FORCES 07

HOW DOES FRICTION SLOW US DOWN?

Does an elephant sink or float in water?

5 key facts about FORCES

GRAVITATIONAL FORCE

124 USING FORCE

138 HAIR-RAISING FORCE

134 MAGNETIC LEVITATION

5 KEY FACTS ABOUT FORCES

Forces change motion. When we think of motion we think of things that move, such as cars, bikes, scooters and planes. For something to change its motion it must be pushed or pulled. These pushes and pulls are forces. More than one force is acting on everything around us all of the time. The changes in motion and shape shown here are examples of **contact forces**, where one object is in contact with another. Objects can also be changed by **non-contact forces**, such as gravity, and magnetic and electrostatic forces.

The spinnaker sail on maxi-yacht Wild Oats XI has an area of 880 square metres. The yacht has a top speed of 28 knots (52 kilometres per hour).

1 Forces can move objects

When you play golf, the golf club is used to push the ball. The club puts a force on the ball, causing it to begin to move along the ground or through the air. The golf tee and the grass also move. If you miss, there is no extra force on the ball from the club and the ball stays still.

2 Forces can increase speed

The force of the wind on the sail of a yacht causes the yacht to move. The greater the speed of the wind, the faster the yacht goes. The air consists of tiny invisible particles that rapidly move about. When there is a wind, the particles mostly move in the direction of the wind. When they hit objects in their path, the air particles push the objects. Yachts have a very large area of sail so that as many air particles as possible are able to hit the sails and give them a push.

3 Forces can decrease speed

Just Think about a car and the use of brakes. To slow down, the driver applies the brake pedal, which pushes on the brake pads. These, in turn, put a force on the wheels, causing the car to slow down. In drag-racing, cars can reach speeds of 530 kilometres per hour. At the end of the 400-metre run the driver releases a parachute. Air particles hitting and pushing on the huge area of the parachute slow the drag-racing car down so the driver can safely bring it to a stop. The force of the air particles on the parachute is called air resistance.

4 Forces can cause objects to change shape

A tennis racquet provides the force to change the motion of a tennis ball. When a tennis player hits a ball, the ball is compressed by the racquet. The racquet strings bend and stretch a little under the force of the ball. As the ball leaves the racquet, both the ball and the strings return to their normal shape and size.

5 Forces can cause a change in direction

The purpose of a tennis racquet or a baseball or softball bat is to change the direction of the ball. The force of the tennis racquet causes the ball to speed up and change direction.

The fastest recorded serve in tennis is by Australian player Samuel Groth at 263 kilometres per hour.

LOOK IT UP

contact forces forces occurring when two objects are touching each other

force a push or a pull on an object to change its motion

non-contact forces forces that operate between two objects when they are not touching each other, such as gravitational force

CHECK IT OUT

1. List five key facts about forces.
2. Explain how force is used to change the shape of the clay sculpture shown to the left.
3. Sails and parachutes have large areas of material.
   a. What are sails and parachutes designed to do?
   b. Explain how they can cause objects to speed up and slow down.

BALANCING FORCES

Forces are acting on us all the time, whether we are still or moving. We say forces are balanced when there are two forces of the same strength working in opposite directions. That is, they balance each other, and there is no change. We say forces are unbalanced when two forces acting on an object are not equal in size. That is, one force is bigger than the other, causing an object to change its motion.

If the forces on an object are equal and opposite there will be no change in movement. These are known as **balanced forces**. The forces on an object are balanced if it does not:

- » change direction
- » change shape
- » speed up
- » slow down.

If one force is bigger than all of the other forces acting on an object, then the forces are said to be **unbalanced forces**, and the object may:

- » change direction
- » change shape
- » speed up
- » slow down or stop.

Unbalanced forces make the tractor move faster.

As this weightlifter moves and lifts the barbell, there are unbalanced forces in action. The upward force raising the bar is greater than the downward force of gravity. Once the barbell is lifted and held there, balanced forces are in action. The upward and downward forces balance each other and the barbell remains still.

Forces can be added together

If you tried to move a heavy object such as a car, you probably would not succeed because the force you could exert on the car would be too weak. But if several strong people were to exert a force on the car, they could move it. This is because their combined forces would be stronger than the other forces on the car. The **net force** is the force that results when all the forces acting on an object are combined. If the people pictured are able to move the train, there is a net force on the train towards one side.

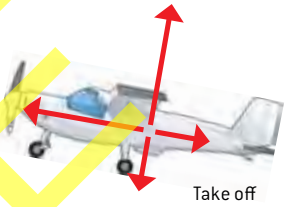
Forces on an aircraft

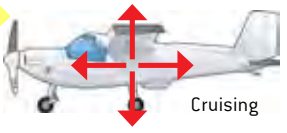
When an aeroplane is cruising at a constant speed, the forces of lift (upward force from the wings), gravity (the downward force), thrust (the push force provided by engines) and drag (air resistance) are balanced. When it takes off, the thrust and lift forces are dominant and the aircraft rises into the air. When a plane comes in to land, the lift and thrust reduce and the plane slows and descends. When a plane takes off or lands, the forces acting on it are unbalanced.

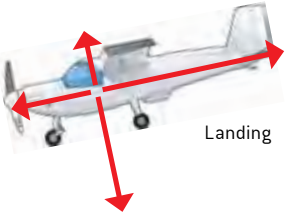
In 2014, train passengers in Perth used their net force to push an entire train onto an angle to free a commuter whose leg became trapped between the train and the platform edge.

