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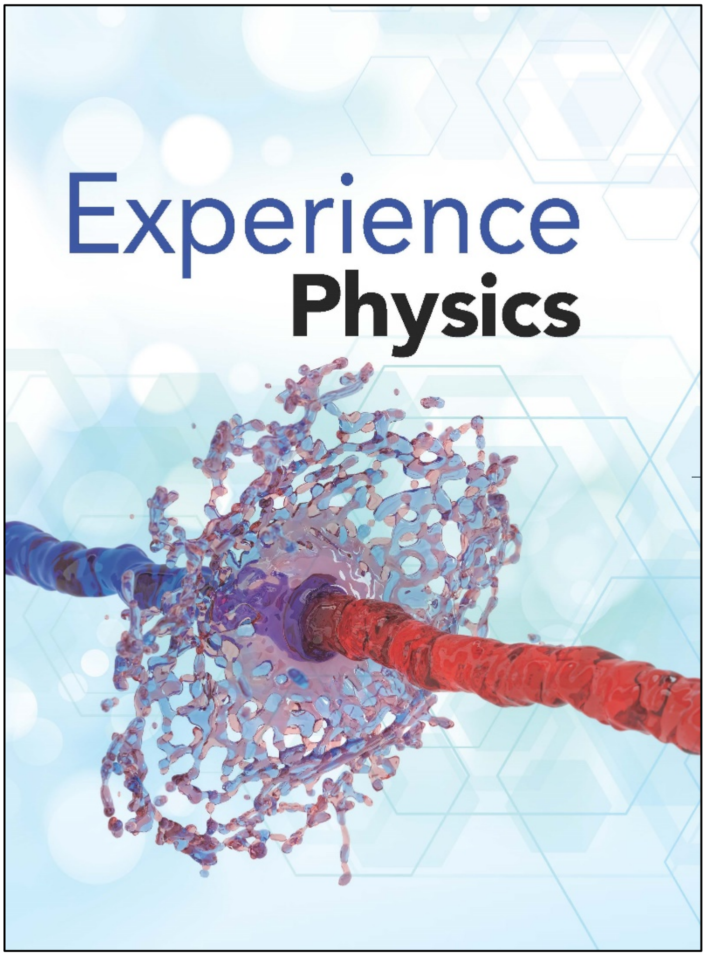

To the

Montgomery County, Maryland
Next Generation Science Curriculum
High School Physics

Prepared by Savvas Learning Company, formerly Pearson K12 Learning

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High School Physics

Introduction

This document demonstrates how ***Experience Physics* ©2022** supports the Montgomery County Next Generation Science Curriculum for High School Physics. Correlation references include the Experience Notebook, Teacher Guide, and online digital assets.

Savvas Learning Company is excited to introduce ***Experience Physics***!

Students best learn science when they *do* science! Therefore ***Experience Physics*** puts the focus on the student experience. This modern program implements a learning model that organizes learning around phenomena giving students an authentic, real-world experience. ***Experience Physics*** includes a variety of hands-on and digital activities designed to reach every learner, and partners with Flinn Scientific to deliver high-quality inquiry labs, engineering workbenches, and performance assessments.

Phenomenal Experiences Begin with a relevant and engaging phenomenon. Learning is organized around learning around phenomena, giving students an authentic, real-world experience. ***Experience Physics*** includes a variety of hands-on and digital activities designed to reach every learner, encouraging students to ask and answer questions, gather evidence, and organize their reasoning as they experience the concepts of physics firsthand.

Flinn Scientific Partnership Labs, Engineering Workbenches, dataset activities, and performance tasks enhance the student experience and encourage your class to do more science! Hands-on inquiry labs are available in open-ended, guided, shortened, and advanced versions, perfect for meeting the needs of every student.

Personalize Instruction The Teacher Guide allows instructors to personalize their course by selecting from our activities or embedding their own. Enhance instructional plan with Got More Time? Activities, or substitute with Related Phenomena when you want to make a change! Additionally, storyline and Investigation Planners use the 5E model to streamline your prep time.

Build Mathematical Fluency Stepped-out examples in the Experience Handbook break down sample problems for clarity and process guidance, while math tutorial videos reinforce mathematical processes. The Physics and Math Skills Workbook includes four pages of review and practice problems for every learning experience. These activities and more guide students as they become more proficient with math and physics concepts.

Savvas Realize™ Award-Winning Digital Platform Access all your digital content, virtual labs, simulations, assessments, and student data in ONE location. Savvas Realize has offline accessibility, so students can study from anywhere.

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Unit 1: Forces, Motion, and Interactions	
Performance Expectation HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	**Inquiry Lab:** Forces and Motion **Digital Activities:** Force, Mass, and Acceleration; Sliding Down **Performance-Based Assessment:** Force, Mass, and Acceleration
Disciplinary Core Ideas	
PS2.A: Forces and Motion	
Newton's second law accurately predicts changes in the motion of macroscopic objects.	**SE:** 54, 56, 58–59, 63, 73, 75, 80–81, 82, 87, 89
Science and Engineering Practices	
Analyzing and Interpreting Data	
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**SE:** 11–13, 15, 19–20, 22–23, 33–34, 38, 64, 66, 69 **Inquiry Labs:** Motion Plots, Free Fall Acceleration, Forces and Motion, The Buoyant Force, Friction, Model Projectile Motion **Digital Activities:** Acceleration, Fast Cars, Satellites in Circular Orbits, Types of Forces, Vehicle Stopping Distance, Coin Drop **Performance-Based Assessment:** Speed, Acceleration, and Trajectory
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.	**SE:** 7, 8, 11–12, 16–17, 26–27, 31, 35, 39, 40, 47, 48, 51, 52, 54, 57, 60, 64, 66, 67, 69, 70, 76, 78, 80–81, 83, 84–85, 90, 91, 92, 94 **Digital Activities:** Modeling Motion; Acceleration on a Ramp; Circular and Projectile Motion; Horizontal Motion of Falling Objects; Force, Mass, and Acceleration in Action; Pinball Launcher Model **Engineering Workbench:** Design an Airdrop System
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**SE:** 5, 48, 51, 52, 54, 70–71, 76, 78, 80, 94 **Inquiry Lab:** Model Projectile Motion **Digital Activities:** Forces, Forces on Systems, Atmospheric Pressure on a Sealed Container **Performance-Based Assessment:** Speed, Acceleration, and Trajectory

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Performance Expectation HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.	**SE:** 331, 332, 333, 335, 337, 338, 343, 345, 346 **Digital Activity:** Minimizing Car Crash Injuries
Disciplinary Core Ideas	
PS2.A: Forces and Motion	
Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.	**SE:** 322, 323, 326, 329
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**SE:** 336–337, 338–339, 340, 341, 342–343, 345, 346, 347 **Digital Activity:** Minimizing Car Crash Injuries **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical representations of phenomena to describe explanations.	**SE:** 323, 324, 327, 328, 329, 332, 335, 336–337, 340, 341, 343, 345, 346, 347 **Inquiry Labs:** Momentum and Impulse During Collisions, Elastic and Inelastic Collisions **Digital Activities:** Momentum and Impulse, Momentum and Baseball, Minimizing Car Crash Injuries **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
Crosscutting Concepts	
Systems and System Models	
When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	**SE:** 324, 326, 330, 338–339, 342–343 **Digital Activities:** Momentum and Baseball, Kinetic Energy and Collisions **Engineering Workbench:** Egg Supply Drop

