

Statewide Framework Document for: 149991

Engineering Essentials

Standards may be added to this document prior to submission but may not be removed from the framework to meet state credit equivalency requirements. Performance assessments may be developed at the local level. In order to earn state approval, performance assessments must be submitted within this framework. **This course is eligible for 1.0 credit laboratory science.**

The Washington State Science Standards performance expectations for high school blend core ideas (Disciplinary Core Ideas, or DCIs) with scientific and engineering practices (SEPs) and crosscutting concepts (CCCs) to support students in developing usable knowledge that can be applied across the science disciplines. These courses are to be taught in a [three-dimensional manner](#). The details about each performance expectation can be found at [Next Generation Science Standards](#).

School District Name		
Course Title: Engineering Essentials		Total Framework Hours: 180
CIP Code: 149991	<input checked="" type="checkbox"/> Exploratory <input type="checkbox"/> Preparatory	Date Last Modified: March 22, 2023
Career Cluster: STEM		Cluster Pathway: Engineering Technology
Course Summary: Students explore the work of engineers and their role in the design and development of solutions to real-world problems. The course introduces students to engineering concepts that are applicable across multiple engineering disciplines and empowers them to build technical skills through the use of a variety of engineering tools, such as geographic information systems (GIS), 3-D solid modeling software, and prototyping equipment. Students learn and apply the engineering design process to develop mechanical, electronic, process, and logistical solutions to relevant problems across a variety of industry sectors, including health care, public service, and product development and manufacturing.		
Eligible for Equivalent Credit in: Lab science		Total Number of Units: 4
Course Resources:		

Outline:

Units	Hours
Unit 1	45
lesson 1.1 Engineers and Engineering	10
lesson 1.2 Systems and the Engineering Design Process	5
lesson 1.3 Product Design	10
lesson 1.4 Natural Disaster Relief Center	20
Unit 2	40
lesson 2.1 Machines	10
lesson 2.2 Mechanical Motion	15
lesson 2.3 Mechanical Systems	15
Unit 3	45
lesson 3.1 Energy Conversion	15
lesson 3.2 Logic	20
lesson 3.3 Electromechanical Systems	10
Unit 4	50
lesson 4.1 Urban Design	10
lesson 4.2 Maps as Models	15
lesson 4.3 The Sustainable Urban Environment	15
lesson 4.4 A Better Place	10
Total	180

Unit 1: Inclined to Design**Total Learning Hours for Unit: 45****Unit Summary:**

Lesson 1.1: Students consider their perception of engineers and engineering. They learn brainstorming techniques, define mindset characteristics that are important to success in engineering, and identify their own personal traits that align with engineering. Using their personal engineering perspective, students reflect individually and within a team on global engineering challenges, choose a challenge that they feel is the most important challenge facing their generation, and gather evidence to make a persuasive presentation to convince an audience of its importance.

Lesson 1.2: Students are introduced to the concepts of systems and systems thinking as a mindset used to consider the interconnectedness of our world and the far-reaching impacts of engineering decisions. Students use geographic information systems to investigate natural and artificial systems to inform design decisions. Students also practice brainstorming techniques as they address ethical considerations related to systems thinking.

Lesson 1.3: Students explore a variety of ethical perspectives, then analyze a scientific experiment and learn to design experiments in order to gain specific knowledge and understanding. The lesson also introduces the concept of sustainability as students design and carry out an experiment related to sustainability, consider the impacts and trade-offs necessary in engineering decision-making, and discuss the ethical implications of those decisions.

Lesson 1.4: Students develop basic skills necessary to create maps and layers in a geographic information system in order to address the unit problem. Students work independently and as part of a team to apply the knowledge and skills developed throughout the unit to design a relief center system to serve a community devastated by a natural disaster.

