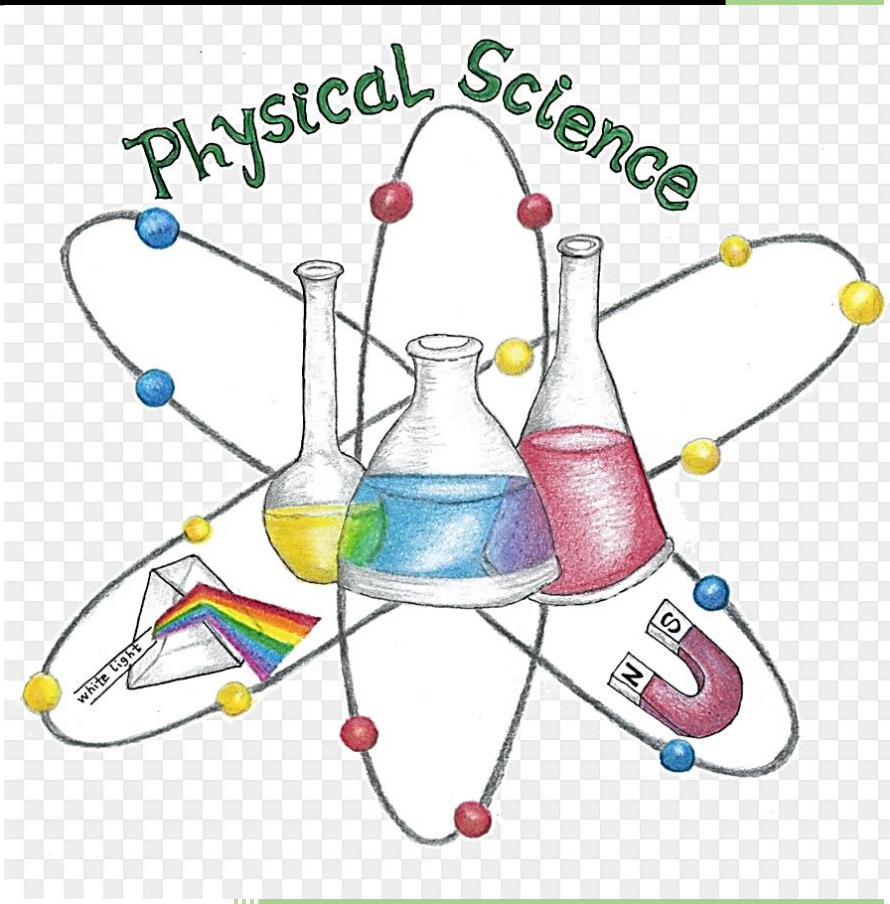
9th grade
Physical Science

A Field Guide to Alabama Science Standards



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9th grade Physical Science Compendium
Abbeville High School

Physical Science is a conceptual, inquiry-based course that provides students with an investigation of the basic concepts of chemistry and physics. Students use evidence from their own investigations as well as the investigations of others to develop and refine knowledge of core ideas. Increased sophistication, both of their model-based explanations and the argumentation by which evidence and explanation are linked, is developed through language and mathematical skills appropriate to the individual student's cognitive ability level. The standards provide a depth of conceptual understanding that will adequately prepare them for college, career, and citizenship with an appropriate level of scientific literacy. Resources specific to the local area as well as external resources, including evidence-based literature found within scientific journals, should be used to extend and increase the complexity of the core ideas. Content standards are organized according to the disciplinary core ideas for the Physical Science domain.

I. The core idea, ***Matter and Its Interactions***, deals with the substances and processes that encompass our universe on both microscopic and macroscopic levels.

ALCOS # 1. Use the periodic table as a model to predict the relative properties and trends (e.g., reactivity of metals; types of bonds formed, including ionic, covalent, and polar covalent; numbers of bonds formed; reactions with oxygen) of main group elements based on the patterns of valence electrons in atoms.

Scientific & Engineering Practices: Developing and Using Models
Crosscutting Concepts: Patterns
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Periodic table
- Valence electrons
- Protons
- Neutrons
- Electrons
- Family
- Period
- Covalent
- Ionic
- Oxidation number
- Cations
- Anions
- Ions
- Main group elements
- Metal
- Non-metal

Knowledge:
Students know:

- 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 the periodic table reflect patterns of outer electron states.

Skills:
Students are able to:

- Identify and describe of the main group elements.
- Describe how the number of protons determines an elements place on the periodic table.
- Predict patterns of behavior of an element based on its position on the Periodic Table.
- Predict number and charges of stable ions formed from atoms in a compound.
- Determine the number and type of bonds formed.
- Predict numbers of protons, neutrons, and electrons based on periodic table information.

