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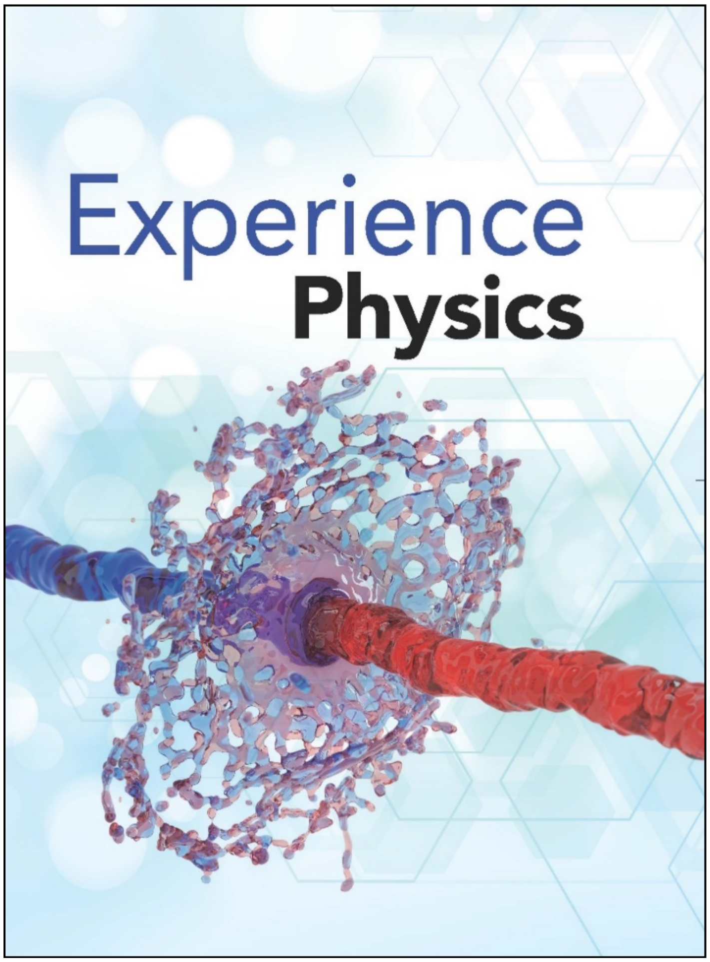

to the

Utah Science with Engineering Education (SEEd) Standards 2019 High School Physics

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Table of Contents

A Correlation of Experience Physics ©2022 to the
Utah Science with Engineering Education (SEEd) Standards 2019
High School Physics

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.1) Forces and Interactions	
(PHYS.1.1) Analyze and interpret data to determine the cause and effect relationship between the net force on an object and its change in motion as summarized by Newton's Second Law of Motion. Emphasize one-dimensional motion and macroscopic objects moving at non-relativistic speeds. Examples could include objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.	**Student Experience Notebook:** 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 CCC Cause and Effect, 48 CCC Cause and Effect, 51 CCC Cause and Effect, 52 Force Causes an Acceleration, 54 Momentum, 56 Representing Forces, 58 Mowing the Lawn, 55 Modeling Force, 60 Writing Force-Acceleration Equations, 61 SEP Analyze and Interpret Data, 64 SEP Analyze and Interpret Data, 66 CCC Cause and Effect, 70 SEP Argue from Evidence, 71 SEP Use Mathematics, 72 CCC Cause and Effect, 76 CCC Cause and Effect, 78 CCC Cause and Effect, 80 CCC Cause and Effect, 94 **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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(PHYS.1.2) Use mathematics and computational thinking to support the claim that the total momentum of a system is conserved when there is no net force acting on the system. Emphasize the quantitative conservation of momentum in interactions and the qualitative meaning of this principle. Examples could include one-dimensional elastic or inelastic collisions between objects within the system.	**Student Experience Notebook:** SEP Use Mathematics, 323 SEP Use Mathematics, 324 SEP Use Mathematics, 327 SEP Construct an Explanation, 328 SEP Use Mathematics, 329 SEP Argue From Evidence, 331 Conserving Momentum in Space, 332 Conserving Angular Momentum, 333 SEP Use Models, 333 SEP Use Mathematics, 336 Impulse and Momentum in Collisions, 338 High-Speed Collision, 341 SEP Use Mathematics, 343 Inelastic Collision, 346 **Teacher Guide:** **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
(PHYS.1.3) Design a solution that has the function of minimizing the impact force on an object during a collision. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize problems that require application of Newton's Second Law of Motion or conservation of momentum.	**Student Experience Notebook:** SEP Construct an Explanation, 347 Investigation Assessment, 363 **Teacher Guide:** **Digital Activity:** Minimizing Car Crash Injuries **Engineering Workbench:** Egg Supply Drop **Performance-Based Assessment:** Build Your Own Egg-Transport Vehicle