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

Lesson 1.1:

- Demonstrate awareness of certifications and their relationship to career pathways and employability within the content area through a group presentation.
- Take on the role of various stakeholders and professionals to experience scientific problem solving and collaboratively develop solutions to real-world problems
- Work collaboratively on a team to design a product and solve a problem using a scientific method
- Document in detail the engineering design process used to solve a problem or design a product
- Develop a detailed and comprehensive design brief
- Brainstorm to generate creative ideas and potential solutions to a problem
- Carry out an investigation to compare alternate solutions and select the best solution path
- Evaluate a design solution with respect to design requirements

Lesson 1.2:

- Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a subsystem of a larger system

- Assess the sustainability of an engineering solution based on the impacts – within the system or interrelated systems – that result from implementation of the solution
- Use GIS technology to interpret spatial information, collect geocoded data, and identify patterns
- Construct and use maps to make engineering decisions
- Conduct a feasibility study for the location of a facility
- Create concept sketches (models?) to represent ideas
- Create hand-drawn and scaled technical drawings of simple objects

Lesson 1.3:

- Design an experimental protocol to investigate a phenomenon and gain knowledge
- Develop a test plan to compare alternate solutions
- Collect and analyze data to draw conclusions
- Accurately represent experimental data using proper visualization techniques and statistical models

Lesson 1.4:

- Apply project management tools – including a project schedule and collaborative tools – when designing and developing a solution
- Act as a project lead to solve an engineering problem
- Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a subsystem of a larger system
- Assess the sustainability of an engineering solution based on the impacts – within the system or interrelated systems – that result from implementation of the solution

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

Leadership activity embedded in curriculum and instruction. This includes the leadership skills that are being taught and assessed within the class for all students – and students learn 21st Century Skills by: researching career options in engineering fields. Assume shared responsibility for collaborative work, and value the individual contributions made by each team member when producing a group presentation. (3.B.3)

- Use technology as a tool to research, to organize, evaluate and communicate information to add to the High School & Beyond Plan. (6.A.1)
- Working creatively with others and using creative thinking and problem-solving skills to create working designs. (1.A.1, 1.B.2, 2.D.1, 10.B.1)
- Working positively to multi-task and managing time efficiently, and making judgments and decisions for project completion. (8.A.3)
- Make judgments that effectively analyze and evaluate evidence, arguments, claims and beliefs that lead to decisions.
- Reflect critically on learning experiences and processes.
- Solve different kinds of non-familiar problems in both conventional and innovative ways.

CTSO activities may be appropriate if all students, within the course, are taking part in the specific event.

Industry Standards and/or Competencies: Industry Standards and Competencies

International Technology Education Association

Standards for Technological Literacy

<https://www.iteea.org/File.aspx?id=67767&v=b26b7852>

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

J. The nature and development of technological knowledge and processes are functions of the setting.

Standard 2. Students will develop an understanding of the core concepts of technology.

W. Systems thinking applies logic and creativity with appropriate compromises in complex real-life problems.

Standard 3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

J. Technological progress promotes the advancement of science and mathematics.

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

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.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

Standard 8. Students will develop an understanding of the attributes of design.

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.

Standard 9. Students will develop an understanding of engineering design.

J. Engineering design is influenced by personal characteristics, such as creativity, resourcefulness, and the ability to visualize and think abstractly.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

- L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
- P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

Aligned Washington State Academic Standards

Science	HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.	
	HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	
	HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	
	HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.	
	<u>Computer Science</u>	
	Recommended	
	3B-AP-11: Evaluate algorithms in terms of their efficiency, correctness, and clarity.	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions	ETS1.B: Developing Possible Solutions	Stability and Feedback Stability and Change

Unit Summary:

Lesson 2.1: Students review simple and compound machines as they develop and use models to represent objects and systems. Students employ experimental design to inform development of a model that represents important aspects of a phenomenon and develop a protocol to test the function of a compound machine compared to design criteria. Finally, students work collaboratively using a design process to develop a mechanical device.

Lesson 2.2: This lesson begins by examining the importance of energy and electricity in our lives. Students view a video timeline of the impact of electricity on society and learn about how energy is converted to electricity and transferred to our homes and businesses – where it is transformed into other forms of energy for our use. Students examine local and global electrical usage and consider the ethical implications associated with energy sources and energy use. In addition, students are introduced to electrical circuits and various models used to represent electrical circuits, including physical models, schematics, and computer simulations. Students use technology to measure voltage, current, and resistance, and experiment to determine a mathematical model to represent the relationship among those quantities in a circuit.

