2019 GeoPhysics Objectives

Unit: Constant Speed

Objectives: Students will be able to...

1. Solve conversion problems involving ratios and proportions. [C]
2. Create graphs and tables from lab data (d, t, v, slope).
3. Interpret d vs. t graphs.
4. Solve one variable equations to investigate speed (v=d/t).
5. Calculate slope.
6. Use statistics (line of best fit, r^2) to determine strength of data (correlations).
7. Use Google Sheets to analyze and present lab data.

Labs/Projects/Practicals:

- Lab: Tumble buggy
- Lab: Motion sensor graph matching
- Practical: Predict distance of car at constant speed

Unit: Speed Application: Plate Tectonics

Objectives: Students will be able to...

1. Create graphs and tables from lab data (d, t, v, slope).
2. Interpret m vs. v graphs.
3. Solve one variable equations to investigate density (d=m/v). [C]
4. Describe how the Kinetic Molecular Theory (KMT) impacts the density of materials. [C]
5. Calculate slope.
6. Calculate the density of various materials.
7. Relate the KMT to states of matter. [C]
8. Use Google Sheets to analyze and present lab data.
9. Identify, diagram, and describe the types of plate boundaries.
10. Explain how density affects plate subduction and seafloor spreading.
11. Calculate the speed of tectonic plates movement (v=d/t) (using hot spots to determine speed and direction of plates).
12. **ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.**
13. **ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.**

Labs/Projects/Practicals:

- Lab: Density 1
- Lab: Density 2
- Lab: Computer simulations

- Practical: Determine the density of an irregular object

Unit: Waves

Objectives: Students will be able to...

1. Create graphs and tables from lab data (f, ƛ, v).
2. Interpret f vs. ƛ graphs.
3. Solve one variable equations to investigate wave speed (v =fƛ).
4. Solve one variable equations to investigate period of a wave (T = 1/f) or frequency (f = 1/T).
5. Identify and calculate wave characteristics (amplitude, wavelength, wave speed, frequency and period) from distance and time graphs.
6. Identify the independent and dependent variables in an experiment.
7. Explain how extended ranges, multiple trials, and multiple data points enhance the validity of an experiment.
8. Reflect on the strength of an experiment based on components of experimental design.
9. Describe and identify the types of waves (compression and transverse) and state how these waves can be generated.
10. **PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**

Labs/Projects/Practical:
- Lab: Independent vs. Dependent Variables
- Lab: Pendulum 1
- Lab: Pendulum 2
- Lab: Slinky 1
- Lab: Slinky 1
- Lab: Wave on a String

Unit: Waves Application: Earthquakes

Objectives: Students will be able to...

1. Identify and describe the three types of earthquake waves (primary, secondary, surface waves).
2. Describe how the properties of the three types of earthquake waves impact how they travel through Earth.
3. Design, refine, and build an earthquake resistant structure.
4. Describe how scientists use earthquake waves to determine the structure of the interior of the Earth.
5. Identify how forces (tension, compression, torsion, and shear) relate to earthquake boundaries and the elastic rebound theory.
6. Diagram the epicenter vs. focus of an earthquake.
7. Interpret data to triangulate the epicenter of an earthquake.

Labs/Projects/Practicals:
- Project: Design, build and refine an earthquake resistant buildings

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<u>Unit: Waves Application: Sound and Light</u>

<u>Objectives</u>: Students will be able to...

1. Solve one variable equations to investigate characteristics of sound waves ($v = d/t$).
2. Model the motion of an object to show how it affects the wavelength of sound and light waves (Doppler Effect).
3. Describe how wave properties affect sound quality.
4. Solve one variable equations to investigate characteristics of light waves ($v = f\lambda$).
5. Describe and diagram characteristics of wave behavior (reflection, refraction, absorption, diffraction).
6. Compare properties of light and pigment. [B]
7. **PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.**

<u>Labs/Projects/Practicals:</u>
- Lab: Light Properties
- Lab: Wave Behavior

<u>Unit: Capstone for Semester 1: Sun and Stars</u>

<u>Objectives</u>: Students will be able to...

1. Solve one variable equations to investigate energy production in stars ($E = mc^2$).
2. Identify and describe the parts of an atom and related charges. [C]
3. Describe the three of the four fundamental forces (Strong, Gravity, Electromagnetic). [C]
4. Describe the conditions needed for fusion (KMT - speed, temperature, density of atoms). [C]
5. **ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.**
6. **PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of ~~fission~~, fusion~~, and radioactive decay~~.**
7. Analyze sunspot graphs to predict frequency of a coronal mass ejection.
8. Describe how an increase in sunspot activity would affect life on Earth.
9. Describe how the outer core creates a magnetic field which protects us from coronal mass ejections.
10. Create a model to show the life cycle of a star.
11. **ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.**
12. Interpret temperature vs. luminosity graphs (HR Diagrams) and relate it to the life cycle of a star, relationship between luminosity vs. mass and temperature vs color.
13. Diagram the structure of a black hole.

<u>Labs/Projects/Practicals:</u>

- Project: Star Cycle

Unit: Projectile Motion

Objectives: Students will be able to...

1. Solve one variable equations to investigate acceleration ($a = \Delta v/\Delta t$).
2. Use kinematic equations to solve for range, time, acceleration, initial and final velocity.
3. Create graphs and tables from lab data (d, t, v, a, slope).
4. Interpret v vs. t graphs.
5. Calculate slope.
6. Use statistics (line of best fit, r^2) to determine strength of data (correlations).
7. Identify the independent and dependent variables in an experiment.
8. Explain how extended ranges, multiple trials, and multiple data points enhance the validity of an experiment.
9. Explain the independence of horizontal and vertical motion.
10. Describe gravity as a force that accelerates all objects at 9.8 m/s^2 independent of their mass.
11. Use Google Sheets to analyze and present lab data.
12. Interpret angle vs. range polynomial graphs.
13. Solve for an unknown using multiple steps and multiple equations.

Labs/Projects/Practicals:
- Lab: Acceleration
- Lab: Picket Fence
- Lab: Reaction Time
- Lab: Battle of Gettysburg Projectiles
- Practical: Determining Range

Unit: Forces

Objectives: Students will be able to...

1. Solve one variable equations to investigate net force ($F_{net}= ma$).
2. Describe the difference between mass and weight
3. Use force gravity equations to solve for F_g, mass, acceleration.
4. Create and interpret graphs and tables from lab data (F_g, m, acceleration, slope).
5. Use force tension equations to solve for F_t, k, x.
6. Create and interpret graphs and tables from lab data (F_T, k, x, slope).
7. Use force friction equations to solve for F_f, F_N, μ.
8. Create and interpret graphs and tables from lab data (F_f, F_N, μ, slope).
9. Describe how the coefficient of friction relates to the characteristics of the surface.
10. Calculate slope.
11. Use statistics (line of best fit, r^2) to determine strength of data (correlations).
12. Determine net force by analyzing all forces acting on an object.
13. **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.

14. Given a scenario, model forces acting on an object (force diagrams).
15. Given a scenario, identify applications of Newton's laws of motion.

Labs/Projects/Practicals:

- Lab: Force gravity lab
- Lab: Spring Constant
- Practical: Spring Constant
- Lab: Coefficient of Friction
- Practical: Coefficient of Friction (shoe)

Unit: Energy

Objectives: Students will be able to...

1. Solve one variable equations to investigate kinetic (E_k=mv^2), potential (E_g=mgh), elastic energy (PE=1/2kx^2) and total energy (E_{tot}=E_{k+} E_g).
2. Given a scenario, identify the types of energy seen at various locations of the depiction.
3. Use mathematical representations to support the claim that the total energy of a system is conserved.
4. Describe how energy transfers between energy types as an object moves within a system.
5. Calculate slope as applied to heat transfer.
6. Create graphical representations of energy transfer.
7. Relate states of matter and density to the efficiency of insulators and conductors.
8. Explain why metals are good conductors due to their ability to share electrons. [C]
9. Interpret temperature-time graphs.
10. Create graphs and tables from lab data (temperature and time).
11. Given an scenario, identify the three types of heat energy transfer (convection, conduction, radiation). [B]

Labs/Projects/Practicals:

- Project: Rube Goldberg
- Lab: Thermal Equilibrium
- Project and Lab: Thermal Insulation Design
- Lab: Rollercoaster Lab
- Lab: Computer Simulations

Unit: Momentum

Objectives: Students will be able to...

1. Solve one variable equations to investigate momentum ($p = mv$).
2. Solve one variable equations to investigate impulse ($F_t = m\Delta v$).
3. Demonstrate how changing the time of impact affects the average force on an object.
4. Use conservation of momentum equations to investigate inelastic collisions and explosion problems.
5. **PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.***
6. **PS2-2. Use mathematical representations to support the claim that the total momentum of a**

system of objects is conserved when there is no net force on the system.

Labs/Projects/Practicals:

- Project: Egg Drop Design Challenge
- Lab: Momentum Lab
- Lab: Inelastic Collisions

Unit: Electricity

Objectives: Students will be able to...

1. Solve one variable equations to solve for unknowns in Ohm's Law (V=IR).
2. Describe the differences between series and parallel circuits.
3. Define current, voltage, and resistance.
4. Describe the role of a capacitor and a resistor in a circuit.
5. Model series and parallel circuits with components (schematics).

Labs/Projects/Practicals:

- Project: Friendship detector
- Lab: Circuits Discovery
- Lab: Circuits: Series vs. Parallel
- Lab: Computer Simulations

Unit: Capstone Semester 2: Solar System and the Universe

Objectives: Students will be able to...

1. Use Universal Law of Gravity equation to investigate gravity between two objects ($F = G ((m_1m_2)/r^2)$.
2. Use velocity equation to calculate stellar distances (light years).
3. Model the formation of the solar system.
4. Graph planet trends based on temperature, revolution, rotation, satellites, orbital velocity, density, distance from the sun, and mass.
5. Compare characteristics of terrestrial and Jovian planets.
6. Use conservation of angular momentum to explain the formation of planets and their orbits.
7. Describe the formation of the sun using concepts of KMT and fusion. [C]
8. **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.**
9. Use light years to describe distances; relate to the size of the universe.
10. **ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.**
11. Compare and contrast absorption vs emission spectra.
12. Describe how the Doppler effect indicates that the universe is expanding (blue shift/red shift).
13. What Drake equation tell us about the probability of life on other planets.

Labs/Projects/Practicals:

- Lab: Spectroscopy
- Lab: Redshift/Blueshift Star Spectra Simulation

Unit 1: Science Practices

Scientific Practices Objectives	
1a	**I can plan and carry out scientific investigations.**
1a1	I can apply the following three key techniques for obtaining data that accurately depicts a relationship: maximize the domain of the independent variable, collect as many different data points as possible, and utilize repeated trials to obtain an average value and a numerical value for *uncertainty*, (difference in the highest and lowest repeated trials).
1a2	I can distinguish between an independent variable and a dependent variable, and can plot them on the appropriate axes.
1b	**I can organize, analyze and interpret data.**
1b1	I can appropriately organize data into tables, and sketch free-hand graphs that have: labeled axes (variable and units), maximum values listed on each axis, and a best fit line/curve, (no data points).
1b2	I can calculate uncertainty using repeated trials, and use this value to determine if there is a covariant or noncovariant trend in the data.
1b3	I can use SPREADSHEETS (e.g., EXCEL/SHEETS) to determine the average of repeated trials, plot data sets on a scatter plot, generate an appropriate trendline, and obtain an linear or quadratic mathematical model for the curve.
1b4	I can summarize an experiment I carried out by outlining the following parts: Purpose, Setup/Procedure, Results/Analysis, & Findings/Conclusion
1b5	I can evaluate and critique other teams' data according to the three key techniques for collecting data, (see 1a1).
1c	**I can apply mathematical and computational thinking.**
1c1	I can write a mathematical model, which includes determining the units on all coefficients, and write these units within the mathematical model.
1c2	I can make predictions using mathematical models & equations, [i.e., given variables, algebraically solve for an unknown variable, (linear and quadratic functions)].
1c3	Given a conversion factor, I can perform conversions using proportional reasoning.

Unit 2: Constant Velocity

Constant Velocity Objectives	
2a	**I can create and utilize models to problem-solve constant velocity situations.**
2a1	I can identify what each of the following variables represent: x, v, t, x_o, Δx
2a2	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.
2a3	I can obtain the following equation from position vs. time graphs: $x = vt + x_o$, or $\Delta x = vt$

2a4	I can use a position vs. time graph to quantitatively determine Δx and $\Delta t$from the x- and y-axes, and velocity by calculating the slope.
2a5	I can qualitatively describe the velocity of an object by examining the steepness of a position vs. time graph.
2a6	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa) for constant velocity motion .
2a7	I can describe the motion that is depicted by an x-t or v-t graph.
2a8	I can design, construct, and carry-out an experiment on an object moving at a constant velocity to examine its motion.
2a9	I am able to make predictions by algebraically solving the constant velocity equation.

Unit 3: Acceleration

Acceleration Objectives	
3a	**I can create and utilize models to problem-solve accelerated situations.** **I can read, describe, and make predictions for any object's motion (constant speed or gaining/losing speed) using experimental-setup construction (e.g., cars on a tilted track), written descriptions, graphs, diagrams, video analysis, and math (algebra/equations).**
3a1	I am able to interpret the meaning of the y-intercept of any graph (lin. or quad.); and more specifically, for position vs. time (x-t) and velocity vs. time (v-t).
3a2	I am able to interpret the meaning of the slope (as a rate); and more specifically, for position vs. time and velocity vs. time.
3a3	I am able to obtain numerical values (a, t, v_o, v and Δx), for variables from x-t and v-t graphs [i.e., (x, y) coordinates (& y-intercept), slope, and coefficients from regressions].
3a4	I am able to qualitatively describe motion given only an x-t or v-t graph (i.e., moving or stopped, gaining or losing speed, constant speed, going forwards or backwards).
3a5	I can collect, analyze, & interpret data using technology: Logger Pro (video analysis & motion sensors) and photogates.
3a6	I am able to qualitatively recognize that acceleration is represented as both a parabola on a x-t graph, and slope of a v-t graph.
3a7	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction for the following variables: Δx, v_o, v, a
3a8	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa).
3a9	I am able to make predictions by algebraically solving kinematic equations.
3a10	I am able to diagram the motion of an object that includes the following characteristics: before and after states, all relevant variables drawn as arrows labeled with variable letter, number and units.
3a11	I am able to recognize when objects are in free-fall and apply the free-fall acceleration (9.8 m/s^2 down) for those objects. This also includes understanding that ALL objects fall at the same acceleration regardless of mass or weight.
3a12	I can design, construct, and carry-out an experiment on a object moving with a constant acceleration to examine its motion.

Unit 4: Forces

Force Objectives	
4a	**I can use Newton's Laws to make and justify claims about the forces acting on an object.**
4a1	I can use *Newton's 1st law* to justify and make claims about the forces acting on an object, (inertia is the tendency of an object to maintain its current state of motion—either at rest or a constant speed; it's the tendency for an object to resist acceleration),
4a2	(PS2-1). I can analyze data to support the claim that *Newton's second law* describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration, (i.e., an *unbalanced* force causes acceleration according to the relationship: $F_{net} = ma$).
4a3	I can use *Newton's 3rd law* to justify and make claims about the forces acting on an object, (by switching the "on___, by___" notation for a force, you can identify an equal & opposite force). Ex. There is a 10 N force "on the wall, by my hands," so there is also a 10 N force "on my hands, by the wall.
4b	**I can create and utilize models to problem-solve accelerated situations that involve forces.**
4b1	I can distinguish between *mass* and *force of gravity* (or *weight)*, and calculate each value using the following relationship: $F_g = (9.8N/kg)m$
4b2	I can draw force diagrams of any object. This is includes identifying which forces are present and in which direction they point.
4b3	I can resolve angled forces into horizontal and vertical components using right-triangle trigonometry. This includes the force of gravity for objects on an inclined surface.
4b4	Using a force diagram, I can write a mathematical expression for Newton's 2nd law (also known as writing the "sum of forces"), by summing all positive and negative forces, and setting them equal to *ma* according to the relationship: $F_{net} = ma$.
4b5	I can identify the variables that affect the force of friction, (*coefficient of friction, μ*, and normal force), and the way in each affects it according the following relationships: $(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$.
4b6	I can differentiate between static and kinetic friction.
4b7	I can algebraically solve for unknown variables using Newton's 2nd law expressions and the friction equations.
4b8	I can design, construct, and carry-out an experiment to determine the coefficient of friction between the surfaces of two objects.

Unit 5: Projectiles

Projectiles Objectives	
5a	**I can create and utilize models to problem-solve projectile situations.**
5a1	I am able to diagram the motion of a projectile that includes the following characteristics: before and after states, all relevant variables drawn as arrows labeled with variable letter, number and units.

5a2	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.
5a3	I can qualitatively describe the horizontal motion and vertical motion of any projectile.
5a4	I can apply and justify any projectile's horizontal acceleration as zero, $a_x = 0$
5a5	I can solve quadratic equations by determine its roots using a graphing calculator.
5a6	I can resolve angled vectors into horizontal and vertical components using right-triangle trigonometry. This includes the angled initial velocity for an projectile.
5a7	I can utilize that velocity must be momentarily zero when an object changes direction (e.g., $v_y = 0$ at the top of any projectile's path.)
5a8	I am able to make predictions by algebraically solving kinematic equations.
5a9	I can design, construct, and carry-out an experiment on a projectile to predict the position of its landing.

Unit 6: Impulse & Momentum (Collisions)

Impulse & Momentum Objectives	
6a	**I can create and utilize models to problem-solve situations involving the linear collision of an isolated object.**
6a1	I can analyze a *v-t, &/or F-t* graph of a collision to determine information such as impulse, velocity before/after a collision, average/maximum impact force, and time of impact. This includes understanding that area under an F-t graph can be used to calculate impulse delivered to an object.
6a2	I am able to make quantitative predictions by algebraically solving the impulse equation: $\Delta p = mv - mv_o$.
6a3	I can use the impulse equation to qualitatively justify and make claims about relationship between the net force acting on an object and time duration of that net force.
6a4	(PS2-3). I can apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force of impact on a object during a collision.
6a5	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.
6b	**I can demonstrate the concept of conservation of total linear momentum, and utilize it to problem-solve situations involving the linear collision of a two isolated objects.**
6b1	(PS2-2). I can use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. This means I can mathematically justify that the total momentum of two objects before and after any collision is always the same when the objects are free to move along a line, (e.g., no outside forces acting alongthe line motion). This law is called "conservation of total linear momentum."
6b2	I can algebraically solve for the speed before or after a collision between two movable objects using the law of conservation of linear momentum.

Unit 7: Circular Motion

Circular Motion Objectives	
7a	**I can create and utilize models to problem-solve situations involving circular motion.**
7a1	I can recognize and apply the fact that velocity is always directed tangent to the circular path.
7a2	I can explain how inertia relates to objects in circular motion, (i.e., I can explain why one *feels* pushed outward when going around a bend in a car).
7a3	I can justify why an object moving in a circle at a constant speed is accelerating.
7a4	I can draw a force diagram to identify the net force inward (i.e., the "centripetal force"), which always points along the radius toward the center of the circular path.
7a5	I can mathematically and conceptually utilize the equations of circular motion to make claims about the relationships among variables and solve for unknown quantities. These equations include: $F_{net} = \frac{mv^2}{r}$, $a_c = \frac{v^2}{r}$, $v_{avg} = \frac{2\pi r}{T}$
7a6	*(PS2-4). I can use Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.*

Unit 8: Energy

Energy Objectives	
8a	**I can conceptually and mathematically apply the concept of *work* as the *change in* energy due to a force acting along a distance.**
8a1	I can assess gains and losses in energy as positive or negative work.
8a2	I can algebraically solve for the unknown variables using the mathematical equation for work: $W = F \cdot x$ or $W = Fx \cos \theta$.
8a3	I can graphically solve for work done by a force by determining the area under an *F-x* graph.
8a4	I can describe the *type* of energy gained/lost depends on the *type* of force.
8a5	I can mathematically apply the concept of power as the time rate of change in energy using the relationship: $P = \frac{W}{\Delta t}$.
8a6	I can design, construct, and carry-out an experiment on a object that examine the changes in energy it experiences due to a force.
8b	**I can identify the forms of energy present for objects at any particular moment.**
8b1	I can identify that *elastic potential energy* is dependent upon spring's compression or stretching, and is mathematically defined as: $E_{el} = ½kx^2$
8b2	(PS3-2). I can develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects), (i.e., I can identify that *gravitational potential energy* is dependent upon height/altitude, and is mathematically defined as: $E_g = mgh$).

8b3	I can identify that *kinetic energy* is dependent upon velocity, and is mathematically defined as: $E_k = ½mv^2$
8b4	I can identify that *work* is being done when there is a force acting along the displacement (e.g., friction, tension, push, etc.).
8c	**I can demonstrate the concept of conservation of total energy, and utilize it to problem-solve situations involving exchanges between height/distance and speed.**
8c1	(PS3-1). I can create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. This means I can mathematically justify that the total energy of all objects that are interacting with one another, and isolated from their environment, must remain the same at all times. This law is called "conservation of energy," and it is represented mathematically by the following equation: $\pm W_F + E_g + E_k + E_{el} = E_g + E_k + E_{el}$..
8c2	(PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.
8c3	I can utilize the law of conservation of energy to solve for the energy lost during a collision.
8c4	I can describe collisions as *elastic*, *inelastic*, or *perfectly inelastic*.
8c5	I can design, construct, and carry-out an experiment on a object to determine the energy it loses during a collision.