A Correlation of Experience Physics ©2022 to the Utah Science with Engineering Education (SEEd) Standards 2019 High School Physics

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.2) Energy	
(PHYS.2.1) Analyze and interpret data to track and calculate the transfer of energy within a system. Emphasize the identification of the components of the system, along with their initial and final energies, and mathematical descriptions to depict energy transfer in the system. Examples of energy transfer could include the transfer of energy during a collision or heat transfer.	**Student Experience Notebook:** Energy Bar Charts, 289 Modeling Systems, 311 Revisit Investigative Phenomenon, #60, 318 Sample Problem: Inelastic Collision, 346 Practice Problem, #31, 346 Transferring Energy Through Heating, 374-375 SEP Analyze Data, 375 SEP Use Mathematics, 376 Revisit Investigative Phenomenon, #22, #23, 380 **Teacher Guide:** **Inquiry Lab:** The Impact of Position on Energy; Pendulums and the Conservation of Energy; Elastic and Inelastic Collisions; Heat Transfer **Digital Activities:** Mechanical Energy; Thermal Equilibrium and Heat Flow **Performance-Based Assessment:** Heating Curve of Water
(PHYS.2.2) 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. Emphasize that uniform distribution of energy is a natural tendency. Examples could include the measurement of the reduction of temperature of a hot object or the increase in temperature of a cold object.	**Student Experience Notebook:** SEP Plan an Investigation, 365 Transferring Energy Through Heating, 374–375 The First Law of Thermodynamics, 376 Thermodynamic Processes, 377 CCC Systems and System Models, 380 The Second Law of Thermodynamics, 384–385 Thermodynamic Heat Engines, 386–387 Thermodynamic Cycles, 388–389 SEP Design a Solution, 393 SEP Construct an Explanation, 393 **Teacher Guide:** **Inquiry Lab:** Heat Transfer **Digital Activity:** Thermal Equilibrium and Heat Flow **Performance-Based Assessments:** Heating Curve of Water; Meltdown at the Pool **Engineering Workbench:** Build an Efficient Travel Mug

A Correlation of Experience Physics ©2022 to the
Utah Science with Engineering Education (SEEd) Standards 2019
High School Physics

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.2.3) Develop and use models on the macroscopic scale to illustrate that energy can be accounted for as a combination of energies associated with the motion of objects and energy associated with the relative positions of objects. Emphasize relationships between components of the model to show that energy is conserved. Examples could include mechanical systems where kinetic energy is transformed to potential energy or vice versa.	**Student Experience Notebook:** Defining Energy of Motion, 287 Potential Energy, 294 Gravitational Potential Energy, 295 Elastic Potential Energy, 296-297 Mechanical Energy Bar Charts, 303 Energy – A Conserved Quality, 309 Expanded Work-Energy Theorem, 312 SEP Develop a Model, 312 Energy Transformed Within a System, 313 SEP Develop a Model, 313 Revisit Investigative Phenomenon, #60, 318 **Teacher Guide:** **Inquiry Lab:** The Impact of Position on Energy; Pendulums and the Conservation of Energy **Digital Activities:** Mechanical Energy; Conservation of Energy **Performance-Based Assessment:** Rocket Launch
(PHYS.2.4) Design a solution by constructing a device that converts one form of energy into another form of energy to solve a complex real-life problem. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Examples of energy transformation could include electrical energy to mechanical energy, mechanical energy to electrical energy, or electromagnetic radiation to thermal energy.	**Student Experience Notebook:** SEP Design a Solution, 238 **Teacher Guide:** **Inquiry Labs:** Build a Battery, Electric Motors and Generators **Engineering Workbenches:** Build a Flashlight Without Batteries; Design a Roller Coaster **Performance-Based Assessments:** Build a DC Motor; Design, Build, and Refine a Wind-Turbine Rotor

