Digital Electronics (DE)

Lesson 1.1

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Digital Electronics (DE)

Lesson 1.1

Common Core State Standards for Mathematics

N.RN.1 - The Real Number System

Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. For example, we define 51/3 to be the cube root of 5 because we want (51/3)3 = 5(1/3)3 to hold, so (51/3)3 must equal 5.

N.RN.2 - The Real Number System

Rewrite expressions involving radicals and rational exponents using the properties of exponents.

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context.

A.SSE.3 - Seeing Structure in Expressions

Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

Digital Electronics (DE)

Lesson 1.1

Next Generation Science Standards

HS.PS2.6 - Motion and Stability: Forces and Interactions

Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

HS.PS3.2 - Energy

Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as either motions of particles or energy stored in fields.

HS.PS3.3 - Energy

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

HS.ETS1.3 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Crosscutting Concepts - Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Digital Electronics (DE)

Lesson 1.1

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffusion is increasing rapidly.

1.9-12.L Students will develop an understanding of the characteristics and scope of technology.

L. Inventions and innovations are the results of the specific, goal-directed research.

1.9-12.M Students will develop an understanding of the characteristics and scope of technology.

M. Most development of technologies these days is driven by the profit motive and the market.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

4.9-12.J Students will develop an understanding of the cultural, social, economic, and political effects of technology.

J. Ethical considerations are important in the development, selection, and use of technologies.

5.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.

5.9-12.K Students will develop an understanding of the cultural, social, economic, and political effects of technology.

K. Humans devise technologies to reduce the negative consequences of other technologies.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

7.9-12.J Students will develop an understanding of the influence of technology on history.

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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

10.9-12.J Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

J. Technological problems must be researched before they can be solved.

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

16.9-12.K Students will develop an understanding of and be able to select and use energy and power technologies.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.L Students will develop an understanding of and be able to select and use information and communication technologies.

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

17.9-12.M Students will develop an understanding of and be able to select and use information and communication technologies.

M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.

17.9-12.O Students will develop an understanding of and be able to select and use information and communication technologies.

O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

17.9-12.Q Students will develop an understanding of and be able to select and use information and communication technologies.

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.

Digital Electronics (DE)

Lesson 1.2

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.W.10 - Writing

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 1.2

Common Core State Standards for Mathematics

N.RN.1 - The Real Number System

Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. For example, we define 51/3 to be the cube root of 5 because we want (51/3)3 = 5(1/3)3 to hold, so (51/3)3 must equal 5.

N.RN.2 - The Real Number System

Rewrite expressions involving radicals and rational exponents using the properties of exponents.

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context.

A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients.

A.SSE.2 - Seeing Structure in Expressions

Use the structure of an expression to identify ways to rewrite it. For example, see x4 – y4 as (x2)2 – (y2)2, thus recognizing it as a difference of squares that can be factored as (x2 – y2)(x2 + y2).

A.SSE.3 - Seeing Structure in Expressions

Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

A.APR.6 - Arithmetic with Polynomials and Rational Expressions

Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.

A.APR.7 - Arithmetic with Polynomials and Rational Expressions

(+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.

A.CED.1 - Creating Equations

Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

A.CED.3 - Creating Equations

Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or non-viable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints on combinations of different foods.

A.CED.4 - Creating Equations

Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

A.REI.1 - Reasoning with Equations and Inequalities

Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

A.REI.2 - Reasoning with Equations and Inequalities

Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.

A.REI.3 - Reasoning with Equations and Inequalities

Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

A.REI.5 - Reasoning with Equations and Inequalities

Prove that, given a system of two equations in two variables, replacing one equation by the sum of that equation and a multiple of the other produces a system with the same solutions.

F.IF.4 - Interpreting Functions

For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

F.IF.5 - Interpreting Functions

Relate the domain of a function to its graph and, where applicable, to the quantitative relationship it describes. For example, if the function h(n) gives the number of person-hours it takes to assemble n engines in a factory, then the positive integers would be an appropriate domain for the function.

