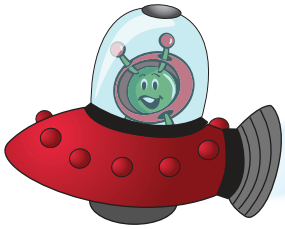
primary | PR51

esa Kids

teach with space

→ WHY IS THERE JUNK IN SPACE?

Teacher guide & student worksheets



TEACH WITH SPACE - Why is there junk in space | PR51
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WHY IS THERE JUNK IN SPACE?

Fast facts

Subject: Mathematics, Physics

Age range: 7-11

Type: student activity

Complexity: easy

Lesson time required: 2 hours and 30 minutes

Cost: low (0 – 10 euros)

Location: indoors or outdoors, classroom, school hall

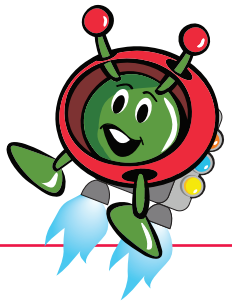
Includes the use of: craft material (cardboard) marbles, small balls, crisps

Keywords: materials, forces, Earth and space, solar system, orbit, forces, contact, collision, friction, impact, debris, gravity

Brief description

In the first activity, the children will investigate how collisions between objects can produce further impacts. In the second activity, they go on to investigate how such impacts can cause some materials to fracture into many particles.

These activities may be taught separately or combined for progressive learning.



Learning objectives

Having completed these activities, students will now...

- Understand that collisions between objects in Earth's orbit can lead to several more collisions
- Understand that satellites burn up upon re-entry to Earth's atmosphere
- Understand that repeated impacts increase the amount of space debris
- Be able to work scientifically by making careful observations, looking for patterns and relationships

Success Criteria

During these activities, students will demonstrate their ability to...

- Collect and record data from their own observations and measurements
- Make predictions based on preliminary results and set up further tests
- Relate their results to the wider scientific issue in question

Summary of activities

Title	Description	Outcome	Requirements	Time
1.Collisions in Space	Students will model collisions between debris and satellites, and observe that one collision can lead to several more.	Students will learn that collisions between objects in Earth's orbit can lead to several more collisions, and that satellites burn up upon re-entry to Earth's atmosphere.	None	1 hour
2.How big are space debris?	Students will investigate how collisions with space debris can cause some materials to fracture into many pieces.	Students will learn that repeated impacts increase the amount of space debris. They will also learn to work scientifically by making careful observations, looking for patterns and relationships	None	1.5 hours

INTRODUCTION

Humans have been sending satellites into space for decades. These missions allow us to gain more information about our Sun, the Earth, and other planets, and look deep into space at black holes, distant stars and galaxies. There are also communications satellites, weather satellites, and the International Space Station. But what happens to a satellite once it has served its purpose? It continues to circle (orbit) around Earth! Space debris, or space 'junk', refers to human-made objects that are orbiting the Earth but no longer serve a useful purpose. Examples include large objects such as non-functioning satellites as well as smaller objects such as flecks of paint.

Space debris is posing an increasingly large threat to spacecraft and functioning satellites - the more debris that accumulates, the more likely a collision is. Scientists are constantly monitoring large pieces of debris (larger than 10cm) using space telescopes to assess the risk the debris poses. If possible, they take action to protect satellites and spacecraft. The International Space Station sometimes conducts 'an avoidance manoeuvre' to prevent damage from debris.

However, there are millions of pieces of space debris that are too small to be tracked by scientists, and the number is rapidly increasing. The amount of space debris within Earth's orbit is now at a point that we can no longer ignore, and the situation is only going to get worse if we do not act. The European Space Agency's (ESA) Clean Space programme is attempting not only to minimise the debris produced by future space missions, but to actively reduce the debris already in orbit.

