PRIMARY + STEM

Teaching Resource

ACTIVITY: Parachutes

ACTIVITY OVERVIEW

A dangerous mission and lots of excitement await students in this hands-on Mathematics lesson, featuring tossing a small toy figurine off a treacherous precipice.

Skills in all STEM learning areas are engaged, as students explore forces, measure, design, and build a parachute to save their toy figurine from a terrible fate.

This 'measurement' and 'geometry-based' activity gives students many opportunities to exercise the language of numbers, to express their ideas and make comparisons, with focus using units of measurement and shapes.

SYNOPSIS

A dangerous mission and lots of excitement await students in this hands-on Mathematics lesson, featuring tossing a small toy figurine off a treacherous precipice. Skills in all STEM learning areas are engaged, as students explore forces, measure, design, and build a parachute to save their toy figurine from a terrible fate.

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Foundation – Year 2

- F: Use direct comparison to sort three-dimensional objects and two-dimensional shapes.(VCMMG064)
- Y1: Measure and compare the lengths, masses and capacities of pairs of objects, using uniform informal units.(VCMMG095)
- Y2: Compare and order several shapes and objects, based on length, area, volume and capacity, using appropriate uniform informal units.(VCMMG115)
- The way objects move depends on a variety of factors, including their size and shape. A push or a pull affects how an object moves or changes shape.(VCSSU048)

Year 3 - 4

- Y3: Measure, order and compare objects, using familiar metric units of length, area, mass and capacity.(VCMMG140)
- Y3: Tell time to the minute and investigate the relationship between units of time.(VCMMG141)
- Y4: Use scaled instruments to measure and compare lengths, masses, capacities and temperatures.(VCMMG165)
- Y4: Compare objects using familiar metric units of area and volume.(VCMMG166)
- Forces can be exerted by one object on another, through direct contact or from a distance.(VCSSU064)

Year 5 - 6

- Y5: Choose appropriate units of measurement for length, area, volume, capacity and mass.(VCMMG195)
- Y5: Calculate the perimeter and area of rectangles and the volume and capacity of prisms using familiar metric units. (VCMMG196)
- Y6: Solve problems involving the comparison of lengths and areas, using appropriate units.(VCMMG224)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

The aim of this activity is for students to design and make a parachute that can ensure the safe landing of their small toy figurine. A safe landing is defined by the unattached figurine staying inside the cup.

The best place for the parachute drop is from a second or third floor, overlooking an indoor foyer. A stairwell also suffices.

Do this activity outdoors.

Materials for 30 students (working in groups of 2 or 3)

- 20 x pre-cut lightweight plastic sheets*
- 15 x small lightweight plastic cups
- 15 x small figurines (e.g. Lego people)
- 15 x measuring tape or rulers, at least 40 cm long
- 15 x markers
- 15 x scissors
- 3 x stopwatches
- String (e.g. cotton twine, yarn, plastic)
- Adhesives (e.g. sticky tape, masking tape, rubber band)
- Stationery (e.g. hole-puncher, plastic straws)
- Accompanying worksheet
- Optional: calculators

***Preparation beforehand**

Cut the plastic bags or sheets (from shopping bags or tablecloths) into squares of about 60 cm in length. It does not need to be exactly 60 cm in length – variations in the measurements are useful for older students to measure and make calculations with.

Troubleshooting Tips

If the parachute keeps collapsing on its descent,

1. hold open the parachute as wide as possible before dropping it
2. rearrange the strings so that they are evenly distributed
3. lessen the mass of the cup or figurine

Theory

The teacher introduces students to the idea of forces acting in opposites (i.e. gravity pulling the figurine towards the earth, and drag in an upward direction against the open parachute).

Figurines will eventually make their way to the ground, but parachutes will slow down the descent and lessen the impact on landing.

Instructions

1. Students work in groups of three or four.

2. Measure the dimensions of the parachute.

   Younger students can measure the perimeter using uniform informal units (e.g. handspans or ice-cream sticks), while older students measure the perimeter with a measuring tape and calculate the area of the parachute.

   Students use the accompanying worksheet to record the measurements.

3. Cut out four equal lengths of string, 50 cm long.

   Older students measure this using measuring tape, but younger ones may use an equivalent in the form of an informal measure.

4. Attach one end of the string to a corner of the plastic square and the other end to the cup.

   This can be done either by punching holes in reinforced corners (reinforced by masking tape) or edges of the plastic sheets, or simply by taping them down securely. The string can be secured to the cups using rubber bands or sticky tape. Younger students will require more assistance with this.

5. Place the figurine in the cup. It should sit freely, not taped down.

6. Hold the parachute as widely as possible and drop when ready. It may take more than one student to prepare the parachute for the drop.

   For younger children, the mission is achieved so long as the figurine stays in the cup.

   For older children, the drop times can be measured and recorded. In this instance, the mission is achieved if the figurine stays in the cup, but the winner is the parachute which has taken the longest time to drop.

