●●●○○ Level 3 · Science S3.7

Speed, forces and pressure

Forces change how things move, and pressure tells you how spread out a force is.

Work out speed and draw it as a graph, add up forces on an object, tell mass from weight, stretch a rubber band and plot the pattern, balance a ruler seesaw, and find out why a knife cuts and a camel does not sink.

YOU ARE READY FOR THIS BOOK IF

You can measure a distance in metres with a stick or a string.

One step up	S4.8 Newton's laws
This book	**S3.7 Speed, forces and pressure**
One step down	S2.5 Forces: friction, falling and floating

Contents

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S3.7.2 Distance and time graphs

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S3.7.5 Stretching and springs

S3.7.6 Levers and turning forces

S3.7.7 Pressure

S3.7.8 Pressure in water and air

Key words, A to Z

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S3.7.1 CHAPTER 1

Speed

How fast do I walk? Can I measure it at home?

YOUR GUESS

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

- ☐ **A** Measure a distance, time your walk, then divide the distance by the time.
- ☐ **B** You need a machine, so you cannot measure it at home.
- ☐ **C** Speed is just how long the walk takes.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Measuring, M2.6.1. You measure a distance in metres.
- Level 2, Measuring, M2.6.7. You work out how many seconds something takes.

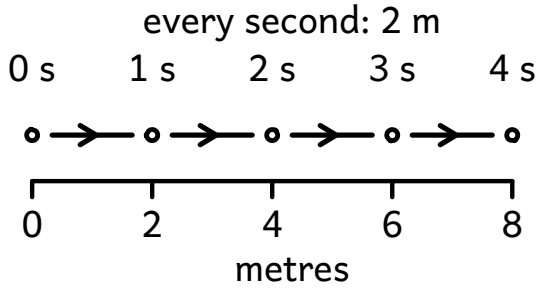
BY THE END YOU CAN

- Calculate speed from distance and time
- Measure your walking speed in metres per second

Amina and her brother go to the well. Amina walks and her brother runs. He gets there first, so he was faster. But how much faster? To say, we need a number.

The **speed** of a thing tells how far it goes in one second. We measure speed in **metres per second**. We write m/s.

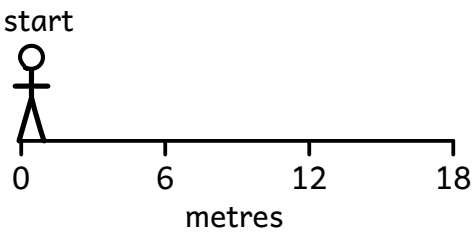
A speed of 2 m/s means 2 metres every second. A person walking goes about 1 to 1.5 metres each second.



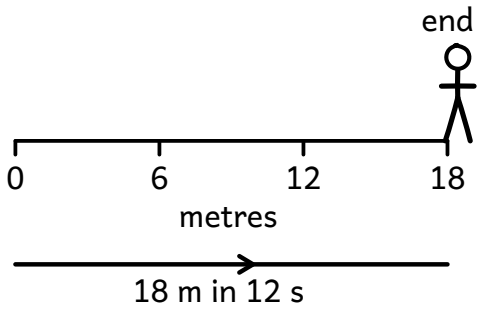
A walker at 2 m/s is 2 metres farther on every second. After 4 seconds she has gone 8 metres.

DRAW IT FIRST

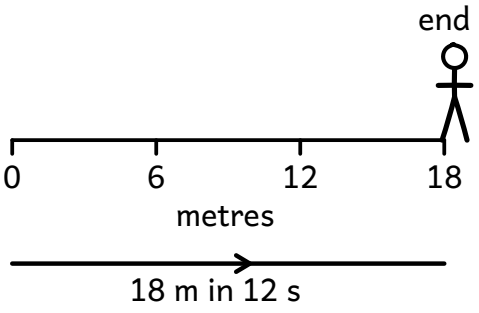
Draw a walk and its speed



1 Draw a track. Mark 0, 6, 12 and 18 metres. Draw the walker at the start.



2 Move the walker to the end. Write the distance and the time: 18 m in 12 s.



speed = 18 m ÷ 12 s = 1.5 m/s

3 Divide the distance by the time. 18 ÷ 12 = 1.5. The speed is 1.5 m/s.

To find a speed you need two measurements. One is the **distance**, how far the thing went, in metres. The other is the time it took, in seconds.

Then share the distance out among the seconds. That gives the metres for each second.

SEE IT THREE WAYS

As a picture

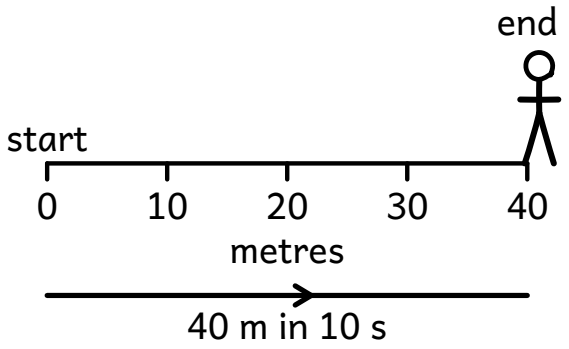
seconds	metres
0	0
2	3
4	6
6	9
8	12

In words

A walker goes 1.5 metres every second. In 2 seconds she goes 3 metres. The distance grows by the same amount each second.

In symbols

speed = distance ÷ time. 18 m ÷ 12 s = 1.5 m/s.



The runner in the next worked example. Read the distance and the time from the picture.

WORKED EXAMPLE

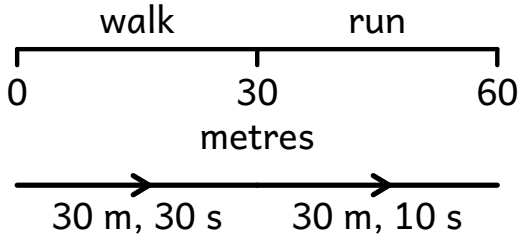
Kofi runs 40 m in 10 s. What is his speed?

1. Speed = distance ÷ time.
2. The distance is 40 m. The time is 10 s.
3. Speed = 40 ÷ 10 = 4 m/s.

Answer: 4 m/s

You can turn the rule around. If you know the speed and the time, then distance = speed × time. If you know the distance and the speed, then time = distance ÷ speed.

A real walk is never perfectly even. You slow down on a hill and speed up on flat ground. So the number you find is the ***average speed***: the total distance divided by the total time.



60 m ÷ 40 s = 1.5 m/s

A slow part and a fast part. The average speed uses the whole distance and the whole time.

TRY IT

Measure your walking speed

You need: a string or stick to measure 12 metres, two stones to mark the start and the end, a clock, or a friend who counts seconds ("one thousand and one, one thousand and two"), paper and a pencil.

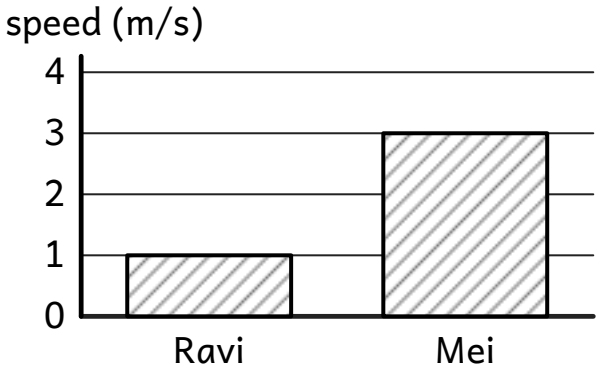
Be safe: Walk on flat ground, well away from roads and holes. Do not run.

1. Mark a start and an end 12 metres apart on flat ground. Put a stone at each.
2. Stand at the start. Your friend says "go" and starts counting seconds.
3. Walk at your normal pace to the end stone. Do not run.
4. Write the time in seconds. Do the walk three times.
5. For each walk, divide 12 by the time. Write the speed in metres per second.

What you will see: Your three speeds will be close, but not the same. Ours are 1.2, 1.2, 1 m/s. A walk usually comes out between 1 and 1.5 m/s. Your numbers will differ from ours, and that is fine.

If you cannot try it, this is what happens.

walk	seconds	m/s
1	10	1.2
2	10	1.2
3	12	1



Ravi walks 60 m in 60 s. Mei runs 30 m in 10 s. Ravi goes farther, but Mei is faster.

A WRONG IDEA MANY PEOPLE HAVE

~~The one that goes the farthest is the fastest.~~

Why it feels right: Going a long way looks like hard work, so it seems to need more speed.

The test that breaks it: Ravi walks 60 m in 60 s. Mei runs 30 m in 10 s. Ravi went farther. Divide each: Ravi 1 m/s, Mei 3 m/s. Mei is faster.

What is true: Speed needs the distance and the time together. A short trip in a short time can be faster than a long, slow trip.

KEY WORDS

speed
how far a thing goes in one second.

metres per second
the unit of speed. We write m/s.

distance
how far a thing goes, measured in metres.

average speed
the total distance divided by the total time.

BACK TO YOUR GUESS

The answer is A: Measure a distance, time your walk, then divide the distance by the time.

Measure a distance, time your walk, then divide the distance by the time. A string and a clock are enough. Speed needs both numbers, not only the time.

CHECK YOURSELF

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

1. Mei walks 36 m in 30 s. What is her speed?

   Answer at the back of the book.

2. A cyclist rides at 4 m/s for 10 s. How far does she go?

   A 2.5 m

   B 40 m

   C 14 m

   Answer at the back of the book.

3. Joseph walks at 2 m/s. How long does he take to walk 50 m?

   A 0.04 s

   B 100 s

   C 25 s

   D 52 s

   Answer at the back of the book.

4. Ana walks 20 m in 10 s. Tariq walks 30 m in 20 s. Who is faster?

   A Ana

   B Tariq

   C They are the same speed.

   Answer at the back of the book.

5. Kofi walks 40 m in 40 s. Then he runs 40 m in 10 s. What is his average speed for the whole trip?

   A 2.5 m/s

   B 1.6 m/s

   C 4 m/s

   Answer at the back of the book.

6. To find your walking speed at home, which two measurements do you need?

   A Only the time, because a fast walker takes less time.

   B Only the distance, because a fast walker goes farther.

   C The distance you walk and the time it takes.

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Speed is how far a thing goes in one second. Speed = distance ÷ time. We write it in metres per second, m/s. Distance = speed × time.

Draw: A track marked 0 and 12 metres. Under it write 12 m ÷ 10 s = 1.2 m/s.

S3.7.2 CHAPTER 2

Distance and time graphs

Can a picture show how a whole journey went?

YOUR GUESS

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

- ☐ **A** A flat line on the graph means the walker is standing still.
- ☐ **B** A flat line on the graph means the walker is going along flat ground.
- ☐ **C** A flat line on the graph means the walker is going very fast.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Speed, forces and pressure, S3.7.1. Speed is distance ÷ time.
- Level 2, Tables and charts, M2.7.6. You read a line graph with a number scale.

BY THE END YOU CAN

- Draw a distance and time graph for a journey
- Tell from a graph when an object is still, slow or fast

Mei walks to the market. She goes quickly, stops to talk, then walks on slowly. A list of numbers would be hard to read. A picture shows the whole journey at once.

A **distance and time graph** shows how far something is from home as time goes by. Time goes across. Distance goes up. Both start at 0.

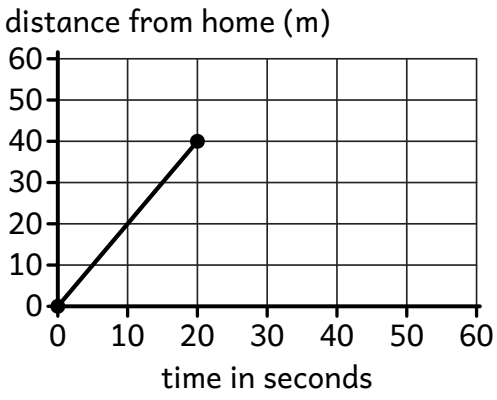
Start with a table. It says where Mei was after each 10 seconds. Each row is one point on the line we draw.

seconds	metres from home
0	0
10	20
20	40
30	40
40	40
50	45
60	50

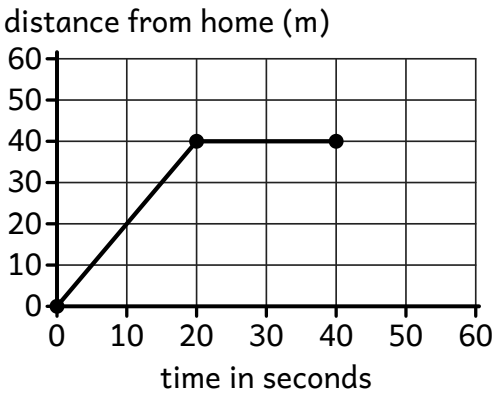
Mei is at 0 metres from home when she starts. Read down to see her move, stop and move on.

