●●○○○ Level 2 · Science S2.5

Forces: friction, falling and floating

Why a sliding stone stops, and why a steel ship floats.

Draw forces as arrows, make a rubber band force meter, test friction on different surfaces, drop things to see how gravity and air act, and find out why a lump of clay sinks but a clay boat floats.

YOU ARE READY FOR THIS BOOK IF

You can show a push and a pull and say which way each one acts.

One step up	S3.7 Speed, forces and pressure
This book	**S2.5 Forces: friction, falling and floating**
One step down	S1.5 Pushes and pulls

Contents

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S2.5.8 Shape and floating

Key words, A to Z

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S2.5.1 CHAPTER 1

Forces are pushes and pulls

What makes a thing start to move, or stop?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Only a living thing can make it move.
- ☐ **B** Things move by themselves.
- ☐ **C** Only a push can move a thing. A pull cannot.
- ☐ **D** A push or a pull.

BY THE END YOU CAN

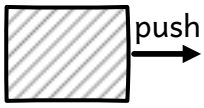
- Draw arrows to show the direction of a push or a pull
- Explain that forces can change speed, direction and shape

You open a door. You kick a ball. You squeeze a sponge. Each time you use a force.

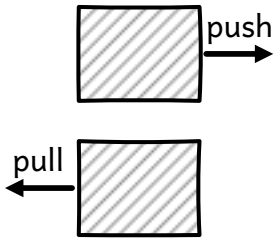
A **force** is a push or a pull. A **push** moves a thing away from you. A **pull** brings a thing towards you.

DRAW IT FIRST

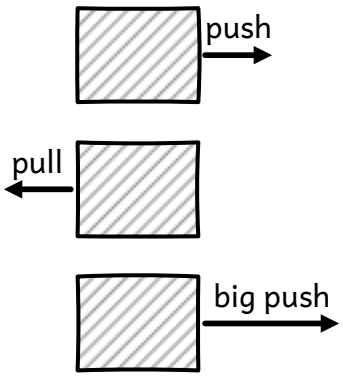
Draw a push and a pull



1 Draw a box. Draw an arrow pointing right. Write push.



2 Draw a second box. Draw an arrow pointing left. Write pull.



3 Draw a third box. Draw a longer arrow pointing right. Write big push.

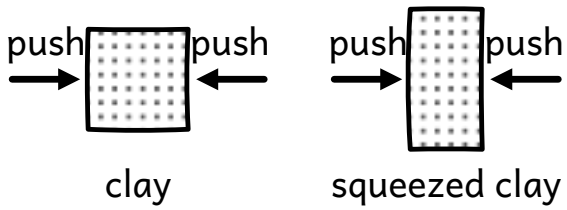
An arrow shows a force. It points the way the force acts. A longer arrow means a bigger force.

A force needs nothing alive. Wind pushes a leaf. A magnet pulls a nail. The Earth pulls a fruit down from a tree.

A force can start a thing moving, or stop it. It can speed it up or slow it down. It can turn it. It can also change its shape.

Force	What changes
kick a ball	its speed
push it aside	its direction
squeeze clay	its shape

A force can change speed, direction or shape.

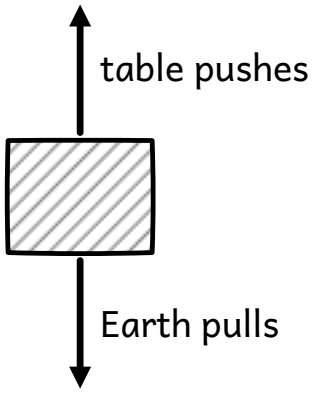


Two pushes that meet change the shape of clay.

A book lies still on a table. Are there forces on it? Yes, there are two.

SEE IT THREE WAYS

As a picture



In words

The Earth pulls the book down. The table pushes it up. The two forces are the same size. We say they are **balanced**, so the book stays still.

TRY IT

Push, pull and squeeze

You need: a bottle top or a small stone, a table or a smooth floor, a lump of clay, soft mud or a sponge.

Be safe: Wash your hands after you touch clay or mud.

1. Put the bottle top on the table. Flick it with a finger. What does it do?
2. Flick it again, from the side, while it moves. What does it do now?
3. Put your hand in its way. What does it do?
4. Squeeze the clay in your hand. What does it do?

What you will see: Your flick started the bottle top moving. A flick from the side turned it. Your hand stopped it. Your squeeze changed the shape of the clay. Each time you used a force.

If you cannot try it, this is what happens.

You did	It did
flick it	it moved
flick the side	it turned
block it	it stopped
squeeze clay	new shape

A WRONG IDEA MANY PEOPLE HAVE

~~A thing that lies still has no forces on it.~~

Why it feels right: Nothing moves, so it looks as if nothing pushes or pulls.

The test that breaks it: Hold a book on your flat hand. Feel your hand push up. Now pull your hand away. The book falls. The Earth was pulling it down all the time.

What is true: A still thing can have forces on it. They are balanced, so nothing changes.

KEY WORDS

force
a push or *a* pull.

push
a force that moves *a* thing *a*way.

pull
a force that brings *a* thing closer.

balanced
two forces of the same size that *a*ct in opposite ways.

BACK TO YOUR GUESS

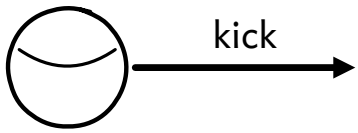
The answer is D: A push or *a* pull.

A push or *a* pull makes *a* thing start, stop or turn. A pull can move *a* thing as well as *a* push can. Wind and magnets can push and pull too. They are not alive.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Kofi kicks *a* ball. Which way does the arrow point?



A Back to the foot

B The way the ball is kicked

C Up

D Down to the ground

Answer at the back of the book.

2. Which of these is a pull?

   A A magnet draws a nail towards it

   B Wind blows a leaf along

   C A hand squashes clay

   D A child kicks a ball

   Answer at the back of the book.

3. Amina squeezes a sponge. What does her force change?

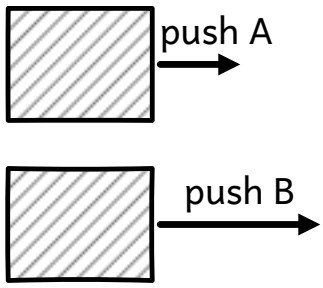
   A Its speed

   B Its weight

   C Its shape

   Answer at the back of the book.

4. Look at the picture. Which push is bigger?



   A They are the same

   B Push B

   C Push A

   Answer at the back of the book.

5. A book lies still on a table. The Earth pulls it down. What else acts on it?

   A Nothing. The book is still.

   B The book pushes the table, and the table does nothing.

   C The table pushes it up.

   Answer at the back of the book.

6. Draw a box. Add a push to the right and a pull to the left. Make the pull longer.

   Answer at the back of the book.

7. A ball rolls straight along the ground. Ravi taps it from the side, and it turns. What did the tap change?

   A Its shape

   B Its weight

   C Its direction

   D Nothing. Only a kick can change how a ball moves.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

A force is a push or a pull. An arrow shows its way. A longer arrow is a bigger force. Forces can change speed, direction and shape. A still thing has balanced forces.

Draw: A box. A push arrow to the right. A longer pull arrow to the left. Labels.

S2.5.2 CHAPTER 2

Measuring forces

How can I tell how big a pull is?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** You cannot measure a pull.
- ☐ **B** A rubber band stretches more for a bigger pull.
- ☐ **C** A bigger pull always makes more noise.

BY THE END YOU CAN

- Make a force meter with a rubber band and a ruler
- Explain that forces are measured in newtons

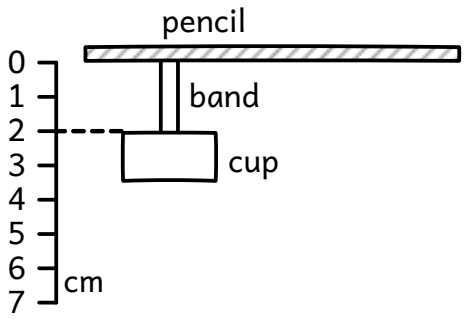
A pull can be small or big. Your hand can tell you a little. A ruler can tell you more.

A rubber band gets longer when you pull it. We call this a **stretch**. A bigger pull gives a bigger stretch.

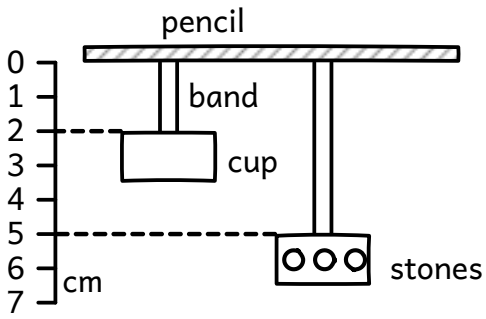
So the stretch of a band shows how big the pull is. A band and a ruler make a **force meter**. A force meter measures a pull.

DRAW IT FIRST

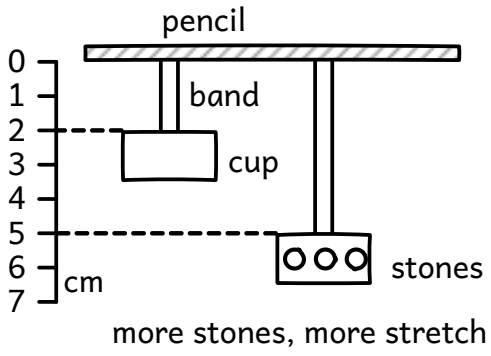
Draw a force meter



1 Draw a pencil, a ruler and a band with an empty cup. Mark 2 cm.



2 Draw a second band. Put three stones in its cup. Mark 5 cm.



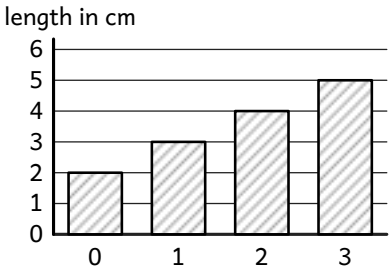
more stones, more stretch

3 Write more stones, more stretch.

Put in the stones one at a time. Read the band each time. Write it in a table.

SEE IT THREE WAYS

As a picture



In words

These numbers come from one test. Each stone pulls the band a little more. The band gets longer each time. More pull, more stretch. Your numbers will differ from ours.

In symbols

0 stones: 2 cm. 3 stones: 5 cm. Three stones stretch the band 3 cm more.

Be safe. A rubber band can snap and hit an eye. Keep your face away. Stop at four stones, or sooner if the band looks thin.

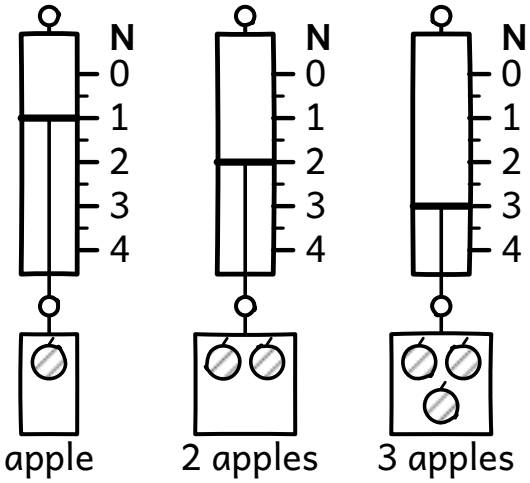
The unit of force is the **newton**. We write N. It is named after Isaac Newton.

The Earth pulls on a small apple with about 1 newton. That apple is about 100 grams.

People often say a sack weighs 5 kilograms. That is fine in daily life. In science, kilograms tell how much stuff a thing has. Newtons tell how strong a pull is.

