Autumn Block 1

Forces

White Rose SCIENCE

Small steps

Step 1	Friction
Step 2	Air resistance
Step 3	Plan – parachute experiment
Step 4	Investigate – parachute experiment
Step 5	Evaluate – parachute experiment
Step 6	Plan – water resistance
Step 7	Investigate – water resistance
Step 8	Explore gravity
Step 9	Use small forces for greater effects

Key resources

Step 1 – Friction

- Modelling clay
- Piece of wood to use as a ramp
- Block of wood
- Ice cubes

Step 2 – Air resistance

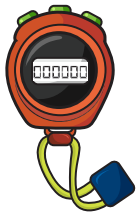
- Pieces of A4 paper

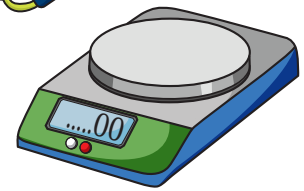
Step 3 – Plan – Parachute experiment

- Plastic bags
- Scissors
- Pieces of string 30cm each
- Ruler
- Metre stick
- Stopwatch
- Scales
- Modelling clay to attach to the strings

Step 4 – Investigate – Parachute experiment

- Plastic bags
- Scissors
- Pieces of string 30cm each
- Ruler
- Metre stick
- Stopwatch
- Scales
- Modelling clay to attach to the strings





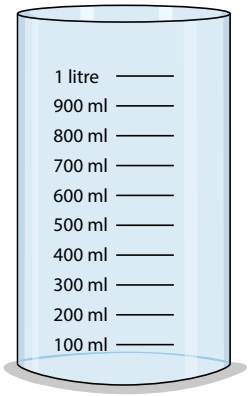
Step 5 – Evaluate – Parachute experiment

- Cupcake cases
- Paper to make paper aeroplanes and paper helicopters
- Sycamore seeds
- Pictures of aircraft over time, such as biplanes and fighter jets

Key resources

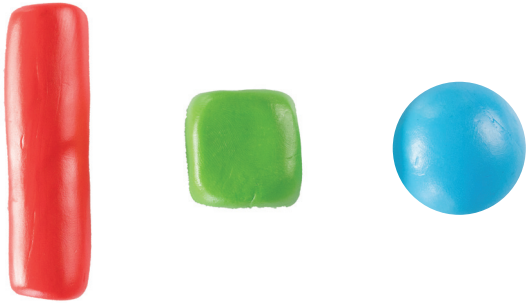
Step 6 – Plan - Water resistance

- Tall measuring cylinder
- Scales
- Water
- Modelling clay
- Stopwatch
- Ruler



Step 7 – Investigate water resistance

- Tall measuring cylinder
- Scales
- Water
- Modelling clay
- Stopwatch
- Ruler

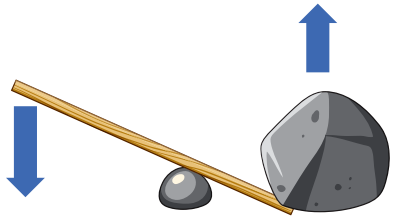


Step 8 – Gravity

- Modelling clay or plasticine
- Scales
- Metre ruler

Step 9 – Use small forces for greater effects

- Tin of paint
- Two pence piece
- Screwdriver



Friction

Notes and guidance

In Year 3, children were introduced to the concept of forces and explored friction. Children should know that friction is a contact force between two surfaces that are trying to move across each other.

In this small step, children recap what friction is and look at the effects of friction. They should understand that friction always works in the opposite direction to that in which the object is moving.

Children also explore how friction is useful in everyday life including real-life examples, such as car tyres and the brakes on a bicycle wheel.

Key questions

- What is meant by a force?
- What is meant by a contact force?
- What is friction?
- How is friction caused?
- What are some examples of where friction occurs?
- How can friction help us?
- What happens when two sticks are rubbed together?
- Does friction only occur between rough surfaces?

  Explain how you know.

Things to look out for

- Children may think friction only occurs when two surfaces are moving. Clarify that friction occurs even when the two surfaces are not moving.
- They may think that friction only occurs between rough surfaces. It also occurs between smooth surfaces such as glass.

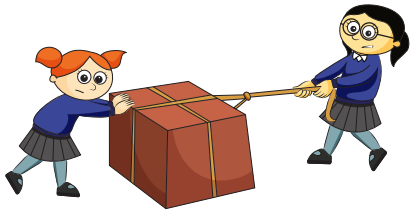
National curriculum links

- Identify the effects of air resistance, water resistance and friction that act between moving surfaces.
- **Working scientifically** – Use relevant scientific language and illustrations to discuss, communicate and justify their scientific ideas (non-statutory).