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Performance Expectation HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.	**SE:** 347 **Digital Activity:** Minimizing Car Crash Injuries **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
Disciplinary Core Ideas	
PS2.A: Forces and Motion	
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system.	**SE:** 336–337, 338–339, 340, 341, 342–343, 345, 346, 347
ETS1.A: Defining and Delimiting Engineering Problems	
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**Digital Activity:** Minimizing Car Crash Injuries **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
ETS1.C: Optimizing the Design Solution	
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**Digital Activity:** Minimizing Car Crash Injuries **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**SE:** 347 **Inquiry Labs:** Momentum and Impulse During Collisions, Elastic and Inelastic Collisions **Digital Activity:** Explosions, Kinetic Energy and Collisions **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle
Crosscutting Concepts	
Cause and Effect	
Systems can be designed to cause a desired effect.	**SE:** 327, 328, 331, 336–337 **Inquiry Lab:** Momentum and Impulse During Collisions **Digital Activities:** Momentum and Impulse, Momentum and Baseball, Minimizing Car Crash Injuries

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Performance Expectation HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	**SE:** 305, 311, 315, 318 **Performance-Based Assessment:** Energy Conversion
Disciplinary Core Ideas	
PS3.A Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 294–297, 299, 300–301, 302, 303, 305, 306, 308
PS3.B Conservation of Energy and Energy Transfer	
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**SE:** 289, 291, 292, 303, 305, 306, 309, 311, 312, 313, 315, 316–317, 318
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**SE:** 294–297, 299, 302, 303, 305, 306, 308, 312, 318 **Digital Activity:** Rocket Launch
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**SE:** 295–297, 299, 300–301, 303, 305, 306
The availability of energy limits what can occur in any system.	**SE:** 287, 288, 294, 299, 303, 305, 306, 307, 315, 318
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Create a computational model or simulation of a phenomenon, designed device, process, or system.	**SE:** 286, 287, 288, 291, 292, 296, 299, 301, 303, 305, 307, 308, 313, 315, 318 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy **Digital Activities:** Classifying Energy and Work, Hooke's Law and Elastic Potential Energy **Performance-Based Assessment:** Energy Conversion

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Crosscutting Concepts	
Systems and System Models	
Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	**SE:** 283, 285–286, 288, 295, 300, 303, 305, 306, 308, 310, 311, 318 **Inquiry Lab:** Gas Particles and Work **Digital Activities:** Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models, Conservation of Energy, Rocket Launch **Performance-Based Assessment:** Energy Conversion
Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
Science assumes the universe is a vast single system in which basic laws are consistent.	**SE:** 285–286, 288, 289, 294, 295, 302, 306, 308 **Inquiry Lab:** The Impact of Position on Energy **Digital Activities:** Energy, Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models

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Performance Expectation HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	**Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature **Performance-Based Assessment:** Heating Curve of Water
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 309, 310, 311, 312, 313, 377, 379 **Digital Activity:** Temperature
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**SE:** 310, 311, 374–375, 376 **Inquiry Lab:** Kinetic Energy
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**SE:** 306, 367, 369, 371–372, 377 **Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature
Science and Engineering Practices	
Developing and Using Models	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 380 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy in a Moving Cart, Conservation of Energy, Simple Harmonic Motion, Pendulum Decay, Gasoline Expansion

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Crosscutting Concepts	
Energy and Matter	
Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.	**SE:** 310, 365, 371, 380 **Inquiry Labs:** Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy, Conservation of Energy, Thermal Energy, Rocket Launch, Meltdown at the Pool, Temperature, Gasoline Expansion **Performance-Based Assessment:** Heating Curve of Water
Performance Expectation HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**Inquiry Labs:** Binary Logic, Converting Electrical Signals to Sound, Build a Battery, Electric Fields, Indirect Observation of the Atom, Cohesive Forces and Surface Tension, Electric Motors and Generators, Interference of Sound Waves **Digital Activity:** Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Landslide Prevention, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.C Optimizing the Design Solution	
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**SE:** 561 **Inquiry Labs:** Build a Battery, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Build a Flashlight Without Batteries, Design a Roller Coaster, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries, Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 45, 84, 94, 124, 164, 206, 212, 219, 232, 238, 393, 497, 528, 551 **Digital Activities:** Junkyard Electromagnet **Engineering Workbench:** Landslide Prevention, Defy Gravity, Earthquake-Resistant Structures, Design a Roller Coaster, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Performance Expectation HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	**Inquiry Labs**: Momentum and Impulse, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Landslide Prevention, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.B 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.	**SE:** 109, 452–453, 455–456, 457, 601–602 **Inquiry Labs:** Momentum and Impulse, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Electric Circuits, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Energy Sources: Costs and Benefits, Solar Panel Art, Rover, Landslide Prevention, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Send Messages with a Telegraph **Problem-Based Learning:** Electromagnetic Roller Coaster

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 49, 109, 269, 409, 434, 455, 459, 492, 541, 564 **Digital Activities:** Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor **Problem-Based Learning:** Electromagnetic Roller Coaster, A Mystery on Planet K
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 453, 545 **Digital Activities:** Vehicle Stopping Distance, Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs, Transistors and Integrated Circuits, Junkyard Electromagnet **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor

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Unit 2: Forces at a Distance and Energy Conservation	
Performance Expectation HS-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.	**SE:** 119, 120, 122, 128, 159, 160, 161, 173, 174, 175 **Inquiry Lab:** Electric Charges and Coulomb's Law
Disciplinary Core Ideas	
PS2.B Types of Interactions	
Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.	**SE:** 116–120, 156–162, 251, 252 **Inquiry Lab:** Electric Charges and Coulomb's Law **Performance-Based Assessment:** Build and Test and Electroscope
Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**SE:** 121, 122, 129–132, 171–180, 198-199, 200, 202, 203, 205, 207, 209, 211, 213–214, 216–217, 219, 220–222, 252, 255 **Inquiry Labs:** Magnetic Force and Separation Distance, Electromagnets and Magnetism, Induction of Electrical Current, Electric Fields
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical representations of phenomena to describe explanations.	**SE:** 119, 120, 128, 159, 160, 161, 173, 174, 175, 208, 209, 210, 214, 215, 218, 221, 223, 260, 261, 262 **Inquiry Labs:** Model Projectile Motion, Investigate Gravity Using Pendulums, Model the Orbital Motion of Planets, Electric Charges and Coulomb's Law, Cohesive Forces and Surface Tension
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
Theories and laws provide explanations in science. Laws are statements or descriptions of the relationships among observable phenomena.	**SE:** 175, 176, 179, 185–192 **Inquiry Labs:** Model the Orbital Motion of Planets, Kepler's Laws of Planetary Motion **Digital Activities:** Magnetic Forces, Generator Testing, Magnetism, Breaking Magnets, Magnetic Fields **Performance-Based Assessment:** Design an Airdrop System, Build and Test an Electroscope

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Crosscutting Concepts	
Patterns	
Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	**SE:** 137, 138, 152, 220, 247–248, 255 **Inquiry Lab:** Physical Properties of Solid Materials **Digital Activities:** Atoms and Atomic Structure, Forces Between Atoms, Geomagnetic Polarity Reversal, Breaking Magnets **Performance-Based Assessment:** Design an Airdrop System
Performance Expectation HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.	**Inquiry Labs:** Electromagnets and Magnetism, Induction of Electrical Current, Electric Motors and Generators **Digital Activities:** Generator Testing, Magnetic Fields, Inducing Current **Engineering Workbench:** Build a Flashlight Without Batteries **Performance-Based Assessment:** Build a DC Motor
Disciplinary Core Ideas	
PS2.B: Types of Interactions	
Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields.	**SE:** 199–200, 203–209, 211, 213–225, 230–237, 436–443 **Inquiry Lab:** Induction of Electrical Current **Digital Activities:** Magnetic Forces, Combining Magnetic Fields, Magnetic Fields, Magnetic Field in a Moving Wire, Inducing Current, Properties of Electric Motors **Engineering Workbench:** Build a Flashlight Without Batteries
PS3.A: Definitions of Energy	
“Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents.	**SE:** 219, 229–230, 237, 424, 435, 439, 442, 451 **Inquiry Lab:** Induction of Electrical Current **Engineering Workbench:** Build a Flashlight Without Batteries