Lesson 2.3: Students apply prior learning and technical skills, a design process, experimental design, systems thinking, and project management to design and test a mechanical solution to improve people's lives. In the process, students continue to improve their collaboration and communication skills.

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

Lesson 2.1:

- Develop models (including conceptual, graphical, mathematical, physical, and computer) and simulations to represent information, objects, electrical circuits, systems, and processes
- Identify the purpose and limitation of a given model.
- Use models to inform a design process and create solutions.
- Communicate scientific and technical information about Newton's second law, and the impact on systems.
- Design, build, and refine a device to convert one form of energy to another.
- Use Excel to calculate summary statistics, create histograms, and find trend lines

Lesson 2.2:

- Consider the impact of energy generation on the environment.
- Analyze different solutions for power production and the use of natural resources.
- Build a circuit physically and virtually.
- Measure circuit parameters.
- Use Excel or Google Sheets to calculate summary statistics, create histograms, and find trend lines.
- Collect, organize, and analyze data to help define a problem.
- Perform circuit calculations using Ohm's Law.

- Use data to determine cause and effect relationships.
- Design and build an electromechanical system.

Lesson 2.3:

- Solve a problem using an iterative engineering design process (the scientific method).
- Work collaboratively on a team to design a product or solve a problem.
- Document in detail the engineering design process used to solve a problem or design a product.
- Develop a detailed and comprehensive design brief.
- Brainstorm to generate creative ideas and potential solutions to a problem.
- Carry out a plan (an experiment) to compare alternate solutions and select the best solution path.
- Evaluate a design solution with respect to design requirements.
- Develop a test plan to compare alternate solutions.
- Collect and analyze data to draw conclusions.
- Accurately represent experimental data using proper visualization techniques and statistical models.

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

Leadership activity embedded in curriculum and instruction. This includes the leadership skills that are being taught and assessed within the class for all students – and students learn 21st Century Skills by:

- Documenting engineering failures as opportunities to implement innovations and using various types of reasoning. (1.C.1, 2.A.1)
- Working creatively with others and using creative thinking and problem-solving skills to create working designs. (1.A.1, 1.B.2, 2.D.1, 10.B.1)
- Make decisions when interpreting information and draw conclusions based on best analysis and judgment.
- Identify and ask significant questions that clarify various points of view and lead to problem solving.
- Manage time efficiently and use digital project management tools to complete a project by the given deadline. (6.A.2, 7.A.2, 8.A.3)

CTSO activities may be appropriate if all students, within the course, are taking part in the specific event.

Industry Standards and/or Competencies:

International Technology Education Association

Standards for Technological Literacy

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Standard 1. Students will develop an understanding of the characteristics and scope of technology.

J. The nature and development of technological knowledge and processes are functions of the setting.

Standard 2. Students will develop an understanding of the core concepts of technology.

X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.
EE. Management is the process of planning, organizing, and controlling work.

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

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.

Standard 8. Students will develop an understanding of the attributes of design.

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.

J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.

Standard 9. Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach.

Standard 11. Students will develop abilities to apply the design process.

O. Refine a design by using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.

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.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

N. Troubleshoot, analyze, and maintain systems to ensure safe and proper function and precision.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

- M. Energy resources can be renewable or nonrenewable.
 N. Power systems must have a source of energy, a process, and loads.

Aligned Washington State Academic Standards

Science	HS-PS2-1: Analyze data to support the claim that Newton’s second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions:	ETS1.B: Developing Possible Solutions: PS3.A: Definitions of Energy ETS1.A: Defining and Delimiting an Engineering Problem ETS1.B: Developing Possible Solutions: ETS1.C: Optimizing the Design Solution:	Influence of Science, Engineering, and Technology on Society and the Natural World: Energy and Matter:

Unit Summary:

Lesson 3.1: This lesson begins by examining the importance of energy and electricity in our lives. Students view a video timeline of the impact of electricity on society and learn about how energy is converted to electricity and transferred to our homes and businesses – where it is transformed into other forms of energy for our use. Students examine local and global electrical usage and consider the ethical implications associated with energy sources and energy use. In addition, students are introduced to electrical circuits and various models used to represent electrical circuits, including physical models, schematics, and computer simulations. Students use technology to measure voltage, current, and resistance, and experiment to determine a mathematical model to represent the relationship among those quantities in a circuit.

