ASTROEDU

Peer-reviewed Astronomy Education Activities

Investigating the Atmosphere – Air Takes Up Space

Let's explore if air takes up space even though you cannot see it.

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KEYWORDS

Geography, Earth, Mathematics, Air, Gas, Atmosphere

LOCATION

Small Indoor Setting (e.g. classroom)

AGE

6 - 10

LEVEL

Primary, Secondary

TIME

1h

GROUP

Group

SUPERVISED

Yes

COST

Low Cost

SKILLS

Asking questions, Planning and carrying out investigations, Analysing and interpreting data, Constructing explanations, Communicating information

TYPE OF LEARNING

Structured-inquiry learning, Modelling

GOALS

The goal is to understand that gas occupies space and relate it to real situations that prove it.

LEARNING OBJECTIVES

- Students experiment with syringes, balloons and water to become aware of and explore the concept of air.
- Students will be able to recognise that a gas, such as air, occupies space.

BACKGROUND

Air takes up space.

A layer of air, called the atmosphere, surrounds the Earth like a thick blanket. Plants and animals use the air in the atmosphere to survive.

Although the atmosphere extends far above the Earth's surface, most of the air is concentrated in the lowest 5 kilometres (3 miles). This is because gravity acts on the air, pulling it towards the Earth's surface.

The higher you go in the atmosphere, the thinner the air gets. This means that each breath contains less air (and therefore less oxygen), so mountain-climbers climbing a very high mountain find it harder to breathe the higher they go.

Air is made up of a variety of gases (mainly nitrogen and oxygen) and other particles.

Meteorites or spacecraft approaching the Earth at a high speed can explode when they reach the atmosphere. The force of the meteorites or spacecraft crashing into the blanket of air we call the atmosphere can release lots of heat.

Meteorites usually disintegrate and burn up when they crash into Earth's atmosphere (but some survive and made big dents on the Earth called craters). Obviously it would not be good for spacecraft (which can be travelling extremely fast, e.g. 28000 km/hour) to burn up when they re-enter the Earth's atmosphere, so various methods are used to prevent this, e.g. reducing their speed and using insulating materials.

FULL DESCRIPTION

Preparation

Accessing a video of a meteor exploding as it enters the atmosphere would be helpful, e.g. the Chelyabinsk Meteor which exploded over the Urals in Russia in February 2013. Download here or watch online at: https://goo.gl/xbFisl

Engaging/Trigger Questions:

Show the video of a meteorite exploding far up in the sky. Discuss why the meteorite travelled a long distance through outer space (a vacuum) without exploding, and why it did not wait to explode until it hit the Earth's surface (it hit the atmosphere). Ask the students to offer some possible explanations.

Other discussions could be based around air being necessary for us to breathe and stay alive; astronauts carrying oxygen with them into space. Can they think of other objects in which air is stored? (tyres of bikes and cars, bubbles, footballs).

Suggested trigger questions:

- Can you see air? Smell it/ feel it /taste it? (Probably not. But you can hear and feel moving air, e.g. on a windy day or near a fan. And you can see air if there are impurities in it? (e.g. dust in sunlight or smoke).
- If you take everything (i.e. all the people and all the objects) out of this room, what is left? (Nothing? Are you sure?).

Note: Students test out the following activities individually or in small groups. Students should discuss in small groups or write down what they think is happening in each activity.

Activity 1: Fill a Balloon with Air

Step 1:

Take a balloon and blow it up (i.e. fill it with air but do not let it explode).

Step 2:

Can you describe what is happening? (As the air enters the balloon from your lungs, it takes up space in the balloon. The balloon expands because the air inside needs more space).

Activity 2: Fill a Syringe with Air and Feel the Air Pushing

Step 1:

Pull the plunger of the syringe out towards you, then push it in again. Was this easy? What was happening inside the syringe? (The syringe was filled with air, which was pushed out again).

