Science 7–8

Chapter 15 — Physical sciences A: forces and simple machines

Aboriginal and Torres Strait Islander content has been excluded as accuracy cannot be guaranteed, and it is better to be respectful than cover the entire curriculum inaccurately.

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Contents

Forces investigated and represented: contact and non-contact forces, gravitational force, measuring with a force meter, and balanced and unbalanced forces on a force diagram

What we teach here — `VC2S8U14` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *“balanced and unbalanced forces acting on objects, including gravitational force, may be investigated and represented using force diagrams; changes in an object’s motion can be related to its mass and the magnitude and direction of the forces acting on it”* **This subtopic owns the first clause only**: balanced and unbalanced forces acting on objects — including gravitational force — investigated and represented using force diagrams; measuring forces with a force meter; and gravity as the pull toward Earth’s centre that also reaches the Moon and the planets. The second clause — relating changes in an object’s motion to its mass and to the magnitude and direction of the forces — belongs to the partner subtopic **15B** († split delivery, D6), so the `VC2S8U14.E01` and `VC2S8U14.E02` investigation contexts are 15B’s and are not drawn on here. **In our words:** a force is a push or a pull, and every force has a size and a direction, so every force can be drawn as an arrow. Some forces need touching; gravity does not. When the arrows on an object cancel out, nothing about its motion changes; when they do not cancel, the leftover — the net force — points the way the motion will change. Measuring pulls with a force meter, drawing the arrows to scale, and reading off whether they balance is the whole of this subtopic. **Achievement-standard extract served here (D13):** *“They represent and explain the effects of forces acting on objects.”* 15A is the owner of `VC2S8U14`, so the extract appears here in full; the partner subtopic 15B cites it by reference to this header. **Elaborations drawn on:** `VC2S8U14.E03` (measuring the magnitude of a force using a force meter, and representing the magnitude and direction of forces acting on an object using force diagrams), `VC2S8U14.E04` (investigating how Earth’s gravitational force pulls objects towards the centre of Earth and how its magnitude is related to the mass of an object), `VC2S8U14.E05` (how gravity affects objects in space — here bounded per D9 to the Earth–Moon attraction and the Sun–planet attraction; stars, galaxies and black holes are not part of this band’s story) and `VC2S8U14.E06` (the forces acting on boomerangs and the airfoil profile designed by Aboriginal and/or Torres Strait Islander Peoples, delivered from the named published sources listed in Sources (D10)). **Authored from the CD text and the elaboration contexts (D12):** the CD names forces that may be balanced or unbalanced, including gravitational force, and says they may be investigated and represented using force diagrams; E03 supplies the measuring instrument and the representation, E04 supplies the gravity investigation run in the first Try-it, E05 (bounded) supplies the Earth–Moon and Sun–planet reach of gravity, and E06 supplies the boomerang case study read in the final theory section. Scope is capped by D9: no `F = ma`, no named Newton’s laws, and no quantitative motion — no speed, velocity, acceleration or motion graphs — and the motion-changes-versus-mass-and-forces relationship is 15B’s clause, not this one.

Word watch — *magnitude* and *weight*. In everyday talk, *magnitude* is a formal word for “how big something is”, and in this subtopic it keeps exactly that meaning: the **magnitude** of a force is its size — how many newtons of push or pull there are — which on a force diagram is shown by the length of the arrow. *Weight* is the trickier one. In everyday talk, people say “weight” when they mean the number of kilograms something is — but kilograms measure **mass**, the amount of matter in an object, which is the same everywhere. **Weight** in science is the pull that gravity exerts on that mass — a force, measured in newtons, which is different on the Moon and on Earth. Keep the pair apart: the mass of this book is the same on the Moon; its weight is not.

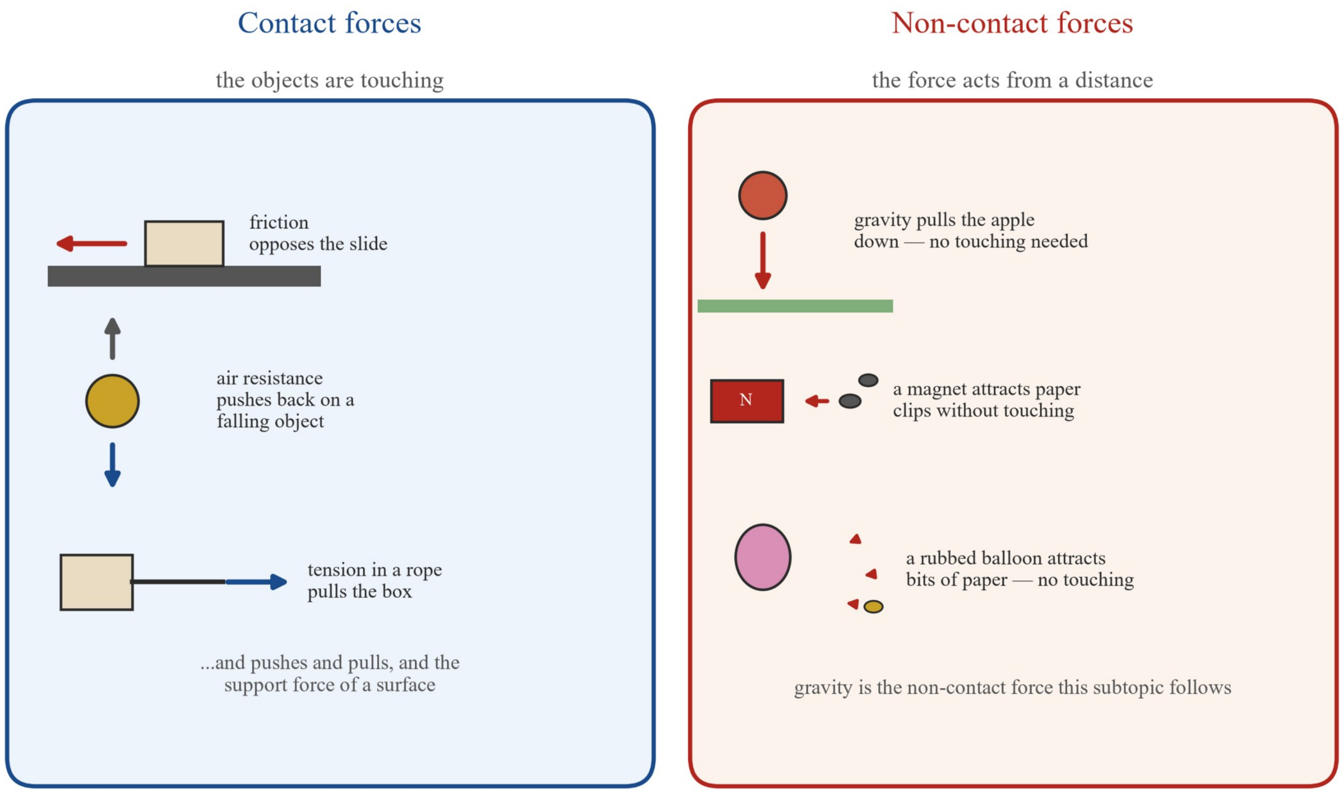
Theory

A force is a push or a pull

Every time you shove a door open, haul a bag off the floor, or catch a ball, you are using a force. In science, a **force** is simply a **push or a pull** acting on an object. Two things are true of every force:

- **It has a size.** A gentle nudge and a hard shove are both pushes, but they are not the same force. The size of a force is called its **magnitude**, and it is measured in **newtons**, written **N**, after Isaac Newton.
- **It has a direction.** A push and a pull of the same size act in opposite directions, and they do opposite things to an object. So a force is never just a number — it is a number *pointing somewhere*.

Because a force has a size and a direction, it can be drawn as an arrow: the arrow points the way the force acts, and its length shows the magnitude. That idea — force as arrow — is what a force diagram is built from.



Forces come in two families — decide first: are the objects touching, or is the force reaching across a gap?

Two panels sorting six examples of forces into contact forces, where the objects are touching (friction on a sliding block, air resistance on a falling ball, tension in a rope pulling a box), and non-contact forces, where the force reaches across a gap (gravity on a falling apple, a magnet attracting paper clips, a rubbed balloon attracting bits of paper)

Two families: contact and non-contact forces

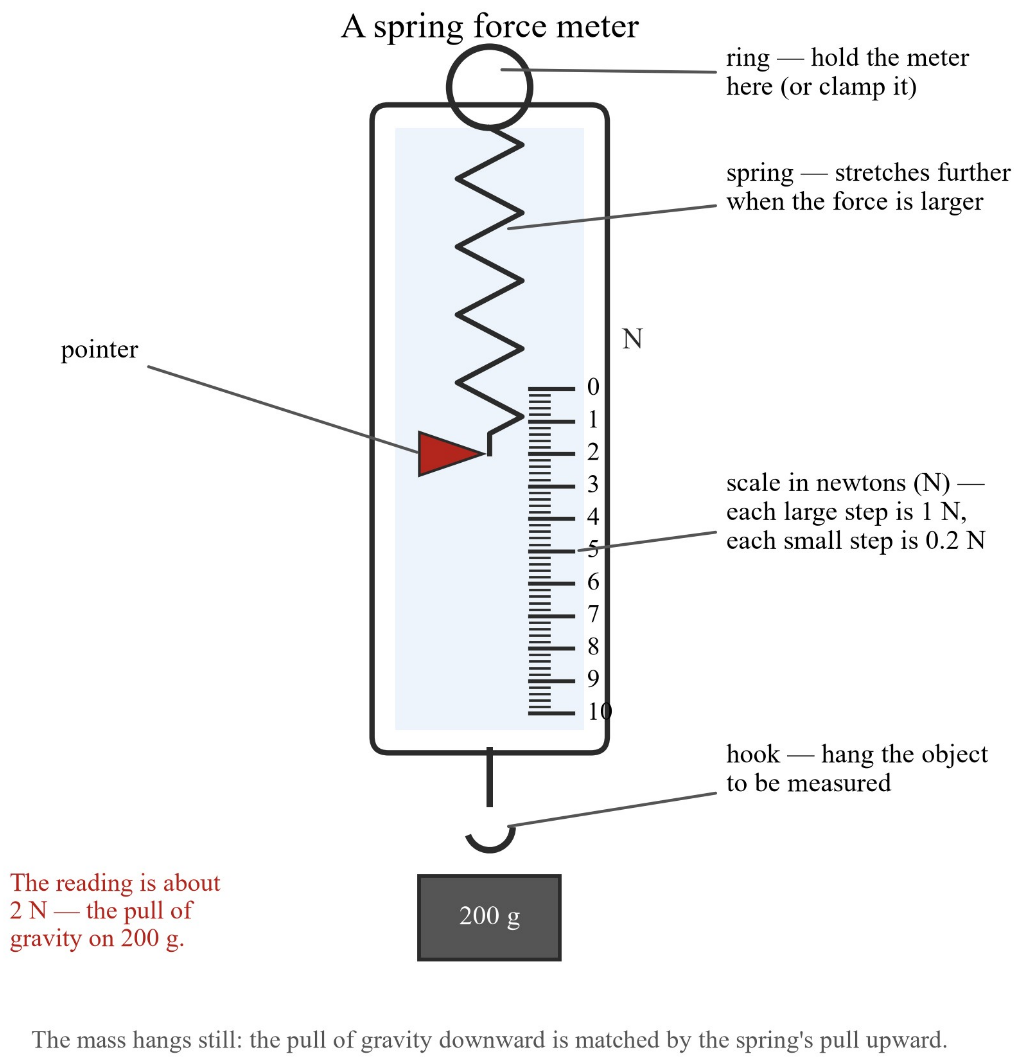
Forces sort into two families by one test: *are the objects touching, or is the force reaching across a gap?*

- **Contact forces** act only while objects touch. Friction between a sliding block and a bench, air resistance pushing back on a falling ball, tension in a rope, and the support force of a surface pushing up on whatever rests on it — all of these stop acting the moment the contact ends.
- **Non-contact forces** act across a gap, with nothing touching. A magnet pulls paper clips to it through the air; a rubbed balloon holds bits of paper without touching them; and gravity pulls a falling apple down with nothing at all between the apple and the Earth.

Gravity — the attractive pull between objects that have mass — is the non-contact force this subtopic follows.

Measuring a force with a force meter (`VC2S8U14.E03`)

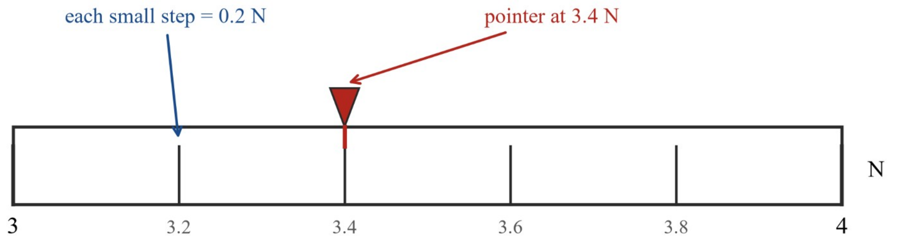
You cannot put a push on a balance and weigh it. Forces are measured with a **force meter** (often called a spring balance): a spring inside a clear tube, with a hook at the bottom and a scale marked in newtons beside it. Hang or pull something on the hook and the spring stretches; the pointer moves down the scale and shows the size of the force in newtons. The rule of the instrument is simple: **the bigger the force, the more the spring stretches**, so a bigger force gives a bigger reading.



Cutaway diagram of a force meter hanging from a stand with a mass on its hook, showing the spring inside stretched by the pull, the scale marked in newtons from 0 to 10, and the pointer resting at a reading of 2 N

Two habits make the reading trustworthy (the scale-reading habit is the `3C` inquiry skill — *reading a scale to its finest graduation*):

- **Check the zero.** With nothing on the hook, the pointer must sit exactly on 0 N. If it does not, the meter will misread every force by the same amount.
- **Read to the finest graduation.** On the meter shown, each small step of the scale is 0.2 N, so a reading is given to the nearest 0.2 N — never rounded off to the nearest whole newton.



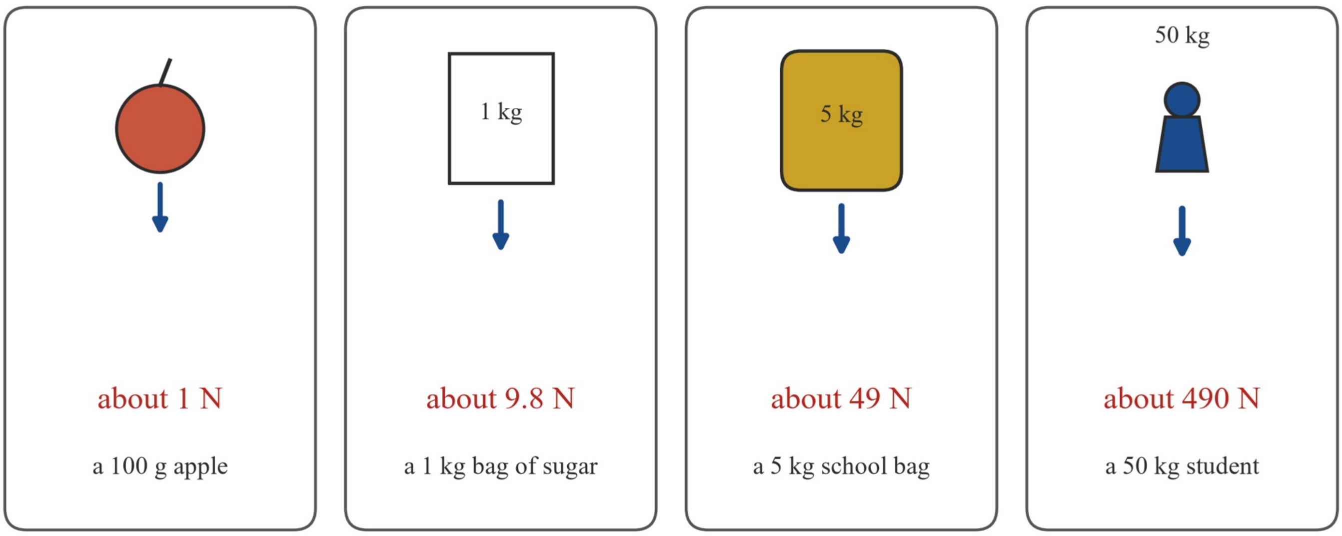
Read the scale from straight in front — not from an angle — and record it to the smallest step: this pointer is exactly on the second small step past 3 N, so the reading is 3.4 N.

Close-up of a force meter scale between 3 N and 4 N with graduations every 0.2 N, and the pointer resting two graduations below 3 N at a reading of 3.4 N

How big is a newton?

A newton is a small force by everyday standards — about the pull of Earth's gravity on a 100 g apple. Bigger masses feel bigger pulls:

The pull of gravity on familiar objects near Earth's surface (measured with a force meter)



Same pattern every time: every extra kilogram of mass is pulled with about 9.8 N more.

Four panels showing the pull of gravity near Earth's surface on familiar objects, measured with a force meter: a 100 g apple pulled with about 1 N, a 1 kg bag of sugar with about 9.8 N, a 5 kg school bag with about 49 N, and a 50 kg student with about 490 N

Holding a bag of sugar, your hand is supplying about 9.8 N of upward push to balance Earth's pull. That is the size of force your fingers can feel all day long.

Try it — how does Earth's pull change with mass? (`VC2S8U14.E04`; inquiry links: `3C` equipment and precision, `4C` reading patterns in data)

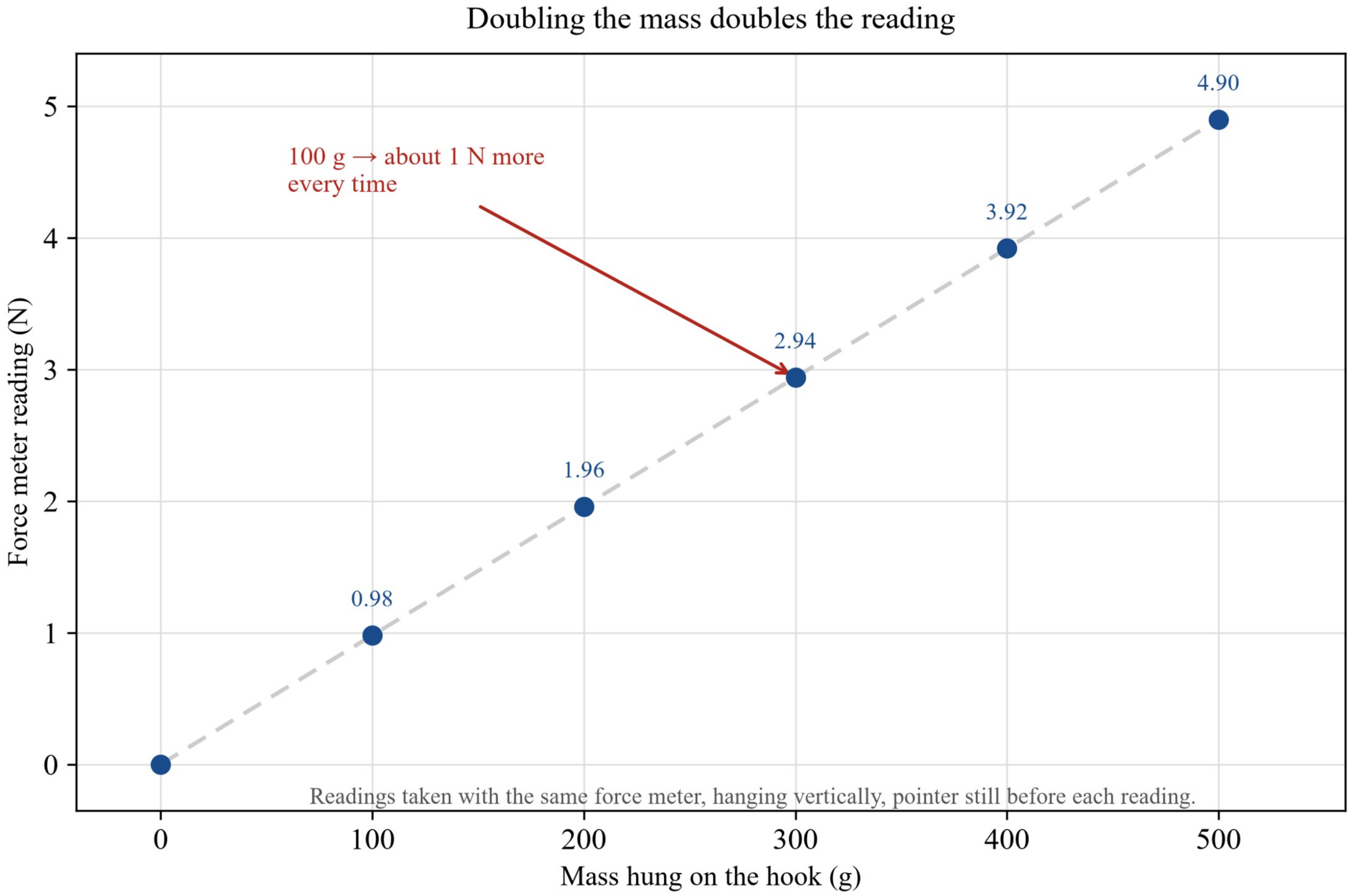
You will need: a force meter with a digital display (0–10 N, reading to 0.01 N), a stand to hang it from, five 100 g slotted masses, and a soft mat or clear bench space under the masses. The force meter is the measuring instrument of

E03 and E04 — here with a fine digital display so the pattern shows clearly (reading a marked scale to its finest graduation is the `3C` inquiry skill, practised in the theory section and the next Try-it) — and the slotted masses let you change the mass one 100 g step at a time while everything else stays the same.

1. Hang the force meter from the stand with nothing on the hook. Check the zero and record the reading (0 N).
2. Hang one 100 g mass on the hook. Wait for the reading to settle, then record the force from the display.
3. Add masses one at a time — 200 g, 300 g, 400 g, 500 g — reading and recording the force each time.
4. Look for the pattern: how much does the reading grow for each extra 100 g of mass?

Safety: hang the masses over the mat or the bench, not over your feet — a dropped 500 g mass hurts. Do not pull the spring past the top of its scale, or the spring will not return to zero.