F.IF.6 - Interpreting Functions

Calculate and interpret the average rate of change of a function (presented symbolically or as a table) over a specified interval. Estimate the rate of change from a graph.

F.BF.4 - Building Functions

Find inverse functions.

F.LE.1 - Linear, Quadratic, and Exponential Models

Distinguish between situations that can be modeled with linear functions and with exponential functions.

F.LE.1.b - Linear, Quadratic, and Exponential Models

Recognize situations in which one quantity changes at a constant rate per unit interval relative to another.

F.LE.2 - Linear, Quadratic, and Exponential Models

Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

Digital Electronics (DE)

Lesson 1.2

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.PS4.1 - Waves and their Applications in Technologies for Information Transfer

Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

HS.ETS1.3 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Observed patterns in nature guide organization and classification and prompt questions about relationships and causes underlying them.

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Scale, Proportion, and Quantity

In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.

Crosscutting Concepts - Scale, Proportion, and Quantity

Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).

Crosscutting Concepts - Systems and System Models

A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.

Crosscutting Concepts - Systems and System Models

When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 1.2

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

1.9-12.M Students will develop an understanding of the characteristics and scope of technology.

M. Most development of technologies these days is driven by the profit motive and the market.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

7.9-12.J Students will develop an understanding of the influence of technology on history.

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.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

10.9-12.J Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

J. Technological problems must be researched before they can be solved.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.6-8.H Students will develop an understanding of and be able to select and use energy and power technologies.

H. Power systems are used to drive and provide propulsion to other technological products and systems.

16.9-12.K Students will develop an understanding of and be able to select and use energy and power technologies.

K. Energy can be grouped into major forms: thermal, radiant, electrical, mechanical, chemical, nuclear, and others.

16.9-12.M 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.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.L Students will develop an understanding of and be able to select and use information and communication technologies.

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

17.9-12.M Students will develop an understanding of and be able to select and use information and communication technologies.

M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

17.9-12.Q Students will develop an understanding of and be able to select and use information and communication technologies.

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.

Digital Electronics (DE)

Lesson 2.1

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.W.10 - Writing

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.5 - Speaking and Listening

Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 2.1

Common Core State Standards for Mathematics

N.RN.1 - The Real Number System

Explain how the definition of the meaning of rational exponents follows from extending the properties of integer exponents to those values, allowing for a notation for radicals in terms of rational exponents. For example, we define 51/3 to be the cube root of 5 because we want (51/3)3 = 5(1/3)3 to hold, so (51/3)3 must equal 5.

N.RN.2 - The Real Number System

Rewrite expressions involving radicals and rational exponents using the properties of exponents.

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context.

A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients.

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

A.APR.2 - Arithmetic with Polynomials and Rational Expressions

Know and apply the Remainder theorem: For a polynomial p(x) and a number a, the remainder on division by x – a is p(a), so p(a) = 0 if and only if (x – a) is a factor of p(x).

A.APR.6 - Arithmetic with Polynomials and Rational Expressions

Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.

A.APR.7 - Arithmetic with Polynomials and Rational Expressions

(+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.

A.CED.4 - Creating Equations

Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.

A.REI.1 - Reasoning with Equations and Inequalities

Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

A.REI.2 - Reasoning with Equations and Inequalities

Solve simple rational and radical equations in one variable, and give examples showing how extraneous solutions may arise.

A.REI.3 - Reasoning with Equations and Inequalities

Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.

Digital Electronics (DE)

Lesson 2.1

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 2.1

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

1.9-12.M Students will develop an understanding of the characteristics and scope of technology.

M. Most development of technologies these days is driven by the profit motive and the market.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

13.9-12.K Students will develop the abilities to assess the impact of products and systems.

K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.L Students will develop an understanding of and be able to select and use information and communication technologies.

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

17.9-12.M Students will develop an understanding of and be able to select and use information and communication technologies.

M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.

17.9-12.N Students will develop an understanding of and be able to select and use information and communication technologies.

N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.

17.9-12.O Students will develop an understanding of and be able to select and use information and communication technologies.