Step 2:

Pull the plunger again, and this time cover the other end of the syringe with your finger. Press down on the plunger. Was this easy? What did you feel? Can you explain what was happening inside the syringe? Was there any difference this time, and if so why? (It is easy to push the plunger a little, but gets difficult because the air trapped inside the syringe resists the plunger. The more compressed the air becomes, the harder it is to push the plunger).

Step 3:

Let the plunger go. What happens? (The plunger pops back and then stops). Why do you think this happens? (The air which was compressed in the syringe expands to its original state and pushes the plunger back out).

Activity 3: Controlling Movement with a Syringe Attached to Each End of Plastic Tubing.

Using 2 syringes of the same size:

Step 1:

Push the end of one syringe fully in, and attach the tubing to it.

Step 2:

Push the end of the other syringe only partially, and attach the tubing to it. (This is to make sure that the syringes are not pushed out of the tubing).

Step 3:

Predict what will happen to the other syringe when you push one syringe in and out? Now try and see! (The other syringe moves out).

Step 4:

Why does this happen? (The trapped air has the power to move things).

Step 5:

Can you compare how much both the syringes moved? (Approximately the same).

Step 6:

Repeat the above activity using two different sized syringes.

Step 7:

Do you think the syringes will move the same distance this time? Try and see! What do you notice? Is there any connection between the size of the syringes and the distances they move? (A small syringe pushes a bigger syringe by a small distance. A large syringe can push a small syringe by a much greater distance).

Activity 4: Fill a Straw with Water from the Top

Block up the bottom of a narrow straw with a piece of Blu tack. Then fill the straw with water from the top, using a pipette. Was this difficult? If so, why do you think it was not easy? (Air got in the way). Slowly release the Blu tack. What happens and why? (The water moves down, because the air escapes).

Activity 5: Dry Tissue under Water

Step 1:

Crumple up some tissues into a ball and push them tightly into the bottom of a cup, so that they do not fall out when the cup is turned upside down. (A few tissues tightly packed are less likely to fall out than one tissue). Predict what will happen to the water and tissue when you turn the cup upside down in the water.

Step 2:

Now turn the cup upside down and place it in water contained in a bowl. Take it out and feel the tissue. What do you notice? Why do you think the tissue did not get wet? (Air prevented the water from going up into the cup).

Step 3:

Discuss where air pockets can occur: in water pipes, capsized canoes, central heating radiators, etc.

Step 4:

- Discuss what a vacuum is.
- What do you call the layer of air surrounding the Earth? (The atmosphere).
- What happens when things crash into the atmosphere? (Discussion could include the heat caused by friction. Students can rub or clap their hands – what do they feel? Planes catch fire when they crash because of the intense heat).
- Think of spacecraft returning to the Earth at a high speed after a mission in Space, what do they encounter first? (Air, i.e. the atmosphere). What you think it has to do? (Slow down). Otherwise what would happen? (It would break and burn up).
- How do you think a spacecraft can be prevented from burning up? (It is covered in insulating materials, and also it slows down).

Safety: In Activity 3, always use sterile syringes that have not been used for medical purposes. Be careful with the sizes of syringes – a big syringe could push out a small syringe with great force.

Maths: Display these questions for the students to answer.

1) Air is a mixture of gases that consists of carbon dioxide, argon and very small amounts of other gases.

- Approximately what percentage of the air consists of (i) nitrogen and (ii) oxygen?
- What is the approximate ratio of nitrogen to oxygen in the air?
- Can you convert the three percentages above to decimals?

2) In Activity 3, use two different-sized syringes connected by tubing, calculate the ratio of the sizes of syringes. Then measure the distances that the two syringes moved.

- Is there any connection between these two ratios?
- Investigate which combination of syringes gives the greatest movement.

Analysis/Conclusion: Air takes up space (even though you cannot see it).

Follow-up activity: Filling a Bottle Using a Funnel

Step 1:

Put the funnel into the mouth of the bottle and ask the students to predict what will happen when they pour water into the funnel.