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Abbeville High School

Understanding:
Students understand that:

- Students will understand how to propose an argument and defend their claim on electromagnetic radiation safety.
- Non-ionizing radiation, such as those emitted in electronic cannot cause immediate damage, but does interact with the body to potentially cause indirect damage, following long-term exposure.
- Ionizing radiation, such as X-rays and gamma rays, can be hazardous.

  - ASIM LABS:
    - Chemicool People
    - Electron Configuration Battleship
    - It's In The Cards
    - Mendeleev's Periodic Table Simulator
    - Covalent Bonding/Lewis Structures
    - Periodic Table – PS
    - Journey into the Atom - PS
  - ALEX RESOURCES
    - 3D Model of the Modern Periodic Table https://alex.state.al.us/lesson_view.php?id=34401
    - Phet Simulation – Build an Atom
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 5 Periodic Table
      - 5.1 Organizing Elements
      - 5.2 Exploring the Periodic Table
      - 5.3 Families of Elements

ALCOS # 2. Plan and carry out investigations (e.g., squeezing a balloon, placing a balloon on ice) to identify the relationships that exist among the pressure, volume, density, and temperature of a confined gas.

Scientific & Engineering Practices: Planning and Carrying out Investigations
Crosscutting Concepts: Cause and Effect
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Pressure
- Volume
- Temperature
- Density
- Mass
- Gas
- Solid
- Liquid
- Charles Law
- Boyles Law
- States of Matter
- Direct relationship
- Indirect relationship
- Molecular-kinetic theory of matter

  - ASIM LABS:
    - Celsius to Fahrenheit
    - Density of Solids - PS
    - Cartesian Diver - PS
    - Pressure – Volume Relationship of Gases (Boyle's Law)
    - Temperature – Volume Relationship of Gases (Charles Law)

9th grade Physical Science Compendium
Abbeville High School

- ALEX RESOURCES
  - Phet Simulation – States of Matter
  - Phet Simulation – Gases Intro
  - Phet Simulation – Density
  - Phet Simulation – Gas Properties
- RESOURCES:
  - Textbook – HOLT Physical Science ISBN 9780030672132
  - Chapter 3 States of Matter
    - 3.1 Matter & Energy
    - 3.2 Changes of State
    - 3.4 Behavior of Gases

ALCOS # 3. Analyze and interpret data from a simple chemical reaction or combustion reaction involving main group elements.

Scientific & Engineering Practices: Analyzing and Interpreting Data
Crosscutting Concepts: Patterns
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Products
- Reactants
- Reaction
- Single replacement
- Double replacement
- Synthesis
- Decomposition
- Combustion
- Chemical formula
- solutions
- Solutes
- Solvents
- Chemical reactions
- Ions
- ionic compounds

Knowledge:
Students know:

- The total number of atoms of each element in the reactant and products is the same.
- The numbers and types of bonds (ionic, covalent) that each atom forms are determined by the outermost (valence) electron states and the electronegativity.
- The outermost (valence) electron state of the atoms that make up both the reactants and the products of the reaction is based on the atom's position in the periodic table.

Skills:
Students are able to:

- Interpret data to determine the type of chemical reaction.
- Analyze data to determine the patterns for each type of chemical reaction.
- Balance simple chemical equations.
- Write simple binary compound formulas and names.

Understanding:
Students understand that:

- The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions.
- There is a causal relationship between the observable macroscopic patterns of reactivity of elements in the periodic table and the patterns of outermost electrons for each atom and its relative electronegativity.

- ASIM LABS:
  - Chemical Reactions
  - Evidence of Chemical Reactions - PS
- ALEX RESOURCES
  - Chemical Reactions Lab - https://alex.state.al.us/lesson_view.php?id=34522
  - Phet Simulation – Reactants, Products, Leftovers
  - Phet Simulation – Balancing Chemical Equations
- RESOURCES:
  - Textbook – HOLT Physical Science ISBN 9780030672132
  - Chapter 6 - The Structure of Matter
    - 6.2 Ionic & Covalent Bonds
    - 6.3 Compound Names & Formulas
  - Chapter 7 Chemical Reactions
    - 7.2 Chemical Reactions
    - 7.3 Reaction Types

ALCOS # 4. Analyze and interpret data using acid-base indicators (e.g., color-changing markers, pH paper) to distinguish between acids and bases, including comparisons between strong and weak acids and bases.

