A Correlation of

College Physics:
Explore and Apply

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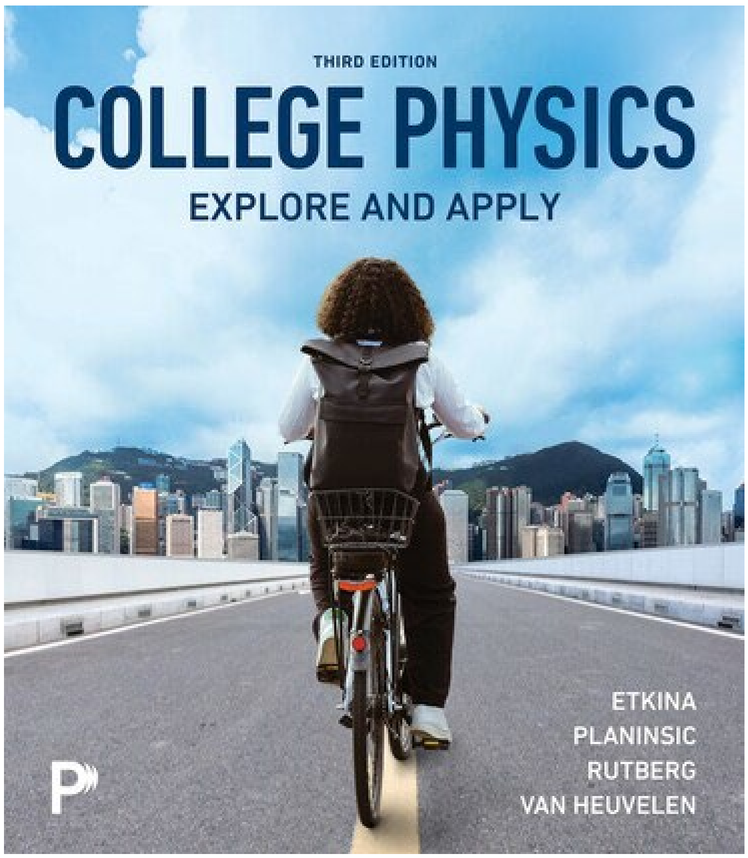

To the

AP® Physics 1
Course Framework
Effective Fall 2024

Pearson

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The units above reflect the College Board's AP® Physics 1 Course Framework.

Topic	Learning Objective	Essential Knowledge	College Physics 3e
1.1 Scalars and Vectors in One dimension	1.1.A Describe a scalar or vector quantity using magnitude and direction, as appropriate.	1.1.A.1 Scalars are quantities described by magnitude only; vectors are quantities described by both magnitude and direction.	Section 1.5
		1.1.A.2 Vectors can be visually modeled as arrows with appropriate direction and lengths proportional to their magnitude.	Section 1.5
		1.1.A.3 Distance and speed are examples of scalar quantities, while position, displacement, velocity, and acceleration are examples of vector quantities.	Section 1.5
	1.1.B Describe a vector sum in one dimension.	1.1.B.1 When determining a vector sum in a given one-dimensional coordinate system, opposite directions are denoted by opposite signs.	Section 2.3
1.2 Displacement, Velocity, and Acceleration	1.2.A Describe a change in an object's position.	1.2.A.1 When using the object model, the size, shape, and internal configuration are ignored. The object may be treated as a single point with extensive properties such as mass and charge.	Section 1.2
		1.2.A.2 Displacement is the change in an object's position.	Section 2.4

	1.2.B Describe the average velocity and acceleration of an object.	1.2.B.1 Averages of velocity and acceleration are calculated considering the initial and final states of an object over an interval of time.	Section 2.7
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		1.2.B.5 Calculating average velocity or average acceleration over a very small time interval yields a value that is very close to the instantaneous velocity or instantaneous acceleration.	Section 2.7
1.3 Representing Motion	1.3.A Describe the position, velocity, and acceleration of an object using representations of that object's motion.	1.3.A.1 Motion can be represented by motion diagrams, figures, graphs, equations, and narrative descriptions.	Sections 2.2, 2.9
		1.3.A.2 For constant acceleration, three kinematic equations can be used to describe instantaneous linear motion in one dimension.	Section 2.8
		1.3.A.3 Near the surface of Earth, the vertical acceleration caused by the force of gravity is downward, constant, and has a measured value approximately equal to 10 m/s^2.	Section 2.7
		1.3.A.4 Graphs of position, velocity, and acceleration as functions of time can be used to find the relationships between those quantities.	Sections 2.5, 2.6, 2.7

