UtahState UNIVERSITY JUNIOR ENGINEERING

Revised 6/00

## Lesson #15

# Newton's Laws

**Grade Level: 5-6**

> Teachers, this is a basic lesson plan that you may modify at your discretion.

**Modifications to video:** There may have been changes to the lesson plan since the video was made. This lesson plan reflects the latest updates made as a result of suggestions from teachers who have presented the lesson during the daytime program. Please continue to send us your ideas!

**Overall educational objective**: Students will be able to analyze moving objects and explain their motion in relation to Newton's Laws of Motion.

**Associated Standard and Core objective**:
**3030-0402** Determine a relationship between force and distance. Classify forces as pushes and pulls.

**Materials list**:

| | | |
|---|---|---|
| 16 - Car kits | 1 - Wooden block | 1 - Steelie |
| 8 - 1-meter board runways | 1 - Ping pong ball | 16 - Tops |
| 8 - Air pumps | 1 - Golf ball | - Washers |
| 1 - Newton's Cradle | 1 - Tennis ball | - Balloons |
| 1 - Hot Wheels Track & clamp | 1 - Basketball | - Rubber bands |

**Lesson Activities**:
Introduction:

1. Inform students' they will become Engineers in class today. Ask " What is an Engineer?" ( Someone that uses Math and Science to solve problems.)

2. Inform the students they will use their knowledge of forces and motion to design and construct a car that is powered by a balloon.

**Explanation of Newton's Laws of Motion:**
*1st Law of Motion: Objects in motion stay in motion, objects at rest stay at rest, until a force changes their speed or direction.*

1. Write this law on the board and read it to the students. This law can be demonstrated by a top. Distribute the tops throughout the room.- Have students lay the tops on the table. Ask if the tops are at rest or in motion? Ans. Rest

2. Ask what is needed to make the tops move? Ans. A force

3. Ask students to apply a force to the top. Restate the 1st law, then ask what should happen according to the first law. Ans. They should stay moving forever.

4. As the tops begin to slow, ask the students what force is acting on the top? Ans. Friction

5. Ask students to predict what would happen if they could spin the tops in outer space? Ans. The tops do not stop because friction is eliminated in space.

*2nd Law of Motion: Changes in motion are equal to the applied force and in the direction of the applied force. Mathematically described as Force = Mass x Acceleration.*

1. Have one student help with the Swinging Wonder Demonstrator. Have the student pull one steel marble back and hold it while you ask, " If one marble is dropped, predict what will happen to the other four marbles?" Ans. Only one marble will move in the direction of the applied force.

2. Continue Predictions with 2 , 3, and 4 marbles pulled back.

3. Force = mass x acceleration
   1. Demonstrate that the wooden ball and the metal ball fall at the same rate of acceleration when dropped at the same time from equal heights.
   2. Since the acceleration is the same, ask the students to predict which would have more force when they collide with the wooden block at the end of the track.
   3. Have one student place the wooden block near the end of the track. Roll the wooden ball and measure the distance the block traveled from the force of the wooden ball. Reset the wooden block and repeat using the metal ball. Measure the distance the wooden block was displaced by the force of the metal ball.

4. Mathematical illustration:

*No washers*

Force of balloon = 50 Newton    Mass of car = 10 grams    Acceleration = 5 meters/second/second

*5 washers added*

Force of balloon = 50 Newton    Mass of car = 25 grams    Acceleration = 2 meters/second/second

*3rd Law of Motion: For every action there is an equal and opposite reaction.*

1. Have one student drop the basketball and another drop a tennis ball. Ask why the ball bounces back? Ans. As the ball hits the floor with a force, the floor pushes back with the same force in the opposite direction. Therefore, the ball bounces up.

2. Now place the tennis ball on top of the basketball. Ask the students to predict, then observe and explain what happens in terms of Newton's Laws of Motion. Drop the combination. Ans. The tennis ball is launched to the ceiling because it absorbs both the force of the floor pushing up on the basketball and the floor pushing up on the tennis ball.

**Design a car:**

Students work two in a group.

1. Explain that each group will receive a box containing: 1 car, 2 washers, 2 rubber bands, 1 balloon, and a pvc pipe elbow.

**Note:** If a balloon pops, the student needs to bring the broken balloon to you before they get another balloon.

2. Ask students, “How can you make the car move with these materials?“ Have them discuss that question with their partner while you pass out the materials.

3. Once the materials are passed out, ask for volunteers to share their suggestions with the class.
   a. Lead the class to the understanding that the balloon is attached to the pvc pipe with the rubber band.
   b. Lead the class to understand that the rubber band on the car is used to hold the pvc pipe to the car.