Scientific & Engineering Practices: Analyzing and Interpreting Data
Crosscutting Concepts: Patterns
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Acid
- Base
- Indicator
- pH
- Arrhenius theory
- Strong acid/base
- Weak acid/base
- Neutralization
- Titration

Knowledge:
Students know:

- An acid may be strong or weak, depending on its reaction with water to produce ions.
- When an acid dissolves in water, a proton (hydrogen ion) is transferred to a water molecule and produces a hydronium ion.
- A base may be strong or weak, depending on the number of hydroxide ions readily produced in solution.

Skills:
Students are able to:

- Recognize common inorganic acids including hydrochloric (muriatic) acid, sulfuric acid, acetic acid, nitric acid and citric acid.
- Recognize common bases including sodium bicarbonate, and hydroxides of sodium, potassium, calcium, magnesium, barium and ammonium.
- Use the pH scale to measure acidity or basicity.

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Abbeville High School

Understanding:
Students understand that:

- Acids are compounds that contain hydrogen and can dissolve in water to release hydrogen ions in solution.
- Bases are substances that dissolve in water to release hydroxide ions (OH-) into solution.
- The neutralization of an acid with a base produces water and a salt.

  - ASIM LABS:
    - Using Indicators and the PH scale – PS
    - MOM to the Rescue
  - ALEX RESOURCES
    - Exploring Acids & Bases - https://alex.state.al.us/learningasset_view.php?asset_id=2127&res_id=2127&res_type=LA
    - Phet Simulation – Acid & Base Solutions
    - Phet Simulation – PH Scale Basics
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 9 Acids, Bases, and Salts
      - 9.1 Acids, Bases, and Salts
      - 9.2 Reactions of Acids with Bases
      - 9.3 Acids, Bases, Salts in the Home

ALCOS # 5. Use mathematical representations to support and verify the claim that atoms, and therefore mass, are conserved during a simple chemical reaction.

Scientific & Engineering Practices: Using Mathematics and Computational Thinking
Crosscutting Concepts: Energy and Matter
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Atoms
- Conservation
- Chemical reaction
- Mass
- Balanced chemical equation
- Reactants
- Products
- Molar mass
- Avogadro's number
- Stoichiometry
- Ion
- Molecule
- Law of conservation of mass
- Polyatomic ion

Knowledge:
Students know:

- Matter can be understood in terms of the types of atoms present and the interactions both between and within them.
- Chemical reactions, which underlie so many observed phenomena in living and nonliving systems alike, conserve the number of atoms of each type but change their arrangement into molecules.

Skills:
Students are able to:

- Students use the mole to convert between the atomic and macroscopic scale in the analysis.

- Given a chemical reaction, students use the mathematical representations to predict the relative number of atoms in the reactants versus the products at the atomic molecular scale.
- Given a chemical reaction, students use the mathematical representations to calculate the mass of any component of a reaction, given any other component.

Understanding:
Students understand that:

- When substances react chemically with other substances to form new substances with different properties, the atoms are combined and rearranged to form new substances, but the total number of each atom is conserved and the mass does not change.
- The property of conservation can be used to help describe and predict the outcomes of reactions.

  - ASIM LABS:
    - Law of Conservation of Matter – PS
    - Numerical and Chemical Equations
  - ALEX RESOURCES
    - Phet Simulation – Balancing Chemical Equations
    - Phet Simulation – Reactants, Products, and Leftovers
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 6 - The Structure of Matter
      - 6.2 Ionic & Covalent Bonds
      - 6.3 Compound Names & Formulas
    - Chapter 7 Chemical Reactions
      - 7.2 Chemical Reactions
      - 7.3 Reaction Types

ALCOS #6. Develop models to illustrate the concept of half-life for radioactive decay. a. Research and communicate information about types of naturally occurring radiation and their properties. b. Develop arguments for and against nuclear power generation compared to other types of power generation.

Scientific & Engineering Practices: Developing and Using Models; Engaging in Argument from Evidence; Obtaining, Evaluating, and Communicating Information
Crosscutting Concepts: Systems and System Models; Energy and Matter
Disciplinary Core Idea: Matter and Its Interactions

Teacher Vocabulary:

- Atom
- Isotopes
- Protons
- Neutrons
- Electrons
- Radioactivity
- Half-life
- Radioactive decay
- Alpha particles
- Beta particles
- Positrons
- Gamma
- Fission
- Fusion
- Kinetic energy
- Electromagnetic radiation
- Emission
- Nuclear power
- Hydroelectric power
- Solar power
- Wind power
- Penetrability
- Fossil fuel combustion
- Decay series

9th grade Physical Science Compendium
Abbeville High School

Knowledge:
Students know:

- The atom is made of protons, neutrons, electrons.
- The types of radioactive decay include alpha, beta, and gamma.