Unit 9: Circuits

Circuit Objectives	
9a	**I can design, construct, and obtain measurements from circuits.**
9a1	I recognize that current only flows if there is a closed loop, and in the direction that positive charges would flow.
9a2	I can graphically obtain a value for resistance by calculating the slope of a voltage vs. current graph.
9a3	I can build circuits when given a circuit diagram, and vice versa.
9a4	I can take measurements of voltage, current, and resistance using a multimeter.
9a5	I can draw voltmeters and ammeters into a circuit diagrams.
9a6	I can identify components in a circuit as being in either in series (same current) or parallel (presence of junctions)
9b	**I can use Kirchhoff's and Ohm's Laws to make and justify claims about the voltages and currents within a circuit.**
9b1	I can conceptually and mathematically describe the equivalent resistance of a multiple resistor circuit that is comprised of series and parallel combinations of resistors.
9b2	I can determine which parallel branches receive the most (or least) current.
9b3	I can apply Ohm's Law (V = IR) to any closed circuit, and parts within a closed circuit, in order to calculate the total current through a power source and individual resistors, and the voltage across a power source and individual resistors.
9b4	I can apply Kirchhoff's Loop Rule, which states that voltages around any closed loop must add to zero, (conservation of energy).

9b5	I can apply Kirchhoff's Junction Rule, which states that currents through branches all add up to total current through the battery
9b6	I can calculate the power generated or dissipated by various circuit components.
9b7	I can qualitatively describe the voltage gains and losses throughout a closed circuit loop, as well as the changes to the current.
9b8	*(PS3-2). I can 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.*
9b9	*(PS2-5). I can develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.*

Unit 10: Mechanical Waves

Mechanical Waves Objectives	
10a	**I can utilize both the particle and pulse models of waves to make and justify claims about waves.**
10a1	I understand a wave's energy is carried in its amplitude, which manifests itself as loudness in sound and brightness in light.
10a2	I can describe how a standing wave is created, and how to measure all of its wave characteristics.
10a3	I understand wave motion: back and forth motion of source (particle/oscillation) moves in a straight-line through a medium away from source (pulse/propagation).
10a4	I can measure and calculate the following wave characteristics: period, frequency, angular frequency, wavelength, amplitude, and propagational speed.
10a5	I understand relationships among all wave characteristics, and how changes to one characteristic affects the others. This includes comparing/contrasting period, frequency, and angular frequency using units.
10a6	I can identify wave characteristics from a position vs. time graph: period, frequency, angular frequency, amplitude.
10a7	I can mathematically model a wave source's back-&-forth motion using a cosine function (i.e., convert between radians and cycles; determine amplitude, period, frequency, and angular frequency; and write an expression for y as a function of t).
10a8	I can distinguish between transverse and longitudinal waves.
10a9	(PS4-1). I can use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media, (i.e., I can demonstrate an understanding of how the frequency and period of a wave depends on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$).
10a10	I can design a plan for collecting data to quantify the amplitude changes when two or more wave pulses interact within a given medium.
10b	***I understand how electromagnetic raditation interacts with matter, and applications to current technologies.***
10b1	*(PS4-2). I can evaluate questions about the advantages of using digital transmission and storage of*

	information. Digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages include issues of easy deletion, security, and theft. NOT DONE.
10b2	*(PS4-3). I can evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. NOT DONE.*
10b3	*(PS4-5). I can evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. NOT DONE.*
10b4	*(PS4-5). I can communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy. For example, solar cells capture light and convert it to electricity. NOT DONE.*

We are considering cutting sound or combining it with mechanical waves to make room for the *10b* objectives.

Unit 11: Sound

Sound Objectives	
11a	**I understand the properties and behaviors of sound waves.**
11a1	I understand an echo is a sound wave reflecting off a surface back to the original source.
11a2	I apply the 5 sec/mile approximation to calculate the distance an observer is away from the source of a sound. (e.g., delay between thunder & lightning)
11a3	I understand that the frequency of sound waves is pitch, and amplitude is loudness.
11a4	I can apply Doppler Effect to explain how the motion of an object affects the frequency and wavelength of its sound to a listener.
11a5	I know that sound is a longitudinal wave, and can explain why longitudinal waves can pass through solids, liquids, and gases while transverse can only propagate through solids.
11a6	I know that speed of sound depends on its medium--air, and therefore fluctuates with temperature.
11b	**I can design and construct a musical instrument by applying the concept of standing waves to a string or column of air.**
11b1	I can conceptually and mathematically describe how harmonics and octaves affect music and sound waves.
11b2	I can calculate the frequency of a musical note that is one octave higher.
11b3	I can explain the role of standing waves in the production of musical notes by tubular and stringed instruments.
11b4	I can calculate wavelengths and frequencies (if given wave speed) of standing waves using knowledge of the length of the string or tube.

Science Department		[AP Physics-1: 3930]			
Timeline (Estimated # of School Days)	**Sltudent Learning Objective (SLO)**	**Learning Targets (Students will be able to…)**	**Standards (College Board)**	**Assessments (Summative: Tests, Projects, Essays, Labs, Other) [1]**	**References [2]**
14 days	Unit 1: Students will understand Kinematics in one and two dimensions.	The student is able to express the motion of an object using narrative, mathematical, and graphical representations. [SP 1.5, 2.1, 2.2]	3.A.1.1		
		The student is able to design an experimental investigation of the motion of an object. [SP 4.2]	3.A.1.2		
		The student is able to analyze experimental data describing the motion of an object and is able to express the results of the analysis using narrative, mathematical, and graphical representations. [SP 5.1]	3.A.1.3		
14 days	Unit 2: Students will understand Newton's Three laws and how Forces cause the motion of objects. [I.B]	The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration. [SP 4.2]	1.C.1.1		
		The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass, and to distinguish between the two experiments. [SP 4.2]	1.C.3.1		
		The student is able to apply F = mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [SP 2.2, 7.2]	2.B.1.1		
		The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1]	3.A.2.1		
		The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [SP 6.4, 7.2]	3.A.3.1		
		The student is able to challenge a claim that an object can exert a force on itself. [SP 6.1]	3.A.3.2		

		The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4]	3.A.3.3		
		The student is able to construct explanations of physical situations involving the interaction of bodies using Newton’s third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2]	3.A.4.1		
		The student is able to use Newton’s third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2]	3.A.4.2		
		The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton’s third law to identify forces. [SP 1.4]	3.A.4.3		
		The student is able to predict the motion of an object subject to forces exerted by several objects using an application of Newton’s second law in a variety of physical situations with acceleration in one dimension. [SP 6.4, 7.2]	3.B.1.1		
		The student is able to design a plan to collect and analyze data for motion (static, constant, or accelerating) from force measurements and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces. [SP 4.2, 5.1]	3.B.1.2		
		The student is able to re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [SP 1.5, 2.2]	3.B.1.3		
		The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [SP 1.1, 1.4, 2.2]	3.B.2.1		
		The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces. [SP 6.1]	3.C.4.1		

		The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [SP 6.2]	3.C.4.2		
		The student is able to make predictions about the motion of a system based on the fact that acceleration is equal to the change in velocity per unit time, and velocity is equal to the change in position per unit time. [SP 6.4]	4.A.2.1		
		The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. [SP 5.3]	4.A.2.2		
		The student is able to create mathematical models and analyze graphical relationships for acceleration, velocity, and position of the center of mass of a system and use them to calculate properties of the motion of the center of mass of a system. [SP 1.4, 2.2]	4.A.2.3		
		The student is able to apply Newton's second law to systems to calculate the change in the center-ofmass velocity when an external force is exerted on the system. [SP 2.2]	4.A.3.1		
		The student is able to use visual or mathematical representations of the forces between objects in a system to predict whether or not there will be a change in the center-of-mass velocity of that system. [SP 1.4]	4.A.3.2		
9 days	Unit 3: Students will understand how to apply Energy concepts to force-distance situations. [I.C]	The student is able to design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration. [SP 4.2]	1.C.1.1		
		The student is able to design a plan for collecting data to measure gravitational mass and to measure inertial mass, and to distinguish between the two experiments. [SP 4.2]	1.C.3.1		
		The student is able to apply F =mg to calculate the gravitational force on an object with mass m in a gravitational field of strength g in the context of the effects of a net force on objects and systems. [SP 2.2, 7.2]	2.B.1.1		

		The student is able to apply g = GM/R2 to calculate the gravitational field due to an object with mass M, where the field is a vector directed toward the center of the object of mass M. [SP 2.2]	2.B.2.1		
		The student is able to approximate a numerical value of the gravitational field (g) near the surface of an object from its radius and mass relative to those of the Earth or other reference objects. [SP 2.2]	2.B.2.2		
		The student is able to represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. [SP 1.1]	3.A.2.1		
		The student is able to analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces. [SP 6.4, 7.2]	3.A.3.1		
		The student is able to challenge a claim that an object can exert a force on itself. [SP 6.1]	3.A.3.2		
		The student is able to describe a force as an interaction between two objects and identify both objects for any force. [SP 1.4]	3.A.3.3		
		The student is able to construct explanations of physical situations involving the interaction of bodies using Newton's third law and the representation of action-reaction pairs of forces. [SP 1.4, 6.2]	3.A.4.1		
		The student is able to use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. [SP 6.4, 7.2]	3.A.4.2		
		The student is able to analyze situations involving interactions among several objects by using free-body diagrams that include the application of Newton's third law to identify forces. [SP 1.4]	3.A.4.3		
		The student is able to re-express a free-body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the object. [SP 1.5, 2.2]	3.B.1.3		

		The student is able to create and use free-body diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively. [SP 1.1, 1.4, 2.2]	3.B.2.1		
		The student is able to use Newton's law of gravitation to calculate the gravitational force the two objects exert on each other and use that force in contexts other than orbital motion. [SP 2.2]	3.C.1.1		
		The student is able to use Newton's law of gravitation to calculate the gravitational force between two objects and use that force in contexts involving orbital motion [SP 2.2]	3.C.1.2		
		The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [SP 7.2]	3.C.2.2		
		The student is able to make claims about various contact forces between objects based on the microscopic cause of those forces. [SP 6.1]	3.C.4.1		
		The student is able to explain contact forces (tension, friction, normal, buoyant, spring) as arising from interatomic electric forces and that they therefore have certain directions. [SP 6.2]	3.C.4.2		
		The student is able to articulate situations when the gravitational force is the dominant force and when the electromagnetic, weak, and strong forces can be ignored. [SP 7.1]	3.G.1.1		
		The student is able to evaluate using given data whether all the forces on a system or whether all the parts of a system have been identified. [SP 5.3]	4.A.2.2		
taught with energy	Unit 4: Students will understand how to apply Energy concepts to force-distance situations. [I.C]	The student is able to make predictions about the changes in kinetic energy of an object based on considerations of the direction of the net force on the object as the object moves. [SP 6.4, 7.2]	3.E.1.1		
		The student is able to use net force and velocity vectors to determine qualitatively whether kinetic energy of an object would increase, decrease, or remain unchanged. [SP 1.4]	3.E.1.2		

		The student is able to use force and velocity vectors to determine qualitatively or quantitatively the net force exerted on an object and qualitatively whether kinetic energy of that object would increase, decrease, or remain unchanged. [SP 1.4, 2.2]	3.E.1.3		
		The student is able to apply mathematical routines to determine the change in kinetic energy of an object given the forces on the object and the displacement of the object. [SP 2.2]	3.E.1.4		
		The student is able to calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy. [SP 1.4, 2.1, 2.2]	4.C.1.1		
		The student is able to predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. [SP 6.4]	4.C.1.2		
		The student is able to make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass. [SP 6.4]	4.C.2.1		
		The student is able to apply the concepts of Conservation of Energy and the Work-Energy theorem to determine qualitatively and/or quantitatively that work done on a two-object system in linear motion will change the kinetic energy of the center of mass of the system, the potential energy of the systems, and/or the internal energy of the system. [SP 1.4, 2.2, 7.2]	4.C.2.2		
		The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2]	5.A.2.1		
		The student is able to set up a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy. [SP 1.4, 2.2]	5.B.1.1		

		The student is able to translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies. [SP 1.5]	5.B.1.2		
		The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [SP 1.4, 2.1]	5.B.2.1		
		The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. [SP 2.2, 6.4, 7.2]	5.B.3.1		
		The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. [SP 1.4, 2.2]	5.B.3.2		
		The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system. [SP 1.4, 2.2]	5.B.3.3		
		The student is able to describe and make predictions about the internal energy of systems. [SP 6.4, 7.2]	5.B.4.1		
		The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [SP 1.4, 2.1, 2.2]	5.B.4.2		
		The student is able to design an experiment and analyze data to examine how a force exerted on an object or system does work on the object or system as it moves through a distance. [SP 4.2, 5.1]	5.B.5.1		
		The student is able to design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system. [SP 4.2, 5.1]	5.B.5.2		

		The student is able to predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance. [SP 1.4, 2.2, 6.4]	5.B.5.3		
		The student is able to make claims about the interaction between a system and its environment in which the environment exerts a force on the system, thus doing work on the system and changing the energy of the system (kinetic energy plus potential energy). [SP 6.4, 7.2]	5.B.5.4		
		The student is able to predict and calculate the energy transfer to (i.e., the work done on) an object or system from information about a force exerted on the object or system through a distance. [SP 2.2, 6.4]	5.B.5.5		
		The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. [SP 6.4, 7.2]	5.D.1.1		
		The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations. [SP 2.2, 3.2, 5.1, 5.3]	5.D.1.2		
		The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy. [SP 2.1, 2.2]	5.D.1.3		

		The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome. [SP 4.2, 5.1, 5.3, 6.4]	5.D.1.4		
		The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. [SP 2.1, 2.2]	5.D.1.5		
		The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [SP 6.4, 7.2]	5.D.2.1		
		The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [SP 6.4, 7.2]	5.D.2.3		
11 days	Unit 5: Students will understand how to apply Momentum concepts to force-time situations. [I.D]	The student is able to justify the selection of data needed to determine the relationship between the direction of the force acting on an object and the change in momentum caused by that force. [SP 4.1]	3.D.1.1		
		The student is able to justify the selection of routines for the calculation of the relationships between changes in momentum of an object, average force, impulse, and time of interaction. [SP 2.1]	3.D.2.1		
		The student is able to predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [SP 6.4]	3.D.2.2		
		The student is able to analyze data to characterize the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. [SP 5.1]	3.D.2.3		

		The student is able to design a plan for collecting data to investigate the relationship between changes in momentum and the average force exerted on an object over time. [SP 4.2]	3.D.2.4		
		The student is able to analyze data to find the change in linear momentum for a constant-mass system using the product of the mass and the change in velocity of the center of mass. [SP 5.1]	4.B.1.2		
		The student is able to apply mathematical routines to calculate the change in momentum of a system by analyzing the average force exerted over a certain time on the system. [SP 2.2]	4.B.2.1		
		The student is able to perform analysis on data presented as a force-time graph and predict the change in momentum of a system. [SP 5.1]	4.B.2.2		
		The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2]	5.A.2.1		
		The student is able to make qualitative predictions about natural phenomena based on conservation of linear momentum and restoration of kinetic energy in elastic collisions. [SP 6.4, 7.2]	5.D.1.1		
		The student is able to apply the principles of conservation of momentum and restoration of kinetic energy to reconcile a situation that appears to be isolated and elastic, but in which data indicate that linear momentum and kinetic energy are not the same after the interaction, by refining a scientific question to identify interactions that have not been considered. Students will be expected to solve qualitatively and/or quantitatively for one-dimensional situations and only qualitatively in two-dimensional situations. [SP 2.2, 3.2, 5.1, 5.3]	5.D.1.2		

		The student is able to apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of those mathematical routines based on conservation of momentum and restoration of kinetic energy. [SP 2.1, 2.2]	5.D.1.3		
		The student is able to design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome. [SP 4.2, 5.1, 5.3, 6.4]	5.D.1.4		
		The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values. [SP 2.1, 2.2]	5.D.1.5		
		The student is able to qualitatively predict, in terms of linear momentum and kinetic energy, how the outcome of a collision between two objects changes depending on whether the collision is elastic or inelastic. [SP 6.4, 7.2]	5.D.2.1		
		The student is able to plan data collection strategies to test the law of conservation of momentum in a two-object collision that is elastic or inelastic and analyze the resulting data graphically. [SP 4.1, 4.2, 5.1]	5.D.2.2		
		The student is able to apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. [SP 6.4, 7.2]	5.D.2.3		
		The student is able to analyze data that verify conservation of momentum in collisions with and without an external friction force. [SP 4.1, 4.2, 4.4, 5.1, 5.3]	5.D.2.4		

		The student is able to classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum as the appropriate solution method for an inelastic collision, recognize that there is a common final velocity for the colliding objects in the totally inelastic case, solve for missing variables, and calculate their values. [SP 2.1, 2.2]	5.D.2.5		
		The student is able to predict the velocity of the center of mass of a system when there is no interaction outside of the system but there is an interaction within the system (i.e., the student simply recognizes that interactions within a system do not affect the center of mass motion of the system and is able to determine that there is no external force). [SP 6.4]	5.D.3.1		
25 days	Unit 6: Students will understand how forces can cause Circular motion and rotation. [I.E]	The student is able to use representations of the relationship between force and torque. [SP 1.4]	3.F.1.1		
		The student is able to compare the torques on an object caused by various forces. [SP 1.4] 3.F.1.3: The student is able to estimate the torque on an object caused by various forces in comparison to other situations. [SP 2.3]	3.F.1.2		
		The student is able to design an experiment and analyze data testing a question about torques in a balanced rigid system. [SP 4.1, 4.2, 5.1]	3.F.1.4		
		The student is able to calculate torques on a two-dimensional system in static equilibrium, by examining a representation or model (such as a diagram or physical construction). [SP 1.4, 2.2]	3.F.1.5		
		The student is able to make predictions about the change in the angular velocity about an axis for an object when forces exerted on the object cause a torque about that axis. [SP 6.4]	3.F.2.1		
		The student is able to plan data collection and analysis strategies designed to test the relationship between a torque exerted on an object and the change in angular velocity of that object about an axis. [SP 4.1, 4.2, 5.1]	3.F.2.2		

		The student is able to predict the behavior of rotational collision situations by the same processes that are used to analyze linear collision situations using an analogy between impulse and change of linear momentum and angular impulse and change of angular momentum. [SP 6.4, 7.2]	3.F.3.1		
		In an unfamiliar context or using representations beyond equations, the student is able to justify the selection of a mathematical routine to solve for the change in angular momentum of an object caused by torques exerted on the object. [SP 2.1]	3.F.3.2		
		The student is able to plan data collection and analysis strategies designed to test the relationship between torques exerted on an object and the change in angular momentum of that object. [SP 4.1, 4.2, 5.1, 5.3]	3.F.3.3		
		The student is able to use representations of the center of mass of an isolated two-object system to analyze the motion of the system qualitatively and semi-quantitatively. [SP 1.2, 1.4, 2.3, 6.4]	4.A.1.1		
		The student is able to describe a representation and use it to analyze a situation in which several forces exerted on a rotating system of rigidly connected objects change the angular velocity and angular momentum of the system. [SP 1.2, 1.4]	4.D.1.1		
		The student is able to plan data collection strategies designed to establish that torque, angular velocity, angular acceleration, and angular momentum can be predicted accurately when the variables are treated as being clockwise or counterclockwise with respect to a well-defined axis of rotation, and refine the research question based on the examination of data. [SP 3.2, 4.1, 4.2, 5.1, 5.3]	4.D.1.2		
		The student is able to describe a model of a rotational system and use that model to analyze a situation in which angular momentum changes due to interaction with other objects or systems. [SP 1.2, 1.4]	4.D.2.1		

		The student is able to plan a data collection and analysis strategy to determine the change in angular momentum of a system and relate it to interactions with other objects and systems. [SP 4.2]	4.D.2.2		
		The student is able to use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. [SP 2.2]	4.D.3.1		
		The student is able to plan a data collection strategy designed to test the relationship between the change in angular momentum of a system and the product of the average torque applied to the system and the time interval during which the torque is exerted. [SP 4.1, 4.2]	4.D.3.2		
		The student is able to make qualitative predictions about the angular momentum of a system for a situation in which there is no net external torque. [SP 6.4, 7.2]	5.E.1.1		
		The student is able to make calculations of quantities related to the angular momentum of a system when the net external torque on the system is zero. [SP 2.1, 2.2]	5.E.1.2		
		The student is able to describe or calculate the angular momentum and rotational inertia of a system in terms of the locations and velocities of objects that make up the system. Students are expected to do qualitative reasoning with compound objects. Students are expected to do calculations with a fixed set of extended objects and point masses. [SP 2.2]	5.E.2.1		
14 days	Unit 7: Students will understand how Oscillations can be applied to Wavelike mathematics.[I.F]	The student is able to predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. [SP 6.4, 7.2]	3.B.3.1		
		The student is able to design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. [SP 4.2]	3.B.3.2		