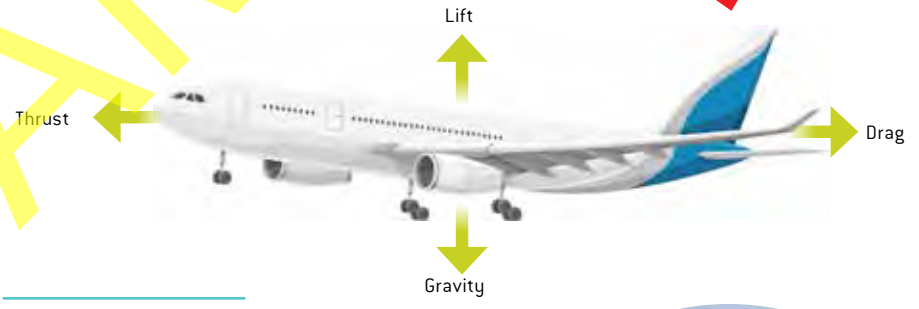
Drawing force diagrams

A force diagram uses arrows to show the direction and strength of a force. A short arrow shows a weak force and a long arrow shows a strong force. We use a separate arrow to represent each different force. The direction of the arrow shows the direction of the force and the length of the arrow indicates the relative strength of the force.









CHECK IT OUT

1. What are the features of balanced and unbalanced forces?
2. The weightlifter pictured is lifting a heavy mass. Explain what happened to the forces before and after this picture.
3. Explain how you might combine forces to move a heavy piano.
4. Draw a diagram to show the main forces acting on an aircraft cruising at a constant speed.
5. Draw a force diagram to represent the movement of the parachutist shown here.

LOOK IT UP

balanced forces two forces that are equal in size and opposite in direction

net force the combined effect of all the forces acting on an object

unbalanced forces two forces, not equal in size, acting on an object

FRICTION: FRIEND OR ENEMY?

Friction is found everywhere that objects come into contact with each other. Friction is a contact force applied to the surface of an object when it contacts the surface of another object. Friction always slows a moving object down.

If a car needs to stop, it slows because of friction between the brakes and the wheels. Without friction, your feet would slip over the ground, like trying to walk on ice. The rough surfaces on your shoes and on the ground provide the friction you need to push you forward.

This type of friction is known as **traction**. Without traction, a car's wheels would spin and it couldn't start moving. Moving cars could not turn corners or stop without friction. Less friction on wet and icy roads makes it difficult to control a car.

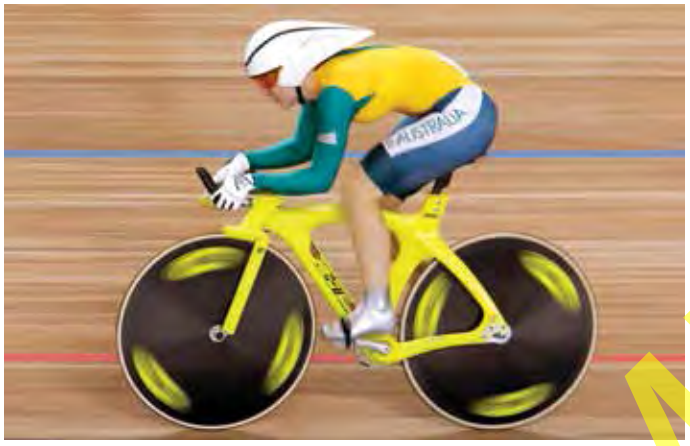
A simple way to experience friction is to rub your hands together as fast as you can. You can feel the friction and the heat it generates. All friction forces generate heat because the energy that was causing the movement is converted into heat.

This woman has slipped on the ice. Less friction is produced on smooth surfaces such as ice.

Friction slows you down

Friction slows everything that is moving. The more friction there is, the more quickly the movement slows. Friction happens because objects rub together. A moving bicycle is pushing through the air and against the road, and the wheels are rubbing against the axles. When you are swimming, you are pushing against water. The water slows you down. With less friction, you could ride further and swim faster with less effort. Friction acts opposite to the direction that the object is moving in, so it will always slow you down.

Ice on the surface of a road reduces friction and makes it difficult for vehicles to get the traction they need to steer and stop.



This Australian Olympic cyclist reduces air resistance by wearing a smooth, curved helmet and smooth, tight clothes. The rider bends down to let the air flow over her. The wheels are closed in to help the air flow around them.

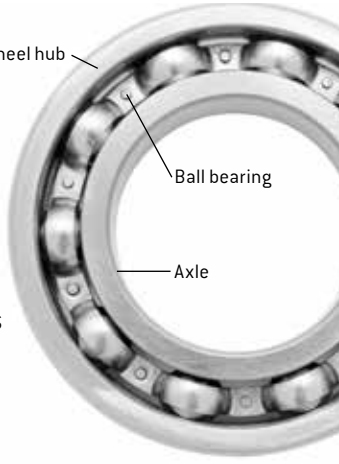
Reducing friction

Oil and grease are used to reduce friction. They are known as lubricants, and reducing friction in this way is known as **lubrication**. Lubricants work by coating a surface with an oily or waxy substance, which makes them slippery. Putting oil on bicycle chains and grease on wheel axles makes the moving parts move against each other more easily, with less friction.

Objects travelling through air slow down because of air resistance. Cars and aeroplanes have smooth, streamlined shapes to reduce the drag of air resistance. Air resistance is the friction between a moving object and the air it is moving through. Streamlining makes the surface smooth and rounded and helps reduce air resistance.

Ball bearings

One way of reducing friction between objects is by using rollers or balls. Ball bearings reduce the friction on wheels as they spin around an axle. Ball bearings allow the wheels to turn faster as the tiny metal balls inside them reduce the contact between the surfaces of the wheel and the axle. By doing this, they reduce the amount of friction.



Ball bearings reduce friction on wheels as they spin around the axle.

LOOK IT UP

friction a force that acts to oppose the motion between two surfaces as they move over each other

lubrication decreasing friction by applying a substance between the surfaces, such as oil or grease

traction the grip an object exerts on a surface

CHECK IT OUT

1. Why have the cars and trucks shown in the image crashed?
2. What is friction?
3. Explain how the orange car pictured has been designed to reduce friction.
4. Look at these two bike tyres and suggest what each is designed to do.

EXPERIMENT #9

MEASURING FORCE

AIM: TO MEASURE A VARIETY OF FORCES IN COMMON SITUATIONS.