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.2.5) Design a solution to a major global problem that accounts for societal energy needs and wants. Define the problem, identify criteria and constraints, develop possible solutions using models, analyze data to make improvements from iteratively testing solutions, and optimize a solution. Emphasize problems that require the application of conservation of energy principles through energy transfers and transformations. Examples of devices could include one that uses renewable energy resources to perform functions currently performed by nonrenewable fuels or ones that are more energy efficient to conserve energy.	**Student Experience Notebook:** Energy Use, Population, and Impact, 446 Human Power Needs, 449-450 Energy Storage Technologies, 451 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 Sustainable Energy Future, 458–459 SEP Design a Solution, 497 SEP Design a Solution, 528 SEP Design Solutions, 551 Energy from the Sun, 558 **Teacher Guide:** **Inquiry Labs:** Converting Sunlight to Electricity, Natural Resource Management **Digital Activities:** Resource Use and Biodiversity Trade Offs, Operate a Nuclear Fission Reactor **Performance-Based Assessment:** Design, Build and Refine a Wind-Turbine Rotor
(PHYS.3) Fields	
(PHYS.3.1) Use mathematics and computational thinking to compare the scale and proportion of gravitational and electric fields using Newton's Law of Gravitation and Coulomb's Law. Emphasize the comparative strength of these two field forces, the effect of distance between interacting objects on the magnitudes of these forces, and the use of models to understand field forces.	**Student Experience Notebook:** Gravitational Force, 118-119 SEP Use a Model, 119 SEP Develop a Model, 119 Sample Problem: Earth and the Moon, 120 Practice Problem, #11, 120 Gravitational Fields, 121-123 SEP Use Mathematics, 128 Electric Force, 158-159 SEP Use Mathematics, 159 SEP Systems and System Models, 160 Sample Problem: Electric Force Between Particles, 161 Practice Problem, #10, 161 Comparing Electric and Gravitational Forces, 162 Sample Problem: Electric Field Due to Two Charges, 173 SEP Systems and System Models, 174 SEP Use Math, 175 **Teacher Guide:** **Inquiry Lab:** Electric Charges and Coulomb's Law **Digital Activities:** Universal Gravitation; Coulomb's Law

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.3.2) Plan and conduct an investigation to provide evidence that an electric current causes a magnetic field and that a changing magnetic field causes an electric current. Emphasize the qualitative relationship between electricity and magnetism without necessarily conducting quantitative analysis. Examples could include electromagnets or generators.	**Student Experience Notebook:** Magnetic Force on a Wire, 213–215 SEP Plan an Investigation, 214 Modeling a Simple Motor, 219 Current and Magnetic Fields, 220–222 **Teacher Guide:** **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
(PHYS.3.3) Analyze and interpret data to compare the effect of changes in position of interacting objects on electric and gravitational forces and energy. Emphasize the similarities and differences between charged particles in electric fields and masses in gravitational fields. Examples could include models, simulations, or experiments that produce data or illustrate field lines between objects.	**Student Experience Notebook:** Gravitational Force, 118-119 SEP Use a Model, 119 SEP Develop a Model, 119 Inverse Square Laws, 123 Electric Force, 158-159 SEP Use Mathematics, 159 Comparing Electric and Gravitational Forces, 162 Electric Field, 172 SEP Use Models, 172 Sample Problem: Electric Field Due to Two Charges, 173 Field Lines for Multiple Charges, 175 SEP Use a Model, 175 **Teacher Guide:** **Inquiry Labs:** Electric Fields **Digital Activities:** Universal Gravitation; Charges and Fields; Modeling Electric Fields