Mass hung (g)	Force meter reading (N)
0	0
100	0.98
200	1.96
300	2.94
400	3.92
500	4.9



Graph of force meter reading against mass hung, with points at every 100 g from 0 to 500 g falling on a straight line through zero, showing the pull of gravity growing by about 0.98 N for each extra 100 g of mass

What you did	What you saw	What it tells you
Checked the zero with nothing on the hook	Pointer at 0 N	The meter reads only the pull on what is hung, so every later reading is trustworthy
Added mass 100 g at a time	The reading grew by the same step (about 0.98 N) each time	Earth's pull grows evenly with mass — double the mass, double the pull

What you did	What you saw	What it tells you
Read each force from the display	Steps of about 0.98 N per 100 g, which is about 9.8 N per kilogram	The pattern a 1 kg bag of sugar (about 9.8 N) and a 50 kg student (about 490 N) both fit

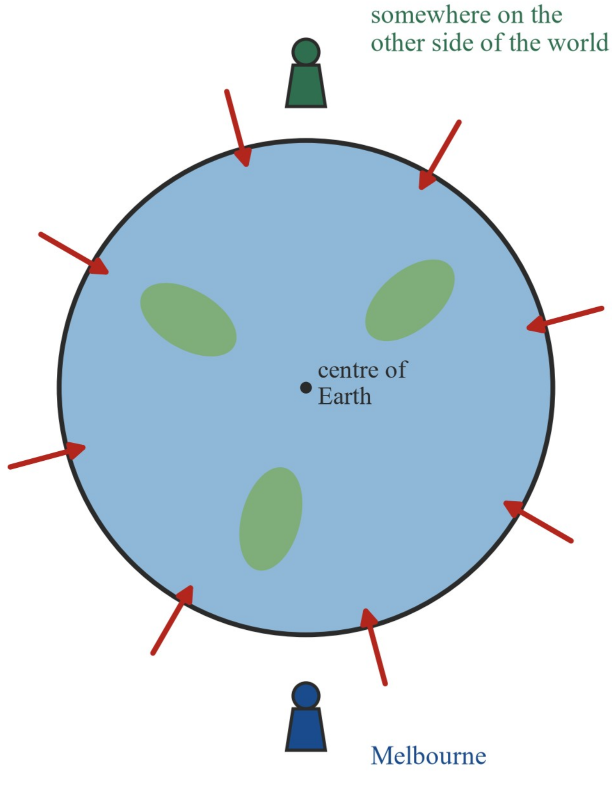
Every investigation has limits, and naming them is part of the skill. Ask yourself:

- A hand-held force meter with a marked scale shows steps of 0.2 N, so on it each of your recorded readings would sit between two graduations. What does the finer digital display give the investigation that the marked scale cannot?
- The masses are labelled 100 g each. If one label were wrong, what would your graph do at that point?
- This investigation measured the pull of gravity on masses in one classroom. What would you expect the same investigation to give on the Moon, and why is that a prediction and not a measurement?

Gravitational force: the pull toward Earth's centre (`VC2S8U14.E04`)

The pattern in your data is the signature of **gravitational force**. The Earth pulls every object toward its **centre**, and the size of that pull is related to the object's mass: about 0.98 N for each 100 g, or about 9.8 N for each kilogram. That is why the masses in the Try-it fell toward the ground when you let them go, and why the force meter stretched at all — the spring was holding each mass up against Earth's pull.

Wherever you stand, gravity pulls toward the centre of Earth



'Down' in Melbourne and 'down' on the far side of Earth point in opposite directions in space — both mean toward the centre of Earth.

Diagram of Earth as a circle with four objects at the top, bottom and sides of the globe, each with an arrow pointing from the object toward the centre of the Earth, showing that gravity pulls every object toward the centre no matter where it stands

This settles what "down" really means. *Down* in Australia and *down* in Canada point in opposite directions in space, yet a dropped ball falls "down" in both places — because **down is the direction toward Earth's centre**, and that direction is different at every place on the globe. “Down” is not one direction in space; it is a direction that depends on where you stand. What is the same everywhere is the rule: gravity pulls toward the centre.

Gravity reaches into space (`VC2S8U14.E05`, bounded per D9)

Gravity does not stop at the top of the sky. The **same force** that pulls an apple to the ground reaches across the gap to the Moon: Earth pulls the Moon, and the Moon pulls Earth back, with two pulls that are equal in size and opposite in direction.

Gravity reaches across empty space: each body pulls on the other with a force of the same size.

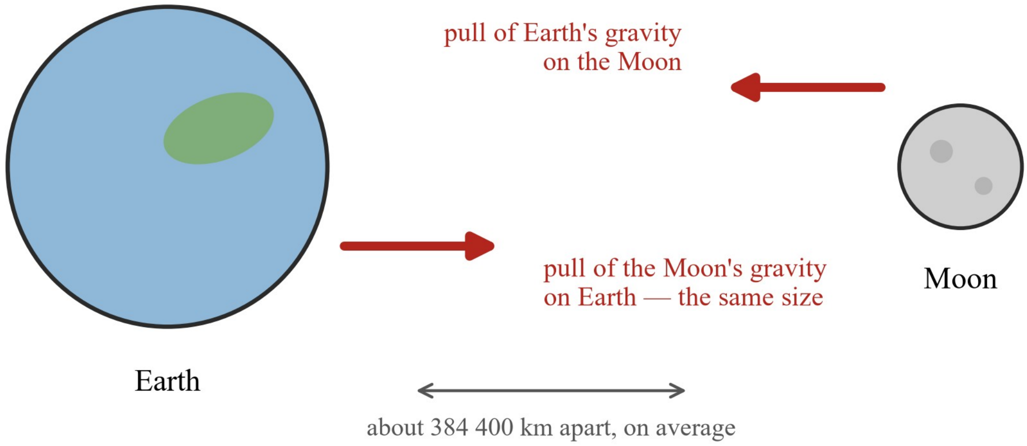
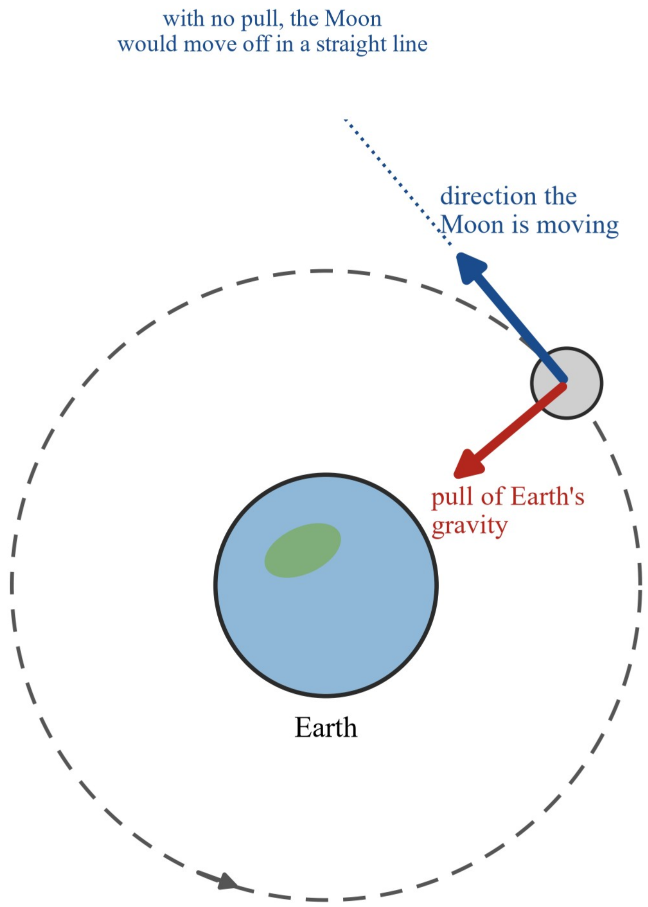


Diagram of Earth and the Moon with two equal-length arrows between them, one showing Earth’s gravitational pull on the Moon and the other the Moon’s equal pull back on Earth

It is that unbroken pull toward Earth that bends the Moon’s path into its closed circuit around us. Without the pull, the Moon would travel in a straight line and leave; the constant sideways-while-falling dance is what an orbit is. The same story holds one scale up: the Sun’s gravitational pull reaches across to each planet and bends its path into an orbit too.



The inward pull keeps bending the Moon's path into a curve — that curve is its orbit.

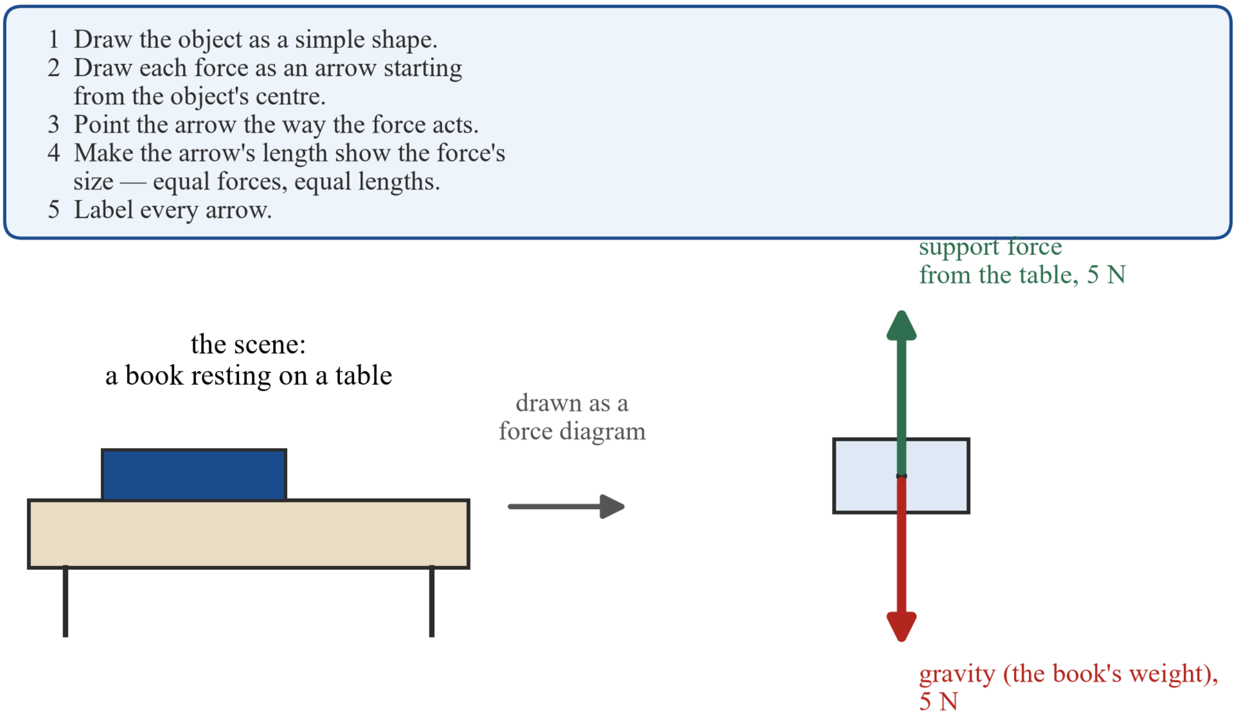
Diagram of the Sun with a planet on a dashed orbital path around it, showing the planet's straight-line path it would follow without gravity and the Sun's gravitational pull constantly drawing the planet inward, bending that path into the orbit

In this band the story stops at the Earth–Moon system and the Sun–planet system: gravity's pull between moons and planets is the reach of `VC2S8U14.E05` here.

Force diagrams: drawing forces (`VC2S8U14.E03`)

A **force diagram** is a picture of every force acting **on** one object, drawn as arrows. Four rules:

1. **Draw the object simply** — a box or a dot is enough.
2. **Draw one arrow per force**, starting on the object and pointing the way that force acts.
3. **Draw the length of each arrow to match the magnitude** — twice the force, twice the length.
4. **Label each arrow** with the name of the force and its size in newtons.



Equal forces → equal arrow lengths, drawn from the same point.

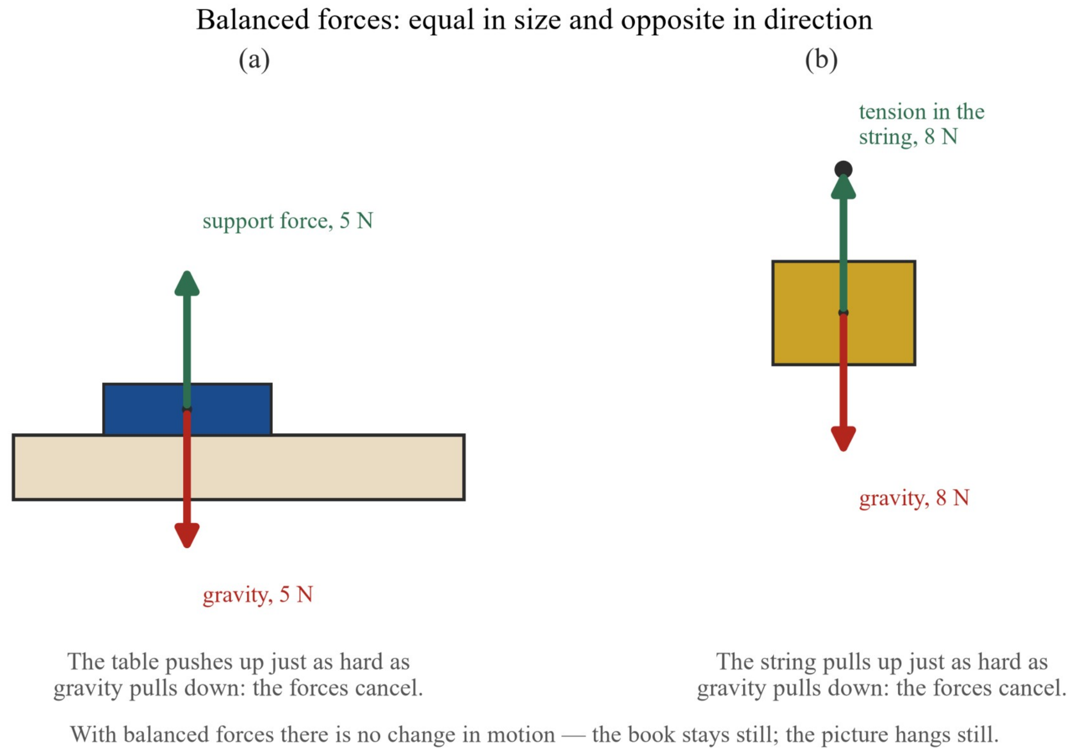
Diagram of a book on a table drawn as a box with two labelled arrows of equal length, gravity 5 N down and support force 5 N up, beside the four rules of force diagrams: one arrow per force, arrow points the way the force acts, length matches magnitude, and label every arrow with name and size

The diagram is a claim you can check: measure the forces with a force meter, draw the arrows, and the picture tells you at a glance whether the forces balance.

Balanced forces: no change in motion

A book rests on a table. Earth pulls it down with 5 N of gravity; the table pushes it up with a 5 N support force. Two forces, equal in size, opposite in direction: they cancel, and the book's motion does not change — it stays still. A picture hangs from a string the same way: gravity 8 N down, tension 8 N up, cancelled, hanging still. Forces that cancel like this are **balanced**, and the rule is:

Balanced forces produce no change in motion. An object at rest stays at rest; an object that is moving keeps moving the same way.



Two force diagrams of balanced forces with equal and opposite arrows: a book on a table with support force 5 N up and gravity 5 N down, and a picture hanging from a string with tension 8 N up and gravity 8 N down, each staying still because the forces cancel

Balanced does not mean “no forces” — it means the forces are all there but cancel out.

Unbalanced forces: the net force

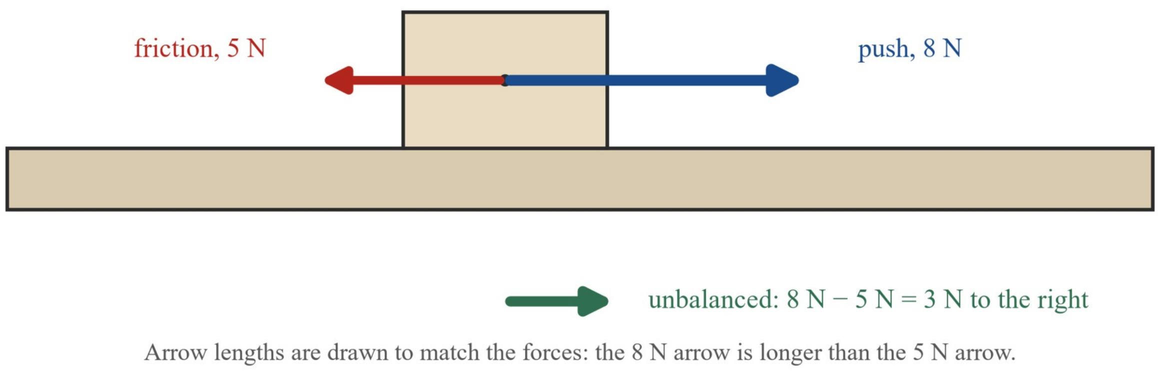
Now push a box across the floor with 8 N while friction pushes back with 5 N. The two forces oppose each other but are not equal, so they do not cancel. What is left over is the **net force**:

8 N − 5 N = 3 N to the right.

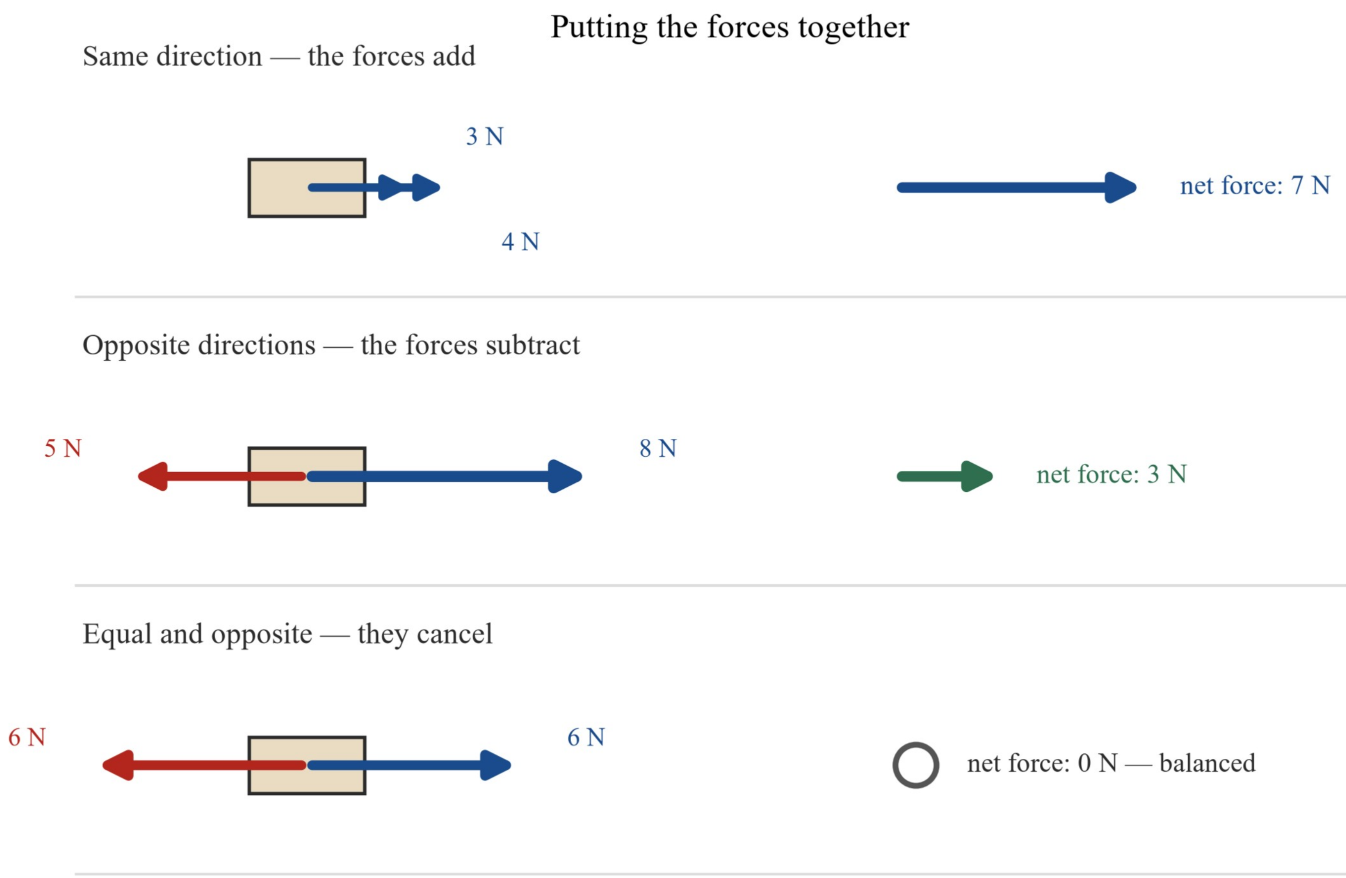
Forces acting along one line add or subtract like this: forces pointing the same way add together; forces pointing opposite ways subtract, and the net force points the way of the larger one. When the net force is not zero, the forces are **unbalanced**, and the rule is:

Unbalanced forces change an object’s motion, toward the direction of the net force.

The forces do not cancel — the box speeds up toward the larger force.



Force diagram of a box pushed with 8 N to the right against friction of 5 N to the left, with the arrows drawn to different lengths and a shorter green arrow below showing the unbalanced net force of 3 N to the right, toward which the box's motion changes



Three rows of force diagrams showing how forces along one line combine: 3 N and 4 N the same way giving a net force of 7 N that way, 3 N and 4 N opposite ways giving a net force of 1 N the way of the larger, and 3 N each way opposite giving a net force of 0 N, balanced

Reading a force diagram is now a two-step habit: add up the arrows, and if the net force is zero the motion is unchanged; if it is not zero, the motion changes the way the net arrow points. *How much* the motion changes for a given mass and force — the deeper relationship — is the partner subtopic 15B.

Try it — measure a pull, then draw it (`VC2S8U14.E03`; inquiry links: `3C` equipment and precision, `4B` representing with models and their limits)

You will need: a force meter (0–10 N), a 200 g mass, a second force meter, and a partner.

1. Check the zero of the first meter. Hang the 200 g mass on it, let it settle, and read the force to the finest graduation. Record it (about 2 N).
2. Draw the force diagram for the hanging mass: one arrow down (gravity, the size you just read) and one arrow up (the spring's pull, the same size, because the mass hangs still).
3. Hook the two force meters together, one in your hand and one in your partner's. Pull gently and steadily. Both of you read your own meter at the same moment and call out the values. Compare.
4. Draw the force diagram for your partner's meter's hook end: your pull one way, their meter's spring the other way.

Safety: pull gently and keep the pull low — a spring yanked past its scale will not return to zero, and a slipped hook can crack knuckles.

What you did	What you saw	What it tells you
Read the meter holding the 200 g mass	About 2 N	The meter reads the size of Earth's pull on the mass — gravity measured, not guessed
Drew the hanging mass's diagram with equal up and down arrows	Two equal, opposite arrows: balanced	A still object always has balanced forces on it — the diagram shows why it stays still
Two meters hooked together, both read at once	The same reading on both meters	A pull is mutual: you cannot pull on your partner harder than your partner pulls back

Ask yourself:

- Your diagram in step 2 has two arrows, yet the mass is not moving. A classmate says "no motion means no forces". Use your diagram to answer them.
- The arrows on a force diagram show size and direction. Name two things about the hanging mass that your diagram does not show.