Hang a small apple in your cup. Mark how much the band grows. That is about 1 newton. Two apples make about 2 newtons.

A real force meter has a spring in a tube. A pointer moves along a scale. The scale is marked in newtons.



Each small apple pulls with about 1 N. More apples, more newtons.

TRY IT

Make a force meter

You need: a rubber band, a pencil, two piles of books, a small cup or a small bag with string, a ruler, about six stones of the same size, or beans, paper and a pencil.

Be safe: Keep your face away from the band. Stop if the band looks very thin.

1. Rest the pencil across two tall piles of books. Hang the band from it.
2. Hang the cup from the band. Hold the ruler upright. Put its 0 at the top of the band.
3. Read how long the band is. Write the number.
4. Put in one stone. Read the band again. Write it.
5. Add stones one at a time. Read each time. Stop at four.

What you will see: The band gets longer with every stone. A bigger pull gives a bigger stretch. Your numbers will not be the same as ours. That is fine.

If you cannot try it, this is what happens.

Stones	Band
0	2 cm
1	3 cm
2	4 cm
3	5 cm

A WRONG IDEA MANY PEOPLE HAVE

~~You can only feel how big a force is. You cannot measure it.~~

Why it feels right: A force is not a thing you can see or hold. It is only a feeling in your hand.

The test that breaks it: Hang three stones on your force meter. Read the band. Take them off. Hang the same three stones again. You get the same reading. One stone gives a smaller reading.

What is true: A force can be measured. The stretch of a band gives a number. The same pull gives the same number.

KEY WORDS

stretch
to get longer when you pull.

force meter
a tool that measures a pull.

newton
the unit for force. We write N.

BACK TO YOUR GUESS

The answer is B: A rubber band stretches more for a bigger pull.

A rubber band stretches more for a bigger pull. We can read the stretch on a ruler. That measures the pull.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Look at the table. How long is the band with 2 stones?

Stones	Band
0	2 cm
1	3 cm
2	4 cm
3	5 cm

A 2 cm

B 5 cm

C 4 cm

D 3 cm

Answer at the back of the book.

2. The band is 2 cm long with an empty cup. It is 5 cm long with three stones. How much longer is it with the stones?

A 5 cm

B 7 cm

C 2 cm

D 3 cm

Answer at the back of the book.

3. In what unit do scientists measure force?

A Newtons

B Kilograms

C Centimetres

Answer at the back of the book.

4. Ravi hangs a pebble in the cup. The band is 3 cm long. A bigger stone makes it 5 cm. Which pull is bigger?

   A The pebble pulls more.

   B They pull the same.

   C The bigger stone pulls more.

   Answer at the back of the book.

5. **From an earlier chapter**

   A stone hangs still from a band. The Earth pulls the stone down. What does the band do?

   A It pulls the stone up as hard as the Earth pulls down.

   B Nothing. The stone is still.

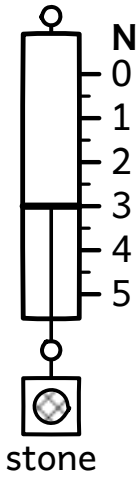
   C It pushes the stone down.

   Answer at the back of the book.

6. Draw a force meter with two stones in the cup. Write the reading from the table.

   Answer at the back of the book.

7. Priya hangs a stone from a force meter. Look at the picture. What does the meter read?



A 3 kg

B 3 N

C 5 N

D 0 N

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

A rubber band stretches more for a bigger pull. A band and a ruler make a force meter. Force is measured in newtons, written N. A small apple weighs about 1 newton.

Draw: A band hanging from a pencil. A cup of stones. A ruler beside it.

S2.5.3 CHAPTER 3

Friction

Why does a sliding thing slow down and stop?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Its push runs out.
- ☐ **B** It gets tired.
- ☐ **C** Gravity holds it in place.
- ☐ **D** The ground rubs against it.

BY THE END YOU CAN

- Compare how far an object slides on smooth and rough surfaces
- Explain how friction helps us walk and slows things down

Slide a book across a table. It slows down and stops. Nobody caught it. Why did it stop?

When two surfaces rub, there is a force called **friction**. Friction pushes against the way a thing slides.

DRAW IT FIRST

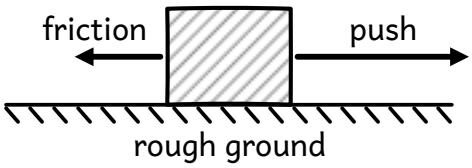
Draw friction on a sliding box



1 Draw a box on a ground line. Draw a long arrow pointing right. Write push.



2 Draw a shorter arrow pointing left. Write friction.

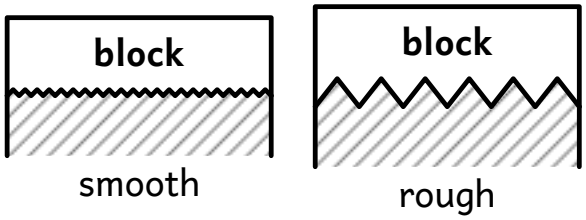


3 Draw little bumps under the ground. Write rough ground.

The friction arrow points the other way from the push. Friction acts against the slide.

A **rough** surface has bumps you can feel. A **smooth** surface feels flat. Even a smooth surface has tiny bumps.

The bumps on two surfaces catch on each other. A rough surface gives more friction than a smooth one.



Close up, a rough surface has big bumps that catch. A smooth surface has tiny ones.

A ball rolling on the ground slows down too. The ground and the air push against it.

TRY IT

How far does it slide?

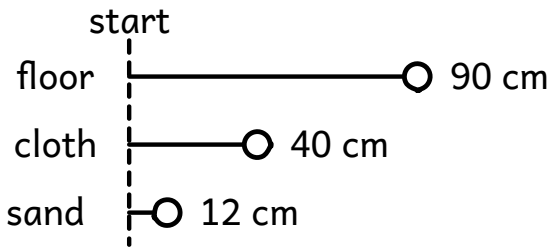
You need: a bottle top or a flat stone, a book and a pile of books, for a ramp, a smooth floor or table, a cloth or mat, a little dry sand or fine soil, a ruler or a string marked in cm, paper and a pencil.

Be safe: Keep sand and soil away from your eyes. Wash your hands afterwards.

1. Lean the book on the pile to make a ramp. Put its foot on the smooth floor.
2. Put the bottle top flat at a mark on the ramp. Let it go. Do not push it. If it will not slide, make the ramp steeper.
3. Measure how far it slides past the foot of the ramp. Write it down.
4. Lay the cloth flat past the ramp. Do it again from the same mark.
5. Spread a thin layer of sand. Do it again from the same mark.

What you will see: The bottle top slides far on the smooth floor. It slides less on the cloth. It slides least on the sand. Each time it started the same way. Only the surface changed. In our test it slid 90, 40 and 12 cm. Your numbers will differ.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A thing stops because its push runs out.~~

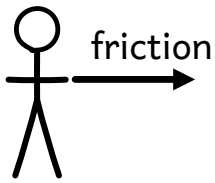
Why it feels right: You gave it a push. It slowed down and stopped. It seems the push was used up.

The test that breaks it: Use the ramp again. Let the top go from the same mark. Do it on the floor, then on the cloth. The start is the same. If the push ran out, the slide would be the same. It is not.

What is true: The surface slows the bottle top. More friction means a shorter slide.

SEE IT THREE WAYS

As a picture



In words

When you walk, your shoe pushes back on the ground. Friction stops the shoe slipping. The ground pushes you forward.

Friction helps us. You could not walk on a floor with no friction. On a wet, smooth floor you slip, because there is little friction.

Friction lets you hold a cup. It lets the brakes of a bicycle slow the wheel. The brake pads rub the wheel.

Friction also makes heat. Rub your hands together fast. They get warm.

KEY WORDS

friction
the force between two surfaces that rub. It acts against the slide.

rough
a surface with bumps you can feel.

smooth

a surface that feels flat.

BACK TO YOUR GUESS

The answer is D: The ground rubs against it.

The ground rubs against it. The rubbing is a force called friction. It pushes against the way the thing slides.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which surface gives the most friction?

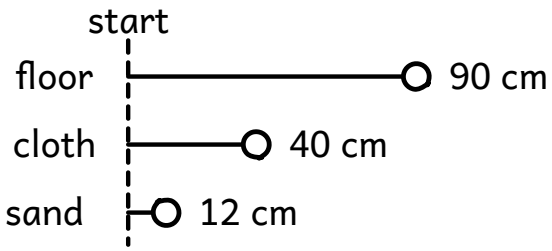
   A A smooth floor

   B A rough mat

   C A sheet of glass

   Answer at the back of the book.

2. Look at the picture. How much further did it slide on the floor than on sand?



   A 78 cm

   B 102 cm

   C 90 cm

   Answer at the back of the book.

3. A ball rolls over grass and stops. What slows it?

   A Its push runs out.

   B The ball gets tired.

   C Friction from the grass, and the air

   Answer at the back of the book.

4. Why does your shoe not slip when you walk?

   A The air holds the shoe.

   B Friction between the shoe and the ground

   C Friction makes us slip.

   Answer at the back of the book.

5. **From an earlier chapter**

   Amina pulls a box with her force meter. What unit would a science book use?

   A Kilograms

   B Metres

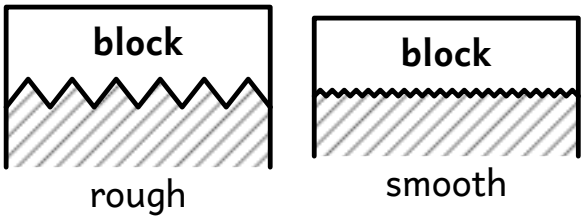
   C Newtons

   Answer at the back of the book.

6. Draw a box sliding to the right. Draw the friction arrow.

   Answer at the back of the book.

7. Look at the two surfaces, close up. Which block is harder to slide?



A The block on the rough surface

B The block on the smooth surface

C Both are the same, because both are blocks.

Answer at the back of the book.

8. Which sentence about friction is true?

A Friction is always bad, so we should get rid of it.

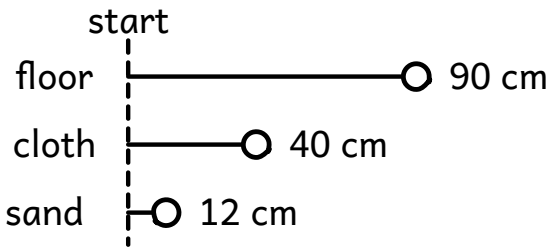
B Friction helps us to walk and to hold things.

C Friction happens only when a thing moves fast.

D Friction pushes a thing the way it slides.

Answer at the back of the book.

9. Look at the picture. A bottle top slid down the same ramp onto three surfaces. Which surface gave the most friction?



A floor

B cloth

C They are all the same

D sand

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Friction is a force between two surfaces that rub. It acts against the slide. Rough surfaces give more friction than smooth ones. Friction helps us walk and hold things. It also slows things down.

Draw: A box sliding right. A push arrow right. A shorter friction arrow left.

S2.5.4 CHAPTER 4

More friction or less

How can we get less friction, or more?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Only a smooth floor gives less friction.
- ☐ **B** Nothing changes friction.
- ☐ **C** Oil, water and wheels give less friction.
- ☐ **D** A rough mat gives less friction.

BY THE END YOU CAN

- Give ways to reduce friction, such as oil, water or wheels
- Explain why shoe soles and tyres have grooves

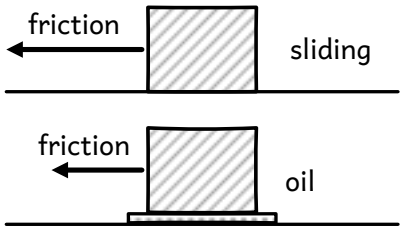
Sometimes we want less friction. Sometimes we want more. We can change it.

