce mechanical power.
- Design, construct, and test recyclable insulation materials.
- Test and apply the relationship between R-values and recyclable insulation.
- Complete calculations for conduction, R-values, and radiation.

**Lesson 1.4 Design Problem – Energy and Power** (13 days):
**Concepts Addressed in Lesson**:

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and to establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for a design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.
- Present a workable solution to the design problem.

# Unit 2 Materials and Structures
# Time Days: 40 days

**Lesson 2.1 Statics** (14 Days):
**Concepts Addressed in Lesson:**

1. Laws of motion describe the interaction of forces acting on a body.
2. Structural member properties including centroid location, moment of inertia, and modulus of elasticity are important considerations for structure design.
3. Static equilibrium occurs when the sum of all forces acting on a body are equal to zero.
4. Applied forces are vector quantities with a defined magnitude, direction, and sense, and can be broken into vector components.
5. Forces acting at a distance from an axis or point attempt or cause an object to rotate.
6. In a statically determinate truss, translational and rotational equilibrium equations can be used to calculate external and internal forces.
7. Free body diagrams are used to illustrate and calculate forces acting upon a given body.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Create free body diagrams of objects, identifying all forces acting on the object.
- Mathematically locate the centroid of structural members.
- Calculate moment of inertia of structural members.
- Differentiate between scalar and vector quantities.
- Identify magnitude, direction, and sense of a vector.
- Calculate the X and Y components given a vector.
- Calculate moment forces given a specified axis.
- Use equations of equilibrium to calculate unknown forces.
- Use the method of joints strategy to determine forces in the members of a statically determinate truss.

**Lesson 2.2 Material Properties** (11 Days):
**Concepts Addressed in Lesson:**

1. Materials are the substances with which all objects are made.
2. Materials are composed of elements and area categorized by physical and chemical properties.
3. Materials consist of pure elements. Compounds and mixtures and are typically classified as metallic, ceramic, organic, polymeric, and composite.

4. Material properties including recyclability and cost are important considerations for engineers when choosing appropriate materials for a design.
5. Material selection is based upon mechanical, thermal, electromagnetic, and chemical properties.
6. Raw materials undergo various manufacturing processes in the production of consumer goods.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Investigate specific material properties related to a common household product.
- Conduct investigative non-destructive material property tests on selected common household products. Property testing conducted to identify continuity, ferrous metal, hardness, and flexure.
- Calculate weight, volume, mass, density, and surface area of selected common household product
- Identify the manufacturing processes used to create the selected common household product.
- Identify the recycling codes.
- Promote recycling using current media trends.

**Lesson 2.3 Material Testing** (10 Days):
**Concepts Addressed in Lesson:**

1. Engineers utilize a design process and mathematical formulas to solve and document design problems.
2. Material testing aids in determining a product's reliability, safety, and predictability in function.
3. Engineers perform destructive and non-destructive tests on material specimens for the purpose of identifying and verifying the properties of various materials.
4. Material testing provides a reproducible evaluation of material properties.
5. Tensile testing data is used to create a test sample stress strain curve.
6. Stress strain data points are used to identify and calculate sample material properties including elastic range, proportional limit, modulus of elasticity, elastic limit, resilience, yield point, plastic deformation, ultimate strength, failure, and ductility.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Utilize a five-step technique to solve word problems.
- Obtain measurements of material samples.
- Tensile test a material test sample.
- Identify and calculate test sample material properties using a stress strain curve.

**Lesson 2.4 Design Problem – Materials and Structures** (5 Days):

**Concepts Addressed in Lesson:**

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision making matrix for the design problem.
- Select an approach that meets or satisfies the constraints given in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon your team's decision matrix.
- Present a workable design solution.

# Unit3 Control Systems
# Time Days: 46 days

**Lesson 3.1 Machine Control** (16 days):
**Concepts Addressed in Lesson:**

1. Flowcharts provide a step by step schematic representation of an algorithm or process.
2. Control systems are designed to provide consentient process control and reliability.
3. Control system protocols are an established set of commands or functions typically created in a computer programming language.
4. Closed loop systems use digital and analog sensor feedback to make operational and process decisions.
5. Open loop systems use programming constants such as time to make operational and process decisions.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Create detailed flow charts utilizing a computer software application.
- Create control system operating programs utilizing computer software.
- Create system control programs that utilize flowchart logic.
- Choose appropriate inputs and output devices based on the need of a technological system.
- Differentiate between the characteristics of digital and analog devices.
- Judge between open and closed loop systems in order to choose the most appropriate system for a given technological problem.
- Design and create a control system based on given needs and constraints.

**Lesson 3.2 Fluid Power** (15 days):
**Concepts Addressed in Lesson:**

1. Fluid power systems are categorized as either pneumatic, which utilizes gas, or hydraulic, which utilizes liquid.
2. Fluid power is possible because in a system of confined fluid, pressure acts equally in all directions.
3. The most basic components of all fluid power systems include a reservoir or receiver, a pump or compressor, a valve, and a cylinder.
4. Fluid power systems are designed to transmit force over great distances, multiply an input force, and increase the distance that an output will move.
5. Laws about the behavior of fluid systems and standard conventions for calculating values within fluid systems aid in the design and understanding of such systems.

6. Standard schematic symbols and conventions are used to communicate fluid power designs.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Identify devices that utilize fluid power.
- Identify and explain basic components and functions of fluid power devices.
- Differentiate between the characteristics of pneumatic and hydraulic systems.
- Distinguish between hydrodynamic and hydrostatic systems.
- Design, create, and test a hydraulic device.
- Design, create, and test a pneumatic device.
- Calculate values in a fluid power system utilizing Pascal's Law.
- Distinguish between pressure and absolute pressure.
- Distinguish between temperature and absolute temperature.
- Calculate values in a pneumatic system, utilizing the perfect gas laws.
- Calculate flow rate, flow velocity, and mechanical advantage in a hydraulic system.

**Lesson 3.3 Design Problem – Control Systems** (15 days):

**Concepts Addressed in Lesson:**

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and to establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

**Performance Objectives Addressed in Lesson**:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for a design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.
- Present a workable solution to the design problem.

# Unit 4 Statistics and Kinematics
# Time: 30 Days

**Lesson 4.1 Statistics** (5 Days):
**Concepts Addressed in Lesson:**

1. Engineers use statistics to make informed decisions based upon established principles.
2. Visual representations of data analyses allow for easy distribution and understanding of data.
3. Statistics is based upon both theoretical and experimental data analysis.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Calculate the theoretical probability that an event will occur.
- Calculate the experimental frequency distribution of an event occurring.
- Apply the Bernoulli process to events that only have two distinct possible outcomes.
- Apply AND, OR, and NOT logic to probability.
- Apply Bayes' theorem to calculate the probability of multiple events occurring.
- Create a histogram to illustrate frequency distribution.
- Calculate the central tendency of a data array, including mean, median, and mode.
- Calculate data variation, including range, standard deviation, and variance.

**Lesson 4.2 Kinematics** (10 Days):
**Concepts Addressed in Lesson**:

1. When working with bodies in motion, engineers must be able to differentiate and calculate distance, displacement, speed, velocity, and acceleration.
2. When air resistance is not taken into account, released objects will experience acceleration due to gravity, also known as freefall.
3. Projectile motion can be predicted and controlled using kinematics equations.
4. When a projectile is launched, velocity in the x direction remains constant; whereas, with time, the velocity in the Y direction in magnitude and direction changes due to gravity.

**Performance Objectives Addressed in Lesson:**

It is expected that students will:

- Calculate distance, displacement, speed, velocity, and acceleration from data.
- Design, build, and test a vehicle that stores and releases potential energy for propulsion.
- Calculate acceleration due to gravity given data from a free fall device.

- Calculate the X and Y components of a projectile motion.
- Determine the angle needed to launch a projectile a specific range given the projectile's initial velocity.

**Lesson 4.3 Design Problem – Statistics and Kinematics** (15 Days):
**Concepts Addressed in Lesson:**

1. Design problems can be solved by individuals or in teams.
2. Engineers use a design process to create solutions to existing problems.
3. Design briefs are used to identify the problem specifications and establish project constraints.
4. Teamwork requires constant communication to achieve the desired goal.
5. Design teams conduct research to develop their knowledge base, stimulate creative ideas, and make informed decisions.

**Performance Objectives Addressed in Lesson**:

It is expected that students will:

- Brainstorm and sketch possible solutions to an existing design problem.
- Create a decision-making matrix for their design problem.
- Select an approach that meets or satisfies the constraints provided in a design brief.
- Create a detailed pictorial sketch or use 3D modeling software to document the best choice, based upon the design team's decision matrix.
- Present a workable solution to the design problem.

# Principles Of Engineering

## National Science Education Standards Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| **NSES Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • Systems, order, and organization | √ | √ | √ | √ |
| • Evidence, models, and explanation | √ | √ | √ | √ |
| • Change, constancy, and measurement | √ | √ | √ | √ |
| • Evolution and equilibrium | √ | √ | √ | √ |
| • Form and function | √ | √ | √ | √ |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities necessary to do scientific inquiry | √ | √ | √ | √ |
| • Understandings about scientific inquiry | √ | √ | √ | √ |
| **NSES Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Structure of atoms | √ | ● | ● | |
| • Structure and properties of matter | √ | ● | ● | |
| • Chemical reactions | √ | ● | | |
| • Motions and forces | √ | ● | √ | √ |
| • Conservation of energy and increase in disorder | √ | ● | √ | √ |
| • Interactions of energy and matter | √ | ● | √ | √ |
| **NSES Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • The cell | | | | |
| • Molecular basis of heredity | | | | |
| • Biological evolution | | | | |
| • Interdependence of organisms | | | | |
| • Matter, energy, and organization in living systems | √ | | | |
| • Behavior of organisms | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| **NSES Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Energy in the earth system | | | | |
| • Geochemical cycles | | | | |
| • Origin and evolution of the earth system | | | | |
| • Origin and evolution of the universe | | | | |
| **NSES Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities of technological design | √ | √ | √ | √ |
| • Understandings about science and technology | √ | √ | √ | √ |
| **NSES Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Personal and community health | | | | |
| • Population growth | | | | |
| • Natural resources | √ | √ | | |
| • Environmental quality | | | | |
| • Natural and human-induced hazards | | | | |
| • Science and technology in local, national, and global challenges | √ | √ | | |
| **NSES Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Science as a human endeavor | | | | |
| • Nature of scientific knowledge | | | | |
| • Historical perspectives | | | √ | |

Table 1. Comparison of National Science Education Standards (NSES) and PLTW – Principles Of Engineering

Source: National Research Council (NRC) *National Science Education Standards*.

# Principles Of Engineering

## Standards for Technological Literacy Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | | |
| **9-12** | **J.** | The nature and development of technological knowledge and processes are functions of the setting. | √ | √ | √ | √ |
| | **K.** | The rate of technological development and diffusion is increasing rapidly. | **x** | **x** | **x** | **x** |
| | **L.** | Inventions and innovations are the results of specific, goal-directed research. | √ | √ | √ | √ |
| | **M.** | Most development of technologies these days is driven by the profit motive and the market. | **x** | **x** | **x** | **x** |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | | |
| **9-12** | **W.** | Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | √ | x | √ | |
| | **X.** | Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | √ | x | √ | |
| | **Y.** | The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | √ | x | √ | |
| | **Z.** | Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | √ | √ | √ | √ |
| | **AA.** | Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | √ | √ | √ | √ |
| | **BB.** | Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | √ | √ | √ | √ |
| | **CC.** | New technologies create new processes. | √ | √ | √ | ● |
| | **DD.** | Quality control is a planned process to ensure that a product, service, or system meets established criteria. | x | x | **x** | **x** |

| | | | | | |
|---|---|---|---|---|---|
| | **EE.** Management is the process of planning, organizing, and controlling work. | x | x | **x** | **x** |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | ● | | √ | |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | √ | ● | √ | |
| | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | √ | x | **x** | |
| | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | ● | ● | ● | ● |
| | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | √ | | | |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | |
| **9-12** | **H.** Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | ● | ● | | |
| | **I.** Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | √ | √ | √ | √ |
| | **J.** Ethical considerations are important in the development, selection, and use of technologies. | √ | √ | √ | √ |
| | **K.** The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | • | ● | ● | ● |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | √ | √ | | |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | √ | √ | | |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | x | | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | √ | √ | | |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | √ | √ | | |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | √ | √ | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | values. | | | | |
| | **I.** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | ● | ● | | |
| | **J.** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | ● | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| **9-12** | **G.** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | √ | √ | | |
| | **H.** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. | √ | √ | | |
| | **I.** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | √ | √ | | |
| | **J.** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | √ | √ | | |
| | **K.** | The Iron Age was defined by the use of iron and steel as the primary materials for tools. | √ | ● | | |
| | **L.** | The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | ● | | |
| | **M.** | The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | ● | | |
| | **N.** | The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | ● | | |
| | **O.** | The Information Age places emphasis on the processing and exchange of information. | | ● | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | |
| **9-12** | **H.** | The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | √ | √ | √ | √ |
| | **I.** | Design problems are seldom presented in a clearly defined form. | ● | ● | ● | ● |
| | **J.** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | √ | √ | √ | √ |
| | **K.** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | √ | √ | √ | √ |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | |
| **9-12** | **I.** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | √ | √ | √ | √ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **J.** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | √ | √ | √ | √ |
| | **K.** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | √ | √ | √ | √ |
| | **L.** | The process of engineering design takes into account a number of factors. | √ | √ | √ | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | |
| **9-12** | **I.** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | ● | ● | ● | ● |
| | **J.** | Technological problems must be researched before they can be solved. | √ | √ | √ | √ |
| | **K.** | Not all problems are technological, and not every problem can be solved using technology. | ● | ● | ● | ● |
| | **L.** | Many technological problems require a multidisciplinary approach. | x | x | **x** | **x** |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | |
| **9-12** | **M.** | Identify the design problem to solve and decide whether or not to address it. | √ | √ | √ | √ |
| | **N.** | Identify criteria and constraints and determine how these will affect the design process. | √ | √ | √ | √ |
| | **O.** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | √ | √ | √ | √ |
| | **P.** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed | √ | √ | √ | √ |
| | **Q.** | Develop and produce a product or system using a design process. | √ | √ | √ | √ |
| | **R.** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | √ | √ | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | |
| **9-12** | **L.** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | √ | √ | √ | √ |
| | **M.** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | | | √ | **x** |
| | **N.** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | | | √ | **x** |
| | **O.** | Operate systems so that they function in the way they were designed. | | | √ | √ |
| | **P.** | Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | √ | | √ | √ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** | Collect information and evaluate its quality. | √ | | | √ |
| | **K.** | Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | √ | | | √ |
| | **L.** | Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | | √ |
| | **M.** | Design forecasting to evaluate the results of altering natural systems. | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | |
| **9-12** | **K.** | Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | |
| | **L.** | Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | |
| | **M.** | The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | |
| **9-12** | **K.** | Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | |
| | **L.** | Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | |
| | **M.** | Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | |
| | **N.** | The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | |
| **9-12** | **J.** | Energy cannot be created or destroyed; however, it can be converted from one form to another. | √ | | | |
| | **K.** | Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | √ | | | |
| | **L.** | It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | √ | | | |
| | **M.** | Energy resources can be renewable or nonrenewable. | √ | | | |
| | **N.** | Power systems must have a source of energy, a process, and loads. | √ | | **X** | |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| use information and communication technologies. | | | | | | |
| **9-12** | **L.** | Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | √ | |
| | **M.** | Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | √ | | √ | |
| | **N.** | Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | √ | | | |
| | **O.** | Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | | | |
| | **P.** | There are many ways to communicate information, such as graphic and electronic means. | √ | x | √ | x |
| | **Q.** | Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | √ | √ | √ | √ |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | |
| **9-12** | **J.** | Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | |
| | **K.** | Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | |
| | **L.** | Transportation services and methods have led to a population that is regularly on the move. | | | | |
| | **M.** | The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | |
| **9-12** | **L.** | Servicing keeps products in good operating condition. | | x | | |
| | **M.** | Materials have different qualities and may be classified as natural, synthetic, or mixed. | | √ | | |
| | **N.** | Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | x | | |
| | **O.** | Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | √ | | |
| | **P.** | The interchangeability of parts increases the effectiveness of manufacturing processes. | | √ | | |
| | **Q.** | Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | x | | |
| | **R.** | Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | x | | |

| **STL Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** | Infrastructure is the underlying base or basic framework of a system. | | √ | | |
| | **K.** | Structures are constructed using a variety of processes and procedures. | | √ | | |
| | **L.** | The design of structures includes a number of requirements. | | √ | | |
| | **M.** | Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | √ | | |
| | **N.** | Structures can include prefabricated materials. | | √ | | |

Table 1. Comparison of Standards for Technological Literacy (STL) and Principles Of Engineering.
Source: International Technology Education Association's (ITEA) *Standards for Technological Literacy: Content for the Study of Technology.*

# Principles Of Engineering

## Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | **x** | **x** | **x** | **x** |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | ● | ● | ● | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | **x** | **x** | **x** | **x** |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing | √ | √ | **x** | **x** |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | √ | √ | √ | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | ● | ● | ● | ● |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ |

Table 1. Comparison of Standards for the English Language Arts (SELA) and Principles Of Engineering
Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) *Standards for the English Language Arts*.

# Principles Of Engineering

## Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | √ | √ | √ | √ |
| • understand meanings of operations and how they relate to one another; | √ | √ | √ | √ |
| • compute fluently and make reasonable estimates | √ | √ | √ | √ |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions; | √ | √ | **x** | √ |
| • represent and analyze mathematical situations and structures using algebraic symbols; | √ | √ | **x** | √ |
| • use mathematical models to represent and understand quantitative relationships; | √ | √ | **x** | √ |
| • analyze change in various contexts. | √ | √ | **x** | √ |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | **x** | √ | ● | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | **x** | √ | ● | |
| • apply transformations and use symmetry to analyze mathematical situations; | **x** | √ | ● | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | **x** | √ | ● | |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| grade 12 should enable all students to— | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | √ | √ | √ | √ |
| • apply appropriate techniques, tools, and formulas to determine measurements. | √ | √ | √ | √ |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | | **x** | ● | √ |
| • select and use appropriate statistical methods to analyze data; | | **x** | ● | √ |
| • develop and evaluate inferences and predictions that are based on data; | | **x** | ● | √ |
| • understand and apply basic concepts of probability. | | **x** | ● | √ |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving; | √ | √ | √ | √ |
| • solve problems that arise in mathematics and in other contexts; | √ | √ | √ | √ |
| • apply and adapt a variety of appropriate strategies to solve problems; | √ | √ | √ | √ |
| • monitor and reflect on the process of mathematical problem solving. | √ | √ | √ | √ |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | √ |
| • make and investigate mathematical conjectures; | | | | √ |
| • develop and evaluate mathematical arguments and proofs; | | | | √ |
| • select and use various types of reasoning and methods of proof. | | | | √ |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication; | √ | √ | √ | √ |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | √ | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | √ | √ | √ | √ |
| • use the language of mathematics to express mathematical ideas precisely | √ | √ | √ | √ |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas; | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Energy and Power | Unit 2: Materials and Structures | Unit 3: Control Systems | Unit 4: Statistics and Kinematics |
|---|---|---|---|---|
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | √ | √ | √ | √ |
| • recognize and apply mathematics in contexts outside of mathematics. | √ | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | | √ | √ | √ |
| • select, apply, and translate among mathematical representations to solve problems; | | √ | √ | √ |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | √ | √ | √ |

Table 1. Comparison of Principles and Standards for School Mathematics (PSSM) and Principles Of Engineering.
Source: National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics.*

# DE

# Digital Electronics Course Description

Digital Electronics ™ is the study of electronic circuits that are used to process and control digital signals. In contrast to analog electronics, where information is represented by a continuously varying voltage, digital signals are represented by two discreet voltages or logic levels. This distinction allows for greater signal speed and storage capabilities and has revolutionized the world electronics. Digital electronics is the foundation of all modern electronic devices such as cellular phones, MP3 players, laptop computers, digital cameras, high definition televisions, etc.

The major focus of the DE course is to expose students to the design process of combinational and sequential logic design, teamwork, communication methods, engineering standards, and technical documentation.

Utilizing the activity-project-problem-based (APPB) teaching and learning pedagogy, students will analyze, design and build digital electronic circuits. While implementing these designs students will continually hone their interpersonal skills, creative abilities and understanding of the design process.

Digital Electronics ™ (DE) is a high school level course that is appropriate for 10th or 11th grade students interested in electronics. Other than their concurrent enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

Digital Electronics ™ is one of three foundation courses in the Project Lead The Way® high school pre-engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Foundations of Digital Electronics
  - Scientific and Engineering Notations
  - Electronic Component Identification
  - Basic Soldering and PCB Construction
  - Electron Theory & Circuit Theory Laws
  - Circuit Simulation
  - Breadboard Prototyping
  - Component Datasheets & Troubleshooting
- Combinational Logic Analysis and Design
  - Binary, Octal and Hexadecimal Number Systems
  - Boolean Algebra and DeMorgan's Theorems
  - AND-OR-INVERT, NAND Only, and NOR Only Logic Design.
  - Binary Adders and Two's Complement Arithmetic
  - Combinational Logic Design with Field Programmable Gate Arrays

- Sequential Logic Analysis and Design
  - Flip-Flops, Latches and Their Applications.
  - Asynchronous Counter Design with Small and Medium Scale Integrated Circuits.
  - Synchronous Counter Design with Small and Medium Scale Integrated Circuits.
  - Sequential Logic Design with Field Programmable Gate Arrays
  - Introduction to State Machines.
- Introduction to Microcontrollers
  - Software Development for a Introductory Microcontroller
  - Real-World Interface: Introduction to Hardware Controls
  - Process Control with a Microcontroller

# Digital Electronics Detailed Outline

## Unit 1: Fundamentals of Analog and Digital Electronics (32 Total Days)

### Lesson 1.1: Foundations and the Board Game Counter (9 days)

Concepts Addressed in Lesson:

1. Safety is an important concept that must be considered for the safety of the individual, class, and overall environment of the classroom/laboratory.
2. Electricity, even at the nominal levels used in this curriculum, can cause bodily harm or even death.
3. Engineers and technicians use scientific notation, engineering notation, and Systems International (SI) notation to conveniently write very large or very small numbers frequently encountered when working with electronics.
4. Manufacturers of resistors and capacitors use an accepted industry standard to label the nominal value of resistors and capacitors.
5. Soldering is the process of joining two metal surfaces together to form an electrical connection. Soldering is used extensively in the assembly of electronic components.
6. The ability to properly solder electronic components and recognition of improper solder connections is an important skill for engineers and technicians.

### Lesson 1.2: Introduction to Analog (11 days)

Concepts Addressed in Lesson:

1. Analog and digital signals have different waveforms with distinctive characteristics.
2. Digital signals have two well-defined voltage levels, one for a logic high and one for a logic low.
3. Analog signals have an infinite number of voltage levels that vary continuously over the voltage range for that particular system.
4. The atomic structure of a material determines whether it is a conductor, an insulator, or a semiconductor.
5. An understanding of the basics of electricity requires the understanding of three fundamental concepts of voltage, current, and resistance

6. Engineers and technicians use Circuit Design Software as a tool to verify functionality of their analog and digital designs.

### Lesson 1.3: Introduction to Digital (12 days)

Concepts Addressed in Lesson:

1. The manufacturer datasheet contains a logic gate's general description, connection diagram, and function table.
2. Integrated circuits are categorized by their underlying circuitry, scale of integration, and packaging style.
3. Transistor-Transistor Logic (TTL) gates are available in a series of sub-families, each having their own advantages and disadvantages related to speed and power.
4. Logic gates are depicted by their schematic symbol, logic expression, and truth table.
5. The input and output values of combinational and sequential logic function differently.
6. Combinational logic designs implemented with AND gates, OR gates, and INVERTER gates are referred to as AOI designs.
7. The flip-flop is the fundamental building block of sequential logic.

## Unit 2: Combinational Logic (60 Total Days)

### Lesson 2.1: Introduction to AOI Logic (20 days)

Concepts Addressed in Lesson:

1. An understanding of the binary number system and its relationship to the decimal number system is essential in the combinational logic design process.
2. The first step in designing a combinational logic circuit is to translate a set of design specifications into a truth table.
3. A truth table describes the behavior of a combinational logic design by listing all possible input combinations and the desired output for each.
4. Logic expressions can be derived from a given truth table; likewise, a truth table can be constructed from a given logic expression.
5. All logic expressions can be expressed in one of two forms: sum-of-products (SOP) or products of sum (POS).
6. All logic expressions, whether simplified or not, can be implemented using AND, OR, & Inverter Gates.
7. There is a formal design process for translating a set of design specifications into a functional combinational logic circuit.

**Lesson 2.2: Introduction to NAND and NOR Logic (14 days)**

Concepts Addressed in Lesson:

1. Karnaugh Mapping is a graphical technique for simplifying logic expressions containing two, three, and four variables.
2. A don’t care condition is a situations where the design specifications “don’t care” what the output is for one or more input conditions. Don’t care conditions in K-Maps can lead to significantly simpler logic expressions and circuit implementations.
3. A NAND gate is considered a universal gate because it can be used to implement an AND gate, OR gate, and an inverter gate. Any combinational logic expression can be implemented using only NAND gates.
4. A NOR gate is considered a universal gate because it can be used to implement an AND gate, OR gate, and an inverter gate. Any combinational logic expression can be implemented using only NOR gates.
5. There is a formal design process for translating a set of design specifications into a functional combinational logic circuit implement with NAND or NOR gates.
6. Combinational logic designs implemented with NAND gates or NOR gates will typically required fewer Integrated Circuits (IC) than AOI equivalent implementations.

**Lesson 2.3: Date of Birth Design (9 days)**

Concepts Addressed in Lesson:

1. Seven-segment displays are used to display the digits 0-9 as well as some alpha characters.
2. The two varieties of seven-segment displays are common cathode and common anode.
3. Any combinational logic expression can be implemented with AOI, NAND, or NOR logic.
4. A formal design process exists for translating a set of design specifications into a functional combinational logic circuit.

**Lesson 2.4: Specific Comb Logic Circuits & Misc. Topics (8 days)**

Concepts Addressed in Lesson:

1. An understanding of the hexadecimal and octal number systems and their relationship to the decimal number system is necessary for comprehension of digital electronics.

2. XOR and XNOR gates can be used to implement combinational logic circuits, but their primary intended purpose is for implementing binary adder circuits.
3. The addition of two binary numbers of any bit length can be accomplished by cascading one half-adder with one or more full adders.
4. Multiplexer/de-multiplexer pairs are most frequently used when a single connection must be shared between multiple inputs and multiple outputs.
5. Electronics displays that use multiple seven-segment display utilize de-multiplexers to significantly reduce the amount of power required to operate the display.
6. Two's complement arithmetic is the most commonly used method for handling negative numbers in digital electronics.

**Lesson 2.5: Programmable Logic – Combinational (9 days)**

Concepts Addressed in Lesson:

1. Engineers and technicians use Circuit Design Software to enter and synthesize digital designs into programmable logic devices.
2. Programmable logic devices can be used to implement combinational logic circuits.
3. Circuits implemented with programmable logic devices require significantly less wiring than discrete logic, but they typically require a dedicated printed circuit board to hold the device.
4. Programmable logic devices can be used to implement any combinational logic circuits but are best suited for larger, more complex designs.

## Unit 3: Sequential Logic (56 Total Days)

**Lesson 3.1: Latches & Flip-Flops (6 days)**

Concepts Addressed in Lesson:

1. The flip-flop and transparent latch are logic devices that have the capability to store data and can act as a memory device.
2. Flip-flops and transparent latches have both synchronous and asynchronous inputs.
3. Flip-flops can be used to design single event detection circuits, data synchronizers, shift registers, and frequency dividers.

**Lesson 3.2: Asynchronous Counter (14 days)**

Concepts Addressed in Lesson:

1. Asynchronous counters, also called ripple counters, are characterized by an external signal clocking the first flip-flop. All subsequent flip-flips are clocked by the output of the previous flip-flop.
2. Asynchronous counters can be implemented using small scale integrated (SSI) and medium scale integrated (MSI) logic gates.
3. Asynchronous counters can be implemented with either D or J/K flip-flops.
4. Up counters, down counters, and modulus counters all can be implemented using the asynchronous counter method.

### Lesson 3.3: Synchronous Counters (14 days)

Concepts Addressed in Lesson:

1. Synchronous counters, also called parallel counters, are characterized by an external signal clocking all flip-flops simultaneously.
2. Synchronous counters can be implemented using small scale integrated (SSI) and medium scale integrated (MSI) logic gates.
3. Synchronous counters can be implemented with either D or J/K flip-flops.
4. Up counters, down counters, and modulus counters all can be implemented using the synchronous counter method.

### Lesson 3.4: Introduction to State-Machine Design (20 days)

Concepts Addressed in Lesson:

1. A state machine is a circuit design that sequences through a set of predetermined states controlled by a clock and other input signals.
2. State machines are used to control common everyday devices such as elevator doors, traffic lights, and combinational (electronics) locks.
3. State machines can be implemented in one of two variations: Mealy or Moore.
4. State machines can be implemented using small and medium scale integrated gates and programmable logic devices.

## Unit 4: Microcontrollers (29 Total Days)

### Lesson 4.1: Introduction to Microcontrollers (9 days)

Concepts Addressed in Lesson:

1. Flowcharting is a powerful graphical organizer used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities.
2. Basic programming skills include variable declaration, loops, and debugging.
3. Programming languages have their own grammar, called syntax.
4. Many everyday products use microcontrollers.
5. Variables used in programming are declared and given a size that is expressed in binary.

**Lesson 4.2: Microcontrollers – Boe-Bot (9 days)**

Concepts Addressed in Lesson:

1. Microcontrollers are used to control many everyday products like robots, garage door openers, traffic lights, and home thermostats.
2. A servo motor is one that delivers continuous motion at various speeds.
3. Microcontrollers can be programmed to sense and respond to outside stimuli

**Lesson 4.3: Boe-Bot Design Projects (11 days)**

Concepts Addressed in Lesson:

1. Digital devices are only relevant if they can interact with the real world.
2. Digital control devices are increasingly necessary for mechanical systems.
3. Realistic problem solving with a control system requires the ability to interface analog inputs and outputs with a digital device.
4. Microcontrollers are a practical tool for controlling a mechanical system.

# Digital Electronics

## National Science Education Standards Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| **NSES Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • Systems, order, and organization | **x** | √ | √ | **x** |
| • Evidence, models, and explanation | **x** | √ | **x** | ● |
| • Change, constancy, and measurement | ● | **x** | **x** | **x** |
| • Evolution and equilibrium | ● | | | |
| • Form and function | **x** | √ | √ | **x** |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities necessary to do scientific inquiry | | √ | √ | √ |
| • Understandings about scientific inquiry | | √ | √ | √ |
| **NSES Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Structure of atoms | √ | ● | ● | |
| • Structure and properties of matter | ● | | | |
| • Chemical reactions | ● | | | |
| • Motions and forces | ● | ● | ● | |
| • Conservation of energy and increase in disorder | | | | |
| • Interactions of energy and matter | ● | | | |
| **NSES Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • The cell | | | | |
| • Molecular basis of heredity | | | | |
| • Biological evolution | | | | |
| • Interdependence of organisms | | | | |
| • Matter, energy, and organization in living systems | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| • Behavior of organisms | | | | |
| **NSES Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Energy in the earth system | | | | |
| • Geochemical cycles | | | | |
| • Origin and evolution of the earth system | | | | |
| • Origin and evolution of the universe | | | | |
| **NSES Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities of technological design | ● | √ | √ | √ |
| • Understandings about science and technology | ● | √ | √ | √ |
| **NSES Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Personal and community health | | | | |
| • Population growth | | | | |
| • Natural resources | ● | | | |
| • Environmental quality | ● | | | |
| • Natural and human-induced hazards | ● | | | |
| • Science and technology in local, national, and global challenges | ● | | √ | |
| **NSES Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Science as a human endeavor | | | **x** | |
| • Nature of scientific knowledge | | | **x** | |
| • Historical perspectives | ● | | **x** | |

Table 1. Comparison of National Science Education Standards (NSES) and PLTW – Digital Electronics™.

Source: National Research Council (NRC) *National Science Education Standards*.

PROJECT LEAD THE WAY
PLTW

# Digital Electronics

## Standards for Technological Literacy Matrix

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | **x** | **x** | ● | ● |
| | **K.** The rate of technological development and diffusion is increasing rapidly. | √ | ● | ● | ● |
| | **L.** Inventions and innovations are the results of specific, goal-directed research. | ● | ● | ● | ● |
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | | ● | | |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | ● | **x** | **x** | **x** |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | **x** | ● | ● | |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | √ | √ | √ | √ |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | | **x** | **x** | |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | **x** | √ | √ | √ |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | ● | √ | √ | ● |
| | **CC.** New technologies create new processes. | **x** | **x** | **x** | ● |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | **x** | ● | ● |

| | | | | | |
|---|---|---|---|---|---|
| | **EE.** Management is the process of planning, organizing, and controlling work. | | | | |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | X | **X** | **X** | |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | ● | ● | **X** | **X** |
| | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | **X** | ● | ● | ● |
| | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | | | | |
| | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | **X** | ● | **X** | **X** |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | |
| **9-12** | **H.** Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | ● | | | |
| | **I.** Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | ● | ● | ● | |
| | **J.** Ethical considerations are important in the development, selection, and use of technologies. | ● | ● | ● | |
| | **K.** The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | | | | |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | | | |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | ● | ● | ● | ● |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | | | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | | | | |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | ● | ● | ● | ● |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | values. | | | | |
| | **I.** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | | | |
| | **J.** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| **9-12** | **G.** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | **X** | **X** | ● | ● |
| | **H.** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. | ● | ● | ● | |
| | **I.** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | ● | | ● | |
| | **J.** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | ● | ● | ● | ● |
| | **K.** | The Iron Age was defined by the use of iron and steel as the primary materials for tools. | | | | |
| | **L.** | The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | | | |
| | **M.** | The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | | | |
| | **N.** | The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | | | |
| | **O.** | The Information Age places emphasis on the processing and exchange of information. | **X** | ● | ● | ● |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | |
| **9-12** | **H.** | The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | √ | √ | √ | √ |
| | **I.** | Design problems are seldom presented in a clearly defined form. | ● | | | ● |
| | **J.** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | ● | **X** | **X** | |
| | **K.** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | ● | ● | ● | ● |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | |
| **9-12** | **I.** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **J.** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | ● | ● | ● | |
| | **K.** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | **x** | **x** | **x** | **x** |
| | **L.** | The process of engineering design takes into account a number of factors. | √ | √ | √ | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | |
| **9-12** | **I.** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | | | | |
| | **J.** | Technological problems must be researched before they can be solved. | ● | ● | ● | |
| | **K.** | Not all problems are technological, and not every problem can be solved using technology. | | ● | | |
| | **L.** | Many technological problems require a multidisciplinary approach. | ● | **x** | **x** | |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | |
| **9-12** | **M.** | Identify the design problem to solve and decide whether or not to address it. | | | | |
| | **N.** | Identify criteria and constraints and determine how these will affect the design process. | ● | ● | ● | ● |
| | **O.** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | **x** | **x** | **x** | **x** |
| | **P.** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed | ● | **x** | **x** | ● |
| | **Q.** | Develop and produce a product or system using a design process. | **x** | **x** | **x** | **x** |
| | **R.** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | ● | ● | ● | ● |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | |
| **9-12** | **L.** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | √ | √ | √ | √ |
| | **M.** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | √ | √ | √ | √ |
| | **N.** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | √ | √ | √ | √ |
| | **O.** | Operate systems so that they function in the way they were designed. | √ | √ | √ | √ |
| | **P.** | Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | √ | √ | √ | √ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** Collect information and evaluate its quality. | ● | ● | | ● |
| | **K.** Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | | | |
| | **L.** Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | | |
| | **M.** Design forecasting to evaluate the results of altering natural systems. | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | |
| **9-12** | **K.** Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | |
| | **L.** Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | |
| | **M.** The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | |
| **9-12** | **K.** Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | |
| | **L.** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | |
| | **M.** Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | |
| | **N.** The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | |
| **9-12** | **J.** Energy cannot be created or destroyed; however, it can be converted from one form to another. | ● | ● | ● | ● |
| | **K.** Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | | | |
| | **L.** It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | |
| | **M.** Energy resources can be renewable or nonrenewable. | ● | | | |
| | **N.** Power systems must have a source of energy, a process, and loads. | ● | ● | ● | ● |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| use information and communication technologies. | | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | √ | √ | √ | √ |
| | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | √ | √ | √ | √ |
| | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | √ | √ | √ | √ |
| | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | √ | √ | √ | √ |
| | **P.** There are many ways to communicate information, such as graphic and electronic means. | √ | √ | √ | √ |
| | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | √ | √ | √ | √ |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | | | |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | | | |

| **STL Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** Infrastructure is the underlying base or basic framework of a system. | | | | | |
| | **K.** Structures are constructed using a variety of processes and procedures. | | | | | |
| | **L.** The design of structures includes a number of requirements. | | | | | |
| | **M.** Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | | |
| | **N.** Structures can include prefabricated materials. | | | | | |

Table 1. Comparison of Standards for Technological Literacy (STL) and Digital Electronics.
Source: International Technology Education Association's (ITEA) *Standards for Technological Literacy: Content for the Study of Technology.*

# Digital Electronics

## Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | | ● | | ● |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | ● | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | | ● | √ | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | | ● | | |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | | | | ● |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | | | | |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | **x** |

Table 1. Comparison of Standards for the English Language Arts (SELA) and Introduction to Engineering Design™
Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) *Standards for the English Language Arts*.

# Digital Electronics

## Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | √ | √ | √ | √ |
| • understand meanings of operations and how they relate to one another; | √ | √ | √ | √ |
| • compute fluently and make reasonable estimates | √ | √ | √ | √ |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions; | √ | √ | √ | **x** |
| • represent and analyze mathematical situations and structures using algebraic symbols; | √ | √ | √ | **x** |
| • use mathematical models to represent and understand quantitative relationships; | **x** | **x** | **x** | **x** |
| • analyze change in various contexts. | √ | √ | √ | **x** |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | | | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | | | |
| • apply transformations and use symmetry to analyze mathematical situations; | | | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | | | |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| grade 12 should enable all students to— | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | ● | ● | ● | ● |
| • apply appropriate techniques, tools, and formulas to determine measurements. | ● | | | ● |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | ● | ● | ● | ● |
| • select and use appropriate statistical methods to analyze data; | **x** | **x** | ● | **x** |
| • develop and evaluate inferences and predictions that are based on data; | ● | **x** | ● | ● |
| • understand and apply basic concepts of probability. | ● | ● | ● | **x** |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving; | √ | √ | √ | √ |
| • solve problems that arise in mathematics and in other contexts; | √ | √ | √ | √ |
| • apply and adapt a variety of appropriate strategies to solve problems; | √ | √ | √ | √ |
| • monitor and reflect on the process of mathematical problem solving. | √ | √ | √ | √ |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | |
| • make and investigate mathematical conjectures; | ● | ● | ● | ● |
| • develop and evaluate mathematical arguments and proofs; | | | | |
| • select and use various types of reasoning and methods of proof. | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication; | √ | √ | √ | **x** |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | √ | √ | √ | **x** |
| • analyze and evaluate the mathematical thinking and strategies of others; | | **x** | **x** | ● |
| • use the language of mathematics to express mathematical ideas precisely | **x** | **x** | **x** | √ |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas; | ● | ● | ● | ● |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Fundamentals of Analog and Digital Electronics | Unit 2: Combinational Logic | Unit 3: Sequential Logic | Unit 4: Microcontrollers |
|---|---|---|---|---|
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | ● | ● | ● | ● |
| • recognize and apply mathematics in contexts outside of mathematics. | √ | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | √ | √ | √ | √ |
| • select, apply, and translate among mathematical representations to solve problems; | √ | √ | √ | √ |
| • use representations to model and interpret physical, social, and mathematical phenomena. | √ | √ | √ | √ |

Table 1. Comparison of Principles and Standards for School Mathematics (PSSM) and Digital Electronics™
Source: National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics.*

# AE

# Aerospace Engineering Course Description

The major focus of the Aerospace Engineering$^{TM}$ (AE) course is to expose students to the world of aeronautics, flight, and engineering. Students will be introduced to the Project Lead The Way® activity-based, project-based, and problem-based learning through exploring the world of aerospace engineering. Students should have experience in physics, mathematics, and technology education. They will employ engineering and scientific concepts in the solution of aerospace problems. The entire curriculum sequence will include experiences from the diverse fields of Aeronautics, Aerospace Engineering$^{TM}$, and related areas of study. Lessons will engage students in engineering design problems related to aerospace information systems, astronautics, rocketry, propulsion, the physics of space science, space life sciences, the biology of space science, principles of aeronautics, structures and materials, and systems engineering.
.
The AE course is intended to serve as a specialization course within the Project Lead The Way® sequence. The course is structured to enable all students to have a variety of experiences that will provide an overview of the field. Students work in teams, exploring hands-on projects and activities to learn the characteristics of aerospace engineering and work on major problems to be exposed to the various situations that aerospace engineers face in their careers.

In addition, students use Inventor, which is a state of the art 3D design software package from AutoDesk, to help them design solutions to solve proposed problems. Students design intelligent vehicles and learn about documenting their project, solving problems, and communicating their solutions to their peers and members of the professional community.

The course of study includes:

- Overview of Aerospace Engineering$^{TM}$
- Aerodynamics and Aerodynamics Testing
- Flight Systems
- Astronautics
- Space Life Sciences
- Aerospace Materials
- Systems Engineering

# Aerospace Engineering Detailed Outline

## Unit 1: Overview of Aerospace Engineering™
## Time Days: 11 days

**Lesson 1.1: History of Flight (11 days):**

**Concepts Addressed in Lesson:**

1. Knowledge of the history of flight enables an appreciation and understanding of past engineering accomplishments to be recognized.
2. Knowledge of aerospace history provides insight to future challenges involving travel through the atmosphere and space.
3. Many types of vehicles have been designed to fly.
4. Airplanes consist of several major components each of which has a specific function in the design and operation of the airplane.
5. The forces acting on an aircraft enable it to fly.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the various vehicles used for human flight.
- Identify and explain the function of the main components of an airplane.
- Identify and explain the forces acting on an airplane.
- Evaluate and compare the effects of design changes on the performance of an airplane.
- Experience the flight characteristics of an airplane through the use of a flight simulator.

## Unit 2: Aerodynamics and Aerodynamics Testing
## Time Days: 43 days

**Lesson 2.1: Aerodynamics (19 days):**

**Concepts Addressed in Lesson:**

1. The forces applied to an airplane in flight are lift, weight, drag, and thrust.
2. Wings provide the lifting forces needed to overcome the weight of an airplane.
3. Engines provide the thrust force needed to overcome the aerodynamic drag from the body of an airplane.

4. The design of an aircraft wing requires knowledge of aerodynamics and physics.
5. The design process involves the use of computer simulation tools to predict the performance of a design prior to the building of a physical model.
6. The design process involves creating multiple solutions to a problem and then evaluating and ranking the solutions in order select the best solution.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the various forces acting on an airplane in flight.
- Identify the various factors that affect the lift and drag forces generated by an airfoil.
- Define the technical terms used to describe the geometry and performance of an airfoil.
- Analyze using a computer simulation tool the performance of an airfoil design.
- Evaluate and compare using a computer simulation several airfoil designs.
- Apply their knowledge of aerodynamics to design an airfoil that meets specifications.

**Lesson 2.2: Airfoil Construction (10 days):**

**Concepts Addressed in Lesson:**

1. Design ideas are verified by the construction and testing of prototypes and models.
2. Sub-scale models are used to represent a full size system.
3. Coordinate geometry is used to create varied shapes, such as airfoils.
4. Basic hand tools and equipment can be used to create accurate scale models.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Extract geometric data from the FoilSim applet.
- Use a spreadsheet application to scale the geometric data points extracted from FoilSim to define an airfoil with a given chord length.
- Use modeling software to design templates to be used for accurately cutting airfoil shapes from a foam core.
- Use appropriate tools and machines to safely and accurately construct an airfoil to be tested in a wind tunnel.
- Evaluate different types of readily available foam products to determine the advantages and disadvantages of each in the construction of airfoil shapes

**Lesson 2.3: Wind Tunnel Testing (14 days):**

**Concepts Addressed in Lesson:**

1. Testing prototypes is an important part of the design process.
2. Engineers use scaled models to evaluate, to test, and to determine the performance of their designs.
3. Test results are best analyzed through the use of graphs and other methods to depict the data collected during testing.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the various components of a wind tunnel.
- Identify the various instruments used to measure the lift and drag forces generated by an airfoil.
- Synthesize a test plan to measure the performance of an airfoil .
- Measure the performance of an airfoil using lab equipment.
- Analyze the performance data gathered during testing.
- Evaluate and compare several performance characteristics of the airfoil.
- Communicate their test results through a technical report and a presentation to the class.

**Optional Lesson 2.4: Introduction to Propulsion (6-12 days):**

**Concepts Addressed in Lesson:**

1. Newton's Three Laws of Motion are central to the idea of propulsion.
2. An external force is required to change the state of an object from rest to motion and from motion to rest.
3. The direction of acceleration is the same as the direction of the external force.
4. Newton's Third Law of Motion can be used to explain the production of thrust by a propulsion system.
5. The three principal propulsion systems are the propeller, the jet engine, and the rocket engine.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Learn about Newton's Three Laws of Motion and how they relate to propulsion.
- Research and investigate propulsion and propulsion systems.
- Identify the four main propulsion systems and the parts of an engine.
- Conduct a propulsion systems analysis with calculations and graphs of data of various types of airplanes and propulsion systems.
- Design an engine and test the design using Engine Simulation software.

- Optional: Design, construct, and launch a water bottle rocket and make predictions of the rocket's altitude.
- Calculate the average altitude and relate Newton's Three Laws of Motion to the height the rocket achieved.