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1.4 Reference Frames and Relative Motion	1.4.A Describe the reference frame of a given observer.	1.4.A.1 The choice of reference frame will determine the direction and magnitude of quantities measured by an observer in that reference frame.	Section 2.1
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		1.5.A.2 Vectors can be resolved into components using a chosen coordinate system.	Section 4.1
		1.5.A.3 Vectors can be resolved into perpendicular components using trigonometric functions and relationships.	Section 4.1
	1.5.B Describe the motion of an object moving in two dimensions.	1.5.B.1 Motion in two dimensions can be analyzed using one-dimensional kinematic relationships if the motion is separated into components.	Section 4.5
		1.5.B.2 Projectile motion is a special case of two-dimensional motion that has zero acceleration in one dimension and constant, nonzero acceleration in the second dimension.	Section 4.5

Topic	Learning Objective	Essential Knowledge	College Physics 3e
2.1 Systems and Center of Mass	2.1.A Describe the properties and interactions of a system.	2.1.A.1 System properties are determined by the interactions between objects within the system.	Section 3.1
		2.1.A.2 If the properties or interactions of the constituent objects within a system are not important in modeling the behavior of the macroscopic system, the system can itself be treated as a single object.	Section 3.1
		2.1.A.3 Systems may allow interactions between constituent parts of the system and the environment, which may result in the transfer of energy or mass.	Section 3.1
		2.1.A.4 Individual objects within a chosen system may behave differently from each other as well as from the system as a whole.	Section 3.1
		2.1.A.5 The internal structure of a system affects the analysis of that system.	Section 3.1
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	2.1.B Describe the location of a system's center of mass with respect to the system's constituent parts.	2.1.B.1 For systems with symmetrical mass distributions, the center of mass is located on lines of symmetry.	Section 8.4
		2.1.B.2 The location of a system's center of mass along a given axis can be calculated.	Section 8.4
		2.1.B.3 A system can be modeled as a singular object that is located at the system's center of mass.	Section 8.4

2.2 Forces and Free-Body Diagrams	2.2.A Describe a force as an interaction between two objects or systems.	2.2.A.1 Forces are vector quantities that describe the interactions between objects or systems.	Section 3.1
		2.2.A.2 Contact forces describe the interaction of an object or system touching another object or system and are macroscopic effects of interatomic electric forces.	Section 3.1
	2.2.B Describe the forces exerted on an object or system using a free-body diagram.	2.2.B.1 Free-body diagrams are useful tools for visualizing forces being exerted on a single object or system and for determining the equations that represent a physical situation.	Section 3.1
		2.2.B.2 The free-body diagram of an object or system shows each of the forces exerted on the object by the environment.	Section 3.1
		2.2.B.3 Forces exerted on an object or system are represented as vectors originating from the representation of the center of mass, such as a dot. A system is treated as though all of its mass is located at the center of mass.	Section 3.1
		2.2.B.4 A coordinate system with one axis parallel to the direction of acceleration of the object or system simplifies the translation from free-body diagram to algebraic representation. For example, in a free-body diagram of an object on an inclined plane, it is useful to set one axis parallel to the surface of the incline.	Section 4.4
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		2.3.A.2 Interactions between objects within a system (internal forces) do not influence the motion of a system's center of mass.	Section 3.1
		2.3.A.3 Tension is the macroscopic net result of forces that segments of a string, cable, chain, or similar system exert on each other in response to an external force.	Section 4.4

2.4 Newton's First Law	2.4.A Describe the conditions under which a system's velocity remains constant.	2.4.A.1 The net force on a system is the vector sum of all forces exerted on the system.	Section 3.2
		2.4.A.2 Translational equilibrium is a configuration of forces such that the net force exerted on a system is zero.	Section 8.3
		2.4.A.3 Newton's first law states that if the net force exerted on a system is zero, the velocity of that system will remain constant.	Section 3.4
		2.4.A.4 Forces may be balanced in one dimension but unbalanced in another. The system's velocity will change only in the direction of the unbalanced force.	Section 4.4
		2.4.A.5 An inertial reference frame is one from which an observer would verify Newton's first law of motion.	Section 3.4
2.5 Newton's Second Law	2.5.A Describe the conditions under which a system's velocity changes.	2.5.A.1 Unbalanced forces are a configuration of forces such that the net force exerted on a system is not equal to zero.	Sections 3.5, 4.2, 4.4
		2.5.A.2 Newton's second law of motion states that the acceleration of a system's center of mass has a magnitude proportional to the magnitude of the net force exerted on the system and is in the same direction as that net force.	Sections 3.5, 4.2, 4.4
		2.5.A.3 The velocity of a system's center of mass will only change if a nonzero net external force is exerted on that system.	Sections 3.5, 4.2, 4.4