DRAW IT FIRST

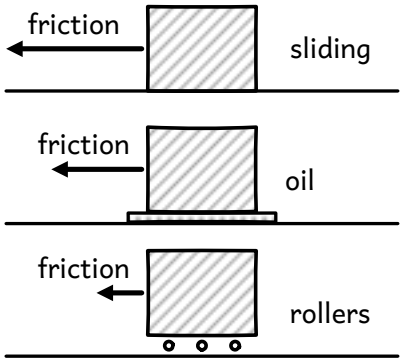
Draw three ways to slide a box



1 Draw a box on the ground. Draw a long friction arrow pointing left.



2 Draw oil under a box. Draw a shorter friction arrow.



3 Draw a box on round pencils. Draw the shortest friction arrow.

Oil gives less friction. A drop of oil between moving parts lets them slide. A bicycle chain needs oil.

Water can give less friction too. A wet, smooth floor is slippery.

A **roller** is a round thing that rolls under a load. Wheels and rollers give less friction. Rolling rubs much less than sliding. A heavy box on rollers needs a smaller push.

TRY IT

Slide it, then roll it

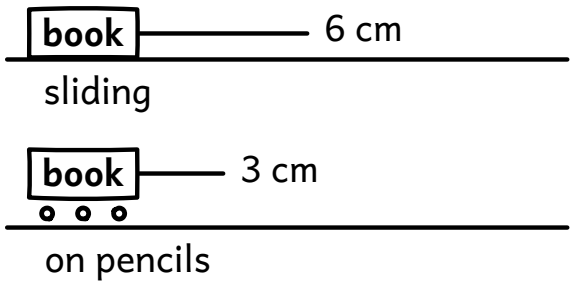
You need: a heavy book, string, the band from your force meter, a table, three round pencils, a ruler.

Be safe: Keep your face away from the band. Do not let the book fall on your feet.

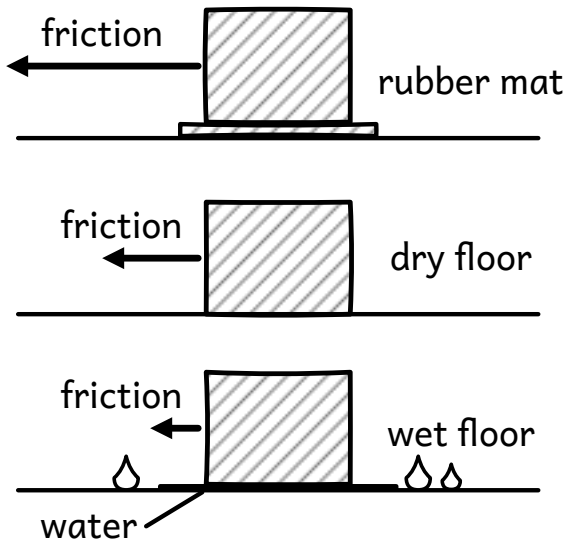
1. Tie the string round the book. Tie the band to the string.
2. Pull the band slowly along the table. Keep it steady. Read the length of the band as the book slides.
3. Put three round pencils under the book, side by side. Pull again. Move each pencil to the front once the book has passed it.
4. Read the band again. Which pull was bigger?

What you will see: The band is shorter when the book rolls on the pencils. A shorter band means a smaller pull. Rolling gives less friction than sliding. Our band went from 6 cm to 3 cm. Yours may differ.

If you cannot try it, this is what happens.



We also need more friction. A rubber mat stops a cup sliding. Chalk on the hands of a climber helps them hold. Sand on a slippery path helps your shoes grip.



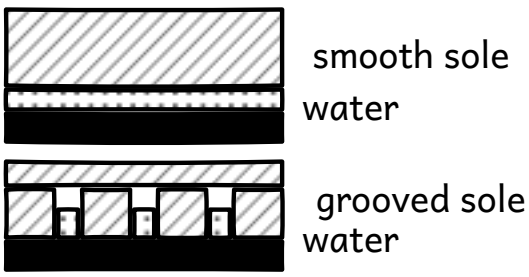
A mat gives a lot of friction. A wet floor gives very little.

To **grip** is to hold on without slipping. Shoes grip best when the rubber touches the ground.

Wet or muddy ground is slippery. Water and mud get between the sole and the ground. The shoe slides.

SEE IT THREE WAYS

As a picture



In words

A **groove** is a narrow gap cut in the sole. Water and mud go into the grooves. The rubber touches the ground, and the shoe grips.

Tyres have grooves for the same reason. On a wet road, grooves move water from under the tyre. On a dry road, a smooth tyre can grip well.

A WRONG IDEA MANY PEOPLE HAVE

~~Friction is always bad. We should get rid of all of it.~~

Why it feels right: Friction slows things down and makes them warm. It seems like a waste.

The test that breaks it: Try to turn a tight bottle top with dry fingers. It turns. Put a drop of oil or soapy water on your fingers. Try again. Your fingers slip. With less friction you cannot hold on. Wash your hands afterwards.

What is true: We need friction to hold, walk and stop. We want less in some places and more in others.

KEY WORDS

roller
a round thing that rolls under a load.

grip
to hold on without slipping.

groove
a narrow gap cut in a sole or a tyre.

BACK TO YOUR GUESS

The answer is C: Oil, water and wheels give less friction.

Oil, water and wheels give less friction. Rough rubber and sand give more grip. Grooves help on wet or muddy ground.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which gives less friction under a heavy box?

   A A rough mat

   B Round rollers

   C A layer of sand

   Answer at the back of the book.

2. Why does a bicycle chain get a drop of oil?

   A The oil makes the chain grip the wheel.

   B The oil makes more heat.

   C The oil gives less friction between the moving parts.

   Answer at the back of the book.

3. Why do boots for mud have grooves?

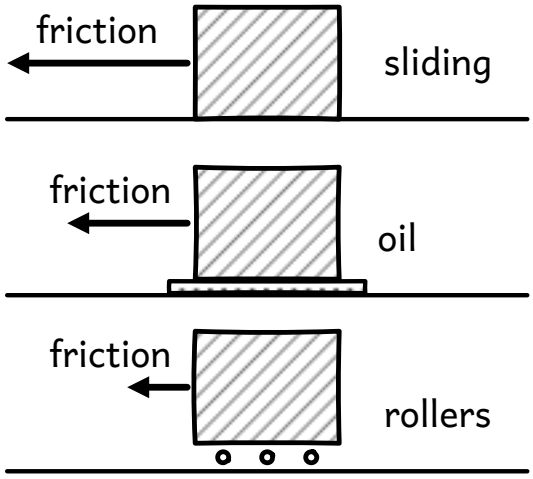
   A Mud goes into the grooves, so the rubber can grip.

   B The grooves make the boot smooth.

   C The grooves make the boot lighter.

   Answer at the back of the book.

4. Look at the picture. Which row has the least friction?



A sliding

B oil

C They are the same

D rollers

Answer at the back of the book.

5. **From an earlier chapter**

A box slides to the right and stops. Which way does the friction arrow point?

A Right, with the slide

B Left, against the slide

C Up

Answer at the back of the book.

6. Write two ways to get less friction. Write two ways to get more.

Answer at the back of the book.

7. Why is a wet, smooth floor slippery?

   A The floor is cold, so the shoe slides.

   B The water makes the floor rough.

   C The water makes the shoe stick.

   D Water between the shoe and the floor gives less friction.

   Answer at the back of the book.

8. A climber puts chalk on her hands. Why?

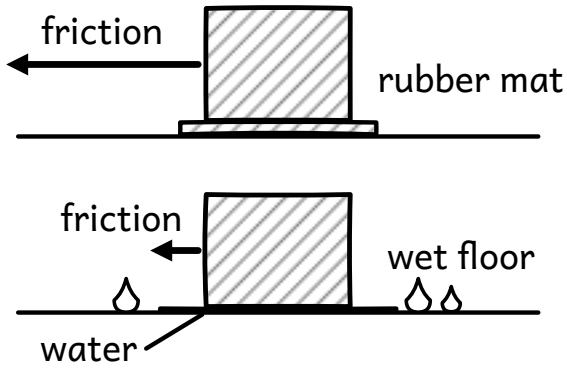
   A Chalk gives the hands more grip.

   B Chalk makes the hands slide more easily.

   C Chalk makes the hands wet, so they stick.

   Answer at the back of the book.

9. Look at the picture. Leila walks on a rubber mat and then on a wet floor. Where is she more likely to slip?



   A On the rubber mat

   B On the wet floor

   C She is as likely to slip on one as on the other.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Oil, water and wheels give less friction. Rough rubber and sand give more grip. On wet or muddy ground, grooves help shoes and tyres grip. Water and mud go into the grooves. The rubber touches the ground.

Draw: A sole with grooves on wet ground. Water in the grooves.

S2.5.5 CHAPTER 5

Gravity and falling

Why does a stone fall down when I let go?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** The air pushes it down.
- ☐ **B** The Earth pulls it down.
- ☐ **C** It falls because it is heavy.
- ☐ **D** Gravity only pulls where there is air.

BY THE END YOU CAN

- Explain that gravity pulls things towards the centre of the Earth
- Explain that weight is the pull of gravity on an object

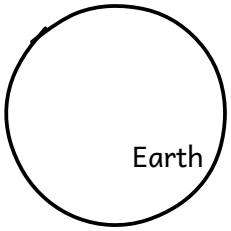
You let go of a stone. It falls. Nobody pushes it. What makes it fall?

The Earth pulls it. This pull is **gravity**. Gravity is the pull of the Earth on things.

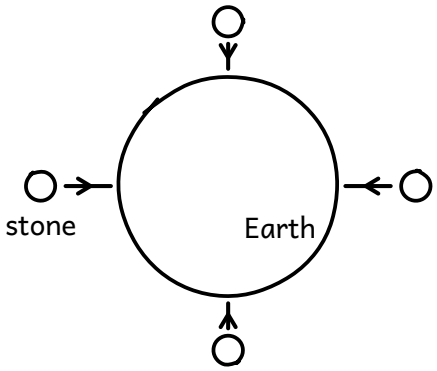
Gravity is a force. It is a pull. You cannot see it. You can see what it does.

DRAW IT FIRST

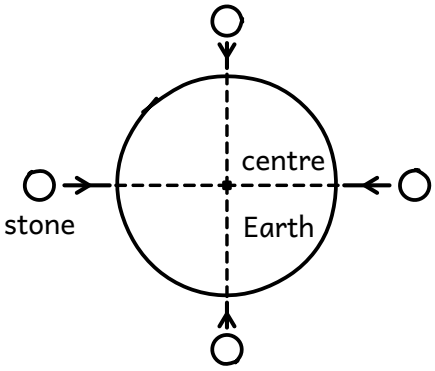
Draw how gravity pulls



1 Draw a big circle. Write Earth.



2 Draw a stone above, below and at each side. Draw an arrow from each to the Earth.



3 Draw a dashed line from each arrow to the middle. Write centre.

Gravity pulls things towards the **centre** of the Earth. The centre is the middle.

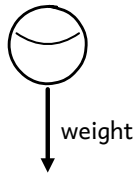
Down means towards the centre of the Earth, wherever you stand.

Mei lives on the far side of the Earth from Kofi. She does not fall off. Gravity pulls her towards the centre too.

Gravity gives things **weight**. Weight is the pull of gravity on a thing.

