Forces at work: Drag and lift

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Educator notes

Learning objectives

- Understanding the names of the forces that act on an object as it moves through air and water
- Explaining the effects of lift and drag on an object at different angles
- Showing lift and drag in one dimension using arrows

This lesson builds on the learning from two other modules on forces: **Friction and grip** and **Bounce**. If you haven't delivered those modules yet, and your students haven't had any other lessons on those forces this activity may be quite challenging, though definitions of all these forces are included.

Curriculum links

- Science (Physics)
  - Motion and forces
  - Working scientifically

Equipment needed

- Electric fans*
- Scales*
- Pieces of card
- Clamp stands
- Protractor

* Each group will need a fan and set of scales, unless you choose to run this as a demonstration

Resources required

- Drag and lift slides
- Measuring lift student sheet

Time needed: 40 minutes

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Slide 1
Forces at work: Drag and lift

- Explain to students that they're going to think about the science that affects the movement of all things, forces, by finding out a bit more about where they exist in the world around us

Slide 2
Starter activity

- Ask students to think about what they can feel when they put their hand out the window of a moving car
- Encourage them to consider even though you can't see the air, it has substance and pushes against your hand in more than one direction
- Further discuss how the force created by fast flowing air has two parts – lift and drag

Slide 3 and 4
Introducing drag and lift

- Tell students there are also forces working on objects as they move through air, caused by the air itself
- Move to **Slide 4** and ask students if they think pilots would rather take off in a headwind, or tailwind?
- Explain that the answer is in fact headwind, because the headwind provides more lift, which means taking off is easier in these conditions as they need less speed and a shorter runway
- Lift is one of the forces caused by the air itself. Objects, from planes to people, experience lift, and a similar force known as drag, whenever they move through gases and liquids, like air or water

Slide 5
Defining drag and lift

- Share the definitions of drag and lift with the class
- Explain that drag pushes in the same direction as the airflow (like wind), whilst lift pushes at right angles to the airflow

Slide 6
Direction of the forces

- Refer to the starter activity, which discussed how planes actually take off more easily when flying into a headwind due to the lift force it creates
- Further explain that once a plane is no longer gaining altitude (getting higher in the sky), headwind slows it down because it creates more drag, rather than lift
- Ask students to volunteer the labels for each of the arrows on the slide

Slide 7
Which direction are the forces acting in?

- Show the answers so students can check if they're correct

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Slide 8
Introducing downforce

- Explain that when an object is angled downwards into a headwind, the opposite of a plane taking off, the object will experience a force called negative lift, or downforce
- Downforce is a combination of air resistance and gravity, which students should know pulls things towards the Earth
- Explain that the 'wing' at the front of a Formula 1™ car is designed specifically to increase the downforce, helping the car stay on the road at high speed (under high winds)

Slide 9 and 10
Measuring lift

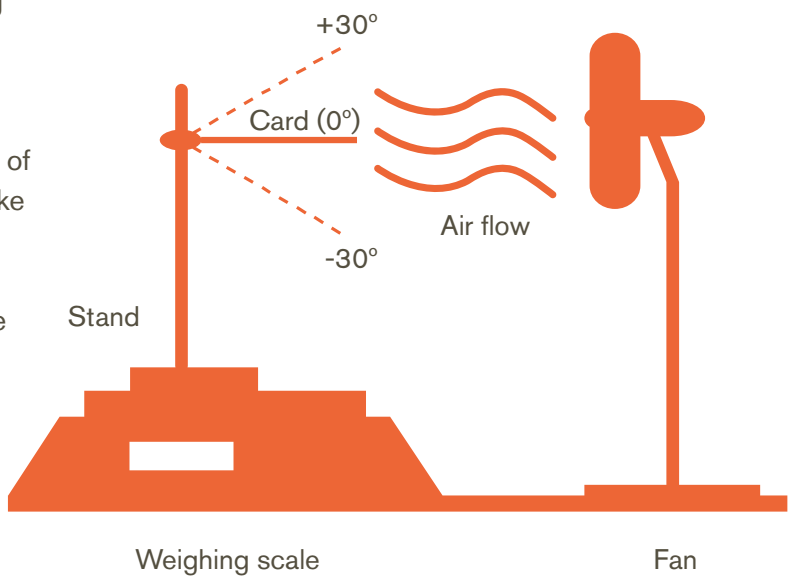
- Tell the class they will now run an experiment to measure lift

Activity 1
Measuring lift

25 mins

1. Divide students into groups based on the number of fans and scales you have access to and distribute the **Measuring lift student sheet**
2. If you don't have access to multiple fans, you can run this as a demonstration, getting students to help at points and completing the experiment as a class
3. A diagram of the setup is also on **Slide 10**
4. Make sure to remind students the unit forces are measured in newtons
5. The class should measure the dimensions of the card and calculate the surface area by multiplying these together
6. Groups or volunteers should set up the clamp stand, card and fan as shown below
7. Before switching the fan on, students take a note of the mass of the stand and card in grams, and make sure that the card is horizontal (level)
8. Next, switch the fan to its lowest setting, move it to a sensible distance so the reading on the scale changes but the card isn't bending or flapping too much
9. Wait until the reading on the scales has settled and record it, then calculate the change in weight and convert into newtons (N), using the equation on the **Measuring lift student sheet**

_____ kg x 9.81 = _____ N



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Activity 1

Measuring lift Continued…

10. Then repeat the test with the fan on its highest setting
11. Next, the protractor should be used to adjust the card so that it is sloping upwards by approximately 30° and repeat steps 4-6
12. Then adjust the card to slope downwards by about 30° and repeat steps 4-6
13. Time permitting, students should repeat steps 1-8 with a differently sized piece of card

Discussion and quiz

- The following questions will encourage the students to think about the forces that have impacted their results and are on the **Measuring lift student sheet**. The questions with their answers are below for your reference
- There is also space for additional answers on the **Measuring lift student sheet**, as some of the questions are optional. Add them if suitable

Q: What effect do you think a greater angle of the card would have on lift?

A greater angle creates more lift, or more downforce (negative lift) if the card is angled towards the ground.

Q: What effect does the wind speed have on lift?

A higher speed creates more lift.

Q: Can you explain how ski jumpers can actually travel further if they jump into a headwind?

A ski jumper angles their skis upwards in order to create lift, rather than drag. A stronger headwind will generate more lift.

If students completed the activity with more than one size of card, ask them this additional question which they can answer in the spare space on their sheet.

Q: What effect does the surface area of the card have on lift?

A larger card will gain more lift, when compared to a smaller card experiencing the same wind speed.

If students have already completed the **Friction and grip module**, you can also ask them this additional question:

Q: We know that Formula 1™ cars have an upside down "wing" at the front to improve wheel grip (traction). How does that work?

The wing experiences negative lift, or downforce. This increases the weight pushing down on the tyres, in turn creating more friction between the tyres and the ground and therefore more grip. This helps them stay on the road.

Try next: This is one of three GSK STEM Education modules on Forces at work. The others look at **Friction and grip and Bounce** in more detail, as well as practising scientific skills.