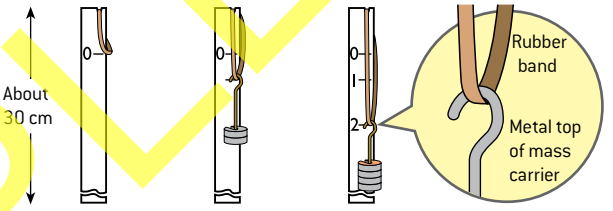
MATERIALS

- Rubber band
- Thin wooden strip (or a ruler)
- Mass carrier and masses
- Pen

METHOD

A rubber band can measure the sizes of forces in a similar way to a spring balance. But before it can, it must be calibrated. This means matching the stretch of the rubber band to the number of Newtons (a measure of force) pulling on it.

1 Calibrate the rubber band on the wooden strip, as shown.



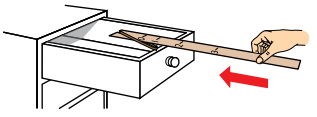
Calibrating the force measurer.

2 Mark the distance that the rubber band is stretched on the wood when the carrier holds a 100 g mass.

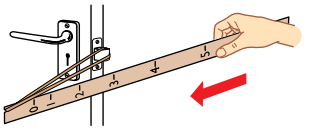
3 Repeat for masses of 200 g, 300 g, 400 g and so on, marking the wood each time. Note: The weight force of 100 g equals 1 Newton of force.

4 Use your force measurer to measure the size of the force needed to:

- **a** open the door to the room
- **b** drag a chair across the floor
- **c** close a drawer in the laboratory
- **d** move your pencil case
- **e** pull up your sock
- **f** do three other movements of your choice.



Measuring the force needed to close a drawer.



Measuring the force needed to open a door.

RESULTS

Include a neat, labelled and accurate diagram of the rubber band force measurer, and set out your measurements in a table.

DISCUSSION

Write a sentence for each of the measurements you made, as well as several sentences comparing the measurements.

CONCLUSION

What have you learned about a variety of forces in common situations?

EXPERIMENT #10

REDUCING FRICTION

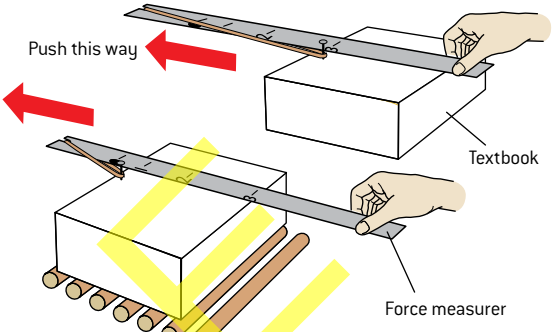
AIM: TO INVESTIGATE HOW FRICTION MAY BE REDUCED.

MATERIALS

- Force measurer (see experiment 'Measuring force')
- Thick textbook
- Wooden rollers (round pencils)
- Book
- Sand

METHOD

1. Use your force measurer to measure the friction created by dragging your textbook across the table. (Hint: Drag the book at constant speed.)
2. Place a second book on top of the first book and measure the friction.
3. Place rollers under the book and measure the friction.
4. Place sand under the book and measure the friction.



Measuring the friction of a textbook.

RESULTS

Record your results in a table.

OBJECT	FORCE NEEDED TO MAKE IT MOVE (N)			
	TRIAL 1	TRIAL 2	TRIAL 3	AVERAGE
Textbook				
Textbook with a second book on it				
Textbook with rollers under it				
Textbook with sand under it				

DISCUSSION

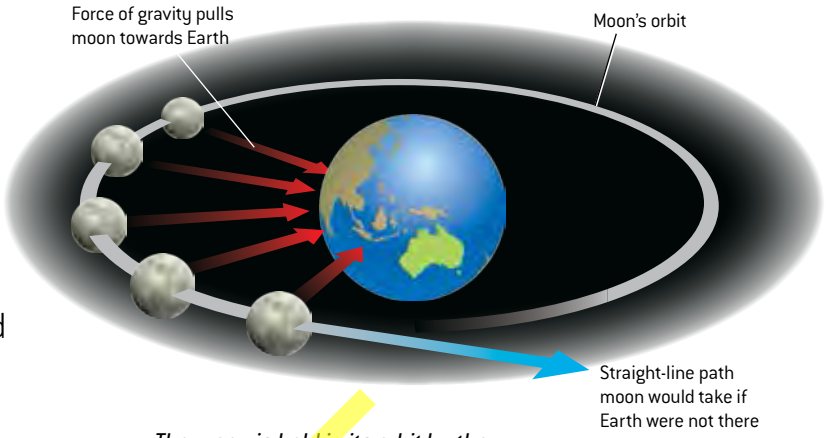
1. What was the best way to reduce friction?
2. Would five rollers be better than two for reducing friction?
3. Would ten rollers be better than five for reducing friction?
4. Would bigger or smaller rollers be better for reducing friction?
5. What are some problems with using rollers?
6. Write down a practical example of rollers being used to reduce friction.
7. Why wouldn't square rollers work?
8. Would fine sand or coarse (large-grained) sand be better to increase friction?
9. Write down a practical example of sand being used to increase friction.
10. What are some problems with using sand for this purpose?

CONCLUSION

What do you know about how to reduce friction?

GRAVITY

Gravity is a non-contact force of attraction between two objects. Non-contact forces push and pull objects without touching them. Gravity keeps the planets orbiting the Sun and keeps our Moon orbiting the Earth. It holds an atmosphere of gases and stops you drifting into space.



The moon is held in its orbit by the gravitational field of the Earth.

How gravity works

Gravity is the force that causes two objects to pull towards each other. These BASE-jumpers are being pulled towards the centre of the Earth. On Earth, gravity keeps the air and everything else from drifting into space.