Lesson 3.2: Students gain knowledge and skills necessary to design and build circuits – starting with truth tables and logic expressions – used to represent the input and output of a logic gate, the basic building block of digital circuits. Students investigate how circuits work, learn to represent circuits with truth tables and logic expressions, and build physical models using integrated chips. Students also learn the basics of programming a microcontroller to electronically control products and devices through data collection, sensing, and actuation of physical components. Using a microcontroller to gather data from multiple sensors, students collaboratively design an input device that can be used later in the design of an electromechanical device.

Lesson 3.3: Students work in teams to develop a proof-of-concept design and prototype of an electromechanical system to perform specific functions. This problem provides opportunities for students to continue building skills in communication, collaboration, and ethical engineering practice.

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

Lesson 3.1:

- Consider the impact of energy generation on the environment.
- Analyze different solutions for power production and the use of natural resources.
- Build a circuit physically and virtually
- Measure circuit parameters
- Use Excel or Google Sheets to calculate summary statistics, create histograms, and find trend lines.
- Collect, organize, and analyze data to help define a problem.
- Perform circuit calculations using Ohm's Law.
- Use data to determine cause and effect relationships.
- Design and build an electromechanical system

Lesson 3.2:

- Apply problem decomposition skills to break problems and processes into manageable parts
- Use algorithms to create solutions with or without computer programs
- Formulate solutions that use automation and programming to solve a problem.
- Collect, organize, and analyze data to help define a problem

- Apply abstraction to generalize a problem and solutions
- Use data to inform decisions and make predictions
- Investigate and design a device that uses structure to perform a function or task.
- Practice team collaboration
- Develop team norms
- Provide peer review and feedback
- Apply project management tools – including a project schedule and collaborative tools – when designing and developing a solution
- Solve a problem using an iterative engineering design process
- Develop oral communication and presentation skills
- Document in detail the engineering design process used to solve a problem or design a product using technical writing skills
- Apply ethical reasoning

Lesson 3.3:

- Practice team collaboration
- Develop team norms
- Provide peer review and feedback
- Apply project management tools – including a project schedule and collaborative tools – when designing and developing a solution
- Solve a problem using an iterative engineering design process
- Develop oral communication and presentation skills
- Document in detail the engineering design process used to solve a problem or design a product using technical writing skills
- Apply ethical reasoning

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

Leadership activity embedded in curriculum and instruction. This includes the leadership skills that are being taught and assessed within the class for all students – and students learn 21st Century Skills by:

- Use digital tools to research and test designs and find creative solutions to the problem (6.A.2, 1.A.2)
- Working creatively with others and using creative thinking and problem-solving skills to create working designs. (1.A.1, 1.B.2, 2.D.1, 10.B.1)
- Students will research and present information on design and how this impacted the community. (6.A.1, 5.B.1, 11.B.1)
- Use digital challenges to arrive at creative solutions to programming tasks (1.A.3, 2.D.1)

CTSO activities may be appropriate if all students, within the course, are taking part in the specific event.

Industry Standards and/or Competencies:

International Technology Education Association

Standards for Technological Literacy

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Standard 1. Students will develop an understanding of the characteristics and scope of technology.

J. The nature and development of technological knowledge and processes are functions of the setting.

Standard 2. Students will develop an understanding of the core concepts of technology.

X. Systems, which are the building blocks of technology, are embedded within larger technological, social, and environmental systems.

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.

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

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.

Standard 8. Students will develop an understanding of the attributes of design.

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.

Standard 9. Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach.

Standard 11. Students will develop abilities to apply the design process.

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.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

- L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.
- P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

- J. Collect information and evaluate its quality.

Standard 16. Students will develop an understanding of and be able to select and use energy and power technologies.

- M. Energy resources can be renewable or nonrenewable.