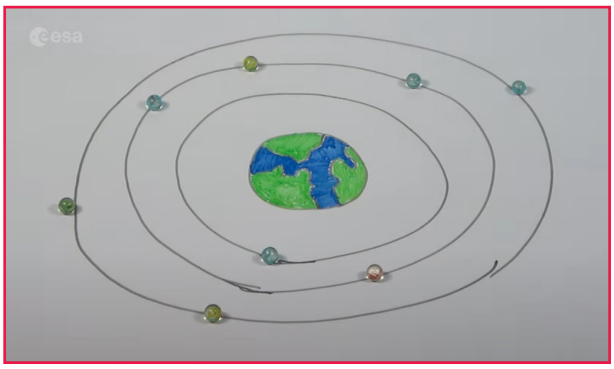
DID YOU KNOW?

As more collisions occur, debris is broken into smaller and smaller pieces. This means that small pieces of space debris are more common than large pieces. Statistical models estimate the amount of space debris orbiting Earth to be:

As of November 2021:
36500 objects greater than 10 cm
1000000 objects from 1 to 10 cm
330 million objects from 1 mm to 1 cm

ACTIVITY 1 – COLLISIONS IN SPACE

In this activity, students will model collisions between debris and satellites, and observe that one collision can lead to several more. You can watch the video of the activity here.



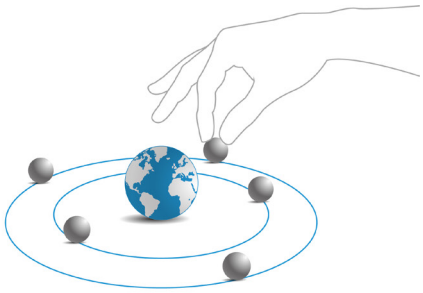
Equipment

- Marbles or balls (up to 100)
- Large sheet of paper
- Marker pens or chalk
- Activity sheet 1 (optional)

ADVANCE PREPARATION

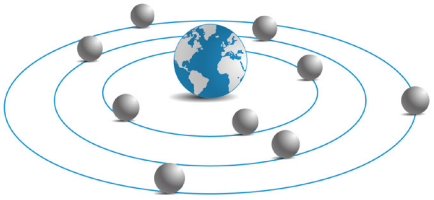
Draw 5 concentric circular orbits on a large sheet of paper. Draw Earth in the centre. Alternatively, chalk the orbits on the floor of the hall or on the playground.

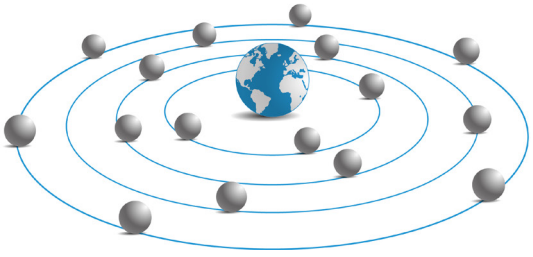
Exercise



Hold a class discussion around the following points:

- *What happens when you throw something into the bin? Where does it end up? You may choose to show the class an image of landfill.*
- *What happens to garbage in space? What kinds of things might be classed as space 'junk'?*
- *You may choose to show the class the image at the beginning of this resource of space debris orbiting Earth.*





Encourage the class to think about how garbage is created here on Earth – when people are finished with something they throw it away and, unless they recycle it, it ends up in a large pile of landfill. Explain that a similar thing happens in space – unless space junk is removed, it stays in orbit around the Earth, littering the space around us.

Watch the Paxi animation. *The video shows why we need to tackle the space debris problem. Paxi guides the children into Low Earth Orbit (LEO), 500-2000 kilometres from Earth! There, he finds there is a traffic jam of (anthropomorphised) satellites, which are sometimes colliding with each other. The situation is chaotic.* ***Pause the video once you have seen the satellites arguing.***

Next, gather the class for the collision demonstration. Place marbles or balls in small groups onto your pre-prepared circular orbits. Explain that the marbles or balls represent satellites and items of space debris. It may be useful to use one colour of marbles for the space debris, and another for the active satellites. If this is not possible, you might like to draw small circles around the marbles that are 'satellites'. Demonstrate that pushing a marble (this represents a piece of space debris) into the groups causes impacts that produce secondary impacts.