SEE IT THREE WAYS

As a picture



In words

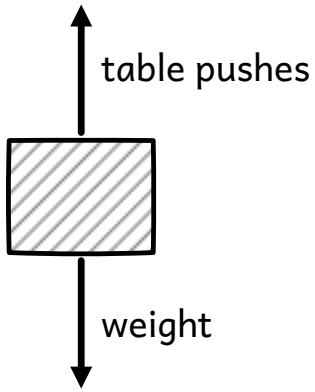
You let go of a ball. Gravity pulls it down. The size of that pull is its weight.

In symbols

Weight is a force, so we measure it in newtons. A small apple weighs about 1 newton. Ten small apples weigh about 10 newtons.

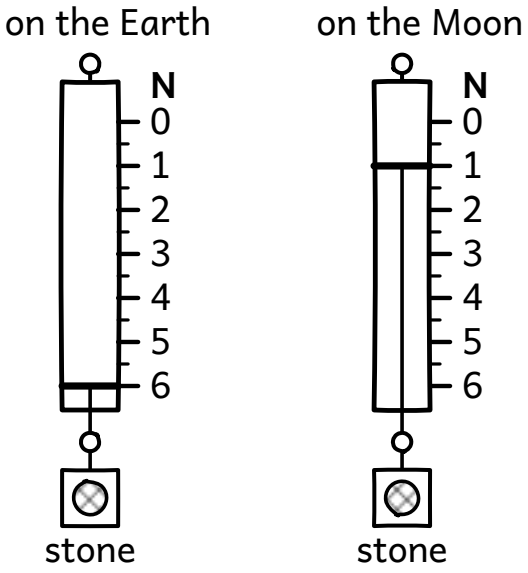
People say a bag weighs 2 kilograms. That is fine in daily life. In science, kilograms tell how much stuff is in a thing. Weight is a force, so it is in newtons.

A box on a table does not fall. The table pushes up on it. The push up equals the pull down. So the box stays still.



Two equal forces balance. The box stays still.

The Moon has gravity too, but it is weaker. A stone would weigh about $^1/_6$ as much there. It is still the same amount of stuff.



The same stone weighs 6 N on the Earth. On the Moon it weighs about 1 N.

TRY IT

Do big stones fall faster?

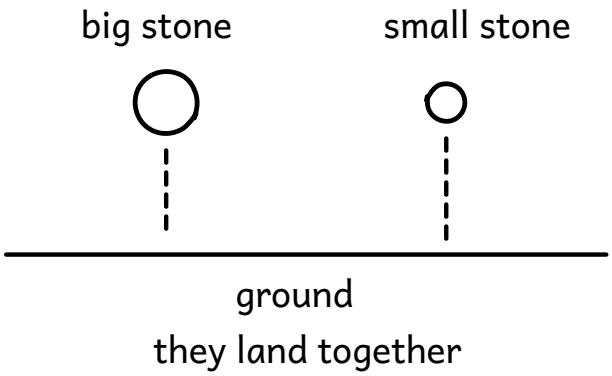
You need: a stone as big as your fist, a stone as big as a bean, soft ground, sand or a thick pile of cloth, a friend to watch and listen, a sheet of paper.

Be safe: Hold stones no higher than your waist. Drop them onto soft ground only. Keep your feet back. Nobody stands below or close. Never drop anything from a window, a roof or a wall.

1. Lay the cloth or find soft ground. Make sure nobody stands near.
2. Hold the big stone in one hand. Hold the small stone in the other. Keep them at the same height.
3. Open both hands at the same moment.
4. Listen. Do you hear one thud or two? Try three times.
5. Now drop a flat sheet of paper. Then crumple it into a tight ball and drop it.

What you will see: The two stones land together. You hear one thud. The flat paper floats down slowly. The tight paper ball falls fast. It is the same paper, so its weight is the same.

If you cannot try it, this is what happens.



they land together

A WRONG IDEA MANY PEOPLE HAVE

~~Heavy things fall faster than light things.~~

Why it feels right: A stone drops fast. A leaf or a sheet of paper drifts down slowly.

The test that breaks it: Drop a big stone and a small stone together onto soft ground. Hold them at the same height. They land together. Now drop a flat sheet of paper. Then drop it crumpled into a ball. The ball falls much faster. It weighs the same as the sheet.

What is true: Gravity makes big and small stones fall together. Air slows a flat, light sheet. The next chapter shows how.

KEY WORDS

gravity
the pull of the Earth on things. It pulls towards the centre.

centre
the middle of the Earth.

weight
the pull of gravity on a thing. It is measured in newtons.

BACK TO YOUR GUESS

The answer is B: The Earth pulls it down.

The Earth pulls it down. This pull is gravity. It pulls big stones and small stones the same way. Gravity needs no air.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Which way does gravity pull things?

    A Away from the Earth

    B Towards the Sun

    C Towards the centre of the Earth

    Answer at the back of the book.

2. Mei lives on the far side of the Earth. Why does she not fall off?

    A Gravity pulls her towards the centre of the Earth too.

    B She holds on tight to the ground.

    C The air above her pushes her down.

    Answer at the back of the book.

3. What is weight?

    A How much room a thing takes up

    B The pull of gravity on a thing

    C How fast a thing falls

    Answer at the back of the book.

4. Amina drops a big stone and a small stone. She drops both from the same height. What happens?

    A The big stone lands first.

    B The small stone lands first.

    C It depends on how heavy the stones are.

    D They land together.

    Answer at the back of the book.

5. A stone weighs 12 newtons on the Earth. The Moon pulls about $^1/_6$ as hard. About how many newtons does it weigh on the Moon?

    Answer at the back of the book.

6. **From an earlier chapter**

Which unit do scientists use to measure a force such as weight?

A The centimetre

B The litre

C The kilogram

D The newton

Answer at the back of the book.

7. There is no air on the Moon. Does gravity pull a ball dropped there?

A No. Gravity needs air to work.

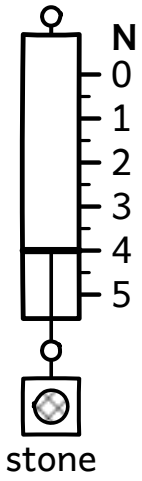
B No. Only the Earth has gravity.

C Yes, but the pull is weaker than on the Earth.

D Yes, and it is just as strong as on the Earth.

Answer at the back of the book.

8. Kofi hangs a stone from a force meter and keeps it still. Look at the picture. What is the weight of the stone?



A 4 N

B 4 kg

C 0 N

D 8 N

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Gravity is the pull of the Earth on things. It pulls towards the centre of the Earth. Weight is the pull of gravity on a thing, in newtons. Big and small stones fall together.

Draw: Draw the Earth and four stones. Draw an arrow from each stone towards the centre.

S2.5.6 CHAPTER 6

Air and water resistance

Why does paper fall slowly when a stone falls fast?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Gravity does not pull on paper.
- ☐ **B** Paper is too light for gravity.
- ☐ **C** Air pushes up against the paper.
- ☐ **D** Heavy things always fall faster.

BY THE END YOU CAN

- Make paper spinners and compare how fast they fall
- Explain why fish and boats have smooth, pointed shapes

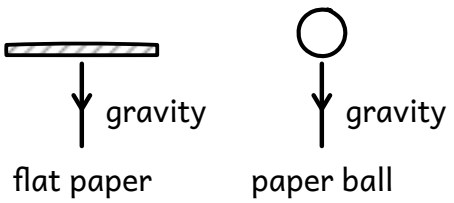
A stone falls fast. A sheet of paper falls slowly. Gravity pulls both. So why the difference?

You cannot see air, but it is there. It pushes on things that move through it.

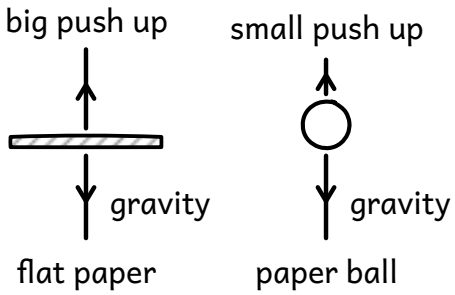
Air resistance is the push of air against a moving thing.

DRAW IT FIRST

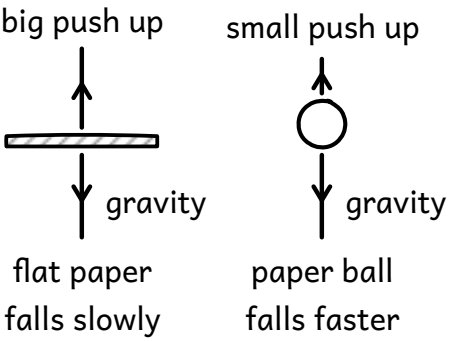
Draw why *a* flat sheet falls slowly



1 Draw *a* flat sheet and *a* paper ball. Draw *a* gravity arrow down from each.



2 Draw *a* long arrow up from the sheet. Draw *a* short arrow up from the ball.

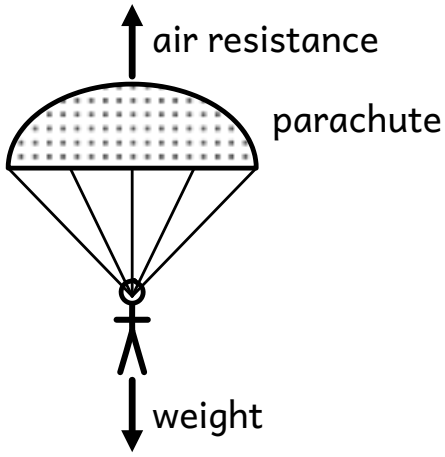


3 Write falls slowly under the sheet. Write falls faster under the ball.

A flat sheet meets *a* lot of air. The air pushes up hard. The sheet falls slowly.

Crumple the same paper. It weighs the same. But less of it meets the air. The push up is smaller. It falls faster.

A parachute has *a* wide canopy. It meets *a* lot of air, so the air pushes up hard.

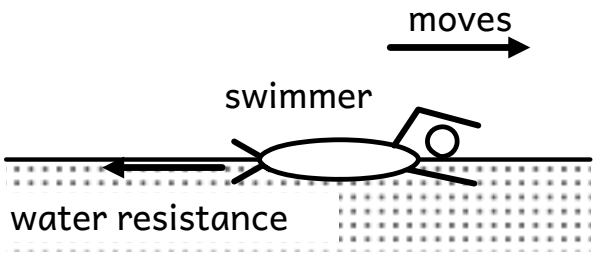


A parachutist falling at a steady speed.

This parachutist falls at a steady speed. The air pushes up as hard as gravity pulls down. The forces are balanced.

Water pushes on moving things too. **Water resistance** is the push of water against a moving thing. It is much stronger than air resistance.

A swimmer feels water resistance. The water pushes back against the swimmer all the time.



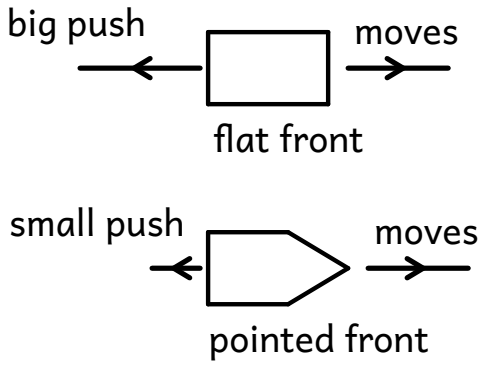
The water pushes back on the swimmer. It acts against the movement.

Be safe. Swim only where an adult says it is safe. Never swim alone.

Fish, boats and flying birds have smooth, pointed shapes. We say they are **streamlined**. Water and air slide past them.

SEE IT THREE WAYS

As a picture



In words

A flat front meets a lot of water. A pointed front meets less. The push back is smaller. The body moves on with less effort.