		The student can analyze data to identify qualitative or quantitative relationships between given values and variables (i.e., force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion to use that data to determine the value of an unknown. [SP 2.2, 5.1]	3.B.3.3		
		The student is able to construct a qualitative and/or a quantitative explanation of oscillatory behavior given evidence of a restoring force. [SP 2.2, 6.2]	3.B.3.4		
		The student is able to calculate the expected behavior of a system using the object model (i.e., by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. [SP 1.4, 2.1]	5.B.2.1		
		The student is able to describe and make qualitative and/or quantitative predictions about everyday examples of systems with internal potential energy. [SP 2.2, 6.4, 7.2]	5.B.3.1		
		The student is able to make quantitative calculations of the internal potential energy of a system from a description or diagram of that system. [SP 1.4, 2.2]	5.B.3.2		
		The student is able to apply mathematical reasoning to create a description of the internal potential energy of a system from a description or diagram of the objects and interactions in that system. [SP 1.4, 2.2]	5.B.3.3		
		The student is able to describe and make predictions about the internal energy of systems. [SP 6.4, 7.2]	5.B.4.1		
		The student is able to calculate changes in kinetic energy and potential energy of a system, using information from representations of that system. [SP 1.4, 2.1, 2.2]	5.B.4.2		

taught with waves	Unit 8: Students will understand the mathematics behind Wave motion (including sound) [IV.A]	The student is able to use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. [SP 6.2]	6.A.1.1		
		The student is able to describe representations of transverse and longitudinal waves. [SP 1.2]	6.A.1.2		
		The student is able to describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples. [SP 6.4, 7.2]	6.A.2.1		
		The student is able to use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. [SP 1.4]	6.A.3.1		
		The student is able to explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave, and/or apply this concept to a real-world example. [SP 6.4]	6.A.4.1		
		The student is able to use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. [SP 1.4, 2.2]	6.B.1.1		
		The student is able to use a visual representation of a periodic mechanical wave to determine wavelength of the wave. [SP 1.4]	6.B.2.1		
		The student is able to design an experiment to determine the relationship between periodic wave speed, wavelength, and frequency and relate these concepts to everyday examples. [SP 4.2, 5.1, 7.2]	6.B.4.1		
		The student is able to create or use a wave front diagram to demonstrate or interpret qualitatively the observed frequency of a wave, dependent upon relative motions of source and observer. [SP 1.4]	6.B.5.1		
		The student is able to use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses. [SP 1.1, 1.4]	6.D.1.1		

		The student is able to design a suitable experiment and analyze data illustrating the superposition of mechanical waves (only for wave pulses or standing waves). [SP 4.2, 5.1]	6.D.1.2		
		The student is able to design a plan for collecting data to quantify the amplitude variations when two or more traveling waves or wave pulses interact in a given medium. [SP 4.2]	6.D.1.3		
		The student is able to analyze data or observations or evaluate evidence of the interaction of two or more traveling waves in one or two dimensions (i.e., circular wave fronts) to evaluate the variations in resultant amplitudes. [SP 5.1]	6.D.2.1		
		The student is able to refine a scientific question related to standing waves and design a detailed plan for the experiment that can be conducted to examine the phenomenon qualitatively or quantitatively. [SP 2.1, 3.2, 4.2]	6.D.3.1		
		The student is able to predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. [SP 6.4] 6.D.3.3: The student is able to plan data collection strategies, predict the outcome based on the relationship under test, perform data analysis, evaluate evidence compared to the prediction, explain any discrepancy and, if necessary, revise the relationship among variables responsible for establishing standing waves on a string or in a column of air. [SP 3.2, 4.1, 5.1, 5.2, 5.3]	6.D.3.2		
		The student is able to describe representations and models of situations in which standing waves result from the addition of incident and reflected waves confined to a region. [SP 1.2]	6.D.3.4		
		The student is able to challenge with evidence the claim that the wavelengths of standing waves are determined by the frequency of the source regardless of the size of the region. [SP 1.5, 6.1]	6.D.4.1		

		The student is able to calculate wavelengths and frequencies (if given wave speed) of standing waves based on boundary conditions and length of region within which the wave is confined, and calculate numerical values of wavelengths and frequencies. Examples should include musical instruments. [SP 2.2]	6.D.4.2		
		The student is able to use a visual representation to explain how waves of slightly different frequency give rise to the phenomenon of beats. [SP 1.2]	6.D.5.1		
13 days	Unit 9: Students will understand the force and energy aspects of Electrostatics. [III.A]	The student is able to make claims about natural phenomena based on conservation of electric charge. [SP 6.4]	1.B.1.1		
		The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [SP 6.4, 7.2]	1.B.1.2		
		The student is able to construct an explanation of the two-charge model of electric charge based on evidence produced through scientific practices. [SP 6.2]	1.B.2.1		
		The student is able to challenge the claim that an electric charge smaller than the elementary charge has been isolated. [SP 1.5, 6.1, 7.2]	1.B.3.1		
		The student is able to use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges. [SP 2.2, 6.4]	3.C.2.1		
		The student is able to connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. [See SP 7.2]	3.C.2.2		
		The student is able to define open and closed systems for everyday situations and apply conservation concepts for energy, charge, and linear momentum to those situations. [SP 6.4, 7.2]	5.A.2.1		
14 days	Unit 10: Students will be able to solve energy and current problems for DC electric circuits.. [III.C]	The student is able to make claims about natural phenomena based on conservation of electric charge. [SP 6.4]	1.B.1.1		

		The student is able to make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. [SP 6.4, 7.2]	1.B.1.2		
		The student is able to choose and justify the selection of data needed to determine resistivity for a given material. [SP 4.1]	1.E.2.1		
		The student is able to construct or interpret a graph of the energy changes within an electrical circuit with only a single battery and resistors in series and/or in, at most, one parallel branch as an application of the conservation of energy (Kirchhoff's loop rule). [SP 1.1, 1.4]	5.B.9.1		
		The student is able to apply conservation of energy concepts to the design of an experiment that will demonstrate the validity of Kirchhoff's loop rule ($\sum \Delta V=0$) in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. [SP 4.2, 6.4, 7.2]	5.B.9.2		
		The student is able to apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch. [SP 2.2, 6.4, 7.2]	5.B.9.3		
		The student is able to apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed. [SP 6.4, 7.2]	5.C.3.1		
		The student is able to design an investigation of an electrical circuit with one or more resistors in which evidence of conservation of electric charge can be collected and analyzed. [SP 4.1, 4.2, 5.1]	5.C.3.2		

		The student is able to use a description or schematic diagram of an electrical circuit to calculate unknown values of current in various segments or branches of the circuit. [SP 1.4, 2.2]	5.C.3.3	

Chemistry: Chemistry of Earth Systems
Units and Objectives

This course covers the skills and content of a first-year Chemistry course within the context of Earth Systems. Topics include: The Big Bang and the origin of elements, atomic structure, chemical reactions and their role in Earth processes, bonding, chemistry topics applied to environmental issues, stoichiometry, thermodynamics, and equilibrium. (Fall 2020)

Units	NGSS
Big Bang and Nuclear Chemistry	ESS1-1, ESS1-2, ESS1-3, PS1-8
Atomic Structure	PS1-1
The Periodic Table	PS1-1
Chemical Bonding	PS1-3
Chemical Quantities	PS1-2
Chemical Reactions	PS1-2
Stoichiometry	PS1-7
Copper Unlimited Project	ESS3-2
Thermochemistry	PS1-4, PS3-1, PS3-4
Gases	
Weather and Climate	ESS2-2
Climate Change	ESS2-4, ESS3-5, ESS3-6
Reaction Rates and Equilibrium	PS1-5, PS1-6
Acid-Base Equilibria	
Ocean Acidification	ESS2-6
Organic Chemistry	PS2-6

Chemistry: Chemistry of Earth Systems

1: WHERE DOES "STUFF" COME FROM? (Investigation 1 and 17)

Big Bang, Nuclear (10 days)

Question: Where does "stuff" come from?

Extension (project?) if time: Experience 3: Nuclear Technologies (Nuclear power plants, nuclear medical technology)

1a	**The Big Bang**
1a1	Describe the big bang theory and compositional evidence for it.
1b	**Investigation 1 Experience 2: Modeling atoms (p. 12-21)**
1b1	Describe atomic structure using a model of the atom that includes protons, neutrons and electrons.
1b2	Compare and contrast atoms of different elements and isotopes of the same element including mass number, atomic mass, isotopic notation and isotopic abundance.
1c	**Investigation 17 Experience 2: Fusion: Stars/Life Cycle, Formation of Elements**
1c1	Explain the role of fusion in the formation of new elements in the three different life cycles of stars.
1c2	Develop models to explain the conservation of mass and energy during the processes of fission and fusion.
1c3	Describe conversions between mass and energy during the Big Bang and other nuclear processes.
1d	**Investigation 17 Experience 1: Radioactivity and Half-Lives, Radioactive Decay, Half-life and Applications**
1d1	Describe the particles and forces present in the atomic nucleus.
1d2	Develop models to illustrate the changes in the composition of the atomic nucleus and the energy released during radioactive decay.
1d3	Use mathematics to calculate the half-life of a radioactive substance and the approximate age of earth materials in order to decipher the age and history of the earth.
1d4	Calculate the age of ocean crust to infer plate movement direction and rate of movement.

<u>2: WHERE DOES "STUFF" COME FROM? (Investigation 1)</u>

Atomic structure, Emissions Spectra and Electrons (9 days)

Phenomena: What causes colors in a fireworks display?

2a	**Investigation 1 Experience 3: Atomic Emissions Spectra and the Bohr model (p. 19-20)**
2a1	Develop and use Bohr models for atoms illustrating electron energy levels and the placement of electrons within those levels with an emphasis on valence electrons.
2a2	Use the Bohr model to explain why elements have unique atomic emission spectra and use spectra as an identification technique.
2a3	Relate the Spectra of elements to the structure of their atoms, particularly the patterns of electrons and the changes in their energy.
2a4	Evaluate the spectra of different light sources and differentiate between spectral types.
2a5	Use spectra to gauge the composition of stars, galaxies, nebulae
2a6	Evaluate the Doppler effect on spectra to determine direction and relative speeds of objects and as evidence for the Big Bang.
2b	**Investigation 1 Experience 5: Electrons in Atoms (33-39)**
2b1	Predict the valence electrons in an atom using the periodic table as a model.
2b3	Use electron dot structures to represent an atom's valence electrons.

2. THE PERIODIC TABLE

The Periodic Table (9.5 days)

Phenomena: Why are elements in pure form so rare?

3a	**Investigation 1 Experience 1: The Particle Nature of Matter (p. 6-11)**
3a1	I can define and differentiate between atoms, molecules, elements and compounds and develop models to describe them.
3a2	Use particle level models to explain interactions of energy and matter within a system as it relates to states of matter.
3a3	Use evidence to determine whether a physical or chemical change has occurred.
3b	**Investigation 2 Experience 1: The Periodic Table - An Overview (p. 44-49)**
3b1	Identify various groups of elements on the periodic table (e.g., families, periods, metals, nonmetals, metalloids).
3b2	Describe how elements in the periodic table are arranged by the number of protons in atoms.
3b3	Identify how the arrangement of the main groups of the periodic table reflects the patterns of valence electrons.
3b4	Explain how the position of an element in the table can be used to predict some of its chemical and physical properties.
3c	**Investigation 4 Experience 4 Comparing Metals & Nonmetals (p. 141-145)**
3c1	Analyze data comparing metals and nonmetals and construct explanations for their differences.
3c2	Summarize defining properties of metals.
3c3	Describe how delocalized electrons give rise to metallic properties.
3d	**Investigation 2 Experience 3: Periodic Trends (p. 56-64)**
3d1	Investigate and explain reactivity patterns in the periodic table using concepts of ionization energy, net effective charge and atomic radius.
3d2	Use models of elements to explain the formation of ions.
3d3	Use periodic trends to predict and explain elemental properties: metallic character, nonmetallic character, electron affinity, atomic radius, ion size, ionization energy, common charges for group numbers.

3. CHEMICAL BONDING

Chemical Bonding (11.5 days)

Phenomena: Why do gems have different properties than metals?

4a	**Experience 1: Ionic Bonds (p. 68-76)**
4a1	Explain that atoms gain or lose electrons to become ions so that they have a full valence shell.
4a2	Explain that ionic bonds are electrostatic attractions between cations and anions.
4a3	Describe how the structure of ionic compounds affects their properties (including becoming electrolytes when dissolved).
4b	**Experience 2: Metallic Bonds (77-80)**
4b1	Describe the electron sea model of metallic bonds.
4b2	Explain how the bonding in metals and alloys affects their properties.
4c	**Experience 3: Covalent Bonds (81-90)**
4c1	Explain how nonmetals share electrons to share their valence shell octet, resulting in the formation of a covalent bond.
4c2	Identify single and double and triple covalent bonds and draw electron dot diagrams for each.
4c3	Describe how elements of different electronegativities can share electrons unequally, leading to the formation of a polar covalent bond.
4c4	Use VSEPR theory to determine shapes of molecules.
4c5	Determine the polarity of a molecule based on the shape of a molecule.
4d	**Experience 4: Intermolecular Attractions (p. 91-96)**
4d1	Describe the types of attractions between molecules.
4d2	Explain how intermolecular attractions between molecules influence the bulk properties of a material (ex. Surface tension, boiling point, state of matter at room temp).
4d3	Describe mineral crystalline structures and how they influence mineral properties including cleavage, fracture, and hardness
4e	**Experience 5: Names and Formulas of Compounds (p. 97-106)**
4e1	Given the name, write the formulas of molecular compounds and ionic compounds.
4e2	Predict bond types in a compound based on its name or formula.
4e3	Describe the ways in which mineral resources impact our daily lives and how these resources are extracted and processed.

5. CHEMICAL QUANTITIES

Chemical Quantities (9.5 days)

Phenomena: Why do we quantify matter in different ways?

5a	**Experience 1: The Mole Concept (p. 174-182)**
5a1	Investigate the three methods used to measure matter -- count, mass, and volume.
5a2	Explain the relationship between the mole and Avogadro's number (for atoms, molecules, and formula units).
5a3	Use Avogadro's number to convert from moles to particles and particles to moles.
5a4	Use the periodic table to find the molar mass of elements and compounds.
5b	**Experience 2: Molar Relationships (p. 183-191)**
5b1	Convert mole quantities to masses or volumes (for a gas at STP), and mass or Volume (gas at STP) quantities to moles.
5c	**Experience 3: Percent Composition and Empirical Formulas (p. 192-202)**
5c1	Explain how to find the percent composition of a compound.
5d	**Experience 4: Concentrations of Solutions (p. 203-212)**
5d1	Find the molarity of a solution.
5d2	Investigate how the ratio of solute to solvent affects the concentration of a solution.
5d3	Devise a method to make a solution of a specific concentration.

6. CHEMICAL REACTIONS

Chemical Reactions (7.5 days)

Phenomena: How is energy obtained from chemical reactions? Rocket launching.

6a	**Experience 1: Modeling Chemical Reactions (p. 216-226)**
6a1	Identify the parts of a chemical reaction, and balance equations for these chemical reactions.
6b	**Experience 2: Predicting Outcomes of Chemical Reactions (p. 227-240)** **Experience 3: Reactions in Aqueous Solution (p. (241-248)**
6b1	Identify the five general types of chemical reactions.
6b2	Predict the outcome of certain reactions based on the reactants, including identifying precipitates.

7. STOICHIOMETRY

Stoichiometry (8 days) + Copper Unlimited project (5 days)

Phenomena: What can make a recipe fail?

Project: Copper Unlimited

7a	**Experience 1: Quantifying Reactants and Products (p. 252-258)**
7a1	Analyze data on proportionality of reactants and products to predict their stoichiometric ratios in the corresponding chemical equation.
7a2	Develop a model that demonstrates conservation of mass in a chemical equation.
7b	**Experience 2: Chemical Calculations (p, 259-268)**
7b1	Use the mole ratio in a chemical reaction to relate amounts of participating substances.
7b2	Use stoichiometry to convert between grams and moles in a chemical reaction.
7c	**Experience 3: Limiting Reagent and Percent Yield (p. 269-278)**
7c1	Explain the concept of limiting reactant and compute theoretical yield.
7c2	Explain the theoretical and actual yield and calculate percent yield.

Copper Unlimited Lab Project

7d	**Copper Unlimited Lab Project**
7d1	ESS3-2: Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources on cost benefit ratios.
7d2	Describe the ways in which energy resources are extracted and processed, as well as their environmental costs.

<u>8. THERMOCHEMISTRY</u>

Thermochemistry (8 days)

Phenomena: Why do you get hot when you exercise?

8a	**Experience 1: Energy in Chemical Bonds (p. 282-290)**
8a1	Explain how molecules must collide with each other with sufficient energy and in the correct orientation for a chemical reaction to take place.
8a2	Represent energy changes in exothermic and endothermic reactions using an enthalpy diagram.
8a3	Calculate enthalpy of reaction from bond energies and molar enthalpy of reaction data.
8b	**Experience 3: Enthalpy in Changes of State**
8b1	Understand how and why substances change in enthalpy when transitioning between physical states.
8b2	Calculate the change in enthalpy for state changes between solid, liquid, and gas.
8b3	Describe the link between state change enthalpies and the strength of intermolecular forces.
8c	**Enthalpy and Changes in Temperature**
8c1	Calculate the quantity of energy involved in temperature changes ($q=sm\Delta T$).
8c2	Explain how specific heat of water compared to other Earth materials produces differences in the temperature profile of: locations at the same latitude near and far from oceans, locations at the same latitude in the Northern vs. Southern Hemisphere

9. GASES

The Behavior of Gases (9.5 days)

Phenomena: What causes the Santa Ana winds?

9a	**Experience 1: Properties of Gases (p. 6-9)**
9a1	Use particle pictures to explain the differences between solids, liquids and gases.
9a2	Use the kinetic theory to explain the properties of gases (motion of particles, diffusion, compressibility, have mass, volume, exert pressure, etc.)
9a3	Describe the effects on gases of changes in volume, temperature, pressure, and the number of particles.
9b	**Experience 2: The Gas Laws (p. 11-22)**
9b1	Investigate and explain the relationship between the volume, temperature, and pressure of a gas.
9b2	Develop and use models to explain the gas laws.
9b3	Relate the patterns of interaction between gas particles at the molecular scale to the patterns of gas behavior at the macroscopic scale.
9c	**Experience 4: Gases in Earth's Atmosphere (p. 37-40)**
9c1	Identify the main gases in Earth's atmosphere.
9c2	Explain Dalton's law of partial pressure.
9c3	Describe the process that causes wind and its impact at local, regional, and global scales.
9c4	Relate relative humidity to water vapor partial pressure and air temperature.

10. WEATHER AND CLIMATE

Weather and Climate (10.5 days)

Phenomena: What is causing a drought in California?

10a	**Experience 1: Earth's Surface Systems (p. 37, 39, 52, 75)**
10a1	Analyze data to make a claim that a change to Earth's surface can cause changes to other Earth systems; describe the impact of various geochemical cycles.
10b	**Experience 2: Water and Energy in the Atmosphere**
10b1	Discuss how small changes can affect Earth's energy budget and climate.
10b2	Explain the impact of albedo in Earth's climate.
10b3	Analyze the amount of incoming and outgoing energy absorbed by the atmosphere.
10b4	Explain how unequal heating of the Earth's surface produces local winds, but when combined with the Coriolis Effect can produce consistent, predictable global winds.
10b5	Identify the processes and the reservoirs of the carbon cycle, and identify the impacts humans have had on this cycle
10c	**Experience 3: Atmospheric System Feedbacks**
10c1	Investigate and model the effects of changes on Earth's systems, including feedback that accelerates or slows changes to the systems.
10c2	Differentiate between positive and negative feedback loops; describe examples of each, particularly as relate to climate change
10d	**Experience 4: Long-Term Climate Factors**
10d1	Describe the factors that affect carbon dioxide concentration in Earth's atmosphere and use these factors to make predictions about the atmosphere under changing conditions.
10d2	Analyze and interpret data relating to the impact of carbon dioxide in Earth's atmosphere.
10e	**Experience 5: Short-Term Climate Factors**
10e1	Understand how changes in solar energy, ocean circulation, tectonic events, and human activity can cause changes in regional and global climate on a variety of time scales.

11. CLIMATE CHANGE

Climate Change (13 days)

Phenomena: What is causing an increase in floods?

11a	**Experience 1: The Chemistry of Earth’s Atmosphere**
11a1	Develop a model to explain what happens when the sun’s energy is absorbed by Earth’s surface and then converted into infrared radiation.
11a2	Describe how a greenhouse gas differs from other atmospheric gases such as nitrogen and oxygen.
11a3	Describe the three ways molecules oscillate as they absorb energy.
11a4	Identify the most common greenhouse gases.
11b	**Experience 2: Evidence of Climate Change**
11b1	Discover how ice cores can be used to reconstruct a picture of past changes in Earth’s climate.
11b2	Investigate the relationship between past sea levels and average global temperatures.
11b3	Discover how living organisms, such as coral and trees, can be used to make inferences about climate trends.
11c	**Experience 3: Anthropogenic Carbon Emissions**
11c1	Investigate the relationship between atmospheric carbon dioxide concentrations and global climate change.
11c2	Describe how the isotopic composition of atmospheric carbon can be used to predict its source.
11d	**Experience 4: Climate Models**
11d1	Discover how computer models are used to predict long-term climate trends.
11d2	Investigate the relationship between climate change and extreme weather events.

12. REACTION RATES AND EQUILIBRIUM

Investigation 12: Reaction Rates and Equilibrium (10.5 days)

Phenomena: How do limestone caves form?

12a	**Experience 1: Rate of Reaction**
12a1	Develop and use a model to show the effect of concentration and temperature on reaction rate (collision theory).
12a2	Use a graph of concentration changes vs time to describe how rates change.
12a3	Make predictions about changes in reaction with changes in concentration and temperature.
12b	**Experience 2: The Progress of Chemical Reactions**
12b1	Interpret an energy diagram, being able to explain activation energy, activated complex and the impact of catalysts/enzymes on the diagram.
12c	**Experience 3: Reversible Reactions and Equilibrium**
12c1	Define equilibrium and use Le Chatelier's principle to predict the direction a reaction at equilibrium will shift if disrupted by a change in concentration, temperature, or pressure.
12c2	Explain how variables such as temperature and pressure can be adjusted to increase or decrease yield in a reaction.
12d	**Phenomena: Limestone Cave Formation**
12d1	Explain how limestone is dissolved by (and precipitates from) underground water and what features result.

13. ACID-BASE EQUILIBRIA

Investigation 13: Acid-Base Equilibria (10 days)

Phenomena: How does acid rain impact the environment?

