The Mathematics of Projectiles

Level: 5 - 10

Learning Objectives: We understand that the motion of projectiles is dependant on the angle from which it is fired and the force.

Intended Outcome: To provide a practical introduction to the motion of projectiles with a focus on angles. It is designed as a lead in to parabolic and quadratic functions.

Game Objective:
To make a projectile launcher and use it to investigate trajectories.

Materials:

- Launching Cannon (Instructions to make it are on the next page)
- Protractor
- Ping pong ball
- Markers
- Tape measure
- Ice cream tub

Instructions:

- Students get into groups of 3 or 4
- Using the Launching Cannon students will fire the ping pong ball at different angles
- Students will record the distances of 3 angle shots and then work out the average distance for each angle
- Once they have done this they can work out which angle travels the greatest distance
- After this is completed students can then have a go at hitting a target by trying to get the ball to land in an ice tub

More detailed instructions and background information about this game are available on the next page.

Activity 1: Making a Directional Launching Cannon

Equipment:

- Plastic cup
- Balloon
- Party Popper
- Rubber band
- Washer
- Printed protractor
- Scissors
- Ruler
- Sticky tape
- Ping pong ball
- Post it notes
- Markers
- Tape measure

Instructions:

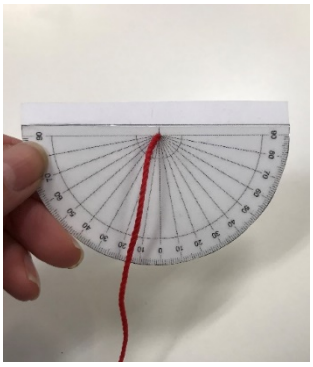
1. Cut the bottom of the balloon off approximately 1cm from the rounded end.

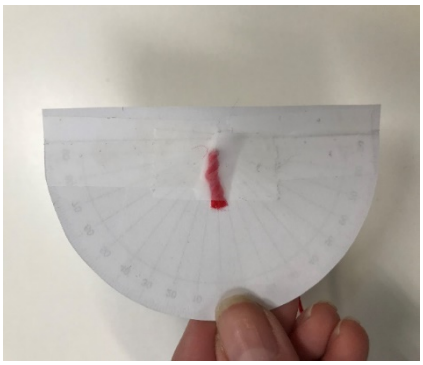
2. Stretch this over the base of your cup and fix it with sticky tape. Tie a knot in the end of the balloon.

3. Place your party popper into the cup so that the neck of the popper fits snuggly into the neck of the balloon.

4. Pinch the two firmly together and secure it with a rubber band so that it sits firmly in place to form your trigger.

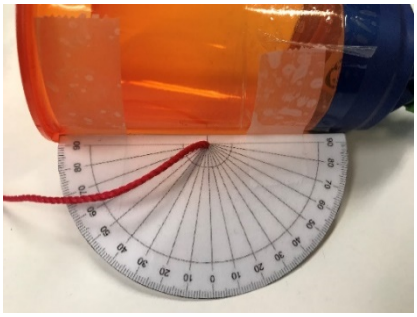
5. Carefully cut around your protractor **including the tabs**. Using a needle, thread the twine through the origin of the protractor and secure with tape at the back to hold the twine in place.

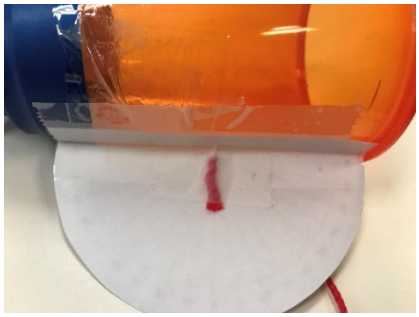




6. Tie the weight to the bottom end of the piece of twine. Ensure that your string swings freely from the origin of the protractor with no obstructions. Also make sure that it is weighted enough to ensure easy reading of the angles on your protractor.

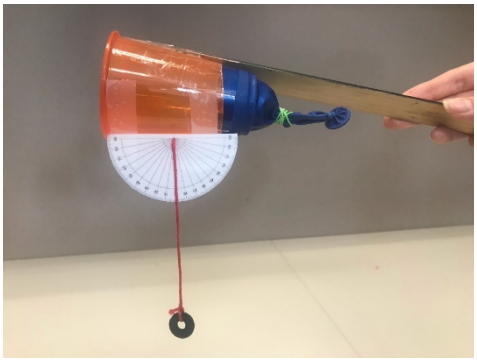
7. Use the tabs on the bottom of your protractor to stick it to your cup. Make sure that the base of the protractor is parallel to the cup.





8. Place your wooden ruler at the top of your cup. Make sure that it is directly over the top of your protractor and parallel to its base.

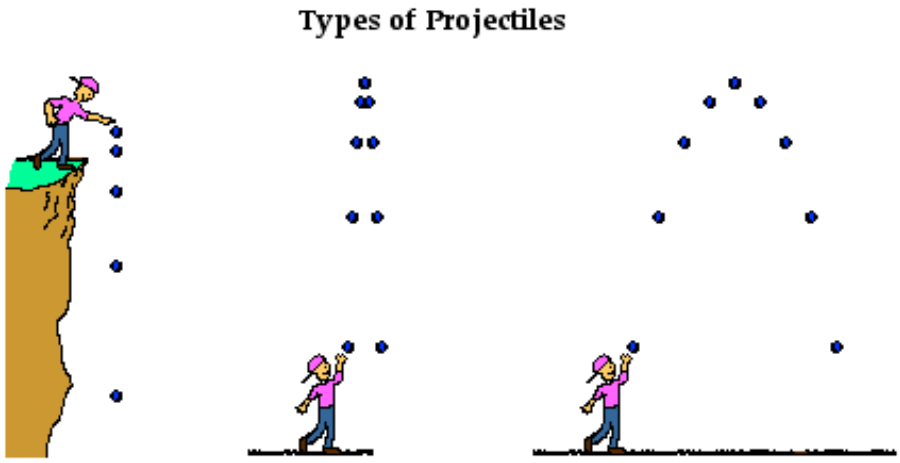
9. Your directional cannon is now ready to use.