DRAW IT FIRST

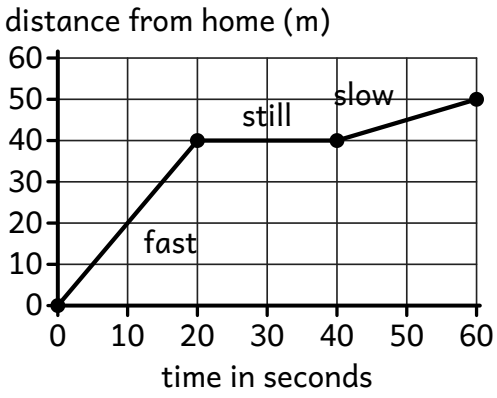
Draw the graph of a journey



1 Draw the axes. Mei walks 40 m in 20 s. Mark that point and join it to the start.



2 She stands still for 20 s. Her distance stays at 40 m, so draw a flat line.

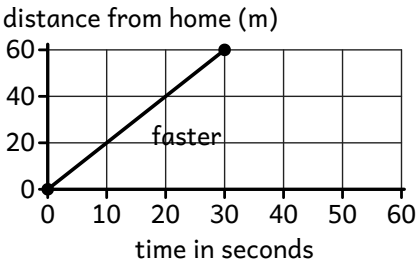


3 Then she walks 10 m in 20 s. Draw a gentle line. Write fast, still and slow.

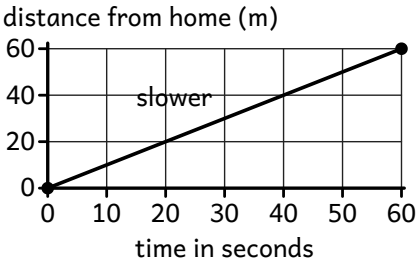
Read the graph from left to right, like a story. A flat line means the distance is not changing. The thing is **still**.

A line that climbs means the thing is moving away from home. The **steeper** the line, the faster the thing is going. A gentle climb is slow.

Kofi: 60 m in 30 s



Lucía: 60 m in 60 s



Both walkers go the same distance. Kofi takes less time, so his line is steeper.

You can find the speed of any part of a journey. Take the distance that part covers and divide it by the time it takes. This is the same rule as before.

SEE IT THREE WAYS

As a picture

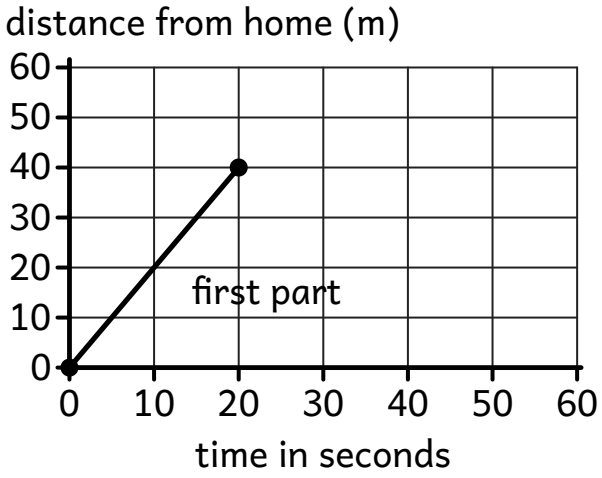
part	seconds	metres	m/s
1st	20	40	2
2nd	20	0	0
3rd	20	10	0.5

In words

The steep part has the biggest speed. The flat part has a speed of zero. The gentle part is in between.

In symbols

Fast part: 40 ÷ 20 = 2 m/s. Still part: 0 ÷ 20 = 0 m/s. Slow part: 10 ÷ 20 = 0.5 m/s.



Read two numbers from this part: how far, and how long. Then divide.

WORKED EXAMPLE

Use Mei's graph. What is her speed in the first part, from 0 s to 20 s?

1. At 20 s the graph is at 40 m.
2. The part starts at 0 s and ends at 20 s. It lasts 20 s.
3. Speed = distance ÷ time = 40 ÷ 20 = 2 m/s.
4. The line is steep, so this is the fast part.

Answer: 2 m/s

All the graphs here show distance from home. So a line that goes down means the walker is coming back towards home.

TRY IT

Draw the graph of your own walk

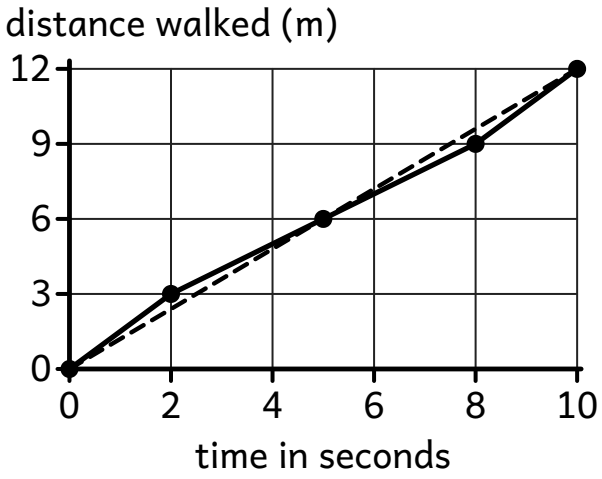
You need: five stones, a string and a stick to space them 3 metres apart, a clock, or a friend who counts seconds, paper with a ruler for the lines, and a pencil.

Be safe: Walk on flat ground, well away from roads. Do not run.

1. Put the stones in a straight line, 3 metres apart. Stand at the first stone.
2. Your friend says "go". Walk at your normal pace past all the stones.
3. Your friend writes the second you reach each stone.
4. On paper, draw time across and distance up. Both start at 0.
5. Mark a point for each stone. Join the points with straight lines.

What you will see: The line is close to straight, with a few small bends. A walk is never perfectly even. A straight line means a steady speed. The dashed line shows the pattern.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A line that goes up on the graph means the walker is going uphill.~~

Why it feels right: The line looks like a hill, so it is tempting to read it as a path.

The test that breaks it: Walk 10 steps on flat ground, then stand still for 10 seconds. Draw the graph. It climbs, then goes flat. The ground was flat the whole way.

What is true: The graph is not a picture of the path. Up means farther from home as time goes by. Flat means not moving.

KEY WORDS

distance and time graph
a graph with time across and distance from home up.

still
not moving. The graph line is flat.

steeper
climbing more quickly. A steeper line means a faster speed.

BACK TO YOUR GUESS

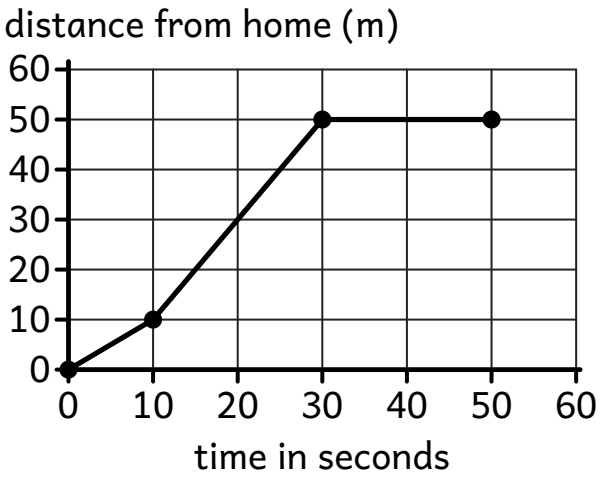
The answer is A: A flat line on the graph means the walker is standing still.

A flat line means the distance is not changing, so the walker is standing still. The graph shows distance from home against time. It does not show the shape of the ground.

CHECK YOURSELF

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

1. Look at Ravi's graph. In which part is he standing still?



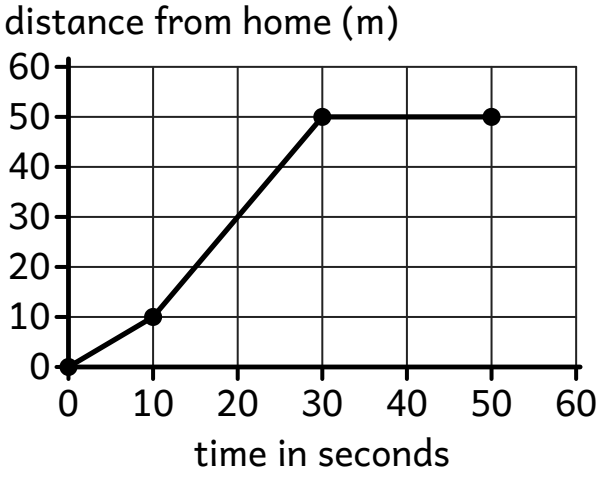
A From 0 s to 10 s

B From 30 s to 50 s

C From 10 s to 30 s

Answer at the back of the book.

2. Use the same graph. In which part does Ravi move fastest?



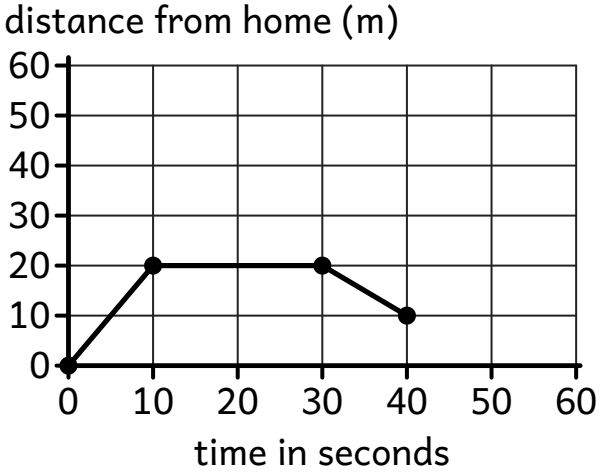
A From 30 s to 50 s

B From 0 s to 10 s

C From 10 s to 30 s

Answer at the back of the book.

3. Ana's graph shows her distance from home. What does she do between 30 s and 40 s?



A She walks back towards home.

B She walks on, away from home.

C She stands still.

Answer at the back of the book.

4. Mei is 40 m from home after 20 s. You draw her graph. Where do you mark this point?

A Across to 40, then up to 20

B Across to 20 on the time scale, then up to 40 on the distance scale

C Up to 40 on the distance scale, on the line at 0 seconds

Answer at the back of the book.

5. Tariq walks 30 m away from home in 10 s. He stands still for 10 s. Then he walks 5 m farther from home in 20 s. What does his distance and time graph look like?

A It climbs steeply, then goes down to 0, then climbs gently.

B It climbs gently, then goes flat, then climbs steeply.

C It climbs steeply, then goes flat, then climbs steeply again.

D It climbs steeply, then goes flat, then climbs gently.

Answer at the back of the book.

6. At 4 s a walker is 6 m from home. At 10 s the walker is 21 m from home. What is the speed between these times?

   Answer at the back of the book.

7. **From an earlier chapter**

   Review: Tariq runs 60 m in 12 s. What is his speed?

   A 72 m/s

   B 0.2 m/s

   C 5 m/s

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

A distance and time graph has time across and distance from home up. A flat line is still. A steeper line is faster. A line going down is coming back home.

Draw: Axes marked 0 to 60. A line that climbs steeply, goes flat, then climbs gently. Write fast, still, slow.

S3.7.3 CHAPTER 3

Balanced and unbalanced forces

Why does a bag of rice on a table not move, when gravity is pulling it down?

YOUR GUESS

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

- ☐ **A** The forces on it are balanced.
- ☐ **B** No forces act on it, because it is not moving.
- ☐ **C** It is too heavy to move.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Forces: friction, falling and floating, S2.5.1. A force is a push or a pull, drawn as an arrow.
- Level 2, Forces: friction, falling and floating, S2.5.2. Forces are measured in newtons, N.
- Level 2, Forces: friction, falling and floating, S2.5.3. Friction is a force that acts against movement.

BY THE END YOU CAN

- Draw force arrows on an object and find the overall force
- Explain why balanced forces do not change speed or direction

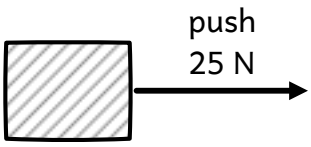
Almost nothing has only one force on it. A bag of rice on a table has two. Gravity pulls it down. The table pushes it up.

We draw a force as an arrow. The arrow points the way the force acts. A longer arrow is a bigger force. We write the size in newtons, N.

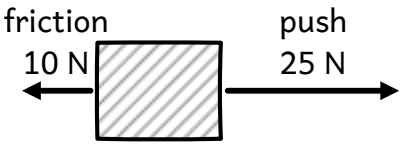
Often there are two forces in opposite directions. To see what happens, we add them up into one: the **overall force**.

DRAW IT FIRST

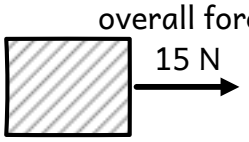
Draw the forces on a pushed box



1 Draw the box. Draw the push as an arrow to the right. It is 25 N.



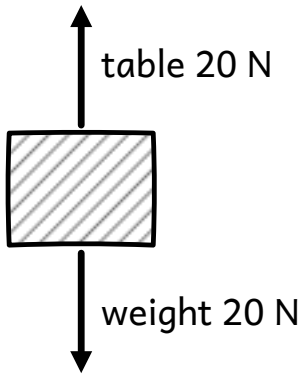
2 Friction pulls the other way. Draw a shorter arrow to the left. It is 10 N.



3 Take the small force from the big one. 25 − 10 = 15. The overall force is 15 N to the right.

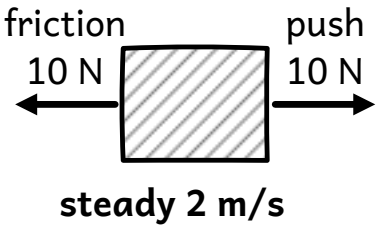
When two forces act on a thing in opposite directions, the overall force is the difference between them. It points the way of the bigger force.

If the two forces are the same size, the overall force is zero. We say the forces are **balanced**. If they are not the same size, they are **unbalanced**.



The table pushes up with 20 N. Gravity pulls down with 20 N. The forces are balanced, so the bag does not move.