13a	**Experience 1: Acids, Bases, and Salts**
13a1	Be able to identify and describe why molecules behave as acids or bases (Bronsted-Lowry).
13a2	Calculate the pH value for a solution given its H+ ion concentration.
13a3	Describe the differences in properties between acids and bases.
13b	**Experience 2: Strong and Weak Acids and Bases**
13b1	Explain the difference between strong and weak acids and bases.
13c	**Experience 3: Reactions of Acids and Bases**
13c1	Describe acid-base neutralization reactions, both qualitatively and quantitatively.
13c2	Perform an acid-base titration, and use the data to find the concentration of unknown solutions.
13c3	Design an experiment that investigates how the properties of water (pH) affect earth materials (limestone)

14. OCEAN ACIDIFICATION

Investigation 14: Ocean Acidification (8 days)

Phenomena: What is happening to the world's coral reefs?

14a	**Experience 1: Ocean pH Levels**
14a1	Identify global patterns of ocean pH.
14a2	Apply principles of chemical equilibrium to explain ocean pH.
14b	**Experience 2: The Ocean as a Carbon Sink**
14b1	Explain the relationship between temperature and dissolved gas in ocean water.
14b2	Analyze data to explain how human carbon emissions have affected ocean pH.
14b3	Develop a model of the cycling of carbon in the ocean and explain the multiple factors affecting ocean pH
14c	**Experience 4: Consequences of Ocean Acidification**
14c1	Investigate how the presence of carbonate or bicarbonate ions affects the formation and breakdown of calcium carbonate in a marine environment.
14c2	Argue a claim, using evidence and reasoning, about the impact of temperature and pH on ocean ecosystems.
14c3	Analyze data to make the claim that one change in Earth's surface can create feedbacks that cause changes to other Earth systems.
14c4	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
14c5	Describe other consequences of ocean acidification; including coral bleaching, red tides, and the disruption of marine ecosystems

Unit 16: ORGANIC CHEMISTRY

Investigation 16: Organic Chemistry (7.5 days)

Phenomena: How is energy stored in food?

16a	**Experience 1: Hydrocarbons**
16a1	Use models to represent straight-chain, branched, and cyclical hydrocarbons.
16b	**Experience 2: Functional Groups and Polymers**
16b1	Identify functional groups in organic molecules.
16b2	Use models to represent various reactions involving organic molecules, including addition, substitution, and condensation reactions.
16b3	Describe the process of polymerization.
16c	**Experience 3: The Chemistry of Life**
16c1	Distinguish the structures and functions of the major classes of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.
16c2	Explain how large biomolecules form from smaller molecules.

Additional Units (if time):

Nuclear Power Plants, nuclear medical technologies (Investigation 17, Experience 3)

Redox: The Battery

Chemistry Honors: Chemistry of Earth Systems
Units and Objectives

This course covers the skills and content of a first-year Chemistry course within the context of Earth Systems. Topics include: The Big Bang and the origin of elements, atomic structure, chemical reactions and their role in Earth processes, bonding, chemistry topics applied to environmental issues, stoichiometry, thermodynamics, and equilibrium. (Fall 2020)

Units	NGSS
Big Bang and Nuclear Chemistry	ESS1-1, ESS1-2, ESS1-3, PS1-8
Atomic Structure	PS1-1
The Periodic Table	PS1-1
Chemical Bonding	PS1-3
Chemical Quantities	PS1-2
Chemical Reactions	PS1-2
Stoichiometry	PS1-7
Copper Unlimited Project	ESS3-2
Thermochemistry	PS1-4, PS3-1, PS3-4
Gases	
Weather and Climate	ESS2-2
Climate Change	ESS2-4, ESS3-5, ESS3-6
Reaction Rates and Equilibrium	PS1-5, PS1-6
Acid-Base Equilibria	
Ocean Acidification	ESS2-6
Organic Chemistry	PS2-6

Regular and Honors have the same units, however the Honors course has additional learning objectives within units that increase the rigor of the course. In addition, Honors level students will be asked to delve deeper into objectives, to use critical thinking skills that incorporate multiple learning objectives across multiple units, and to apply those skills to novel situations.

Chemistry: Chemistry of Earth Systems

1: WHERE DOES "STUFF" COME FROM? (Investigation 1 and 17)

Big Bang, Nuclear (10 days)

Question: Where does "stuff" come from?

Extension (project?) if time: Experience 3: Nuclear Technologies (Nuclear power plants, nuclear medical technology)

1a	**The Big Bang**
1a1	Describe the big bang theory and compositional evidence for it.
1b	**Investigation 1 Experience 2: Modeling atoms (p. 12-21)**
1b1	Describe atomic structure using a model of the atom that includes protons, neutrons and electrons.
1b2	Compare and contrast atoms of different elements and isotopes of the same element including mass number, atomic mass, isotopic notation and isotopic abundance.
1b3	I can calculate the atomic mass of an element given isotope data.
1c	**Investigation 17 Experience 2: Fusion: Stars/Life Cycle, Formation of Elements**
1c1	Explain the role of fusion in the formation of new elements in the three different life cycles of stars.
1c2	Develop models to explain the conservation of mass and energy during the processes of fission and fusion.
1c3	Describe conversions between mass and energy during the Big Bang and other nuclear processes.
1d	**Investigation 17 Experience 1: Radioactivity and Half-Lives, Radioactive Decay, Half-life and Applications**
1d1	Describe the particles and forces present in the atomic nucleus.
1d2	Develop models to illustrate the changes in the composition of the atomic nucleus and the energy released during radioactive decay.
1d3	Use mathematics to calculate the half-life of a radioactive substance and the approximate age of earth materials in order to decipher the age and history of the earth.
1d4	Calculate the age of ocean crust to infer plate movement direction and rate of movement.

2: WHERE DOES “STUFF” COME FROM? (Investigation 1)

Atomic structure, Emissions Spectra and Electrons (9 days)

Phenomena: What causes colors in a fireworks display?

2a	**Investigation 1 Experience 3: Atomic Emissions Spectra and the Bohr model (p. 19-20)**
2a1	Develop and use Bohr models for atoms illustrating electron energy levels and the placement of electrons within those levels with an emphasis on valence electrons.
2a2	Use the Bohr model to explain why elements have unique atomic emission spectra and use spectra as an identification technique.
2a3	Relate the Spectra of elements to the structure of their atoms, particularly the patterns of electrons and the changes in their energy.
2a4	Evaluate the spectra of different light sources and differentiate between spectral types.
2a5	Use spectra to gauge the composition of stars, galaxies, nebulae
2a6	Evaluate the Doppler effect on spectra to determine direction and relative speeds of objects and as evidence for the Big Bang.
2b	**Investigation 1 Experience 4: Modern Atomic Theory (p. 28-32)**
2b1	Explain how the quantum mechanical nature of the electron gave rise to modern atomic orbital theory.
2b2	Evaluate how the quantum mechanical nature of the electron can be used to refine models of the atom up to and including atomic orbitals.
2c	**Investigation 1 Experience 5: Electrons in Atoms (33-39)**
2c1	Predict the valence electrons in an atom using the periodic table as a model.
2c2	Write the electron configuration of an atom using the periodic table as a model, including Noble gas shorthand configuration.
2c3	Use electron dot structures to represent an atom’s valence electrons.

2. THE PERIODIC TABLE

The Periodic Table (9.5 days)

Phenomena: Why are elements in pure form so rare?

3a	**Investigation 1 Experience 1: The Particle Nature of Matter (p. 6-11)**
3a1	I can define and differentiate between atoms, molecules, elements and compounds and develop models to describe them.
3a2	Use particle level models to explain interactions of energy and matter within a system as it relates to states of matter.
3a3	Use evidence to determine whether a physical or chemical change has occurred.
3b	**Investigation 2 Experience 1: The Periodic Table - An Overview (p. 44-49)**
3b1	Identify various groups of elements on the periodic table (e.g., families, periods, metals, nonmetals, metalloids).
3b2	Describe how elements in the periodic table are arranged by the number of protons in atoms.
3b3	Identify how the arrangement of the main groups of the periodic table reflects the patterns of valence electrons.
3b4	Explain how the position of an element in the table can be used to predict some of its chemical and physical properties.
3c	**Investigation 4 Experience 4 Comparing Metals & Nonmetals (p. 141-145)**
3c1	Analyze data comparing metals and nonmetals and construct explanations for their differences.
3c2	Summarize defining properties of metals.
3c3	Describe how delocalized electrons give rise to metallic properties.
3d	**Investigation 2 Experience 2: The Periodic Table and Atomic Structure (p. 50-55)**
3d1	Explain how the periodic table can be used to predict the electron configuration of an element.
3d2	Use Coulomb's law to explain effective nuclear charge and why the positive charge exerted by an atomic nucleus is not equal to the charge of its protons.
3d3	Describe how electron configuration and Coulomb's law give rise to trends in the periodic table.
3d4	Explain periodic table patterns of effective nuclear charge across a period of main group elements.
3e	**Investigation 2 Experience 3: Periodic Trends (p. 56-64)**
3e1	Investigate and explain reactivity patterns in the periodic table using concepts of ionization energy, net effective charge and atomic radius.
3e2	Use models of elements to explain the formation of ions.
3e3	Use periodic trends to predict and explain elemental properties: metallic character, nonmetallic character, electron affinity, atomic radius, ion size, ionization energy, common charges for group numbers.

3. CHEMICAL BONDING

Chemical Bonding (11.5 days)

Phenomena: Why do gems have different properties than metals?

4a	**Experience 1: Ionic Bonds (p. 68-76)**
4a1	Explain that atoms gain or lose electrons to become ions so that they have a full valence shell.
4a2	Explain that ionic bonds are electrostatic attractions between cations and anions.
4a3	Describe how the structure of ionic compounds affects their properties (including becoming electrolytes when dissolved).
4a4	Explain how the strength of an ionic bond is related to Coulomb's law.
4b	**Experience 2: Metallic Bonds (77-80)**
4b1	Describe the electron sea model of metallic bonds.
4b2	Explain how the bonding in metals and alloys affects their properties.
4c	**Experience 3: Covalent Bonds (81-90)**
4c1	Explain how nonmetals share electrons to share their valence shell octet, resulting in the formation of a covalent bond.
4c2	Identify single and double and triple covalent bonds and draw electron dot diagrams for each.
4c3	Describe how elements of different electronegativities can share electrons unequally, leading to the formation of a polar covalent bond.
4c4	Use VSEPR theory to determine shapes of molecules.
4c5	Determine the polarity of a molecule based on the shape of a molecule.
4d	**Experience 4: Intermolecular Attractions (p. 91-96)**
4d1	Describe the types of attractions between molecules.
4d2	Explain how intermolecular attractions between molecules influence the bulk properties of a material (ex. Surface tension, boiling point, state of matter at room temp).
4d3	Describe mineral crystalline structures and how they influence mineral properties including cleavage, fracture, and hardness
4e	**Experience 5: Names and Formulas of Compounds (p. 97-106)**
4e1	Given the name, write the formulas of molecular compounds and ionic compounds.
4e2	Predict bond types in a compound based on its name or formula.
4e3	Describe the ways in which mineral resources impact our daily lives and how these resources are extracted and processed.

5. CHEMICAL QUANTITIES

Chemical Quantities (9.5 days)

Phenomena: Why do we quantify matter in different ways?

5a	**Experience 1: The Mole Concept (p. 174-182)**
5a1	Investigate the three methods used to measure matter -- count, mass, and volume.
5a2	Explain the relationship between the mole and Avogadro's number (for atoms, molecules, and formula units).
5a3	Use Avogadro's number to convert from moles to particles and particles to moles.
5a4	Use the periodic table to find the molar mass of elements and compounds.
5b	**Experience 2: Molar Relationships (p. 183-191)**
5b1	Convert mole quantities to masses or volumes (for a gas at STP), and mass or Volume (gas at STP) quantities to moles.
5b2	Calculate the density of a gas at STP, given the molar mass of the gas.
5c	**Experience 3: Percent Composition and Empirical Formulas (p. 192-202)**
5c1	Explain how to find the percent composition of a compound.
5c2	Find the empirical and molecular formulas for a compound.
5d	**Experience 4: Concentrations of Solutions (p. 203-212)**
5d1	Find the molarity of a solution.
5d2	Investigate how the ratio of solute to solvent affects the concentration of a solution.
5d3	Devise a method to make a solution of a specific concentration.

6. CHEMICAL REACTIONS

Chemical Reactions (7.5 days)

Phenomena: How is energy obtained from chemical reactions? Rocket launching.

6a	**Experience 1: Modeling Chemical Reactions (p. 216-226)**
6a1	Identify the parts of a chemical reaction, and balance equations for these chemical reactions.
6a2	Distinguish between endothermic reactions and exothermic reactions.
6a3	Develop a basic conceptual and mathematical model for the generation of energy from the reaction of two substances based on bond energies.
6b	**Experience 2: Predicting Outcomes of Chemical Reactions (p. 227-240)** **Experience 3: Reactions in Aqueous Solution (p. (241-248)**
6b1	Identify the five general types of chemical reactions.
6b2	Predict the outcome of certain reactions based on the reactants, including identifying precipitates.
6c1	Be able to write net ionic equations in order to describe reactions in aqueous solution and identify the spectator ions.

7. STOICHIOMETRY

Stoichiometry (8 days) + Copper Unlimited project (5 days)
Phenomena: What can make a recipe fail?
Project: Copper Unlimited

7a	**Experience 1: Quantifying Reactants and Products (p. 252-258)**
7a1	Analyze data on proportionality of reactants and products to predict their stoichiometric ratios in the corresponding chemical equation.
7a2	Develop a model that demonstrates conservation of mass in a chemical equation.
7b	**Experience 2: Chemical Calculations (p, 259-268)**
7b1	Use the mole ratio in a chemical reaction to relate amounts of participating substances.
7b2	Use stoichiometry to convert between grams and moles in a chemical reaction.
7c	**Experience 3: Limiting Reagent and Percent Yield (p. 269-278)**
7c1	Explain the concept of limiting reactant and compute theoretical yield.
7c2	Explain the theoretical and actual yield and calculate percent yield.
7c3	Compute the amount of excess reactant remaining in a limiting reactant situation.

Copper Unlimited Lab Project

7d	**Copper Unlimited Lab Project**
7d1	ESS3-2: Evaluate competing design solutions for developing, managing and utilizing energy and mineral resources on cost benefit ratios.
7d2	Describe the ways in which energy resources are extracted and processed, as well as their environmental costs.

8. THERMOCHEMISTRY

Thermochemistry (8 days)

Phenomena: Why do you get hot when you exercise?

8a	**Experience 1: Energy in Chemical Bonds (p. 282-290)**
8a1	Explain how molecules must collide with each other with sufficient energy and in the correct orientation for a chemical reaction to take place.
8a2	Represent energy changes in exothermic and endothermic reactions using an enthalpy diagram.
8a3	Calculate enthalpy of reaction from bond energies and molar enthalpy of reaction data.
8b	**Experience 3: Enthalpy in Changes of State**
8b1	Understand how and why substances change in enthalpy when transitioning between physical states.
8b2	Calculate the change in enthalpy for state changes between solid, liquid, and gas.
8b3	Describe the link between state change enthalpies and the strength of intermolecular forces.
8c	**Enthalpy and Changes in Temperature**
8c1	Calculate the quantity of energy involved in temperature changes ($q=sm\Delta T$).
8c2	Explain how specific heat of water compared to other Earth materials produces differences in the temperature profile of: locations at the same latitude near and far from oceans, locations at the same latitude in the Northern vs. Southern Hemisphere

<u>9. GASES</u>

The Behavior of Gases (9.5 days)

Phenomena: What causes the Santa Ana winds?

9a	**Experience 1: Properties of Gases (p. 6-9)**
9a1	Use particle pictures to explain the differences between solids, liquids and gases.
9a2	Use the kinetic theory to explain the properties of gases (motion of particles, diffusion, compressibility, have mass, volume, exert pressure, etc.)
9a3	Describe the effects on gases of changes in volume, temperature, pressure, and the number of particles.
9b	**Experience 2: The Gas Laws (p. 11-22)**
9b1	Investigate and explain the relationship between the volume, temperature, and pressure of a gas.
9b2	Develop and use models to explain the gas laws.
9b3	Relate the patterns of interaction between gas particles at the molecular scale to the patterns of gas behavior at the macroscopic scale.
9c	**Experience 4: Gases in Earth's Atmosphere (p. 37-40)**
9c1	Identify the main gases in Earth's atmosphere.
9c2	Explain Dalton's law of partial pressure.
9c3	Describe the process that causes wind and its impact at local, regional, and global scales.
9c4	Relate relative humidity to water vapor partial pressure and air temperature.

10. WEATHER AND CLIMATE

Weather and Climate (10.5 days)

Phenomena: What is causing a drought in California?

10a	**Experience 1: Earth's Surface Systems (p. 37, 39, 52, 75)**
10a1	Analyze data to make a claim that a change to Earth's surface can cause changes to other Earth systems; describe the impact of various geochemical cycles.
10b	**Experience 2: Water and Energy in the Atmosphere**
10b1	Discuss how small changes can affect Earth's energy budget and climate.
10b2	Explain the impact of albedo in Earth's climate.
10b3	Analyze the amount of incoming and outgoing energy absorbed by the atmosphere.
10b4	Explain how unequal heating of the Earth's surface produces local winds, but when combined with the Coriolis Effect can produce consistent, predictable global winds.
10b5	Identify the processes and the reservoirs of the carbon cycle, and identify the impacts humans have had on this cycle
10c	**Experience 3: Atmospheric System Feedbacks**
10c1	Investigate and model the effects of changes on Earth's systems, including feedback that accelerates or slows changes to the systems.
10c2	Differentiate between positive and negative feedback loops; describe examples of each, particularly as relate to climate change
10d	**Experience 4: Long-Term Climate Factors**
10d1	Describe the factors that affect carbon dioxide concentration in Earth's atmosphere and use these factors to make predictions about the atmosphere under changing conditions.
10d2	Analyze and interpret data relating to the impact of carbon dioxide in Earth's atmosphere.
10e	**Experience 5: Short-Term Climate Factors**
10e1	Understand how changes in solar energy, ocean circulation, tectonic events, and human activity can cause changes in regional and global climate on a variety of time scales.

11. CLIMATE CHANGE

Climate Change (13 days)

Phenomena: What is causing an increase in floods?

11a	**Experience 1: The Chemistry of Earth's Atmosphere**
11a1	Develop a model to explain what happens when the sun's energy is absorbed by Earth's surface and then converted into infrared radiation.
11a2	Describe how a greenhouse gas differs from other atmospheric gases such as nitrogen and oxygen.
11a3	Describe the three ways molecules oscillate as they absorb energy.
11a4	Identify the most common greenhouse gases.
11b	**Experience 2: Evidence of Climate Change**
11b1	Discover how ice cores can be used to reconstruct a picture of past changes in Earth's climate.
11b2	Investigate the relationship between past sea levels and average global temperatures.
11b3	Discover how living organisms, such as coral and trees, can be used to make inferences about climate trends.
11c	**Experience 3: Anthropogenic Carbon Emissions**
11c1	Investigate the relationship between atmospheric carbon dioxide concentrations and global climate change.
11c2	Describe how the isotopic composition of atmospheric carbon can be used to predict its source.
11d	**Experience 4: Climate Models**
11d1	Discover how computer models are used to predict long-term climate trends.
11d2	Investigate the relationship between climate change and extreme weather events.

12. REACTION RATES AND EQUILIBRIUM

Investigation 12: Reaction Rates and Equilibrium (10.5 days)

Phenomena: How do limestone caves form?

12a	**Experience 1: Rate of Reaction**
12a1	Develop and use a model to show the effect of concentration and temperature on reaction rate (collision theory).
12a2	Use a graph of concentration changes vs time to describe how rates change.
12a3	Make predictions about changes in reaction with changes in concentration and temperature.
12b	**Experience 2: The Progress of Chemical Reactions**
12b1	Interpret an energy diagram, being able to explain activation energy, activated complex and the impact of catalysts/enzymes on the diagram.
12c	**Experience 3: Reversible Reactions and Equilibrium**
12c1	Define equilibrium and use Le Chatelier's principle to predict the direction a reaction at equilibrium will shift if disrupted by a change in concentration, temperature, or pressure.
12c2	Explain how variables such as temperature and pressure can be adjusted to increase or decrease yield in a reaction.
12c3	Quantitatively describe equilibrium using Keq values. (ICE tables, etc.)
12d	**Experience 4: Free Energy and Entropy**
12d1	Explain what entropy is.
12d2	Identify the four kinds of changes that increase the disorder or predictability of a system.
12d3	Relate entropy, enthalpy, and free energy.
12e	**Phenomena: Limestone Cave Formation**
12e1	Explain how limestone is dissolved by (and precipitates from) underground water and what features result.

13. ACID-BASE EQUILIBRIA

Investigation 13: Acid-Base Equilibria (10 days)

Phenomena: How does acid rain impact the environment?

13a	**Experience 1: Acids, Bases, and Salts**
13a1	Be able to identify and describe why molecules behave as acids or bases (Bronsted-Lowry).
13a2	Calculate the pH value for a solution given its H+ ion concentration.
13a3	Describe the differences in properties between acids and bases.
13b	**Experience 2: Strong and Weak Acids and Bases**
13b1	Explain the difference between strong and weak acids and bases.
13b2	Rank acids in order of strength.
13b3	Describe how the equilibrium conditions for strong and weak acids and bases are different.
13b4	Use the acid ionization constant (K_a) to predict the relative concentrations of the acid and hydronium ion at equilibrium.
13b5	Calculate the pH for weak acids and bases, using K_a and K_b expressions.
13c	**Experience 3: Reactions of Acids and Bases**
13c1	Describe acid-base neutralization reactions, both qualitatively and quantitatively.
13c2	Perform an acid-base titration, and use the data to find the concentration of unknown solutions.
13c3	Design an experiment that investigates how the properties of water (pH) affect earth materials (limestone)

14. OCEAN ACIDIFICATION

Investigation 14: Ocean Acidification (8 days)

Phenomena: What is happening to the world's coral reefs?

