Science 7–8

Chapter 14 — Earth and space sciences C: the Earth–Sun–Moon system

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Contents

Earth and the Sun: axial tilt, light intensity on a surface, and why Victoria has seasons opposite to the northern hemisphere

> **What we teach here** — `VC2S8U12` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"cyclic changes in the relative positions of Earth, the Sun and the Moon can be modelled to show how these cycles cause eclipses and influence predictable phenomena on Earth, including seasons and tides"* **This subtopic owns the seasons clause only**: modelling the Earth–Sun positions to explain the seasons — Earth's tilt, its orbit of the Sun, the light intensity on a surface, and why Victoria's seasons run opposite to the northern hemisphere's. The rest of the CD — the Moon's cycle, solar and lunar eclipses, and the tides — belongs to the partner subtopic **14B** († split delivery, D6). **In our words:** the seasons are not about how close Earth is to the Sun — they are about a lean. Earth's axis keeps pointing the same way all year, so for half the year Victoria leans toward the Sun and sunlight arrives high and packed together, and for the other half it leans away and the same sunlight arrives low and spread out. That lean, and what it does to the light, is the whole story of why Christmas here falls in summer. **Achievement-standard extract served here (D13):** *"They model the Earth–Sun–Moon system's cyclic changes to explain the observable phenomena of seasons and tides."* 14A is the owner of `VC2S8U12`, so the extract appears here in full; the partner subtopic 14B cites it by reference to this header. **Elaborations drawn on:** `VC2S8U12.E01` (using physical models or virtual simulations to explain how Earth's tilt and position relative to the Sun cause differences in light intensity on Earth's surface, resulting in seasons) and `VC2S8U12.E05` (examples of Aboriginal and/or Torres Strait Islander Peoples' seasonal calendars and how these can be used to predict seasonal change — here, the seasonal calendar of D'harawal Country, south-west of Sydney, delivered from the named published sources listed in Sources (D10). **Authored from the CD text and the elaboration contexts (D12):** the CD names "seasons" among the predictable phenomena the cycles influence but does not say what causes them; E01 supplies the mechanism modelled here (tilt and position → differences in light intensity → seasons), and E05 supplies the seasonal-calendar context read in the final theory section. Scope is capped by D9: this subtopic stays inside the Earth–Sun system — the Moon, eclipses and tides are 14B's, and nothing beyond the Earth–Sun–Moon system appears at all.
>
> **Word watch — *intensity* and *direct*.** In everyday talk, *intensity* just means how strong something is. In this subtopic, the **intensity** of sunlight on a surface means how much light energy arrives on a given patch of that surface — the same sunlight spread over a wide patch has a lower intensity than the same sunlight packed onto a small one. And *direct*: in everyday talk it can mean straightaway, or frank. Here, sunlight hitting a surface **directly** means arriving straight onto it, at a steep angle — not glancing across it at a low angle. Keep both meanings apart: a low Sun does not send *weak* light to Earth, it sends the same light spread wider.

Theory

Victoria's seasons — and the wrong explanation

In Victoria, summer runs through December, January and February; winter runs through June, July and August. In Canada, Japan and Britain it is the other way around: when Melbourne is hot, those places are cold, and when Melbourne is cold, they are hot. The two halves of the world take turns. Any explanation of the seasons has to match that fact.

The most common first guess is wrong: *the seasons happen because Earth gets closer to the Sun in summer and farther away in winter.* It sounds sensible — closer to a fire feels warmer. But the guess does not match what Earth actually does.

Earth's path around the Sun is almost a perfect circle, though not quite: Earth is closest to the Sun (about 147.1 million km) around 3 January and farthest (about 152.1 million km) around 4 July. So Earth is nearest the Sun in the middle of Victoria's **summer** — and farthest in the middle of Victoria's winter. If distance were the cause, Victoria's seasons would line up with that, not run against it. And there is a deeper problem with the guess: at any moment, Melbourne and Canada are riding the same Earth, the same distance from the Sun. Something that acts on the whole planet at once cannot be the reason the two hemispheres have opposite seasons at the same time. The cause must be something that differs *between* the hemispheres. That something is the tilt.

Source: Wikipedia, “Earth’s orbit”, 2026. en.wikipedia.org — retrieved 2026-08-20.

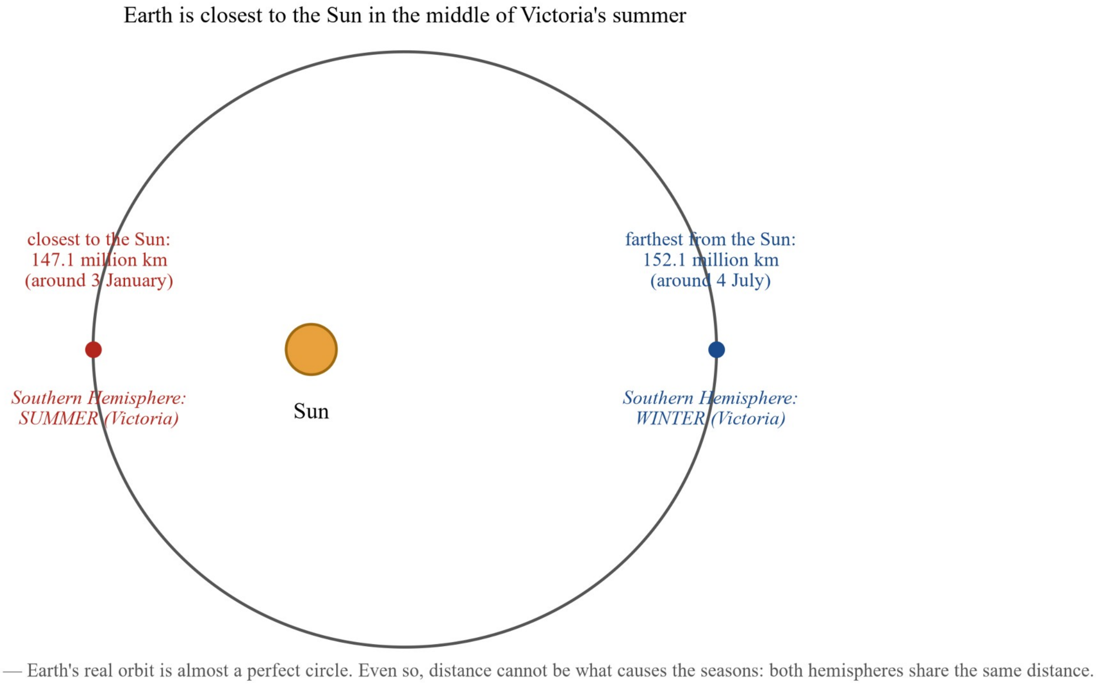

Diagram of Earth’s slightly oval orbit drawn wider than real life, showing Earth closest to the Sun around 3 January during the Southern Hemisphere’s summer and farthest around 4 July during its winter

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Earth’s year: one tilt, one direction

Two facts about Earth set up everything else.

- **Earth’s axis is tilted.** The imaginary line through Earth from the South Pole to the North Pole does not stand upright compared with Earth’s path around the Sun. It leans over by about **23.4°**.
- **The tilt keeps pointing the same way all year.** As Earth travels around the Sun, the axis does not swing around to follow the Sun — it stays aimed in the same direction in space. One full circuit of the Sun takes one year.