- N. Power systems must have a source of energy, a process, and loads.

Aligned Washington State Academic Standards

Science

HS-PS3-3: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems

HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering

HE-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts

HE-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Computer Science

Recommended

3B-CS-02: Illustrate ways computing systems implement logic, input, and output through hardware components

3B-AP-21: Develop and use a series of test cases to verify that a program performs according to its design specifications.

3B-AP-22: Modify an existing program to add additional functionality and discuss intended and unintended implications

Environmental and Sustainability

Recommended

	ESE Standard 3: Sustainability and Civic Responsibility. Students develop and apply the knowledge, perspective, vision, skills, and habits of mind necessary to make personal and collective decisions and take actions that promote sustainability.	
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept
Constructing Explanations and Designing Solutions	PS3.A: Definitions of Energy PS3.D: Energy in Chemical Processes ETS1.A: Defining and Delimiting an Engineering Problem	Energy and Matter: Influence of Science, Engineering and Technology on Society and the Natural World

Unit Summary:

Lesson 4.1: Students predict global population growth and investigate impacts and challenges of population growth and urbanization. They investigate urban subsystems that allow high-density population centers to function and are introduced to the concept of urban planning. The ideas of risk and trade-offs in engineering design are discussed, and students consider risks and rewards related to potential solutions to urban infrastructure problems. In collaborative teams, students apply their learning as they design a city development plan and consider the environmental, social, and economic impacts of their design.

Lesson 4.2: This unit provides opportunities to investigate a variety of online geographic information system tools that support urban planning and engineering design (e.g., determining flood probabilities, locating traffic controls, conducting feasibility studies for new waste disposal facilities). Students practice geospatial data collection strategies and produce maps to model geospatial information.

Lesson 4.3: Students learn additional GIS development skills and use geographic information systems as a tool to consider sustainable solutions to modern challenges from a systems perspective. They use GIS technology to investigate population density and the ethical implications related to high versus low population density development. Students explore the UN Sustainable Development Goal of making cities inclusive, safe, resilient, and sustainable, then students create a map to help communicate the problem. Students further investigate a local sustainability issue (land cover resulting in increased stormwater runoff and erosion) and modify a previously created GIS map to include additional geospatial features. They use their maps to estimate impervious land cover and compare their model to published map data to assess its accuracy. Students design a method to reduce runoff and use an online mathematical model to predict the impact of their solution on the volume of stormwater runoff.

Lesson 4.4: Students have the opportunity to fully apply the engineering design process and prior learning related to systems thinking, modeling, and project management as they work in collaborative teams to develop a solution to improve the safety and well-being of the citizens of a local community. As part of the design process, teams reflect on the impact and ethical implications of their design decisions and solutions.

Performance Assessments: (Districts to complete for each unit)

Example assessments for this unit include:

Lesson 4.1:

- Solve a problem using an iterative engineering design process
- Work collaboratively on a team to design a product or solve a problem
- Document in detail the engineering design process used to solve a problem or design a product
- Develop a detailed and comprehensive design brief
- Brainstorm to generate creative ideas and potential solutions to a problem
- Carry out a plan to compare alternate solutions and select the best solution path
- Evaluate a design solution with respect to design requirements
- Consider engineering disciplines, including mechanical, electrical/electronics, industrial, and civil, as well as blended and sub-disciplines
- Apply global challenges and real-world engineering projects and research

Lesson 4.2:

- Use GIS technology to interpret spatial information, collect geocoded data, and identify patterns
- Construct and use maps to make engineering decisions
- Conduct a feasibility study for the location of a facility
- Design a story map to present GIS-informed design solutions

Lesson 4.3:

- Use GIS technology to interpret spatial information, collect geocoded data, and identify patterns
- Construct and use maps to make engineering decisions
- Conduct a feasibility study for the location of a facility
- Design a story map to present GIS-informed design solutions
- Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a subsystem of a larger system
- Assess the sustainability of an engineering solution based on the impacts – within the system or interrelated systems – that result from implementation of the solution

Lesson 4.4:

- Apply systems thinking to consider how an engineering problem and its solution may be thought of as containing subsystems and as being a subsystem of a larger system
- Assess the sustainability of an engineering solution based on the impacts – within the system or interrelated systems – that result from implementation of the solution
- Solve a problem using an iterative engineering design process
- Work collaboratively on a team to design a product or solve a problem
- Document in detail the engineering design process used to solve a problem or design a product
- Develop a detailed and comprehensive design brief
- Brainstorm to generate creative ideas and potential solutions to a problem
- Carry out a plan to compare alternate solutions and select the best solution path
- Evaluate a design solution with respect to design requirements
- Design an experimental protocol to investigate a phenomenon and gain knowledge
- Develop a test plan to compare alternate solutions
- Collect and analyze data to draw conclusions
- Accurately represent experimental data using proper visualization techniques and statistical models

Leadership Alignment: (Districts to complete for each unit)

Leadership alignment must include a unit specific project/activity that aligns with the 21st Century Leadership Skills.

Example:

Leadership activity embedded in curriculum and instruction. This includes the leadership skills that are being taught and assessed within the class for all students – and students learn 21st Century Skills by:

- Document and build increasingly complex designs keeping record of how different systems interact and affect the outcome (2.B.1, 2.C.5)
- Make judgments that effectively analyze and evaluate evidence, arguments, claims and beliefs that lead to decisions.
- Make decisions when interpreting information and draw conclusions based on best analysis and judgment.
- Identify and ask significant questions that clarify various points of view and lead to problem solving.

CTSO activities may be appropriate if all students, within the course, are taking part in the specific event.

Industry Standards and/or Competencies:

International Technology Education Association

Standards for Technological Literacy

<https://www.iteea.org/File.aspx?id=67767&v=b26b7852>

Standard 1. Students will develop an understanding of the characteristics and scope of technology.

J. The nature and development of technological knowledge and processes are functions of the setting.

Standard 2. Students will develop an understanding of the core concepts of technology.

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.

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.

EE. Management is the process of planning, organizing, and controlling work.

Standard 4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.

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.

Standard 5. Students will develop an understanding of the effects of technology on the environment.

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.

L. Decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment.

Standard 8. Students will develop an understanding of the attributes of design.

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.

K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.

Standard 9. Students will develop an understanding of engineering design.

K. A prototype is a working model used to test a design concept by making actual observations and necessary adjustments.

Standard 10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

L. Many technological problems require a multidisciplinary approach.

Standard 11. Students will develop abilities to apply the design process.

N. Identify criteria and constraints and determine how these will affect the design process.

Standard 12. Students will develop the abilities to use and maintain technological products and systems.

L. Document processes and procedures and communicate them to different audiences using appropriate oral and written techniques.

P. Use computers and calculators to access, retrieve, organize, process, maintain, interpret, and evaluate data and information in order to communicate.

Standard 13. Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

Standard 20. Students will develop an understanding of and be able to select and use construction technologies.

J. Infrastructure is the underlying base or basic framework of a system.

Aligned Washington State Academic Standards

Science	<p>HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.</p> <p>HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.</p> <p>HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity</p> <p>HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.</p> <p>HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.</p>
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	<p>HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p> <p>HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering</p> <p>HE-ETS1-3: Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts</p> <p>HE-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem</p> <p><u>Integrated Environmental and Stainability</u></p> <p>Recommended</p> <p>ESE Standard 1: Ecological, Social, and Economic Systems. Students develop knowledge of the interconnections and interdependency of ecological, social, and economic systems. They demonstrate understanding of how the health of these systems determines the sustainability of natural and human communities at local, regional, national, and global levels.</p> <p>ESE Standard 2: The Natural and Built Environment. Students engage in inquiry and systems thinking and use information gained through learning experiences in, about, and for the environment to understand the structure, components, and processes of natural and human-built environments.</p>		
Science and Engineering Practice	Disciplinary Core Idea	Crosscutting Concept	
Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking	ESS3.C: Human Impacts on Earth Systems ETS1.B: Developing Possible Solutions ESS2.D: Weather and Climate:	Stability and Change Systems and System Models	