## Unit 3: Flight Systems
## Time Days: 15 days

**Lesson 3.1: Glider Design, Construction, and Test (15 Days):**

**Concepts Addressed in Lesson:**

1. Aircraft designs are the result of the best available theories, knowledge, and skills available to the designer at the time of their creation.
2. Software utilizing the mathematics of flight theory can be used to predict the flight performance of an aircraft prior to its construction.
3. Construction of a multi-component device is aided by the use of assembly and alignment jigs.
4. Flight testing data is essential for evaluating an aircraft design.
5. Radically different designs can achieve similar results.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Describe the requirements for a glider to remain stable in flight.
- Utilize software to layout a glider that complies with characteristics provided by the instructor.
- Design a glider for maximum flight distance.
- Construct a glider that accurately represents their design.
- Summarize test data to identify the best glider design.
- Write a proposal for "phase two" funding for a revised glider design.

**Lesson 3.2: GPS and Spatial Awareness (15 Days):**

**Concepts Addressed in Lesson:**

1. Pilots need to know where they are and how to proceed to the next waypoint in their flight plan.
2. Flight safety requires spatial awareness.
3. Numerous methods have been used to communicate positional information to pilots using old, current, and cutting edge technology to improve flight safety through redundancy.
4. Global Positioning Systems use information provided by a constellation of satellites to calculate a position and motion in all three axes and through time.

5. Location and motion information is tremendously enhanced when it is correlated to 2D and 3D representations of the world around a pilot.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Gain a familiarity with the evolving technology of aerial navigation.
- Use a GPS unit to measure the location of objects.
- Summarize GPS data and create a navigational chart.
- Plan a multi-segment flight through a simulated airspace.
- Compare the ease of maintaining situational awareness using textual versus visual information when completing a “flight” through a simulated airspace.
- Explore the enhancements of the Wide Area Augmentation System (WAAS), Local Area Augmentation Systems (L.A.A.S.), and Synthetic Vision systems to the Global Positioning System.

## Unit 4: Astronautics
## Time: 38 Days

**Lesson 4.1: Measuring Rocket Engine Thrust (10 days):**

**Concepts Addressed in Lesson:**

1. Rocket thrust can be measured using a simple device.
2. Calibration of a thrust measurement device can provide accurate data.
3. Thrust vs. time data can be acquired using a strip chart recorder.
4. Rocket thrust must be controlled to reduce the damaging effects of traveling through dense atmosphere.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design and build a rocket engine thrust testing device.
- Test the thrust of a model rocket engine.
- Modify the test to provide thrust vs. time data.

**Lesson 4.2: Model Rocket Trajectory (9 Days):**

**Concepts Addressed in Lesson:**

1. Parts of a model rocket and parts of a model rocket engine have specific function(s) during a rocket's flight.
2. The forces of weight, thrust, drag, and lift interact differently on a rocket in flight than on an aircraft in flight.
3. Newton's three laws of motion (inertia, F = ma, and action-reaction) can be used to describe and predict events during each phase of a rocket launch.
4. Rocket design features are interrelated and determine how well a rocket will perform during powered flight.
5. The maximum velocity and maximum acceleration of a rocket during flight can be calculated mathematically given model rocket and engine performance data.
6. A rocket's maximum altitude can be calculated by using indirect measurement.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Define the terms and concepts of the design, flight, and forces on a model rocket and be able to explain how they interaction.
- Investigate how changes in various design characteristics of a model rocket will affect the model rocket's flight performance.
- Work as an engineering team to construct a model rocket from a kit, fly it safely, and make predications, observations, and comparisons of flight data.
- Use trigonometry to calculate an estimate for the maximum altitude a model rocket obtains during a launch.
- Calculate a rocket's maximum velocity and maximum acceleration given rocket data and rocket engine performance specifications.

**Lesson 4.3: Rocket Camera (12 Days)**

**Concepts Addressed in Lesson:**

1. The Internet and the library are useful tools for conducting research.
2. Aerial photography has many applications.
3. Using the scientific method to design a project to answer a research question is an important skill to conducting a scientific/engineering investigation.
4. Formulating a research question based on research, gathering data, analyzing data, and making judgments about experimental data are vital processes for conducting a research project/an investigation.
5. The scale factor of aerial photographs can be used to determine a rocket's altitude, number, and kind of objects in the photograph, and the dimension of objects in the photographs.
6. Aerial photographs can be used to identify, classify, and enumerate objects in the photograph.
7. A rocket's launch angle affects the forces of lift, thrust, weight, and drag.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use the Internet and the library to conduct research on the importance of aerial photography.
- Demonstrate an understanding of the scientific method by formulating a testable research question, and designing and conducting an aerial photography project/experiment.
- Calculate the scale factor of aerial photographs, and use the scale factor to determine the rocket's altitude when the photography was taken, and determine the length of objects in the photographs using the photograph's scale factor.
- Describe how the launch angle relates to or affects the forces of lift, thrust, weight, and drag.

**Lesson 4.4: Orbital Mechanics (7 Days):**

**Concepts Addressed in Lesson:**

1. Ellipses are conic sections, and circles are special cases of ellipses.
2. Orbits involve the steady procession of a small mass object around a large mass object. This includes planets processing around the sun, as well as satellites processing around a planet.
3. Objects in orbit are continuously "falling" toward the body about around which they orbit.
4. Orbital elements can be used to fully define a satellite's orbit, allowing the accurate prediction of the precise location of the satellite at a given time.
5. Orbital mechanics provides a means for describing orbital behavior of bodies.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Be able to define conic sections.
- Learn about historical figures in orbit theory.
- Observe basic orbit theory through a laboratory exercise.
- Learn about satellite motion and the application of orbit parameters by observing actual earth satellite motion.

## Unit 5: Space Life Sciences
## Time: 32 Days

**Lesson 5.1: Life Support and Environmental Systems (10 Days):**

**Concepts Addressed in Lesson:**

1. Basic physiological needs of the human body when living safely within and outside of Earth's atmosphere are oxygen, pressure, food and water, sleep, gravity, temperature, protective clothing, voiding by bladder and bowel.
2. The environment on earth and in space must be considered when designing solutions to problems in aerospace engineering.
3. Engineers have solved many technological challenges faced when designing solutions for living higher atmospheres and space.
4. The force, mass, and acceleration phenomena or G-forces that astronauts, fighter pilots, and Formula One drivers might experience is because of the rocket, jet, or internal combustion engine that provides the force needed to accelerate them, not gravity.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Work cooperatively in a team to design and conduct experiments related to positive g-force.
- Safely conduct experiments and collect data.
- Analyze the results of experiments through careful observation of experiment videotape.
- Synthesize the data and apply experimental conclusions to real-world situations.

**Lesson 5.2: Effect of Gravity on the Human Body (7 Days):**

Concepts Addressed in Lesson:

1. Reduced gravity environments can be simulated in a 1-g, Earth-normal, environment.
2. The action of spinning can fool the senses and stimulate the vestibular system in the inner ear.
3. An increase stress-filled environment is physically unique and can affect the ability to perform mental functions.
4. Cooperative and supportive team behaviors result in increased safety and higher quality data.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Experience the feeling of vestibular stimulation.

- Acquire data such as pulse rate and response time during stress tests performed in a reduced gravity environment.
- Analyze data and draw conclusions regarding the effects of reduced gravity and vestibular stimulation on the human body.
- Research the effects gravity has on the body both in space and on earth.

**Lesson 5.3: Microgravity Drop Tower (15 days):**

**Concepts Addressed in Lesson:**

1. Gravity is the weakest force known in nature, yet it holds galaxies and the solar system together.
2. Any object in freefall experiences microgravity conditions, which occur when the object falls toward the Earth with an acceleration equal to that due to gravity alone (approximately 9.8 meters per second squared [m/s2], or 1 g at Earth's surface).
3. Brief periods of microgravity can be achieved on Earth by dropping objects from tall structures.
4. The microgravity environment associated with the space shuttle is a result of the spacecraft being in orbit, which is a state of continuous freefall around the Earth.
5. A microgravity environment gives researchers a unique opportunity to isolate and study the influence of gravity on physical processes, as well as phenomena that are normally masked by gravity and thus difficult, if not impossible, to study on Earth.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Show and describe the videotape of drop experiment.
- Evaluate the results of the drop experiment with regard to anticipated outcomes.
- Describe recommendations for modifying the experiment.
- Keep a journal, including a daily entry that explains what was done, what needs to be done and their results.

## Unit 6: Aerospace Materials
## Time: 15 days

**Lesson 6.1 Composites Fabrication and Testing (5 days)**

**Concepts Addressed in Lesson:**

1. Multiple layers of any material are stronger than a single layer of that material.
2. Composite materials are fabricated by molding together layers of reinforced fabric, such as often glass or carbon fiber with a plastic matrix, such as epoxy.
3. Composite materials are used in the aerospace industry because they have excellent strength to weight ratios, which means they are able to carry large loads with a lighter structure.
4. The strength and stiffness of composite materials can be significantly increased by altering the distance between adjacent sheets using a core material to create a sandwich construction.
5. Material performance is sometimes assessed by comparing strength to weight ratios.
6. A deflection test can be used to accurately determine the modulus of elasticity of a composite plastic sample.
7. A deflection test can be used to indicate the stiffness of various composite plastic samples.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Mold various composite materials into the standard size 1” x 12” test sample.
- Build a test jig to test each composite sample for deflection.
- Conduct experiments and record data on the deflection of various composite samples using a micrometer and a dial indicator.
- Analyze and graph the results of the deflection experiments.

**Lesson 6.2: Thermal Protection Systems for Space Vehicles (10 Days)**

**Concepts Addressed in Lesson:**

1. An understanding of the physics of space vehicle re-entry into the atmosphere is important for designing thermal protection systems.
2. Knowledge of material properties and testing is essential when trying to protect a space vehicle.
3. Heat transfer is a process that creates high temperatures in a space vehicle.
4. Energy is dissipated and converted into heat during a space vehicle re-entry.
5. Thermal Protection Systems (TPS) consist of various materials and coatings that are designed to protect a space vehicle.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the material properties that are necessary for an effective Thermal Protection Systems (TPS).
- Describe the process of a space vehicle re-entry and the temperature extremes that a space vehicle may be subjected to.
- Determine the thermal protection capability of several materials through tests of materials and related research.
- Evaluate and compare the thermal test results of several materials.
- Apply their knowledge of material properties to select the best candidate materials for use in a thermal protection system.

## Unit 7: Systems Engineering
## Time: 20 Days

**Lesson 7.1: Intelligent Vehicles (20 Days):**

**Concepts Addressed in Lesson:**

1. The two incentives for building robots are social, replacing humans in undesirable or dangerous jobs, and economic, reducing the cost of manufacturing while improving its quality.
2. Interactive systems are used in complicated arenas, such as science exploration.
3. Electronic data communication allows information to be transferred from human to human, human to machine, machine to human, and machine-to-machine.
4. The determination of the pH (potential of Hydrogen) of an unknown substance or substances aids in identifying the substance.
5. Robotic devices must be designed to perform effectively in the environment in which they will be used.
6. Robotic devices are composed of mechanical, electrical, and computer based systems that can be programmed to make decisions and control actions based upon sensor readings.
7. The fundamental challenge when working in robotics is deciding what motions the robot should perform in order to achieve a goal.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design a computer driven system for a robot to perform a series of predetermined functions without having anything impede its progress while successfully delivering a payload to a predetermined location.
- Develop a rubric that will be used to assess the design-build-operate criteria of the robot.
- Design, build, and test an intelligent vehicle that will meet criteria determined by the goals established by the students.

# National Science Education Standards Matrix Grades 9-12

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 – Overview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes:** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | **X** | √ | √ | √ | √ | √ | √ |
| • Systems, order, and organization | | √ | √ | √ | √ | √ | √ |
| • Evidence, models, and explanation | √ | √ | √ | √ | √ | √ | √ |
| • Change, constancy, and measurement | | √ | √ | √ | √ | √ | √ |
| • Evolution and equilibrium | | | | | | | |
| • Form and function | | √ | √ | √ | √ | √ | √ |
| ***NSES* Content Standard A Science As Inquiry:** As a result of activities in grades 9-12, all students should develop— | √ | √ | √ | √ | √ | √ | √ |
| • Abilities necessary to do scientific inquiry | √ | √ | √ | √ | √ | √ | √ |
| • Understandings about scientific inquiry | √ | √ | √ | √ | √ | √ | √ |
| ***NSES* Content Standard B Physical Science:** As a result of activities in grades 9-12, all students should develop an understanding of— | | √ | √ | | | √ | |
| • Structure of atoms | | | | | | | |
| • Structure and properties of matter | | √ | | | | √ | |
| • Chemical reactions | | √ | | | | √ | |
| • Motions and forces | √ | √ | √ | √ | √ | √ | √ |
| • Conservation of energy and increase in disorder | | √ | | | | √ | |
| • Interactions of energy and matter | | √ | | | | √ | |
| ***NSES* Content Standard C Life Science:** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | **X** | | |
| • The cell | | | | | | | |
| • Molecular basis of heredity | | | | | | | |
| • Biological evolution | | | | | | | |
| • Interdependence of organisms | | | | | √ | | |
| • Matter, energy, and organization in living systems | | | | | √ | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 – Overview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| • Behavior of organisms | | | | | √ | | |
| ***NSES* Content Standard D Earth and Space Science:** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | |
| • Energy in the earth system | | | | | | | |
| • Geochemical cycles | | | | | | | |
| • Origin and evolution of the earth system | | | | | | | |
| • Origin and evolution of the universe | | | | | | | |
| ***NSES* Content Standard E Science and Technology:** As a result of activities in grades 9-12, all students should develop— | √ | √ | √ | √ | √ | √ | √ |
| • Abilities of technological design | √ | √ | √ | √ | √ | √ | √ |
| • Understandings about science and technology | √ | √ | √ | √ | √ | √ | √ |
| ***NSES* Content Standard F Science in Personal and Social Perspectives:** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | √ | | |
| • Personal and community health | | | | | √ | | |
| • Population growth | | | | | | | |
| • Natural resources | | | | | | | |
| • Environmental quality | | | | | | | |
| • Natural and human-induced hazards | | | | | √ | | |
| • Science and technology in local, national, and global challenges | ● | | | | √ | | ● |
| ***NSES* Content Standard G History and Nature of Science:** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | | |
| • Science as a human endeavor | **X** | | | | **X** | | **X** |
| • Nature of scientific knowledge | | | | | | | |
| • Historical perspectives | **X** | | | | **X** | | **X** |

**Table 1.** Comparison of *National Science Education Standards* (*NSES*) and **PLTW – Aerospace Engineering**.

Source: National Research Council (NRC) ***National Science Education Standards***.

# Standards for Technological Literacy Matrix

| Grade | Key / Standard | Unit 1 – Ovwerview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | | | | | | |
| | ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | **X** | **X** | **X** | ● | ● | ● |
| K-2 | **A.** The natural world and human-made world are different. | | | | | | | |
| K-2 | **B.** All people use tools and techniques to help them do things. | | | | | | | |
| 3-5 | **C.** Things that are found in nature differ from things that are human-made in how they are produced and used. | | | | | | | |
| 3-5 | **D.** Tools, materials, and skills are used to make things and carry out tasks. | | √ | | | | | |
| 3-5 | **E.** Creative thinking and economic and cultural influences shape technological development. | | | | | | | |
| 6-8 | **F.** New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. | | | | **X** | | | |
| 6-8 | **G.** The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative. | | | | | | | |
| 6-8 | **H.** Technology is closely linked to creativity, which has resulted in innovation. | | | **X** | **X** | | | |
| 6-8 | **I.** Corporations can often create demand for a product by bringing it onto the market and advertising it. | | | | | | | |
| 9-12 | **J.** The nature and development of technological knowledge and processes are functions of the setting. | | | | **X** | | | ● |
| 9-12 | **K.** The rate of technological development and diffusion is increasing rapidly. | | | | | | | ● |
| 9-12 | **L.** Inventions and innovations are the results of specific, goal-directed research. | ● | | ● | **X** | ● | ● | **X** |
| 9-12 | **M.** Most development of technologies these days is | | | | ● | ● | ● | ● |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 – Ovwerview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | driven by the profit motive and the market. | | | | | | | |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | | **X** | | |
| **K-2** | **A.** Some systems are found in nature, and some are made by humans. | | • | • | • | | | |
| | **B.** Systems have parts or components that work together to accomplish a goal. | | | **X** | **X** | | | **X** |
| | **C.** Tools are simple objects that help humans complete tasks. | | • | | | | | |
| | **D.** Different materials are used in making things. | | | | | | **X** | |
| | **E.** People plan in order to get things done. | | | | | | | |
| **3-5** | **F.** A subsystem is a system that operates as a part of another system. | | | **X** | • | | | **X** |
| | **G.** When parts of a system are missing, it may not work as planned. | | | **X** | • | | | **X** |
| | **H.** Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. | | | **X** | • | | | **X** |
| | **I.** Tools are used to design, make, use, and assess technology. | | • | | | | | • |
| | **J.** Materials have many different properties. | | | | | | √ | |
| | **K.** Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing. | | • | | | | | |
| | **L.** Requirements are the limits to designing or making a product or system. | | • | | | | | |
| **6-8** | **M.** Technological systems include input, processes, output, and, at times, feedback. | | | **X** | | • | | **X** |
| | **N.** Systems thinking involves considering how every part relates to others. | | | **X** | | • | | **X** |
| | **O.** An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. | | | • | | • | | **X** |
| | **P.** Technological systems can be connected to one another. | | | • | | • | | **X** |
| | **Q.** Malfunctions of any part of a system may affect the function and quality of the system. | | | **X** | | • | | **X** |
| | **R.** Requirements are the parameters placed on the development of a product or system. | | **X** | | | • | | |
| | **S.** Trade-off is a decision process recognizing the need for careful compromises among competing factors. | | • | **X** | | • | | **X** |
| | **T.** Different technologies involve different sets of processes. | | | | | | | |
| | **U.** Maintenance is the process of inspecting and servicing a product or system on a regular basis in | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 – Ovwerview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | order for it to continue functioning properly, to extend its life, or to upgrade its capability. | | | | | | | |
| | **V.** Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. | | | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | | | √ | | √ | | **X** |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | | | √ | | √ | | **X** |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | | | √ | | √ | | √ |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | | | | | | | |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | | **X** | | | | | **X** |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | | | | | | ● | **X** |
| | **CC.** New technologies create new processes. | | | **X** | | √ | √ | |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | | | | | | ● |
| | **EE.** Management is the process of planning, organizing, and controlling work. | | | | | | | **X** |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | | | | | | | √ |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | **X** | | **X** | | | |
| **K-2** | **A.** The study of technology uses many of the same ideas and skills as other subjects. | | | | | | | |
| **3-5** | **B.** Technologies are often combined. | | | | | | | |
| | **C.** Various relationships exist between technology and other fields of study. | | | | | | | |
| **6-8** | **D.** Technological systems often interact with one another. | | | | | | | |
| | **E.** A product, system, or environment developed for one setting may be applied to another setting. | | | | √ | | | |
| | **F.** Knowledge gained from other fields of study has a direct effect on the development of technological | | √ | | √ | | | |

**Key:**
√ denotes a correlation in ideas and concepts in both standard and lessons
**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities
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| Grade | | Standard | Unit 1 – Owverview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|---|
| | | products and systems. | | | | | | | |
| 9-12 | **G.** | Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | | | | | | | |
| 9-12 | **H.** | Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | | | **X** | √ | √ | | |
| 9-12 | **I.** | Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | | | | | | | |
| 9-12 | **J.** | Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | | | | √ | √ | | |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | | | √ | | |
| K-2 | **A.** | The use of tools and machines can be helpful or harmful. | | | | | | | |
| 3-5 | **B.** | When using technology, results can be good or bad. | | | | | | | |
| 3-5 | **C.** | The use of technology can have unintended consequences. | | | | | | | |
| 6-8 | **D.** | The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use. | | | | | √ | | |
| 6-8 | **E.** | Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. | | | | | √ | | |
| 6-8 | **F.** | The development and use of technology poses ethical issues. | | | | | | | |
| 6-8 | **G.** | Economic, political, and cultural issues are influenced by the development and use of technology. | | | | | | | |
| 9-12 | **H.** | Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | | | | | | | |
| 9-12 | **I.** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | | | | | | | √ |
| 9-12 | **J.** | Ethical considerations are important in the development, selection, and use of technologies. | | | | | | | √ |
| 9-12 | **K.** | The transfer of a technology from one society to another can cause cultural, social, economic, and | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 – Owverview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | political changes affecting both societies to varying degrees. | | | | | | | |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | | | |
| **K-2** | **A.** Some materials can be reused and/or recycled. | | | | | | | |
| **3-5** | **B.** Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment. | | | | | | | |
| | **C.** The use of technology affects the environment in good and bad ways. | | | | | | | |
| **6-8** | **D.** The management of waste produced by technological systems is an important societal issue. | | | | | | | |
| | **E.** Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. | | | | | | | |
| | **F.** Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. | | | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | | | | | | |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | | | | | | |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | | | | | | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | | | | | | | |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | | | | | | | |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | | | | | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | | | |
| **K-2** | **A.** Products are made to meet individual needs and wants. | | | | | | | |
| **3-5** | **B.** Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes. | | | | | | | |
| | **C.** Individual, family, community, and economic | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | concerns may expand or limit the development of technologies. | | | | | | | |
| **6-8** | **D.** Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. | | | | | | | |
| | **E.** The use of inventions and innovations has led to changes in society and the creation of new needs and wants. | | | | | | | |
| | **F.** Social and cultural priorities and values are reflected in technological devices. | | | | | | | |
| | **G.** Meeting societal expectations is the driving force behind the acceptance and use of products and systems. | | | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. | | | | | | | |
| | **I.** The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | | | | | | |
| | **J.** A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | | | | | | |
| ***STL*** **Standard 7:** Students will develop an understanding of the influence of technology on history. | | **X** | | | | | | |
| **K-2** | **A.** The way people live and work has changed throughout history because of technology. | | | | | | | |
| **3-5** | **B.** People have made tools to provide food, to make clothing, and to protect themselves. | | | | | | | |
| **6-8** | **C.** Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements. | ● | | | | | | |
| | **D.** The specialization of function has been at the heart of many technological improvements. | | | | | | | |
| | **E.** The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships. | | | | | | | |
| | **F.** In the past, an invention or innovation was not usually developed with the knowledge of science. | **X** | | | | | | |
| **9-12** | **G.** Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | √ | √ | | | | | |
| | **H.** The evolution of civilization has been directly affected by, and has in turn affected, the | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | development and use of tools and materials. | | | | | | | |
| | **I.** Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | ● | | | | | | |
| | **J.** Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | √ | | | | | | |
| | **K.** The Iron Age was defined by the use of iron and steel as the primary materials for tools. | | | | | | | |
| | **L.** The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | | | | | | |
| | **M.** The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | | | | | | |
| | **N.** The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | | | | | | |
| | **O.** The Information Age places emphasis on the processing and exchange of information. | ● | | | | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | √ | √ | | | | | |
| **K-2** | **A.** Everyone can design solutions to a problem. | | **X** | | | | | |
| **K-2** | **B.** Design is a creative process. | | **X** | | | | | |
| **3-5** | **C.** The design process is a purposeful method of planning practical solutions to problems. | | **X** | | | | | |
| **3-5** | **D.** Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. | | **X** | | | | | |
| **6-8** | **E.** Design is a creative planning process that leads to useful products and systems. | **X** | **X** | | | | | |
| **6-8** | **F.** There is no perfect design. | **X** | **X** | | | | | |
| **6-8** | **G.** Requirements for a design are made up of criteria and constraints | **X** | **X** | | | | | |
| **9-12** | **H.** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | √ | √ | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | **I.** Design problems are seldom presented in a clearly defined form. | **X** | **X** | | | | | √ |
| | **J.** The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | √ | √ | √ | | | | √ |
| | **K.** Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | **X** | | | | | | |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | **X** | **X** | | | | | |
| **K-2** | **A.** The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. | | • | | | | | |
| **K-2** | **B.** Expressing ideas to others verbally and through sketches and models is an important part of the design process | | • | | | | | |
| **3-5** | **C.** The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results. | | • | | | | | |
| **3-5** | **D.** When designing an object, it is important to be creative and consider all ideas. | • | **X** | | | | | |
| **3-5** | **E.** Models are used to communicate and test design ideas and processes. | | **X** | | | | | |
| **6-8** | **F.** Design involves a set of steps, which can be performed in different sequences and repeated as needed. | | | | | | | |
| **6-8** | **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. | | **X** | | | | | |
| **6-8** | **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. | | **X** | √ | | | √ | |
| **9-12** | **I.** Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | | | √ | | | | |
| **9-12** | **J.** Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | √ | **X** | | | | | |
| **9-12** | **K.** A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | | √ | | | | | |
| **9-12** | **L.** The process of engineering design takes into account a number of factors. | **X** | | | | | √ | |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem | | | | **X** | | **X** | √ | |

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|---|---|---|---|---|---|---|---|---|
| solving. | | | | | | | | |
| **K-2** | **A.** Asking questions and making observations helps a person to figure out how things work. | ● | | | | | | |
| | **B.** All products and systems are subject to failure. Many products and systems, however, can be fixed. | ● | | | | | | |
| **3-5** | **C.** Troubleshooting is a way of finding out why something does not work so that it can be fixed. | **X** | | | | | | |
| | **D.** Invention and innovation are creative ways to turn ideas into real things. | ● | | | | | | |
| | **E.** The process of experimentation, which is common in science, can also be used to solve technological problems. | ● | | | | | | |
| **6-8** | **F.** Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. | | | | | | √ | |
| | **G.** Invention is a process of turning ideas and imagination into devices and systems. | ● | | | | | √ | |
| | **H.** Some technological problems are best solved through experimentation | **X** | | | | | √ | |
| **9-12** | **I.** Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | | | | | | | |
| | **J.** Technological problems must be researched before they can be solved. | ● | | | | | | |
| | **K.** Not all problems are technological, and not every problem can be solved using technology. | | | **X** | √ | √ | | |
| | **L.** Many technological problems require a multidisciplinary approach. | ● | | **X** | √ | √ | √ | |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | **X** | **X** | **X** | **X** | **X** | **X** |
| **K-2** | **A.** Brainstorm people's needs and wants and pick some problem that can be solved through the design process. | **X** | **X** | | | | | |
| | **B.** Build or construct an object using the design process. | | ● | | | | | |
| | **C.** Investigate how things are made and how they can be improved. | ● | | | | | | |
| **3-5** | **D.** Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem. | | | | | | | |
| | **E.** The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many. | | **X** | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | **F.** Test and evaluate the solutions for the design problem. | | | | | | | |
| | **G.** Improve the design solutions. | | | | | | | |
| **6-8** | **H.** Apply a design process to solve problems in and beyond the laboratory-classroom. | | **X** | | | | | |
| | **I.** Specify criteria and constraints for the design. | | | | | | | |
| | **J.** Make two-dimensional and three-dimensional representations of the designed solution. | | | | | | | |
| | **K.** Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. | | √ | | | | | |
| | **L.** Make a product or system and document the solution. | | √ | | | | | |
| **9-12** | **M.** Identify the design problem to solve and decide whether or not to address it. | | **X** | | | | | |
| | **N.** Identify criteria and constraints and determine how these will affect the design process. | | **X** | | | | | |
| | **O.** Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | | **X** | **X** | **X** | **X** | **X** | √ |
| | **P.** Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. | | √ | | | | √ | |
| | **Q.** Develop and produce a product or system using a design process. | | | | | | | √ |
| | **R.** Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | | **X** | **X** | **X** | **X** | | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | **X** | | | | **X** |
| **K-2** | **A.** Discover how things work. | | | | | | | |
| | **B.** Use hand tools correctly and safely and be able to name them correctly. | | | | | | | |
| | **C.** Recognize and use everyday symbols. | | | | | | | |
| **3-5** | **D.** Follow step-by-step directions to assemble a product. | | | | | | | |
| | **E.** Select and safely use tools, products, and systems for specific tasks. | | | | | | | |
| | **F.** Use computers to access and organize information. | | | | | | | |
| | **G.** Use common symbols, such as numbers and words, to communicate key ideas. | | | | | | | |
| **6-** | **H.** Use information provided in manuals, protocols, or | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| **8** | | by experienced people to see and understand how things work. | | | | | | | |
| | **I.** | Use tools, materials, and machines safely to diagnose, adjust, and repair systems. | | | | | | | |
| | **J.** | Use computers and calculators in various applications. | | | | | | | |
| | **K.** | Operate and maintain systems in order to achieve a given purpose. | | | | | | | |
| **9-12** | **L.** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | | | | | | | |
| | **M.** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | | | | | | | |
| | **N.** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | | | | | | | |
| | **O.** | Operate systems so that they function in the way they were designed. | | | | | | | |
| | **P.** | Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | | | | | | | |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | **X** | | **X** | | **X** |
| **K-2** | **A.** | Collect information about everyday products and systems by asking questions. | | | | | | | |
| | **B.** | Determine if the human use of a product or system creates positive or negative results. | | | | | | | |
| **3-5** | **C.** | Compare, contrast, and classify collected information in order to identify patterns. | | | | | | | |
| | **D.** | Investigate and assess the influence of a specific technology on the individual, family, community, and environment. | | | | | | | |
| | **E.** | Examine the trade-offs of using a product or system and decide when it could be used. | | | | | | | |
| **6-8** | **F.** | Design and use instruments to gather data. | | | | | | | |
| | **G.** | Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology. | | | | | | | |
| | **H.** | Identify trends and monitor potential consequences of technological development. | | | | | | | |
| | **I.** | Interpret and evaluate the accuracy of the information obtained and determine if it is useful. | | | | | | | |
| **9-12** | **J.** | Collect information and evaluate its quality. | | | | | | | **X** |
| | **K.** | Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on | | | √ | | √ | | **X** |

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|---|---|---|---|---|---|---|---|---|
| | the individual, society, and environment. | | | | | | | |
| | **L.** Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | √ | √ | √ | √ | |
| | **M.** Design forecasting to evaluate the results of altering natural systems. | | | | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | | | |
| **K-2** | **A.** Vaccinations protect people from getting certain diseases. | | | | | | | |
| | **B.** Medicine helps sick people get better. | | | | | | | |
| | **C.** There are many products designed specifically to help people take care of themselves. | | | | | | | |
| **3-5** | **D.** Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing. | | | | | | | |
| | **E.** Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility. | | | | | | | |
| | **F.** Many tools and devices have been designed to help provide clues about health and to provide a safe environment. | | | | | | | |
| **6-8** | **G.** Advances and innovations in medical technologies are used to improve healthcare. | | | | | | | |
| | **H.** Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety. | | | | | | | |
| | **I.** The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced. | | | | | | | |
| | **J.** Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups. | | | | | | | |
| **9-12** | **K.** Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | | | | |
| | **L.** Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | artificial intelligence, robotics, materials science, and perceptual psychology. | | | | | | | |
| | **M.** The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | | | |
| **K-2** | **A.** The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources. | | | | | | | |
| | **B.** There are many different tools necessary to control and make up the parts of an ecosystem. | | | | | | | |
| **3-5** | **C.** Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals. | | | | | | | |
| | **D.** Most agricultural waste can be recycled. | | | | | | | |
| | **E.** Many processes used in agriculture require different procedures, products, or systems. | | | | | | | |
| **6-8** | **F.** Technological advances in agriculture directly affect the time and number of people required to produce food for a large population. | | | | | | | |
| | **G.** A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals. | | | | | | | |
| | **H.** Biotechnology applies the principles of biology to create commercial products or processes. | | | | | | | |
| | **I.** Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment. | | | | | | | |
| | **J.** The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food. | | | | | | | |
| **9-12** | **K.** Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | | | | |
| | **L.** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | | | | |
| | **M.** Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | **N.** The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | | | | |
| ***STL* Standard 16:** Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | | | |
| **K-2** | **A.** Energy comes in many forms. | | | | | | | |
| | **B.** Energy should not be wasted. | | | | | | | |
| **3-5** | **C.** Energy comes in different forms. | | | | | | | |
| | **D.** Tools, machines, products, and systems use energy in order to do work. | | | | | | | |
| **6-8** | **E.** Energy is the capacity to do work. | | | | | | | |
| | **F.** Energy can be used to do work, using many processes. | | | | | | | |
| | **G.** Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done. | | | | | | | |
| | **H.** Power systems are used to drive and provide propulsion to other technological products and systems. | | | | | | | |
| | **I.** Much of the energy used in our environment is not used efficiently. | | | | | | | |
| **9-12** | **J.** Energy cannot be created or destroyed; however, it can be converted from one form to another. | | ● | ● | ● | ● | ● | ● |
| | **K.** Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | **X** | **X** | **X** | | ● | √ |
| | **L.** It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | | | | |
| | **M.** Energy resources can be renewable or nonrenewable. | | **X** | **X** | **X** | | | √ |
| | **N.** Power systems must have a source of energy, a process, and loads. | | ● | ● | ● | ● | ● | ● |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | | | | | | | | |
| **K-2** | **A.** Information is data that has been organized. | | | | | | | |
| | **B.** Technology enables people to communicate by sending and receiving information over a distance. | | | | | | | |
| | **C.** People use symbols when they communicate by technology. | | | | | | | |
| **3-5** | **D.** The processing of information through the use of technology can be used to help humans make decisions and solve problems. | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | **E.** Information can be acquired and sent through a variety of technological sources, including print and electronic media. | | | | | | | |
| | **F.** Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. | | | | | | | |
| | **G.** Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. | | | | | | | |
| **6-8** | **H.** Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. | | | | | | | |
| **6-8** | **I.** Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. | | | | | | | |
| **6-8** | **J.** The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. | | | | | | | |
| **6-8** | **K.** The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas. | | | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | | | | | |
| **9-12** | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine-to-machine. | ● | **X** | **X** | **X** | **X** | **X** | √ |
| **9-12** | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | **X** | **X** | **X** | **X** | **X** | **X** | √ |
| **9-12** | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | | | | | | |
| **9-12** | **P.** There are many ways to communicate information, such as graphic and electronic means. | | | | | | | |
| **9-12** | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | | | | | | | |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | | | |
| **K-2** | **A.** A transportation system has many parts that work together to help people travel. | | | | | | | |
| **K-2** | **B.** Vehicles move people or goods from one place to | | | | | | | |

| | | Unit 1 – Ovwerview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | another in water, air, or space and on land. | | | | | | | |
| | **C.** Transportation vehicles need to be cared for to prolong their use. | | | | | | | |
| **3-5** | **D.** The use of transportation allows people and goods to be moved from place to place. | | | | | | | |
| | **E.** A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. | | | | | | | |
| **6-8** | **F.** Transporting people and goods involves a combination of individuals and vehicles. | | | | | | | |
| | **G.** Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. | | | | | | | |
| | **H.** Governmental regulations often influence the design and operation of transportation systems. | | | | | | | |
| | **I.** Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently. | | | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | | | |
| **K-2** | **A.** Manufacturing systems produce products in quantity. | | | | | | | |
| | **B.** Manufactured products are designed. | | | | | | | |
| **3-5** | **C.** Processing systems convert natural materials into products. | | | | | | | |
| | **D.** Manufacturing processes include designing products, gathering resources, and using tools to | | | | | | | |

**Key:**
√ denotes a correlation in ideas and concepts in both standard and lessons
**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities
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| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 – Owverview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| | separate, form, and combine materials in order to produce products. | | | | | | | |
| | **E.** Manufacturing enterprises exist because of a consumption of goods. | | | | | | | |
| **6-8** | **F.** Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them. | | | | | | | |
| | **G.** Manufactured goods may be classified as durable or non-durable. | | | | | | | |
| | **H.** The manufacturing process includes the designing, development, making, and servicing of products and systems. | | | | | | | |
| | **I.** Chemical technologies are used to modify or alter chemical substances. | | | | | | | |
| | **J.** Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining. | | | | | | | |
| | **K.** Marketing a product involves informing the public about it as well as assisting in selling and distributing it. | | | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | | | | | | |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | | | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | | | | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | | | | | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | | | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | | | | | | |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | | | |
| **K-2** | **A.** People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools. | | | | | | | |
| | **B.** The type of structure determines how the parts are put together. | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**X** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 – Owwerview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|---|
| **3-5** | **C.** Modern communities are usually planned according to guidelines. | | | | | | | |
| | **D.** Structures need to be maintained. | | | | | | | |
| | **E.** Many systems are used in buildings. | | | | | | | |
| **6-8** | **F.** The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. | | | | | | | |
| | **G.** Structures rest on a foundation. | | | | | | | |
| | **H.** Some structures are temporary, while others are permanent. | | | | | | | |
| | **I.** Buildings generally contain a variety of subsystems. | | | | | | | |
| **9-12** | **J.** Infrastructure is the underlying base or basic framework of a system. | | | | | | | |
| | **K.** Structures are constructed using a variety of processes and procedures. | | | | | | | |
| | **L.** The design of structures includes a number of requirements. | | | | | | | |
| | **M.** Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | | | | |
| | **N.** Structures can include prefabricated materials. | | | | | | | |

**Table 1.** Comparison of *Standards for Technological Literacy* (*STL*) and PLTW Aerospace Engineering.

Source: International Technology Education Association's (ITEA) ***Standards for Technological Literacy: Content for the Study of Technology***.

# Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activities | Unit 1– Overview of Aerospace Engineering | Unit 2 – Aeronautics and Aeronautics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | | **x** | | | **x** | | |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | • | • | • | • | • | • | • |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | √ | √ | √ | √ | √ | √ | √ |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | √ | √ | √ | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts. | **x** | **x** | **x** | **x** | **x** | **x** | **x** |
| ***SELA* Standard 7:** Students conduct research on | √ | √ | **x** | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activities | Unit 1– Overview of Aerospace Engineering | Unit 2 – Aeronautics and Aeronautics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | √ | √ | √ | √ | √ | √ | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | **X** | **X** | **X** | **X** | **X** | **X** | **X** |

**Table 1.** Comparison of *Standards for the English Language Arts* (*SELA*) and **PLTW Aerospace Engineering**.

Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Principles and Standards for School Mathematics Matrix

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activities | Unit 1 – Overview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | |
| understand numbers, ways of representing numbers, relationships among numbers, and number systems; | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| understand meanings of operations and how they relate to one another; | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| compute fluently and make reasonable estimates | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| ***PSSM* Algebra Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| understand patterns, relations, and functions; | | | | | | | |
| represent and analyze mathematical situations and structures using algebraic symbols; | | | | | | | |
| use mathematical models to represent and understand quantitative relationships; | | | | | | | |
| analyze change in various contexts. | | | | | | | |
| ***PSSM* Geometry Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | | | | | | |
| specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | | | | | | |
| apply transformations and use symmetry to analyze mathematical situations; | | | | | | | |
| use visualization, spatial reasoning, and geometric modeling to solve problems. | | | | | | | |
| ***PSSM* Measurement Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | √ | √ | √ | √ | √ | √ | √ |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activities | Unit 1 – Overview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| understand measurable attributes of objects and the units, systems, and processes of measurement; | √ | √ | √ | √ | √ | √ | √ |
| apply appropriate techniques, tools, and formulas to determine measurements. | √ | √ | √ | √ | √ | √ | √ |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | √ | √ | √ | √ | √ | √ |
| formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | | √ | √ | √ | √ | √ | √ |
| select and use appropriate statistical methods to analyze data; | | √ | √ | √ | √ | √ | √ |
| develop and evaluate inferences and predictions that are based on data; | | √ | √ | √ | √ | √ | √ |
| understand and apply basic concepts of probability. | | | | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | |
| build new mathematical knowledge through problem solving; | | | | | | | |
| solve problems that arise in mathematics and in other contexts; | **X** | **X** | **X** | **X** | **X** | **X** | **X** |
| apply and adapt a variety of appropriate strategies to solve problems; | | | | | | | |
| monitor and reflect on the process of mathematical problem solving. | | | | | | | |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | |
| recognize reasoning and proof as fundamental aspects of mathematics; | | | | | | | |
| make and investigate mathematical conjectures; | | | | | | | |
| develop and evaluate mathematical arguments and proofs; | | | | | | | |
| select and use various types of reasoning and methods of proof. | | | | | | | |
| ***PSSM* Communication Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | √ | √ | √ | √ | √ | √ | √ |
| organize and consolidate their mathematical thinking through communication; | √ | √ | √ | √ | √ | √ | √ |
| communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | √ | √ | √ | √ | √ | √ | √ |
| analyze and evaluate the mathematical thinking and strategies of others; | √ | √ | √ | √ | √ | √ | √ |
| use the language of mathematics to express mathematical ideas precisely | √ | √ | √ | √ | √ | √ | √ |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activities | Unit 1 – Overview of Aerospace Engineering | Unit 2 – Aerodynamics and Aerodynamics Testing | Unit 3 – Flight Systems | Unit 4 – Astronautics | Unit 5 – Space Life Sciences | Unit 6 – Aerospace Materials | Unit 7 – Systems Engineering |
|---|---|---|---|---|---|---|---|
| ***PSSM* Connections Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | |
| recognize and use connections among mathematical ideas; | | | | | | | |
| understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | | | | | | | |
| recognize and apply mathematics in contexts outside of mathematics. | | | | | | | |
| ***PSSM* Representation Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | |
| create and use representations to organize, record, and communicate mathematical ideas; | √ | √ | √ | √ | √ | √ | √ |
| select, apply, and translate among mathematical representations to solve problems; | **x** | **x** | **x** | **x** | **x** | **x** | **x** |
| use representations to model and interpret physical, social, and mathematical phenomena. | **x** | **x** | **x** | **x** | **x** | **x** | **x** |

Table 1. Comparison of Principles and Standards for School Mathematics (PSSM) and PLTW Aerospace Engineering.

Source: National Council of Teachers of Mathematics (NCTM) ***Principles and Standards for School Mathematics***.

PROJECT LEAD THE WAY PLTW

# BE

# Biotechnical Engineering (BE) Course Description

The major focus of the Biotechnical Engineering™ (BE) course is to expose students to the diverse fields of biotechnology including biomedical engineering, bio-molecular genetics, bioprocess engineering, and agricultural and environmental engineering. Lessons engage students in engineering design problems that can be accomplished in a high school setting related to biomechanics, cardiovascular engineering, genetic engineering, agricultural biotechnology, tissue engineering, biomedical devices, human interface, bioprocesses, forensics, and bio-ethics.

The BE course is a high school course that may be taken by 11th or 12th grade students as part of the Project Lead The Way® sequence of courses or as an elective. Students should have experience in biology, chemistry, mathematics, and technology education. It is a project as well as problem-based curriculum similar to all Project Lead the Way® courses. Students in this course will apply biological and engineering concepts to design materials and processes that directly measure, repair, improve, and extend living systems.

Biotechnical Engineering™ is one of the specialty courses in the Project Lead The Way® pre-engineering curriculum, which applies and concurrently develops secondary level knowledge and skills in biology, physics, technology, and mathematics.

The course of study includes:

- Safety and Documentation Review
- Introduction to Biotechnical Engineering
- Biochemical Engineering
- Environmental and Agricultural Engineering
- Biomedical

# Biotechnical Engineering Detailed Outline

**Unit 1 – Safety and Documentation Review (9 days)**

**Lesson 1.1 – Biotechnical Engineering Procedures (9 days)**

**Concepts Addressed in Lesson:**
1. Project documentation is necessary to solve complex design problems and provide accurate communication.
2. Journals are used to document communication and the entire design process.
3. It is critical that lab instruments are giving reliable results (precise) and are representative (accurate) of what they are supposed to measure.
4. Workers in a biotechnical laboratory must follow safety procedures to protect themselves and others.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Communicate ideas for designing a project using various drawing methods, sketches, graphics, or other media collected and documented.
- Amend ideas, notes, and presentations based on personal review and feedback from others and will document them.
- Describe in daily journals the advantages and disadvantages of various information-gathering techniques, communications, and design processes in the development of the project.
- Follow procedures for ensuring accuracy and precision in measuring solutions.
- Follow laboratory safety procedures.

**Unit 2 – Introduction to Biotechnical Engineering (29 days)**

**Lesson 2.1 – Biotechnical Engineering History and Industry (21 days)**

**Concepts Addressed in Lesson:**
1. Biotechnical engineering involves the application of biological and engineering concepts in order to design materials and processes that directly measure, repair, improve, and extend living systems.
2. Historically, the use of engineering concepts has aided scientists to further their knowledge of biological information and engineers by using scientific principles to enhance their design solutions.

3. The rapid rate of new biological discoveries is due in a large part to scientists' knowledge and their use of engineering concepts.
4. The fields of biotechnology are interconnectedby the common elements of living organisms.
5. There is a correlation between what is happening in the financial markets and what drives the biotechnology industry.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Conduct a Biotechnology Timeline WebQuest to gather information about the evolution of biotechnical engineering.
- Develop a scaled timeline illustrating major biotechnical engineering milestones through the use of the internet, available hard copy resources, and their individual milestone impact cards describing future biotechnical developments.
- Assess the impact of each milestone based on their research.
- Identify the fundamental concepts common to all major industries in biotechnical engineering.
- Identify and explain how biotechnical engineered products impact society.
- Predict future developments in biotechnical engineering.
- Investigate and begin to develop an understanding of the relationship between financial markets and scientific research.

**Lesson 2.2 – Lessons from Prometheus (8 days)**

**Concepts Addressed in Lesson:**
1. Technology in the life sciences cannot be studied without considering the impact of new technologies and the potential to benefit or harm living systems.
2. In order to make policy decisions regarding bioethics, it is important to understand what variables shape one's ethics and how those variables are distributed in society.
3. Due to the controversial nature of bioethical issues, they generally pose questions that have no clear-cut easy answers.
4. Bioethical issues involve questions of responsibility and obligations to others; such as, doing what is right involves reflecting on one's values, moral principles, and self-image.
5. Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects.
6. Consequences of actions need to be considered for the individual, for others, and for society as a whole.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Work individually and as a group to generate definitions of key terms to be addressed in the lesson.
- Discuss the differences between values and morals.
- Discuss the differences between morals and ethics.
- Describe the variables that shape one's ethics.
- Role-play a bioethics case study to address and personalize the different perspectives involved.
- Analyze the bioethical issues that arise when various technological advancements create new options.
- Create and test a public opinion survey on the bioethics of biotechnology.