2.6 Gravitational Force	2.6.A Describe the gravitational interaction between two objects or systems with mass.	2.6.A.1 Newton's law of universal gravitation describes the gravitational force between two objects or systems as directly proportional to each of their masses and inversely proportional to the square of the distance between the systems' centers of mass.	Section 5.5
		2.6.A.2 A field models the effects of a noncontact force exerted on an object at various positions in space.	Section 5.5
		2.6.A.3 The gravitational force exerted by an astronomical body on a relatively small nearby object is called weight.	Section 3.6
	2.6.B Describe situations in which the gravitational force can be considered constant.	2.6.B.1 If the gravitational force between two systems' centers of mass has a negligible change as the relative position of the two systems changes, the gravitational force can be considered constant at all points between the initial and final positions of the systems.	Section 3.6
		2.6.B.2 Near the surface of Earth, the strength of the gravitational field is $g \approx 10$ N/kg.	Section 3.6
	2.6.C Describe the conditions under which the magnitude of a system's apparent weight is different from the magnitude of the gravitational force exerted on that system.	2.6.C.1 The magnitude of the apparent weight of a system is the magnitude of the normal force exerted on the system.	Section 3.7
		2.6.C.2 If the system is accelerating, the apparent weight of the system is not equal to the magnitude of the gravitational force exerted on the system.	Section 3.7
		2.6.C.3 A system appears weightless when there are no forces exerted on the system or when the force of gravity is the only force exerted on the system.	Section 5.5
		2.6.C.4 The equivalence principle states that an observer in a noninertial reference frame is unable to distinguish between an object's apparent weight and the gravitational force exerted on the object by a gravitational field.	Section 26.11

	2.6.D Describe inertial and gravitational mass.	2.6.D.1 Objects have inertial mass, or inertia, a property that determines how much an object's motion resists changes when interacting with another object.	Section 5.5
		2.6.D.2 Gravitational mass is related to the force of attraction between two systems with mass.	Section 5.5
		2.6.D.3 Inertial mass and gravitational mass have been experimentally verified to be equivalent.	Section 5.5
2.7 Kinetic and Static Friction	2.7.A Describe kinetic friction between two surfaces.	2.7.A.1 Kinetic friction occurs when two surfaces in contact move relative to each other.	Sections 4.3, 4.4, 4.6
		2.7.A.2 The magnitude of the kinetic friction force exerted on an object is the product of the normal force the surface exerts on the object and the coefficient of kinetic friction.	Sections 4.3, 4.4, 4.6
	2.7.B Describe static friction between two surfaces.	2.7.B.1 Static friction may occur between the contacting surfaces of two objects that are not moving relative to each other.	Sections 4.3, 4.4, 4.6
		2.7.B.2 Static friction adopts the value and direction required to prevent an object from slipping or sliding on a surface.	Sections 4.3, 4.4, 4.6
		2.7.B.3 The coefficient of static friction is typically greater than the coefficient of kinetic friction for a given pair of surfaces.	Sections 4.3, 4.4, 4.6
2.8 Spring Forces	2.8.A Describe the force exerted on an object by an ideal spring.	2.8.A.1 An ideal spring has negligible mass and exerts a force that is proportional to the change in its length as measured from its relaxed length.	Section 7.4
		2.8.A.2 The magnitude of the force exerted by an ideal spring on an object is given by Hooke's law.	Section 7.4
		2.8.A.3 The force exerted on an object by a spring is always directed toward the equilibrium position of the object–spring system.	Section 7.4

2.9 Circular Motion	2.9.A Describe the motion of an object traveling in a circular path.	2.9.A.1 Centripetal acceleration is the component of an object's acceleration directed toward the center of the object's circular path.	Sections 5.1, 5.2, 5.4
		2.9.A.2 Centripetal acceleration can result from a single force, more than one force, or components of forces exerted on an object in circular motion.	Sections 5.1, 5.2, 5.4
		2.9.A.3 Tangential acceleration is the rate at which an object's speed changes and is directed tangent to the object's circular path.	Section 9.1
		2.9.A.4 The net acceleration of an object moving in a circle is the vector sum of the centripetal acceleration and tangential acceleration.	(none)
		2.9.A.5 The revolution of an object traveling in a circular path at a constant speed (uniform circular motion) can be described using period and frequency.	Sections 5.3, 5.4
	2.9.B Describe circular orbits using Kepler's third law.	2.9.B.1 For a satellite in circular orbit around a central body, the satellite's centripetal acceleration is caused only by gravitational attraction. The period and radius of the circular orbit are related to the mass of the central body.	Section 5.5

