Westside High School
Physics Curriculum Map
2018-2019

Teacher: C. Campbell **Revised: June 2018**

Map is still under construction and will be revised throughout the year.

WESTSIDE HIGH SCHOOL PHYSICS CURRICULUM MAP

Teacher: C. Campbell

Topic 1: ~ 10 Weeks

Topic: Motion

Students investigate concepts of motion and create models, including algebraic expressions and conceptual models.

Essential Questions:

Students will investigate……

- Vectors
- 1-D Motion
- 2-D Motion
- Rotational Motion
- Projectile Motion
- Newton's Law of Gravity

Students will…..

- --Under Construction--

AR STANDARDS / SKILLS

CONTENT VOCABULARY WITHIN THE STANDARD WILL BE TAUGHT THROUGHOUT DAILY OBJECTIVES / GOALS.

P-PS1-1AR Create a model of motion and forces, including vectors graphed on the coordinate plane, to describe and predict the behavior of a system. [Clarification Statement: Emphasis is on vector addition for 1-D (frame of reference), 2-D motion (projectile, rotational motion), vectors applied to force diagrams, and vector direction for gravitational forces.]

P-PS1-2AR Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electrical fields.]
P-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [AR Clarification Statement: Examples of data could include tables and graphs of position or velocity as functions of time for objects subject to a net unbalanced force (falling object, object rolling down a ramp, moving object being pulled by a constant force.]
P-PS2-2 Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [AR Clarification Statement: Emphasis is on balanced and unbalanced forces (Newton's first law) in a system, qualitative and quantitative comparisons of forces, mass and changes in motion (Newton's second law), frame of reference, and specification of units.] [Assessment Boundary: Assessment includes use of trigonometry.]
P-ESS1-2 Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [AR Clarification Statement: Emphasis is on gravity as the force that holds the solar system and Milky Way galaxy together and controls orbital motions within them. Examples of models could be physical (analogy of distance along a football field, computer simulations of elliptical orbits) or conceptual (mathematical proportions relative to size of familiar objects).]
P-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system. [AR Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions as they apply to human-made satellites, planets, and moons.]
P1-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Problems could include acceleration factors (one-dimensional motion), vectors (two-dimensional motion), and gravity (Newton's laws).]

Science/Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts:	
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. ● Use a model to predict the relationships between systems or between components of a system. (P-PS1-1AR, P-ESS1-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ● 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	**PS2.A: Forces and Motion** ● Newton's second law accurately predicts changes in the motion of macroscopic objects. (P-PS2-1, P-PS2-2, P-PS-1-1AR, P-ESS1-2, P-ESS1-4, P1-ETS1-2) **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.(P-PS1-2AR, P-ESS1-2) **ETS1.C: Optimizing the Design Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.	**Patterns** ● Empirical evidence is needed to identify patterns. (P-ESS1-4) ● 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. (P-ESS1-2 P-ESS1-4) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.(P-PS1-2AR, P-PS2-2, P-ESS1-2) ● Systems can be designed to cause a desired effect. (P-PS1-2AR, P-PS2-2, P-ESS1-2) **Systems and System Models**	

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. (P-PS2-2) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical representations of phenomena to support claims. (P-PS1-2AR, P-ESS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● 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	(P1-ETS1-2) **ETS1.C: Optimizing the Design Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (P1-ETS1-2)	● 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. (P-PS1-1AR) ● 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. (P-PS1-1AR) **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. (P-PS2-1) ------------------------------------- **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. (P-PS1-2AR, P-ESS1-2) ● Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (P-PS1-2AR,	

will continue to do so in the future. (P1-ETS1-2) • Refine a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (P1-ETS1-2) • Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations. (P1-ETS1-2) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (P-PS2-1) • Analyze data using computational models in order to make valid and reliable scientific claims. (P-PS2-1)		P-ESS1-2) ------------------------------------- **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (P1-ETS1-2) **Influence of Engineering, Technology, and Science on Society and the Natural World** • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (P1-ETS1-2) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (P1-ETS1-2)	
Activities/Skills	**Assessments**	**Resources**	**Vocabulary**
• --Under Construction--	• --Under Construction--	• --Under Construction--	• --Under Construction--

<u>Topic 2:</u> ~ 6 Weeks

Topic: Work and Energy

Students conduct investigations and use mathematical models to evaluate kinetic and potential energy of systems.

