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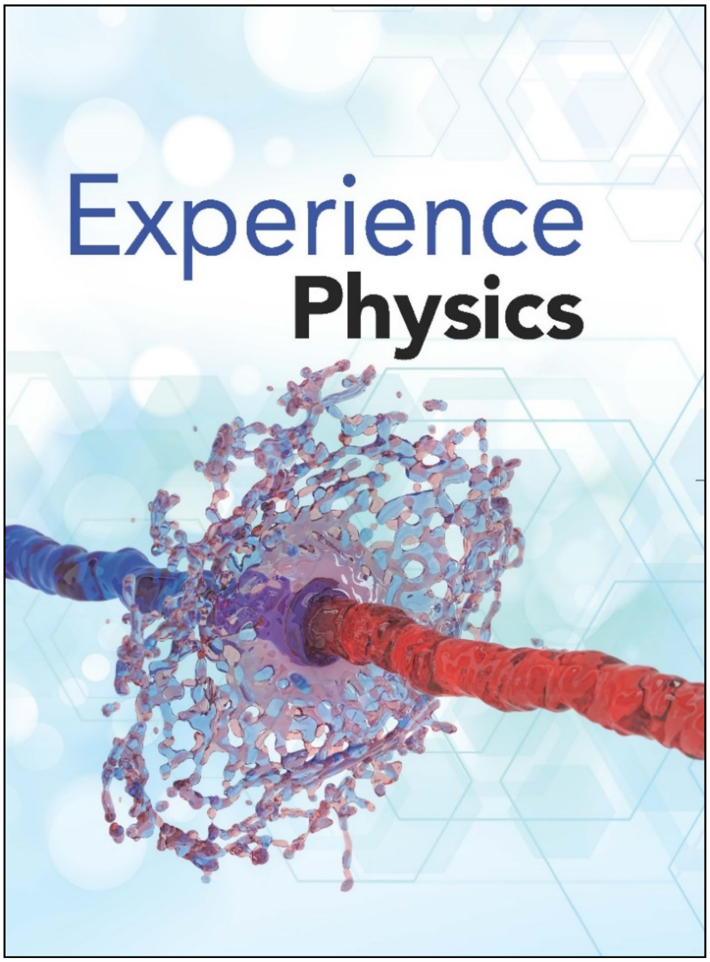

to the

Colorado
2020 Academic Standards in Science
High School Physical Science

Prepared by Savvas Learning Company, formerly Pearson K12 Learning

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Introduction

This document demonstrates how ***Experience Physics* ©2022** supports Colorado 2020 Academic Standards in Science High School Physical Science. 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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1. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding structure, properties and interactions of matter.	
(SC.HS.1.1) 1. The sub-atomic structural model and interactions between electric charges at the atomic scale can be used to explain the structure and interactions of matter.	
Students Can:	
Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy levels of atoms. (HS-PS1-1)	**Student Experience Notebook:** Major Trends on the Periodic Table, 247 CCC Patterns, 247 Relative Sizes of Atoms, 249 CCC Matter and Energy, 250 CCC Structure and Function, 253
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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 (Planning and Carrying Out Investigations) (Personal: Personal responsibility)	**Student Experience Notebook:** SEP Plan an Investigation, 163 SEP Plan an Investigation, 167 SEP Plan an Investigation, 170 SEP Plan an Investigation, 188 **Teacher Guide:** **Inquiry Labs:** Electric Charges and Coulomb's Law, Physical Properties of Solid Materials **Digital Activities:** Properties of Materials, Attractive and Repulsive Forces, Structure and Function **Performance-Based Assessment:** Structure-Property Relationships
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PS1:A Structure and Properties of Matter: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart.	**Student Experience Notebook:** Electric Charge, 156 Electron, Protons, and Neutrons, 157 Electric Force, 158 Electric Force and Vectors, 160 Charge by Contact, 163 Charge by Induction, 164 Van der Waals Forces, 165 Modeling Electric and Contact Forces, 166 Periodic Physical Trends, 247 Atomic Radius, 248 CCC Matter and Energy, 250 Coulomb Forces Between Atoms, 251 Covalent Bonds, 252 Metallic Bonds, 254 Other Atomic Interactions, 255 States of Matter, 256 Fracturing, 267 **Teacher Guide:** **Digital Activities:** Forces Between Atoms, Dielectric Materials, Electric Forces, Structure and Function
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Students Can:	
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Construct and revise 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. Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic Engagement)	**Student Experience Notebook:** SEP Evaluate Scientific Information, 683 CCC Energy and Matter, 684 CCC Energy and Matter (41), 685 CCC Energy and Matter (42), 685 SEP Apply Scientific Reasoning, 687 **Inquiry Labs:** Elemental Composition of Stars, The Expansion of the Universe **Digital Activities:** Origins of the Universe, Elemental Composition of the Solar System
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Inquiry Lab: The Impact of Position on Energy
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<tr><td colspan="2">(SC.HS.1.3) 3. The strong nuclear interaction provides the primary force that holds nuclei together. Nuclear processes including fusion, fission, and radioactive decays of unstable nuclei involve changes in nuclear binding energies.</td></tr>
<tr><td colspan="2">Students Can:</td></tr>
<tr><td>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. (HS-PS1-8)</td><td>Student Experience Notebook:
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2. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding interactions between objects and within systems of objects.	
(SC.HS.1.4) 4. Newton's second law and the conservation of momentum can be used to predict changes in the motion of macroscopic objects.	
Students Can:	
Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. (HS-PS2-1)	**Student Experience Notebook:** Mowing the Lawn, 55 Modeling Force, 60 Writing Force-Acceleration Equations, 61 SEP Analyze and Interpret Data, 66 SEP Use Mathematics, 72 **Teacher Guide:** **Inquiry Lab:** Forces and Motion **Digital Activities:** Force, Mass, and Acceleration; Sliding Down **Performance-Based Assessment:** Force, Mass, and Acceleration
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Colorado Essential Skills and Science and Engineering Practices:	
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. (Analyzing and Interpreting Data) (Entrepreneurial: Critical thinking/Problem solving)	**Student Experience Notebook:** Dot Diagrams, 11 Position Graphs, 12 Speed and Velocity, 13 SEP Analyze and Interpret Data, 13 Speed and Velocity Graphs, 15 SEP Argue from Evidence, 15 SEP Analyze and Interpret Data, 20 Graphs of Changing Velocity, 22 Acceleration, 23 SEP Analyze and Interpret Data, 34 Projectile Motion, 38 SEP Analyze and Interpret Data, 64 SEP Analyze and Interpret Data, 66 **Teacher Guide:** **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
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PS2:A Forces and Motion: Newton's second law accurately predicts changes in the motion of macroscopic objects. Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. 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.	**Student Experience Notebook:** Force Causes an Acceleration, 54 Momentum, 56 Representing Forces, 58 Solving Two-Dimensional Force Problems, 73 Forces in Systems, 80 Determining Internal Forces, 82 Atwood Machine, 87 Impulse-Momentum Theorem, 336–337 Impulse and Momentum in Collisions, 338–339 What A Racket, 340 High-Speed Collision, 341 Types of Collisions, 342–343 A Ballistic Pendulum, 344–345 Inelastic Collision, 346 **Digital Activity:** Minimizing Car Crash Injuries **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle