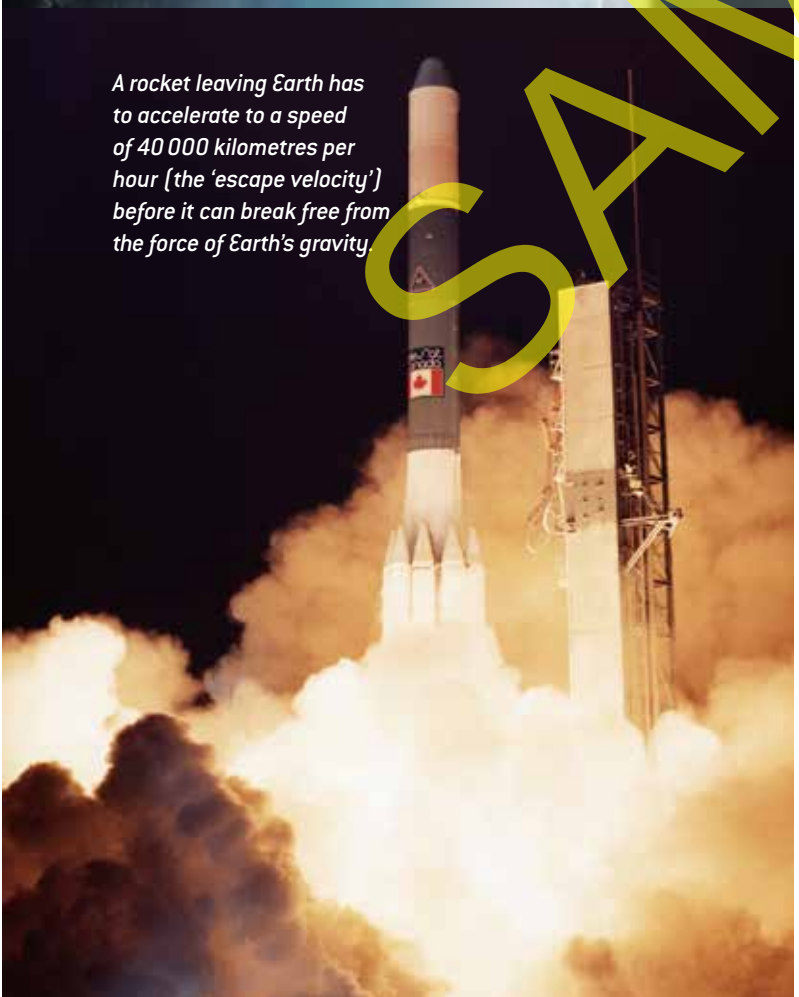
Gravity and mass

Gravity is affected by the mass (amount of material) of objects. The greater the mass of an object, the stronger its **gravitational force**. The Sun has such a large mass that its powerful gravity attracts all other objects in the solar system and keeps them orbiting around it.

Each planet has a different mass, so each has a different pull of gravity. Mercury, the smallest planet in our solar system, has just 38% of the gravity of the Earth. Jupiter, the largest of all the planets, has 254% of the gravity of the Earth.

BASE-jumpers are pulled towards the earth by influence of gravity.

In space, astronauts appear to float. This is because the pull of gravity is not as strong as on Earth. The astronauts and their spacecraft are in fact both falling. They are falling at the same rate, so the astronauts appear to be floating.



A rocket leaving Earth has to accelerate to a speed of 40 000 kilometres per hour (the 'escape velocity') before it can break free from the force of Earth's gravity.

Gravitational fields

We cannot see gravity, but it is real. We feel the effects of gravity every day. Gravity causes a field – a force field – around the Earth. A **gravitational field** is an area around an object in which the object's gravity attracts anything that has mass. People, cars, mountains – even the Moon – all feel a force when they are in the gravitational field of the Earth. Gravitational fields only attract, they never repel. Usually, the closer you are to the centre of the gravitational field, the stronger the force.

When you jump, the gravity of the Earth brings you back to the ground. The Moon has less gravity than the Earth. If you could jump 1 metre high on Earth, on the Moon you would be able to jump more than 6 metres!

For an object to leave the Earth, it has to overcome the pull of the Earth's gravitational field.

LOOK IT UP

gravitational field a region near a particular mass where a gravitational force is experienced

gravitational force the force of attraction between all masses in the universe

CHECK IT OUT

1 Look at the photographs of the BASE-jumpers and the astronauts. Why do the BASE-jumpers fall and the astronauts appear to float?

2 Define the following terms:
   - a gravity
   - b gravitational field
   - c escape velocity.

3 What keeps the planets in our solar system in orbit around the Sun?

4 Why can you jump higher on the Moon than on Earth?

5 Why do you think rockets are needed to allow travel from Earth into space?

6 Where do you think these scientists (pictured) are located? What might they study there?

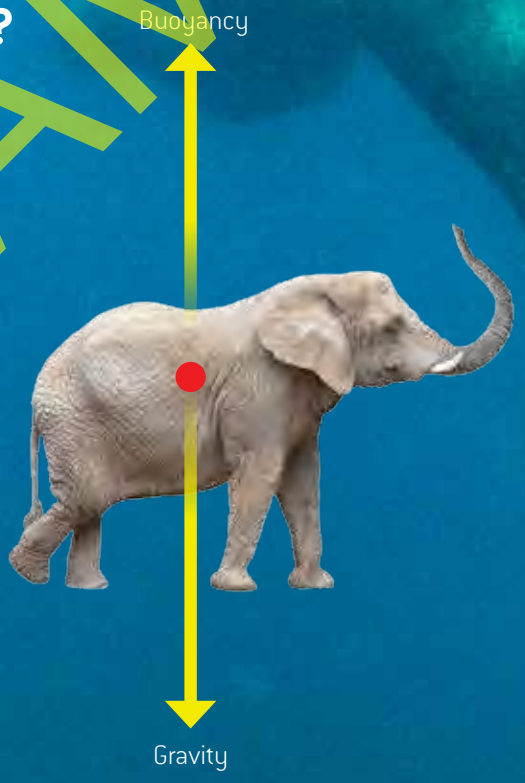
STAYING AFLOAT

How can very heavy animals such as elephants float in water and very small animals such as insects walk on water? The answer is in two very special forces that operate when objects are placed in water: **buoyancy** and **surface tension**.

How do elephants float?

Elephants can float and swim in water. The elephant is helped by the force known as buoyancy – the upward push on an object floating on the top of a liquid or submerged in it.