Boomerangs: a wing-shaped design from First Nations Peoples (`VC2S8U14.E06`)

The boomerang is one of the best-known designs of Aboriginal and/or Torres Strait Islander Peoples, and one of the oldest: rock-art depictions of boomerangs in Australia may be tens of thousands of years old, and boomerangs recovered from Wyrie Swamp in South Australia have been dated to around 10,000 BC. Nor is the design a single object. **Returning boomerangs** — the light, bent, spinning kind famous around the world — come back to the thrower; and **non-returning boomerangs**, heavier and straighter throwing sticks (often called **kylies**), were made in many sizes for hunting and other uses. The CD's phrase "several applications" is exactly this range: a family of wing-shaped tools, varied to the job.

Source: Wikipedia, "Boomerang", 2026. en.wikipedia.org — retrieved 2026-08-21.

Source: CSIRO, "Indigenous Knowledge", 2026. csiro.au — retrieved 2026-08-21.

The physics of the returning boomerang is the physics of this subtopic, worn by a spinning wing. Each arm of a boomerang is shaped in cross-section like a wing — curved on top, flatter underneath — the **airfoil** profile named in the elaboration. As the arm spins through the air, the moving air pushes it with a **lift** force, just as air pushes a wing.

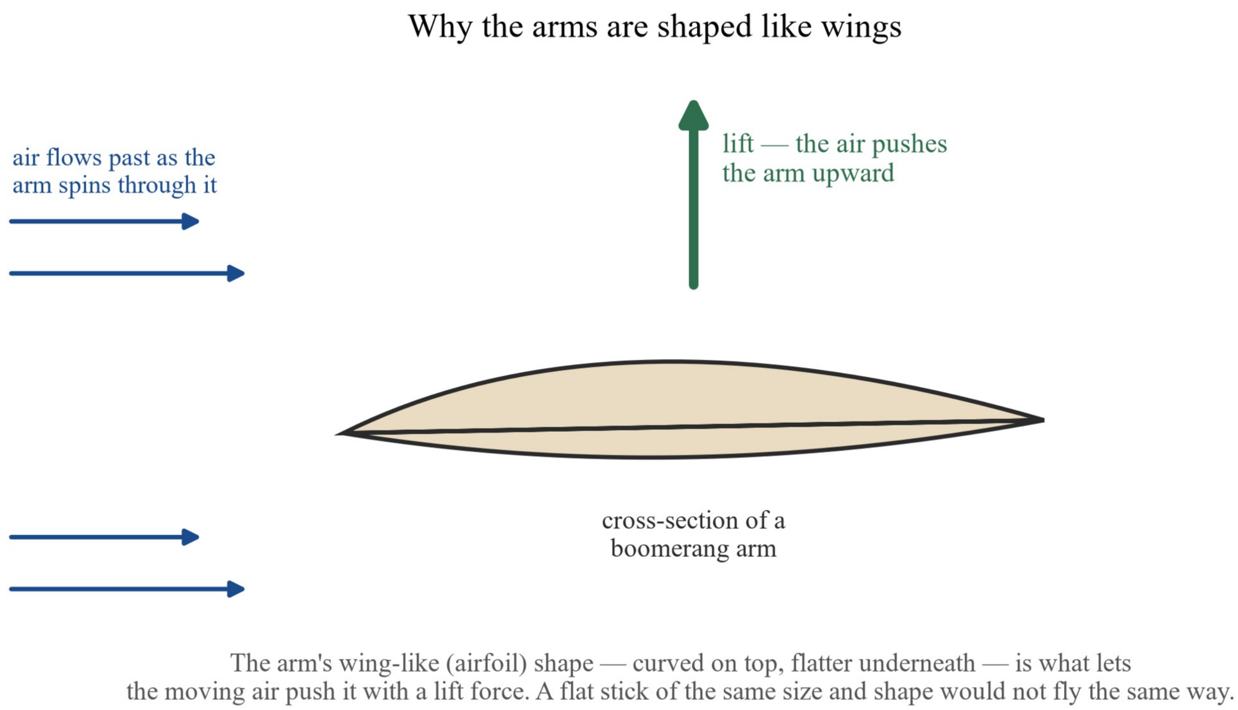
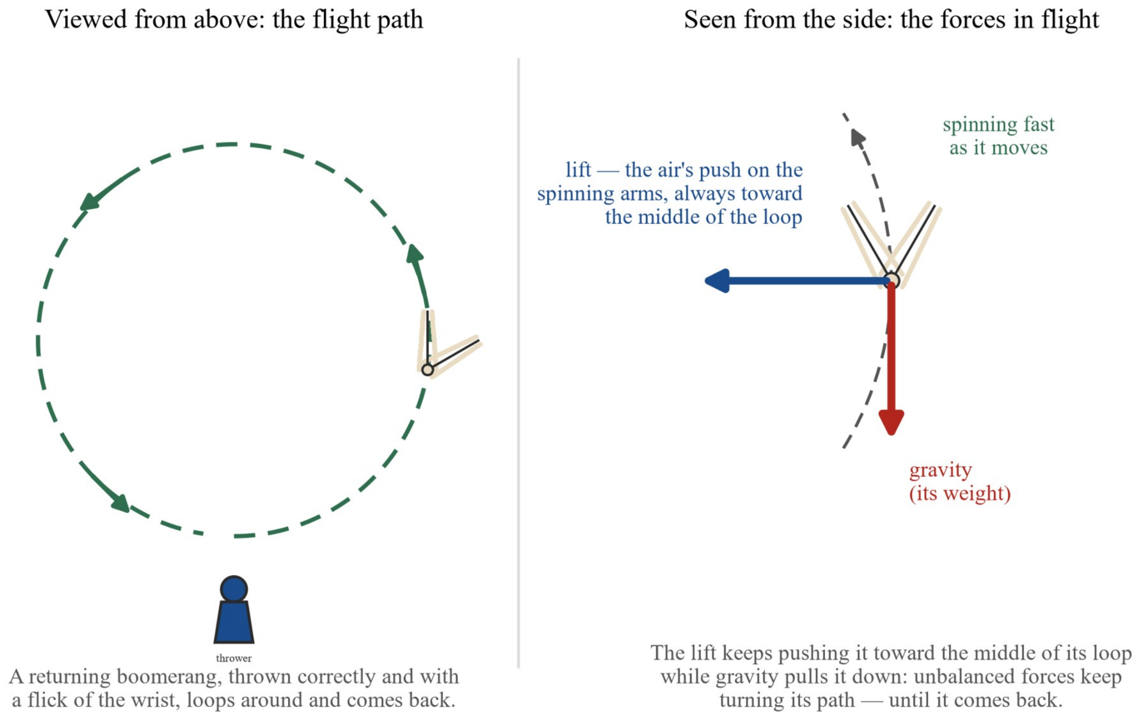


Diagram of the wing-like airfoil cross-section of a boomerang arm, curved on top and flatter underneath, with arrows showing air flowing past as the arm spins and a lift arrow showing the air pushing the arm upward

Thrown with spin, the two arms of the boomerang travel through the air in different ways — the upper arm moves faster through the air than the lower one — so the lift is not even across the spinning shape, and that uneven push steadily turns the spin's path until the boomerang curves all the way around: the returning flight.

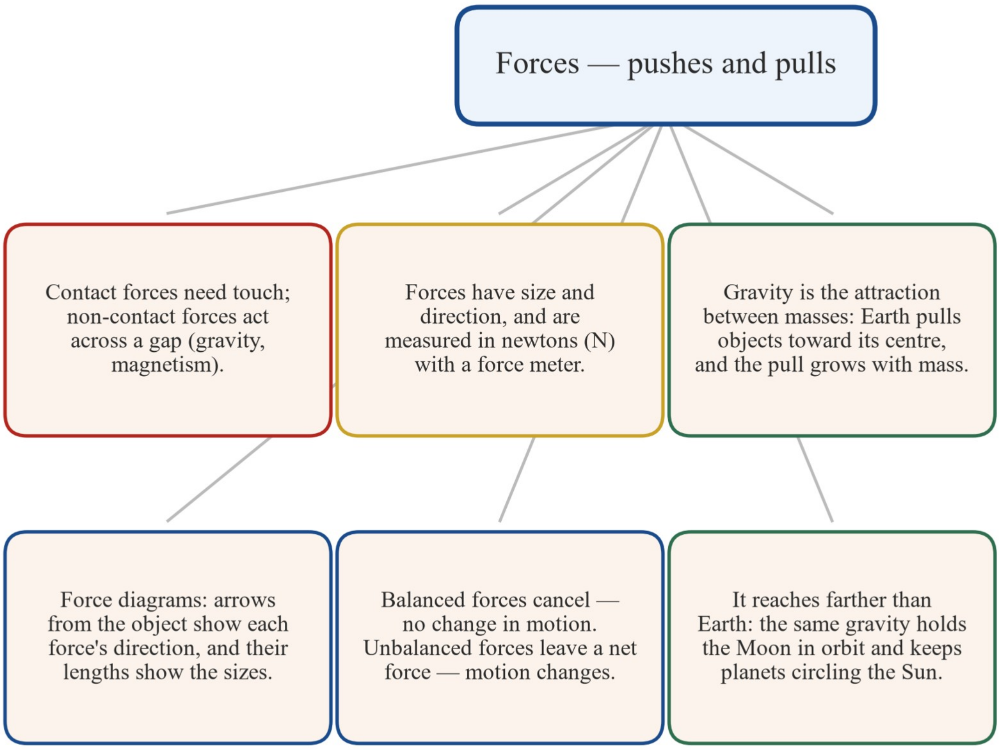


Two-panel diagram of a returning boomerang: from above, the two arms drawn with their lift forces and the curved circular path the uneven lift produces; and from the side, the lift force and gravity on the spinning boomerang with its curved path

Every force in the story is one this subtopic has already met: lift is a contact push — the air touching the arms — and gravity is the non-contact pull of the Earth; the forces are unbalanced where the flight curves, and balanced in the steady parts of the glide. What makes the boomerang remarkable is not new physics but design: First Nations makers shaped wood into a wing and tuned its spin long before the words *airfoil* or *lift* existed in English. Per D10, the cultural knowledge here is delivered from the named published sources only — the design's deep history and its place in culture belong to its Peoples.

The whole story in one picture

A force is a push or a pull with a size (in newtons) and a direction, contact or non-contact. Gravity is the non-contact pull toward Earth's centre — about 9.8 N per kilogram of mass — and the same force reaches the Moon and the planets. A force meter measures a force's magnitude; a force diagram draws every force on one object as a labelled arrow to length. Add the arrows: a net force of zero means balanced forces and no change in motion; a net force that is not zero means unbalanced forces and a change in motion the way the net arrow points.



Concept map of the subtopic: forces as pushes and pulls at the top, branching to six boxes — contact forces need touch while non-contact forces act across a gap; forces have size and direction measured in newtons with a force meter; gravity pulls objects toward Earth's centre and grows with mass; force diagrams draw each force as an arrow with length showing size; balanced forces cancel with no change in motion while unbalanced forces leave a net force; and the same gravity holds the Moon in orbit and keeps planets circling the Sun

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Worked examples

Example 1 — scaffolded

A force meter's scale runs from 0 N to 10 N. Between each whole-newton mark there are four small graduations, making steps of 0.2 N. With a mass hung on the hook, the pointer rests two small graduations below the 3 N mark.

(a) What is the finest graduation of this scale?
(b) What is the reading, in newtons?
(c) Before hanging the mass, what should have been checked, and what would a fault there do to the reading?

Working	Comment
(a) 0.2 N.	The finest graduation is the smallest step the scale shows — here, one fifth of a newton.
(b) 3 N + 2 × 0.2 N = **3.4 N**.	Read to the finest graduation: count the small steps past the whole-number mark.
(c) The zero: with nothing on the hook the pointer must sit at 0 N. A pointer starting below zero would make every reading too big by that amount; above zero, too small.	A force meter is only as good as its zero — check it before every use.

Example 2 — scaffolded

The table is from the Try-it investigation: force meter readings for masses hung on the hook.

Mass (g)	100	200	300	400	500
Force (N)	0.98	1.96	2.94	3.92	4.9

(a) Describe the pattern between mass and force.
(b) Use the pattern to predict the reading for a 600 g mass.
(c) A mass gives a reading of 2.94 N. What is its mass?

Working	Comment
(a) The force grows by the same step (about 0.98 N) for each extra 100 g — double the mass, double the force.	An even step per equal mass step is the signature of gravity's pull near Earth's surface.
(b) 4.9 N + 0.98 N = **about 5.9 N**.	One more 100 g step beyond 500 g adds one more 0.98 N.
(c) **300 g** — read straight from the table.	A pattern works both ways: force to mass as well as mass to force.

Example 3 — unscaffolded

A student draws the force diagram for a book resting on a table with gravity 5 N down and a support force of 3 N up, and says the diagram is fine because the book is not moving. Evaluate the diagram and the claim.

The diagram cannot be right. The book is at rest, so its motion is not changing — and no change in motion means the forces on the book are balanced: equal in size and opposite in direction. Gravity 5 N down can only be cancelled by a support force of 5 N up, so the support arrow must be the same length as the gravity arrow, both labelled 5 N. As drawn (5 N against 3 N), the forces would be unbalanced with a net force of 2 N down, and an unbalanced net force changes motion — the book would be sinking into the table, which it is not. ∴ a still object always has balanced forces on it, and the diagram must show two equal 5 N arrows.

Example 4 — unscaffolded

A classmate says: *"The Moon is far away in space, so Earth's gravity cannot reach it. Things only fall because they are close to Earth."* Evaluate this claim using what force diagrams and orbits show.

The claim fails on the orbit itself. The Moon travels a curved, closed path around Earth, and a curved path is a change in motion — which, by the rules of this subtopic, requires an unbalanced force acting on the Moon. Nothing touches the Moon out there, so the force cannot be a contact force; the only force available across the gap is gravity, the non-contact pull. The force diagram for the Moon has one arrow: Earth's gravitational pull, pointing toward Earth's centre, constantly bending the Moon's straight-line path into its orbit — exactly as the Sun's pull bends each planet's path. The apple and the Moon are in the same situation: both fall toward Earth's centre, the apple straight and the Moon sideways-while-falling around us. ∴ gravity reaches the Moon; far from stopping at the top of the sky, it is the very force that holds the orbit together.

Practice questions

Scaffolded

Q1. Answer the following about forces. (a) A force is a push or a pull. What two things does every force have? (b) In what unit is the magnitude of a force measured, and what is its symbol? (c) Which family of forces needs the objects to be touching?

Q2. Answer the following about a force meter. (a) What does the spring inside do as the force on the hook gets bigger? (b) On a meter whose small steps are 0.2 N, to what value should a reading be given? (c) What must be checked with nothing on the hook before the meter is used?

Q3. Answer the following about the size of a newton near Earth's surface. (a) About how big is Earth's pull on a 100 g apple? (b) About how big is the pull on a 1 kg bag of sugar? (c) About how big is the pull on a 50 kg student?

Q4. Answer the following about the direction of gravity. (a) Which way does Earth's gravitational force pull every object at Earth's surface? (b) *Down* in Australia and *down* in Canada point in opposite directions in space. Why are both still "down"? (c) A ball is let go above the ground. Which force acts on it, and is that force contact or non-contact?

Q5. Answer the following about a book resting on a table. (a) Name the two forces acting on the book. (b) How do their sizes compare, and how do their directions compare? (c) What change in motion do the two forces produce?

Q6. A box is pushed with 8 N to the right while friction pushes back with 5 N to the left. (a) Calculate the net force on the box. (b) Which way does the net force point? (c) Are the forces on the box balanced or unbalanced, and what does that mean for the box's motion?

Unscaffolded

Q7. Sort these forces into the contact family and the non-contact family, and state the one test you used: friction on a sliding box; a magnet pulling a paper clip across a gap; tension in a rope; the support force of a chair; gravity on a falling apple; a rubbed balloon holding a bit of paper. *(2 marks)*

Q8. A 200 g mass hangs still from a force meter that reads about 2 N. Explain, using balanced forces, why the reading of 2 N is a measurement of Earth's gravitational pull on the mass. *(2 marks)*

Q9. The Try-it investigation found the pull of gravity grows by about 0.98 N per 100 g of mass. Predict the force meter reading for a 350 g mass, and show the two steps of your prediction. *(2 marks)*

Q10. A picture of mass 1 kg hangs still from a string. Describe the complete force diagram for the picture: name each force, give its size in newtons, state its direction, and say how the two arrow lengths compare. *(2 marks)*

Q11. A student says: *"Down is the same direction everywhere on Earth — it is the direction things fall."* Evaluate the claim using the direction of Earth's gravitational pull. *(2 marks)*

Q12. Two students push a crate along one line: one pushes 4 N east and the other 3 N east. Then they push against each other, 4 N east against 3 N west. Find the net force in each case and state which case is balanced, if either. *(2 marks)*

Q13. A classmate says: *"Space is beyond gravity — once you leave Earth, the pull stops."* Evaluate the claim using the Moon's orbit. *(2 marks)*

Q14. The arms of a returning boomerang are shaped like wings in cross-section. Explain how that shape produces a force on the spinning boomerang, and name one use of a non-returning boomerang. *(3 marks)*

Answers

Q1. (a) A size (magnitude) and a direction. (b) The newton, N. (c) The contact family. **Q2.** (a) It stretches more — the bigger the force, the more the spring stretches. (b) To the nearest 0.2 N. (c) The zero: the pointer must sit at 0 N with nothing on the hook. **Q3.** (a) About 1 N. (b) About 9.8 N. (c) About 490 N. **Q4.** (a) Toward the centre of the Earth. (b) Because "down" means toward Earth's centre, and that direction is different at every place on the globe. (c) Gravity; non-contact. **Q5.** (a) Gravity (down) and the table's support force (up). (b) Equal in size, opposite in direction. (c) None — the forces balance, so the book's motion does not change. **Q6.** (a) 8 N − 5 N = 3 N. (b) To the right (the way of the larger force). (c) Unbalanced — the box's motion changes toward the right. **Q7.** Contact: friction, tension, the chair's support force. Non-contact: the magnet's pull, gravity, the balloon's pull. Test: are the objects touching, or does the force reach across a gap? **Q8.** The mass hangs still, so its motion is unchanged and the forces on it are balanced: the spring's 2 N pull up cancels Earth's pull down, so Earth's pull must also be 2 N — which is what the meter reads. **Q9.** 300 g gives 2.94 N; one extra 50 g (half a 100 g step) adds about 0.49 N; 2.94 N + 0.49 N ≈ 3.4 N. **Q10.** Gravity, about 9.8 N, down; tension in the string, about 9.8 N, up; the arrows are equal in length (balanced, because the picture hangs still). **Q11.** Wrong: things fall toward Earth's centre, and that direction differs from place to place — "down" in Australia and "down" in Canada point opposite ways in space. What is the same everywhere is the rule, not the direction in space. **Q12.** Same way: 4 N + 3 N = 7 N east. Opposite ways: 4 N − 3 N = 1 N east. Neither case is balanced — both leave a net force that is not zero. **Q13.** Wrong: the Moon's curved orbit is a change in motion, which needs a force; nothing touches the Moon, so the force is gravity reaching across the gap — the same pull that drops an apple, holding the Moon in orbit. **Q14.** The wing-like (airfoil) cross-section makes the moving air push the spinning arm with a lift force; uneven lift across the spin bends the path into the returning curve. Non-returning boomerangs (kylies) were used for hunting.

Fully-worked solutions

Q1. (a) Every force has a **size (its magnitude)** and a **direction** — a force is a number pointing somewhere. (b) The magnitude of a force is measured in **newtons, N**. (c) The **contact** family needs the objects to be touching; the non-contact family reaches across a gap.

Q2. (a) The bigger the force on the hook, **the more the spring stretches** — that is the rule the meter is built on. (b) To the **nearest 0.2 N**, the finest graduation: readings are never rounded to whole newtons. (c) **The zero** — with nothing on the hook the pointer must sit at 0 N, or every reading is wrong by the same amount.

Q3. (a) About **1 N** — a newton is roughly Earth's pull on a 100 g apple. (b) About **9.8 N**. (c) About **490 N** — fifty times the kilogram pull.

Q4. (a) Toward the **centre of the Earth**, from every place on the globe. (b) Because *down* **means toward Earth's centre**; at different places on a round Earth that direction points different ways in space, so two opposite directions in space are both "down". (c) **Gravity**, acting with nothing touching the ball — a **non-contact** force.

Q5. (a) **Gravity** pulling down and the table's **support force** pushing up. (b) **Equal in size and opposite in direction.** (c) **No change** — the forces are balanced, so the book stays at rest.

Q6. (a) 8 N − 5 N = **3 N**. (b) **To the right**, the way of the larger force. (c) **Unbalanced** — a net force that is not zero **changes the box's motion**, toward the right.

Q7. The test is: *are the objects touching, or does the force reach across a gap? (1 mark)* Contact: **friction** on the sliding box, **tension** in the rope, the **support force** of the chair. Non-contact: the **magnet's** pull on the clip, **gravity** on the apple, the rubbed **balloon's** pull on the paper *(1 mark)*.

Q8. The mass hangs **still**, so its motion is not changing, which means the forces on it are **balanced** *(1 mark)*. The meter shows the spring pulling up with 2 N; for the forces to cancel, Earth must pull down with the same 2 N — so the reading **is** the size of Earth's gravitational pull on the mass *(1 mark)*.

Q9. From the table value at 300 g: 2.94 N *(1 mark)*. Half a 100 g step (50 g) adds half of 0.98 N ≈ 0.49 N, so 2.94 N + 0.49 N ≈ **3.4 N** *(1 mark)*.

Q10. Two forces: **gravity, about 9.8 N, down** (the pull on 1 kg near Earth's surface), and the **string's tension, about 9.8 N, up** *(1 mark)*. The picture hangs still, so the forces balance and the **two arrows are drawn equal in length**, labelled with their sizes *(1 mark)*.

Q11. The claim is wrong *(1 mark)*: gravity pulls every object **toward Earth's centre**, so "down" in Australia and "down" in Canada point in **opposite directions in space** — the direction things fall is not one direction in space, it is "toward the centre" from wherever you stand *(1 mark)*.

Q12. Same way: forces add, 4 N + 3 N = **7 N east**. Opposite ways: forces subtract, 4 N − 3 N = **1 N east** *(1 mark)*. **Neither case is balanced** — both leave a net force that is not zero, so the crate's motion changes in both *(1 mark)*.

Q13. The claim is wrong *(1 mark)*: the Moon's orbit is a curved path — a change in motion — which needs an unbalanced force, and with nothing touching the Moon that force can only be **gravity reaching across the gap**; the same pull bends the planets' paths around the Sun, so gravity does not stop at the top of the sky *(1 mark)*.

