Force Makes a Mass Move – Newton's Laws

Teacher Pre-Activity Introduction and Preparation

Texas Essential Knowledge and Skills (TEKS) Alignment within this Activity

Sixth Grade

(6) Science concepts. The student knows that there is a relationship between force and motion. The student is expected to: (A) identify and describe the changes in position, direction of motion, and speed of an object when acted upon by force.

Seventh Grade

(6) Science concepts. The student knows that there is a relationship between force and motion. The student is expected to: (B) demonstrate that an object will remain at rest or move at a constant speed and in a straight line if it is not being subjected to an unbalanced force.

Eighth Grade

(7) Science concepts. The student knows that there is a relationship between force and motion. The student is expected to: (A) demonstrate how unbalanced forces cause changes in the speed or direction of an object's motion.

Teacher Notes

This activity may work better in the classroom with carpet, but will also work on other flooring. You may want to be prepared for the distance that the marble will travel. Newton's Second Law of Motion (F=ma) states that the acceleration of an object depends on the mass of the object and the force applied to it. Since acceleration is a change in velocity with a change in time, both concepts can be explored in relation to Newton's Second Law. A force will cause a change in velocity; and likewise, a change in velocity will generate a force. We have defined force as equal to mass times acceleration, and now we can define acceleration as the force divided by the mass. Greater mass with the same force produces less acceleration and the smaller mass with the same force produces more acceleration. Greater force on the same mass produces more acceleration and less force on the same mass produces less acceleration.

Potential energy is defined as the energy of position. Kinetic energy is defined as energy in motion. Mechanical energy is the sum of the potential energy and the kinetic energy. In the system defined in the activity, the acceleration of the marbles will be relatively constant due to the slope of the ramp and the distance that they travel. What will vary is the mass of each marble, and in this case, the mass becomes the primary component contributing to the force, in other words, for the marbles in this experiment, the greater the mass, the greater the force. Also, the less the mass of the marble, the less the force found in the marble exerts.

Teacher Post-Activity Materials

Answers to Questions

1. How do your predictions compare to the outcomes of the experiment? Answers will vary, but the students should write their predictions and their reasons for these predictions. Remember to answer the students with questions, not provide answers. Appropriate facilitative questions might be the following: What do you think will happen? Why do you think that to be?
2. Which marble has the most potential energy? Why? Potential energy is defined as the energy of position. The larger marble at the highest point will have a greater potential energy (PE) and can be calculated as PE=mass times gravity time height. The force or potential energy will be tied to both mass and acceleration of the marble. The larger marble has more mass than the smaller marble, and since marbles moving down a similar inclined plane have a relatively equal acceleration, the force will be more a product of mass.
3. Which marble has the most kinetic energy? Why? Kinetic energy is defined as energy in motion. The force or kinetic energy will be tied to both mass and acceleration of the marble, and in that way, the heavier marbles released from higher positions on the inclined plane will have higher kinetic energy. The energy will not be completely kinetic until the marbles reach the bottom of the inclined plane.
4. What factors affect the amount of force the marbles can generate? Newton's Second Law of Motion (F=ma) states that the acceleration of an object depends on the mass of the object and the force applied to it. Since acceleration is a change in velocity with a change in time, and on the ramp the acceleration of either marble is relatively constant, force will depend primarily on the mass of the marble.
5. What would happen if the smaller marble was released and collided with a larger one? The larger marble will move, and will impact the movement of the smaller marble. The forces are conserved, yet the greater mass will take more force to move as compared to the smaller mass.
6. What would happen if the larger marble was released and collided with a smaller one? The larger marble will move the smaller one to a greater degree. The forces are conserved, yet the greater mass will deliver more force to move as compared to the smaller mass.
7. What would happen if you used a tennis ball and a golf ball in this activity? This is a nice extension, so that students can see that mass is not always tied to size or volume. Again, as an instructor, you should facilitate this and allow students to try these as extensions, and record their observations and report their findings.

Extensions

You could repeat this activity with added mathematics. Students can use a stop watch to time how long it takes the marbles to reach the end of the incline plane. With the data collected, the students can create a table composed of the time the marbles take to move and the distance they travel. With this information, they can determine the velocity and acceleration of the marbles, and also calculate the force based on the equation F=ma.

Force Makes a Mass Move – Newton's Laws

Student Laboratory Activity

Introduction

Spinning hitchhikers, 180 degree flips, tomahawk links and breakers around the bike. These might sound like part of an overactive travel itinerary, but in reality they are just some of the tricks performed by BMX professional flatlander Art Thomason. Art was born in Louisiana, but moved to the small town of Ponca City, Oklahoma as a child. Art has currently taken up residence in Houston, Texas, where he works for the National Aeronautics and Space Administration (NASA). He also attended Texas A & M University, where he received a Master's degree in Mechanical Engineering to go along with his undergraduate degree in Physics.

Art knows about hard work and practice. In fact, his work ethic in the sport is one of the things that sets him apart from other riders. Art says, "In practice, I do every trick five times in a row, then do my run, and that usually helps me to pull my run perfectly." Obviously this has worked well for Art, who has competed in 4 X-Games competitions, 2 CFB series, as well as getting a lot of national coverage on both ESPN and ESPN2. Art currently rides for one of the biggest names in the sport, Hoffman Bikes.