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Cross Cutting Concepts:	
Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. Systems can be designed to cause a desired effect.	**Student Experience Notebook:** CCC Cause and Effect, 5 CCC Cause and Effect, 48 CCC Cause and Effect, 51 CCC Cause and Effect, 52 CCC Scale, Proportion, and Quantity, 54 CCC Cause and Effect, 70 SEP Argue from Evidence, 71 CCC Cause and Effect, 76 CCC Cause and Effect, 78 CCC Cause and Effect, 80 CCC Cause and Effect, 94 SEP Use Mathematics, 327 SEP Construct an Explanation, 328 Ice Skaters in a System, 331 SEP Argue from Evidence, 331 SEP Develop a Model, 337 **Inquiry Labs:** Model Projectile Motion, Momentum and Impulse During Collisions **Digital Activities:** Forces, Forces on Systems, Atmospheric Pressure on a Sealed Container, Momentum and Impulse, Momentum and Baseball, Minimizing Car Crash In- juries **Performance-Based Assessment:** Speed, Acceleration, and Trajectory
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(SC.HS.1.5) 5. Forces at a distance are explained by fields that can transfer energy and can be described in terms of the arrangement and properties of the interacting objects and the distance between them.	
Students Can:	
Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. (HS-PS2-4) (Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.) (Boundary Statement: Limited to systems with two objects and basic algebraic substitution and/or manipulations.)	**Student Experience Notebook:** SEP Use a Model, 119 SEP Develop a Model, 119 Earth and the Moon, 120 SEP Use Mathematics, 122 SEP Use Mathematics, 128 SEP Use Mathematics, 159 SEP Systems and System Models, 160 Electric Force Between Particles, 161 Electric Field Due to Two Charges, 173 SEP Systems and System Models, 174 SEP Use Math, 175 **Inquiry Lab:** Electric Charges and Coulomb's Law
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Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. (HS-PS2-6) (Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.) (Boundary Statement: Limited to provided molecular structures of specific designed materials.)	**Student Experience Notebook:** SEP Make a Claim, 270 SEP Construct an Explanation, 274 Targeting Receptors to Treat Disease, 275 SEP Construct an Explanation, 276 **Inquiry Lab:** Structures and Properties of Polymers **Digital Activity:** Properties of Materials **Performance-Based Assessment:** Structure-Property Relationships

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Colorado Essential Skills and Science and Engineering Practices:	
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. (Plan and Carry Out an Investigation) (Entrepreneurial: Inquiry/Analysis)	**Student Experience Notebook:** SEP Plan an Investigation, 163 SEP Plan an Investigation, 167 SEP Plan an Investigation, 170 SEP Plan an Investigation, 188 **Teacher Guide:** **Inquiry Labs:** Electric Charges and Coulomb's Law, Physical Properties of Solid Materials **Digital Activities:** Properties of Materials, Attractive and Repulsive Forces, Structure and Function **Performance-Based Assessment:** Structure-Property Relationships
Use mathematical representations of phenomena to describe explanations. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)	**Student Experience Notebook:** SEP Use Mathematics, 323 SEP Use Mathematics, 324 SEP Use Mathematics, 327 SEP Construct an Explanation, 328 SEP Use Mathematics, 329 Conserving Momentum in Space, 332 A Rotating Disk and a Hoop Interact, 334–335 SEP Use Mathematics, 336 What a Racket, 340 High-Speed Collision, 341 A Ballistic Pendulum, 344–345 Inelastic Collision, 346 **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
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 orally, graphically, textually, and mathematically). (Obtaining, Evaluating, and Communicating Information) (Professional: Information and Communications Technologies)	**Student Experience Notebook:** SEP Obtain Information, 186 SEP Obtain Scientific Information, 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