Because the direction of the axis is fixed, the lean changes as Earth moves. For half the year, the Southern Hemisphere leans toward the Sun; for the other half, it leans away. The four key positions have names: the **solstices** (around 21 December and 21 June), when the lean toward or away is greatest, and the **equinoxes** (around 20 March and 23 September), when neither pole leans toward the Sun and the sunlight is shared out evenly.

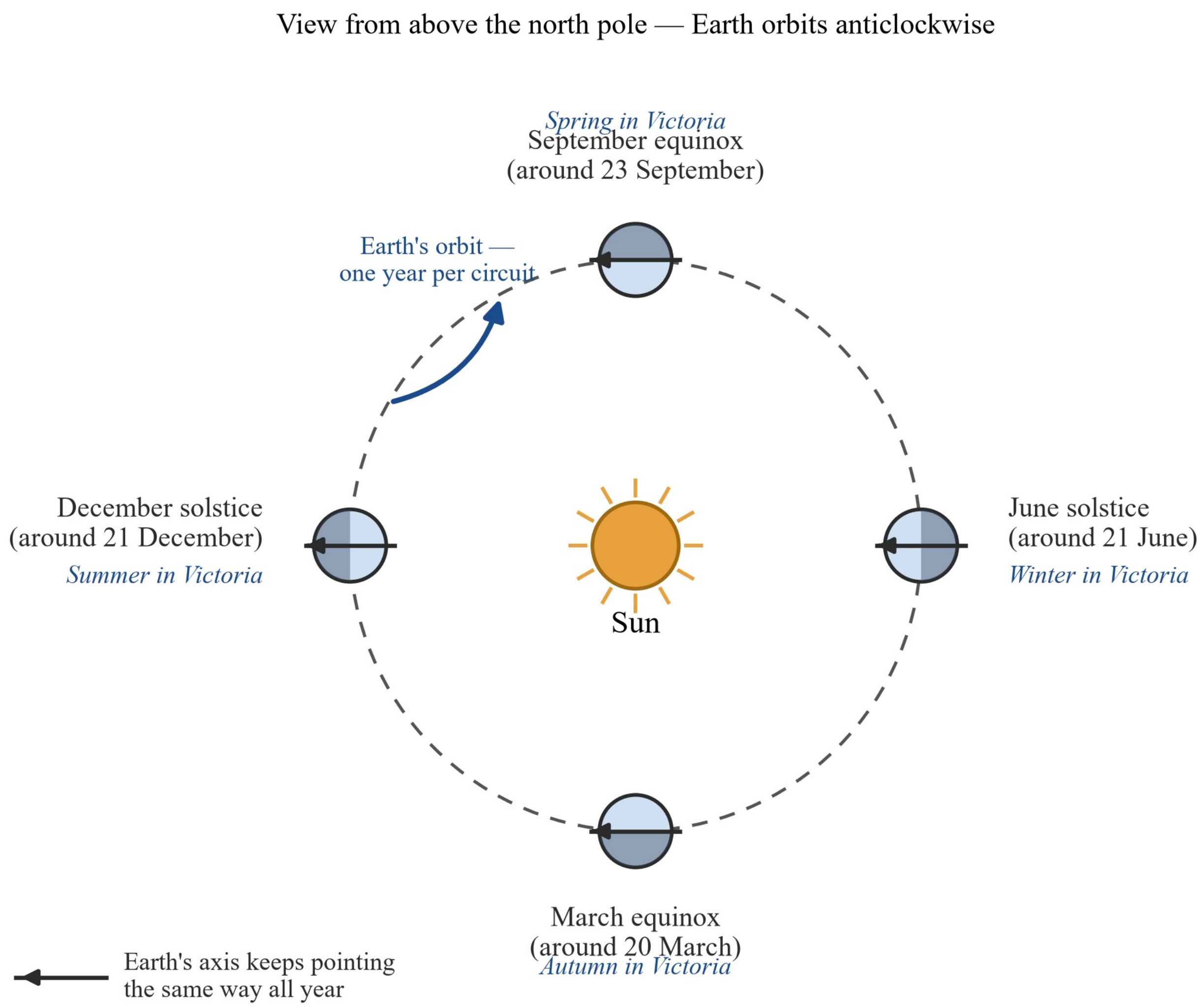


Diagram viewed from above the north pole showing Earth at four positions around its orbit, with the axis kept pointing the same way at every position and each position labelled with its solstice or equinox and with the season it brings to Victoria

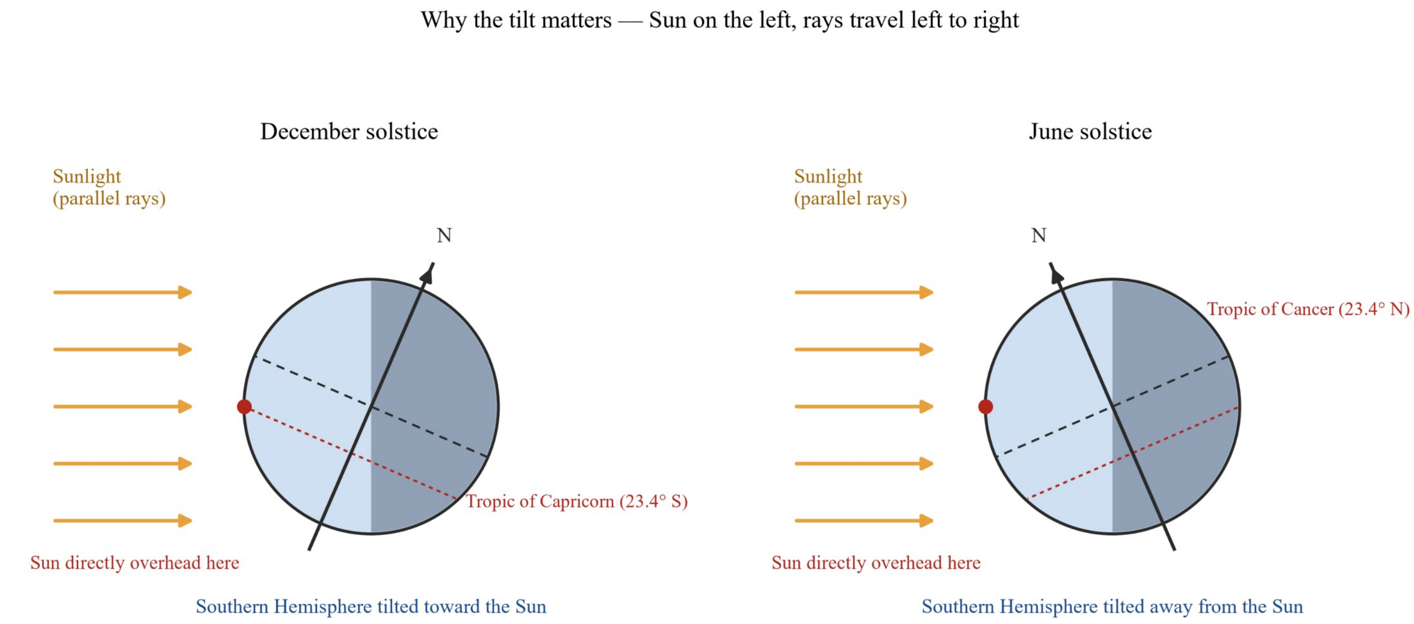
Source: Wikipedia, "Axial tilt", 2026. en.wikipedia.org — retrieved 2026-08-20.