TRY IT

Make paper spinners

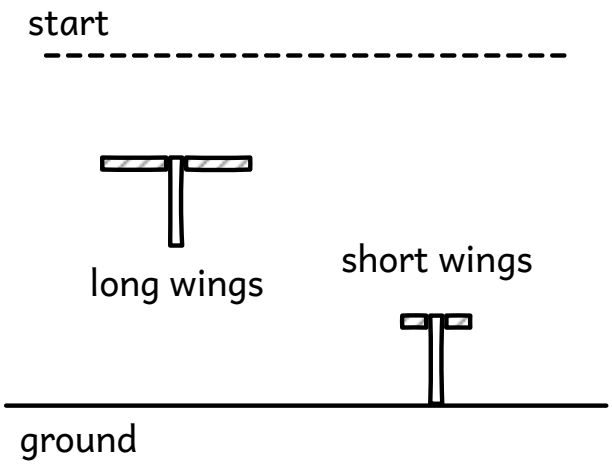
You need: two paper strips, each 4 cm wide and 16 cm long, a grown up with scissors, two paper clips, a friend to watch.

Be safe: A grown up uses the scissors. Do not climb on a chair or a wall to drop them.

1. A grown up cuts each strip down the middle. Cut from the top to half way.
2. Fold the two top flaps out. Fold one forward and one back. These are the wings.
3. Fold the bottom of each strip up by 2 cm. Slide a paper clip on.
4. A grown up cuts the wings of one spinner to half length.
5. Hold both spinners high above your head, at the same height.
6. Let go of both at the same moment. Which lands last? Try three times.

What you will see: Both spinners turn as they fall. The spinner with long wings falls more slowly. It lands last. Long wings meet more air.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~Air is nothing, so it cannot push.~~

Why it feels right: You cannot see air. Your hand moves through it with no trouble.

The test that breaks it: Hold a flat piece of card in front of you. Swing it fast, flat side first. Feel the push on your hand. Now swing it edge first. The push is much smaller.

What is true: Air is real stuff. It pushes against things that move through it. A wide, flat thing meets more air.

KEY WORDS

air resistance
the push of air against a moving thing.

water resistance
the push of water against a moving thing.

streamlined
a smooth, pointed shape that meets little air or water.

BACK TO YOUR GUESS

The answer is C: Air pushes up against the paper.

Air pushes up against the paper. Gravity pulls the paper, but the air slows its fall.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. Why does flat paper fall more slowly than a paper ball?

    A More of the sheet meets air. So air pushes up more.

    B Gravity pulls a flat sheet less.

    C The paper ball is heavier.

    Answer at the back of the book.

2. Mei makes two paper spinners. One has long wings. One has short wings. Which falls more slowly?

    A The one with short wings

    B The one with long wings

    C They fall the same

    Answer at the back of the book.

3. You push your flat hand through air. Then you push it through water. Where is the push back bigger?

    A In air

    B It is the same in both

    C Neither pushes back.

    D In water

    Answer at the back of the book.

4. Why do fish have smooth, pointed shapes?

    A Gravity pulls a pointed shape less.

    B A pointed shape makes water push back harder.

    C Water slides past them, so the push back is small.

    Answer at the back of the book.

5. **From an earlier chapter**

   A bottle top slides on a smooth floor. It slides on a rough mat. Which makes it stop sooner?

   A The rough mat

   B The smooth floor

   C Both stop in the same place

   Answer at the back of the book.

6. Draw a flat sheet of paper falling. Draw an arrow for gravity and an arrow for air resistance.

   Answer at the back of the book.

7. Why does a parachute slow a fall?

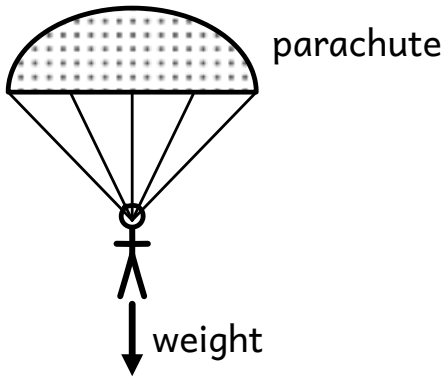
   A Gravity pulls less on a person with a parachute.

   B The wide canopy meets lots of air, so air pushes up hard.

   C A parachute is lighter than air.

   Answer at the back of the book.

8. A parachutist falls at a steady speed. The picture shows only the weight. What does the air do?



A Nothing. Air cannot push on a parachute.

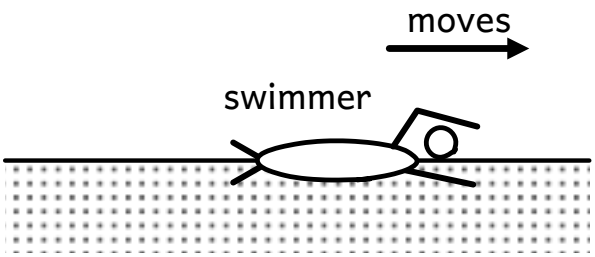
B It pushes down, so the parachutist falls faster.

C It pushes up much harder than the weight pulls down.

D It pushes up as hard as the weight pulls down.

Answer at the back of the book.

9. A swimmer moves through water. Look at the picture. Which way does the water push on the swimmer?



A Forwards, the way the swimmer moves

B Up, towards the sky

C Backwards, against the way the swimmer moves

D Down, towards the bottom

Answer at the back of the book.

10. A feather and a stone fall from the same height. The stone lands first. Why?

    A Gravity does not pull on a feather.

    B The air slows the feather much more than it slows the stone.

    C Heavy things always fall faster.

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Air and water push against things that move through them. This is air resistance and water resistance. A wide, flat thing meets more, so it falls or moves slower. Fish and boats are pointed.

Draw: Draw a flat sheet and a paper ball. Add a long arrow up and a short arrow up.

S2.5.7 CHAPTER 7

Floating and sinking

Why does a big log float but a tiny stone sink?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Heavy things sink and light things float.
- ☐ **B** Big things float and small things sink.
- ☐ **C** It depends on what a thing is made of, and its shape.
- ☐ **D** Only things made of wood float.

BY THE END YOU CAN

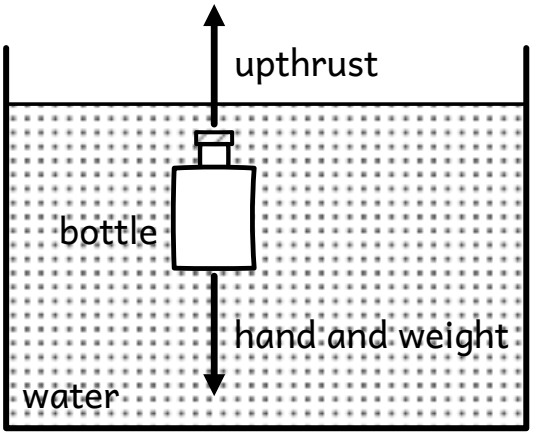
- Predict and test which objects float or sink in water
- Explain that water pushes up on things put into it

A big log floats on a river. A tiny stone sinks. Why?

To **float** is to stay up on the water. To **sink** is to go down to the bottom.

Water pushes up on anything you put in it. This push is called **upthrust**.

Push a closed, empty bottle down into a bucket of water. Feel it push back on your hand. The more you push in, the harder it pushes back.

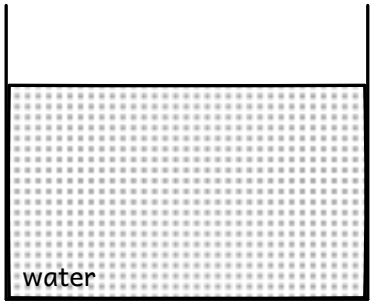


The water pushes the held bottle up.

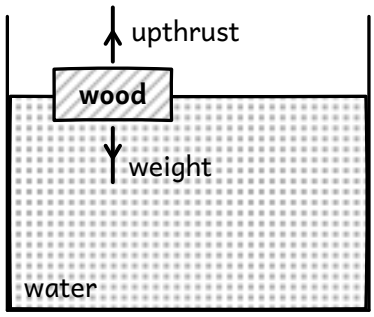
Be safe. Water play is for a bowl or a bucket only. Never play near deep water.

DRAW IT FIRST

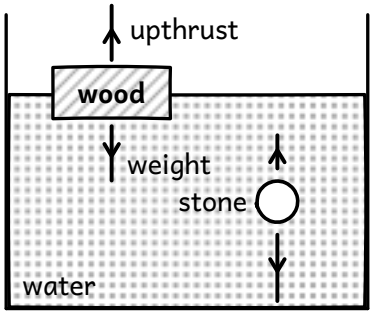
Draw a floating thing and a sinking thing



1 Draw a bowl and fill it with water. Write water.



2 Draw a piece of wood in the top of the water. Draw two arrows of the same length, up and down. Write upthrust and weight.



3 Draw a stone under the water. Draw a short arrow up and a long arrow down.

The wood sinks into the water a little. It stops when the upthrust equals its weight. Then it floats.

A stone is different. Under water, the upthrust is still less than its weight. So it sinks.

So heavy things do not always sink. A big log is heavy and it floats. A small stone, a nail or a pin is light. It sinks.

It depends on what a thing is made of, and its shape. You will see the shape part in the next chapter.

SEE IT THREE WAYS

As a picture

floats	sinks
big log	pin
leaf	small stone
closed bottle	nail

In words

Some big things float. Some tiny things sink. What a thing is made of decides, and so does its shape.

TRY IT

Which things float?

You need: a bowl or a bucket of water, a wooden stick, a leaf, a closed empty plastic bottle with its lid, a metal spoon, a small stone, paper and a pencil.

Be safe: Use a bowl or a bucket only. Never play near deep water. Wash your hands after.

1. Draw a table on paper. Write the names of the things down the side.
2. Guess for each thing. Will it float or sink? Write your guess.
3. Put one thing into the water, gently.
4. Write what happened: floats or sinks.
5. Compare your guesses with what happened.

What you will see: Most sticks and leaves float. The closed bottle floats. The spoon and the small stone sink. Some guesses may be wrong. That is how you learn.

If you cannot try it, this is what happens.

thing	result
wooden stick	floats
leaf	floats
closed bottle	floats
metal spoon	sinks
small stone	sinks

A WRONG IDEA MANY PEOPLE HAVE

~~Heavy things sink and light things float.~~

Why it feels right: A stone is heavy and sinks. A feather is light and floats.

The test that breaks it: Find a thick piece of wood and a small metal key. Hold one in each hand. The wood feels heavier. Put both in water. The wood floats. The key sinks.

What is true: Weight alone does not decide. It depends on what a thing is made of, and its shape.

KEY WORDS

float
to stay up on the water.

sink
to go down to the bottom of the water.

upthrust
the push up that water gives to a thing in it.

BACK TO YOUR GUESS

The answer is C: It depends on what a thing is made of, and its shape.

It depends on what a thing is made of, and its shape. A big log is heavy, but it floats.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A big log and a small stone go into water. What happens?

   A Both sink, because both are heavy.

   B The log floats and the stone sinks.

   C The stone floats, because it is lighter.

   Answer at the back of the book.

2. You push a closed empty bottle under water and let go. It pops up. Why?

   A The water pushes it up harder than its weight pulls down.

   B Gravity stops pulling it under water.

   C The air above the water pushes it up.

   Answer at the back of the book.

3. A block of wood floats and stays still. What is true?

   A The upthrust is bigger than its weight.

   B The upthrust is smaller than its weight.

   C There is no upthrust, because the block floats.

   D The upthrust matches its weight.

   Answer at the back of the book.

4. Mei tests 12 things in water. 7 of them float. The rest sink. How many sink?

   Answer at the back of the book.