**Unit 3 – Biochemical Engineering (30 days)**

**Lesson 3.1 – CSI Forensics: Engineers Needed (30 days)**

**Concepts Addressed in Lesson:**

1. Engineers provide the technological advances necessary for the identification and processing of DNA.
2. Advances in the techniques of DNA sequence analysis and DNA amplification has revolutionized medicine and forensic science.
3. The wealth of DNA sequence information that has recently been achieved has led to the development of a new field in biotechnology called bioinformatics.
4. The ability to rapidly perform comparative analysis pathology data and large databases of genetic information can potentially save lives and prevent human suffering.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Investigate molecular techniques that are used by bioinformaticists.
- Create a portfolio demonstrating the research and integration of forensics with engineering.
- Design and create a 3D model of a fuming chamber for lifting prints from evidence.
- Analyze the technology utilized in the field of forensics.
- Apply the skills of reverse engineering to a crime scene and solve the mystery.
- Create methods for evaluating collected evidence from a crime scene and prepare justifications for their conclusions.
- Apply their practical knowledge of genetic engineering to the design of a novel and beneficial application of the reporter gene, green fluorescent protein.
- Determine the proper techniques for isolating proteins.
- Form a start-up pharmaceutical company with an appropriate name that will attempt to produce a pharmaceutical via previous genetic engineering work followed by scaled up growth of genetically modified bacteria.
- Conduct facial reconstruction and experience the role of a forensic artist.

**Unit 4 – Environmental and Agricultural Engineering (21 days)**

**Lesson 4.1 – Grow to Go (44 days)**

**Concepts Addressed in Lesson:**

1. Whole organisms can be used as bioreactors to produce useful products instead of practicing complex synthetic approaches in the laboratory.
2. Chemostats are important tools of process engineers that require aseptic techniques and a thorough understanding of microbial metabolism.
3. Optimization of reactants or substrates is critical for efficient use of bioreactors.
4. Bioprocessing can lead to novel approaches of renewable energy.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Determine the applications of fermentation in food production and renewable energy.
- Design a method or instrumentation to be used for measuring rates of fermentation.
- Research and test different variables which affect CO2 production in yeast in order to determine the ideal conditions for fermentation.
- Design and run a yeast-powered vehicle.

**Unit 5 - Biomedical (61 days)**

**Lesson 5.1 - Biomedical Engineering (12 days)**

**Concepts Addressed in Lesson:**

1. Extensive and detailed engineering plans exist to better assist professionals at work.
2. Continued product evaluation must exist to improve equipment and meet the needs of patients.
3. Extensive communication and documentation are essential throughout the team of professionals.
4. Continued education must exist in order to advance with changes in technology.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Demonstrate the application of engineering design principles by improving upon existing hospital designs or surgical equipment designs.
- Demonstrate the application of product liability, product reliability, product reusability, and product failure.

**Lesson 5.2 - Orthopedics (30 days)**

**Concepts Addressed in Lesson:**

1. The human musculo-skeletal anatomy is the primary support system in the human body.
2. The human skeletal system has five functions that affect the quality of human life.
3. Common disorders of the human musculo-skeletal anatomy can be overcome by use of artificial orthopedic devices.
4. A variety of specialized materials can be used for joint replacement devices.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Develop a portfolio identifying anatomical joint features and movements.
- Build a joint model with the same degrees of freedom as the human counterpart.
- Design and sketch a new joint replacement and solid model approved sketches.
- Develop a materials and development cost for the joint design and surgical implant.
- Synthesize skeletal system concepts with the design process for engineering joints.

**Lesson 5.3 – Cardiovascular Devices and Imaging (19 days)**

**Concepts Addressed in Lesson:**

1. Normal cardiac function can be accurately measured and abnormal cardiac functions can be diagnosed using a medical tool called an ECG.
2. Some cardiac defects can be corrected using prosthetic devices such as heart valves or stents.
3. The heart is an electrical as well as a mechanical organ which produces electrical fields that can be measured.
4. Electrical signals correspond to the cardiac cycle.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Research heart diseases and disorders.
- Sketch and provide a solid model of heart chambers and valves.
- Research procedures involving artificial heart surgery and present the cost of a proposed noninvasive implant.
- Research and create a set of improvements for imaging techniques.
- Design a portable ECG monitor and study the electrical aspects associated with the heart.
- Research and design improvements in heart implants or instruments.
- Perform a virtual heart surgery to better understand the instruments and implants in need of improving.

**Total days: 173 Days**

# Biotechnical Engineering National Science Education Standards Grades 9-12 Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | | |
| • Systems, order, and organization | | | | **x** | **x** |
| • Evidence, models, and explanation | | √ | √ | √ | √ |
| • Change, constancy, and measurement | • | • | **x** | **x** | **x** |
| • Evolution and equilibrium | | | | | |
| • Form and function | | | **x** | **x** | **x** |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | | |
| • Abilities necessary to do scientific inquiry | | **x** | **x** | **x** | **x** |
| • Understandings about scientific inquiry | | • | • | • | • |
| ***NSES* Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | |
| • Structure of atoms | | | **x** | | |
| • Structure and properties of matter | | | **x** | **x** | √ |
| • Chemical reactions | | | | **x** | |
| • Motions and forces | | | | **x** | √ |
| • Conservation of energy and increase in disorder | | | | **x** | |
| • Interactions of energy and matter | | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | |
| • The cell | | | • | | • |
| • Molecular basis of heredity | | | √ | | • |
| • Biological evolution | | | | | |
| • Interdependence of organisms | | **x** | • | • | |
| • Matter, energy, and organization in living systems | | **x** | • | • | • |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|
| • Behavior of organisms | | | | | |
| ***NSES* Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | |
| • Energy in the earth system | | | | | |
| • Geochemical cycles | | | | | |
| • Origin and evolution of the earth system | | | | | |
| • Origin and evolution of the universe | | | | | |
| ***NSES* Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | | |
| • Abilities of technological design | | √ | √ | √ | √ |
| • Understandings about science and technology | | √ | √ | √ | √ |
| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | |
| • Personal and community health | | | | **x** | • |
| • Population growth | | | | **x** | |
| • Natural resources | | | | **x** | |
| • Environmental quality | | | | **x** | |
| • Natural and human-induced hazards | | | | **x** | |
| • Science and technology in local, national, and global challenges | | | | **x** | |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | |
| • Science as a human endeavor | | √ | | | |
| • Nature of scientific knowledge | | √ | | | |
| • Historical perspectives | | √ | | | |

**Table 1.** Comparison of *National Science Education Standards (NSES)* and Project Lead The Way® Biotechnical Engineering™.

Source: National Research Council (NRC) ***National Science Education Standards***.

# Biotechnical Engineering Standards for Technological Literacy Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | | |
| **K-2** | **A.** The natural world and human-made world are different. | | | | | |
| | **B.** All people use tools and techniques to help them do things. | | | | | |
| **3-5** | **C.** Things that are found in nature differ from things that are human-made in how they are produced and used. | | | | | |
| | **D.** Tools, materials, and skills are used to make things and carry out tasks. | | | | | |
| | **E.** Creative thinking and economic and cultural influences shape technological development. | | | | | |
| **6-8** | **F.** New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. | | | | | |
| | **G.** The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative. | | | | | |
| | **H.** Technology is closely linked to creativity, which has resulted in innovation. | | | | | |
| | **I.** Corporations can often create demand for a product by bringing it onto the market and advertising it. | | | | | |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | | **x** | **x** | **x** | **x** |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **K.** The rate of technological development and diffusion is increasing rapidly. | | **x** | **x** | **x** | **x** |
| | **L.** Inventions and innovations are the results of specific, goal-directed research. | | **x** | **x** | **x** | **x** |
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | | | | | |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | | |
| **K-2** | **A.** Some systems are found in nature, and some are made by humans. | | | | | |
| | **B.** Systems have parts or components that work together to accomplish a goal. | | | | | |
| | **C.** Tools are simple objects that help humans complete tasks. | | | | | |
| | **D.** Different materials are used in making things. | | | | | |
| | **E.** People plan in order to get things done. | | | | | |
| **3-5** | **F.** A subsystem is a system that operates as a part of another system. | | | | | |
| | **G.** When parts of a system are missing, it may not work as planned. | | | | | |
| | **H.** Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. | | | | | |
| | **I.** Tools are used to design, make, use, and assess technology. | | | | | |
| | **J.** Materials have many different properties. | | | | | |
| | **K.** Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing. | | | | | |
| | **L.** Requirements are the limits to designing or making a product or system. | | | | | |
| **6-8** | **M.** Technological systems include input, processes, output, and, at times, feedback. | | | | | |
| | **N.** Systems thinking involves considering how every part relates to others. | | | | | |
| | **O.** An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **P.** Technological systems can be connected to one another. | | | | | |
| | **Q.** Malfunctions of any part of a system may affect the function and quality of the system. | | | | | |
| | **R.** Requirements are the parameters placed on the development of a product or system. | | | | | |
| | **S.** Trade-off is a decision process recognizing the need for careful compromises among competing factors. | | | | | |
| | **T.** Different technologies involve different sets of processes. | | | | | |
| | **U.** Maintenance is the process of inspecting and servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability. | | | | | |
| | **V.** Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | | | √ | √ | √ |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | | **x** | **x** | **x** | **x** |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | | | | | |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | | √ | **x** | **x** | **x** |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | | | √ | √ | √ |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | | | √ | √ | √ |
| | **CC.** New technologies create new processes. | | √ | √ | √ | √ |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | | | | |
| | **EE.** Management is the process of planning, organizing, and controlling work. | | **x** | **x** | **x** | **x** |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | | | | | |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | **x** | **x** | **x** | **x** |
| **K-2** | **A.** The study of technology uses many of the same ideas and skills as other subjects. | | | | | |
| **3-5** | **B.** Technologies are often combined. | | | | | |
| | **C.** Various relationships exist between technology and other fields of study. | | | | | |
| **6-8** | **D.** Technological systems often interact with one another. | | | | | |
| | **E.** A product, system, or environment developed for one setting may be applied to another setting. | | | | | |
| | **F.** Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. | | | | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | | | | | |
| | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | | √ | | | |
| | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | **x** | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | | √ | | | |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | | |
| **K-2** | **A.** The use of tools and machines can be helpful or harmful. | | | | | |
| **3-5** | **B.** When using technology, results can be good or bad. | | | | | |
| | **C.** The use of technology can have unintended consequences. | | | | | |
| **6-8** | **D.** The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use. | | | | | |
| | **E.** Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. | | | | | |
| | **F.** The development and use of technology poses ethical issues. | | | | | |
| | **G.** Economic, political, and cultural issues are influenced by the development and use of technology. | | | | | |
| **9-12** | **H.** Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | | √ | **x** | **x** | **x** |
| | **I.** Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | √ | | √ | √ | √ |
| | **J.** Ethical considerations are important in the development, selection, and use of technologies. | | √ | √ | √ | √ |
| | **K.** The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | | **x** | **x** | **x** | **x** |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| **K-2** | **A.** Some materials can be reused and/or recycled. | | | | | |
| **3-5** | **B.** Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment. | | | | | |
| | **C.** The use of technology affects the environment in good and bad ways. | | | | | |
| **6-8** | **D.** The management of waste produced by technological systems is an important societal issue. | | | | | |
| | **E.** Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. | | | | | |
| | **F.** Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | √ | | **x** | |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | | | √ | |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | | | √ | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | | | | √ | |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | | | √ | √ | √ |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | |
| **K-2** | **A.** Products are made to meet individual needs and wants. | | | | | |
| **3-5** | **B.** Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes. | | | | | |
| | **C.** Individual, family, community, and economic concerns may expand or limit the development of technologies. | | | | | |
| **6-8** | **D.** Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. | | | | | |
| | **E.** The use of inventions and innovations has led to changes in society and the creation of new needs and wants. | | | | | |
| | **F.** Social and cultural priorities and values are reflected in technological devices. | | | | | |
| | **G.** Meeting societal expectations is the driving force behind the acceptance and use of products and systems. | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. | | **X** | | | |
| | **I.** The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | **X** | | **X** | **X** |
| | **J.** A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | **X** | | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| **K-2** | **A.** The way people live and work has changed throughout history because of technology. | | | | | |
| **3-5** | **B.** People have made tools to provide food, to make clothing, and to protect themselves. | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| **6-8** | **C.** Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements. | | | | | |
| | **D.** The specialization of function has been at the heart of many technological improvements. | | | | | |
| | **E.** The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships. | | | | | |
| | **F.** In the past, an invention or innovation was not usually developed with the knowledge of science. | | | | | |
| **9-12** | **G.** Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | | √ | **x** | **x** | **x** |
| | **H.** The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. | | √ | • | • | • |
| | **I.** Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | | √ | | | |
| | **J.** Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | | √ | | | |
| | **K.** The Iron Age was defined by the use of iron and steel as the primary materials for tools. | | **x** | | | |
| | **L.** The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | **x** | | | |
| | **M.** The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | **x** | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **N.** The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | **x** | | | |
| | **O.** The Information Age places emphasis on the processing and exchange of information. | | **x** | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | |
| **K-2** | **A.** Everyone can design solutions to a problem. | | | | | |
| | **B.** Design is a creative process. | | | | | |
| **3-5** | **C.** The design process is a purposeful method of planning practical solutions to problems. | | | | | |
| | **D.** Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. | | | | | |
| **6-8** | **E.** Design is a creative planning process that leads to useful products and systems. | | | | | |
| | **F.** There is no perfect design. | | | | | |
| | **G.** Requirements for a design are made up of criteria and constraints | | | | | |
| **9-12** | **H.** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | √ | √ | √ | √ | √ |
| | **I.** Design problems are seldom presented in a clearly defined form. | √ | √ | √ | √ | √ |
| | **J.** The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | √ | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **K.** Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | √ | √ | √ | √ | √ |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | |
| **K-2** | **A.** The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. | | | | | |
| | **B.** Expressing ideas to others verbally and through sketches and models is an important part of the design process | | | | | |
| **3-5** | **C.** The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results. | | | | | |
| | **D.** When designing an object, it is important to be creative and consider all ideas. | | | | | |
| | **E.** Models are used to communicate and test design ideas and processes. | | | | | |
| **6-8** | **F.** Design involves a set of steps, which can be performed in different sequences and repeated as needed. | | | | | |
| | **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. | | | | | |
| | **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. | | | | | |
| **9-12** | **I.** Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | | **x** | **x** | **x** | **x** |
| | **J.** Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | | **x** | **x** | **x** | **x** |
| | **K.** A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | **x** | **x** | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **L.** The process of engineering design takes into account a number of factors. | **x** | **x** | √ | √ | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | |
| **K-2** | **A.** Asking questions and making observations helps a person to figure out how things work. | | | | | |
| | **B.** All products and systems are subject to failure. Many products and systems, however, can be fixed. | | | | | |
| **3-5** | **C.** Troubleshooting is a way of finding out why something does not work so that it can be fixed. | | | | | |
| | **D.** Invention and innovation are creative ways to turn ideas into real things. | | | | | |
| | **E.** The process of experimentation, which is common in science, can also be used to solve technological problems. | | | | | |
| **6-8** | **F.** Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. | | | | | |
| | **G.** Invention is a process of turning ideas and imagination into devices and systems. | | | | | |
| | **H.** Some technological problems are best solved through experimentation | | | | | |
| **9-12** | **I.** Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | | **x** | **x** | **x** | **x** |
| | **J.** Technological problems must be researched before they can be solved. | | √ | √ | √ | √ |
| | **K.** Not all problems are technological, and not every problem can be solved using technology. | | **x** | **x** | **x** | **x** |
| | **L.** Many technological problems require a multidisciplinary approach. | | **x** | **x** | **x** | **x** |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| **K-2** | **A.** Brainstorm people's needs and wants and pick some problem that can be solved through the design process. | | | | | |
| | **B.** Build or construct an object using the design process. | | | | | |
| | **C.** Investigate how things are made and how they can be improved. | | | | | |
| **3-5** | **D.** Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem. | | | | | |
| | **E.** The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many. | | | | | |
| | **F.** Test and evaluate the solutions for the design problem. | | | | | |
| | **G.** Improve the design solutions. | | | | | |
| **6-8** | **H.** Apply a design process to solve problems in and beyond the laboratory-classroom. | | | | | |
| | **I.** Specify criteria and constraints for the design. | | | | | |
| | **J.** Make two-dimensional and three-dimensional representations of the designed solution. | | | | | |
| | **K.** Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. | | | | | |
| | **L.** Make a product or system and document the solution. | | | | | |
| **9-12** | **M.** Identify the design problem to solve and decide whether or not to address it. | | | √ | √ | √ |
| | **N.** Identify criteria and constraints and determine how these will affect the design process. | | | √ | √ | √ |
| | **O.** Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | | | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **P.** Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. | | | √ | √ | √ |
| | **Q.** Develop and produce a product or system using a design process. | | | **x** | √ | √ |
| | **R.** Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | | | √ | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | |
| **K-2** | **A.** Discover how things work. | | | | | |
| | **B.** Use hand tools correctly and safely and be able to name them correctly. | | | | | |
| | **C.** Recognize and use everyday symbols. | | | | | |
| **3-5** | **D.** Follow step-by-step directions to assemble a product. | | | | | |
| | **E.** Select and safely use tools, products, and systems for specific tasks. | | | | | |
| | **F.** Use computers to access and organize information. | | | | | |
| | **G.** Use common symbols, such as numbers and words, to communicate key ideas. | | | | | |
| **6-8** | **H.** Use information provided in manuals, protocols, or by experienced people to see and understand how things work. | | | | | |
| | **I.** Use tools, materials, and machines safely to diagnose, adjust, and repair systems. | | | | | |
| | **J.** Use computers and calculators in various applications. | | | | | |
| | **K.** Operate and maintain systems in order to achieve a given purpose. | | | | | |
| **9-12** | **L.** Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | √ | | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **M.** Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | | | **x** | **x** | **x** |
| | **N.** Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | √ | | **x** | **x** | √ |
| | **O.** Operate systems so that they function in the way they were designed. | | | **x** | **x** | √ |
| | **P.** Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | √ | √ | √ | √ | √ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | |
| **K-2** | **A.** Collect information about everyday products and systems by asking questions. | | | | | |
| | **B.** Determine if the human use of a product or system creates positive or negative results. | | | | | |
| **3-5** | **C.** Compare, contrast, and classify collected information in order to identify patterns. | | | | | |
| | **D.** Investigate and assess the influence of a specific technology on the individual, family, community, and environment. | | | | | |
| | **E.** Examine the trade-offs of using a product or system and decide when it could be used. | | | | | |
| **6-8** | **F.** Design and use instruments to gather data. | | | | | |
| | **G.** Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology. | | | | | |
| | **H.** Identify trends and monitor potential consequences of technological development. | | | | | |
| | **I.** Interpret and evaluate the accuracy of the information obtained and determine if it is useful. | | | | | |
| **9-12** | **J.** Collect information and evaluate its quality. | √ | | √ | √ | √ |
| | **K.** Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | √ | √ | √ | √ |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **L.** Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | **x** | **x** | √ | √ |
| | **M.** Design forecasting to evaluate the results of altering natural systems. | | | | • | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | |
| **K-2** | **A.** Vaccinations protect people from getting certain diseases. | | | | | |
| | **B.** Medicine helps sick people get better. | | | | | |
| | **C.** There are many products designed specifically to help people take care of themselves. | | | | | |
| **3-5** | **D.** Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing. | | | | | |
| | **E.** Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility. | | | | | |
| | **F.** Many tools and devices have been designed to help provide clues about health and to provide a safe environment. | | | | | |
| **6-8** | **G.** Advances and innovations in medical technologies are used to improve healthcare. | | | | | |
| | **H.** Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety. | | | | | |
| | **I.** The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced. | | | | | |
| | **J.** Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| **9-12** | **K.** Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | √ | | • | √ |
| | **L.** Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | • | • | • | • |
| | **M.** The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | √ | **x** | **x** | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | |
| **K-2** | **A.** The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources. | | | | | |
| | **B.** There are many different tools necessary to control and make up the parts of an ecosystem. | | | | | |
| **3-5** | **C.** Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals. | | | | | |
| | **D.** Most agricultural waste can be recycled. | | | | | |
| | **E.** Many processes used in agriculture require different procedures, products, or systems. | | | | | |
| **6-8** | **F.** Technological advances in agriculture directly affect the time and number of people required to produce food for a large population. | | | | | |
| | **G.** A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **H.** Biotechnology applies the principles of biology to create commercial products or processes. | | | | | |
| | **I.** Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment. | | | | | |
| | **J.** The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food. | | | | | |
| **9-12** | **K.** Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | √ | | √ | |
| | **L.** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | √ | √ | √ | √ |
| | **M.** Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | **x** | |
| | **N.** The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | **x** | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | |
| **K-2** | **A.** Energy comes in many forms. | | | | | |
| | **B.** Energy should not be wasted. | | | | | |
| **3-5** | **C.** Energy comes in different forms. | | | | | |
| | **D.** Tools, machines, products, and systems use energy in order to do work. | | | | | |
| **6-8** | **E.** Energy is the capacity to do work. | | | | | |
| | **F.** Energy can be used to do work, using many processes. | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **G.** Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done. | | | | | |
| | **H.** Power systems are used to drive and provide propulsion to other technological products and systems. | | | | | |
| | **I.** Much of the energy used in our environment is not used efficiently. | | | | | |
| **9-12** | **J.** Energy cannot be created or destroyed; however, it can be converted from one form to another. | | | | **X** | |
| | **K.** Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | | | • | |
| | **L.** It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | • | |
| | **M.** Energy resources can be renewable or nonrenewable. | | | | • | |
| | **N.** Power systems must have a source of energy, a process, and loads. | | | | | |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | | | | | | |
| **K-2** | **A.** Information is data that has been organized. | | | | | |
| | **B.** Technology enables people to communicate by sending and receiving information over a distance. | | | | | |
| | **C.** People use symbols when they communicate by technology. | | | | | |
| **3-5** | **D.** *The processing of information through the use of technology can be used to help humans make decisions and solve problems.* | | | | | |
| | **E.** Information can be acquired and sent through a variety of technological sources, including print and electronic media. | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **F.** Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. | | | | | |
| | **G.** Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. | | | | | |
| **6-8** | **H.** Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. | | | | | |
| | **I.** Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. | | | | | |
| | **J.** The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. | | | | | |
| | **K.** The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas. | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | | | |
| | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | • | • | | | |
| | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | | • | • | • | • |
| | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | | | | |
| | **P.** There are many ways to communicate information, such as graphic and electronic means. | • | • | • | • | • |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | | • | • | • | • |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | |
| **K-2** | **A.** A transportation system has many parts that work together to help people travel. | | | | | |
| | **B.** Vehicles move people or goods from one place to another in water, air, or space and on land. | | | | | |
| | **C.** Transportation vehicles need to be cared for to prolong their use. | | | | | |
| **3-5** | **D.** The use of transportation allows people and goods to be moved from place to place. | | | | | |
| | **E.** A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. | | | | | |
| **6-8** | **F.** Transporting people and goods involves a combination of individuals and vehicles. | | | | | |
| | **G.** Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. | | | | | |
| | **H.** Governmental regulations often influence the design and operation of transportation systems. | | | | | |
| | **I.** Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently. | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | |
| **K-2** | **A.** Manufacturing systems produce products in quantity. | | | | | |
| | **B.** Manufactured products are designed. | | | | | |
| **3-5** | **C.** Processing systems convert natural materials into products. | | | | | |
| | **D.** Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products. | | | | | |
| | **E.** Manufacturing enterprises exist because of a consumption of goods. | | | | | |
| **6-8** | **F.** Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them. | | | | | |
| | **G.** Manufactured goods may be classified as durable or non-durable. | | | | | |
| | **H.** The manufacturing process includes the designing, development, making, and servicing of products and systems. | | | | | |
| | **I.** Chemical technologies are used to modify or alter chemical substances. | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| | **J.** Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining. | | | | | |
| | **K.** Marketing a product involves informing the public about it as well as assisting in selling and distributing it. | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | | | **x** | **x** |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | | | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | • | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | | | • | • |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |
| **K-2** | **A.** People live, work, and go to school in buildings, which are of different types: houses, apartments, office buildings, and schools. | | | | | |
| | **B.** The type of structure determines how the parts are put together. | | | | | |
| **3-5** | **C.** Modern communities are usually planned according to guidelines. | | | | | |
| | **D.** Structures need to be maintained. | | | | | |
| | **E.** Many systems are used in buildings. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 Safety & Documentation Review | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|---|
| **6-8** | **F.** The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. | | | | | |
| | **G.** Structures rest on a foundation. | | | | | |
| | **H.** Some structures are temporary, while others are permanent. | | | | | |
| | **I.** Buildings generally contain a variety of subsystems. | | | | | |
| **9-12** | **J.** Infrastructure is the underlying base or basic framework of a system. | | | | | |
| | **K.** Structures are constructed using a variety of processes and procedures. | | | | | |
| | **L.** The design of structures includes a number of requirements. | | | | | |
| | **M.** Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | | |
| | **N.** Structures can include prefabricated materials. | | | | | |

**Table 1.** Comparison of *Standards for Technological Literacy* (*STL*) and Project Lead The Way® Biotechnical Engineering™.

Source: International Technology Education Association's (ITEA) **http://www.iteaconnect.org**

# Biotechnical Engineering Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Envrion. & Ag.Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and nonprint texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | • | • | • | • | • |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | | |
| ***SELA* Standard 3:** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | • | • | • | • | • |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | √ | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | | | | | |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | **x** | √ | √ | √ | √ |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | √ | √ | √ | √ | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Envrion. & Ag.Eng. | Unit 5 Biomedical |
|---|---|---|---|---|---|
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ | √ |

**Table 1.** Comparison of *Standards for the English Language Arts (SELA)* and Project Lead The Way® Biotechnical Engineering™.

Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Biotechnical Engineering Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng | Unit 5 Biomedical |
|---|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | | **x** | **x** | **x** | **x** |
| • understand meanings of operations and how they relate to one another; | | **x** | **x** | **x** | **x** |
| • compute fluently and make reasonable estimates | | **x** | **x** | **x** | **x** |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • understand patterns, relations, and functions; | | **x** | **x** | **x** | **x** |
| • represent and analyze mathematical situations and structures using algebraic symbols; | • | **x** | **x** | **x** | **x** |
| • use mathematical models to represent and understand quantitative relationships; | • | **x** | √ | √ | √ |
| • analyze change in various contexts. | | **x** | **x** | √ | √ |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | **x** | **x** | **x** | **x** |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | **x** | **x** | **x** | **x** |
| • apply transformations and use symmetry to analyze mathematical situations; | | **x** | • | • | • |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | • | • | • | • |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | √ | √ | √ | √ | √ |
| • apply appropriate techniques, tools, and formulas to determine measurements. | √ | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>• denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 Safety & Doc. Rev. | Unit 2 Introduction to BE | Unit 3 Biochemical Eng. | Unit 4 Environ. & Ag. Eng | Unit 5 Biomedical |
|---|---|---|---|---|---|
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | | | √ | √ | |
| • select and use appropriate statistical methods to analyze data; | | | √ | √ | √ |
| • develop and evaluate inferences and predictions that are based on data; | | | √ | √ | √ |
| • understand and apply basic concepts of probability. | | | **x** | √ | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • build new mathematical knowledge through problem solving; | | **x** | **x** | **x** | **x** |
| • solve problems that arise in mathematics and in other contexts; | | **x** | **x** | **x** | **x** |
| • apply and adapt a variety of appropriate strategies to solve problems; | | **x** | **x** | **x** | **x** |
| • monitor and reflect on the process of mathematical problem solving. | | **x** | **x** | **x** | **x** |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | | |
| • make and investigate mathematical conjectures; | | | | | |
| • develop and evaluate mathematical arguments and proofs; | | | | | |
| • select and use various types of reasoning and methods of proof. | | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • organize and consolidate their mathematical thinking through communication; | | √ | √ | √ | √ |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | | √ | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | | √ | √ | √ | √ |
| • use the language of mathematics to express mathematical ideas precisely | | **x** | **x** | **x** | **x** |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • recognize and use connections among mathematical ideas; | | **x** | **x** | **x** | **x** |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | | • | • | • | • |
| • recognize and apply mathematics in contexts outside of mathematics. | | √ | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | | **x** | **x** | **x** | **x** |
| • select, apply, and translate among mathematical representations to solve problems; | | | | | |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | **x** | **x** | **x** | **x** |

**Table 1.** Comparison of *Principles and Standards for School Mathematics (PSSM)* and Project Lead The Way® - Biotechnical Engineering™.

Source: National Council of Teachers of Mathematics (NCTM) **Principles and Standards for School Mathematics**.

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PLTW

# CEA

# Civil Engineering and Architecture Course Description

Civil Engineering and Architecture is the study of the design and construction of residential and commercial building projects. The course includes an introduction to many of the varied factors involved in building design and construction including building components and systems, structural design, storm water management, site design, utilities and services, cost estimation, energy efficiency, and careers in the design and construction industry.

The major focus of the CEA course is to expose students to the design and construction of residential and commercial building projects, design teams and teamwork, communication methods, engineering standards, and technical documentation.

Utilizing the activity-project-problem-based (APPB) teaching and learning pedagogy, students will analyze, design and build electronic and physical models of residential and commercial facilities. While implementing these designs students will continually hone their interpersonal skills, creative abilities and understanding of the design process.

Civil Engineering and Architecture is a high school level course that is appropriate for 10th or 11th grade students interested in careers related to civil engineering and architecture. Other than their concurrent enrollment in college preparatory mathematics and science courses, this course assumes no previous knowledge.

Civil Engineering and Architecture is one of four specialization courses in the Project Lead The Way® high school pre-engineering program. The course applies and concurrently develops secondary level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Overview of Civil Engineering and Architecture
  - History of Civil Engineering and Architecture
    - Past Civil Engineering and Architecture
    - Principles and Elements of Design
    - Architectural Styles
  - Careers in Civil Engineering and Architecture

- Residential Design
  - Building Design and Construction practices
    - Building codes
    - Building components
    - Green technology

    - Universal Design
    - 3D architectural software
    - Design and construction documentation
  - Cost Analysis
  - Energy Efficiency
  - Storm water analysis
  - Water supply
  - Plumbing
  - Electrical Systems
  - Wastewater management
  - Affordable housing design
  - Universal design

- Commercial Applications
  - Commercial Buildings
    - Building codes
    - Land Use and Development
    - Commercial building components
    - Structural design
  - Structural Design
    - Steel deck
    - Precast concrete floors
    - Steel joints
    - Structural steel beams
    - Spread footings
  - Services and Utilities
    - Energy Codes
    - Plumbing (Optional)
    - Electrical systems (Optional)
    - Heating, Ventilating and Air-Conditioning systems
    - Wastewater management
  - Site Considerations
    - Land surveying
    - Soil analysis
    - Road design (Optional)
    - Parking lot design
    - Storm water management
    - Site grading (Optional)
    - Low impact development

- Commercial Building Design
  - Commercial Building Design Project
    - Property description
    - Site discovery
    - Commercial project viability
    - Project management
  - Commercial Building Design Presentation

# Civil Engineering and Architecture Detailed and Performance Objective Outline

## Unit 1: Overview of Civil Engineering and Architecture (23 Total Days)

### Lesson 1.1: History of Civil Engineering and Architecture

**Concepts Addressed in Lesson:**

1. Many features of ancient structures are seen in modern buildings.
2. Architectural style is often an important key to understanding how a community or neighborhood has developed and the aesthetic customs that have formed over time.
3. The multiple architectural styles that have been developed throughout history are an indication of changing needs of people and society and uses for space.
4. Visual design principles and elements constitute an aesthetic vocabulary that can be used to describe buildings and may contribute to their function, location, or time period.

**Performance Objectives Addressed In Lesson:**
*It is expected that students will:*

- Connect modern structural and architectural designs to historical architectural and civil engineering achievements.
- Identify three general categories of structural systems used in historical buildings.
- Explain how historical innovations have contributed to the evolution of civil engineering and architecture.
- Identify and explain the application of principles and elements of design to architectural buildings.
- Determine architectural style through identification of building features, components, and materials.
- Create a mock-up model depicting an architectural style or feature using a variety of materials. .

### Lesson 1.2: Careers in Civil Engineering and Architecture

**Concepts Addressed in Lesson:**

1. Civil engineers and architects apply math, science, and discipline-specific skills to design and implement solutions.

2. Civil engineering and architecture careers are comprised of several specialties and offer creative job opportunities for individuals with a wide variety of backgrounds and goals.
3. Civil engineers are problem solvers involved in the design and construction of a diverse array of projects in a wide range of disciplines including structural, environmental, geotechnical, water resources, transportation, construction and urban planning.
4. Architects primarily focus on designing the interior and exterior “look and feel” of commercial and residential structures meant for human habitation.
5. An effective method for brainstorming possible solutions involves a collaboration of many stakeholders with a variety of skills coming together in an organized meeting called a charrette.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Identify the primary duties, and attributes of a civil engineer and an architect along with the traditional path for becoming a civil engineer or architect.
- Identify various specialty disciplines associated with civil engineering.
- Participate in a design charrette and recognize the value of using a charrette to develop innovative solutions to support whole building design.
- Understand the relationship among the stakeholders involved in the design and construction of a building project.

## Unit 2: Residential Design (55 Total Days)

### Lesson 2.1: Building Design and Construction

**Concepts Addressed in Lesson:**

1. Many residential structures are constructed with wood framing systems and are built using standard practices.
2. A variety of roof shapes and materials are available for residential structures to address aesthetic preferences, carry design loads, and meet environmental challenges.
3. Designers design, modify, and plan structures using 3D architectural software.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Identify typical components of a residential framing system.
- Recognize conventional residential roof designs.
- Model a common residential roof design and detail advantages and disadvantages of that style.
- Use 3D architectural software to create a small building.

**Lesson 2.2: Cost and Efficiency Analysis**

**Concepts Addressed in Lesson:**

1. The combination of concrete and rebar, called reinforced concrete, is an important component of residential foundations.
2. Accurately determining the cost and quantities for a construction project can ensure a successful building project providing a high quality structure with less material and financial waste.
3. An effective residential structure should include methods for adequate heating and cooling.
4. R-value and U-factor measurements are used to select materials that with ensure a structure is properly insulated.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Apply basic math skills to calculate the quantity and cost of concrete needed to pour the pad for a small building.
- Create a cost estimate for a small construction project, including a detailed cost break-down.
- Calculate the heat loss through one wall of a conditioned building.
- Calculate the heat loss for a building envelope with given conditions appropriate for the project.
- Apply principles of sustainable design to a small project.

**Lesson 2.3: Residential Design**

**Concepts Addressed in Lesson:**

1. Responsible designers maximize the potential of the property, minimize impact on the environment, and incorporate universal design concepts in order to create an attractive and functional space.
2. Responsible designers anticipate the needs and requirements of the users.
3. Codes are created to protect the health and safety of the public, dictate the minimum requirements that must be met in a building project, and constrain the location of structures, utilities, building construction, and landscape components placed on a site.
4. Appropriate flow rate, pressure, and water quality are necessary for effective water supply and use.
5. When utilities are not available within a reasonable distance to be economically brought on site, substitutions must be designed and constructed.
6. Utilities and systems must be properly sized to minimize cost and appropriately serve the project and the structure occupants.

7. The design of electrical and plumbing systems must be carefully integrated into the architectural and structural design of a building.
8. Careful landscape design that takes into consideration local environmental conditions can improve energy efficiency, reduce noise, reduce water usage, reduce storm water runoff, and improve the visual impact of a building project.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Apply elements of good residential design to the design of a basic house to meet the needs of a client.
- Design a home design that complies with applicable codes and requirements.
- Incorporate sustainable building principles and universal design concepts into a residential design.
- Create bubble diagrams and sketch a floor plan.
- Identify residential foundation types and choose an appropriate foundation for a residential application.
- Calculate the head loss and estimate the water pressure for a given water supply system.
- Create sketches to document a preliminary plumbing and a preliminary electrical system layout for a residence that comply with applicable codes.
- Design an appropriate sewer lateral for wastewater management for a building that complies with applicable codes.
- Create a site opportunities map and sketch a project site.
- Choose an appropriate building location on a site based on orientation and other site-specific information.
- Calculate the storm water runoff from a site before and after development.
- Document the design of a home using 3D architectural design software and construction drawings.

## Unit 3: Commercial Applications (57 Total Days)

### Lesson 3.1: Commercial Building Systems

**Concepts Addressed in Lesson:**

1. Commercial building systems differ from residential building systems in many significant ways.
2. Codes and building regulations define and constrain all aspects of building design and construction including the structure, site design, utilities, and building usage.
3. Zoning regulations are used to control land use and development.
4. Wall, roof, floor, and framing systems for commercial facilities are chosen based on many factors.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Identify applicable building codes and regulations that apply to a given development.
- Classify a building according to its use, occupancy, and construction type using the International Building Code.
- Research Land Use regulations to identify zoning designations and allowable uses of property.
- Comply with specifications, regulations, and codes during a design process.
- Compare a variety of commercial wall systems and select an appropriate system for a given commercial application based on materials, strength, aesthetics, durability, and cost.
- Compare a variety of commercial low-slope roof systems and select an appropriate system for a given commercial application based on materials, strength, durability, and cost.
- Incorporate sustainable building practices, especially a green roof, into the design of a commercial building.
- Use 3D architectural design software to incorporate revisions for the redesign of a building.
- Use 3D architectural design software to create appropriate documentation to communicate a commercial building design.
- Calculate the structural efficiency of a structure.
- Use load-span tables to design structural elements.

**Lesson 3.2: Structures**

**Concepts Addressed in Lesson:**

1. The purpose of a structure is to withstand all applied loads and forces and to transfer these forces to the Earth.
2. Structural engineering involves the critical analysis of forces and loads, the anticipated effect of these loads on a structure, and the design of structural elements to safely and efficiently resist the anticipated forces and loads.
3. Design loads are often dictated by building codes.
4. Structural design includes the determination of how structures disperse the applied loads.
5. The application of loads to a building results in resisting forces from the structure which can be predicted through the use of mathematics and physical science principles.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Identify the work of a structural engineer.

- Use building codes and other resources to calculate roof loading to a structure and select appropriate roof beams to safely carry the load.
- Analyze a simply supported beam subjected to a given loading condition to determine reaction forces, sketch shear and moment diagrams, and determine the maximum moment resulting in the beam.
- Use beam formula to calculate end reactions and the maximum moments of a simply supported beam subjected to a given loading condition.
- Use structural analysis software to create shear and moment diagrams of simply supported beams subjected to a given loading condition.
- Calculate the deflection of a simply supported beam subjected to a given loading condition.
- Use building codes and other resources to determine the required floor loading and design a structural steel floor framing system (beams and girders) for a given building occupancy.
- Identify and describe the typical usage of foundation systems commonly used in commercial construction.
- Determine the loads transferred from a steel framed structure to the ground through a foundation.
- Size a spread footing for a given loading condition.
- Check structural calculations created by others for correctness.

**Lesson 3.3: Services and Utilities**

**Concepts Addressed in Lesson:**

1. When utilities are not available within a reasonable distance to be economically brought on site, substitutions must be designed and constructed.
2. Utilities and systems must be properly sized to minimize cost and appropriately serve the project.
3. Responsible designers anticipate the needs and requirements of the users.
4. The design of mechanical systems impact the architectural and structural design of a building.
5. Energy codes are designed to conserve natural resources, reduce operating costs, protect the environment and create healthier living and working spaces. They dictate the minimum requirements for the building envelope, lighting, mechanical systems, and service water heating for commercial facilities.
6. The design of internal systems is documented with construction drawings specific to each system.

**Performance Objectives Addressed In Lesson**

*It is expected that students will:*

- Interpret and apply code requirements and constraints as they pertain to the installation of services and utilities.
- Read and understand HVAC construction drawings for a commercial project.

- Apply criteria and constraints to size and locate the new utility service connections for a commercial facility.
- Modify system designs to incorporate energy conservation techniques.

### Lesson 3.4: Site Considerations

**Concepts Addressed in Lesson:**

1. Land surveying is used for many purposes during the design and construction of a project including establishing the topography of a site, setting control points, and establishing the location of project features.
2. Engineers must consider parking requirements, pedestrian access, ingress and egress, landscaping, storm water management, and site grading when creating a site design.
3. Ingress and egress, parking, pedestrian, and handicapped access must be planned to efficiently and safely move traffic, goods, and people.
4. The characteristics of soils present on a site impact the design and construction of improvements to a property.
5. Codes determine the type, sizing, and placement of site features such as parking lots, entrance and exit roads, pedestrian and handicapped access, and storm water facilities.
6. The surface conditions and topography of a site affect the quantity and quality of storm water runoff and the design of the storm water management system.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Use differential leveling to complete a control survey to establish a point of known elevation for a project.
- Design appropriate pedestrian access, vehicular access and a parking lot for a commercial facility.
- Analyze a site soil sample to determine the United Soil Classification System designation and predict soil characteristics important to the design and construction of a building on the site.
- Estimate the increase in storm water runoff from a commercial site and create a preliminary design for a storm water storage facility.
- Apply Low Impact Development techniques to a commercial site design reduce the impact of development on storm water runoff quantity and quality.
- Follow specifications and codes during a design process.
- Given 3D architectural design software, document a commercial site design.

## Unit 4: Commercial Building Design (35 Total Days)

### Lesson 4.1: Commercial Building Design Problem

**Concepts Addressed in Lesson:**

1. People work in teams to produce solutions to complex problems.
2. A legal description of property is used to identify real estate in a legal transaction and can be found in a deed, mortgage, plat or other purchase documents.
3. The selection of a site and the project being planned are interrelated. A site should be thoroughly research to determine whether it is compatible with the project to be built.
4. Legal, physical, and financial conditions as well as the needs of the surrounding community should be taken into consideration when determining the viability of a project.
5. Detailed planning and management of a project is essential to its success.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Work individually and in groups to produce a solution to a team project.
- Research codes, zoning ordinances and regulations to determine the applicable requirements for a project.
- Identify the boundaries of a property based on its legal description.
- Perform research and visit a site to gather information pertinent to the viability of a project on the site.
- Identify the criteria and constraints, and gather information to promote viable decisions regarding the development of their solution.
- Create an architectural program, a project organization chart, and a Gantt chart and hold project progress meetings to help manage the team project.
- Communicate ideas while developing a project using various drawing methods, sketches, graphics, or other media collected and documented.
- Investigate the legal, physical, and financial requirements of a project and consider the needs of the community to determine project viability.
- Apply current common practices utilized in Civil Engineering and Architecture to develop a viable solution in their project.
- Develop an understanding of how software is used as a tool to aid in the solution and then the communication of a project.

**Lesson 4.2: Commercial Building Design Presentation**

**Concepts Addressed in Lesson:**

1. Critiques and reviews are used to inform and provide suggestions for improvement.
2. Presentations and displays of work provide the means to effectively promote the implementation of a project.
3. A well-done presentation will enhance the quality of a team's project.

**Performance Objectives Addressed In Lesson**
*It is expected that students will:*

- Assemble and organize work from a commercial project to showcase the project in an effective and professional manner.
- Create visual aids for a presentation that include the appropriate drawings, renderings, models, documentation, and the rationale for choosing the proposal for project development.
- Conduct an oral presentation to present a proposal for the design and development of a commercial building project.

# Civil Engineering and Architecture

## National Science Education Standards Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| **NSES Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • Systems, order, and organization | | x | x | x |
| • Evidence, models, and explanation | | x | x | x |
| • Change, constancy, and measurement | ● | x | x | x |
| • Evolution and equilibrium | | | | |
| • Form and function | x | x | x | x |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities necessary to do scientific inquiry | | x | x | x |
| • Understandings about scientific inquiry | | x | x | x |
| **NSES Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Structure of atoms | | | | |
| • Structure and properties of matter | | ● | ● | ● |
| • Chemical reactions | | | | |
| • Motions and forces | ● | ● | √ | ● |
| • Conservation of energy and increase in disorder | | | | |
| • Interactions of energy and matter | | √ | √ | ● |
| **NSES Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • The cell | | | | |
| • Molecular basis of heredity | | | | |
| • Biological evolution | | | | |
| • Interdependence of organisms | | | | |
| • Matter, energy, and organization in living systems | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| • Behavior of organisms | | | | |
| **NSES Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Energy in the earth system | | | | |
| • Geochemical cycles | | | | |
| • Origin and evolution of the earth system | | | | |
| • Origin and evolution of the universe | | | | |
| **NSES Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities of technological design | ● | √ | √ | √ |
| • Understandings about science and technology | √ | **x** | **x** | **x** |
| **NSES Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Personal and community health | | | | |
| • Population growth | | | | |
| • Natural resources | ● | **x** | **x** | **x** |
| • Environmental quality | ● | √ | √ | **x** |
| • Natural and human-induced hazards | ● | √ | √ | √ |
| • Science and technology in local, national, and global challenges | ● | **x** | **x** | **x** |
| **NSES Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Science as a human endeavor | **x** | **x** | **x** | **x** |
| • Nature of scientific knowledge | | | | |
| • Historical perspectives | √ | | | |

Table 1. Comparison of National Science Education Standards (NSES) and PLTW – Digital Electronics™.

Source: National Research Council (NRC) *National Science Education Standards*.