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Science and Engineering Practices	
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.	**Inquiry Labs:** Electromagnets and Magnetism, Induction of Electrical Current, Electric Motors and Generators **Digital Activities:** Generator Testing, Magnetic Fields, Inducing Current **Engineering Workbench:** Build a Flashlight Without Batteries **Performance-Based Assessment:** Build a DC Motor
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**SE:** 229 **Inquiry Labs:** Electromagnets and Magnetism, Induction of Electrical Current, Electric Motors and Generators **Digital Activities:** Generator Testing, Magnetic Forces, Combining Magnetic Fields, Magnetic Fields, Inducing Current, Properties of Electric Motors **Performance-Based Assessment:** Build a DC Motor
Performance Expectation HS-PS2-6 Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*	**SE:** 270, 274, 275, 276 **Inquiry Lab:** Structures and Properties of Polymers **Digital Activity:** Properties of Materials **Performance-Based Assessment:** Structure-Property Relationships
Disciplinary Core Ideas	
PS1.A: Structure and Properties of Matter	
The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**SE:** 164–167, 168, 183, 185, 186–188, 243, 246, 247–248, 254, 256, 257, 264
PS2.B: Types of Interactions	
Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**SE:** 164–167, 168, 183, 185, 186–188, 247–248, 251, 252-253, 254, 256, 257, 259, 264, 274

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Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	
Communicate scientific and technical information (e.g., about the process of development and the design and performance of a proposed process or system) in multiple formats (including oral, graphical, textual and mathematical).	**SE:** 186, 257 **Inquiry Labs:** Indirect Observations of the Atom, Cohesive Forces and Surface Tension, Physical Properties of Solid Materials, Structures and Properties of Polymers, **Digital Activity:** Enantiomers **Engineering Workbench:** Earthquake-Resistant Structures **Performance-Based Assessment:** Structure-Property Relationships
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.	**SE:** 182, 194, 241, 253, 254, 257, 258, 259, 267, 269, 271, 272, 273, 275, 276 **Inquiry Labs:** Physical Properties of Solid Materials, Structures and Properties of Polymers **Digital Activities:** Forces in Materials, Properties of Materials, Atoms and Atomic Structure, Atomic Models, Soap Bubbles, Combining Materials, Structure and Function, Enantiomers, Polymer Models **Engineering Workbench:** Earthquake-Resistant Structures **Performance-Based Assessment:** Structure-Property Relationships
Performance Expectation HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	**SE:** 305, 311, 315, 318 **Performance-Based Assessment:** Energy Conversion
Disciplinary Core Ideas	
PS3.A Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 294–297, 299, 300–301, 302, 303, 305, 306, 308
PS3.B Conservation of Energy and Energy Transfer	
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**SE:** 289, 291, 292, 303, 305, 306, 309, 311, 312, 313, 315, 316–317, 318

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Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**SE:** 294–297, 299, 302, 303, 305, 306, 308, 312, 318 **Digital Activity:** Rocket Launch
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**SE:** 295–297, 299, 300–301, 303, 305, 306
The availability of energy limits what can occur in any system.	**SE:** 287, 288, 294, 299, 303, 305, 306, 307, 315, 318
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Create a computational model or simulation of a phenomenon, designed device, process, or system.	**SE:** 286, 287, 288, 291, 292, 296, 299, 301, 303, 305, 307, 308, 313, 315, 318 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy **Digital Activities:** Classifying Energy and Work, Hooke's Law and Elastic Potential Energy **Performance-Based Assessment:** Energy Conversion
Crosscutting Concepts	
Systems and System Models	
Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	**SE:** 283, 285–286, 288, 295, 300, 303, 305, 306, 308, 310, 311, 318 **Inquiry Lab:** Gas Particles and Work **Digital Activities:** Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models, Conservation of Energy, Rocket Launch **Performance-Based Assessment:** Energy Conversion
Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
Science assumes the universe is a vast single system in which basic laws are consistent.	**SE:** 285–286, 288, 289, 294, 295, 302, 306, 308 **Inquiry Lab:** The Impact of Position on Energy **Digital Activities:** Energy, Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models

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Performance Expectation HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	**Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature **Performance-Based Assessment:** Heating Curve of Water
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 309, 310, 311, 312, 313, 377, 379 **Digital Activity:** Temperature
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**SE:** 310, 311, 374–375, 376 **Inquiry Lab:** Kinetic Energy
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**SE:** 306, 367, 369, 371–372, 377 **Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature
Science and Engineering Practices	
Developing and Using Models	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 380 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy in a Moving Cart, Conservation of Energy, Simple Harmonic Motion, Pendulum Decay, Gasoline Expansion

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Crosscutting Concepts	
Energy and Matter	
Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.	**SE:** 310, 365, 371, 380 **Inquiry Labs:** Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy, Conservation of Energy, Thermal Energy, Rocket Launch, Meltdown at the Pool, Temperature, Gasoline Expansion **Performance-Based Assessment:** Heating Curve of Water
Performance Expectation HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	**Inquiry Labs:** Build a Battery, Electric Motors and Generators **Engineering Workbench:** Design a Roller Coaster **Performance-Based Assessment:** Design, Build, and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
PS3.A Definitions of Energy	
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**SE:** 411, 412, 422, 426, 442
PS3.D Energy in Chemical Processes and Everyday Life	
Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**SE:** 422, 423, 427, 428, 429, 433, 442 **Digital Activity:** Junkyard Electromagnet
ETS1.A Defining and Delimiting Engineering Problems	
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**SE:** 492 **Inquiry Lab:** Build a Battery **Digital Activity:** Junkyard Electromagnet **Engineering Workbench:** Energy Sources: Costs and Benefits **Performance-Based Assessment:** Design, Build, and Refine a Wind-Turbine Rotor

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Science and Engineering Practices	
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.	**SE:** 409, 425, 426, 434, 436, 439, 444, 486, 492 **Inquiry Labs:** Build a Battery, Energy Transmission in Circuits, Electric Motors and Generators **Digital Activities:** Electromagnetic Energy, Junkyard Electromagnet, Potential Difference in a Battery, Series and Parallel Circuits, Properties of Electric Motors **Engineering Workbench:** Energy Sources: Costs and Benefits **Performance-Based Assessment:** Design, Build, and Refine a Wind-Turbine Rotor
Crosscutting Concepts	
Energy and Matter	
Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	**SE:** 411, 422, 423, 430, 434, 437, 444, 479, 485, 486, 487, 488, 490–491 **Inquiry Lab:** Build a Battery **Digital Activity:** Power Generation
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**SE:** 421, 422, 423, 424–425, 426, 427, 428, 430, 431, 434, 435, 437, 436, 439, 441, 442, 443, 444, 484, 485, 486, 489 **Inquiry Labs:** Build a Battery, Energy Transmission in Circuits, Electric Motors and Generators **Digital Activities:** Electromagnetic Energy, Junkyard Electromagnet, Electric Potential, Potential Difference in a Battery, Energy in Electric Circuits, Electric Circuits, Series and Parallel Circuits, Power Generation **Engineering Workbench:** Energy Sources: Costs and Benefits **Performance-Based Assessment:** Design a Roller Coaster; Design, Build, and Refine a Wind-Turbine Rotor