As an object floats in water, it moves water aside according to how much it weighs. Archimedes, an ancient Greek mathematician and inventor, found that the water will push upwards against the object with a force equal to the weight of water moved. A rock that was the same size as the elephant would sink because rock is denser than water. The elephant contains air and fat that is less dense than the water it floats in. The weight of the elephant is less than the weight of the water it has pushed aside. This means that there is an upward buoyancy force acting on the elephant that balances the downward force of its weight.



The elephant is buoyant and floats.

A rock is denser than water and sinks.

To make the air inside the balloon less dense than the air outside, the air inside the balloon is heated. Air in a hot air balloon is typically heated to 100°C.

How can you walk on water?

Water can create a skin on its surface that is strong enough to allow some insects and other small creatures such as spiders to walk on water. Water particles have a force of attraction, known as **cohesion**. Cohesion is a force that sticks things together. Cohesion at the surface of water is referred to as surface tension. The small weight of the spider pictured is spread out over the surface and is not great enough to push the water particles apart. The force of cohesion forms a 'skin' on the water that allows the spider to walk across it.

Thanks to surface tension, this spider can walk on the surface of water.

How do hot air balloons fly?

Hot air balloons rise because the hot air inside the balloon is less dense than the cold air outside the balloon. Buoyancy acts in liquids and in gases, and is related to the differences in **density** of the two objects.

LOOK IT UP

buoyancy upward force of a liquid or gas on an object

density the mass per unit volume

cohesion attractive force that holds parts of a substance together

surface tension the force existing in the surface of a body, especially a liquid, that makes behave as an elastic sheet

CHECK IT OUT

1 Explain which forces act on you when you float on your back in a swimming pool.

2 Why do you think underwater divers wear weight belts?

3 Solid steel is denser than water.
   a Why do large steel ships float?
   b Use a force diagram (page xx) to show why a ship floats.

4 How can insects walk on water?

5 How do hot air balloons fly?

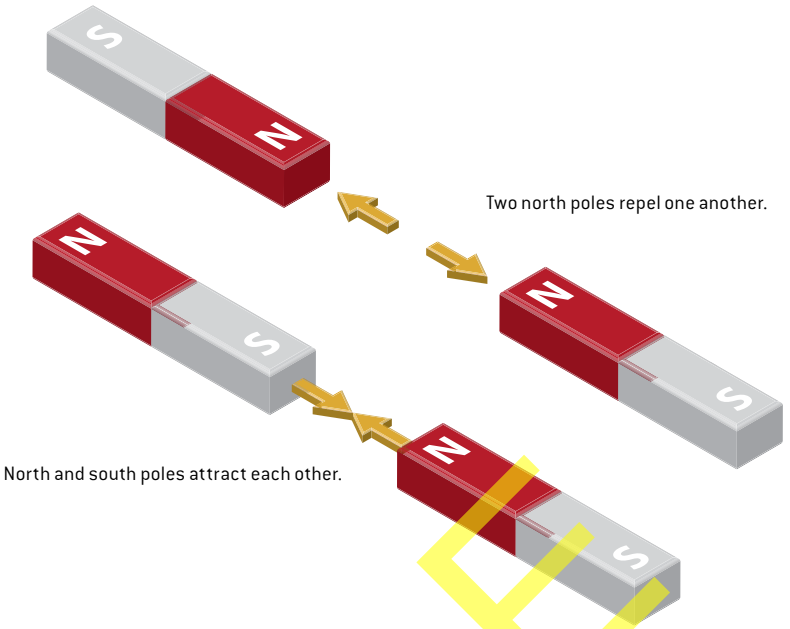
MAGNETIC FORCE

Magnets produce an invisible force that can pull or push objects without touching them. Magnets attract and repel each other. They are used to help operate computers, speakers, motors and the fastest trains in the world.

Researchers test a hoverboard that uses magnetic force to levitate above a rail. The Magsurf is a skateboard that rides a few centimetres above a magnetic track. Super-cold liquid nitrogen turns the material on the bottom of the board into a superconductor, which repels the magnetic field in the track.

How magnets work

Magnetic force is a non-contact force. Magnetic forces are strongest when the magnets are touching, but most magnets have the ability to push and pull from a distance. The forces are strongest at the ends of the magnets, called the **poles**. Magnets have a north pole and a south pole. Magnets push away from one another (repel) when the same poles are brought close together. Magnets pull towards each other (attract) when different poles are brought together.



Magnetic materials

Magnets attract magnetic metals – iron, nickel and cobalt. They also attract **alloys** such as steel that contain some magnetic materials (steel contains a large amount of iron). Magnets do not attract non-magnetic metals such as gold, tin or copper.

The horseshoe magnet shown here attracts an iron nail and steel paperclips and screws. It does not attract the plastic building block, the wooden pencil, the coin (zinc and copper) or the brass hose fitting.