Q14. Each arm's cross-section is **wing-like (an airfoil): curved on top, flatter underneath** *(1 mark)*; as the arm spins through the air, the moving air pushes it with a **lift force**, and the uneven lift between the faster upper arm and the slower lower arm steadily turns the path into the returning curve *(1 mark)*. Non-returning boomerangs (kylies) were made in many sizes **for hunting and other uses** *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- CSIRO, "Indigenous Knowledge", 2026. csiro.au
- Wikipedia, "Boomerang", 2026. en.wikipedia.org
- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8U14` and its elaborations, 2026. vcaa.vic.edu.au

The force values throughout (about 0.98 N per 100 g, about 9.8 N per kilogram, and the derived values of about 1 N, 9.8 N, 49 N and 490 N) are the measured pattern of the Try-it investigation, computed as mass × 9.8 N per kilogram — the standard pull of gravity near Earth's surface — and are presented as investigation data, not as a formula: no `W = mg` is taught at this band. The force-meter readings in the worked examples are as drawn on the figures (0.2 N finest graduation). The boomerang facts — returning and non-returning (kylie) forms, the airfoil arm profile, the lift-and-spin returning flight, rock-art depictions possibly tens of thousands of years old, and the Wyrie Swamp boomerangs dated to around 10,000 BC — are as given in Wikipedia, "Boomerang".

Elaboration contexts used: `VC2S8U14.E03` (measuring the magnitude of a force using a force meter, and representing the magnitude and direction of forces acting on an object using force diagrams), `VC2S8U14.E04` (investigating how Earth's gravitational force is the attractive force that pulls objects towards the centre of Earth and how its magnitude is related to the mass of an object), `VC2S8U14.E05` (how gravity affects objects in space — bounded per D9 to the Earth–Moon attraction and the Sun–planet attraction) and `VC2S8U14.E06` (analysing the forces acting on boomerangs and how early Aboriginal and/or Torres Strait Islander Peoples designed an airfoil profile that could be varied and had several applications).

Teacher-facing note — E06 delivery under D10/ICIP (not student text). The sources used for the boomerang case study (Wikipedia, "Boomerang"; CSIRO, "Indigenous Knowledge") describe the design as an achievement of Aboriginal and/or Torres Strait Islander Peoples without attributing it to a specific People; accordingly this subtopic keeps the CD's own attribution level ("early Aboriginal and/or Torres Strait Islander Peoples") and does not invent a People's name for the design. Per CSIRO, Indigenous Knowledge is the Indigenous Cultural and Intellectual Property (ICIP) of the communities who hold it; this subtopic therefore teaches only the sourced physical facts — the airfoil arm profile, the lift force on the spinning arms, the returning and non-returning (kylie) forms and their uses, and the antiquity of the design — and does not reproduce or redraw cultural designs, stories or ceremony. The Wyrie Swamp dating and the rock-art antiquity are reported as given by Wikipedia, "Boomerang".

Changing an object's motion: relating the change to the object's mass and to the magnitude and direction of the forces acting on it

What we teach here — `VC2S8U14` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"balanced and unbalanced forces acting on objects, including gravitational force, may be investigated and represented using force diagrams; changes in an object's motion can be related to its mass and to the magnitude and direction of the forces acting on it"* **This subtopic owns the second clause only**: relating the change in an object's motion to the object's mass and to the magnitude (size) and direction of the forces acting on it. The first clause — balanced and unbalanced forces, including gravitational force, and force diagrams — belongs to the partner subtopic **15A** († split delivery, D6). Here we *use* force arrows and the balanced/unbalanced idea; 15A builds them. **In our words:** a change of motion — starting, stopping, speeding up, slowing down, turning — never just happens. There is always an unbalanced force behind it, the size of the change grows with the size of that force, shrinks with the object's mass, and the change points the way the force points. **Achievement-standard extract served here (D13):** cited by reference to the header of the owner subtopic 15A, where the extract appears in full. **Elaborations drawn on:** `VC2S8U14.E01` (investigating the effects of applying different forces to familiar objects of the same mass and different masses) and `VC2S8U14.E02` (analysing the effect of balanced and unbalanced forces on an object's motion, such as starting, stopping and changing direction). **Scope ceiling (D9):** this subtopic stays qualitative — no $F = ma$, no named laws of motion, no speed calculations and no motion graphs. Instead, each figure shows snapshot positions at equal time intervals (the gaps between snapshots show how the motion is changing) and force arrows drawn to scale. The one bar chart is read for comparison only, never for slope or best-fit (D11). **Maths interlocks:** measuring distance in centimetres (cm) and time in seconds (s), and reading a bar chart for comparison (D11).

Word watch — *mass* and *weight*. Everyday talk mixes these up, but science keeps them separate. **Mass** is how much matter an object has — how much "stuff" is in it — measured in kilograms (kg) or grams (g). Mass is the same everywhere: a trolley loaded with masses has the same mass on the Moon as on Earth. **Weight** is the pull of gravity on that mass — a force, measured in newtons (N). On the Moon the pull of gravity is weaker, so the same mass has a smaller weight. Mass says how much stuff; weight says how hard gravity pulls on it.

Word watch — *net force*, and the two kinds of arrow. Several forces often act on an object at once. The **net force** is the overall push or pull when all the forces are combined, taking their directions into account. Balanced forces leave a net force of zero; unbalanced forces mean the net force is not zero. In this subtopic's figures, **solid red arrows are forces**, while **grey dashed arrows show the object's motion**. Motion is not a force — an object does not carry a push inside it — so the motion arrow is never drawn as a force arrow.

Theory

The force ideas we borrow from 15A

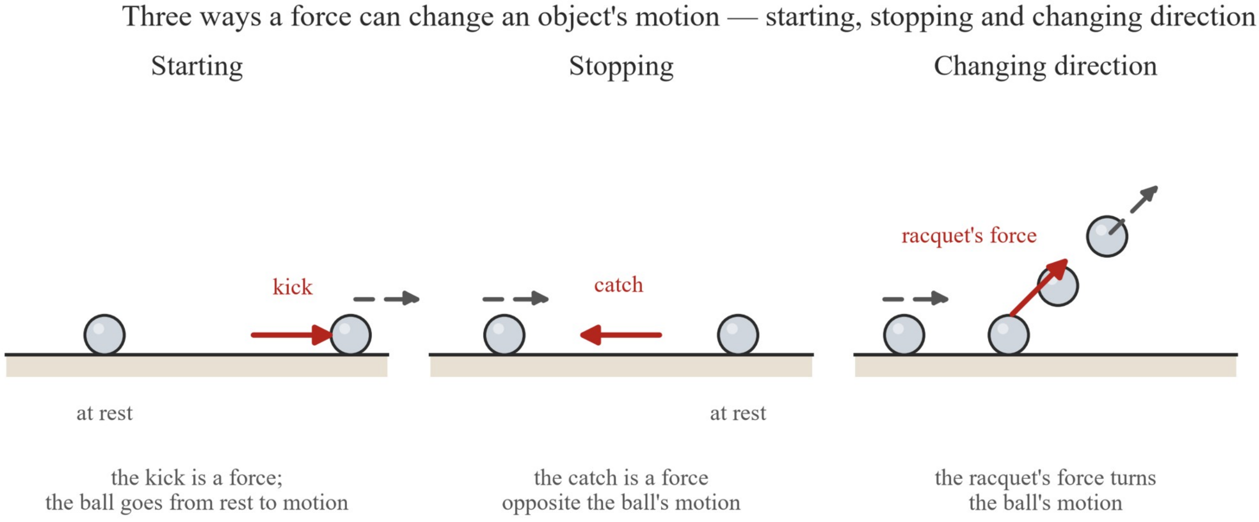
Subtopic 15A builds the first clause of this unit: forces are pushes and pulls, measured in newtons (N); a force diagram represents each force on an object as an arrow pointing the way the force pushes or pulls, with a longer arrow for a bigger force; gravitational force (weight) pulls straight down on every object; and forces on an object are either **balanced** (they balance out, net force zero) or **unbalanced** (a net force is left over). Here is the short version this subtopic leans on.

- **Balanced forces** → net force is zero → the object's motion does not change.
- **Unbalanced forces** → net force is not zero → the object's motion changes.

Every result in this subtopic follows from those two lines, plus *how much* the motion changes and *which way* it changes.

Three ways a force can change motion (`VC2S8U14.E02`)

A change of motion is one of three things: **starting** (rest to moving), **stopping** (moving to rest), or **changing direction** (turning). Speeding up and slowing down are changes too — they are starting-like and stopping-like changes along the line of motion. In every case, the change is caused by an unbalanced force.



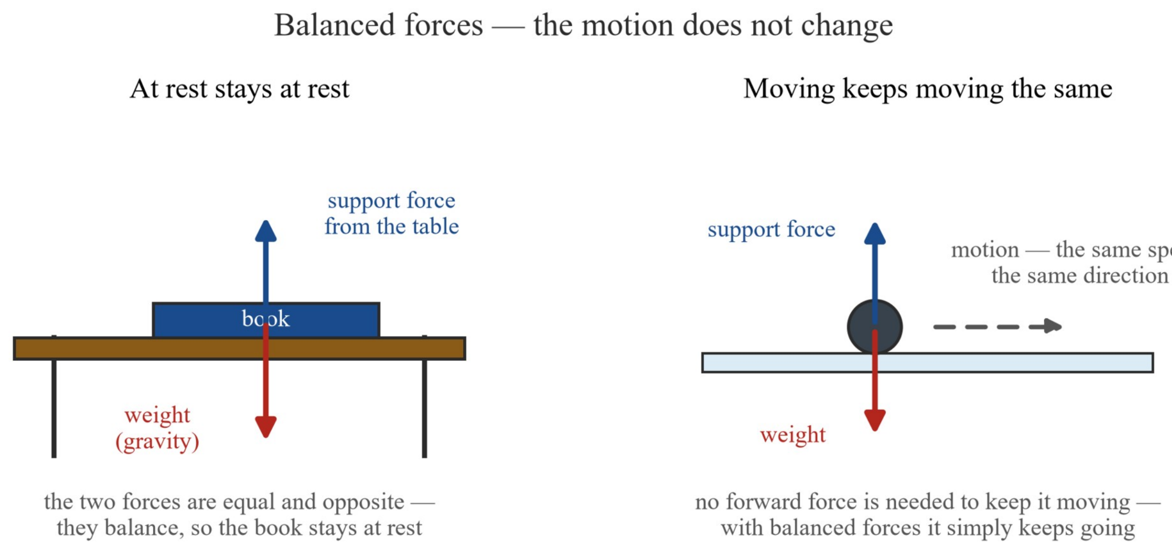
Three panels showing the three ways a force changes an object's motion: starting, where a kick sends a ball at rest moving; stopping, where a catch acts opposite the ball's motion and brings it to rest; and changing direction, where a racquet's force turns the ball's path; solid red arrows show the forces and grey dashed arrows show the motion

Notice the direction of the force in each panel: to start the ball, the kick pushes the way the ball will move; to stop it, the catch pushes opposite the motion; to turn it, the racquet pushes from the side. The change of motion always points the same way as the net force — that idea gets its own section below.

Balanced forces — the motion does not change

When the forces on an object are balanced, the net force is zero and nothing about the motion changes. Two cases:

- **At rest stays at rest.** A book on a table has its weight pulling down and the table's support force pushing up, equal and opposite. The forces balance, so the book just sits there.
- **Moving keeps moving the same.** A puck sliding on smooth ice also has weight and support balanced, and the tiny friction of ice almost nothing. With no unbalanced force, the puck keeps the same speed and the same direction. No forward force is needed to keep it moving.



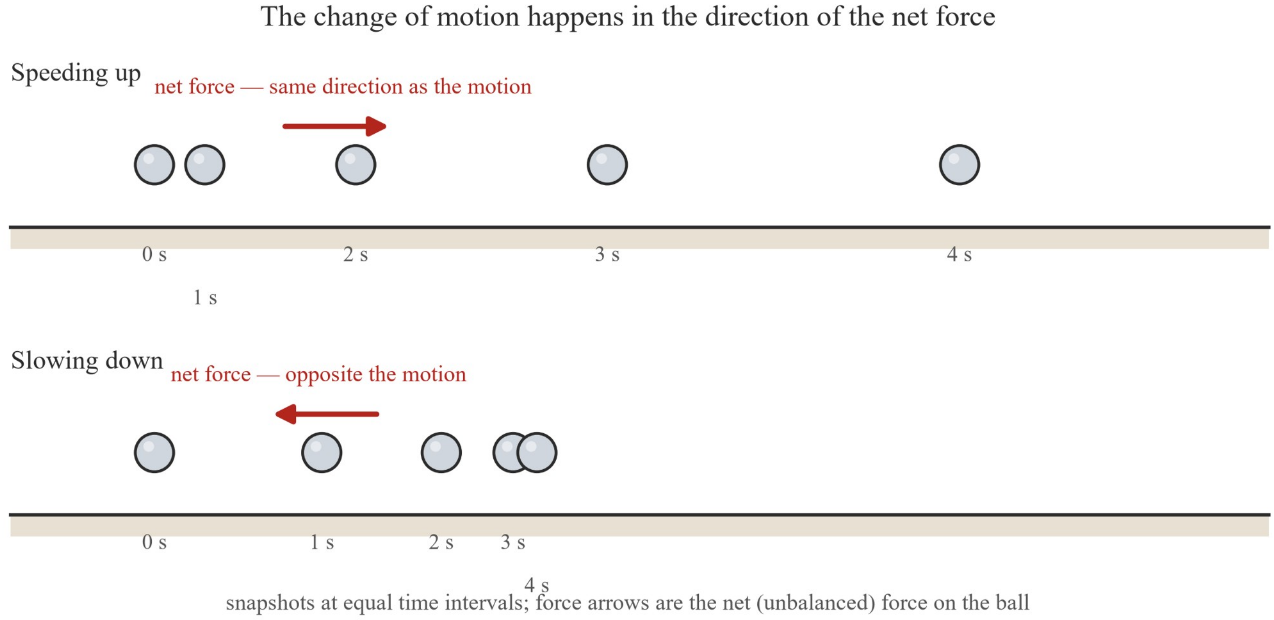
Two panels of balanced forces: a book at rest on a table with its weight (gravity) down and the table's support force up, equal and opposite, so the book stays at rest; and a puck sliding on smooth ice with weight and support balanced, keeping the same speed and the same direction, so no forward force is needed to keep it moving

That second case is the one everyday life hides from us, because on Earth there is nearly always friction around to slow things down. More on that in the friction section.

Unbalanced forces — the change points the way the net force points

When the forces are unbalanced, the motion changes, and the change happens along the direction of the net force:

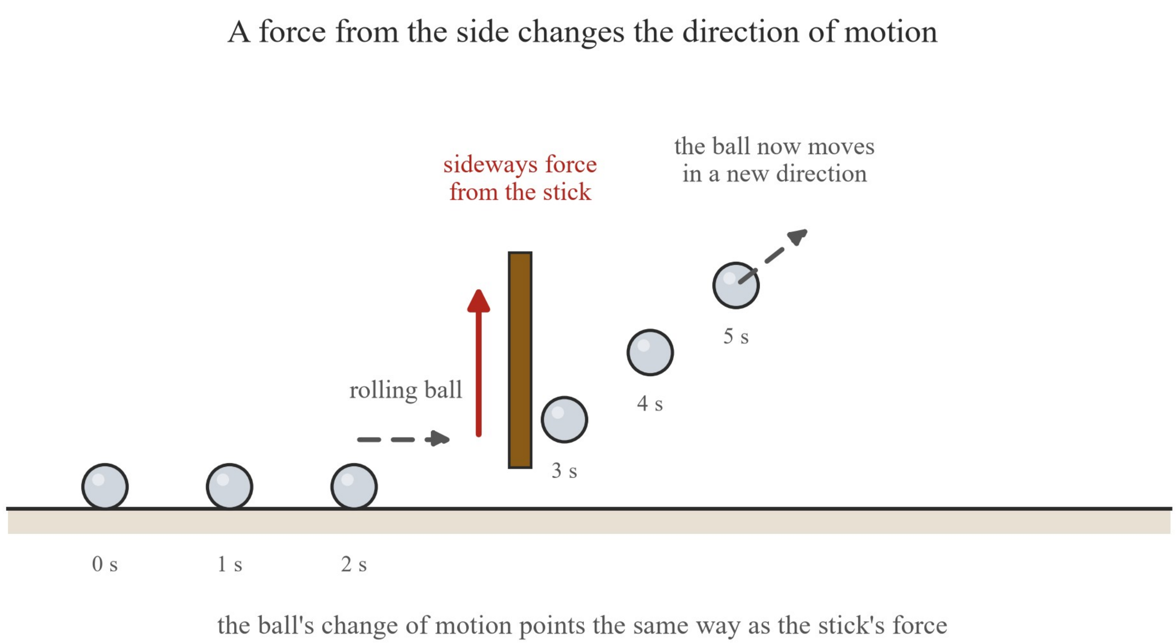
- **Net force the same way as the motion** → the object speeds up.
- **Net force opposite the motion** → the object slows down.
- **Net force from the side** → the object turns, bending its path toward the force.



Two strips of snapshot positions at equal time intervals: a ball speeding up, with the gaps between snapshots widening under a net force in the same direction as the motion; and a ball slowing down, with the gaps narrowing under a net force opposite the motion

Read the strips like a camera taking a picture every second: where the gaps widen, the ball covers more ground each second — it is speeding up; where the gaps narrow, it is slowing down. The red arrow in each strip is the net (unbalanced) force.

A force from the side works the same way. A ball rolling straight past a hockey stick gets a tap from the side, and its path bends toward the direction of that tap:

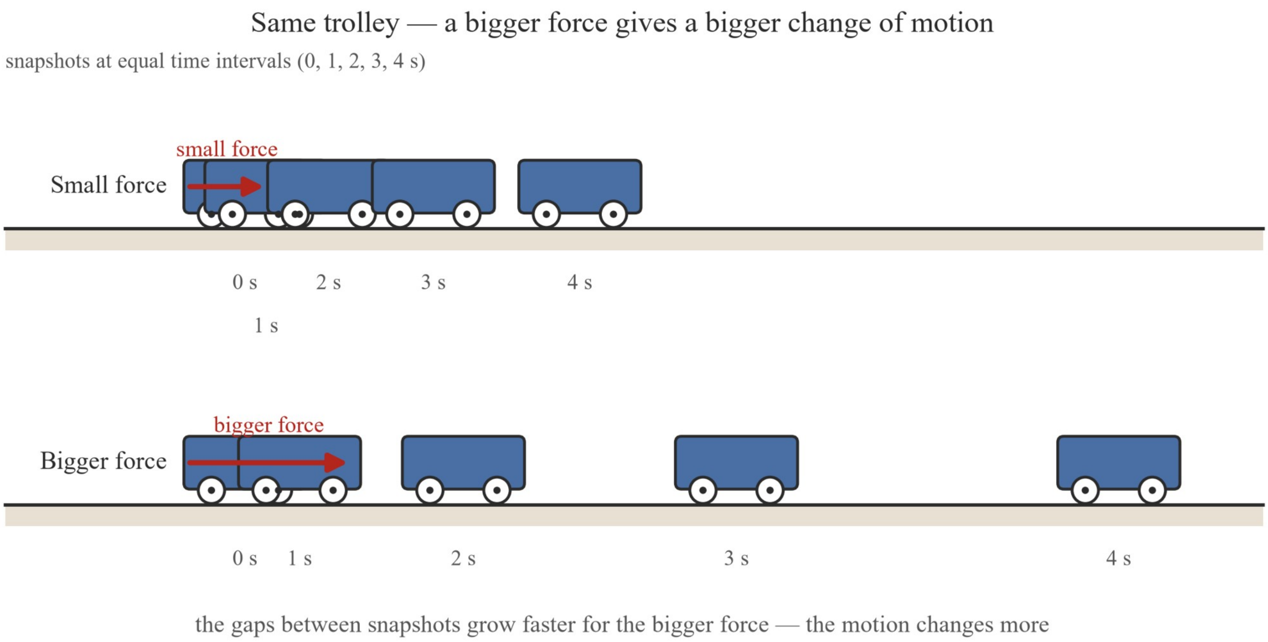


A ball rolling straight, shown by snapshots at 0, 1 and 2 s, tapped by a hockey stick; the stick's force acts from the side at the tap, and the snapshots at 3, 4 and 5 s show the ball moving off in a new direction, bent toward the stick's force

The ball's change of motion points the same way as the stick's force. That is the direction rule in one picture.

The magnitude of the force — bigger force, bigger change

Keep the mass the same and change only the force. The figures below show the same trolley in two trials, with snapshot positions every second; the only difference is the size of the pull.

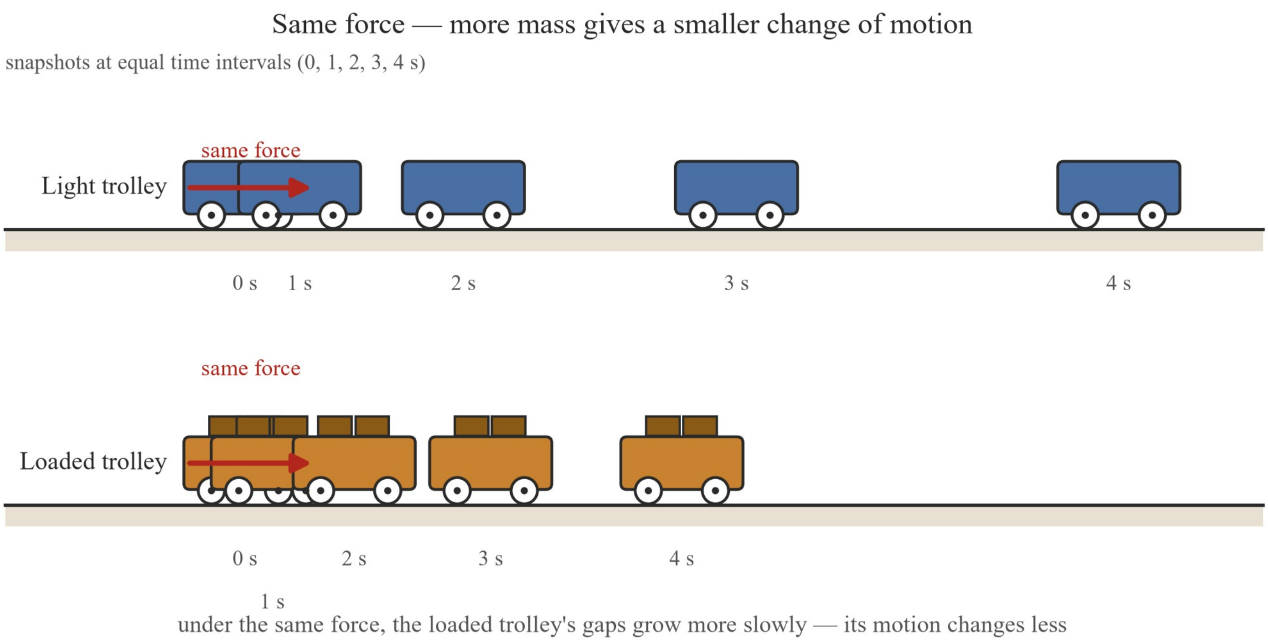


Two strips of snapshot positions at equal time intervals from 0 to 4 s for the same trolley: under a small force the gaps between snapshots grow slowly, and under a bigger force the gaps grow much faster, showing that the bigger force gives the bigger change of motion

Under the bigger force the gaps open up faster — the trolley's motion changes more. Same mass, bigger force, bigger change of motion.