Skills:
Students are able to:

- Exemplify the radioactive decay of unstable nuclei using the concept of half-life.
- Perform simple half-life calculations based on an isotope's half-life value, time of decay, and/or amount of substance.
- Cite specific textual evidence to support analysis of science and technical texts attending to the precise details of explanations or descriptions.
- Determine the central ideas or conclusions of a text; trace the explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text distinct from prior knowledge or opinions.
- Engage in argument from evidence.
- Communicate information.

Understanding:
Students understand that:

- Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy.
- Half-life can be used to date the age of organic objects.

  - ASIM LABS:
    - Analyzing Radiation – PS
    - Half Life Simulation - PS
  - ALEX RESOURCES
    - Radioactive List Group Label - https://alex.state.al.us/learningasset_view.php?asset_id=772&res_id=772&res_type=LA
    - Radioactive Half Life - https://alex.state.al.us/learningasset_view.php?asset_id=2120&res_id=2120&res_type=LA
    - Phet Simulation – Alpha Decay
    - Phet Simulation – Isotopes & Atomic Masses
    - Phet Simulation – Nuclear Fission
    - Phet Simulation – Radioactive Dating
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 10 Nuclear Changes
      - 10.1 What is Radioactivity
      - 10.2 Nuclear Fission and Fusion
      - 10.3 Nuclear Radiation Today

II. The second core idea, *Motion and Stability: Forces and Interactions*, includes the components of forces and motion, types of interactions, and stability/instability in physical systems.

ALCOS # 7. Analyze and interpret data for one- and two-dimensional motion applying basic concepts of distance, displacement, speed, velocity, and acceleration (e.g., velocity versus time graphs, displacement versus time graphs, and acceleration versus time graphs).

Scientific & Engineering Practices: Analyzing and Interpreting Data
Crosscutting Concepts: Cause and Effect
Disciplinary Core Idea: Motion and Stability: Forces and Interactions

Teacher Vocabulary:

- Distance
- Displacement
- Scalar
- Vector
- Speed
- Velocity
- Acceleration
- Equation of a line
- Slope
- Trend line

Knowledge:
Students know:

- A body is in motion if its position changes with respect to its surroundings.
- A particle moving in a straight line undergoes one dimensional motion.
- A particle moving along a curved path in a plane has two dimensional motion.

Skills:
Students are able to:

- Create graphs from sets of data points.
- Identify distance and displacement as a scalar/ vector pair.
- Identify speed and velocity as a scalar/ vector pair.
- Describe motion mathematically in terms of an object's change of position, distance traveled, and displacement.
- Apply concepts of average speed and average velocity to solve conceptual and quantitative problems.
- Explain velocity as a relationship between displacement and time. ($\Delta d = v\Delta t$)
- Explain acceleration as a relationship between velocity and time. ($a = \Delta v/\Delta t$)
- Use graphical analysis to understand conceptual trends in displacement, velocity, acceleration, and time.
- Use graphical analysis to solve for displacement, velocity, acceleration, and time.
- Calculate velocity and acceleration from displacement vs. time graphs.

Understanding:
Students understand that:

- Motion graphs (displacement vs. time, velocity vs. time, and acceleration vs. time) for one- and two-dimensional motion may be used to derive (conceptual and mathematical) relationships of motion.

  - ASIM LABS:
    - Run For It – PS
    - Analyzing Motion Graphs – PS
    - Batter Up

9th grade Physical Science Compendium
Abbeville High School

- ALEX RESOURCES
  - Tower of Terror, Creating a Free Fall Ride- https://alex.state.al.us/lesson_view.php?id=34799
  - Radioactive Half Life - https://alex.state.al.us/learningasset_view.php?asset_id=2120&res_id=2120&res_type=LA
  - Phet Simulation – The Moving Man
  - Phet Simulation – My Solar System
  - Phet Simulation – Projectile Motion
- RESOURCES:
  - Textbook – HOLT Physical Science ISBN 9780030672132
  - Chapter 11 Motion
    - 11.1 Measuring Motion/Speed
    - 11.2 Acceleration
    - 11.3 Motion & Forces

ALCOS # 8. Apply Newton's laws to predict the motion of a system by constructing force diagrams that identify the external forces acting on the system, including friction (e.g., a book on a table, an object being pushed across a floor, an accelerating car).