Step 2:

Ask them to pour water into the funnel and observe what happens (The water fills the bottle).

Step 3:

Now, secure the funnel to the bottle such that there is no space between the two. **THIS SPACE MUST BE TOTALLY AIRTIGHT.** The students again predict what will happen when they pour water into the funnel. They then pour water into the funnel.

Note: It can be difficult to get an airtight seal. A rubber O-ring, available in DIY stores, placed around the neck of the funnel and then pressing down on the funnel by hand can produce a good seal. Tape, well-sealed, may work also).

Step 4:

Observe what happens. What do you see? What do you hear? Why was it hard for the water to enter? (Air inside the bottle got in the way). What else do you notice? (In case of a fully airtight seal, no water will enter the bottle because the air gets in the way and cannot escape. If there is a slight air leak, there is a glug-glug sound of some water getting in while bubbles of air escape).

Students Can:

- Find out more about central heating radiators not giving out much heat because of air getting trapped in them – 'air locks', and how this air is released.
- Explore the five different layers which make up the atmosphere – find out their names, and at what approximate level you will find clouds, aeroplanes, the ozone layer, satellites, the International Space Station, etc. See the additional information section for links.

Did You Know?

In October 2014 Space X Dragon Spacecraft, returning to the Earth carrying a cargo of biological samples (including plants grown in space) from the International Space Station, produced intense heat as it entered the atmosphere. The temperature was nearly 3000º Fahrenheit (1649ºCelsius). It was protected from burning by a very strong heat shield.

Image credit: NASA/SpaceX

On Monday, 19 January 2015 an amateur photographer captured a fireball over Dalkey Island, south Co. Dublin. (Photo in Irish Examiner on Tues 20 January 2015).

“It is definitely a fireball or bright meteor,” confirmed David Moore the editor of the Astronomy Ireland magazine. “These objects come through the atmosphere at 70,000mph, burning up as they enter and are extremely rare to photograph.”

A fisherman survived 60 hours in an air pocket under an upturned boat which capsized off the coast of Nigeria in May 2013.

EVALUATION

At each step of the activity, students are encouraged to answer questions and discuss their hypothesis with the teacher. Afterwards, discuss with the class what happened in each activity. What explanations do the students offer? Do they discuss the movement and pushing of air appropriately? Conclude that air takes up space, even though we cannot see it.

CURRICULUM

Country	Level	Subject	Exam board	Section
UK	KS2: Year 5	Science	-	Forces: Identify the effects of air resistance, water resistance and friction that act between moving surfaces. Explain that unsupported objects fall towards the Earth because of the force of gravity acting between the Earth and the falling object.
UK	KS2: Year 4	Science	-	States of matter: compare and group materials together, according to whether they are solids, liquids or gases.
UK	KS1	Science	-	Working scientifically: performing simple tests, using their observations and ideas to suggest answers to questions.

ADDITIONAL INFORMATION

- An activity to discover the different layers of the Earth's atmosphere: How high is the sky? http://astroedu.iau.org/activities/how-high-is-the-sky/
- Air and Water power http://www.primaryscience.ie/media/pdfs/col/dpsm_class_activity_air_water.pdf
- For a meteor entering the Earth's atmosphere above the UK, see www.esero.org.uk/news/meteor-fireball-seen-across-the-uk
- For more about the layers which make up the atmosphere see www.ducksters.com/science/atmosphere.php
- For a more detailed investigation on the ' Dry Tissue Under Water' activity see the NASA (National Aeronautics and Space Administration of the USA) 'Aeronautics Educator's Guide': http://www.nasa.gov/pdf/205704main_Dunked_Napkin.pdf

CONCLUSION

In this activity, students investigate different scenarios, which show that a gas occupies space and learn about what happens when objects hit the atmosphere. The activity can be followed by lessons about the atmosphere and its different layers or activities about greenhouse gases.

CITATION

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