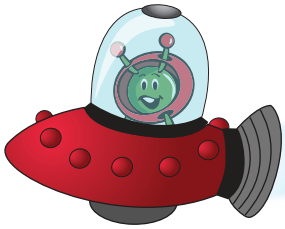
primary | PR53

esa Kids

teach with space

→ COMING BACK TO EARTH SAFELY

Teacher guide & student worksheets



TEACH WITH SPACE - Coming back to Earth safely | PR53
www.esa.int/education

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COMING BACK TO EARTH SAFELY

Fast facts

Subject: Science, Design Technology, Engineering, Maths

Age range: 7-11

Type: pupil activity

Complexity: moderate

Lesson time required: 2 hours and 15 minutes

Cost: Low- spinners widely available from internet suppliers

Location: classroom, playground or hall

Includes the use of: two bladed helicopter spinners and/or Frisbee style spinners

Curriculum area/keywords: Materials, forces, measures

Vocab: satellite, orbit, friction, air, area, re-entry, atmosphere

Brief description

In these activities, the students are introduced to the idea of controlled or uncontrolled re-entry for satellites. They are challenged to devise a way of reducing space debris by designing alterations to satellites so that they bring themselves back to Earth. In the first activity, the students pretend to be satellites in orbit and experience how increasing the surface area of an object moving in air can cause it to slow down. They go on to discuss and test their own ideas using spinning helicopter 'satellites', before deciding what could be packed in a satellite's 'backpack' and used for a controlled re-entry or slow down.

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

Learning objectives

Having completed these activities, students will now...

- Understand that drag is a type of friction that can exist between objects and air
- Understand that increasing the surface area of an object increases the amount of drag it experiences
- Understand that space debris such as satellites can be slowed down by drag, and this can be utilised for space debris removal techniques

Success Criteria

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

- Identify the effects of drag that acts between moving objects and air
- 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
- Give reasons for the particular uses of everyday materials, based on evidence from comparative tests