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Performance Expectation HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.	**Inquiry Lab:** Magnetic Force and Separation Distance **Digital Activity:** Junkyard Electromagnet **Performance-Based Assessment:** Build and Test an Electroscope
Disciplinary Core Ideas	
PS3.C: Relationship Between Energy and Forces	
When two objects interacting through a field change relative position, the energy stored in the field is changed.	**SE:** 171, 178, 203, 205, 206, 207, 213–214, 224-225, 410–419, 436–439, 443
Science and Engineering Practices	
Developing and Using Models	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 202, 203, 204, 205, 212, 213, 216, 217, 220, 222, 224, 226, 411, 416, 418, 420, 424, 425, 437, 439, 444 **Inquiry Labs:** Electric Motors and Generators, Magnetic Force and Separation Distance, **Digital Activities:** Electromagnetic Energy, Energy in Electric Circuits, Series and Parallel Circuits, Power Generation, Properties of Electric Motors, Magnetic Forces, Magnetism, Geomagnetic Polarity Reversal, Breaking Magnets, Magnetic Fields, Combining Magnetic Fields **Engineering Workbench:** Energy Sources: Costs and Benefits, Build a Flashlight Without Batteries **Performance-Based Assessment:** Build a DC Motor
Crosscutting Concepts	
Cause and Effect	
Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.	**SE:** 229, 409, 421, 435, 442 **Digital Activities:** Junkyard Electromagnet, Electric Potential, Potential Difference in a Battery, Energy in Electric Circuits, Electric Circuits, Magnetic Forces, Combining Magnetic Fields

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Performance Expectation HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**Inquiry Labs:** Converting Sunlight to Electricity, Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Earthquake-Resistant Structures **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation
Disciplinary Core Ideas	
ETS1.A Defining and Delimiting Engineering Problems	
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**SE:** 317 **Inquiry Lab:** Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Energy Sources: Costs and Benefits, Earthquake-Resistant Structures, Waves and Erosion, Landslide Prevention **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries **Problem-Based Learning:** Energy in Complex Machines, Staying Fit to Mars and Back, Ultraviolet Radiation
Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**SE:** 100, 103, 109, 274–275, 409, 445–446, 458–459, 465, 534-535, 599 **Inquiry Labs:** Converting Sunlight to Electricity, Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Energy Sources: Costs and Benefits, Energy Production **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Design a Roller Coaster **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation

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Science and Engineering Practices	
Asking Questions and Defining Problems	
Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**SE:** 49, 123, 528 **Digital Activity:** Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Send Messages with a Telegraph **Problem-Based Learning:** Energy in Complex Machines, Staying Fit to Mars and Back, Ultraviolet Radiation
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 447, 599 **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Send Messages with a Telegraph **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation

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Performance Expectation HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**Inquiry Labs:** Binary Logic, Converting Electrical Signals to Sound, Build a Battery, Electric Fields, Indirect Observation of the Atom, Cohesive Forces and Surface Tension, Electric Motors and Generators, Interference of Sound Waves **Digital Activity:** Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Landslide Prevention, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.C Optimizing the Design Solution	
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**SE:** 561 **Inquiry Labs:** Build a Battery, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Build a Flashlight Without Batteries, Design a Roller Coaster, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries, Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 45, 84, 94, 124, 164, 206, 212, 219, 232, 238, 393, 497, 528, 551 **Digital Activities:** Junkyard Electromagnet **Engineering Workbench:** Landslide Prevention, Defy Gravity, Earthquake-Resistant Structures, Design a Roller Coaster, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor

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Performance Expectation HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	**Inquiry Labs**: Momentum and Impulse, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Landslide Prevention, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.B 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.	**SE:** 109, 452–453, 455–456, 457, 601–602 **Inquiry Labs:** Momentum and Impulse, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Electric Circuits, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Energy Sources: Costs and Benefits, Solar Panel Art, Rover, Landslide Prevention, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Send Messages with a Telegraph **Problem-Based Learning:** Electromagnetic Roller Coaster

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 49, 109, 269, 409, 434, 455, 459, 492, 541, 564 **Digital Activities:** Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor **Problem-Based Learning:** Electromagnetic Roller Coaster, A Mystery on Planet K
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 453, 545 **Digital Activities:** Vehicle Stopping Distance, Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs, Transistors and Integrated Circuits, Junkyard Electromagnet **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor

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Performance Expectation HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	**Inquiry Lab:** Natural Resource Management **Digital Activities:** Generator Testing, Junkyard Electromagnet **Engineering Workbench:** Rover, Energy Sources: Costs and Benefits
Disciplinary Core Ideas	
ETS1.B Developing Possible Solutions	
Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**SE:** 121, 402, 403 **Inquiry Lab:** Natural Resource Management **Digital Activities:** Generator Testing, Junkyard Electromagnet **Engineering Workbench:** Rover, Energy Sources: Costs and Benefits
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**SE:** 38, 446, 448, 457, 504 **Digital Activities:** Vehicle Stopping Distance, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Rover, Defy Gravity, Design an Electronic Quiz Board, Design a Roller Coaster, Energy Production **Performance-Based Assessment:** Build and Test an Electroscope, Structure-Property Relationships, Energy Conversion
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.	**SE:** 319, 511, 524, 539 **Digital Activity:** Electric Circuits **Engineering Workbench:** Rover, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Design a Roller Coaster **Performance-Based Assessment:** Build and Test an Electroscope, Structure-Property Relationships

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Unit 3: Communities Facing Environmental Changes	
Performance Expectation HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	**SE:** 305, 311, 315, 318 **Performance-Based Assessment:** Energy Conversion
Disciplinary Core Ideas	
PS3.A Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 294–297, 299, 300–301, 302, 303, 305, 306, 308
PS3.B Conservation of Energy and Energy Transfer	
Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system.	**SE:** 289, 291, 292, 303, 305, 306, 309, 311, 312, 313, 315, 316–317, 318
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**SE:** 294–297, 299, 302, 303, 305, 306, 308, 312, 318 **Digital Activity:** Rocket Launch
Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior.	**SE:** 295–297, 299, 300–301, 303, 305, 306
The availability of energy limits what can occur in any system.	**SE:** 287, 288, 294, 299, 303, 305, 306, 307, 315, 318
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Create a computational model or simulation of a phenomenon, designed device, process, or system.	**SE:** 286, 287, 288, 291, 292, 296, 299, 301, 303, 305, 307, 308, 313, 315, 318 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy **Digital Activities:** Classifying Energy and Work, Hooke's Law and Elastic Potential Energy **Performance-Based Assessment:** Energy Conversion

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Crosscutting Concepts	
Systems and System Models	
Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.	**SE:** 283, 285–286, 288, 295, 300, 303, 305, 306, 308, 310, 311, 318 **Inquiry Lab:** Gas Particles and Work **Digital Activities:** Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models, Conservation of Energy, Rocket Launch **Performance-Based Assessment:** Energy Conversion
Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
Science assumes the universe is a vast single system in which basic laws are consistent.	**SE:** 285–286, 288, 289, 294, 295, 302, 306, 308 **Inquiry Lab:** The Impact of Position on Energy **Digital Activities:** Energy, Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models
Performance Expectation HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	**Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature **Performance-Based Assessment:** Heating Curve of Water
Disciplinary Core Ideas	
PS3.A: Definitions of Energy	
Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms.	**SE:** 309, 310, 311, 312, 313, 377, 379 **Digital Activity:** Temperature
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**SE:** 310, 311, 374–375, 376 **Inquiry Lab:** Kinetic Energy