LOOK IT UP

alloy a metallic substance made by mixing two or more metals

magnetic able to be magnetised or attracted by a magnet

poles the ends of a magnet where the magnetic field is strongest

CHECK IT OUT

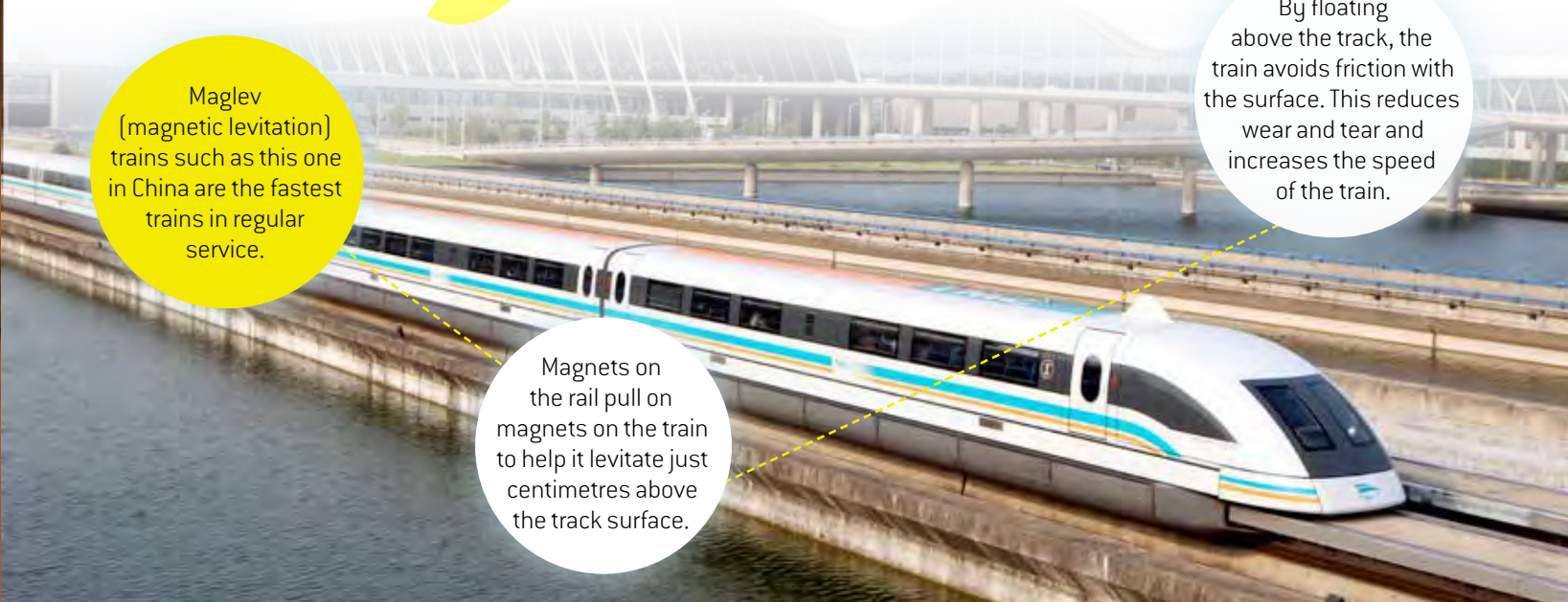
1 Why is magnetism considered to be a non-contact force?

2 When magnets are together, which two poles:
   a attract each other?
   b repel the magnets from one other?

3 What objects have been picked up by the horseshoe magnet opposite? Why?

4 How does magnetic force help maglev trains travel much faster than other trains?

5 What magnetic experiment are the scientists on the opposite page conducting?



MAGNETIC FIELDS

Magnetism and other non-contact forces operate through an invisible force field to push and pull. A **magnetic field** is the area around a magnet where magnetic force is felt.

Earth is a giant magnet

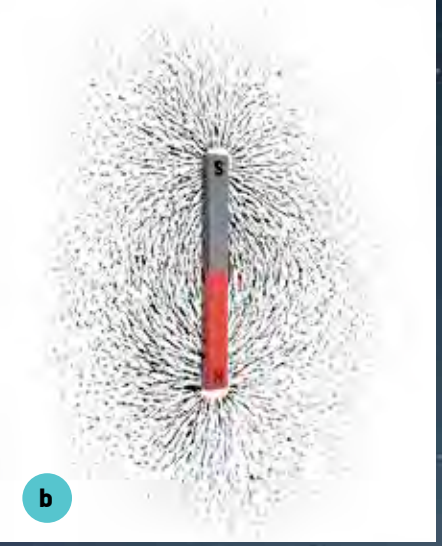
All magnets, no matter what their size or shape, have a north pole at one end and a south pole at the other. Even if you cut a magnet in half, each half will still have north and south poles.

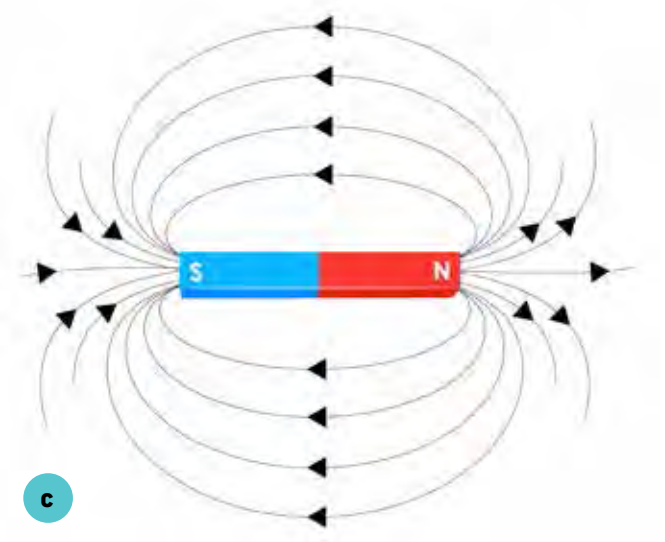
The Earth itself is a giant magnet, with north and south poles like the two ends of a bar magnet. A **compass** needle is a small magnet and will always point to the Earth's North Magnetic Pole.

The North Magnetic Pole isn't a fixed point – it wanders according to the magnetic field of the Earth. The Earth is surrounded by a magnetic field that extends way beyond the atmosphere into space, where it is called the **magnetosphere**. This magnetic field extends far beyond the atmosphere and into space, where it is called the **magnetosphere**.

The magnetosphere changes the direction of charged particles from the Sun so they do not hit the Earth. This produces displays of light in the sky called **auroras**. In the southern hemisphere this display is called the aurora australis, and in the northern hemisphere it is called the aurora borealis. The auroras are mostly seen in the night sky near the Arctic and Antarctic regions.

Auroras are light shows in the sky caused by the Earth's magnetic field.





Invisible magnetic fields can be shown by (a) compasses and a magnet; (b) iron filings; (c) magnetic field lines on a map.