7. Select two or three students to act as timekeepers for every drop. Older students can record their own drop times.

   Decide, as a class, how to determine the start and stop times and how to reduce errors in recording the drop times (e.g. if all three times taken are very similar, record the time of the main timekeeper, but if the times are vastly different, eliminate the most different, and choose one drop time of the remaining two). Record the numbers in the worksheet.

8. Repeat this at least two more times.

   Each time, students adjust their parachutes to prolong the drop-time and lessen the impact upon landing. Should they make their strings longer/shorter to increase the surface area of the plastic in contact with the air?

   Older students use this as an opportunity to calculate average drop times.

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

Students who can use a measuring tape or ruler to measure the perimeter should do so, but for those who are not yet ready, uniform informal units such as ice cream sticks or piece of string could be used. They can use these numbers to find the perimeter of the parachute.

In Science, students learn that the way an object moves depends on how it is pulled and pushed. What do students notice about the effect of the size of the parachute to the way the parachutes move?

Because this activity is rather involved, it may be best for students to make parachutes using the 60 cm square, while the teacher makes both the 40 cm and 80 cm squares.

This will allow students to observe the differences in the way the parachutes move and the time they take to drop as their sizes differ.

Years 3/4

With guidance, students could take measurements using a measuring tape, record the drop times with a stopwatch, and make calculations (e.g. perimeter and area of the plastic sheet, and average drop times) with or without the aid of a calculator.

This exercise allows students to apply skills like working with decimals.

In Science, students study the effects of indirect forces, such as gravity and direct forces exerted by air (i.e. air resistance on the shape and motion of objects).

They can alter these forces acting on their parachutes by changing the size of the parachute, or simply by adjusting the string length or arrangement around the cup so that more of the parachute is able to 'catch' the air.

Years 5/6

Students are expected to be able to calculate the perimeter and area of shapes, which is ideal for this activity because students can make parachutes from different shapes (e.g. circular, rectangular, triangular), and compare drop times between them.

If the surface area were kept constant (e.g. 3600 cm^2), the teacher can help with simple calculations to determine the dimensions of their different shapes.

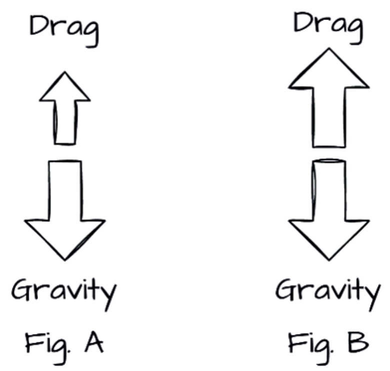
For example, a rectangular sheet at 80 cm x 45 cm, a triangular sheet with base 80 cm and height 90 cm, a circular sheet with radius 33 cm.

DISCUSSION SECTION AND KEY THEMES

KEY THEMES

Forces on a parachute

The two main forces acting on a parachute are gravity, which pulls the parachute downwards; and drag, which pushes the parachute in the upwards direction. Drag is brought by air-resistance, which is the action of the air particles on the parachute. The faster an object falls towards the ground, the more air-resistance (and therefore drag) increases, which causes more air to get pushed against the parachute.



When the parachute first drops (Fig. A), gravity is greater than air resistance, so the parachute falls faster and faster towards the ground. As the parachute keeps going faster and faster, air resistance increases in the opposite direction until it eventually becomes the same in magnitude as gravity (Fig. B). At this point, the parachute reaches terminal velocity, which is the fastest speed reached by the parachute, and it continues to drop at this steady speed for the rest of the way.

Average times

Average times are calculated in this activity to give a general idea, or a typical representation, of the drop time. In Mathematics, averages can be calculated in different ways – mean, median, and mode - but the most widely used method is finding the mean.

- Mean time

  The mean time is found by adding all the time together and then dividing it by the number of times the experiment was carried out.

$$\text{Average time (s)} = \frac{\text{Attempt 1 (s)} + \text{Attempt 2 (s)} + \text{Attempt 3 (s)}}{3}$$

- Median

  The median is found by arranging the numbers in order, and then finding the middle number.

- Mode

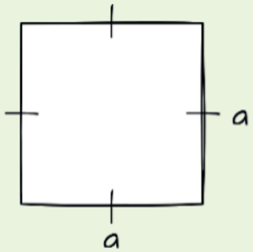
  The mode is determined by counting how many times each value occurs; and the value that occurs most often is the mode.

Perimeter and Area

If a fenced playground is used as an analogy, the perimeter can be likened to the amount of fencing that is required while the area is the amount of space that the kids can play within.

Perimeter = 4 x a = 4a cm

Area = a x a = a^2 cm^2



QUESTIONS AND ANSWERS

Do heavier objects fall faster?

Gravity pulls downwards on all things the same and without air resistance, all objects would fall faster and faster at the same rate. The classic free-falling experiment of the feather and bowling ball illustrates this spectacularly.