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These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space.	**SE:** 306, 367, 369, 371–372, 377 **Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature
Science and Engineering Practices	
Developing and Using Models	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 380 **Inquiry Labs:** Gas Particles and Work, The Impact of Position on Energy, Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy in a Moving Cart, Conservation of Energy, Simple Harmonic Motion, Pendulum Decay, Gasoline Expansion
Crosscutting Concepts	
Energy and Matter	
Energy cannot be created or destroyed; it only moves between one place and another place, between objects and/or fields, or between systems.	**SE:** 310, 365, 371, 380 **Inquiry Labs:** Pendulums and the Conservation of Energy, Kinetic Energy **Digital Activities:** Energy, Conservation of Energy, Thermal Energy, Rocket Launch, Meltdown at the Pool, Temperature, Gasoline Expansion **Performance-Based Assessment:** Heating Curve of Water

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Performance Expectation HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	**Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug
Disciplinary Core Ideas	
PS3.B Conservation of Energy and Energy Transfer	
Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**SE:** 374–375, 376, 377, 378, 379, 380, 381, 382–383, 385, 386–387, 390–391, 392, 393
Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down).	**SE:** 381, 382–383, 384–385, 386, 393
PS3.D Energy in Chemical Processes and Everyday Life	
Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment.	**SE:** 386–387, 388–389, 390–391, 392, 393
Science and Engineering Practices	
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.	**SE:** 365 **Inquiry Labs:** Kinetic Energy, Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug
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.	**SE:** 385, 386, 388–389, 390–391, 392, 393 **Inquiry Lab:** Kinetic Energy **Digital Activities:** Thermal Equilibrium and Heat Flow, Why Metals Feel Cool **Engineering Workbench:** Build an Efficient Travel Mug

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Performance Expectation HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	**SE:** 467, 469, 471 **Inquiry Lab:** Mechanical Waves **Digital Activities:** Making Waves, Properties of Waves, Waves and Shallow Water
Disciplinary Core Ideas	
PS4.A: Wave Properties	
The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**SE:** 467–475, 477, 480–481, 485–487, 490, 491, 492 **Inquiry Lab:** Mechanical Waves **Digital Activity:** Properties of Waves
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**SE:** 467, 469, 470, 474, 477, 478, 481, 482, 483, 484, 487, 489, 490, 492, 499, 504, 505, 507 **Inquiry Labs:** Mechanical Waves, Interference of Sound Waves **Digital Activities:** Making Waves, Properties of Waves, Waves and Shallow Water **Performance-Based Assessment:** The Speed of Sound in Open Air
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**SE:** 469, 473, 475, 491, 498 **Inquiry Labs:** Mechanical Waves, Interference of Sound Waves, Reflection and Refraction **Digital Activities:** Waves, Making Waves, Properties of Waves, Wave Speed, Wave Behavior and Energy, Interference, Wave Optics, Refraction **Engineering Workbench:** Waves

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Performance Expectation HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.	**SE:** 630, 633, 634, 640, 641, 642, 645, 647, 649 **Inquiry Lab:** Plate Tectonics and Seafloor Spreading **Performance-Based Assessment:** Uranium-Lead Dating
Disciplinary Core Ideas	
ESS1.C: The History of Planet Earth	
Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.	**SE:** 629–630, 634, 636–637, 641–642, 644, 646
PS1.C: Nuclear Processes	
Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials.	**SE:** 610, 612–613, 618–619, 622–628 **Inquiry Lab:** Radiometric Dating of Rocks
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.	**SE:** 609, 623, 629, 630, 633, 635, 642, 645, 649, 650 **Inquiry Labs:** Half-Life Simulation, Radiometric Dating of Rocks **Digital Activity:** Radiometric Dating **Engineering Workbench:** Build a Glove Box
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.	**SE:** 625, 631, 633, 644 **Inquiry Labs:** Radiometric Dating of Rocks, Half-Life Simulation
Crosscutting Concepts	
Stability and Change	
Much of science deals with constructing explanations of how things change and how they remain stable.	**SE:** 612, 615, 618–619, 622–623, 627, 642, 644, 645 **Inquiry Lab:** Half-Life Simulation **Digital Activities:** Radioactive Decay, Radiometric Dating

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Performance Expectation HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	**Inquiry Labs:** Mechanical Weathering of Rock, Collisions at a Fault Line, Plate Tectonics and Seafloor Spreading **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**SE:** 95–109, 629, 636–642
ESS2.B: Plate Tectonics and Large-Scale System Interactions	
Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust.	**SE:** 95, 108, 348–361, 639–649
Science and Engineering Practices	
Developing and Using Models	
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 357, 358, 361, 642 **Inquiry Labs:** Mechanical Weathering of Rock, Collisions at a Fault Line, Plate Tectonics and Seafloor Spreading **Digital Activities:** Mountain Building, Plate Boundaries
Crosscutting Concepts	
Stability and Change	
Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**SE:** 98-99, 100, 636–639, 642 **Inquiry Lab:** Plate Tectonics and Seafloor Spreading **Digital Activity:** Seafloor Spreading
Performance Expectation HS-ESS2-2: Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.	**SE:** 95-96, 349-361, 636-637, 638-639, 640, 641-642, 643, 646-647, 648-649, 650-651 **Teacher Guide:** **Inquiry Labs:** Mechanical Weathering of Rock, Collisions at a Fault Line, Plate Tectonics and Seafloor Spreading **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading

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Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes	**SE:** 95-96, 97, 98-99, 636-637, 638-639, 640, 641-642, 643 **Teacher Guide:** **Inquiry Labs:** Mechanical Weathering of Rock, Collisions at a Fault Line, Plate Tectonics and Seafloor Spreading **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading
ESS2.B: Plate Tectonics and Large-Scale System Interactions:	
Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE)	**SE:** 95-96, 349-361, 638-639, 640, 641, 643-644 **Teacher Guide:** **Inquiry Lab:** Collisions at a Fault Line **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading
Science and Engineering Practices	
Developing and Using Models	
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 95-96, 349-361 **Teacher Guide:** **Inquiry Lab:** Collisions at a Fault Line **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading
Crosscutting Concepts	
Stability and Change	
Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**SE:** 95-96, 349-361, 636-637, 638-639, 640, 641-642, 643, 646-647, 648-649, 650-651 **Teacher Guide:** **Inquiry Labs:** Mechanical Weathering of Rock, Collisions at a Fault Line, Plate Tectonics and Seafloor Spreading **Digital Activities:** Mountain Building, Plate Boundaries, Seafloor Spreading

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Performance Expectation HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.	**SE:** 404 **Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activity:** Convection Currents
Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems	
Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.	**SE:** 394–405
ESS2.B: Plate Tectonics and Large-Scale System Interactions	
The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.	**SE:** 395, 399, 404
PS4.A: Wave Properties	
Geologists use seismic waves and their reflection at interfaces between layers to probe structures deep in the planet.	**SE:** 396, 403
Science and Engineering Practices	
Developing and Using Models	
Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**SE:** 395, 396, 400, 401, 402–405 **Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activities:** Convection Currents, Heat Flow Within Earth
Connections to Nature of Science: Scientific Knowledge is Based on Empirical Evidence	
Science knowledge is based on empirical evidence. Science disciplines share common rules of evidence used to evaluate explanations about natural systems. Science includes the process of coordinating patterns of evidence with current theory.	**SE:** 396–397, 403–405 **Digital Activity:** Heat Flow on Earth's Surfaces