'Seeing' invisible magnetic fields

a Using a magnet and compasses to show the invisible magnetic field

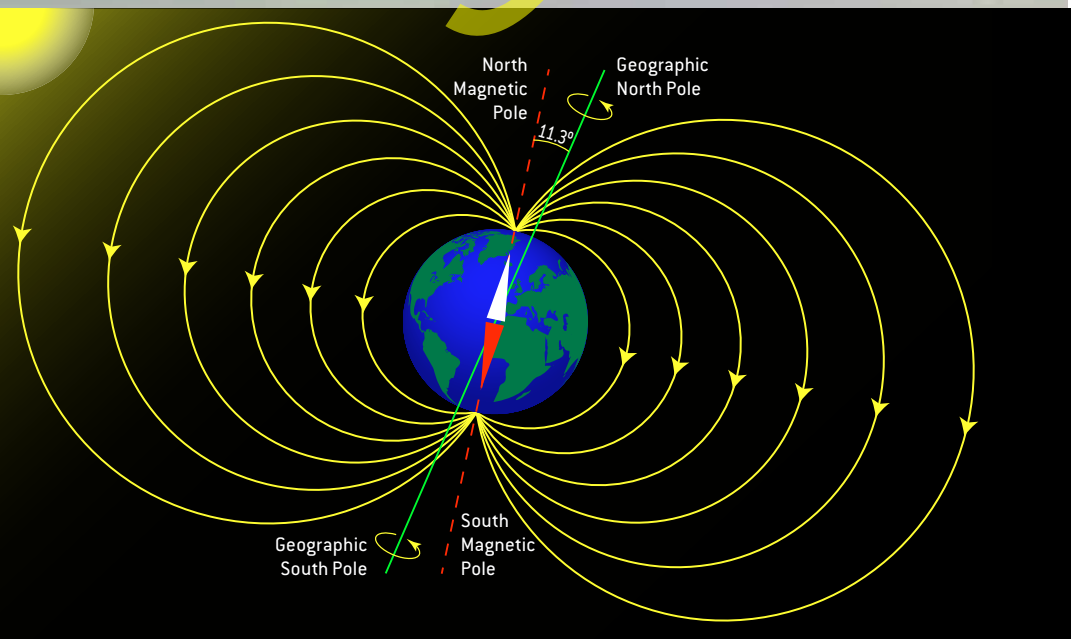
A compass is a small magnet used to point towards the North Pole of the Earth. Compass needles line up with the Earth's magnetic field, so if another magnet is brought near a compass, the north pole of the compass will point towards the south pole of the other magnet. If you place many compasses near to the magnet, the compass needles draw a map of the magnetic field.

b Using iron filings to show the invisible magnetic field

Magnetic metals such as iron are attracted to magnets. We can use iron filings to 'see' the magnetic field. If you put iron filings near a strong magnet, they become temporary magnets. They line up like tiny compass needles around the strong magnet. This lets us see what a magnetic field looks like.

c Drawing magnetic field lines to make a map

We can draw lines to clearly see the invisible magnetic field. Where the lines are close together, the magnetic force is greatest, and where they are further apart, the magnetic force is weakest. Magnetic field lines never cross, and they always point away from the north pole of the magnet and towards the south pole. We use arrows to show the direction of the field.



LOOK IT UP

aurora bands of coloured light in the night sky due to charged particles interacting with the Earth's magnetic field

compass an instrument showing the direction of magnetic north

magnetic field region around a magnetic material or a moving electric charge within which the force of magnetism acts

magnetosphere the magnetic field surrounding planets, stars etc.

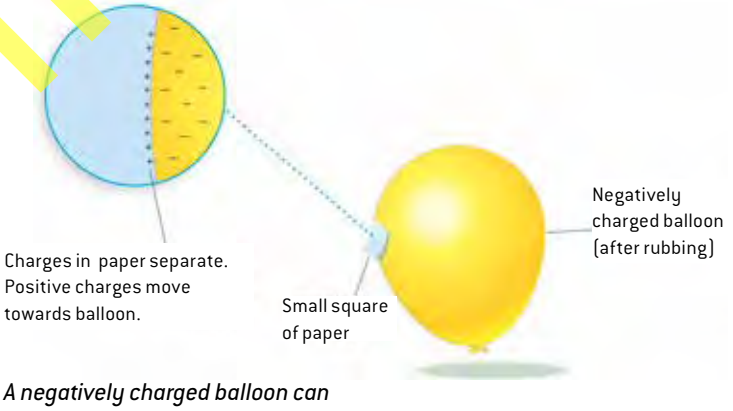
CHECK IT OUT

1. How is the Earth like a giant magnet?
2. How does a compass work and why is it useful?
3. How can people in the Arctic or Antarctic 'see' the invisible magnetic field around the Earth?
4. How can we 'see' the magnetic field around a bar magnet?
5. In which direction do magnetic field lines flow?

Lightning is the result of rapid charge movements in storm clouds.

ELECTROSTATIC CHARGES

Substances become charged with the addition or removal of **electrons**. This can happen by **friction**, when materials are rubbed together. It can also happen when an object comes into direct contact with another.



A negatively charged balloon can attract a neutral object such as paper by causing its charges to separate.

Creating charge

Matter is made of atoms. At the centre of each atom is a nucleus containing protons and neutrons. Each proton carries a positive electric charge. Electrons have a negative charge and constantly move around the nucleus. Atoms have equal numbers of electrons and protons. Atoms have no overall charge. If you add electrons to a substance, it will become negatively charged. Remove electrons from a substance and it will become positively charged.

A Van de Graaff generator creates static electricity. Standing on an insulated rubber surface, the girl touching the metal dome of the generator receives a positive charge from it as negative charges leave her body. Her positively charged hair follicles try to repel each other and stand on end.

Static electricity

Static electricity refers to the charge on the surface of an object. 'Static' means staying still or remaining unchanged. Static electricity can also be neutralised or discharged by a spark or movement of electrons.

Friction

When some objects are rubbed together, such as a balloon and someone's hair, electrons may move between them. The rubber balloon removes electrons from the hair. This leaves the balloon with a negative charge. The shortage of electrons on the hair leaves it with a positive change.

Contact

As well as charging an object by friction, objects can be charged by contact. The girl touching the Van de Graff generator (pictured) has become positively charged because she has lost electrons to the generator.

