**Energy**

**Lesson #4:** **Newton’s Laws of Motion**

**Time Frame:** 60 minutes

*Please write the vocabulary on the board before each lesson.*

**Vocabulary**

**Newton’s First Law of Motion** - An object that is moving will keep moving, and an object at rest will remain at rest, unless energy is used to change its motion

**Newton’s Third Law of Motion** - For every action there is an equal and opposite reaction

**Inertia** - An object's resistance to movement or to a change in motion

**Learning Standards:**

*Science*

Energy

1. Ask questions and predict outcomes about the changes in energy that occur when objects collide.
2. When objects collide, the contact forces transfer energy so as to change the objects’ motions

Science and Engineering Practices

1. Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships.
2. Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

Crosscutting Concepts

1. Energy can be transferred in various ways and between objects.

**Student will be able to:**

1. Explain Newton’s First and Third Laws of Motion.
2. Describe the flow of energy in a collision.

**Resources and Materials:**

|  |  |
| --- | --- |
| **Item** | **Amount** |
| Science Journals |  |
| Newton’s Laws of Motion Student Activity Sheet | 25 (in bin) |
| Nickels | 20 (in bin) |
| Table (not provided) | (in classroom) |
| Newton’s cradle | 1 (in bin) |
| Different types of balls | 10 (in bin) |

**Focus Activity: Coin Shoot**

Stack all but one of the nickels (at least 10) on top of each other to form a column on a flat surface. Make sure that the column is straight. Flick the free nickel sharply towards the bottom of the stack so that it strikes the bottom nickel. This nickel should shoot out from under the other coins without disturbing the rest of the column (remember, practice makes perfect). With good aim, you should be able to shoot all of the coins out of the column one by one. Ask the students to write in their science journals about what they see happening and why they think this is happening. When a free nickel strikes the stack, what happens to the nickels in the column? Why is it that only the bottom nickel moves?

*Teacher explanation: Each nickel in the column has inertia, as does the entire column. The sharp force of the flicked nickel contains only enough energy to overcome the inertia of the bottom coin, but not enough to move or shake the entire column. Thus, only the bottom nickel is set into motion.*

**Introduction:** Ask students about any observations they can think of about how things move or change their movements when they come into contact with other objects. Ask them if they’ve ever seen things bounce or crash into each other? Have they ever thought about why that happens or why things fall? Introduce the idea of Isaac Newton and his Laws of Motion. Newton had three Laws of Motion, but today we’ll just talk about two of them, the first and the third.

**Newton’s first law** says that “An object that is moving will keep moving, and an object at rest will remain at rest, unless energy is used to change its motion”. Demonstrate this law with a ball. Talk about how inertia is involved in this law by using examples of trying to move stationary objects or stop moving objects. **Inertia** is an object's resistance to movement or to a change in motion. So this explains why if something is moving, it will tend to keep moving in the same direction and at the same speed and if something is still, it will tend to keep still, unless you forcibly change its motion. It would be hard to stop a speeding shopping cart or move a big refrigerator because of the object's inertia, it would take energy to overcome the inertia, which is why it feels strenuous to try to do so.

**Newton’s third law** says that “For every action there is an equal and opposite reaction”. Demonstrate this law by pushing against the side of a table. Discuss how neither you nor the table move. Point out how your hand becomes squished against the side of the table to prove that there is force being used. Ask students what would happen if you pushed harder than the table pushed back? What about the opposite scenario, where the table "pushes" back harder than you push it?

Tell students that now they will see how Newton's laws apply to collisions. Ask, what do you think happens to energy in a collision? If energy allows something to move, why would one ball move if you hit it with another ball? (The energy of the first ball is **transferred** to the second ball).

**Activity:**

1. Hold up a medium sized ball to show it to the class. Ask students to predict what will happen when the ball collides with the floor. Drop the ball, and then catch it after it has bounced back to roughly its starting height. Repeat, but now let it bounce a few times before you catch it. Ask students to explain what just happened using Newton’s laws. How does the first law apply to this situation? If energy must be used to change something’s movement, why does the ball not stay in the same place after you let go of it? What is the source of energy acting on the ball to move it downwards? How does the third law apply to this situation? Why didn’t the floor seem to move, if the ball hits it and it responds equally? What happens to the total energy in this collision?