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Performance Expectation HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	**Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activities:** Convection Currents, Heat Flow Within Earth, Heat Flow on Earth's Surfaces
Disciplinary Core Ideas	
ESS1.B: Earth and the Solar System: Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. (secondary)	For supporting content, please see: **SE:** 137, 655 **Digital Activities:** Heat Flow Within Earth, Heat Flow on Earth's Surfaces
ESS2.A: Earth Materials and System: The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.	**SE:** 137, 349-361, 636-649, 655 **Digital Activities:** Convection Currents, Heat Flow Within Earth, Heat Flow on Earth's Surfaces
ESS2.D: Weather and Climate: The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's reradiation into space.	**SE:** 655, 656-657 **Digital Activities:** Heat Flow Within Earth, Heat Flow on Earth's Surfaces
Science and Engineering Practices	
Developing and Using Models: Use a model to provide mechanistic accounts of phenomena.	**Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activities:** Convection Currents, Heat Flow Within Earth, Heat Flow on Earth's Surfaces
Scientific Knowledge is Based on Empirical Evidence: Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activities:** Convection Currents, Heat Flow Within Earth, Heat Flow on Earth's Surfaces
Crosscutting Concepts	
Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Inquiry Lab:** Convection, Conduction, and Radiation **Digital Activities:** Convection Currents, Heat Flow Within Earth, Heat Flow on Earth's Surfaces

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Performance Expectation HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	**Inquiry Labs:** Converting Sunlight to Electricity, Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Earthquake-Resistant Structures **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation
Disciplinary Core Ideas	
ETS1.A Defining and Delimiting Engineering Problems	
Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.	**SE:** 317 **Inquiry Lab:** Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Energy Sources: Costs and Benefits, Earthquake-Resistant Structures, Waves and Erosion, Landslide Prevention **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries **Problem-Based Learning:** Energy in Complex Machines, Staying Fit to Mars and Back, Ultraviolet Radiation
Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	**SE:** 100, 103, 109, 274–275, 409, 445–446, 458–459, 465, 534-535, 599 **Inquiry Labs:** Converting Sunlight to Electricity, Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Energy Sources: Costs and Benefits, Energy Production **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Design a Roller Coaster **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation

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Science and Engineering Practices	
Asking Questions and Defining Problems	
Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**SE:** 49, 123, 528 **Digital Activity:** Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Send Messages with a Telegraph **Problem-Based Learning:** Energy in Complex Machines, Staying Fit to Mars and Back, Ultraviolet Radiation
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 447, 599 **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Send Messages with a Telegraph **Problem-Based Learning:** Staying Fit to Mars and Back, Ultraviolet Radiation

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Performance Expectation HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	**Inquiry Labs:** Binary Logic, Converting Electrical Signals to Sound, Build a Battery, Electric Fields, Indirect Observation of the Atom, Cohesive Forces and Surface Tension, Electric Motors and Generators, Interference of Sound Waves **Digital Activity:** Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Landslide Prevention, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.C Optimizing the Design Solution	
Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**SE:** 561 **Inquiry Labs:** Build a Battery, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Design an Airdrop System, Egg Supply Drop, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Build a Flashlight Without Batteries, Design a Roller Coaster, Build an Efficient Travel Mug, The Colors of Light **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries, Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 45, 84, 94, 124, 164, 206, 212, 219, 232, 238, 393, 497, 528, 551 **Digital Activities:** Junkyard Electromagnet **Engineering Workbench:** Landslide Prevention, Defy Gravity, Earthquake-Resistant Structures, Design a Roller Coaster, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor

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Performance Expectation HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	**Inquiry Labs**: Momentum and Impulse, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Landslide Prevention, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.B 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.	**SE:** 109, 452–453, 455–456, 457, 601–602 **Inquiry Labs:** Momentum and Impulse, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Electric Circuits, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Energy Sources: Costs and Benefits, Solar Panel Art, Rover, Landslide Prevention, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Send Messages with a Telegraph **Problem-Based Learning:** Electromagnetic Roller Coaster

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Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 49, 109, 269, 409, 434, 455, 459, 492, 541, 564 **Digital Activities:** Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor **Problem-Based Learning:** Electromagnetic Roller Coaster, A Mystery on Planet K
Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 453, 545 **Digital Activities:** Vehicle Stopping Distance, Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs, Transistors and Integrated Circuits, Junkyard Electromagnet **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor

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Unit 4: Electromagnetic Energy and the Earth's Place in the Universe	
Performance Expectation HS-PS1-8 Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.	**SE:** 591, 592, 596, 598, 615, 619 **Teacher Guide:** **Inquiry Lab:** Subatomic Particles **Digital Activities:** Nuclear Physics, Fission and Fusion, Radioactive Decay **Performance-Based Assessment:** Model Nuclear Forces
Disciplinary Core Ideas	
PS1.C Nuclear Processes	
Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.	**SE:** 575, 584–592, 594–598, 603–604, 610–619
Science and Engineering Practices	
Developing and Using Models	
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 571, 584, 591, 592, 593, 595, 596, 597, 598, 603, 614, 615, 616, 617, 619 **Teacher Guide:** **Inquiry Labs:** Subatomic Particles, Forces and Atomic Nuclei **Digital Activities:** Valley of Stability, Operate a Nuclear Fission Reactor, Nuclear Physics, Fission and Fusion, Radioactive Decay **Engineering Workbench:** Energy Production **Performance-Based Assessment:** Model Nuclear Forces
Crosscutting Concepts	
Energy and Matter	
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**SE:** 575, 584–586, 591, 593, 594–595, 601, 603, 604, 605, 606, 615, 617, 618 **Teacher Guide:** **Inquiry Labs:** Subatomic Particles

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Performance Expectation HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.	**SE:** 467, 469, 471 **Inquiry Lab:** Mechanical Waves **Digital Activities:** Making Waves, Properties of Waves, Waves and Shallow Water
Disciplinary Core Ideas	
PS4.A: Wave Properties	
The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing.	**SE:** 467–475, 477, 480–481, 485–487, 490, 491, 492 **Inquiry Lab:** Mechanical Waves **Digital Activity:** Properties of Waves
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**SE:** 467, 469, 470, 474, 477, 478, 481, 482, 483, 484, 487, 489, 490, 492, 499, 504, 505, 507 **Inquiry Labs:** Mechanical Waves, Interference of Sound Waves **Digital Activities:** Making Waves, Properties of Waves, Waves and Shallow Water **Performance-Based Assessment:** The Speed of Sound in Open Air
Crosscutting Concepts	
Cause and Effect	
Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**SE:** 469, 473, 475, 491, 498 **Inquiry Labs:** Mechanical Waves, Interference of Sound Waves, Reflection and Refraction **Digital Activities:** Waves, Making Waves, Properties of Waves, Wave Speed, Wave Behavior and Energy, Interference, Wave Optics, Refraction **Engineering Workbench:** Waves
Performance Expectation HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.	**SE:** 548 **Inquiry Lab:** Binary Logic **Digital Activity:** Music Storage for Home Recording **Performance-Based Assessment:** Send Messages with a Telegraph
Disciplinary Core Ideas	
PS4.A: Wave Properties	
Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**SE:** 542–547, 549–553, 554–555 **Digital Activity:** Music Storage for Home Recording **Engineering Workbench:** Rover

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Science and Engineering Practices	
Asking Questions and Defining Problems	
Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set or the suitability of a design.	**SE:** 547 **Inquiry Lab:** Binary Logic **Digital Activity:** Music Storage for Home Recording **Engineering Workbench:** Rover
Crosscutting Concepts	
Stability and Change	
Systems can be designed for greater or lesser stability.	**SE:** 547 **Digital Activity:** Music Storage for Home Recording **Performance-Based Assessment:** Send Messages with a Telegraph
Connections to Engineering, Technology, and Applications of Science: Influence of Engineering, Technology, and Science on Society and the Natural World	
Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	**SE:** 545, 549–554 **Digital Activities:** Music Storage for Home Recording, Transistors and Integrated Circuits **Performance-Based Assessment:** Send Messages with a Telegraph
Performance Expectation HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.	**SE:** 521, 523 **Inquiry Lab:** Particle Nature of Light **Digital Activities:** Particle-Wave Duality of Light, Particle-Wave Duality
Disciplinary Core Ideas	
PS4.A: Wave Properties	
Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other.	**SE:** 482–487, 494–495, 501–502 **Digital Activity:** Electromagnetic Waves and Their Properties
PS4.B: Electromagnetic Radiation	
Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features.	**SE:** 495–507, 512–518, 520–525 **Inquiry Lab:** Particle Nature of Light
Science and Engineering Practices	