O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

17.9-12.Q Students will develop an understanding of and be able to select and use information and communication technologies.

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.

Digital Electronics (DE)

Lesson 2.2

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.W.10 - Writing

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.5 - Speaking and Listening

Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 2.2

Common Core State Standards for Mathematics

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context.

A.SSE.1.a - Seeing Structure in Expressions

Interpret parts of an expression, such as terms, factors, and coefficients.

A.SSE.1.b - Seeing Structure in Expressions

Interpret complicated expressions by viewing one or more of their parts as a single entity. For example, interpret P(1+r)n as the product of P and a factor not depending on P.

A.SSE.2 - Seeing Structure in Expressions

Use the structure of an expression to identify ways to rewrite it. For example, see x4 – y4 as (x2)2 – (y2)2, thus recognizing it as a difference of squares that can be factored as (x2 – y2)(x2 + y2).

A.SSE.3 - Seeing Structure in Expressions

Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

A.APR.5 - Arithmetic with Polynomials and Rational Expressions

(+) Know and apply the Binomial theorem for the expansion of (x + y)n in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle. (The Binomial Theorem can be proved by mathematical induction or by a combinatorial argument.)

Digital Electronics (DE)

Lesson 2.2

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 2.2

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

1.9-12.M Students will develop an understanding of the characteristics and scope of technology.

M. Most development of technologies these days is driven by the profit motive and the market.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

11.9-12.R Students will develop the abilities to apply the 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.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.L Students will develop an understanding of and be able to select and use information and communication technologies.

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

17.9-12.M Students will develop an understanding of and be able to select and use information and communication technologies.

M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.

17.9-12.N Students will develop an understanding of and be able to select and use information and communication technologies.

N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.

17.9-12.O Students will develop an understanding of and be able to select and use information and communication technologies.

O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 2.3

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.W.10 - Writing

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.4 - Speaking and Listening

Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

AS.SL.5 - Speaking and Listening

Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 2.3

Common Core State Standards for Mathematics

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

A.APR.4 - Arithmetic with Polynomials and Rational Expressions

Prove polynomial identities and use them to describe numerical relationships. For example, the polynomial identity (x2 + y2)2 = (x2 – y2)2 + (2xy)2 can be used to generate Pythagorean triples.

A.APR.5 - Arithmetic with Polynomials and Rational Expressions

(+) Know and apply the Binomial theorem for the expansion of (x + y)n in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle. (The Binomial Theorem can be proved by mathematical induction or by a combinatorial argument.)

A.APR.6 - Arithmetic with Polynomials and Rational Expressions

Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.

A.APR.7 - Arithmetic with Polynomials and Rational Expressions

(+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.

A.CED.1 - Creating Equations

Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.

A.REI.1 - Reasoning with Equations and Inequalities

Explain each step in solving a simple equation as following from the equality of numbers asserted at the previous step, starting from the assumption that the original equation has a solution. Construct a viable argument to justify a solution method.

Digital Electronics (DE)

Lesson 2.3

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g., economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 2.3

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural,political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.L Students will develop an understanding of and be able to select and use information and communication technologies.

L. Information and communication technologies include the inputs, processes, and outputs associated with sending and receiving information.

17.9-12.M Students will develop an understanding of and be able to select and use information and communication technologies.

M. Information and communication systems allow information to be transferred from human to human, human to machine, machine to human, and machine to machine.

17.9-12.N Students will develop an understanding of and be able to select and use information and communication technologies.

N. Information and communication systems can be used to inform, persuade, entertain, control, manage, and educate.

17.9-12.O Students will develop an understanding of and be able to select and use information and communication technologies.

O. Communication systems are made up of source, encoder, transmitter, receiver, decoder, storage, retrieval, and destination.

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

17.9-12.Q Students will develop an understanding of and be able to select and use information and communication technologies.

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.

Digital Electronics (DE)

Lesson 2.4

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.SL.1 - Speaking and Listening

Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.5 - Speaking and Listening

Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

9-10.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

9-10.WHST.7 - Writing HS/S/T

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the

inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.WHST.1.e - Writing HS/S/T

Provide a concluding statement or section that follows from or supports the argument presented.