PROJECT LEAD THE WAY
PLTW

# Civil Engineering and Architecture

## Standards for Technological Literacy Matrix

**Key:**
√ denotes a correlation in ideas and concepts in both standard and lessons
**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities
● denotes an implied idea or concept that may be used in both lesson and activity

| | | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | √ | ● | ● | ● |
| | **K.** The rate of technological development and diffusion is increasing rapidly. | **x** | | | |
| | **L.** Inventions and innovations are the results of specific, goal-directed research. | √ | ● | ● | ● |
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | ● | ● | ● | ● |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | ● | ● | ● | ● |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | ● | ● | √ | √ |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | | | | |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | | √ | √ | √ |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | | √ | √ | √ |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | | **x** | **x** | **x** |
| | **CC.** New technologies create new processes. | ● | ● | ● | ● |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **EE.** | Management is the process of planning, organizing, and controlling work. | | | ● | √ |
| | **FF.** | Complex systems have many layers of controls and feedback loops to provide information. | | x | ● | √ |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | | |
| **9-12** | **G.** | Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | | | | |
| | **H.** | Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | ● | | | |
| | **I.** | Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | | | | |
| | **J.** | Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | | ● | ● | ● |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | | |
| **9-12** | **H.** | Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | ● | ● | ● | ● |
| | **I.** | Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | | √ | √ | √ |
| | **J.** | Ethical considerations are important in the development, selection, and use of technologies. | | ● | x | ● |
| | **K.** | The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | ● | | | |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | |
| **9-12** | **G.** | Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | x | √ | ● |
| | **H.** | When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | ● | x | ● |
| | **I.** | With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | ● | ● | ● |
| | **J.** | The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | | √ | √ | ● |
| | **K.** | Humans devise technologies to reduce the negative consequences of other technologies. | | x | x | ● |
| | **L.** | Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | x | x | ● |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | |
| **9-12** | **H.** | Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and | √ | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | values. | | | | |
| | **I.** | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | | | |
| | **J.** | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | | ● | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| **9-12** | **G.** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | ● | | | |
| | **H.** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. | √ | | | |
| | **I.** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | ● | | | |
| | **J.** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | ● | | | |
| | **K.** | The Iron Age was defined by the use of iron and steel as the primary materials for tools. | ● | | | |
| | **L.** | The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | | | |
| | **M.** | The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | | | |
| | **N.** | The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | x | | | |
| | **O.** | The Information Age places emphasis on the processing and exchange of information. | | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | |
| **9-12** | **H.** | The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | | √ | √ | √ |
| | **I.** | Design problems are seldom presented in a clearly defined form. | | | √ | √ |
| | **J.** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | | √ | x | x |
| | **K.** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | | x | x | x |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | |
| **9-12** | **I.** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | ● | √ | √ | √ |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **J.** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | ● | ● | ● | ● |
| | **K.** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | | ● | ● | ● |
| | **L.** | The process of engineering design takes into account a number of factors. | x | √ | √ | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | |
| **9-12** | **I.** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | | ● | ● | ● |
| | **J.** | Technological problems must be researched before they can be solved. | | x | x | x |
| | **K.** | Not all problems are technological, and not every problem can be solved using technology. | | | | |
| | **L.** | Many technological problems require a multidisciplinary approach. | √ | ● | ● | x |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | |
| **9-12** | **M.** | Identify the design problem to solve and decide whether or not to address it. | | | | √ |
| | **N.** | Identify criteria and constraints and determine how these will affect the design process. | | x | √ | √ |
| | **O.** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | | √ | √ | √ |
| | **P.** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed | | √ | √ | √ |
| | **Q.** | Develop and produce a product or system using a design process. | | √ | √ | √ |
| | **R.** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | | √ | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | |
| **9-12** | **L.** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | | √ | √ | √ |
| | **M.** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | | | | |
| | **N.** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | | | | |
| | **O.** | Operate systems so that they function in the way they were designed. | | | | |
| | **P.** | Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | x | x | x | x |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| and systems. | | | | | | |
| **9-12** | **J.** | Collect information and evaluate its quality. | ● | ● | ● | ● |
| | **K.** | Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | | | |
| | **L.** | Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | | |
| | **M.** | Design forecasting to evaluate the results of altering natural systems. | | ● | ● | ● |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | |
| **9-12** | **K.** | Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | |
| | **L.** | Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | |
| | **M.** | The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | |
| **9-12** | **K.** | Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | |
| | **L.** | Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | |
| | **M.** | Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | √ | √ | ● |
| | **N.** | The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | |
| **9-12** | **J.** | Energy cannot be created or destroyed; however, it can be converted from one form to another. | | | | |
| | **K.** | Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | | | |
| | **L.** | It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | |
| | **M.** | Energy resources can be renewable or nonrenewable. | | ● | | |
| | **N.** | Power systems must have a source of energy, a process, and loads. | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | | | |
| | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | | | | | |
| | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | | | | | |
| | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | | | | |
| | **P.** There are many ways to communicate information, such as graphic and electronic means. | | **x** | **x** | **√** | |
| | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | | **x** | **√** | **√** | |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | ● | ● | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | ● | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | | ● | ● | |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | | | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | distributing it, and selling it. | | | | |
| **STL Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |
| **9-12** | **J.** | Infrastructure is the underlying base or basic framework of a system. | ● | | ● | |
| | **K.** | Structures are constructed using a variety of processes and procedures. | ● | √ | √ | **x** |
| | **L.** | The design of structures includes a number of requirements. | ● | √ | √ | √ |
| | **M.** | Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | ● | √ | √ | √ |
| | **N.** | Structures can include prefabricated materials. | ● | √ | √ | ● |

Table 1. Comparison of Standards for Technological Literacy (STL) and Digital Electronics.
Source: International Technology Education Association’s (ITEA) *Standards for Technological Literacy: Content for the Study of Technology.*

# Civil Engineering and Architecture

## Standards for the English Language Arts Matrix

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | **x** | ● | ● | ● |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | ● | ● | ● | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | **x** | x | **x** | **x** |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | ● | ● | ● | ● |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | √ | | | √ |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, | √ | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| video) to gather and synthesize information and to create and communicate knowledge. | | | | |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ |

Table 1. Comparison of Standards for the English Language Arts (SELA) and Introduction to Engineering Design™
Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) *Standards for the English Language Arts*.

# Civil Engineering and Architecture

## Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | | ● | ● | ● |
| • understand meanings of operations and how they relate to one another; | | ● | ● | ● |
| • compute fluently and make reasonable estimates | | √ | √ | √ |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions; | | ● | ● | ● |
| • represent and analyze mathematical situations and structures using algebraic symbols; | | ● | ● | ● |
| • use mathematical models to represent and understand quantitative relationships; | | √ | √ | ● |
| • analyze change in various contexts. | | **x** | **x** | **x** |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | **x** | **x** | **x** |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | **x** | **x** | √ |
| • apply transformations and use symmetry to analyze mathematical situations; | | | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | √ | √ | √ |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| grade 12 should enable all students to— | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | | √ | √ | √ |
| • apply appropriate techniques, tools, and formulas to determine measurements. | | √ | √ | √ |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | | ● | ● | ● |
| • select and use appropriate statistical methods to analyze data; | | ● | ● | ● |
| • develop and evaluate inferences and predictions that are based on data; | | | | |
| • understand and apply basic concepts of probability. | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving; | | √ | √ | √ |
| • solve problems that arise in mathematics and in other contexts; | | √ | √ | √ |
| • apply and adapt a variety of appropriate strategies to solve problems; | | √ | √ | √ |
| • monitor and reflect on the process of mathematical problem solving. | | √ | √ | √ |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | |
| • make and investigate mathematical conjectures; | | ● | ● | ● |
| • develop and evaluate mathematical arguments and proofs; | | | | |
| • select and use various types of reasoning and methods of proof. | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication; | | √ | √ | √ |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | | | √ | √ |
| • use the language of mathematics to express mathematical ideas precisely | | √ | √ | √ |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas; | | ● | ● | ● |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Overview of Civil Engineering and Architecture | Unit 2: Residential Design | Unit 3: Commercial Applications | Unit 4: Commercial Building Design and Development |
|---|---|---|---|---|
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | | ● | ● | ● |
| • recognize and apply mathematics in contexts outside of mathematics. | | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | | √ | √ | √ |
| • select, apply, and translate among mathematical representations to solve problems; | | ● | ● | ● |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | √ | √ | √ |

Table 1. Comparison of Principles and Standards for School Mathematics (PSSM) and Digital Electronics™
Source: National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics.*

PROJECT LEAD THE WAY PLTW

# CIM

# Computer Integrated Manufacturing Course Description

Computer Integrated Manufacturing (CIM) is the study of manufacturing planning, integration, and implementation of automation.

The course explores manufacturing history, individual processes, systems, and careers. In addition to technical concepts, the course incorporates finance, ethics, and engineering design. This reflects an integrated approach that leading manufacturers have adopted to improve safety, quality, and efficiency.

Utilizing the activity-project-problem-based (APPB) teaching and learning pedagogy, students will analyze, design, and build manufacturing systems. While implementing these designs, students will continually hone their interpersonal skills, creative abilities, and understanding of the design process. Students apply knowledge gained throughout the course in a final open-ended problem to build a factory system.

Computer Integrated Manufacturing is a high school level course that is appropriate for $10^{th}$, $11^{th}$, or $12^{th}$ grade students interested in manufacturing and automation. It is recommended that students are concurrently enrolled in college preparatory mathematics and science courses and have successfully completed the Introduction to Engineering Design (IED) course.

CIM is one of the specialization courses in the Project Lead The Way high school pre-engineering program. The course applies and concurrently develops secondary-level knowledge and skills in mathematics, science, and technology.

The course of study includes:

- Principles of Manufacturing
  - History of manufacturing
  - Manufacturing as an enterprise
  - System process flow
  - Automated control
  - Cost of manufacturing
- Manufacturing Processes
  - Design considerations for manufacturability
  - Property analysis
  - Ethics and safety
  - Creating a prototype
  - Manufacturing processes and machines

    - CNC mill programming and usage
- Elements of Automation
    - Robotic simulation and physical testing
    - Power systems
    - Pneumatic system design and construction
- Integration of Manufacturing Elements
    - Computer Integrated Manufacturing system types
    - Manufacturing and automation career research
    - Manufacturing system design and construction

# Computer Integrated Manufacturing Detailed Outline

## Unit 1: Principles of Manufacturing
## Time Days: 32 days

### Lesson 1.1: History of Manufacturing (8 days)

Concepts Addressed in Lesson

1. Manufacturing is a series of interrelated activities and operations that involve product design, planning, producing, materials control, quality assurance, management, and marketing of that product.
2. Manufacturing is essential to a healthy economy, including jobs and attainment of personal goals.
3. National manufacturing avoids health risks that are accepted in other countries.
4. Many careers are associated with the area of manufacturing.
5. Different procedures are used in the creation of products.

Performance Objectives

*It is expected that students will:*

- Explore manufacturing through research and projects.
- Understand what the enterprise wheel represents and how it represents the overall manufacturing scheme.
- Research a topic in manufacturing, develop a presentation, and present findings to a group.
- Explain the different procedures used in manufacturing.

### Lesson 1.2: Control Systems (10 days)

Concepts Addressed in Lesson

1. Flowcharting is a powerful graphical organizer used by technicians, computer programmers, engineers, and professionals in a variety of roles and responsibilities.

2. During the design and development process, flowcharting is used to plan and depict the process flow for an entire system and all of its subsystems.
3. Computer programmers use flowcharting symbols to graphically organize the flow of program control, including all inputs, outputs, and conditions that may occur.
4. Everyday products including cars, microwaves, ovens, hair dryers, coffee pots, and washing machines all use control systems to manage their operation.

Performance Objectives

*It is expected that students will:*

- Identify basic flowcharting symbols and discuss their functions.
- Create a flowchart that portrays a manufacturing process.
- Apply flowcharting to areas other than manufacturing.
- Identify a control system and explain its application to manufacturing.
- Model and create a program to control an automated system.

**Lesson 1.3: The Cost of Manufacturing (14 days)**

Concepts Addressed in Lesson

1. When designing a control system, cost and safety are two key factors that must be considered.
2. Many factors come into play when calculating the cost of manufacturing a product.
3. Tradeoffs may be made between hiring highly skilled or experienced workers and keeping costs down.
4. The less time a part takes to make, the more potential profit is available.
5. Long term planning and investments may cost more up front but may provide additional savings in the future.

Performance Objectives

*It is expected that students will:*

- Create a control system that replicates a factory cell.
- Maximize the efficiency of the manufacturing system with respect to time and cost.
- Compare the efficiency of running multiple systems against that of one large system.

# Unit 2: Manufacturing Processes
# Time Days: 54 days

### Lesson 2.1: Designing for Manufacturability (10 days)

Concepts Addressed in Lesson

1. Design is a process that is used to systematically solve problems.
2. Many considerations must be made when manufacturing a quality part.
3. Material properties must be considered as part of the design process.
4. Manufacturers have an ethical responsibility to create safe products and to provide a safe work environment.
5. Manufacturers have a legal responsibility to provide safety information about their products.
6. Many engineering disciplines have a code of conduct or code of ethics that their members are expected to follow.
7. Analyzing case studies of engineering failures is a good way for engineers to avoid future failures.

Performance Objectives

*It is expected that students will:*

- Use the design process.
- Use knowledge of design to analyze products with flaws.
- Use calculated volume, mass, surface area of parts to determine material cost, waste, and packaging requirements.
- Use solid modeling software to improve a flawed design.
- Determine whether a product is safe for a given audience (e.g., children under the age of three).
- Make ethical decisions about manufacturing.
- Create a product using solid modeling software.

### Lesson 2.2: How We Make Things (6 days)

Concepts Addressed in Lesson

1. Prototyping is part of a design process where a physical model can be evaluated to refine the design.
2. Before raw material can be used in manufacturing, it must undergo primary processing.

3. The separating process is one of the oldest manufacturing processes.
4. Milling and shearing utilize the subtractive process to create products.
5. ECM, EDM, water-, and laser-cutting are using newer technologies to enhance the accuracy and efficiency of material removal.
6. Metals, plastics, and ceramics are types of materials that are well suited to the manufacturing process.
7. The way in which a product is made is dependent upon the properties of the material that will be used.

Performance Objectives

*It is expected that students will:*

- Explain the difference between primary and secondary manufacturing processes.
- Analyze a product to propose the manufacturing processes used to create it.
- Explore manufacturing processes via research.
- Explore prototyping processes.

**Lesson 2.3: Product Development (38 days)**

Concepts Addressed in Lesson

1. Many machines exist to perform manufacturing processes.
2. Machine code is an essential tool used to communicate with some machines.
3. Jigs and fixtures are essential in maintaining consistency and quality control.
4. Computer Aided Manufacturing (CAM) programming tools make it possible to manufacture physical models using Computer Aided Design (CAD) programs.
5. Products manufactured today have been greatly influenced by the advancement of machines and technology.
6. Several variables in machining operations affect the final product in manufacturing.
7. Profit margins are essential to a company’s survival in a competitive market.
8. Prototyping is a major step in the design cycle of manufactured goods and has been greatly advanced with the advent and use of rapid prototyping processes.

Performance Objectives

*It is expected that students will:*

- Identify machines when given a process and identify the process that a given machine performs.
- Determine the appropriate speed rate for a given material using a tool with a given diameter.
- Determine the feed rate for a given material using a tool with a given diameter.
- Read and interpret G & M codes.
- Transfer the drawings made in CAD to a CAM program.
- Create numerical code using a CAM program.
- Verify the creation of a part using a simulation software.
- Create parts using the machines demonstrated by the instructor.
- Create a product on the computer using knowledge of manufacturing processes.

## Unit 3: Elements of Automation
## Time Days: 46 days

### Lesson 3.1: Introduction to Automation (19 Days)

Concepts Addressed in Lesson

1. Many factors have influenced the evolution of automation.
2. A variety of automation careers exist.
3. Robots are widely used in industry to assist in the production of manufactured goods.
4. Robots have distinct advantages over humans in some industrial settings (e.g., hazardous environments, repetitive motion or long hours).
5. Robots and machines communicate and coordinate their activities through a process called handshaking.

Performance Objectives

*It is expected that students will:*

- Research a topic in automation.
- Explore automation careers.
- Identify the advantages and disadvantages of robotic labor versus human labor.
- Explore materials handling.
- Create and program virtual robotic work cells with simulation software.

- Program the interface between a robot and another machine.

**Lesson 3.2: Elements of Power (10 Days)**

Concepts Addressed in Lesson

1. Power is produced in many ways and transmitted through various forms (e.g. electrical, pneumatic, hydraulic, and motion).
2. Fluid power is inversely proportional to the area upon which the force is being applied.
3. Sensors provide feedback to control systems and products used by consumers.
4. Pneumatics is one form of fluid power that can be used to operate machines and products.

Performance Objectives

*It is expected that students will:*

- Identify the three main power types.
- Solve problems involving electrical, pneumatic, and mechanical power.
- Convert power between units.
- Calculate torque and use it to calculate power.
- Solve problems involving fluid power.
- Construct a system to convert pneumatic power into mechanical power.

**Lesson 3.3: Robotic Programming and Usage (17 Days)**

Concepts Addressed in Lesson

1. Basic programming skills include variable declaration, loops, and debugging.
2. A variety of robots and unique programming languages are used in the manufacturing industry.
3. Many everyday products use microcontrollers.
4. Robots are used to perform diverse functions and work in diverse environments.
5. The size of a robot is based on the work envelope and payload needed to perform the task.

Performance Objectives

*It is expected that students will:*

- Build the Lynxmotion robot if the robots are not already built.

- Learn the programming language needed to operate the Lynx robot.
- Create programs using robotic software that will allow the robot to perform a set of tasks.
- Configure servo motors to operate the Lynxmotion robot.
- Formulate a list of tasks in which the robot used in class can be used in a large scale CIM cell operation.

# Unit 4: Integration of Manufacturing Elements
# Time: 47 Days

### Lesson 4.1: Integration of Manufacturing Elements (10 Days)

Concepts Addressed in Lesson

1. The process of mass production is used when the same product is created repeatedly.
2. A workcell is a group of machines in which each individual machine has its own specialty.
3. A flexible manufacturing system is one that can adapt to a wide variety of products.
4. Tradeoffs are made when one system is utilized over another.
5. Process flow design has a major impact on overall production time and product profit.
6. During the design and development process, flowcharting is used to plan and depict the detailed process flow for an entire system and all of its subsystems.
7. Flowcharting can be used to illustrate the phases of the product development process.
8. Manufacturing and automation careers are varied in scope and location.

Performance Objectives

*It is expected that students will:*

- Identify the three categories of CIM systems.
- Compare and contrast the benefits and drawbacks of the three categories of CIM systems.
- Identify the components of a FMS.
- Create a process design chart for a manufacturing process.
- Explore a manufacturing or automation career of interest and determine the appropriateness and steps required to be a professional in that role.

**Lesson 4.2: Manufacturing Application (37 Days)**

Concepts Addressed in Lesson

1. Process flow design has a major impact on overall production time and product profit.
2. During the design and development process, flowcharting is used to plan and depict the detailed process flow for an entire system as well as all of its subsystems.
3. Flowcharting can be used to illustrate the overall phases of the product development process.
4. Safe operating procedures must be addressed in a CIM environment at all times to avoid serious injury.
5. Tradeoffs occur between efficiency and cost when choosing a manufacturing system.
6. Engineers choose appropriate sensors to ensure high quality part production.
7. Proper sequencing of automated operations is important in factory design.
8. Identification of correct electrical and fluid power systems is required to complete the desired manufacturing system.

Performance Objectives

*It is expected that students will:*

- Identify the potential safety issues with a CIM system and identify solutions for these problems.
- Understand the significance of teamwork and communication.
- Design a manufacturing system that contains at least two automated components.
- Complete the construction of each individual component of the miniature FMS and verify that each component works.
- Assemble components into a working miniature FMS.
- Refine each component to improve the total process flow and cycle time.
- Start and maintain a journal that documents daily work.

# Computer Integrated Manufacturing
## National Science Education Standards Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| **NSES Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • Systems, order, and organization | √ | √ | √ | √ |
| • Evidence, models, and explanation | √ | √ | | |
| • Change, constancy, and measurement | ● | √ | ● | |
| • Evolution and equilibrium | ● | ● | | |
| • Form and function | **x** | √ | √ | √ |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities necessary to do scientific inquiry | | √ | √ | √ |
| • Understandings about scientific inquiry | | √ | √ | √ |
| **NSES Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Structure of atoms | | | | |
| • Structure and properties of matter | ● | ● | ● | ● |
| • Chemical reactions | | | | |
| • Motions and forces | ● | ● | √ | √ |
| • Conservation of energy and increase in disorder | | | | |
| • Interactions of energy and matter | | | | |
| **NSES Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • The cell | | | | |
| • Molecular basis of heredity | | | | |
| • Biological evolution | | | | |
| • Interdependence of organisms | | | | |
| • Matter, energy, and organization in living systems | | | | |
| • Behavior of organisms | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| **NSES Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • Energy in the earth system | | | | |
| • Geochemical cycles | | | | |
| • Origin and evolution of the earth system | | | | |
| • Origin and evolution of the universe | | | | |
| **NSES Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • Abilities of technological design | √ | √ | √ | √ |
| • Understandings about science and technology | √ | √ | √ | √ |
| **NSES Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Personal and community health | **x** | | | **x** |
| • Population growth | **x** | | | **x** |
| • Natural resources | √ | √ | **x** | √ |
| • Environmental quality | **x** | √ | **x** | √ |
| • Natural and human-induced hazards | √ | √ | √ | √ |
| • Science and technology in local, national, and global challenges | √ | √ | √ | √ |
| **NSES Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • Science as a human endeavor | √ | **x** | √ | √ |
| • Nature of scientific knowledge | √ | **x** | √ | √ |
| • Historical perspectives | √ | **x** | √ | √ |

Table 1. Comparison of National Science Education Standards (NSES) and PLTW – Digital Electronics™.

Source: National Research Council (NRC) *National Science Education Standards*.

# Computer Integrated Manufacturing
## Standards for Technological Literacy Matrix

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>x denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | √ | x | x | √ |
| | **K.** The rate of technological development and diffusion is increasing rapidly. | √ | x | x | √ |
| | **L.** Inventions and innovations are the results of specific, goal-directed research. | x | √ | | x |
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | √ | √ | | x |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | √ | √ | √ | √ |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | x | √ | √ | √ |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | √ | √ | √ | √ |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | √ | √ | √ | √ |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | √ | √ | | √ |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | x | √ | x | √ |
| | **CC.** New technologies create new processes. | x | √ | | x |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | √ | √ | x | √ |

| | | | | | |
|---|---|---|---|---|---|
| | **EE.** Management is the process of planning, organizing, and controlling work. | √ | √ | **x** | √ |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | √ | √ | √ | √ |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | **x** | **x** | **x** | **x** |
| | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | **x** | **x** | **x** | **x** |
| | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | | | | |
| | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | **x** | **x** | **x** | **x** |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | |
| **9-12** | **H.** Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | √ | | | **x** |
| | **I.** Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | √ | √ | √ | √ |
| | **J.** Ethical considerations are important in the development, selection, and use of technologies. | | √ | | |
| | **K.** The transfer of a technology from one society to another can cause cultural, social, economic, and political changes affecting both societies to varying degrees. | **x** | √ | **x** | **x** |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | √ | √ | **x** | **x** |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | √ | **x** | **x** |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | • | • | | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | **x** | √ | **x** | **x** |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | **x** | √ | **x** | **x** |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | **x** | √ | **x** | **x** |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and | **x** | **x** | **x** | **x** |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | values. | | | | |
| | I. | The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | X | √ | X | X |
| | J. | A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | √ | √ | | X |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| **9-12** | **G.** | Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | √ | √ | X | ● |
| | **H.** | The evolution of civilization has been directly affected by, and has in turn affected, the development and use of tools and materials. | √ | X | X | ● |
| | **I.** | Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | X | X | X | ● |
| | **J.** | Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | √ | X | X | ● |
| | **K.** | The Iron Age was defined by the use of iron and steel as the primary materials for tools. | ● | ● | ● | ● |
| | **L.** | The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | ● | ● | ● | ● |
| | **M.** | The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | ● | ● | ● | ● |
| | **N.** | The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | √ | X | X | ● |
| | **O.** | The Information Age places emphasis on the processing and exchange of information. | X | X | X | ● |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | |
| **9-12** | **H.** | The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | X | X | X | X |
| | **I.** | Design problems are seldom presented in a clearly defined form. | X | X | X | X |
| | **J.** | The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | √ | √ | √ | √ |
| | **K.** | Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | √ | √ | √ | √ |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | |
| **9-12** | **I.** | Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | X | X | X | X |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **J.** | Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | √ | √ | **x** | **x** |
| | **K.** | A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | √ | √ | √ | √ |
| | **L.** | The process of engineering design takes into account a number of factors. | √ | √ | √ | √ |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | |
| **9-12** | **I.** | Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | | **x** | | **x** |
| | **J.** | Technological problems must be researched before they can be solved. | • | • | • | • |
| | **K.** | Not all problems are technological, and not every problem can be solved using technology. | | √ | **x** | **x** |
| | **L.** | Many technological problems require a multidisciplinary approach. | √ | **x** | **x** | √ |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | |
| **9-12** | **M.** | Identify the design problem to solve and decide whether or not to address it. | | **x** | | √ |
| | **N.** | Identify criteria and constraints and determine how these will affect the design process. | **x** | **x** | **x** | √ |
| | **O.** | Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | √ | **x** | **x** | √ |
| | **P.** | Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed | | √ | **x** | √ |
| | **Q.** | Develop and produce a product or system using a design process. | **x** | **x** | **x** | √ |
| | **R.** | Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | √ | √ | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | |
| **9-12** | **L.** | Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | √ | √ | √ | √ |
| | **M.** | Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | √ | **x** | | √ |
| | **N.** | Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | √ | **x** | **x** | √ |
| | **O.** | Operate systems so that they function in the way they were designed. | √ | √ | √ | √ |
| | **P.** | Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | **x** | **x** | **x** | **x** |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** | Collect information and evaluate its quality. | √ | | | **X** |
| | **K.** | Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | | | **X** |
| | **L.** | Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | | |
| | **M.** | Design forecasting to evaluate the results of altering natural systems. | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | |
| **9-12** | **K.** | Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | |
| | **L.** | Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | |
| | **M.** | The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | |
| **9-12** | **K.** | Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | |
| | **L.** | Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | |
| | **M.** | Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving water, and improving water quality. | | | | |
| | **N.** | The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | |
| **9-12** | **J.** | Energy cannot be created or destroyed; however, it can be converted from one form to another. | ● | ● | ● | |
| | **K.** | Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | ● | **X** | √ | √ |
| | **L.** | It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | ● | ● | ● | |
| | **M.** | Energy resources can be renewable or nonrenewable. | √ | | | |
| | **N.** | Power systems must have a source of energy, a process, and loads. | √ | √ | √ | √ |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| use information and communication technologies. | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | | | | |
| | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | √ | √ | √ | √ |
| | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | | | | |
| | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | √ | √ | √ | √ |
| | **P.** There are many ways to communicate information, such as graphic and electronic means. | **X** | √ | √ | √ |
| | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | √ | √ | √ | √ |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | **X** | √ | √ | √ |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | **X** | √ | | **X** |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | **X** | √ | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | √ | **X** | | **X** |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | √ | √ | √ | √ |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | √ | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | **X** | | | **X** |

| **STL Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |
|---|---|---|---|---|---|---|
| **9-12** | **J.** | Infrastructure is the underlying base or basic framework of a system. | **X** | **X** | **X** | **X** |
| | **K.** | Structures are constructed using a variety of processes and procedures. | | | | |
| | **L.** | The design of structures includes a number of requirements. | | | | |
| | **M.** | Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | |
| | **N.** | Structures can include prefabricated materials. | **X** | | | **X** |

Table 1. Comparison of Standards for Technological Literacy (STL) and Digital Electronics.
Source: International Technology Education Association's (ITEA) *Standards for Technological Literacy: Content for the Study of Technology.*

# Computer Integrated Manufacturing

## Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | √ | √ | | √ |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | ● | ● | | ● |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | | | | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | | | ● | ● |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing | | | √ | ● |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | | √ | | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ |

Table 1. Comparison of Standards for the English Language Arts (SELA) and Introduction to Engineering Design™
Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) *Standards for the English Language Arts*.

# Computer Integrated Manufacturing
## Principles and Standards for School Mathematics Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | √ | √ | √ | √ |
| • understand meanings of operations and how they relate to one another; | √ | √ | √ | √ |
| • compute fluently and make reasonable estimates | √ | √ | √ | √ |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions; | **x** | | **x** | |
| • represent and analyze mathematical situations and structures using algebraic symbols; | **x** | √ | √ | √ |
| • use mathematical models to represent and understand quantitative relationships; | √ | √ | √ | √ |
| • analyze change in various contexts. | **x** | √ | √ | √ |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | √ | √ | √ |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | √ | √ | √ |
| • apply transformations and use symmetry to analyze mathematical situations; | | √ | √ | √ |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | √ | √ | √ |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | ● | √ | √ | √ |
| • apply appropriate techniques, tools, and formulas to determine measurements. | √ | √ | √ | √ |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | ● | √ | ● | √ |
| • select and use appropriate statistical methods to analyze data; | ● | √ | ● | √ |
| • develop and evaluate inferences and predictions that are based on data; | ● | √ | ● | √ |
| • understand and apply basic concepts of probability. | ● | √ | ● | √ |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving; | √ | √ | √ | √ |
| • solve problems that arise in mathematics and in other contexts; | √ | √ | √ | √ |
| • apply and adapt a variety of appropriate strategies to solve problems; | √ | √ | √ | √ |
| • monitor and reflect on the process of mathematical problem solving. | √ | √ | √ | √ |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | ● | ● | ● |
| • make and investigate mathematical conjectures; | ● | ● | ● | ● |
| • develop and evaluate mathematical arguments and proofs; | | | | |
| • select and use various types of reasoning and methods of proof. | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication; | √ | √ | √ | √ |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | √ | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | | | ● | √ |
| • use the language of mathematics to express mathematical ideas precisely | ● | ● | √ | √ |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas; | ● | √ | √ | √ |
| • understand how mathematical ideas interconnect and build on one | ● | √ | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1: Principles of Manufacturing | Unit 2: Manufacturing Processes | Unit 3: Elements of Automation | Unit 4: Integration of Manufacturing Elements |
|---|---|---|---|---|
| another to produce a coherent whole; | | | | |
| • recognize and apply mathematics in contexts outside of mathematics. | √ | √ | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | √ | √ | √ | √ |
| • select, apply, and translate among mathematical representations to solve problems; | √ | √ | √ | √ |
| • use representations to model and interpret physical, social, and mathematical phenomena. | √ | √ | √ | √ |

Table 1. Comparison of Principles and Standards for School Mathematics (PSSM) and Digital Electronics™
Source: National Council of Teachers of Mathematics (NCTM) *Principles and Standards for School Mathematics.*

PROJECT LEAD THE WAY
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# EDD

# Engineering Design and Development (EDD) Course Description

An Engineering Design and Development™ (EDD)  project differs from a stereotypical science fair project in that the results of the experiment can not be readily gained or "looked-up." In addition to putting great care into the methodology of testing a hypothesis, a research project requires the student to suggest and justify a unique and original solution to a problem. As an example, choosing to find the rate at which bread becomes moldy under certain conditions may be both valuable and important information to the food industry, but experiments answering questions like this have already been performed and documented thousands of times.

A true research project would involve investigating a concern or problem in the food industry that attempts to add to the industry in a positive manner. Examples might include longer lasting preservatives, more efficient methods of processing or harvesting plants, or less expensive containers in which to package the food. The task of justifying and repeating the results of another researcher's work is an extremely valuable part in determining the validity of new information or verifying the effectiveness of a given product. However, with the possible exception of determining a more effective testing method, the act of repeating any research is not original work and only serves to validate rather than add information to a given field of interest. Therefore, finding and justifying a "question" to answer, or problem to address, and carefully defining the solution to the question or problem is one of the biggest challenges of this course. Engineers or other professionals are not hired solely because they have the skills to solve problems, but more importantly because they can identify and justify problems that need solving.

The course of study includes:

- Problem Identification and Justification
- Research
- Design Process
- Innovation vs Invention
- Building and Testing a Prototype
- Engineering Drawing Standards
- CAD Solid Modeling
- Tool Safety
- Jury Presentation

The EDD course should be taken as a capstone course in the 12th grade because it applies the knowledge and skills from the Project Lead The Way® foundation courses in solving an identified technical problem.

The course will be field tested during the 2010 – 2011 school year. The revised course will be published for the use by the Project Lead The Way® network in the 2011 – 2012 school year.

# Engineering Design and Development Detailed Outline

## Unit 1: Course Introduction and Justification
## Time Days: 17 days

**Lesson 1.1: Introduction to Engineering Design and Development™ (17 days):**

**Concepts Addressed in Lesson:**

1. An informed decision-making process is a valuable tool in solving a problem.
2. The ability to use technical and expository writing is an essential skill of communication.
3. Technical writing involves communicating a problem and its potential solution to a particular audience.
4. The use of expository writing provides the reader with facts about a subject in an informative style.
5. Good project management will ensure the success of a project.
6. A design process most used by engineers includes defining a problem, brainstorming, researching, identifying requirements, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing, refining, making, and communicating results.
7. A designer uses an engineer’s notebook to chronologically document all aspects of a design project.

**Performance Objectives Addressed in Lesson:**
*It is expected the student will:*

- Identify the design process steps used in given scenarios and be able to list the steps.
- Explain the process used to organize a research project.
- Apply engineering notebook standards and protocols when documenting work.
- Define and demonstrate time management skills as related to his or her project.
- Distinguish between when it is appropriate to use technical writing and expository writing styles.

## Unit 2: Problem Identification
## **Time Days: 30 days**

**Lesson 2.1: Introduction to Problem Statement (9 days):**

**Concepts Addressed in Lesson:**

1. Brainstorming is an effective technique used to generate problem statements to identified problems.
2. Writing a concise problem statement is the foundation in solving problems.
3. An accurately written problem statement aids in determining if the result of the engineering design and development process has solved the identified problem.

**Performance Objectives Addressed in Lesson:**
*It is expected the student will:*

- Brainstorm problem statements for unique innovations or inventions.
- Write concise problem statements using technical writing skills.
- Document research that justifies the problem statement for the engineering design and development project.

**Lesson 2.2: Verify and Justify the Problem (21 days):**

**Concepts Addressed in Lesson**:

1. An accurately written problem statement identifies a need and guides the design process that will be used in engineering design problems.
2. Experts are professionals that guide the research needed for accurate justification and solutions to design problems.

**Performance Objectives Addressed in Lesson:**
*It is expected the student will:*

- Be able to speak to experts appropriately.
- Ask valid questions that will be used to further the student's knowledge of the problem statement.
- Write a problem statement as well as verify and justify the statement.
- Document the project process in an engineering notebook.
- Use strong oral and written skills to communicate with experts.

## Unit 3: Research
## **Time Days: 15 days**

**Lesson 3.1: Research and Development (3 days):**

**Concepts Addressed in Lesson:**

1. Research refers to the advancement of knowledge and development refers to the application of knowledge.
2. Market research aids business and industry in making better decisions about the development and marketing of new products.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Study cases (articles supplied by the teacher) regarding research and development and its impact on the invention and innovation of products, processes, or services.
- Create market research to investigate and determine the merit of their solution.
- Self-assess their performance and research based on the goals for developing a solution to a problem.

**Lesson 3.2: Investigate Current and Past Solutions (6 days):**

**Concepts Addressed in Lesson:**

1. A patent is a legally binding agreement between an inventor, owner, and the people of the United States that grants the exclusive right to produce and sell an invention or innovation for a certain length of time.
2. Securing a patent involves a series of steps that must be followed.
3. Research is used to investigate what solutions exist to a technical problem and if an innovation or new invention is warranted.

**Performance Objectives Addressed in Lesson:**
*It is expected the student will:*

- Use a list of specifications and constraints identified in a decision matrix to develop a list of alternative solutions to the stated problem.
- Research and identify patents related to their identified problem.
- Conduct research to investigate and determine the merit of his or her alternative solution based on past solutions to the problem.
- Explain the feasibility of his or her solution based on his or her research.
- Develop research strategies for his or her solution, including the use of surveys, phone interviews, and personal contact with experts related to the field of his or her technical problem.
- Create a matrix table to analyze the data found from the patent research.

**Lesson 3.3: Invent or Innovate (6 days):**

**Concepts Addressed in Lesson:**

1. Engineers design solutions to technical problems that may be an invention, something new, or they may be an innovation, a modification of an already existing solution.
2. Inventions and innovations are the results of specific, goal-directed research.
3. Creative thinking and economic and cultural influences shape the development of solutions to technical problems.
4. The use of assessment techniques, such as trend analysis provides information to determine if a solution should be pursued to design and development.

**Performance Objectives Addressed in Lesson:**
*It is expected the student will:*

- Conduct research to identify the difference between innovation and invention.
- Write a fictional scenario for an innovation of interest.
- Discuss the pros and cons of a decision matrix.
- Conduct research and perform a trend analysis on a technical problem.
- Sketch one invention and one innovation related to the technical problem.

## Unit 4: Decision Process
## **Time Days: 8 days**

**Lesson 4.1: Defining Product Specifications (8 days):**

**Concepts Addressed in Lesson:**

1. Specifications for a design solution enhance creativity by identifying the criteria and constraints of the design process.
2. Engineers use a decision matrix to evaluate the preliminary design solution by implementing mulitple parameters.
3. The use of optimization improves the final design solution by justifying the specifications applied.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Create a description of the product specifications for the design solution.
- Objectively evaluate proposed design solutions using specific criteria.
- Select the best design solution option using a decision matrix.
- Graphically represent the results of the design solution evaluation.

## Unit 5: Design

## Time Days: 20 days

### Lesson 5.1: Sketching and Technical Drawings (20 days):

**Concepts Addressed in Lesson:**

1. The use of symbols and drawings promotes clear communication of a design solution.
2. Drawings and sketches are used to organize, record, and communicate ideas to experts.
3. Engineers use working drawings to show all the information needed to make a single part, subassembly, or a complete design solution.
4. Technical drawings are used to evaluate design solutions for any necessary refinements.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Sketch all parts of their design solution including an isometric view of the assembled product.
- Create a set of working drawings for their design solution.
- Interpret and apply the feedback they receive from experts to improve their design solution.
- Refine their design solution, if necessary, based upon expert feedback.
- Document the project's progress in their engineering notebooks.

## Unit 6: Build
## Time Days: 35 days

### Lesson 6.1: Building a Prototype (35 days):

**Concepts Addressed in Lesson:**

1. The use of tool machine safety allows engineers to prevent accidents during the construction of the prototype.
2. Engineers write step-by-step instructions for the prototype assembly to guide the fabrication of the design solution.
3. Availability of materials and equipment is determined by using a materials and cost analysis during the prototyping phase of a project.
4. Prototyping provides the engineer with a scaled working model of the design solution.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Identify safe practices for the use of tools and equipment.
- Create a detailed set of instructions for producing a testable prototype based on the information gained through their research.
- Identify methods and sources for obtaining materials and supplies.
- Compile a materials list that includes vendors and cost for all necessary materials and equipment to build their prototype.
- Write a step-by-step procedure for the assembly of their prototype.
- Build a working prototype that can be tested.

## Unit 7: Test
## **Time Days: 24 days**

### Lesson 7.1: Test Method (6 days):

**Concepts Addressed in Lesson:**

1. Specific criteria for success or failure of a test must be determined before testing commences.
2. Prototype testing is a controlled procedure that is used to evaluate a specific aspect of a design solution.
3. The results of prototype testing are used to refine the design and to improve the design solution.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Select and describe a valid testing method that will be used to accurately evaluate their design solution's ability to solve their problem.
- Prepare a description of the testing method that will be used to valid the designed solution.
- Create a valid justification for the selected testing method.
- Devise a list of testing criteria that will be used to evaluate the success or failure of their prototype testing
- Identify, define, and implement needed modifications to their testing method based on expert feedback and their ongoing research.
- Document their project's progress in their engineer's notebook.

### Lesson 7.2: Test Designed Solution (18 days):

**Concepts Addressed in Lesson:**

1. Engineers write a detailed description of the testing procedure to ensure the testing of the design solution is valid.
2. Evaluation of the test results allows engineers to determine if the test is accurate and repeatable.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Create a detailed set of instructions for testing the prototype that will be valid, repeatable, and reliable.
- Apply the appropriate statistical analysis tools to the test results to ensure validity.
- Identify, define, and implement necessary modifications to their design based upon their test results.
- Identify how their solution has removed obsolescence of the original product, if appropriate.
- Evaluate and explain the effectiveness of their design at solving the problem they have defined.
- Document the test results and project progress in their engineering notebooks.

## Unit 8: Presentation
## **Time Days: 26 days**

**Lesson 8.1: Project Documentation (17 days):**

**Concepts Addressed in Lesson:**

1. The use of PowerPoint® allows engineers to present visual aids and project information in a professional manner.
2. Engineers use a technical report to provide thorough communication of all aspects of a design solution.
3. Various media formats are chosen to effectively communicate the design solution process to a target audience.

**Performance Objectives Addressed in Lesson:**
*It is expected students will:*

- Gather data and information compiled throughout the project and create a technical research paper, PowerPoint, and three panel display of their design solution.
- Create a website, if they choose, in order to depict all aspects of their design solution.
- Choose one of the formats used to depict the design solution, such as technical reseach paper, PowerPoint, three panel display, or website, if created, for the presentation of the solution to their chosen problem.

**Lesson 8.2: Juried Presentation (9 days):**

**Concepts Addressed in Lesson:**

1. Engineers develop skills in public speaking to effectively communicate their design solutions.
2. Computerized visual presentations are used to emphasize the content of the engineer's design process.
3. Presentations and displays of work provide the means to effectively promote the implementation of a project.
4. A well-done presentation will enhance the quality work of a team's project.
5. Resumes are used by engineers to promote their knowledge and skills when searching for employment.

**Performance Objectives Addressed in Lesson:**

*It is expected students will:*

- Identify appropriate techniques for delivering formal presentations.
- Orally present an effective technical presentation on the chosen design solution.
- Write a resume to prepare for an interview in college or the workforce.
- Update their portfolio with accompanying resume as professional documentation of their knowledge and skills and work completed in this course.

## Total days: 175 Days

# Engineering Design and Development National Science Education Standards

## Grades 9-12

## MATRIX

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1— | Unit 2— | Unit 3— | Unit 4— | Unit 5— | Unit 6— | Unit 7— | Unit 8 – |
|---|---|---|---|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | | | | | |
| • Systems, order, and organization | √ | √ | √ | | | √ | | √ |
| • Evidence, models, and explanation | √ | √ | | | | | √ | √ |
| • Change, constancy, and measurement | √ | √ | √ | | | √ | √ | |
| • Evolution and equilibrium | | | | | | | | |
| • Form and function | √ | √ | √ | | | √ | | √ |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | | | | | |
| • Abilities necessary to do scientific inquiry | | | ● | | ● | ● | √ | **x** |
| • Understandings about scientific inquiry | | | | | | | √ | **x** |
| ***NSES* Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |
| • Structure of atoms | | | | | | | | |
| • Structure and properties of matter | | | | | | ● | ● | |
| • Chemical reactions | | | | | | | | |
| • Motions and forces | | | | | | **x** | **x** | |
| • Conservation of energy and increase in disorder | | | | | | | | |
| • Interactions of energy and matter | | | | | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1— | Unit 2— | Unit 3— | Unit 4— | Unit 5— | Unit 6— | Unit 7— | Unit 8 – |
|---|---|---|---|---|---|---|---|---|
| • The cell | | | | | | | | |
| • Molecular basis of heredity | | | | | | | | |
| • Biological evolution | | | | | | | | |
| • Interdependence of organisms | | | | | | | | |
| • Matter, energy, and organization in living systems | | | | | | | | |
| • Behavior of organisms | | | | | | | | |
| ***NSES* Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |
| • Energy in the earth system | | | | | | | | |
| • Geochemical cycles | | | | | | | | |
| • Origin and evolution of the earth system | | | | | | | | |
| • Origin and evolution of the universe | | | | | | | | |
| ***NSES* Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | | | | | |
| • Abilities of technological design | ● | ● | √ | | | √ | √ | √ |
| • Understandings about science and technology | ● | ● | √ | | | √ | √ | √ |
| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | | | |
| • Personal and community health | | | √ | | | **x** | ● | |
| • Population growth | | | | | | | | |
| • Natural resources | | | **x** | | | **x** | ● | |
| • Environmental quality | | | ● | | | ● | | |
| • Natural and human-induced hazards | | | √ | | | √ | **x** | |
| • Science and technology in local, national, and global challenges | ● | ● | √ | | | **x** | | ● |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | | | |
| • Science as a human endeavor | | | | | | | | |
| • Nature of scientific knowledge | | | | | | | | |
| • Historical perspectives | | | | | | | | |

**Table 1.** Comparison of *National Science Education Standards* (*NSES*) and Project Lead The Way® – **Engineering Design and Development™**.

