HONORS PHYSICS

CURRICULUM

CARLISLE AREA SCHOOL DISTRICT

DATE OF BOARD APPROVAL: OCTOBER 20, 2022

COURSE OVERVIEW

Title:	Honors Physics
Grade Level:	Grades 11-12
Level:	High School - Honors
Length:	Full Year
Duration:	85 Minute Block
Frequency:	90 Days
Pre-Requisites or Concurrent:	Pre-Calculus or Calculus
Credit:	1 Credit
Description:	This is an advanced course for students who are interested in pursuing careers in science, technology, engineering, or mathematics (STEM). Topics studied include the following: sound, light, electricity, motion, forces, and energy. The course assumes a strong mathematical background. Investigative-style laboratory exercises are of major importance. This course culminates with an amusement park physics project. Successful completion of safety training is mandatory for students within this course prior to participation in any laboratory experiments.

COURSE TIMELINE

UNIT	TITLE	KEY CONCEPTS	DURATION (DAYS)
1	Waves	• Introduction to safety in a lab • Hooke's law • Period and frequency in oscillations • Simple harmonic motion • Superposition of waves/wave interference	10 days
2	Sound	• Speed of sound, frequency, and wavelength • Sound intensity • Doppler effect	10 days
3	Geometric Optics	• Ray aspect of light • Law of reflection/plane mirrors and curved mirrors • Law of refraction/plane boundary and curved lenses • Total internal reflection	10 days
4	Electricity	• Electric charge and fields • Electric current, resistance, Ohm's law • Circuits	9 days
5	One-Dimensional Motion	• Displacement, velocity, acceleration • One-dimensional kinematics • Falling objects • Motion graphical analysis	11 days
6	Two-Dimensional Motion	• Kinematics in two dimensions • Vector addition • Projectile motion • Relative velocity	8 days
7	Dynamics (Newton's Laws)	• Forces • Newton's laws of motion • Friction	8 days
8	Work, Energy, Power	• Work-kinetic energy theorem • Gravitational and elastic potential energy • Conservation of energy • Power	7 days

9	Momentum	• Linear momentum • Impulse • Conservation of momentum • Elastic and inelastic collisions • Center of mass	6 days
10	Circular and Rotational Motion	• Uniform circular motion • Angular acceleration/rotational kinematics • Rotational kinetic energy • Rotational dynamics	9 days

DISCIPLINARY SKILLS and PRACTICES

DISCIPLINARY SKILLS/PRACTICE	DESCRIPTION
Asking questions and defining problems	Identify patterns that exist in physical situations that link physics concepts.
Constructing explanations & defining solutions	Analyze physical situations to determine how the system will change when various factors are altered.
Analyzing and interpreting data	Use data that has been collected to predict how objects will behave on a larger scale.
Developing and using models	Identify the physical systems and/or models that are relevant to various situations.
Planning and carrying out investigations	Analyze the total energy in a system and how that energy is transferred within the system specifically and in the system as a whole.
Obtaining, evaluating and communicating information	Investigate how the shape, size, and composition of an object will affect how it behaves in various physical situations.
Using mathematics, information and computer technology and computational thinking	Observe how various quantities change and stay the same within a physical system by using PASCO interface software, laboratory investigations/ demonstrations, and conclude with data analysis to determine stability and change within our universe.
Engaging in argument from evidence	Deduce the overall relationships between the physical world and the forces acting upon it by performing investigations and analyzing data to come to a sound conclusion.

Unit 1

Unit Title	Waves		
Unit Description	Students learn about the types of waves and how they change direction, as well as basic wave properties such as wavelength, frequency, amplitude, and speed. Engineers apply their knowledge of waves to design an array of useful products and tools, many of which are evident in our everyday lives. For example: microwave ovens, x-ray machines, eyeglasses, tsunami prediction, radios, and speakers. Engineers must understand all the properties of waves and how waves can differ from one another in order to design safe and effective products.		
Unit Assessment	problem set wave lab		

Essential Question	Learning Goals	Content and Vocabulary	Standards
How does the restoring force acting on an object in periodic motion dictate the motion of the object? **3 Days**	☐ **Successful completion of safety training is mandatory for students within this course prior to any laboratory experiments occurring.** ☐ Describe the restoring force and its relationship to the displacement of a pendulum. ☐ Use Hooke's law to calculate stored energy in a spring. ☐ Develop a procedure to use Hooke's law to determine the spring constant of a spring (lab).	**Vocabulary:** amplitude, spring constant **Concepts:** - Hooke's law is used to relate the force applied to a spring and how far the spring will stretch. $\boldsymbol{F = -kx}$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