Balanced forces change nothing. A thing that is still stays still. A thing that is moving keeps moving at the same speed in the same direction.



The push and the friction are balanced. The box keeps its steady speed. It does not speed up and it does not slow down.

SEE IT THREE WAYS

As a picture

push	friction	overall
25 N	10 N	15 N right
20 N	20 N	0 N
10 N	25 N	15 N left

In words

If the push is bigger, the overall force is forward and the box speeds up. If the two are equal, nothing changes. If friction is bigger, a box that is already sliding slows down.

In symbols

overall force = bigger force − smaller force. 25 − 10 = 15 N.

WORKED EXAMPLE

A box is pushed to the right with 25 N. Friction pulls it to the left with 10 N. What is the overall force?

1. The forces point in opposite directions, so we take one from the other.
2. The bigger force is the push: 25 N to the right.
3. The smaller force is friction: 10 N to the left.
4. Overall force = 25 − 10 = 15 N.
5. The overall force points right, so the box speeds up to the right.

Answer: 15 N to the right

TRY IT

Pull a shoe at a steady speed

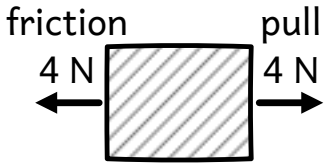
You need: an old shoe or a small box, a rubber band and a piece of string, a ruler, a smooth floor indoors.

Be safe: Pull on a clear floor. Keep your face away from the band in case it slips.

1. Tie the band to the shoe with the string. Hold the other end of the band.
2. Pull the shoe along the floor slowly. Try to keep it going at a steady speed.
3. Hold the ruler beside the band while you pull. Look at how long the band is.
4. Now pull harder so that the shoe speeds up. Watch the band.
5. Let go. Watch how the shoe slows down and stops.

What you will see: At a steady speed the band stays the same length. Your pull and the friction are balanced. When you pull harder the band gets longer and the shoe speeds up. When you let go, friction slows it down until it stops.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~A moving thing needs a force to keep it moving.~~

Why it feels right: In daily life things stop when we stop pushing them.

The test that breaks it: Slide a book across a table and let go. It stops quickly. Now put the book on three round pencils and push it the same way. It rolls much farther. The less friction, the farther it goes.

What is true: A moving thing keeps its speed and direction unless the forces on it are unbalanced. Friction and air resistance are the forces that slow things down.

KEY WORDS

overall force
all the forces on a thing added up into one.

balanced
two forces that are equal and opposite. The overall force is zero.

unbalanced
forces that are not equal. There is an overall force.

BACK TO YOUR GUESS

The answer is A: The forces on it are balanced.

Two forces act on the bag. Gravity pulls it down and the table pushes it up. They are the same size, so they are balanced and the bag stays still.

CHECK YOURSELF

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

1. A box is pushed to the right with 45 N. Friction pulls it to the left with 15 N. What is the overall force?

   Answer at the back of the book.

2. Two children pull a rope from opposite ends. Kofi pulls with 60 N. Ana pulls with 45 N. What is the overall force on the rope?

   A 105 N towards Kofi

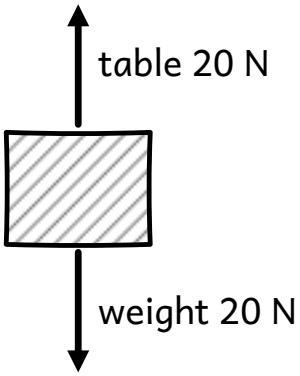
   B 15 N towards Ana

   C 0 N, so the rope does not move

   D 15 N towards Kofi

   Answer at the back of the book.

3. A bag of rice lies on a table. Its weight is 20 N down and the table pushes up with 20 N. What is the overall force on the bag?



   A 40 N. It speeds up.

   B 0 N. Nothing changes.

   C 20 N upwards. It rises.

   Answer at the back of the book.

4. A skater glides on smooth ice in a straight line at a steady speed. What can you say about the forces on her?

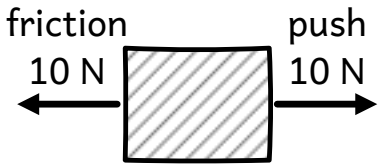
   A There must be a forward force bigger than all the others.

   B There are no forces on her at all.

   C The forces on her are balanced.

   Answer at the back of the book.

5. A box slides along the floor at a steady speed. The push is 10 N and the friction is 10 N. You keep pushing in the same way. What does the box do?



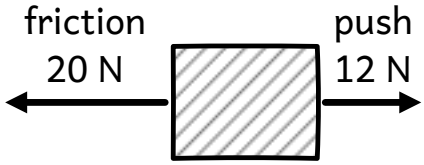
A It keeps the same speed in the same direction.

B It speeds up, because you keep pushing.

C It slows down and stops, because friction pulls back.

Answer at the back of the book.

6. A box slides to the right. You push it right with 12 N. Friction pulls it left with 20 N. What happens to the box?



A It speeds up, because you are still pushing it forward.

B It keeps the same speed, because it is already moving.

C It turns round and slides to the left, because friction is bigger.

D It slows down. The overall force is 8 N to the left.

Answer at the back of the book.

7. **From an earlier chapter**

A walker's graph is flat from 40 s to 50 s. She is 40 m from home the whole time. What is her speed in these 10 seconds?

A 4 m/s

B 0 m/s

C 10 m/s

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Forces in opposite directions: take one from the other. That is the overall force. Balanced forces give zero, so speed and direction do not change.

Draw: A box with a long arrow right, 25 N, and a short arrow left, 10 N. Write overall force 15 N.

S3.7.4 CHAPTER 4

Mass and weight

Would I weigh less on the Moon? Would I get smaller?

YOUR GUESS

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

- ☐ **A** Both my mass and my weight would be less.
- ☐ **B** Nothing would change, because I am still me.
- ☐ **C** My weight would be less, but my mass would stay the same.

IF THIS FEELS HARD, READ THIS FIRST

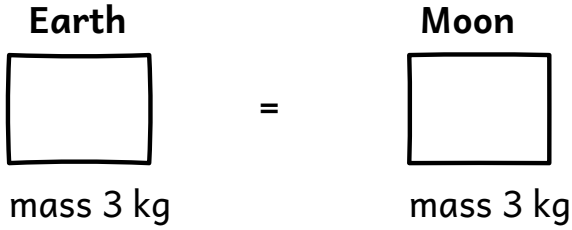
- Level 2, Forces: friction, falling and floating, S2.5.5. Gravity pulls things down and gives them weight.
- Level 2, Forces: friction, falling and floating, S2.5.2. Forces are measured in newtons.
- Level 2, Measuring, M2.6.4. Mass is measured in kilograms.

BY THE END YOU CAN

- Explain the difference between mass in kilograms and weight in newtons
- Explain why your weight would be less on the Moon

Mei says her bag is 3 kilograms. A scientist says it weighs about 30 newtons. Both are right. They are telling you about two different things.

The ***mass*** of a thing is how much stuff is in it. We measure mass in kilograms, kg. Your bag has the same mass in a room, on a mountain or on the Moon.



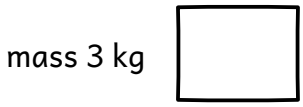
The same bag has the same mass on the Earth and on the Moon. It is the same amount of stuff.

The **weight** of a thing is the pull of gravity on it. Weight is a force, so we measure it in newtons, N.

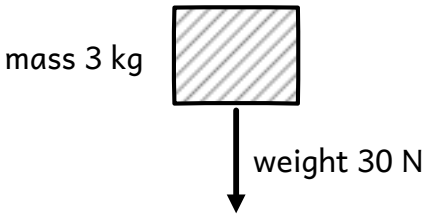
On Earth, each kilogram weighs about 10 N. So a mass of 3 kg weighs about 30 N.
To find a weight on Earth, multiply the mass in kilograms by 10.

DRAW IT FIRST

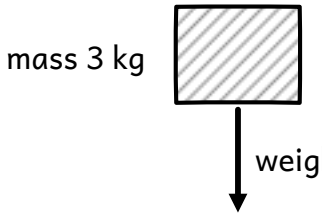
Draw the mass and weight of a bag



1 Draw the bag. Write its mass: 3 kg. This is the amount of stuff.



2 Draw an arrow down from the bag. This is its weight, the pull of gravity. Write 30 N.



3 × 10 = 30 N

3 Show where the number comes from. 3 kg × 10 = 30 N.

mass	weight
1 kg	10 N
2 kg	20 N
3 kg	30 N
5 kg	50 N

Weight on Earth, about. Each kilogram adds about 10 N.

The Moon has much less mass than the Earth, so its gravity is weaker. On the Moon each kilogram weighs only about 1.6 N. That is about one sixth of the Earth number.

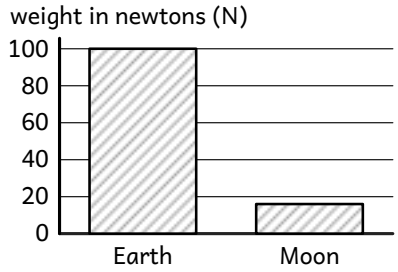
A 10 kg rock has a mass of 10 kg on the Earth and on the Moon. Its weight is not the same. Gravity pulls it less on the Moon.

mass	Earth	Moon
1 kg	10 N	1.6 N
2 kg	20 N	3.2 N
5 kg	50 N	8 N

Each row is one thing. Its mass stays the same. Its weight is smaller on the Moon, about one sixth as big.

SEE IT THREE WAYS

As a picture



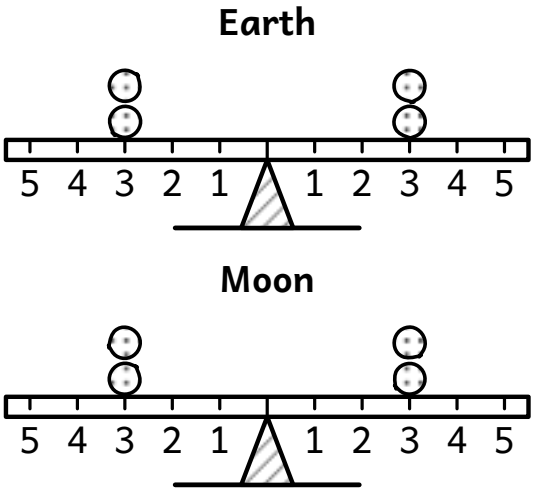
In words

The rock is the same amount of stuff in both places. The Moon pulls on it much less, so it weighs much less there.

In symbols

Earth: 10 kg × 10 = 100 N, about.
Moon: 10 kg × 1.6 = 16 N, about.

A shop scale with a spring really measures weight. A balance with two pans compares mass. On the Moon the balance gives the same answer. Gravity is weaker on both pans by the same amount, so they still match.



Equal masses balance on the Earth. They balance on the Moon too, because gravity weakens on both sides together.

TRY IT

Make a balance and find mass

You need: a ruler or a flat stick, a round pencil, about 15 bottle tops that are all the same, or small stones of the same size, a few small things: a pebble, a key, a teaspoon, a pencil and paper.

Be safe: Keep stones off your feet. Do not drop things from a table.

1. Rest the ruler across the round pencil at its middle, so it balances level.
2. Put the thing you want to measure 5 cm from the middle on one side.
3. Put bottle tops 5 cm from the middle on the other side, one at a time. Stop when the ruler is level again.
4. Count the tops. This is the mass of the thing, in bottle tops.
5. Do the same for each thing. Write your counts in a table.

What you will see: A heavy stone needs more tops than a light one. The tops measure mass by comparing. This would work in the same way on the Moon.

If you cannot try it, this is what happens.

thing	bottle tops
small stone	5
big stone	12
key	4

A WRONG IDEA MANY PEOPLE HAVE

~~Mass and weight are the same thing, so I would have less mass on the Moon.~~

Why it feels right: In daily life people say "she weighs 40 kilograms". They use one word for both.

The test that breaks it: Balance a stone on your ruler with 5 tops. On the Moon the stone and the tops are both pulled less, so the ruler still balances. The same 5 tops match the same stone. The amount of stuff did not change.

What is true: Mass is the amount of stuff, in kg. It is the same everywhere. Weight is the pull of gravity, in N. It changes with the place.

KEY WORDS

mass
how much stuff is in a thing. It is measured in kilograms.

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

kilogram
the unit of mass. We write kg.

newton
the unit of force and of weight. We write N.

BACK TO YOUR GUESS

The answer is C: My weight would be less, but my mass would stay the same.

Your weight would be less, because the Moon pulls less than the Earth. Your mass stays the same, because you are still the same amount of stuff.

CHECK YOURSELF

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

1. Ravi's bag has a mass of 4 kg. About what is its weight on Earth?

   Answer at the back of the book.

2. A stone weighs about 70 N on Earth. What is its mass?

   A 7 kg

   B 70 kg

   C 700 kg

   Answer at the back of the book.

3. On the Moon each kilogram weighs about 1.6 N. A rock has a mass of 20 kg. About what is its weight on the Moon?

   A 200 N

   B 1.6 N

   C 21.6 N

   D 32 N

   Answer at the back of the book.

4. An astronaut goes from the Earth to the Moon. Which one stays the same?

   A Her weight

   B Her mass

   C Neither stays the same

   Answer at the back of the book.

5. A rock weighs less on the Moon than on the Earth. What is the reason?

   A The rock has less mass on the Moon, so there is less of it.

   B There is no air on the Moon to press the rock down.

   C Things have no weight on the Moon.

   D The Moon pulls on the rock less than the Earth does.

