AP Physics C *(Master)*

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Content	Skills	Learning Targets	Assessment	Resources & Technology
CEQ **How do we use mathematical and graphical models to describe motion?** **What is the connection between force and motion?** **How are mathematical and physical models used to explain energy transfers and transformations.** ***UEQ*** ● *What does it mean to say motion is relative?* ● *How do we use mathematical models to describe the way things with*	**Rectilinear Motion** 1) Calculate average velocity, displacement, and time for a moving object. 2) Calculate Acceleration, Displacement, Final Velocity, Initial Velocity, or time for an object moving with changing velocity. 3) Given a position time graph draw the corresponding velocity and acceleration time graphs. 4) Calculate displacement and acceleration from a segment of a velocity time graph. 5) Calculate the velocity and position of an object in freefall if given the time falling or being shot upward as well as the initial velocity. 6) Predict the instantaneous velocity of an accelerating object using the slope of the tangent on a d vs t graph.	**Rectilinear Motion** 1) I can calculate average velocity, displacement, and time for a moving object. 2) I can choose the correct acceleration equation and solve for Vi, Vf, a, d, or t. 3) Given a position time graph i can draw the corresponding velocity and acceleration time graphs. 4) I can calculate displacement and acceleration from a segment of a velocity time graph. 5) I can predict the instantaneous velocity of an accelerating object using the slope of the tangent on a d vs t graph.	**Rectilinear Motion** 1 Constant Velocity of a Train (tape timer) 2 Acceleration of gravity lab 2-4 & 7 Acceleration of a cart on a ramp 5 Human Reaction Time Lab 5 Freefall Lab (Motion Detector) 3,6, & 7 Graphing Packet **Outdoor Lesson=** 3 Mystery Walker Challenge 1-10 Serway Problems Check Quiz 1-10 Multiple Choice Test **Planar Motion**	***Rectilinear Motion*** *Physics for Scientists and Engineers* *Serway and Jewett* *Chapters 1-3* Tape Timers Pasco Motion Sensors Data Studio Software Bucket Lids and Sinkers Graph Paper Stop Watches Meter Sticks and Stop Watches Long Metric Tape Measure **"Outdoor Lesson:** Mystery Walker Challenge" **"tech integration:** Pasco motion detector with capstone software"

constant velocity move? ● *How do we use mathematical models to describe the way things with constant acceleration move?* ● *How do we change the axis of a graph from position vs. time to velocity vs. time to acceleration vs. time?* ● *How does gravity affect the motion of an object?* ● *How are vectors used to add motion in 2 directions?* ● *How is 2 dimensional motion resolved into perpendicular vectors?* ● *How does projectile motion represent an application of both constant velocity and constant acceleration?*	7) Find the displacement of an accelerating object by calculating the area under the curve for a v vs t graph. 8) Solve problems involving accelerations and velocities in opposite directions. 9) Use trigonometry to resolve vectors into x- and y- components 10) Resolve the displacement, velocity, and acceleration of a projectile into their horizontal and vertical components **Planar Motion** 1) Describe the motion of a projectile using the equations for constant velocity and constant acceleration 2) Apply kinematic equations to calculate the motion of objects in two-dimensions 3) Solve projectile problems for hang time, max height, horizontal range, and the magnitude,	6) I can use the derivative to find the speed of a position function 7) I can find the displacement of an accelerating object by calculating the area under the curve for a v. vs t. graph. 8) I can solve problems involving accelerations and velocities in opposite directions. 9) I can use trigonometry to resolve vectors into x- and y- components 10) I can resolve the displacement, velocity, and acceleration of a projectile into their horizontal and vertical components **Planar Motion** 1) I can explain the motion of a projectile using the equations for constant velocity in the x direction and constant acceleration in the y direction.	1) Blow Dart Challenge 1) Horizontal projectile Lab 2) Monkey and Hunter Challenge 3) Softball Toss Lab **Outdoor Lesson=**1-3) Air Rockets Lab 1-3) Ice Cream Pale Shot Group Challenge 1-3) Problems Check Quiz 1-3) Multiple Choice Test	**Key Vocabulary** Distance Displacement Speed Velocity Acceleration Freefall Scalar Vector Rate Terminal Velocity Slope of the Tangent Instantaneous Velocity Average Velocity Area under the curve **Planar Motion** *Physics for Scientists and Engineers* *Serway and Jewett* *Chapter 3*

