Chapter 7: Forces

7.1 A force is a push or pull

Student book answers (pages 120–121)

Check your learning 7.1

Remember and understand

1 What is a force?

A force is a push or pull.

2 List six things that forces do.

An object experiencing a force may begin to move, speed up, slow down or stop moving, change its direction of motion, change shape or remain still.

3 How do you measure force?

Force is measured using a spring balance.

4 What is the unit of force?

The newton (N)

5 Who is the unit of force named after?

Sir Isaac Newton

Apply and analyse

6 Order these forces from biggest to smallest.

a A truck hitting a pole

b A rocket being launched

c Typing one letter on a computer keyboard

d Kicking a soccer ball

e Pushing a car along the street

From largest to smallest: rocket being launched; truck hitting a pole; pushing a car along the street; kicking a soccer ball; typing one letter on a computer keyboard

7 Can you see a force? Always, never or sometimes? Explain.

You cannot see the force itself, only the effect of the force.

8 Many measuring instruments have to be calibrated. What does this mean? Give an example.

Calibrate means to check, adjust or standardise a measuring instrument. This is to ensure an instrument is accurate (e.g. checking that a thermometer is showing the correct temperature).

Evaluate and create

9 A student was using the force measurer in Skills lab 7.1 when the rubber band broke. Can a different rubber band be used with the same scale? Explain.

A different rubber band cannot be used with the same scale because it may not stretch to the same length under the same force. The device will need to be recalibrated to the new rubber band.

7.2 An unbalanced force causes change

Student book answers (pages 122–123)

Check your learning 7.2

Remember and understand

1 What evidence shows that the forces acting on the objects in the following situations are unbalanced?

a Pushing down the lever on the toaster

The lever moves

b Jumping on a trampoline

The person’s direction of motion changes

c A car starts moving

The car begins to move

2 When you push against a brick wall, why doesn’t it fall over? Why can a bulldozer push it over?

When you push against a brick wall it doesn’t fall over because the wall pushes back on you with an equal and opposite force. A bulldozer can push the wall over because it can push harder than you can on the wall and the wall can’t withstand this force with an equal and opposite force. This creates a net unbalanced force in the direction that the bulldozer is pushing, and the wall falls over.

3 Explain why weightlifters get tired when they hold heavy masses in the air.

Weightlifters get tired when they hold heavy masses in the air because the weightlifter must exert the same upward force on the heavy mass as that of the gravitational force pulling the heavy mass down. As the weightlifter tries to maintain this force for a period of time, they get tired. (If they cannot maintain the force any longer, the heavy masses will fall.)

4 Give examples of forces that cancel each other out (net force = 0) and of two forces that add together.

Student answers will vary. Typically, forces that cancel each other out must be equal in size but opposite in direction. Forces that add together are usually in the same or similar directions and hence cannot cancel each other out.

Apply and analyse

5 If Sally can push with 150 N and Marilla with 200 N in the same direction, with what force can they push together? What is the net force if they push in opposite directions?

Encourage students to draw force diagrams to represent these situations.

If Sally and Marilla are pushing in the same direction, the force they are pushing with is 350 N (= 150 + 200).

If they are pushing in opposite directions, the net force is 50 N in the direction Marilla is pushing (= 200  150).

6 Draw two people having a tug of war. Give them names and draw arrows to show the forces they are exerting on the rope. Who is winning?

Student answers will vary, but should show the two people pulling outwards or away from each other on the rope. If their force arrows are equal there is no winner (yet). Whoever’s force arrow is larger will be the winner (if they can maintain it).

7.3 Forces can be contact or non-contact

Student book answers (pages 124–125)

Check your learning 7.3

Remember and understand

1 Name three places where you might find a magnet.

Student answers will vary, but could include: fridge magnets, in a compass, storing data in computers, alarm switches, electric motors, magnetic noticeboards, in recycling yards, in a loudspeaker.

2 Is magnetic force a contact or non-contact force? Explain your answer.

Magnetic force is a non-contact force because it can act at a distance without the magnets having to touch.

3 Why is one part of a magnet called north?

The north pole of a magnet will point to the north if the magnet is suspended and allowed to swing freely.

4 What happens when the following poles of two magnets are pushed close together?

a N and S

The poles are attracted to each other.

b N and N

The poles repel each other.

c S and S

The poles repel each other.

d S and N

The poles are attracted to each other.