14a	**Experience 1: Ocean pH Levels**
14a1	Identify global patterns of ocean pH.
14a2	Apply principles of chemical equilibrium to explain ocean pH.
14b	**Experience 2: The Ocean as a Carbon Sink**
14b1	Explain the relationship between temperature and dissolved gas in ocean water.
14b2	Analyze data to explain how human carbon emissions have affected ocean pH.
14b3	Develop a model of the cycling of carbon in the ocean and explain the multiple factors affecting ocean pH
14c	**Experience 4: Consequences of Ocean Acidification**
14c1	Investigate how the presence of carbonate or bicarbonate ions affects the formation and breakdown of calcium carbonate in a marine environment.
14c2	Argue a claim, using evidence and reasoning, about the impact of temperature and pH on ocean ecosystems.
14c3	Analyze data to make the claim that one change in Earth's surface can create feedbacks that cause changes to other Earth systems.
14c4	Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
14c5	Describe other consequences of ocean acidification; including coral bleaching, red tides, and the disruption of marine ecosystems

Unit 16: ORGANIC CHEMISTRY

Investigation 16: Organic Chemistry (7.5 days)

Phenomena: How is energy stored in food?

16a	**Experience 1: Hydrocarbons**
16a1	Use models to represent straight-chain, branched, and cyclical hydrocarbons.
16b	**Experience 2: Functional Groups and Polymers**
16b1	Identify functional groups in organic molecules.
16b2	Use models to represent various reactions involving organic molecules, including addition, substitution, and condensation reactions.
16b3	Describe the process of polymerization.
16c	**Experience 3: The Chemistry of Life**
16c1	Distinguish the structures and functions of the major classes of biomolecules, including carbohydrates, lipids, proteins, and nucleic acids.
16c2	Explain how large biomolecules form from smaller molecules.

Additional Units (if time):

Nuclear Power Plants, nuclear medical technologies (Investigation 17, Experience 3)

Redox: The Battery

Science (SCI)		Chemistry Honors		
Timeline (Estimated # of School Days)	**Student learning objectives (Students will be able to . . .)**	**Learning Targets**	**Standards (CCSS/NGSS/ NCSS/etc…)**	**Assessments (Summative: Tests, Projects, Essays, Labs, Other) [1]**
14 days	Unit 1: Chp. 1,2: Scientific Method, Measurements and Calculations Students will be able to understand scientific method, measurements, unit analysis and density.	1.1 Know and apply safety in the laboratory. [2]		
		1.2 Know and identify laboratory equipment used in the chemistry laboratory.		
		1.3 Know and use the steps of the scientific method in order to solve a problem.	Science and Engineering Practices: (1) Engaging in an argument from Evidence (2) Obtaining, evaluating, and communicating information	Candy and Soda Lab
		1.4 Convert numbers into and out of scientific notation.		
		1.5 Learn the units of measurement and how to convert between them.	Science and Engineering Practices: Using mathematics and computational thinking	
		1.6 Accurately read and report measurements.		
		1.7 Count significant figures and perform calculations using them.	Science and Engineering Practices: Using mathematics and computational thinking	
		1.8 Solve various types of problems using unit/dimensional analysis.	Science and Engineering Practices: Using mathematics and computational thinking	
		1.9 Understand density and solve problems involving density	Science and Engineering Practices: Using mathematics and computational thinking	
8 days	Unit 2: Chp. 3 Matter Students will be able to understand matter, physical/chemical changes, and density.	2.1 Distinguish between and classify examples of states of matter, elements and compounds, and different types of mixtures and pure substances.		
		2.2 Distinguish between and classify examples of physical and chemical properties and changes		
		2.3 Understand how the conservation of matter applies	HS-PS1-7	
		2.4 Graph mass versus volume and use that to determine density		
		2.5 Understand how density applies to different states of matter and how to determine density		

		2.6 Understand floating versus sinking.		
8 days	Unit 3: Chp 4: Atoms, elements, ions Students will be able to understand the history of the atom and the periodic table.	3.1 Write symbols and formulas for elements and compounds.		
		3.2 Describe the history and structures of the various scientists' models of the atom, including their ideas, discoveries and experiments.		
		3.3 Recognize the similarities and differences between isotopes of an element, and write and interpret an isotopic symbol to describe an atom or ion.		
		3.4 Learn various features of the periodic table and apply this knowledge to a specific element.	HS-PS1-1	
		3.5 Know the diatomic elements.		
		3.6 Use the periodic table to predict the natural states of matter of an element.	HS-PS1-1	
		3.7 Describe the formation of an ion and use the periodic table to predict which ion a given element forms.	HS-PS1-1	
		3.8 Predict the formula of the simplest compounds made between ions.		
5 days [3]	Unit 4: Chp. 5: Nomenclature Students will be able to write formulas from names and names to formulas.	4.1 Write names from formulas for ionic, molecular and acidic compounds.	(Basic knowledge)	
		4.2 Write formulas from names for ionic, molecular and acidic compounds.	(Basic knowledge)	
9 days	Unit 5: Chp. 6,7: Balancing and Types of Rxns Students will be able to understand and balance chemical reactions.	5.1 Identify the characteristics of a chemical reaction and the information given by a chemical equation.		
		5.2 Write and balance equations. (conservation of atoms, NOT necessarily molecules)	HS-PS1-2 (???), HS-PS1-7	
		5.3 Identify ways to classify chemical reactions (types of reactions), including driving forces and understanding oxidation and reduction	HS-PS1-2	
		5.4 Predict products of a reaction, including the use of a solubility chart and activity series where appropriate.	HS-PS1-2	
		5.5 Write molecular, complete ionic and net ionic equations.		

9 days [4]	Unit 6: Chp. 8: The mole Students will be able to understand the mole. and perform calculations involving the mole.	6.1 Understand the concept of the mole and molar mass.	HS-PS1-7	
		6.2 Convert between moles, mass and number of particles in a sample.	HS-PS1-7	
		6.3 Determine the percent composition of an element in a compound.		
		6.4 Calculate/determine the empirical and/or molecular formula of a compound.		
9 days	Unit 7: Chp. 9 and 15.4: Stoichiometry Students will be able to understand stoichiometry and perform stoichiometric calculations, including percent yield and molarity.	7.1 Perform basic stoichiometry conversions (including moles, mass and particles).	HS-PS1-7	
		7.2 Calculate limiting reactant (reagent), excess reactant (reagent) and theoretical yield.	HS-PS1-7	
		7.3 Calculate percent yield.	HS-PS1-7	
		7.4 Perform calculations using molarity	HS-PS1-7 (in context of stoich)	
11 days	Unit 8: Chp. 10 and 14.1,14.2: Thermochemistry Students will be able to understand thermochemistry, including specific heat, energy diagrams, bond energies, heating curves and Hess's Law.	8.1 Define and distinguish between heat and temperature.	(Basic knowledge)	
		8.2 Understand the direction of energy flow as heat in endothermic and exothermic processes.	HS-PS3-1	
		8.3 Understand the concept of specific heat and perform calculations using the calorimetry equation (q=smDT)	HS-PS3-1, HS-PS3-4, PS-PS3-4	
		8.4 Draw and interpret energy diagrams for reactions, labeling and defining all parts.	HS-PS1-4	
		8.5 Understand that bond breaking requires energy and bond forming gives off energy, and that the sum of those processes influences if a reaction is endothermic or exothermic.	HS-PS1-4	
		8.6 Draw and interpret heating curve diagrams.	HS-PS3-1	
		8.7 Calculate energy gain or loss for a phase change using heat of vaporization and/or heat of fusion.	HS-PS3-1	
		8.8 Calculate energy gain or loss for a chemical change using heat of reaction/delta H.	HS-PS1-4, HS-PS3-1	
		8.9 Use Hess's law to determine DH for a reaction using lab data, heats of formation, or manipulating steps of a chemical process.	HS-PS3-1	

8 days	Unit 16: Chp. 19: Nuclear Students will be able to understand nuclear reactions and processes (decay, fission, fusion)	16.1 Describe the various types of nuclear reactions (radioactive decay, nuclear transformation, fission and fusion).	HS-PS1-8	
		16.2 Write a nuclear equation to represent radioactive decay (alpha, beta, beta positron, elecron capture and gamma).	HS-PS1-8	
		16.3 Understand and be able to solve problems involving radioactive decay and half-life.		
		16.4 Recognize the similarities and differences between isotopes of an element, and write and interpret an isotopic symbol to describe an atom or ion.		
		16.5 Know practical applications of nuclear chemistry: radioactive dating, radioactive tracers, nuclear reactors, nuclear bombs.		
9 days	Unit 10: Chp. 11: Atomic Theory Students will be able to describe the atom and the location and behavior of electrons.	10.1 Continue to describe the history and structures of the various scientists' models of the atom, including their ideas, discoveries and experiments.		
		10.2 Understand how atoms emit light and how that relates to the Bohr model of the atom.		
		10.3 Understand the properties of the different wavelengths of electromagnetic radiation.	HS-PS4-4	
		10.4 Based on the quantum mechanical model, write or describe: Types and shapes of orbitals, Electron configurations (including shorthand) and be able to use the periodic table to predict, Orbital Diagrams (including electron spin), Rules governing electron location (Aufbau, Hund's, Pauli)		
		10.5 Determine the number of valence electrons in an atom or ion.	HS-PS1-2	
		10.6 Describe the major periodic trends (atomic properties) and the reasoning behind them.	HS-PS1-2, HS-PS1-1	
7 days	Unit 11: Chp. 12: Bonding Students will be able to understand the concepts of bonding in molecules, including how it affects shapes and	11.1 Compare and contrast ionic and covalent bonding.	HS-PS1-1	
		11.2 Understand why atoms form bonds, including the octet rule.		
		11.3 Understand the nature of bonds and their relationship to electronegativity.	HS-PS1-1	

	including how it affects shapes and polarities.	11.4 Compare and contrast bond polarity and molecular polarity.		
		11.5 Draw Lewis structures and interpret them to find shapes (using VSEPR), bond angles, resonance and molecular polarities.		
13 days	Unit 9: Chp. 13: Gases Students will be able to understand both the conceptual and mathematical aspects of gases.	9.1 Understand the concept and units of pressure, and how pressure can be measured.		
		9.2 Understand and apply the Kinetic Molecular Theory to explain the behavior of gases.	HS-PS3-2	
		9.3 Understand and perform calculations involving gas laws.		
		9.4 Convert between Celsius and Kelvin temperature scales, and understand the importance of an absolute temperature scale (Kelvin) and its significance to gases.		
		9.5 Perform stoichiometric calculations involving gases.		
11 days	Unit 12: Chp. 14, 15: Liquids, Solids and Solutions Students will be able to understand liquids and solids, including phase changes and IMF's, as well as solutions and colligative properties.	12.1 Understand phase changes and the energy involved in those processes.		
		12.2 Identify the types of IMF's a compound has and the effect of these forces on various properties such as (but not limited to): Vapor pressure, boiling point, melting point and states of matter	HS-PS1-3	
		12.3 Compare and contrast different types of solids and the bonding within them.	HS-PS1-3, HS-PS2-6	
		12.4 Interpret phase diagrams.		
		12.5 Use the various units of concentration and convert between them.		
		12.6 Understand factors that affect solubility.	HS-PS1-3	
		12.7 Interpret a solubility curve and its correlation to the terms: saturated, unsaturated and supersaturated.		
		12.8 Perform calculations involving molarity, dilutions and stoichiometry.		
		12.9 Understand and calculate colligative property problems, including: vapor pressure lowering, freezing point depression, and boiling point elevation.	HS-PS1-3	
		13.1 Describe the collision model and the various factors that affect reaction rates.	HS-PS1-5	

7 days	Unit 13: Chp. 17: Equilibrium Students will be able to understand equilibrium as it applies to chemistry.	13.2 Calculate the average rate of reaction from data.	HS-PS1-5	
		13.3 Describe equilibrium qualitatively and quantitatively.	HS-PS1-6, HS-PS1-5	
		13.4 Predict changes that occur when a system at equilibrium is subjected to a stress.	HS-PS1-6, HS-PS1-5 (???)	
10-11 days	Unit 14: Chp. 16: Acids and Bases Students will be able to understand acids and bases and how equilibrium applies, as well as titrations and buffers.	14.1 Memorize the strong acids and bases and what makes them strong.		
		14.2 Describe properties of acids and bases.		
		14.3 Understand and write reactions involving Arrhenius and Bronsted-Lowry acids and bases.		
		14.4 Understand the self-ionization of water and perform calculations involving Kw.		
		14.5 Use the concept of equilibrium to perform acid-base calculations.		
		14.6 Understand the pH scale and perform calculations involving pH and pOH.		
		14.7Perform calculations involved in acid-base titrations.		
		14.8 Understand the general characteristics and purpose of buffered solutions.		
12 days	Unit 15: Chp. 18: Electrochemistry Students will be able to understand various aspects of electrochemistry, including redox reactions, the battery and electroplating.	15.1 Balance oxidation-reduction reactions using the half-reaction method and the change in oxidation states method.		
		15.2 Define and understand vocabulary associated with electrochemistry, including the parts of the battery.		
		15.3 Describe how a battery works, including the half-reactions involved and computing voltages.		
		15.4 Describe the process of electroplating.		
7 days	Unit 17: Chp. 20: Organic Students will be able to understand, name and identify simple organic	17.1 Name and write formulas for organic compounds such as alkanes, alkenes, alkynes ~~and molecules containing basic organic functional groups.~~		
		17.2 Draw organic structures.		
		17.3 Draw and identify the different types of isomers.		

	name and identify simple organic molecules and reactions.	17.4 For a given organic compound, identify the component shapes, bond angles, IMF’s and molecular polarities.		
		~~17.5 Identify organic functional groups.~~		
		~~17.6 Learn various types of chemical reactions that organic molecules undergo.~~	HS-PS2-6	

[1] Removed Formative- These can be different teacher-to-teacher and should be dynamic

[2] To insert additional learning targets:
1. Select a row within the unit by clicking on the row number at the left.
2. Once a row is highlighted, right click and choose "Insert" from the menu.
3. Repeat to add additional learning targets.

[3] To remove units from the map:
1. Highlight the unit by positioning the cursor in the timeline cell (Column A), holding down the left-mouse button, and moving the cursor to the right (Column F).
2. Release the left-mouse button (the unit should remain highlighted).
3. Right click and choose "Delete" from the menu.
4. Select the option "Shift cells up."
5. Repeat to remove additional units.

[4] To add additional units to the map:
1. Highlight the unit above where you would like to insert by positioning the cursor in the timeline cell (column A), holding down the left-mouse button, and moving the cursor to the right (Column F).
2. Release the left-mouse button (the unit should remain highlighted).
3. Right click and choose "Insert" from the menu.
4. Select the option "Shift cells down."
5. Repeat to add additional units.

Science (SCI)		Chemistry Traditional		
Timeline (Estimated # of School Days)	**Student Learning Objectives (Students will be able to…)**	**Learning Targets**	**Standards (CCSS/NGSS/ NCSS/etc…)**	**Assessments (Summative: Tests, Projects, Essays, Labs, Other) [1]**
13 days-Q1	1. Students will be able to understand the scientific method and chemical/physical changes and classify matter.	1.1. Identify 3 states of matter (solid, liquid, gas) in a molecular model		
		1.2. Understand the concept of a diatomic/molecular element and be able to identify the 7 diatomic/molecular elements		
		1.3. Define and differentiate between the vocabulary words of the matter pyramid	PS1-1	
		1.4. Given a molecular model or chemical formula, describe using matter vocabulary as well as be able to draw your own model if given a description.	PS1-1	
		1.55. Define and differentiate between chemical and physical changes in real life situations including laboratory experiments	PS1-1	
13 days-Q1	2. Students will be able to understand the periodic table and be able to use it to determine information about elements.	2.1. Using the periodic table write longhand and shorthand (Noble gas) electron configurations for a given element.	HS-PS1-1	
		2.2. Define isotope; write and interpret notations for isotopes including calculating mass number, protons, neutrons and electrons in neutral atoms	HS-PS1-1	
		2.3. Compare and contrast Mendeleev's periodic table with the modern periodic table and predict properties of an element based on its location on the periodic table (periodicity)		
		2.4. Differentiate between metal, nonmetal and metalloid through properties and experiments performed in the lab	HS-PS1-1	
		2.5. Use the periodic table to obtain information about an element: Metal (including transition), nonmetal or metalloid, Family / Group / Column number and name, The number of energy levels / shells based on period / row number, Symbol, Atomic number, Atomic mass, Number of electrons and protons, Number of valence electrons, and Charge it forms as an ion	HS-PS1-1	
		2.6. Define valence electron and understand why and how an atom would become an ion	HS-PS1-1	

		2.7. Define cation and anion and write the equation for an atom to become a cation or anion.	HS-PS1-1	
5 days-Q1	3. Students will be able to write names from formulas and formulas from names for chemical compounds.	3.1. Differentiate between and name an ionic, molecular (covalent) or acidic compound based on its molecular formula.		
		3.2. Differentiate between and write the formula for an ionic, molecular (covalent) or acidic compound based on its name.		
		3.3. Identify the charge on any ion based on one of the following: location on periodic table, use of polyatomic ion chart and formula of an ionic compound		
11 days-Q1	4. Students will be able to understand measurement, unit analysis and density.	4.1. Convert a number into and out of scientific notation and can properly enter scientific notation in a calculator		
		4.2. Estimate metric measurements		
		4.3. Convert from one metric unit to another		
		4.4. Accurately determine and record measurements from laboratory equipment in a procedural data table and understand the concepts of accuracy and precision		
		4.5. Count significant figures		
		4.6. Perform calculations using significant figures and round to proper number of significant figures		
		4.7. Convert between different units using T-charts and conversion factors using given data or data collected in a lab		
		4.8. Understand density and perform density calculations using given data or data collected in a lab		
5 days-Q2	5. Students will be able to understand and write balanced chemical equations.	5.1. Understand the law of conservation of matter	HS-PS1-7, HS-PS1-7	
		5.2. Identify the parts of a chemical equation		
		5.3. Balance equations given the formulas	HS-PS1-7	
		5.4. Write and balance equations given chemical names	HS-PS1-7	
		6.1. Identify the five types of reactions	HS-PS1-2	
		6.2. Predict products for any of the five types of reactions from formulas or chemical names. Be able to write and balance the complete equation including states of matter.	HS-PS1-2	

9 days-Q2	6. Students will be able to understand the types of chemical reactions and write balanced chemical equations.	6.3. Using the activity series, predict whether a reaction will occur or not for single replacement reactions from formulas or chemical names or in a lab situation	HS-PS1-2	
		6.4. Using the solubility chart, predict whether a reaction will occur or not for double replacement reactions from formulas or chemical names or in a lab situation	HS-PS1-2	
		6.5. Draw molecular diagrams for a single aqueous solution as well as the result of a reaction between two aqueous solutions.		
		6.6. Write complete and net ionic equations for double replacement reactions.		
5 days-Q2	7. Students will be able to understand the mole and perform calculations using molar quantities.	7.1. Understand the mole concept and Avogadro's number		
		7.2. Understand and calculate Molar Mass		
		7.3. Label substances according to the three different types of particles that make up all matter		
		7.4. Perform Molar conversions using mass, moles and particles from givens or lab data	HS-PS1-7	
12 (14) days-Q2	8. Students will be able to understand stoichiometry and perform calcualtions using molar quantities, percent yield and excess/limiting reactants.	8.1. Understand and identify limiting reactant, excess reactant and theoretical yield including in a lab situation	HS-PS1-7	
		8.2. Calculate theoretical yield from given data or lab data	HS-PS1-7	
		8.3. Perform basic stoichiometry conversions including: mole to mole, gram to gram, gram to mole and mole to gram from given data or lab data	HS-PS1-7	
		8.4. Calculate percent yield and percent error from given data or lab data	HS-PS1-7	
		8.5. Calculate moles and/or grams of excess reactant remaining from given data or lab data	HS-PS1-7	
		9.1. Can define and distinguish between heat and temperature		
		9.2. Can define specific heat capacity		

10 days-Q3	9. Students will be able to understand thermodynamics including specific heat capacity, energy diagrams, heating curves and thermochemical equations.	9.3. Can perform simple* calculations (in a written problem or using lab data) using the calorimetry equation; q=smΔT (*only one substance is gaining or losing heat energy).	HS-PS3-1	
		9.4. Can perform complex** calculations (in a written problem or using lab data) using the law of conservation of energy, q=-q, and the calorimetry equation; q=smΔT (**one substance is transferring heat energy to another).	HS-PS3-1, HS-PS3-4	
		9.5.Understand heat flow as it relates to endothermic and exothermic processes (in calorimetry, phase changes and chemical reactions). Understand the meaning of a positive (+) versus a negative (-) value of heat.		
		9.6. Understand and interpret heating curves	HS-PS3-2	
		9.7 Can draw and interpret energy diagrams for endothermic and exothermic reactions labeling and defining all parts including the effect of a catalyst	HS-PS1-4	
		9.8. Can define change in enthalpy of reaction, ΔH. Can calculate the change in enthalpy of a reaction from lab data		
		9.9. Can write complete, balanced thermochemical equations and perform stoichiometry calculations.	HS-PS3-1	
			HS-PS3-1	
		9.11. Thermos Project	HS-ETS1-2, HS-ETS1-3	
	10. Students will be able to	10.1. Distinguish between ionic and covalent (molecular) substances based on their given name or formula and/or properties.		
		10.2. Understand the differences between ionic, covalent and metallic bonds		
		10.3. Understand how atoms achieve a full octet and know the atoms that are exceptions to the octet rule		
		10.4. Build Lewis dot structures for polyatomic ions, covalent compounds and ionic compounds.		