Source: National Research Council (NRC) ***National Science Education Standards*.**

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# Engineering Design and Development Standards for Technological Literacy Matrix

| | Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | | | | |
| **K-2** | **A.** The natural world and human-made world are different. | | | | | | | | |
| **K-2** | **B.** All people use tools and techniques to help them do things. | | | | | | | | |
| **3-5** | **C.** Things that are found in nature differ from things that are human-made in how they are produced and used. | | | | | | | | |
| **3-5** | **D.** Tools, materials, and skills are used to make things and carry out tasks. | | | | | | | | |
| **3-5** | **E.** Creative thinking and economic and cultural influences shape technological development. | | | | | | | | |
| **6-8** | **F.** New products and systems can be developed to solve problems or to help do things that could not be done without the help of technology. | | | | | | | | |
| **6-8** | **G.** The development of technology is a human activity and is the result of individual or corporate needs and the ability to be creative. | | | | | | | | |
| **6-8** | **H.** Technology is closely linked to creativity, which has resulted in innovation. | | | | | | | | |
| **6-8** | **I.** Corporations can often create demand for a product by bringing it onto the market and advertising it. | | | | | | | | |
| **9-12** | **J.** The nature and development of technological knowledge and processes are functions of the setting. | | | √ | **x** | ● | **x** | **x** | ● |
| **9-12** | **K.** The rate of technological development and diffusion is increasing rapidly. | **x** | | √ | **x** | | | | |
| **9-12** | **L.** Inventions and innovations are the results of specific, goal-directed research. | ● | | √ | √ | **x** | **x** | **x** | ● |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | **M.** Most development of technologies these days is driven by the profit motive and the market. | ● | ● | √ | ● | | **x** | **x** | ● |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | | | | | |
| **K-2** | **A.** Some systems are found in nature, and some are made by humans. | | | | | | | | |
| | **B.** Systems have parts or components that work together to accomplish a goal. | | | | | | | | |
| | **C.** Tools are simple objects that help humans' complete tasks. | | | | | | | | |
| | **D.** Different materials are used in making things. | | | | | | | | |
| | **E.** People plan in order to get things done. | | | | | | | | |
| **3-5** | **F.** A subsystem is a system that operates as a part of another system. | | | | | | | | |
| | **G.** When parts of a system are missing, it may not work as planned. | | | | | | | | |
| | **H.** Resources are the things needed to get a job done, such as tools and machines, materials, information, energy, people, capital, and time. | | | | | | | | |
| | **I.** Tools are used to design, make, use, and assess technology. | | | | | | | | |
| | **J.** Materials have many different properties. | | | | | | | | |
| | **K.** Tools and machines extend human capabilities, such as holding, lifting, carrying, fastening, separating, and computing. | | | | | | | | |
| | **L.** Requirements are the limits to designing or making a product or system. | | | | | | | | |
| **6-8** | **M.** Technological systems include input, processes, output, and, at times, feedback. | | | | | | | | |
| | **N.** Systems thinking involves considering how every part relates to others. | | | | | | | | |
| | **O.** An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback. | | | | | | | | |
| | **P.** Technological systems can be connected to one another. | | | | | | | | |
| | **Q.** Malfunctions of any part of a system may affect the function and quality of the system. | | | | | | | | |
| | **R.** Requirements are the parameters placed on the development of a product or system. | | | | | | | | |
| | **S.** Trade-off is a decision process recognizing the need for careful compromises among competing factors. | | | | | | | | |
| | **T.** Different technologies involve different sets of processes. | | | | | | | | |
| | **U.** Maintenance is the process of inspecting and | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | servicing a product or system on a regular basis in order for it to continue functioning properly, to extend its life, or to upgrade its capability. | | | | | | | | |
| | **V.** Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change. | | | | | | | | |
| **9-12** | **W.** Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems. | **x** | | **x** | √ | **x** | **x** | **x** | **x** |
| | **X.** Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems. | **x** | **x** | ● | ● | ● | **x** | ● | ● |
| | **Y.** The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop. | | | | | **x** | **x** | **x** | |
| | **Z.** Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste. | | | **x** | √ | √ | **x** | ● | ● |
| | **AA.** Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development. | **x** | **x** | **x** | √ | √ | √ | √ | |
| | **BB.** Optimization is an on going process or methodology of designing or making a product and is dependent on criteria and constraints. | | | ● | √ | **x** | **x** | √ | |
| | **CC.** New technologies create new processes. | ● | | **x** | ● | ● | ● | | ● |
| | **DD.** Quality control is a planned process to ensure that a product, service, or system meets established criteria. | | | **x** | **x** | √ | √ | **x** | **x** |
| | **EE.** Management is the process of planning, organizing, and controlling work. | √ | **x** | **x** | **x** | ● | **x** | **x** | **x** |
| | **FF.** Complex systems have many layers of controls and feedback loops to provide information. | √ | ● | **x** | ● | **x** | ● | **x** | ● |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | | | | | | |
| **K-2** | **A.** The study of technology uses many of the same ideas and skills as other subjects. | | | | | | | | |
| **3-5** | **B.** Technologies are often combined. | | | | | | | | |
| | **C.** Various relationships exist between technology and other fields of study. | | | | | | | | |
| **6-8** | **D.** Technological systems often interact with one another. | | | | | | | | |
| | **E.** A product, system, or environment developed for one setting may be applied to another setting. | | | | | | | | |

| | **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | **F.** Knowledge gained from other fields of study has a direct effect on the development of technological products and systems. | | | | | | | | |
| **9-12** | **G.** Technology transfer occurs when a new user applies an existing innovation developed for one purpose in a different function. | ● | | **x** | ● | | ● | ● | ● |
| **9-12** | **H.** Technological innovation often results when ideas, knowledge, or skills are shared within a technology, among technologies, or across other fields. | ● | | **x** | ● | | ● | | ● |
| **9-12** | **I.** Technological ideas are sometimes protected through the process of patenting. The protection of a creative idea is central to the sharing of technological knowledge. | ● | | √ | ● | ● | ● | ● | **x** |
| **9-12** | **J.** Technological progress promotes the advancement of science and mathematics. Likewise, progress in science and mathematics leads to advances in technology. | ● | √ | **x** | | | ● | ● | ● |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | | | | | | |
| **K-2** | **A.** The use of tools and machines can be helpful or harmful. | | | | | | | | |
| **3-5** | **B.** When using technology, results can be good or bad. | | | | | | | | |
| **3-5** | **C.** The use of technology can have unintended consequences. | | | | | | | | |
| **6-8** | **D.** The use of technology affects humans in various ways, including their safety, comfort, choices, and attitudes about technology's development and use. | | | | | | | | |
| **6-8** | **E.** Technology, by itself, is neither good nor bad, but decisions about the use of products and systems can result in desirable or undesirable consequences. | | | | | | | | |
| **6-8** | **F.** The development and use of technology poses ethical issues. | | | | | | | | |
| **6-8** | **G.** Economic, political, and cultural issues are influenced by the development and use of technology. | | | | | | | | |
| **9-12** | **H.** Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious. | ● | ● | **x** | ● | | | | |
| **9-12** | **I.** Making decisions about the use of technology involves weighing the trade-offs between the positive and negative effects. | **x** | √ | **x** | √ | **x** | **x** | **x** | ● |
| **9-12** | **J.** Ethical considerations are important in the development, selection, and use of technologies. | **x** | ● | **x** | **x** | **x** | **x** | **x** | **x** |
| **9-12** | **K.** The transfer of a technology from one society to another can cause cultural, social, economic, and | ● | ● | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| | political changes affecting both societies to varying degrees. | | | | | | | | |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | | | | |
| **K-2** | **A.** Some materials can be reused and/or recycled. | | | | | | | | |
| **3-5** | **B.** Waste must be appropriately recycled or disposed of to prevent unnecessary harm to the environment. | | | | | | | | |
| | **C.** The use of technology affects the environment in good and bad ways. | | | | | | | | |
| **6-8** | **D.** The management of waste produced by technological systems is an important societal issue. | | | | | | | | |
| | **E.** Technologies can be used to repair damage caused by natural disasters and to break down waste from the use of various products and systems. | | | | | | | | |
| | **F.** Decisions to develop and use technologies often put environmental and economic concerns in direct competition with one another. | | | | | | | | |
| **9-12** | **G.** Humans can devise technologies to conserve water, soil, and energy through such techniques as reusing, reducing, and recycling. | | ● | ● | ● | | **x** | ● | |
| | **H.** When new technologies are developed to reduce the use of resources, considerations of trade-offs are important. | | **x** | **x** | | | | | |
| | **I.** With the aid of technology, various aspects of the environment can be monitored to provide information for decision-making. | | | | | | | | |
| | **J.** The alignment of technological processes with natural processes maximizes performance and reduces negative impacts on the environment. | | | | | | | | |
| | **K.** Humans devise technologies to reduce the negative consequences of other technologies. | | √ | **x** | | | | | |
| | **L.** Decisions regarding the implementation of technologies involve the weighing of tradeoffs between predicted positive and negative effects on the environment. | | | √ | **x** | | | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | | | | |
| **K-2** | **A.** Products are made to meet individual needs and wants. | | | | | | | | |
| **3-5** | **B.** Because people's needs and wants change, new technologies are developed, and old ones are improved to meet those changes. | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| | **C.** Individual, family, community, and economic concerns may expand or limit the development of technologies. | | | | | | | | |
| **6-8** | **D.** Throughout history, new technologies have resulted from the demands, values, and interests of individuals, businesses, industries, and societies. | | | | | | | | |
| | **E.** The use of inventions and innovations has led to changes in society and the creation of new needs and wants. | | | | | | | | |
| | **F.** Social and cultural priorities and values are reflected in technological devices. | | | | | | | | |
| | **G.** Meeting societal expectations is the driving force behind the acceptance and use of products and systems. | | | | | | | | |
| **9-12** | **H.** Different cultures develop their own technologies to satisfy their individual and shared needs, wants, and values. | ● | ● | **x** | **x** | ● | ● | ● | ● |
| | **I.** The decision whether to develop a technology is influenced by societal opinions and demands, in addition to corporate cultures. | | **x** | **x** | **x** | | | | |
| | **J.** A number of different factors, such as advertising, the strength of the economy, the goals of a company and the latest fads contribute to shaping the design of and demand for various technologies. | ● | √ | √ | ● | ● | ● | ● | ● |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | | | | |
| **K-2** | **A.** The way people live and work has changed throughout history because of technology. | | | | | | | | |
| **3-5** | **B.** People have made tools to provide food, to make clothing, and to protect themselves. | | | | | | | | |
| **6-8** | **C.** Many inventions and innovations have evolved by using slow and methodical processes of tests and refinements. | | | | | | | | |
| | **D.** The specialization of function has been at the heart of many technological improvements. | | | | | | | | |
| | **E.** The design and construction of structures for service or convenience have evolved from the development of techniques for measurement, controlling systems, and the understanding of spatial relationships. | | | | | | | | |
| | **F.** In the past, an invention or innovation was not usually developed with the knowledge of science. | | | | | | | | |
| **9-12** | **G.** Most technological development has been evolutionary, the result of a series of refinements to a basic invention. | ● | | √ | | | | | |
| | **H.** The evolution of civilization has been directly affected by, and has in turn affected, the | ● | | **x** | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | development and use of tools and materials. | | | | | | | | |
| | **I.** Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape. | ● | | **x** | | | | | |
| | **J.** Early in the history of technology, the development of many tools and machines was based not on scientific knowledge but on technological know-how. | ● | | √ | | | | | |
| | **K.** The Iron Age was defined by the use of iron and steel as the primary materials for tools. | | | **x** | | | | | |
| | **L.** The Middle Ages saw the development of many technological devices that produced long-lasting effects on technology and society. | | | **x** | | | | | |
| | **M.** The Renaissance, a time of rebirth of the arts and humanities, was also an important development in the history of technology. | | | **x** | | | | | |
| | **N.** The Industrial Revolution saw the development of continuous manufacturing, sophisticated transportation, and communication systems, advanced construction practices, and improved education and leisure time. | | | **x** | | | | | |
| | **O.** The Information Age places emphasis on the processing and exchange of information. | | | **x** | | | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | | | | | | | |
| **K-2** | **A.** Everyone can design solutions to a problem. | | | | | | | | |
| **K-2** | **B.** Design is a creative process. | | | | | | | | |
| **3-5** | **C.** The design process is a purposeful method of planning practical solutions to problems. | | | | | | | | |
| **3-5** | **D.** Requirements for a design include such factors as the desired elements and features of a product or system or the limits that are placed on the design. | | | | | | | | |
| **6-8** | **E.** Design is a creative planning process that leads to useful products and systems. | | | | | | | | |
| **6-8** | **F.** There is no perfect design. | | | | | | | | |
| **6-8** | **G.** Requirements for a design are made up of criteria and constraints | | | | | | | | |
| **9-12** | **H.** The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design, creating or making it, and communicating processes and results. | **x** | **x** | **x** | √ | √ | √ | **x** | **x** |
| **9-12** | **I.** Design problems are seldom presented in a clearly | **x** | | √ | **x** | **x** | **x** | **x** | ● |

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|---|---|---|---|---|---|---|---|---|---|
| | defined form. | | | | | | | | |
| | **J.** The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved. | **x** | **x** | **x** | √ | √ | √ | √ | **x** |
| | **K.** Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other. | | **x** | **x** | **x** | **x** | √ | √ | ● |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | | | | | | | |
| **K-2** | **A.** The engineering design process includes identifying a problem, looking for ideas, developing solutions, and sharing solutions with others. | | | | | | | | |
| | **B.** Expressing ideas to others verbally and through sketches and models is an important part of the design process | | | | | | | | |
| **3-5** | **C.** The engineering design process involves defining a problem, generating ideas, selecting a solution, testing the solution(s), making the item, evaluating it, and presenting the results. | | | | | | | | |
| | **D.** When designing an object, it is important to be creative and consider all ideas. | | | | | | | | |
| | **E.** Models are used to communicate and test design ideas and processes. | | | | | | | | |
| **6-8** | **F.** Design involves a set of steps, which can be performed in different sequences and repeated as needed. | | | | | | | | |
| | **G.** Brainstorming is a group problem-solving design process in which each person in the group presents his or her ideas in an open forum. | | | | | | | | |
| | **H.** Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions. | | | | | | | | |
| **9-12** | **I.** Established design principles are used to evaluate existing designs, to collect data, and to guide the design process. | | √ | √ | **x** | ● | **x** | √ | ● |
| | **J.** Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly. | | ● | √ | √ | √ | **x** | **x** | **x** |
| | **K.** A prototype is a working model used to test a design concept by making actual observations and necessary adjustments. | | ● | ● | ● | ● | √ | √ | **x** |
| | **L.** The process of engineering design takes into account a number of factors. | | **x** | **x** | **x** | **x** | √ | √ | **x** |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|---|
| **K-2** | **A.** Asking questions and making observations helps a person to figure out how things work. | | | | | | | | |
| | **B.** All products and systems are subject to failure. Many products and systems, however, can be fixed. | | | | | | | | |
| **3-5** | **C.** Troubleshooting is a way of finding out why something does not work so that it can be fixed. | | | | | | | | |
| | **D.** Invention and innovation are creative ways to turn ideas into real things. | | | | | | | | |
| | **E.** The process of experimentation, which is common in science, can also be used to solve technological problems. | | | | | | | | |
| **6-8** | **F.** Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. | | | | | | | | |
| | **G.** Invention is a process of turning ideas and imagination into devices and systems. | | | | | | | | |
| | **H.** Some technological problems are best solved through experimentation. | | | | | | | | |
| **9-12** | **I.** Research and development is a specific problem-solving approach that is used intensively in business and industry to prepare devices and systems for the marketplace. | ● | **x** | **x** | **x** | **x** | **x** | √ | ● |
| | **J.** Technological problems must be researched before they can be solved. | **x** | **x** | **x** | ● | ● | **x** | ● | ● |
| | **K.** Not all problems are technological, and not every problem can be solved using technology. | ● | | | | | | √ | ● |
| | **L.** Many technological problems require a multidisciplinary approach. | ● | | | | | ● | ● | ● |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | | | | | | | |
| **K-2** | **A.** Brainstorm people's needs and wants and pick some problem that can be solved through the design process. | | | | | | | | |
| | **B.** Build or construct an object using the design process. | | | | | | | | |
| | **C.** Investigate how things are made and how they can be improved. | | | | | | | | |
| **3-5** | **D.** Identify and collect information about everyday problems that can be solved by technology, and generate ideas and requirements for solving a problem. | | | | | | | | |
| | **E.** The process of designing involves presenting some possible solutions in visual form and then selecting the best solution(s) from many. | | | | | | | | |
| | **F.** Test and evaluate the solutions for the design | | | | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | problem. | | | | | | | | |
| | **G.** Improve the design solutions. | | | | | | | | |
| **6-8** | **H.** Apply a design process to solve problems in and beyond the laboratory-classroom. | | | | | | | | |
| | **I.** Specify criteria and constraints for the design. | | | | | | | | |
| | **J.** Make two-dimensional and three-dimensional representations of the designed solution. | | | | | | | | |
| | **K.** Test and evaluate the design in relation to pre-established requirements, such as criteria and constraints, and refine as needed. | | | | | | | | |
| | **L.** Make a product or system and document the solution. | | | | | | | | |
| **9-12** | **M.** Identify the design problem to solve and decide whether or not to address it. | | **x** | **x** | ● | ● | **x** | | |
| | **N.** Identify criteria and constraints and determine how these will affect the design process. | | | **x** | | ● | **x** | ● | |
| | **O.** Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product. | ● | **x** | **x** | **x** | **x** | √ | **x** | **x** |
| | **P.** Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed. | | | | | √ | √ | √ | **x** |
| | **Q.** Develop and produce a product or system using a design process. | | | | | | **x** | **x** | ● |
| | **R.** Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models. | | | | | **x** | ● | √ | √ |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | | | | | | | | | |
| **K-2** | **A.** Discover how things work. | | | | | | | | |
| | **B.** Use hand tools correctly and safely and be able to name them correctly. | | | | | | | | |
| | **C.** Recognize and use everyday symbols. | | | | | | | | |
| **3-5** | **D.** Follow step-by-step directions to assemble a product. | | | | | | | | |
| | **E.** Select and safely use tools, products, and systems for specific tasks. | | | | | | | | |
| | **F.** Use computers to access and organize information. | | | | | | | | |
| | **G.** Use common symbols, such as numbers and words, to communicate key ideas. | | | | | | | | |
| **6-** | **H.** Use information provided in manuals, protocols, or | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| **8** | by experienced people to see and understand how things work. | | | | | | | | |
| | **I.** Use tools, materials, and machines safely to diagnose, adjust, and repair systems. | | | | | | | | |
| | **J.** Use computers and calculators in various applications. | | | | | | | | |
| | **K.** Operate and maintain systems in order to achieve a given purpose. | | | | | | | | |
| **9-12** | **L.** Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques. | ● | √ | √ | **x** | **x** | **x** | **x** | √ |
| | **M.** Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it. | ● | | | | | √ | **x** | |
| | **N.** Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision. | | | | | | √ | **x** | |
| | **O.** Operate systems so that they function in the way they were designed. | | | | | | √ | **x** | |
| | **P.** Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate. | | √ | **x** | **x** | **x** | **x** | √ | √ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | | | | |
| **K-2** | **A.** Collect information about everyday products and systems by asking questions. | | | | | | | | |
| | **B.** Determine if the human use of a product or system creates positive or negative results. | | | | | | | | |
| **3-5** | **C.** Compare, contrast, and classify collected information in order to identify patterns. | | | | | | | | |
| | **D.** Investigate and assess the influence of a specific technology on the individual, family, community, and environment. | | | | | | | | |
| | **E.** Examine the trade-offs of using a product or system and decide when it could be used. | | | | | | | | |
| **6-8** | **F.** Design and use instruments to gather data. | | | | | | | | |
| | **G.** Use data collected to analyze and interpret trends in order to identify the positive or negative effects of a technology. | | | | | | | | |
| | **H.** Identify trends and monitor potential consequences of technological development. | | | | | | | | |
| | **I.** Interpret and evaluate the accuracy of the information obtained and determine if it is useful. | | | | | | | | |
| **9-** | **J.** Collect information and evaluate its quality. | | √ | **x** | | | ● | √ | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| **12** | **K.** Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment. | | **x** | ● | | | | | ● |
| | **L.** Use assessment techniques, such as trend analysis and experimentation to make decisions about the future development of technology. | | | √ | | | ● | √ | ● |
| | **M.** Design forecasting to evaluate the results of altering natural systems. | | | | | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | | | | | | | | |
| **K-2** | **A.** Vaccinations protect people from getting certain diseases. | | | | | | | | |
| | **B.** Medicine helps sick people get better. | | | | | | | | |
| | **C.** There are many products designed specifically to help people take care of themselves. | | | | | | | | |
| **3-5** | **D.** Vaccines are designed to prevent diseases from developing and spreading; medicines are designed to relieve symptoms and stop diseases from developing. | | | | | | | | |
| | **E.** Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility. | | | | | | | | |
| | **F.** Many tools and devices have been designed to help provide clues about health and to provide a safe environment. | | | | | | | | |
| **6-8** | **G.** Advances and innovations in medical technologies are used to improve healthcare. | | | | | | | | |
| | **H.** Sanitation processes used in the disposal of medical products help to protect people from harmful organisms and disease, and shape the ethics of medical safety. | | | | | | | | |
| | **I.** The vaccines developed for use in immunization require specialized technologies to support environments in which a sufficient amount of vaccines are produced. | | | | | | | | |
| | **J.** Genetic engineering involves modifying the structure of DNA to produce novel genetic make-ups. | | | | | | | | |
| **9-12** | **K.** Medical technologies include prevention and rehabilitation, vaccines and pharmaceuticals, medical and surgical procedures, genetic engineering, and the systems within which health is protected and maintained. | | | | | | | | |
| | **L.** Telemedicine reflects the convergence of technological advances in a number of fields, including medicine, telecommunications, virtual | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | presence, computer engineering, informatics, artificial intelligence, robotics, materials science, and perceptual psychology. | | | | | | | | |
| | **M.** The sciences of biochemistry and molecular biology have made it possible to manipulate the genetic information found in living creatures. | | | | | | | | |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | | | | |
| **K-2** | **A.** The use of technologies in agriculture makes it possible for food to be available year round and to conserve resources. | | | | | | | | |
| | **B.** There are many different tools necessary to control and make up the parts of an ecosystem. | | | | | | | | |
| **3-5** | **C.** Artificial ecosystems are human-made environments that are designed to function as a unit and are comprised of humans, plants, and animals. | | | | | | | | |
| | **D.** Most agricultural waste can be recycled. | | | | | | | | |
| | **E.** Many processes used in agriculture require different procedures, products, or systems. | | | | | | | | |
| **6-8** | **F.** Technological advances in agriculture directly affect the time and number of people required to produce food for a large population. | | | | | | | | |
| | **G.** A wide range of specialized equipment and practices is used to improve the production of food, fiber, fuel, and other useful products and in the care of animals. | | | | | | | | |
| | **H.** Biotechnology applies the principles of biology to create commercial products or processes. | | | | | | | | |
| | **I.** Artificial ecosystems are human-made complexes that replicate some aspects of the natural environment. | | | | | | | | |
| | **J.** The development of refrigeration, freezing, dehydration, preservation, and irradiation provide long-term storage of food and reduce the health risks caused by tainted food. | | | | | | | | |
| **9-12** | **K.** Agriculture includes a combination of businesses that use a wide array of products and systems to produce, process, and distribute food, fiber, fuel, chemical, and other useful products. | | | | | | | | |
| | **L.** Biotechnology has applications in such areas as agriculture, pharmaceuticals, food and beverages, medicine, energy, the environment, and genetic engineering. | | | | | | | | |
| | **M.** Conservation is the process of controlling soil erosion, reducing sediment in waterways, conserving | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | water, and improving water quality. | | | | | | | | |
| | **N.** The engineering design and management of agricultural systems require knowledge of artificial ecosystems and the effects of technological development on flora and fauna. | | | | | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | | | | |
| **K-2** | **A.** Energy comes in many forms. | | | | | | | | |
| | **B.** Energy should not be wasted. | | | | | | | | |
| **3-5** | **C.** Energy comes in different forms. | | | | | | | | |
| | **D.** Tools, machines, products, and systems use energy in order to do work. | | | | | | | | |
| **6-8** | **E.** Energy is the capacity to do work. | | | | | | | | |
| | **F.** Energy can be used to do work, using many processes. | | | | | | | | |
| | **G.** Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done. | | | | | | | | |
| | **H.** Power systems are used to drive and provide propulsion to other technological products and systems. | | | | | | | | |
| | **I.** Much of the energy used in our environment is not used efficiently. | | | | | | | | |
| **9-12** | **J.** Energy cannot be created or destroyed; however, it can be converted from one form to another. | | | | | | | | |
| | **K.** Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others. | | | | | | | | |
| | **L.** It is possible to build an engine to perform work that does not exhaust thermal energy to the surroundings. | | | | | | | | |
| | **M.** Energy resources can be renewable or nonrenewable. | | | | | | | | |
| | **N.** Power systems must have a source of energy, a process, and loads. | | | | | | | | |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | | | | | | | | | |
| **K-2** | **A.** Information is data that has been organized. | | | | | | | | |
| | **B.** Technology enables people to communicate by sending and receiving information over a distance. | | | | | | | | |
| | **C.** People use symbols when they communicate by technology. | | | | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| **3-5** | **D.** The processing of information through the use of technology can be used to help humans make decisions and solve problems. | | | | | | | | |
| | **E.** Information can be acquired and sent through a variety of technological sources, including print and electronic media. | | | | | | | | |
| | **F.** Communication technology is the transfer of messages among people and/or machines over distances through the use of technology. | | | | | | | | |
| | **G.** Letters, characters, icons, and signs are symbols that represent ideas, quantities, elements, and operations. | | | | | | | | |
| **6-8** | **H.** Information and communication systems allow information to be transferred from human to human, human to machine, and machine to human. | | | | | | | | |
| | **I.** Communication systems are made up of a source, encoder, transmitter, receiver, decoder, and destination. | | | | | | | | |
| | **J.** The design of a message is influenced by such factors as the intended audience, medium, purpose, and nature of the message. | | | | | | | | |
| | **K.** The use of symbols, measurements, and drawings promotes clear communication by providing a common language to express ideas. | | | | | | | | |
| **9-12** | **L.** Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information. | ● | | | | **x** | | | ● |
| | **M.** Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine. | | ● | | | ● | ● | | ● |
| | **N.** Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate. | | ● | | | **x** | **x** | ● | √ |
| | **O.** Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination. | | ● | ● | ● | **x** | ● | | **x** |
| | **P.** There are many ways to communicate information, such as graphic and electronic means. | | √ | **x** | √ | √ | **x** | | √ |
| | **Q.** Technological knowledge and processes are communicated using symbols, measurement, conventions, icons, graphic images, and languages that incorporate a variety of visual, auditory, and tactile stimuli. | | √ | | **x** | √ | √ | | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | | | | |
| **K-2** | **A.** A transportation system has many parts that work together to help people travel. | | | | | | | | |
| | **B.** Vehicles move people or goods from one place to another in water, air, or space and on land. | | | | | | | | |
| | **C.** Transportation vehicles need to be cared for to prolong their use. | | | | | | | | |
| **3-5** | **D.** The use of transportation allows people and goods to be moved from place to place. | | | | | | | | |
| | **E.** A transportation system may lose efficiency or fail if one part is missing or malfunctioning or if a subsystem is not working. | | | | | | | | |
| **6-8** | **F.** Transporting people and goods involves a combination of individuals and vehicles. | | | | | | | | |
| | **G.** Transportation vehicles are made up of subsystems, such as structural, propulsion, suspension, guidance, control, and support, that must function together for a system to work effectively. | | | | | | | | |
| | **H.** Governmental regulations often influence the design and operation of transportation systems. | | | | | | | | |
| | **I.** Processes, such as receiving, holding, storing, loading, moving, unloading, delivering, evaluating, marketing, managing, communicating, and using conventions are necessary for the entire transportation system to operate efficiently. | | | | | | | | |
| **9-12** | **J.** Transportation plays a vital role in the operation of other technologies, such as manufacturing, construction, communication, health and safety, and agriculture. | | | | | | | | |
| | **K.** Intermodalism is the use of different modes of transportation, such as highways, railways, and waterways as part of an interconnected system that can move people and goods easily from one mode to another. | | | | | | | | |
| | **L.** Transportation services and methods have led to a population that is regularly on the move. | | | | | | | | |
| | **M.** The design of intelligent and non-intelligent transportation systems depends on many processes and innovative techniques. | | | | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | | | | |
| **K-2** | **A.** Manufacturing systems produce products in quantity. | | | | | | | | |
| | **B.** Manufactured products are designed. | | | | | | | | |
| **3-** | **C.** Processing systems convert natural materials into | | | | | | | | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| **5** | products. | | | | | | | | |
| | **D.** Manufacturing processes include designing products, gathering resources, and using tools to separate, form, and combine materials in order to produce products. | | | | | | | | |
| | **E.** Manufacturing enterprises exist because of a consumption of goods. | | | | | | | | |
| **6-8** | **F.** Manufacturing systems use mechanical processes that change the form of materials through the processes of separating, forming, combining, and conditioning them. | | | | | | | | |
| | **G.** Manufactured goods may be classified as durable or non-durable. | | | | | | | | |
| | **H.** The manufacturing process includes the designing, development, making, and servicing of products and systems. | | | | | | | | |
| | **I.** Chemical technologies are used to modify or alter chemical substances. | | | | | | | | |
| | **J.** Materials must first be located before they can be extracted from the earth through such processes as harvesting, drilling, and mining. | | | | | | | | |
| | **K.** Marketing a product involves informing the public about it as well as assisting in selling and distributing it. | | | | | | | | |
| **9-12** | **L.** Servicing keeps products in good operating condition. | | | | | | | | |
| | **M.** Materials have different qualities and may be classified as natural, synthetic, or mixed. | | | | | | | | |
| | **N.** Durable goods are designed to operate for a long period of time, while non-durable goods are designed to operate for a short period of time. | | | | | | | | |
| | **O.** Manufacturing systems may be classified into types, such as customized production, batch production, and continuous production. | | | | | | | | |
| | **P.** The interchangeability of parts increases the effectiveness of manufacturing processes. | | | | | | | | |
| | **Q.** Chemical technologies provide a means for humans to alter or modify materials and to produce chemical products. | | | | | | | | |
| | **R.** Marketing involves establishing a product's identity, conducting research on its potential, advertising it, distributing it, and selling it. | | | | | | | | |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | | | | |
| **K-2** | **A.** People live, work, and go to school in buildings, which are of different types: houses, apartments, | | | | | | | | |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|---|
| | office buildings, and schools. | | | | | | | | |
| | **B.** The type of structure determines how the parts are put together. | | | | | | | | |
| **3-5** | **C.** Modern communities are usually planned according to guidelines. | | | | | | | | |
| | **D.** Structures need to be maintained. | | | | | | | | |
| | **E.** Many systems are used in buildings. | | | | | | | | |
| **6-8** | **F.** The selection of designs for structures is based on factors such as building laws and codes, style, convenience, cost, climate, and function. | | | | | | | | |
| | **G.** Structures rest on a foundation. | | | | | | | | |
| | **H.** Some structures are temporary, while others are permanent. | | | | | | | | |
| | **I.** Buildings generally contain a variety of subsystems. | | | | | | | | |
| **9-12** | **J.** Infrastructure is the underlying base or basic framework of a system. | | | | | | | | |
| | **K.** Structures are constructed using a variety of processes and procedures. | | | | | | | | |
| | **L.** The design of structures includes a number of requirements. | | | | | | | | |
| | **M.** Structures require maintenance, alteration, or renovation periodically to improve them or to alter their intended use. | | | | | | | | |
| | **N.** Structures can include prefabricated materials. | | | | | | | | |

**Table 1.** Comparison of *Standards for Technological Literacy* (*STL*) and Project Lead The Way® **Engineering Design and Development™.**

Source: International Technology Education Association's (ITEA)
**http://www.iteaconnect.org**

# Engineering Design and Development Standards for the English Language Arts Matrix

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | ● | | | | | | | |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | | | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | | √ | ● | | | | | |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | √ | √ | **x** | **x** | **x** | √ | √ | √ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | √ | **x** | **x** | ● | ● | √ | √ | √ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and non-print texts. | √ | √ | √ | **x** | ● | √ | ● | **x** |
| ***SELA* Standard 7:** Students conduct research on issues and | ● | √ | √ | ● | ● | | √ | √ |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|
| interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | | | | | | | | |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | ● | √ | **x** | ● | ● | ● | √ | √ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | ● | ● | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | **x** | **x** | **x** | ● | ● | | | |
| ***SELA* Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | √ | √ | √ | √ | √ | √ | √ | √ |

**Table 1.** Comparison of *Standards for the English Language Arts* (*SELA*) and Project Lead The Way® **Engineering Design and Development™.**

Source: National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Engineering Design and Development Principles and Standards for School Mathematics MATRIX

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems; | √ | | **x** | | **x** | √ | √ | |
| • understand meanings of operations and how they relate to one another; | **x** | | **x** | | **x** | **x** | | |
| • compute fluently and make reasonable estimates | ● | | **x** | | **x** | √ | √ | |
| ***PSSM* Algebra Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • understand patterns, relations, and functions; | | | | | **x** | ● | ● | |
| • represent and analyze mathematical situations and structures using algebraic symbols; | | | ● | | **x** | √ | ● | |
| • use mathematical models to represent and understand quantitative relationships; | | | | | √ | | √ | |
| • analyze change in various contexts. | | | ● | | ● | | | |
| ***PSSM* Geometry Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships; | | | √ | | √ | √ | | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems; | | | ● | | √ | √ | | |
| • apply transformations and use symmetry to analyze mathematical situations; | | | ● | | **x** | **x** | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | | √ | | √ | √ | √ | |

| **Key:**<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|
| ***PSSM* Measurement Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement; | | | **x** | | √ | √ | √ | |
| • apply appropriate techniques, tools, and formulas to determine measurements. | | | **x** | | √ | √ | √ | |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; | | √ | √ | | | | √ | |
| • select and use appropriate statistical methods to analyze data; | | ● | ● | | | | √ | |
| • develop and evaluate inferences and predictions that are based on data; | | | | | | | ● | |
| • understand and apply basic concepts of probability. | | | | | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • build new mathematical knowledge through problem solving; | | √ | | | | | | |
| • solve problems that arise in mathematics and in other contexts; | | ● | | | ● | ● | | |
| • apply and adapt a variety of appropriate strategies to solve problems; | | **x** | | | ● | ● | | |
| • monitor and reflect on the process of mathematical problem solving. | | ● | | | | | | |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics; | | | | | | | | |
| • make and investigate mathematical conjectures; | | | | | | | | |
| • develop and evaluate mathematical arguments and proofs; | | | | | | | | |
| • select and use various types of reasoning and methods of proof. | | | | | | | | |
| ***PSSM* Communication Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • organize and consolidate their mathematical thinking through communication; | | | **x** | √ | √ | ● | √ | √ |

| Key:<br>√ denotes a correlation in ideas and concepts in both standard and lessons<br>**x** denotes the ideas and concepts may not be directly addressed, but the ideas are supported in both lesson and activities<br>● denotes an implied idea or concept that may be used in both lesson and activity | Unit 1 | Unit 2 | Unit 3 | Unit 4 | Unit 5 | Unit 6 | Unit 7 | Unit 8 |
|---|---|---|---|---|---|---|---|---|
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others; | | | √ | **x** | **x** | √ | √ | √ |
| • analyze and evaluate the mathematical thinking and strategies of others; | | | ● | | ● | ● | **x** | **x** |
| • use the language of mathematics to express mathematical ideas precisely | | | ● | **x** | √ | √ | √ | √ |
| ***PSSM* Connections Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • recognize and use connections among mathematical ideas; | | ● | ● | ● | ● | ● | ● | |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole; | | | | | ● | | ● | |
| • recognize and apply mathematics in contexts outside of mathematics. | | √ | √ | √ | √ | **x** | √ | √ |
| ***PSSM* Representation Standard:** Instructional programs from pre-kindergarten through grade 12 should enable all students to— | | | | | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas; | | | √ | | ● | √ | √ | √ |
| • select, apply, and translate among mathematical representations to solve problems; | | | ● | | ● | ● | ● | |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | | **x** | | **x** | √ | √ | √● |

**Table 1.** Comparison of *Principles and Standards for School Mathematics* (*PSSM*) and Project Lead The Way® **Engineering Design and Development™.**

Source: National Council of Teachers of Mathematics (NCTM) ***Principles and Standards for School Mathematics***.

# College-Level Recognition

# BMS

PROJECT LEAD THE WAY
PLTW

# PBS

# Principles of the Biomedical Sciences Course Description

This course provides an introduction to the biomedical sciences through exciting hands-on projects and problems. Students investigate the human body systems and various health conditions including heart disease, diabetes, sickle-cell disease, hypercholesterolemia, and infectious diseases. They determine the factors that led to the death of a fictional person, and investigate lifestyle choices and medical treatments that might have prolonged the person's life. The activities and projects introduce students to human physiology, medicine, research processes and bioinformatics. Key biological concepts including homeostasis, metabolism, inheritance of traits, and defense against disease are embedded in the curriculum. Engineering principles including the design process, feedback loops, and the relationship of structure to function are also incorporated. This course is designed to provide an overview of all the courses in the Biomedical Sciences program and lay the scientific foundation for subsequent courses.

# Principles of the Biomedical Sciences Detailed Outline

## Unit One: Human Body Systems
## Time Days (22 days)

**Lesson 1.1: The Mystery** (22 days)
**Concepts Addressed in Lesson:**

1. The human body is composed of multiple body systems working together to maintain good health.
2. Each human body system is composed of specific organs that interact to complete specialized functions in the body.
3. Determining the cause of death involves the investigation of many aspects of the medical condition of a victim, the internal and external examination of the body, the chemical and microscopic analysis of tissues and body fluids, and may involve many different biomedical professionals.
4. Healthcare professionals are bound by laws and ethical standards to maintain the confidentiality of patients.
5. It is important to evaluate a source of information to insure the information is accurate and unbiased; all sources used for information should be properly cited in presentations and reports.
6. Plagiarism invalidates the work of the person who copied the words, and deprives the original author of credit.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Construct a life-size human body poster, showing the location of major systems in the human body and the organs that comprise them.
- Work as a team member to create a visual and oral presentation, containing pictures and text, to explain the major features and functions of a body system.
- Produce a concept map of a body system.
- Make a concept map showing the interconnections between two body systems.
- Write a summary of the Health Insurance Portability and Accountability Act (HIPAA).

## Unit Two: Heart Attack
## Time Days (29 days)

### Lesson 2.1: What Is a Pump? (2 days)

**Concepts Addressed in Lesson:**

1. A pump is a machine that moves a fluid from one location to another.
2. There are multiple ways to construct a pump.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Build a pump that successfully moves 150 mL of water from one location to another.

### Lesson 2.2: The Structure of the Human Heart (7 days)

**Concepts Addressed in Lesson:**

1. The human heart is a four-chambered living pump designed to provide the force needed to transport blood through all the tissues of the body.
2. The design of the four-chambered allows the heart to handle both oxygenated blood from the lungs and un-oxygenated blood from the body without mixing the two types of blood.
3. The human heart has different types of tissue which vary in characteristics.
4. A tissue is a group of similar cells designed to carry out a specific function.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create two dimensional drawings of the human heart labeling all important structures.
- Dissect a sheep's heart, accurately identifying and describing the function of the specified structures.
- Compare and contrast the characteristics of the different cardiac tissue types.
- Explain how the design of the four-chambered heart allows the heart to pump both oxygenated and un-oxygenated blood without mixing.

### Lesson 2.3: The Heart at Work (12 days)

**Concepts Addressed in Lesson:**

1. Heartbeat is caused by the contraction of cardiac muscle cells resulting in the movement of blood from the heart to the arteries and the rest of the body.
2. Heart rate is the number of heart contractions per unit of time, usually per minute.
3. Heart rate, EKG, and blood pressure measurements are indicators of a person's medical condition.
4. Internal and external factors affect heart function including heart rate, EKG, and blood pressure.
5. Blood pressure is a measure of the force put on the vascular walls by the blood as it is pushed by the cardiac muscles through the vascular system.
6. The electrical activity of the heart can be measured and recorded by an electrocardiogram (EKG or ECG).

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Make a simple program using LabVIEW software and be able to describe the purpose of the front panel and block diagram.
- Demonstrate the use of technology as an important tool in the Biomedical Sciences by using various Vernier probes and LabVIEW software to collect cardiovascular data.
- Use the Experimental Design Process to create and carry out experiments on blood pressure and heart rate.
- Collect and analyze EKG data.
- Investigate factors that can impact heart rate and blood pressure.

**Lesson 2.4: Blood – The River of Life** (8 days)

**Concepts Addressed in Lesson:**

1. Blood is liquid connective tissue composed of red cells, white cells and platelets suspended in liquid plasma.
2. Red cells, erythrocytes, contain large amounts of hemoglobin and are essential for transporting oxygen to all body cells.
3. White cells, leukocytes, are responsible for fighting infection.
4. Platelets are cell fragments that are necessary for blood to clot.
5. All blood cells originate in the bone marrow.
6. Blood is the major transport mechanism for substances that must be distributed through the body, including gases, molecules, nutrients, and hormones.
7. The body must continually replenish blood cells.

***Performance Objectives* Addressed in Lesson:**

*It is expected that students will:*

- Identify, sketch, and measure red and white blood cells viewed under a microscope.
- Identify and describe the functions of the major components of human blood.
- Identify and sketch various types of human tissues viewed under a microscope.
- Demonstrate an understanding of the differences between cells, tissues, and organs.
- Use and explain mathematical procedures to estimate size of objects viewed under a microscope.
- Explain the importance of blood to human survival.

## Unit Three: Diabetes
## Time Days (38 days)

**Lesson 3.1: What Is in Our Food?** (11 days)

**Concepts Addressed in Lesson:**

1. Food labels are a useful way to determine which nutrients and what percentages of their daily values are present in a food.
2. Foods are composed of molecules and macromolecules, which in turn are made of atoms.
3. The chemical bonds formed between atoms are sources of energy, and the energy is released when the bonds are broken.
4. Homeostasis depends upon many different chemical reactions.
5. Water is an essential component of human bodies and has unique properties including the ability to dissolve many molecules and compounds.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Analyze food labels for nutritional content.
- Explain the term Dietary Reference Intake and its importance to good nutrition.
- Build and analyze molecular models and diagrams of atoms, molecules and simple compounds.
- Describe the role of chemical bonding in chemical reactions and the transfer of energy.

- Explain the process of calorimetry and how it is used to measure the amount of energy in a food.
- Explain why water is an essential component of human bodies.

**Lesson 3.2: Macromolecules** (7 days)

**Concepts Addressed in Lesson:**

1. Foods contain macromolecules which are broken down and reassembled for use in the human body.
2. Macromolecules are classified into four groups, proteins, carbohydrates, lipids, and nucleic acids, based on their structure.
3. The different classes of macromolecules perform different functions in the body.
4. Macromolecules within the same classification have great variability because of the multiple ways their components can be arranged, and a macromolecule's function is dependent on the specific arrangement of the components.
5. Chemical indicators can be used to identify specific molecules.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Build models of carbohydrates, proteins and lipids.
- Differentiate between the classes of macromolecules in terms of their structures and functions.
- Give examples of different foods that contain each of these types of nutrients.
- Explain the role of indicators in identifying chemical compounds.
- Design a graphic organizer to summarize the results of a food identification activity.

**Lesson 3.3: Molecules Working Together** (3 days)

**Concepts Addressed in Lesson:**

1. Catalysts facilitate chemical reactions by reducing the energy needed for the reaction to occur.
2. Enzymes are usually proteins and act as catalysts in the human body.
3. Enzymes are designed to be highly specific, and the structure of the enzyme's active site determines structure of the substrate it acts upon.
4. Co-enzymes are needed for some enzymes to function, and many vitamins are co-enzymes.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Create a detailed outline demonstrating an understanding of the structure and function of enzymes.
- Create a concept map illustrating the information in the outline describing the structure and function of enzymes.
- Demonstrate an understanding of both Lock and Key Model and Induced Fit Model of enzyme function by creating and explaining a 3-D model of how enzymes link to substrates.
- Explain the importance of enzymes on maintaining homeostasis in the human body.
- Describe the function of co-enzymes and give examples of co-enzymes found in food.

### **Lesson 3.4: The Diabetes Connection** (14 days)

**Concepts Addressed in Lesson:**

1. The human body uses both positive and negative feedback mechanisms to maintain homeostasis.
2. Insulin is the protein that regulates the transfer of glucose into body cells and it is part of a feedback system that maintains the level of glucose in the blood.
3. Diabetes is a disorder caused by insufficient insulin or the inability of the insulin to function properly.
4. Diabetes is a serious health issue in the U.S., with long term impacts on individuals, families, and communities.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Explain how feedback systems are used by the human body to maintain homeostasis.
- Create a 3-D working model that demonstrates the role of insulin in transferring glucose from blood into cells.
- Explain the causes, symptoms, effects, and treatments of both Type I and Type II diabetes.
- Demonstrate an understanding of the dietary requirements and restrictions of people who have diabetes.
- Demonstrate an understanding of the ways in which diabetes can impact one’s daily life.
- Describe behaviors that could help prevent the onset of Type II diabetes.

### **Lesson 3.5: Life with Diabetes** (3 days)

**Concepts Addressed in Lesson:**

1. Diabetes not only affects the individual, but it also impacts the family, friends and associates of the people with this disorder.
2. All carbohydrates, not just simple sugars, must be closely monitored in the daily lives of people with diabetes.
3. The dietary guidelines for individuals who have diabetes are healthy for all people.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Demonstrate an understanding of the lifestyle implications living with diabetes involves.
- Plan a menu that is nutritionally complete and appropriate for a diabetic teenager. (optional)

# Unit 4: Sickle Cell Disease
# Time Days (35 days)

**Lesson 4.1: What Is Sickle Cell Disease?** (5 days)

**Concepts Addressed in Lesson:**

1. Cells need oxygen in order to function properly, and the hemoglobin protein in red blood cells transports oxygen to the cells.
2. People with deformed hemoglobin experience a variety of health issues.
3. Changes to the structure of a protein can change its ability to function properly.
4. The incidence of a particular disease varies between different countries.

***Performance Objectives* Addressed in Lesson:**
*It is expected that students will:*

- Use proper microscope technique to examine and record their observations of normal and sickle red blood cells in their lab journal.
- Use appropriate Internet research techniques to obtain information on the symptoms and complications of the sickle cell trait and anemia.
- Prepare a chart comparing the symptoms and complications of sickle cell trait to sickle cell disease.
- Write a letter to a peer which explains the relationship between the symptoms of anemia and cell energencics.

**Lesson 4.2: What Causes Sickle Cell Disease?** (8 days)

**Concepts Addressed in Lesson:**

1. Chromosomes in reproductive cells carry traits through the generations.
2. The expression of a trait through the generations of a family can be visualized using a pedigree.
3. Genetic diseases are passed from parents to children before birth and are not contagious.
4. Changes in the genetic material may cause changes in the traits of an organism.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use proper laboratory techniques to create chromosome spreads of human HeLa cells.
- Use proper techniques to examine, count, and measure chromosomes from HeLa cells and properly document data.
- Create and analyze pedigree charts to illustrate passage of a trait through at least three generations.
- Calculate the probability of a trait appearing in offspring.

## Lesson 4.3: How Do Chromosomes Carry Information? (10 days)

**Concepts Addressed in Lesson:**

1. Deoxyribonucleic Acid (DNA) is the genetic material for cells and organisms.
2. DNA from all living organisms has the same basic structure—the differences are in the sequences of the nucleotides.
3. Genes, segments of DNA sequence, code for traits.
4. Each chromosome contains numerous genes.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Build a model of the DNA molecule and be able to use appropriate vocabulary to describe its structure.
- Use appropriate laboratory methods to isolate DNA from plant and animal cells.
- Calculate the length of DNA in a cell and properly convert units of nanoscale measurement.

## Lesson 4.4: What Is the DNA Code? (7 days)

**Concepts Addressed in Lesson:**

1. The sequence of nucleotides in DNA determines the sequence of amino acids in a protein.
2. The genetic code is universal.
3. The sequence of amino acids in a protein determines the protein's 3-dimensional shape.
4. Proteins have multiple structural levels.
5. A protein's shape is not constant; it changes depending on its environment.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify the exons, coding regions, of a gene by comparing the DNA code to the amino acid sequence of the protein.
- Work in teams to build accurate 3-dimensional models of the β-globin protein.
- Design a protein with a specific function by specifying the sequence of nucleotides in the protein's gene.