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3.1 Translational Kinetic Energy	3.1.A Describe the translational kinetic energy of an object in terms of the object's mass and velocity.	3.1.A.1 An object's translational kinetic energy is given by the equation $K = (1/2)mv^2$.	Section 7.3
		3.1.A.2 Translational kinetic energy is a scalar quantity.	Section 7.3
		3.1.A.3 Different observers may measure different values of the translational kinetic energy of an object, depending on the observer's frame of reference.	Section 7.3
3.2 Work	3.2.A Describe the work done on an object or system by a given force or collection of forces.	3.2.A.1 Work is the amount of energy transferred into or out of a system by a force exerted on that system over a distance.	Section 7.1
		3.2.A.2 Work is a scalar quantity that may be positive, negative, or zero.	Section 7.1
		3.2.A.3 The amount of work done on a system by a constant force is related to the components of that force and the displacement of the point at which that force is exerted.	Section 7.1
		3.2.A.4 The work-energy theorem states that the change in an object's kinetic energy is equal to the sum of the work being done by all forces exerted on the object.	(none)
		3.2.A.5 Work is equal to the area under the curve of a graph of the parallel component of the force as a function of displacement.	(none)

3.3 Potential Energy	3.3.A Describe the potential energy of a system.	3.3.A.1 A system composed of two or more objects has potential energy if the objects within that system only interact with each other through conservative forces.	(none)
		3.3.A.2 Potential energy is a scalar quantity associated with the position of objects within a system.	Sections 7.3, 7.4, 7.9
		3.3.A.3 The definition of zero potential energy for a given system is a decision made by the observer considering the situation to simplify or otherwise assist in analysis.	Sections 7.3, 7.4, 7.9
		3.3.A.4 The potential energy of common physical systems can be described using the physical properties of that system.	Sections 7.3, 7.4, 7.9
		3.3.A.5 The total potential energy of a system containing more than two objects is the sum of the potential energy of each pair of objects within the system.	(none)
3.4 Conservation of Energy	3.4.A Describe the energies present in a system.	3.4.A.1 A system composed of only a single object can only have kinetic energy.	Section 7.2
		3.4.A.2 A system that contains objects that interact via conservative forces or that can change its shape reversibly may have both kinetic and potential energies.	(none)

	3.4.B Describe the behavior of a system using conservation of mechanical energy principles.	3.4.B.1 Mechanical energy is the sum of a system's kinetic and potential energies.	Section 7.2
		3.4.B.2 Any change to a type of energy within a system must be balanced by an equivalent change of other types of energies within the system or by a transfer of energy between the system and its surroundings.	Section 7.2
		3.4.B.3 A system may be selected so that the total energy of that system is constant.	Section 7.2
		3.4.B.4 If the total energy of a system changes, that change will be equivalent to the energy transferred into or out of the system.	Section 7.2
	3.4.C Describe how the selection of a system determines whether the energy of that system changes.	3.4.C.1 Energy is conserved in all interactions.	Section 7.2
		3.4.C.2 If the work done on a selected system is zero and there are no nonconservative interactions within the system, the total mechanical energy of the system is constant.	(none)
		3.4.C.3 If the work done on a selected system is nonzero, energy is transferred between the system and the environment.	Section 7.2

3.5 Power	3.5.A Describe the transfer of energy into, out of, or within a system in terms of power.	3.5.A.1 Power is the rate at which energy changes with respect to time, either by transfer into or out of a system or by conversion from one type to another within a system.	Section 7.8
		3.5.A.2 Average power is the amount of energy being transferred or converted, divided by the time it took for that transfer or conversion to occur.	Section 7.8
		3.5.A.3 Because work is the change in energy of an object or system due to a force, average power is the total work done, divided by the time during which that work was done.	Section 7.8
		3.5.A.4 The instantaneous power delivered to an object is equal to the product of the component of a constant force parallel to the object's velocity and its speed.	(none)