How can a vibrating system be considered a simple harmonic oscillator? **4 Days**	☐ Describe a simple harmonic oscillator. ☐ Relate physical characteristics of a vibrating system to aspects of simple harmonic motion (SHM). ☐ Use the equations for period of a spring and pendulum to solve problems dealing with simple harmonic oscillators.	**Vocabulary:** mechanical waves, pendulum, period, medium **Concepts:** - A system is considered a simple harmonic oscillator if the restoring force acting on the oscillator is proportional to the displacement of the oscillator from rest. $\boldsymbol{T = 2\pi\sqrt{(l/g)}}$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.
How do different types of waves have similar properties? **2 Days**	☐ Describe various characteristics associated with waves (amplitude, wavelength, crest, trough, wave velocity). ☐ Differentiate between transverse and longitudinal waves.	**Vocabulary:** transverse waves, longitudinal waves, crest, trough, wavelength **Concepts:** - Transverse waves have an amplitude that is perpendicular to the direction the wave is traveling. - Longitudinal waves have an amplitude that is parallel to the direction the wave is traveling.	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

How do multiple waves traveling in the same medium behave when they occupy the same position at the same time? **1 Day**	☐ Determine the resulting waveform when two waves act in superposition relative to each other. ☐ Explain how standing waves are formed. ☐ Describe how changing factors in the standing wave (properties of medium, frequency of source) affects the harmonic that is created in a standing wave.	**Vocabulary:** wave interference, harmonic **Concepts:** - When two waves occupy the same space in a medium at the same time, their amplitudes will combine to result in either constructive interference (both positive or negative amplitude) or destructive interference (one positive and one negative amplitude).	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

Unit 2

Unit Title	Sound		
Unit Description	Students learn the physical properties of sound, how it travels and how noise impacts human health—including the quality of student learning. Students learn how to apply the properties of waves to explain the pitch and loudness of sound. Students will also learn how sound waves propagate.		
Unit Assessment	problem set Sonar lab		
Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How do the properties of sound waves that are created affect the sound that we are able to hear? **3 Days**	☐ Define sound as the waves that are produced by a disturbance in a medium and hearing as the perception of sound. ☐ Describe sound as a longitudinal wave that needs a medium to propagate. ☐ Describe the relationship between the speed of sound, its frequency, and its wavelength. ☐ Describe the effects on the speed of sound as it travels through various media and at various temperatures of certain media, such as air. ☐ Investigate how Sonar uses the speed of sound in various media to help aid in navigation and searching for objects in media we cannot see through.	**Vocabulary:** sound, medium, frequency/pitch **Concepts:** - Sound waves require a medium to propagate, and are a product of a disturbance in that medium. - Sonar is an instrument that uses sound waves to determine the location of objects that cannot be easily seen. $\boldsymbol{v = \Delta x / \Delta t}$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength. **3.2.10.B5** Describe the difference between sound and light waves.

How can sound intensity be described and reported? **2 Days**	☐ Define and determine the intensity and relative intensity of a sound. ☐ Convert from sound intensity in W/m^2 to relative intensity in decibels. ☐ Describe how sound intensity follows the "inverse-squared" law.	**Vocabulary:** decibel **Concepts:** - The intensity of a sound that can be heard is directly proportional to the intensity of the sound and inversely proportional to the square of the distance away from the source. - Relative intensity (decibel level) is used to relate the intensity of a sound to the perceived intensity that a human would hear that sound. $I = P / ((4\pi r^2))$ $\beta = 10 \log ⟦(I / I_o)⟧$ $I = I_o e^{(\beta / 10)}$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.
How is the sound that is heard affected by the Doppler effect? **2 Days**	☐ Describe how Doppler shift affects the sound that is heard by an observer. ☐ Determine the proper sign convention to use in various Doppler effect problems. ☐ Use the equation for Doppler shift to solve problems dealing the with the Doppler effect.	**Vocabulary:** doppler shift **Concepts:** - The Doppler effect is used the describe and calculate the shift in frequency of a sound when there is a relative motion between the source and the observer of the sound. $f_o = ((v - v_o)) / ((v - v_s))$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