Essential Questions:

Students will investigate…

- Conservation of Energy
- Work
- Energy
- Power
- Impulse

Students will…..

- --Under Construction--

AR STANDARDS / SKILLS

CONTENT VOCABULARY WITHIN THE STANDARD WILL BE TAUGHT THROUGHOUT DAILY OBJECTIVES / GOALS

P-PS2-1AR Develop computational and graphical models to calculate and illustrate the work done and changes in energy in a system. [Clarification Statement: Emphasis is on force vs. displacement graph.]
P-PS2-2AR Plan and conduct an investigation to provide evidence that work done equals energy stored in a conservative system. [Clarification Statement: An example of an investigation could include Hooke's law where energy is stored in a spring.]
P-PS2-3AR Plan and conduct an investigation to rate the power used in performing work on a system. [Clarification Statement: Emphasis is on the quantitative determination of power in interactions. Examples could include use of pulleys and electric motors.]
P-PS2-4AR Analyze data to demonstrate the relationship between rotational and linear motion, energy, and momentum. [Clarification Statement: Emphasis is on linear motion and angular motion, force and torque, linear momentum and angular momentum, and linear kinetic energy and rotational kinetic energy, mass and moment of inertia.]

P-PS2-5AR Use mathematical representations to support the claim that the change in kinetic energy of a system is equal to the net work performed upon the system. [Clarification Statement: Emphasis is on quantitative kinetic energy in interactions.]
P-PS2-6AR Use mathematical representations to support the claim that the total impulse on a system of objects is equal to the change in momentum of the system. [Clarification Statement: Emphasis is on quantitative conservation of momentum in interactions.]
P2-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade- offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. [AR Clarification Statement: Examples could include analysis of nuclear, coal, and hydroelectric power plants.]

Science/Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts:	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (P-PS2-1AR) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (P2-ETS1-3) ● Design a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations. (P2-ETS1-3)	**PS2.A: Forces and Motion** ● Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (P-PS2-6AR) ● In any system, total momentum is always conserved. 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. (P-PS2-6AR) **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. (P-PS2-2AR) **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	**Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (P-PS2-4AR, P-PS2-5AR) ● 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. (P-PS2-4AR, P-PS2-5AR) ● Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (P-PS2-4AR, P-PS2-5AR) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (P-PS2-6AR) ● Systems can be designed to cause a desired effect. (P-PS2-6AR) **Systems and System Models** ● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.	

• Evaluate a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade off considerations. (P2-ETS1-3) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (P-PS2-5AR, P-PS2-6AR) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • 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. (P-PS2-2AR, P-PS2-3AR)	or destroyed, but it can be transported from one place to another and transferred between systems. (P-PS2-2AR) • 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. (P-PS2-2AR) **PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a force field change relative position, the energy stored in the force field is changed. (P-PS2-1AR, P-PS2-3AR, P-PS2-5AR) **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. Machines are judged as efficient or inefficient based on the amount of energy input needed to perform a particular useful task. Inefficient machines are those that produce more waste heat while performing a task and thus require more energy input. It is therefore important to design for high efficiency so as to reduce costs, waste materials, and many environmental impacts. (P2-ETS1-3) **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of	(P-PS2-1AR, P-PS2-2AR, P-PS2-3AR) • 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. (P-PS2-1AR, P-PS2-2AR, P-PS2-3AR) ------------------------------------ **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. (P2-ETS1-3) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (P2-ETS1-3) ------------------------------------ **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. (P-PS2-1AR, P-PS2-2AR,	

Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (P-PS2-4AR) -- **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. (P-PS2-2AR, P-PS2-3AR) ● Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (P-PS2-2AR, P-PS2-3AR)	risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (P2-ETS1-3) ● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (P2-ETS1-3) **ETS1.B: Developing Possible Solutions** ● When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (P2-ETS1-3) ● Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (P2-ETS1-3) **ETS1.C: Optimizing the Design Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (tradeoffs) may be needed. (P2-ETS1-3)	P-PS2-3AR)	

Activities/Skills	Assessments	Resources	Vocabulary/Terms
• --Under Construction--	• --Under Construction--	• --Under Construction--	--Under Construction--

Topic 3: ~ 6 Weeks

Topic: Heat and Thermodynamics

Students use computational models to investigate the conservation of energy and the total change of energy in a system.