Friction

Key vocabulary

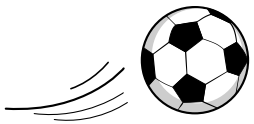
- **Force** – Pushes and pulls in a certain direction. A force can change the speed or shape of an object.



- **Contact force** – A force between two objects that are touching each other.

- **Friction** – The contact force between two surfaces that are touching each other.

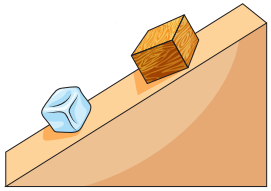
- **Motion** – The process of an object moving in a certain direction.



Practical ideas

- Put a piece of ice and a piece of wood on a ramp. Tilt the ramp until the two objects move.

  Get the children to discuss why the ice moves first.



- Use a bicycle that is turned upside-down.

  Carefully spin one of the wheels and watch what happens.

  Repeat but this time apply the brakes.

  Ask the children what they notice about the two investigations.

Factual knowledge

- Friction can stop or slow down a moving object.
- A stationary object will only move when the force applied is greater than the friction, which acts in the opposite direction to the movement.
- Friction produces heat, which we feel when we rub our hands together.
- Friction can cause some materials to wear away, such as pencils.
- Friction has many useful applications, such as in vehicle brakes, using sandpaper and walking on firm ground.

Air resistance

Notes and guidance

In this small step, children build on their knowledge of friction to look at air resistance. Children learn that air resistance is a type of friction that occurs between air and another material.

The effects and benefits of air resistance in everyday life will also be covered. Children learn how the amount of air resistance is affected by the size and shape of an object and how this is used to help us design objects.

It is important that children are shown a wide range of real-life examples of air resistance, such as trains and aeroplanes, to ensure they do not form a misconception that air resistance only occurs when something is falling in a downward motion.

Key questions

- What is air resistance?
- What does air resistance do to moving objects?
- Why is air resistance a friction force?
- What happens when a skydiver opens their parachute?
- How are aeroplanes and trains designed to reduce air resistance?
- Why is it important for trains and aeroplanes to reduce air resistance when travelling at speed?
- How does speed affect the amount of air resistance?

Things to look out for

- Children may think that because forces are invisible, they do not cause changes in objects. As air resistance is a force, it can also change an object's speed, shape or direction.
- Children may believe that no air resistance is acting on an object if the object is travelling at the same speed in a straight line.

National curriculum links

- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – Recognise which secondary sources will be most useful to research their ideas (non-statutory).

Air resistance

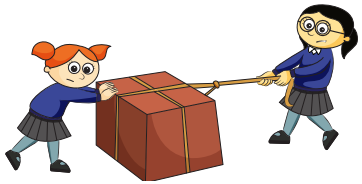
Key vocabulary

- **Air resistance** – A type of friction between air and another object.

- **Drag** – Another word used as an alternative to air resistance.

- **Parachute** – An object that slows a skydiver down.

- **Force** – Pushes and pulls in a certain direction. A force can change the speed or shape of an object.



Practical ideas

- Give the children two pieces of paper.

  Ask them to fold one piece very small and leave the other piece large.

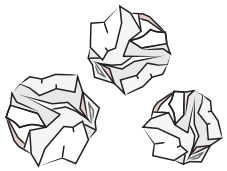
  Ask children to move the two pieces through the air and note down their findings.

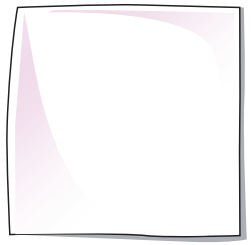
- Get two pieces of A4 paper.

  Scrunch one up into a ball and keep one flat.

  Ask the children what they think will happen when they are dropped.

  Explain this in terms of air resistance.





Factual knowledge

- Air resistance is a friction force between the air and a moving object.
- Air resistance is greater when the surface area of the moving object is large.
- Parachutes have a large surface area, so they have a greater air resistance and slow the skydiver down.
- Air resistance increases with speed.

Plan – parachute experiment

Notes and guidance

Over the next three steps, children carry out a fair test to investigate whether the surface area of a parachute affects the time it takes to fall to the ground.

In this small step, children plan their parachute experiment, make predictions and identify variables. It is essential that they identify the experiment equipment and explain why it is used.