How can the fundamental and subsequent overtones of a standing wave in an air column be used to predict properties of the wave that is being produced? **3 Days**	☐ Define and identify antinode and nodes in standing waves. ☐ Describe how sound interference occurring inside open and closed tubes changes the characteristics of the sound, and how this applies to sounds produced by musical instruments. ☐ Calculate the length of a tube using sound wave measurements.	**Vocabulary:** node, antinode **Concepts:** - Standing waves can be created in both an open-end and closed-end tube resonator by the interaction of the sound waves within the tube. $v = f\lambda$ $f\_n = n(v / (4L))$ **(closed-end tube)** $f\_n = n(v / (2L))$ **(open-end tube)**	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

Unit 3

Unit Title	Geometric Optics		
Unit Description	Students investigate how light travels as a ray and come up with ways to verify this. Students will learn how light behaves when it reflects off of a plane surface or a curved surface, and how to determine quantitatively where the image is created, and properties of the image. Students learn the relevant equations for refraction (index of refraction, Snell's law) and how to use them to predict the behavior of light waves in specified scenarios.		
Unit Assessment	problem set lens lab		
Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can a wave behave as both a ray and a wave? **2 Days**	☐ List and describe the ways by which light travels from a source to another location (ray model, wave model, particle model). ☐ Justify how light can be classified as a ray. ☐ Identify visible light's place in the electromagnetic spectrum, and describe the importance of other types of waves on the electromagnetic spectrum.	**Vocabulary:** electromagnetic wave, speed of light **Concepts:** - Depending on the situation, light can be modeled as a ray (as in analyzing the formation of shadows) or as a wave on the electromagnetic spectrum (as in analyzing the type of wave or color of the light wave).	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength. **3.2.10.B5** Describe the difference between sound and light waves.

How does the law of reflection dictate how light behaves when hitting a plane mirror/surface? **2 Days**	☐ Explain how the law of reflection can be used to predict how light will reflect off of a plane surface. ☐ Describe the difference between specular and diffuse reflection. ☐ Predict where the image is created when an object is placed in front of a plane mirror.	**Vocabulary:** specular reflection, diffuse reflection, angle of incidence, angle of reflection **Concepts:** - Light will follow the law of reflection when hitting a flat surface, which states that the reflected angle must equal the incident angle.	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.
Does the law of reflection still work to predict the image location of an object placed in front of a curved mirror? **2 Days**	☐ Explain with ray diagrams the formation of an image using spherical mirrors (both concave and convex). ☐ Use the mirror equation and magnification equation to solve problems dealing with curved mirrors. ☐ Explain the importance of the focal point of a curved mirror.	**Vocabulary:** concave mirror, convex mirror, real image, virtual image, magnification, focal length, center of curvature **Concepts:** - Ray diagrams and the mirror equations can be used to predict the location, orientation, size, and type of image that is created in both concave and convex mirrors. $1/d_o + 1/d_i = 1/f$ $M = h_i / h_o = -d_i / d_o$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

How does the type of media that light is traveling between when passing through a boundary affect the amount of refraction that will occur to the light ray? **2 Days**	☐ Describe what happens to light when it passes through a boundary from one medium to another. ☐ Use Snell's law to solve problems dealing with light refraction. ☐ Use the index of refraction of various media to determine the speed of sound in that media. ☐ Describe the conditions needed for total internal reflection to occur.	**Vocabulary:** refraction, index of refraction, incident angle, refracted angle, normal line, total internal reflection **Concepts:** - When light passes through a boundary from one medium into another, the light will bend either toward or away from the normal line, depending on the relative indices of refraction of the two media. The light ray will behave following Snell's law in this situation. $n = c / v$ $n_1 \sin \theta_1 = n_2 \sin \theta_2$	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.
How does the law of refraction dictate how images are formed in curved lenses? **2 Days**	☐ Explain the rules for ray tracking for thin lenses. ☐ Illustrate the formation of images in curved lenses using the technique of ray tracing. ☐ Use the thin lens equation and magnification equation to solve problems dealing with lenses.	**Vocabulary:** converging lens, diverging lens **Concepts:** - Ray diagrams and the thin lens equation can be used to determine the location, orientation, size, and type of an object that is created in either a converging or diverging lens.	**3.2.P.B5** Explain how waves transfer energy without transferring matter. Describe the causes of wave frequency, speed, and wavelength.