The tilt decides who leans toward the Sun

Picture the Sun on one side and Earth on the other, with sunlight travelling across in straight, parallel lines.

- At the **December solstice**, the Southern Hemisphere is tilted toward the Sun. The noon Sun stands straight above the **Tropic of Capricorn** (23.4° S). Victoria is leaning into the light: **summer**.
- At the **June solstice**, the Southern Hemisphere is tilted away from the Sun. The noon Sun stands straight above the **Tropic of Cancer** (23.4° N). Victoria is leaning away from the light: **winter**.

The two hemispheres always lean opposite ways. When Victoria leans toward the Sun, the northern hemisphere leans away — so it is winter in Canada and Japan while it is summer here. Six months later the lean swaps, and so do the seasons.



Two side-by-side diagrams of the Sun-Earth geometry at the December and June solstices, showing parallel rays of sunlight, the tilted axis, the equator, the tropic line, and the point where the noon Sun stands straight up

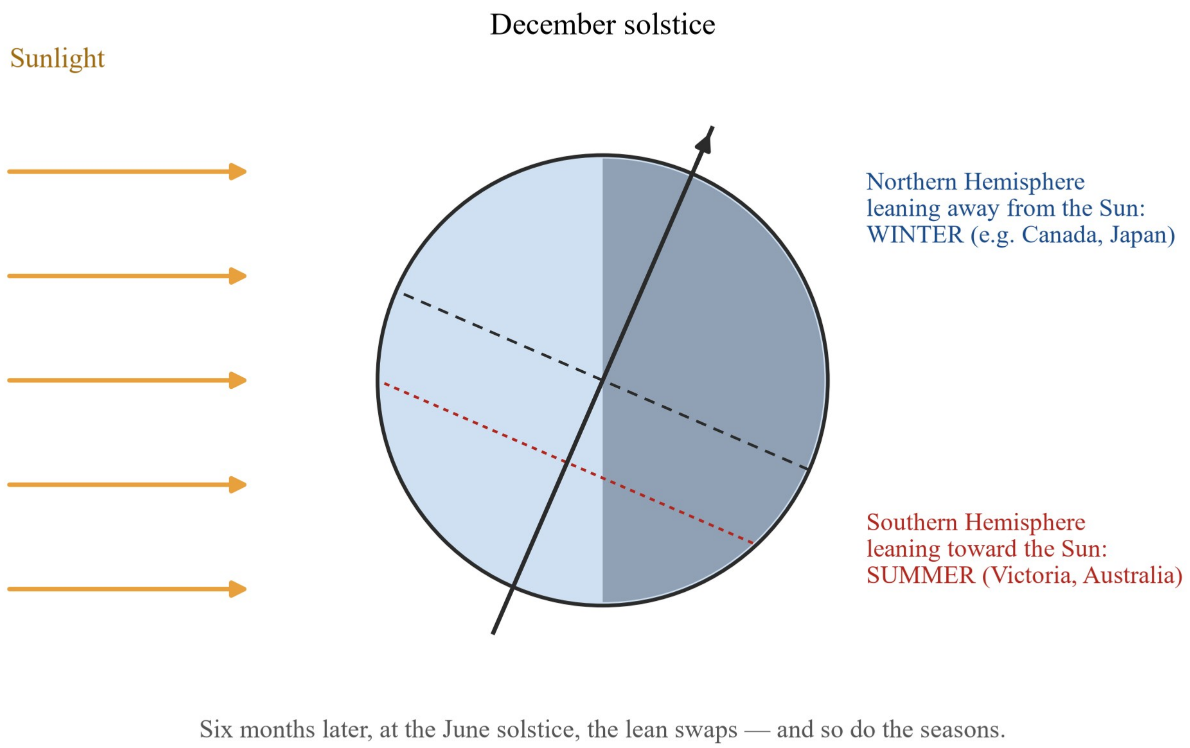


Diagram of Earth at the December solstice with sunlight arriving from the left, showing the northern hemisphere leaning away from the Sun in winter and the southern hemisphere leaning toward the Sun in summer

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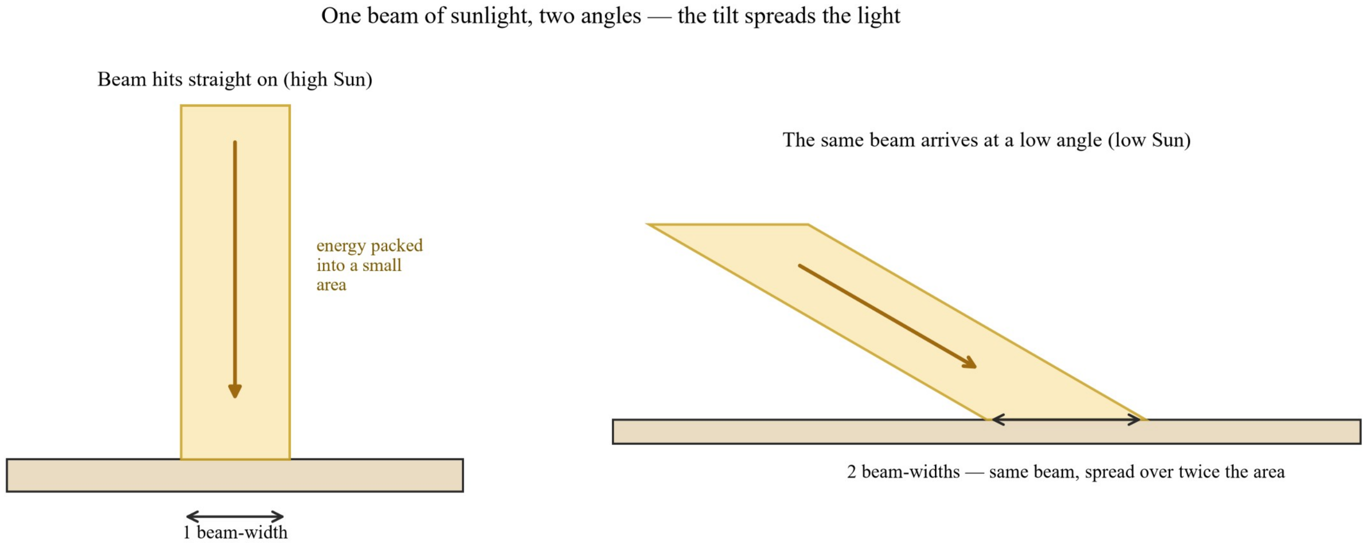
The same light, spread out or packed in

The lean does more than decide which half of Earth faces the Sun — it decides how the sunlight *lands*.

Take one beam of sunlight — a bundle of rays carrying a fixed amount of energy. If the beam arrives at a steep angle and hits the ground close to straight on, its energy lands on one small patch: the light is packed in, its intensity on that patch is high, and the ground heats strongly. If the very same beam arrives at a low angle and glances across the ground, it spreads out over a much wider patch: the same energy now shares itself around, the intensity on each patch is lower, and the heating is weaker. At a 30° angle, one beam-width of light spreads across about two beam-widths of ground — twice the area, half the intensity.

This is the link from the tilt to the seasons. In Victoria's summer, the Southern Hemisphere leans toward the Sun, so sunlight reaches Victoria high in the sky and close to straight on — packed in. In winter, the lean is away, sunlight crosses the sky low and arrives at a shallow angle — spread out. The Sun itself has not changed; the landing angle has.



