Teacher notes – KS2 Science Gliding into the Stratosphere

This unit builds students' ability to work scientifically, investigating the fact that air has weight which creates air pressure. The class will carry out practical demonstrations of this and learn how this practically affects pilots and other people climbing to height.
National curriculum areas addressed include:

- comparative and fair tests, observations, taking measurements.
- Mass, gravitational force and weight.

Introduction

Note – this unit consists of two separate activities. Each takes around 40 minutes, and they can be done separately or together to fit your timetable. You might also want to show one of the optional Role Model videos – see the STEM resources page.

Before starting the video, elicit experiences from the class. Does anyone know anything about gliding? Has anyone been gliding? Seen a glider in the air? Are there any gliding sites local to the school? The video starts with some general gliding footage. Pause the video to discuss how high, far and fast students think gliders will go. Run the video for answers and pause at 'over to you'

Student activity

Students follow the procedure in the student notes below to demonstrate that air has weight. If you don't have a balance that can weigh grammes to 2 decimal places, omit experiment 1.i. The inflated balloons weigh more than the uninflated balloons – in fact because they contain air at slightly higher pressure inside than the surrounding air.

Air has mass and gravitational force gives it weight. Once the students have established this, in the second part of the session they should observe that:

- a taller column of water gives higher pressure, the jet at the bottom squirts out the furthest
- as water runs out and the head of water decreases, the water jets weaken.

The air above our heads acts the same way as the water in the drinks bottles.

INFORMATION

HIGH FLYERS:
Air pressure 5km up is half what it is at sea level**.** Aircraft flying above 4,000m need additional oxygen for the pilots and passengers to breathe. Commercial jets do this by pressurising the cabin – to a level of around 2000m as sea level would be prohibitively heavy/expensive. Glider pilots flying high use personal oxygen systems, either a mask or a 'cannula' that delivers oxygen straight into the nostrils. As you go higher, unpressurised systems won't deliver enough oxygen and so the Perlan glider – like commercial jets - has a pressurised cockpit.

FUN FACT: air pressure officially gets to 0 at what's known as the Kármán line which is 100km above the earth – but in practice above 30km you have to hunt quite hard to find any!

PERLAN PROJECT: Perlan set a height record climbing to 23,195m in September 2018. See more at: https://perlanproject.org/

GO GLIDING:
With around 80 sites from the Highlands of Scotland to the south west tip of England, wherever you live you'll never be far from a gliding club. You can find your closest gliding club on the BGA website www.gliding.co.uk

AWESOME FACT: after completing your training, you can fly a glider solo at age 14!

Post experiment activity

Use similes to help students understand this – for example, imagine all the class lay down on top of each other – the person at the bottom would be the most squashed, ie under the most pressure, but the person on top feels no additional pressure.

Discuss what students know about there being less air at height – for example:

- Have they flown on holiday in a jet and heard the safety warning about oxygen masks in the event of cabin pressure loss? Did their ears pop while climbing or descending?
- Do they know people use oxygen to climb Mt Everest?
- Have they been high up in the mountains and found themselves puffed out?

Then resume the video for the final section which includes a chart showing the reduction in air pressure with height. Most people have heard of the stratosphere, but many do not know that it is the layer above the troposphere. The troposphere goes from ground level to around 12km - 9km at the poles and 16km at the equator - and is where nearly all our weather happens as it is the layer containing water vapour.

Q: How on earth (above earth!) does a glider get up to space?

To stay airborne, a glider pilot needs to find rising air to climb in and there are three main options for this. At low level up to ~3,000m/10,000', gliders generally use 'thermals', convective air currents driven by the sun's heating, or 'ridge lift', created when the wind blows onto a hill and rises over it. To climb really high, such as with Perlan, pilots use 'wave lift'. When air rises over a hill and then sinks back down, it creates ripples in the air above, and in the right conditions these propagate up many thousand meters. You may have seen something similar in a stream or river where it flows over a submerged obstacle – you often see stationary waves on the top surface downstream of the obstacle. Perlan is exploring the limits of this type of lift – at a height where there's hardly enough air to keep a wing flying! – and pushing back the boundaries of both unpowered flight and meteorological research.

Students can find out all about gliding at the British Gliding Association website www.gliding.co.uk and the Junior Gliding and Women Gliding communities at the links below. There's information about flying with and without an engine and all types of aviation at https://stem.caa.co.uk/ & www.airleague.co.uk – aviation is not just about being a pilot! The CAA STEM site is particularly good, showcasing the breadth of aviation and associated careers.

We hope you found this useful and a fun way to encourage young people into the world of STEM and aviation. Girls in particular are under-represented in these areas and we are working to change this. Inspire them with videos of our STEM role models along with other exciting gliding-based STEM resources covering various elements of the National Curriculum on gogliding.uk and at www.gliding.co.uk/STEM. You can contact the Go Gliding team at gogliding@gliding.co.uk.