5 Draw how you might arrange bar magnets to spell your name. Label the north and south poles of the magnets.

Student answers will vary. N and S should be next to each other to join the magnets.

Apply and analyse

6 Describe how you might levitate a magnetic skateboard above a large magnet on the ground. Mention the arrangement of the poles of the magnet in your description.

Student answers will vary. Levitation relies on the repulsion between like poles.

7.4 Magnetic fields can apply a force from a distance

Student book answers (pages 126–127)

Check your learning 7.4

Remember and understand

1 What is a magnetic field?

A magnetic field is the area around a magnet where magnetic force is experienced.

2 How could you map the field around a magnetic nail?

A compass or iron filings could be used to map the field around a magnetic nail.

3 Describe in words the shape of the magnetic field when two magnets are:

a attracting

The lines of magnetic field appear to directly connect the magnets when there is attraction (see Figure 7.18b).

b repelling.

The lines of the magnetic field coming from each magnet appear to deflect to either side (see Figure 7.18c).

4 By looking at the magnetic fields made by different magnets, can you decide which magnet is stronger? Suggest a rule to use.

Stronger magnetic fields cause the iron filings to concentrate in stronger lines and the lines of the magnetic field appear to be closer together than that of weaker magnetic fields.

5 Draw the magnetic field around a broken magnet:

a that has been re-joined

b with the two pieces 10 cm apart

c with the two pieces 1 cm apart.

Student answers will vary depending on how the two broken pieces are positioned, but assuming end-to-end (i.e. with the broken ends towards each other):

a the field lines should look like those in Figure 7.18a

b the field lines should look like those in Figure 7.18b, but because the ends are 10 cm apart the magnetic forces between the two magnets will be weaker with the greater distance

c the field lines should still connect the two magnets as in Figure 7.18b.

Apply and analyse

6 Explain how a compass works.

The magnet in the compass swings under the influence of the Earth’s magnetic field. The result is that it will point in a north–south direction.

7 Explain why you should never leave a library card on the demagnetising panel of a shop.

The library card will have information stored on it magnetically that could be erased by the demagnetiser.

7.5 Electrostatic forces are non-contact forces

Student book answers (pages 128–129)

Check your learning 7.5

Remember and understand

1 Are electrostatic charges contact or non-contact forces?

Non-contact

2 Describe how electrostatic forces can be created.

Electrostatic forces are created when electrical charges (either positive or negative) come close to each other or close to uncharged objects.

3 Finish these statements.

a Unlike charges \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

Attract

b \_\_\_\_\_\_\_\_\_\_\_\_ charges repel.

Like

c Charged objects \_\_\_\_\_\_\_\_\_\_ uncharged objects.

Attract

4 Explain why the hair of a person touching a Van de Graaff machine may be standing up.

Touching the van de Graaff generator has caused the person’s whole body and hair to become charged. Each individual hair has the same charge and so they repel, standing up to get as far away from each other as they can.

Analyse and apply

5 Isaac was leaving the carpeted library to go home. When he touched the door handle, he received an electric shock. Explain why this happened.

The electric shock was caused by the build up of electric charge on Isaac, which was transferred from the carpet on the floor of the library. This build up is discharged when he touches the metal door handle (or another person).

6 When it is about to rain, the water particles in the clouds rub against one another and an electrostatic charge forms. How does this cause lightning?

When enough electrostatic charge has formed it can find a path to Earth, and this discharge forms lightning.

7.6 Friction slows down moving objects

Student book answers (pages 130–131)

Check your learning 7.6

Remember and understand

1 List three examples where friction is useful and three examples where friction is a problem.

Student answers will vary.

Examples of friction being useful could include :when picking up objects, writing, driving, walking, riding a bike, swimming and swallowing.

Examples of friction being a problem could include: when it impedes the desired motion, such as when wheels don’t spin correctly; the wearing away of surfaces; spacecraft re-entering the atmosphere; sticky drawers.

2 Why is a penguin streamlined, but a sea anemone is not?

A penguin is streamlined because it needs to travel through the water and reduce friction as it does so. A sea anemone is attached to a surface and does not need to move through the water. It has no need to be streamlined.

3 Why do surfers wax their surfboards?

Surfers wax their surfboards to reduce friction so they will move more easily through the water.

4 Why does the tread on the tyres of your bike wear down over time? Explain this in terms of force.

The tread of bike tyres wears down over time due to the friction that occurs between the tyre and the road surface. As the two surfaces rub together, small amounts of tyre are worn away because the tyre tends to be softer than the ground surface.