Scientific And Engineering Practices: Developing and Using Models
Crosscutting Concepts: Systems and System Models
Disciplinary Core Idea: Motion and Stability: Forces and Interactions

Teacher Vocabulary:

- Weight
- Mass
- Gravity
- Acceleration
- Velocity
- Terminal velocity
- Free fall
- Friction
- Static friction
- Rolling friction
- Fluid friction
- Inertia
- Force
- Balanced forces
- Unbalanced forces
- Net force
- Action-reaction pairs
- Vectors

Knowledge:
Students know:

- An object will remain at rest or in uniform motion unless acted on by an outside force.
- The velocity of an object changes when it is subjected to an external force.
- Gravity's acceleration is different on different planets.
- Air resistance is responsible for terminal velocity for objects in free fall.
- The property of inertia as related to mass.
- Forces must be unbalanced for an object to change its motion.
- Friction is a force that opposes motion.

Skills:
Students are able to:

- Organize data that represent the net force on an object (mass and acceleration) via tables and graphs.
- Construct force diagrams that identify all external forces acting on the system.

- Explain (conceptually and mathematically) the relationship between force, mass, and acceleration. (The greater the force on an object, the greater its change in motion but the same amount of force applied to an object with more mass will result in less acceleration.)
- Relate the difference between mass and weight. (Weight is a force dependent upon acceleration and mass is constant regardless of acceleration.)
- Calculate weight when given mass. (Fg=mg)
- Explain acceleration due to gravity as an example of uniformly changing velocity. (g=9.8 m/s2)
- Relate the presence of air resistance to the concept of terminal velocity of an object in free fall.
- Identify friction as a force that opposes motion of an object.
- Classify the frictional forces present in different situations. (Sofa resting on the floor is static friction. A box pushed across the floor is sliding friction. A ball rolling across the floor is rolling friction. A boat moving through a river is fluid friction. An object in free-fall is fluid friction.)
- Explain the property of inertia as related to mass. (An object at rest or at constant speed in a straight line will remain in that state unless acted upon by a force causing an unbalanced net force.)
- Explain balanced and unbalanced forces mathematically and graphically with respect to acceleration to establish the relationship between net force, acceleration, and mass.

Understanding:
Students understand that:

- The motion of a system may be predicted by applying Newton's laws of motion to force diagrams that identify all external forces acting on the system.
- Forces acting on an object affect the motion of that object.

  - ASIM LABS:
    - Force Diagrams – PS
    - Horizontal Frictions – PS
  - ALEX RESOURCES
    - Phet Simulation – Collision Lab
    - Phet Simulation – Forces and Motion Basics
    - Phet Simulation – Gravity Force Lab Basics
    - Phet Simulation – Forces in 1 Dimension
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 12 Motion
      - 12.1 Newton's 1st and 2nd Law
      - 12.2 Gravity
      - 12.3 Newton's 3rd Law

ALCOS # 9. Use mathematical equations (e.g., (m1v1 + m2v2) before = (m1v1 + m2v2) after) and diagrams to explain that the total momentum of a system of objects is conserved when there is no net external force on the system. a. Use the laws of conservation of mechanical energy and momentum to predict the result of one-dimensional elastic collisions.

Scientific & Engineering Practices: Using Mathematics and Computational Thinking
Crosscutting Concepts: Energy and Matter
Disciplinary Core Idea: Motion and Stability: Forces and Interactions

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Abbeville High School

Teacher Vocabulary:

- Momentum
- Mass
- Velocity
- Elastic collisions
- Inelastic collisions
- Conservation of momentum
- Conservation of mechanical energy
- External force

Knowledge:

Students know:

- An object's momentum is a relationship between its mass and velocity.
- Students know that total momentum of a system of objects is conserved in a collision when no net external forces act on the system.
- Students know that total mechanical energy of a system of objects is conserved in a one-dimensional elastic collision when no net external forces act on the system.

Skills:

Students are able to:

- Define the system of the two interacting objects mathematically.
- Define the system of the two interacting objects with diagrams. Infer how momentum is a relationship between mass and velocity of an object, $\rho=mv$.
- Identify and describe mathematically the momentum of each object in the system as the product of its mass and its velocity.
- Use diagrams to model, predict and describe the physical interaction (in an elastic collision) of the two objects in terms of the change in the momentum of each object as a result of the interaction.
- Use mathematical representations to model, predict and describe the physical interaction (in an elastic collision) of the two objects in terms of the change in the momentum of each object as a result of the interaction.
- Use mathematical representations to model, predict and describe the physical interaction (in an elastic collision) of the two objects in terms of the change in the mechanical energy of each object as a result of the interaction.

Understanding:

Students understand that:

- 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.

  - ASIM LABS:
  - ALEX RESOURCES
    - Phet Simulation – Collision Lab
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 12 Motion
      - 12.3 Newton's 3rd Law

ALCOS # 10. Construct simple series and parallel circuits containing resistors and batteries and apply Ohm's law to solve typical problems demonstrating the effect of changing values of resistors and voltages.