11-12.WHST.2 - Writing HS/S/T

Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

11-12.WHST.2.e - Writing HS/S/T

Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

11-12.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Digital Electronics (DE)

Lesson 2.4

Common Core State Standards for Mathematics

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

A.APR.4 - Arithmetic with Polynomials and Rational Expressions

Prove polynomial identities and use them to describe numerical relationships. For example, the polynomial identity (x2 + y2)2 = (x2 – y2)2 + (2xy)2 can be used to generate Pythagorean triples.

A.APR.5 - Arithmetic with Polynomials and Rational Expressions

(+) Know and apply the Binomial theorem for the expansion of (x + y)n in powers of x and y for a positive integer n, where x and y are any numbers, with coefficients determined for example by Pascal's Triangle. (The Binomial Theorem can be proved by mathematical induction or by a combinatorial argument.)

A.APR.6 - Arithmetic with Polynomials and Rational Expressions

Rewrite simple rational expressions in different forms; write a(x)/b(x) in the form q(x) + r(x)/b(x), where a(x), b(x), q(x), and r(x) are polynomials with the degree of r(x) less than the degree of b(x), using inspection, long division, or, for the more complicated examples, a computer algebra system.

A.APR.7 - Arithmetic with Polynomials and Rational Expressions

(+) Understand that rational expressions form a system analogous to the rational numbers, closed under addition, subtraction, multiplication, and division by a nonzero rational expression; add, subtract, multiply, and divide rational expressions.

Digital Electronics (DE)

Lesson 2.4

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 2.4

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

5.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. When new technologies are developed to reduce the use of resources, considerations of trade-offs are important.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

10.9-12.J Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

J. Technological problems must be researched before they can be solved.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

11.9-12.R Students will develop the abilities to apply the 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.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

13.9-12.K Students will develop the abilities to assess the impact of products and systems.

K. Synthesize data, analyze trends, and draw conclusions regarding the effect of technology on the individual, society, and environment.

13.9-12.L Students will develop the abilities to assess the impact of products and systems.

L. Use assessment techniques, such as trend analysis and experimentation, to make decisions about the future development of technology.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 3.1

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.W.10 - Writing

Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of tasks, purposes, and audiences.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 3.1

Common Core State Standards for Mathematics

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.1 - Seeing Structure in Expressions

Interpret expressions that represent a quantity in terms of its context.

Digital Electronics (DE)

Lesson 3.1

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible. - Communicate scientific and/or

technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 3.1

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 3.2

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Digital Electronics (DE)

Lesson 3.2

Common Core State Standards for Mathematics

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Digital Electronics (DE)

Lesson 3.2

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 3.2

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 3.3

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.W.9 - Writing

Draw evidence from literary or informational texts to support analysis, reflection, and research.

AS.SL.1 - Speaking and Listening

Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

AS.L.3 - Language

Apply knowledge of language to understand how language functions in different contexts, to make effective choices for meaning or style, and to comprehend more fully when reading or listening.

AS.L.4 - Language

Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.

AS.L.5 - Language

Demonstrate understanding of word relationships and nuances in word meanings.

AS.L.6 - Language

Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

9-10.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

9-10.WHST.7 - Writing HS/S/T

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.WHST.1.e - Writing HS/S/T

Provide a concluding statement or section that follows from or supports the argument presented.

11-12.WHST.2 - Writing HS/S/T

Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

11-12.WHST.2.e - Writing HS/S/T

Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

11-12.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Digital Electronics (DE)

Lesson 3.3

Common Core State Standards for Mathematics

N.Q.1 - Quantities

Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities

Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities

Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

A.SSE.3 - Seeing Structure in Expressions

Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.

A.APR.1 - Arithmetic with Polynomials and Rational Expressions

Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.

Digital Electronics (DE)

Lesson 3.3

Next Generation Science Standards

HS.PS3.3 - Energy

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

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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 - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles,empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.

Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 3.3

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

8.9-12.J Students will develop an understanding of the attributes of design.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 4.1

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.SL.1 - Speaking and Listening

Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

Digital Electronics (DE)

Lesson 4.1

Next Generation Science Standards

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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.

DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety , reliability , and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

Science and Engineering Practice - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 4.1

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.9-12.W 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.

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

2.9-12.Z Students will develop an understanding of the core concepts of technology.

Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

2.9-12.AA Students will develop an understanding of the core concepts of technology.

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.

2.9-12.BB Students will develop an understanding of the core concepts of technology.

BB. Optimization is an ongoing process or methodology of designing or making a product and is dependent on criteria and constraints.

2.9-12.CC Students will develop an understanding of the core concepts of technology.

CC. New technologies create new processes.

2.9-12.FF Students will develop an understanding of the core concepts of technology.

FF. Complex systems have many layers of controls and feedback loops to provide information.

3.9-12.J 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.

4.9-12.H Students will develop an understanding of the cultural, social, economic, and political effects of technology.

H. Changes caused by the use of technology can range from gradual to rapid and from subtle to obvious.

4.9-12.I 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.

7.9-12.G Students will develop an understanding of the influence of technology on history.

G. Most technological development has been evolutionary, the result of a series of refinements to a basic invention.

7.9-12.I Students will develop an understanding of the influence of technology on history.

I. Throughout history, technology has been a powerful force in reshaping the social, cultural, political, and economic landscape.

8.9-12.H 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.

8.9-12.I Students will develop an understanding of the attributes of design.

I. Design problems are seldom presented in a clearly defined form.

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

8.9-12.K Students will develop an understanding of the attributes of design.

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

9.9-12.I Students will develop an understanding of engineering design.

I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.

9.9-12.J 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.

9.9-12.K 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.

9.9-12.L Students will develop an understanding of engineering design.

L. The process of engineering design takes into account a number of factors.

10.9-12.J Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

J. Technological problems must be researched before they can be solved.

11.9-12.M Students will develop the abilities to apply the design process.

M. Identify the design problem to solve and decide whether or not to address it.

11.9-12.N Students will develop the abilities to apply the design process.

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

11.9-12.O Students will develop the 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.

11.9-12.P Students will develop the abilities to apply the design process.

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.

11.9-12.Q Students will develop the abilities to apply the design process.

Q. Develop and produce a product or system using a design process.

12.9-12.L 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.

12.9-12.M Students will develop the abilities to use and maintain technological products and systems.

M. Diagnose a system that is malfunctioning and use tools, materials, machines, and knowledge to repair it.

12.9-12.N Students will develop the abilities to use and maintain technological products and systems.

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

12.9-12.O Students will develop the abilities to use and maintain technological products and systems.

O. Operate systems so that they function in the way they were designed.

12.9-12.P Students will develop the abilities to use and maintain technological products and systems.

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

13.9-12.J Students will develop the abilities to assess the impact of products and systems.

J. Collect information and evaluate its quality.

16.9-12.N Students will develop an understanding of and be able to select and use energy and power technologies.

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

17.9-12.P Students will develop an understanding of and be able to select and use information and communication technologies.

P. There are many ways to communicate information, such as graphic and electronic means.

Digital Electronics (DE)

Lesson 4.2

Common Core State Standards for English Language Arts

AS.R.1 - Reading

Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.

AS.R.4 - Reading

Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.

AS.R.7 - Reading

Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.

AS.R.10 - Reading

Read and comprehend complex literary and informational texts independently and proficiently.

AS.W.2 - Writing

Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.

AS.W.3 - Writing

Write narratives to develop real or imagined experiences or events using effective technique, well-chosen details, and well-structured event sequences.

AS.W.4 - Writing

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

AS.W.6 - Writing

Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.

AS.SL.1 - Speaking and Listening

Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

AS.SL.2 - Speaking and Listening

Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.

AS.SL.6 - Speaking and Listening

Adapt speech to a variety of contexts and communicative tasks, demonstrating command of formal English when indicated or appropriate.