11 days-Q3	understand chemical bonding and how it relates to bond properties, the shape of a compound, bond polarity and intermolecular forces.	10.5. Build structural formulas for covalent compounds and be able to determine if resonance structures exist		
		10.6. Use VSEPR to predict molecular shapes and bond angles of covalent compound		
		10.7. Use electronegativity differences to determine bond polarity		
		10.8. Determine molecular polarity		
		10.9. Define and distinguish between bond polarity and molecular polarity		
		10.10. Define and distinguish among the three different intermolecular forces as well as determine all the intermolecular forces that occur within a substance.	HS-PS1-3	
14 days-Q3	11. Students will be able to understand gases both conceptually as well as mathematically.	11.1. Identify and understand how different gases cause environmental concerns such as global warming, acid rain and hole in the ozone layer.		
		11.2. Understand the properties of gases and be able to apply them to real world and lab situations		
		11.3. Convert between pressure units given pressure conversions		
		11.4. Understand Kinetic Molecular Theory and be able to apply it to real world and lab situations		
		11.5. Write relationship equations based on lab or computer generated data and determine if the relationship between variables is direct or indirect		
		11.6. Convert degrees Celsius to Kelvin and understand what absolute zero is and why the Kelvin scale is used with gases		
		11.7. Solve problems using the combined gas law		
		11.8. Solve problems using the ideal gas law and the ideal gas law constant		
		11.9. Use Dalton's Law of Partial Pressures to solve problems		
		11.10. Know what STP is and the values that correspond with it		
		11.11. Understand Molar Volume		

		11.12. Solve problems using gas stoichiometry		
		11.13. Balloon Project	HS-ETS1-2	
12 days-Q3/4	12. Students will be able to understand solutions including how to calculate molarity and use a solubility curve.	12.1. Define and understand all vocabulary words from the solutions project		
		12.2. Understand the process by which ionic and covalent substances dissolve in water and why or why not they conduct electricity		
		12.3. Understand the term “like dissolves like” as it refers to ionic, polar covalent and non-polar covalent compounds		
		12.4. Use a solubility curve to determine and/or calculate the solubility of a compound		
		12.5. Understand the factors affecting solubility of solids including in lab situations		
		12.6. Understand the factors affecting solubility of gases including in lab or demo situations		
		12.7. Understand how to use the molarity equation and prepare a specific molar solution from a solid solute.		
		12.8. Understand how to calculate and prepare a diluted solution from a stock solution.		
		12.9. Define and understand colligative properties		
5 days-Q4	13. Students will be able to understand equilibrium as it applies to chemical reactions.	13.1. Define and understand equilibrium	HS-PS1-6	
		13.2. Understand LeChatelier’s Principle. Be able to determine the effect a stress will have on a system at equilibrium.	HS-PS1-6	
		14.1. Distinguish between acid, base and neutral compounds based on their properties which can be tested in a lab situation		
		14.2. Understand the definitions of acids and bases according to Arrhenius and Bronsted/Lowry		
		14.3. Determine conjugate acid-base pairs		

11 days-Q4	14. Students will be able to understand acids and bases, titrations and buffers.	14.4. Understand the differences between strong vs. weak and concentrated vs. dilute		
		14.5. Identify the strong acids and strong bases by name and formula		
		14,6. Understand the basic units of the pH scale and be able to distinguish between acid, base and neutral compounds using the pH scale		
		14.7. Understand Kw and its relationship to the ionization of water. Understand the relationship between the [OH-] and the [H+] or [H3O+] in acidic and basic solutions		
		14.8. Calculate pH, pOH, [OH-],[H+] or [H3O+]		
		14.9. Calculate the molarity or volume of an unknown acid or base using data from a titration		
		14.10. Understand how a buffered solution works		
11 days-Q4	15. Students will be able to understand nuclear chemistry as it relates to decay, fission, fusion and transmutations.	15.1. Determine the mass number, number of protons, electrons and neutrons for an atom and write its isotopic symbol		
		15.2. Distinguish between alpha, beta and gamma radiation		
		15.3. Understand and write natural decay reactions and artificial transmutations		
		15.4. Understand and distinguish between fission and fusion	HS-PS1-8	
		15.5. Know how a nuclear power plant works		
		15.6. Understand half-life and be able to perform calculations involving half-life		
3 days-Q4	16. Students will be able to understand reduction and oxidation reactions as they apply to a battery.	16.1. Define and understand oxidation and reduction		
		16.2. Build a voltaic cell/battery, label all parts, write half reactions and a total reaction from given or lab data		
		16.3. Understand electrode potential and how it determines the voltage of a battery. Calculate electrode potential, E˚cell.		
		16.4. Understand how the activity series and reduction potentials are related		

		16.5. Assign oxidation numbers		
		16.6. Balance redox reactions using half reaction method in an acidic solution		

[1] Removed Formative- These can be different teacher-to-teacher and should be dynamic

Physics: Physics in the Universe Units and Objectives

This course covers the skills and content of a first year physics course with the context of the Earth and its place in the Universe. Topics include experimental design, waves, earthquakes, motion, plate tectonics, forces, energy, climate, momentum, gravity, planetary motion, projectiles and the solar system. (Fall 2019)

Physics Units	NGSS
Science Practices	
Constant Velocity	
Waves	PS4-1
Application of Waves: Big Bang	ESS1-2
Application of Waves: Earth's Interior and Plate Tectonics	ESS1-5, ESS2-1, ESS2-3
Acceleration and Gravity	PS2-1, PS2-4
Forces	
Momentum	PS2-2, PS2-3
Energy	PS3-2
Orbital Motion	ESS1-4
Application of Orbital Motion: Seasons and Climate	PS3-1, PS3-3, ESS2-4, ESS3-5

Physics: Physics in the Universe Objectives

1. SCIENTIFIC PRACTICES

OBJ	PITU: Students will be able to...
1a	**DATA COLLECTION. I can confidently collect quality data as part of a scientific investigation.**
1a1	I can apply the following three key techniques for obtaining data that accurately depicts a relationship: (i) maximize the domain of the independent variable, (ii) collect as many different data points as possible, and (iii) utilize repeated trials to obtain an average value and a measure of its *uncertainty*, (difference in the highest and lowest repeated trials).
1a2	I can distinguish between an independent variable and a dependent variable.
1a3	I can evaluate and critique other teams' data according to the three key techniques for collecting data (see 1a1).
1b	**DATA REPRESENTATION. I can organize, analyze, and interpret data.**
1b1	I can appropriately organize data into tables, and given a computer generated graph, I can sketch "free-hand graphs" that have: labeled axes (variable and units), maximum values listed on each axis, and a best fit line/curve, (no data points).
1b2	I can calculate uncertainty using repeated trials, and use this value to determine if there is a trend or no trend in the data.
1b3	I can use a spreadsheet (e.g., GRAPHICAL ANALYSIS) to plot data sets on a scatter plot, generate an appropriate trendline, and obtain values for slope and y-intercept.
1c	**GRAPHING. Using data from an experiment, I can use a graph to make predictions.**
1c1	I can plot the independent and dependent variables on the appropriate axes.
1c2	I can create a best-fit trendline in a scatter plot.
1c3	I can make predictions using graphs (extrapolate and interpolate)

2. CONSTANT VELOCITY

OBJ	PITU: Students will be able to...
2a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant velocity using appropriate science practices.**
2a1	I can obtain the following equation from position vs. time graphs: $v = d/t$
2a2	I can convert between standard and nonstandard units, and metric measures.
2b	**GRAPHS. I can create, interpret, and examine graphs of constant velocity .**
2b1	I can use a position vs. time graph to quantitatively determine d and $\Delta t$from the x- and y-axes, and velocity by calculating the slope.
2b2	I can qualitatively describe the velocity of an object by examining the steepness of a position vs. time graph.
2b3	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa) for constant velocity motion .
2c	**ALGEBRA. I am able to make predictions by algebraically solving the constant velocity equation, ($v = d/t$).**
2c1	I can identify what each of the following variables represent: d, v, t and know each variables' standard units.
2c2	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.

3. WAVES

OBJ	PITU: Students will be able to...
3a	**PROPERTIES. I understand the properties of waves.**
3a1	I understand a wave's energy is carried in its amplitude, which manifests itself as loudness in sound and brightness in light.
3a2	I understand wave motion: back and forth motion of source (oscillation) moves in a straight-line through a medium away from source (propagation).
3a3	I can distinguish between transverse (secondary) and longitudinal (compressional/primary) waves.
3b	**CHARACTERISTICS. I can define and measure characteristics of waves, and explain the interrelationships among them.**
3b1	I can measure and calculate the following wave characteristics: period, frequency, wavelength, amplitude, and propagational speed.
3b2	I understand relationships among all wave characteristics, and how changes to one characteristic affects the others. This includes comparing/contrasting period, frequency, and using units.
3b3	I can identify wave characteristics from a position vs. time graph: period, frequency, and amplitude.
3c	**EQUATION. (PS4-1). I can use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.**
3c1	Algebraic $v = f\lambda$. I am able to make predictions by algebraically solving the wave equation, ($v = f\lambda$).
3c2	Conceptual $v = f\lambda$. I can demonstrate an understanding of how the frequency and period of a wave depend on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$.

4. APPLICATION OF WAVES: BIG BANG

OBJ	PITU: Students will be able to...
4a	**I understand how visible light spectra are produced and their applications to astronomy**
4a1	I can describe and differentiate emission, absorption and continuous spectra - including how they are formed and what information can be inferred from them.
4a2	I can describe and differentiate the emission spectra produced by charged hydrogen and helium - both the graphical (quantitative) and observable (qualitative).
4b	**I understand how distance affects wave properties**
4b1	I can apply the inverse square law qualitatively and quantitatively to measurements of both light and sound
4c	**I understand how movement of the source or observer affects wave properties**
4c1	I can apply the Doppler effect qualitatively to graphical and observable measurements of both light and sound
4d	**I can explain how spectral analysis supports the idea of an expanding universe**
4d1	I can describe how the spectrum from a star or galaxy will change depending on the relative motion of the star or galaxy.
4d2	I can describe the relationship between galactic redshift and distance and the implications of this relationship.
4d3	I can explain how spectral analysis gives insight into the size and age of the universe.

5. APPLICATIONS OF WAVES: PLATE TECTONICS AND EARTH'S INTERIOR

OBJ	PITU: Students will be able to...
5a	**I can describe and explain the evidence used to construct the layers and composition of the Earth's interior**
5a1	I can measure the density of an object using the displacement method.
5a2	I can explain the scientific evidence that supports the compositional layering of the Earth.
5a3	I can identify and describe the three types of seismic waves (primary, secondary, surface waves).
5a4	I can apply my understanding of seismic wave behavior to support the relative thickness and mechanical (solid/liquid) layering of the Earth.
5b	**I can explain how a seismograph is used to characterize an earthquake**
5b1	I can differentiate primary and secondary waves based on their behavior and from analysis of a seismogram.
5b2	I can determine the epicenter and magnitude of an earthquake using triangulation.
5b3	I can list the advantages and disadvantages of different earthquake scales (Richter, Moment Magnitude, Mercalli).
5c	**I can describe the process used to map the ocean floor and the variety of seafloor features discovered by sonar mapping**
5c1	I can use an ultrasonic motion detector to create a topographic representation of an unknown surface and explain how sonar is used to measure depth in the ocean.
5c2	I can classify the major seafloor features based on their depth and slope (shelf, slope, abyssal plain, mid-ocean ridge, seamount, and trench).
5d	**I can describe and explain the evidence for the Theory of Plate Tectonics**
5d1	I can describe and explain the global distribution of earthquakes.
5d2	I can describe and explain the age of ocean floor crust and associated seafloor topography.
5d3	I can describe and explain how a hot spot can be used to determine the velocity (speed and direction) of plate motion.
5d4	I can differentiate the three types of plate boundaries and identify important geographic features that form at each.
5d5	I can synthesize data sets (depth, age, sediment thickness, EQ location - depth and intensity) to make a model of a tectonic boundary.
5d6	I can explain the relationship between age, temperature, and depth of ocean crust and how they

	relate to the thermal cycling of material in the Earth's interior.

6. ACCELERATION AND GRAVITY

OBJ	PITU: Students will be able to...
6a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant acceleration using appropriate science practices.**
6a1	I can design, construct, and carry-out an experiment on a car gaining speed as it rolls down a ramp.
6a2	I can collect, analyze, & interpret data using technology: for example, Logger Pro/Graphical Analysis (video analysis & motion sensors) and photogates.
6a3	I can create and interpret an $a_{g,}$ vs. mass graph and table from lab data to show that all masses fall at 9.8 m/s^2, (slope is zero).
6b	**GRAPHS. I can create, interpret, and examine graphs of accelerated motion.**
6b1	I am able to interpret distance vs. time (x-t) and velocity vs. time (v-t).
6b2	I am able to interpret the meaning of the slope (as a rate); and more specifically, for position vs. time and velocity vs. time.
6b3	I am able to obtain numerical values for variables from x-t and v-t graphs, (a, t, v_o, v and Δx). I.e., using (x, y) coordinates (& y-intercept), slope.
6b4	I am able to qualitatively describe motion given only an x-t or v-t graph (i.e., moving or stopped, gaining or losing speed, constant speed).
6b5	I can create and interpret angle vs. range graphs to determine the range when given an angle..
6c	**ALGEBRA. I am able to make predictions by algebraically solving the 2 kinematic equations.**
6c1	I can solve for various variables in the $a = (v_f-v_i)/(t_f-t_i)$ formula
6c2	I can rearrange and solve for various variables in the $d_y= 4.9t^2$ Formula
6c3	I can solve for range (dx) of a projectile using the dx =v/t formula determining its time to drop given its height using the formula $t = \sqrt{H/4.9}$

7. FORCES

OBJ	PITU: Students will be able to...
7a	**FORCE DIAGRAMS. I can draw force diagrams, (free-body diagrams).**
7a1	I can identify which forces are acting on an object.
7a2	I can draw each force acting on an object as a *labeled arrow* indicating what type of force it is and in which direction it points.
7b	**NEWTON'S LAWS. I can use Newton's Laws to make and justify claims about the forces acting on an object.**
7b1	I can apply *Newton's 1st law* to justify and make claims about balanced forces acting on an object if there is no acceleration, (i.e., inertia is the tendency of an object to maintain its current state of motion—either at rest or a constant speed; it's the tendency for an object to resist acceleration).
7b2	I can apply *Newton's 2nd law* to justify and make claims about unbalanced forces acting on an object if there is an acceleration, (i.e., a net force causes mass to accelerate).
7b3	I can apply *Newton's 3rd law* to identify and justify force pairs that are equal & opposite. (*By switching the "on___, by___" notation for a force, you can identify its force pair. Ex. There is a 10 N force "on the wall, by my hands" to the left, so there is also a 10 N force "on my hands, by the wall to the right.*)
7b4	Using a force diagram, I can write a mathematical and expression for Newton's 2nd law (also known as writing the "sum of forces"), by summing all positive and negative forces, and setting them equal to *ma* according to the relationship: $F_{net} = ma$. *(PS2-1). I can analyze data to support the claim that Newton's second law describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration, (i.e., an unbalanced force causes acceleration based on the relationship: $F_{net} = ma$).*
7c	**ALGEBRA. I am able to make predictions by algebraically solving force equations.**
7c1	I can distinguish between *mass* and *force of gravity* (or *weight)*, and calculate each value using the following relationship: $F_g = (9.8N/kg)m$
7c2	I can apply the net force equation $F_{net} = ma$, (Newton's 2nd Law) to solve for F_{net}, m, a.
7d	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant acceleration using appropriate science practices.**
7d1	I can design, construct, and carry-out an experiment to measure the force of friction.
7d2	I can design, construct, and carry-out an experiment that verifies Newton's 1st Law.
7d3	I can design, construct, and carry-out an experiment that verifies Newton's 2nd Law.

<u>**8. MOMENTUM**</u>

OBJ	PITU: Students will be able to...
8a	**IMPULSE. I can create and utilize models to problem-solve situations involving the linear collision of an isolated object.**
8a1	I can analyze an *F-t* graph of a collision to determine information such as average/maximum force, and time of impact.
8a2	(PS2-3). I can apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force of impact on an object during a collision by increasing the time of impact .
8a3	I can apply the impulse equation: $Ft = mv_f - mv_i$, to solve for F, t, m, v_f , v_i
8a4	I can use the impulse equation to qualitatively justify and make claims about the relationship between the net force acting on an object and time duration of that net force.
8b	**CONSERVATION OF LINEAR MOMENTUM. I can demonstrate the concept of conservation of total linear momentum, and utilize it to problem-solve situations involving the linear collision between two isolated objects.**
8b1	(PS2-2). I can use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. This means I can mathematically justify that the total momentum of two objects before and after any collision is always the same when the objects are free to move along a line, (e.g., no outside forces acting along the line motion). This law is called “conservation of total linear momentum.”
8b2	I can solve one variable equation to investigate momentum ($p = mv$).
8b3	I can apply the conservation of momentum equation to solve for the speed before or after a collision between two movable objects.

9. ENERGY (KE/PE CONSERVATION AND PRODUCTION & CONSUMPTION)

OBJ	PITU: Students will be able to...
9a	**I can identify the forms of energy present for objects at any particular moment**.
9a1	*Same as: (PS3-2). I can develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects).*
9a2	I can identify that *gravitational potential energy* is dependent upon height/altitude.
9a3	I can identify that *kinetic energy* is dependent upon velocity.
9a4	I can identify that *elastic potential energy* is dependent upon spring's compression or stretching.
9b	**ALGEBRA. I am able to make predictions by algebraically solving the energy equations.**
9b1	I can apply the Grav. PE equation $E_g = mgh$, to solve for E_g, m, h.
9b2	I can apply the kinetic equation $E_k = ½mv^2$, to solve for E_k, m, v.
9b3	I can apply the elastic potential energy equation $E_{el} = ½kx^2$, to solve for E_{el}, k, x.
9c	**I can demonstrate the concept of conservation of total energy, and utilize it to problem-solve situations involving exchanges between height/distance and speed.**
9c1	(PS3-1). *I can create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.* This means I can mathematically justify that the total energy of all objects that are interacting with one another, and isolated from their environment, must remain the same at all times. This law is called "conservation of energy," and it is represented mathematically by the following equation: $E_g + E_k = E_g + E_k + E_{lost}$
9c2	I can apply the Conservation of Energy equation: $E_g + E_k = E_g + E_k$, to solve for *speed or height*.
9c3	I can utilize the law of conservation of energy to solve for the energy lost.
9d	**EXPERIMENTS. (PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.**
9d1	I can design, construct, and carry-out an experiment on an object to determine the energy it loses during a collision.
9d2	I can design, construct, and carry-out an experiment on an object to determine the energy lost to friction.

10 ORBITAL MOTION

OBJ	PITU: Students will be able to...
10a	**I can explain how simple observations and measurements can be used to calculate and create an accurate model of the solar system.**
10a1	I can create a scaled model of Mercury's orbit given only measurements of Mercury's angular distance from the Sun (elongation), as seen from Earth.
10a2	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 1st Law - The orbits of planets are ellipses with the Sun at one focus.
10a3	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 2nd Law - Equal areas are swept out in equal times.
10a4	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 3rd Law - The period of revolution is proportional to the semi-major axis.
10a4	I can use the Universal Law of Gravity equation between two objects, $F_g = \frac{GMm}{r^2}$, to solve for unknown variables.
10b	**I can describe how the night sky (visible stars and planets) changes due to the primary Earth motions (rotation and revolution) and the revolution of planets around the Sun.**
10b1	I can differentiate the observable phenomena caused by Earth's rotation and revolution.
10b2	I can determine the location of a planet in the night sky and when it will be visible given a model of the solar system.

11 APPLICATIONS OF ORBITAL MOTION: SEASONS AND CLIMATE

OBJ	PITU: Students will be able to...
11a	**I can describe how energy is transferred from the Sun to the Earth and how that energy is modified before it reaches the surface.**
11a1	I can make a simple diagram that shows the fate of incoming solar radiation - how much is reflected/scattered vs absorbed by the atmosphere.
11a2	I can list the types of incoming solar radiation that are absorbed by the atmosphere and what types penetrate to the surface and cause heating.
11b	**I can explain why energy from the Sun is distributed unequally on the Earth's surface and how characteristics of the surface further contribute to unequal heating.**
11b1	I can explain why locations close to the Equator experience smaller seasonal temperature variations compared to locations closer to the Poles.
11b2	I can describe the two primary causes of seasonal temperature variation and how they result in unequal heating - duration of sunlight, angle of the Sun's rays.
11b2a	I can interpret graphs of sun altitude and hours of daylight for locations at different latitudes (low, mid, high).
11b3	I can explain how proximity to water modifies seasonal temperature variations.
11b3a	I can explain why land and water heat up and cool down at different rates and how that relates to different climatic conditions for coastal and continental locations.
11b4	I can describe how energy from the Sun, after being absorbed by the Earth's surface, is transferred to the air above and to the ground below.
11b5	I can explain why the hottest time of the day (2-3pm) is typically hours after the most intense solar radiation (local noon) and why the hottest month (July) of the year is after the time of most intense solar radiation (June 21st).
11c	**I can describe long term modifiers of Earth's climate; specifically how long term orbital properties of the Earth coupled with the position of continents can lead to climate change.**
11c1	I can describe how differences in solar output can result in climatic changes on Earth.
11c2	I can describe the three primary orbital properties of Earth that change and the resulting variations in solar energy received.
11c3	I can describe the conditions (orbital characteristics and position of continents) that result in long term climatic changes (specifically Ice Ages).
11c4	I can differentiate the three cyclical variations in Earth's orbital properties that influence the amount of solar radiation received. (ie - Milankovitch cycles)

Physics Honors: Physics in the Universe Units and Objectives

This course covers the skills and content of a first year physics course with the context of the Earth and its place in the Universe. Topics include experimental design, waves, earthquakes, motion, plate tectonics, forces, energy, climate, momentum, gravity, planetary motion, projectiles and the solar system. In Honors, this course covers similar topics but at a deeper level and an accelerated pace. This course requires mastery of Algebra 1 and strong math critical thinking skills. (Fall 2019)

Physics Honors Units	NGSS
Science Practices	
Constant Velocity	
Forces & Motion (1-D)	PS2-1, PS2-4
Forces & Motion (2-D)	
Circular Motion	
Momentum	PS2-2, PS2-3
Waves	PS4-1
Application of Waves: Big Bang	ESS1-2, ESS2-3
Energy	PS3-2
Circuits + Electromagnetic Energy Production	
Orbital Motion	ESS1-4
Application of Orbital Motion: Seasons and Climate	PS3-1, PS3-3, ESS2-4, ESS3-5

Physics Honors: Physics in the Universe Objectives

1. SCIENCE PRACTICES

OBJ	PITU H: Students will be able to...
1a	**DATA COLLECTION. I can confidently collect quality data as part of a scientific investigation.**
1a1	I can apply the following three key techniques for obtaining data that accurately depicts a relationship: (i) maximize the domain of the independent variable, (ii) collect as many different data points as possible, and (iii) utilize repeated trials to obtain an average value and a measure of its *uncertainty*, (difference in the highest and lowest repeated trials).
1a2	I can distinguish between an independent variable and a dependent variable and plot them on the appropriate axes.
1a3	I can evaluate and critique other teams' data according to the three key techniques for collecting data (see 1a1).
1b	**DATA REPRESENTATION. I can organize, analyze, and interpret data.**
1b1	I can appropriately organize data into tables, and given a computer-generated graph, I can sketch a "free-hand graph" that has: labeled axes (variable and units), maximum values listed on each axis, and a best fit line/curve, (no data points).
1b2	I can calculate uncertainty using repeated trials, and use this value to determine if there is a trend or no trend in the data.
1b3	II can use a spreadsheet (e.g., GRAPHICAL ANALYSIS) to: (i) plot data sets on a scatter plot, (ii) generate an appropriate trendline (line or parabola), (iii) obtain values for slope and y-intercept, and (iv) perform a linear or quadratic curve-fit.
1c	**MATHEMATICAL MODELS. I can apply mathematical and computational thinking to datasets.**
1c1	Using a linear regression (by hand on graph paper or using graphing software), I can write a mathematical model, which includes determining the units on all coefficients such as slope.
1c2	I can make predictions using mathematical models or equations, [i.e., given constants for variables, I can algebraically solve for an unknown variable, (linear and quadratic functions)].
1c3	Given a conversion factor, I can perform conversions using proportional reasoning.