4. Demonstrate how the students can pump air into the balloons. Explain the health risks of blowing up the balloon with their mouth.

**Test the car:**

1. Have two groups share one track.

2. Goal #1 is to design a car that can run the length of the track.

3. Goal #2 is to design a car that can carry the greatest amount of weight the length of the track.
   a. Weight is determined by adding washers to the car.
   b. All washers are approximately the same weight.

4. Allow 15 – 20 minutes for the students to experiment with the car designs.

5. After all groups have their cars running, as a review, discuss and demonstrate Newton’s Laws.

* Please collect all materials after each class. Tops and balloons are hot commodities for students.

**Background Information:**
**Newton’s Laws**

Forces and motion are governed by three basic principles, which were first formulated by Isaac Newton in the17th and 18th centuries. These principles are known as Newton’s laws. **Newton’s first law** describes inertia, as follows: **Everybody remains in a state of rest or in a state of uniform motion (constant speed in a straight line) unless it is compelled by impressed forces to change that state.** Under this law a moving body is at rest, as far as its own inertia is concerned, as long as its motion continues at the same speed and in the same direction. Therefore, particles (or even worlds) of matter will keep flying through empty space forever, without being driven by any force, until something compels them to change their motion.

**Newton’s second law** describes how a force causes a change of motion, at a rate of change called acceleration. It can be stated as follows: **Change of motion is proportional to the impressed force and takes place in the direction of the straight line in which that force is impressed.** This law is often stated in a different manner: the net force acting on a body is equal to the product of the body’s mass times the resulting acceleration. It can be stated much more simply as a formula, using letters for force, mass, and acceleration: $F = ma$. The wording of the law, however, makes clear how an impressed force acts. It simply causes a change in the body’s motion, its speed, or direction toward the direction in which the force is acting.

**Newton's third law** may be stated as follows: **Action and reaction are equal and opposite.** This law is often expressed as "for every action there is an equal and opposite reaction." For example when you push on a wall the wall pushes back with the same amount of force.

Compton's Interactive Encyclopedia, Compton's NewMedia, Inc , 1993, 1994

**Please make your students aware that this lesson relates to the following:**
**Career Fields:** Science, Social-humanitarian

**Occupations:** **Mechanical Engineer**: They plan and design tools, engines, machines, and other mechanical equipment. They design and develop power-producing machines such as internal combustion engines, steam and gas turbines, and jet and rocket engines. They also design and develop power-using machines such as refrigeration and air-conditioning equipment, robots, machine tools, materials handling systems, and industrial production equipment.

Education: Bachelor's Degree

**Civil Engineer**: They plan, design, and oversee the construction and maintenance of roads, railroads, airports, bridges, harbors, channels, dams, irrigation projects, pipelines, power plants, and water supply and sewage systems. They may work in areas of design, research, construction, or teaching.

Education: Bachelor's Degree

**Physicist**: They explore and identify basic principles governing the structure and behavior of matter, the generation and transfer of energy, and the interaction of matter and energy. Some use these principles in theoretical areas, such as the nature of time and the origin of the universe; others apply their physics knowledge to practical areas such as the development of advanced materials, electronic and optical devices, and medical equipment. They design and perform experiments with lasers, cyclotrons, telescopes, mass spectrometers, and other equipment. They attempt to discover laws that describe the forces of nature, such as gravity, electromagnetism, and nuclear interactions. They also find ways to apply physical laws and theories to problems in nuclear energy, electronics, optics, materials, communications, aerospace technology, navigation equipment, and medical instrumentation.

Education: Doctor of Philosophy

**Teacher**: Instruct students in English, mathematics, science, and social sciences. They plan teaching activities, evaluate students' work, record grades, and meet with parents.

Education: Bachelor's Degree

**Review Questions**

1. How does the balloon cars demonstrate Newton's First Law of Motion?
   **Answer:** Without the elastic force of the balloon the car would not move. The force of friction must be overcome to start the car moving.

2. How do the cars they designed demonstrate Newton's Second Law of Motion?
   **Answer:** The force of the balloon must be great enough to overcome friction and must move the car forward.

3. How do the concepts of Force, Mass, and Acceleration relate to the balloon cars?
   **Answer:** As you increased the mass of the car by adding washers the acceleration (measured by distance ) decreases.

4. Ask the students how the cars they designed demonstrate Newton's Third Law of Motion.
   **Answer:** The balloon pushes the air out the back of the car and the air pushes the car forward with an equal force. This force is greater than the frictional force which keeps the car at rest.



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