5 A hovercraft moves across water on a cushion of air. What is the benefit of this?

The benefit of a hovercraft moving across water on a cushion of air is that it can move faster because of less friction with the air compared with the friction the hovercraft would experience with the water.

Apply and analyse

6 In a world without friction, what would happen if you tried to:

a go down a slide in a playground?

We would go very fast down the slide, would keep getting faster and faster, and go flying off the end.

b play tenpin bowling?

Playing tenpin bowling, the bowler wouldn’t be able to stop after releasing the ball and would also slide down the lane.

c tie your shoelaces?

Shoelaces couldn’t be tied because no friction would exist to hold them together. It would be impossible to pull the knot tight. If you did tie the knot, it wouldn’t hold.

7 How are speed and friction related?

Speed and friction are related because friction limits the top speed that an object can achieve. The more friction, the lower the top speed; the less friction, the faster an object can move. In addition, the faster an object travels, the greater the air friction.

8 If you used the same pushing force in each case, over which surface would an object move the fastest: sand, wood, or metal coated in oil? Explain your answer.

An object would move fastest over a metal surface coated in oil because the oil acts as a lubricant and reduces friction. The next fastest would be over sand, because the sand is made up of lots of tiny little ‘rollers’ that reduce the friction between the two surfaces. The slowest would be over the wood because there would be lots of contact between the surfaces and lots of friction.

7.7 Simple machines decrease the amount of effort needed to do work

Student book answers (pages 132–133)

Check your learning 7.7

Remember and understand

1 Look at Figure 7.36.

a What type of lever is shown?

First-class lever

b Would an effort of less than 200 kg be able to lift the load?

No, an effort of less than 200 kg would not be able to lift the load because the load arm is longer than the effort arm and so is acting as a distance magnifier.

c How would you reposition the fulcrum so that a weight much less than 200 kg can lift the load?

The fulcrum would need to be closer to the load so the lever could work as a force magnifier and enable a force less than 200 kg to lift the load.

2 A crowbar (see Figure 7.37) can be used to move a load.

a What class of lever is it?

First-class lever

b Is this class of lever a force magnifier or a distance magnifier? Explain your answer.

A first-class lever can act as either a force magnifier or distance magnifier, depending on the distance between the load and fulcrum. A crowbar has the fulcrum close to the load, making it a force magnifier.

3 Modern cranes use leverage to lift heavy objects (see Figure 7.38).

a Where is the load located?

The load is on the end of the long, horizontal arm. It is often on a hook, or similar.

b Where is the effort located?

The effort is located where the hydraulic strut is in the photograph, between the vertical arm of the crane and the horizontal arm bearing the load.

c Where is the fulcrum for this lever?

The fulcrum is the connection between the two arms.

d What class of lever is this?

The effort is between the fulcrum and the load, so it is a third-class lever.

e Is this lever designed to magnify force or distance? Explain your answer.

A third-class lever acts to magnify distance. A crane usually uses a winch too, which acts as a force magnifier.

7.8 A pulley changes the size of direction of force

Student book answers (pages 134–135)

Check your learning 7.8

Remember and understand

1 Why are two pulleys better than one?

Two pulleys are better than one because they halve the effort required to move the load.

2 A block and tackle provides a mechanical advantage because it can lift heavy loads. Does it have any disadvantages?

A disadvantage of a block and tackle is that lots of rope needs to be pulled through a long distance.

3 Give three examples of where single pulleys or pulley systems are used.

Examples of where pulleys are used include flagpoles, sailing ships, window blinds, chair lifts, cranes and on gym equipment.

4 Describe how pulleys made loading and sailing huge cargo vessels possible.

Pulleys reduce the effort required of the sailors to lift heavy loads and operate the sails and other controls.

5 Choose the correct option. A pulley system can:

a increase force and distance at the same time

b decrease distance while increasing force

c decrease force and distance at the same time

d change the direction of motion.

(b) decrease distance while increasing force. Figure 7.43 shows this. The person pulls the rope through a long distance with a small force, allowing a larger force to be lifted through a small distance. Compared with the person’s effort, the load has a larger force and moves through a smaller distance.

Analyse and apply

6 A 100 kg mass is used to lift an 800 kg mass.

a How many pulleys are needed?

Eight

b What is the mechanical advantage of this machine?