Essential Questions:

Students will investigate…

- Kinetic Molecular Theory
- Law of Thermodynamics
- Pressure
- Fluid Dynamics

Students will…..

- --Under Construction--

AR STANDARDS / SKILLS

CONTENT VOCABULARY WITHIN THE STANDARD WILL BE TAUGHT THROUGHOUT DAILY OBJECTIVES / GOALS.

P-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [AR Clarification Statement: Emphasis is on systems of two or three components, thermal energy, kinetic energy, and energies in gravitational, magnetic, and electric fields.]
P-PS3-1AR Construct an explanation based on evidence of the relationships between heat, temperature, and the Kinetic Molecular Theory. [Clarification Statement: Emphasis on planning and conducting experiments to collect and analyze data. An example could include measuring temperature changes related to phase change and specific heat.]
P-PS3-2AR Plan and conduct an investigation of the relationships between pressure, volume, temperature, and amount of gas. [Clarification Statement: Emphasis is on use of gas law apparatuses.]
P-PS3-3AR Use mathematical representations to model the conservation of energy in fluids. [Clarification Statement: Emphasis is on fluid dynamics as expressed in Bernoulli's equation and Pascal's principle.]
P-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [AR Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. 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.]

P-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [AR Clarification Statement: Emphasis is on mathematical thinking to describe energy changes. Examples of investigations could include mixing liquids at different initial temperatures and adding objects at different temperatures to water.]
P3-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. [AR Clarification Statement: Examples could include use of wind and solar energy and total energy loss from homes.]
P3-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. [AR Clarification Statement: Examples could include designing and building a machine, using schematics to break down an engine into major functional blocks, and designing improvements to reduce total energy loss from a home.]
P3-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. [AR Clarification Statement: Examples could include evaluating the different parts of a machine, the entire machine, and reducing energy loss in homes.]
P3-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real- world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. [AR Clarification Statement: Examples could include analyzing potential and kinetic energy efficiency (windmills, roller coasters) and modeling energy loss in homes with and without proposed improvements.]

Science/Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts:	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (P-PS3-1, P3-ETS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning	**PS2.C: Stability and Instability in Physical Systems** ● Systems often change in predictable ways; understanding the forces that drive the transformations and cycles within a system, as well as the forces imposed on the system from the outside, helps predict its behavior under a variety of conditions. (P-PS3-4) ● When a system has a great number of component pieces, one may not be able to predict much about its precise future. For such systems (e.g., with very many colliding molecules), one can often predict average but not detailed properties and behaviors (e.g., average temperature, motion, and rates of chemical change but not the trajectories or other changes of particular molecules). (P-PS3-4, P-PS3-1AR, P-PS3-2) PS3.A: **Definitions of Energy**	**Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (P-PS3-3, P-PS3-4, P-PS3-3AR) ● 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. (P-PS3-3, P-PS3-4, P-PS3-3AR) ● Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems. (P-PS3-3, P-PS3-4, P-PS3-3AR) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (P-PS3-1,	

and data support the explanation or conclusion. (P-PS3-1AR, P-PS3-3, P3-ETS1-2) ● Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (P-PS3-1AR, P-PS3-3, P3-ETS1-2) ● Evaluate a solution to a complex real-world problem, based on scientific knowledge, student generated sources of evidence, prioritized criteria, and trade ● off considerations. (P-PS3-1AR, P-PS3-3, P3-ETS1-2) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (P-PS3-3AR) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual,	● 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. (P-PS3-1) **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. (P-PS3-1AR, P-PS3-3) ● 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). Any object or system that can degrade with no added energy is unstable. Eventually it will do so, but if the energy releases throughout the transition are small, the process duration can be very long (e.g., long-lived radioactive isotopes). (P-PS3-4) PS3.D: **Energy in Chemical Processes** ● Although energy cannot be destroyed, it can be converted to less useful forms—for example,	P-PS3-1AR, P-PS3-2AR) Systems can be designed to cause a desired effect. (P-PS3-1, P-PS3-1AR, P-PS3-2AR) ------------------------------------- **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. (P-PS3-1AR, P-PS3-2AR, P-PS3-4) ● Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (P-PS3-1AR, P-PS3-2AR, P-PS3-4) ------------------------------------- **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** ● Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (P3-ETS1-1, P3-ETS1-2, P3-ETS1-3, P3-ETS1-4) ● **Influence of Engineering, Technology, and Science on Society and the Natural World** Engineers continuously modify these	