Topic	**Learning Objective**	**Essential Knowledge**	**College Physics 3e**
4.1 Linear Momentum	4.1.A Describe the linear momentum of an object or system.	4.1.A.1 Linear momentum is equal to the product of an object's mass and its velocity.	Section 6.2
		4.1.A.2 Momentum is a vector quantity and has the same direction as the velocity.	Section 6.2
		4.1.A.3 Momentum can be used to analyze collisions and explosions.	Sections 6.2, 6.7
4.2 Change in Momentum and Impulse	4.2.A Describe the impulse delivered to an object or system.	4.2.A.1 The rate of change of momentum is equal to the net external force exerted on an object or system.	Sections 6.3, 6.4, 6.5
		4.2.A.2 Impulse is defined as the product of the average force exerted on a system and the time interval during which that force is exerted on the system.	Sections 6.3, 6.4, 6.5
		4.2.A.3 Impulse is a vector quantity and has the same direction as the net force exerted on the system.	Sections 6.3, 6.4, 6.5
		4.2.A.4 The impulse delivered to a system by a net external force is equal to the area under the curve of a graph of the net external force exerted on the system as a function of time.	(none)
		4.2.A.5 The net external force exerted on a system is equal to the slope of a graph of the momentum of the system as a function of time.	(none)

	4.2.B Describe the relationship between the impulse exerted on an object or a system and the change in momentum of the object or system.	4.2.B.1 Change in momentum is the difference between a system's final momentum and its initial momentum.	Sections 6.3, 6.4, 6.5
		4.2.B.2 The impulse–momentum theorem relates the impulse exerted on a system and the system's change in momentum.	Sections 6.3, 6.4, 6.5
		4.2.B.3 Newton's second law of motion is a direct result of the impulse–momentum theorem applied to systems with constant mass.	Sections 6.3, 6.4, 6.5
4.3 Conservation of Linear Momentum	4.3.A Describe the behavior of a system using conservation of linear momentum.	4.3.A.1 A collection of objects with individual momenta can be described as one system with one center-of-mass velocity.	(none)
		4.3.A.2 The total momentum of a system is the sum of the momenta of the system's constituent parts.	Section 6.2
		4.3.A.3 In the absence of net external forces, any change to the momentum of an object within a system must be balanced by an equivalent and opposite change of momentum elsewhere within the system. Any change to the momentum of a system is due to a transfer of momentum between the system and its surroundings.	Section 6.2
		4.3.A.4 Correct application of conservation of momentum can be used to determine the velocity of a system immediately before and immediately after collisions or explosions.	Sections 6.2, 6.7
	4.3.B Describe how the selection of a system determines whether the momentum of that system changes.	4.3.B.1 Momentum is conserved in all interactions.	Section 6.2
		4.3.B.2 If the net external force on the selected system is zero, the total momentum of the system is constant.	Section 6.2
		4.3.B.3 If the net external force on the selected system is nonzero, momentum is transferred between the system and the environment.	Section 6.2

4.4 Elastic and Inelastic Collisions	4.4.A Describe whether an interaction between objects is elastic or inelastic.	4.4.A.1 An elastic collision between objects is one in which the initial kinetic energy of the system is equal to the final kinetic energy of the system.	Section 7.7
		4.4.A.2 In an elastic collision, the final kinetic energies of each of the objects within the system may be different from their initial kinetic energies.	Section 7.7
		4.4.A.3 An inelastic collision between objects is one in which the total kinetic energy of the system decreases.	Section 7.7
		4.4.A.4 In an inelastic collision, some of the initial kinetic energy is not restored to kinetic energy but is transformed by nonconservative forces into other forms of energy.	Section 7.7
		4.4.A.5 In a perfectly inelastic collision, the objects stick together and move with the same velocity after the collision.	Section 7.7

Topic	**Learning Objective**	**Essential Knowledge**	**College Physics 3e**
5.1 Rotational Kinematics	5.1.A Describe the rotation of a system with respect to time using angular displacement, angular velocity, and angular acceleration.	5.1.A.1 Angular displacement is the measurement of the angle, in radians, through which a point on a rigid system rotates about a specified axis.	Section 9.1
		5.1.A.2 Average angular velocity is the average rate at which angular position changes with respect to time.	Section 9.1
		5.1.A.3 Average angular acceleration is the average rate at which the angular velocity changes with respect to time.	Section 9.1
		5.1.A.4 Angular displacement, angular velocity, and angular acceleration around one axis are analogous to linear displacement, velocity, and acceleration in one dimension and demonstrate the same mathematical relationships.	Section 9.1
5.2 Connecting Linear and Rotational Motion	5.2.A Describe the linear motion of a point on a rotating rigid system that corresponds to the rotational motion of that point, and vice versa.	5.2.A.1 The linear distance traveled by a point is equal to the product of the distance from the fixed axis of rotation and the angle through which the point rotates.	Section 9.1
		5.2.A.2 Derived relationships of linear velocity and of the tangential component of acceleration to their respective angular quantities are given.	Section 9.1
		5.2.A.3 For a rigid system, all points within that system have the same angular velocity and angular acceleration.	Section 9.1
5.3 Torque	5.3.A Identify the torques exerted on a rigid system.	5.3.A.1 Torque results only from the force component perpendicular to the position vector from the axis of rotation to the point of application of the force.	Section 8.2
		5.3.A.2 The lever arm is the perpendicular distance from the axis of rotation to the line of action of the exerted force.	Section 8.2