   Answer at the back of the book.

6. Which of these is a weight?

   A 5 kg

   B 5 m/s

   C 50 N

   Answer at the back of the book.

7. **From an earlier chapter**

   A bag with a mass of 3 kg rests on a table. It does not move. About how hard does the table push up on it?

   A 30 N

   B 3 N

   C 0 N

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Mass is the amount of stuff, in kg, the same everywhere. Weight is the pull of gravity, in N. On Earth weight is about mass × 10. The Moon pulls about one sixth as much.

Draw: A box marked 3 kg with an arrow down marked about 30 N. Next to it, the same box with a short arrow marked about 5 N, for the Moon.

S3.7.5 CHAPTER 5

Stretching and springs

If I hang twice as many stones on a rubber band, does it stretch twice as far?

YOUR GUESS

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

- ☐ **A** Yes. Twice the stones always gives exactly twice the stretch.
- ☐ **B** It stretches more, but not always in an even way.
- ☐ **C** It stretches the same amount, however many stones I hang.

IF THIS FEELS HARD, READ THIS FIRST

- Level 2, Forces: friction, falling and floating, S2.5.2. You made a force meter from a rubber band.
- Level 2, Tables and charts, M2.7.6. You draw a line graph with a number scale.
- Level 3, Speed, forces and pressure, S3.7.2. You read and draw a graph with two number scales.

BY THE END YOU CAN

- Measure how far a rubber band stretches as you hang more stones
- Plot the results and describe the pattern

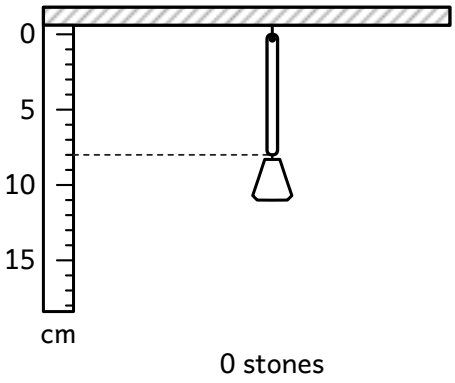
Kofi hangs a stone on a rubber band and it gets longer. He hangs a second stone and it gets longer again. He wants to know the pattern.

The **original length** is how long the band is with only the empty bag on it. The **stretch** is how much longer it gets.

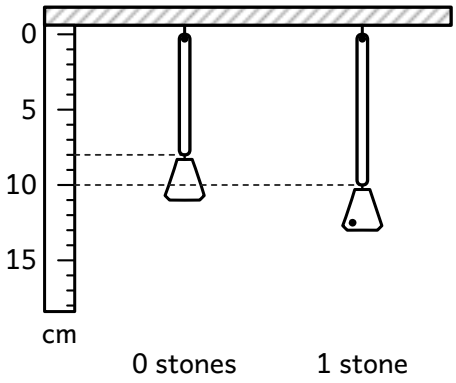
To find the stretch, take the original length from the new length. The stones you hang are the **load**. A bigger load is a bigger pull.

DRAW IT FIRST

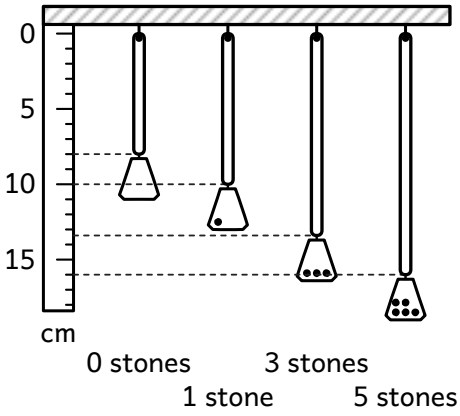
Draw a band with more and more stones



1 Hang a band with an empty bag. Read its length on a ruler. This is the original length: 8 cm.



2 Put in one stone. The band gets longer, to 10 cm.



3 Do it with more stones. Each time the band gets longer. With 5 stones it is 16 cm.

Write the results in a table, one row for each number of stones. Then work out the stretch each time.

SEE IT THREE WAYS

As a picture

stones	cm long	stretch
0	8	0
1	10	2
2	11.8	3.8
3	13.4	5.4
4	14.8	6.8
5	16	8

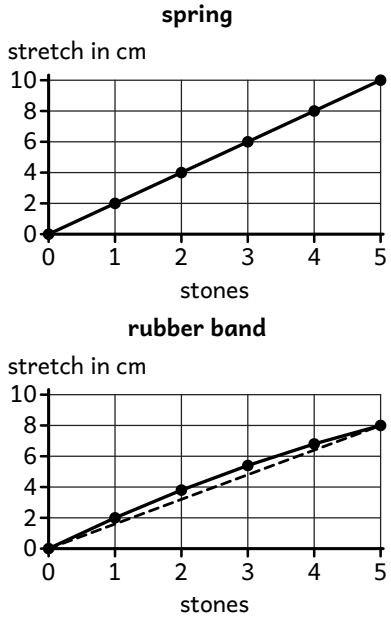
In words

These are one learner's results. More stones give more stretch. The band does not grow by the same amount each time. Your band will give different numbers.

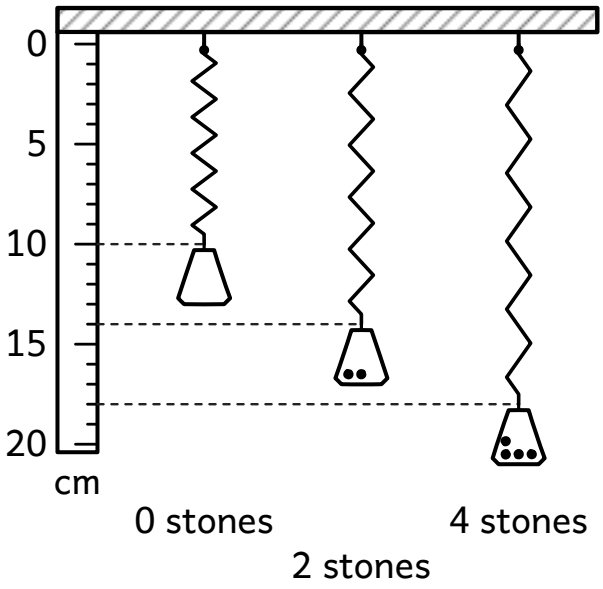
In symbols

stretch = new length − original length. With 3 stones: 13.4 − 8 = 5.4 cm.

A graph shows the pattern better than a table. Put the number of stones across and the stretch up. Plot a point for each row.



A spring gives a straight line. The rubber band bends away from the dashed straight line.



A spring: 0 stones, 10 cm. 2 stones, 14 cm. 4 stones, 18 cm. Each stone adds the same 2 cm.

A steel spring stretches by equal amounts for equal loads. Here each stone adds 2 cm. This holds until the spring is stretched too far. A spring pulled too far stays long.

A rubber band is different. In these results the first stone adds 2 cm. The fifth adds only 1.2 cm. Your band may bend another way. The graph is not a straight line, so we say it bends.

TRY IT

Stretch a rubber band with stones

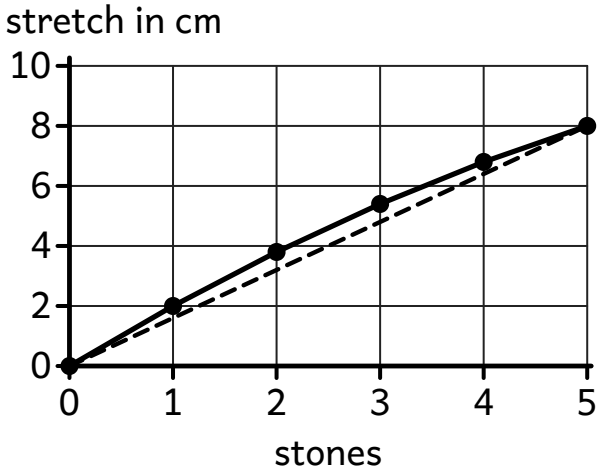
You need: a rubber band, a nail or a pencil to hang it from, held firm between two piles of books, a small bag with string, and 5 stones of the same size, a ruler, or a strip of card marked in centimetres, paper and a pencil.

Be safe: Keep your face away from the band. Stones can hurt feet, so work over a table or a soft cloth. Stop if the band looks thin.

1. Hang the band from the pencil. Hang the empty bag from the band.
2. Hold the ruler beside it with 0 at the top of the band. Read the length. This is the original length.
3. Put in one stone. Read the length again and write it down.
4. Add one stone at a time up to five. Read the length each time.
5. Work out the stretch for each row. Plot stones across and stretch up.

What you will see: The band gets longer with every stone, so the points climb. Join them with a smooth line. Look at it. Is it a straight line or does it bend? The dashed line is a straight line for comparison.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~Twice the load always makes twice the stretch.~~

Why it feels right: A spring does behave like this, so it is tempting to think every stretchy thing does.

The test that breaks it: Look at the band results. 2 stones stretch it 3.8 cm. Twice the stretch would be 7.6 cm. But 4 stones stretch it only 6.8 cm.

What is true: A spring stretches by equal amounts for equal loads. A rubber band does not quite. Its graph bends, so measure before you trust a pattern.

KEY WORDS

original length
how long a band or spring is with no stones, only the empty bag.

stretch
how much longer it gets: new length minus original length.

load
the weight hanging on a band or spring.

BACK TO YOUR GUESS

The answer is B: It stretches more, but not always in an even way.

More stones give more stretch, but a rubber band does not stretch quite evenly. The best way to see the pattern is to measure and plot it.

CHECK YOURSELF

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

1. A band is 8 cm long with no stones. With 3 stones it is 13.4 cm long. What is the stretch?

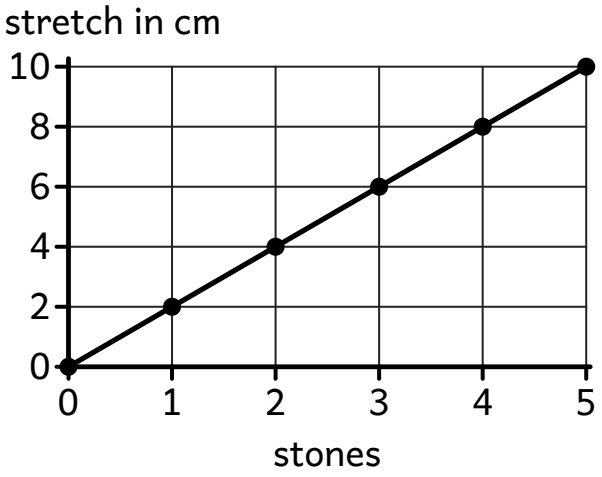
   A 13.4 cm

   B 21.4 cm

   C 5.4 cm

   Answer at the back of the book.

2. Look at the graph of the spring. How far does it stretch with 4 stones?



   A 8 cm

   B 4 cm

   C 6 cm

   Answer at the back of the book.

3. A spring stretches 2 cm for each stone. How far will it stretch with 6 stones? Assume it is not overstretched.

   A 8 cm

   B 12 cm

   C 3 cm

   Answer at the back of the book.

4. Look at the rubber band results in the table. Which sentence describes them best?

stones	cm long	stretch
0	8	0
1	10	2
2	11.8	3.8
3	13.4	5.4
4	14.8	6.8
5	16	8

A Every stone adds exactly the same stretch.

B More stones give less stretch.

C More stones give more stretch, but each stone adds a little less.

Answer at the back of the book.

5. **From an earlier chapter**

Each stone has a mass of 0.1 kg. About what does one stone weigh on Earth?

A 1 N

B 0.1 N

C 10 N

Answer at the back of the book.

6. You stretch a spring much too far and then take the load off. What happens?

A It goes back to its first length, every time.

B It stays longer than before.

C It shrinks to less than its first length.

Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Stretch is new length minus original length. A spring stretches by equal amounts for equal loads, so its graph is straight. A rubber band bends. Measure and plot to see the pattern.

Draw: Axes: stones across, stretch up. A straight line for a spring and a bending line for a band.

S3.7.6 CHAPTER 6

Levers and turning forces

How can a small child balance a bigger child on a seesaw?

YOUR GUESS

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

- ☐ **A** The small child pushes down harder.
- ☐ **B** It cannot happen. The heavier child always goes down.
- ☐ **C** The small child sits farther from the middle.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Speed, forces and pressure, S3.7.3. Balanced forces cancel out.
- Level 2, Measuring, M2.6.1. You measure distances in centimetres.

BY THE END YOU CAN

- Explain how a lever lets a small force lift a big load
- Balance a ruler seesaw with coins at different distances

A seesaw is a plank that turns about a middle point. A heavy child and a light child can still balance it. The trick is where each one sits.

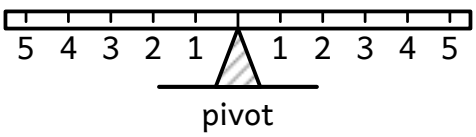
The point a plank turns about is the **pivot**. A force can make a thing turn about a pivot. How strongly it turns is the **turning effect**.

The turning effect depends on two things. One is the size of the force. The other is how far the force is from the pivot.

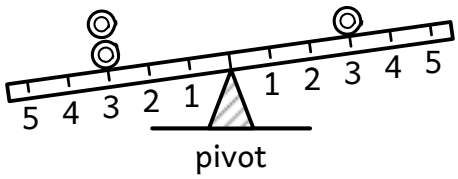
In the pictures, each round cap is a bottle top. All the caps are the same, so each one has the same weight. Count each as one unit of force.