Scientific & Engineering Practices: Developing and Using Models
Crosscutting Concepts: Cause and Effect
Disciplinary Core Idea: Motion and Stability: Forces and Interactions

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Abbeville High School

Teacher Vocabulary:

- Circuit
- Resistor
- Wire
- Battery
- Bulbs
- Capacitor
- Conductor
- Insulator
- Charge
- Amps
- Volts
- Ohms
- Multimeter

Knowledge:

Students know:

- A series circuit is a closed circuit in which resistors are arranged in a chain and the current follows only one path.
- A parallel circuit is a closed in which the current divides into two or more paths before recombining to complete the circuit.
- A multimeter is a device consisting of one or more meters, as an ammeter and voltmeter, used to measure two or more electrical quantities in an electric circuit, as voltage, resistance, and current.
- Energy can be transferred from place to place by electric currents.

Skills:

Students are able to:

- Construct a series circuit with resistors (bulbs) and batteries.
- Construct a parallel circuit with resistors (bulbs) and batteries.
- Use a multimeter to take data of amps, ohms and volts for the circuits.
- Use Ohm's law to verify your circuit current, resistance, and voltage amounts.

Understanding:

Students understand that:

- Energy released by electricity can move from place to place.
- Ohm's law formulas may be used to calculate electrical values to design circuits and use electricity in a useful way.

  - ASIM LABS:
    - Electrical Circuits - PS
  - ALEX RESOURCES
    - Phet Simulation – Battery Resistor Circuit
    - Phet Simulation – Battery Voltage
    - Phet Simulation – Capacitator Lab Basics
    - Phet Simulation – Circuit Construction (AC & DC)
    - Phet Simulation – Ohm’s Law
    - Phet Simulation – Resistance in a Wire
    - Phet Simulation – Signal Circuit
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 17 Electricity
      - 17.1 Electric Charge and Force
      - 17.2 Current
      - 17.3 Circuits

9th grade Physical Science Compendium
Abbeville High School

III. The third core idea, *Energy*, involves the conservation of energy, energy transformations, and applications of energy to everyday life.

ALCOS # 11. Design and conduct investigations to verify the law of conservation of energy, including transformations of potential energy, kinetic energy, thermal energy, and the effect of any work performed on or by the system.

Scientific & Engineering Practices: Planning and Carrying out Investigations
Crosscutting Concepts: Energy and Matter
Disciplinary Core Idea: Energy

Teacher Vocabulary:

- System
- Energy
- Mechanical
- Temperature
- Conduction
- Convection
- Radiation
- Friction
- Force
- Specific heat capacity
- Latent heat
- Heat of vaporization
- Law of Conservation of energy
- Transformation
- Potential energy
- Kinetic energy
- Thermal energy
- Heat
- Work
- Phase changes

Knowledge:
Students know:

- Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.
- Properties of materials cause different materials to absorb and release energy differently.
- Conduction, convection, and radiation are methods of energy transfer.
- Energy can be conserved when there are changes in potential, kinetic, or heat energy.

Skills:
Students are able to:

- Compare thermal energy, heat, and temperature.
- Compare scenarios in which work is done and explain the differences in magnitude of work done using the relationship $W=F\Delta d$
- Infer the ability of various materials to absorb or release thermal energy in order to relate mass, specific heat capacity and temperature of materials to the amount of heat transferred ($q=mC\Delta T$).
- Relate phase changes to latent heat that changes the potential energy of particles while the average kinetic energy of particles (temperature) remains the same.
- Compare conduction, convection, and radiation as methods of energy transfer.
- Exemplify the relationships between kinetic energy, potential energy, and heat to illustrate that total energy is conserved in mechanical systems such as a pendulum, roller coaster, carts/balls on ramps.
- Relate types of friction in a system to the transformation of mechanical energy to heat.
- Explain scenarios in which work is done identifying the force, displacement, and energy transfer. (When work is done on an object, the result is an increase in its energy and is accompanied by a decrease in energy elsewhere.)

Understanding:
Students understand that:

- 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.