When planning, children use the terms "dependent" and "independent variable" for the first time. These are defined in the key vocabulary for guidance. Children also need to know which variables need to be controlled and why.

Things to look out for

- When planning the investigation, children may confuse the variables.
- Children may need extra support when identifying the equipment that is most suitable to use in their experiment.
- Children may need to recap how to use a stopwatch to record time accurately.

Key questions

- How will the parachute be designed?
- What materials and equipment are needed?
- Which variable will you change (the independent variable)?
- Which variable will you measure (the dependent variable)?
- Which variables will you keep the same (the control variables)?
- Make a prediction. What do you think will happen?

Enquiry question

- Does the surface area of a parachute affect how long it takes for it to fall to the ground?

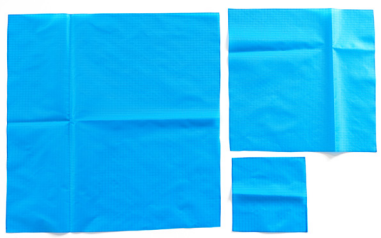
National curriculum links

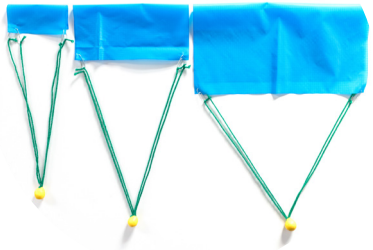
- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary.

Plan – parachute experiment

Experiment variables

- **Independent variable** (what will change) – The surface area of the parachute.





- **Dependent variable** (what will be measured) – The time taken for the parachute to fall to the ground.

- **Controlled variables** (what is kept the same) – The material that the three parachutes are made from, the object that is attached to both parachutes, and the height that the parachutes are dropped from.

Experiment information

Equipment needed

- Plastic bags
- Scissors
- 12 pieces of string 30 cm each
- Ruler
- 12 paper clips
- Stopwatch
- Scales
- Modelling clay to attach to the strings

Practical activity

- Put children in small groups.

  Give each group the equipment needed for the experiment.

  Children should identify what the equipment is and why it is used within the experiment.

Planning sentence stems

- I predict that ...
- I think this will happen because ...
- The independent/dependent variable will be ...
- The controlled variables will be ...

Investigate – parachute experiment

Notes and guidance

In this small step, children carry out the parachute investigation. To get valid results, at least three different surface areas for the parachutes should be used.

When timing the parachute drops, children should record time using decimals as using whole seconds would not give accurate enough results to make a comparison. Children should drop the parachute from the highest point they can without compromising safety. This makes it easier for them to record the time it takes for the parachute to fall to the ground.

Things to look out for

- Children might think that it is wind acting on the parachute that slows it down rather than air resistance.
- Children may not know how to use the stopwatch correctly in terms of start, stop and resetting to zero. Ensure that children practise this before starting the investigation.
- Make sure that the parachute is spread out fully before dropping it.
- Careful consideration must be given to the type of object that is attached to the parachute. If it is too heavy, it will drop too fast to time.

Key questions

- What is your prediction?
- What do you think will happen in the investigation? Why?
- Why is it important to drop the parachutes from the same height?
- How will the results from the investigation be recorded?
- How will the results from the investigation be reliable?

Enquiry question

- Does the surface area of a parachute affect how long it takes for it to fall to the ground?

National curriculum links

- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate.

Investigate – parachute experiment

Key vocabulary

- **Air resistance** – A type of friction between air and another object.

- **Streamline** – Having a shape that has little resistance to a flow of air or water.

- **Repeatability** – The likelihood of getting similar results if the experiment is carried out again.

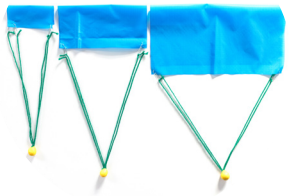
Parachute length (cm)	Time taken in seconds		
	Attempt 1	Attempt 2	Attempt 3
10	0.5	0.3	0.6
20	1	1.1	1.1
30	1.3	1.5	1.2

- **Precision** – All of the measurements obtained in an experiment are close to each other.