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Engaging in Argument from Evidence	
Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**SE:** 489, 502, 508, 509, 513, 515, 516, 528 **Inquiry Labs:** Diffraction, Particle Nature of Light **Digital Activities:** Electromagnetic Radiation, Particle-Wave Duality of Light, Laser Interference, Particle-Wave Duality, Light Intensity and Energy
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment. The science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**SE:** 490, 491, 494, 498, 499, 502, 503, 519, 521, 522 **Digital Activities:** Electromagnetic Waves and Their Properties, Laser Interference, Particle-Wave Duality, Light Intensity and Energy
Crosscutting Concepts	
Systems and System Models	
Models (e.g., physical, mathematical, and computer models) can be used to simulate systems and interactions — including energy, matter and information flows — within and between systems at different scales.	**SE:** 482, 483, 491, 508, 511, 519, 511, 521, 522, 528 **Digital Activities:** Electromagnetic Waves and Their Properties, Particle-Wave Duality
Performance Expectation HS-PS4-4 Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.	**Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** Sunscreen and UV Protection **Performance-Based Assessment:** Clothing and Sun Protection
Disciplinary Core Ideas	
PS4.B: Electromagnetic Radiation	
When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells.	**SE:** 529–536 **Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** EM Radiation and Matter
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	

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Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**SE:** 535, 536 **Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** Sunscreen and UV Protection **Performance-Based Assessment:** Clothing and Sun Protection
Crosscutting Concepts	
Cause and Effect	
Cause and effect relationships can be suggested and predicted for complex natural and human-designed systems by examining what is known about smaller scale mechanisms within the system.	**SE:** 534–535 **Performance-Based Assessment:** Clothing and Sun Protection
Performance Expectation HS-PS4-5 Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.	**SE:** 549, 552, 556 **Inquiry Labs:** Converting Electrical Signals to Sounds, Converting Sunlight to Electricity **Digital Activities:** Antennas, Solar Panels on a Cloudy Day **Performance-Based Assessment:** Send Messages with a Telegraph
Disciplinary Core Ideas	
PS3.D: Energy in Chemical Processes	
Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy.	**SE:** 557–560 **Inquiry Lab:** Converting Sunlight to Electricity
PS4.A: Wave Properties	
Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses.	**SE:** 542–547, 549–553, 554–555 **Performance-Based Assessment:** Send Messages with a Telegraph
PS4.B: Electromagnetic Radiation	
Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**SE:** 522, 523, 558–559 **Inquiry Lab:** Converting Sunlight to Electricity
PS4.C: Information Technologies and Instrumentation	

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Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	**SE:** 486, 489, 492, 549–553, 554–555 **Inquiry Lab:** Converting Electrical Signals to Sounds **Performance-Based Assessment:** Send Messages with a Telegraph
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	
Communicate 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 (including orally, graphically, textually, and mathematically).	**SE:** 489, 555, 561 **Inquiry Labs:** Reflection and Refraction, Converting Electrical Signals to Sounds, Converting Sunlight to Electricity **Engineering Workbench:** Rover
Crosscutting Concepts	
Cause and Effect	
Systems can be designed to cause a desired effect.	**Inquiry Lab:** Converting Sunlight to Electricity **Digital Activity:** Solar Panels on a Cloudy Day
Connections to Engineering, Technology, and Applications of Science: Interdependence of Science, Engineering, and Technology	
Science and engineering complement each other in the cycle known as research and development (R&D).	**SE:** 556, 561, 563, 564 **Inquiry Lab:** Converting Electrical Signals to Sounds **Digital Activities:** Refraction - Snell's Law, Storage for Home Recording, Antennas, Capturing and Transmitting Energy **Engineering Workbench:** Waves
Connections to Engineering, Technology, and Applications of Science: Influence of Engineering, Technology, and Science on Society and the Natural World	
Modern civilization depends on major technological systems.	**SE:** 556, 561, 564 **Inquiry Lab:** Converting Sunlight to Electricity **Digital Activities:** Information and Instrumentation, Capturing and Transmitting Information **Engineering Workbench:** Waves
Performance Expectation HS-ESS1-1 Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy in the form of radiation.	**SE:** 656, 657, 659, 661, 662 **Inquiry Lab:** Sunlight Intensity and Solar Flares **Digital Activities:** The Universe, Build a Star! **Performance-Based Assessment:** Life Cycle of Stars
Disciplinary Core Ideas	

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ESS1.A: The Universe and Its Stars	
The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.	**SE:** 655–658, 669–672, 674–676 **Digital Activity:** Build a Star!
PS3.D: Energy in Chemical Processes and Everyday Life	
Nuclear fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation.	**SE:** 655–658, 669–672, 674–676 **Inquiry Labs:** Sunlight Intensity and Solar Flares, Elemental Composition of Stars **Digital Activities:** The Universe, Build a Star!
Science and Engineering Practices	
Developing and Using Models	
Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**SE:** 655, 656–657, 659, 661 **Inquiry Lab:** Sunlight Intensity and Solar Flares **Digital Activity:** Build a Star!
Crosscutting Concepts	
Scale, Proportion, and Quantity	
The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	**SE:** 654, 655, 663, 666, 670, 678 **Digital Activity:** Build a Star!
Performance Expectation HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.	**SE:** 681, 682, 683, 684, 685, 687 **Inquiry Lab:** The Expansion of the Universe **Digital Activity:** Origins of the Universe
Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars	
The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**SE:** 666–667, 669, 679, 685 **Engineering Workbench:** The Colors of Light
The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non- stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.	**SE:** 679–683 **Inquiry Labs:** Elemental Composition of Stars, The Expansion of the Universe
Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**SE:** 674–677, 685–687 **Inquiry Lab:** Elemental Composition of Stars **Engineering Workbench:** The Colors of Light
PS4.B: Electromagnetic Radiation	

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Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities.	**SE:** 685 **Inquiry Lab:** Elemental Composition of Stars **Engineering Workbench:** The Colors of Light
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**SE:** 682, 684, 685, 687 **Inquiry Labs:** Elemental Composition of Stars, The Expansion of the Universe **Digital Activities:** Origins of the Universe, Elemental Composition of the Solar System
Connections to Nature of Science: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**SE:** 679, 680–681, 682, 683, 684, 685 **Digital Activity:** Origins of the Universe
Crosscutting Concepts	
Energy and Matter	
Energy cannot be created or destroyed– only moved between one place and another place, between objects and/or fields, or between systems.	**SE:** 679, 682, 683, 684, 685, 686, 688
Connections to Engineering, Technology, and Applications of Science: Interdependence of Science, Engineering, and Technology	
Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	**SE:** 680–681, 683, 685
Connections to Nature of Science: Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. Science assumes the universe is a vast single system in which basic laws are consistent.	**SE:** 634, 636, 679, 680, 683, 684, 685 **Digital Activity:** Origins of the Universe