DRAW IT FIRST

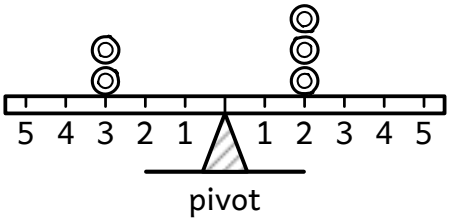
Draw a seesaw that balances



1 Draw a ruler resting on a pivot at its middle. It is level. Number the marks 1 to 5 on each side.



2 Put 2 caps at mark 3 on the left and 1 cap at mark 3 on the right. The left has the bigger turning effect, so it goes down.



6 and 6

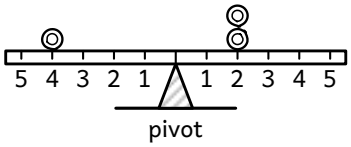
3 Move to 3 caps at mark 2 on the right. Left: 2 × 3 = 6. Right: 3 × 2 = 6. The ruler is level.

turning effect = force × distance from the pivot. A bigger force turns more. A force farther out turns more.

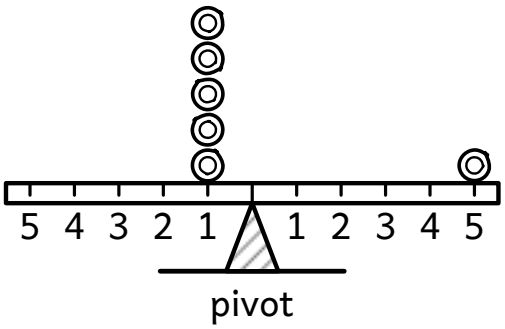
A cap on mark 3 has a turning effect of 1 × 3 = 3. Two caps on mark 3 have 2 × 3 = 6. Add up every cap on a side.

A seesaw balances when the turning effects on the two sides are equal. If one side has the bigger turning effect, that side goes down.

SEE IT THREE WAYS

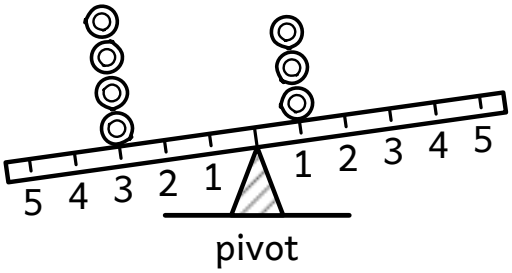
As a picture	In words	In symbols
	One cap far from the pivot balances two caps closer in. The two sides turn just as strongly, one with more force and one with more distance.	**Left: 1 × 4 = 4. Right: 2 × 2 = 4. Equal, so balanced.**

A **lever** is a stiff bar that turns about a pivot. A spade, a crowbar, a pair of scissors and a seesaw are all levers. The load is the thing you want to lift. The **effort** is the force you use.



A big load of 5 caps close to the pivot is balanced by 1 cap far from it. 5 × 1 = 5 and 1 × 5 = 5.

This is why a long crowbar lifts a heavy stone. Your small push is far from the pivot. The heavy stone is close to it. A little more effort and the stone lifts.



The start of the next example. The 3 caps on the right are too near the pivot. They must move out to a mark that makes the ruler level.

WORKED EXAMPLE

A ruler has 4 caps at mark 3 on the left. 3 caps go on the right. At which mark must they go to balance?

1. Turning effect = number of caps × mark.
2. Left: 4 caps at mark 3, so 4 × 3 = 12.
3. To balance, the right side must also have a turning effect of 12.
4. Right: 3 caps at some mark, so 3 × mark = 12.
5. Mark = 12 ÷ 3 = 4.
6. Check: 3 × 4 = 12, the same as the left side.

Answer: Mark 4

TRY IT

Balance a ruler seesaw

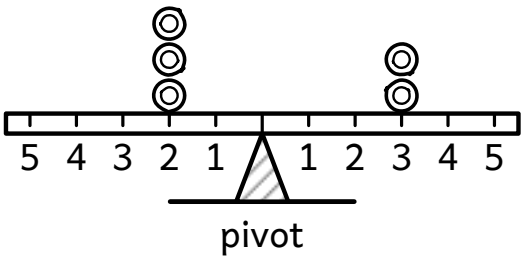
You need: a ruler or a flat stick about 30 cm long, a round pencil to be the pivot, about 10 bottle tops of one size, or coins of one size, to use as weights, a pencil for marking.

Be safe: Bottle tops and coins are small. Keep them away from very young children. Work on a table so nothing falls on your feet.

1. Rest the ruler across the round pencil at its middle, so it is level. This is the pivot.
2. Make a dot every 3 cm out from the middle on each side. Number the dots 1 to 5.
3. Put 3 tops on the left at mark 2. Put 2 tops on the right at mark 1. The left goes down.
4. Slide the 2 tops along the right side until the ruler is level. Note the mark.
5. Try 3 tops on the right. Find the mark where it balances. For each, write tops × mark on both sides.

What you will see: Two tops balance at mark 3, because 3 × 2 = 6 and 2 × 3 = 6. Three tops balance at mark 2. Each time, tops × mark is the same on both sides. A small nudge may be needed, because a real ruler is not perfect.

If you cannot try it, this is what happens.



A WRONG IDEA MANY PEOPLE HAVE

~~The heavier side always goes down.~~

Why it feels right: On a seesaw with children at the ends, the heavier child usually wins.

The test that breaks it: Put 2 tops at mark 1 on the left. Put 1 top at mark 5 on the right. The right side goes down. It has less weight, but it is far from the pivot.

What is true: It is the turning effect that counts, which is force times distance. A small force far out can beat a big force close in.

KEY WORDS

pivot
the point a lever turns about.

turning effect
force × distance from the pivot.

lever
a stiff bar that turns about a pivot.

effort
the force you use to move a load.

BACK TO YOUR GUESS

The answer is C: The small child sits farther from the middle.

A force farther from the middle has a bigger turning effect. A small child far out can balance a bigger child close in.

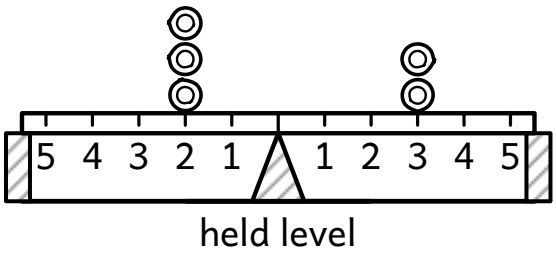
CHECK YOURSELF

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

1. A weight of 5 N hangs 20 cm from the pivot. What is its turning effect? Use N cm as the unit.

   Answer at the back of the book.

2. The ruler rests on a block under each end. If you take the blocks away, does it stay level?



held level

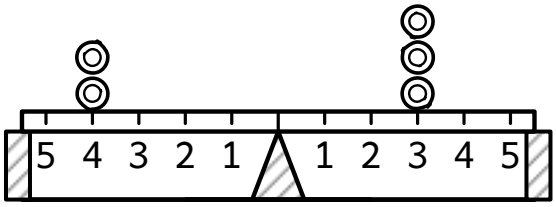
   A Yes. Both sides have the same turning effect.

   B No. The left has more caps, so it goes down.

   C No. The right caps are farther out, so the right side goes down.

   Answer at the back of the book.

3. The ruler rests on a block under each end. If you take the blocks away, which side goes down?



held level

   A The left side goes down.

   B The right side goes down.

   C Neither. It balances.

   Answer at the back of the book.

4. A 6 N weight is 10 cm to the left of the pivot. A 3 N weight is on the right. How far from the pivot must the 3 N weight be to balance?

   A 10 cm

   B 5 cm

   C 60 cm

   D 20 cm

   Answer at the back of the book.

5. Kofi uses a plank as a lever. A stone weighing 80 N sits 15 cm from the pivot. He pushes down on the other side, 60 cm from the pivot. How big a push balances the stone?

   A 80 N

   B 1200 N

   C 20 N

   D 320 N

   Answer at the back of the book.

6. Why does a long spoon handle help open a tin lid more than a short one?

   A Your push is farther from the pivot, so it has a bigger turning effect.

   B The long handle is stronger.

   C A long handle makes the lid weigh less.

   Answer at the back of the book.

7. **From an earlier chapter**

   A stone with a mass of 4 kg is the load on a lever. About what is its weight?

   A 4 N

   B 40 N

   C 14 N

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Turning effect = force × distance from the pivot. A seesaw balances when both sides are equal. A lever lets a small force far from the pivot balance a big load close in.

Draw: A ruler on a pivot. 2 caps at mark 3 on the left, 3 caps at mark 2 on the right. Write 6 and 6.

S3.7.7 CHAPTER 7

Pressure

Why does a sharp knife cut, when a blunt one only squashes?

YOUR GUESS

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

- ☐ **A** The sharp knife is pushed with a bigger force.
- ☐ **B** The sharp knife is heavier.
- ☐ **C** The sharp edge is so thin that the same push is on a much smaller area.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Speed, forces and pressure, S3.7.4. The force is often a weight, in newtons.
- Level 2, Measuring, M2.6.8. Area is measured in square centimetres.

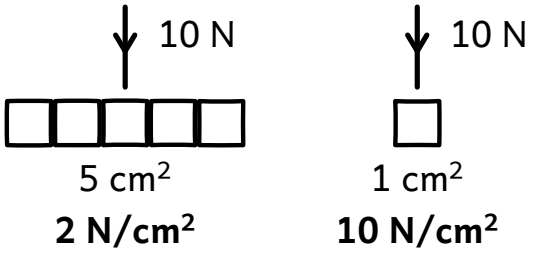
BY THE END YOU CAN

- Calculate pressure as force divided by area
- Explain why sharp knives cut and wide feet stop camels sinking in sand

Press the flat end of a pencil gently into your palm. Then press the sharp tip with the same push. The tip hurts more. The push is the same, but the feeling is not.

The ***area*** is how much surface the force touches. We measure it in square centimetres, cm^2. A tip touches a tiny area. A flat end touches a bigger one.

Pressure tells you how much force pushes on each square centimetre. Look at 10 N pushing down on a flat patch.

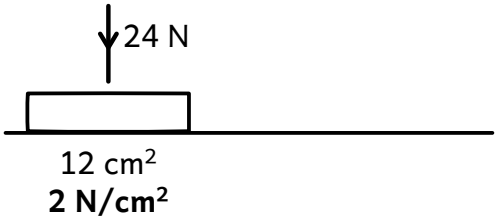


The same 10 N. On 5 squares each square takes 2 N. On 1 square it takes all 10 N.

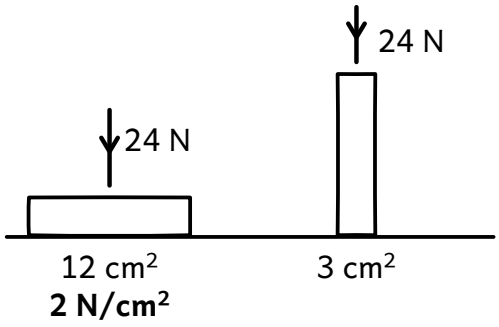
Share the force out over the squares. 10 N over 5 squares is 2 N on each. So pressure = force ÷ area. We read N/cm^2 as "newtons for each square centimetre".

DRAW IT FIRST

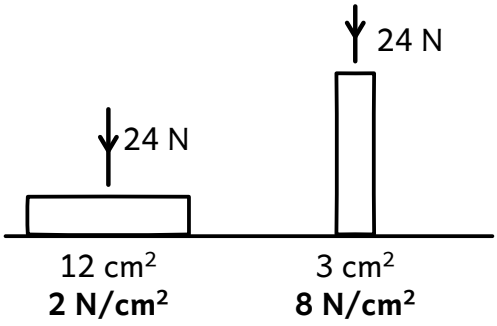
Draw one block on a big face and a small face



1 Draw a light block lying flat. Press down on it with 24 N. The push is on 12 cm². Pressure = 24 ÷ 12 = 2 N/cm².



2 Stand the same block on its end and press down with the same 24 N. Now the push is on only 3 cm².



3 Pressure = 24 ÷ 3 = 8 N/cm². The same force on a smaller area gives more pressure.

Scientists often give pressure in N/m², which is called the **pascal**, Pa. We stay with N/cm² here, because the sums are smaller.

SEE IT THREE WAYS

As a picture

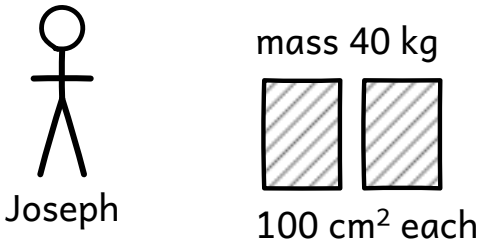
area	force	pressure
12 cm^2	24 N	2 N/cm^2
3 cm^2	24 N	8 N/cm^2

In words

The force stays the same. The area gets smaller, so the pressure gets bigger. A small area means a big pressure.

In symbols

pressure = force ÷ area. 24 ÷ 12 = 2 N/cm^2. 24 ÷ 3 = 8 N/cm^2.



The start of the next example. Joseph stands on two feet, then on one.