*Teacher Explanation: When the ball fell, it kept moving until it was stopped by the force of hitting the ground. The ball fell because gravity exerts a downward force on all objects. The force of gravity, however, does not give the ball enough energy to break through the floor, so the ball did not keep traveling downwards through the floor. Once it hits the floor it starts traveling upwards. This is because the action of the ball hitting the floor is matched with the equal and opposite reaction of the floor “hitting” the ball. The floor moves, but this change is so little compared to the size of the floor that we cannot see the change. The ball, which is much smaller, has a more visible movement. The energy of gravity acting on the ball is transferred to the floor. An equal amount of energy is transferred back into the ball, allowing it to bounce.*

1. Place one billiard ball on a flat surface about 2 feet away from the second billiard ball. Explain to the students that you will be using one of the balls to hit the other one. Ask them to write a prediction in their science journals about what will happen after the collision. Using one of the billiard balls, hit the other. The first ball should stop after colliding with the second, and the second should continue moving at about the same speed as the initial speed of the first ball. Ask students to explain what just happened using Newton’s laws. How does the first law apply to this situation? How does the third law apply to this situation? What happens to the total energy in this collision?

*Teacher Explanation: The ball that was moving kept moving until it hit the second ball, and the second ball was stationary until it was hit by the first ball. After the collision, the first ball stopped moving and remained stationary, and the second ball continued moving until it was stopped. When the first ball hit the second and caused it to start moving, the second ball also “hit” the first, causing it to stop moving. The energy of the first ball is entirely transferred to the second ball.*

1. Split the students into groups of about 4. Each group will have the chance to come to the front of the classroom to demonstrate a collision, with help from the teacher. Show students a variety of balls of different sizes and masses, such as basketballs, golf balls, ping pong balls, fishing weights, tennis balls, etc. You should have multiples of some of these objects so that students can play around with different and/or similar masses. Have one student in the group pick two of the balls available. Have another student in the group decide whether those two balls will collide in a situation where one ball is initially travelling faster than the other, when they travel at the same speed, or when one ball is initially stationary. As a class, make predictions about what would happen when those two balls collide. Students should explain their reasoning using Newton’s first and third laws and also take into account the relative speeds and masses of the balls involved in the collision. The teacher will then ask the remaining two students in the group to demonstrate the collision. Remember to always keep the movement linear. If both balls are moving, they should be moving towards each other. Have each group come up and demonstrate a collision. Students should record observations in their lab notebooks about what actually happened in each collision, including a simple illustration of the paths of the balls. Students should also note the energy transfers that occur in each collision.

**Closure:** Show the students the Newton’s cradle. Pull away one ball on one side and let go. Students should observe that only the last ball moves, then swings back. Then the first ball moves and swings back. Ask students to describe how the Newton’s cradle works using Newton’s laws. Ask them to predict what would happen if more than one ball was initially moved, or introduce a different variation. The Newton’s cradle should eventually stop moving. Ask students why they think this happens.

**Challenge question:** Energy can never be created and destroyed, but it can leave a system, like how heat is given off when fire is produced. Where is the energy lost (from the system) of the Newton's cradle? Why isn’t the swinging movement constant, what type of energy interferes with this movement?

**Assessment:** science journals, question sheet, participation

Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Newton's Laws of Motion: Collisions**

**Student Activity Sheet**

**Newton’s First Law of Motion**: An object that is moving will keep moving, and an object at rest will remain at rest, unless energy is used to change its motion

**Newton’s Third Law of Motion**: For every action there is an equal and opposite reaction

**Inertia**: Resistance to change in motion

How would you explain Newton's Laws in your own words?

Where have you seen examples of these laws in your life?

**Demo 1: Ball bounce**

How does the first law apply to this collision?

How does the third law apply to this collision?

What happened to the total energy in this collision?

**Demo 2: Simple collisions**

How does the first law apply to this collision?

How does the third law apply to this collision?

What happened to the total energy in this collision?

**More collisions!**

Take notes about what happens in each collision in your science journals. Remember to note how Newton's laws apply in each collision and how the total energy in the collision is transferred when you make your predictions about the collision. Keep in mind the masses and initial speeds of the balls you and your classmates select, and draw a simple sketch of the path of the collision after you see it in action.