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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.	**Student Experience Notebook:** Field Lines for Multiple Charges, 175 Conductors and Electric Fields, 176 Changing Particle Velocity, 179 Metals, 184–185 Electric Fields Along a Wire, 186 Current, 187 Conductivity and Resistivity, 188 Current and Resistivity, 189 Series and Parallel Resistance, 190–191 **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
Elaboration on the GLE:	
Students can answer the question: What underlying forces explain the variety of interactions observed?	**Student Experience Notebook:** Disappearing Actor (78), 88–89 CCC Patterns, 99 CCC Scale, Proportion, and Quantity, 135 CCC Patterns, 143 CCC Patterns, 147 CCC Scale, Proportion, and Quantity, 151 SEP Analyze and Interpret Data, 201 SEP Construct an Explanation, 211 CCC Patterns, 465 SEP Construct an Explanation, 480 SEP Engage in Argument from Evidence, 509 CCC Patterns, 571

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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. 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. 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.	**Student Experience Notebook:** What Causes Free Fall?, 116 Gravitational Force, 118 Gravitational Fields, 121 Field Lines, 122 Launching a Satellite, 129 Motions in Orbit, 130 Forces in Orbit, 131 Velocity for a Circular Orbit, 132 Electric Charge, 156 Electrons, Protons, and Neutrons, 157 Electric Force, 158 Electric Force and Vectors, 160 What is a Field?, 171 Electric Field, 172–174 Field Lines for Multiple Charges, 175 Conductors and Electric Fields, 176 Uniform Electric Fields, 177 Parallel Plates, 178–179 Magnetism, 198–199 What Makes Materials Magnetic?, 200 Magnetizing a Ferromagnet, 202 Magnetic Fields, 203 Modeling Multiple Magnets, 205 Force on a Moving Charge, 207–208 Charge Particles in Magnetic Fields, 209–210 Nonperpendicular Motion, 211 Magnetic Force on a Wire, 213–215 Torque on Loops, 216–217 Modeling a Simple Motor, 219 Current and Magnetic Fields, 220–222 Coulomb Forces Between Atoms, 251 Covalent Bonds, 252 **Inquiry Labs:** Electric Charges and Coulomb's Law, Magnetic Force and Separation Distance, Electromagnets and Magnetism, Induction of Electrical Current, Electric Field **Performance-Based Assessment:** Build and Test and Electroscope

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Cross Cutting 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.	**Student Experience Notebook:** CCC Patterns, 137 CCC Patterns, 138 CCC Patterns, 152 CCC Patterns, 220 Periodic Physical Trends, 247 CCC Patterns, 248 CCC Matter and Energy, 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
Cause and Effect: Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Student Experience Notebook:** CCC Cause and Effect, 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
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.	**Student Experience Notebook:** CCC Structure and Function, 182 CCC Structure and Function, 194 CCC Structure and Function, 241 CCC Structure and Function, 253 Other States of Matter, 257 CCC Structure and Function, 258 CCC Structure and Function, 259 CCC Structure and Function, 267 CCC Structure and Function, 269 CCC Structure and Function, 271 CCC Structure and Function, 272 CCC Structure and Function, 273 CCC Structure and Function, 275 CCC Structure and Function, 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, Combining Materials **Engineering Workbench:** Earthquake-Resistant Structures **Performance-Based Assessment:** Structure-Property Relationships

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3. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how energy is transferred and conserved.	
(SC.HS.1.6) 6. Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system.	
Students Can:	
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. (HS-PS3-1) (Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.) (Boundary Statement: Limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.)	**Student Experience Notebook:** Bowling Ball Bounce, 304–305 Modeling Systems, 311 SEP Use Math, 311 Roller Coaster Energy, 314–315 SEP Use Mathematics, 318 **Performance-Based Assessment:** Energy Conversion
Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects). (HS-PS3-2) (Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the Earth, and the energy stored between two electrically charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.)	**Student Experience Notebook:** Defining Energy of Motion, 287 Mechanical Energy and Work, 302–303 Friction as a Change in Energy, 306 Energy Transformed Within a System, 313 Temperature and Energy, 371 Thermal Equilibrium, 381 Sources of Energy, 399 Photoelectric Effect, 522 **Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature **Performance-Based Assessment:** Heating Curve of Water
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (HS-PS3-3) (Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices and on the ability of energy to be transferred but not on the efficiency of energy transfer. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.) (Boundary Statement: Quantitative evaluations are limited to total output for a given input, and are limited to devices constructed with materials provided to students.)	**Student Experience Notebook:** SEP Design a Solution, 206 SEP Design a Solution, 212 SEP Design a Solution, 238 Engineering Performance-Based Assessment, 363 **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

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Colorado Essential Skills and Science and Engineering Practices:	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Personal responsibility)	**Student Experience Notebook:** SEP Develop Models, 571 Experience It, 584 SEP Develop Models, 591 SEP Develop Models, 592 SEP Develop and Use Models, 593 SEP Use Models, 596 SEP Develop and Use Models, 598 SEP Develop and Use a Model, 615 SEP Develop and Use Models, 616 SEP Develop and Use Models, 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
Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)	**Student Experience Notebook:** SEP Use Mathematics, 286 SEP Use Mathematics, 287 SEP Use Mathematics, 288 Work Done on a Book, 290–291 SEP Use Mathematics, 292 Elastic Potential Energy, 296–297 Cart on a Spring, 298–299 SEP Use Mathematics, 301 Mechanical Energy Bar Charts, 303 Bowling Ball Bounce, 304–305 Car Skidding to a Stop, 307–308 SEP Use Mathematical Thinking, 308 SEP Use Mathematics, 313 Roller Coaster Energy, 314–315 SEP Use Mathematics, 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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Elaboration on the GLE:	
Students can answer the question: What is energy?	**Student Experience Notebook:** Defining Energy of Motion, 287 Potential Energy, 294 Gravitational Potential Energy, 295 Elastic Potential Energy, 296–297 Electromagnetic Potential Energy, 300–301 Mechanical Energy and Work, 302–303 Friction as a Change in Energy, 306 Energy Transformed Within a System, 313 Temperature and Energy, 371 Sources of Energy, 399
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. At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal 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.	**Student Experience Notebook:** Potential Energy, 294 Gravitational Potential Energy, 295 Elastic Potential Energy, 296–297 Cart on a Spring, 298–299 Electromagnetic Potential Energy, 300–301 Mechanical Energy and Work, 302 Mechanical Energy Bar Charts, 303 Bowling Ball Bounce, 304–305 Friction as a Change in Energy, 306 Car Skidding to a Stop, 307–308 Defining Systems, 310 Modeling Systems, 311 Structure of Matter, 367 Average Kinetic Energy of Gas Particles, 369 Temperature and Energy, 371 Absolute Zero, 372 Thermodynamic Processes, 377 Transferring Energy Through Heating, 374–375 The First Las of Thermodynamics, 376 Evidence for the Big Bang, 679 **Inquiry Lab:** Kinetic Energy **Digital Activity:** Temperature