Two diagrams showing one beam of sunlight of the same width hitting the ground straight on and covering one beam-width, then arriving at a low angle and spreading across two beam-widths of ground

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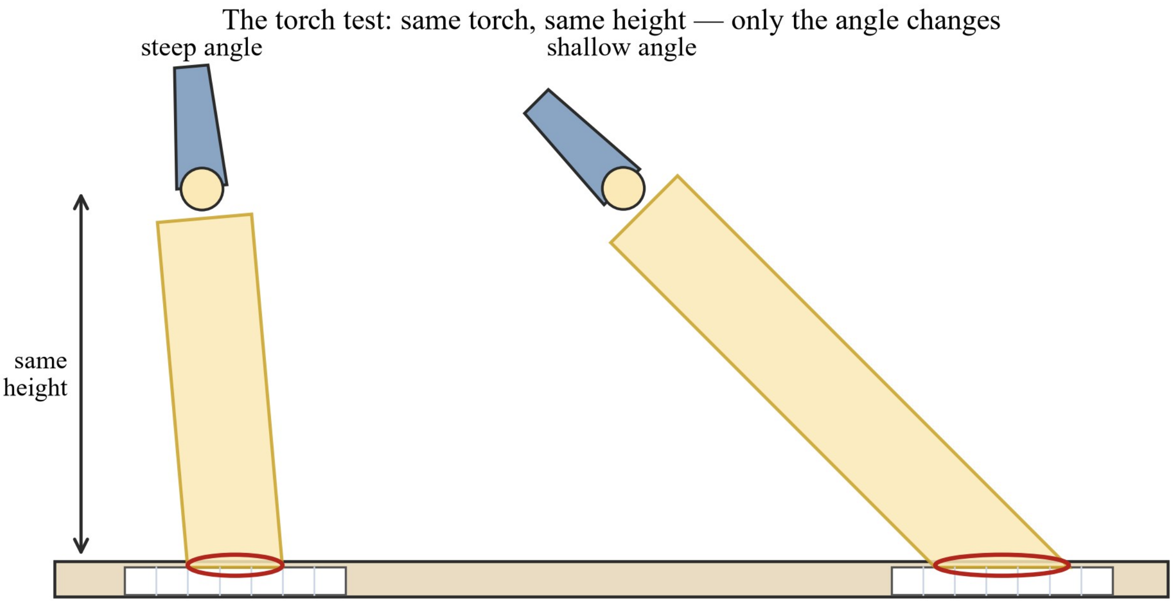
Try it — the torch test (`VC2S8U12.E01`)

You will need: a small torch, two sheets of graph paper, a ruler, a protractor, and something to hold the torch at a fixed height (a stack of books works). The torch stands in for the Sun, the graph paper stands in for a patch of Victoria's ground, and the angle of the torch stands in for how high the Sun climbs in our sky.

1. Lay one sheet of graph paper flat on the bench. Hold the torch at a fixed height directly above it, pointing almost straight down (a steep angle, like the noon Sun in December). Trace the edge of the light spot on the paper and count the squares inside it.
2. Now move to the second sheet. Keep the torch at **the same height**, but tilt it so the beam arrives at a shallow angle (like the noon Sun in June). Trace the spot and count the squares again.
3. Compare the two counts. Which spot covers more squares? In which spot is the light packed into fewer squares?



Trace each light spot on the graph paper on the bench and count the squares inside it.

Diagram of the torch test showing a torch held at the same height above two sheets of graph paper, shining at a steep angle onto one and at a shallow angle onto the other, with the oval light spot traced on each sheet

What you did	What it models	What it stands for in nature
Torch held high, beam steep, small round spot	Sunlight arriving high in the sky, close to straight on, packed into a small patch	The noon Sun in Victoria's summer — high intensity, strong heating
Same torch, same height, beam tilted, wide oval spot	The same sunlight arriving at a low angle, spread across a wide patch	The noon Sun in Victoria's winter — low intensity, weak heating
Counting the squares in each spot	Comparing how much ground a fixed amount of light energy covers	Comparing the intensity of sunlight on the ground between seasons

Every model has limits, and seeing them clearly is part of the skill. Ask yourself:

- A torch is close, so its beam spreads out as it travels. The Sun is so far away that its rays arrive at Earth almost parallel. What difference does that make to your square counts?
- The bench is flat, but Earth's surface curves. Where on a curved Earth does the "steep beam" land, and where does the "shallow beam" land?
- The torch shines on one spot at a time. Can your setup show both hemispheres having opposite seasons at once — and if not, what would you add?

Try it — modelling the year with a lamp and a globe (`VC2S8U12.E01`)

You will need: a bright lamp with its shade off (the Sun), a globe or a ball with a pencil pushed through it as an axis (Earth), and a darkened room. The lamp stands in for the Sun, the globe for Earth, the pencil for Earth's axis, and one slow circuit of the lamp for one year.

1. Tilt the globe's axis by roughly 23° and mark a spot for Melbourne.
2. Hold the axis pointing the same way the whole time — do not let it swing around as you walk.
3. Carry the globe in a slow circle around the lamp. Stop at four positions: leaning toward the lamp, leaning away, and the two in between. At each position, note where the lamp's light falls on the globe at a steep angle and where at a shallow one, and which half gets the longer stretch of light.
4. At the "leaning toward" position, check that your Melbourne spot swings through a long, high arc under the lamp; at "leaning away", a short, low arc.

Safety: lamps get hot while they are on — switch off and let the lamp cool before packing away, and keep cords clear of the floor.

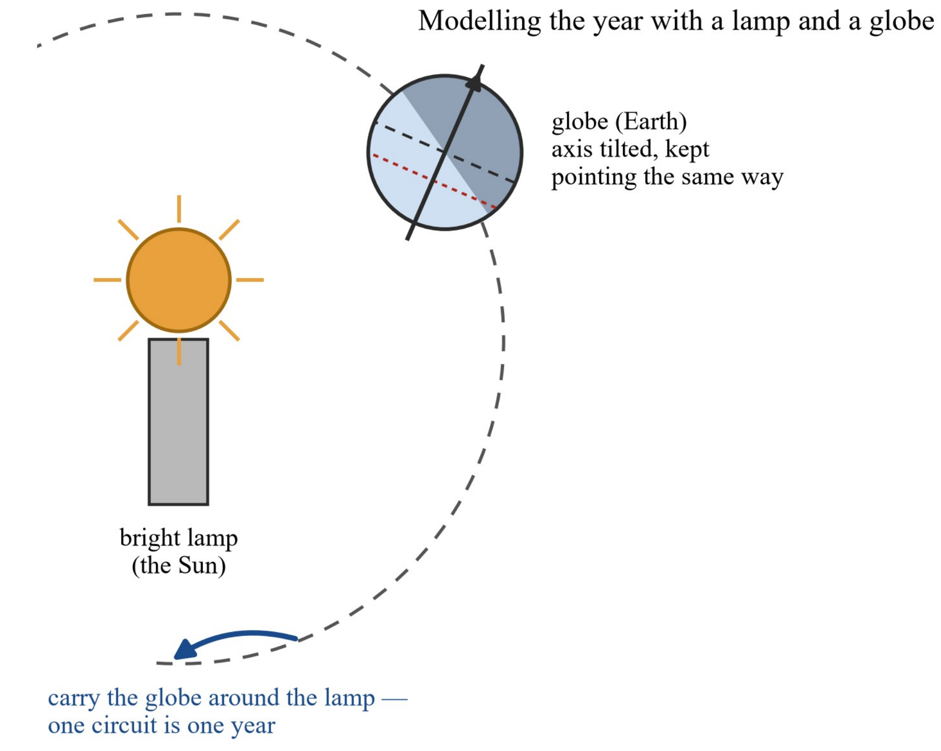


Diagram of a lamp-and-globe model of the year, with a bright lamp as the Sun, a tilted globe on a dashed circular path, and arrows showing the globe carried around the lamp with its axis kept pointing the same way