- ASIM LABS:
  - Bouncy Ball Energy – PS
  - Work, Energy, Power – PS
  - Changing Energies on a Roller Coaster - PS
- ALEX RESOURCES
  - Energy Work and the Amusement Park - https://alex.state.al.us/lesson_view.php?id=548
  - Phet Simulation – Energy Forms and Changes
  - Phet Simulation – Masses and Springs
  - Phet Simulation – Hooke's Law
  - Phet Simulation – Energy Skate Park Basics
  - Phet Simulation – The Ramp
- RESOURCES:
  - Textbook – HOLT Physical Science ISBN 9780030672132
  - Chapter 13 Work and Energy
    - 13.1 Work and Power
    - 13.2 Simple Machines
    - 13.3 Energy
    - 13.4 Conservation of Energy

ALCOS # 12. Design, build, and test the ability of a device (e.g., Rube Goldberg devices, wind turbines, solar cells, solar ovens) to convert one form of energy into another form of energy.*

Scientific & Engineering Practices: Constructing Explanations and Designing Solutions
Crosscutting Concepts: Energy and Matter
Disciplinary Core Idea: Energy

Teacher Vocabulary:

- Energy
- Force
- Machine
- Simple machine
- Complex machine
- Wedge
- Screw
- Inclined plane
- Pulley
- Wheel
- Axle
- Lever
- Work
- Conservation of energy
- Ideal mechanical advantage
- Actual mechanical advantage
- Efficiency
- Heat
- Temperature

Knowledge:
Students know:

- Energy can be converted from one form to another in a designed system.
- Energy can manifest itself in many ways at the macroscopic level such as motion, sound, light and thermal energy.
- No system can be 100% efficient.

Skills:
Students are able to:

- Identify the scientific principles that provide the basis for the energy conversion design.
- Identify the forms of energy that will be converted from one form to another in the designed system.
- Identify losses of energy by the design system to the surrounding environment.

- Describe the scientific rationale for choices made for materials and structure of their device in their design plan.
- Use results of the tests to improve the device performance by increasing the efficiency of energy conversion.
- Determine the component simple machines that make up complex machines such as categorizing a wedge and screw as a variation of an inclined plane; a pulley and wheel/ axle as a variation of a lever.
- Explain the relationship between work input and work output for simple machines using the law of conservation of energy. ($W = F\Delta d$)
- Define and determine ideal and actual mechanical advantage. (IMA = dE/dR AMA = FR/FE)
- Define and determine efficiency of machines. (Wout/Win x 100%)
- Explain why no machine can be 100% efficient.

Understanding:
Students understand that:

- In designing a system for energy storage, for energy distribution, or to perform some practical task, it is important to design for maximum efficiency—thereby ensuring that the largest possible fraction of the energy is used for the desired purpose rather than being transferred out of the system in unwanted ways.
- 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.

  - ASIM LABS:
    - Rude Goldberg Machine – PS
  - ALEX RESOURCES
    - Rude Goldberg Machines & Energy - https://alex.state.al.us/lesson_view.php?id=34501
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 13 Work and Energy
      - 13.1 Work and Power
      - 13.2 Simple Machines
      - 13.3 Energy
      - 13.4 Conservation of Energy

IV. The fourth core idea, *Waves and Their Applications in Technologies* for Information Transfer, examines wave properties, electromagnetic radiation, and information technologies and instrumentation

ALCOS # 13. Use mathematical representations to demonstrate the relationships among wavelength, frequency, and speed of waves (e.g., the relation $v = \lambda f$) traveling in various media (e.g., electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, seismic waves traveling through Earth).

Scientific & Engineering Practices: Using Mathematics and Computational Thinking
Crosscutting Concepts: Cause and Effect
Disciplinary Core Idea: Waves and Their Applications in Technologies for Information Transfer

9th grade Physical Science Compendium
Abbeville High School

Teacher Vocabulary:

- Wavelength
- Frequency
- Period
- Amplitude
- Velocity
- Medium
- Longitudinal wave
- Transverse wave
- Surface wave
- Mechanical
- Refraction
- Light
- Sound
- Reflection
- Diffraction
- Interference

Knowledge:

Students know:

- Waves are a repeating pattern of motion that transfers energy from place to place without overall displacement of matter.
- A simple wave has a repeating pattern of specific wavelength, frequency, and amplitude.

Skills:

Students are able to:

- Use mathematics and computational thinking to solve for one wave component/variable when the other two are given.
- Predict the change in a wave as it passes through different media.
- Compare and contrast longitudinal and transverse waves.
- Construct ray diagrams as light is refracted or reflected through/ from different media.
- Label the components of a wave.
- Classify waves as electromagnetic, mechanical or surface.

Understanding:

Students understand that:

- 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.

  - ASIM LABS:
    - Wave Speed – PS
  - ALEX RESOURCES
    - Rude Goldberg Machines & Energy - https://alex.state.al.us/lesson_view.php?id=34501
    - Phet Simulation – Waves Intro
    - Phet Simulation – Radiowaves & Electromagnetic Fields
    - Phet Simulation – Waves on a String
    - Phet Simulation – Microwaves
    - Phet Simulation – Sound
  - RESOURCES:
    - Textbook – HOLT Physical Science ISBN 9780030672132
    - Chapter 15 Waves
      - 15.1 Types of Waves
      - 15.2 Characteristics of Waves
      - 15.3 Wave Interactions

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ALCOS # 14. Propose and defend a hypothesis based on information gathered from published materials (e.g., trade books, magazines, Internet resources, videos) for and against various claims for the safety of electromagnetic radiation.