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Cross Cutting Concepts:	
System 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.	**Student Experience Notebook:** Force and Displacement, 283 Work and Pressure, 285 Positive and Negative Work, 286 Work and Energy, 288 Energy from Gravity, 295 Comparing Universal Gravitation and Electrostatic Energy, 300 Mechanical Energy Bar Charts, 303 Bowling Ball Bounce, 304–305 Friction and Tires, 306 Rocket Systems, 310 Modeling Systems, 311 **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
Constructing Explanations and Designing Solutions: Design, evaluate, and/or refine a solution to complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations.	**Student Experience Notebook:** SEP Design a Solution, 45 SEP Design a Solution, 84 SEP Design a Solution, 94 SEP Design a Solution, 124 SEP Design Solutions, 164 SEP Design a Solution, 206 SEP Design a Solution, 212 SEP Design a Solution, 219 SEP Design a Solution, 232 SEP Design a Solution, 238 SEP Design a Solution, 393 SEP Design a Solution, 497 SEP Design a Solution, 528 SEP Design Solutions, 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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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. Energy cannot be created or destroyed — only moves between one place and another place, between objects and/or fields, or between systems.	**Student Experience Notebook:** Potential Energy, 294 Gravitational Potential Energy, 295 Elastic Potential Energy, 296–297 Cart on a Spring, 298–299 Mechanical Energy and Work, 302 Mechanical Energy Bar Charts, 303 Bowling Ball Bounce, 304–305 Friction as a Change in Energy, 306 Car Skidding to a Stop, 307–308 Expanded Work-Energy Theorem, 312 CCC Energy and Matter, 318 CCC Matter and Energy, 411 Ohm's Law, 422 Ohmic Materials, 423 Kirchhoff's Junction Rule, 430 CCC Energy and Matter, 434 Direct Current Generators, 437 CCC Energy and Matter, 479 Standing Waves, 485 Waves on a String, 486 Standing Waves on a Rope, 487 Transfer of Wave Energy, 488 Energy in Waves, 490–491 **Inquiry Lab:** Build a Battery **Digital Activities:** Power Generation, Rocket Launch

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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.	**Student Experience Notebook:** What Causes Current, 421 Ohm's Law, 422 Ohmic Materials, 423 Circuit Elements and Diagrams, 424–425 Measurements for Circuits, 426 Joule's Law, 427 Kirchhoff's Loop Rule, 428 Kirchhoff's Junction Rule, 430 Analyzing a Circuit, 431 CCC Energy and Matter, 434 Electric Generators, 435 Alternating Current Generators, 436 Direct Current Generators, 437 Motors, 439 Starting a Motor, 440–441 Induction Devices, 442–443 CCC Energy and Matter, 444 Standing Waves, 485 Waves on a String, 486 Standing Waves on a Rope, 487 Transfer of Wave Energy, 488–489 **Inquiry Labs:** Build a Battery, Energy Transmission in Circuits, Electric Motors and Generators **Digital Activities:** Electromagnetic Energy, Junk-yard 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
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.	**Student Experience Notebook:** Impact Craters and Solar System History, 634 Grand Canyon, 636 Physical and Geologic Time, 636–637 Geologic Time Divisions, 644–645 Ages of Ocean Crust, 646–647 **Digital Activity:** Origins of the Universe

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(SC.HS.1.7) 7. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	
Students Can:	
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. (HS-PS3-1) (Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.) (Boundary Statement: Limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.)	**Student Experience Notebook:** SEP Argue from Evidence, 128 SEP Use Mathematics, 287 SEP Use Mathematics, 288 SEP Use Mathematics, 301 Bowling Ball Bounce, 304–305 Car Skidding to a Stop, 307 SEP Use Math, 311 SEP Use Math, 313 Roller Coaster Energy, 314–315 SEP Use Math (59), 318 SEP Use Math (60), 318 A Ballistic Pendulum, 344–345 Inelastic Collision, 346–347 **Performance-Based Assessment:** Energy Conversion
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). (HS-PS3-4) (Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.) (Boundary Statement: Limited to investigations based on materials and tools provided to students.)	**Student Experience Notebook:** SEP Plan an Investigation, 365 SEP Design a Solution, 393 SEP Construct an Explanation, 393 **Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug

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Colorado Essential Skills and Science and Engineering Practices:	
Create a computational model or simulation of a phenomenon, designed device, process, or system. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)	**Student Experience Notebook:** SEP Use Mathematics, 286 SEP Use Mathematics, 287 SEP Use Mathematics, 288 Work Done on a Book, 290–291 SEP Use Mathematics, 292 Elastic Potential Energy, 296–297 Cart on a Spring, 298–299 SEP Use Mathematics, 301 Mechanical Energy Bar Charts, 303 Bowling Ball Bounce, 304–305 Car Skidding to a Stop, 307–308 SEP Use Mathematical Thinking, 308 SEP Use Mathematics, 313 Roller Coaster Energy, 314–315 SEP Use Mathematics, 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
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. (Planning and Carrying Out Investigations) (Entrepreneurial: Inquiry/Analysis)	**Student Experience Notebook:** SEP Plan an Investigation, 365 SEP Design a Solution, 393 SEP Construct an Explanation, 393 **Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug

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Elaboration on the GLE:	
Students can answer the questions: What is meant by conservation of energy? How is energy transferred between objects or systems?	**Student Experience Notebook:** CCC Energy and Matter, 197 SEP Use Mathematics, 288 Bowling Ball Bounce, 304–305 Car Skidding to a Stop, 307 SEP Construct an Explanation, 309 SEP Develop a Model, 313 SEP Use Mathematics, 313 Roller Coaster Energy, 314–315 SEP Construct an Explanation, 316 CCC Systems and System Models, 319 SEP Use Mathematics, 343 SEP Use Mathematics, 376 CCC Patterns, 377 CCC Systems and System Models, 380 SEP Construct an Explanation, 381 SEP Construct an Explanation, 382 SEP Argue from Evidence, 383 CCC Energy and Matter, 385 **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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<table>
<tr><th>Colorado 2020 Academic Standards in Science
High School Physical Science</th><th>Experience Physics
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<tr><td>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. Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. 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. The availability of energy limits what can occur in any system. 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).</td><td>Student Experience Notebook:
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<tr><td colspan="2">Cross Cutting Concepts:</td></tr>
<tr><td>Systems and Systems 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. 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.</td><td>Student Experience Notebook:
Force and Displacement 283
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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</td></tr>
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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.	**Student Experience Notebook:** Free-Body Diagrams, 59 Mechanical Energy, 294 Gravitational Potential Energy, 295 Electromagnetic Potential Energy, 300 Mechanical Energy and Work, 302 Friction as a Change in Energy, 306 Car Skidding to a Stop, 307–308 Blackbody Radiation, 532 Four Fundamental Forces, 581 Comparing Energy Transformations, 605 **Inquiry Lab:** The Impact of Position on Energy **Digital Activities:** Energy, Energy in a Moving Cart, Mechanical Energy, Asteroid Impact Models
(SC.HS.1.8) 8. Force fields (gravitational, electric, and magnetic) contain energy and can transmit energy across space from one object to another.	
Students Can:	
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. (HS-PS3-5) (Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.) (Boundary Statement: Limited to systems containing two objects.)	**Student Experience Notebook:** Electric Field Due to Two Charges, 173 Modeling Fields, 174 Magnetic Fields, 203 SEP Design a Solution, 219 SEP Construct an Explanation, 393 SEP Design a Solution, 393 Microwave Oven, 562 **Inquiry Lab:** Magnetic Force and Separation Distance **Digital Activity:** Junkyard Electromagnet **Performance-Based Assessment:** Build and Test an Electroscope
Colorado Essential Skills and Science and Engineering Practices:	
Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (Developing and Using Models) (Personal: Initiative/Self direction)	**Student Experience Notebook:** SEP Develop a Model, 127 SEP Use Models, 172 Modeling Fields, 174 SEP Use a Model, 175 SEP Construct an Explanation, 176 SEP Argue from Evidence, 177 SEP Develop and Use a Model, 178 SEP Develop a Model, 182 CCC Patterns, 195 SEP Develop a Model, 203 SEP Develop a Model, 205

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Elaboration on the GLE:	
Students can answer the question: How are forces related to energy?	**Student Experience Notebook:** SEP Argue from Evidence, 128 SEP Develop and Use a Model, 178 CCC Energy and Matter, 252 SEP Use a Model, 256 Work Done on a Book, 290–291 SEP Use Mathematics, 295 Roller Coaster Energy, 314–315 SEP Construct an Explanation, 363
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.	**Student Experience Notebook:** Contact and Noncontact Forces, 65 Field Lines, 122 Electric Field, 172 Potential Energy, 294 Magnetic Potential Energy, 301 Skateboarding Energy, 302
Cross Cutting 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.	**Student Experience Notebook:** Flow of Water, 187 Flow of Electrons, 187 CCC Patterns, 194 Magnetizing a Ferromagnet, 202 SEP Design a Solution, 212 Torque on Loops, 216 CCC Cause and Effect, 229 CCC Cause and Effect, 239 Speed of an Electron, 245 CCC Cause and Effect, 442 Transporting Energy, 512
(SC.HS.1.9) 9. Although energy cannot be destroyed, it can be converted to less useful forms as it is captured, stored and transferred.	
Students Can:	
Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. (HS-PS3-3) (Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices, including the identification of different energy types [starting points] and how they are transferred. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.) (Boundary Statement: Quantitative evaluation is limited to total output for a given input. Limited to devices constructed with materials provided to students.)	**Student Experience Notebook:** SEP Design a Solution, 206 SEP Design a Solution, 212 SEP Design a Solution, 238 Engineering Performance-Based Assessment, 363 **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