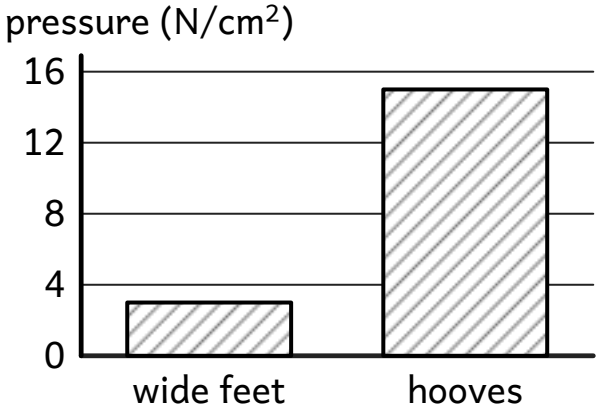
WORKED EXAMPLE

Joseph has a mass of 40 kg. Each of his soles touches the ground over 100 cm^2. What pressure does he put on the ground on two feet, and on one foot?

1. Pressure = force ÷ area. His weight is the force.
2. Weight = 40 × 10 = 400 N.
3. Both soles: 2 × 100 = 200 cm^2.
4. Pressure on two feet = 400 ÷ 200 = 2 N/cm^2.
5. On one foot the area is only 100 cm^2.
6. Pressure on one foot = 400 ÷ 100 = 4 N/cm^2.
7. The pressure doubles when the area halves.

Answer: 2 N/cm^2 on two feet, 4 N/cm^2 on one foot

Now the camel. A camel weighs about 6000 N. Its four wide feet touch the sand over about 2000 cm^2. The pressure is 6000 ÷ 2000 = 3 N/cm^2. That is small, so the camel does not sink far.



The same camel on wide feet puts 3 N/cm² on the sand. On small hooves of 400 cm² in all it would put 15 N/cm², and it would sink.

A knife works the other way. Push a knife with 20 N. A blunt edge touches 4 cm², so the pressure is 5 N/cm². A sharp edge may touch only 0.2 cm², so the pressure is 100 N/cm². That is much bigger, and it cuts.

edge	area	pressure
blunt	4 cm²	5 N/cm²
sharp	0.2 cm²	100 N/cm²

The same 20 N push on a sharp edge gives 20 times the pressure.

Be safe. Never test a knife on anything to see how it cuts. Talk about it and use the numbers instead.

TRY IT

Make a box press into sand

You need: a tray or a wide bowl of dry sand or fine soil, a shoe box with the lid taped shut and stones inside to make it heavy, a ruler or a stick, and paper.

Be safe: The box is heavy. Lower it slowly and keep it off your feet. Keep sand away from your eyes and mouth.

1. Smooth the sand flat with your hand. Lay the box on its widest face. Count five seconds.
2. Lift the box straight up. Measure how deep the dent is with the ruler.
3. Smooth the sand flat again.
4. Stand the box on its narrowest end. Count five seconds, then lift it.
5. Measure the new dent. Compare the two. The box is the same, so its weight is the same.

What you will see: The dent is deeper when the box stands on its narrow end. The weight is the same. The area is smaller, so the pressure is bigger. Our dents were 2 mm and 8 mm. Yours will differ.

If you cannot try it, this is what happens.

box on its	dent in mm
wide face	2
narrow end	8

A WRONG IDEA MANY PEOPLE HAVE

~~A bigger force always means a bigger pressure.~~

Why it feels right: In daily talk, people use "pressure" and "push" to mean the same thing.

The test that breaks it: Joseph on one foot puts 4 N/cm^2 on the ground. The camel puts 3 N/cm^2. The camel's force is 15 times bigger, but its pressure is smaller.

What is true: Pressure is force divided by area. A big force spread over a big area can give a small pressure.

KEY WORDS

area
how much surface a force touches. We measure it in cm^2.

pressure
the force on each unit of area, such as each square centimetre: force ÷ area.

pascal
the unit of pressure in N/m^2. We write Pa.

BACK TO YOUR GUESS

The answer is C: The sharp edge is so thin that the same push is on a much smaller area.

The push can be the same. A sharp edge touches a tiny area, so the force is squeezed into a very small space. That makes a very big pressure.

CHECK YOURSELF

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

1. A force of 60 N pushes on an area of 20 cm^2. What is the pressure?

   Answer at the back of the book.

2. A knife is pushed with 20 N. Its edge touches the food over 0.5 cm^2. What is the pressure?

   A 40 N/cm^2

   B 10 N/cm^2

   C 0.025 N/cm^2

   Answer at the back of the book.

3. Ravi has a mass of 50 kg. He stands on two feet that touch the ground over 250 cm^2 in all. What pressure does he put on the ground?

   A 0.2 N/cm^2

   B 2 N/cm^2

   C 500 N/cm^2

   Answer at the back of the book.

4. Two knives are pushed with the same force. One is sharp and one is blunt. Why does the sharp knife cut better?

   A The sharp knife is pushed with a bigger force.

   B The sharp knife weighs more.

   C The sharp edge touches a much smaller area, so the pressure is much bigger.

   Answer at the back of the book.

5. A camel walks on soft sand and does not sink far. Why?

   A Its wide feet spread its weight over a big area, so the pressure is small.

   B Its feet are small, so they push hard on one spot.

   C A camel is too light to sink.

   Answer at the back of the book.

6. Amina has a mass of 60 kg. Her feet touch the ground over 300 cm^2 in all. Kofi has a mass of 30 kg. His feet touch the ground over 60 cm^2 in all. Who puts the bigger pressure on the ground?

   A Amina, because she is heavier.

   B Kofi. He puts 5 N/cm^2 on the ground, and Amina puts 2 N/cm^2.

   C Amina, because her feet are wider.

   Answer at the back of the book.

7. **From an earlier chapter**

   Review: a skater glides 30 m in 6 s. What is her speed?

   A 36 m/s

   B 0.2 m/s

   C 5 m/s

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Pressure = force ÷ area, in N/cm^2. The same force on a smaller area gives a bigger pressure. Sharp edges cut. Wide feet spread weight out.

Draw: A block with 24 N on 12 cm^2, and the same block on 3 cm^2. Write 2 N/cm^2 and 8 N/cm^2.

S3.7.8 CHAPTER 8

Pressure in water and air

Why does water shoot out of a bottle, and why does it go farthest from the lowest hole?

YOUR GUESS

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

- ☐ **A** Deeper water has more water above it pushing down, so the pressure is bigger.
- ☐ **B** The lowest hole is bigger, so more water comes out.
- ☐ **C** Water gets heavier near the bottom of the bottle.

IF THIS FEELS HARD, READ THIS FIRST

- Level 3, Speed, forces and pressure, S3.7.7. Pressure is a force on an area.
- Level 2, Forces: friction, falling and floating, S2.5.7. Water pushes up on things put in it.
- Level 3, Speed, forces and pressure, S3.7.3. Balanced forces do not change how a thing moves.

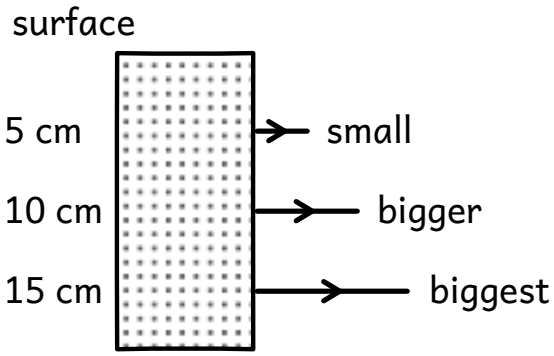
BY THE END YOU CAN

- Show that water pressure grows with depth using a bottle with holes
- Explain how air pressure lets you drink through a straw
- Explain floating as an upward push balancing weight

Make a hole in the side of a bottle full of water. A jet of water shoots out. Water is pushing on the sides of the bottle, and it pushes out through the hole.

Water pushes in every direction: down, up and sideways. This push is **water pressure**. The **depth** is how far you are below the surface.

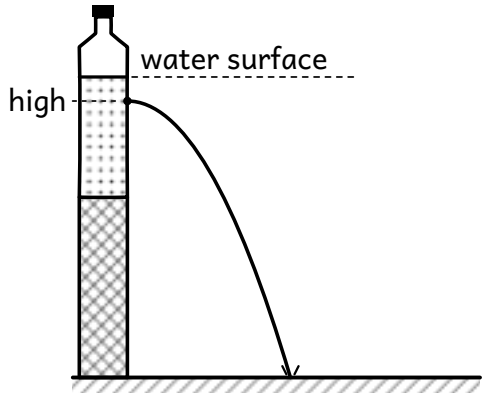
The deeper you go, the more water is above you. So the pressure grows with depth.



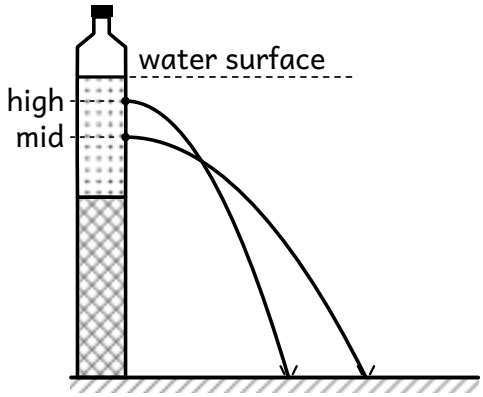
The water pushes out of the wall. The deeper the point, the longer the arrow, because the pressure is bigger.

DRAW IT FIRST

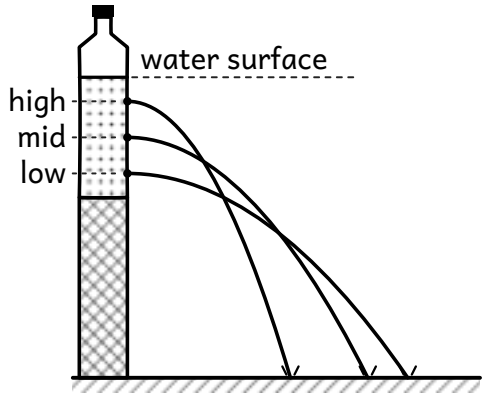
Draw *a* bottle with jets



1 Draw *a* bottle with water 20 cm deep, on *a* tall block. Make *a* hole 4 cm below the surface. A short jet leaves it.



2 Add *a* hole 10 cm below the surface. Its jet leaves faster and lands farther out.



3 Add *a* hole 16 cm below the surface. Its jet lands farthest of all.

The deepest hole has the biggest pressure behind it, so its water leaves fastest. The bottle must stand high up. Then the water has *a* long way to fall, and *a* faster jet lands farther out.

If the bottle stood on the ground, the lowest jet would have almost no height to fall. It would land close, even though its pressure is the biggest. So stand the bottle on

something high.

SEE IT THREE WAYS

As a picture

hole	depth	lands
high	4 cm	22 cm
mid	10 cm	32 cm
low	16 cm	38 cm

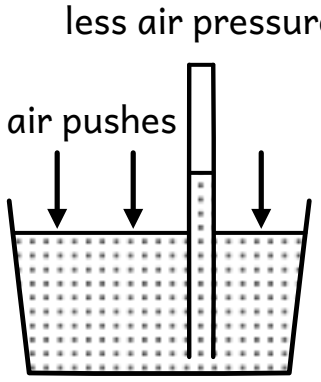
In words

A deeper hole has a bigger water pressure. The water leaves faster and lands farther out, as long as the bottle stands high.

In symbols

Depth 4 cm: lands about 22 cm out. Depth 16 cm: lands about 38 cm out.

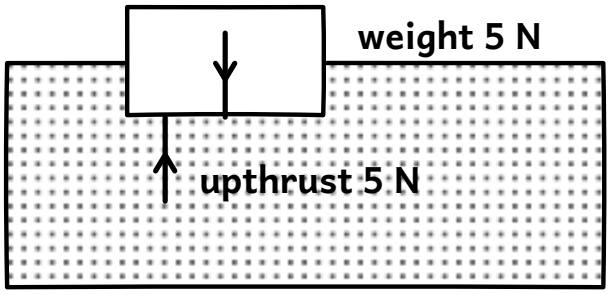
The push of the air is ***air pressure***. The air above us is very deep, so it pushes on everything. We do not feel it, because our bodies push out from inside just as hard.



Air pushes down on the water in the cup. When you drink, you lower the air pressure in the straw. The air outside pushes the water up.

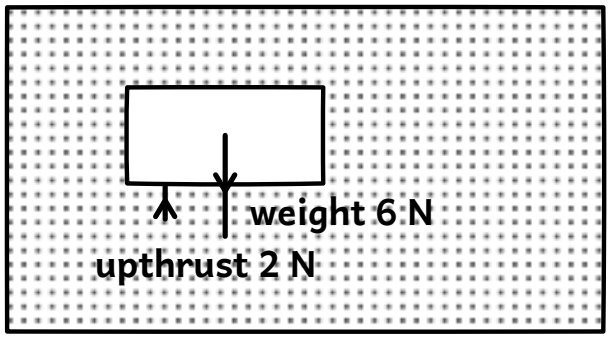
When you drink through a straw, you lower the air pressure in your mouth and in the straw. The air pressing on the drink outside is now stronger. It pushes the drink up the straw. You do not pull the drink up.

Water also pushes up on anything in it. The water below a thing is deeper. It pushes up harder than the water or air above pushes down. The difference is the **upthrust**.



A boat with a mass of 0.5 kg weighs 5 N. It floats when the upthrust is also 5 N. The two forces are balanced.

A thing floats when the upthrust equals its weight. It settles into the water until the water pushes up as hard as gravity pulls down. If the water can never push up that hard, the thing sinks.



This stone weighs 6 N, but the water pushes up with only 2 N. The arrows are not equal, so the stone sinks. Arrows are drawn to the same scale as the boat.