Experiment information

Equipment needed

- Plastic bags
- Scissors
- 12 pieces of string 30 cm each
- Ruler
- 12 paper clips
- Stopwatch
- Scales
- Modelling clay to attach to the strings



Method

1. Cut 3 squares from a plastic bag.

   10 cm × 10 cm 20 cm × 20 cm 30 cm × 30 cm

2. Cut 12 pieces of string (30 cm).
3. Measure the mass of the modelling clay so there are 3 equal masses and shape into spheres.
4. Tie one piece of string to each paperclip.
5. Pierce the paperclips through each corner of the parachute.
6. Attach the 4 pieces of string to the modelling clay sphere.
7. Repeat this process to create the second and third parachute.
8. Measure the height that the parachute will be dropped from.
9. Drop the first parachute from the chosen height and measure the time taken for it to hit the ground. Repeat this with the second and third parachute.

Evaluate – parachute experiment

Notes and guidance

In this small step, children look at the results from the parachute investigation in Step 4. Children evaluate and suggest improvements for their experiment.

Children should determine that the greater the surface area of the parachute, the more air resistance acts on the parachute and hence the longer it takes to reach the ground.

There are a variety of ways to extend the investigation. Extending an investigation is not about doing more repeats, it is about doing something different, such as dropping the parachute from different heights or using different materials for the parachutes.

Things to look out for

- If the investigation does not properly test what it is meant to, then repeating it again will not improve the results.
- Children may not have a clear understanding of the terms anomalous results and repeatability. Ensure children are confident with these terms stated in the key vocabulary.

Key questions

- What was your prediction?
- How does the surface area of the parachute affect the amount of air resistance?
- Did your results match your prediction? Why/why not?
- How could the investigation be improved?
- What could be done differently to improve the results?

Enquiry question

- Does the surface area of a parachute affect how long it takes for it to fall to the ground?

National curriculum links

- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – Reporting and presenting findings from enquiries, including conclusions, causal relationships and explanations of and a degree of trust in results.

Evaluate – parachute experiment

Key vocabulary

- **Surface area** – The total area of the surface of an object.

- **Anomalous result** – A result that does not fit the pattern. In maths, this is called an "outlier".

Time taken in seconds		
Attempt 1	Attempt 2	Attempt 3
0.54	7.82	0.65

- **Repeatability** – The likelihood of getting similar results if the experiment is carried out again.

Parachute length (cm)	Time taken in seconds		
	Attempt 1	Attempt 2	Attempt 3
10	0.54	0.38	0.65
20	1	1.12	1.11
30	1.36	1.54	1.56

- **Precision** – When all of the measurements obtained in an experiment are close to each other.

Practical ideas

- Here are some ways that the experiment can be extended.
  - Cupcake paper cases can be dropped instead of parachutes.
  - Different designs for paper aeroplanes can be tested to see which design has the lowest air resistance and will fly the furthest.

  - Paper helicopters can be made and compared to designs seen in nature, such as a sycamore seed.

Evaluation sentence stems

- I predicted that ...
- My prediction was correct/incorrect because ...
- From looking at our results, I can see that ...
- This happened because ...
- For future investigation, I would like to find out ...

Plan – water resistance

Notes and guidance

In this step, children are introduced to water resistance. They plan a comparative test to observe whether the shape of an object affects the time it takes to fall to the bottom of a measuring cylinder filled with water.

Children should understand that the more streamlined an object is, the less water resistance is acting upon it. This means that more streamlined objects will move through water more easily and with less effort. Children can link this to real-life examples such as sharks and dolphins.

When children complete the experiment plan, ensure they are using the terms "independent" and "dependent" variables correctly. They should also be able to identify variables that they will control during the experiment.

Key questions

- What is water resistance?
- How can water resistance be reduced?
- What does "streamline" mean?
- Which shape is the most streamlined?
- Which shape do you predict will have the least/most water resistance?
- What is the independent variable?
- What is the dependent variable?
- What are the controlled variables?

Things to look out for

- Children may think that water resistance only occurs in water and not in other liquids.
- Discuss ways they can improve their experiment plan, such as controlling variables and repeating their results to reduce the effects of anomalous results.

National curriculum links

- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – Planning different types of scientific enquiries to answer questions, including recognising and controlling variables where necessary.

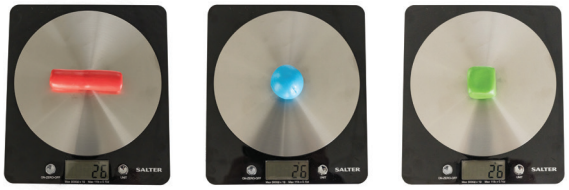
Plan – water resistance

Experiment variables

- **Independent variable** (what will change) – The shape of the object being dropped in the water.

- **Dependent variable** (what will be measured) – The time taken for the object to sink to the bottom.