	5.3.B Describe the torques exerted on a rigid system.	5.3.B.1 Torques can be described using force diagrams.	Section 8.2
		5.3.B.2 The magnitude of the torque exerted on a rigid system by a force is equal to the product of the distance from the axis of rotation to the point where the force is applied and the perpendicular component of the force.	Section 8.2
5.4 Rotational Inertia	5.4.A Describe the rotational inertia of a rigid system relative to a given axis of rotation.	5.4.A.1 Rotational inertia measures a rigid system's resistance to changes in rotation and is related to the mass of the system and the distribution of that mass relative to the axis of rotation.	Section 9.2
		5.4.A.2 The rotational inertia of an object rotating a perpendicular distance r from an axis is described by the equation $I = mr^2$.	Section 9.3
		5.4.A.3 The total rotational inertia of a collection of objects about an axis is the sum of the rotational inertias of each object about that axis.	Section 9.3
	5.4.B Describe the rotational inertia of a rigid system rotating about an axis that does not pass through the system's center of mass.	5.4.B.1 A rigid system's rotational inertia in a given plane is at a minimum when the rotational axis passes through the system's center of mass.	(none)
		5.4.B.2 The parallel axis theorem relates the rotational inertia of a rigid system about any axis that is parallel to an axis through its center of mass.	(none)
5.5 Rotational Equilibrium and Newton's First Law in Rotational Form	5.5.A Describe the conditions under which a system's angular velocity remains constant.	5.5.A.1 A system may exhibit rotational equilibrium (constant angular velocity) without being in translational equilibrium, and vice versa.	Sections 8.3, 8.5
		5.5.A.2 A rotational corollary to Newton's second law states that if the torques exerted on a rigid system are not balanced, the system's angular velocity must be changing.	Section 9.2

5.6 Newton's Second Law in Rotational Form	5.6.A Describe the conditions under which a system's angular velocity changes.	5.6.A.1 Angular velocity changes when the net torque exerted on the object or system is not equal to zero.	Sections 9.2, 9.3
		5.6.A.2 The rate at which the angular velocity of a rigid system changes is directly proportional to the net torque exerted on the rigid system and is in the same direction. The angular acceleration of the rigid system is inversely proportional to the rotational inertia of the rigid system.	Sections 9.2, 9.3
		5.6.A.3 To fully describe a rotating rigid system, linear and rotational analyses may need to be performed independently.	Sections 9.2, 9.3

Topic	Learning Objective	Essential Knowledge	College Physics 3e
6.1 Rotational Kinetic Energy	6.1.A Describe the rotational kinetic energy of a rigid system in terms of the rotational inertia and angular speed of that rigid system.	6.1.A.1 The rotational kinetic energy of a rigid system is related to the rotational inertia and angular speed of the rigid system.	Section 9.5
		6.1.A.2 A rigid system can have rotational kinetic energy while its center of mass is at rest due to the individual points within the rigid system having linear speed and, therefore, kinetic energy.	Section 9.5
		6.1.A.3 Rotational kinetic energy is a scalar quantity.	Section 9.5
6.2 Torque and Work	6.2.A Describe the work done on a rigid system by a given torque or collection of torques.	6.2.A.1 A torque can transfer energy into or out of an object or rigid system if the torque is exerted over an angular displacement.	(none)
		6.2.A.2 The amount of work done on a rigid system by a torque is related to the magnitude of that torque and the angular displacement through which the rigid system rotates during the interval in which that torque is exerted.	(none)
		6.2.A.3 Work done on a rigid system by a given torque can be found from the area under the curve of a graph of torque as a function of angular position.	(none)
6.3 Angular Momentum and Angular Impulse	6.3.A Describe the angular momentum of an object or rigid system.	6.3.A.1 The magnitude of the angular momentum of a rigid system about a specific axis is equal to the product of rotational inertia and angular speed.	Section 9.4
		6.3.A.2 The magnitude of the angular momentum of an object about a given point depends on the distance between the reference point and the object, the mass of the object, the speed of the object, and the angle between the radial distance and the velocity of the object.	(none)