Unit 4

Unit Title	Electricity		
Unit Description	Students learn how electrically charged materials interact with each other depending on the type and amount of charge on the object. Students use Coulomb's Law to determine the force on a point charge when multiple other point charges are present and determine the electric field strength at a certain point in space relative to a set of point charges. Students learn how to draw schematics for circuits and how to mathematically analyze circuits (simple, resistors in series, parallel).		
Unit Assessment	problem set circuit lab		
Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How does the type of electric charge on an object dictate how it interacts with other electrically charged objects? **2 Days**	☐ Recognize that there are two types of electric charge an object can have, and that opposites attract and similar repel. ☐ Describe how the principle of conservation of charge helps to predict the relative charge between two objects. ☐ Explain how the Millikan experiment proved that electric charge can be quantized. ☐ Describe the ways in which electric charge can be transferred between two materials.	**Vocabulary:** conductor, insulator, induction, polarization **Concepts:** - An object can be either positively or negatively charged, depending on the composition of protons and electrons within the object. - Electric charge can be transferred from one object to another through multiple methods, including induction and polarization.	**3.2.P.B4** Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connection among them.

How can Coulomb's law be used to determine the electric force between two-point charges? **1 Day**	☐ Calculate electric force using Coulomb's law. ☐ Apply the superposition principle to find the resultant force on a charge. ☐ Apply the superposition principle to determine the position in which the net force on a charge is zero.	**Vocabulary:** point charge **Concepts:** - Coulomb's law can be used the determine the electric force between two-point charges that are a certain distance away from each other. $\boldsymbol{F\_elec = k_c((q_1\, q_2)\, /\, r^2\,)}$	**3.2.P.B4** Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connection among them.
How can the electric field strength at any point relative to a set of point charges be determined? **2 Days**	☐ Calculate electric field strength relative to a point charge. ☐ Relate Coulomb's law to the equation to determine electric field strength. ☐ Determine the electric field strength at a point in space when multiple point charges are positioned relative to that point.	**Vocabulary:** electric field, point charge **Concepts:** - The strength of an electric field produced by a point change can be determined using an equation that can be derived from Coulomb's law. $\boldsymbol{E = F_{elec}/q_2\ = k_C(q/r^2)}$	**3.2.P.B4** Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connection among them.

How can the current flowing through a wire be regulated using resistors? **2 Days**	☐ Describe the basic properties of electric current, and solve problems relating current, charge, and time. ☐ Calculate resistance, current, and potential difference (voltage) by using Ohm's law. ☐ Identify the factors that affect resistance in a wire and use them to predict the relative resistance between multiple given wires. ☐ Use the colored bands on resistors to determine the resistance, and use Ohm's law to investigate how different resistors change the current flowing in a circuit.	**Vocabulary:** current, potential difference, resistance, equivalent resistance **Concepts:** - Ohm's law is used to relate current, resistance, and potential difference. - The colored bands painted on resistors have defined values, which are used in determining the magnitude of that resistor. $\boldsymbol{V = IR}$	**3.2.P.B4** Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connection among them.
How does the configuration of resistors in a circuit affect the properties of the circuit? **2 Days**	☐ Interpret and construct schematic diagrams of circuits. ☐ Explain the difference between an open and a closed circuit. ☐ Calculate the equivalent resistance for a circuit of resistors in either series, parallel, or a combination of both. ☐ Use Ohm's law to calculate the current in and potential difference across each resistor in a series, parallel, or combination circuit.	**Vocabulary:** schematic diagram, open circuit, closed circuit **Concepts:** - A schematic diagram can be used to help simplify a complex circuit where resistors are placed in either series, parallel, or both. Ohm's law can then be used to determine the current in and potential difference across each resistor in the circuit. $\boldsymbol{R_{eq} = R_1 + R_2 + R_3 + \cdots}$ **(series)** $\boldsymbol{R_{eq} = 1/R_1 + 1/R_2 + 1/R_3 + \cdots}$ **(parallel)**	**3.2.P.B4** Explain how stationary and moving particles result in electricity and magnetism. Develop qualitative and quantitative understanding of current, voltage, resistance, and the connection among them.

Unit 5

Unit Title	One-Dimensional Motion		
Unit Description	Students learn the difference between vector quantities and scalar quantities and how it lends to the difference between distance and displacement and speed and velocity. Students learn multiple ways to describe the motion of an object traveling with a constant velocity or a constant acceleration. Students learn how to solve problems dealing with objects under both types of motion, and relate objects in free fall to objects under constant acceleration.		
Unit Assessment	problem set free fall lab mouse trap car lab		
Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can the motion of an object traveling with constant velocity be described mathematically and visually? **3 Days**	☐ Describe motion in terms of frame of reference, displacement, time, and velocity. ☐ Use motion maps to represent to motion of objects visually. ☐ Construct and interpret graphs of position vs time. ☐ Use the equations for constant velocity and average velocity to calculate displacement, velocity, and time.	**Vocabulary:** frame of reference, displacement, velocity **Concepts:** - An object is traveling under constant velocity if the displacement over set time intervals does not change. - Position vs. time and velocity vs. time graphs can be used to compare, relate, and interpret the motion of an object. If the object is traveling with a constant velocity, the position vs. time graph will have a constant slope, and the velocity vs. time graph will be a horizontal line. $\Delta x = x_f - x_i v_{avg} = \Delta x / \Delta t$	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