2. CONSTANT VELOCITY

OBJ	PITU H: Students will be able to...
2a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant velocity using appropriate science practices.**
2a1	I can obtain the following equation from position vs. time graphs: $x = vt + x_o$, or $\Delta x = vt$
2a2	I can convert between metric measures, and between standard and nonstandard units, (e.g., meters ↔ feet & mph ↔ m/s).
2b	**GRAPHS. I can create, interpret, and examine graphs of constant velocity .**
2b1	I can use a position vs. time graph to quantitatively determine Δx and Δt from the x- and y-axes, and velocity by calculating the slope.
2b2	I can qualitatively describe the velocity of an object by examining the steepness of a position vs. time graph, or the y-axis of a v-t graph.
2b3	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa) for constant velocity motion .
2b4	I can plot numerical values on an object's velocity vs. time graph when given its quantitative graph of its position vs. time, and vice versa, for constant velocity motion .
2c	**ALGEBRA. I am able to make predictions by algebraically solving the constant velocity equation, ($\Delta x = vt$).**
2c1	I can identify what each of the following variables represent: x, v, t, x_o, Δx and know each variables' standard units.
2c2	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.

3. FORCES & MOTION (1-D)

OBJ	PITU H: Students will be able to...
3a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant acceleration using appropriate science practices.**
3a1	I can design, construct, and carry-out an experiment on a car gaining speed as it rolls down a ramp.
3a2	I can collect, analyze, & interpret data using technology: for example, Logger Pro/Graphical Analysis (video analysis & motion sensors) and photogates.
3a3	I can create and interpret an $a_{g,}$ vs. mass graph and table from lab data to show that all masses fall at 9.8 m/s^2, (slope is zero).
3a4	I can design, construct, and carry-out an experiment that verifies Newton's 1st Law.
3a5	I can design, construct, and carry-out an experiment that verifies Newton's 2nd Law.
3a6	I can design, construct, and carry-out an experiment to measure the force of friction.
3a7	I can design, construct, and carry-out an experiment to determine the coefficient of friction between the surfaces of two objects.
3b	**FORCE DIAGRAMS. I can draw force diagrams, (free-body diagrams).**
3b1	I can identify which forces are acting on an object.
3b2	I can draw each force acting on an object as a *labeled arrow* indicating what type of force it is and in which direction it points.
3c	**NEWTON'S LAWS. I can use Newton's Laws to make and justify claims about the forces acting on an object.**
3c1	I can apply *Newton's 1st law* to justify and make claims about balanced forces acting on an object if there is no acceleration, (i.e., inertia is the tendency of an object to maintain its current state of motion—either at rest or a constant speed; it's the tendency for an object to resist acceleration).
3c2	I can apply *Newton's 2nd law* to justify and make claims about unbalanced forces acting on an object if there is an acceleration, (i.e., a net force causes mass to accelerate).
3c3	I can apply *Newton's 3rd law* to identify and justify force pairs that are equal & opposite. (*By switching the "on___, by___" notation for a force, you can identify its force pair. Ex. There is a 10 N force "on <u>the wall</u>, by <u>my hands</u>" to the left, so there is also a 10 N force "on <u>my hands</u>, by <u>the wall</u> to the right.*)
3c4	Using a force diagram, I can write a mathematical and expression for Newton's 2nd law (also known as writing the "sum of forces"), by summing all positive and negative forces, and setting them equal to *ma* according to the relationship: $F_{net} = ma$. *Same as: (PS2-1). I can analyze data to support the claim that Newton's second law describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration, (i.e., an unbalanced force causes acceleration according to the relationship:* $F_{net} = ma$*).*

3d	**ALGEBRA. I am able to make predictions by algebraically solving forces and motion equations.**
3d1	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction for the following variables: *Δx, v_o, v, a, F.*
3d2	I can apply the friction equations, $(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$, to solve for any unknown variable.
3d3	I am able to make predictions by algebraically solving the 4 kinematic equations.
3d4	I am able to recognize when objects are in free-fall and apply the free-fall acceleration (9.8 m/s^2 down) for those objects. This also includes understanding that ALL objects fall at the same acceleration regardless of mass or weight.
3d5	I can distinguish between *mass* and *<u>force</u> of gravity* (or *weight)*, and calculate each value using the following relationship: $F_g = (9.8N/kg)m$
3d6	I can apply the net force equation $F_{net} = ma$, (Newton's 2nd Law) to solve for F_{net}, m, a.
3e	**GRAPHS. I can create, interpret, and examine graphs of accelerated motion.**
3e1	I am able to interpret the meaning of the y-intercept of any graph (lin. or quad.); and more specifically, for position vs. time (x-t) and velocity vs. time (v-t).
3e2	I am able to interpret the meaning of the slope (as a rate); and more specifically, for position vs. time and velocity vs. time.
3e3	I am able to obtain numerical values for variables from x-t and v-t graphs, (*a, t, v_o, v* and Δ*x*). I.e., using (x, y) coordinates (& y-intercept), slope, and coefficients from regressions.
3e4	I am able to qualitatively describe motion given only an x-t or v-t graph (i.e., moving or stopped, gaining or losing speed, constant speed, going forwards or backwards).
3e5	I am able to qualitatively recognize that acceleration is represented as both a parabola on a x-t graph, and slope of a v-t graph.
3e6	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa).
3f	**FRICTION. I can qualitatively explain the coefficients of friction, and quantitatively predict values using the friction equations, ($(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$.).**
3f1	I can differentiate between static and kinetic friction.
3f2	I can differentiate between the force of friction and the coefficient of friction.
3f3	I can qualitatively explain the following relationships: $(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$.

4. FORCES & MOTION (2-D)

OBJ	PITU H: Students will be able to...
4a	**I can create and utilize models to problem-solve situations involving angled forces and projectiles.**
4a1	I can qualitatively describe the horizontal motion and vertical motion of any projectile.
4a2	I am able to diagram the motion of a projectile that includes the following characteristics: before and after states, all relevant variables drawn as arrows labeled with variable letter, number and units.
4a3	I can apply and justify any projectile's horizontal acceleration as zero, $a_x = 0$
4a4	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.
4a5	I am able to make predictions by algebraically solving kinematic equations.
4a6	I can solve quadratic equations by solving for its roots using a graphing calculator.
4a7	I can resolve angled vectors into horizontal and vertical components using right-triangle trigonometry. This includes the angled initial velocity for a projectile.
4a8	I can design, construct, and carry-out an experiment on a projectile to predict the position of its landing.
4a9	I can utilize that velocity must be momentarily zero when an object changes direction (e.g., $v_y = 0$ at the top of any projectile's path.)
4a10	I can resolve angled forces into horizontal and vertical components using right-triangle trigonometry. This includes the force of gravity for objects on an inclined surface.

5. CIRCULAR MOTION

OBJ	PITU H: Students will be able to...
5a	**I can create and utilize models to problem-solve situations involving circular motion.**
5a1	I can recognize and apply the fact that velocity is always directed tangent to the circular path.
5a2	I can explain how inertia relates to objects in circular motion, (i.e., I can explain why one *feels* pushed outward when going around a bend in a car).
5a3	I can justify why an object moving in a circle at a constant speed is accelerating.
5a4	I can draw a force diagram to identify the net force inward force (i.e., the “centripetal” force), which always points along the radius toward the center of the circular path.
5a5	I can mathematically and conceptually utilize the equations of circular motion to make claims about the relationships among variables and solve for unknown quantities. These equations include: $F_{net} = \frac{mv^2}{r}$, $a_c = \frac{v^2}{r}$, $v_{avg} = \frac{2\pi r}{T}$

6. MOMENTUM

OBJ	PITU H: Students will be able to...
6a	**IMPULSE. I can create and utilize models to problem-solve situations involving the linear collision of an isolated object.**
6a1	I am able to diagram the collision of an object(s) that includes the following characteristics: all relevant variables drawn as arrows labeled with variable letter, number and units. Emphasis on assignment of (+) and (-) signs to variables based upon direction.
6a2	I can analyze a *v-t, &/or F-t* graph of a collision to determine information such as impulse, velocity before/after a collision, average/maximum impact force, and time of impact. This includes understanding that area under an F-t graph can be used to calculate impulse delivered to an object.
6a3	I can apply the impulse equation: $Ft = mv - mv_o$, to solve for F, t, m, v , v_o
6a4	I can use the impulse equation to qualitatively justify and make claims about the relationship between the net force acting on an object and time duration of that net force.
6a5	(PS2-3). I can apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force of impact on an object during a collision.
6b	**CONSERVATION OF LINEAR MOMENTUM. I can demonstrate the concept of conservation of total linear momentum, and utilize it to problem-solve situations involving the linear collision between two isolated objects.**
6b1	(PS2-2). I can use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. This means I can mathematically justify that the total momentum of two objects before and after any collision is always the same when the objects are free to move along a line, (e.g., no outside forces acting along the line motion). This law is called “conservation of total linear momentum.”
6b2	I can apply the conservation of momentum equation to algebraically solve for the speed before or after a collision between two movable objects.

7. WAVES & OSCILLATION

OBJ	PITU H: Students will be able to...
7a	**PROPERTIES. I understand the properties of waves.**
7a1	I understand a wave's energy is carried in its amplitude.
7a2	I understand wave motion: back and forth motion of source (particle/oscillation) moves in a straight-line through a medium away from source (pulse/propagation).
7b	**CHARACTERISTICS. I can define and measure characteristics of waves, and explain the interrelationships among them.**
7b1	I can measure and calculate the following wave characteristics: period, frequency, angular frequency, wavelength, amplitude, and propagational speed.
7b2	I understand relationships among all wave characteristics, and how changes to one characteristic affects the others. This includes comparing/contrasting period, frequency, and angular frequency using units.
7b3	I can identify wave characteristics from a position vs. time graph: period, frequency, angular frequency, and amplitude.
7b4	I can mathematically model a wave source's back-&-forth motion using a cosine function (i.e., convert between radians and cycles; determine amplitude, period, frequency, and angular frequency; and write an expression for y as a function of t).
7c	**EQUATION. (PS4-1). I can use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** (i.e., I can demonstrate an understanding of how the frequency and period of a wave depends on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$).
7c1	Algebraic $v = f\lambda$. I am able to make predictions by algebraically solving the wave equation, ($v = f\lambda$).
7c2	Conceptual $v = f\lambda$. I can demonstrate an understanding of how the frequency and period of a wave depend on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$.

<u>8. APPLICATION OF WAVES: BIG BANG</u>

OBJ	PITU H: Students will be able to...
8a	**I understand how visible light spectra are produced and their applications to astronomy**
8a1	I can describe and differentiate emission, absorption and continuous spectra - including how they are formed and what information can be inferred from them.
8a2	I can describe and differentiate the emission spectra produced by charged hydrogen and helium - both the graphical (quantitative) and observable (qualitative).
8b	**I understand how distance affects wave properties**
8b1	I can apply the inverse square law qualitatively and quantitatively to measurements of both light and sound
8c	**I understand how movement of the source or observer affects wave properties**
8c1	I can apply the Doppler effect qualitatively and quantitatively to graphical and observable measurements of both light and sound
8c2	I can explain what the cosmic microwave background radiation tells us about the universe at its early stages
8d	**I can explain Hubble's Law and how it supports the idea of an expanding universe**
8d1	I can describe the process used by Hubble and other astronomers to determine the distance and recessional velocity of galaxies.
8d2	I can describe the relationship between recessional velocity and distance and how it is used to approximate the age of the universe.

9. ENERGY (KE/PE CONSERVATION AND PRODUCTION & CONSUMPTION)

OBJ	PITU H: Students will be able to...
9a	**WORK. I can conceptually and mathematically apply the concept of *work* as the *change in* energy due to a force acting along a distance.**
9a1	I can assess gains and losses in energy as positive or negative work.
9a2	I can algebraically solve for the unknown variables using the mathematical equation for work: $W = F \cdot x$ or $W = Fx \cos \theta$.
9a3	I can graphically solve for work done by a force by determining the area under an *F-x* graph.
9a4	I can describe the *type* of energy gained/lost depends on the *type* of force.
9a5	I can qualitatively and quantitatively apply the concept of power as the time rate of change in energy using the relationship: $P = \frac{W}{\Delta t}$.
9a6	I can design, construct, and carry-out an experiment on an object that examines the changes in energy it experiences due to a force.
9b	**FORMS OF ENERGY. I can identify the forms of energy present for objects at any particular moment**.
9b1	I can identify that *elastic potential energy* is dependent upon spring's compression or stretching, and is mathematically defined as: $E_{el} = ½kx^2$
9b2	(PS3-2). I can develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects), (i.e., I can identify that *gravitational potential energy* is dependent upon height/altitude, and is mathematically defined as: $E_g = mgh$).
9b3	I can identify that *kinetic energy* is dependent upon velocity, and is mathematically defined as: $E_k = ½mv^2$
9b4	I can identify that *work* is being done when there is a force acting along the displacement (e.g., friction, tension, push, etc.).
9c	**I can demonstrate the concept of conservation of total energy, and utilize it to problem-solve situations involving exchanges between height/distance and speed.**
9c1	(PS3-1). I can create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. This means I can mathematically justify that the total energy of all objects that are interacting with one another, and isolated from their environment, must remain the same at all times. This law is called "conservation of energy," and it is represented mathematically by the following equation: $\pm W_F + E_g + E_k + E_{el} = E_g + E_k + E_{el}$..
9c2	(PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.

9c3	I can utilize the law of conservation of energy to solve for the energy lost during a collision.
9c4	I can describe collisions as *elastic*, *inelastic*, or *perfectly inelastic*.
9c5	I can design, construct, and carry-out an experiment on an object to determine the energy it loses during a collision.
9d	**EXPERIMENTS. (PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.**
9d1	I can design, construct, and carry-out an experiment on an object to determine the energy it loses during a collision.
9d2	I can design, construct, and carry-out an experiment on an object to determine the energy lost to friction.

10. CIRCUITS

OBJ	PITU H: Students will be able to...
10a	**EXPERIMENTS. I can design, construct, and obtain measurements from circuits.**
10a1	I recognize that current only flows if there is a closed loop, and in the direction that positive charges would flow.
10a2	I can build circuits when given a circuit diagram, and draw circuit diagrams if given a circuit.
10a3	I can measure voltage, current, and resistance using a multimeter.
10a4	I can draw voltmeters and ammeters within circuit diagrams.
10a5	I can identify components in a circuit as being in either in series (same current) or parallel (presence of junctions)
10b	**CIRCUIT LAWS. I can use Kirchhoff's and Ohm's Laws to make and justify claims about the voltages and currents within a circuit.**
10b1	I can conceptually and mathematically describe the equivalent resistance of a multiple resistor circuit that consists of series and parallel combinations of resistors.
10b2	I can determine which parallel branches receive the most (or least) current.
10b3	I can apply Ohm's Law (V = IR) to any closed circuit, and parts within a closed circuit, in order to calculate the total current through a power source and individual resistors, and the voltage across a power source and individual resistors.
10b4	I can apply Kirchhoff's Loop Rule, which states that voltages around any closed loop must add to zero, (conservation of energy).
10b5	I can apply Kirchhoff's Junction Rule, which states that currents through branches all add up to total current through the battery
10b6	I can calculate the power generated or dissipated by various circuit components.
10b7	I can qualitatively describe the voltage gains and losses throughout a closed circuit loop, as well as the changes to the current.

11. ORBITAL MOTION

OBJ	PITU H: Students will be able to...
11a	**I can explain how simple observations and measurements can be used to calculate and create an accurate model of the solar system.**
11a1	I can create a scaled model of Mercury's orbit given only measurements of Mercury's angular distance from the Sun (elongation), as seen from Earth.
11a2	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 1st Law - The orbits of planets are ellipses with the Sun at one focus.
11a3	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 2nd Law - Equal areas are swept out in equal times.
11a4	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 3rd Law - The period of revolution is proportional to the semi-major axis.
11b	**I can describe how the night sky (visible stars and planets) changes due to the primary Earth motions (rotation and revolution) and the revolution of planets around the Sun.**
11b1	I can differentiate the observable phenomena caused by Earth's rotation and revolution.
11b2	I can determine the location of a planet in the night sky and when it will be visible given a model of the solar system.
11b3	I can differentiate the observable phenomena caused by rotation and revolution
11b4	I can explain which Earth motions are responsible for the ecliptic and changes in the location of the Sun on the ecliptic since the development of the astrological signs
11b5	I can use important stars and constellations to locate geographic North and find the ecliptic
1b6	I can use clues from the motions of stars and constellations to infer latitude and time of year
11c	**GRAVITATION. I apply Newton's law of gravity and circular motion to orbiting bodies.**
11c1	I can use the Universal Law of Gravity equation between two objects, $F_g = \frac{GMm}{r^2}$, to solve for unknown variables.
11c2	I can use the Universal Force of Gravity, $F_g = \frac{GMm}{r^2}$, as the centripetal force that would cause circular orbits, and calculate orbital speed.

12. APPLICATION OF ORBITAL MOTION: SEASONS AND CLIMATE

OBJ	PITU H: Students will be able to...
12a	**I can describe how energy is transferred from the Sun to the Earth and how that energy is modified before it reaches the surface.**
12a1	I can make a simple diagram that shows the fate of incoming solar radiation - how much is reflected/scattered vs absorbed by the atmosphere.
12a2	I can list the types of incoming solar radiation that are absorbed by the atmosphere and what types penetrate to the surface and cause heating.
12b	**I can explain why energy from the Sun is distributed unequally on the Earth's surface and how characteristics of the surface further contribute to unequal heating.**
12b1	I can explain why locations close to the Equator experience smaller seasonal temperature variations compared to locations closer to the Poles.
12b2	I can describe the two primary causes of seasonal temperature variation and how they result in unequal heating - duration of sunlight, angle of the Sun's rays.
12b2a	I can interpret graphs of sun altitude and hours of daylight for locations at different latitudes (low, mid, high).
12b3	I can explain how proximity to water modifies seasonal temperature variations.
12b3a	I can explain why land and water heat up and cool down at different rates and how that relates to different climatic conditions for coastal and continental locations.
12b4	I can describe how energy from the Sun, after being absorbed by the Earth's surface, is transferred to the air above and to the ground below.
11b5	I can explain why the hottest time of the day (2-3pm) is typically hours after the most intense solar radiation (local noon) and why the hottest month (July) of the year is after the time of most intense solar radiation (June 21st).
12c	**I can describe long term modifiers of Earth's climate; specifically how long term orbital properties of the Earth coupled with the position of continents can lead to climate change.**
11d1	I can describe how differences in solar output can result in climatic changes on Earth.
11d2	I can describe the three primary orbital properties of Earth that change and the resulting variations in solar energy received.
11d3	I can describe the conditions (orbital characteristics and position of continents) that result in long term climatic changes (specifically Ice Ages).
11d4	I can differentiate the three cyclical variations in Earth's orbital properties that influence the amount of solar radiation received. (ie - Milankovitch cycles)

Physics Honors: Physics in the Universe Units and Objectives

This course covers the skills and content of a first year physics course with the context of the Earth and its place in the Universe. Topics include experimental design, waves, earthquakes, motion, plate tectonics, forces, energy, climate, momentum, gravity, planetary motion, projectiles and the solar system. In Honors, this course covers similar topics but at a deeper level and an accelerated pace. This course requires mastery of Algebra 1 and strong math critical thinking skills. (Fall 2019)

Physics Honors Units	NGSS
Science Practices	
Constant Velocity	
Forces & Motion (1-D)	PS2-1, PS2-4
Forces & Motion (2-D)	
Circular Motion	
Momentum	PS2-2, PS2-3
Waves	PS4-1
Application of Waves: Big Bang	ESS1-2, ESS2-3
Energy	PS3-2
Circuits + Electromagnetic Energy Production	
Orbital Motion	ESS1-4
Application of Orbital Motion: Seasons and Climate	PS3-1, PS3-3, ESS2-4, ESS3-5

Physics Honors: Physics in the Universe Objectives

1. SCIENCE PRACTICES

OBJ	PITU H: Students will be able to...
1a	**DATA COLLECTION. I can confidently collect quality data as part of a scientific investigation.**
1a1	I can apply the following three key techniques for obtaining data that accurately depicts a relationship: (i) maximize the domain of the independent variable, (ii) collect as many different data points as possible, and (iii) utilize repeated trials to obtain an average value and a measure of its *uncertainty*, (difference in the highest and lowest repeated trials).
1a2	I can distinguish between an independent variable and a dependent variable and plot them on the appropriate axes.
1a3	I can evaluate and critique other teams' data according to the three key techniques for collecting data (see 1a1).
1b	**DATA REPRESENTATION. I can organize, analyze, and interpret data.**
1b1	I can appropriately organize data into tables, and given a computer-generated graph, I can sketch a "free-hand graph" that has: labeled axes (variable and units), maximum values listed on each axis, and a best fit line/curve, (no data points).
1b2	I can calculate uncertainty using repeated trials, and use this value to determine if there is a trend or no trend in the data.
1b3	I can use a spreadsheet (e.g., GRAPHICAL ANALYSIS) to: (i) plot data sets on a scatter plot, (ii) generate an appropriate trendline (line or parabola), (iii) obtain values for slope and y-intercept, and (iv) perform a linear or quadratic curve-fit.
1c	**MATHEMATICAL MODELS. I can apply mathematical and computational thinking to datasets.**
1c1	Using a linear regression (by hand on graph paper or using graphing software), I can write a mathematical model, which includes determining the units on all coefficients such as slope.
1c2	I can make predictions using mathematical models or equations, [i.e., given constants for variables, I can algebraically solve for an unknown variable, (linear and quadratic functions)].
1c3	Given a conversion factor, I can perform conversions using proportional reasoning.