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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). (HS-PS3-4) (Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.) (Boundary Statement: Limited to investigations based on materials and tools provided to students.)	**Student Experience Notebook:** SEP Plan an Investigation, 365 SEP Design a Solution, 393 SEP Construct an Explanation, 393 **Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug
Colorado Essential Skills and Science and Engineering Practices:	
Design, evaluate, and/or refine a solution to complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade-off considerations. (Constructing Explanations and Designing Solutions) (Civic/Interpersonal: Civic engagement)	**Student Experience Notebook:** SEP Design a Solution, 409 SEP Plan an Investigation, 426 SEP Design a Solution, 434 SEP Construct an Explanation, 436 SEP Use Models, 439 SEP Develop and Use a Model, 444 SEP Construct an Explanation, 486 SEP Design a Solution, 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
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. (Planning on Carrying Out Investigations) (Personal: Initiative/Self-direction)	**Student Experience Notebook:** SEP Plan an Investigation, 365 SEP Design a Solution, 393 SEP Construct an Explanation, 393 **Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Engineering Workbench:** Build an Efficient Travel Mug

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Elaboration on the GLE:	
Students can answer the questions: How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used?	**Student Experience Notebook:** Culinary Molecules, 273 Energy–A Conserved Quantity, 309 Experience It!, 449 U.S. Energy Sources and Uses, 449 Daily Variations in Supply and Demand, 450 Benefits of Fossil Fuels, 452 Costs and Benefits of Renewable Energy, 453 Costs and Benefits: Oil, Gas, and Coal, 454 Costs and Benefits: Wind, Solar, and Biomass, 455 Costs and Benefits: Hydroelectric, Geothermal, Tides, and Waves, 456 Costs and Benefits: Nuclear Power, 457
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.	**Student Experience Notebook:** Ohm's Law, 422 Ohmic Materials, 423 Joule's Law, 427 Kirchhoff's Loop Rule, 428–429 Induction Devices, 442 **Digital Activity:** Junkyard Electromagnet
Cross Cutting 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.	**Student Experience Notebook:** CCC Matter and Energy, 411 Ohm's Law, 422 Ohmic Materials, 423 Kirchhoff's Junction Rule, 430 CCC Energy and Matter, 434 Direct Current Generators, 437 CCC Energy and Matter, 479 Standing Waves, 485 Waves on a String, 486 Standing Waves on a Rope, 487 Transfer of Wave Energy, 488 Energy in Waves, 490–491 **Inquiry Lab:** Build a Battery **Digital Activity:** Power Generation

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Systems and Systems 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.	**Student Experience Notebook:** Heat Flow, 385 Understanding Heat Engines, 386–387 Thermodynamic Cycles, 388–389 Heat Pumps, 390–391 Heat Engine Efficiency, 392–393 **Inquiry Lab:** Kinetic Energy **Digital Activities:** Thermal Equilibrium and Heat Flow, Why Metals Feel Cool **Engineering Workbench:** Build an Efficient Travel Mug
4. Students can use the full range of science and engineering practices to make sense of natural phenomena and solve problems that require understanding how waves are used to transfer energy and information.	
(SC.HS.1.10) 10. Waves have characteristic properties and behaviors.	
Students Can:	
Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. (HS-PS4-1) (Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.) (Boundary Statement: Limited to algebraic relationships and describing those relationships qualitatively.)	**Student Experience Notebook:** SEP Analyze Data, 467 SEP Use Mathematics, 467 SEP Analyze and Interpret Data, 469 SEP Argue from Evidence, 471 **Inquiry Lab:** Mechanical Waves **Digital Activities:** Making Waves, Properties of Waves, Waves and Shallow Water
Evaluate questions about the advantages of using a digital transmission and storage of information. (HS-PS4-2) (Clarification Statement: Examples of advantages [compared to waves] could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.)	**Student Experience Notebook:** Storing Pictures in Digital Code, 543 Storing Sounds in Digital Code, 544 Computer Memory, 545 Advantages and Disadvantages of Digital Information, 547 Investigating Phenomenon, 548 **Inquiry Lab:** Binary Logic **Digital Activity:** Music Storage for Home Recording **Performance-Based Assessment:** Send Messages with a Telegraph

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Colorado Essential Skills and Science and Engineering Practices:	
Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (Asking Questions and Defining Problems) (Entrepreneurial: Inquiry/Analysis)	**Student Experience Notebook:** SEP Construct an Explanation, 457 SEP Develop a Model, 468 SEP Design a Solution, 492 SEP Analyze and Interpret Data, 509 SEP Argue from Evidence, 537 **Engineering Workbench:** Design a water break to reduce the erosion caused by water waves.
Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (Using Mathematics and Computational Thinking) (Entrepreneurial: Critical thinking/Problem solving)	**Student Experience Notebook:** SEP Construct an Explanation, 457 SEP Use Mathematics, 467 Wave on a Rope, 470 Properties of Sound Waves, 474 SEP Use Math, 475 Modeling a Sound Wave, 476–478 SEP Use Mathematics, 484 Standing Waves on a Rope, 487 SEP Use Mathematics, 490 SEP Use a Model,493 Determining the Index of Refraction, 500
Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)	**Student Experience Notebook:** SEP Analyze and Interpret Data, 489 SEP Argue from Evidence, 489 SEP Argue from Evidence, 502 SEP Argue from Evidence, 508 SEP Analyze and Interpret Data, 509 SEP Engage in Argument from Evidence, 509 SEP Argue from Evidence, 513 SEP Argue from Evidence, 515 SEP Construct an Argument, 516 SEP Use Evidence, 528 **Inquiry Lab:** Diffraction, Particle Nature of Light **Digital Activities:** Electromagnetic Radiation, Particle-Wave Duality of Light, Laser Interference, Particle-Wave Duality, Light Intensity and Energy