	6.3.B Describe the angular impulse delivered to an object or rigid system by a torque.	6.3.B.1 Angular impulse is defined as the product of the torque exerted on an object or rigid system and the time interval during which the torque is exerted.	Section 9.4
		6.3.B.2 Angular impulse has the same direction as the torque exerted on the object or system.	Section 9.4
		6.3.B.3 The angular impulse delivered to an object or rigid system by a torque can be found from the area under the curve of a graph of the torque as a function of time.	(none)
	6.3.C Relate the change in angular momentum of an object or rigid system to the angular impulse given to that object or rigid system.	6.3.C.1 The magnitude of the change in angular momentum can be described by comparing the magnitudes of the final and initial angular momenta of the object or rigid system.	Section 9.4
		6.3.C.2 A rotational form of the impulse–momentum theorem relates the angular impulse delivered to an object or rigid system and the change in angular momentum of that object or rigid system.	Section 9.4
		6.3.C.3 The net torque exerted on an object is equal to the slope of the graph of the angular momentum of an object as a function of time.	(none)
		6.3.C.4 The angular impulse delivered to an object is equal to the area under the curve of a graph of the net external torque exerted on an object as a function of time.	(none)
6.4 Conservation of Angular Momentum	6.4.A Describe the behavior of a system using conservation of angular momentum.	6.4.A.1 The total angular momentum of a system about a rotational axis is the sum of the angular momenta of the system's constituent parts about that axis.	Section 9.4
		6.4.A.2 Any change to a system's angular momentum must be due to an interaction between the system and its surroundings.	Section 9.4

	6.4.B Describe how the selection of a system determines whether the angular momentum of that system changes.	6.4.B.1 Angular momentum is conserved in all interactions.	Section 9.4
		6.4.B.2 If the net external torque exerted on a selected object or rigid system is zero, the total angular momentum of that system is constant.	Section 9.4
		6.4.B.3 If the net external torque exerted on a selected object or rigid system is nonzero, angular momentum is transferred between the system and the environment.	Section 9.4
6.5 Rolling	6.5.A Describe the kinetic energy of a system that has translational and rotational motion.	6.5.A.1 The total kinetic energy of a system is the sum of the system's translational and rotational kinetic energies.	Section 9.5
	6.5.B Describe the motion of a system that is rolling without slipping.	6.5.B.1 While rolling without slipping, the translational motion of a system's center of mass is related to the rotational motion of the system itself.	Section 9.5
		6.5.B.2 For ideal cases, rolling without slipping implies that the frictional force does not dissipate any energy from the rolling system.	(none)
	6.5.C Describe the motion of a system that is rolling while slipping.	6.5.C.1 When slipping, the motion of a system's center of mass and the system's rotational motion cannot be directly related.	(none)
		6.5.C.2 When a rotating system is slipping relative to another surface, the point of application of the force of kinetic friction exerted on the system moves with respect to the surface, so the force of kinetic friction will dissipate energy from the system.	(none)

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6.6 Motion of Orbiting Satellites	6.6.A Describe the motions of a system consisting of two objects interacting only via gravitational forces.	6.6.A.1 In a system consisting only of a massive central object and an orbiting satellite with mass that is negligible in comparison to the central object's mass, the motion of the central object itself is negligible.	(none)
		6.6.A.2 The motion of satellites in orbits is constrained by conservation laws.	Section 7.9
		6.6.A.3 The escape speed of a satellite is the satellite's speed such that the mechanical energy of the satellite–central-object system is equal to zero.	Section 7.9