TRY IT

Make a bottle with holes

You need: a tall plastic bottle, filled with water, a nail, and an adult to push it through the plastic, tape, a stool or box about 30 cm high, a string or ruler, and stones to mark where the water lands.

Be safe: An adult must push the nail through the plastic. Never heat the nail. Push away from your hand.

1. Ask an adult to push the nail through the plastic. Make three holes in a line down one side, well spaced. Put one long strip of tape over all three holes.
2. Stand the bottle on the stool near the edge, outside or over a sink. Face the holes out. Fill the bottle.
3. Pull the strip off in one go. Watch the jets.
4. Put a stone where each jet lands. Measure each distance from the bottle with the string.
5. Refill the bottle and stand it on the ground instead. Where does the lowest jet land now?

What you will see: The jet from the lowest hole leaves fastest and lands farthest. The top jet lands closest. Our marks were 22, 32, 38 cm, from top to bottom. Real jets land a little closer than a perfect jet would. They land closer still as the water runs down. Yours will differ. On the ground the lowest jet has little height to fall, so it no longer lands the farthest.

If you cannot try it, this is what happens.

hole	depth	lands
high	4 cm	22 cm
mid	10 cm	32 cm
low	16 cm	38 cm

A WRONG IDEA MANY PEOPLE HAVE

~~When you drink through a straw, you pull the drink up with your mouth.~~

Why it feels right: It feels as if you are pulling, because your cheeks work to drink.

The test that breaks it: Ask an adult to snip a small hole near the top of a straw. Now try to drink with the straw in a cup. It is much harder, or does not work at all, because air comes in at the hole.

What is true: Your mouth lowers the air pressure in the straw. The air outside is at a higher pressure, and it pushes the drink up.

KEY WORDS

water pressure
the push of water in every direction. It grows with depth.

depth
how far a point is below the surface.

air pressure
the push of the air on everything it touches.

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

BACK TO YOUR GUESS

The answer is A: Deeper water has more water above it pushing down, so the pressure is bigger.

The deeper the water, the more water is above it. That makes the pressure bigger. A bigger pressure pushes the water out faster.

CHECK YOURSELF

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

1. A bottle of water stands on a tall block. It has three holes, 4, 10, 16 cm below the surface. Which hole's jet lands farthest from the bottle?

   A The hole 4 cm down

   B The hole 16 cm down

   C The hole 10 cm down

   Answer at the back of the book.

2. Kofi swims down to the bottom of a deep pool. What does the water do to his body?

   A It pushes only from above, and it pushes harder as he goes down.

   B It pushes the same at every depth, because it is all the same water.

   C It pushes less as he goes down, because he is farther from the air.

   D It pushes on him from every side, and it pushes harder the deeper he goes.

   Answer at the back of the book.

3. You drink through a straw. What pushes the drink up the straw?

   A You pull it up with your mouth.

   B The straw squeezes the drink.

   C The air pressing on the drink outside the straw.

   Answer at the back of the book.

4. A toy boat has a mass of 2 kg and floats at rest. How big is the upthrust on it?

   A 2 N

   B 0 N, because floating needs no push

   C 40 N, a bigger push than the weight

   D 20 N

   Answer at the back of the book.

5. A stone weighs 30 N. The most the water can push up on it is 12 N. What is the overall force on the stone as you let it go in the water?

   Answer at the back of the book.

6. In the bottle test, why must the bottle stand high up?

   A The water then has a long way to fall, so a faster jet lands farther out.

   B It gives the water more pressure.

   C It makes the holes bigger.

   Answer at the back of the book.

7. **From an earlier chapter**

   Review: a force of 80 N pushes on an area of 20 cm^2. What is the pressure?

   A 100 N/cm^2

   B 4 N/cm^2

   C 0.25 N/cm^2

   Answer at the back of the book.

KEEP IT

Copy this into your exercise book.

Water pressure grows with depth and pushes in every direction. Air pressure pushes a drink up a straw. A thing floats when the upthrust equals its weight.

Draw: A bottle on a tall block with three holes. Draw the longest jet from the lowest hole.

Key words, A to Z

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

air pressure
the push of the air on everything it touches. S3.7.8

area
how much surface a force touches. We measure it in cm^2. S3.7.7

average speed
the total distance divided by the total time. S3.7.1

balanced
two forces that are equal and opposite. The overall force is zero. S3.7.3

depth
how far a point is below the surface. S3.7.8

distance
how far a thing goes, measured in metres. S3.7.1

distance and time graph
a graph with time across and distance from home up. S3.7.2

effort
the force you use to move a load. S3.7.6

kilogram
the unit of mass. We write kg. S3.7.4

lever
a stiff bar that turns about a pivot. S3.7.6

load
the weight hanging on a band or spring. S3.7.5

mass
how much stuff is in a thing. It is measured in kilograms. S3.7.4

metres per second
the unit of speed. We write m/s. S3.7.1

newton
the unit of force and of weight. We write N. S3.7.4

original length
how long a band or spring is with no stones, only the empty bag. S3.7.5

overall force
all the forces on a thing added up into one. S3.7.3

pascal
the unit of pressure in N/m^2. We write Pa. S3.7.7

pivot
the point a lever turns about. S3.7.6

pressure
the force on each unit of area, such as each square centimetre: force ÷ area. S3.7.7

speed
how far a thing goes in one second. S3.7.1

steeper
climbing more quickly. A steeper line means a faster speed. S3.7.2

still
not moving. The graph line is flat. S3.7.2

stretch
how much longer it gets: new length minus original length. S3.7.5

turning effect
force × distance from the pivot. S3.7.6

unbalanced
forces that are not equal. There is an overall force. S3.7.3

upthrust
the push up that water gives a thing in it. S3.7.8

water pressure
the push of water in every direction. It grows with depth. S3.7.8

weight
the pull of gravity on a thing. It is measured in newtons. S3.7.4

Answers

S3.7.1. Speed

1. **1.2 m/s**

   Speed = distance ÷ time = 36 ÷ 30 = 1.2 m/s.

2. **40 m**

   Distance = speed × time = 4 × 10 = 40 m.

   - **If you chose A:** You divided the time by the speed. To find a distance, multiply the speed by the time. Go to S3.7.1.
   - **If you chose C:** You added the speed and the time. A speed of 4 m/s means 4 metres every second, so multiply by the seconds. Go to S3.7.1.

3. **25 s**

   Time = distance ÷ speed = 50 ÷ 2 = 25 s.

   - **If you chose A:** You divided the speed by the distance, upside down. Time = distance ÷ speed. Go to S3.7.1.
   - **If you chose B:** You multiplied the distance by the speed. That gives a distance, not a time. Divide the distance by the speed. Go to S3.7.1.
   - **If you chose D:** You added the distance and the speed. They are different kinds of number, so they cannot be added. Divide instead. Go to S3.7.1.

4. **Ana**

   Ana: 20 ÷ 10 = 2 m/s. Tariq: 30 ÷ 20 = 1.5 m/s. Ana has the bigger number.

   - **If you chose B:** Tariq went farther, but he also took longer. Divide each distance by its time and compare. Go to S3.7.1.
   - **If you chose C:** Work out each speed. Distance ÷ time is not the same for both. Go to S3.7.1.

5. **1.6 m/s**

   Total distance = 40 + 40 = 80 m. Total time = 40 + 10 = 50 s. 80 ÷ 50 = 1.6 m/s.

   - **If you chose A:** You added the two speeds and halved them. Use the total distance and the total time instead. Go to S3.7.1.
   - **If you chose C:** That is only the running part. Average speed uses the whole trip. Go to S3.7.1.

6. **The distance you walk and the time it takes.**

   Speed is distance divided by time, so you need both. Mark a distance with stones, time the walk, then divide. Do it three times, because a walk is never perfectly even.

   - **If you chose A:** The time alone cannot tell the speed. A short walk takes little time even when it is slow. Go to S3.7.1.
   - **If you chose B:** The distance alone cannot tell the speed. A long walk is slow if it takes a long time. Go to S3.7.1.

S3.7.2. Distance and time graphs

1. **From 30 s to 50 s**

   A flat line means the distance does not change. He is still from 30 s to 50 s.

   - **If you chose A:** The line climbs here, so the distance is growing. He is moving. Look for the flat part. Go to S3.7.2.
   - **If you chose C:** The line climbs steeply here. A fast walk is not standing still. Look for the flat part. Go to S3.7.2.

2. **From 10 s to 30 s**

   The middle part is the steepest. He goes 40 m in 20 s, which is 2 m/s.

   - **If you chose A:** This part is flat, so he is not moving. The fastest part is the steepest. Go to S3.7.2.
   - **If you chose B:** The line climbs here, but not as steeply as later. Find the steepest part. Go to S3.7.2.

3. **She walks back towards home.**

   The line goes down, so her distance from home gets smaller.

   - **If you chose B:** Her distance from home gets smaller here, so she is coming closer. Check which way the line goes. Go to S3.7.2.
   - **If you chose C:** A still walker has a flat line. This line goes down. Go to S3.7.2.

4. **Across to 20 on the time scale, then up to 40 on the distance scale**

   Time goes across and distance goes up. The point is 20 s across and 40 m up.

   - **If you chose A:** You swapped the two scales. On this graph time goes across and distance goes up, so start with the time. Go to S3.7.2.
   - **If you chose C:** That puts the point at 0 seconds, on the up line. Go across to the time first, then up. Go to S3.7.2.

5. **It climbs steeply, then goes flat, then climbs gently.**

   First he goes at 3 m/s, which is the steepest part. Then his speed is 0 m/s, so the line is flat. Last he goes at 0.25 m/s, a gentle climb.

   - **If you chose A:** Standing still makes his speed 0, not his distance. He stays 30 m from home, so the line stays flat at 30 m. Go to S3.7.2.
   - **If you chose B:** You swapped fast and slow. The first part covers more distance in less time, so it is the steeper line. Go to S3.7.2.
   - **If you chose C:** The last part covers a short distance in a long time. That is slow, so the last line is gentle, not steep. Go to S3.7.2.

6. **2.5 m/s**

   Distance covered = 21 − 6 = 15 m. Time = 10 − 4 = 6 s. Speed = 15 ÷ 6 = 2.5 m/s.

7. **5 m/s**

   Speed = distance ÷ time = 60 ÷ 12 = 5 m/s.

   - **If you chose A:** You added the two numbers. Speed is distance divided by time. Go to S3.7.1.
   - **If you chose B:** You divided time by distance. Put the distance first: distance ÷ time. Go to S3.7.1.

S3.7.3. Balanced and unbalanced forces

1. **30 N to the right**

   The forces are opposite, so take one from the other. 45 − 15 = 30 N. The push is bigger, so the overall force points right.

2. **15 N towards Kofi**

   The pulls are opposite, so take one from the other. 60 − 45 = 15 N. Kofi pulls harder, so the rope moves towards Kofi.

   - **If you chose A:** You added the two pulls. They are in opposite directions, so they work against each other. Take one from the other. Go to S3.7.3.
   - **If you chose B:** The size is right, but the direction is not. The overall force points the way of the bigger pull, and Kofi pulls harder. Go to S3.7.3.
   - **If you chose C:** Zero is only for equal pulls. These two are different, so the rope moves towards the stronger one. Go to S3.7.3.

3. **0 N. Nothing changes.**

   The forces are equal and opposite, so 20 − 20 = 0 N. The bag stays still.

   - **If you chose A:** You added the two forces. They point in opposite directions, so take one from the other. Go to S3.7.3.
   - **If you chose C:** The forces are equal. Neither one is bigger, so there is no overall force. Go to S3.7.3.

4. **The forces on her are balanced.**

   Her speed and direction do not change, so the overall force is zero. The forces are balanced.

   - **If you chose A:** A moving thing does not need a force to keep it moving. This is the idea the wrong idea box talks about. Go to S3.7.3.
   - **If you chose B:** Gravity pulls her down and the ice pushes her up. They are balanced, not missing. Go to S2.5.1.

5. **It keeps the same speed in the same direction.**

   The push is 10 N and the friction is 10 N, so the overall force is 0 N. Balanced forces do not change speed or direction.

   - **If you chose B:** A push only speeds a box up when it is bigger than the friction. Here the two are equal. Go to S3.7.3.
   - **If you chose C:** Friction does pull back, but the push pulls forward just as hard. The overall force is zero, so the speed does not change. Go to S3.7.3.

6. **It slows down. The overall force is 8 N to the left.**

   The forces are opposite, so take one from the other. 20 − 12 = 8 N. Friction is bigger, so the overall force points left, against the movement, and the box slows down.

   - **If you chose A:** A push only speeds a box up when it is bigger than the friction. Here the friction is bigger. Go to S3.7.3.
   - **If you chose B:** Only balanced forces keep the speed the same. These two forces are not equal, so the speed changes. Go to S3.7.3.
   - **If you chose C:** Friction slows a moving thing and stops it. It does not make it turn round and go the other way. Go to S3.7.3.

7. **0 m/s**

   On a distance and time graph a flat line means she is still. She moves 0 m in 10 s, so the speed is 0 ÷ 10 = 0 m/s.

   - **If you chose A:** You divided the distance from home by the time. Speed uses the distance she moved during those seconds. Go to S3.7.2.
   - **If you chose C:** That is the time. Find how far she moved in that time and divide. Go to S3.7.2.

S3.7.4. Mass and weight

1. **40 N**

   On Earth each kilogram weighs about 10 N. 4 × 10 = 40 N.

