STEM LAB:
Projectile Launcher Design

TEACHER

LEVEL: Year 10-12 | TOPIC: Physics | TIME REQUIREMENT: 45 mins

CURRICULUM ALIGNMENT

- *The motion of objects can be described and predicted using the laws of physics (ACSSU229)*

BACKGROUND

The definition of a projectile is any object propelled through the air with only the force of gravity acting on it. This means that a cricket ball that has been thrown is a projectile. Humans can even be projectiles when jumping off a diving board or shot out of a cannon. However, any object with additional force, beyond gravity, acting upon it is not a projectile. A flying airplane cannot be considered a projectile as the engines provide force which propels it forward. In reality, the force of air resistance also acts on projectiles, but in cases of minimal air resistance the object is still considered a projectile. Streamlined heavy objects such as cricket balls have little air resistance, and are therefore a projectile.

A trajectory refers to the path of a projectile. Parabola is the mathematical name for the curved shape of a projectile's trajectory. The range of a projectile is defined by the horizontal distance it travels while in motion. A projectile instantaneously moves both horizontally and vertically. A projectile's horizontal velocity remains constant throughout its flight as there are no horizontal forces acting on it. Gravity's force acts downward and therefore a projectile accelerates at a rate of 9.8 m/s2 in the downward direction. This acceleration varies slightly depending on the location on Earth. A projectile's range is dependent on the speed, angle and height it is launched at. When launched from ground, a projectile has the greatest range when it is launched at 45 degrees.

In this investigation, students explore the concept of gravity in relation to projectiles by first making a projectile launcher according to the instructions and then designing their own projectile launcher. By experimenting with a number of conditions students will observe the impact that the angle, starting position, height, acceleration and speed have on the projectile's range, as well as its trajectory.

METHOD - STUDENT PRACTICAL

Assembling the Projectile

1. Place the string on a flat, even surface and mark the string at 25 cm intervals using a marker and ruler. You will use this string to measure the distance travelled by the launched projectiles.
2. Position the wooden block on the table so that the square side is facing upwards.
3. Place the protractor upright and secure the bottom edge of the protractor to the side of the wooden block using sticky tape. Be sure not to block the protractor's swing arm with the sticky tape.
4. Collect the plastic tube and stretch the rubber band over it lengthways. The rubber band should cover both open ends of the tube.
5. Wrap a strip of sticky tape around the plastic tube, towards one end, to secure the rubber band in place. To ensure the rubber band is secure, repeat this step until you have several layers of tape securing the band.
6. Using scissors, cut the rubber band so that it covers only the end of the plastic tube closest to the tape.

MATERIALS

- 1 Protractor with swing arm
- 1 Wooden Block
- 1 Plastic Tube
- 4m String
- 1 Pipe Cleaner
- 2 Rubber Bands
- 2 Straws
- Sticky tape
- Scissors
- Marker
- Ruler
- Projectiles

SAFETY PRECAUTIONS

- Use caution when launching projectiles. Do not launch any object with a sharp end. Keep your face away from the end of the barrel. Before launching, be sure that no other students are in the direction that the launcher is aimed.

7. Using sticky tape, secure the plastic tube against the swing arm, so that the end with the rubber band is placed towards the bottom of the swing arm.
8. Position the assembled projectile launcher along the edge of a table. It should be possible to pull down and stretch the rubber band. Once you are happy with the positioning, secure the projectile launcher to the table with tape.
9. Insert the plastic straw into the open end of the tube.
10. Hold the swing arm securely with one hand and carefully pull down on the rubber band from the plastic tube using your fingertips. Ensuring the bottom of the straw rests against the rubber band.
11. Using the protractor as a guide, take note of the angle of the swing arm. Release the rubber band to launch the straw in the air. Watch the projectile's motion.
12. Using the string you prepared earlier, measure the distance from the bottom of the plastic tube to the landing spot of the projectile.
13. Record the distance travelled along with any additional information about the launch. It does not have to be an exact measurement, but try your best.
14. If you have a launch failure, check that the projectile launcher is assembled correctly and try again.
15. Fire the projectile several times, and record your data.

Designing your own Projectile

1. Based on your experience assembling the projectile in the above activity, consider how the assembly method can be changed, improved or used to test a hypothesis.
2. Develop a 1 sentence design challenge. For example, design a projectile launcher to make the straw fly higher rather than longer distances. Write your design challenge here:
3. Develop a design plan for a projectile launcher that fulfills the needs of your design challenge.
    - Describe and draw the projectile launcher you will construct. Include annotations.
    - List of the required materials you will need
    - Describe the building steps you will follow.
    - Describe the method you will use for testing your launcher.
    - List the safety measures you will use to ensure no harm comes to yourself or others. List the safety equipment you will use to do this.
    - Using the template below, design a data table of what you will measure as you conduct your tests.
    - Develop a criteria for success for determining if you met or exceeded your design challenge goals.
4. Based on your design plan, construct the modified launcher.
5. Record any modifications that you make to the design as you construct the launcher.
6. Test your launcher and record the results in the data table you created earlier.
7. If necessary, make changes to the design. Record these modifications and determine if these changes had the desired impact.

OBSERVATION AND RESULTS

Assembling the Projectile

The projectile launcher should have a range of approximately 1-5 metres.

Designing your own Projectile

Student results will vary. Regardless of the outcome, students should provide a detailed description of how their design performed against the design criteria and an analysis of why they believe their design yielded such results.

INVESTIGATIONS

- Ask students to describe further modifications they would make to improve their design and how these modifications changed their results. Students should also identify what further modifications they would make to improve the design and describe what impact these changes would have.
- Rockets and torpedoes commonly have a long narrow body with a pointed end. Based on their understanding of projectiles, ask students to describe the advantages this shape provides.