Rectilinear Motion *Constant Velocity* *Changing Velocity* *Position vs Time Graphs* *Velocity vs Time Graphs* *Acceleration vs Time Graphs* *Instantaneous Velocity* *Average Velocity* *Average Speed* *Free Fall* *Problem Solving* Resolving Vectors Adding Vectors Solving 2 dimensional motion problems ***UEQ*** *How are vectors used to add motion in 2 directions?* *How is 2 dimensional motion resolved into perpendicular vectors?* *How does projectile motion represent an application of*	and direction of the velocity vector at impact.	2) I can apply kinematic equations to calculate the motion of objects in two-dimensions 3) I can solve projectile problems for hang time, max height, horizontal range, and the magnitude, and direction of the velocity vector at impact.		CPO marble launchers, photogates Pasco Projectile Launcher Ramps Marbles Graph paper Meter sticks Stopwatches Protractors Air Pressure Rockets "**Outdoor Lesson:** Air Rockets Lab" **Key Vocabulary** Resultant Resolve Components Trajectory

both constant velocity and constant acceleration? **Planar Motion** Solving horizontal projectile problems Solving projectiles launched at angles Solving off plane target problems				Projectile Range Equilibrium

January

Content	Skills	Learning Targets	Assessment	Resources & Technology
UEQ • *How are Free Body Diagrams used to express the interaction of forces?* • *How do Newton's laws of motion allow us to make predictions about the acceleration of masses acted on by forces?*	**Newtons Laws** 1) Draw free body diagrams for a mass acted on by several forces 2) Solve for net force acting on an object 3) Resolve force vectors to find net force in each dimension 4) Use Newtons 2nd law to solve for the acceleration	**Newtons Laws** 1) I can draw free body diagrams for a mass acted on by several forces 2) I can solve for net force acting on an object 3) I can resolve force vectors to find net force in each dimension 4) I can use Newtons 2nd law to solve for the	**Newtons Laws** 1,2, 4-6) Newtons 2nd Law Lab 5-6) Friction Lab 1-7) Problem Check Quiz 1-7) Coin and book cover challenge 1-7) Test **Application of Newtons**	**Newtons Laws** *Physics for Scientists and Engineers* *Serway and Jewett* *Chapter 5* Pulleys Ramps String

• *How are vectors used to resolve 2-D forces into perpendicular components?* • *How is the force of weight resolved for objects on inclined planes?* • *How do frictional forces affect the motion of an object?* **Introduction to Newton's Laws** Newtons Laws Free Body Diagrams Net Force 2D Forces Inclined Planes Weight Mass Normal Force Frictions Tension **UEQ** • *How does air resistance affect the motion of a falling object* • *How do we analyze the motion of objects joined by strings*	of a mass acted on by a net force. 5) Use accelerations of objects to solve for individual forces acting on the object such as friction, weight, normal force or tension. 6) Calculate the coefficient of friction between surfaces for static and kinetic friction. 7) Resolve the force of weight on inclined planes. **Application of Newtons Laws** 1)Use Newton's Second Law to write a differential equation for the velocity of the object as a function of time. 2)Use the method of separation of variables to derive the equation for the velocity as a function of time from the differential equation that follows from Newton's Second Law. 3) Derive an expression for the acceleration as a function of time for an object falling under the influence of drag forces.	acceleration of a mass acted on by a net force. 5) I can use accelerations of objects to solve for individual forces acting on the object such as friction, weight, normal force or tension. 6) I can calculate the coefficient of friction between surfaces for static and kinetic friction. 7) I can resolve the force of weight on inclined planes into parallel and normal force. **Application of Newtons Laws** 1) I can use Newton's Second Law to write a differential equation for the velocity of the object as a function of time. 2) I can use the method of separation of variables to derive the equation for the velocity as a function of time from the differential equation that follows from Newton's Second Law. 3) I can derive an expression for the acceleration as a function of time for an object	**Laws** 1-9) University of Oregon Problems 1,2,4) Attwoods challenge 1,2,4) Tibometer challenge 1,2,4) Double Incline Problem 3) Coffee Filter Lab 4-7) Circular Motion Lab 4-7) Turning Pt Challenge 8) Coin on LP Challenge 1-9) Test	Newtons Scales Tension Protractors Dynamics Track Pasco Cars Pasco Motion Sensors CPO Energy Cars CPO Energy Tracks Photogates **Key Terms** Force Mass Weight Net Force FBD Inertia F=ma Newtons 3rd Law Tension Normal Force Friction Coefficient of Friction Equilibrant Inclined Plane Force Parallel Force Perpendicular