mathematical, physical, and empirical models. • 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. (P-PS3-2AR, P-PS3-4) **Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (P3-ETS1-1, P3-ETS1-3)	to thermal energy in the surrounding environment. Machines are judged as efficient or inefficient based on the amount of energy input needed to perform a particular useful task. Inefficient machines are those that produce more waste heat while performing a task and thus require more energy input. It is therefore important to design for high efficiency so as to reduce costs, waste materials, and many environmental impacts (P-PS3-3, P3-ETS1-1) **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (P3-ETS1-1, P3-ETS1-3) • Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (P3-ETS1-1, P3-ETS1-3) **ETS1.B: Developing Possible Solutions** • When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider	technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (P3-ETS1-1, P3-ETS1-2, P3-ETS1-3, P3-ETS1-4) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (P3-ETS1-1, P3-ETS1-2, P3-ETS1-3, P3-ETS1-4)	

	social, cultural, and environmental impacts. (P3-ETS1-2, P3-ETS1-4)		
Activities/Skills	**Assessments**	**Resources**	**Vocabulary/Terms**
• --Under Construction--	• --Under Construction--	• --Under Construction--	• --Under Construction--

Topic 4: ~ 6 Weeks

Topic: Waves, Sound, and Simple Harmonic Motion

Students use data to analyze wave properties and create visual and mathematical representations for the propagation of light and sound. Students use principles of simple harmonic motion to relate periodic properties of waves to vibrations. The differences and similarities of mechanical waves and electromagnetic waves are investigated through experiments involving light and sound.

Essential Questions:

Students will investigate……

- Longitudinal/Transverse
- Light
- Optics

Students will…..

- --Under Construction--

AR STANDARDS / SKILLS

CONTENT VOCABULARY WITHIN THE STANDARD WILL BE TAUGHT THROUGHOUT DAILY OBJECTIVES / GOALS.

P-PS4-1AR Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, speed, and energy of waves traveling in various media. [Clarification Statement: Emphasis is on the dependence of wave speed upon media properties and the proportionality between the quantities (frequency and speed, wavelength and speed, frequency and wavelength, energy and wavelength).]
P-PS4-2AR Develop and use models to investigate longitudinal and transverse waves in various media. [Clarification Statement: Emphasis is on structure and function of waves.]
P-PS4-3AR Develop and use models to describe the interaction of light with matter. [Clarification Statement: Emphasis is on both geometric (ray diagrams) and algebraic models (mirror and thin lens equation, Snell's law).]
P4-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real- world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem. [AR Clarification Statement: Emphasis is on solutions with various constraints and criteria. An example could include effect of wind resistance on structural integrity of a skyscraper as a function of its height.]

Science/Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts:	

Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9-12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (P-PS4-1AR) • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (P4-ETS1-4) **Developing and Using Models** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model to predict the relationships between systems or between components of a system. (P-PS4-2AR, P-PS4-3AR, P4-ETS1-4) --- **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	**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.(P-PS4-1AR, P-PS4-2AR) • The reflection, refraction, and transmission of waves at an interface between two media can be modeled on the basis of these properties.(P-PS4-3) • Resonance is a phenomenon in which waves add up in phase in a structure, growing in amplitude due to energy input near the natural vibration frequency. Structures have particular frequencies at which they resonate. This phenomenon (e.g., waves in a stretched string, vibrating air in a pipe) is used in speech and in the design of all musical instruments. (P4-ETS1-4) **ETS1.B: Developing Possible Solutions** • Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (P4-ETS1-4)	**Patterns** • Empirical evidence is needed to identify patterns. (P-PS4-1AR, P-PS4-3AR) • 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. (P-PS4-1AR, P-PS4-3AR) **Energy and Matter** • The total amount of energy and matter in closed systems is conserved. (P-PS4-1AR, P-PS4-3AR) • 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. (P-PS4-1AR, P-PS4-3AR) • Energy cannot be created or destroyed— it only moves between one place and another place, between objects and/or fields, or between systems. (P-PS4-1AR, P-PS4-3AR) **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. (P-PS4-2AR) ----------------------------- **Connections to Engineering, Technology, and Applications of**	

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. (P4-ETS1-4)		**Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). (P4-ETS1-4) **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems. (P4-ETS1-4)	
Activities/Skills	**Assessments**	**Resources**	**Vocabulary/Terms**
• --Under Construction--	• --Under Construction--	• --Under Construction--	--Under Construction--

Topic 5: ~ 4 Weeks

Topic: Electricity

Students analyze data related to the interaction of electric and magnetic fields. By creating circuits and measuring electrical quantities, students investigate fundamental laws governing electricity and magnetism. Students use Ohm's law and the power law to analyze aspects of electrical circuits.