Encourage the children to participate in launching the marble, predicting where collisions might occur when the direction or force of the launch is changed.

Discussion

Gather the students and hold a discussion about what they learned from this activity. Points to consider may include:

- *In this activity, the marbles were able to pass over the picture of the Earth. What do the students think would happen if an actual satellite or piece of space debris started falling towards Earth? Do they think this would be a good or a bad thing?*

Explain that satellites are designed so that they burn up on re-entry to the Earth's atmosphere. The Earth's atmosphere can be thought of as a bubble of 'air' that surrounds us – because we live inside this bubble, we are able to breathe. This 'air bubble' has a lot more friction than outer space, and it is this friction that causes debris to burn up upon re-entry. Explain that debris falling through the atmosphere is generally a good thing because if it burns up, it will not impact life on Earth.

- *Each time the students push a marble in this activity, what could this represent in terms of space debris?*

Explain that a 'push' could represent the piece of debris falling out of its orbit. In reality, this would be caused by the low levels of friction experienced in Low Earth Orbit (the outer edges of the 'air bubble').

- *What do they notice when a piece of 'debris' hits a 'satellite'?*

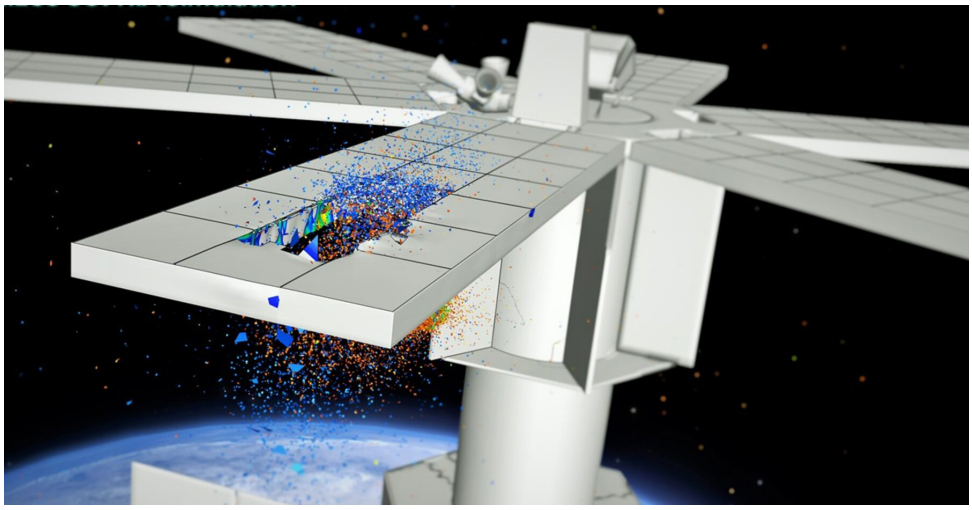
The students should observe that the satellite is knocked out of its orbit. Explain that it would take a large piece of debris to cause this to happen in real life, which is why space scientists monitor debris larger than 10cm. More commonly, debris causes parts of satellites to break off, as will be demonstrated in Activity 2.