The mass of the object — more mass, smaller change

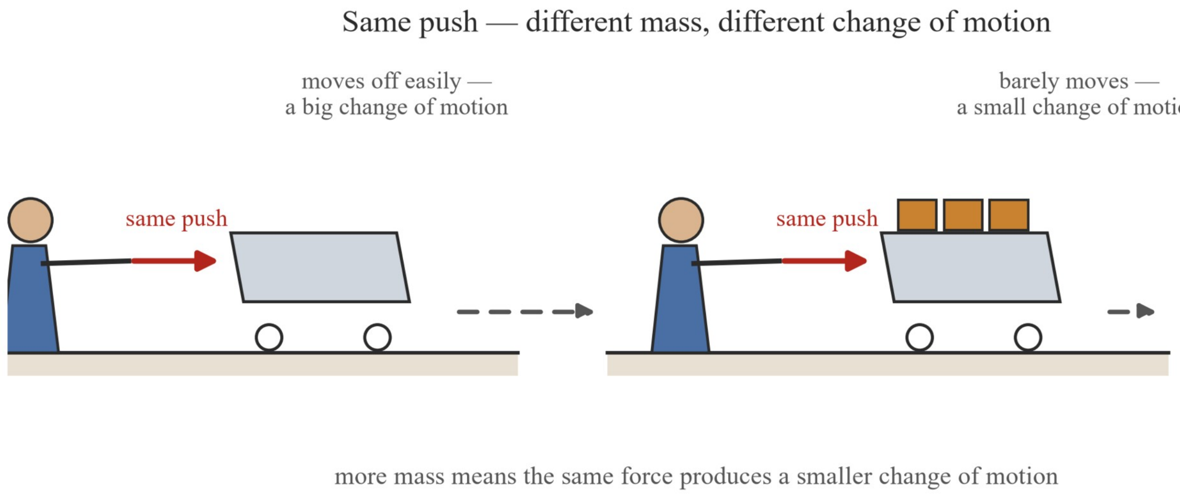
Now keep the force the same and change only the mass. The loaded trolley carries extra slotted masses, so it has more mass than the light one.



Two strips of snapshot positions at equal time intervals under the same force: the light trolley's gaps grow quickly, while the loaded trolley's gaps grow more slowly, showing that more mass means a smaller change of motion

Under the same force, the loaded trolley's motion changes less. Same force, more mass, smaller change of motion.

The same idea in an everyday picture: the same push on an empty shopping trolley sends it moving off easily, while a full one only just moves.

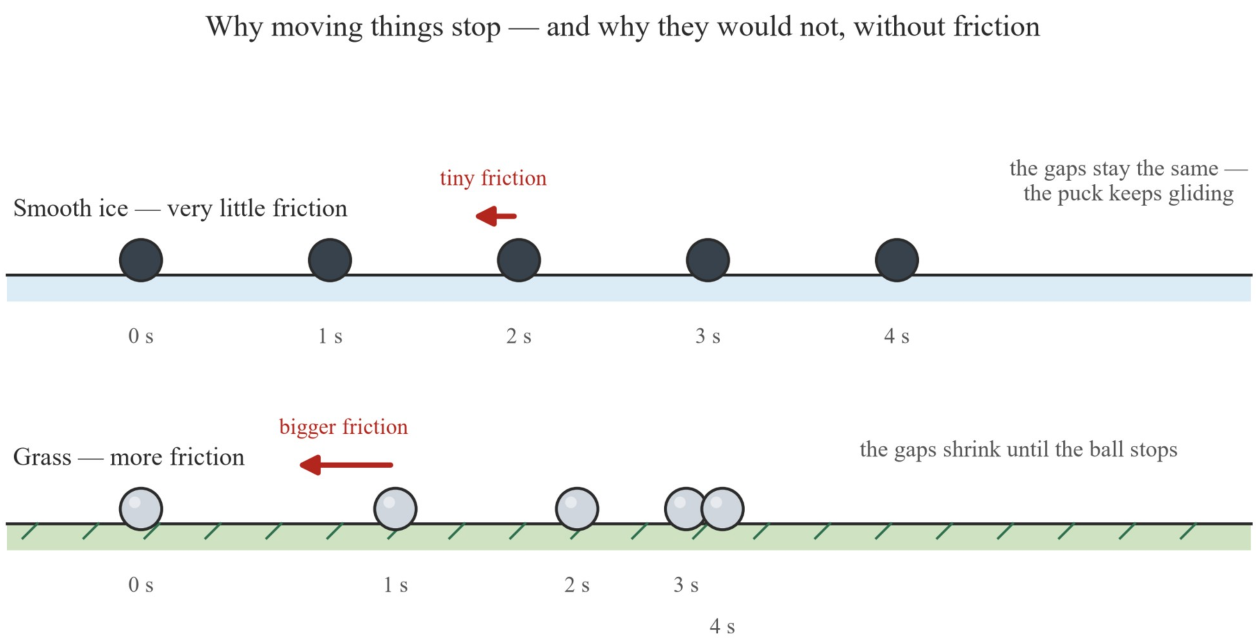


The same push applied to an empty shopping trolley, which moves off easily — a big change of motion — and to a loaded shopping trolley, which only just moves — a small change of motion; the grey dashed motion arrow is long for the empty trolley and short for the loaded one

This is why mass is sometimes described as how hard an object is to get going (or to stop): the more mass, the smaller the change of motion a given force produces.

Friction — the force that usually does the slowing

So why do moving things on Earth nearly always slow down and stop, when balanced forces should let them keep going? Because there is nearly always an unbalanced force present: **friction**, the force between surfaces that rubs against the motion. On grass, friction is big and a rolling ball stops in a few seconds. On smooth ice, friction is tiny and a puck keeps gliding with almost no change of motion.

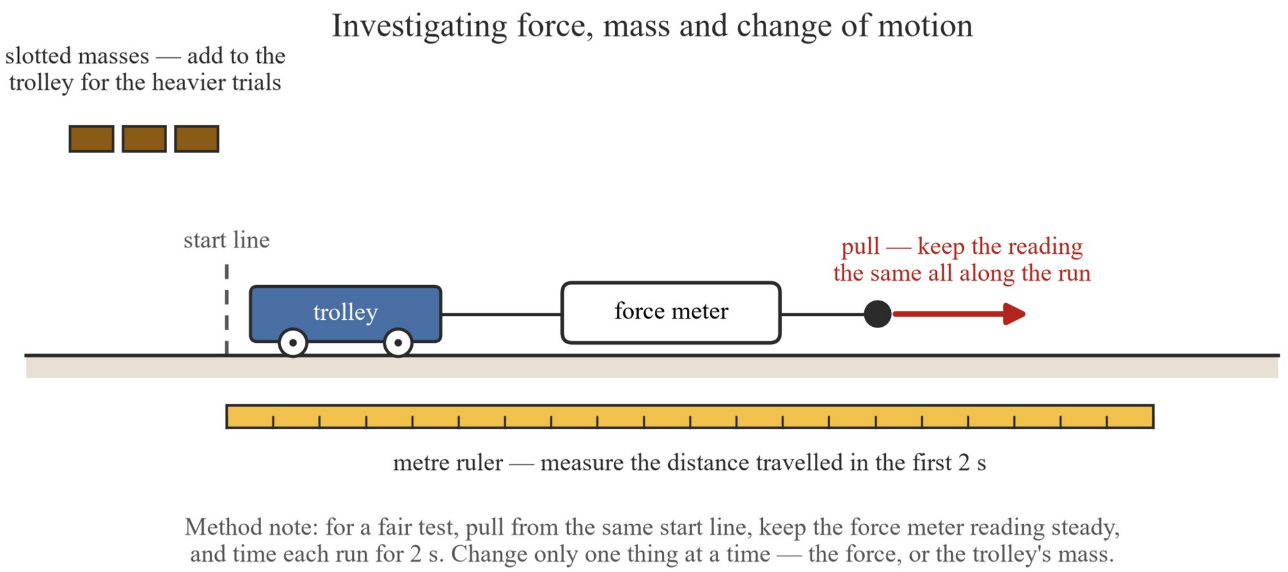


Two strips of snapshots at equal time intervals: a puck on smooth ice, where tiny friction acts against the motion and the gaps stay almost the same, so the puck keeps gliding; and a ball on grass, where bigger friction acts against the motion and the gaps shrink until the ball stops

The ball on grass is not "running out of push" — it is being slowed by an unbalanced force, friction, acting opposite its motion, exactly like the slowing-down strip above. Take friction almost away (ice) and the motion almost does not change. That is the balanced-forces case from the previous section, happening in real life.

Investigation — force, mass and change of motion (`VC2S8U14.E01`)

The classic way to see both relationships at once is to pull a dynamics trolley along a bench with a force meter, and measure how far it travels in the first 2 s.



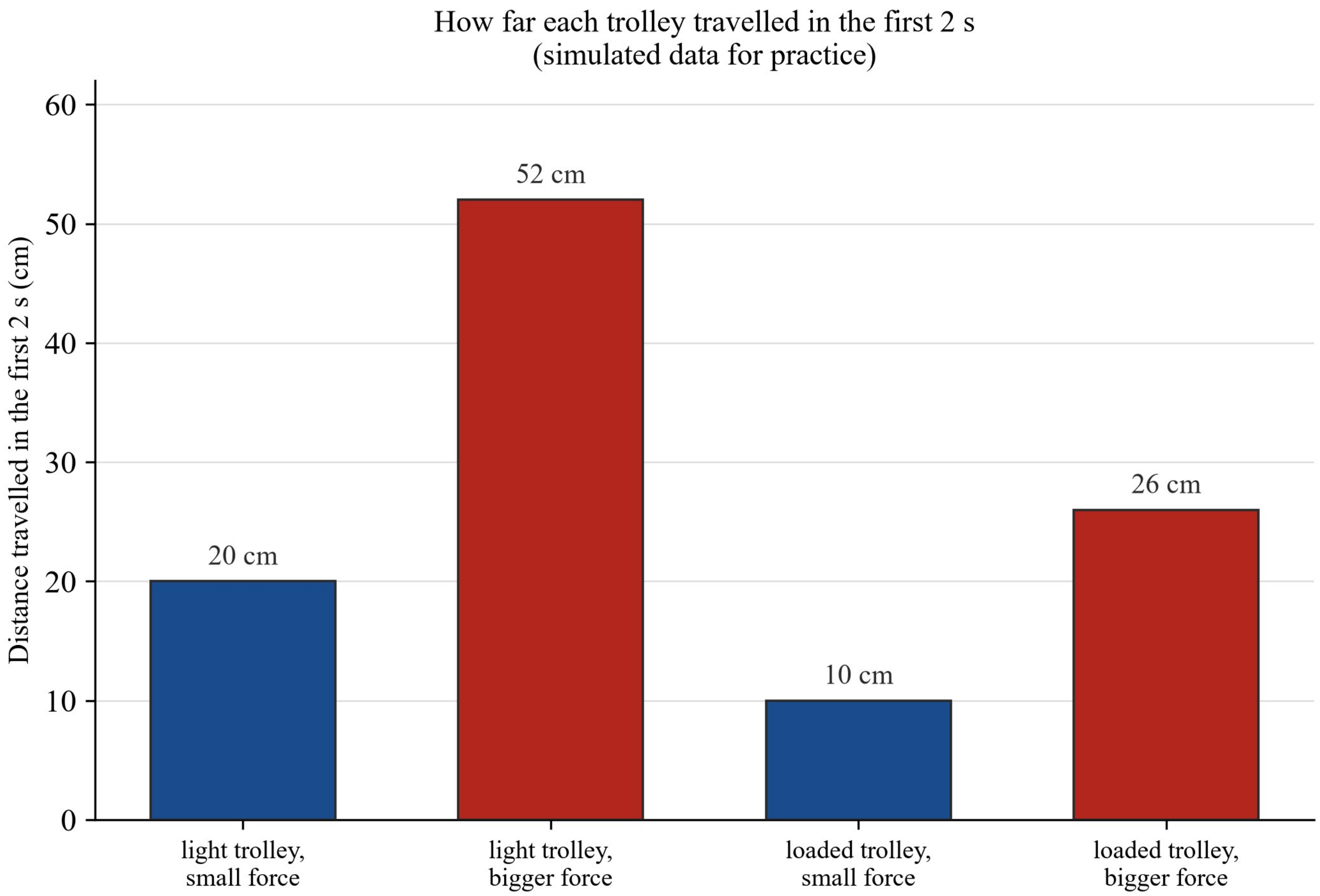
The investigation setup: a trolley at a start line on a bench, pulled by a string through a force meter held at a steady reading, with a metre ruler along the run to measure the distance travelled in the first 2 s, and slotted masses ready to add to the trolley for the heavier trials

- **Equipment:** a dynamics trolley, a force meter (spring balance), a string, a metre ruler, a stopwatch, and slotted masses to load the trolley.
- **Method:** pull the trolley from the same start line each run, keeping the force meter reading steady all the way, and time each run for 2 s; read the distance travelled from the metre ruler. Change only one thing at a time — the size of the pull, or the trolley's mass — so the test is fair.
- **Risk:** a low-risk activity, run with the guidance of Science ASSIST (see Sources): keep the run clear of bags and feet, keep the bench and floor dry so nobody slips, and lift the slotted masses with care so they are not dropped on feet or the bench.

A set of simulated results for practice:

Trial	Trolley	Pull (force meter reading)	Distance travelled in the first 2 s
1	light	small (2 N)	20 cm
2	light	bigger (4 N)	52 cm
3	loaded	small (2 N)	10 cm
4	loaded	bigger (4 N)	26 cm

(Simulated data for practice.)



Bar chart of the simulated results: the distance travelled in the first 2 s for each trial — light trolley with a small force, 20 cm; light trolley with a bigger force, 52 cm; loaded trolley with a small force, 10 cm; and loaded trolley with a bigger force, 26 cm

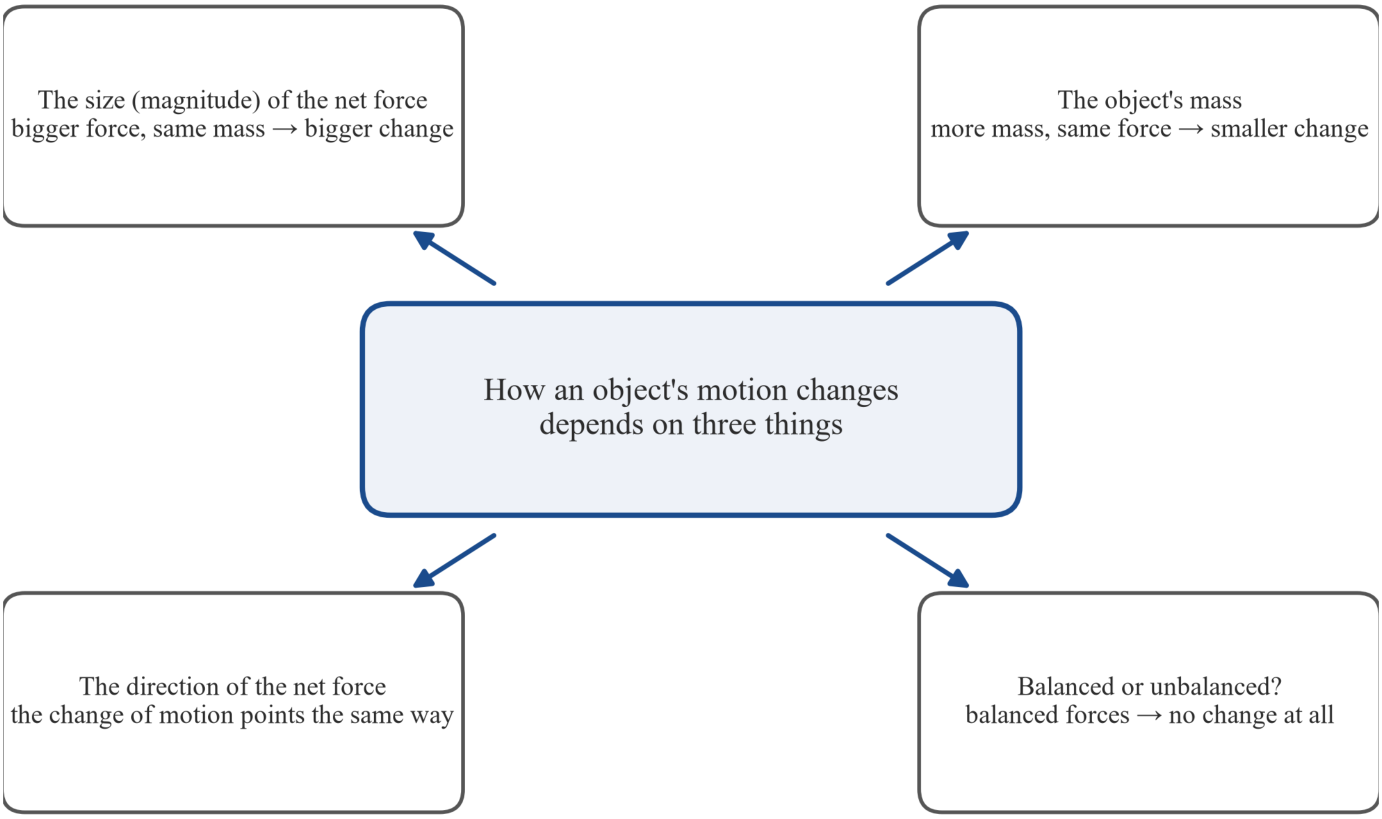
Read the chart in pairs, changing only one thing at a time:

- **Trials 1 and 2** (same mass): the bigger force travels 52 cm against 20 cm — the bigger force gives the bigger change of motion.
- **Trials 1 and 3** (same force): the loaded trolley travels only 10 cm against 20 cm — more mass gives the smaller change of motion.
- **Trial 4 against 3** (same mass): again the bigger force wins; **trial 4 against 2** (same force): again the loaded trolley changes less.

Both relationships hold at the same time, which is exactly what the investigation was built to show.

Putting it together

Every change of motion in this subtopic — starting, stopping, speeding up, slowing down, turning — comes back to the same four ideas: whether the forces are balanced or unbalanced, the size (magnitude) of the net force, the mass of the object, and the direction of the net force.



A summary map with a centre box, "how an object's motion changes depends on three things", and four spokes: the size (magnitude) of the net force — bigger force, same mass, bigger change; the object's mass — more mass, same force, smaller change; the direction of the net force — the change of motion points the same way; and balanced or unbalanced — balanced forces mean no change at all

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Words to know in 15B

Word	What it means here
force	a push or a pull on an object, measured in newtons (N)
mass	how much matter an object has, in grams (g) or kilograms (kg)
weight	the pull of gravity on an object's mass — a force, in newtons (N)
net force	the overall push or pull when all the forces on an object are combined, taking their directions into account
balanced forces	forces that balance out, leaving a net force of zero — no change of motion
unbalanced forces	forces that do not balance out, leaving a net force — the motion changes
magnitude	the size of a force — a bigger force has a bigger magnitude
friction	a force between surfaces that acts against the motion of an object sliding or rolling over another surface
change of motion	starting, stopping, speeding up, slowing down, or changing direction
force diagram	a picture that represents each force on an object as an

Word	What it means here
	arrow: the arrow points the way the force acts, and a longer arrow means a bigger force (built in 15A)
newton (N)	the unit of force
fair test	an investigation that changes only one thing at a time, keeping everything else the same

Worked examples

Example 1 — scaffolded

A camera takes a picture of a moving ball once every second. The pictures show gaps that get wider and wider, left to right, and the ball moves left to right. State (a) whether the ball's motion is changing, (b) whether the forces on the ball are balanced or unbalanced, and (c) the direction of the net force compared with the motion.

Working	Comment
1. Wider gaps each second → the ball covers more ground each second → it is speeding up.	Equal time intervals make the gaps a picture of the change of motion.
2. (a) Speeding up is a change of motion, so **yes, the motion is changing**.	A change of motion includes speeding up, not just turning.
3. (b) A change of motion needs an unbalanced force → **the forces are unbalanced**.	Balanced forces would keep the gaps equal.
4. (c) The ball speeds up, so the net force points **the same way as the motion**.	Net force along the motion → speed up; opposite → slow down.

Example 2 — scaffolded

Use the investigation's results table (Trials 1–4) to answer: (a) which pair of trials shows the effect of the force's magnitude, and what does it show? (b) which pair shows the effect of mass, and what does it show?

Working	Comment
(a) Trials 1 and 2: same trolley (light), different pull. 52 cm against 20 cm → **the bigger force gives the bigger change of motion**.	A fair comparison changes only the force.
(b) Trials 1 and 3: same pull (2 N), different trolley. 10 cm against 20 cm → **more mass gives the smaller change of motion**.	A fair comparison changes only the mass.
∴ distance travelled in the same time works as a measure of the size of the change of motion.	More ground in the same time → a bigger change from rest.

Example 3 — unscaffolded

A shopper gives an empty trolley a push and it moves off easily. The same push on the same trolley, now full of shopping, only just moves it. Explain the difference, relating the change of motion to the mass.

The push (the force) is the same in both cases; the thing that changes is the mass. The full trolley has much more mass, and more mass means the same force produces a smaller change of motion. ∴ the empty trolley shows a big change of motion (moves off easily) and the full trolley a small one (only just moves) — the mass of the object sets how big the change of motion is for a given force.

Example 4 — unscaffolded

A ball kicked across grass slows down and stops within a few seconds. The same kick on a puck on smooth ice sends it gliding a long way with almost no change of motion. Explain both observations using balanced and unbalanced forces.

On the grass, friction between the ball and the grass is a big unbalanced force acting opposite the motion, so the ball slows down and stops. On smooth ice, friction is tiny, so the up-and-down forces (weight and the ice's support) are nearly balanced and almost nothing acts against the motion — the net force is nearly zero, so the puck's motion nearly does not change and it keeps gliding. ∴ the difference is not in the kick but in the forces after it: unbalanced friction stops the ball; nearly balanced forces let the puck keep going.

Practice questions

Scaffolded

Q1. Name the three ways a force can change an object's motion, as in `VC2S8U14.E02`.

Q2. The forces acting on a moving object are balanced. Describe the object's motion from here on.

Q3. An object sits at rest and the forces on it are balanced. What happens to it?

Q4. The same trolley is pulled by a small force in one trial and a bigger force in another. Which trial shows the bigger change of motion?

Q5. Use the results table: which trial shows the smallest change of motion? Give the evidence from the table.

Q6. Complete each sentence with *speeds up*, *slows down* or *changes direction*: (a) a net force the same way as the motion → the object … (b) a net force opposite the motion → the object … (c) a net force from the side → the object …

Unscaffolded

Q7. A ball kicked across grass slows down and stops. Explain what force does this, and give its direction compared with the ball's motion.

Q8. A puck sliding on smooth ice keeps going with almost the same speed and direction. Explain why, using balanced and unbalanced forces, and state whether a forward force is needed to keep it moving.