How can the motion of an accelerating object be described mathematically and visually? **2 Days**	☐ Describe motion in terms of changing velocity (acceleration). ☐ Compare graphical representations of accelerated and nonaccelerated motion. ☐ Describe how the relationship between the direction of the motion and the direction of the acceleration dictates how the object is moving.	**Vocabulary:** acceleration **Concepts:** - Acceleration is defined as a change in velocity over time. - For an object that is accelerating, the position vs. time graph will not have a constant slope. The velocity vs. time graph will have a non-zero slope. $\boldsymbol{a_{avg} = \Delta v/\Delta t}$	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.
How is the motion of an object under constant acceleration different from nonconstant accelerated motion? **3 Days**	☐ Apply kinematics equations to calculate distance, time, velocity, or acceleration under conditions of constant acceleration. ☐ Describe the difference in motion of an object in constant acceleration to one in nonconstant acceleration. ☐ Show how the kinematics equations are derived and explain how to choose when to use each of the four equations.	**Vocabulary:** acceleration, motion **Concepts:** - For an object traveling with constant acceleration the four kinematics equations can be employed to solve problems relating the displacement, initial and final velocities, acceleration, and time of travel. $\boldsymbol{v_f = v_i + at}$ $\boldsymbol{\Delta x = v_i t + 1/2\, at^2}$ $\boldsymbol{\Delta x = (1/2)(v_f + v_i)t}$ $\boldsymbol{{v_f}^2 = {v_i}^2 + 2a\Delta x}$	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

How is the motion of an object in free fall related to that of an object in constant acceleration? **3 Days**	☐ Relate the motion of a freely falling body to motion with constant acceleration. ☐ Calculate displacement, velocity, and time at various points in the motion of a freely falling object. ☐ Compare the motion of different objects in free fall. ☐ Create and interpret position vs time and velocity vs time graphs for freely falling objects under all situations (dropped from rest, thrown upward, thrown downward).	**Vocabulary:** free fall **Concepts:** - An object under only the influence of gravity is said to be in free fall, and the kinematics equations can be modified for this specific situation.	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

Unit 6

Unit Title	Two-Dimensional Motion
Unit Description	Students learn how to add vectors that are not in the same plane together in a variety of ways, including multiple graphical methods as well as adding vectors analytically. Students learn what it means for an object to be in projectile motion, and how they can break down the motion of an object in projectile motion down into a horizontal component that acts as an object with constant velocity, and a vertical component that acts as an object in free fall. Students will learn how to determine the relative velocity of an object by means of vector addition. Students will solve problems dealing with all types of two-dimensional motion.
Unit Assessment	problem set free fall lab projectile launcher lab

Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can two vectors that are not in the same plane be added together or subtracted from one another, both graphically and analytically? **2 Days**	☐ Use the head-to-tail method and the parallelogram method to add two vectors that are not in the same plane graphically. ☐ Add two vectors together analytically (break into components, add components independently, return the resultant components to a single vector). ☐ Subtract one vector from another vector by adding the first vector to the antiparallel of the second vector.	**Vocabulary:** vector, scalar, resultant vector **Concepts:** - Two or more vectors can be added together to determine the resultant vector graphically by using either the head-to-tail method or parallelogram method. These methods are mainly used to get a general estimate of the resultant vector. - Two or more vectors can be added together algebraically to achieve an exact value for the magnitude and direction of the resultant vector.	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

How can the kinematics equations be used to make predictions about the motion of a projectile traveling through the air? **4 Days**	☐ Describe the motion of an object in two dimensions using quantities such as displacement, distance, velocity, speed, and acceleration, in an appropriate way for a chosen coordinate system. ☐ Identify the key features of projectile motion and how to interpret this type of motion. ☐ Solve problems involving projectile motion.	**Vocabulary:** projectile **Concepts:** - The motion of an object traveling in projectile motion can be broken down into a motion in the horizontal which travels as an object with constant velocity and a motion in the vertical which travels as an object in free fall.	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.
How can the relative velocity of an object be determined quantitatively? **2 Days**	☐ Apply principles of vector addition to determine relative velocity. ☐ Explain the significance of the observer in the measurement of velocity. ☐ Solve problems involving relative velocity.	**Vocabulary:** relative velocity **Concepts:** - The velocity of an object relative to a defined observer can be determined by employing vector addition of the velocities of the object relative to significant frames of reference.	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