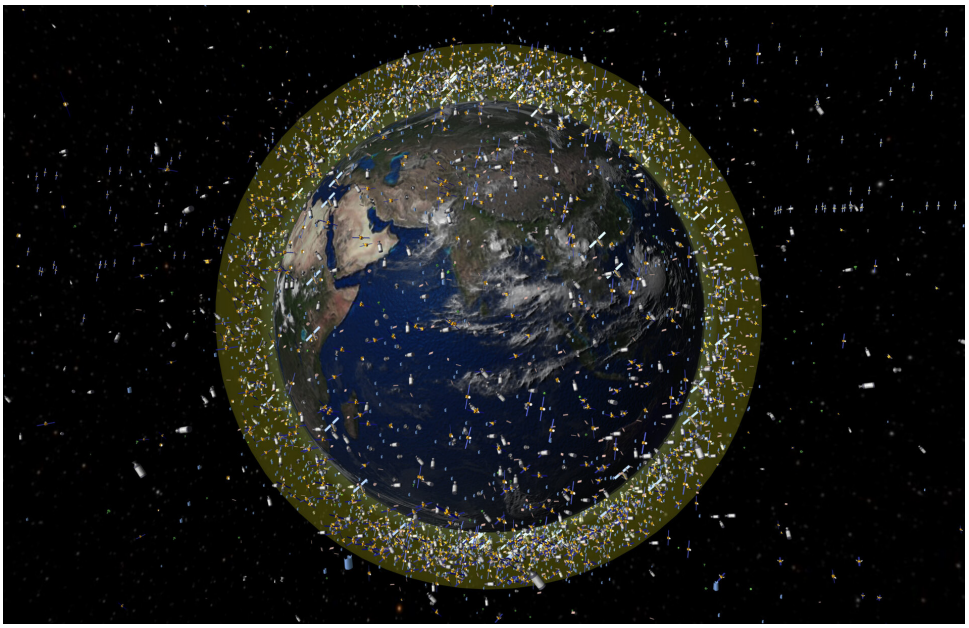
Conclude that an isolated collision generally leads to further collisions which can have varying effects.

Explain that scientists investigate the effect of collisions between objects using computer simulations and by physical impact tests. ESA has a test facility where scientists investigate the effects of impacts on materials used for spacecraft or satellites, to make sure that they can meet the strict standards required for space missions.

DID YOU KNOW?

With this activity we try to simulate the Kessler effect. It is a theory proposed by' NASA debris expert Donald Kessler. Successive collisions can cause chain reactions involving satellites and other objects in orbit around Earth – this is the Kessler effect. But the Kessler effect can be stopped if enough debris items are removed from key orbits.

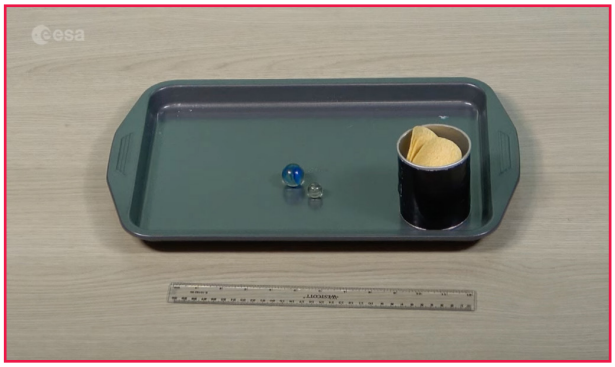




ACTIVITY 2 – HOW BIG ARE SPACE DEBRIS?

In this activity, the students will investigate how collisions with space debris can cause some materials to fracture into many pieces. You can watch the video of this activity here.

Equipment



- Marble
- Crisps
- Deep sided tray or box
- Ruler
- Activity sheet 2

Exercise

Instruct the students to set up their testing station. This should involve clearing an area in which to conduct the tests and placing newspaper sheets on the floor to minimise post-experiment clean-up. The groups should predict what they think will happen and why. They should try a couple of test drops before starting the investigation in order to decide on the most appropriate height of drop. Encourage them to think of a way of sorting or separating the fragments of crisp into three groups.

Instruct the students to drop the marble three times onto the same crisp. After each drop, the students should count according to size (<1cm, 1-5cm, >5cm) the number of pieces of crisp produced and record them. The students can choose their own method of recording or they may like to use the table provided on Activity sheet 2.

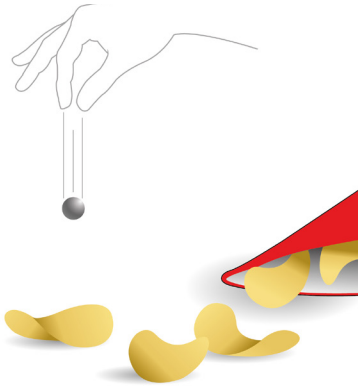


Table 1 shows example data collected from impact testing.