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.3.4) Develop and use a model to evaluate the effects on a field as characteristics of its source and surrounding space are varied. Emphasize how a field changes with distance from its source. Examples of electric fields could include those resulting from point charges. Examples of magnetic fields could include those resulting from dipole magnets or current-bearing wires.	**Student Experience Notebook:** Electric Force, 158-159 Electric Field, 172 SEP Use Models, 172 Magnetic Fields, 203-204 Modeling Multiple Magnets, 205 SEP Develop a Model, 205 Revisit Investigative Phenomenon, #23, 212 SEP Develop a Model, 217 Current and Magnetic Fields, 220-222 SEP Develop and Use a Model, 220 **Teacher Guide:** **Inquiry Labs:** Electric Fields; Magnetic Force and Separation Distance **Digital Activities:** Electric Fields; Modeling Electric Fields; Magnetic Fields; Combining Magnetic Fields **Performance-Based Assessment:** Build and Test an Electroscope
(PHYS.4) Waves	
(PHYS.4.1) Analyze and interpret data to derive both qualitative and quantitative relationships based on patterns observed in frequency, wavelength, and speed of waves traveling in various media. Emphasize mathematical relationships and qualitative descriptions. Examples of data could include electromagnetic radiation traveling in a vacuum or glass, sound waves traveling through air or water, or seismic waves traveling through Earth.	**Student Experience Notebook:** Properties of Waves, 467 SEP Analyze Data, 467 SEP Use Mathematics, 467 SEP Analyze and Interpret Data, 469 Sample Problem: Wave on a Rope, 470 Practice Problems, #8, #9, 470 SEP Argue from Evidence, 471 Sample Problem: Properties of Sound Waves, 474 Modeling Waves, 475 Sample Problem: Modeling a Sound Wave, 476 Practice Problems, #16-#20, 477 Revisit Investigative Phenomenon, #22, 478 **Teacher Guide:** **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

A Correlation of Experience Physics ©2022 to the
Utah Science with Engineering Education (SEEd) Standards 2019
High School Physics

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	Experience Physics ©2022
(PHYS.4.2) Engage in argument based on evidence that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model better explains interactions within a system than the other. Emphasize how the experimental evidence supports the claim and how models and explanations are modified in light of new evidence. Examples could include resonance, interference, diffraction, or the photoelectric effect.	**Student Experience Notebook:** Wave Behavior of Electromagnetic Radiation, 516 SEP Construct and Argument, 516 Shortcomings of Eave Theory, 520 Photoelectric Effect, 521 SEP Evaluate Claims, 521 Particles of Light, 523 SEP Argue from Evidence, 523 **Teacher Guide:** **Inquiry Lab:** Particle Nature of Light **Digital Activities:** Particle-Wave Duality of Light, Particle-Wave Duality
(PHYS.4.3) Evaluate information about the effects that different frequencies of electromagnetic radiation have when absorbed by biological materials. Emphasize that the energy of electromagnetic radiation is directly proportional to frequency and that the potential damage to living tissue from electromagnetic radiation depends on the energy of the radiation.	**Student Experience Notebook:** Photon-Electron Interactions, 529 CCC Energy and Matter, 529 Photon Energy Absorption by Matter, 530–531 SEP Construct an Explanation, 531 Blackbody Radiation, 532–533 Damage to Living Cells, 534–536 SEP Evaluate Claims, 535 SEP Evaluate Claims, 536 **Teacher Guide:** **Inquiry Lab:** Electromagnetic Radiation and Matter **Digital Activity:** Sunscreen and UV Protection **Performance-Based Assessment:** Clothing and Sun Protection
(PHYS.4.4) Ask questions and construct an explanation about the stability of digital transmission and storage of information and their impacts on society. Emphasize the stability of digital signals and the discrete nature of information transmission. Examples of stability and instability could include that digital information can be stored in computer memory, is transferred easily, copied and shared rapidly, can be easily deleted, has limited fidelity based on sampling rates, or is vulnerable to security breaches and theft.	**Student Experience Notebook:** 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 SEP Ask Questions, 547 Revisit Investigative Phenomenon, #14, 548 **Teacher Guide:** **Performance-Based Assessment:** Music Storage for Home Recording

Utah Science with Engineering Education (SEEd) Standards 2019: Physics	**Experience Physics ©2022**
(PHYS.4.5) Obtain, evaluate, and communicate information about how devices use the principles of electromagnetic radiation and their interactions with matter to transmit and capture information and energy. Emphasize the ways in which devices leverage the wave-particle duality of electromagnetic radiation. Examples could include solar cells, medical imaging devices, or communication technologies.	**Student Experience Notebook:** Medical Imaging, 552–553 Antennas, 554-555 SEP Obtain Information, 555 Capturing an EM Wave Energy, 557-559 Cooking, 562 Radiotherapy, 563 **Teacher Guide:** **Inquiry Labs:** Converting Sunlight to Electricity **Digital Activities:** Antennas, Solar Panels on a Cloudy Day