In a vacuum chamber (without air), we see gravity pulling on them both in the same way. That means that, after one second, both the feather and bowling ball are moving at 9.8 metres per second. After two seconds, they are moving at 19.6 metres per second, and after three seconds, they are rushing headlong at 29.4 metres per second. Since there is no air and no drag force as a result, both the feather and bowling ball hit the ground at the same time.

Recreating this experiment in a classroom setting would result in the bowling ball racing towards the ground followed by the feather's slow and graceful descent. This has to do with the shape of the feather which allows air to push against it more, creating a bigger drag force which acts in the opposite direction to gravity.

Watch Brian Cox visiting the world's biggest vacuum to see this very experiment: https://youtu.be/E43-CfukEgs

If the parachute in this activity is dropped from a higher ground, does it travel faster?

On Earth, yes, but up to a limit. Things that are dropped from a greater height will reach the ground at a higher speed. This is because gravity has more time to act on it – and that means more time to make it go faster and faster. Because the drag force also increases at the parachute goes faster, the parachute will eventually reach its maximum speed.

From what altitude do people jump out of planes?

Depending on the plane and type of skydiving, this can vary between 10,000 feet (¬3,000 m) above ground level to extreme skydiving at about 14,000 feet (¬4,300 m). No matter the altitude, the parachutes are deployed at 5,000 feet (¬1,500 m). At the lower altitude, the freefall lasts about 30 seconds with the remaining minutes falling to the ground with the parachute open. At the higher altitude, the freefall lasts for about 60 seconds. In other words, the lower the jump height, the less time one has to pull silly faces at the camera.

Who invented the parachute?

The history of parachute-like devices goes as far back as the 1100s in China, when it was thought to have been used to entertain guest at royal court events. Many more people had imagined the parachute since then, including Leonardo da Vinci when he sketched it in 1514. However, the credit for this invention goes to Frenchman Louis-Sebastian Lenormand, when he recorded his first successful parachute jump in 1783. He jumped off the top of an observatory while holding onto a cloth parachute. Unbelievably, he floated safely to the ground!

What material are parachutes made of?

Other than being lightweight and strong, parachute fabric also must be elastic, durable and resistant to tears. Parachutes were originally made of canvas and then silk, but they are now made of polymers (plastics) like nylon and Kevlar (the same material that is used to make bulletproof vests!).

What shape are parachutes?

The traditional shape of parachutes was round or dome-shaped. But the rectangular-shaped parachute is more popular now because it is easier to control.

How old do I have to be to jump off a plane with a parachute?

The extreme sport where one can use a parachute is called skydiving. The minimum age for skydiving in Australia is 16 but any person under 18 requires parental permission. Once you turn 16, you may skydive in tandem with an instructor (tandem skydiving) or even sign up for a sky diving course to be certified skydiver. There is no upper limit for age but there are weight and heights limits to consider as well.

How is it that skydivers can create formations in the air?

This is only possible if all skydivers are falling at the same speed, otherwise it would be impossible to grab one another and be stable enough to hold the formation. To make sure this happens, skydivers wear weight belts to have the same weight and move at the same speed because more weight results in higher speeds. All skydivers in 'face-to-earth' position will typically reach the maximum speed of around 200km/h after 12 seconds of freefall. Skydivers change their body positions to speed up or slow down.

Watch this Guinness World Records record-breaking skydiving formation: https://youtu.be/30rynuCX0I4

Why do we drop the parachutes several times in this activity?

The more times an experiment is repeated, the more the results are reliable because it lowers the chances of an unusual result. It lowers the likelihood of errors.

What are some of the most unexpected things to be dropped by parachute?

It's not just people who use parachutes to move through the air. Food, equipment, space capsules and even animals have used parachutes. In 1948, when a community of beavers became a nuisance in a town in Idaho (USA), the people in charge decided that the beavers would be happier if moved elsewhere in the state.

They relocated 76 beavers by putting them in crates attached to parachutes and dropped them off a plane.

There was only one casualty. Other animals that have been dropped by parachutes include a bear, dogs, cats, bats, monkeys, and even hamsters!

OUTSIDE OR SUPPLEMENTARY READING

History of parachutes

- Early History of Parachuting - Australian Parachute Federation (apf.com.au)

Forces related to skydiving

- Terminal velocity - Forces, acceleration and Newton's laws
- Distance and Time to Reach Terminal Velocity While Skydiving | Enjoy Free Fall

TOPIC WORDS

- Time
- Shape
- Size
- Perimeter
- Area
- Average
- Square
- Rectangle
- Circle
- Parachute
- Drop
- Gravity
- Drag
- Air-resistance
- Forces

TABLE OF DROP TIMES

Time for figurine to drop without parachute: __________ (s)

	Parachute A				Parachute B				Parachute C			
Perimeter (cm)												
Area (cm2)												
Length of string (cm)												
	Attempt 1	Attempt 2	Attempt 3	Average time (s)	Attempt 1	Attempt 2	Attempt 3	Average time (s)	Attempt 1	Attempt 2	Attempt 3	Average time (s)

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