• *What is the magnitude and direction of velocity and acceleration when moving at a constant speed in a circular path?* • *How do mass, radius, and velocity relate to the force on an object moving in a circular path?* • *How may Newton's laws be utilized to analyze real and perceived phenomena for a body in circular motion?* **Application of Newton's Laws** Pulley Systems Uniform Circular Motion Nonuniform Circular Motion Nonconstant Friction	4) Students should know that the tension is constant in a light string that passes over a massless pulley and should be able to use this fact in analyzing the motion of a system of two objects joined by a string. 5) Calculate centripetal acceleration of an object revolving with a constant speed. 6) Calculate centripetal force of an object revolving with a constant speed. 7) Calculate centripetal force as the horizontal component of tension for an object being whirled by a rope. 8) Calculate centripetal force as friction for an object traveling around an unbanked corner 9) Calculate centripetal force as a component of weight for an object going around a banked corner	falling under the influence of drag forces. 4) I can use tension in analyzing the motion of a system of two objects joined by a string. 5) I can calculate centripetal acceleration of an object revolving with a constant speed. 6) I can calculate centripetal force of an object revolving with a constant speed. 7) I can calculate centripetal force as the horizontal component of tension for an object being whirled by a rope. 8) I can calculate centripetal force as friction for an object traveling around an unbanked corner 9) I can calculate centripetal force as a component of weight for an object going around a banked corner		Attwoods Machine Tibometer Statics Dynamics **Application of Newtons Laws** *Physics for Scientists and Engineers* *Serway and Jewett* *Chapter 6* Rubber Stoppers Plastic Tubes String Mass Set Flying Pig Demo Record player Graph Paper CPO Pendulum kit Stop Watches **Key Terms** Linear Velocity Angular Velocity Radius Period Centripetal Acceleration (radial) Centripetal Force

February

Content	Skills	Learning Targets	Assessment	Resources & Technology
UEQ ● *What is energy?* ● *How do we use conservation of mechanical energy to interpret interactions between objects?* ● *What are some forms of potential energy and how is potential energy gained?* ● *How does power fit into the energy accounting system?* **Vector Multiplication Work and Energy** Calculating Work Calculating gravitational potential energy Spring Potential Energy Calculating Kinetic Energy Work Energy Theorem Conservative and Nonconservative Forces Energy Conservation Power Calculations	**Vector Multiplication Work and Energy** 1) Calculate work done by a force as well as net work done by all forces acting on a system. 2) Calculate work done by a variable force as area under the curve of force vs. distance. 3) Use the work energy theorem to calculate changes in potential and kinetic energy 4) Calculate gravitation potential energy 5) Calculate spring potential energy 6) Calculate kinetic energy 7) Use consevation of mechanical energy to solve physics problems involving work done by consevative forces. 8) Explain how energy is conserved as it is transformed. 9) Calculate power.	**Vector Multiplication Work and Energy** 1) I can calculate work done by a force as well as net work done by all forces acting on a system. 2) I can calculate work done by a variable force as area under the curve of force vs. distance. 3) I can show that work done on an object is equal to changes in its potential and or kinetic energy 4) I can calculate gravitation potential energy 5) I can calculate spring potential energy 6) I can calculate kinetic energy 7) I can use consevation of mechanical energy to solve physics problems involving work done by consevative forces. 8) I can explain how energy is conserved as it is transformed. 9) I can calculate power.	**Vector Multiplication Work and Energy** 1-3) Rubberband Car Lab 4,6, 7) Marble Roll Lab II 2) Vertical Loop Challenge 4-7) Bungee Jumper Lab 1-9) Chapter Problem Check Quiz 1-9) Test	**Vector Multiplication Work and Energy** ***Physics for Scientists and Engineers*** ***Serway and Jewett*** ***Chapter 7-8*** CPO Energy Track Marble tracking and loop Pasco Cars Stop Watches Balistic Pendulum Spring Sets Rubberbands Mass Sets Marbles **Key Vocabulary** Work Conservative Forces Work-Energy-Theorem Potential Energy Kinetic Energy Mechanical Energy Conservation of Energy Power