**Lesson 4.5: Mistakes Happen** (5 days)

**Concepts Addressed in Lesson:**

1. Chromosomal abnormalities cause multiple, often morbid complications and can be detected by karyotyping.
2. Humans have two copies of each of the 23 different chromosomes.
3. Many diseases are caused by mutations in genes.
4. Changing a single amino acid in a protein can change the properties of a protein and its 3-dimensional shape.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Complete and analyze karyotypes.
- Summarize and present information on syndromes associated with chromosomal abnormalities.
- Assemble models of specified amino acids.
- Create and present PowerPoint presentations on assigned diseases which are caused by a genetic mutation.

# Unit 5: Hypercholesterolemia
# Time Days (11 days)

## Lesson 5.1: Cholesterol (5 days)

**Concepts Addressed in Lesson:**

1. There are many types of fat or lipid molecules and each has different physical properties and functions in the body.
2. The type of bond between the carbon atoms in a fatty acid determines whether it is saturated or unsaturated with hydrogen atoms.
3. Cholesterol is a lipid and is necessary for the proper functioning of cells and for maintaining a healthy body.
4. Cholesterol is transported in the blood by protein complexes called high density lipoprotein (HDL) and low density lipoprotein (LDL); the measurement of these complexes may indicate a person's risk for heart disease.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Interpret molecular structure diagrams and correctly construct three dimensional models of stearic acid, oleic acid, linoleic acid, stearidonic acid, and cholesterol.
- Identify a fatty acid as saturated or unsaturated by examining either the structural diagram or a three dimensional model.
- Create a poster or brochure informing other students about HDL and LDL and how these molecules are associated with the risk for heart disease.

## Lesson 5.2: Molecular Biological Techniques for Diagnosing Disease (6 days)

**Concepts Addressed in Lesson:**

1. DNA from numerous sources including blood and saliva can be amplified and analyzed.
2. The Polymerase Chain Reaction (PCR) exponentially increases the number of DNA molecules.
3. Restriction Fragment Length Polymorphism allows for genetic diseases and disorders to be diagnosed by analysis of DNA samples without DNA sequencing.
4. DNA gel electrophoresis separates DNA fragments based on size and is used in Restriction Fragment Length Polymorphism analysis.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Calculate the amplification of DNA during the polymerase chain reaction.
- Create a graph of the amplification rate.
- Use proper laboratory techniques to separate DNA fragments by gel electrophoresis.
- Analyze the results of the gel electrophoresis to correctly diagnose the presence of the familial hypercholesterolemia mutation.

# Unit 6: Infectious Diseases
# Time Days (17 days)

### **Lesson 6.1: Bacteria** (8 days)

**Concepts Addressed in Lesson:**

1. Many different types of bacteria exist and only a few cause disease.
2. Bacteria are classified by their reaction to the Gram stain, shape, and metabolism.
3. Antibiotics can be used to treat bacterial infections, but the choice of antibiotic depends on the type of bacteria causing the infection.
4. Many strains of bacteria are developing resistance to antibiotics.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use proper aseptic technique to sample and transfer bacterial cells to microscope slides.
- Use proper Gram staining and microscope techniques to stain and observe bacteria.
- Perform and analyze a test of antibiotic efficiency using pour plates and antibiotic discs.

### **Lesson 6.2: Viruses** (4 days)

**Concepts Addressed in Lesson:**

1. Viruses are non-living particles that can infect cells and cause disease.
2. Antibiotics have no effect on viruses and are ineffective treatments for viral diseases.
3. Viruses are very specific and must be able to attach to a cell to be able to infect it.
4. Viruses contain genetic material that can mutate causing a change in the characteristics of the virus, including allowing the virus to attach to new types of cells.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use proper research techniques to find information from a variety of sources about the structure of viruses.
- Build an accurate, labeled, and scaled model of a virus particle.
- Produce an accurate and informative PowerPoint presentation about the symptoms, prevalence, prevention, treatment, and the global economic and social impact of an infectious disease caused by a virus.

### Lesson 6.3: Public Health Campaign (5 days)

**Concepts Addressed in Lesson:**

1. Public education can help prevent the spread of disease.
2. Infectious diseases are spread in a wide variety of ways.
3. Basic personal preventive measures including hand washing, surface cleaning, and using tissues can prevent the spread of many diseases.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design and produce a Public Health Awareness Campaign to inform people about the cause, symptoms, and prevention of an infectious disease.

## Unit 7: Medical Interventions
## Time Days (13 days)

### Lesson 7.1: Medical Interventions (13 days)

**Concepts Addressed in Lesson:**

1. The field of biomedical sciences includes all sciences related to the prevention of disease and the development of effective treatments.
2. A wide variety of medical interventions are available to prevent and treat disease.
3. Not all patients respond the same way to a medical intervention, and the physician should carefully select the best treatment for each patient.
4. Development of treatment and prevention methods is directly related to engineering principles and technology development.
5. The need for medical interventions drives the development, improvement, and application of technology.
6. The availability of technology drives the development, improvement, and application of medical interventions.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Analyze the effect of replacing an enzyme on the ability of a living cell (yeast) to complete a chemical reaction.
- Create a product (e.g. game, comic book, or cartoon) that demonstrates the steps or stages in the development, trial, and approval of medical interventions.
- Research, categorize, and summarize the medical interventions that prevent or treat an assigned disease.
- Present and explain the modes of action of the researched medical interventions to the class.

## Unit 8: Grant Proposal
## Time Days (10 days)

**Lesson 8.1: Grant Proposal** (10 class days interspersed through last 10 weeks)

**Concepts Addressed in Lesson:**

1. Medical research is an essential component in the quest to increase longevity and improve quality of life.
2. Medical research has lead to the improved quality of medical care.
3. The necessity for medical research continues to be an important aspect of modern society.
4. Medical research is funded through the grant process.
5. A grant is a detailed proposal describing all aspects of a research project and is used to acquire funds to support research work.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use consensus to identify a medical condition or disease of interest.
- Identify an aspect of the disease or medical condition in need of research.
- Prepare a detailed grant proposal requesting funds for a research project to impact a specific aspect of the disease or medical condition.
- Use consensus as a decision making strategy on the team.
- Present the grant proposal in the form of an oral presentation.
- Use a rubric to evaluate all team presentations including their own.
- Complete a peer evaluation for team members including a self evaluation.

# National Science Education Standards in Principles of the Biomedical Sciences

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Human Body Systems | Unit 2—Heart Attack | Unit 3—Diabetes | Unit 4—Sickle-Cell Disease | Unit 5— Hypercholesterolemia | Unit 6—Infectious Diseases | Unit 7— Medical Interventions | Unit 8— Grant Proposal |
|---|---|---|---|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | | | | | |
| • **Systems, order, and organization** | | | | | | | | |
| o A system is an organized group of related objects or components that form a whole. | ✓ | x | x | x | | | ✓ | |
| o Systems have boundaries, components, resources flow (input and output), and feedback. | ✓ | x | x | x | | | ✓ | |
| o Order—behavior of units of matter, objects, organisms, or events in the universe—can be described statistically. | ✓ | | x | x | ● | X | ● | |
| o Types and levels of organization provide useful ways of thinking about the world. | ● | ● | x | ● | ● | x | ● | ● |
| • **Evidence, models, and explanation** | | | | | | | | |
| o Evidence consists of observations and data on which to base scientific explanations. | ✓ | x | x | ✓ | x | x | ✓ | ✓ |
| o Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. | ✓ | x | x | x | x | x | ✓ | ✓ |
| o Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. | ✓ | ● | x | x | ● | x | ● | ✓ |
| • **Change, constancy, and measurement** | | | | | | | | |
| o Although most things are in the process of becoming different—changing—some properties of objects and processes are characterized by constancy. | | x | x | x | | | | |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Human Body Systems | Unit 2—Heart Attack | Unit 3—Diabetes | Unit 4—Sickle-Cell Disease | Unit 5— Hypercholesterolemia | Unit 6—Infectious Diseases | Unit 7— Medical Interventions | Unit 8— Grant Proposal |
|---|---|---|---|---|---|---|---|---|
| o Interactions within and among systems result in change. | ● | **x** | **x** | **x** | ● | ● | | |
| o Changes in systems can be quantified. | | **x** | **x** | **x** | | ● | | |
| o Mathematics is essential for accurately measuring change. | ● | **x** | **x** | **x** | **x** | **x** | ● | |
| o Scale includes understanding that different characteristics, properties, or relationships within a system might change as its dimensions are increased or decreased. | ✓ | **x** | **x** | **x** | | ● | ● | |
| • **Evolution and equilibrium** | | | | | | | | |
| o Evolution is a series of changes, some gradual and some sporadic, that accounts for the present form and function of objects, organisms, and natural and designed systems. | | | | | | | | |
| o Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. | | | **x** | | | | | |
| o Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible. | | | | | | | | |
| • **Form and function** | | | | | | | | |
| o The form or shape of an object or system is frequently related to use, operation, or function. | ✓ | ✓ | **x** | ✓ | **x** | **x** | | |
| o Students should be able to explain function by referring to form and to explain form by referring to function. | ✓ | **x** | **x** | ✓ | **x** | **x** | | |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | | | | | |
| • **Abilities necessary to do scientific inquiry** | | | | | | | | |
| o Identify questions and concepts that guide scientific investigation. | ✓ | **x** | **x** | ✓ | ✓ | ✓ | ✓ | ✓ |
| o Design and conduct scientific investigations. | | **x** | **x** | **x** | **x** | **x** | | ✓ |
| o Use technology and mathematics to improve investigations and communications. | ✓ | **x** | **x** | ✓ | **x** | ✓ | ✓ | ✓ |
| o Formulate and revise scientific explanations and models using logic and evidence. | ✓ | **x** | **x** | **x** | **x** | ✓ | ✓ | ✓ |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Human Body Systems | Unit 2—Heart Attack | Unit 3—Diabetes | Unit 4—Sickle-Cell Disease | Unit 5— Hypercholesterolemia | Unit 6—Infectious Diseases | Unit 7— Medical Interventions | Unit 8— Grant Proposal |
|---|---|---|---|---|---|---|---|---|
| o Recognize and analyze alternative explanations and models. | ✓ | x | x | x | | ✓ | ✓ | ✓ |
| o Communicate and defend a scientific argument. | ✓ | x | x | x | x | ✓ | ✓ | ✓ |
| • **Understandings about scientific inquiry** | | | | | | | | |
| o Scientists usually inquire about how physical, living, or designed systems function. | ● | x | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| o Scientists conduct investigations for a variety of reasons. | ● | x | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| o Scientists rely on technology to enhance the gathering and manipulation of data. | ✓ | x | x | ✓ | ✓ | ✓ | ✓ | ✓ |
| o Mathematics is essential in scientific inquiry. | ✓ | x | x | x | ✓ | x | ✓ | ✓ |
| o Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. | ✓ | x | x | x | ✓ | x | ● | ✓ |
| o Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. | ✓ | x | x | x | x | x | ✓ | ✓ |
| ***NSES* Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |
| • **Structure of atoms** | | | | | | | | |
| o Matter is made of minute particles called atoms | | | x | | | | | |
| o The atom's nucleus is composed of protons and neutrons | | | x | | | | | |
| o The nuclear forces that hold the nucleus of an atom together | | | | | | | | |
| o Radioactive isotopes are unstable and undergo spontaneous nuclear reactions | | | | | | | | |
| • **Structure and properties of matter** | | | | | | | | |
| o Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. | | | x | | x | | | |
| o An element is composed of a single type of | | | x | | ● | | | |

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|---|---|---|---|---|---|---|---|---|
| atom. | | | | | | | | |
| o Bonds between atoms are created when electrons are paired up by being transferred or shared. | | | **x** | | **x** | | | |
| o The physical properties of compounds reflect the nature of the interactions among its molecules. | | | **x** | **x** | **x** | | | |
| o Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. | | | | | | | | |
| o Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life. | | | **x** | ● | **x** | | | |
| • **Chemical reactions** | | | | | | | | |
| o Chemical reactions occur all around us, for example health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies. | | | **x** | | **x** | | ● | |
| o Chemical reactions may release or consume energy. | | | **x** | | | | ● | |
| o A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. | | | **x** | | | | | |
| • **Motions and forces** | | | | | | | | |
| o Objects change their motion only when a net force is applied. | | | | | | | | |
| o Gravitation is a universal force that each mass exerts on any other mass. | | | | | | | | |
| o The electric force is a universal force that exists between any two charged objects. | | | | | | | | |
| o Between any two charged particles, electric force is vastly greater than the gravitational force. | | | | | | | | |
| o Electricity and magnetism are two aspects of a | | | | | | | | |

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| single electromagnetic force. | | | | | | | | |
| • **Conservation of energy and increase in disorder** | | | | | | | | |
| o The total energy of the universe is constant. | | | | | | | | |
| o All energy can be considered to be kinetic energy, potential energy, or energy contained by a field. | | | | | | | | |
| o Heat consists of random motion and the vibrations of atoms, molecules, and ions. | | | | | | | | |
| o Everything tends to become less organized and less orderly over time. | | | | | | | | |
| • **Interactions of energy and matter** | | | | | | | | |
| o Waves have energy and transfer energy when they interact with matter. | | | | | | | | |
| o Electromagnetic waves result when a charged object is accelerated or decelerated. | | | | | | | | |
| o Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. | | | | | | | | |
| o In some materials electrons flow easily, whereas in insulating materials they can hardly flow at all. | | | | | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |
| • **The cell** | | | | | | | | |
| o Cells have particular structures that underlie their functions. | ● | **x** | **x** | ✓ | **x** | **x** | ● | |
| o Most cell functions involve chemical reactions. | ● | ● | **x** | **x** | **x** | **x** | | |
| o Cells store and use information to guide their functions. | ● | ● | ● | **x** | ● | **x** | | |
| o Cell functions are regulated. | ● | **x** | **x** | **x** | **x** | **x** | | |
| o Plant cells contain chloroplasts, the site of photosynthesis. | | | | | | | | |
| o The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. | | | | | | | | |

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| o Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. | **x** | **x** | ● | **x** | ● | ● | ● | |
| • **Molecular basis of heredity** | | | | | | | | |
| o In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). | | | | **x** | **x** | | | |
| o Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: females have two X chromosomes and males have one X and one Y chromosome. | | | | **x** | **x** | | | |
| o Changes in DNA (mutations) occur spontaneously at low rates. | | | | **x** | **x** | | | |
| • **Biological evolution** | | | | | | | | |
| o Species evolve over time. | | | | | | **x** | | |
| o The great diversity of organisms is the result of more than 3.5 billion years of evolution. | | | | | | | | |
| o Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. | | | | | | | | |
| o The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors. | | | | | | | | |
| o Biological classifications are based on how organisms are related. | | | | | | **x** | | |
| • **Interdependence of organisms** | | | | | | | | |
| o The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere. | | | **x** | | | | | |
| o Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers. | | | | | | | | |
| o Organisms both cooperate and compete in | | | | | | | | |

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| ecosystems. | | | | | | | | |
| o Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. | | | | | | | | |
| o Human beings live within the world's ecosystems. | | | | | | | | |
| • **Matter, energy, and organization in living systems** | | | | | | | | |
| o All matter tends toward more disorganized states. | | | | | | | | |
| o The energy for life primarily derives from the sun. | | | | | | | | |
| o The chemical bonds of food molecules contain energy. | | | **x** | | **x** | | ● | |
| o The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism. | ✓ | **x** | **x** | **x** | **x** | ● | ● | |
| o The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials. | | | | | | | | |
| o As matter and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. | ● | ● | **x** | ● | **x** | ● | ● | |
| o Matter and energy are conserved in each recombination of elements. | | | **x** | | | | | |
| • **Behavior of organisms** | | | | | | | | |
| o Multicellular animals have nervous systems that generate behavior. | | | | | | | | |
| o Organisms have behavioral responses to internal changes and to external stimuli. | | | | | | | | |
| o Like other aspects of an organism's biology, behaviors have evolved through natural selection. | | | | | | | | |

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| o Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology. | | | | | | | | |
| ***NSES* Content Standard D: Earth and Space Science**<br>As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | | | |
| • **Energy in the earth system** | | | | | | | | |
| • **Geochemical cycles** | | | | | | | | |
| • **Origin and evolution of the earth system** | | | | | | | | |
| • **Origin and evolution of the universe** | | | | | | | | |
| ***NSES* Content Standard E: Science and Technology**<br>As a result of activities in grades 9-12, all students should develop— | | | | | | | | |
| • **Abilities of technological design** | | | | | | | | |
| o Identify a problem or design an opportunity. | | **x** | **x** | ● | ● | **x** | ✓ | ✓ |
| o Propose designs and choose between alternative solutions. | | **x** | **x** | ● | | **x** | ✓ | ✓ |
| o Implement a proposed solution. | | **x** | **x** | ● | | **x** | ✓ | ✓ |
| o Evaluate the solution and its consequences. | | **x** | **x** | ● | | **x** | ✓ | ✓ |
| o Communicate the problem, process, and solution. | | **x** | **x** | ● | | **x** | ✓ | ✓ |
| • **Understandings about science and technology** | | | | | | | | |
| o Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. | ● | **x** | **x** | **x** | **x** | **x** | ✓ | ✓ |
| o Science often advances with the introduction of new technologies. | ● | **x** | **x** | **x** | **x** | **x** | ✓ | ✓ |
| o Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. | ● | **x** | **x** | **x** | **x** | **x** | ✓ | ✓ |
| o Science and technology are pursued for different purposes. | | **x** | | **x** | | | ✓ | ✓ |
| o Technical knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentation at professional meetings and publications in scientific journals. | | | | **x** | | | ✓ | ✓ |

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| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | | | |
| • **Personal and community health** | | | | | | | | |
| o Hazards and potential for accidents exist. | ✓ | | | | | ✓ | ✓ | |
| o The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. | ✓ | | | | | ✓ | ✓ | |
| o Personal choice concerning fitness and health involves multiple factors. | | **x** | **x** | | **x** | **x** | ✓ | |
| o An individual's mood and behavior may be modified by substances. | | | | | | | | |
| o Selection of foods and eating patterns determine nutritional balance. | | | **x** | | **x** | | ● | |
| o Families serve basic health needs, especially for young children. | | | | | | | | |
| o Sexuality is basic to the physical, mental, and social development of humans. | | | | | | | | |
| • **Population growth** | | | | | | | | |
| o Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. | | | | | | | | |
| o Various factors influence birth rates and fertility rates. | | | | | | | | |
| o Populations can reach limits to growth. | | | | | | | | |
| • **Natural resources** | | | | | | | | |
| o Human populations use resources in the environment in order to maintain and improve their existence. | | | | | | | | |
| o The earth does not have infinite resources. | | | | | | | | |
| o Humans use many natural systems as resources. | | | | | | | | |
| • **Environmental quality** | | | | | | | | |
| o Natural ecosystems provide an array of basic processes that affect humans. | | | | | | | | |
| o Materials from human societies affect both physical and chemical cycles of the earth. | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| o Many factors influence environmental quality. | | | | | | | | |
| • **Natural and human-induced hazards** | | | | | | | | |
| o Normal adjustments of earth may be hazardous for humans. | | | | | | | | |
| o Human activities can enhance potential for hazards. | | | | | | | | |
| o Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. | | | | | | | | |
| o Natural and human-induced hazards present the need for humans to assess potential danger and risk. | | | | | | | | |
| • **Science and technology in local, national, and global challenges** | | | | | | | | |
| o Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. | | | | **X** | | | ✓ | ✓ |
| o Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. | | **x** | ● | **X** | ● | ● | ✓ | ✓ |
| o Progress in science and technology can be affected by social issues and challenges. | | | ● | **X** | | ● | ✓ | ✓ |
| o Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. | | | | **x** | | | ✓ | ✓ |
| o Humans have a major effect on other species. | | | | | | | | |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | | | |
| • **Science as a human endeavor** | | | | | | | | |
| o Individuals and teams have contributed and will continue to contribute to the scientific enterprise. | ● | ● | **x** | **x** | ● | ● | ✓ | ✓ |
| o Scientists have ethical traditions. | | | | | | | | ✓ |
| o Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. | | | | **x** | | | ✓ | ✓ |

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| • **Nature of scientific knowledge** | | | | | | | | |
| o Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world. | | | **x** | **x** | ● | ● | ● | ✓ |
| o Scientific explanations must meet certain criteria. | ● | ● | **x** | **x** | ● | ● | ● | ✓ |
| o Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. | ● | | **x** | **x** | | | ● | ✓ |
| • **Historical perspectives** | | | | | | | | |
| o In history, diverse cultures have contributed scientific knowledge and technologic inventions. | | | | | | | ✓ | ✓ |
| o Usually, changes in science occur as small modifications in extant knowledge. | | | **x** | **X** | | | ✓ | ✓ |
| o Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. | | | | **X** | | ● | ✓ | ✓ |
| o The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge. | ● | ● | **x** | **x** | ● | ● | ✓ | ✓ |

National Research Council (NRC) ***National Science Education Standards***

# Standards for Technological Literacy in Principles of the Biomedical Sciences

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| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | | | ● | ✓ |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | ✓ | | | | | | ● | ● |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | | | | x | x | | ✓ | ✓ |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | | | | ● | | | | |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | | ● | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | ● | | | ● | | |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | ● | | | | | |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | | | | | | ● |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | ● | | | | | |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | ✓ | x | x | x | ✓ | ✓ | ✓ | ✓ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | | x | ● | x | x | ● | ✓ | ● |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | | | | | |

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| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | | | |
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | ✓ | **x** | **x** | ● | ● | ● | ● | ● |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | | | |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | | | |

International Technology Education Association's (ITEA) **Standards for Technological Literacy: Content for the Study of Technology**

# English Language Arts Standards in Principles of the Biomedical Sciences

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|---|---|---|---|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | ● | ● | ● | x | ● | ● | ● | ● |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | | | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | ✓ | x | x | x | ● | x | ● | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | ✓ | x | ● | ● | x | ● | ✓ | ✓ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | ✓ | x | ✓ | ● | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | ✓ | x | x | ● | x | ● | ● | ✓ |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, and people) to communicate their discoveries in ways that suit their purpose and audience. | ✓ | x | x | x | x | ✓ | ✓ | ✓ |

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|---|---|---|---|---|---|---|---|---|
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | ✓ | **x** | **x** | **x** | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | | | | | |
| **SELA Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | ✓ | **x** | **x** | **x** | ✓ | ✓ | ✓ | ✓ |

[1]National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Principles and Standards for School Mathematics in Principles of the Biomedical Sciences

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|---|---|---|---|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems. | ● | **x** | ● | **x** | **x** | **x** | **x** | ● |
| • understand meanings of operations and how they relate to one another. | | ● | ● | | ● | | | |
| • compute fluently and make reasonable estimates. | | **x** | **x** | | **x** | | | |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • understand patterns, relations, and functions. | | | | | **x** | | | |
| • represent and analyze mathematical situations and structures using algebraic symbols. | | | | | | | | |
| • use mathematical models to represent and understand quantitative relationships. | | | | | | | | |
| • analyze change in various contexts. | | ● | ● | ● | ● | ● | ● | |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships. | | | | | | | | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems. | | | | | | | | |
| • apply transformations and use symmetry to analyze mathematical situations. | | | | | | | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | | ● | **x** | **x** | | | |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| • understand measurable attributes of objects and the units, systems, and processes of measurement. | ● | **x** | **x** | **x** | **x** | **x** | ● | |
| • apply appropriate techniques, tools, and formulas to determine measurements. | ✓ | **x** | **x** | **x** | **x** | **x** | ● | |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. | | **x** | **x** | **x** | **x** | **x** | ✓ | |
| • select and use appropriate statistical methods to analyze data. | | **x** | **x** | **x** | **x** | **x** | | |
| • develop and evaluate inferences and predictions that are based on data. | ✓ | **x** | **x** | **x** | **x** | **x** | ✓ | |
| • understand and apply basic concepts of probability. | | | | **x** | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • build new mathematical knowledge through problem solving. | | | | | | | | |
| • solve problems that arise in mathematics and in other contexts. | | | | | | | | |
| • apply and adapt a variety of appropriate strategies to solve problems. | | | **x** | ● | **x** | ● | ● | |
| • monitor and reflect on the process of mathematical problem solving. | | | | | **x** | | | |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics. | | | | | | | | |
| • make and investigate mathematical conjectures. | | | | | | | | |
| • develop and evaluate mathematical arguments and proofs. | | | | | | | | |
| • select and use various types of reasoning and methods of proof. | | | | | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • organize and consolidate their mathematical thinking through communication. | | | | ● | ● | ● | | |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others. | | | | | **x** | | | |
| • analyze and evaluate the mathematical thinking and strategies of others. | | | | | ● | | | |

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|---|---|---|---|---|---|---|---|---|
| • use the language of mathematics to express mathematical ideas precisely. | | | | | **x** | | | |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • recognize and use connections among mathematical ideas. | | | | | | | | |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole. | | | | | | | | |
| • recognize and apply mathematics in contexts outside of mathematics. | **x** | **x** | **x** | **x** | **x** | ● | ● | **x** |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas. | | | | | | | | |
| • select, apply, and translate among mathematical representations to solve problems. | | | | | | | | |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | | **x** | **x** | **x** | **x** | ● | |

National Council of Teachers of Mathematics (NCTM) ***Principles and Standards for School Mathematics***.

# National Healthcare Foundation Standards and Accountability Criteria in Principles of the Biomedical Sciences

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|---|---|---|---|---|---|---|---|---|
| **Foundation Standard 1: Academic Foundation**<br>Healthcare professionals will know the academic subject matter required for proficiency within their area. They will use this knowledge as needed in their role. The following accountability criteria are considered essential for students in a health science program of study. | | | | | | | | |
| **1.1 Human Structure and Function** | | | | | | | | |
| 1.11 Classify basic structural and functional organization of the human body (tissue, organ, and system). | ✓ | x | x | ✓ | ✓ | | ✓ | |
| 1.12 Recognize body planes, directional terms, quadrants, and cavities. | | x | | | | | | |
| 1.13 Analyze basic structure and function of the human body. | ✓ | x | ● | ● | | | | |
| **1.2 Diseases and Disorders** | | | | | | | | |
| 1.21 Describe common diseases and disorders of each body system (prevention, pathology, diagnosis, and treatment). | | x | x | x | ✓ | ✓ | ✓ | ✓ |
| 1.22 Recognize emerging diseases and disorders. | | | x | x | x | x | | ✓ |
| 1.23 Investigate biomedical therapies as they relate to prevention, pathology, and treatment of disease. | | | x | x | x | ✓ | ✓ | ✓ |
| **1.3 Medical Mathematics** | | | | | | | | |
| 1.31 Apply mathematical computations related to healthcare procedures (metric and household, conversions and measurements). | ● | x | x | x | x | ✓ | ✓ | ✓ |
| 1.32 Analyze diagrams, charts, graphs, and tables to interpret healthcare data. | ● | x | x | x | x | ✓ | ✓ | ✓ |
| 1.33 Record time using 24-hour clock. | | | | | | | | |
| **Foundation Standard 2: Communications**<br>Healthcare professionals will know the various methods of giving and obtaining information. They will communicate effectively, both orally and in writing. | | | | | | | | |
| **2.1 Concepts of Effective Communication** | | | | | | | | |

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| | Unit 1—Human Body Systems | Unit 2—Heart Attack | Unit 3—Diabetes | Unit 4—Sickle-Cell Disease | Unit 5— Hypercholesterolemia | Unit 6—Infectious Diseases | Unit 7— Medical Interventions | Unit 8— Grant Proposal |
|---|---|---|---|---|---|---|---|---|
| 2.11 Interpret verbal and nonverbal communication. | ● | x | ✓ | ● | ● | x | ✓ | ✓ |
| 2.12 Recognize barriers to communication. | ● | ● | x | ● | ● | x | ✓ | ✓ |
| 2.13 Report subjective and objective information. | | x | x | | | x | | |
| 2.14 Recognize elements of communication using a sender-receiver model. | | | | | | | | |
| 2.15 Apply speaking and active listening skills. | ✓ | ✓ | ✓ | ● | ● | x | ✓ | ✓ |
| **2.2 Medical Terminology** | | | | | | | | |
| 2.21 Use roots, prefixes, and suffixes to communicate information. | ✓ | x | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2.22 Use medical abbreviations to communicate information. | ✓ | x | x | ✓ | ✓ | ✓ | ✓ | ✓ |
| **2.3 Written Communication Skills** | | | | | | | | |
| 2.31 Recognize elements of written and electronic communication (spelling, grammar, and formatting). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Foundation Standard 3: Systems** Healthcare professionals will understand how their role fits into their department, their organization and the overall healthcare environment. They will identify how key systems affect services they perform and quality of care. | | | | | | | | |
| **3.1 Healthcare Delivery Systems** | | | | | | | | |
| 3.11 Understand healthcare delivery system (public, private, government, and non-profit). | | | | | | | ✓ | |
| 3.12 Explain factors influencing healthcare delivery systems. | | | | | | | ✓ | |
| 3.13 Describe responsibilities of consumers within the healthcare system. | | | | | | | ✓ | |
| 3.14 Explain the impact of emerging issues such as technology, epidemiology, bioethics, and socioeconomics on healthcare delivery systems. | | | | | | | ✓ | |
| 3.15 Discuss common methods of payment for healthcare. | | | | | | | | |
| **Foundation Standard 4: Employability Skills** Healthcare professionals will understand how employability skills enhance their employment opportunities and job satisfaction. They will demonstrate key employability skills and will maintain and upgrade skills, as needed. | | | | | | | | |
| **4.1 Personal Traits of the Healthcare Professional** | | | | | | | | |
| 4.11 Classify personal traits or attitudes desirable in a member of the healthcare team. | | | | | | | | |
| 4.12 Summarize professional standards as they apply to hygiene, dress, language, confidentiality and behavior. | ✓ | | | | | | | |
| **4.2 Employability Skills** | | | | | | | | |
| 4.21 Apply employability skills in healthcare. | | | | | | | | |
| **4.3 Career Decision-making** | | | | | | | | |
| 4.31 Discuss levels of education, credentialing requirements, | ✓ | x | x | x | x | x | ✓ | |

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|---|---|---|---|---|---|---|---|---|
| and employment trends in healthcare. | | | | | | | | |
| 4.32 Compare careers within the health science career pathways (diagnostic services, therapeutic services, health informatics, support services, or biotechnology research and development). | ✓ | x | x | x | x | x | ✓ | |
| **4.4. Employability Preparation** | | | | | | | | |
| 4.41 Develop components of a personal portfolio. | ✓ | x | x | x | x | x | ✓ | ✓ |
| 4.42 Demonstrate process for obtaining employment. | | | | | | | | |
| **Foundation Standard 5: Legal Responsibilities**<br>Healthcare professionals will understand the legal responsibilities, limitations, and implications of their actions within the healthcare delivery setting. They will perform their duties according to regulations, policies, laws and legislated rights of clients. | | | | | | | | |
| **5.1 Legal Implications** | | | | | | | | |
| 5.11 Analyze legal responsibilities. | ✓ | | | | | | | |
| 5.12 Apply procedures for accurate documentation and record keeping. | | | | | | | | |
| **5.2 Legal Practices** | | | | | | | | |
| 5.21 Apply standards for Health Insurance Portability and Accountability Act (HIPAA). | ✓ | | | | | | | |
| 5.22 Describe advance directives. | | | | | | | | |
| 5.23 Summarize the Patient's Bill of Rights. | | | | | | | | |
| 5.24 Understand informed consent. | | | | | | | | |
| 5.25 Explain laws governing harassment, labor, and scope of practice. | | | | | | | | |
| **Foundation Standard 6: Ethics**<br>Healthcare professionals will understand accepted ethical practices with respect to cultural, social, and ethnic differences within the healthcare environment. They will perform quality healthcare delivery. | | | | | | | | |
| **6.1 Ethical Boundaries** | | | | | | | | |
| 6.11 Differentiate between ethical and legal issues impacting healthcare. | ✓ | | | x | | | | |
| 6.12 Recognize ethical issues and their implications related to healthcare. | | | | x | | | | |
| **6.2 Ethical Practice** | | | | | | | | |
| 6.21 Apply procedures for reporting activities and behaviors that affect health, safety, and welfare of others. | | | | | | | | |
| **6.3 Cultural, Social, and Ethnic Diversity** | | | | | | | | |
| 6.31 Understand religious and cultural values as they impact healthcare. | | | | | | | | |
| 6.32 Demonstrate respectful and empathetic treatment of | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| ALL patients/clients (customer service). | | | | | | | | |
| **Foundation Standard 7: Safety Practices**<br>Healthcare professionals will understand the existing and potential hazards to clients, co-workers, and self. They will prevent injury or illness through safe work practices and follow health and safety policies and procedures. | | | | | | | | |
| **7.1 Infection Control** | | | | | | | | |
| 7.11 Explain principles of infection control. | | | | | | x | | |
| 7.12 Describe methods for controlling the spread and growth of microorganisms. | | | | | | x | | |
| **7.2 Personal Safety** | | | | | | | | |
| 7.21 Apply personal safety procedures based on Occupational Safety and Health Administration (OSHA) and Centers for Disease Control (CDC) regulations. | | ● | ● | ● | ● | x | ● | |
| 7.22 Apply principles of body mechanics. | | | | | | | | |
| **7.3 Environmental Safety** | | | | | | | | |
| 7.31 Apply safety techniques in the work environment. | ● | ● | ● | ● | ● | x | ● | |
| **7.4 Common Safety Hazards** | | | | | | | | |
| 7.41 Comply with safety signs, symbols, and labels. | ● | ● | ● | ● | ● | ● | ● | |
| 7.42 Understand implications of hazardous materials. | | | | | | x | | |
| **7.5 Emergency Procedures and Protocols** | | | | | | | | |
| 7.51 Practice fire safety in a healthcare setting. | | | | | | | | |
| 7.52 Apply principles of basic emergency response in natural disasters and other emergencies. | | | | | | | | |
| **Foundation Standard 8: Teamwork**<br>Healthcare professionals will understand the roles and responsibilities of individual members as part of the healthcare team, including their ability to promote the delivery of quality healthcare. They will interact effectively and sensitively with all members of the healthcare team. | | | | | | | | |
| **8.1 Healthcare Teams** | | | | | | | | |
| 8.11 Understand roles and responsibilities of team members. | | | | | | | | |
| 8.12 Recognize characteristics of effective teams. | | | | | | | | |
| **8.2 Team Member Participation** | | | | | | | | |
| 8.21 Recognize methods for building positive team relationships. | ✓ | ✓ | x | ● | ● | x | ✓ | ✓ |
| 8.22 Analyze attributes and attitudes of an effective leader. | ✓ | ✓ | x | ● | ● | x | ✓ | ✓ |
| 8.23 Apply effective techniques for managing team conflict. | ✓ | ✓ | x | ● | ● | x | ✓ | ✓ |
| **Foundation Standard 9: Health Maintenance Practices**<br>Healthcare professionals will understand the fundamentals of wellness and the prevention of disease processes. They | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| will practice preventive health behaviors among the clients. | | | | | | | | |
| **9.1 Healthy Behaviors** | | | | | | | | |
| 9.11 Apply behaviors that promote health and wellness. | | | **x** | | ✓ | **x** | ✓ | |
| 9.12 Describe strategies for the prevention of diseases including health screenings and examinations. | | **x** | **x** | | ✓ | **x** | ✓ | |
| 9.13 Discuss complementary (alternative) health practices as they relate to wellness and disease prevention. | | | **x** | | | **x** | ✓ | |
| ***Foundation Standard 10: Technical Skills**<br>Healthcare professionals will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate<br>*Additional technical skills may be included in a program of study based on career specialties | | | | | | | | |
| **10.1 Technical Skills** | | | | | | | | |
| 10.11 Apply procedures for measuring and recording vital signs, including the normal ranges. | | **x** | | | | | | |
| 10.12 Apply skills to obtain training or certification in cardiopulmonary resuscitation (CPR), automated external defibrillator. | | | | | | | | |
| **Foundation Standard 11: Information Technology Applications**<br>Healthcare professionals will use information technology applications required within all career specialties. They will demonstrate use as appropriate to healthcare applications. | | | | | | | | |
| **11.1 Health Information Management** | | | | | | | | |
| 11.11 Identify records and files common to the healthcare setting. | | | | | | | | |
| **11.2 Information Technology** | | | | | | | | |
| 11.21 Communicate using technology (fax, e-mail, and Internet). | ✓ | **x** | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

National Consortium on Health Science and Technology Education. **National Healthcare Foundation Standards and Accountability Criteria.**

# HBS

# Human Body Systems Course Description

Students examine the interactions of body systems as they explore identity, communication, power, movement, protection, and homeostasis. Students design experiments, investigate the structures and functions of the human body, and use data acquisition software to monitor body functions such as muscle movement, reflex and voluntary action, and respiration. Exploring science in action, students build organs and tissues on a skeletal manikin, work through interesting real world cases and often play the role of biomedical professionals to solve medical mysteries.

# Human Body Systems Detailed Outline

## Unit One- Identity
## Time Days (26 Days)

### Lesson 1: Identity: Human (4 Days)

**Concepts Addressed in Lesson**

1. The human body is made up of complex systems functioning together to maintain homeostasis.
2. Similarities in function and overall anatomical organization unite and identify all humans.
3. Directional terms describe the position of anatomical structures in relation to other structures or locations in the body and regional terms specify specific anatomical landmarks on the body.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Research interesting facts about the human body and identify the systems and structures involved in these facts.
- Display information about human body systems using graphic organizers.
- Diagram the relationship between multiple human body systems.
- Design a visual system that demonstrates correct use of directional and regional terms.

### Lesson 2: Identity: Tissues (12 Days)

**Concepts Addressed in Lesson:**

1. The structure and distribution of tissues in the body contribute to human identity.
2. A tissue is a group of similar cells designed to carry out a specific function.
3. The 206 bones of the human skeletal system protect the body's internal organs while allowing for movement and great range of mobility.
4. The specific structure of bone reveals information about a person's gender, stature, age and ethnicity.

5. The length of long bones in the human body can be used to mathematically predict the overall height of an individual.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- View prepared slides of human tissue and compare and contrast the structure and function of various types.
- Build muscles and fat of the face on a skeletal model to explore personal identity.
- Identify and locate bones of the human skeletal system.
- Analyze bones to determine a person's gender, age, stature and ethnicity.
- Derive a mathematical equation to determine height of an individual using the length of long bone.

### **Lesson 3: Identity: Molecules and Cells** (10 Days)

**Concepts Addressed in Lesson:**

1. Cells contain chromosomes, structures that house genes and ultimately code for traits.
2. Human DNA is a unique code of over three billion base pairs that provides a genetic blueprint of an individual.
3. Restriction enzymes recognize and cut specific sequences in DNA.
4. Gel electrophoresis separates DNA fragments based on size and is used in Restriction Fragment Length Polymorphism (RFLP) analysis.
5. Both physical characteristics and behavioral characteristics can be used to confirm or authenticate identity.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Digest DNA samples using two different restriction enzymes.
- Run gel electrophoresis and analyze the resulting restriction fragment length polymorphisms (RFLPs) to link a missing person with skeletal remains.
- Evaluate current technology used to verify and protect identity and design a biometrics plan specific to a real-world situation.
- Read an interview with a forensic anthropologist and write an interview with a DNA analyst.

# Unit Two – Communication
# Time Days (38 Days)

**Lesson 1: The Brain** (9 Days)

**Concepts Addressed in Lesson:**

1. Communication between body systems is crucial to maintaining homeostasis.
2. The two main subdivisions of the nervous system are the central nervous system (CNS), brain and spinal cord, and the peripheral nervous system (PNS), all nervous tissues outside the brain and spinal cord.
3. The brain receives stimuli from the outside world, interprets this information and generates an appropriate response.
4. Each region within the brain helps control and regulate specific functions in the body.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Identify types of communication that occur inside the human body.
- Build components of the central nervous system on a skeletal model.
- Identify major regions of the human brain.
- Design a "brain map" that links regions of the brain with specific human actions, emotions, personality traits or functions.
- Investigate the history of brain mapping technology, including the mapping of the motor cortex and the language centers of the brain.

**Lesson 2: Electrical Communication** (15 Days)

**Concepts Addressed in Lesson:**

1. Human body systems depend upon electricity as a means of sending messages between and within systems.
2. The nervous system relies on specialized cells called neurons to pass signals to and from the brain and spinal cord.
3. Neurons convey information using electrical and chemical signals.
4. An action potential is an electrical signal that is generated by the movement of ions across the cell membrane of a neuron.
5. The body's reaction time to reflex and voluntary actions is related to the degree of processing in the nervous system.
6. Errors in electrical communication can impact homeostasis in the human body.

**Performance Objectives Addressed in Lesson:**

*It is expected that students will:*

- Construct a 3D, labeled model of a neuron.
- Produce a flow chart that outlines what goes on in the body from an initial stimulus to a response.
- Use an interactive website to manipulate ions in a membrane and generate an action potential in a neuron.
- Complete a laboratory investigation using data acquisition software and probes to explore reflexes in the human body.
- Design an experiment to test factors that could impact reaction time.
- Analyze a case study, relate disease to an error in communication and create a presentation of findings.
- Use models from activities in the unit to demonstrate how an error in communication occurs and affects the function of other body systems.

**Lesson 3: Chemical Communication** (6 Days)

**Concepts Addressed in Lesson:**

1. The endocrine system helps the body communicate through the use of chemical signals called hormones.
2. Hormones interact with receptors on the cell membrane or inside the cell to bring about change in a target organ.
3. Endocrine glands secrete substances directly into the blood stream while exocrine glands secrete their products through ducts into body cavities.
4. Hormones help maintain homeostasis through feedback loops.
5. A hormone imbalance can lead to disease or dysfunction.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Produce a concept map for the endocrine system.
- Design a feedback loop that shows how the body maintains proper blood glucose levels.
- Create an evidence board with a team and use this board to solve a medical mystery.
- Analyze physical symptoms of a patient and relate these symptoms to errors in chemical communication.

**Lesson 4: Communication with the Outside World** (8 Days)

**Concepts Addressed in Lesson:**

1. The human eye converts light into a stream of nerve signals to be interpreted by the brain.
2. The structures within the human eye work to focus and process light.
3. The eye allows perception of color, depth, brightness, and optical illusions.
4. Problems with focusing light in the eye can be corrected with lenses.
5. Errors in the structure and function of the eye can lead to minor problems in acuity or debilitating disease and dysfunction.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Dissect a cow eye to observe key structures.
- Diagram the path of light as it enters the eyes and travels to the brain for processing.
- Evaluate visual perception by testing depth perception, peripheral vision, color vision, and visual acuity.
- Use a model of the human eye to simulate normal vision, as well as myopia and hyperopia
- Experiment with lenses to correct problems in vision.
- Edit digital images to show how the world looks to people with various eye conditions or simulate vision disorders using modified glasses.
- Write a reflection about what life would be like with a vision disease or disorder.
- Design an informative handout that explains the tests and procedures in an eye exam.
- Research careers in the field of vision.

## Unit Three - Power
## Time Days (33 Days)

**Lesson 1: Introduction to Power** (2 Days)

**Concepts Addressed in Lesson:**

1. The human body is powered by the food we consume, the water that we drink and the air that we breathe.
2. Many human body systems work to create, process and distribute the body's main resources – food, water and oxygen.
3. Factors unique to the person, such as age, weight, and overall health affect the body's ability to utilize biological resources and maintain homeostasis.
4. Factors in the environment, such as climate or temperature, affect the body's ability to utilize biological resources and maintain homeostasis.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create a chart comparing the role food, water and oxygen play in the human body.
- List the body systems that create, process, and distribute food, water and oxygen.
- Estimate how long the human body can last without key resources and compare this estimate to a survival "rule."
- Write a disclaimer that explains how factors in the environment and how characteristics of the individual affect the ability to conserve energy.

**Lesson 2: Food** (12 Days)

**Concepts Addressed in Lesson:**

1. The digestive system consists of the gastrointestinal tract and the accessory digestive organs which function together to chemically and mechanically digest food, absorb water and nutrients, and remove wastes.
2. Specific enzymes digest carbohydrates, fats and proteins at sites along the digestive tract.
3. The energy provided by ingested food must be balanced against the energy expended by the body, or a weight change will occur.
4. Factors such as temperature, pH, and enzyme and substrate concentration affect the rate of an enzyme-catalyzed reaction.
5. When a process in the body requires energy, ATP is broken down to liberate energy stored in its chemical bonds.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design and build a model of the human digestive system.
- Outline what happens to a bite of food as it travels down the digestive tract.
- Design and carry out a laboratory experiment investigating the impact environmental changes can have on enzyme function.
- Analyze diet by comparing energy inputs and outputs.
- Assess overall dietary health by preparing a detailed nutrition report for a fictional client.
- Complete an Internet investigation to learn about the structure and function of ATP.

**Lesson 3: Oxygen** (8 Days)

**Concepts Addressed in Lesson:**

1. Oxygen is essential for human life because it is necessary for the production of ATP, the primary source of cellular energy.
2. The structure of the lungs and the close association between the lungs and the vessels of the cardiovascular system facilitate the transport of oxygen to all cells in the body.
3. The transfer of oxygen and carbon dioxide molecules between the lungs, bloodstream, and cells is by simple diffusion and is dependent on concentration gradients.
4. During normal breathing, a healthy individual is using only a small percentage of the total capacity of his or her lungs.
5. The efficiency of oxygen removal from the air is dependent on the physical conditioning of the individual; during and after exercise the concentration of oxygen removed from the air is increased compared to when the individual is at rest.
6. Various diseases or medical conditions can affect lung capacity and efficiency.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use proper technique and LabVIEW to measure lung capacity and absorption of oxygen from air.
- Analyze data collected using a spirometer to determine tidal volume, vital capacity, and minute volume.
- Analyze data collected using an oxygen sensor to determine the change in oxygen concentration of inhaled air versus exhaled air.
- Explore careers related to lung function by writing a resume for a respiratory therapist.

**Lesson 4: Water** (11 Days)

**Concepts Addressed in Lesson:**

1. The urinary system helps maintain homeostasis in the body by filtering the blood, regulating water and electrolyte concentration, maintaining the pH balance of the blood and ridding the body of liquid waste called urine.
2. The nephron is the structural and functional unit of the kidney.
3. Through filtration, reabsorption, and secretion, the nephron assists in maintaining normal values of water, electrolytes, pH, and blood pressure in the body.
4. The hormones aldosterone and antidiuretic hormone (ADH) both help regulate the amount of water in the body; however, they each work by a different mechanism.