Unit 7

Unit Title	Dynamics (Newton's Laws)
Unit Description	Students are introduced to Newton's three laws of motion and learn how to apply these laws. Students will learn what a force is, how a force acting on an object affects the motion of the object, how to represent forces acting on an object using a free body diagram, and be able to complete calculations regarding forces acting on an object. Students will apply Newton's laws to various problems to complete calculations such as: determining if an object is in equilibrium, what force is needed to bring it to equilibrium, whether an object is accelerating or not, the force of friction acting on an object, forces acting on an object on an incline, and more.
Unit Assessment	problem set acceleration and gravity lab

Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
What types of forces can act on an object, and how can these forces be shown in a free body diagram to make analyzing the motion of the object easier? **1 Day**	☐ Understand the definition of force. ☐ Identify various forces that can act on an object in a given situation. ☐ Determine the resultant force acting on an object using vector addition. ☐ Determine if an object is in equilibrium based on the forces acting on it, and determine the force needed to return it to equilibrium if it is not there already.	**Vocabulary:** force, equilibrium, tension, free body diagram **Concepts:** - A free body diagram, a diagram showing on the forces acting on an object being analyzed, can be used to determine the net force acting on an object, and if that object is in equilibrium or not.	**3.2.P.B1** Use force and mass to explain translational motion or simple harmonic motion of objects. **3.2.10.B1** Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's second law of motion.

How can Newton's three laws of motion be used to describe how forces are going to affect the motion of an object with mass? **3 Days**	☐ Create and use free body diagrams to analyze physical situations to solve problems with motion quantitatively and qualitatively. ☐ Re-express a free body diagram representation into a mathematical representation and solve the mathematical representation for the acceleration of the body. ☐ 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. ☐ 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.	**Vocabulary:** inertia **Concepts:** - The inertia of an object, which is related to its mass, is the object's tendency to resist a change in its motion. This is described in Newton's first law, often called the law of inertia. - Newton's second law of motion can be used to relate the acceleration of an object to the mass of the object and the net force acting on the object. $\boldsymbol{a = \Sigma F/m}$	**3.2.P.B1** Use force and mass to explain translational motion or simple harmonic motion of objects. **3.2.10.B1** Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's second law of motion.

How are action and reaction forces related to each other when two objects are interacting with each other, and when is a reaction force present in a system? **1 Day**	☐ Describe a force as an interaction between two objects and identify both objects for a given force. ☐ Use Newton's third law to make claims and predictions about the action-reaction pairs of forces when two objects interact. ☐ Analyze situations involving interactions among several objects by using free body diagrams that include the application of Newton's third law to identify forces.	**Vocabulary:** force pair, action force, reaction force **Concepts:** - According to Newton's third law of motion, all forces must act in pairs. This means that for every action force, there must an equal reaction force that acts in the opposite direction and on opposing objects.	**3.2.10.B1** Use Newton's third law to explain forces as interactions between bodies.
How can Newton's three laws of motion be used to solve problems dealing with the motion of an object under the influence of a variety of forces, including friction? **3 Days**	☐ Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction, and units during the analysis of a situation. ☐ 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. ☐ Calculate the magnitudes of static and kinetic friction acting in a variety of situations.	**Vocabulary:** friction, static friction, kinetic friction, coefficient of friction **Concepts:** - When two surfaces slide across one another, a friction force is present between the two surfaces. This friction force is related to the types of surfaces that are sliding across one another and the pressure between the surfaces.	**3.2.10.B1** Analyze the relationships among the net forces acting on a body, the mass of the body, and the resulting acceleration using Newton's second law of motion.

Unit 8

Unit Title	Work, Energy, Power
Unit Description	Work is defined as the transfer of energy into or out of a system. Energy comes in multiple forms, such as potential energy (energy due to relative location of an object in a system) and kinetic energy (energy due to motion). Power is the rate that the work is being done, or the rate that the energy is being transferred.
Unit Assessment	problem set work and energy lab

Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can one know when work is being done on an object, and how does the work done affect the motion of the object? **2 Days**	☐ 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. ☐ 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.	**Vocabulary:** work, energy **Concepts:** - Work is being done on an object if a force being applied to the object causes a displacement of the object. - The work-kinetic energy theorem states that when a net work is done on an object, there will be a change in the object's kinetic energy. $W = Fd\cos\theta$ $K = 1/2\, mv^2$ $W = \Delta K$	**3.2.10.B2** Describe the work-energy theorem.