March

Content	**Skills**	**Learning Targets**	**Assessment**	**Resources & Technology**
UEQ ● *How is impulse momentum theorem related to Newton's 2nd law?* ● *How do we use conservation of momentum to interpret interactions between objects?* ● *How do we distinguish between elastic and inelastic collisions?* ● *What is meant by center of mass and why is it important in analyzing the motion of an object or system?* **Impulse, Momentum, and Collisions** Impact vs Impulse Momentum	**Impulse, Momentum, and Collisions** 1) Use the impulse momentum theorem to calcuate the change in velocity of an object acted on by a force for a given amount of time. 2) Calculate impulse as the area under the curve of a graph of force vs. time. 3) Use conservation of momentum to solve velocities of masses before or after elastic and inelastic collisions. 4) Use conservation of energy and conservation of momentum to make calculations of velocities of multiple objects in perfectly elastic collisions. 5) Use conservation of momentum to solve for velocities of objects before or after collisions in 2 dimensions. 6) Calculate the center of	**Impulse, Momentum, and Collisions** 1) I can use the impulse momentum theorem to calcuate the change in velocity of an object acted on by a force for a given amount of time. 2) I can calculate impulse as the area under the curve of a graph of force vs. time. 3) I can use conservation of momentum to solve velocities of masses before or after elastic and inelastic collisions. 4) I can use conservation of energy and conservation of momentum to make calculations of velocities of multiple objects in perfectly elastic collisions. 5) I can use conservation of momentum to solve for velocities of objects before or after collisions in 2 dimensions. 6) I can calculate the	**Impulse, Momentum, and Collisions** 1,3, 4 Elastic Momentum Lab 1,3,4 Inelastic Momentum Lab 1-6) Balistic Pendulum Lab 5 Nickel Collisions 1-6 Chapter Problem Quiz 1-6 Unit Test	**Impulse, Momentum, and Collisions** ***Physics for Scientists and Engineers*** ***Serway and Jewett*** ***Chapter 7-8*** CPO Energy Track CPO Photogates Pasco Cars Meter Sticks Stop Watches Balistic Pendulum **Key Vocabulary** Impulse Momentum Elastic Collision Inelastic Collision Perfectly Elastic Collision Center of Mass

Impulse=change in momentum Elastic and Inelastic Collisions Collisions in 2 dimensions Perfectly Elastic Collisions Balistic Pendulums Center of Mass calculations	mass of a system of particles.	center of mass of a system of particles.		

April

Content	**Skills**	**Learning Targets**	**Assessment**	**Resources & Technology**