5. Malfunctions in the body can be identified through noticeable changes in the composition of urine and these changes can be detected through urinalysis.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Build the organs of the urinary system on a skeletal model.
- Complete a dissection to explore the anatomy of the kidney.
- Create a “map” of the kidney that shows the path of urine formation.
- Create a poster that shows the connections between urine and blood and demonstrates the exchange of ions and fluids that occurs across the nephron.
- Complete mathematics calculations to estimate the filtration rate of the glomerulus.
- Use appropriate Internet sources to investigate the role of hormones in maintaining a water balance in the body.
- Add glands, hormones, and target organs that are involved in water balance to a graphic organizer, to feedback loops, as well as to a skeletal model.
- Analyze the urine of four fictional patients to diagnose disease and dysfunction in other human body systems.

## Unit Four - Movement
## Time Days (42 Days)

**Lesson 1: Joints and Motion** (5 Days)

**Concepts Addressed in Lesson:**

1. The skeletal system works with the muscular system to move the human body.
2. A joint is the location at which two or more bones connect, allowing movement and providing support to the human skeleton.
3. Joints can be classified by either their structure or their function.
4. Synovial joints, freely moveable joints, allow both gross and precise movements of the appendicular skeleton.
5. Range of motion describes a joint’s possible movements as well as provides a measure of overall flexibility at a joint.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use appropriate Internet research techniques to obtain information about the different types of synovial joints.

- Dissect and manipulate a cow elbow to learn about joint anatomy and motion.
- Demonstrate terms that describe the types of movement possible at a joint and match range of motion photographs to specific actions.
- Measure range of motion of human joints using a goniometer.

### Lesson 2: Muscles (15 Days)

**Concepts Addressed in Lesson:**

1. Through contraction and relaxation, the three different types of muscle tissue - skeletal, cardiac, and smooth - produce body movements, stabilize body position, move substances within the body and regulate heat.
2. The structure of the muscle and attachment of this muscle to bone directly relates to the function of each skeletal muscle.
3. Muscles are composed of units called sarcomeres, which contract and shorten when exposed to electrical stimuli.
4. Calcium ions and ATP play a role in the contraction of muscle fibers.
5. Neurons are packed together in wiring called nerves, and these nerves take electrical messages from the brain to muscle.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use proper microscope technique to examine the different types of muscle tissue.
- Construct a spaghetti muscle to investigate muscle structure.
- Build simple arm muscles on a skeletal model to illustrate the rules of muscle structure and action.
- Sculpt a muscle group on a skeletal model.
- Identify the action of “mystery muscles” by observing muscle structure.
- Test the effect of varying solutions of ATP on the contraction of muscle tissue.
- Design a model to demonstrate the process of muscle contraction as well as the phenomenon of rigor mortis.
- Build nerve roots and nerves on a skeletal model.

### Lesson 3: Blood Flow (11 Days)

**Concepts Addressed in Lesson:**

1. Cardiac and smooth muscle play a role in the movement of blood around the human body.

2. The heart pumps blood to the lungs to pick up oxygen and to the body to deliver this oxygen.
3. The structure of arteries, veins, and capillaries relates directly to the function of each vessel and to the amount of pressure exerted on the vessel walls.
4. Veins contain valves that prevent the backflow of blood.
5. Changes in cardiac output, the amount of blood that is pumped out by the ventricles per minute, often signal diseases of the heart and these changes can impact the function of other body systems.
6. Increased blood pressure in vessels can indicate possible blockages and these blockages can interrupt blood flow to an organ or limb.
7. Lifestyle choices, such as poor diet and smoking, can lead to the development of blood flow disorders.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Trace blood flow in pulmonary and systemic circulation by creating a graphic organizer of the heart.
- Compare and contrast the structure of arteries, veins and capillaries.
- Design a way to explain the formation of varicose veins.
- Build a heart and circulatory routes on a skeletal model.
- Find various pulse points around the body and use heart rate data to calculate and assess cardiac output.
- Analyze a four-part case that looks at the effects of smoking on circulation and blood pressure.
- Measure peripheral pulses using Doppler ultrasound and calculate an ankle brachial index (ABI).

## Lesson 4: Energy and Motion: Exercise Physiology (10 Days)

**Concepts Addressed in Lesson:**

1. The body uses high energy molecules such as creatine phosphate, glycogen and glucose to supply ATP to working muscle.
2. Exercise requires the coordinated effort of many human body systems, including the nervous system, the muscular system, the skeletal system, the cardiovascular system, and the respiratory system.
3. Performance-enhancing drugs may initially produce noticeable changes in athletic performance, but come with serious health risks.
4. An athlete training for an intense physical event needs to consider diet, exercise, hydration, and injury prevention as well as track his or her progress and modify the plan to meet the demands of exercise.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use appropriate Internet research techniques to investigate the reaction of the body systems to moderate and intense exercise.
- Create a timeline of the body's response to the stages of exercise.
- Complete a laboratory investigation using data acquisition software and probes to explore muscle fatigue.
- Design an experiment to test the effect of feedback, coaching or competition on muscle fatigue.
- Design a comprehensive training plan for an athlete training for a particular event.
- Present a detailed training plan to the perspective client.

## Unit Five – Protection
## Time Days (22 Days)

**Lesson 1: The Skin** (6 Days)

**Concepts Addressed in Lesson:**

1. The skin is composed of two main layers, the epidermis and the dermis, and contains accessory organs such as sweat glands and hair follicles.
2. The skin is a dynamic organ that functions in protection, temperature regulation, sensation, excretion and absorption in the human body.
3. Burn damage to skin can impact numerous body functions and body systems.
4. Both the body's ability to sense pain and to suppress pain help protect the human body from injury and death.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design and build a 3-D model of human skin displaying tissue layers and accessory organs.
- Model and describe how damage to skin through burns can affect both the functions of the skin and other body systems.
- Write diary entries that describe the role of various treatment methods and biomedical professionals in the care and rehabilitation of burn victims.
- Outline what happens inside the body when a person feels pain.

**Lesson 2: Bones** (8 Days)

**Concepts Addressed in Lesson:**

1. Bones provide clues to human identity, assist muscles with movement of the body, and protect the internal organs from damage and injury.
2. Bone is a living connective tissue composed of cells and protein fibers wrapped in hard mineral salts that can adapt and change to fit the needs of the person.
3. Osteoclasts and osteoblasts are specialized bone cells that function to break down old bone tissue and replace it with new.
4. Damage to bone, through a sprain or a fracture, can impact the function of other body organs and systems.
5. Bone is constantly being broken down and reformed through the process of bone remodeling.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Dissect a section of long bone and draw a detailed diagram of relevant anatomy.
- Use proper microscope technique to view prepared slides of compact and spongy bone.
- Use appropriate Internet research techniques to obtain information about the different types of bone fractures.
- Analyze bone breaks shown in X-rays and match the images with descriptions of the injuries.
- Write an advertisement for a job opening for an X-ray technician.
- Produce a feedback loop that illustrates how the body maintains a calcium balance.
- Draw diagrams of the stages of bone healing after injury.

**Lesson 3: Lymph and Blood Cells** (8 Days)

**Concepts Addressed in Lesson:**

1. The lymphatic and immune system functions to drain and distribute fluid in the body as well as protect the human body against specific invaders.
2. Antibodies are proteins found in the blood or lymph that seek out and bind to specific antigens.
3. A type of white blood cells called B lymphocytes is responsible for the production of antibodies and has the ability to remember invaders once they have entered the body.
4. Many organ systems as well as other cells, tissues, organs and secretions play a role in protecting the human body.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use appropriate Internet research techniques to obtain information about the structure and function of the lymphatic and immune system.
- Build lymph vessels and nodes on a skeletal model.
- Analyze simulated blood samples to determine blood type and determine potential donors for a transfusion.
- Produce and analyze a family pedigree for blood type.
- Graph antibody data collected after an infection and relate this data to the response of body cells.
- Use information presented in a computer animation to create a flow chart of immune response to a common cold.

## Unit Six – Homeostasis
## Time Days (14 Days)

**Lesson 1: Health and Wellness** (14 Days)

**Concepts Addressed in Lesson:**

1. Factors in the external environment affect the body's internal environment and overall ability to maintain homeostasis.
2. Human body systems work together to defend against disease and injury and to maintain health and wellness.
3. Medical interventions, measures that improve health or alter the course of a disease, include preventative measures, diagnostic tests, treatments, and rehabilitation.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design an innovative medical intervention or invention to protect the human body in extreme external environments.
- Organize information about body function in detailed graphic organizers.
- Create and present computer presentations to defend the design of a medical intervention.
- Use appropriate Internet research techniques to study the etiology, diagnosis and treatment of a disease or disorder.
- Trace disease in human systems by generating a fictional case study and compiling a patient case file.
- Model a disease and a medical intervention on a skeletal model.
- Write a reflection on personal identity and on career aspirations.

# National Science Education Standards[1] in Human Body Systems

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|---|---|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | | | |
| • **Systems, order, and organization** | | | | | | |
| o A system is an organized group of related objects or components that form a whole. | x | x | ✓ | ✓ | ✓ | ✓ |
| o Systems have boundaries, components, resources flow (input and output), and feedback. | ● | ✓ | x | ✓ | ✓ | ✓ |
| o Order—behavior of units of matter, objects, organisms, or events in the universe—can be described statistically. | | | | | | |
| o Types and levels of organization provide useful ways of thinking about the world. | x | ● | ● | ● | ● | ● |
| • **Evidence, models, and explanation** | | | | | | |
| o Evidence consists of observations and data on which to base scientific explanations. | x | x | ✓ | x | x | x |
| o Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. | ● | ✓ | x | x | x | x |
| o Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. | x | x | x | ✓ | x | ✓ |
| • **Change, constancy, and measurement** | | | | | | |
| o Although most things are in the process of becoming different—changing—some properties of objects and processes are characterized by constancy. | ● | | ● | ● | | ● |
| o Interactions within and among systems result in change. | x | x | x | ✓ | x | ● |

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|---|---|---|---|---|---|---|
| o Changes in systems can be quantified. | | x | | x | x | |
| o Mathematics is essential for accurately measuring change. | x | ● | x | x | x | |
| o Scale includes understanding that different characteristics, properties, or relationships within a system might change as its dimensions are increased or decreased. | x | ● | x | ● | ● | |
| • **Evolution and equilibrium** | | | | | | |
| o Evolution is a series of changes, some gradual and some sporadic, that accounts for the present form and function of objects, organisms, and natural and designed systems. | | | | | | |
| o Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. | | | | | | |
| o Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible. | | | | | | |
| • **Form and function** | | | | | | |
| o The form or shape of an object or system is frequently related to use, operation, or function. | x | ✓ | ✓ | ✓ | x | ✓ |
| o Students should be able to explain function by referring to form and to explain form by referring to function. | x | x | x | x | x | x |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | | | |
| • **Abilities necessary to do scientific inquiry** | | | | | | |
| o Identify questions and concepts that guide scientific investigation. | ✓ | x | ✓ | ✓ | ✓ | ✓ |
| o Design and conduct scientific investigations. | x | x | x | x | x | x |
| o Use technology and mathematics to improve investigations and communications. | x | x | x | x | x | x |
| o Formulate and revise scientific explanations and models using logic and evidence. | x | x | x | ✓ | x | x |
| o Recognize and analyze alternative explanations and models. | x | x | x | x | ● | ✓ |
| o Communicate and defend a scientific argument. | x | x | x | x | x | ✓ |
| • **Understandings about scientific inquiry** | | | | | | |

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|---|---|---|---|---|---|---|
| o Scientists usually inquire about how physical, living, or designed systems function. | **x** | ● | **x** | ● | ● | ● |
| o Scientists conduct investigations for a variety of reasons. | **x** | **x** | **x** | **x** | **x** | **x** |
| o Scientists rely on technology to enhance the gathering and manipulation of data. | **x** | ✓ | **x** | ✓ | **x** | **x** |
| o Mathematics is essential in scientific inquiry. | **x** | **x** | **x** | **x** | **x** | |
| o Scientific explanations must adhere to criteria such as: a proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. | **x** | **x** | **x** | **x** | ● | **x** |
| o Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. | **x** | ✓ | **x** | **x** | **x** | **x** |
| ***NSES* Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | |
| • **Structure of atoms** | | | | | | |
| o Matter is made of minute particles called atoms | | | | | | |
| o The atom's nucleus is composed of protons and neutrons | | | | | | |
| o The nuclear forces that hold the nucleus of an atom together | | | | | | |
| o Radioactive isotopes are unstable and undergo spontaneous nuclear reactions | | | | | | |
| • **Structure and properties of matter** | | | | | | |
| o Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. | | | **x** | | | |
| o An element is composed of a single type of atom. | | | | | | |
| o Bonds between atoms are created when electrons are paired up by being transferred or shared. | | | **x** | | | |
| o The physical properties of compounds reflect the nature of the interactions among its molecules. | | | | | | |
| o Solids, liquids, and gases differ in the distances and angles between molecules or atoms and | | | | | | |

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| therefore the energy that binds them together. | | | | | | |
| o Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life. | | | | | | |
| • **Chemical reactions** | | | | | | |
| o Chemical reactions occur all around us, for example health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies. | | | **x** | | | |
| o Chemical reactions may release or consume energy. | | | **x** | | | |
| o A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. | | | **x** | | | |
| • **Motions and forces** | | | | | | |
| o Objects change their motion only when a net force is applied. | | | | | | |
| o Gravitation is a universal force that each mass exerts on any other mass. | | | | | | |
| o The electric force is a universal force that exists between any two charged objects. | | | | | | |
| o Between any two charged particles, electric force is vastly greater than the gravitational force. | | | | | | |
| o Electricity and magnetism are two aspects of a single electromagnetic force. | | | | | | |
| • **Conservation of energy and increase in disorder** | | | | | | |
| o The total energy of the universe is constant. | | | | | | |
| o All energy can be considered to be kinetic energy, potential energy, or energy contained by a field. | | | | | | |
| o Heat consists of random motion and the vibrations of atoms, molecules, and ions. | | | | | | |
| o Everything tends to become less organized and less orderly over time. | | | | | | |
| • **Interactions of energy and matter** | | | | | | |
| o Waves have energy and transfer energy when | | | | | | |

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|---|---|---|---|---|---|---|
| they interact with matter. | | | | | | |
| o Electromagnetic waves result when a charged object is accelerated or decelerated. | | | | | | |
| o Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. | | | | | | |
| o In some materials electrons flow easily, whereas in insulating materials they can hardly flow at all. | | | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | |
| • **The cell** | | | | | | |
| o Cells have particular structures that underlie their functions. | **x** | **x** | **x** | ✓ | **x** | **x** |
| o Most cell functions involve chemical reactions. | | | | **x** | | |
| o Cells store and use information to guide their functions. | ● | **x** | | | **x** | |
| o Cell functions are regulated. | ● | **x** | **x** | **x** | **x** | |
| o Plant cells contain chloroplasts, the site of photosynthesis. | | | | | | |
| o The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. | | | | | | |
| o Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. | **x** | **x** | ● | **x** | **x** | |
| • **Molecular basis of heredity** | | | | | | |
| o In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). | **x** | | ● | ● | **x** | |
| o Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: females have two X chromosomes and males have one X and one Y chromosome. | | | | | | |
| o Changes in DNA (mutations) occur spontaneously at low rates. | | | | | | |

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|---|---|---|---|---|---|---|
| • **Biological evolution** | | | | | | |
| o Species evolve over time. | | | | | | |
| o The great diversity of organisms is the result of more than 3.5 billion years of evolution. | | | | | | |
| o Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. | | | | | | |
| o The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors. | | | | | | |
| o Biological classifications are based on how organisms are related. | | | | | | |
| • **Interdependence of organisms** | | | | | | |
| o The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere. | | | | | | |
| o Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers. | | | | | | |
| o Organisms both cooperate and compete in ecosystems. | | | | | | |
| o Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. | | | | | | |
| o Human beings live within the world's ecosystems. | | | | | | |
| • **Matter, energy, and organization in living systems** | | | | | | |
| o All matter tends toward more disorganized states. | | | | | | |
| o The energy for life primarily derives from the sun. | | | | | | |
| o The chemical bonds of food molecules contain energy. | | | **x** | | | |
| o The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism. | **x** | **x** | ✓ | ✓ | **x** | ● |
| o The distribution and abundance of organisms and | | | | | | |

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|---|---|---|---|---|---|---|
| populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials. | | | | | | |
| o As matter and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. | | **x** | ✓ | | | ● |
| o Matter and energy are conserved in each recombination of elements. | | | **x** | | | |
| • **Behavior of organisms** | | | | | | |
| o Multicellular animals have nervous systems that generate behavior. | | **x** | | | **x** | |
| o Organisms have behavioral responses to internal changes and to external stimuli. | | **x** | | **x** | **x** | |
| o Like other aspects of an organism's biology, behaviors have evolved through natural selection. | | | | | | |
| o Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology. | | | | | | |
| ***NSES* Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | | | |
| • **Energy in the earth system** | | | | | | |
| • **Geochemical cycles** | | | | | | |
| • **Origin and evolution of the earth system** | | | | | | |
| • **Origin and evolution of the universe** | | | | | | |
| ***NSES* Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | | | |
| • **Abilities of technological design** | | | | | | |
| o Identify a problem or design an opportunity. | ● | ● | ● | ● | ● | ✓ |
| o Propose designs and choose between alternative solutions. | | | **x** | ● | | ✓ |
| o Implement a proposed solution. | | | **x** | ● | | **x** |
| o Evaluate the solution and its consequences. | | | | ● | | **x** |
| o Communicate the problem, process, and solution. | | | **x** | **x** | | ✓ |
| • **Understandings about science and technology** | | | | | | |

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|---|---|---|---|---|---|---|
| o Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. | **x** | ● | ● | ● | ● | ● |
| o Science often advances with the introduction of new technologies. | **x** | ● | **x** | ● | ● | **x** |
| o Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. | **x** | ● | **x** | ● | ● | **x** |
| o Science and technology are pursued for different purposes. | | | | | | |
| o Technical knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentation at professional meetings and publications in scientific journals. | | | | **x** | | |
| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | |
| • **Personal and community health** | | | | | | |
| o Hazards and potential for accidents exist. | ● | | | ● | | |
| o The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. | | | | | ● | |
| o Personal choice concerning fitness and health involves multiple factors. | | | ● | ● | | |
| o An individual's mood and behavior may be modified by substances. | | | | | | |
| o Selection of foods and eating patterns determine nutritional balance. | | | **x** | ● | | |
| o Families serve basic health needs, especially for young children. | | | | | | |
| o Sexuality is basic to the physical, mental, and social development of humans. | | | | | | |
| • **Population growth** | | | | | | |
| o Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. | | | | | | |
| o Various factors influence birth rates and fertility | | | | | | |

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|---|---|---|---|---|---|---|
| rates. | | | | | | |
| o Populations can reach limits to growth. | | | | | | |
| • **Natural resources** | | | | | | |
| o Human populations use resources in the environment in order to maintain and improve their existence. | | | | | | |
| o The earth does not have infinite resources. | | | | | | |
| o Humans use many natural systems as resources. | | | | | | |
| • **Environmental quality** | | | | | | |
| o Natural ecosystems provide an array of basic processes that affect humans. | | | | | | |
| o Materials from human societies affect both physical and chemical cycles of the earth. | | | | | | |
| o Many factors influence environmental quality. | | | | | | |
| • **Natural and human-induced hazards** | | | | | | |
| o Normal adjustments of earth may be hazardous for humans. | | | | | | |
| o Human activities can enhance potential for hazards. | | | | | | |
| o Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. | | | | | | |
| o Natural and human-induced hazards present the need for humans to assess potential danger and risk. | | | | | | |
| • **Science and technology in local, national, and global challenges** | | | | | | |
| o Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. | | | | | | |
| o Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. | | | | | | |
| o Progress in science and technology can be affected by social issues and challenges. | | | ● | ● | | ● |
| o Individuals and society must decide on proposals | | | | | | |

| Key:<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| involving new research and the introduction of new technologies into society. | | | | | | |
| o Humans have a major effect on other species. | | | | | | |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | | | |
| • **Science as a human endeavor** | | | | | | |
| o Individuals and teams have contributed and will continue to contribute to the scientific enterprise. | ● | ● | ● | ● | ● | ● |
| o Scientists have ethical traditions. | | | | | | |
| o Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. | | | | | | |
| • **Nature of scientific knowledge** | | | | | | |
| o Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world. | ● | ● | ● | ● | ● | ● |
| o Scientific explanations must meet certain criteria. | ● | ● | ● | ● | ● | ● |
| o Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. | ● | ● | ● | ● | | |
| • **Historical perspectives** | | | | | | |
| o In history, diverse cultures have contributed scientific knowledge and technologic inventions. | | | | | | |
| o Usually, changes in science occur as small modifications in extant knowledge. | | | | | | |
| o Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. | | | | | | |
| o The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge. | | x | ● | ● | | |

[1]National Research Council (NRC) ***National Science Education Standards***.

# Standards for Technological Literacy[1] in Human Body Systems

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | | | | | | |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | | | | | | |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | ● | ● | ● | ● | ● | ● |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | **x** | ● | | ● | | ● |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | | | | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | | | | | | |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | | | | | | |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | | | **x** | ● | | ● |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | | | ● | | | |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | | | ● | ● | | ● |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | | | ● | | | |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | ● | ● | **x** | **x** | **x** | ✓ |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | ● | | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | | | |

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|---|---|---|---|---|---|---|
| ***STL* Standard 17:** Students will develop an understanding of and be able to select and use information and communication technologies. | **x** | ● | ● | ● | ● | ● |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | | | |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | | | |

[1]International Technology Education Association's (ITEA) ***Standards for Technological Literacy: Content for the Study of Technology*.**

# English Language Arts Standards[1] in Human Body Systems

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | ● | ● | x | x | ● | ✓ |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | | | |
| ***SELA* Standard 3;** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | ● | ● | ● | ● | ● | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | x | ● | ● | x | ● | ✓ |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | ● | ● | ● | ● | ● | ● |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | ✓ | x | ✓ | ✓ | ✓ | ✓ |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | ✓ | ✓ | **x** | ✓ | ✓ | ✓ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic groups, geographic regions, and social roles. | | | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | | | |
| **SELA Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

[1]National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Principles and Standards for School Mathematics[1] in Human Body Systems

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems. | ● | ● | x | x | x | ● |
| • understand meanings of operations and how they relate to one another. | | | ● | ● | ● | |
| • compute fluently and make reasonable estimates. | | | x | | | |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • understand patterns, relations, and functions. | ● | | ● | ● | | |
| • represent and analyze mathematical situations and structures using algebraic symbols. | ● | | | ● | | |
| • use mathematical models to represent and understand quantitative relationships. | x | | x | | x | |
| • analyze change in various contexts. | ● | | ● | ● | ● | |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships. | | | | | | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems. | | | | x | | |
| • apply transformations and use symmetry to analyze mathematical situations. | | | | | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | | | ● | | |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement. | x | x | x | ✓ | x | |
| • apply appropriate techniques, tools, and formulas to determine measurements. | ✓ | ● | x | ✓ | x | |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all | | | | | | |

| Key:<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| students to— | | | | | | |
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. | ● | ● | x | x | ● | ● |
| • select and use appropriate statistical methods to analyze data. | | | x | x | x | |
| • develop and evaluate inferences and predictions that are based on data. | x | x | x | x | x | x |
| • understand and apply basic concepts of probability. | | | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • build new mathematical knowledge through problem solving. | | | | | | |
| • solve problems that arise in mathematics and in other contexts. | | | ● | | | ● |
| • apply and adapt a variety of appropriate strategies to solve problems. | | | | | | |
| • monitor and reflect on the process of mathematical problem solving. | ● | ● | ● | x | ● | x |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics. | | | | | | |
| • make and investigate mathematical conjectures. | | | | | | |
| • develop and evaluate mathematical arguments and proofs. | | | | | | |
| • select and use various types of reasoning and methods of proof. | | | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • organize and consolidate their mathematical thinking through communication. | ● | | ● | | ● | |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others. | ● | | ● | | ● | |
| • analyze and evaluate the mathematical thinking and strategies of others. | | | | | | |
| • use the language of mathematics to express mathematical ideas precisely. | | | | | | |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • recognize and use connections among mathematical ideas. | | | | | | |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole. | | | | | | |
| • recognize and apply mathematics in contexts outside of mathematics. | x | x | x | x | x | ● |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas. | | | | | | |

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|---|---|---|---|---|---|---|
| • select, apply, and translate among mathematical representations to solve problems. | ● | | ● | | ● | |
| • use representations to model and interpret physical, social, and mathematical phenomena. | | | | | ● | |

[1]National Council of Teachers of Mathematics (NCTM) ***Principles and Standards for School Mathematics***.

# National Healthcare Foundation Standards and Accountability Criteria[1] in Human Body Systems

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| **Foundation Standard 1: Academic Foundation**<br>Healthcare professionals will know the academic subject matter required for proficiency within their area. They will use this knowledge as needed in their role. The following accountability criteria are considered essential for students in a health science program of study. | | | | | | |
| **1.1 Human Structure and Function** | | | | | | |
| 1.11 Classify basic structural and functional organization of the human body (tissue, organ, and system). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 1.12 Recognize body planes, directional terms, quadrants, and cavities. | x | x | ● | x | ● | |
| 1.13 Analyze basic structure and function of the human body. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **1.2 Diseases and Disorders** | | | | | | |
| 1.21 Describe common diseases and disorders of each body system (prevention, pathology, diagnosis, and treatment). | ● | x | x | x | x | x |
| 1.22 Recognize emerging diseases and disorders. | | | | | ● | |
| 1.23 Investigate biomedical therapies as they relate to prevention, pathology, and treatment of disease. | | x | x | x | x | x |
| **1.3 Medical Mathematics** | | | | | | |
| 1.31 Apply mathematical computations related to healthcare procedures (metric and household, conversions and measurements). | x | | x | x | ● | |
| 1.32 Analyze diagrams, charts, graphs, and tables to interpret healthcare data. | | x | x | ✓ | x | |
| 1.33 Record time using 24-hour clock. | | | | | | |
| **Foundation Standard 2: Communications**<br>Healthcare professionals will know the various methods of giving and obtaining information. They will communicate effectively, both orally and in writing. | | | | | | |
| **2.1 Concepts of Effective Communication** | | | | | | |
| 2.11 Interpret verbal and nonverbal communication. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| 2.12 Recognize barriers to communication. | | | | | | |
| 2.13 Report subjective and objective information. | **x** | **x** | ✓ | ✓ | **x** | **x** |
| 2.14 Recognize elements of communication using a sender-receiver model. | | | | | | |
| 2.15 Apply speaking and active listening skills. | **x** | ✓ | **x** | **x** | **x** | **x** |
| **2.2 Medical Terminology** | | | | | | |
| 2.21 Use roots, prefixes, and suffixes to communicate information. | **x** | **x** | ● | **x** | | ● |
| 2.22 Use medical abbreviations to communicate information. | | | ● | ● | | ● |
| **2.3 Written Communication Skills** | | | | | | |
| 2.31 Recognize elements of written and electronic communication (spelling, grammar, formatting and confidentiality). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **Foundation Standard 3: Systems**<br>Healthcare professionals will understand how their role fits into their department, their organization and the overall healthcare environment. They will identify how key systems affect services they perform and quality of care. | | | | | | |
| **3.1 Healthcare Delivery Systems** | | | | | | |
| 3.11 Understand healthcare delivery system (public, private, government, and non-profit). | | | | | | |
| 3.12 Explain factors influencing healthcare delivery systems. | | | | | | |
| 3.13 Describe responsibilities of consumers within the healthcare system. | | | | | | |
| 3.14 Explain the impact of emerging issues such as technology, epidemiology, bioethics, and socioeconomics on healthcare delivery systems. | | | | | | |
| 3.15 Discuss common methods of payment for healthcare. | | | | | | |
| **Foundation Standard 4: Employability Skills**<br>Healthcare professionals will understand how employability skills enhance their employment opportunities and job satisfaction. They will demonstrate key employability skills and will maintain and upgrade skills, as needed. | | | | | | |
| **4.1 Personal Traits of the Healthcare Professional** | | | | | | |
| 4.11 Classify personal traits or attitudes desirable in a member of the healthcare team. | | | | | | |
| 4.12 Summarize basic professional standards of healthcare workers as they apply to hygiene, dress, language, confidentiality and behavior (i.e. courtesy and self-introductions). | | | | | | |
| **4.2 Employability Skills** | | | | | | |
| 4.21 Apply employability skills in healthcare. | | | | | | |
| **4.3 Career Decision-making** | | | | | | |
| 4.31 Discuss levels of education, credentialing requirements, and employment trends in healthcare. | **x** | **x** | **x** | **x** | **x** | **x** |

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|---|---|---|---|---|---|---|
| 4.32 Compare careers within the health science career pathways (diagnostic services, therapeutic services, health informatics, support services, or biotechnology research and development). | **x** | **x** | **x** | **x** | **x** | |
| **4.4. Employability Preparation** | | | | | | |
| 4.41 Develop components of a personal portfolio. | ● | ● | ● | ● | ● | ● |
| 4.42 Demonstrate process for obtaining employment. | | | | | | |
| **Foundation Standard 5: Legal Responsibilities**<br>Healthcare professionals will understand the legal responsibilities, limitations, and implications of their actions within the healthcare delivery setting. They will perform their duties according to regulations, policies, laws and legislated rights of clients. | | | | | | |
| **5.1 Legal Implications** | | | | | | |
| 5.11 Analyze legal responsibilities and limitations. | | | | | | |
| 5.12 Explain practices that could result in malpractice, liability, and/or negligence. | | | | | | |
| **5.2 Legal Practices** | | | | | | |
| 5.21 Apply standards for Health Insurance Portability and Accountability Act (HIPAA). | | | | | | |
| 5.22 Describe advance directives. | | | | | | |
| 5.23 Summarize the Patient's Bill of Rights. | | | | | | |
| 5.24 Understand informed consent. | | | | | | |
| 5.25 Explain the laws governing harassment, labor, and employment. | | | | | | |
| **Foundation Standard 6: Ethics**<br>Healthcare professionals will understand accepted ethical practices with respect to cultural, social, and ethnic differences within the healthcare environment. They will perform quality healthcare delivery. | | | | | | |
| **6.1 Ethical Boundaries** | | | | | | |
| 6.11 Differentiate between ethical and legal issues impacting healthcare. | | | | | | |
| 6.12 Recognize ethical issues and their implications related to healthcare. | **x** | | | | | |
| **6.2 Ethical Practice** | | | | | | |
| 6.21 Apply procedures for reporting activities and behaviors that affect health, safety, and welfare of others. | | | | | | |
| **6.3 Cultural, Social, and Ethnic Diversity** | | | | | | |
| 6.31 Understand religious and cultural values as they impact healthcare. | | | | | | |
| 6.32 Demonstrate respectful and empathetic interactions with diverse age, cultural, economic, ethnic, and religious groups. | | | | | | |
| **Foundation Standard 7: Safety Practices**<br>Healthcare professionals will understand the existing and potential hazards to clients, co-workers, and self. They will prevent injury or | | | | | | |

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|---|---|---|---|---|---|---|
| illness through safe work practices and follow health and safety policies and procedures. | | | | | | |
| **7.1 Infection Control** | | | | | | |
| 7.11 Explain principles of infection control. | | | | | ● | |
| 7.12 Describe methods of controlling growth of microorganisms. | | | | | ● | |
| **7.2 Personal Safety** | | | | | | |
| 7.21 Apply personal safety procedures based on Occupational Safety and Health Administration (OSHA) and Centers for Disease Control (CDC) regulations (including standard precautions). | ● | ● | ● | ● | ● | |
| 7.22 Apply principles of body mechanics. | | | | | | |
| **7.3 Environmental Safety** | | | | | | |
| 7.31 Apply safety techniques to prevent accidents and to maintain a safe work environment. | **x** | **x** | **x** | **x** | **x** | |
| **7.4 Common Safety Hazards** | | | | | | |
| 7.41 Comply with safety signs, symbols, and labels. | ● | ● | ● | ● | ● | |
| 7.42 Understand implications of hazardous materials. | | | | | | |
| **7.5 Emergency Procedures and Protocols** | | | | | | |
| 7.51 Practice fire safety in a healthcare setting. | | | | | | |
| 7.52 Apply principles of basic emergency response in natural disasters and other emergencies. | | | | | | |
| **Foundation Standard 8: Teamwork**<br>Healthcare professionals will understand the roles and responsibilities of individual members as part of the healthcare team, including their ability to promote the delivery of quality healthcare. They will interact effectively and sensitively with all members of the healthcare team. | | | | | | |
| **8.1 Healthcare Teams** | | | | | | |
| 8.11 Understand roles and responsibilities of team members. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 8.12 Recognize characteristics of effective teams. | ● | ● | ● | ● | ● | ● |
| **8.2 Team Member Participation** | | | | | | |
| 8.21 Recognize methods for building positive team relationships. | ✓ | ✓ | **x** | ✓ | ✓ | ✓ |
| 8.22 Analyze attributes and attitudes of an effective leader. | | | | | | |
| 8.23 Apply effective techniques for managing team conflict. | ● | ● | ● | ● | ● | ● |
| **Foundation Standard 9: Health Maintenance Practices**<br>Healthcare professionals will understand the fundamentals of wellness and the prevention of disease processes. They will practice preventive health behaviors among the clients. | | | | | | |
| **9.1 Healthy Behaviors** | | | | | | |
| 9.11 Apply behaviors that promote health and wellness. | ● | **x** | **x** | **x** | **x** | **x** |
| 9.12 Describe strategies for prevention of diseases including health screenings and examinations. | | **x** | **x** | **x** | **x** | **x** |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—Identity | Unit 2—Communication | Unit 3—Power | Unit 4—Movement | Unit 5— Protection | Unit 6—Homeostasis |
|---|---|---|---|---|---|---|
| 9.13 Discuss complementary and alternative health practices. | | | | | | |
| **Foundation Standard 10: Technical Skills**<br>Healthcare professionals will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate<br>*Additional technical skills may be included in a program of study based on career specialties | | | | | | |
| **10.1 Technical Skills** | | | | | | |
| 10.11 Apply procedures for measuring and recording vital signs including the normal ranges. | | | | ● | | |
| 10.12 Apply skills to obtain training or certification in cardiopulmonary resuscitation (CPR), automated external defibrillator (AED), foreign body airway obstruction (FBAO), and first aid. | | | | | | |
| **Foundation Standard 11: Information Technology Applications**<br>Healthcare professionals will use information technology applications required within all career specialties. They will demonstrate use as appropriate to healthcare applications. | | | | | | |
| **11.1 Health Information Management** | | | | | | |
| 11.11 Identify records and files common to healthcare. | | | | | | |
| **11.2 Information Technology** | | | | | | |
| 11.21 Communicate using technology (fax, e-mail, and Internet). | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 11.22 Recognize technology applications in healthcare | **x** | **x** | **x** | **x** | **x** | **x** |

[1] National Consortium on Health Science and Technology Education. **National Healthcare Foundation Standards and Accountability Criteria.**.

PROJECT LEAD THE WAY PLTW

# MI

# Medical Interventions Course Description

In the Medical Interventions course, students will investigate the variety of interventions involved in the prevention, diagnosis and treatment of disease as they follow the lives of a fictitious family. A “How-To” manual for maintaining overall health and homeostasis in the body, the course will explore how to prevent and fight infection, how to screen and evaluate the code in our DNA, how to prevent, diagnose and treat cancer, and how to prevail when the organs of the body begin to fail. Through these scenarios, students will be exposed to the wide range of interventions related to Immunology, Surgery, Genetics, Pharmacology, Medical Devices, and Diagnostics. Each family case scenario will introduce multiple types of interventions and will reinforce concepts learned in the previous two courses, as well as present new content. Interventions may range from simple diagnostic tests to treatment of complex diseases and disorders. These interventions will be showcased across the generations of the family and will provide a look at the past, present and future of biomedical science. Lifestyle choices and preventive measures are emphasized throughout the course as well as the important role scientific thinking and engineering design play in the development of interventions of the future.

# Medical Interventions Detailed Outline

## Unit One: How to Fight Infection
## Time Days (45 Days)

**Lesson 1.1: The Mystery Infection** (17 Days)

**Concepts Addressed in Lesson:**

1. Medical interventions are measures to improve health or alter the course of an illness and can be used to prevent, diagnose, and treat disease.
2. Bioinformatics, the collection, classification, storage, and analysis of biochemical and biological information using computers, can be used to identify disease pathogens.
3. Diagnostic tests for infectious diseases can provide qualitative results, indicating the presence or absence of disease, as well as quantitative results, indicating the concentration of the infectious agent or of an antibody produced in response to the disease agent.
4. Antibody-based diagnostic tests, such as the ELISA assay, utilize fundamentals of human immune response to detect the presence of disease.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- List medical interventions to create a classroom display.
- Group common medical interventions into categories.
- Maintain case notes of an outbreak investigation.
- Create a graphic organizer displaying connections between individuals in a disease outbreak.
- Use publically available molecular databases to search for DNA sequences and identify pathogens.
- Build a model or draw a diagram that illustrates how ELISA can be used to detect disease.
- Compute serial dilutions and calculate resultant concentrations.
- Perform ELISA testing to determine the concentration of infectious bacteria in simulated body fluids and identify infected patients.
- Write a report summarizing the multi-step process followed to investigate an outbreak of bacterial meningitis.

## Lesson 1.2: Antibiotic Treatment (9 Days)

**Concepts Addressed in Lesson:**

1. Antibiotics disrupt the pathways that bacteria use to survive.
2. Bacterial cells use multiple pathways to gain resistance to antibiotics.
3. Overuse and misuse of antibiotics will promote the selection of resistant bacteria.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Draw and label a diagram of a bacterial cell.
- Research the method of action for different classes of antibiotics.
- Use proper laboratory techniques to "mate" a streptomycin resistant strain of E. coli with an ampicillin resistant strain of E. coli.
- Design and construct a 3-D model that demonstrates one of the pathways through which bacterial cells transfer genes.
- Use a model to simulate the effects of antibiotics on the population of bacteria during an infection.

## Lesson 1.3: The Aftermath: Hearing Loss (10 Days)

**Concepts Addressed in Lesson:**

1. Sound waves have two important properties: frequency (which the ear interprets as pitch) and amplitude (which the ear interprets as loudness).
2. Problems with one or more structures within the ear cause various types of hearing loss.
3. Hearing loss can be evaluated with several, simple hearing tests.
4. There are a variety of interventions available to help people with hearing loss.
5. There are bioethical concerns related to the use of cochlear implant technology.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create a 3-D model of the structures of the ear.
- Give a short presentation to describe the type of hearing loss experienced by a patient.
- Demonstrate hearing loss on the model of the ear.
- Perform several simple hearing tests.
- Trace the pathway of sound.
- Match up audiograms with their corresponding patients with hearing loss.

- Recommend the most appropriate type of intervention for a patient with hearing loss.
- Write a letter from the opposing perspectives of an adult deaf person expressing his or her reasons for choosing to get a cochlear implant versus an adult deaf person expressing his or her reasons for choosing not to get a cochlear implant.

### Lesson 1.4: Vaccination (9 Days)

**Concepts Addressed in Lesson:**

1. Vaccines are medical interventions that activate the immune system to recognize a disease antigen and produce antibodies necessary to defend the body.
2. Many diseases have been eradicated by large-scale vaccination campaigns.
3. Vaccines can be produced in the laboratory by various methods, including recombinant DNA techniques.
4. Plasmids can be employed as an important tool in genetic engineering and can serve as vectors, vehicles for the movement of genetic information.
5. *Epidemiologists* are dedicated medical professionals at the heart of the public health field who monitor the health of human populations, search for patterns in the development of both infectious and chronic illnesses assist in outbreak investigations, and design disease treatment and prevention strategies.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Interview people from different generations about their vaccination history and organize findings in a graphic organizer.
- Design a user-friendly vaccination schedule for the parents of a newborn.
- Produce a concept map outlining the laboratory processes used to generate vaccines.
- Engineer a paper plasmid to include the genetic code necessary to produce a vaccine.
- Assume the role of an epidemiologist and complete four tasks to showcase their skills as a professional.

## Unit 2: How to Screen What Is In Your Genes
## Time Days (23 Days)

### Lesson 2.1: Genetic Testing and Screening (16 Days)

**Concepts Addressed in Lesson:**

1. Genetic testing is the use of molecular methods to determine if someone has a genetic disorder, will develop one, or is a carrier of a genetic illness and involves sampling a person's DNA and examining the chromosomes or genes for abnormalities.
2. Genetic counseling can help a family understand the risks of having a child with a genetic disorder, the medical facts about an already diagnosed condition, and other information necessary for a person or a couple to make decisions suitable to their cultural, religious and moral beliefs.
3. The polymerase chain reaction (PCR) is a laboratory procedure that produces multiple copies of a specific DNA sequence.
4. Single base pair changes called single nucleotide polymorphisms (SNPs) can be identified through genetic testing and often correlate to specific diseases or traits.
5. Proper prenatal care and monitoring of the fetus are vital to maternal and child health during a pregnancy.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Analyze a genetic counseling case file and provide written and oral feedback to a patient or family.
- Amplify a segment of DNA in the laboratory using PCR.
- Use laboratory techniques such as DNA extraction, PCR, and restriction analysis to identify single base pair differences in DNA.
- Test their ability to taste the chemical PTC and relate this trait to laboratory genetic testing results.
- Create a Venn diagram to compare the process of amniocentesis and chorionic villus sampling.
- Analyze prenatal screening results.
- Write a diary entry that describes proper prenatal care and the medical interventions that function to monitor a pregnancy.

**Lesson 2.2: Our Genetic Future** (7 Days)

**Concepts Addressed in Lesson:**

1. Gene therapy is a type of disease treatment in which faulty genes are replaced by functional copies.
2. Various vectors, including viruses, can be used to transfer DNA into human cells.
3. Both sperm sorting and embryo selection by preimplantation genetic diagnosis (PDG) provide parents the option to select the gender of a child.
4. Advances in reproductive technology open many moral, ethical, and scientific debates.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Construct a graphic organizer comparing and contrasting potential gene therapy vectors.
- Read and summarize current news articles debating the overall safety and value of gene therapy as a treatment option for genetic disorders.
- Write a policy statement governing future gene therapy research.
- Complete a survey of their personal feelings regarding reproductive options of the future.

## Unit Three: How to Conquer Cancer
## Time Days (58 Days)

**Lesson 3.1: Detecting Cancer** (15 Days)

**Concepts Addressed in Lesson:**

1. Cancer is a term used for more than 100 different diseases in which cell regulation genes are mutated causing the cells to reproduce out of control.
2. X-rays, CT scans, and MRI scans are used to create pictures of the inside of the body to diagnose and treat many disorders.
3. DNA microarrays measure the amount of mRNA for genes that is present in a cell sample.
4. Scientists use DNA microarray technology to determine the differences in gene expression between different tissue samples.
5. Scientists calculate the similarities of gene expression patterns between different individuals using statistical analysis.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Display information about cancer case studies on graphic organizers.
- Create a concept map that describes the different uses for various diagnostic imaging technologies.
- Compare normal cells and cancer cells.
- Perform a simulated DNA microarray to analyze the gene expression patterns of two patients.
- Use statistical analysis to determine the similarity between gene expression patterns of three patients.

**Lesson 3.2: Reducing Cancer Risk** (17 Days)

**Concepts Addressed in Lesson:**

1. Behavioral, biological, environmental, and genetic risk factors increase the chance that a person will develop cancer.
2. The risk for developing many cancers can be reduced with life-style changes.
3. Molecular diagnostic tests, such as marker analysis, can be used to detect inherited genetic mutations associated with certain cancers and can be used to predict risk for developing those cancers.
4. Viruses insert their DNA or RNA into a host cell, causing the host cell's genes to mutate which can sometimes cause the cell to become cancerous.
5. Routine cancer screenings can prevent certain types of cancer or can increase the chance that cancer is detected at an early stage when treatment is more effective.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Read an article about a potential risk factor that interests them and share it with the class.
- Complete a skin cancer risk questionnaire and evaluate which risks are in their control.
- Use proper laboratory techniques to design and conduct an experiment to test the effectiveness of various sunscreens or types of cloth against UV light using UV sensitive yeast cells.
- Perform marker analysis to determine the presence of a genetic mutation associated with breast cancer.
- Create a mock interview with a virologist either working to develop a new vaccine or drug for a virus associated with cancer.
- Create a timeline of cancer screenings they should do throughout their life using Inspiration® software.

**Lesson 3.3: Treating Cancer** (12 Days)

**Concepts Addressed in Lesson:**

1. Chemotherapy and radiation therapy are cancer treatments that work to destroy cancer cells by stopping or slowing their growth; both treatments can cause negative side effects to the patient.
2. Biofeedback therapy is a technique in which patients are trained to improve their health or manage pain by learning to control certain internal bodily processes that normally occur involuntarily, such as heart rate, respiration rate, and skin temperature.
3. Artificial limbs are built to allow patients who have suffered from the loss of a limb to regain lost function.

4. Advances in technology are allowing the development of artificial limbs that look and move more like actual human limbs.
5. Physical and occupational therapists work to help patients with disabilities or patients recovering from surgery or injury, restore function, improve mobility, relieve pain, and improve the ability to perform the tasks necessary to lead an independent and productive life.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Write journal entries or a blog describing the experiences of teenagers undergoing cancer treatments.
- Design and create a simple model of an arm that is able to pick-up an empty Styrofoam cup.
- Create an outline of an article about the history and future of prosthetic limbs.
- Complete a laboratory investigation using data acquisition software and probes to explore biofeedback therapy.
- Design an experiment to test the effect of relaxation techniques on their heart rate, respiration rate, and skin temperature.
- Design and present a comprehensive rehabilitation plan for an assigned patient.