2. **7 kg**

   Each kilogram weighs about 10 N. 70 ÷ 10 = 7 kg.

   - **If you chose B:** You wrote the weight as if it were the mass. 70 is in newtons. Each kilogram weighs about 10 N, so divide by 10. Go to S3.7.4.
   - **If you chose C:** You multiplied. To go from a weight back to a mass, divide by 10. Each kilogram weighs about 10 N. Go to S3.7.4.

3. **32 N**

   The weight is the mass times the pull for each kilogram. 20 × 1.6 = 32 N.

   - **If you chose A:** That is the weight on the Earth. The Moon pulls less, so the weight there is smaller. Go to S3.7.4.
   - **If you chose B:** That is the weight of one kilogram on the Moon. The rock has 20 kg, so multiply by the mass. Go to S3.7.4.
   - **If you chose C:** You added the mass and the pull for each kilogram. Multiply them instead. Go to S3.7.4.

4. **Her mass**

   Her mass is the amount of stuff in her, so it stays the same. Her weight changes, because the Moon pulls less.

   - **If you chose A:** Weight is the pull of gravity, and the Moon pulls less. Her weight is smaller there. Go to S2.5.5.
   - **If you chose C:** Her mass is the amount of stuff in her. That does not change when she travels. Go to S3.7.4.

5. **The Moon pulls on the rock less than the Earth does.**

   Weight is the pull of gravity on a thing. The Moon pulls less than the Earth, so the same rock weighs less there. Its mass stays the same.

   - **If you chose A:** The rock is the same amount of stuff everywhere, so its mass does not change. Only the pull on it changes. Go to S3.7.4.
   - **If you chose B:** Weight is the pull of gravity, not the push of air. The Moon has gravity, but a weaker one. Go to S2.5.5.
   - **If you chose C:** The Moon does pull. Each kilogram weighs about 1.6 N there. That is less than on Earth, but not zero. Go to S3.7.4.

6. **50 N**

   Weight is a force. Forces are measured in newtons, N.

   - **If you chose A:** Kilograms measure mass, the amount of stuff. A weight is a force, in newtons. Go to S3.7.4.
   - **If you chose B:** Metres per second is a speed. A weight is a force, in newtons. Go to S3.7.4.

7. **30 N**

   The weight is 3 × 10 = 30 N. The bag does not move, so the forces are balanced. The table pushes up with the same force.

   - **If you chose B:** That is the mass in kilograms, not a force. First find the weight in newtons. Go to S3.7.4.
   - **If you chose C:** Zero is the overall force, not the push. The table pushes up, and the push matches the weight. Go to S3.7.3.

S3.7.5. Stretching and springs

1. **5.4 cm**

   Stretch = new length − original length = 13.4 − 8 = 5.4 cm.

   - **If you chose A:** That is the new length. The stretch is how much longer it got: take away the original length. Go to S3.7.5.
   - **If you chose B:** You added the two lengths. Take the original length away from the new length. Go to S3.7.5.

2. **8 cm**

   Go up from 4 stones to the line, then across. The stretch is 8 cm. Each stone adds 2 cm.

   - **If you chose B:** You read the number of stones across. Go up from 4 on the stones scale to the line, then read the stretch. Go to S3.7.5.
   - **If you chose C:** That is the stretch for 3 stones. Find 4 on the bottom scale. Go to S3.7.5.

3. **12 cm**

   A spring stretches by equal amounts for equal loads. 6 × 2 = 12 cm.

   - **If you chose A:** You added the stones and the stretch for each stone. A spring adds the same stretch for every stone, so multiply. Go to S3.7.5.
   - **If you chose C:** You divided. Each stone adds 2 cm, so 6 stones add 6 lots of 2 cm. That is a multiplication. Go to S3.7.5.

4. **More stones give more stretch, but each stone adds a little less.**

   The stretch grows from 0 to 8 cm, so more stones give more stretch. The steps are 2, 1.8, 1.6, 1.4, 1.2 cm. They get smaller, so each stone adds a little less.

   - **If you chose A:** That is true for a spring. In this table the extra stretch for each stone gets smaller. Look at the stretch column. Go to S3.7.5.
   - **If you chose B:** Read down the stretch column. It gets bigger, not smaller. Go to S2.5.2.

5. **1 N**

   On Earth each kilogram weighs about 10 N. 0.1 × 10 = 1 N.

   - **If you chose B:** That is the mass in kilograms, not the weight. Each kilogram weighs about 10 N. Go to S3.7.4.
   - **If you chose C:** That would be a mass of 1 kg. Multiply 0.1 by 10. Go to S3.7.4.

6. **It stays longer than before.**

   A spring only stretches evenly and springs back if it is not overstretched. Too much load changes it for good.

   - **If you chose A:** That is true for a spring that is not overstretched. Too much load changes its shape for good. Go to S3.7.5.
   - **If you chose C:** A spring does not shrink below its first length. An overstretched one stays longer. Go to S3.7.5.

S3.7.6. Levers and turning forces

1. **100 N cm**

   Turning effect = force × distance from the pivot = 5 × 20 = 100 N cm.

2. **Yes. Both sides have the same turning effect.**

   Left: 3 × 2 = 6. Right: 2 × 3 = 6. They are equal.

   - **If you chose B:** You only counted the caps. The distance from the pivot matters too. Work out both turning effects. Go to S3.7.6.
   - **If you chose C:** You only looked at the distance. The left has more caps, and the right has fewer but farther out. Work out both turning effects before you decide. Go to S3.7.6.

3. **The right side goes down.**

   Left: 2 × 4 = 8. Right: 3 × 3 = 9. The right has the bigger turning effect.

   - **If you chose A:** The left caps are farther out, but there are fewer of them. Work out both turning effects and compare. Go to S3.7.6.
   - **If you chose C:** Work out left and right. They are not equal, so one side goes down. Go to S3.7.6.

4. **20 cm**

   Left turning effect = 6 × 10 = 60 N cm. Right: 3 × distance = 60, so distance = 60 ÷ 3 = 20 cm.

   - **If you chose A:** You put it at the same distance, as on a seesaw with equal children. This weight is smaller, so it has to make up for that. Go to S3.7.6.
   - **If you chose B:** You moved it nearer, but a smaller force must go farther out. It needs more distance to turn as strongly. Go to S3.7.6.
   - **If you chose C:** That number is the turning effect on the left, in N cm. It is not the distance. Divide it by the 3 N on the right. Go to S3.7.6.

5. **20 N**

   The stone's turning effect is 80 × 15 = 1200 N cm. The push needs the same: push × 60 = 1200, so push = 20 N.

   - **If you chose A:** You gave the weight of the stone. A push far from the pivot turns more. So it can be smaller than the weight. Go to S3.7.6.
   - **If you chose B:** That is the turning effect of the stone, in N cm. It is not a force. Divide it by the distance of the push from the pivot. Go to S3.7.6.
   - **If you chose D:** You swapped the distances, as if a push far from the pivot needs more force. It needs less. Multiply the weight by its own distance, then divide by the distance of the push. Go to S3.7.6.

6. **Your push is farther from the pivot, so it has a bigger turning effect.**

   The same push farther from the pivot has a bigger turning effect. A small effort can then lift the lid.

   - **If you chose B:** Strength is not the reason. The handle length changes how far your push is from the pivot. Go to S3.7.6.
   - **If you chose C:** The lid weighs the same. What changes is the turning effect of your push. Go to S3.7.6.

7. **40 N**

   On Earth each kilogram weighs about 10 N. 4 × 10 = 40 N.

   - **If you chose A:** That is the mass in kilograms. Each kilogram weighs about 10 N on Earth. Go to S3.7.4.
   - **If you chose C:** You added 10 to the mass. Multiply the mass by 10 instead. Go to S3.7.4.

S3.7.7. Pressure

1. **3 N/cm^2**

   Pressure = force ÷ area = 60 ÷ 20 = 3 N/cm^2.

2. **40 N/cm^2**

   Pressure = force ÷ area = 20 ÷ 0.5 = 40 N/cm^2. A small area gives a big pressure.

   - **If you chose B:** You multiplied the force by the area. Pressure is the force shared out over the area, so divide. Go to S3.7.7.
   - **If you chose C:** You divided the area by the force, upside down. Put the force first: force ÷ area. Go to S3.7.7.

3. **2 N/cm²**

   His weight is 50 × 10 = 500 N. Pressure = 500 ÷ 250 = 2 N/cm².

   - **If you chose A:** You divided the mass in kilograms. Pressure needs a force in newtons, so find the weight first: kilograms × 10. Go to S3.7.4.
   - **If you chose C:** That is his weight in newtons. You still have to divide it by the area to get the pressure. Go to S3.7.7.

4. **The sharp edge touches a much smaller area, so the pressure is much bigger.**

   Pressure = force ÷ area. The same force on a smaller area gives a bigger pressure.

   - **If you chose A:** The force is the same here. What differs is the area the edge touches. Go to S3.7.7.
   - **If you chose B:** The weight is not the reason. A thin edge puts the same force on a tiny area. Go to S3.7.4.

5. **Its wide feet spread its weight over a big area, so the pressure is small.**

   Pressure = force ÷ area. The camel is heavy. Its wide feet give a big area, so the pressure on the sand is small.

   - **If you chose B:** Small feet would put the weight on a small area and sink deep. A camel has wide feet. Go to S3.7.7.
   - **If you chose C:** A camel is heavy. It is the wide feet that matter: the same weight on a bigger area gives a smaller pressure. Go to S3.7.7.

6. **Kofi. He puts 5 N/cm² on the ground, and Amina puts 2 N/cm².**

   Kofi weighs 30 × 10 = 300 N, so his pressure is 300 ÷ 60 = 5 N/cm². Amina weighs 600 N, so her pressure is 600 ÷ 300 = 2 N/cm².

   - **If you chose A:** A bigger force does not always mean a bigger pressure. You must divide the weight by the area of the feet. Go to S3.7.7.
   - **If you chose C:** Wider feet spread the weight over more area, which makes the pressure smaller, not bigger. Go to S3.7.7.

7. **5 m/s**

   Speed = distance ÷ time = 30 ÷ 6 = 5 m/s.

   - **If you chose A:** You added the two numbers. Speed is distance divided by time. Go to S3.7.1.
   - **If you chose B:** You divided time by distance. Speed is distance divided by time. Go to S3.7.1.

S3.7.8. Pressure in water and air

1. **The hole 16 cm down**

   Water pressure grows with depth. The lowest hole has the biggest pressure, so its jet leaves fastest and lands farthest.

   - **If you chose A:** The top hole has the least water above it, so the smallest pressure. Its jet lands closest. Go to S3.7.8.
   - **If you chose C:** The middle hole is deeper than the top one, but not as deep as the lowest. Look at which jet goes farthest. Go to S3.7.8.

2. **It pushes on him from every side, and it pushes harder the deeper he goes.**

   Water pushes in every direction. The deeper he goes, the more water is above him, so the pressure grows.

   - **If you chose A:** Water pressure pushes in every direction, not just down. It pushes on his sides and from below too. Go to S3.7.8.
   - **If you chose B:** The deeper he goes, the more water is above him. That makes the pressure bigger, not the same. Go to S3.7.8.
   - **If you chose C:** It is the water above him that makes the pressure. More water above means more pressure, so it grows with depth. Go to S3.7.8.

3. **The air pressing on the drink outside the straw.**

   You lower the air pressure in the straw. The air outside is at a higher pressure, so it pushes the drink up.

   - **If you chose A:** Your mouth only lowers the pressure inside the straw. Something else does the pushing. Go to S3.7.8.
   - **If you chose B:** A straw is only a tube. It does not squeeze. The push comes from the air. Go to S3.7.8.

4. **20 N**

   The weight is 2 × 10 = 20 N. The boat floats at rest, so the forces are balanced. The upthrust is also 20 N.

   - **If you chose A:** You used the mass in kilograms as if it were newtons. First find the weight: each kilogram weighs about 10 N. Go to S3.7.4.
   - **If you chose B:** A floating boat still has gravity pulling it down. The water pushes up to hold it, so the upthrust is not zero. Go to S3.7.8.
   - **If you chose C:** The upthrust does not need to be bigger. When it equals the weight, the forces are balanced and the boat stays at rest. Go to S3.7.3.

5. **18 N downwards. It sinks.**

   The forces are opposite, so take one from the other. 30 − 12 = 18 N. The weight is bigger, so the overall force points down and the stone sinks.

6. **The water then has a long way to fall, so a faster jet lands farther out.**

   On the ground the lowest jet has hardly any height to fall, so it lands close. A tall stand lets the faster jet reach farther.

   - **If you chose B:** The pressure depends on depth, not on how high the bottle stands. The height gives the water room to fall and spread out. Go to S3.7.8.
   - **If you chose C:** The holes stay the same size. The height is about how far the water falls. Go to S3.7.8.

7. **4 N/cm²**

   Pressure = force ÷ area = 80 ÷ 20 = 4 N/cm².

   - **If you chose A:** You added the two numbers. Pressure is force divided by area. Go to S3.7.7.
   - **If you chose C:** You divided area by force. Put the force first: force ÷ area. Go to S3.7.7.

About this book

For learners who can measure a distance in metres and do sums with the four operations. In many schools this fits children of about 11 to 13, and older learners can use it too. Activities use string, a stick, stones, a plastic bottle, a rubber band, a ruler or a strip of card marked in centimetres, water, and a clock or a counted second. Making holes in a bottle needs an adult with a nail. Walking tests are done away from roads. A learner can work alone: every exercise has its answer and the reason for it.

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