8

7.9 There are different types of machines

Student book answers (pages 136–137)

Check your learning 7.9

Remember and understand

1 List the six types of simple machine.

The six types of simple machines are wedge, lever, ramp (or inclined plane), screw, pulley, wheel and axle.

2 Are any of the six simple machines similar? Explain your answer.

Similarities between the six simple machines include the following: a wedge is a double ramp or inclined plane, a screw is a ramp wound around in a spiral, and a wheel is a type of lever.

3 Which one of the following is not considered an inclined plane?

a A knife used to cut bread

b A screwdriver used to turn a screw

c A nail driven into a piece of wood

d A spear thrust into a tree

(b) A screwdriver used to turn a screw. The screw is an inclined plane wound around in a spiral, but the screwdriver is a wheel and axle.

4 Which part of a circular doorknob is the wheel and which part is the axle?

In a circular doorknob, the wheel is the actual doorknob and the axle is the shaft (which turns the latch).

Apply and analyse

5 Is a circular doorknob a force magnifier or a distance magnifier?

Force magnifier

6 Is the can opener shown in Figure 7.50 acting as a wheel and axle? Explain how it works.

Yes. The handle is the wheel and the inner cutting wheel, which runs around the can’s rim cutting the lid, is the axle.

7.10 Science as a human endeavour: Forces are involved in sport

Student book answers (pages 138–139)

Extend your understanding 7.10

Student answers to questions 1–4 will vary depending on the chosen sport.

Review 7

Student book answers (pages 140–141)

Remember and understand

1 Think back to the start of your day. Describe the forces that you experienced from the time you got up, to the time you arrived at school.

Students will most likely talk about experiencing forces when a car, train or bus speeds up, slows down, stops or changes direction. They should also talk about gravity pulling them downward and the ground pushing up.

2 Copy and complete the following sentences.

a A force is a \_\_\_\_\_\_\_ or a \_\_\_\_\_\_\_ between \_\_\_\_\_\_\_ objects.

A force is a **push** or a **pull** between **two** objects.

b To measure a force, you can use a \_\_\_\_\_\_\_ \_\_\_\_\_\_\_.

To measure a force, you can use a **spring balance**.

c The unit used to measure forces is called the \_\_\_\_\_\_\_. Its symbol is \_\_\_\_\_\_\_. The weight force of 50 g is about \_\_\_\_\_\_\_ newtons.

The unit used to measure forces is called the **newton**. Its symbol is N. The weight force of 50 g is about **0.5** newtons.

d When an object is not moving, its forces are said to be \_\_\_\_\_\_\_. Evidence of an unbalanced force is a change in \_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_ or \_\_\_\_\_\_\_\_\_\_\_.

When an object is not moving, its forces are said to be **balanced**. Evidence of an unbalanced force is a change in direction, **speed** or **shape**.

3 Which of the following involve forces, and which do not? Explain.

a Opening a window

b Turning a screw with a screwdriver

c Smelling food cooking

d Modelling clay

e Standing on a diving board

f Watching a candle burn

Opening a window, turning a screw with a screwdriver, moulding clay and standing on a diving board all involve forces because two or more objects are interacting with each other to change or maintain their motion. Smelling food cooking and watching a candle burn do not involve forces because they are just observations.

4 How is mechanical advantage calculated?

Mechanical advantage = load ÷ effort

5 What is the difference between a contact force and a non-contact force? Give an example of each.

A contact force is one that occurs between two objects that are touching. A non-contact force is one that acts at a distance where the two objects are not touching.

Apply and analyse

6 Explain the following in terms of friction.

a Gymnasts put chalk on their hands.

Gymnasts put chalk on their hands because the chalk increases friction and so their hands don’t slip on the bar.

b People driving cars on ice or snow put chains on their tyres.

People driving cars on ice or snow put chains on their tyres to increase friction and traction between the tyre and the slippery ice.

c A car uses more petrol when it has a load on the roof.

A car uses more petrol when it has a load on the roof because the additional items on the roof increase air resistance and therefore friction. In addition, the car will have more mass and will push down harder on the road, which also increases friction.

d It is hard to run on ice.

It is hard to run on ice because less friction makes it hard to grip the surface, and therefore harder to run.

7 Investigate the action of an Olympic shot-putter.

a Why does the athlete bend backwards just before releasing the shot?

The athlete bends back so that their arm can move through a longer distance in order to accelerate the shot to a higher speed OR to increase the force at which they can throw the shot.

b What class of lever is formed by the upper torso?