Student notes are shown overleaf.

Gliding into the Stratosphere

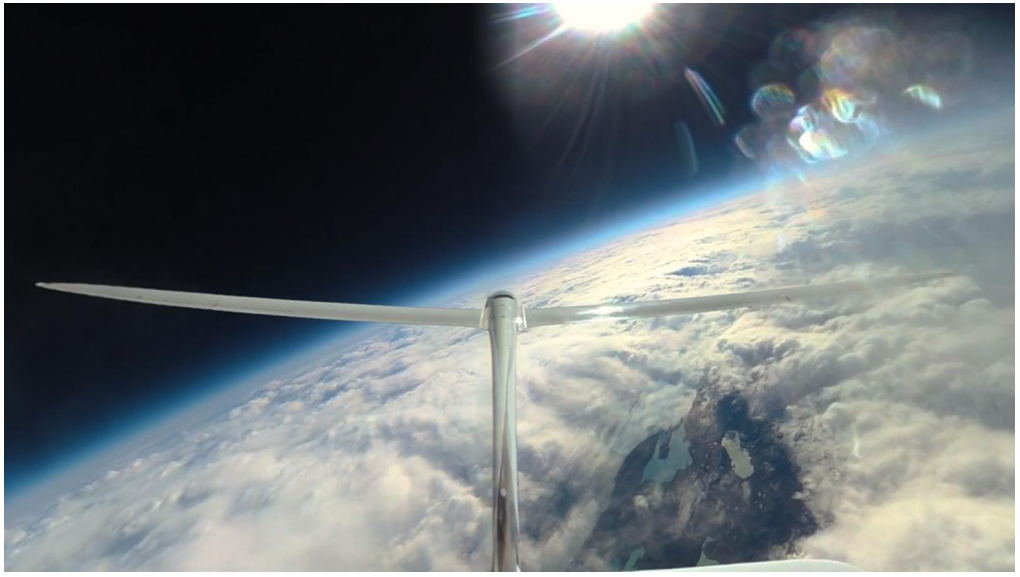
Do you know about gliding?

Do you know what a glider can do? It's an awesome way to fly, and glider pilots fly hundreds of kilometres at high speed, and climb higher than airliners just using renewable energy from the sun and the wind.

Your challenge: to show that air has weight which creates air pressure, and to learn what this means for pilots flying high.

What you need:

- Balloons, string, pins and a bamboo cane or similar rod around 60cm long. Optionally an accurate electronic balance/scales.
- A clear 2l plastic drinks bottle with the top cut off and a skewer, knitting needle or similar to make small holes in the drinks bottle
- Water… AND… a sink or washing up bowl to contain the water!!



Experiment 1 – demonstrate that air has weight

How might you measure the weight of air?

1. Weigh the balloon. Inflate the balloon and weigh it on the accurate scales. POP the balloon and reweigh it to confirm empty weight.
2. Rod balance method
    a. Pick two balloons roughly the same size and shape and inflate them both to the same size. Create a balance apparatus by attaching them to each end of a balance rod and suspend the rod with string in the centre so that it is balanced nicely. Use a stand if you have one, otherwise attach it beneath a table top or just hold the string steady.
    b. Pop one of the balloons!! – Observe and record what happens. Check that the popped balloon is all in one piece, and if not, balance any exploded bits back on the apparatus. Does it still balance?

What happened……

Why do you think that happened?……

Experiment 2 – show that air pressure decreases with height

Look up! There's a lot of air overhead – this is the **earth's atmosphere**. Now we know that air has weight, we can demonstrate that the more air overhead, the greater the weight and higher the pressure it causes on the earth. Because we don't have a glider in the classroom, and we can't run up the nearest mountain, we'll use water and a drinks bottle to show this. Liquids, for example water, work the same way as gases to create pressure as they both flow freely.

1. Cut the top off the drinks bottle. Using the skewer, make a hole 2cm above the base and further holes at 5cm intervals above this. Make sure all the holes are the same size. Ask if you need help to do this – some bottles are easy, some more difficult!!
2. Put a piece of sticky tape over the holes with a tag on the end so that you can easily peel it off later.
3. Put your bottle in the sink or somewhere to contain the water that flows out. Fill the bottle with water to just below the top.
4. Remove the sticky tape and observe what happens. How far is the water squirted out of each hole? Does this change over time?

Record what happened:

……

……

……

Gliding into the Stratosphere

Discuss your results with your teacher and then watch the video to see what this means in practice for pilots who want to fly high! Can you think of other ways that you could maintain enough oxygen to breathe as you get higher? List them here:

……

We hope you had fun demonstrating that air has weight and creates air pressure!
Find out more about GLIDING at the addresses below and all types of AVIATION at www.airleague.co.uk & www.careersinaerospace.com
We hope to see you on an airfield soon!