- **Controlled variables** (what is kept the same) – The mass of the three objects, the type of liquid into which the objects are dropped (water), the height the objects are dropped from, and the volume of water in the measuring cylinder.



Experiment information

Equipment needed

- Tall measuring cylinder
- Scales
- Water
- Modelling clay
- Stopwatch
- Ruler

Method

1. Fill the measuring cylinder with water.
2. Record the volume of water added to the measuring cylinder so this can be filled up to that amount if any is lost as shapes are retrieved.
3. Use the scales to measure the mass of the three pieces of modelling clay.
4. Make one cube, one sphere and one long cylindrical shape from the modelling clay.
5. Measure the height that the children will drop the objects from using a ruler. Mark this on the measuring cylinder.
6. Drop the first shape from the mark on the side of the measuring cylinder and use the stopwatch to time how long it takes to reach the bottom of the measuring cylinder.
7. Repeat this with the second and third shapes.
8. Repeat this process so children have three sets of results per object.

Investigate – water resistance

Notes and guidance

In this small step, children carry out a comparative test to explore whether the shape of an object affects the time it takes to fall to the bottom of a measuring cylinder. They should understand that more streamlined objects have less water resistance and should fall to the bottom of the measuring cylinder more quickly.

Children should discuss their findings and make conclusions using the data collected from the experiment. They will also discuss ways of extending their investigation.

Extending an investigation is not about doing more repeats, it is about doing something different, such as using different shapes, or dropping the objects into a different liquid.

Key questions

- What is water resistance?
- How can water resistance be reduced?
- What does streamline mean?
- Why is water resistance a type of friction force?
- Which shape is the most streamlined?
- Which shape will have the least water resistance? Why?
- Which shape will have the most water resistance? Why?
- Why is it important to keep the mass of the modelling clay the same?

Things to look out for

- Children may think that water resistance must always have water to create a force against an object, but water resistance can occur in any liquid.
- Children may think that water resistance is not a type of friction. Clarify that water resistance is a type of friction as the water reduces the speed of the object.

National curriculum links

- Identify the effects of air resistance, water resistance and friction, that act between moving surfaces.
- **Working scientifically** – Taking measurements, using a range of scientific equipment, with increasing accuracy and precision, taking repeat readings when appropriate.

Investigate – water resistance

Key vocabulary

- **Water resistance** – A type of force caused by friction slowing things down that are moving through a liquid. Water resistance occurs in all liquids, not just water.

- **Streamlined** – Having a shape that has little resistance to a flow of air or water.

- **Repeatability** – The likelihood of getting similar results if the experiment is carried out again.

Shape	Time taken in seconds		
	Attempt 1	Attempt 2	Attempt 3
Cube	1.78	1.65	1.79
Sphere	1.23	1.43	1.31
Cylinder	0.98	1.03	0.96

- **Precision** – When all of the measurements obtained in an experiment are close to each other.

Practical ideas

- Class results can be gathered and used to identify anomalous results.
- The investigation can be extended further by dropping the objects through different liquids, such as cooking oil.
- Discuss the similarities between the shapes of animals that swim through water.

Evaluation sentence stems

- I predicted that ...
- My prediction was correct/incorrect because ...
- From looking at our results, I can see that ...
- This happened because ...
- To make our investigation more accurate, we could ...
- For future investigation, I would like to find out ...

Explore gravity

Notes and guidance

In this small step, children look at gravity. Gravity is a non-contact force. It is difficult for children to understand because it cannot be seen. All objects have gravity, but gravity is only seen with large objects. The larger the mass of the object, the larger the gravity. This is why the Earth has greater gravity than the Moon.

The force of gravity always acts towards the centre of the Earth. This is why objects always move towards the Earth when dropped. In this step, children should complete simple tests to explore whether heavier objects fall faster than lighter objects. Children should be encouraged to create their own investigation plan more independently, using knowledge learnt from the previous steps.

Key questions

- What is gravity?
- Why is gravity described as a non-contact force?
- Do you predict heavier or lighter objects will fall to the ground quickest? Why?
- How will you test to see whether heavier objects fall to the ground quicker than lighter objects?
- What will you change and keep the same?
- What were your results?

Things to look out for

- Children may think that heavier objects will fall to the ground quicker than lighter objects.
- Children often think that there is no gravity in space as astronauts are often shown floating around. There is gravity in space. The gravitational pull on the Moon from the Earth stops the Moon drifting off into space.