AS.L.1 - Language

Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

AS.L.2 - Language

Demonstrate command of the conventions of standard English capitalization, punctuation, and spelling when writing.

9-10.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

9-10.WHST.7 - Writing HS/S/T

Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

11-12.WHST.1.e - Writing HS/S/T

Provide a concluding statement or section that follows from or supports the argument presented.

11-12.WHST.2 - Writing HS/S/T

Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

11-12.WHST.2.e - Writing HS/S/T

Provide a concluding statement or section that follows from and supports the information or explanation provided (e.g., articulating implications or the significance of the topic).

11-12.WHST.4 - Writing HS/S/T

Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Digital Electronics (DE)

Lesson 4.2

Next Generation Science Standards

HS.ETS1.2 - Engineering Design

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 - Engineering Design

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 - Engineering Design

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.

DCI - ETS1.B - Engineering Design - Developing Possible Solutions

When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3)

Science and Engineering Practice - Asking questions and defining problems

Ask questions

- o that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.
- o that arise from examining models or a theory, to clarify and/or seek additional information and relationships.
- o to determine relationships, including quantitative relationships, between independent and dependent variables.
- o to clarify and refine a model, an explanation, or an engineering problem.

Science and Engineering Practice - Developing and Using Models

Develop a complex model that allows for manipulation and testing of a proposed process or system.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.

Science and Engineering Practice - Planning and Carrying Out Investigations

Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.

Science and Engineering Practice - Analyzing and Interpreting Data

Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.

Science and Engineering Practice - Using Mathematics and Computational Thinking

Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

Science and Engineering Practice - Constructing Explanations and Designing Solutions

Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.

Science and Engineering Practice - Engaging in Argument from Evidence

Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.

Science and Engineering Practice - Engaging in Argument from Evidence

Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).

Science and Engineering Practice - Obtaining, Evaluating, and Communicating Information

Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (i.e., orally, graphically, textually, mathematically).

Crosscutting Concepts - Patterns

Patterns of performance of designed systems can be analyzed and interpreted to reengineer and improve the system.

Crosscutting Concepts - Cause and Effect: Mechanism and Prediction

Systems can be designed to cause a desired effect.

Crosscutting Concepts - Systems and System Models

Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales.

Crosscutting Concepts - Structure and Function

Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.

Digital Electronics (DE)

Lesson 4.2

Standards for Technological Literacy

1.9-12.J 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.

1.9-12.K Students will develop an understanding of the characteristics and scope of technology.

K. The rate of technological development and diffsion is increasing rapidly.

2.6-8.M Students will develop an understanding of the core concepts of technology.

M. Technologies systems include input, processes, output, and at times, feedback.

2.6-8.O Students will develop an understanding of the core concepts of technology.

O. An open-loop system has no feedback path and requires human intervention, while a closed-loop system uses feedback.

2.6-8.P Students will develop an understanding of the core concepts of technology.

P. Technological systems can be connected to one another.

2.6-8.Q Students will develop an understanding of the core concepts of technology.

Q. Malfunctions of any part of a system may affect the function and quality of the system.

2.6-8.R Students will develop an understanding of the core concepts of technology.

R. Requirements are the parameters placed on the development of a product or system.

2.6-8.S Students will develop an understanding of the core concepts of technology.

S. Trade-off is a decision process recognizing the need for careful compromises among competing factors.

2.6-8.T Students will develop an understanding of the core concepts of technology.

T. Different technologies involve different sets of processes.

2.6-8.V Students will develop an understanding of the core concepts of technology.

V. Controls are mechanisms or particular steps that people perform using information about the system that causes systems to change.

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

2.9-12.X 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.

2.9-12.Y Students will develop an understanding of the core concepts of technology.

Y. The stability of a technological system is influenced by all of the components in the system, especially those in the feedback loop.

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Z. Selecting resources involves trade-offs between competing values, such as availability, cost, desirability, and waste.

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L. The process of engineering design takes into account a number of factors.

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L. Many technological problems require a multidisciplinary approach.

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