Q9. The same push moves an empty shopping trolley easily but a full one only just. Explain the difference, relating the change of motion to the mass.

Q10. A tennis ball moving straight at a racquet is hit back across the court. Relate the ball's change of motion to the force the racquet applies.

Q11. In the trolley investigation: (a) to test the effect of the force's magnitude in a fair test, what must be kept the same? (b) to test the effect of mass in a fair test, what must be kept the same?

Q12. Snapshot pictures of a moving object at equal time intervals show equal gaps. (a) Are the forces on the object balanced or unbalanced? Explain. (b) Is a forward force needed to keep the object moving? Explain.

Q13. Two snapshot strips at equal time intervals: strip X has widening gaps, strip Y has narrowing gaps, and both objects move left to right. For each strip, state whether the object speeds up or slows down, and the direction of the net force compared with the motion.

Q14. A classmate says a ball rolling on grass stops because it "runs out of push". Explain what actually stops the ball, and predict what would happen to a ball kicked across perfectly smooth ice with no friction.

Answers

Q1. Starting, stopping and changing direction (speeding up and slowing down count as changes along the line of motion). **Q2.** It keeps moving at the same speed in the same direction — the motion does not change. **Q3.** It stays at rest. **Q4.** The bigger force — same mass, bigger force, bigger change of motion. **Q5.** Trial 3 (loaded trolley, small force): only 10 cm in the first 2 s, the shortest distance of the four trials. **Q6.** (a) speeds up. (b) slows down. (c) changes direction. **Q7.** Friction between the ball and the grass; it acts opposite the ball's motion, an unbalanced force that slows the ball to a stop. **Q8.** Weight and the ice's support force are balanced and friction is tiny, so the forces are (nearly) balanced and the motion does not (nearly) change; no forward force is needed to keep it moving. **Q9.** The force is the same but the full trolley has more mass, and more mass means the same force gives a smaller change of motion. **Q10.** The racquet's force acts on the ball from the side/front, and the ball's change of motion points the same way as that force — the path turns. **Q11.** (a) Keep the trolley's mass the same (same trolley, no added masses) and change only the pull. (b) Keep the pull the same (same force meter reading) and change only the mass. **Q12.** (a) Balanced — equal gaps mean the motion is not changing, and no change of motion means no net force. (b) No — with balanced forces an object simply keeps moving; a forward force is not needed. **Q13.** Strip X: speeds up; the net force points the same way as the motion. Strip Y: slows down; the net force points opposite the motion. **Q14.** The ball stops because friction (an unbalanced force opposite the motion) slows it — not because push runs out. With no friction, the forces would be balanced and the ball would keep moving at the same speed in the same direction.

Fully-worked solutions

Q1. The three changes are **starting, stopping and changing direction** *(1 mark)*; speeding up and slowing down are changes along the line of motion *(1 mark)*.

Q2. Balanced forces mean no change of motion *(1 mark)*, so the object **keeps moving at the same speed in the same direction** *(1 mark)*.

Q3. With balanced forces there is no change of motion, so the object **stays at rest** *(1 mark)*.

Q4. The trial with the **bigger force** *(1 mark)*: with the mass the same, a bigger force gives a bigger change of motion *(1 mark)*.

Q5. **Trial 3**, the loaded trolley with the small force *(1 mark)* — it travels only **10 cm** in the first 2 s, the shortest distance in the table, so its motion changed least *(1 mark)*.

Q6. (a) **speeds up** *(1 mark)*. (b) **slows down** *(1 mark)*. (c) **changes direction** *(1 mark)*.

Q7. The force is **friction** between the ball and the grass *(1 mark)*, acting **opposite the ball's motion** *(1 mark)*; as an unbalanced force it slows the ball until it stops *(1 mark)*.

Q8. On ice, weight and support are balanced and friction is tiny, so the forces are **(nearly) balanced** *(1 mark)* and the motion does not (nearly) change; **no forward force is needed** to keep the puck moving *(1 mark)*.

Q9. The push is the same in both cases, but the full trolley has **more mass** *(1 mark)*, and more mass means **the same force produces a smaller change of motion** *(1 mark)* — so the full trolley only just moves.

Q10. The racquet applies a force to the ball *(1 mark)*; the ball's **change of motion points the same way as that force**, so its path turns back across the court *(1 mark)*.

Q11. (a) Keep the **mass the same** and change only the pull *(1 mark)*. (b) Keep the **pull (force meter reading) the same** and change only the mass *(1 mark)* — one thing changed at a time makes the test fair.

Q12. (a) **Balanced** — equal gaps at equal time intervals mean the motion is not changing *(1 mark)*, and no change of motion means the net force is zero *(1 mark)*. (b) **No** — balanced forces let a moving object keep moving at the same speed and direction; a forward force is not needed *(1 mark)*.

Q13. Strip X: widening gaps → **speeds up**, net force **the same way as the motion** *(1 mark)*. Strip Y: narrowing gaps → **slows down**, net force **opposite the motion** *(1 mark)*.

Q14. The ball stops because **friction, an unbalanced force opposite the motion, slows it** — there was no "push" inside the ball to run out *(1 mark)*. On perfectly smooth ice with no friction the forces would be balanced, so the ball would **keep moving at the same speed in the same direction** *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- Science ASSIST (Australian Science Teachers' Association), "What is Science ASSIST?", n.d. asta.edu.au

The investigation's results (20 cm, 52 cm, 10 cm, 26 cm) are **simulated data for practice**; the patterns they show — a bigger force on the same mass giving a bigger change of motion, and the same force on more mass giving a smaller change — are the real behaviour of objects.

Elaboration contexts used: `VC2S8U14.E01` (investigating the effects of applying different forces to familiar objects of the same mass and different masses) and `VC2S8U14.E02` (analysing the effect of balanced and unbalanced forces on an object's motion, such as starting, stopping and changing direction).

Simple machines: the lever, inclined plane, wedge, pulley, screw, and wheel and axle — altering the direction and the magnitude of a force

What we teach here — `VC2S8U13` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"simple machines, including the lever, inclined plane, wedge, pulley, screw, and wheel and axle, alter the direction and magnitude of forces"* **This subtopic owns the whole CD** — it is one of the eleven whole-CD subtopics (no † split), so everything in the CD is taught here. **In our words:** every machine, from a seesaw to a bicycle, is built from six simple ideas — the lever, the inclined plane, the wedge, the pulley, the screw, and the wheel and axle. Each one takes the force you apply and changes it: it makes the force bigger, or it turns the force around, so the job becomes easier to do. **Achievement-standard extract served here (D13):** "They demonstrate how simple machines can be used for a purpose." **Elaborations drawn on:** `VC2S8U13.E01` (evaluating different simple machines for their mechanical advantage), `VC2S8U13.E02` (designing a series of simple machines that take a specified time to move an object a specific height), `VC2S8U13.E03` (investigating how simple machines such as levers and pulleys are used to change the magnitude of force needed to perform a task), `VC2S8U13.E05` (identifying the simple machines in a complex machine such as a Rube Goldberg machine) and `VC2S8U13.E06` (designing and constructing Rube Goldberg machines that use at least 3 different simple machines to perform a specified task). **Held back under the ICIP decision (D10):** `VC2S8U13.E04` (spearthrowers and bows as levers) is reserved and is **not** taught here. **Maths interlocks (D11):** ratio (`VC2M7N09`) carries all of the mechanical-advantage work in this subtopic — every calculation is a ratio or a division. No force laws and no energy calculations are used (those belong to 15A–15B and 16A–16B). **Authored from the CD text and the elaboration contexts (D12):** the CD names the six machines and the two changes they make (direction and magnitude); the worked numbers, the investigation and the design tasks are authored fresh from the elaboration contexts above.

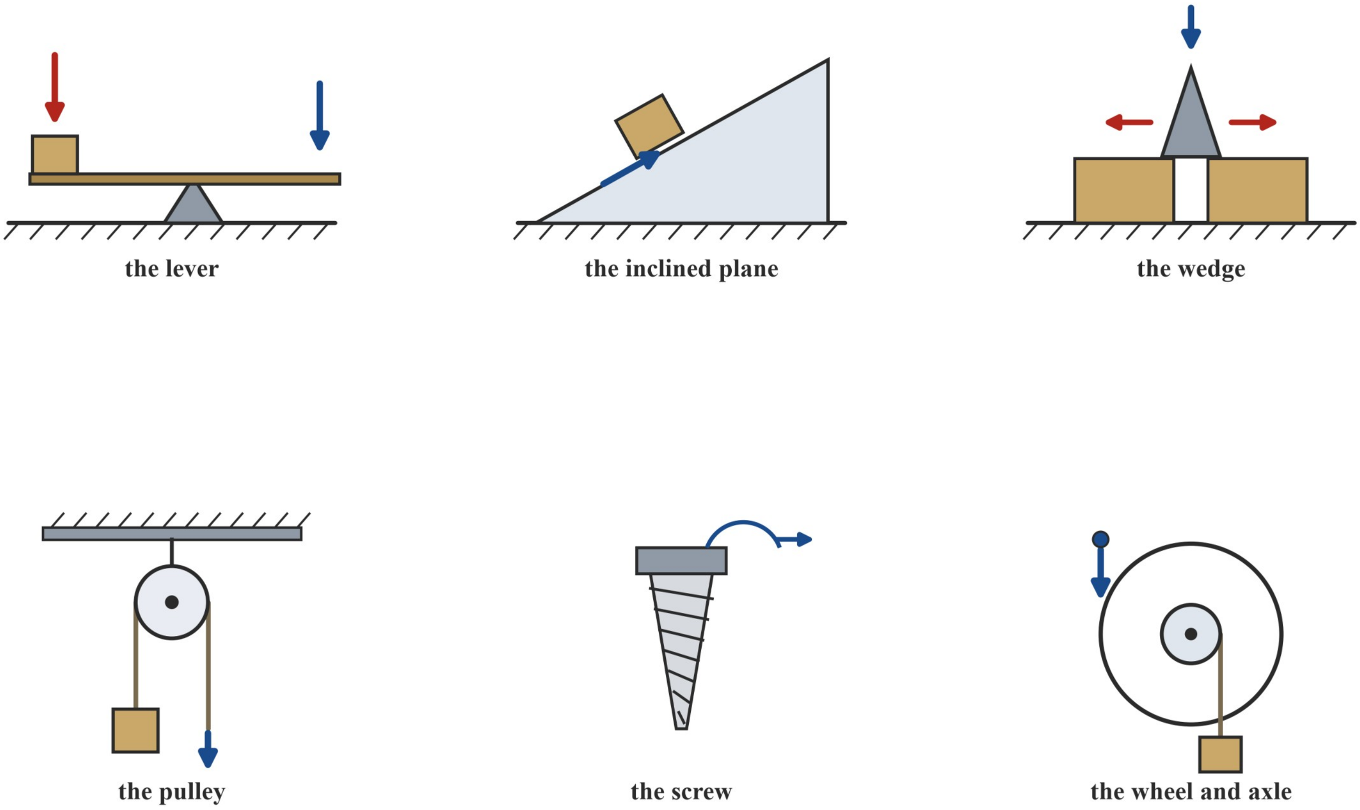
Word watch — *load* and *effort*. Every machine in this subtopic is described with the same two words. The **load** is the force the machine must overcome — the weight of the crate, the bucket, the rock. The **effort** is the force *you* apply to the machine. In every figure in this subtopic, the effort arrow is drawn blue and the load arrow is drawn red, pointing down the way gravity pulls. A machine does its job when the effort you give is smaller than the load it moves — or when it sends your push in a more useful direction.

Word watch — a machine never gives you something for nothing. A machine can make the needed force smaller, but it always asks for that smaller force over a *longer* distance. Push a crate up a long ramp and the push is gentle but the distance is long; lift it straight up and the distance is short but the force is big. The machine changes the size and the direction of the force — it never removes the job.

Theory

The six simple machines

Almost every machine ever built — from a pair of scissors to a crane — uses only six simple ideas.



Six pictograms, one for each simple machine: a lever as a bar on a pivot with a load block at one end and a push at the other; an inclined plane as a ramp with a block being pushed up it; a wedge as a pointed blade pushed down between two blocks that move apart; a pulley as a wheel on a beam with a rope over it; a screw as a threaded rod with a turning arrow; and a wheel and axle as a big wheel with a small axle lifting a load on a rope

- **the lever** — a rigid bar that turns about a pivot (the fulcrum)
- **the inclined plane** — a ramp that lets you raise a load with a smaller push over a longer way
- **the wedge** — a moving double inclined plane that turns one push into two sideways forces
- **the pulley** — a wheel on an axle with a rope running over it
- **the screw** — an inclined plane wrapped around a rod
- **the wheel and axle** — a big wheel fixed to a small axle so both turn together

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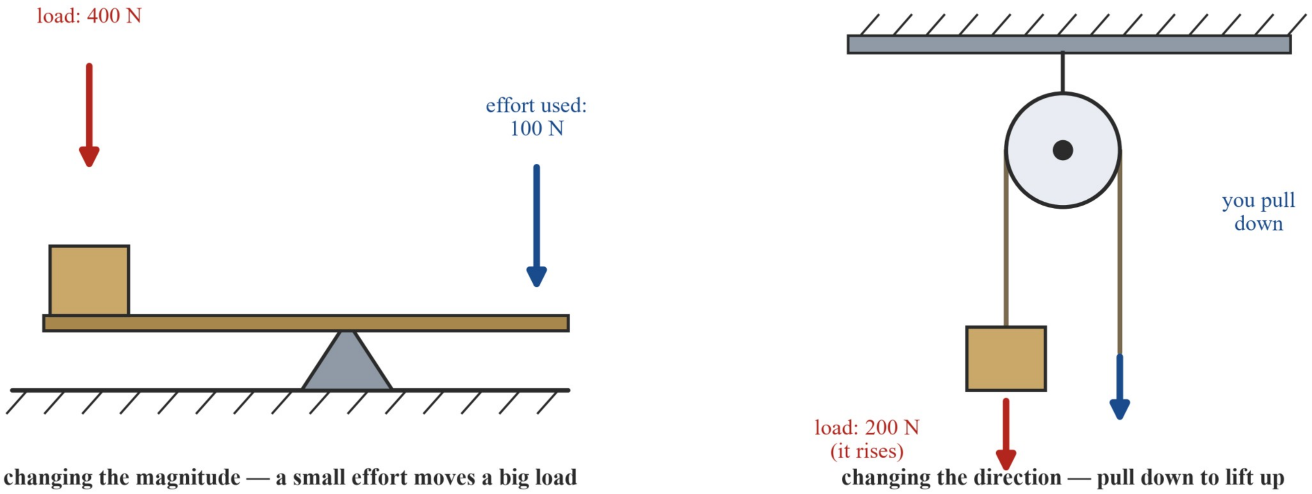
What every machine changes

A machine changes a force in one or both of two ways: it changes the **magnitude** (the size) of the force, or it changes the **direction** of the force.



changing the magnitude — a small effort moves a big load **changing the direction — pull down to lift up**

Two panels. Left: a lever with a 400 N load arrow pointing down at one end and a 100 N effort arrow pointing down at the far end, captioned changing the magnitude — a small effort moves a big load. Right: a fixed pulley with a 200 N load on one side of the rope and a person pulling down on the other side, captioned changing the direction — pull down to lift up

- **Changing the magnitude.** A small effort of 100 N lifts a 400 N load when the machine multiplies your force 4 times.
- **Changing the direction.** Your pull *down* on the rope becomes an upward lift on the load, because the rope runs over the pulley. Pulling down is easier than lifting up — your own weight helps you pull.

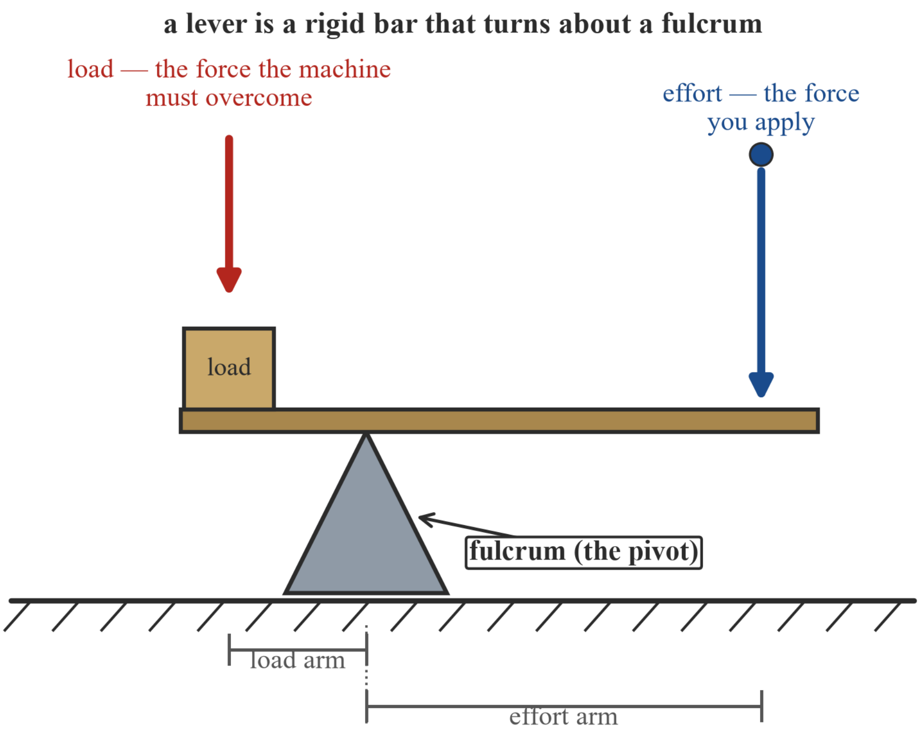
The size of the multiply is called the **mechanical advantage** (MA):

mechanical advantage = load force ÷ effort force

A machine with MA = 4 turns a 100 N effort into a 400 N lift. If a machine only changes the direction (like a single fixed pulley), its MA is 1.

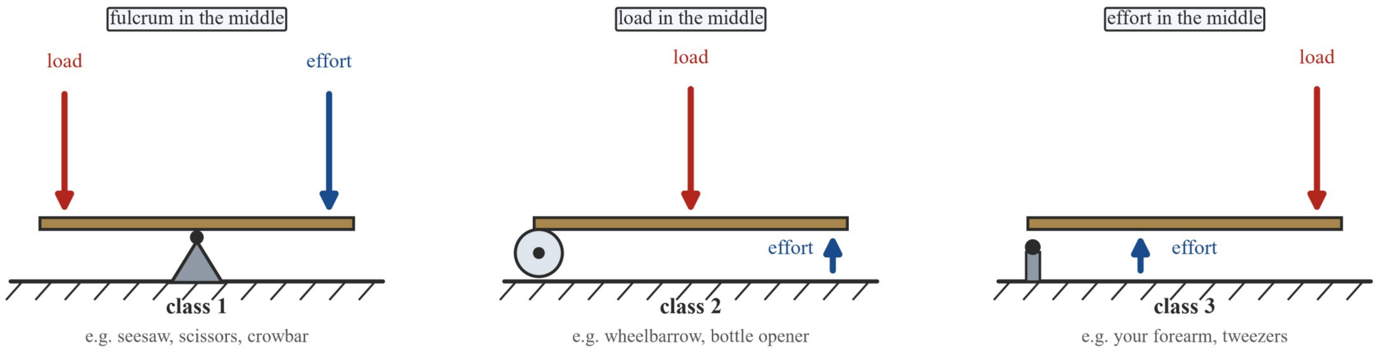
The lever — a bar and a pivot

A **lever** is a rigid bar that turns about a fixed pivot called the **fulcrum**. The distance from the fulcrum to where the load presses is the **load arm**; the distance from the fulcrum to where the effort is applied is the **effort arm**.



A first-class lever labelled in full: a load block pressing down on the short side, a blue effort arrow pressing down on the long side, the fulcrum triangle between them, and dimension lines marking the load arm and the effort arm

Levers come in three classes, named by what sits in the middle:

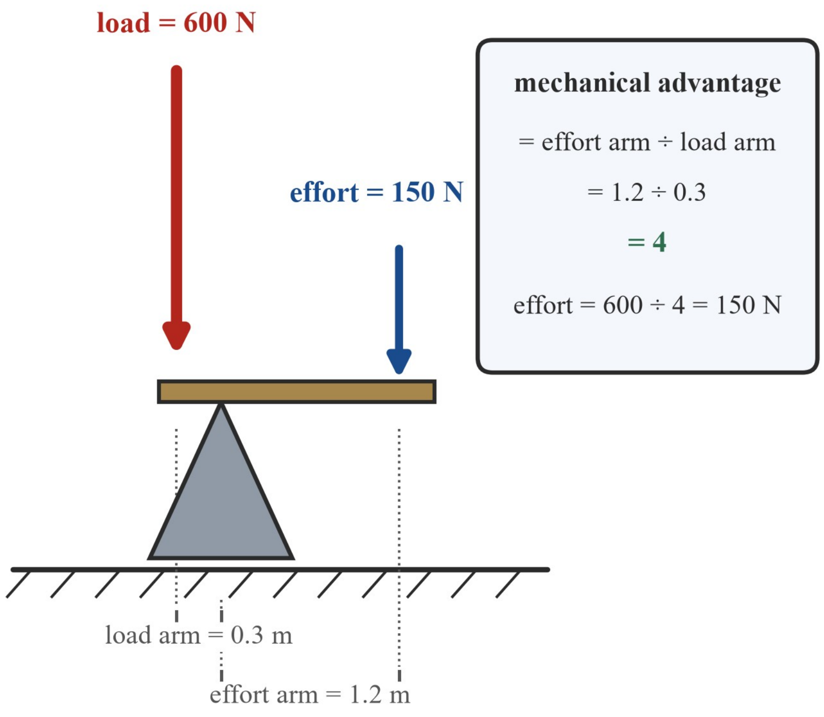


Three panels. Class 1: the fulcrum in the middle with the load and the effort at the two ends, as in a seesaw. Class 2: the pivot at one end, the load in the middle and the effort lifting the far end, as in a wheelbarrow. Class 3: the pivot at one end, the effort applied in the middle and the load at the far end, as in your forearm

- **Class 1 — fulcrum in the middle:** seesaw, scissors, crowbar.
- **Class 2 — load in the middle:** wheelbarrow, bottle opener. The effort arm is always longer than the load arm, so a class 2 lever always multiplies force (MA greater than 1).
- **Class 3 — effort in the middle:** your forearm, tweezers. The effort arm is shorter than the load arm, so the force is *not* multiplied — what you gain is reach and speed at the far end.