2. CONSTANT VELOCITY

OBJ	PITU H: Students will be able to...
2a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant velocity using appropriate science practices.**
2a1	I can obtain the following equation from position vs. time graphs: $x = vt + x_o$, or $\Delta x = vt$
2a2	I can convert between metric measures, and between standard and nonstandard units, (e.g., meters ↔ feet & mph ↔ m/s).
2b	**GRAPHS. I can create, interpret, and examine graphs of constant velocity .**
2b1	I can use a position vs. time graph to quantitatively determine Δx and $\Delta t$from the x- and y-axes, and velocity by calculating the slope.
2b2	I can qualitatively describe the velocity of an object by examining the steepness of a position vs. time graph, or the y-axis of a v-t graph.
2b3	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa) for constant velocity motion .
2b4	I can plot numerical values on an object's velocity vs. time graph when given its quantitative graph of its position vs. time, and vice versa, for constant velocity motion .
2c	**ALGEBRA. I am able to make predictions by algebraically solving the constant velocity equation, ($\Delta x = vt$).**
2c1	I can identify what each of the following variables represent: x, v, t, x_o, $\Delta x$and know each variables' standard units.
2c2	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.

3. FORCES & MOTION (1-D)

OBJ	PITU H: Students will be able to...
3a	**EXPERIMENTS. I can design, construct, and carry-out an experiment on an object moving at a constant acceleration using appropriate science practices.**
3a1	I can design, construct, and carry-out an experiment on a car gaining speed as it rolls down a ramp.
3a2	I can collect, analyze, & interpret data using technology: for example, Logger Pro/Graphical Analysis (video analysis & motion sensors) and photogates.
3a3	I can create and interpret an $a_{g,}$ vs. mass graph and table from lab data to show that all masses fall at 9.8 m/s^2, (slope is zero).
3a4	I can design, construct, and carry-out an experiment that verifies Newton's 1st Law.
3a5	I can design, construct, and carry-out an experiment that verifies Newton's 2nd Law.
3a6	I can design, construct, and carry-out an experiment to measure the force of friction.
3a7	I can design, construct, and carry-out an experiment to determine the coefficient of friction between the surfaces of two objects.
3b	**FORCE DIAGRAMS. I can draw force diagrams, (free-body diagrams).**
3b1	I can identify which forces are acting on an object.
3b2	I can draw each force acting on an object as a *labeled arrow* indicating what type of force it is and in which direction it points.
3c	**NEWTON'S LAWS. I can use Newton's Laws to make and justify claims about the forces acting on an object.**
3c1	I can apply *Newton's 1st law* to justify and make claims about balanced forces acting on an object if there is no acceleration, (i.e., inertia is the tendency of an object to maintain its current state of motion—either at rest or a constant speed; it's the tendency for an object to resist acceleration).
3c2	I can apply *Newton's 2nd law* to justify and make claims about unbalanced forces acting on an object if there is an acceleration, (i.e., a net force causes mass to accelerate).
3c3	I can apply *Newton's 3rd law* to identify and justify force pairs that are equal & opposite. (*By switching the "on___, by___" notation for a force, you can identify its force pair. Ex. There is a 10 N force "on the wall, by my hands" to the left, so there is also a 10 N force "on my hands, by the wall to the right.*)
3c4	Using a force diagram, I can write a mathematical and expression for Newton's 2nd law (also known as writing the "sum of forces"), by summing all positive and negative forces, and setting them equal to *ma* according to the relationship: $F_{net} = ma$. *Same as: (PS2-1). I can analyze data to support the claim that Newton's second law describes the mathematical relationship among the net force on a macroscopic object, its mass, and its*

	acceleration, (i.e., an unbalanced force causes acceleration according to the relationship: F_{net} = ma).
3d	**ALGEBRA. I am able to make predictions by algebraically solving forces and motion equations.**
3d1	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction for the following variables: Δx, v_o, v, a, F.
3d2	I can apply the friction equations, $(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$, to solve for any unknown variable.
3d3	I am able to make predictions by algebraically solving the 4 kinematic equations.
3d4	I am able to recognize when objects are in free-fall and apply the free-fall acceleration (9.8 m/s^2 down) for those objects. This also includes understanding that ALL objects fall at the same acceleration regardless of mass or weight.
3d5	I can distinguish between *mass* and *<u>force</u> of gravity* (or *weight)*, and calculate each value using the following relationship: $F_g = (9.8N/kg)m$
3d6	I can apply the net force equation F_{net} = ma, (Newton's 2nd Law) to solve for F_{net}, m, a.
3e	**GRAPHS. I can create, interpret, and examine graphs of accelerated motion.**
3e1	I am able to interpret the meaning of the y-intercept of any graph (lin. or quad.); and more specifically, for position vs. time (x-t) and velocity vs. time (v-t).
3e2	I am able to interpret the meaning of the slope (as a rate); and more specifically, for position vs. time and velocity vs. time.
3e3	I am able to obtain numerical values for variables from x-t and v-t graphs, (*a, t,* v_o*, v* and Δx). I.e., using (x, y) coordinates (& y-intercept), slope, and coefficients from regressions.
3e4	I am able to qualitatively describe motion given only an x-t or v-t graph (i.e., moving or stopped, gaining or losing speed, constant speed, going forwards or backwards).
3e5	I am able to qualitatively recognize that acceleration is represented as both a parabola on a x-t graph, and slope of a v-t graph.
3e6	I can sketch a free-hand graph of an object's velocity vs. time when given its position vs. time graph, (and vice versa).
3f	**FRICTION. I can qualitatively explain the coefficients of friction, and quantitatively predict values using the friction equations, ($(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$.).**
3f1	I can differentiate between static and kinetic friction.
3f2	I can differentiate between the force of friction and the coefficient of friction.
3f3	I can qualitatively explain the following relationships: $(\max F_{fs}) = \mu_s F_N$ and $F_k = \mu_k F_N$.

4. FORCES & MOTION (2-D)

OBJ	PITU H: Students will be able to...
4a	**I can create and utilize models to problem-solve situations involving angled forces and projectiles.**
4a1	I can qualitatively describe the horizontal motion and vertical motion of any projectile.
4a2	I am able to diagram the motion of a projectile that includes the following characteristics: before and after states, all relevant variables drawn as arrows labeled with variable letter, number and units.
4a3	I can apply and justify any projectile's horizontal acceleration as zero, $a_x = 0$
4a4	I can recognize that the forward direction is represented by positive values, and the backwards direction is represented by negative values; (+) & (-) implies direction.
4a5	I am able to make predictions by algebraically solving kinematic equations.
4a6	I can solve quadratic equations by solving for its roots using a graphing calculator.
4a7	I can resolve angled vectors into horizontal and vertical components using right-triangle trigonometry. This includes the angled initial velocity for a projectile.
4a8	I can design, construct, and carry-out an experiment on a projectile to predict the position of its landing.
4a9	I can utilize that velocity must be momentarily zero when an object changes direction (e.g., $v_y = 0$ at the top of any projectile's path.)
4a10	I can resolve angled forces into horizontal and vertical components using right-triangle trigonometry. This includes the force of gravity for objects on an inclined surface.

5. CIRCULAR MOTION

OBJ	PITU H: Students will be able to...
5a	**I can create and utilize models to problem-solve situations involving circular motion.**
5a1	I can recognize and apply the fact that velocity is always directed tangent to the circular path.
5a2	I can explain how inertia relates to objects in circular motion, (i.e., I can explain why one *feels* pushed outward when going around a bend in a car).
5a3	I can justify why an object moving in a circle at a constant speed is accelerating.
5a4	I can draw a force diagram to identify the net force inward force (i.e., the “centripetal” force), which always points along the radius toward the center of the circular path.
5a5	I can mathematically and conceptually utilize the equations of circular motion to make claims about the relationships among variables and solve for unknown quantities. These equations include: $F_{net} = \frac{mv^2}{r}$, $a_c = \frac{v^2}{r}$, $v_{avg} = \frac{2\pi r}{T}$

6. MOMENTUM

OBJ	PITU H: Students will be able to...
6a	**IMPULSE. I can create and utilize models to problem-solve situations involving the linear collision of an isolated object.**
6a1	I am able to diagram the collision of an object(s) that includes the following characteristics: all relevant variables drawn as arrows labeled with variable letter, number and units. Emphasis on assignment of (+) and (-) signs to variables based upon direction.
6a2	I can analyze a *v-t, &/or F-t* graph of a collision to determine information such as impulse, velocity before/after a collision, average/maximum impact force, and time of impact. This includes understanding that area under an F-t graph can be used to calculate impulse delivered to an object.
6a3	I can apply the impulse equation: $Ft = mv - mv_o$, to solve for F, t, m, v , v_o
6a4	I can use the impulse equation to qualitatively justify and make claims about the relationship between the net force acting on an object and time duration of that net force.
6a5	(PS2-3). I can apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force of impact on an object during a collision.
6b	**CONSERVATION OF LINEAR MOMENTUM. I can demonstrate the concept of conservation of total linear momentum, and utilize it to problem-solve situations involving the linear collision between two isolated objects.**
6b1	(PS2-2). I can use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. This means I can mathematically justify that the total momentum of two objects before and after any collision is always the same when the objects are free to move along a line, (e.g., no outside forces acting along the line motion). This law is called “conservation of total linear momentum.”
6b2	I can apply the conservation of momentum equation to algebraically solve for the speed before or after a collision between two movable objects.

7. WAVES & OSCILLATION

OBJ	PITU H: Students will be able to...
7a	**PROPERTIES. I understand the properties of waves.**
7a1	I understand a wave's energy is carried in its amplitude.
7a2	I understand wave motion: back and forth motion of source (particle/oscillation) moves in a straight-line through a medium away from source (pulse/propagation).
7b	**CHARACTERISTICS. I can define and measure characteristics of waves, and explain the interrelationships among them.**
7b1	I can measure and calculate the following wave characteristics: period, frequency, angular frequency, wavelength, amplitude, and propagational speed.
7b2	I understand relationships among all wave characteristics, and how changes to one characteristic affects the others. This includes comparing/contrasting period, frequency, and angular frequency using units.
7b3	I can identify wave characteristics from a position vs. time graph: period, frequency, angular frequency, and amplitude.
7b4	I can mathematically model a wave source's back-&-forth motion using a cosine function (i.e., convert between radians and cycles; determine amplitude, period, frequency, and angular frequency; and write an expression for y as a function of t).
7c	**EQUATION. (PS4-1). I can use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** (i.e., I can demonstrate an understanding of how the frequency and period of a wave depends on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$).
7c1	Algebraic $v = f\lambda$. I am able to make predictions by algebraically solving the wave equation, ($v = f\lambda$).
7c2	Conceptual $v = f\lambda$. I can demonstrate an understanding of how the frequency and period of a wave depend on the source's motion, and move at a particular speed dependent only on the medium, and whose wavelength must adjust such that $v = f\lambda$.

8. APPLICATION OF WAVES: BIG BANG

OBJ	PITU H: Students will be able to...
8a	**I understand how visible light spectra are produced and their applications to astronomy**
8a1	I can describe and differentiate emission, absorption and continuous spectra - including how they are formed and what information can be inferred from them.
8a2	I can describe and differentiate the emission spectra produced by charged hydrogen and helium - both the graphical (quantitative) and observable (qualitative).
8b	**I understand how distance affects wave properties**
8b1	I can apply the inverse square law qualitatively and quantitatively to measurements of both light and sound
8c	**I understand how movement of the source or observer affects wave properties**
8c1	I can apply the Doppler effect qualitatively and quantitatively to graphical and observable measurements of both light and sound
8c2	I can explain what the cosmic microwave background radiation tells us about the universe at its early stages
8d	**I can explain Hubble's Law and how it supports the idea of an expanding universe**
8d1	I can describe the process used by Hubble and other astronomers to determine the distance and recessional velocity of galaxies.
8d2	I can describe the relationship between recessional velocity and distance and how it is used to approximate the age of the universe.

9. ENERGY (KE/PE CONSERVATION AND PRODUCTION & CONSUMPTION)

OBJ	PITU H: Students will be able to...
9a	**WORK. I can conceptually and mathematically apply the concept of *work* as the *change in* energy due to a force acting along a distance.**
9a1	I can assess gains and losses in energy as positive or negative work.
9a2	I can algebraically solve for the unknown variables using the mathematical equation for work: $W = F \cdot x$ or $W = Fx \cos \theta$.
9a3	I can graphically solve for work done by a force by determining the area under an *F-x* graph.
9a4	I can describe the *type* of energy gained/lost depends on the *type* of force.
9a5	I can qualitatively and quantitatively apply the concept of power as the time rate of change in energy using the relationship: $P = \frac{W}{\Delta t}$.
9a6	I can design, construct, and carry-out an experiment on an object that examines the changes in energy it experiences due to a force.
9b	**FORMS OF ENERGY. I can identify the forms of energy present for objects at any particular moment**.
9b1	I can identify that *elastic potential energy* is dependent upon spring's compression or stretching, and is mathematically defined as: $E_{el} = \frac{1}{2}kx^2$
9b2	(PS3-2). I can develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motion of particles (objects) and energy associated with the relative positions of particles (objects), (i.e., I can identify that *gravitational potential energy* is dependent upon height/altitude, and is mathematically defined as: $E_g = mgh$).
9b3	I can identify that *kinetic energy* is dependent upon velocity, and is mathematically defined as: $E_k = \frac{1}{2}mv^2$
9b4	I can identify that *work* is being done when there is a force acting along the displacement (e.g., friction, tension, push, etc.).
9c	**I can demonstrate the concept of conservation of total energy, and utilize it to problem-solve situations involving exchanges between height/distance and speed.**
9c1	(PS3-1). I can create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. This means I can mathematically justify that the total energy of all objects that are interacting with one another, and isolated from their environment, must remain the same at all times. This law is called "conservation of energy," and it is represented mathematically by the following equation: $\pm W_F + E_g + E_k + E_{el} = E_g + E_k + E_{el}$..

9c2	(PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.
9c3	I can utilize the law of conservation of energy to solve for the energy lost during a collision.
9c4	I can describe collisions as *elastic*, *inelastic*, or *perfectly inelastic*.
9c5	I can design, construct, and carry-out an experiment on an object to determine the energy it loses during a collision.
9d	**EXPERIMENTS. (PS 3-3). I can design, build, and refine an experimental setup that works within given constraints to convert one form of energy into another form of energy.**
9d1	I can design, construct, and carry-out an experiment on an object to determine the energy it loses during a collision.
9d2	I can design, construct, and carry-out an experiment on an object to determine the energy lost to friction.

10. CIRCUITS

OBJ	PITU H: Students will be able to...
10a	**EXPERIMENTS. I can design, construct, and obtain measurements from circuits.**
10a1	I recognize that current only flows if there is a closed loop, and in the direction that positive charges would flow.
10a2	I can build circuits when given a circuit diagram, and draw circuit diagrams if given a circuit.
10a3	I can measure voltage, current, and resistance using a multimeter.
10a4	I can draw voltmeters and ammeters within circuit diagrams.
10a5	I can identify components in a circuit as being in either in series (same current) or parallel (presence of junctions)
10b	**CIRCUIT LAWS. I can use Kirchhoff's and Ohm's Laws to make and justify claims about the voltages and currents within a circuit.**
10b1	I can conceptually and mathematically describe the equivalent resistance of a multiple resistor circuit that consists of series and parallel combinations of resistors.
10b2	I can determine which parallel branches receive the most (or least) current.
10b3	I can apply Ohm's Law (V = IR) to any closed circuit, and parts within a closed circuit, in order to calculate the total current through a power source and individual resistors, and the voltage across a power source and individual resistors.
10b4	I can apply Kirchhoff's Loop Rule, which states that voltages around any closed loop must add to zero, (conservation of energy).
10b5	I can apply Kirchhoff's Junction Rule, which states that currents through branches all add up to total current through the battery
10b6	I can calculate the power generated or dissipated by various circuit components.
10b7	I can qualitatively describe the voltage gains and losses throughout a closed circuit loop, as well as the changes to the current.

<u>11. ORBITAL MOTION</u>

OBJ	PITU H: Students will be able to...
11a	**I can explain how simple observations and measurements can be used to calculate and create an accurate model of the solar system.**
11a1	I can create a scaled model of Mercury's orbit given only measurements of Mercury's angular distance from the Sun (elongation), as seen from Earth.
11a2	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 1st Law - The orbits of planets are ellipses with the Sun at one focus.
11a3	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 2nd Law - Equal areas are swept out in equal times.
11a4	I can make measurements and perform calculations that prove my model for Mercury's orbit confirms Kepler's 3rd Law - The period of revolution is proportional to the semi-major axis.
11b	**I can describe how the night sky (visible stars and planets) changes due to the primary Earth motions (rotation and revolution) and the revolution of planets around the Sun.**
11b1	I can differentiate the observable phenomena caused by Earth's rotation and revolution.
11b2	I can determine the location of a planet in the night sky and when it will be visible given a model of the solar system.
11b3	I can differentiate the observable phenomena caused by rotation and revolution
11b4	I can explain which Earth motions are responsible for the ecliptic and changes in the location of the Sun on the ecliptic since the development of the astrological signs
11b5	I can use important stars and constellations to locate geographic North and find the ecliptic
1b6	I can use clues from the motions of stars and constellations to infer latitude and time of year
11c	**GRAVITATION. I apply Newton's law of gravity and circular motion to orbiting bodies.**
11c1	I can use the Universal Law of Gravity equation between two objects, $F_g = \frac{GMm}{r^2}$, to solve for unknown variables.
11c2	I can use the Universal Force of Gravity, $F_g = \frac{GMm}{r^2}$, as the centripetal force that would cause circular orbits, and calculate orbital speed.

12. APPLICATION OF ORBITAL MOTION: SEASONS AND CLIMATE

OBJ	PITU H: Students will be able to...
12a	**I can describe how energy is transferred from the Sun to the Earth and how that energy is modified before it reaches the surface.**
12a1	I can make a simple diagram that shows the fate of incoming solar radiation - how much is reflected/scattered vs absorbed by the atmosphere.
12a2	I can list the types of incoming solar radiation that are absorbed by the atmosphere and what types penetrate to the surface and cause heating.
12b	**I can explain why energy from the Sun is distributed unequally on the Earth's surface and how characteristics of the surface further contribute to unequal heating.**
12b1	I can explain why locations close to the Equator experience smaller seasonal temperature variations compared to locations closer to the Poles.
12b2	I can describe the two primary causes of seasonal temperature variation and how they result in unequal heating - duration of sunlight, angle of the Sun's rays.
12b2a	I can interpret graphs of sun altitude and hours of daylight for locations at different latitudes (low, mid, high).
12b3	I can explain how proximity to water modifies seasonal temperature variations.
12b3a	I can explain why land and water heat up and cool down at different rates and how that relates to different climatic conditions for coastal and continental locations.
12b4	I can describe how energy from the Sun, after being absorbed by the Earth's surface, is transferred to the air above and to the ground below.
11b5	I can explain why the hottest time of the day (2-3pm) is typically hours after the most intense solar radiation (local noon) and why the hottest month (July) of the year is after the time of most intense solar radiation (June 21st).
12c	**I can describe long term modifiers of Earth's climate; specifically how long term orbital properties of the Earth coupled with the position of continents can lead to climate change.**
11d1	I can describe how differences in solar output can result in climatic changes on Earth.
11d2	I can describe the three primary orbital properties of Earth that change and the resulting variations in solar energy received.
11d3	I can describe the conditions (orbital characteristics and position of continents) that result in long term climatic changes (specifically Ice Ages).
11d4	I can differentiate the three cyclical variations in Earth's orbital properties that influence the amount of solar radiation received. (ie - Milankovitch cycles)