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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.	**Student Experience Notebook:** Energy in Waves, 490–492 Diffraction, 494–495 Refraction, 498–500 Formation of Images, 502–503 Intensity of Polarized Light, 518–519 Shortcomings of the Wave Theory, 520–521 Photoelectric Effect, 522 **Digital Activities:** Electromagnetic Waves and Their Properties, Laser Interference, Particle- Wave Duality, Light Intensity and Energy
Elaboration on the GLE:	
Students can answer the question: What are the characteristic properties and behaviors of waves?	**Student Experience Notebook:** Seismic Tomography, 403 CCC Energy and Matter, 479 SEP Develop a Model, 483 SEP Plan an Investigation, 485 Standing Waves on a Rope, 487 SEP Construct an Explanation, 491 SEP Argue from Evidence, 515 SEP Construct an Argument, 516 **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

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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. 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. 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. (Boundary Statement: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.)	**Student Experience Notebook:** Properties of Waves, 467 Transverse Waves, 468–470 Wave Speed at an Interface, 471 Longitudinal Waves, 472–474 Modeling Waves, 475 Moving Wave Source, 480–481 Modeling Wave Interactions, 482–483 Beats, 484 Standing Waves, 485–487 Energy in Waves, 490–492 Diffraction, 494–495 Lenses, 501 Formation of Images, 502–503 Representing Information Digitally, 542 Storing Pictures in Digital Code, 543 Storing Sounds in Digital Code, 544 Computer Memory, 545 Advantages and Disadvantages of Digital Information, 547 Audio Information, 549 Visual Information, 550–551 Medical Imaging, 552–553 Antennas, 554–555 **Inquiry Lab:** Mechanical Waves **Digital Activity:** Properties of Waves, Music Storage for Home Recording, Electromagnetic Waves and Their Properties **Engineering Workbench:** Rover
Cross Cutting 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.	**Student Experience Notebook:** CCC Matter and Energy, 411 Ohm's Law, 422 Ohmic Materials, 423 Kirchhoff's Junction Rule, 430 CCC Energy and Matter, 434 Direct Current Generators, 437 CCC Energy and Matter, 479 Standing Waves, 485 Waves on a String, 486 Standing Waves on a Rope, 487 Transfer of Wave Energy, 488 Energy in Waves, 490–491 SEP Develop a Model, 492 **Inquiry Lab:** Build a Battery **Digital Activity:** Power Generation

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Systems and Systems 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.	**Student Experience Notebook:** SEP Use Models, 396 SEP Analyze and Interpret Data, 397 SEP Develop a Model, 466 SEP Argue from Evidence, 471 SEP Develop a Model, 478 SEP Develop a Model, 482 SEP Develop a Model, 483 SEP Use a Model, 490 SEP Use a Model, 491 SEP Develop a Model, 493 SEP Evaluate and Communicate Information, 496 SEP Develop a Model, 508 SEP Develop a Model, 519
(SC.HS.1.11) 11. Both an electromagnetic wave model and a photon model explain features of electromagnetic radiation broadly and describe common applications of electromagnetic radiation.	
Students Can:	
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. (HS-PS4-3) (Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.) (Boundary Statement: Does not include using quantum theory.)	**Student Experience Notebook:** SEP Evaluate Claims, 521 SEP Argue from Evidence, 523 **Inquiry Lab:** Particle Nature of Light **Digital Activities:** Particle-Wave Duality of Light, Particle-Wave Duality
Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. (HS-PS4-4) (Clarification Statement: Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Some examples may include: sunscreen SPF, lasers stimulating particular material to resonate at a particular frequency, and a discussion of how color is perceived as it relates to frequency. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.)	**Student Experience Notebook:** SEP Evaluate Claims, 521 Damage to Living Cells, 534–535 SEP Evaluate Claims, 535 **Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** Sunscreen and UV Protection **Performance-Based Assessment:** Clothing and Sun Protection

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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. (HS-PS4-5) (Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.) (Boundary Statement: Limited to qualitative information and does not include band theory.)	**Student Experience Notebook:** CCC Energy and Matter, 549 SEP Construct Explanations, 552 SEP Construct Explanations (21), 556 SEP Construct Explanations (23), 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
Colorado Essential Skills and Science and Engineering Practices:	
Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (Engaging in Argument from Evidence) (Personal: Initiative/Self-direction)	**Student Experience Notebook:** SEP Analyze and Interpret Data, 489 SEP Argue from Evidence, 489 SEP Argue from Evidence, 502 SEP Argue from Evidence, 508 SEP Analyze and Interpret Data, 509 SEP Engage in Argument from Evidence, 509 SEP Argue from Evidence, 513 SEP Argue from Evidence, 515 SEP Construct an Argument, 516 SEP Use Evidence, 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
Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. 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). (Obtaining, Evaluating, and Communicating Information) (Entrepreneurial: Inquiry/Analysis)	**Student Experience Notebook:** SEP Evaluate Claims, 535 SEP Evaluate Claims, 536 **Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** Sunscreen and UV Protection **Performance-Based Assessment:** Clothing and Sun Protection

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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.	**Student Experience Notebook:** Energy in Waves, 490–492 Diffraction, 494–495 Refraction, 498–500 Formation of Images, 502–503 Intensity of Polarized Light, 518–519 Shortcomings of the Wave Theory, 520–521 Photoelectric Effect, 522 **Digital Activities:** Electromagnetic Waves and Their Properties, Laser Interference, Particle- Wave Duality, Light Intensity and Energy
Elaboration on the GLE:	
Students can answer the questions: What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there?	**Student Experience Notebook:** SEP Define Problems, 123 SEP Construct an Explanation, 382 CCC Energy and Matter, 383 SEP Construct an Explanation, 480 CCC Scale, Proportion, and Quantity, 495 SEP Evaluate and Communicate Information, 496 SEP Argue from Evidence, 515 CCC Energy and Matter, 519 SEP Evaluate Claims, 535 SEP Construct Explanations, 562 CCC Energy and Matter, 669 SEP Evaluate Scientific Information, 683 CCC Energy and Matter, 684