UEQ • *What factors affect the rotational inertia of a rigid object?* • *How do we distinguish between linear and angular velocity, acceleration, and momentum?* • *What is the difference between torque and work?* **Rotational Motion** Diplacement in Radians Angular Velocity Angular Acceleration Rolling without slipping Torque Torque and Rotational Inertia Rotational Kinetic Energy Consevation of Angular Momentum Vector nature of angular momentum **UEQ**	**Rotational Motion** 1) Calculate the angular displacement, velocity, and acceleration of a rotating object. 2) Balance Torques about a fixed point. 3) Calculate the net torque on an object. 4) Find the net acceleration on a rotating object by adding radial and angular acceleration as vectors. 5) Make predictions about the motion of rotating objects based on their rotational inertia. 6) Calculate the rotational inertia of a various types of masses and systems 6) Calculate the rotational kinetic energy of a rotating object, 7) Explain the effects and applications of conservation of angular momentum as a rotating object changes its rotational inertia or axis of rotation.	**Rotational Motion** 1) I can calculate the angular displacement, velocity, and acceleration of a rotating object. 2) I can balance Torques about a fixed point. 3) I can calculate the net torque on an object. 4) I can find the net acceleration on a rotating object by adding radial and angular acceleration as vectors. 5) I can calculate the rotational inertia of: a set of point masses in a plane a thin rod a thin cylindrical shell 6) I can state and apply the parallel axis theorem. 7) I can calculate the rotational kinetic energy of a rotating object, 8) I can explain the effects and applications of conservation of angular momentum as a rotating object changes its rotational inertia or axis of rotation. 9) I can solve problems involving rotational and	**Rotational Motion** 2) Balancing torques challenge 6-7) Marble Roll Lab 7-9) Rotational Inertia Lab 1-9) Chapter Problem check quiz 2) Rotational statics worksheet 1-9) Unit Test **Gravitation** 1-12 Jupiter Satellite Orbit Lab 6 Geosynchronous satellite challenge 12 Escape Velocity challenge 1-12 Chapter problem check quiz 1-12Unit Test	**Rotational Motion** *Physics for Scientists and Engineers* *Serway and Jewett* *Chapter* 10-12 Rot Inertia Wands Balancing Torques Mobile Rot Inertia Spheres hoops and cylinders Record Player Protractors Rotational Inertia Apparatus **Key Vocabulary** radian angular velocity angular acceleration torque rotational inertia rotational kinetic energy angular momentum **Gravitation** ***Physics for Scientists and Engineers*** ***Serway and Jewett*** ***Chapter* 14** Jupiter Satellite Data Earth, Sun, and moon data **Key Vocabulary**

How does the law of universal gravitation help us explain satellite and planetary motion? *How does the inverse square law help us explain certain field forces?* *What are the implications of gravity being only attractive* **Gravitation** Keplers Laws Newtons Law of Universal Gravitation Gravitational Potential Energy Angular Momentum	**Gravitation** Students should know Newton's Law of Universal Gravitation and the laws of planetary motion, so they can: 1) Determine the force that one spherically symmetrical mass exerts on another. 2) Determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass. 3) Describe the gravitational force inside and outside a uniform sphere. 4) Calculate how the field at the surface depends on the radius and density of the sphere. 5) Describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and 6) derive expressions for the velocity and period of revolution in circular orbits. 7) Derive Kepler's Third Law for the case of circular orbits. 8) Derive and apply the relations among kinetic energy, potential energy, and total energy for such an orbit.	translational equilibrium. **Gravitation** 1) I can determine the force that one spherically symmetrical mass exerts on another. 2) I can determine the strength of the gravitational field at a specified point outside a spherically symmetrical mass. 3) I can describe the gravitational force inside and outside a uniform sphere. 4) I can calculate how the field at the surface depends on the radius and density of the sphere. 5) I can describe qualitatively how the velocity, period of revolution, and centripetal acceleration depend upon the radius of the orbit; and 6) I can derive expressions for the velocity and period of revolution in circular orbits. 7) I can derive Kepler's Third Law for the case of circular orbits. 8) I can derive and apply the relations among kinetic energy, potential energy, and total energy for such an orbit.		gravitational mass inverse square law geosynchronous universal gravitation constant escape velocity Keplers laws