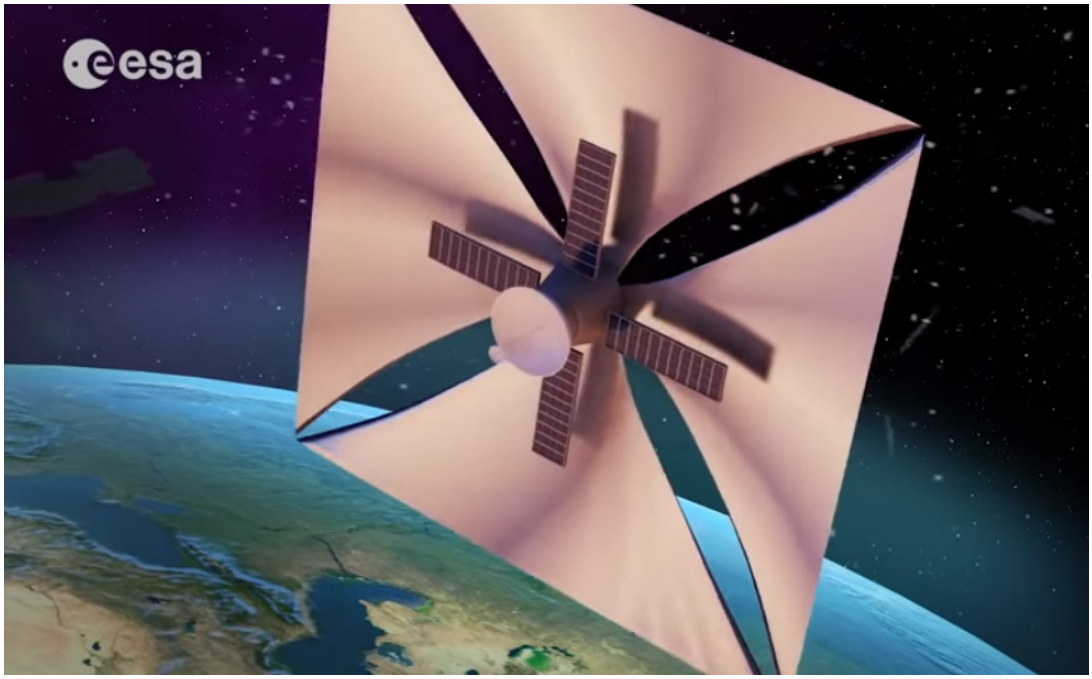
Summary of activities

Title	Description	Outcome	Requirements	Time
1.Satellite Slowdown!	Students pretend to be moving satellites and explore how increasing the surface area of an object moving in air can cause it to slow down.	Students will learn that drag is a type of friction that can exist between objects and air, and that increasing the surface area of an object increases the amount of drag it experiences.	None	45 mins
2.The satellite Backpack Challenge	Students will test ideas for slowing a spinning satellite and then decide what the satellite needs in its 'backpack' to deorbit.	Students will learn that space debris such as satellites can be slowed down by drag, and this can be utilised for Clean Space debris removal techniques.	None	1 hour

INTRODUCTION

The amount of space debris, or space 'junk', surrounding Earth 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 program is attempting not only to minimise the debris produced by future space missions, but to actively reduce the debris already in orbit. However, the Clean Space team intend active debris removal (where other vessels are sent to retrieve the debris) to be only a temporary solution to remove the satellites that are currently inactive in space; ideally, the permanent solution would be to design the satellites so that they fall towards Earth themselves, as this is much more sustainable then sending other vessels to retrieve the debris.

Debris that is orbiting the Earth needs to be slowed down so that Earth's gravity can pull it through the atmosphere. Drag – a type of friction that acts between moving objects and air – can be utilised to slow down debris. One of the methods, being used in a mission called Icarus-1, which is currently being tested, involves deployment of a drag sail to increase the surface area of a satellite at the end of its mission, slowing it down and causing it to burn up on re-entry. As the satellite moves away from the thin air that exists in Low Earth Orbit and towards the thicker air that humans breathe, the friction that the debris experiences rapidly increases, which leads to a large buildup of heat until eventually the debris starts to burn up.



ACTIVITY 1: SATELLITE SLOWDOWN!

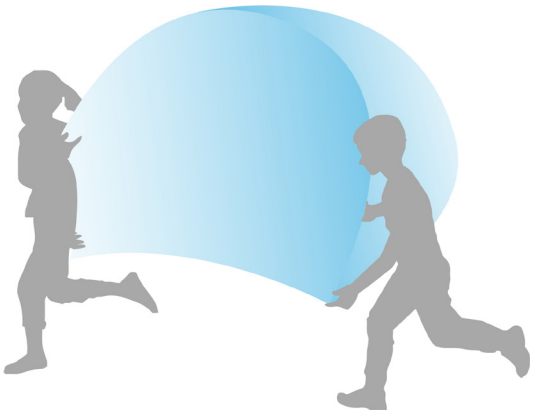
In this activity, students pretend to be moving satellites and explore how increasing the surface area of an object moving in air can cause it to slow down.

Equipment

- Bedsheets
- Paper (varying sizes - A5, A4, A3, A2)
- Umbrella

Exercise

Explain that the students are going to pretend to be satellites. Let the students investigate the effects of air resistance by running across the hall or playground. They should then try running whilst holding sheets of paper of various shapes and sizes at either side of them. They could even try running with a partner whilst holding a large bedsheet between them, or with an opened umbrella carried behind or in front of them.



Discussion

In class, lead a discussion about what the students learned from the activity:

- *What did they notice when they ran with increasingly large pieces of paper?*
- *How would they compare the paper, bedsheet, and umbrella in terms of how fast they were able to run?*

Increasing the surface area of objects causes them to move more slowly through air. This is because of something known as drag. Drag is a type of friction caused by air that creates resistance against movement, and the amount of drag a moving object experiences is related to the object's surface area.

ACTIVITY 2: THE SATELLITE BACKPACK CHALLENGE

In this activity, students pretend to be moving satellites and explore how increasing the surface area of an object moving in air can cause it to slow down. The video of this activity can be found here.