5. **From an earlier chapter**

   A small apple weighs about 1 newton. Kofi holds a bag of 8 small apples. About how many newtons is the weight of the bag?

   Answer at the back of the book.

6. Draw a stick floating in water. Draw two arrows on it, one for weight and one for upthrust.

   Answer at the back of the book.

7. A big log floats. A big stone sinks. A tiny pin sinks. What does this show?

   A Heavy things float and light things sink.

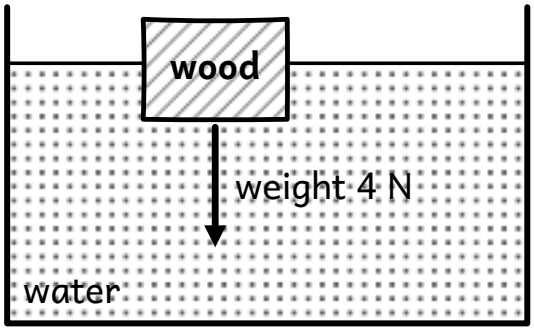
   B Big things float and small things sink.

   C Weight alone does not decide. What a thing is made of matters.

   D The log is lighter than the pin.

   Answer at the back of the book.

8. A block of wood floats. Look at the picture. How big is the upthrust on it?



   A 4 N

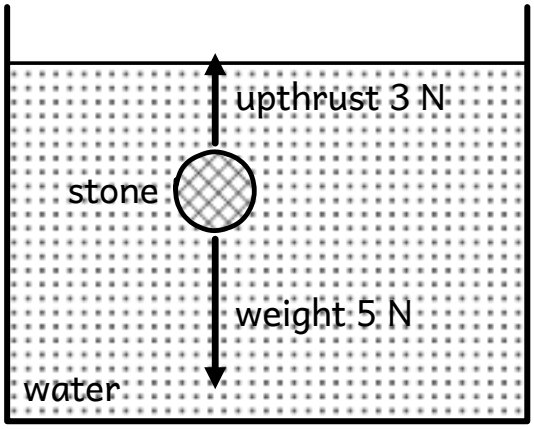
   B 0 N

   C 8 N

   D 2 N

   Answer at the back of the book.

9. A stone is let go under water. Look at the picture. What happens to it?



A It floats.

B It sinks, because its weight is bigger than the upthrust.

C It stays still in the middle.

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Water pushes up on things in it. This is upthrust. A thing floats if upthrust matches its weight before it goes under. Heavy things can float and light things can sink. It depends on what a thing is made of.

Draw: Draw a bowl of water. Draw a stick floating and a stone sinking, with arrows.

S2.5.8 CHAPTER 8

Shape and floating

How can a ship made of steel float?

YOUR GUESS

Pick one before you read on. It is fine to be wrong.

- ☐ **A** Steel floats if it is thin.
- ☐ **B** Big things float because they are big.
- ☐ **C** Steel is lighter than water.
- ☐ **D** The ship is hollow and pushes aside a lot of water.

BY THE END YOU CAN

- Make a lump of clay float by shaping it into a boat
- Explain why a big steel ship floats

You press a lump of clay into water. It sinks. Now you shape the same clay into a boat. It floats.

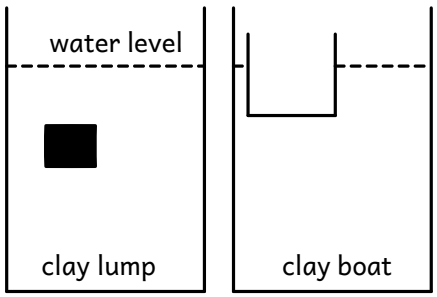
The clay did not change. Its weight is the same. Only its shape changed.

A **hollow** shape has a space inside it. A clay boat is hollow.

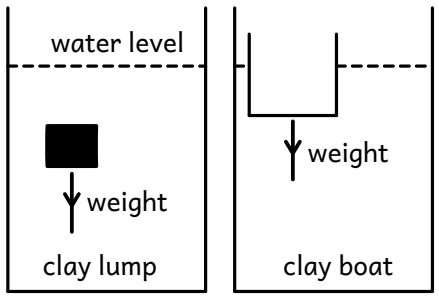
A hollow boat pushes aside much more water than a lump does. A thing that pushes aside more water gets a harder push up.

DRAW IT FIRST

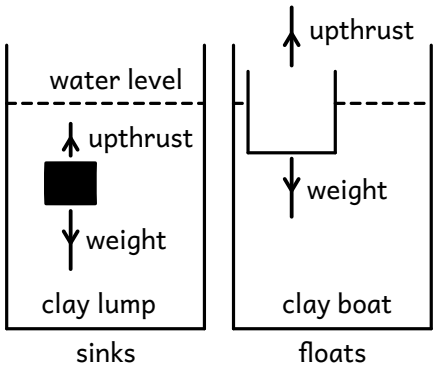
Draw why *a* clay boat floats



1 Draw *a* lump of clay and *a* clay boat in two bowls. Mark the water level.



2 Draw an arrow down from each. Make them the same length. Write weight.



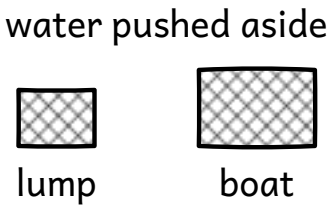
3 Draw *a* short arrow up from the lump. Draw *a* long arrow up from the boat. Write upthrust.

The lump pushes aside *a* little water. The upthrust is less than the weight. So the lump sinks.

The boat pushes aside *a* lot of water. The upthrust grows until it matches the weight. So the boat floats.

SEE IT THREE WAYS

As a picture



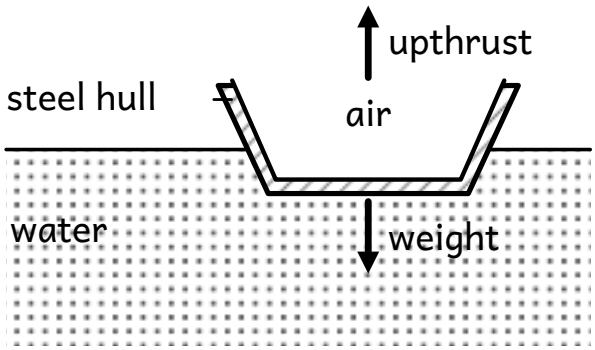
In words

The boat pushes aside more water than the lump. So the water pushes up harder on the boat.

In symbols

Say the clay weighs 1 newton, like a small apple. As a lump, the water pushes up about half a newton. It sinks. As a boat, the water pushes up 1 newton. It floats.

A big steel ship floats for the same reason. Its body is called the **hull**. The hull is hollow and full of air.

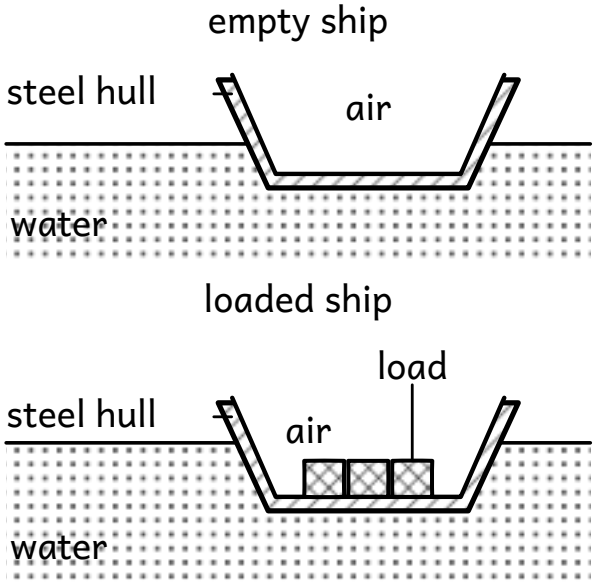


A hollow steel hull. Weight and upthrust are equal.

The ship pushes aside a huge amount of water. That water weighs as much as the whole ship. So the upthrust matches the ship, and it floats.

A lump of steel sinks. Shape the same steel into a hollow hull and it floats.

A ship carries a **load**. The load adds weight. The ship sinks a little lower and pushes aside more water.



The load adds weight. The ship sits lower and pushes aside more water.

If the load is too big, water pours over the edge. The ship fills and sinks.

TRY IT

Make a clay boat

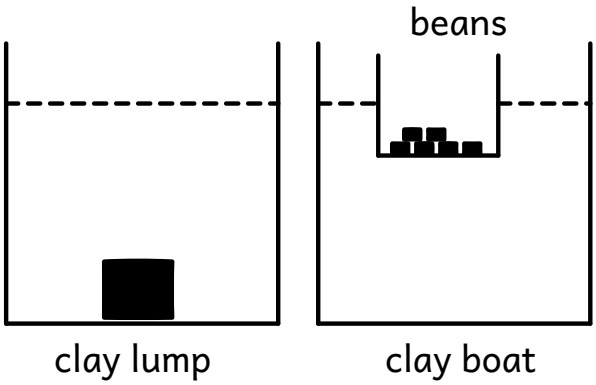
You need: clay from the ground or a river bank, a bowl of water, a handful of dry beans or small stones, kitchen foil, if you have no clay.

Be safe: Use a bowl only. Do not eat the clay or the beans. Wash your hands after.

1. Roll a ball of clay as big as a small egg. Put it on the water. It sinks.
2. Take it out. Shape the same clay into a boat.
3. Make the sides high and thin. Press the clay so it has no holes.
4. Put the boat on the water. Does it float? If water comes in, make the sides higher.
5. Put in beans, one at a time. Count them.
6. Stop when the boat sinks. Write down the number.

What you will see: The lump sinks. The boat floats and holds some beans. A boat with higher sides holds more. A foil boat floats too. A tight foil ball may sink.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A ship made of steel must sink, because steel sinks.~~

Why it feels right: A steel nail sinks. A ship is made of steel, and it is huge.

The test that breaks it: Squeeze a sheet of kitchen foil into a tight ball. It may sink. Take a second sheet the same size. Fold it into a boat with high sides. It floats. Foil is a thin metal, so it shows the same idea.

What is true: Shape counts. A hollow ship pushes aside a lot of water. The water pushes up on it as hard as its weight.

KEY WORDS

hollow
having a space inside it, like a bowl.

hull
the body of a ship or a boat.

load
the things a boat carries. A load adds weight.

BACK TO YOUR GUESS

The answer is D: The ship is hollow and pushes aside a lot of water.

The ship is hollow. It pushes aside a lot of water. So the water pushes up very hard.

CHECK YOURSELF

Try each one before you look. A wrong answer tells you where to go next.

1. A clay lump sinks. The same clay shaped as a boat floats. Why?

   A The boat pushes aside more water, so the water pushes up harder.

   B The boat weighs less than the lump.

   C Water pushes up on the boat, but not on the lump.

   Answer at the back of the book.

2. Why does a big steel ship float?

   A Steel is lighter than water.

   B It is hollow, so it pushes aside a lot of water.

   C Big things float.

   Answer at the back of the book.

3. Two clay boats are alike, but one has higher sides. Which holds more beans before it sinks?

   A The boat with lower sides

   B They hold the same

   C The boat with higher sides

   Answer at the back of the book.

4. Ana's clay boat holds 18 beans before it sinks. Ravi's holds 24. How many more beans does Ravi's boat hold?

   Answer at the back of the book.

5. **From an earlier chapter**

   Kofi pushes a heavy box over a floor. Which change gives less friction?

   A Put a rough mat under the box.

   B Spread sand under the box.