	9) State Kepler's three laws of planetary motion and use them to describe in qualitative terms the motion of an object in an elliptical orbit. 10) Apply conservation of angular momentum to determine the velocity and radial distance at any point in the orbit. 11)Apply angular momentum conservation and energy conservation to relate the speeds of an object at the two extremes of an elliptical orbit. 12) Apply energy conservation in analyzing the motion of an object that is projected straight up from a planet's surface or that is projected directly toward the planet from far above the surface.	**9)** I can state Kepler's three laws of planetary motion and use them to describe in qualitative terms the motion of an object in an elliptical orbit. 10) I can apply conservation of angular momentum to determine the velocity and radial distance at any point in the orbit. 11) I can apply angular momentum conservation and energy conservation to relate the speeds of an object at the two extremes of an elliptical orbit. 12) I can apply energy conservation in analyzing the motion of an object that is projected straight up from a planet's surface or that is projected directly toward the planet from far above the surface		

May 2020

Content	Skills	Learning Targets	Assessment	Resources & Technology
UEQ ● *What are the characteristics of a simple harmonic oscillator?*	**Simple Harmonic Motion** Students should understand simple harmonic motion, so they can: 1)Sketch or identify a graph of displacement as a	**Simple Harmonic Motion** 1)I can sketch or identify a graph of displacement as a function of time, and determine from such a graph the amplitude, period	**Simple Harmonic Motion** 12-14 Conical pendulum lab 8 mass on spring lab 1-14 chapter problem check quiz 1-14 unit test	**Simple Harmonic Motion** ***Physics for Scientists and Engineers*** ***Serway and Jewett*** ***Chapter*** *13* *Pendulum kits from CPO*

• *How is simple harmonic motion used to analyze the motion of masses on springs and simple pendulums?* **Simple Harmonic Motion** Frequency period amplitude (max displacement) max velocity Restoring force springs pendulums	function of time, and determine from such a graph the amplitude, period and frequency of the motion. 2) Find an expression for velocity as a function of time. 3) State the relations between acceleration, velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values. 4) State and apply the relationship between frequency and period. 5) Calculate the kinetic and potential energies of an oscillating system as functions of time. 6) Calculate the maximum displacement or velocity of a particle that moves in simple	and frequency of the motion. 2) I can find an expression for velocity as a function of time. 3) I can state the relations between acceleration, velocity, and displacement, and identify points in the motion where these quantities are zero or achieve their greatest positive and negative values. 4) I can state and apply the relationship between frequency and period. 5) I can calculate the kinetic and potential energies of an oscillating system as functions of time. 6) I can calculate the maximum displacement or velocity of a particle that moves in simple harmonic motion with specified initial position and velocity.		*Masses* *Springs* *Data Studio Capstone software* **Key Vocabulary** Frequency period amplitude (max displacement) max velocity Restoring force springs pendulums resonance Oscillator phase angular velocity

	harmonic motion with specified initial position and velocity. 7) Develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force <u>Mass on a spring</u> Students should be able to apply their knowledge of simple harmonic motion to the case of a mass on a spring, so they can: 8) Derive the expression for the period of oscillation of a mass on a spring. 9)Apply the expression for the period of oscillation of a mass on a spring. 10) Analyze problems in which a mass hangs from a spring and oscillates vertically. 11) Analyze problems in which a mass attach	7) I can develop a qualitative understanding of resonance so they can identify situations in which a system will resonate in response to a sinusoidal external force 8) I can derive the expression for the period of oscillation of a mass on a spring. 9) I can apply the expression for the period of oscillation of a mass on a spring. 10) I can analyze problems in which a mass hangs from a spring and oscillates vertically. 11) I can analyze problems in which a mass attach ed to a spring oscillates horizontally. 12) I can determine the period of oscillation for systems involving series or parallel combinations of identical springs, or springs of differing lengths.		

	ed to a spring oscillates horizontally. 12) Determine the period of oscillation for systems involving series or parallel combinations of identical springs, or springs of differing lengths. <u>Pendulum and other oscillations</u> Students should be able to apply their knowledge of simple harmonic motion to the case of a pendulum, so they can: 13) Derive and apply the expression for the period of a simple pendulum. 14) Analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations.	13) I can derive and apply the expression for the period of a simple pendulum. 14) I can analyze the motion of a torsional pendulum or physical pendulum in order to determine the period of small oscillations.		