5E Lesson Plan

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Date: June 3, 2019

Time: 90 Min.

Subject/grade level: Science/ Middle School

Materials:
- Bucket
- String
- Water
- Marbles
- Mables of three different masses
- Ramp
- Newtons Cradle
- Rubber band board

State Standards:

Colorado State Science Standards 2020

3. Motion is described relative to a reference frame that must be shared with others and is determined by the sum of the forces acting on it. The greater the mass of the object, the greater the force needed to achieve the same change in motion.

4. Forces that act a distance (gravitational, electric, and magnetic) can be explained by force fields that extend through space and can be mapped by their effect on a test object.

Lesson objective(s):
- Students will demonstrate understanding of Newtons Laws of Motion.

ENGAGEMENT
- Fill a bucket with water.
- Tie the bucket to the string.
- Ask students what they think will happen if you swing the bucket on the string over your head.
- Discuss centrifugal force. Why did the water stay in the bucket? What forces were acting during this demonstration?
- Tell students we are going to experiment with different laws.

EXPLORATION

- Set up three stations for Newtons Laws.
- Have students work through each station.
- Station 1: Have students roll a marble down a ramp. Have students observe and answer these questions: What force caused the marble to roll down the ramp? Why did the marble continue to roll after reaching the bottom of the ramp? What made the marble stop rolling? What would have to happen to make the marble start rolling again?

  The first law says that an object at **rest** tends to stay at rest, and an object in **motion** tends to stay in motion, with the same direction and **speed**. Motion (or lack of motion) cannot change without an unbalanced **force** acting. If nothing is happening to you, and nothing does happen, you will never go anywhere. If you're going in a specific direction, unless something happens to you, you will always go in that direction. Forever.

- Station 2: Set up rubber band board (see appendix). Have students roll three different sized marbles using the rubber band board. The board should create an equal amount of force on each marble. Have students repeat at least three times to ensure consistency of results. Answer the following questions: Which marble accelerated fastest? Why? Which marble accelerated the slowest? Why?

  The second law says that the **acceleration** of an object produced by a net (total) applied force is directly related to the **magnitude** of the force, the same direction as the force, and inversely related to the mass of the object (inverse is a value that is one over another number... the inverse of 2 is 1/2). The second law shows that if you exert the same force on two objects of different mass, you will get different accelerations (changes in motion). The effect (acceleration) on the smaller mass will be greater (more noticeable). The effect of a 10 newton force on a baseball would be much greater than that same force acting on a truck. The difference in effect (acceleration) is entirely due to the difference in their masses.

- Station 3: Use created Newtons Cradle (see appendix). Have students swing one ball at the other. Answer the following questions: What made the first ball slow down? What made the second ball accelerate?

  The third law says that for every action (force) there is an equal and opposite reaction (force). Forces are found in pairs. Think about the time you sit in a chair. Your body exerts a force downward and that chair needs to exert an equal force upward or the chair will collapse. It's an issue of symmetry. Acting forces encounter other forces in the opposite direction. There's also the example of shooting a cannonball. When the cannonball is fired through the air (by the explosion), the cannon is pushed backward. The force pushing the ball out was equal to the force pushing the cannon back, but the effect on the cannon is less noticeable because it has a much larger mass. That example is similar to the kick when a gun fires a bullet forward.

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EXPLANATION (Assessment)

- Have students explain their findings from the three stations.
- Have them come up with Newton's Three Laws using the following: 1. Objects in motions will _____________ until __________________. 2. The more ____________________ an object has, the more ____________________ is required to accelerate it. 3. When an object applies a force to another object, ____.

ELABORATION

- We are going to launch some satellites into orbit around the earth.
- We need to use what we just learned from the previous experiments and the following formula to figure out how fast our satellite will need to move in order to stay in orbit.
- Before we begin, think about whether a satellite needs to move faster or slower if it is farther away from the Earth. Write down your hypothesis and explain why you think this will be the case.
- $v = \sqrt{\dfrac{Gravity \times Mass}{Radius}}$
- Gravity represents the force that gravity exerts on our satellite. The force of gravity is represented by the number .00000000006673
- The larger an object is, the more gravity it generates. Since the Earth is the largest object near our satellite, it will be exerting the strongest force on the satellite. We need to multiply the mass of the Earth by the force of gravity in order to determine the extent of this force. The mass of the Earth is 5,980,000,000,000,000,000,000,000 kilograms.
- The radius is the distance between the center of the Earth and the satellite. Since the radius of the Earth is 6,370,000 meters we need to add the height of the satellite to this number to find the radius of our orbit.
- We are going to determine the velocities needed for satellites at several different heights: 200 kilometers, 1000 kilometers, 2000 kilometers, 5000 kilometers, 10,000 kilometers, 15,000 kilometers, 20,000 kilometers, and 25,000 kilometers. Students will work in small groups to determine the velocities needed for each of the satellites.

EVALUATION (Assessment)

- Students will share the velocities they derived for the satellites at different altitudes and the velocities will be compared.
- Was your hypothesis correct? Explain.

Appendix:

Rubber Band Board:
Take a large piece of plywood. Place three pairs of nails in one end of the board an equal distance apart. Attach a rubber band between each pair of nails. Draw a line behind the nails. (See diagram below) To operate the board, have three different students pull the rubber bands back to the line and place a marble directly in front of each rubber band. Have the students release the rubber bands simultaneously.

Homemade Newton's Cradle:
Take two similar objects (tennis ball, whole roll of toilet paper, water bottles) and drill a hole through the middle of each one. Thread a string through the hole of each object and fasten the ends of the string to the ceiling a foot or two apart so that the objects are hanging right next to each other. Pull one object back and let it swing into the other object.