Now that Art is a professional flatland BMX rider, he believes that the large shows and national contests in which he participates have allowed him to interact with a lot of new riders and people interested in BMX. He relates the difference, "To the audience, the tricks look easy so they think they are easy. With the riders, it's really cool, because they know the difference." There is a lot of cooperation and camaraderie in the BMX flatland world. "The spirit of helping each other out, on a personal level, is really good. Although it can be competitive, everyone has a stake in it, so they help each other out."

Purpose

The student knows that there is a relationship between force and motion. The student is expected to demonstrate how unbalanced forces cause changes in the speed or direction of an object's motion. The student also must demonstrate that an object will remain at rest or move at a constant speed and in a straight line if it is not being subjected to an unbalanced force. The student is expected to identify and describe the changes in position, direction of motion, and speed of an object when acted upon by force.

Things You Need

- Small marbles
- Large marbles
- Meter sticks (at least 3 per group)
- Balance for weighing objects
- Masking tape
- Inclined plane board (Approximately 100 cm width by 1000 cm length)
- Ring stand
- Iron ring
- Wooden blocks

What to Do

1. Looking at the different marbles you will use in the experiment, can you predict which will have greater forces? Make a series of predictions and record them in your notebook.
2. Select two marbles of different sizes and place them on a flat plane, such as the top of a table or the floor. Which marble do you think has more force? Why? If the marbles were at the top of an inclined plane, would they have potential or kinetic energy? Why? Record your predictions in your notebook.
3. Use the inclined plane board and either a ring stand and iron ring or wooden blocks in order to construct a ramp. The ramp should be approximately 15 cm in height. The ramp is an inclined plane that can also be considered a simple machine. Be sure and secure the ramp to the iron ring or wooden block in order to hold it in a consistent position.
4. Make a track by taping two meter sticks to the board with a small gap between them for the marble to roll down the ramp.
5. Weigh each marble on the balance and record its mass on the data table.
6. At the top of the ramp, position one marble that will drop in on the ramp. At the bottom of the inclined place, position a second marble, either bigger or smaller than the marble at the top of the ramp. Hold the marble at the top of the incline in place.
7. Release the marble at the top of the ramp and try to hit the second marble. It may be useful to start at a lower distance on the ramp and work your way up to the top. Whichever you choose, be sure to use the same distance for all 3 trials in your experiment.
8. Measure the distance traveled by both marbles after the collision. Record the data on a piece of paper.
9. Repeat this process three times and calculate the average distance.
10. Once you have recorded the data on the small marble switch the marbles' positions. Repeat steps 6-9 three times and record the distances the marbles move. Average the results.

Student Laboratory Data Sheet

Data Table 1

Trial	**Mass of Marble 1 (g)**	**Mass of Marble 2 (g)**	**Distance traveled by Marble 1 down ramp (cm)**	**Distance traveled by Marble 2 after collision (cm)**
1				
2				
3				
Average				

Data Table 2

Trial	**Mass of Marble 1 (g)**	**Mass of Marble 2 (g)**	**Distance traveled by Marble 1 down ramp (cm)**	**Distance traveled by Marble 2 after collision (cm)**
1				
2				
3				
Average				

Questions to Answer

Once your experiment is done, answer these questions and draw some conclusions.

1. How do your predictions compare to the outcomes of the experiment?

2. Which marble has the most potential energy at the top of the ramp? Why?

3. Which marble has the most kinetic energy at the bottom of the ramp? Why?

4. What factors affect the amount of force the marbles can generate?

5. What happened when the smaller marble was released and collided with a larger one?

6. What happened when the larger marble was released and collided a smaller one?

7. Predict what would happen if you used a tennis ball and a golf ball in this activity and explain why you made that prediction.

What Is Going On?

Newton's Second Law of Motion states that the acceleration of an object depends on the mass of the object and the force applied to it. Since acceleration is a change in velocity with a change in time, both concepts can be explored in relation to Newton's Second Law. The important fact is that a force will cause a change in velocity; and likewise, a change in velocity will generate a force. We have defined force as equal to mass times acceleration (F=ma), and now we can define acceleration as the force divided by the mass (a=F/m). Greater mass with the same force produces less acceleration and a smaller mass with the same force produces more acceleration. Greater force on the same mass produces more acceleration and less force on the same mass produces less acceleration.

Where Does This Happen in Real Life?

Have you ever been at a traffic light, and seen a large truck next to a small car? What happens when they both step on the gas and try to accelerate down the road? Often, the smaller car can accelerate quicker from a stop than a larger truck, as the smaller car has less mass to accelerate. This will cause the smaller car to move ahead of the bigger truck initially. In other words, both the car and the truck can create equal forces even though they are of different masses and moving at different accelerations. If the car (smaller mass) has a high acceleration and the truck (large mass) has a lower acceleration, they may be equal in force. In some ways, that is why a traffic accident can cause a lot of damage even at low speeds as the force exerted by the cars is a product of both the mass and the acceleration of the cars.

In skateboarding and BMX, the constant mass of the rider and the board or bike define a system that will go faster as more force is applied to it. As discussed in the forces segment, a skateboarder can maintain a constant level ollie in which the force of gravity is balanced by the lift and the drag is balanced by the thrust. However, if the forces become unbalanced, the rider moves in the direction of the greater force.