How can one determine the type of energy that is present in a system and calculate these energies? **2 Days**	☐ 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. ☐ Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. ☐ Describe and make predictions about the internal energy of a system.	**Vocabulary:** kinetic energy, gravitational potential energy, elastic potential energy **Concepts:** - An object that is in motion will have kinetic energy. Gravitational potential energy is the energy of an object relative to its height above a defined zero line. - Elastic potential energy is the energy of a system where a spring or other elastic object is stretched away from its rest position. $U_g = mgh$ $U_e = 1/2\, kx^2$	**3.2.P.B2** Explain the translation and simple harmonic motion of objects using conservation of energy and conservation of momentum.
How can the conservation of mechanical energy be applied to solve problems? **2 Days**	☐ 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 system, and/or the internal energy of the system. ☐ Calculate changes in kinetic energy and potential energy of a system using information from representations of that system.	**Vocabulary:** conservation of energy **Concepts:** - In the absence of an outside force the total mechanical energy within a system (sum of kinetic and all potential energies) will remain constant.	**3.2.C.B3** Describe the law of conservation of energy.

When is power being done in a system and how can it be calculated? **1 Day**	☐ Calculate power by calculating changes in energy (work) over time.	**Vocabulary:** power **Concepts:** - The power being delivered to an object can be determined by the work done on the object (the change in energy of the object) divided by the time that the work is being done. $\boldsymbol{P = W/\Delta t}$	**3.2.10.B2** Explain the relationship between work and power.

Unit 9

Unit Title	Momentum		
Unit Description	Any object in motion will have momentum, which is defined as the product of an object's mass and velocity. When a force is applied for any amount of time (impulse) the momentum of an object will change. Momentum is conserved in both elastic (hit and bounce) and inelastic (hit and stick) collisions. In elastic collisions, the total kinetic energy is equal before and after the collision. In inelastic collisions, the kinetic energy is not the same before and after the collision.		
Unit Assessment	problem set elastic and inelastic collision lab		
Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can a force being applied to an object change the linear momentum of that object? **2 Days**	☐ Define the linear momentum of an object and explain how it differs from kinetic energy. ☐ 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. ☐ 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.	**Vocabulary:** momentum, impulse **Concepts:** - Momentum is the property of an object that is determined by multiplying the mass of an object and its velocity. - A force acting on an object will cause the object to have a change in momentum. $\boldsymbol{p = mv}$ $\boldsymbol{J = F\Delta t = \Delta p}$	**3.2.P.B1** Use force and mass to explain translational motion or simple harmonic motion of objects. **3.2.P.B2** Explain the translational and simple harmonic motion of objects using conservation of energy and conservation of momentum.

What happens regarding momentum of individual objects when they collide in various types of collisions? **2 Days**	☐ Identify the differences and similarities between elastic, inelastic, and superelastic collisions. ☐ Apply conservation of momentum and mechanical energy to problems involving elastic collisions.	**Vocabulary:** elastic collision, inelastic collision, superelastic collision **Concepts:** - Momentum is conserved in a closed system during any type of collision. - Collisions can be categorized depending on what happens during the short time the collision is taking place between hit and bounce (elastic), hit and stick (inelastic) and explosions (superelastic).	**3.2.P.B1** Use force and mass to explain translational motion or simple harmonic motion of objects. **3.2.P.B2** Explain the translational and simple harmonic motion of objects using conservation of energy and conservation of momentum.
What is the process that can be taken to find the center of mass of a system, and why is this helpful in describing the motion of macroscopic objects? **2 Days**	☐ Find the center of mass of a system and describe how the net force on a system affects the motion of the system's center of mass. ☐ Use the concepts of momentum, center of mass, and system to predict the behavior of objects in everyday situations.	**Vocabulary:** center of mass **Concepts:** - The center of mass of a system is a point where all forces can be assumed to be acting to analyze the motion of the system.	**3.2.P.B1** Use force and mass to explain translational motion or simple harmonic motion of objects. **3.2.P.B2** Explain the translational and simple harmonic motion of objects using conservation of energy and conservation of momentum.