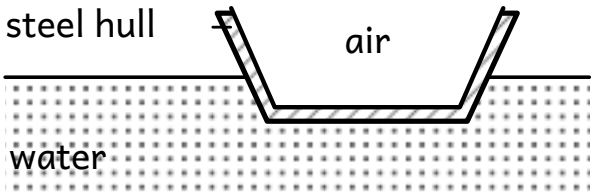
   C Put the box on round pencils.

   Answer at the back of the book.

6. Draw a boat floating on water. Draw an arrow for weight and an arrow for upthrust.

   Answer at the back of the book.

7. A ship takes on more load. Look at the ship. What happens to it in the water?



   A It stays level, because the load is inside the ship.

   B It sits lower and pushes aside more water.

   C It sits higher, because the load pushes it up.

   D It sinks at once.

   Answer at the back of the book.

8. What fills most of the inside of a steel ship?

   A Air

   B Water

   C Solid steel

   Answer at the back of the book.

9. Tariq squeezes foil into a tight ball. It sinks. He folds a second sheet of the same size into a boat. It floats. Why?

   A The foil boat weighs less than the ball.

   B Water pushes up on the boat but not on the ball.

   C A thin sheet of foil always floats.

   D The boat pushes aside more water, so the upthrust is bigger.

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

A hollow shape pushes aside more water. The water pushes up harder. That is why a clay boat floats and a lump sinks. A steel ship is hollow. It pushes aside a lot of water, so it floats.

Draw: Draw a lump sinking and a boat floating. Add arrows for weight and upthrust.

Key words, A to Z

Every key word in this book, what it means, and the chapter that teaches it.

air resistance
the push of air against a moving thing. S2.5.6

balanced
two forces of the same size that act in opposite ways. S2.5.1

centre
the middle of the Earth. S2.5.5

float
to stay up on the water. S2.5.7

force
a push or a pull. S2.5.1

force meter
a tool that measures a pull. S2.5.2

friction
the force between two surfaces that rub. It acts against the slide. S2.5.3

gravity
the pull of the Earth on things. It pulls towards the centre. S2.5.5

grip
to hold on without slipping. S2.5.4

groove
a narrow gap cut in a sole or a tyre. S2.5.4

hollow
having a space inside it, like a bowl. S2.5.8

hull
the body of a ship or a boat. S2.5.8

load
the things a boat carries. A load adds weight. S2.5.8

newton
the unit for force. We write N. S2.5.2

pull
a force that brings a thing closer. S2.5.1

push
a force that moves *a* thing *away*. S2.5.1

roller
a round thing that rolls under *a* load. S2.5.4

rough
a surface with bumps you *can* feel. S2.5.3

sink
to go down to the bottom of the water. S2.5.7

smooth
a surface that feels flat. S2.5.3

streamlined
a smooth, pointed shape that meets little air or water. S2.5.6

stretch
to get longer when you pull. S2.5.2

upthrust
the push up that water gives to *a* thing in it. S2.5.7

water resistance
the push of water *against a* moving thing. S2.5.6

weight
the pull of *gravity* on *a* thing. It is measured in newtons. S2.5.5

Answers

S2.5.1. Forces are pushes and pulls

1. **The way the ball is kicked**

   An arrow points the way the force acts. The kick acts on the ball in the way it moves.

   - **If you chose A:** The arrow shows the way the force acts on the ball. The kick sends the ball away from the foot.
   - **If you chose C:** The kick sends the ball sideways, so the arrow points sideways.
   - **If you chose D:** Down is the way the Earth pulls. The kick is a different force, and it acts sideways.

2. **A magnet draws a nail towards it**

   A pull brings a thing closer. The magnet pulls the nail towards itself.

   - **If you chose B:** The wind pushes the leaf away from itself. That is a push.
   - **If you chose C:** The hand pushes on the clay. That is a push.
   - **If you chose D:** The foot pushes the ball away. That is a push.

3. **Its shape**

   The sponge gets squashed. A force can change the shape of a thing.

   - **If you chose A:** The sponge does not start to move. Squeezing changes how it looks.
   - **If you chose B:** A squeeze does not change how heavy a dry sponge is. It changes its shape.

4. **Push B**

   A longer arrow means a bigger force. The arrow for push B is longer.

   - **If you chose A:** The arrows differ in length, so the forces differ in size.
   - **If you chose C:** A short arrow means a smaller force.

5. **The table pushes it up.**

   The table pushes up as hard as the Earth pulls down. The forces are balanced.

   - **If you chose A:** A still thing can have forces on it. The table pushes up and the two forces balance.
   - **If you chose B:** The table pushes back up on the book. That push is why the book does not fall through.

6. **A box. A short arrow points right. A longer arrow points left.**

   An arrow points the way the force acts. A longer arrow is a bigger force.

7. **Its direction**

   The ball moved straight, and the tap made it turn. A force can change the direction of a thing.

   - **If you chose A:** A hard ball keeps its shape when it is tapped. The tap changed the way it moves.
   - **If you chose B:** A tap does not change how heavy the ball is. It changes the way the ball moves.
   - **If you chose D:** Any push or pull can change how a thing moves. Even a tap can.

S2.5.2. Measuring forces

1. **4 cm**

   The row for 2 stones says 4 cm.

   - **If you chose A:** You read the number of stones, or the empty band. Find the row for 2 stones.
   - **If you chose B:** That is the length with 3 stones. Find the row for 2 stones.
   - **If you chose D:** That is the length with 1 stone. The first row is 0 stones. So 2 stones is row three.

2. **3 cm**

   The band grew from 2 cm to 5 cm. 5 − 2 = 3 cm.

   - **If you chose A:** That is the whole length with the stones. Take away the 2 cm it had before.
   - **If you chose B:** You added the two lengths. Take the short one away from the long one.
   - **If you chose C:** That is how long the band was at the start. Find how much it grew.

3. **Newtons**

   Force is measured in newtons. We write N.

   - **If you chose B:** Kilograms tell how much stuff *a* thing has. A force is *a* push or *a* pull.
   - **If you chose C:** Centimetres tell how long the band is. That shows the pull, but it is not the unit of force.

4. **The bigger stone pulls more.**

   The band is longer with the bigger stone. More stretch means more pull.

   - **If you chose A:** The band stretches more for *a* bigger pull. The longer band shows the bigger pull.
   - **If you chose B:** The lengths are different, so the pulls are different.

5. **It pulls the stone up as hard as the Earth pulls down.**

   The two forces are balanced, so the stone stays still.

   - **If you chose B:** A still thing can have forces on it. They are balanced. Go to S2.5.1.
   - **If you chose C:** A stretched band pulls back towards where it started. That is up. Go to S2.5.1.

6. **A band hangs from *a* pencil. Two stones are in the cup. The reading is 4 cm.**

   The table says 4 cm for 2 stones.

7. **3 N**

   The pointer stands at the mark 3. The scale is in newtons. The stone pulls with 3 N.

   - **If you chose A:** This meter measures *a* pull. Its scale is in newtons, N. Kilograms tell how much stuff *a* thing has.
   - **If you chose C:** That is the biggest number on the scale. Read the number at the pointer, not at the end.
   - **If you chose D:** The pointer stands at 0 N when nothing hangs. The stone pulls it down to *a* bigger number.

S2.5.3. Friction

1. **A rough mat**

   A rough surface has big bumps that catch. It gives the most friction.

   - **If you chose A:** A smooth surface has fewer bumps. It gives less friction.
   - **If you chose C:** Glass is very smooth. It gives little friction.

2. **78 cm**

   It slid 90 cm on the floor. It slid 12 cm on sand. 90 − 12 = 78 cm.

   - **If you chose B:** You added the two slides. Take the short one away from the long one.
   - **If you chose C:** That is the slide on the floor. Take away the slide on the sand.

3. **Friction from the grass, and the air**

   The grass rubs against the ball, and the air pushes against it. These forces slow it.

   - **If you chose A:** On smoother ground the same push goes further. So the ground is slowing it.
   - **If you chose B:** A ball is not alive. A force slows it.

4. **Friction between the shoe and the ground**

   Your shoe pushes back on the ground. Friction holds the shoe, so you move forward.

   - **If you chose A:** The air pushes on you a little. The ground grips your shoe.
   - **If you chose C:** Friction stops slipping. On a wet floor there is little friction. That is when you slip.

5. **Newtons**

   Force is measured in newtons. We write N.

   - **If you chose A:** Kilograms tell how much stuff a thing has. Force is measured in newtons. Go to S2.5.2.
   - **If you chose B:** Metres measure length. Force is measured in newtons. Go to S2.5.2.

6. **A box with an arrow pointing left, labelled friction.**

   Friction acts against the slide. The box slides right, so the arrow points left.

7. **The block on the rough surface**

   The big bumps of a rough surface catch on the block. That gives more friction, so the block is harder to slide.

   - **If you chose B:** A smooth surface has tiny bumps, so little catches. That block slides more easily.
   - **If you chose C:** The surfaces differ, so the friction differs. Big bumps catch more than tiny bumps.

8. **Friction helps us to walk and to hold things.**

   Friction lets a shoe grip the ground. It lets a hand grip a cup. It also slows things down.

   - **If you chose A:** We need friction to walk, hold a cup and stop a bicycle.
   - **If you chose C:** Friction acts when two surfaces rub or try to slide. It acts at any speed.
   - **If you chose D:** Friction acts against the slide. It does not help the thing along.

9. **sand**

   The top slid the shortest way on sand. The surface that stops it soonest gives the most friction.

   - **If you chose A:** The top slid furthest on the floor. A long slide means little friction.
   - **If you chose B:** The cloth is in the middle. One surface slowed the top even more.
   - **If you chose C:** The slides are different lengths, so the friction is different.

S2.5.4. More friction or less

1. **Round rollers**

   Rolling rubs much less than sliding. Rollers give less friction.

   - **If you chose A:** A rough mat catches the box. It gives more friction.
   - **If you chose C:** Sand makes a surface rougher. It gives more friction.

2. **The oil gives less friction between the moving parts.**

   The oil lets the parts slide past each other. There is less friction.

   - **If you chose A:** Oil does the opposite. It makes surfaces slide, so there is less friction.
   - **If you chose B:** Friction makes heat. Oil gives less friction, so less heat. Go to S2.5.3.

3. **Mud goes into the grooves, so the rubber can grip.**

   Mud and water move into the grooves. The rubber touches the ground and grips.

   - **If you chose B:** Grooves are gaps. They give mud and water a place to go.
   - **If you chose C:** The grooves are there for grip, not for weight.

4. **rollers**

   The friction arrow is the shortest in the rollers row.

   - **If you chose A:** The friction arrow in this row is the longest. It has the most friction.
   - **If you chose B:** The oil row has a short arrow. The rollers row has a shorter one.
   - **If you chose C:** The arrows differ in length, so the friction differs.

5. **Left, against the slide**

   Friction pushes against the way a thing slides. The box slides right, so friction points left.

   - **If you chose A:** Friction acts against the slide. It does not help the box along. Go to S2.5.3.
   - **If you chose C:** Friction acts along the surface, against the way the box slides. Go to S2.5.3.

6. **Less: oil, or wheels and rollers. More: grooved soles, or sand on a slippery path.**

   Oil and rollers help things slide. Grooves and sand help things grip.

7. **Water between the shoe and the floor gives less friction.**

   A film of water lets the shoe slide. With less friction your foot slips.

   - **If you chose A:** Cold is not the reason. The water between shoe and floor gives less friction.
   - **If you chose B:** A film of water makes a floor smoother, not rougher.
   - **If you chose C:** It is the other way round. Water gets between shoe and floor. The shoe slides.

8. **Chalk gives the hands more grip.**

   Chalk gives more friction between the hands and the rock. The hands do not slip.

   - **If you chose B:** Chalk is not oil. It helps the hands hold on without slipping.
   - **If you chose C:** Chalk dries the hands. Sweat is slippery. Dry hands grip the rock better.