What you did	What it models	What it stands for in nature
Tilted the axis by about 23°	Earth's 23.4° axial tilt	The lean that never goes away
Kept the axis pointing one way all the way around	The axis keeping its direction in space as Earth orbits	Why the lean toward or away swaps over the year
One circuit of the lamp	One orbit of the Sun	One year
The lit half and the dark half of the globe at each stop	Day and night at that point of the year	Why summer days are long and winter days are short

Ask yourself:

- The lamp is small and close; the real Sun is enormous and very far away. How does that change the rays that reach the globe?
- Your walk around the lamp takes a minute. A real orbit takes a year. What does the model gain, and what does it lose, by speeding time up this much?
- The globe's surface is smooth. Name two things about real Victoria that this model cannot show.

What the tilt does to Melbourne's sky

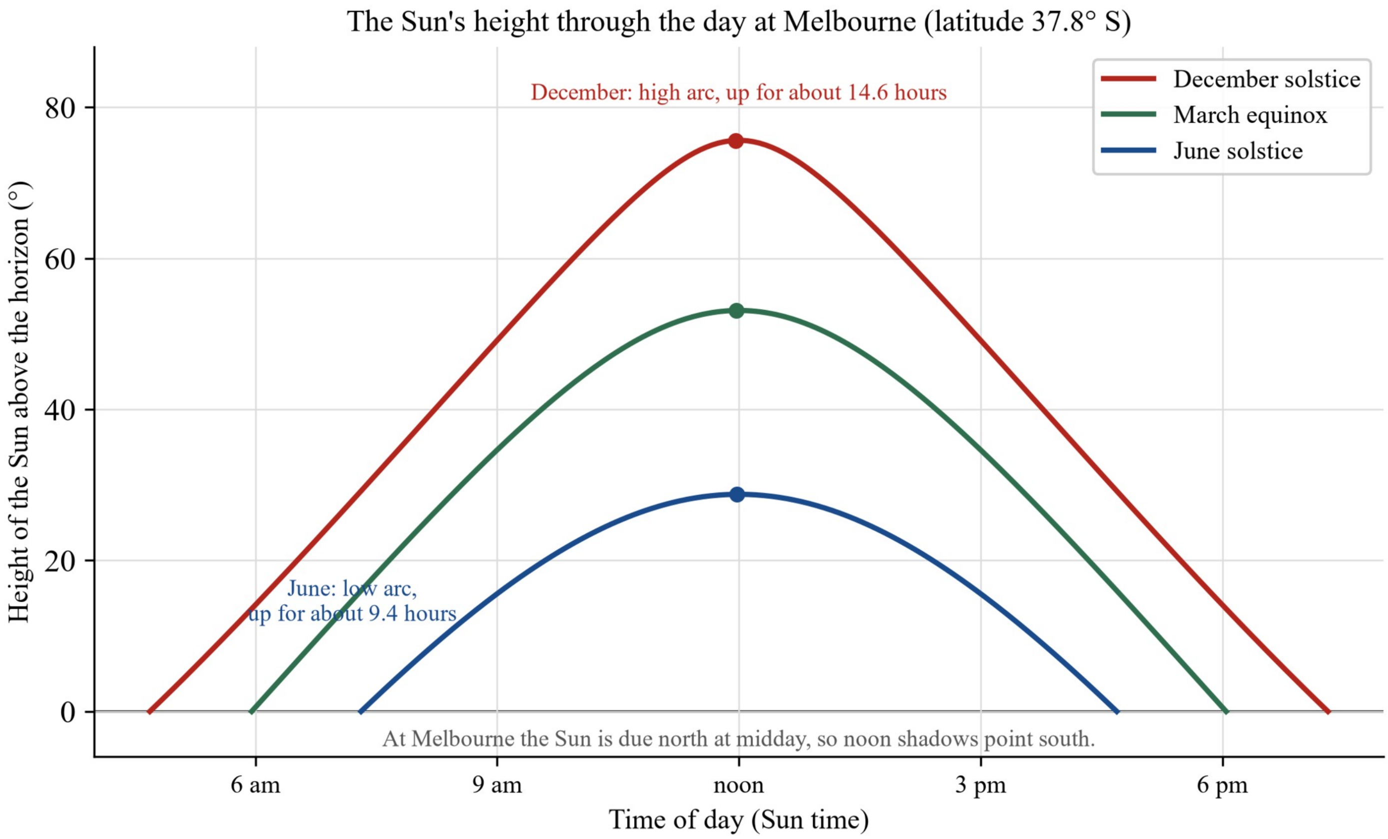
Melbourne sits at about 37.8° S. That puts it far enough south for the lean to change the sky a great deal through the year. Three things swing together: how high the noon Sun climbs, how long it stays up, and how long the shadows fall.

- **How high the Sun climbs.** At the December solstice the noon Sun stands about **75.6°** above the horizon — high in the sky. At the equinoxes it reaches **52.2°**. At the June solstice it manages only **28.8°** — not even a third of the way up the sky.