The upper torso forms a third-class lever.

c Identify as many levers acting as possible. Label each lever as first, second or third class.

Student answers will vary, but may include the following as levers that are acting: upper torso = third-class lever; elbow extension = first-class lever; action of biceps = second-class lever.

Analyse and evaluate

8 Think about how far a toy car and a marble would roll along a flat bench. Which has the least friction? Which rolls the furthest? What is the connection between rolling and friction?

Student answers will vary. Typically, a marble would have the least friction and would therefore roll further than the toy car. Eventually the marble will come to a stop due to friction. The smooth round surface of the marble has a smaller area in contact with the surface and so little friction occurs than with the four wheels of the car.

9 Consider the pulley system in Figure 7.54. How far will the 100 kg load rise if 2 m of rope is pulled through the pulleys?

The mechanical advantage is 4 because there are four pulleys, so the distance moved will be ¼ of 2 m = 50 cm or 0.5 m.

10 Figure 7.55 shows what happens when you stand on your toes.

a What type of lever is formed by the foot when you do this?

Second-class lever

b Discuss why this lever is a force magnifier.

The foot is a force magnifier because it reduces the amount of effort required to move the body.

11 Investigate the kicking action of a soccer player.

a Draw a picture of a leg kicking a ball. On your diagram identify which of the muscles are involved in moving the foot.

Muscles involved in moving the foot include the hamstrings, quadriceps, adductors, plantaris, flexors and gluteus.

b What class of lever is formed by the muscle and bone attachments?

A third-class lever is formed by the muscle and bone attachments in the knee and hip. A second-class lever is formed by the muscle and bone attachments in the foot.

c Are they force magnifiers or distance magnifiers?

The lever created by the knee and hip is a distance magnifier, whereas the lever created by the foot is a force magnifier.

Critical and creative thinking

12 Suppose Matilda fills her car with petrol and drives 100 km along a freeway. She then turns off the freeway and travels 100 km along country roads, one of which is very rough.

a Which part of the trip would the car use more petrol?

More petrol will be consumed by the car on the rough country road.

b Explain your answer using your knowledge of forces and friction.

This is because of an increase in friction between the car tyres and the rough road. The energy to run the car and overcome this additional friction comes from the petrol, so therefore the greater force demand to keep the car moving requires the consumption of more petrol to provide the energy.

Review

13 Forces are needed to keep cells together, to pump blood around the body and to move our muscles. Research the different forces in the human body and how they work. Present your findings as a poster.

This activity is a research activity, so student answers will vary.

14 Musical instruments often use simple machines. For instance, levers are used in pianos. Consider the following questions as part of your research:

a How are levers used in pianos?

The keys of a piano are first-class levers, like a see-saw. The pedals are also levers.

b Which other musical instruments use levers?

The keys on woodwind or brass instruments are also levers.

c How does the lever help make sounds?

In the piano, pressing the key makes the opposite end of the lever go up. A small felt-covered hammer hits a string and makes a note. In brass or woodwind instruments, pressing the key opens the hole and allows air to come out, changing the length of the pipe and hence the note.

15 The wearing of seatbelts in cars was first made law in Australia in 1970. Research the materials that are used to make seatbelts. Use your knowledge of forces to explain how seatbelts prevent injury in a car accident.

This activity is a research activity, so student answers will vary. However, seatbelts prevent injury by attaching the person to the car so that they start and stop together. Without a seatbelt, the person is free to move around in the car and, in a car accident, their body can collide with parts of the car or even exit the car through the windscreen or window, causing injury.

16 Even though Leonardo da Vinci lived long before the Industrial Revolution, he designed numerous machines. Some of these machines were designed for civil purposes and some for military purposes. Find out about some of his machines. What types of simple machine did he use in his designs? Have any of his machines become a reality? What factors might have prevented his machines becoming a reality?

This activity is a research activity, so student answers will vary. However, Leonardo da Vinci’s machines include:

• a single-span 720-foot (220 metre) bridge

• an automated bobbin winder

• a machine for testing the tensile strength of wire

• several flying machines

• concentrated solar power

• a calculator.

Machines that have become reality include:

• an automated bobbin winder

• calculator

• the use of solar power

• flying machines

• bridge.

Factors that may have prevented his machines becoming a reality include:

• availability of materials

• acceptance of his ideas

• money

• ways of making them

• fuel that didn’t exist.