Unit 10

Unit Title	Circular and Rotational Motion
Unit Description	Circular motion describes the motion of an object that travels around in a circular path at a set distance (radius) from a midpoint. An object traveling in uniform circular motion is one that is traveling at a constant speed around the circular path or is only under the influence of a centripetal force. Rotational motion describes an object that is rotating around an axis of rotation that is located within the object. Objects that are rotating with a uniform rotational acceleration (angular acceleration) follow equations like the kinematics equations. A torque is a force that is applied to an object at some distance away from the axis of rotation and can cause the object or system to rotate. A system is in static equilibrium if the net torque is zero, as well as the net forces acting on the object.
Unit Assessment	problem set

Essential Question	**Learning Goals**	**Content and Vocabulary**	**Standards**
How can the motion of an object in uniform circular motion be related to the motion of an object traveling with constant velocity? **2 Days**	☐ Define arc length, angular displacement, radius of curvature, and angular velocity. ☐ Solve problems involving centripetal force and centripetal acceleration. ☐ Relate the angular quantities for motion to linear quantities, and be able to transfer between them when the radius is given.	**Vocabulary:** centripetal, arc length, angular displacement, radius of curvature, angular velocity **Concepts:** - An object that is traveling in a circle around a central point at a constant speed is said to be in uniform circular motion. This motion is caused by a centripetal (center pointing) force. $\boldsymbol{a_c = v^2/r}$ $\boldsymbol{F_c = m(v^2/r)}$	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.

How can the kinematics equations used with linear motion be modified and applied when an object undergoes an angular acceleration? **3 Days**	☐ Select from the kinematic equations for rotational motion with constant angular acceleration the appropriate equations to solve for unknowns in the analysis of systems undergoing fixed-axis rotation. ☐ Use solutions found with the kinematic equations to verify the graphical analysis of fixed-axis rotation with constant angular acceleration.	**Vocabulary:** angular acceleration **Concepts:** - The motion of a rotating object that is undergoing a constant angular acceleration can be described by the kinematic equations for rotational motion, which are derived in a similar way to the kinematics equations of linear motion.	**3.2.P.B1** Differentiate among translational motion, simple harmonic motion, and rotational motion in terms of position, velocity, and acceleration.
How can the motion of an object in uniform circular motion be related to the motion of an object traveling with constant velocity? **2 Days**	☐ Describe the differences between rotational and translational kinetic energy. ☐ Explain how the moment of inertia of rigid bodies affects their rotational kinetic energy. ☐ Calculate the rotational kinetic energy of objects that are rotating around a fixed axis at their center of mass.	**Vocabulary:** moment of inertia **Concepts:** - An object that is rotating around a central axis has a certain amount of kinetic energy that can be determined if the moment of inertia and the angular velocity is known. - The moment of inertia equation is dependent on shape.	**3.2.P.B2** Explain the translational, rotational, and simple harmonic motion of objects using conservation of energy and conservation of momentum.

What is the role of torque and linear forces in whether a system can be determined to be in either static or dynamic equilibrium? **2 Days**	☐ Describe the role of torques in rotational dynamics. ☐ Compare objects that are in static and dynamic equilibrium, using the two conditions for equilibrium to determine when a system has each type of equilibrium. ☐ Use the conditions for objects to be in static and dynamic equilibrium to solve problems.	**Vocabulary:** torque, static equilibrium, dynamic equilibrium **Concepts:** - Any system that is not rotating will be in equilibrium if the net force on it is zero. If it is not moving, it is said to be in static equilibrium. - An object is in total equilibrium if the net force acting on it and the net torque acting on it are both zero. $\boldsymbol{\tau = Fd\cos\varphi}$	**3.2.P.B1** Use force and mass to explain translational, rotational, or simple harmonic motion of objects.

ACCOMMODATIONS AND MODIFICATIONS

Adaptations or modifications to this planned course will allow exceptional students to earn credits toward graduation or develop skills necessary to make a transition from the school environment to community life and employment. The I.E.P. team has determined that modifications to this planned course will meet the student's I.E.P. needs.

<u>Adaptations/Modifications may include but are not limited to</u>:

INSTRUCTION CONTENT

- Modification of instructional content and/or instructional approaches
- Modification or deletion of some of the essential elements

SETTING

- Preferential seating

METHODS

- Additional clarification of content
- Occasional need for one to one instruction
- Minor adjustments or pacing according to the student's rate of mastery
- Written work is difficult, use verbal/oral approaches
- Modifications of assignments/testing
- Reasonable extensions of time for task/project completion
- Assignment sheet/notebook
- Modified/adjusted mastery rates
- Modified/adjusted grading criteria
- Retesting opportunities

MATERIALS

- Supplemental texts and materials
- Large print materials for visually impaired students
- Outlines and/or study sheets
- Carbonless notebook paper
- Manipulative learning materials
- Alternatives to writing (tape recorder/calculator)