Key Physics Concepts

Section Summaries	Physics Principles
Section 1 Velocity and Acceleration: The Big Thrill Students investigate methods of making mechanical drawings. During motion in class, they determine at which points changes that they associate with roller coasters occur. The velocity and acceleration of a steel ball are determined as it rolls along different tracks using a velocity meter.	**Velocity** **Acceleration** **Acceleration due to gravity**
Section 2 Gravitational Potential Energy and Kinetic Energy: What Goes Up and What Comes Down Students discover what determines the speed of a ball as it rolls down an incline. This result is compared with the velocity of a pendulum swinging from different heights by graphing velocity squared versus height. Gravitational potential energy and kinetic energy are used to explain the similarity of results. Conservation of energy is explored in the transformation of energy forms.	**Velocity versus distance** **Gravitational potential energy** **Kinetic energy** **Law of conservation of energy**
Section 3 Spring Potential Energy: More Energy Students use a spring "pop-up" toy to investigate spring potential energy stored in a compressed spring. Using the concepts of kinetic and gravitational potential energy, they explore the law of conservation of mechanical energy that includes the energy stored when springs are compressed or stretched.	**Stoichiometry** **Gravitational potential energy** **Kinetic energy** **Spring potential energy** **Law of conservation of energy**
Section 4 Newton's Law of Universal Gravitation: The Ups and Downs of a Roller Coaster Students investigate how the force of gravity varies with distance from the center of Earth using data for the acceleration due to gravity at various points. Using a graph, they determine the inverse square relationship between gravitational force and distance. The shape of Earth's gravitational field is noted. Newton's derivation of gravitational force and the shape of celestial orbits are discussed.	**Acceleration due to gravity** **The force of gravity** **Inverse square relationships** **Earth's gravitational field**
Section 5 Hooke's Law: Finding Your "At Rest" Weight Students explore the difference between mass and weight, and how the weight of an object depends upon the acceleration due to gravity. They determine how the stretch of the spring relates to the force applied to stretch or compress. By graphing their data, the students determine Hooke's law and calculate a spring constant. A spring is then used to determine the size of an unknown mass. Equilibrium of forces is discussed.	**Weight versus mass** **Force due to springs** **Hooke's law** **Equilibrium and Newton's laws**
Section 6 Forces Acting During Acceleration: Apparent Weight on a Roller Coaster Students use a spring scale to investigate the net force required for an objet to travel upward and downward, first at a constant velocity, then for upward and downward acceleration. Newton's second law for net forces is used to analyze a free-body diagram for objects undergoing accelerations. The apparent weight change in an elevator is related to its acceleration and the acting net force. Why the force of gravity accelerates all objects at the same rate is discussed.	**Newton's second law** **Free-body diagrams** **Apparent weight** **Acceleration due to gravity**

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Section 7 Circular Motion: Riding on the Curves Students investigate centripetal force. They identify the direction of the centripetal force, acceleration, and velocity for objects moving in circles. The students investigate the relationship between centripetal force and the object's mass, speed, and the radius of the circle for both horizontal and vertical circles. The changing force required for a vertical circle is explored in depth in relation to Newton's second law.	**Tangential velocity** **Centripetal force** **Centripetal acceleration** **Apparent weight** **Net force** **Free-body diagrams** **Normal force**
Section 8 Work and Power: Getting to the Top Students pull a dynamics cart up a fixed height by various paths to demonstrate the independence of path on the work being done. The definition of work is then developed from the student's data, and related to gravitational potential energy. Uncertainty in measurement and the development of scientific principles from data is discussed. The relationship between work and power is discussed, and the formula for power is introduced.	**Work** **Work and energy transformations** **Power** **Horsepower** **Measuring uncertainty**
Section 9 Force and Energy: Different Insights Students develop concept maps on forces and energy relationships to organize their knowledge. The relationship between force and energy (work) is explored. Explicit examples of the law of conservation of energy are explored for various points on the roller coaster. Analysis using energy considerations is explored, as well as situations where energy alone is insufficient and force considerations are appropriate. The students do an exercise using vectors to locate the position of an object.	**Gravitational potential energy** **Spring potential energy** **Kinetic energy** **Work** **Vectors and scalars** **Vector addition** **Forces**
Section 10 Safety Is Required but Thrills Are Desired Students investigate parameters that determine what limits are placed on their design. Students calculate centripetal force, apparent weight, normal force, and the net force acting on the roller-coaster cars at various points.	**Force** **Newton's second law** **Centripetal force** **Centripetal acceleration** **Normal force** **Apparent weight** **Net force**