How do charged objects behave?

Charged objects behave in a similar way to magnets. Like (or similar) poles of two magnets will repel and unlike poles will attract. In the same way, like charges repel and unlike charges attract. So two negatively charged objects will repel each other, as will two positively charged objects. A positively charged object and a negatively charged object will attract. The girl's hair is positively charged. Each hair is repelling the next one, leading the hairs to separate from each other and stand on end.

When a balloon is rubbed on your jumper it becomes negatively charged with electrons. If the same balloon then touches a piece of paper, the negative charges in the paper are repelled and the positive charges are attracted. This causes the paper to stick to the surface of the balloon. Neutral objects such as paper will attract charged objects such as the balloon.

Static electricity is useful in an inkjet printer, where the positively charged ink is attracted to areas of negative charge on the paper to form the required pattern. Static electricity can sometimes be unhelpful. It can cause some light objects such as dust to 'stick' to other objects such as television screens.

LOOK IT UP

electron a negatively charged particles found in atoms

friction a force that acts to oppose the motion between two surfaces as they move over each other

static electricity a stationary electric charge that builds up on a material

CHECK IT OUT

1. How do substances become positively charged?
2. Why is the hair of the girl in the photograph standing on end?
3. Explain how friction causes a balloon to be able to attract a piece of paper.
4. How are charged objects similar to magnets? Give an example.
5. How can static electricity be both helpful and a hindrance?
6. How is lightning a good example of discharging static electricity?

REVIEW

FORCES

5 KEY FACTS ABOUT FORCES (PAGES 124–125)

1 Give three examples of how forces change motion.

2 Look at the photograph of the BASE-jumper above. Explain how the shape of his suit is changing his motion.

3 Explain how force can change the shape of a tube of toothpaste.

BALANCING FORCES (PAGES 126–127)

4 What is the term for forces on an object that do not change direction or speed?

5 What is the result when several forces act on an object in the same direction? What is the special name for this?

FRICTION: FRIEND OR ENEMY? (PAGES 128–129)

6 What is friction?

7 Look carefully at the racing car below.

- **a** Why do racing cars have a streamlined shape?
- **b** Why has grease been used to lubricate the wheel axles?
- **c** Look at the tyres. Why is there not a lot of tread on these racing car tyres?
- **d** In what weather conditions might a racing car be fitted with tyres that give greater traction?
- **e** What does the smoke from the tyres tells you about friction and heat energy?

GRAVITY (PAGES 132–133)

A8 Why is gravity a non-contact force?

9 How does gravity hold the Moon in its orbit around the Earth?

10 Look at the photograph of the BASE-jumper opposite. How is the force of gravity acting on this BASE-jumper?

11 Are astronauts who are spacewalking in orbit around the Earth floating or falling?

STAYING AFLOAT (PAGES 134–135)

12 How do hot air balloons become buoyant enough to fly?

13 How can a spider walk on water?

14 The *Oasis of the Seas* (pictured below) is one of the world's largest cruise ships. It has 16 passenger decks, is 20 storeys high and 362 metres long, weighs 100 000 tonnes and carries 5400 passengers.

- **a** Explain how buoyancy helps such a heavy object to float.
- **b** The *Oasis of the Seas* displaces (moves aside) the equivalent of 100 000 tonnes of water. How does this allow it to float?
- **c** If the *Oasis of the Seas* was just a block of dense, solid steel, would it float? Explain your answer

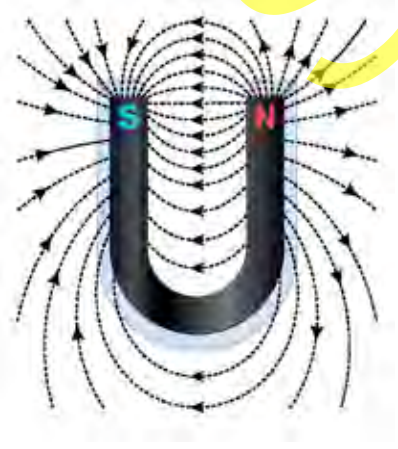
MAGNETIC FORCE (PAGES 136–137)

15 Why is magnetism a non-contact force?

16 What objects do magnets attract?

17 Explain how magnets can attract and repel one another.

18 What is the effect of magnets on a maglev train? Why is this an advantage?



MAGNETIC FIELDS (PAGES 138–139)

19 Explain why a compass needle always points towards the North Magnetic Pole (when it is away from other magnets).

20 What happens when auroras occur?

21 Look carefully at the diagram below and complete the following sentences.

- **a** Magnetic field lines point away from the [north/south] pole of the magnet towards the [north/south] pole of the magnet.
- **b** When magnetic field lines are close together the magnetic force is [weak/strong] and when magnetic field lines are further apart the magnetic force is [weak/strong].

ELECTROSTATIC CHARGES (PAGES 140–141)

22 Describe how friction can separate positive and negative charges.

23 When the soles of your shoes rub on some types of carpet, your body becomes negatively charged. Explain what will happen to the additional negative charge if you:

- **a** immediately touch a metal door handle
- **b** place your hand near a negatively charged balloon
- **c** place your hand near a positively charged balloon.

KEY IDEAS

1 Forces change motion. They make objects speed up, slow down or change direction.

2 If the forces on an object are equal and opposite, there will be no movement. These are known as balanced forces.

3 Friction is a contact force that slows moving objects.

4 Gravity is the force that causes two objects to pull towards each other. It is a non-contact force of attraction. The force of gravity pulls us towards the Earth's surface.

5 The greater the mass of an object, the stronger its gravitational force. The Sun exerts a stronger gravitational force than the Earth.

6 Buoyancy is the upward push on an object floating on the top of a liquid or submerged in it.

7 Magnetic force is a non-contact force. The force is strongest at the ends of the magnet, called the poles. Magnets have a north pole and a south pole.

8 Substances become charged with the addition or removal of electrons. This can happen by friction, when materials are rubbed together. It can also happen when an object directly contacts another with a charge.