Essential Questions:

Students will investigate……

- Potential Difference
- DC Circuits
- Power Laws
- Current and Voltage
- Transmission of Electricity
- Magnetism
- Static Charge
- Safety

Students will…..

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AR STANDARDS / SKILLS

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P-PS2-4 Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [AR Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of forces between static electric charges.]
P-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [AR Clarification Statement: Examples of investigations could be to create electromagnets and manipulate bar magnets through a coil of wire connected to an ammeter.]
P-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [AR Clarification Statement: Emphasis is on electric potential difference.]
P-PS5-1AR Use mathematical representations and conduct investigations to provide evidence of the relationships between power, current, voltage, and resistance. [Clarification Statement: Emphasis is on insulators and conductors accounting for Ohm's Law, total resistance for combinations of resistors, and P=IV.]

P-PS5-2AR Evaluate competing design solutions for construction and use of electrical consumer products.* [Clarification Statement: Examples could include efficiency of light bulbs (visible intensity vs. power) and thermal energy limits of wire.]
P-PS5-3AR Obtain and combine information on alternating and direct current circuits in various applications. [Clarification Statement: Examples could include why public utilities use AC while many devices use DC and energy loss in transmission of electricity.]
P5-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants. [AR Clarification Statement: Examples could include analysis of renewable energy systems for electricity generation and the effect of autonomous electric cars on the economy, society, and the environment.]

Science/Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts:	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (P-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (P-PS5-1AR, P5-ETS1-1) ● Design a solution to a complex real world problem, based on scientific knowledge, student-generated sources of	**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. (P-PS2-4) **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. (P-PS5-1AR) **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. (P-PS2-5) ● Mathematical expressions, which	**Systems and System Models** ● When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (P-PS5-1AR, P-PS5-2AR) ● 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. (P-PS5-1AR, P-PS5-2AR) **Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (P-PS2-4, P-PS2-5) ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale	

evidence, prioritized criteria, and trade off considerations. (P-PS5-1AR, P5-ETS1-1) ● Evaluate a solution to a complex real world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. (P-PS5-1AR, P-PS5-2AR, P5-ETS1-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (P-PS2-4, P-PS5-1AR) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. ● 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	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.(P-PS2-5) **PS3.C: Relationship Between Energy and Forces** ● When two objects interacting through a force field change relative position, the energy stored in the force field is changed.(P-PS3-2) **PS3.D: Energy in Chemical Processes** ● All forms of electricity generation and transportation fuels have associated economic, social, and environmental costs and benefits, both short and long term. (P-PS5-2AR, P-PS5-3AR) Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. Machines are judged as efficient or inefficient based on the amount of energy input needed to perform a particular useful task. Inefficient machines are those that produce more waste heat while performing a task and thus require more energy input. It is therefore important to design for high efficiency so as to reduce costs, waste materials, and many environmental impacts. (P-PS5-2AR, P-PS5-3AR) **PS4.C: Information Technologies and**	mechanisms within the system. (P-PS2-4, P-PS2-5) **Scale, Proportion, and Quantity** ● Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (P-PS3-2) ------------------------------- **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** ● Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (P-PS5-2AR, P5-ETS1-1)	

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. (P-PS2-5, P-PS5-1AR) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. ● Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (P-PS5-3AR) -- **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** ● Theories and laws provide explanations in science. (P-PS2-4) ● Laws are statements or descriptions of the relationships among observable phenomena. (P-PS2-4, P-PS5-1AR)	**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, and 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. Knowledge of quantum physics enabled the development of semiconductors, computer chips, and lasers, all of which are now essential components of modern imaging, communications, and information technologies. (Boundary: Details of quantum physics are not formally taught at this grade level.) (P-PS5-3AR) **ETS1.C: Optimizing the Design Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (P5-ETS1-1)		
Activities/Skills	**Assessments**	**Resources**	**Vocabulary/Terms**
● --Under Construction--	● --Under Construction--	● --Under Construction--	--Under Construction--