The lever maths (`VC2M7N09`). For a lever, the mechanical advantage is the ratio of the arms:

mechanical advantage = effort arm ÷ load arm



A worked lever drawn to scale: a 600 N load arrow 0.3 m from the fulcrum and a 150 N effort arrow 1.2 m from the fulcrum, with a panel showing mechanical advantage = effort arm ÷ load arm = 1.2 ÷ 0.3 = 4, and effort = 600 ÷ 4 = 150 N

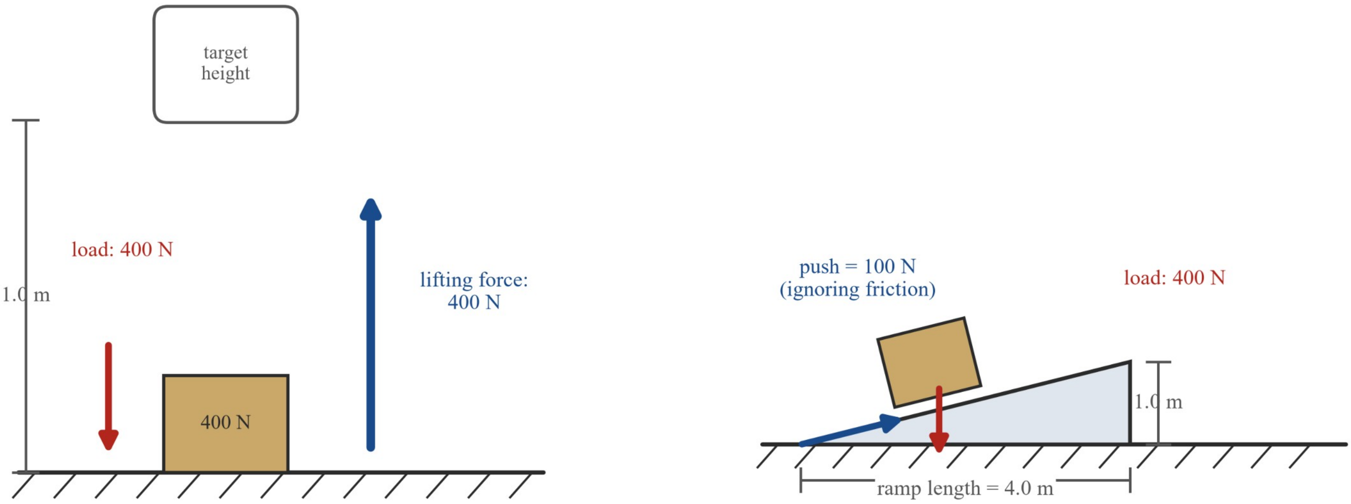
Because the effort arm (1.2 m) is 4 times the load arm (0.3 m), the MA is 4, and the effort needed is the load divided by 4: 600 ÷ 4 = 150 N. The price is the distance rule from the word watch: the effort end moves 4 times as far as the load end.

Investigation — how a lever changes the force needed (`VC2S8U13.E03`)

- **Equipment:** a metre ruler as the beam, a triangular block as the fulcrum, two force meters (spring balances), and a hook to hang one force meter as the load.
- **Method:** rest the ruler on the fulcrum. Hang the load force meter 10 cm from the fulcrum and record its reading. Hook the effort force meter 40 cm from the fulcrum, pull straight down until the beam just balances, and record the effort. Repeat with the effort at 20 cm and at 50 cm.
- **Results to compare:** for each run, compare effort arm ÷ load arm with load force ÷ effort force. The two ratios match (within reading error): the longer the effort arm, the smaller the effort needed for the same task.
- **Risk:** a low-risk activity, run with the risk-management guidance from Science ASSIST (see Sources): wear safety glasses as for any lab work, keep the masses low so nothing falls far, and clamp or hold the fulcrum so the beam cannot slide off the bench.

The inclined plane — the ramp

Lifting a 400 N crate straight up onto a 1.0 m platform takes a 400 N lift. Pushing the same crate up a 4.0 m ramp to the same height takes only a 100 N push (ignoring friction).



lifting straight up takes the full 400 N | **MA = 4.0 ÷ 1.0 = 4, so the push is 400 ÷ 4 = 100 N**

Two panels at the same scale. Left: a 400 N crate lifted straight up 1.0 m, with a red load arrow down and a blue lifting-force arrow up, both 400 N. Right: the same crate pushed up a ramp 4.0 m long and 1.0 m high with a 100 N push along the slope and a red load arrow down, captioned MA = 4.0 ÷ 1.0 = 4, so the push is 400 ÷ 4 = 100 N

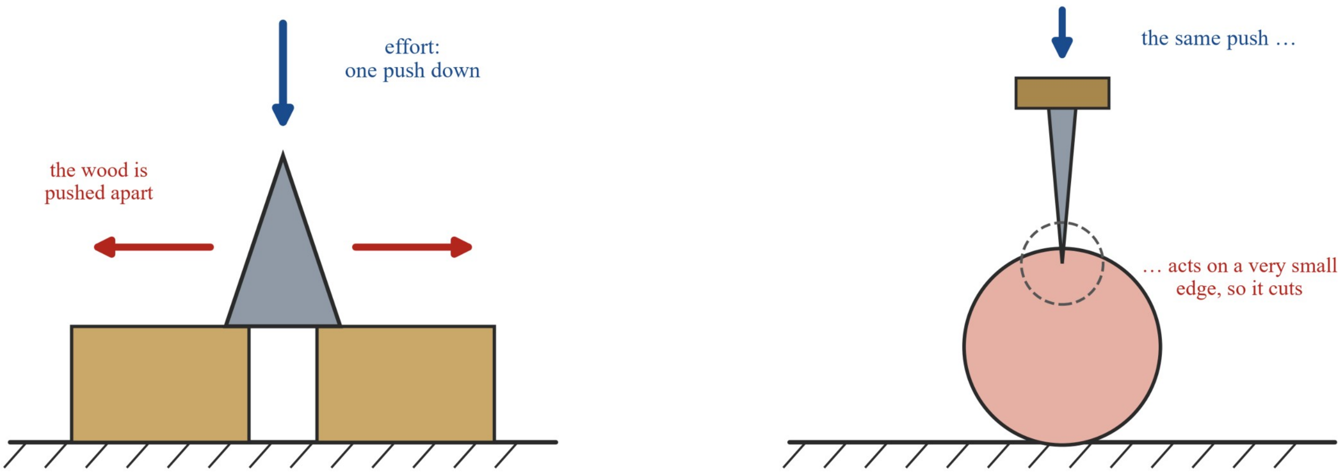
For a ramp, the mechanical advantage is the ratio of its length to its height:

mechanical advantage = ramp length ÷ height

The 4.0 m ramp is 4 times as long as it is high, so MA = 4 and the push is 400 ÷ 4 = 100 N. The distance rule again: the crate travels 4.0 m along the slope to rise 1.0 m. A longer, gentler ramp has a bigger MA; a short, steep ramp has a smaller one. Friction always makes the real push a little bigger than the ideal value, which is why ramp surfaces are kept smooth and loads are put on wheels or rollers where possible.

The wedge — a moving ramp

A **wedge** is two inclined planes joined back to back. Where a ramp stays still and the load moves along it, a wedge *moves*: the wedge is driven in, and the material is pushed apart.



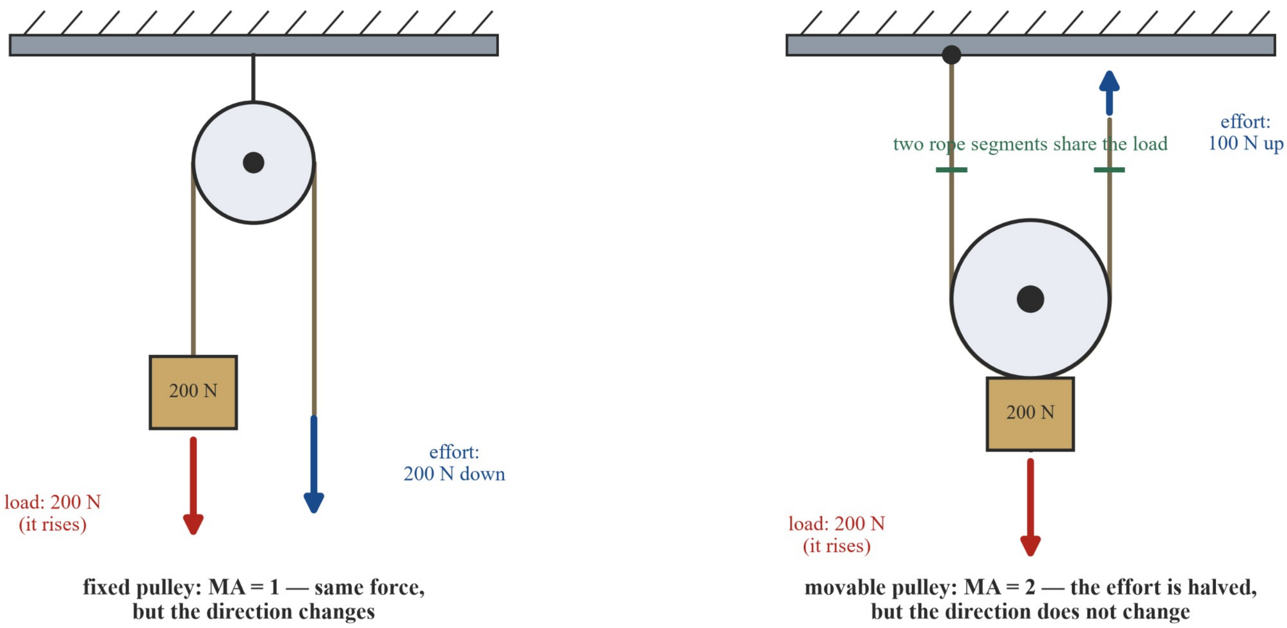
a wedge turns one force into two sideways forces | **a sharp edge concentrates the force onto a tiny area**

Two panels. Left: a wedge driven down between two blocks of wood, with a blue effort arrow down and two red arrows pushing the blocks apart, captioned a wedge turns one force into two sideways forces. Right: a knife edge on an apple with the thin tip circled, captioned a sharp edge concentrates the force onto a tiny area

The wedge changes a force in two ways at once: it turns one downward push into two strong sideways forces, and its thin edge concentrates the push onto a very small area. That is why the same push that does nothing with a blunt edge cuts cleanly with a sharp one — axes, knives, nails and pins are all wedges. The thinner the wedge (the longer it is for its width), the greater its mechanical advantage.

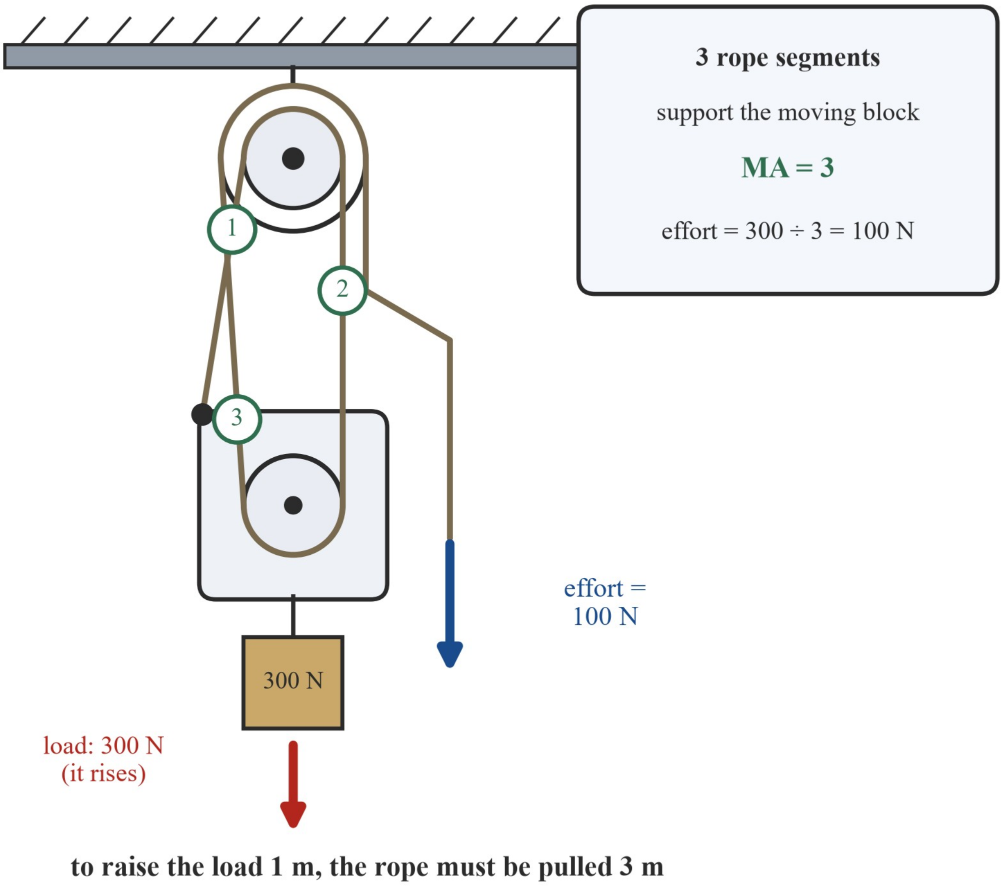
The pulley — changing direction, then changing size

A **fixed pulley** is tied to a beam and only changes the direction of the force: pull down 200 N and the 200 N load rises. Its MA is 1. A **movable pulley** rides up with the load: the load hangs from the pulley, and *two* segments of rope share the load, so the effort is halved and MA = 2.



Two panels. Left: a fixed pulley on a beam with a 200 N load on one side of the rope and a 200 N downward effort on the other, captioned fixed pulley: MA = 1 — same force, but the direction changes. Right: a movable pulley with the rope anchored to the beam, two rope segments marked as sharing a 200 N load, and a 100 N upward effort, captioned movable pulley: MA = 2 — the effort is halved, but the direction does not change

Pulleys can be combined into a **block and tackle**: a fixed block of two wheels above and a moving block below. Count the rope segments that support the moving block — here there are 3 — and that count is the mechanical advantage.



A block and tackle: a fixed double pulley on a beam above and a moving single pulley below carrying a 300 N load; the rope is anchored to the moving block and threads over, under and over, with the three supporting rope segments numbered 1, 2 and 3; the free end is pulled down with a 100 N effort; a panel reads 3 rope segments support the moving block, MA = 3, effort = 300 ÷ 3 = 100 N, and the caption notes that to raise the load 1 m the rope must be pulled 3 m

With MA = 3, a 100 N effort holds a 300 N load — and the distance rule shows plainly: to raise the load 1 m, each of the 3 supporting segments must shorten by 1 m, so 3 m of rope is pulled.

mechanical advantage of a pulley system = number of rope segments supporting the moving block

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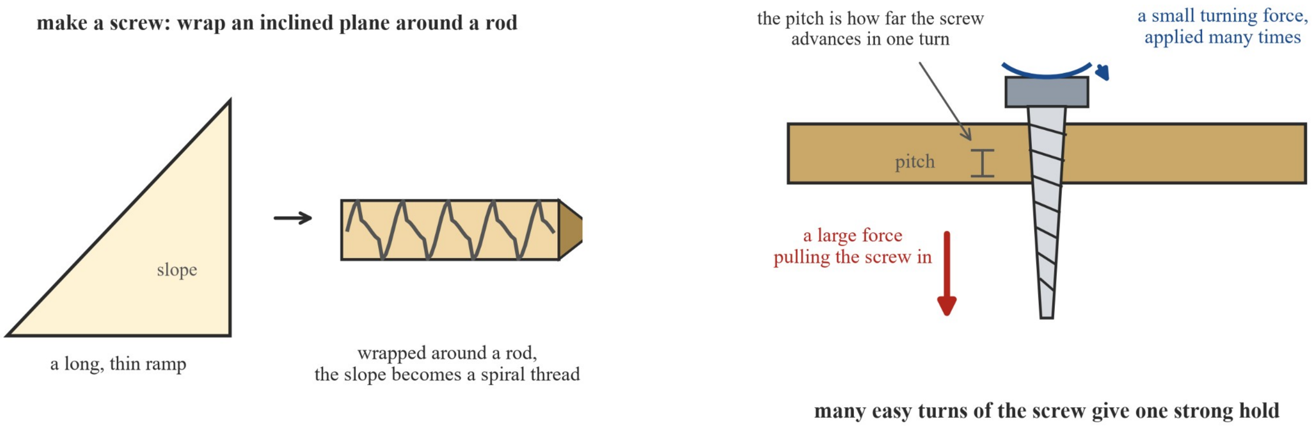
The screw — a ramp wrapped around a rod

Wrap the long, thin ramp of an inclined plane around a rod and the slope becomes a spiral thread: a **screw**.

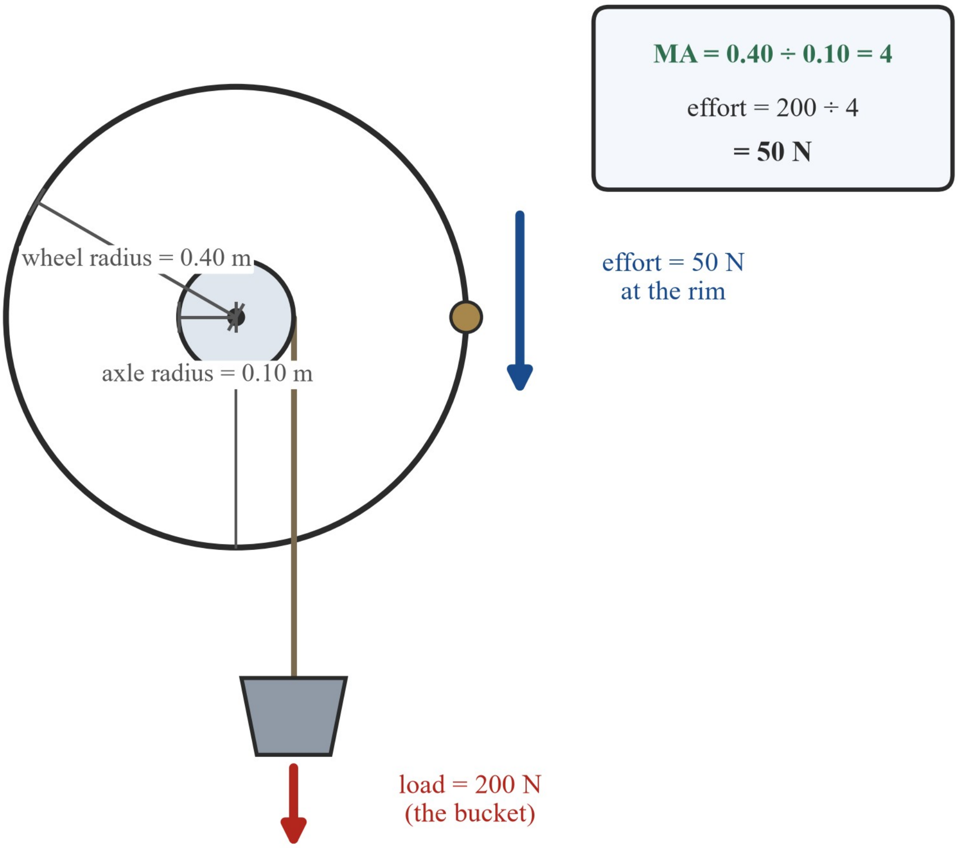


Two panels. Left: a triangle labelled a long thin ramp, an arrow, and the same triangle wrapped around a pencil so the slope becomes a spiral thread, captioned make a screw: wrap an inclined plane around a rod. Right: a screw through a timber plank with a turning arrow at the head, the pitch marked as the distance between neighbouring threads, a red arrow showing the large force pulling the screw in, and the caption many easy turns of the screw give one strong hold

One full turn of the screw drives it in by only one **pitch** — the distance from one thread to the next. Your small turning force acts over the long circle your hand travels, while the screw advances a tiny way, so the machine multiplies the force greatly. That is why a screw grips timber so hard, and why a jar lid with a fine thread (a small pitch) can grip so well. The smaller the pitch for a given thickness, the greater the mechanical advantage.

The wheel and axle — turning force into lifting force

A **wheel and axle** is a big wheel fixed to a small axle so that both turn together, as in the handle of an old well: the rope to the bucket winds onto the axle, and the hand pushes at the rim of the wheel.



door handles, steering wheels and pedal cranks are wheel-and-axle machines

A wheel and axle drawn to scale: a wheel of radius 0.40 m with a handle at the rim where a 50 N effort is applied, and an axle of radius 0.10 m with a rope down to a 200 N bucket; a panel shows MA = 0.40 ÷ 0.10 = 4 and effort = 200 ÷ 4 = 50 N; the caption notes that door handles, steering wheels and pedal cranks are wheel-and-axle machines

mechanical advantage = wheel radius ÷ axle radius

Here 0.40 ÷ 0.10 = 4, so a 50 N effort at the rim holds the 200 N bucket. The hand travels 4 times as far as the bucket rises — the distance rule once more. Door handles, steering wheels, winches and pedal cranks are all wheel-and-axle machines.

Comparing machines — evaluating mechanical advantage (`VC2S8U13.E01`)

The four worked machines above, side by side:

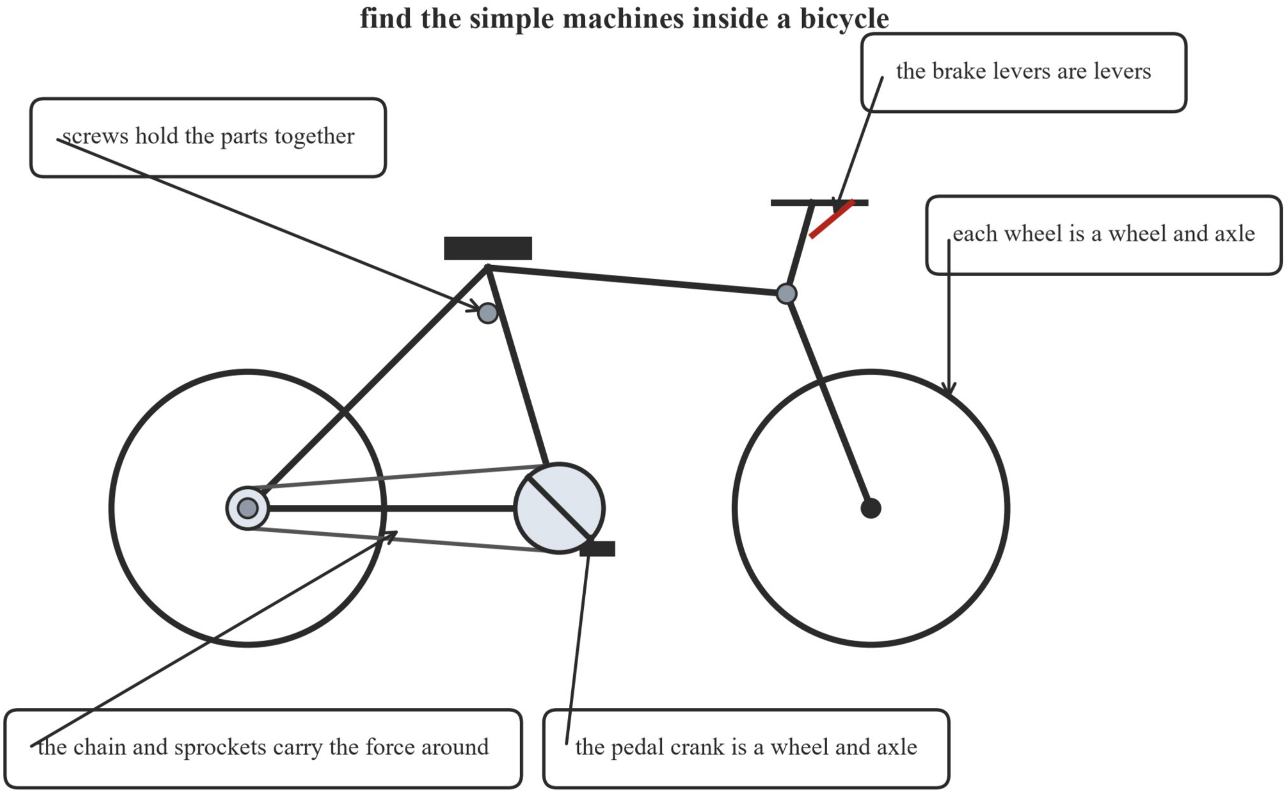
Machine	Load	Effort	MA = load ÷ effort
lever (1.2 m and 0.3 m arms)	600 N	150 N	4
ramp (4.0 m long, 1.0 m high)	400 N	100 N	4
block and tackle (3 segments)	300 N	100 N	3
wheel and axle (0.40 m and 0.10 m)	200 N	50 N	4

(Values chosen for practice.)