Number of pieces after each drop				
Drop from 25 cm	<1cm	1-5cm	>5cm	Total
1	2	2	1	5
2	10	2	1	13
3	13	3	1	17

Discussion

Display each group's drop test results and ask the class to compare them. Some points to consider in the discussion may include:

- *What did each group/the class notice? Is there a pattern in their results?*
- *What happens to the number of pieces as the number of impacts increases?*
- *Explain that the more collisions that take place, the more pieces of debris will be created. Furthermore, the more particles produced, the greater the risk of collisions.*
- *What advice would they give to the scientists and engineers designing satellites and spacecraft?*
- *What kind of materials do they think would be suitable? Why?*

Watch the first minute of this animation

Extension

The students could extend the impact tests by

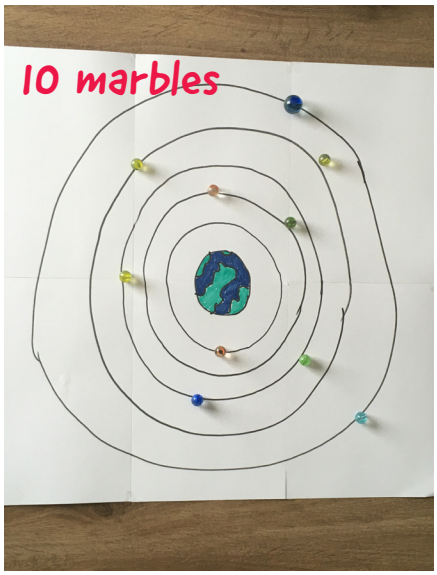
- changing the height of marble drop
- dropping the marbles from different heights could be linked to debris colliding at different speeds – the higher the marble is dropped from, the faster it will collide with the crisp.
- changing the mass of the marble
- using marbles which have different masses could be seen to represent lighter/heavier pieces of debris colliding with satellites.
- changing the material being tested
- using a different testing material could emphasise that some materials fracture more easily than others, therefore scientists need to be careful when choosing materials to build their satellites with.
- changing the number of layers of material or number of crisps
- using multiple layers of the testing material could be a good way of showing why layers are used in the engineering of satellites – what happens when they have a sturdier layer on top of a more fragile layer?
- designing a new way of impact testing
- scientists and engineers are always looking to test their designs in many different ways, as different tests can highlight different strengths/flaws.

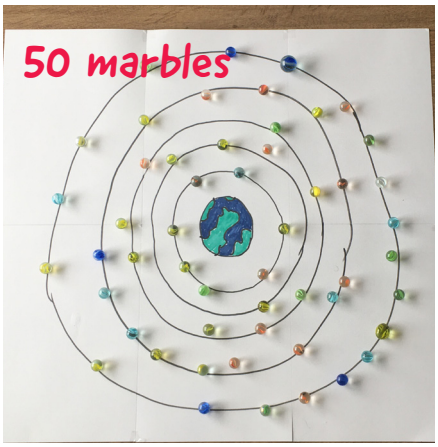
When investigating each of the above variables, students should consider how these changes could relate to space debris.