Scientific & Engineering Practices: Engaging in Argument from Evidence
Crosscutting Concepts: Cause and Effect
Disciplinary Core Idea: Waves and Their Applications in Technologies for Information Transfer

Teacher Vocabulary:

- Electromagnetic waves
- E/M spectrum
- Visible light
- Microwaves
- Frequency
- Radio frequencies
- Video terminals
- Magnetic fields
- Internet resources
- Ionizing radiation
- Non-ionizing radiation
- Wavelength

Knowledge:
Students know:

- Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave pattern of changing electric and magnetic fields or, alternatively, as particles.
- Electromagnetic radiation may be ionizing or non-ionizing type. Non-ionizing type of radiation is used in common electronic devices.
- Non-ionizing type of radiation is used in common electronic devices.

Skills:
Students are able to:

- Identify types of electromagnetic radiation.
- Select credible resources from the Internet and AVL for use in the argument.
- Categorize electromagnetic radiation according to safety levels for humans.
- Cite specific textual evidence to support analysis of science and technical texts.
- Determine the central ideas or conclusions of a text; trace the explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text distinct from prior knowledge or opinions.
- Engage in argument from evidence on the safety of electromagnetic radiation.

Understanding:
Students understand that:

- Non-ionizing radiation, such as those emitted in electronics, cannot cause immediate damage, but does interact with the body to potentially cause indirect damage, following long-term exposure.
- Ionizing radiation, such as X-rays and gamma rays, can be hazardous.

  - ASIM LABS:
  - ALEX RESOURCES
    - The Case of the Invisible Signal - https://alex.state.al.us/lesson_view.php?id=35681
    - Phet Simulation – Waves Intro
    - Phet Simulation – Photoelectric Effect
    - Phet Simulation – Fourier: Making Waves
    - Phet Simulation – Color Vision
    - Phet Simulation – Blackbody Spectrum

9th grade Physical Science Compendium
Abbeville High School

- RESOURCES:
  - Textbook – HOLT Physical Science ISBN 9780030672132
  - Chapter 15 Waves
    - 15.1 Types of Waves
    - 15.2 Characteristics of Waves
    - 15.3 Wave Interactions

ALCOS # 15. Obtain and communicate information from published materials to explain how transmitting and receiving devices (e.g., cellular telephones, medical-imaging technology, solar cells, wireless Internet, scanners, Sound Navigation and Ranging [SONAR]) use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy

Scientific & Engineering Practices: Obtaining, Evaluating, and Communicating Information
Crosscutting Concepts: Cause and Effect; Energy and Matter
Disciplinary Core Idea: Waves and Their Applications in Technologies for Information Transfer

Teacher Vocabulary:

- Transmit
- Receive
- Devices
- Waves
- Frequency
- Wavelength
- Amplitude
- Period
- Velocity
- Longitudinal waves (compression)
- Transverse waves
- Rarefactions
- Interference (constructive and destructive)
- Superposition
- Reflection
- Refraction
- Wave behavior
- Wave interactions
- Matter
- Capture
- Energy

Knowledge:
Students know:

- Three ways that waves may interact with matter are reflection, refraction, and diffraction.
- The controlled use of waves have applications in science. Wave types vary based on wave speed, type of material (medium) required, motion of particles, and how they are produced.
- Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. Photoelectric materials emit electrons when they absorb light of a high-enough frequency.
- When a light wave encounters an object, they are either transmitted, reflected, absorbed, refracted, polarized, diffracted, or scattered depending on the composition of the object and the wavelength of the light.

Skills:
Students are able to:

- Cite specific textual evidence to support analysis of science and technical texts attending to the precise details of explanations or descriptions.
- Determine the central ideas or conclusions of a text; trace the explanation or depiction of a complex process, phenomenon, or concept; provide an accurate summary of the text distinct from prior knowledge or opinions.
- Communicate information.

9th grade Physical Science Compendium
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Understanding:
Students understand that:

- 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.
- Transmitting and receiving devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.
- 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.
    - ASIM LABS:
    - ALEX RESOURCES
        - The Case of the Invisible Signal - https://alex.state.al.us/lesson_view.php?id=35681
        - Phet Simulation – Waves Intro
        - Phet Simulation – Photoelectric Effect
        - Phet Simulation – Fourier: Making Waves
        - Phet Simulation – Color Vision
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    - RESOURCES:
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        - Chapter 15 Waves
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