HAPPY LAUNCHING!!

Activity 2: Launching Projectiles

When we throw a ball and the ball is in motion, it is called a projectile. A projectile can be an object that is dropped straight down from a height, thrown straight up in the air or thrown at an angle.



By definition, a projectile is an object where the only force acting upon it is gravity. This is often a confusing concept for people because we usually associate motion with forces, but if we look at Newton's laws of motion, we can see why. Newton's laws suggest that forces are only required in order to create an **acceleration** and **not** a motion. Seeing as our projectile is not accelerating once in the air, there are no longer any forces acting upon it…apart from gravitational forces that is. This force acts on every single thing living on earth. It's what keeps us from floating off the face of the planet.

In this activity, you will be using the directional cannons to investigate projectile motion in a variety of different ways.

Investigation:

Students will be working in groups of 3 – 4

In this investigation, you will be looking at the relationship between the angle of motion of a projectile and the horizontal distance the object travels. But first, we will learn how to use our launching cannon.

Learning to use your directional cannon

1. To launch the projectile, place the ping-pong ball into the barrel of your cannon so that it is sitting on the popper.
2. Holding onto the ruler for leverage, use the clinometer (protractor) to determine the launch angle. The ruler also has a second purpose that will be discussed later.
3. Now firmly grasp the balloon at the neck of the popper. We will call this part of your cannon the 'trigger'. To launch your ball, pull back hard on the trigger and release.

The diagram provided shows the barrel at an inclination angle of 40 degrees. We will call this the launch angle. Once launched, the ball will leave the barrel at this angle, and travel in a relatively parabolic path before landing a certain distance away. To make the experiment simpler, we will be ignoring air resistance.

Speed and height of projection as a variable

Now we need to look at the speed that the projectile is travelling as well as the height that it is launched from. These two things will affect the distance that the ball will travel in the following ways:

- The greater the force that you apply to launch the projectile, the greater the distance.
- The greater the launch height from the ground, the greater the distance.

Launch Force

To ensure that your ball will be travelling at a constant speed at each angle, you must apply the following conditions at each launch:

1. Your ruler can be also used to help you apply a constant speed to your projectile.
2. Grasp your trigger and pull it back firmly until you are satisfied that it will apply sufficient force to launch your projectile.
3. Make a note of this measurement. You will be pulling the trigger back to this measurement with every launch to ensure that the ball leaves the barrel with approximately the same force each time.

Launch Height

Keeping a constant launch height is much simpler. Once you decide on the height that you will activate your cannon, you must repeat each launch from this height. Don’t forget your units.

Launch force (ruler measurement): _____

Launch height (from ground): _____

Investigating Projectiles

In this activity, you will be investigating the relationship between the launch angle and distance that the projectile travels if the launch speed is constant. Accuracy for this part is extremely important so follow the steps below carefully.

1. Each member of the team will be assigned a task. **One team member** will be responsible for holding the cannon and launching the projectile, **one team member** will need to read the clinometer and ensure a correct launch angle and **one team member** will be measuring the distance that the projectile travels once launched. *Each team will need to work collaboratively in order to guarantee a safe and accurate launch.*
2. The table below indicates the various launch angles that you will be using to fire the cannon. You will notice that each angle needs to be repeated three times.

Angle	**Launch 1 – distance (m)**	**Launch 2 – distance (m)**	**Launch 3 – distance (m)**	**Average Distance (m)**
15˚				
30˚				
45˚				
60˚				

i) Why do you need to repeat each launch three times?

_____

_____

ii) At what angle do you predict the projectile will travel the greatest distance?

_____

_____

You can now begin your launch sequence and start completing the above table.

3. For each angle, you can use the post-it-notes to mark the position that launch 1,2 and 3 first hits the ground. This will make measuring the distances at each angle much more efficient.
4. Once you have each of the three distances at each angle, calculate the average distance that the projectile has travelled at that angle.
5. *Repeat the process for each launch angle.*

iii) At what angle did the projectile travel the greatest distance?

_____

You will now be using this information to help you complete the next activity.

Hitting a Target

Now that you have learned to use your launching cannon and discovered its optimal launch angle, let's have some fun!

You may all have heard or played the game Angry Birds. Just like in the game of Angry Birds, in this activity, you will all be launching your projectile with the aim of hitting and/or knocking over a target.

Using the information that you have gathered from the above investigation, you will need to determine the following:

1. The distance you must stand from the target
2. The height from the ground, your projectile must be launched from
3. The launch angle of your projectile.

This may seem simple, but there are several other variables that will need to be considered. Once you have had a few goes at hitting your target, see if you can make some suggestions below about what these other variables may be and make any necessary adjustments.

_____

_____

_____

If you're now confident in your ability at a missile launch specialist, see if you can launch your projectile into an open container!

HAPPY LAUNCHING!!