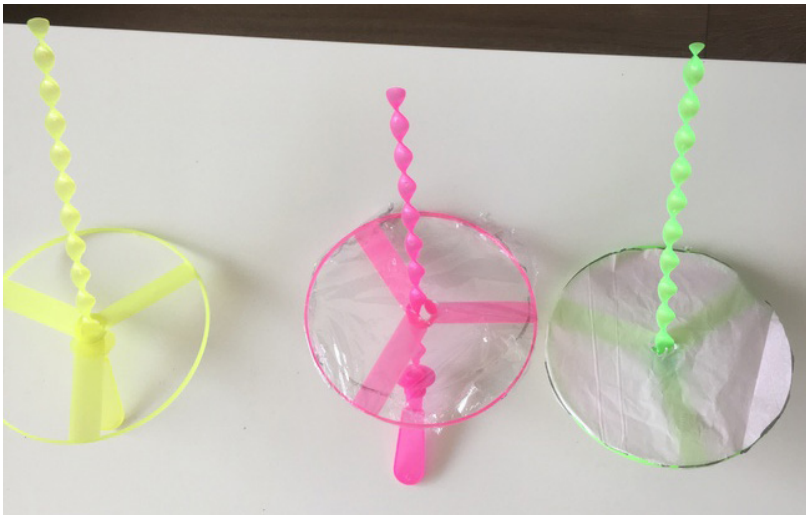
Equipment

- Plastic two bladed helicopter spinner and/or Frisbee style spinner
- Sugar paper
- Cling film
- Sticky tape
- Stopwatches

Exercise

Give each group a two bladed helicopter spinner and/or a Frisbee style spinner, which will be used to represent satellites in orbit around Earth.

The students should build 3 prototypes of spinners: One without additions, one sticking sugar paper on the surface, and one sticking cling film on the surface, as shown in the picture on the right. Note that It is very important to use very lightweight materials (cling film and sugar paper, and a minimal amount of film) to add on top of the spinners, otherwise they will become too heavy and this won't allow the spinners to stay in the air for long.



Outside or in a hall, the students should launch the spinners and record the flight times.

The groups might come up with their own method of recording the flight times, such as tables or charts, or use the format in Activity Sheet 2.

Once each group has at least 3 flight times recorded, get them to consider how they might slow down the spinners. They may wish to consider what they learned from Activity 1.

They should discuss ideas and may wish to draw their designs before trying to implement them. For the helicopter spinner, suggestions might include extending the length, width, angle or shape of the wings by attaching paper, balloons or other materials to the wings. For the Frisbee style spinner, they may wish to add materials between the propellers.

The groups should adapt their spinners, test them, and record the new flight times.

Discussion

Lead a discussion surrounding each groups' findings. Points to consider may include:

- *How can slowing down the spinner in this activity be related to to how satellites come back to Earth?*
- *Which ideas did they think worked well/not so well? Why?*
- *Using the results of their tests, what do they think we should put into the satellites' backpacks?*
- *What advice would they give to ESA?*

Conclusion

Adding materials to a spinner slows down how the speed at which they spin – this makes them fall back to Earth faster. Dragsails slow down the spinning of satellites around Earth, leaving more opportunity for Earth's gravity to attract those satellites and fall to Earth faster.

DID YOU KNOW?

ESA is testing many different ideas for slowing down satellites to bring them back to Earth, including dragsails. Using everyday materials to slow down the spinners works in a similar way to how dragsails would slow down debris. The materials increase the drag that the spinners experience, which mean they spend less time in the air and come quickly back to 'Earth'. For satellites, the dragsails are used to increase the drag they experience, slowing them down and allowing the Earth's gravity to pull them through the Earth's atmosphere, where they burn up as a result of friction.

Watch togetherr with the students the following **Paxi animation:**

STUDENT WORKSHEET

ACTIVITY 2: THE SATELLITE BACKPACK CHALLENGE

1. Launch your spinning 'satellite'. Time how long it stays in the air. Repeat twice. Add up the three results and divide by three to find the average (mean) spin time.

2. Then try a way of slowing your satellite. Time how long it stays in the air this time.

3. Find another way to slow the satellite and time how long it stays in the air.

Time spinner stays in the air (seconds)				
	Test 1	**Test 2**	**Test 3**	**Mean time**
1. Spinner without modification				
2. Spinner with cling film				
3. Spinner with sugar paper				

Which idea worked best to make the spinner spin more slowly (and therefore fall more quickly)?
What should Paxi pack in the satellite's backpack bring it back to Earth?
Using your knowledge from this experiment, how do you think dragsails would work to bring debris back to Earth?

Useful links

ESA resources:

ESA classroom resources: www.esa.int/Education/Classroom_resources
ESA Kids homepage: www.esa.int/kids

Extra notes on ESA space projects:

The following video link is an excellent demonstration of the sail developed by the University of Surrey, used to create drag during debris capture.

https://youtu.be/3DYYHiW6x44