9. **On the wet floor**

   The friction arrow is the shortest on the wet floor. With little friction a shoe slips.

   - **If you chose A:** The friction arrow is long on the mat. A mat gives a lot of friction, so the shoe grips.
   - **If you chose C:** The arrows differ in length, so the friction differs.

S2.5.5. Gravity and falling

1. **Towards the centre of the Earth**

   Wherever you stand, gravity pulls you towards the middle of the Earth.

   - **If you chose A:** Things fall to the Earth. They do not float away from it. Gravity pulls in.
   - **If you chose B:** The Sun is very far away. The Earth pulls the things near it much harder.

2. **Gravity pulls her towards the centre of the Earth too.**

   For everyone on the Earth, down means towards the centre.

   - **If you chose B:** Holding on is not what keeps her there. Gravity pulls her to the Earth.
   - **If you chose C:** Air does not hold her down. The pull of the Earth does.

3. **The pull of gravity on a thing**

   Weight is a force. It is the pull of gravity on a thing.

   - **If you chose A:** That is its size. Weight is a pull, a force.
   - **If you chose C:** Speed is how fast. Weight is the pull that makes it fall.

4. **They land together.**

   Big and small stones fall at the same rate. Try it on soft ground.

   - **If you chose A:** The big stone is pulled harder. But it has more to move. They land together.
   - **If you chose B:** Small things do not fall faster. Both stones land together.
   - **If you chose C:** Stones of any weight fall together. Weight does not change how fast they fall.

5. **2 newtons**

   The Moon pulls about one sixth as hard. So 12 divided by 6 gives 2. The stone is still the same amount of stuff.

6. **The newton**

   Forces are measured in newtons. Weight is a force.

   - **If you chose A:** A centimetre measures length. A force is measured in newtons. Go to S2.5.2.
   - **If you chose B:** A litre measures how much liquid. A force is measured in newtons. Go to S2.5.2.
   - **If you chose C:** A kilogram tells how much stuff is in a thing. A force is measured in newtons. Go to S2.5.2.

7. **Yes, but the pull is weaker than on the Earth.**

   Gravity pulls things with or without air. The Moon is smaller than the Earth, so its pull is weaker.

   - **If you chose A:** Gravity does not need air. The Moon pulls a ball down, with no air at all.
   - **If you chose B:** Every big world has gravity, and so does the Moon. Its pull is weaker than the Earth's.
   - **If you chose D:** The Moon pulls about one sixth as hard as the Earth. A stone weighs less there.

8. **4 N**

   The pointer stands at 4 and the scale is in newtons. The weight of the stone is 4 N.

   - **If you chose B:** Weight is a force, so it is read in newtons. Kilograms tell how much stuff is in the stone.
   - **If you chose C:** A still stone still has forces on it. They are balanced. Gravity pulls it down with the number on the scale.
   - **If you chose D:** The meter pulls up and gravity pulls down with equal forces. They are not added. The weight is the one pull, 4 N.

S2.5.6. Air and water resistance

1. **More of the sheet meets air. So air pushes up more.**

   The sheet and the ball weigh the same. The sheet meets more air, so it falls more slowly.

   - **If you chose B:** It is the same paper. Gravity pulls it the same, flat or crumpled. Go to S2.5.5.
   - **If you chose C:** Crumpling does not change the weight. The ball just meets less air.

2. **The one with long wings**

   Long wings meet more air. The air pushes up harder, so the spinner falls more slowly.

   - **If you chose A:** Short wings meet less air. The air pushes up less, so it falls faster.
   - **If you chose C:** Wing length changes how much air they meet. Make two and test them.

3. **In water**

   Water resistance is stronger than air resistance. You feel it at once.

   - **If you chose A:** You can feel air push, but water pushes back much harder.
   - **If you chose B:** Water resistance is much stronger than air resistance.
   - **If you chose C:** Air is real stuff. Swing a flat card fast. You feel it push on your hand.

4. **Water slides past them, so the push back is small.**

   A pointed front meets less water. The water resistance is smaller. A fish moves on with less effort.

   - **If you chose A:** Gravity does not care about shape. Water resistance does. Go to S2.5.5.
   - **If you chose B:** It is the other way round. A flat front meets more water and gets pushed back harder.

5. **The rough mat**

   A rough surface gives more friction. More friction stops the bottle top sooner.

   - **If you chose B:** A smooth floor gives less friction. The top slides further. Go to S2.5.3.
   - **If you chose C:** Rough surfaces give more friction than smooth ones. The mat stops it sooner. Go to S2.5.3.

6. **A sheet with an arrow down for gravity. A long arrow up for the air. It is almost as long as the gravity arrow.**

   Gravity pulls the sheet down. The air pushes up against it, so it falls slowly.

7. **The wide canopy meets lots of air, so air pushes up hard.**

   A wide canopy meets much more air than a person alone. The air resistance is big, so the fall is slow.

   - **If you chose A:** Gravity pulls the same. The wide canopy is what changes the fall. Go to S2.5.5.
   - **If you chose C:** A parachute still falls, so it is not lighter than air. It meets a lot of air, and the air pushes up.

8. **It pushes up as hard as the weight pulls down.**

   A steady speed means the forces are balanced. The air pushes up as hard as gravity pulls down.

   - **If you chose A:** Air is real stuff. A wide canopy meets a lot of it. The air pushes back.
   - **If you chose B:** Air resistance acts against the way a thing moves. The parachutist moves down, so it pushes up.
   - **If you chose C:** Then the parachutist would be slowed more and more. A steady speed needs the two forces equal.

9. **Backwards, against the way the swimmer moves**

   Water resistance pushes against the way a thing moves. The swimmer moves forwards, so the push is backwards.

   - **If you chose A:** Water does not carry a swimmer along here. It pushes against the movement.
   - **If you chose B:** Water does push up on a swimmer. Water resistance acts against the movement.
   - **If you chose D:** Down is the way the Earth pulls. Water resistance acts against the movement.

10. **The air slows the feather much more than it slows the stone.**

    A feather is light and wide. The air slows it a lot. A stone is hardly slowed.

    - **If you chose A:** Gravity pulls on everything. The feather falls more slowly because the air slows it a lot.
    - **If you chose C:** A big stone and a small stone land together. The feather is slowed by air, not just by its weight.

S2.5.7. Floating and sinking

1. **The log floats and the stone sinks.**

   Wood floats. Stone sinks. Weight alone does not decide.

   - **If you chose A:** A log is heavy, but it floats. What a thing is made of matters, not weight alone.
   - **If you chose C:** The stone is lighter than the log, but it still sinks. Light things can sink.

2. **The water pushes it up harder than its weight pulls down.**

   The upthrust is bigger than the weight. So the bottle rises until it floats.

   - **If you chose B:** Gravity still pulls it. The upthrust from the water is bigger. Go to S2.5.5.
   - **If you chose C:** The push comes from the water, not the air.

3. **The upthrust matches its weight.**

   A floating thing stays still. The push up equals the pull down.

   - **If you chose A:** Then the block would rise. It stays still, so the two forces match.
   - **If you chose B:** Then the block would sink. It floats, so the upthrust matches its weight.
   - **If you chose C:** Water pushes up on a floating block. That push is what holds it up.

4. **5**

   The rest sink, so 12 − 7 = 5.

5. **8 newtons**

   Each apple weighs about 1 newton. Eight apples weigh about 8 newtons.

6. **A stick in the top of the water. An arrow up and an arrow down, the same length.**

   A floating stick stays still. The upthrust up equals the weight down.

7. **Weight alone does not decide. What a thing is made of matters.**

   A heavy log floats and a light pin sinks. Weight is not all. What it is made of matters, and so does its shape.

   - **If you chose A:** The big stone is heavy, and it sinks. Weight alone does not decide.
   - **If you chose B:** The big stone is big, and it sinks. Size alone does not decide.
   - **If you chose D:** The log is much heavier than the pin. It floats because of what it is made of, and its shape.

8. **4 N**

   A floating block stays still, so the upthrust matches the weight. The weight is 4 N, so the upthrust is 4 N.

   - **If you chose B:** Water pushes up on a floating block. With no push the block would sink.
   - **If you chose C:** The upthrust matches the weight. It is not doubled.
   - **If you chose D:** Part of the block is above the water. The upthrust still matches the whole weight. With less, the block would sink deeper.

9. **It sinks, because its weight is bigger than the upthrust.**

   The pull down is bigger than the push up. So the stone goes down.

   - **If you chose A:** A thing floats when the upthrust matches its weight. Here the upthrust is smaller.
   - **If you chose C:** It would stay still only if the two forces were equal.

S2.5.8. Shape and floating

1. **The boat pushes aside more water, so the water pushes up harder.**

   The clay weighs the same either way. The hollow boat gets a bigger push up, so it floats.

   - **If you chose B:** It is the same clay, so the weight is the same. Only the shape changed.
   - **If you chose C:** Water pushes up on both. On the lump the push is too small. Go to S2.5.7.

2. **It is hollow, so it pushes aside a lot of water.**

   The water it pushes aside weighs as much as the whole ship. So the ship floats.

   - **If you chose A:** A steel nail sinks. The hollow shape lets the ship float.
   - **If you chose C:** A big stone sinks. Size alone does not decide. Go to S2.5.7.

3. **The boat with higher sides**

   A boat with higher sides can sit deeper before water pours in. It pushes aside more water, so it can hold more.

   - **If you chose A:** Water pours over low sides sooner. The boat fills and sinks.
   - **If you chose B:** Shape changes how much a boat holds. Higher sides keep water out for longer.

4. **6 more beans**

   Take 18 from 24. That leaves 6.

5. **Put the box on round pencils.**

   Rolling rubs much less than sliding. The pencils work as rollers.

   - **If you chose A:** A rough mat gives more friction, not less. Rolling rubs less than sliding. Go to S2.5.4.
   - **If you chose B:** Sand makes the floor rougher. It gives more friction, not less. Go to S2.5.4.

6. **A boat on the water. An arrow down for weight. An arrow up for upthrust. Both the same length.**

   A floating boat stays still. The upthrust matches the weight.

7. **It sits lower and pushes aside more water.**

   More load means more weight. The ship sinks in until the upthrust matches the new weight.

   - **If you chose A:** The load adds weight. The upthrust must grow to match it, so the ship sits lower.
   - **If you chose C:** A load adds weight. It pulls the ship down, not up.
   - **If you chose D:** A ship can carry a load until water pours over its edge. First it sits lower.

8. **Air**

   The hull is hollow and full of air. That is why it pushes aside so much water.

   - **If you chose B:** A hull full of water would sink. The hull is hollow and full of air.
   - **If you chose C:** A ship of solid steel would sink like a nail. The hull has a space inside it.

9. **The boat pushes aside more water, so the upthrust is bigger.**

   The foil weighs the same in both shapes. The hollow boat pushes aside more water. So the water pushes up harder.

   - **If you chose A:** The two sheets are the same size, so they weigh the same. Only the shape changed.
   - **If you chose B:** Water pushes up on both. On the ball the push is too small.
   - **If you chose C:** The ball is made of the same thin foil, and it sinks. Shape decides.

About this book

For learners who can read short sentences and show a push and a pull. In many schools this fits children of about 8 to 10, and older learners can use it too. Activities use a rubber band, a ruler, stones, paper, a bowl of water and clay or kitchen foil. Water play is in a bowl or bucket, never near deep water. A learner can work alone: every exercise has its answer and the reason for it.

Written and drawn by attnom. Edition 1.0, 2026-11-09.

This book is free. You may read it, print it, copy it and share it with anyone.

The newest copy is at https://attnom.com/academy/forces-friction-falling-and-floating.