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Performance Expectation HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.	**SE:** 656, 657, 674, 675, 676, 677, 678, 685 **Digital Activities:** Build a Star!, Stars, The Universe **Performance-Based Assessment:** Life Cycle of Stars
Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars	
The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**SE:** 654, 660, 665–671, 679, 685 **Digital Activity:** Discovering Exoplanets **Inquiry Lab:** Elemental Composition of Stars **Engineering Workbench:** The Colors of Light
Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**SE:** 656–657, 671–677, 685 **Digital Activities:** Build a Star!, Stars
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information	
Communicate scientific 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 (including orally, graphically, textually, and mathematically).	**SE:** 656, 657, 674, 675, 676, 677, 678, 685 **Inquiry Lab:** Elemental Composition of Stars **Digital Activities:** Build a Star!, Stars, The Universe **Performance-Based Assessment:** Life Cycle of Stars
Crosscutting Concepts	
Energy and Matter	
In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**SE:** 656–657, 675, 676, 678 **Digital Activity:** The Universe

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Performance Expectation HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.	**SE:** 130, 131, 132, 133, 134, 135, 137, 138, 142, 144, 146, 147 **Inquiry Labs:** Model the Orbital Motion of Planets, Kepler's Laws of Planetary Motion **Digital Activities:** Gravitational Forces on Satellites, Eccentric Orbits, Kepler's Law of Planetary Periods
Disciplinary Core Ideas	
ESS1.B: Earth and the Solar System	
Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.	**SE:** 142–144, 146–148 **Inquiry Labs:** Model the Orbital Motion of Planets, Kepler's Laws of Planetary Motion **Digital Activity:** Kepler's Law of Planetary Periods **Performance-Based Assessment:** What Causes the Seasons?
Science and Engineering Practices	
Using Mathematical and Computational Thinking	
Use mathematical or computational representations of phenomena to describe explanations.	**SE:** 131, 133, 134, 135, 139, 140, 141, 142, 143, 144, 146, 148, 152 **Inquiry Labs:** Model the Orbital Motion of Planets, Kepler's Laws of Planetary Motion **Digital Activities:** Evidence for a non-circular Earth, Eccentric Orbits, Kepler's Law of Planetary Periods **Engineering Workbench:** Defy Gravity
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).	**SE:** 130, 132, 135, 149, 151 **Inquiry Labs:** Model the Orbital Motion of Planets, Kepler's Laws of Planetary Motion **Digital Activities:** Gravity and Orbits - Model, Eccentric Orbits, Kepler's Law of Planetary Periods, Mercury's Resonant Orbit **Engineering Workbench:** Defy Gravity **Performance-Based Assessment:** What Causes the Seasons?

<table>
<tr><th>Montgomery County Next Generation Science Curriculum for High School Physics</th><th>Experience Physics ©2022</th></tr>
<tr><td>Performance Expectation HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</td><td>Inquiry Labs: Binary Logic, Converting Electrical Signals to Sound, Build a Battery, Electric Fields, Indirect Observation of the Atom, Cohesive Forces and Surface Tension, Electric Motors and Generators, Interference of Sound Waves
Digital Activity: Operate a Nuclear Fission Reactor
Engineering Workbench: Waves and Erosion, Landslide Prevention, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Build an Efficient Travel Mug, The Colors of Light
Performance-Based Assessment: Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor</td></tr>
<tr><td colspan="2">Disciplinary Core Ideas</td></tr>
<tr><td colspan="2">ETS1.C Optimizing the Design Solution</td></tr>
<tr><td>Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.</td><td>SE: 561

Inquiry Labs: Build a Battery, Electric Motors and Generators, Natural Resource Management
Digital Activities: Junkyard Electromagnet, Operate a Nuclear Fission Reactor
Engineering Workbench: Design an Airdrop System, Egg Supply Drop, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Build a Flashlight Without Batteries, Design a Roller Coaster, Build an Efficient Travel Mug, The Colors of Light
Performance-Based Assessment: Build Your Own Egg-Transport Vehicle, Minimizing Car Crash Injuries, Build and Test an Electroscope, Build a DC Motor, Design, Build and Refine a Wind-Turbine Rotor</td></tr>
<tr><td colspan="2">Science and Engineering Practices</td></tr>
<tr><td colspan="2">Constructing Explanations and Designing Solutions</td></tr>
<tr><td>Design a solution to a complex real-world problem based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.</td><td>SE: 45, 84, 94, 124, 164, 206, 212, 219, 232, 238, 393, 497, 528, 551

Digital Activities: Junkyard Electromagnet
Engineering Workbench: Landslide Prevention, Defy Gravity, Earthquake-Resistant Structures, Design a Roller Coaster, The Colors of Light
Performance-Based Assessment: Design, Build and Refine a Wind-Turbine Rotor</td></tr>
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Performance Expectation HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	**Inquiry Labs**: Momentum and Impulse, Electric Motors and Generators, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Landslide Prevention, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Disciplinary Core Ideas	
ETS1.B 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.	**SE:** 109, 452–453, 455–456, 457, 601–602 **Inquiry Labs:** Momentum and Impulse, Natural Resource Management **Digital Activities:** Vehicle Stopping Distance, Electric Circuits, Generator Testing, Transistors and Integrated Circuits, Junkyard Electromagnet, Operate a Nuclear Fission Reactor **Engineering Workbench:** Waves and Erosion, Energy Sources: Costs and Benefits, Solar Panel Art, Rover, Landslide Prevention, Earthquake-Resistant Structures **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor, Send Messages with a Telegraph **Problem-Based Learning:** Electromagnetic Roller Coaster
Science and Engineering Practices	
Constructing Explanations and Designing Solutions	
Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**SE:** 49, 109, 269, 409, 434, 455, 459, 492, 541, 564 **Digital Activities:** Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor **Problem-Based Learning:** Electromagnetic Roller Coaster, A Mystery on Planet K

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Crosscutting Concepts	
Connections to Engineering, Technology, and Applications of Science: Influence of Science, Engineering, and Technology on Society and the Natural World	
New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.	**SE:** 453, 545 **Digital Activities:** Vehicle Stopping Distance, Enantiomers, Electric Circuits, Resource Use and Biodiversity Trade Offs, Transistors and Integrated Circuits, Junkyard Electromagnet **Engineering Workbench:** Design an Airdrop System, Landslide Prevention, Defy Gravity, Design an Electronic Quiz Board, Build a Flashlight Without Batteries, Earthquake-Resistant Structures, Design a Roller Coaster, Egg Supply Drop, Build an Efficient Travel Mug, Energy Sources: Costs and Benefits, Waves and Erosion, Solar Panel Art, Rover, Energy Production, Build a Glove Box, The Colors of Light **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
Performance Expectation HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	**Inquiry Lab:** Natural Resource Management **Digital Activities:** Generator Testing, Junkyard Electromagnet **Engineering Workbench:** Rover, Energy Sources: Costs and Benefits
Disciplinary Core Ideas	
ETS1.B Developing Possible Solutions	
Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**SE:** 121, 402, 403 **Inquiry Lab:** Natural Resource Management **Digital Activities:** Generator Testing, Junkyard Electromagnet **Engineering Workbench:** Rover, Energy Sources: Costs and Benefits
Science and Engineering Practices	
Using Mathematics and Computational Thinking	
Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**SE:** 38, 446, 448, 457, 504 **Digital Activities:** Vehicle Stopping Distance, Resource Use and Biodiversity Trade Offs **Engineering Workbench:** Rover, Defy Gravity, Design an Electronic Quiz Board, Design a Roller Coaster, Energy Production **Performance-Based Assessment:** Build and Test an Electroscope, Structure-Property Relationships, Energy Conversion

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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.	**SE:** 319, 511, 524, 539 **Digital Activity:** Electric Circuits **Engineering Workbench:** Rover, Design an Electronic Quiz Board, Energy Sources: Costs and Benefits, Design a Roller Coaster **Performance-Based Assessment:** Build and Test an Electroscope, Structure-Property Relationships

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