## Lesson 3.4: Building a Better Cancer Treatment (14 Days)

**Concepts Addressed in Lesson:**

1. All drugs do not act the same way for all individuals.
2. SNPs can cause changes in enzymes that metabolize certain drugs in the body.
3. The field of pharmocogenetics investigates how genetic variations correlate with responses to specific medication and strives to develop medical treatments tailored to the individual.
4. Clinical trials are regulated by strict guidelines that ensure data collected is valid and human subjects are treated ethically.
5. Nanomedicine shows great promise, particularly for cancer research, in the hope that medical interventions can be developed at the cellular and molecular scale to diagnose and treat disease.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Complete an alignment to arrange DNA sequences side-by-side to locate any base pair differences between different individuals.

- Use patients' SNP profiles to predict how they will respond to particular medicines.
- Research and present cases of human abuse that lead to the regulations governing clinical trials.
- Determine how many cuts are necessary to cut a 10 cm x 1 cm strip of paper in half before the paper is approximately ten nanometers long.
- Summarize an article pertaining to the application of nanotechnology in medicine.
- Develop and present a clinical trial proposal to test the safety and efficacy of a nanotechnology-based cancer treatment for an assigned patient.

## Unit Four: How to Prevail When Organs Fail
## Time Days (49 Days)

**Lesson 4.1: Manufacturing Human Proteins** (20 Days)

**Concepts Addressed in Lesson:**

1. The methods used to diagnose and treat diabetes have changed dramatically over the last 200 years, including the use of insulin.
2. Recombinant DNA technology allows scientists to custom-design bacteria that can produce a variety of important protein products, including insulin.
3. Plasmids, rings of DNA containing genes of interest, can be inserted into bacteria cells via the process of bacterial transformation.
4. Chromatography is a technique used to separate components of a mixture and can be used to separate proteins based on the properties of their side chains.
5. Electrophoresis can be used to separate proteins in a mixture and determine the purity of a sample.
6. Numerous biomedical professionals assist with the production, distribution, and marketing of a new pharmaceutical or bioengineered product.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create a timeline using Inspiration software chronicling the methods used to diagnose and treat diabetes from the 1800s through today.
- Insert plasmid DNA into bacterial cells in the laboratory and observe how this genetic information relates to new traits of the bacteria.
- Calculate transformation efficiency to determine the success of a laboratory experiment.
- Create a 3-D model of a protein that demonstrates how amino acids interact.

- Isolate a protein based on its chemical properties using column chromatography.
- Set up and run protein gel electrophoresis to test the purity of a protein sample.
- Graph electrophoresis results to determine the molecular weight of an unknown protein.
- Produce a flow chart or graphic organizer that outlines the entire process of protein production and purification.
- Write a cover letter for a biomedical professional looking for a job in the field of protein production or biomanufacturing.

**Lesson 4.2: Organ Failure** (3 Days)

**Concepts Addressed In Lesson:**

1. End stage renal failure is diagnosed when a patient loses 85 to 90 percent of his/her normal kidney function.
2. When the kidneys are not functioning properly, they will not filter adequately and harmful wastes products such as urea, creatinine and blood urea nitrogen build up in the blood stream and the body will make fewer red blood cells because of the lack of the hormone erythropoietin.
3. Patients with End Stage Renal Disease have three medical options for treatment, including hemodialysis, peritoneal dialysis and kidney transplant.
4. Dialysis is an artificial process that removes waste products and excess water from the blood when the kidneys can no longer function.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Create an evidence board to document the symptoms of a patient.
- Describe what diagnostic tests need to be run to determine the cause of a patient's mystery symptoms.
- Research the interventions available for patients with ESRD.
- Write a one-page description of which treatment they would recommend for a patient with ESRD.

**Lesson 4.3: Transplant** (15 Days)

**Concepts Addressed in Lesson:**

1. Deciding who receives donated organs is not always a clear-cut issue and involves many difficult decisions guided by federal policies.
2. For the best chance of a successful organ transplant, the donor's and recipient's tissue types need to match as closely as possible.

3. The surgical techniques involved in a live donor kidney transplant require skill, dexterity, and eye-hand coordination.
4. The various members of a surgical transplant team work together to make sure the transplant is a success.
5. There are many similarities and differences between a heart transplant and a kidney transplant.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Prepare a computer presentation that details who should receive a donated organ in a given situation.
- Use the information gathered from blood typing tests and HLA typing to determine which of Diana's relatives is the most appropriate match to be her kidney donor.
- View a laparoscopic nephrectomy and outline the general steps of the surgical procedure.
- Perform general laparoscopic surgical techniques.
- Perform a simulated portion of a kidney transplant surgery.
- Design a heart transplant procedure.
- Complete a Venn diagram to compare and contrast kidney and heart transplants.

**Lesson 4.4: Building a Better Body** (11 Days)

**Concepts Addressed in Lesson:**

1. A variety of tissues and organs can be transplanted from one organism to another.
2. Scientific research is investigating the possibility of replacing damaged organs and tissues using xenotransplantation and tissue engineering.
3. There are benefits and risks of using xenotransplantation and tissue engineering for organ and tissue replacements.
4. Xenotransplantation and tissue engineering pose many ethical questions.
5. Advancing medical knowledge and technology will enable scientists to enhance the human body.
6. Medical interventions prevent, diagnose, and treat disease.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Research a technology being investigated to provide replacement tissues or organs for patients needing a transplant.

- Display information about xenotransplantation or tissue engineering using graphic organizers.
- Formulate and write arguments from the perspective of different stakeholders as to whether or not further research for xenotransplantation and tissue engineering should be banned.
- Design the blueprints for eight replacements and/or enhancements to the human body to create a “super” human.
- Create and present computer presentations that outline the replacements and/or enhancements to create their “super” human.
- Review and write a reflection on all of the medical interventions encountered throughout the course.
- Write a reflection on their career aspirations.

# National Science Education Standards in Medical Interventions

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|---|---|---|---|---|
| ***NSES* Content Standard K-12: Unifying Concepts and Processes** As a result of activities in grades K-12, all students should develop understanding and abilities aligned with the following concepts and processes— | | | | |
| • **Systems, order, and organization** | | | | |
| o A system is an organized group of related objects or components that form a whole. | ● | ● | ● | ● |
| o Systems have boundaries, components, resources flow (input and output), and feedback. | ● | | | ● |
| o Order—behavior of units of matter, objects, organisms, or events in the universe—can be described statistically. | ● | | ● | ● |
| o Types and levels of organization provide useful ways of thinking about the world. | ● | | | ● |
| • **Evidence, models, and explanation** | | | | |
| o Evidence consists of observations and data on which to base scientific explanations. | x | ✓ | x | x |
| o Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. | x | | x | x |
| o Scientific explanations incorporate existing scientific knowledge and new evidence from observations, experiments, or models into internally consistent, logical statements. | x | ✓ | x | x |
| • **Change, constancy, and measurement** | | | | |
| o Although most things are in the process of becoming different—changing—some properties of objects and processes are characterized by constancy. | x | | | |
| o Interactions within and among systems result in change. | ● | ● | ● | ● |
| o Changes in systems can be quantified. | x | | ● | |
| o Mathematics is essential for accurately measuring change. | x | x | ● | x |

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|---|---|---|---|---|
| o Scale includes understanding that different characteristics, properties, or relationships within a system might change as its dimensions are increased or decreased. | x | x | | x |
| • **Evolution and equilibrium** | | | | |
| o Evolution is a series of changes, some gradual and some sporadic, that accounts for the present form and function of objects, organisms, and natural and designed systems. | ● | | | |
| o Equilibrium is a physical state in which forces and changes occur in opposite and off-setting directions. | | | | |
| o Interacting units of matter tend toward equilibrium states in which the energy is distributed as randomly and uniformly as possible. | | | | |
| • **Form and function** | | | | |
| o The form or shape of an object or system is frequently related to use, operation, or function. | x | ✓ | x | x |
| o Students should be able to explain function by referring to form and to explain form by referring to function. | x | x | x | x |
| ***NSES* Content Standard A: Science As Inquiry** As a result of activities in grades 9-12, all students should develop— | | | | |
| • **Abilities necessary to do scientific inquiry** | | | | |
| o Identify questions and concepts that guide scientific investigation. | x | ✓ | x | x |
| o Design and conduct scientific investigations. | x | x | x | x |
| o Use technology and mathematics to improve investigations and communications. | x | x | x | x |
| o Formulate and revise scientific explanations and models using logic and evidence. | x | x | x | x |
| o Recognize and analyze alternative explanations and models. | x | x | ● | x |
| o Communicate and defend a scientific argument. | x | x | x | x |
| • **Understandings about scientific inquiry** | | | | |
| o Scientists usually inquire about how physical, living, or designed systems function. | x | ● | ● | ● |
| o Scientists conduct investigations for a variety of reasons. | x | ✓ | x | x |
| o Scientists rely on technology to enhance the gathering and manipulation of data. | ✓ | ✓ | ✓ | x |
| o Mathematics is essential in scientific inquiry. | ✓ | x | x | x |
| o Scientific explanations must adhere to criteria such as: a | x | x | x | x |

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|---|---|---|---|---|
| proposed explanation must be logically consistent; it must abide by the rules of evidence; it must be open to questions and possible modification; and it must be based on historical and current scientific knowledge. | | | | |
| o Results of scientific inquiry—new knowledge and methods—emerge from different types of investigations and public communication among scientists. | **x** | **x** | **x** | ● |
| ***NSES*** **Content Standard B: Physical Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • **Structure of atoms** | | | | |
| o Matter is made of minute particles called atoms | | ● | | |
| o The atom's nucleus is composed of protons and neutrons | | | | |
| o The nuclear forces that hold the nucleus of an atom together | | | | |
| o Radioactive isotopes are unstable and undergo spontaneous nuclear reactions | | | | |
| • **Structure and properties of matter** | | | | |
| o Atoms interact with one another by transferring or sharing electrons that are furthest from the nucleus. | | | | |
| o An element is composed of a single type of atom. | | | | |
| o Bonds between atoms are created when electrons are paired up by being transferred or shared. | | | | |
| o The physical properties of compounds reflect the nature of the interactions among its molecules. | | | | **x** |
| o Solids, liquids, and gases differ in the distances and angles between molecules or atoms and therefore the energy that binds them together. | | | | |
| o Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life. | | ● | ● | |
| • **Chemical reactions** | | | | |
| o Chemical reactions occur all around us, for example health care, cooking, cosmetics, and automobiles. Complex chemical reactions involving carbon-based molecules take place constantly in every cell in our bodies. | ● | ● | ● | ● |
| o Chemical reactions may release or consume energy. | | | | |
| o A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, | | | | |

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|---|---|---|---|---|
| or atoms. | | | | |
| • **Motions and forces** | | | | |
| o Objects change their motion only when a net force is applied. | | | | |
| o Gravitation is a universal force that each mass exerts on any other mass. | | | | |
| o The electric force is a universal force that exists between any two charged objects. | | | | |
| o Between any two charged particles, electric force is vastly greater than the gravitational force. | | | | |
| o Electricity and magnetism are two aspects of a single electromagnetic force. | | | | |
| • **Conservation of energy and increase in disorder** | | | | |
| o The total energy of the universe is constant. | | | | |
| o All energy can be considered to be kinetic energy, potential energy, or energy contained by a field. | | | | |
| o Heat consists of random motion and the vibrations of atoms, molecules, and ions. | | | | |
| o Everything tends to become less organized and less orderly over time. | | | | |
| • **Interactions of energy and matter** | | | | |
| o Waves have energy and transfer energy when they interact with matter. | | | | |
| o Electromagnetic waves result when a charged object is accelerated or decelerated. | | | ● | |
| o Each kind of atom or molecule can gain or lose energy only in particular discrete amounts and thus can absorb and emit light only at wavelengths corresponding to these amounts. | | | | |
| o In some materials electrons flow easily, whereas in insulating materials they can hardly flow at all. | | | | |
| ***NSES* Content Standard C: Life Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • **The cell** | | | | |
| o Cells have particular structures that underlie their functions. | **x** | ✓ | ✓ | **x** |
| o Most cell functions involve chemical reactions. | **x** | **x** | ✓ | ● |
| o Cells store and use information to guide their functions. | **x** | ✓ | ✓ | **x** |
| o Cell functions are regulated. | **x** | **x** | ✓ | **x** |

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|---|---|---|---|---|
| o Plant cells contain chloroplasts, the site of photosynthesis. | | | | |
| o The process of photosynthesis provides a vital connection between the sun and the energy needs of living systems. | | | | |
| o Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. | ● | ● | **x** | ● |
| • **Molecular basis of heredity** | | | | |
| o In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from subunits of four kinds (A, G, C, and T). | **x** | ✓ | ● | **x** |
| o Most of the cells in a human contain two copies of each of 22 different chromosomes. In addition, there is a pair of chromosomes that determines sex: females have two X chromosomes and males have one X and one Y chromosome. | ● | ✓ | ● | ● |
| o Changes in DNA (mutations) occur spontaneously at low rates. | **x** | **x** | ● | ● |
| • **Biological evolution** | | | | |
| o Species evolve over time. | **x** | | | |
| o The great diversity of organisms is the result of more than 3.5 billion years of evolution. | | | | |
| o Natural selection and its evolutionary consequences provide a scientific explanation for the fossil record of ancient life forms, as well as for the striking molecular similarities observed among the diverse species of living organisms. | ● | | | |
| o The millions of different species of plants, animals, and microorganisms that live on earth today are related by descent from common ancestors. | | | | |
| o Biological classifications are based on how organisms are related. | | | | |
| • **Interdependence of organisms** | | | | |
| o The atoms and molecules on the earth cycle among the living and nonliving components of the biosphere. | | | | |
| o Energy flows through ecosystems in one direction, from photosynthetic organisms to herbivores to carnivores and decomposers. | | | | |
| o Organisms both cooperate and compete in ecosystems. | | | | |
| o Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. | | | | |

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|---|---|---|---|---|
| o Human beings live within the world's ecosystems. | | | | |
| • **Matter, energy, and organization in living systems** | | | | |
| o All matter tends toward more disorganized states. | | | | |
| o The energy for life primarily derives from the sun. | | | | |
| o The chemical bonds of food molecules contain energy. | ● | | | ● |
| o The complexity and organization of organisms accommodates the need for obtaining, transforming, transporting, releasing, and eliminating the matter and energy used to sustain the organism. | | | | |
| o The distribution and abundance of organisms and populations in ecosystems are limited by the availability of matter and energy and the ability of the ecosystem to recycle materials. | | | | |
| o As matter and energy flows through different levels of organization of living systems—cells, organs, organisms, communities—and between living systems and the physical environment, chemical elements are recombined in different ways. | | | | |
| o Matter and energy are conserved in each recombination of elements. | | | | |
| • **Behavior of organisms** | | | | |
| o Multicellular animals have nervous systems that generate behavior. | ● | ● | **x** | **x** |
| o Organisms have behavioral responses to internal changes and to external stimuli. | **x** | ● | **x** | **x** |
| o Like other aspects of an organism's biology, behaviors have evolved through natural selection. | | | | |
| o Behavioral biology has implications for humans, as it provides links to psychology, sociology, and anthropology. | | | | |
| ***NSES* Content Standard D: Earth and Space Science** As a result of activities in grades 9-12, all students should develop an understanding of— | | | | |
| • **Energy in the earth system** | | | | |
| • **Geochemical cycles** | | | | |
| • **Origin and evolution of the earth system** | | | | |
| • **Origin and evolution of the universe** | | | | |
| ***NSES* Content Standard E: Science and Technology** As a result of activities in grades 9-12, all students should develop— | | | | |
| • **Abilities of technological design** | | | | |

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|---|---|---|---|---|
| o Identify a problem or design an opportunity. | x | ● | x | ● |
| o Propose designs and choose between alternative solutions. | x | | x | ● |
| o Implement a proposed solution. | | | x | ● |
| o Evaluate the solution and its consequences. | | | x | |
| o Communicate the problem, process, and solution. | | | x | |
| • **Understandings about science and technology** | | | | |
| o Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. | x | ● | x | ● |
| o Science often advances with the introduction of new technologies. | x | ● | x | x |
| o Creativity, imagination, and a good knowledge base are all required in the work of science and engineering. | ● | ● | x | x |
| o Science and technology are pursued for different purposes. | ● | ● | ● | ● |
| o Technical knowledge is often not made public because of patents and the financial potential of the idea or invention. Scientific knowledge is made public through presentation at professional meetings and publications in scientific journals. | ● | ● | | ● |
| ***NSES* Content Standard F: Science in Personal and Social Perspectives** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • **Personal and community health** | | | | |
| o Hazards and potential for accidents exist. | ● | ● | x | ● |
| o The severity of disease symptoms is dependent on many factors, such as human resistance and the virulence of the disease-producing organism. | x | | | |
| o Personal choice concerning fitness and health involves multiple factors. | | | x | |
| o An individual's mood and behavior may be modified by substances. | | | | |
| o Selection of foods and eating patterns determine nutritional balance. | | | | |
| o Families serve basic health needs, especially for young children. | | | | |
| o Sexuality is basic to the physical, mental, and social development of humans. | | | | |
| • **Population growth** | | | | |

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|---|---|---|---|---|
| o Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. | | | | |
| o Various factors influence birth rates and fertility rates. | | ● | | |
| o Populations can reach limits to growth. | | | | |
| • **Natural resources** | | | | |
| o Human populations use resources in the environment in order to maintain and improve their existence. | ● | ● | ● | ● |
| o The earth does not have infinite resources. | | | | |
| o Humans use many natural systems as resources. | | | | |
| • **Environmental quality** | | | | |
| o Natural ecosystems provide an array of basic processes that affect humans. | | | | |
| o Materials from human societies affect both physical and chemical cycles of the earth. | | | | |
| o Many factors influence environmental quality. | | | | |
| • **Natural and human-induced hazards** | | | | |
| o Normal adjustments of earth may be hazardous for humans. | | | | |
| o Human activities can enhance potential for hazards. | | | ● | |
| o Some hazards, such as earthquakes, volcanic eruptions, and severe weather, are rapid and spectacular. | | | | |
| o Natural and human-induced hazards present the need for humans to assess potential danger and risk. | | | | |
| • **Science and technology in local, national, and global challenges** | | | | |
| o Science and technology are essential social enterprises, but alone they can only indicate what can happen, not what should happen. | ● | ● | ● | ● |
| o Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. | ● | ● | ● | ● |
| o Progress in science and technology can be affected by social issues and challenges. | ● | ● | ● | ● |
| o Individuals and society must decide on proposals involving new research and the introduction of new technologies into society. | ● | ● | ● | ● |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that may not be directly addressed but the ideas and concepts are supported or implied in at least one lesson within the unit. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| o Humans have a major effect on other species. | ● | | | ● |
| ***NSES* Content Standard G: History and Nature of Science** As a result of activities in grades 9-12, all students should develop understanding of— | | | | |
| • **Science as a human endeavor** | | | | |
| o Individuals and teams have contributed and will continue to contribute to the scientific enterprise. | ● | ● | ● | ● |
| o Scientists have ethical traditions. | ● | ● | ● | ● |
| o Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. | ● | ● | ● | ● |
| • **Nature of scientific knowledge** | | | | |
| o Science distinguishes itself from other ways of knowing and from other bodies of knowledge through the use of empirical standards, logical arguments, and skepticism, as scientists strive for the best possible explanations about the natural world. | ● | ● | ● | ● |
| o Scientific explanations must meet certain criteria. | ● | ● | ● | ● |
| o Because all scientific ideas depend on experimental and observational confirmation, all scientific knowledge is, in principle, subject to change as new evidence becomes available. | ● | ● | ● | ● |
| • **Historical perspectives** | | | | |
| o In history, diverse cultures have contributed scientific knowledge and technologic inventions. | | | | |
| o Usually, changes in science occur as small modifications in extant knowledge. | | | | |
| o Occasionally, there are advances in science and technology that have important and long-lasting effects on science and society. | ● | ● | ● | ● |
| o The historical perspective of scientific explanations demonstrates how scientific knowledge changes by evolving over time, almost always building on earlier knowledge. | ● | ● | ● | ● |

[1]National Research Council (NRC) ***National Science Education Standards***.

# Standards for Technological Literacy in Medical Interventions

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| ***STL* Standard 1:** Students will develop an understanding of the characteristics and scope of technology. | ● | ● | ● | ● |
| ***STL* Standard 2:** Students will develop an understanding of the core concepts of technology. | ● | ● | ● | ● |
| ***STL* Standard 3:** Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study. | ● | ● | ● | ● |
| ***STL* Standard 4:** Students will develop an understanding of the cultural, social, economic, and political effects of technology. | ● | ● | ● | ● |
| ***STL* Standard 5:** Students will develop an understanding of the effects of technology on the environment. | | | ● | |
| ***STL* Standard 6:** Students will develop an understanding of the role of society in the development and use of technology. | ● | ● | ● | ● |
| ***STL* Standard 7:** Students will develop an understanding of the influence of technology on history. | ● | | | ● |
| ***STL* Standard 8:** Students will develop an understanding of the attributes of design. | ● | | ● | ● |
| ***STL* Standard 9:** Students will develop an understanding of engineering design. | ● | | ● | |
| ***STL* Standard 10:** Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. | ● | ● | ● | ● |
| ***STL* Standard 11:** Students will develop the abilities to apply the design process. | x | | ● | |
| ***STL* Standard 12:** Students will develop the abilities to use and maintain technological products and systems. | ✓ | ✓ | ✓ | ✓ |
| ***STL* Standard 13:** Students will develop the abilities to assess the impact of products and systems. | | | | |
| ***STL* Standard 14:** Students will develop an understanding of and be able to select and use medical technologies. | x | ✓ | ● | x |
| ***STL* Standard 15:** Students will develop an understanding of and be able to select and use agricultural and related biotechnologies. | | | | |
| ***STL* Standard 16**: Students will develop an understanding of and be able to select and use energy and power technologies. | | | | |
| ***STL* Standard 17:** Students will develop an understanding of and be able | ● | ● | ● | ● |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| to select and use information and communication technologies. | | | | |
| ***STL* Standard 18:** Students will develop an understanding of and be able to select and use transportation technologies. | | | | |
| ***STL* Standard 19:** Students will develop an understanding of and be able to select and use manufacturing technologies. | | | | |
| ***STL* Standard 20:** Students will develop an understanding of and be able to select and use construction technologies. | | | | |

[1]International Technology Education Association's (ITEA) ***Standards for Technological Literacy: Content for the Study of Technology*.**

# English Language Arts Standards in Medical Interventions

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| ***SELA* Standard 1:** Students read a wide range of print and non-print texts to build an understanding of texts of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these texts are fiction and nonfiction, classical and contemporary works. | ● | ● | ● | ● |
| ***SELA* Standard 2:** Students read a wide range of literature from many periods in many genres to build an understanding of the many dimensions (e.g. philosophical, ethical, aesthetic) of human experience. | | | | |
| ***SELA* Standard 3:** Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and other texts, their word identification strategies, and their understanding of textual features (e.g. sound-letter correspondence, sentence structure, context, graphics). | ● | ● | ● | ● |
| ***SELA* Standard 4:** Students adjust their use of spoken, written, and visual language (e.g. conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes. | ● | ✓ | ● | ● |
| ***SELA* Standard 5:** Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences and for a variety of purposes. | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 6:** Students apply knowledge of language structure, language conventions (e.g. spelling and punctuation), media techniques, figurative language, and genre to create, critique, and discuss print and nonprint texts. | ● | ● | ● | ● |
| ***SELA* Standard 7:** Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g. print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience. | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 8:** Students use a variety of technological and informational resources (e.g. libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge. | ✓ | ✓ | ✓ | ✓ |
| ***SELA* Standard 9:** Students develop an understanding of and respect for diversity in language use, patterns, and dialects across cultures, ethnic | | | | |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| groups, geographic regions, and social roles. | | | | |
| ***SELA* Standard 10:** Students whose first language is not English make use of their first language to develop competency in English language arts and to develop understanding of content across social roles. | | | | |
| ***SELA* Standard 11:** Students participate as knowledgeable reflective, creative, and critical members of a variety of literacy communities. | | | | |
| **SELA Standard 12:** Students use spoken, written and visual language to accomplish their own purposes (e.g. for learning, enjoyment, persuasion, and the exchange of information). | ✓ | **x** | ✓ | ✓ |

[1]National Council of Teachers of English (NCTE) and International Reading Association (IRA) ***Standards for English Language Arts***.

# Principles and Standards for School Mathematics in Medical Interventions

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| ***PSSM* Number Operations Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand numbers, ways of representing numbers, relationships among numbers, and number systems. | x | ✓ | x | x |
| • understand meanings of operations and how they relate to one another. | ● | | | ● |
| • compute fluently and make reasonable estimates. | x | | ● | ● |
| ***PSSM* Algebra Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand patterns, relations, and functions. | ● | ● | | ● |
| • represent and analyze mathematical situations and structures using algebraic symbols. | ● | | | ● |
| • use mathematical models to represent and understand quantitative relationships. | x | x | | x |
| • analyze change in various contexts. | | | | x |
| ***PSSM* Geometry Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships. | | | | |
| • specify locations and describe spatial relationships using coordinate geometry and other representational systems. | | | | |
| • apply transformations and use symmetry to analyze mathematical situations. | | | | |
| • use visualization, spatial reasoning, and geometric modeling to solve problems. | | | | |
| ***PSSM* Measurement Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • understand measurable attributes of objects and the units, systems, and processes of measurement. | x | x | x | ● |
| • apply appropriate techniques, tools, and formulas to determine measurements. | x | x | x | ● |
| ***PSSM* Data Analysis and Probability Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| • formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them. | **x** | ● | ● | **x** |
| • select and use appropriate statistical methods to analyze data. | **x** | **x** | **x** | ● |
| • develop and evaluate inferences and predictions that are based on data. | **x** | ● | ● | **x** |
| • understand and apply basic concepts of probability. | | | | |
| ***PSSM* Problem Solving Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • build new mathematical knowledge through problem solving. | | | | |
| • solve problems that arise in mathematics and in other contexts. | ● | | | ● |
| • apply and adapt a variety of appropriate strategies to solve problems. | ● | ● | ● | ● |
| • monitor and reflect on the process of mathematical problem solving. | | | | |
| ***PSSM* Reasoning and Proof Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize reasoning and proof as fundamental aspects of mathematics. | | | | |
| • make and investigate mathematical conjectures. | | | | |
| • develop and evaluate mathematical arguments and proofs. | | | | |
| • select and use various types of reasoning and methods of proof. | | | | |
| ***PSSM* Communication Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • organize and consolidate their mathematical thinking through communication. | | | | |
| • communicate their mathematical thinking coherently and clearly to peers, teachers, and others. | | | | |
| • analyze and evaluate the mathematical thinking and strategies of others. | | | | |
| • use the language of mathematics to express mathematical ideas precisely. | ● | | ● | ● |
| ***PSSM* Connections Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • recognize and use connections among mathematical ideas. | | | | |
| • understand how mathematical ideas interconnect and build on one another to produce a coherent whole. | | | | |
| • recognize and apply mathematics in contexts outside of mathematics. | ● | | ● | ● |
| ***PSSM* Representation Standard:** Instructional programs from prekindergarten through grade 12 should enable all students to— | | | | |
| • create and use representations to organize, record, and communicate mathematical ideas. | | | | |
| • select, apply, and translate among mathematical representations to solve problems. | | | | |
| • use representations to model and interpret physical, social, and mathematical phenomena. | ● | | | ● |

[1]National Council of Teachers of Mathematics (NCTM) ***Principles and Standards for School Mathematics***.

# National Healthcare Foundation Standards and Accountability Criteria in Medical Interventions

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>x denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| **Foundation Standard 1: Academic Foundation**<br>Healthcare professionals will know the academic subject matter required for proficiency within their area. They will use this knowledge as needed in their role. The following accountability criteria are considered essential for students in a health science program of study. | | | | |
| **1.1 Human Structure and Function** | | | | |
| 1.11 Classify basic structural and functional organization of the human body (tissue, organ, and system). | x | ✓ | x | x |
| 1.12 Recognize body planes, directional terms, quadrants, and cavities. | | | | |
| 1.13 Analyze basic structure and function of the human body. | x | ✓ | x | x |
| **1.2 Diseases and Disorders** | | | | |
| 1.21 Describe common diseases and disorders of each body system (prevention, pathology, diagnosis, and treatment). | ✓ | ✓ | ✓ | x |
| 1.22 Recognize emerging diseases and disorders. | x | ● | ● | ● |
| 1.23 Investigate biomedical therapies as they relate to prevention, pathology, and treatment of disease. | ✓ | ✓ | ✓ | ✓ |
| **1.3 Medical Mathematics** | | | | |
| 1.31 Apply mathematical computations related to healthcare procedures (metric and household, conversions and measurements). | x | | x | ● |
| 1.32 Analyze diagrams, charts, graphs, and tables to interpret healthcare results. | x | x | x | x |
| 1.33 Record time using 24-hour clock. | | | | |
| **Foundation Standard 2: Communications**<br>Healthcare professionals will know the various methods of giving and obtaining information. They will communicate effectively, both orally and in writing. | | | | |
| **2.1 Concepts of Effective Communication** | | | | |
| 2.11 Interpret verbal and nonverbal communication. | x | ✓ | ✓ | x |
| 2.12 Recognize barriers to communication. | ● | ● | ● | ● |

| **Key:**<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| 2.13 Report subjective and objective information. | **x** | ✓ | ● | **x** |
| 2.14 Recognize the elements of communication using a sender-receiver model. | | | | |
| 2.15 Apply speaking and active listening skills. | ✓ | ✓ | ✓ | ✓ |
| **2.2 Medical Terminology** | | | | |
| 2.21 Use roots, prefixes, and suffixes to communicate information. | **x** | **x** | ● | ● |
| 2.22 Use medical abbreviations to communicate information. | | | | |
| **2.3 Written Communication Skills** | | | | |
| 2.31 Recognize elements of written and electronic communication (spelling, grammar, and formatting). | **x** | ✓ | ✓ | **x** |
| **Foundation Standard 3: Systems** Healthcare professionals will understand how their role fits into their department, their organization and the overall healthcare environment. They will identify how key systems affect services they perform and quality of care. | | | | |
| **3.1 Healthcare Delivery Systems** | | | | |
| 3.11 Understand healthcare delivery system (public, private, government, and non-profit). | | | | |
| 3.12 Explain factors influencing healthcare delivery systems. | | | | |
| 3.13 Describe responsibilities of consumers within the healthcare system. | ● | ● | ● | ● |
| 3.14 Explain the impact of emerging issues such as technology, epidemiology, bioethics, and socioeconomics on healthcare delivery systems. | **x** | ● | ● | ● |
| 3.15 Discuss common methods of payment for healthcare. | | | | |
| **Foundation Standard 4: Employability Skills** Healthcare professionals will understand how employability skills enhance their employment opportunities and job satisfaction. They will demonstrate key employability skills and will maintain and upgrade skills, as needed. | | | | |
| **4.1 Personal Traits of the Healthcare Professional** | | | | |
| 4.11 Classify personal traits or attitudes desirable in a member of the healthcare team. | ● | ● | ● | ● |
| 4.12 Summarize professional standards as they apply to hygiene, dress, language, confidentiality and behavior. | | | | |
| **4.2 Employability Skills** | | | | |
| 4.21 Apply employability skills in healthcare. | ● | ● | ● | ● |
| **4.3 Career Decision-making** | | | | |
| 4.31 Discuss levels of education, credentialing requirements, and employment trends in healthcare. | **x** | **x** | **x** | **x** |
| 4.32 Compare careers within the health science career pathways (diagnostic services, therapeutic services, health informatics, support services, or biotechnology research and development). | **x** | ✓ | **x** | **x** |
| **4.4. Employability Preparation** | | | | |

| Key:<br>✓ denotes a direct correlation in ideas and concepts between the standard and all lessons in the unit<br>**x** denotes a direct correlation in ideas and concepts between the standard and some lessons in the unit<br>● denotes an idea or concept that is supported or implied in at least one lesson within the unit, although it is not directly addressed. | Unit 1—How to Fight Infection | Unit 2—How to Screen What Is In Your Genes | Unit 3—How to Conquer Cancer | Unit 4—How to Prevail When Organs Fail |
|---|---|---|---|---|
| 4.41 Develop components of a personal portfolio. | | | | |
| 4.42 Demonstrate process for obtaining employment. | | | | ● |
| **Foundation Standard 5: Legal Responsibilities**<br>Healthcare professionals will understand the legal responsibilities, limitations, and implications of their actions within the healthcare delivery setting. They will perform their duties according to regulations, policies, laws and legislated rights of clients. | | | | |
| **5.1 Legal Implications** | | | | |
| 5.11 Analyze legal responsibilities. | | | | |
| 5.12 Apply procedures for accurate documentation and record keeping. | ● | ● | ● | ● |
| **5.2 Legal Practices** | | | | |
| 5.21 Apply standards for Health Insurance Portability and Accountability Act (HIPAA). | | | | |
| 5.22 Describe advance directives. | | | | |
| 5.23 Summarize the Patient's Bill of Rights. | | | | |
| 5.24 Understand informed consent. | | | | |
| 5.25 Explain laws governing harassment, labor, and scope of practice. | | | | |
| **Foundation Standard 6: Ethics**<br>Healthcare professionals will understand accepted ethical practices with respect to cultural, social, and ethnic differences within the healthcare environment. They will perform quality healthcare delivery. | | | | |
| **6.1 Ethical Boundaries** | | | | |
| 6.11 Differentiate between ethical and legal issues impacting healthcare. | | | | |
| 6.12 Recognize ethical issues and their implications related to healthcare. | ● | ● | ● | ● |
| **6.2 Ethical Practice** | | | | |
| 6.21 Apply procedures for reporting activities and behaviors that affect the health, safety, and welfare of others. | ● | | ● | |
| **6.3 Cultural, Social, and Ethnic Diversity** | | | | |
| 6.31 Understand religious and cultural values as they impact healthcare. | ● | ● | ● | ● |
| 6.32 Demonstrate respectful and empathetic treatment of ALL patients/clients (customer service). | | | | |
| **Foundation Standard 7: Safety Practices**<br>Healthcare professionals will understand the existing and potential hazards to clients, co-workers, and self. They will prevent injury or illness through safe work practices and follow health and safety policies and procedures. | | | | |
| **7.1 Infection Control** | | | | |
| 7.11 Explain principles of infection control. | **x** | | | **x** |
| 7.12 Describe methods for controlling the spread and growth of microorganisms. | **x** | | | **x** |
| **7.2 Personal Safety** | | | | |
| 7.21 Apply personal safety procedures based on Occupational Safety and Health Administration (OSHA) and Centers for Disease Control (CDC) | ● | ● | ● | ● |

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|---|---|---|---|---|
| regulations. | | | | |
| 7.22 Apply principles of body mechanics. | | | ● | |
| **7.3 Environmental Safety** | | | | |
| 7.31 Apply safety techniques in the work environment. | **x** | **x** | **x** | **x** |
| **7.4 Common Safety Hazards** | | | | |
| 7.41 Comply with safety signs, symbols, and labels. | | | | |
| 7.42 Understand implications of hazardous materials. | ● | | | ● |
| **7.5 Emergency Procedures and Protocols** | | | | |
| 7.51 Practice fire safety in a healthcare setting. | | | | |
| 7.52 Apply principles of basic emergency response in natural disasters and other emergencies. | | | | |
| **Foundation Standard 8: Teamwork**<br>Healthcare professionals will understand the roles and responsibilities of individual members as part of the healthcare team, including their ability to promote the delivery of quality healthcare. They will interact effectively and sensitively with all members of the healthcare team. | | | | |
| **8.1 Healthcare Teams** | | | | |
| 8.11 Understand roles and responsibilities of team members. | ● | ● | ● | ● |
| 8.12 Recognize characteristics of effective teams. | ● | ● | ● | ● |
| **8.2 Team Member Participation** | | | | |
| 8.21 Recognize methods for building positive team relationships. | **x** | ✓ | **x** | ✓ |
| 8.22 Analyze attributes and attitudes of an effective leader. | ● | ● | ● | ● |
| 8.23 Apply effective techniques for managing team conflict. | **x** | ✓ | **x** | ✓ |
| **Foundation Standard 9: Health Maintenance Practices**<br>Healthcare professionals will understand the fundamentals of wellness and the prevention of disease processes. They will practice preventive health behaviors among the clients. | | | | |
| **9.1 Healthy Behaviors** | | | | |
| 9.11 Apply behaviors that promote health and wellness. | **x** | ● | ● | ● |
| 9.12 Describe strategies for the prevention of diseases including health screenings and examinations. | **x** | **x** | ● | ● |
| 9.13 Discuss complementary (alternative) health practices as they relate to wellness and disease prevention. | | | | |
| ***Foundation Standard 10: Technical Skills**<br>Healthcare professionals will apply technical skills required for all career specialties. They will demonstrate skills and knowledge as appropriate<br>*Additional technical skills may be included in a program of study based on career specialties | | | | |
| **10.1 Technical Skills** | | | | |
| 10.11 Apply procedures for measuring and recording vital signs, including | | | ● | |

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|---|---|---|---|---|
| the normal ranges. | | | | |
| 10.12 Apply skills to obtain training or certification in cardiopulmonary resuscitation (CPR), automated external defibrillator (AED), foreign body airway obstruction (FBAO), and first aid. | | | | |
| **Foundation Standard 11: Information Technology Applications** Healthcare professionals will use information technology applications required within all career specialties. They will demonstrate use as appropriate to healthcare applications. | | | | |
| **11.1 Health Information Management** | | | | |
| 11.11 Identify records and files common to the healthcare setting. | | | | |
| **11.2 Information Technology** | | | | |
| 11.21 Communicate using technology (fax, e-mail, and Internet) to access and distribute data and other information. | ✓ | ✓ | ✓ | ✓ |
| 11.22 Recognize technology applications in health care. | | | | |

[1] National Consortium on Health Science and Technology Education. **National Healthcare Foundation Standards and Accountability Criteria.**.

PROJECT LEAD THE WAY
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# BI

# Biomedical Innovation Course Description

In this capstone course, students apply their knowledge and skills to answer questions or solve problems related to the biomedical sciences. Students design innovative solutions for the health challenges of the $21^{st}$ century as they work through progressively challenging open-ended problems, addressing topics such as clinical medicine, physiology, biomedical engineering, and public health. They have the opportunity to work on an independent project and may work with a mentor or advisor from a university, hospital, physician's office, or industry. Throughout the course, students are expected to present their work to an adult audience that may include representatives from the local business and healthcare community.

# Biomedical Innovation Detailed Outline

## Problem One: Design of an Effective Emergency Room
## Time Days (24 Days)

**Concepts Addressed in Lesson:**

1. Biomedical innovation is vital to treating disease and disability and to prolonging life in the face of illness and injury.
2. Internet and print resources must be evaluated for accurate content and reliability.
3. Producing effective presentations of scientific material relies on accurate content, effective delivery, and if applicable, visuals that support the key points.
4. Innovations in healthcare and medicine can help reduce wait time and promote efficient care in emergency rooms and emergency care centers.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Brainstorm unique solutions to the health and medical problems of this century.
- Complete an Internet scavenger hunt to review research techniques, assessment of credible web resources, and proper documentation of sources.
- Use online search engines and journal databases to locate scientific articles.
- Analyze the format of a presentation and list weaknesses in design.
- Compile a resource sheet listing tips for the creation and delivery of effective oral and visual presentations.
- Design an innovative emergency medicine delivery system.
- Diagnose a fictitious patient and demonstrate movement of this patient through an emergency room.
- Produce a Gantt chart to manage the work of the emergency design project.
- Present an innovative ER design to the class in a formal presentation.

## Problem Two: Exploring Human Physiology
## Time Days (23 Days)

**Concepts Addressed in Lesson:**

1. A variety of research study designs can be used to find answers to testable questions.
2. Statistics can be used inappropriately to manipulate data and/or mislead readers.
3. Research results presented in the popular media differ from research results presented in scientific literature.
4. Scientists use various statistical analysis methods to draw meaningful conclusions from experimental results.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Write a brief study design to investigate the association between an activity/treatment and disease pair.
- Investigate the various ways in which data can be manipulated.
- Present a short presentation to "sell" a fictitious product or medical intervention using at least three statistical fallacies.
- Critique science data presented in popular media and compare with science data presented in scientific journals.
- Complete statistical analysis for an assigned study.
- Design, conduct, and analyze an experimental study to find the answer to a question relating to one or multiple body systems.
- Create and present a poster presentation to display results of their experimental study.

## Problem Three: Design of a Medical Innovation
## Time Days (16 Days)

**Concepts Addressed in Lesson:**

1. The design process is a series of steps used to design a new product or system.
2. Research on what solutions currently exist for a problem must be completed before a new solution can be designed.
3. When designing a solution, all criteria need to be specified and all possible designs need to be explored.
4. Marketing is the process of introducing and promoting a product into the market.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Investigate the evolution of various biomedical products.
- Brainstorm ideas for a new biomedical product or for a way to improve an existing product.
- Research and compile information about their chosen problem and evaluate solutions of the past and present.
- Explore possible design solutions, select the best approach, and develop a design proposal.
- Create a model, prototype, or schematic for the chosen solution.
- Design a marketing plan to pitch their chosen solution to potential investors.

## Problem Four: Investigating Water Contamination
## Time Days (19 Days)

**Concepts Addressed in Lesson:**

1. Water contamination is a global health issue, although the type of contamination varies with the geographic region.
2. Water can be contaminated by a wide variety of chemicals and biological agents that have health implications for humans and animals.
3. Nonpoint source pollution is caused by runoff water picking up and carrying contaminants to locations far from the source of the contamination and is a major cause of water pollution.
4. Water can be tested for a wide variety of contaminants using specific assays.
5. The presence of coliform in water indicates contamination with human or animal fecal material.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use a variety of chemical assays to detect specific contaminants in water samples.
- Perform and analyze a culture assay to detect coliform in water.
- Isolate bacterial DNA from a spiked water sample, amplify the DNA using a polymerase chain reaction assay, and analyze the results by gel electrophoresis.
- Research and propose reasonable solutions to prevent or treat the water contamination described in a fictitious case study.
- Prepare a written or oral report of the action plan to prevent or treat the case study water.

- Use a variety of chemical assays to analyze local water samples for contamination.
- Determine potential hazards or sources of contamination of the local water source by using local and Internet resources to investigate the condition of the water delivery system and the physical and geographic conditions surrounding water source.
- Prepare a written report on the quality of the local water, potential sources of contamination, possible health risks, and an action plan to prevent or treat water contamination.

## Problem Five: Combating a Public Health Issue
## Time Days (18 Days)

**Concepts Addressed in Lesson:**

1. Epidemiologists or other public health investigators analyze patient symptoms, results of diagnostic tests, and other clues relevant to person, place, and time of the outbreak to successfully pinpoint the specific nature of the disease as well as a source.
2. Measures of association such as relative risk and the odds ratio describe the correlation between specific risk factors and the development of disease.
3. Public health intervention plans may include education efforts, screening and diagnosis, treatment, distribution of medication or vaccinations, and research.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Design an organizer to catalog and compare symptoms of patients in a suspected outbreak.
- Examine evidence documents to determine the source of a mystery infection.
- Calculate measures of risk used to demonstrate a possible association between a risk factor and a disease.
- Map local, national, and global health issues.
- Write a detailed grant proposal outlining an intervention plan for a particular disease, illness, or injury.
- Present and defend the proposed intervention plan to a professional audience.

## Problem Six: Molecular Biology in Action (Optional)
## Time Days (19 or 45 Days)

**Concepts Addressed in Lesson:**

1. Plasmids, circular rings of DNA, that are cut with restriction enzymes can be joined or ligated to DNA (from any species) that has been cut with the same enzyme. This new genetic information becomes part of the plasmid DNA and provides the code for a new protein.
2. Plasmids can be mapped or described in terms of the location of their restriction sites, sites that are recognized and cut by specific restriction enzymes.
3. The results of a ligation experiment can be gauged by restriction analysis of an extracted plasmid and subsequent visualization of resultant bands via electrophoresis.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Solve restriction enzyme action logic problems.
- Ligate DNA from two organisms to create a unique plasmid vector.
- Draw and label possible ligation products and describe digestion results of each product.
- Insert a new plasmid into bacterial cells through the process of bacterial transformation.
- Isolate the plasmid DNA from the bacterial cells and analyze the composition of the plasmid using restriction enzymes and gel electrophoresis.
- Analyze a gene sequence using bioinformatics tools and databases (optional).

## Problem Seven: Forensic Autopsy (Optional)
## Time Days (12 Days)

**Concepts Addressed in Lesson:**

1. External and internal investigations of the body during an autopsy allow forensic pathologists to determine the cause of death.
2. Size measurements and weights of organs are used in an autopsy to determine any abnormalities.
3. Whether cause of death is natural, accident, or homicide, the body leaves clues to tell the story of how a person died.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Examine a fetal pig using the same protocol as a human autopsy, including examination of the tissues, organs, systems, and body fluids.

- Fill in an autopsy report for a fetal pig, including all size measurements and weights.
- Create a fictitious death scenario and showcase the clues left behind in the body to tell the story of how the fictional person died through an autopsy report, medical history forms, and other documents of their choosing.
- Solve a mysterious death scenario.

## Problem Eight: Independent Project (Optional)
## Time Days (24+ Days)

**Concepts Addressed in Lesson:**

1. Biomedical sciences is a broad field and incorporates many fields of study including biology, molecular biology, genetics, anatomy, physiology, immunology, infectious diseases, medicine, and healthcare.
2. A long-term project requires planning in order to have the proper materials and to schedule the work to be completed in time.
3. Breaking a large project into many smaller tasks allows for modifications to be made as necessary and is a means to monitor progress towards completion of the project.

**Performance Objectives Addressed in Lesson:**
*It is expected that students will:*

- Use appropriate Internet search techniques to gather information about a topic from appropriate websites.
- Research a topic of their choice and develop a proposal for an independent project that adds to the knowledge base about the topic.
- Write a well-constructed project proposal that clearly articulates the purpose and plan for the project, and is free of grammar, spelling, or factual errors.
- Determine the necessary materials and supplies to complete the proposed project.
- Work with a teacher or mentor to establish a protocol, timeline, and a means to measure progress towards completing the project.
- Perform the work required to complete the project, including making a product, a written report, a portfolio, and an oral presentation.
- Demonstrate good time and project management skills by completing the approved project in the allotted time.
- Write a well-constructed final report that clearly informs the reader about why the project was chosen, what was done, and what conclusions were drawn by completing the project.

- Demonstrate an understanding of the elements of a good presentation, by giving an oral presentation about the project.