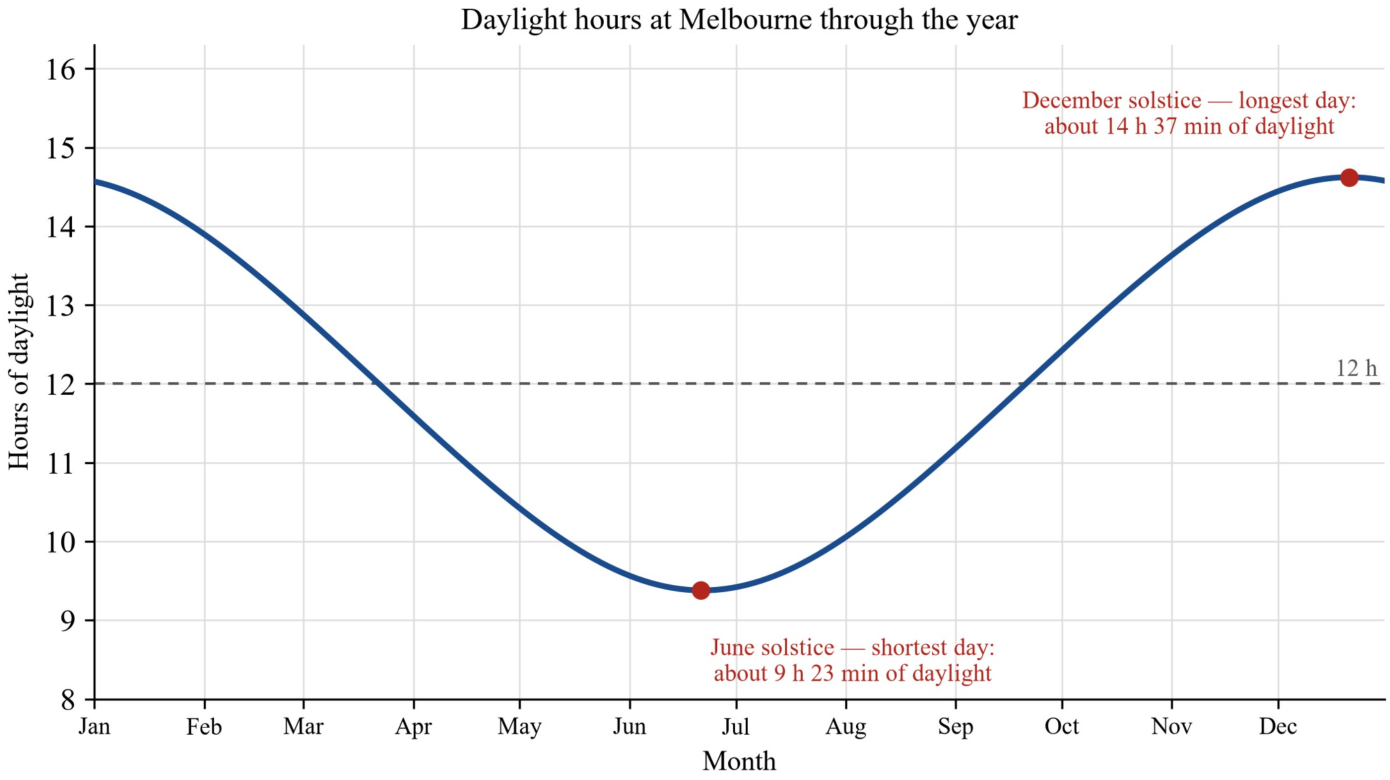
- **How long it stays up.** At the December solstice Melbourne gets about **14 h 37 min** of daylight; at the June solstice, only about **9 h 23 min** — a difference of over five hours. Long days give the ground more hours to soak up sunlight; short days give it fewer.
- **How long the shadows fall.** Stand a 1 m stick upright in the ground. At noon on the December solstice its shadow is only about **0.26 m** long. At noon on the June solstice the same stick throws a shadow about **1.82 m** long. A low Sun makes long shadows; a high Sun shrinks them. (At Melbourne the Sun is due north at midday, so noon shadows point south.)

Add the two effects of the lean together — light arriving at a steeper angle (higher intensity) *and* staying up longer (more hours of heating) — and the result is exactly what the weather records show. At Melbourne's Olympic Park weather station, the average midday temperature in January is **26.8 °C**; in July it is **14.5 °C**.

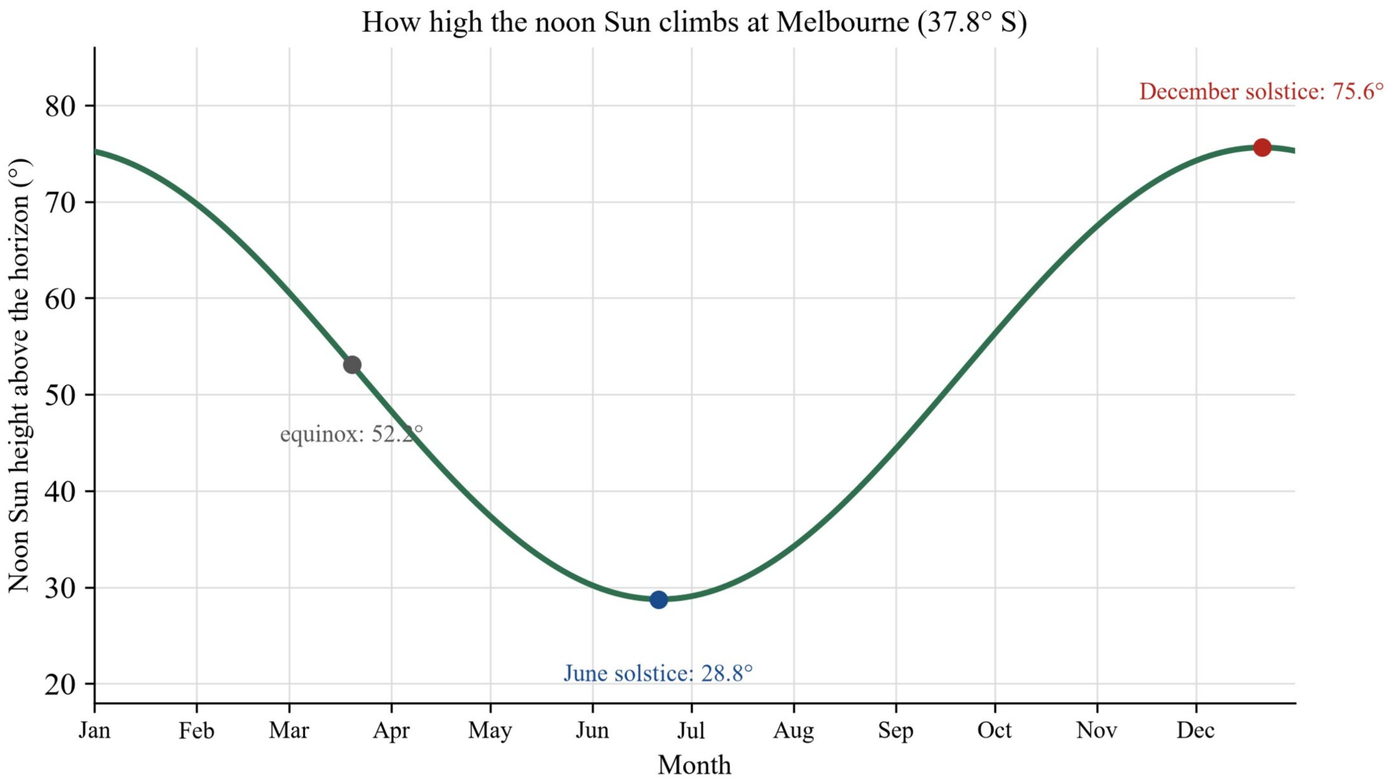
Source: Bureau of Meteorology, "Climate statistics for Australian locations — Melbourne Olympic Park (station 086338)", n.d. bom.gov.au — retrieved 2026-08-20.



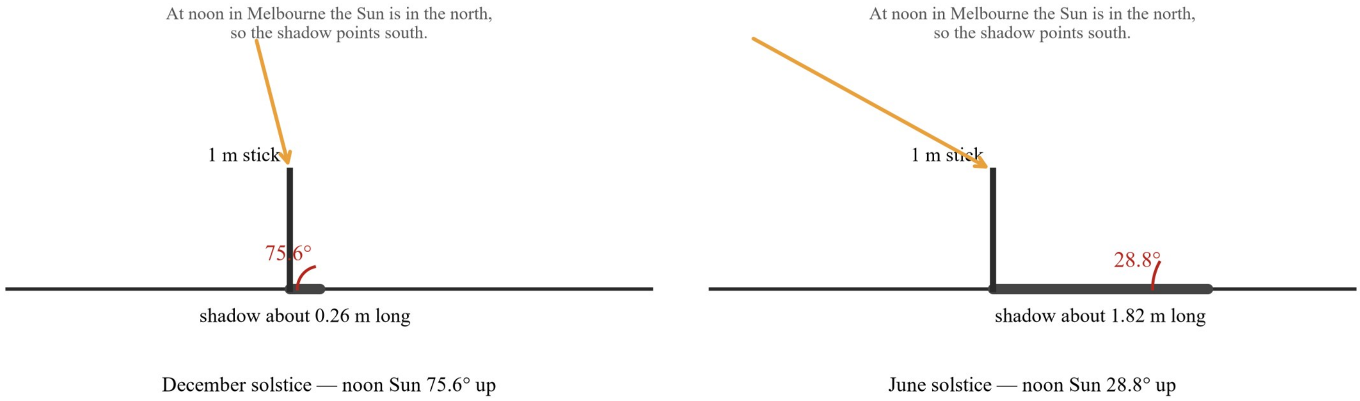
Graph of the height of the Sun above the horizon through the day at Melbourne on the December solstice, the March equinox and the June solstice, showing a high long arc in December and a low short arc in June