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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. 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-ray s, gamma rays) can ionize atoms and cause damage to living cells. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**Student Experience Notebook:** Diffraction, 494–495 Reflection, 496–497 Refraction, 498–500 Lenses, 501 Formation of Images, 502–503 The Lens Equation, 504 Image of a Rubber Duck, 505 Reading with a Magnifying Glass, 506–507 Photoelectric Effect, 522 Particles of Light, 523 Photon-Electron Interactions, 529 Photon Energy Absorption by Matter, 530–531 Blackbody Radiation, 532–533 Damage to Living Cells, 534–536 Energy from the Sun, 558 Solar Panels, 559 Gamma Decay, 616 **Inquiry Labs:** Electromagnetic Radiation and Matter, Particle Nature of Light, Converting Sunlight to Electricity **Digital Activity:** EM Radiation and Matter
Cross Cutting 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. Systems can be designed to cause a desired effect.	**Student Experience Notebook:** Electromotive Force, 229 Electromagnetic Energy, 409 What Causes Current? 421 Electric Generators, 435 Induction Devices, 442 Solar Panels, 559 SEP Construct Explanations, 559 **Inquiry Lab:** Converting Sunlight to Electricity **Digital Activities:** Junkyard Electromagnet, Electric Potential, Potential Difference in a Battery, Energy in Electric Circuits, Electric Circuits, Magnetic Forces, Combining Magnetic Fields, Solar Panels on a Cloudy Day

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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.	**Student Experience Notebook:** SEP Develop a Model, 482 SEP Develop a Model, 483 SEP Use a Model, 491 SEP Develop a Model, 508 CCC Systems and System Models, 511 SEP Develop a Model, 519 SEP Develop a Model, 521 SEP Use a Model, 522 SEP Develop a Model, 528 **Digital Activities:** Electromagnetic Waves and Their Properties, Particle-Wave Duality
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).	**Student Experience Notebook:** SEP Reason Quantitatively, 556 SEP Obtain Information, 561 Radiotherapy, 563 CCC Matter and Energy, 564 SEP Design Solutions, 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

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Influence of Engineering, Technology, and Science on Society and the Natural World: Modern civilization depends on major technological systems.	**Student Experience Notebook:** What Causes Current, 421 Ohm's Law, 422 Ohmic Materials, 423 Circuit Elements and Diagrams, 424–425 Measurements for Circuits, 426 Joule's Law, 427 Kirchhoff's Loop Rule, 428 Kirchhoff's Junction Rule, 430 Analyzing a Circuit, 431 CCC Energy and Matter, 434 Electric Generators, 435 Alternating Current Generators, 436 Direct Current Generators, 437 Motors, 439 Starting a Motor, 440–441 Induction Devices, 442–443 CCC Energy and Matter, 444 Standing Waves, 485 Waves on a String, 486 Standing Waves on a Rope, 487 Transfer of Wave Energy, 488–489 **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
(SC.HS.1.12) 12. Multiple technologies that are part of everyday experiences are based on waves and their interactions with matter.	
Students Can:	
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. (HS-PS4-5) (Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.) (Boundary Statement: Limited to qualitative information. Does not include band theory.)	**Student Experience Notebook:** CCC Energy and Matter, 549 SEP Construct Explanations, 552 SEP Construct Explanations (21), 556 SEP Construct Explanations (23), 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

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Colorado Essential Skills and Science and Engineering Practices:	
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). (Obtaining, Evaluating, and Communicating Information) (Professional: Information literacy)	**Student Experience Notebook:** SEP Argue from Evidence, 489 SEP Construct an Explanation, 492 SEP Argue from Evidence, 513 SEP Argue from Evidence, 515 SEP Construct an Explanation, 531 SEP Obtain Information, 555 SEP Construct Explanations, 559 SEP Construct an Argument, 561 **Inquiry Labs:** Reflection and Refraction, Converting Electrical Signals to Sounds, Converting Sunlight to Electricity **Engineering Workbench:** Rover
Influence of Engineering, Technology, and Science on Society and the Natural World: Modern civilization depends on major technological systems.	**Student Experience Notebook:** What Causes Current, 421 Ohm's Law, 422 Ohmic Materials, 423 Circuit Elements and Diagrams, 424–425 Measurements for Circuits, 426 Joule's Law, 427 Kirchhoff's Loop Rule, 428 Kirchhoff's Junction Rule, 430 SEP Design a Solution, 434 Electric Generators, 435 Motors, 439 Induction Devices, 442–443 CCC Energy and Matter, 444 Transfer of Wave Energy, 488–489 **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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Elaboration on the GLE:	
Students can answer the question: How are instruments that transmit and detect waves used to extend human senses?	**Student Experience Notebook:** CCC Energy and Matter, 549 SEP Construct Explanations, 552 SEP Construct Explanations (21), 556 SEP Construct Explanations (23), 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
PS4:C Information Technologies and Instrumentation: 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.	**Student Experience Notebook:** Waves on a String, 486–487 Transfer of Wave Energy, 488–489 Energy in Waves, 490–492 Audio Information, 549 Visual Information, 550–551 Medical Imaging, 552–553 Antennas, 554–555 **Inquiry Lab:** Converting Electrical Signals to Sounds **Performance-Based Assessment:** Send Messages with a Telegraph
Cross Cutting Concepts:	
Cause and Effect: Systems can be designed to cause a desired effect.	**Student Experience Notebook:** Solar Panels, 559 SEP Construct Explanations, 559 **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).	**Student Experience Notebook:** SEP Reason Quantitatively, 556 SEP Obtain Information, 561 Radiotherapy, 563 CCC Matter and Energy, 564 SEP Design Solutions, 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