Topic	**Learning Objective**	**Essential Knowledge**	**College Physics 3e**
7.1 Defining Simple Harmonic Motion (SHM)	7.1.A Describe simple harmonic motion.	7.1.A.1 Simple harmonic motion is a special case of periodic motion.	Section 10.2
		7.1.A.2 SHM results when the magnitude of the restoring force exerted on an object is proportional to that object's displacement from its equilibrium position.	Sections 10.3, 10.5
7.2 Frequency and Period of SHM	7.2.A Describe the frequency and period of an object exhibiting SHM.	7.2.A.1 The period of SHM is related to the frequency f of the object's motion by the following equation: $T = 1/f$.	Sections 10.1, 10.3, 10.5
7.3 Representing and Analyzing SHM	7.3.A Describe the displacement, velocity, and acceleration of an object exhibiting SHM.	7.3.A.1 For an object exhibiting SHM, the displacement of that object measured from its equilibrium position can be represented by sine or cosine functions.	Section 10.2
		7.3.A.2 Changing the amplitude of a system exhibiting SHM will not change the period of that system.	Sections 10.3, 10.5
		7.3.A.3 Properties of SHM can be determined and analyzed using graphical representations.	Section 10.2
7.4 Energy of Simple Harmonic Oscillators	7.4.A Describe the mechanical energy of a system exhibiting SHM.	7.4.A.1 The total energy of a system exhibiting SHM is the sum of the system's kinetic and potential energies.	Sections 10.1, 10.4, 10.5
		7.4.A.2 Conservation of energy indicates that the total energy of a system exhibiting SHM is constant.	Sections 10.1, 10.4, 10.5
		7.4.A.3 The kinetic energy of a system exhibiting SHM is at a maximum when the system's potential energy is at a minimum.	Sections 10.1, 10.4, 10.5
		7.4.A.4 The potential energy of a system exhibiting SHM is at a maximum when the system's kinetic energy is at a minimum.	Sections 10.1, 10.4, 10.5

Topic	Learning Objective	Essential Knowledge	College Physics 3e
8.1 Internal Structure and Density	8.1.A Describe the properties of a fluid.	8.1.A.1 Distinguishing properties of solids, liquids, and gases stem from the varying interactions between atoms and molecules.	Section 12.1
		8.1.A.2 A fluid is a substance that has no fixed shape.	Section 12.1
		8.1.A.3 Fluids can be characterized by their density. Density is defined as a ratio of mass to volume.	Sections 12.2, 13.1
		8.1.A.4 An ideal fluid is incompressible and has no viscosity.	Section 12.1
8.2 Pressure	8.2.A Describe the pressure exerted on a surface by a given force.	8.2.A.1 Pressure is defined as the magnitude of the perpendicular force component exerted per unit area over a given surface area.	Section 12.2
		8.2.A.2 Pressure is a scalar quantity.	Section 12.2
		8.2.A.3 The volume and density of a given amount of an incompressible fluid is constant regardless of the pressure exerted on that fluid.	Section 12.1
	8.2.B Describe the pressure exerted by a fluid.	8.2.B.1 The pressure exerted by a fluid is the result of the entirety of the interactions between the fluid's constituent particles and the surface with which those particles interact.	Section 13.2
		8.2.B.2 The absolute pressure of a fluid at a given point is equal to the sum of a reference pressure, such as atmospheric pressure, and the gauge pressure.	Section 12.2
		8.2.B.3 The gauge pressure of a vertical column of fluid is equal to the product of density, magnitude of the acceleration due to gravity, and height.	Section 13.3

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8.3 Fluids and Newton's Laws	8.3.A Describe the conditions under which a fluid's velocity changes.	8.3.A.1 Newton's laws can be used to describe the motion of particles within a fluid.	Section 14.2
		8.3.A.2 The macroscopic behavior of a fluid is a result of the internal interactions between the fluid's constituent particles and external forces exerted on the fluid.	Section 14.2
	8.3.B Describe the buoyant force exerted on an object interacting with a fluid.	8.3.B.1 The buoyant force is a net upward force exerted on an object by a fluid.	Section 13.5
		8.3.B.2 The buoyant force exerted on an object by a fluid is a result of the collective forces exerted on the object by the particles making up the fluid.	Section 13.5
		8.3.B.3 The magnitude of the buoyant force exerted on an object by a fluid is equivalent to the weight of the fluid displaced by the object.	Section 13.5
8.4 Fluids and Conservation Laws	8.4.A Describe the flow of an incompressible fluid through a cross-sectional area by using mass conservation.	8.4.A.1 A difference in pressure between two locations causes a fluid to flow.	Section 14.2
		8.4.A.2 The continuity equation for fluid flow describes conservation of mass flow rate in incompressible fluids.	Section 14.2
	8.4.B Describe the flow of a fluid as a result of a difference in energy between two locations within the fluid–Earth system.	8.4.B.1 A difference in gravitational potential energies between two locations in a fluid will result in a difference in kinetic energy and pressure between those two locations that is described by conservation laws.	Section 14.4
		8.4.B.2 Bernoulli's equation describes the conservation of mechanical energy in fluid flow.	Section 14.4
		8.4.B.3 Torricelli's theorem relates the speed of a fluid exiting an opening to the difference in height between the opening and the top surface of the fluid and can be derived from conservation of energy principles.	Section 14.5

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