Graph of the hours of daylight at Melbourne through the year, peaking at about 14 hours 37 minutes at the December solstice and bottoming at about 9 hours 23 minutes at the June solstice



Graph of how high the noon Sun climbs at Melbourne through the year, reaching 75.6 degrees at the December solstice, 52.2 degrees at the equinoxes and 28.8 degrees at the June solstice



Two diagrams to scale of a 1 metre stick and its noon shadow at Melbourne, showing a short 0.26 metre shadow under the high December-solstice Sun and a long 1.82 metre shadow under the low June-solstice Sun

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Reading the seasons from Country (`VC2S8U12.E05`)

The Western calendar splits the year into four roughly equal phases — summer, autumn, winter, spring — no matter where you live or what the land is actually doing. Aboriginal and Torres Strait Islander Peoples, Australia's First Scientists, have long kept a different kind of calendar: **seasonal calendars** built from Country itself, in which the seasons are marked by what plants, animals and weather are doing, and they can be different lengths in different places. CSIRO has worked with Indigenous language groups to record and share these calendars, and notes that they are the **Indigenous Cultural and Intellectual Property (ICIP)** of the communities who shared them — published with permission, and with conditions on their use.

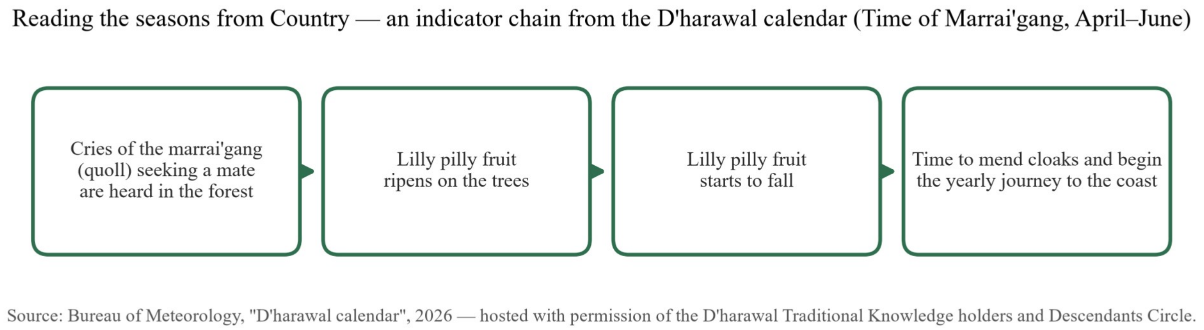
One example is the seasonal calendar of the **D'harawal** People of the country south-west of Sydney, published by the Bureau of Meteorology with permission of the D'harawal Traditional Knowledge holders and Descendants Circle. The D'harawal calendar names **six seasons**, each known by its indicators. One of them, the **Time of Marrai'gang** (April to June), shows how the calendar predicts what comes next through a chain of signs:

- the cries of the **marrai'gang** (quoll) seeking a mate ring through the forests and woodlands;
- as they do, the **lilly pilly** fruit ripens on the trees;
- when the lilly pillies start to fall, it is the sign to mend the warm cloaks from last cold season — or make new ones — and begin the annual journey to the coast for other seasonal resources.

Each link in the chain is something you can see or hear *now*, pointing to something that follows. The calendar is not a set of dates on a page — it is Country telling you what time it is and what to do next.

Source: Bureau of Meteorology, "D'harawal calendar", 2026. bom.gov.au — retrieved 2026-08-20.

Source: CSIRO, "Indigenous seasonal calendars", 2026. csiro.au — retrieved 2026-08-20.



Flow diagram of four linked stages from the D'harawal calendar's Time of Marrai'gang: quoll cries heard, lilly pilly fruit ripens, fruit starts to fall, then the annual journey to the coast begins

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The whole story in four sentences

Earth's axis is tilted 23.4° and keeps pointing the same way all year, so as Earth orbits the Sun, Victoria spends half the year leaning toward the Sun and half leaning away. Leaning toward the Sun means a high noon Sun, long days, and sunlight arriving at a steep angle and packed in; leaning away means a low noon Sun, short days, and sunlight arriving shallow and spread out. That difference in light intensity and daylight hours is what makes Victoria warm in December and cool in June. And because the two hemispheres always lean opposite ways, Victoria's seasons run opposite to the northern hemisphere's — not because of distance, which acts on the whole planet at once, but because of a lean that the hemispheres take turns wearing.

Worked examples

Example 1 — scaffolded

The table shows how high the noon Sun climbs at Melbourne (latitude 37.8° S) on four dates. *(Computed from Melbourne's latitude and Earth's 23.4° tilt.)*

Date	Noon Sun height above the horizon
December solstice	75.6°
March equinox	52.2°
June solstice	28.8°
September equinox	52.2°

(a) On which date does the noon Sun climb highest, and how high is it?
(b) On which date does a 1 m stick cast its longest noon shadow? Explain your choice.
(c) In which direction does that noon shadow point at Melbourne, and why?

Working	Comment
(a) December solstice, 75.6°.	Read the table: 75.6° is the greatest of the four heights.
(b) June solstice. The noon Sun is lowest there (28.8°), and the lower the Sun, the longer the shadow.	Low Sun → shallow rays → long shadow; high Sun → steep rays → short shadow.
(c) South. At Melbourne the Sun is due north at midday, so shadows point the other way — south.	Melbourne is south of the Tropic of Capricorn, so the noon Sun is always in the northern sky.

Example 2 — scaffolded

At Melbourne, the day length is about **14 h 37 min** at the December solstice and about **9 h 23 min** at the June solstice. *(Sun time — clock time differs a little. Time-and-duration arithmetic here is the `VC2M8M04` interlock (D11).)*

(a) How much longer than 12 hours is the December-solstice day?
(b) In Sun time, noon sits in the middle of the day. Roughly when does the Sun rise and set at Melbourne on the December solstice?
(c) How much daylight does Melbourne lose between the December solstice and the June solstice?

Working	Comment
(a) 14 h 37 min − 12 h = **2 h 37 min longer**.	Subtract hours from hours and minutes from minutes.
(b) Half of 14 h 37 min is about 7 h 19 min. Sunrise ≈ 12:00 − 7 h 19 min ≈ **4:41 am**; sunset ≈ 12:00 + 7 h 19 min ≈ **7:19 pm**.	Noon splits the daylight into two equal halves.
(c) 14 h 37 min − 9 h 23 min = **5 h 14 min**.	The year's daylight swing at Melbourne is over five hours.

Example 3 — unscaffolded

A student says: *"Victoria has summer in December because that is when Earth is closest to the Sun."* Evaluate this claim. In your answer, use the real dates of Earth's closest and farthest points from the Sun, and the fact that the two hemispheres have opposite seasons at the same time.