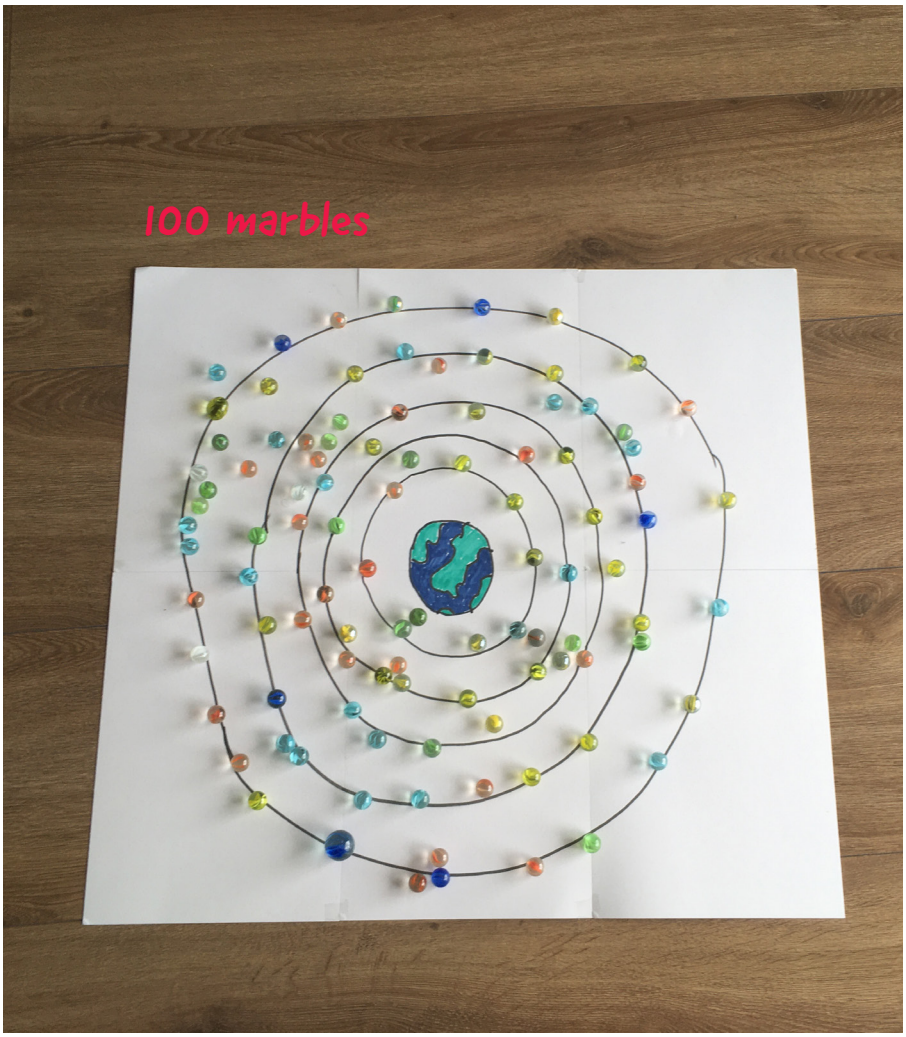
ACTIVITY 1

You will be rolling 'debris' (a marble) towards Earth to investigate chain-reaction collisions. Take before and after pictures for 3 impact tests: one with 10 marbles in orbit, one with 50 and one with 100 and add your results to the table below.

Note: *if you do not have enough marbles, adjust the numbers in the table and use what you have. Be aware that the difference in number of collisions will not be as obvious when using less marbles.*







Number of satellites (marbles) in orbit	Picture before	Picture after
10		
50		
100		

1. What do you notice about the amount of collisions compared to the number of satellites in orbit?

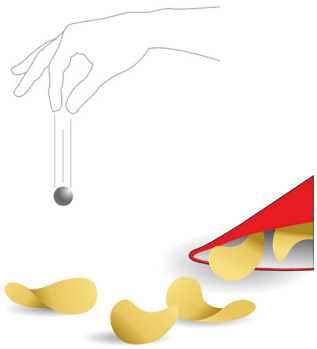
2. Use your knowledge from this activity to explain why space junk is a problem.

ACTIVITY SHEET 2

Drop a marble onto the same crisp three times. After each drop, count the number of pieces of each size. Record the results in the table below.

Number of pieces after each drop				
Drop from __ cm	<1cm	1-5cm	>5cm	Total
1				
2				
3				

1. Did you see a pattern in your results?



2. What conclusions can you make? Think about what happens to the number of pieces as the number of impacts increases.