Educational Innovations®

MAR-600
Wall Coaster

Background

Forces and Motion

Motion is caused by forces. Motion can be described. Motion follows rules.

There are many forces and principles involved with motion. These include:

Gravity, the force of attraction of an object toward the center of the earth, or toward another object having mass.

Inertia, an object retains its state of rest or its velocity along a straight line so long as it is not acted upon by an external force.

Centripetal force, a force acting on a moving object at an angle to the direction of motion, tending to make the object follow a circular or curved path.

Friction, surface resistance to the relative motion of an object that is sliding or rolling.

Forces can be **balanced**—acting equally on an object, or **unbalance**—acting unequally (one having a stronger influence than the other.)

Motion can be described, including speed, direction, and changes in motion:

Speed, how fast an object is moving measured as distance traveled divided by time of travel. Speed is a number value only.

Velocity, the rate at which an object changes position. Velocity includes speed and direction. It is measured as change in position divided by time.

Acceleration, the rate of increase of speed or the rate of change of velocity.

Deceleration, the rate of decrease of speed or velocity.

Simple Movements, movement that is of constant velocity and in a straight line.

Complex Movements, movement that includes changes in direction, and/or circular motion with forces acting at angles.

Force Vector, a specific amount of force applied to an object in a specific direction.

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Motion follows rules. These were first described by Sir Isaac Newton in 1687 in *Principia Mathematica*.

The first law (the law of inertia) states that an object at rest stays at rest or an object in motion moves in a straight line unless it is acted upon by a force.

The second law states that the acceleration of an object is proportional to the net force acting on the object, and to the object's mass. (As the force on an object is increased, its acceleration is increased. As the mass of an object is increased, its acceleration decreases.)

The third law states that for every action, there is an equal and opposite reaction. (All forces come in pairs, acting in equal strength, and opposite directions)

Resources

There are many online tutorials, activities, and interactive games using the laws of physics. For some good basic information about physics, try:

www.physicsclassroom.com which has good explanations, activities and labs.

www.physics4kids.com which has very clear explanations.

There are a number of You Tube videos about forces and motion. You might want to watch this one about Newton's 3 Laws http://youtu.be/UVdqxYyFRKY by Ignite Learning or this one http://youtu.be/NWE_aGqfUDs a great animation made by a 9th grader. You might even like this techo-music version created by a science teacher! http://youtu.be/PkAO8F-Tm-w

National Science Standards

Grades 5-8
Content Standard B-- Forces and Motion

- The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.
- An object that is not subjected to a force will continue to move at a constant speed and in a straight line.
- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

Content Standard E--Science and Technology

- Design a solution or product.
- Implement a proposed design
- Evaluate completed technological designs or products
- Communicate the process of technological design

Grades 9-12
Content Standard B--Motions and Forces

- Objects change their motion only when a net force is applied. Laws of motions are used to calculate precisely the effects of forces on the motion of objects.

Content Standard B--Conservation of Energy and the Increase of Disorder

- The total energy of the universe is constant. Energy can be transferred by collisions.
- All energy can be considered either kinetic energy, which is the energy of motion; potential energy, which depends on relative position; or energy contained in a field.

Content Standard E--Science and Technology

- Propose designs and choose between alternative solutions
- Implement a proposed solution
- Evaluate the solution and its consequences
- Communicate the problem, process, and solution

<u>Next Generation Science Standards (Draft 2012)</u>
Elementary

Grade 3.IF Interactions of Forces

a. Investigate the motion of objects to determine observable patterns to predict future motions.
b. Investigate the motions of object by comparing relative sizes and direction of forces on an object at rest to the forces on an object whose motion is changing.
c. Use models to explain the effects of balanced and unbalanced forces on a system.

Grade 4.E Energy

a. Construct a simple explanation for the relationship between energy and motion.
b. Carry out investigations to provide evidence that energy is transferred from place to place by moving or colliding objects.

Middle School

MS.PS Forces and Motion

b. Communicate observations and information graphically and mathematically to represent how and object's relative position, velocity, and direction of motion are affected by forces acting on the object.
c. Collect data to generate evidence supporting Newton's Third Law, which states that when two objects interact they exert equal and opposite forces on each other.

High School

HS.PS-E Energy

h. Design, build, and evaluate devices that convert one form of energy into another form of energy.

HS.PS-FM Forces and Motion

a. Plan and carry out investigations to show that the algebraic formulation of Newton's second law of motion accurately predicts the relationship between the net force on macroscopic objects, their mass, and acceleration and the resulting changes in motion.

Activities (appropriate for middle grades or high school with added depth, explanation, and mathematical modeling)

Physics Law and Order

Materials (For each group of 4-6 students)

One Wall Coaster Starter Kit

One plastic container to catch the exiting marbles

One set of the challenge questions—split into the 3 challenge areas

Stop watch

Measuring tape or meter stick

Each group will need a section of wall to work on—about 3-4 feet wide. They will stick the track to the wall using the coaster tack.

1. Allow groups time to try out the track in several configurations before assigning any challenges ~10 minutes or until groups seem comfortable with the Wall Coaster.
2. Give each group a set of the 5 **Forces and Principles** cards. The challenge is to demonstrate each of the forces or principles. The group should keep notes and a sketch of how they demonstrated that card.
3. Give each group a set of the 7 **Describing Motions** cards. The challenge is to demonstrate each of the motion descriptions. The group should keep notes and a sketch of how they demonstrated that card.
4. Give each group a set of the 3 **Newton's Laws** cards. The challenge is to demonstrate each of the Laws. The group should keep notes and a sketch of how they demonstrated that card.

Groups may either progress independently as they meet each challenge, or the class may discuss each card in turn.

Monitor group progress. If groups seem to be stuck at any point, you can call for a class discussion of that card. This discussion could include having groups draw a quick diagram on the board about how they answered that challenge.

Groups may keep a Wall Coaster layout that demonstrates several cards, or may have to reconfigure the layout for a challenge.

Graphing Velocity

Each group will design a trackway and measure and graph the velocity of the ball's movement.

Mapping Forces

Each group will design a complex trackway and map the forces in action on the course.

Design Challenge

Each group will design and test a complex trackway. This route can either "work"—with the ball making it to the apparent end, or "not work". Once the groups have designed their trackways, switch groups. The new group will examine the trackway (without trying it) and anticipate whether the trackway will "work" or "not work." They must write an explanation of their examination and their determination before trying the trackway. If they were not correct, or any surprises occurred, they should explain what happened and why.

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