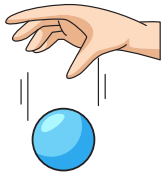
National curriculum links

- Explain that unsupported objects fall towards the Earth because of gravity acting between the Earth and the falling object.
- **Working scientifically** – Identifying scientific evidence that has been used to support or refute ideas or arguments.

Explore gravity

Key vocabulary

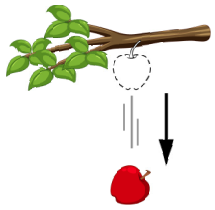
- **Gravity** – An invisible force that pulls things to the centre of the Earth (or other planets).



- **Weight** – The pull of gravity on an object.

- **Contact force** – A force that requires direct physical contact between two objects.

- **Non-contact force** – A force that does not require physical contact between two objects.



Practical ideas

- Ask children to measure the mass of two pieces of modelling clay of different sizes.

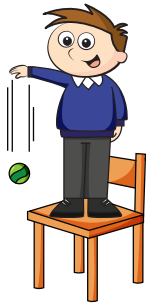
The greater the difference in the mass the better.

Ask children to drop the objects from the same height at exactly the same time.

Both objects should hit the floor at the same time.

Ask children what they observed.

Children could write down their results and conclusions.



Factual knowledge

- Gravity is a non-contact force.
- Gravity is an invisible force that pulls things to the centre of the Earth (or other planets).
- Heavier objects do not fall to the ground quicker than lighter objects.

Use small forces for greater effects

Notes and guidance

In this small step, children look at different mechanisms including levers, pulleys and gears. They learn that these mechanisms are designed to make some jobs easier, by changing a smaller force into a larger force.

Children also look at everyday uses of levers, pulleys and gears including bicycle gears and opening tins of paint. By the end of this step, children need to know that smaller gears with fewer teeth will cause a faster rotation.

Children could look for examples of levers, gears and pulleys in their classroom, school or wider area. Whenever possible, children should link their knowledge of gears, levers and pulleys to real-life examples to allow them to understand why they are used.

Key questions

- What is a gear? How do gears work?
- What is a lever? How do levers work?
- What is a pulley? How does a pulley work?
- How do levers, pulleys and gears work to allow a smaller force to have a greater effect?
- Where can you find examples of levers, pulleys and gears in everyday life?
- Why do you need a greater force when using a smaller lever?
- Do larger or smaller gears create a faster rotation?

Things to look out for

- Children may believe that the larger the gear and the more teeth it has, then the faster the movement will be.
- Use as many real life examples of gears, levers and pulleys to help children understand this concept. Examples include gears on a bike, seesaws and exercise equipment.

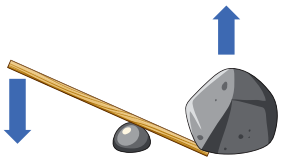
National curriculum links

- Recognise that some mechanisms, including levers, pulleys and gears, allow a smaller force to have a greater effect.
- **Working scientifically** – Recognise which secondary sources will be most useful to research their ideas (non-statutory).

Use small forces for greater effects

Key vocabulary

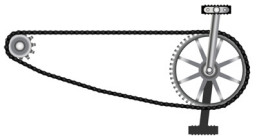
- **Lever** – A rigid bar resting on a pivot, used to move a heavy load.



- **Gear** – A wheel and axle that has teeth along the wheel, mostly used in machines to increase speed.

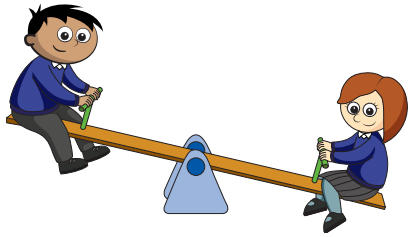
- **Pulley** – A rope or a cable on one or more wheels, used to lift heavy objects.

- **Machine** – A device that does a particular task. Some machines make moving or lifting things easier.



Practical ideas

- Use a bicycle turned upside-down and see the effect on the force needed and the speed of the wheels caused by changing the gears.
- Try to open a tin of paint with a two pence piece and then try to open it with a lever such as a screwdriver. Note the difference in the force required.
- If you have a local park, look at the effects of moving children closer to the centre of a seesaw on the force applied.



Factual knowledge

- Levers, pulleys and gears are all mechanisms that will allow a smaller force to have a greater effect.
- Gears are wheels with teeth that allow a small force to produce a larger force with greater speed.
- A lever is a machine that allows movement of heavy objects.
- Pulleys use a rope or cable through a wheel to allow lifting of heavy objects.