Evaluating them: the lever, the ramp and the wheel and axle each multiply the effort 4 times, while this block and tackle multiplies it only 3 times — but the tackle also changes the direction of the effort (pull down, load up), which the ramp does not. The best machine for a job is not always the one with the biggest MA: a bigger MA means a longer effort distance, and sometimes direction, reach or speed matters more (as a class 3 lever shows).

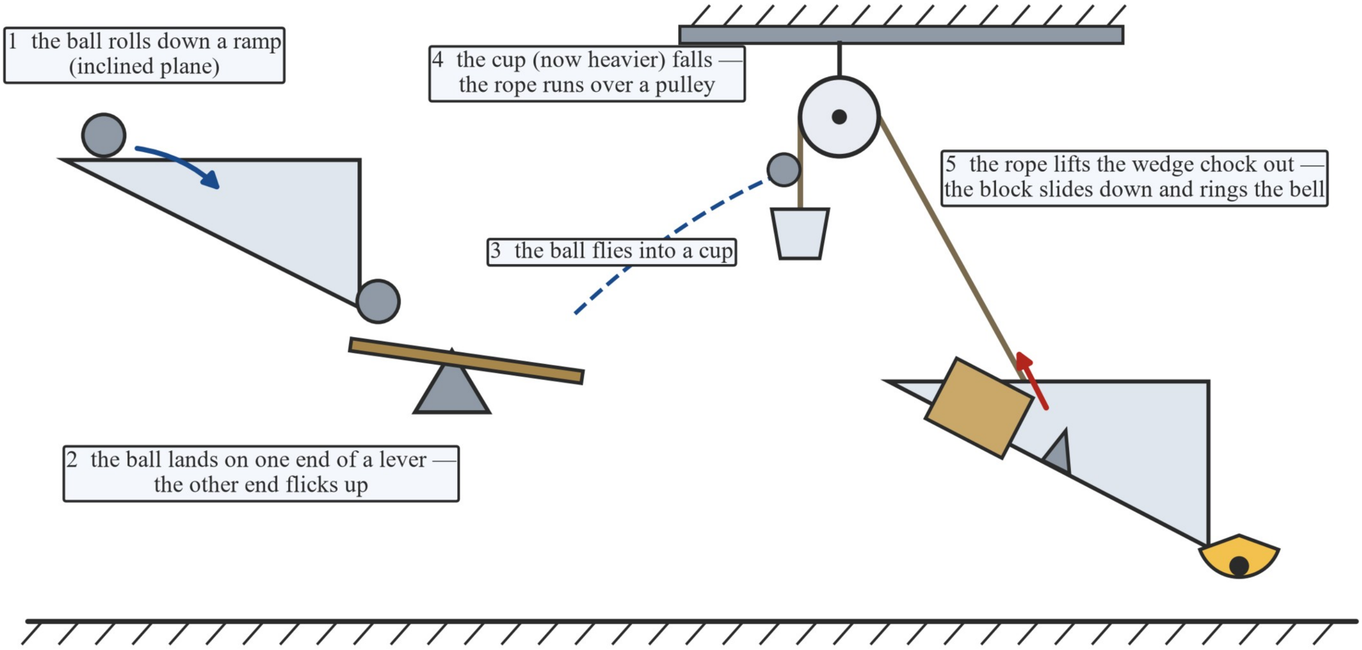
Machines inside machines (`VC2S8U13.E05`)

A complex machine is simple machines joined together. A bicycle hides several at once.



A labelled bicycle: callouts mark the brake levers as levers, each wheel as a wheel and axle, the pedal crank as a wheel and axle, the bolts as screws holding the parts together, and the chain and sprockets as the parts that carry the force around

The pedal crank is a wheel and axle (the foot pushes at the rim of the circle the pedal makes); the brake lever is a lever; each wheel is a wheel and axle about its hub; and screws hold the parts together. Even a **Rube Goldberg machine** — a comic chain reaction — is only simple machines in a row, each one passing its output on as the next one's input.



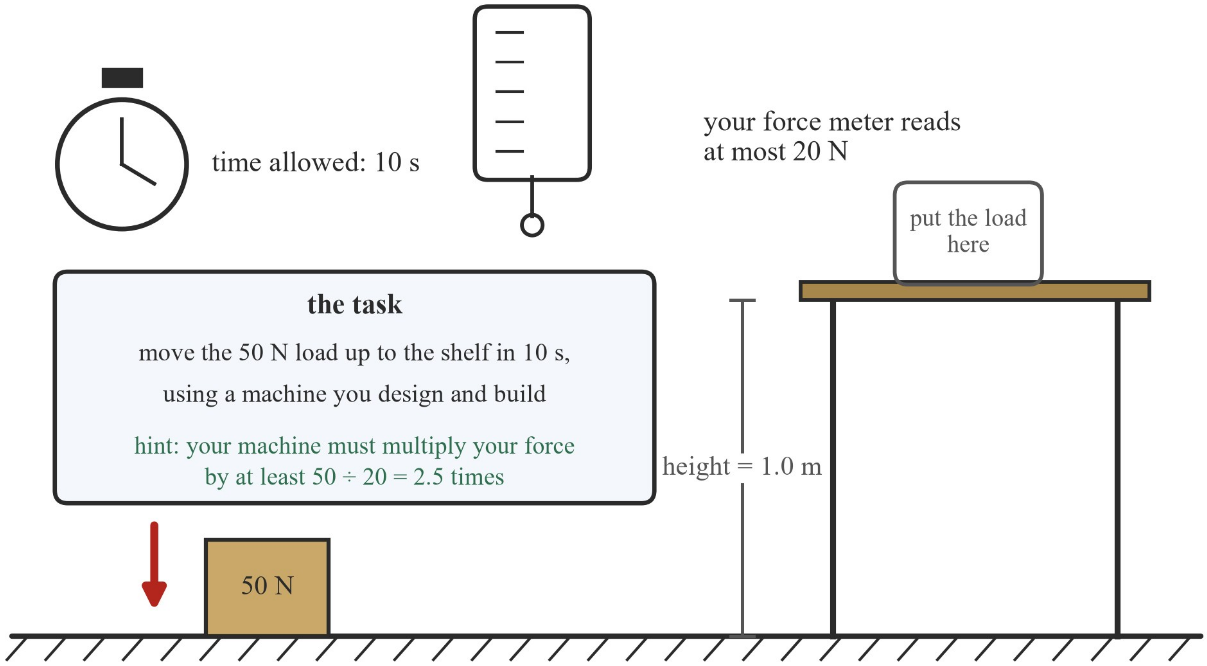
simple machines used: inclined plane (twice), lever, pulley, wedge

A five-step chain-reaction machine: 1 a ball rolls down a ramp (inclined plane); 2 the ball lands on one end of a lever and the other end flicks up; 3 the ball flies into a cup; 4 the cup, now heavier, falls as the rope runs over a pulley; 5 the rope lifts a wedge chock out, a block slides down a second ramp and rings a bell; the caption lists the simple machines used: inclined plane (twice), lever, pulley, wedge

Build a Rube Goldberg machine (`VC2S8U13.E06`)

- **The task:** in a small group, design and construct a chain-reaction machine that uses **at least three different simple machines** to perform a specified task — for example, ringing a desk bell or dropping a paper cup into a bin.
- **Plan first:** sketch the machine and label every simple machine in it, the way the figure above labels its five steps. Check each step: what is the load of this machine, and what is the effort that the previous step supplies?
- **Risk:** a low-risk activity, run with the risk-management guidance from Science ASSIST (see Sources): wear safety glasses as for any lab work, keep balls and rolling parts off the walkways so nobody slips, and use scissors and cutting tools with care.

Design challenge — move a load in a specified time (`VC2S8U13.E02`)



The design brief as a scene: a 50 N load crate on the floor with a red load arrow, a shelf 1.0 m high marked put the load here, a stopwatch marked time allowed: 10 s, a force meter marked your force meter reads at most 20 N, and a task panel reading move the 50 N load up to the shelf in 10 s using a machine you design and build, with the hint your machine must multiply your force by at least 50 ÷ 20 = 2.5 times

- **The brief:** move the 50 N load up to the shelf (a rise of 1.0 m) within 10 s, while the force meter you pull with never reads more than 20 N.
- **The ratio that rules the design:** the machine must multiply your force by at least 50 ÷ 20 = 2.5, so its MA must be 2.5 or more.
- **Options to compare:** a ramp at least 2.5 times as long as it is high (for example 3.0 m long and 1.0 m high, MA = 3); a lever with the effort arm at least 2.5 times the load arm; or a block and tackle with 3 supporting segments (MA = 3).
- **Series of machines:** for a harder version, join two machines in series — a lever handing its output to a pulley system, say — and the total MA is the first MA multiplied by the second (2 × 2 = 4, comfortably above 2.5).

Words to know in 15C

Word	What it means here
simple machine	one of the six basic force-changers: lever, inclined plane, wedge, pulley, screw, wheel and axle
load	the force the machine must overcome
effort	the force you apply to the machine
fulcrum	the fixed pivot a lever turns about
effort arm / load arm	the distances from the fulcrum to the effort and to the load
mechanical advantage (MA)	load force ÷ effort force; how many times the machine multiplies your force
inclined plane	a ramp that raises a load with a smaller push over a longer way
wedge	a moving double inclined plane that turns one push into

Word	What it means here
	two sideways forces
pulley	a wheel on an axle with a rope running over it; fixed (MA = 1) or movable (MA = 2)
block and tackle	pulleys combined so several rope segments share the load
screw	an inclined plane wrapped around a rod
pitch	how far a screw advances in one full turn
wheel and axle	a big wheel fixed to a small axle, turning together

Worked examples

Example 1 — scaffolded

A crowbar is used as a lever. The load arm is 0.2 m and the effort arm is 1.0 m. The load (a heavy rock pressing down) is 500 N. Work out the effort needed to just lift the rock.

Working	Comment
1. MA = effort arm ÷ load arm = 1.0 ÷ 0.2 = 5	The lever multiplies the effort 5 times (`VC2M7N09`).
2. effort = load ÷ MA = 500 ÷ 5	The effort is the load divided by the multiply.
3. effort = 100 N	∴ a 100 N push lifts the 500 N rock.

Example 2 — scaffolded

A block and tackle has 4 rope segments supporting the moving block. It is used to raise a 360 N engine part. (a) State the mechanical advantage. (b) Calculate the effort. (c) How much rope is pulled to raise the part 0.5 m?

Working	Comment
(a) MA = 4	The MA of a pulley system is the number of supporting segments.
(b) effort = 360 ÷ 4 = 90 N	effort = load ÷ MA.
(c) rope = 4 × 0.5 = 2.0 m	The distance rule: the effort moves MA times as far as the load.

Example 3 — unscaffolded

A ramp 5.0 m long rises 1.0 m. A 450 N crate is pushed up it at steady speed, and friction is small. Explain, with numbers, why the push is much smaller than 450 N, and state the size of the push.

MA = ramp length ÷ height = 5.0 ÷ 1.0 = 5, so the ramp multiplies the push 5 times. The push is load ÷ MA = 450 ÷ 5 = 90 N. ∴ the ramp changes the magnitude of the needed force from 450 N to 90 N, at the price of pushing over 5.0 m instead of lifting through 1.0 m.

Example 4 — unscaffolded

A flagpole uses a single fixed pulley at the top. The flag has a weight of 12 N. State the effort needed to raise the flag at steady speed, and explain what the pulley is for if it does not multiply the force.

With a fixed pulley MA = 1, so the effort equals the load: 12 N. The pulley is still useful because it changes the **direction** of the force: the flag rises while the person pulls *down*, which is far easier to do from the ground than climbing up and lifting.

Practice questions

Scaffolded

Q1. Name the six simple machines.

Q2. A lever has a load arm of 0.3 m and an effort arm of 0.9 m. (a) Calculate its mechanical advantage. (b) Calculate the effort needed to lift a 270 N load.

Q3. A ramp 3.0 m long rises 0.5 m. (a) Calculate the MA of the ramp. (b) Calculate the push needed (ignoring friction) to move a 480 N crate up it.

Q4. A single movable pulley is used to lift a 160 N bag. (a) State the MA. (b) Calculate the effort. (c) State one thing this pulley does *not* change.

Q5. A winch handle turns a wheel of radius 0.50 m on an axle of radius 0.10 m. (a) Calculate the MA. (b) Calculate the effort that holds a 250 N load.

Q6. The table below lists two machines offered for a job. Complete the MA column.

Machine	Load	Effort	MA
ramp A	400 N	100 N	?
ramp B	400 N	200 N	?

Unscaffolded

Q7. A delivery driver pushes a barrel up a plank into the back of a truck instead of lifting it straight up. Explain, using the ideas of this subtopic, why the plank makes the job easier, and state what the driver gives in return.

Q8. A wheelbarrow is a class 2 lever with the wheel as the fulcrum, the load in the tray in the middle, and the effort at the handles. Explain why a wheelbarrow always has MA greater than 1.

Q9. Compare a single fixed pulley and a single movable pulley lifting the same 200 N load. State the effort for each, and state what each pulley changes (direction, magnitude, or both).

Q10. A screw is described as “an inclined plane wrapped around a rod”. Use that idea to explain why many easy turns of a screwdriver produce a very strong hold in timber.

Q11. An axe splits a log. Explain, using the wedge, how the one downward swing becomes the forces that part the wood, and why a sharper axe splits more easily.

Q12. You must lift a 60 N load, and your force meter reads at most 20 N. (a) Show that your machine needs MA of at least 3. (b) Describe one machine from this subtopic that meets the need, with numbers to back it up.

Q13. Name two simple machines hidden in a bicycle and state what each one does there.

Q14. Two ramps both rise 1.0 m: ramp P is 4.0 m long and ramp Q is 2.0 m long. The same 400 N crate is pushed up each (ignore friction). (a) Calculate the MA of each ramp. (b) Calculate the push on each. (c) State which ramp needs the push applied over the longer distance, and give that distance.

Answers

Q1. The lever, the inclined plane, the wedge, the pulley, the screw, and the wheel and axle. **Q2.** (a) 0.9 ÷ 0.3 = 3. (b) 270 ÷ 3 = 90 N. **Q3.** (a) 3.0 ÷ 0.5 = 6. (b) 480 ÷ 6 = 80 N. **Q4.** (a) 2. (b) 160 ÷ 2 = 80 N. (c) The direction — the effort still pulls upward, the same way the load must move. **Q5.** (a) 0.50 ÷ 0.10 = 5. (b) 250 ÷ 5 = 50 N. **Q6.** Ramp A: 400 ÷ 100 = 4. Ramp B: 400 ÷ 200 = 2. **Q7.** The plank is an inclined plane: its length is several times its height, so the push along the plank is several times smaller than the lift straight up. In return, the driver pushes over the longer distance of the plank. **Q8.** In a class 2 lever the effort is farther from the fulcrum than the load is, so the effort arm is longer than the load arm; MA = effort arm ÷ load arm is therefore always greater than 1. **Q9.** Fixed pulley: effort 200 N (MA = 1) — changes direction only. Movable pulley: effort 100 N (MA = 2) — changes magnitude only (the effort still pulls up). **Q10.** Each turn of the screw is the effort moving around the long wrapped ramp while the screw advances only one small pitch; the small turning force is multiplied into a large pulling force, so the thread grips the timber hard. **Q11.** The axe head is a wedge: the one downward force becomes two strong sideways forces that push the wood apart. A sharper axe is a thinner wedge, so it has a greater MA and parts the wood with a smaller swing. **Q12.** (a) MA needed = load ÷ biggest effort = 60 ÷ 20 = 3. (b) Any machine with MA ≥ 3, for example a ramp 3.0 m long rising 1.0 m (MA = 3), or a lever with effort arm 1.2 m and load arm 0.4 m (MA = 3), or a block and tackle with 3 supporting segments. **Q13.** Any two of: the brake lever (a lever — a small hand force gives a strong pull on the brake); the pedal crank (a wheel and axle — the foot force at the rim turns the chain wheel); each wheel (a wheel and axle about its hub); the bolts (screws holding parts together). **Q14.** (a) P: 4.0 ÷ 1.0 = 4; Q: 2.0 ÷ 1.0 = 2. (b) P: 400 ÷ 4 = 100 N; Q: 400 ÷ 2 = 200 N. (c) Ramp P — the push of 100 N is applied over 4.0 m.

Fully-worked solutions

Q1. The six simple machines are **the lever, the inclined plane, the wedge, the pulley, the screw, and the wheel and axle** *(1 mark)*.

Q2. (a) MA = effort arm ÷ load arm = 0.9 ÷ 0.3 *(1 mark)* = **3** *(1 mark)*. (b) effort = load ÷ MA = 270 ÷ 3 *(1 mark)* = **90 N** *(1 mark)*.

Q3. (a) MA = length ÷ height = 3.0 ÷ 0.5 *(1 mark)* = **6** *(1 mark)*. (b) push = 480 ÷ 6 *(1 mark)* = **80 N** *(1 mark)*.

Q4. (a) A single movable pulley has **MA = 2** — two rope segments share the load *(1 mark)*. (b) effort = 160 ÷ 2 = **80 N** *(1 mark)*. (c) It does not change the **direction** — the effort pulls up, the same way the load moves *(1 mark)*.

Q5. (a) MA = wheel radius ÷ axle radius = 0.50 ÷ 0.10 *(1 mark)* = **5** *(1 mark)*. (b) effort = 250 ÷ 5 *(1 mark)* = **50 N** *(1 mark)*.

Q6. MA = load ÷ effort: ramp A = 400 ÷ 100 = **4** *(1 mark)*; ramp B = 400 ÷ 200 = **2** *(1 mark)*.

Q7. The plank is an **inclined plane**; because the plank is several times as long as the tray is high, the push along it is **several times smaller than lifting the barrel straight up** *(1 mark)*. In return, the driver must push over **the longer distance of the plank** — the machine changes the size of the force, not the size of the job *(1 mark)*.

Q8. In a wheelbarrow the **effort at the handles is farther from the fulcrum (the wheel) than the load in the tray**, so the effort arm is longer than the load arm *(1 mark)*; MA = effort arm ÷ load arm is therefore **always greater than 1** — the lift at the handles is smaller than the weight in the tray *(1 mark)*.

Q9. Fixed pulley: MA = 1, so the effort is **200 N**, and it changes **direction only** (pull down, load up) *(1 mark)*. Movable pulley: MA = 2, so the effort is **200 ÷ 2 = 100 N**, and it changes **magnitude only** — the effort still pulls upward *(1 mark)*.

Q10. The thread is a **long ramp wrapped around the rod**; each turn, the effort travels the long way around while the screw advances only **one small pitch** *(1 mark)*; so the small turning force is **multiplied into a large force pulling the screw in**, which is why the hold is so strong *(1 mark)*.

Q11. The axe head is a **wedge**: the one downward force of the swing becomes **two strong sideways forces** that push the wood apart *(1 mark)*; a sharper axe is a **thinner wedge with a greater MA**, so the same swing parts the wood more easily *(1 mark)*.

Q12. (a) MA needed = load ÷ effort = 60 ÷ 20 *(1 mark)* = **3**, so the machine must have MA of at least 3 *(1 mark)*. (b) For example a **ramp 3.0 m long rising 1.0 m**: MA = 3.0 ÷ 1.0 = 3 *(1 mark)*, giving a push of 60 ÷ 3 = **20 N**, which the meter can read *(1 mark)*.

Q13. Any two, each with its job: the **brake lever — a lever** that turns a small hand force into a strong pull on the brake *(1 mark)*; the **pedal crank — a wheel and axle** that turns the foot force at the rim into the turning of the chain wheel *(1 mark)*. (Also acceptable: each wheel as a wheel and axle; the bolts as screws.)

Q14. (a) MA of P = 4.0 ÷ 1.0 = **4**; MA of Q = 2.0 ÷ 1.0 = **2** *(1 mark)*. (b) Push on P = 400 ÷ 4 = **100 N**; push on Q = 400 ÷ 2 = **200 N** *(1 mark)*. (c) **Ramp P**, where the smaller push is applied over the longer distance of **4.0 m** *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-21.

- Science ASSIST (Australian Science Teachers' Association), "Risk management", n.d. asta.edu.au

Curriculum authority: `S:\Files\projects\mcq-system\data\vc2_books\science_7-8.json`, content description `VC2S8U13` and elaborations `VC2S8U13.E01–E06`, read in full 2026-08-07. Elaboration `VC2S8U13.E04` is held back under the ICIP decision (D10) and is not taught here.

All forces, lengths and mechanical advantages in the figures, tables, examples and questions are **authored practice values, chosen so that every calculation is a ratio or a division** (the maths of `VC2M7N09`); the relationships they show — longer effort arm giving bigger MA, more supporting rope segments giving bigger MA, a gentler ramp giving a smaller push — are the real behaviour of simple machines.

Elaboration contexts used:

- `VC2S8U13.E01` — evaluating different simple machines for their mechanical advantage (the comparing-machines table, Q6, Q14)
- `VC2S8U13.E02` — designing a series of simple machines that take a specified time to move an object a specific height (the design challenge)
- `VC2S8U13.E03` — investigating how simple machines such as levers and pulleys are used to change the magnitude of force needed to perform a task (the lever investigation)
- `VC2S8U13.E05` — identifying the simple machines in a complex machine such as a Rube Goldberg machine (the bicycle figure, the chain reaction)
- `VC2S8U13.E06` — designing and constructing Rube Goldberg machines that use at least 3 different simple machines to perform a specified task (the build task)

`VC2S8U13.E04` is held back under the ICIP decision (D10) and is not drawn on here.