The claim is wrong in two ways. First, Earth is actually closest to the Sun (about 147.1 million km) around 3 January and farthest (about 152.1 million km) around 4 July — so Earth is nearest in the middle of Victoria's summer, but it is also nearest in the middle of the northern hemisphere's **winter**. If distance drove the seasons, both hemispheres would warm together in January; they do not. Second, and deeper, both hemispheres ride the same Earth, so at any moment Melbourne and Canada are exactly the same distance from the Sun — yet they have opposite seasons at the same time. A cause that acts on the whole planet at once cannot explain a difference *between* the hemispheres. The difference between the hemispheres is the tilt: in December the Southern Hemisphere leans toward the Sun and the northern hemisphere leans away. ∴ the seasons are caused by the tilt, not by distance.

Example 4 — unscaffolded

A 1 m stick stood upright in Melbourne casts a noon shadow about 0.26 m long at the December solstice and about 1.82 m long at the June solstice. Explain this difference, linking your answer to Earth's tilt, the noon Sun's height, and the way light spreads when it arrives at a low angle.

Earth's axis is tilted 23.4° and keeps pointing the same way all year. At the December solstice the Southern Hemisphere leans toward the Sun, so at Melbourne the noon Sun stands high — 75.6° above the horizon. Its rays arrive at a steep angle, close to straight on: the light is packed onto a small patch of ground, and the stick blocks only a short strip of it, so the shadow is only 0.26 m. At the June solstice the Southern Hemisphere leans away, so the noon Sun climbs just 28.8°. Its rays arrive at a shallow angle and spread across a wide patch of ground — the same light, lower intensity — and because the rays come in low, the stick blocks them far along the ground, stretching the shadow to 1.82 m. Nothing about the stick or the Sun has changed; only the lean has. ∴ the noon shadow's length records the noon Sun's height, and the noon Sun's height records the tilt.

Practice questions

Scaffolded

Q1. Answer the following about Earth's orbit and tilt. (a) By about how many degrees is Earth's axis tilted compared with upright? (b) As Earth travels around the Sun, does the axis swing around to follow the Sun, or keep pointing the same way? (c) How long does one full circuit of the Sun take?

Q2. Answer the following about the noon Sun at Melbourne. (a) On which date of the year does the noon Sun climb highest, and how high does it get? (b) How high does the noon Sun climb at the equinoxes? (c) Why is the June noon Sun so much lower than the December noon Sun?

Q3. Answer the following about day length at Melbourne. (a) About how many hours of daylight does Melbourne get at the December solstice? (b) About how many hours of daylight does it get at the June solstice? (c) What is the difference between the two?

Q4. Answer the following about light intensity on a surface. (a) One beam of sunlight arrives at the ground at a low angle instead of straight on. What happens to the patch of ground the beam covers? (b) The beam carries the same energy as before. What happens to the intensity of the light on each part of the wider patch? (c) In Victoria's summer, is noon sunlight more packed in or more spread out than in winter? Name the cause.

Q5. Answer the following about opposite seasons. (a) At the December solstice, what season is it in Canada? (b) At that same moment, which way is the northern hemisphere leaning — toward the Sun or away from it? (c) Six months later, at the June solstice, what season is it in Victoria?

Q6. Answer the following about the D'harawal seasonal calendar (Bureau of Meteorology, "D'harawal calendar"). (a) How many named seasons does the D'harawal calendar shown by the Bureau of Meteorology have? (b) In which months does the Time of Marrai'gang fall? (c) State two of the season indicators listed for the Time of Marrai'gang.

Unscaffolded

Q7. A student says: *"It is warmer in January because Earth is closer to the Sun then."* Evaluate this claim using two facts about Earth's orbit and the hemispheres. *(2 marks)*

Q8. Explain why Victoria has summer from December to February. In your answer, link the tilt, the noon Sun's height, the intensity of sunlight on the ground, and the length of the day. *(3 marks)*

Q9. At the March equinox the noon Sun at Melbourne stands 52.2° above the horizon. Predict how the noon shadow of a 1 m stick at the equinox compares with its December-solstice shadow (0.26 m) and its June-solstice shadow (1.82 m) — longer, shorter, or in between — and explain your reasoning without measuring anything. *(2 marks)*

Q10. In the Try-it torch test, a torch is held at the same height above graph paper and shone first at a steep angle, then at a shallow angle. State one strength of this model for explaining the seasons, and one way it falls short of the real Sun–Earth system. *(2 marks)*

Q11. In the lamp-and-globe model of the year, you are told to keep the globe's axis pointing the same way as you carry it around the lamp. Explain why that instruction matters — what would the model get wrong if the axis swung around to face the lamp as you walked? *(2 marks)*

Q12. The D'harawal calendar reads the seasons from Country: quoll cries, ripening lilly pillies, falling fruit, and the annual journey to the coast form a chain of signs. Explain how a chain of signs like this one lets the D'harawal People predict seasonal change. *(2 marks)*

Q13. The Western calendar splits the year into four roughly equal phases, while the D'harawal calendar names six seasons of different lengths, each known by what Country is doing. State one difference between the two calendars, and explain why a calendar built from local indicators is useful for living on Country. *(2 marks)*

Q14. At the June solstice, a student in Canada sends you a photo of a low midday Sun and a very long shadow. Use Earth's tilt to explain both of those observations, and state what a student in Melbourne would see at that same moment. *(3 marks)*

Answers

Q1. (a) About 23.4°. (b) It keeps pointing the same way all year. (c) One year. **Q2.** (a) The December solstice, 75.6°. (b) 52.2°. (c) At the June solstice the Southern Hemisphere is tilted away from the Sun, so the Sun crosses the sky low. **Q3.** (a) About 14 h 37 min. (b) About 9 h 23 min. (c) 5 h 14 min. **Q4.** (a) It spreads out over a wider patch. (b) It drops — the same energy is shared over more ground. (c) More packed in: in summer the Southern Hemisphere leans toward the Sun, so sunlight arrives high in the sky and at a steep angle. **Q5.** (a) Winter. (b) Away from the Sun. (c) Winter. **Q6.** (a) Six. (b) April to June. (c) Any two of: quolls (marrai'gang) seeking mates; lilly pilly fruit ripening; wet weather becoming cooler. **Q7.** The claim is wrong: Earth is closest to the Sun around 3 January, yet the northern hemisphere has winter then; and both hemispheres share the same Earth–Sun distance at every moment, so distance cannot explain their opposite seasons. **Q8.** From December to February the Southern Hemisphere leans toward the Sun, so the noon Sun stands high, sunlight arrives at a steep angle and is packed into small patches (high intensity), and the days are long — more hours of strong heating. **Q9.** In between. The equinox noon Sun (52.2°) sits between the December height (75.6°) and the June height (28.8°); the lower the Sun, the longer the shadow, so the equinox shadow sits between 0.26 m and 1.82 m. **Q10.** Strength (any one): it shows the same light source spreading over more ground at a low angle, so the angle alone changes the intensity. Falls short (any one): a nearby torch's beam spreads out as it travels, while the Sun's rays arrive almost parallel; the flat paper does not show Earth's curved surface; the model shows no day–night change and no orbit. **Q11.** Earth's real axis keeps pointing the same way in space all year — that fixed lean is why the hemispheres take turns facing the Sun. If the axis swung to face the lamp, every point on the globe would keep the same lean all the way around, and the model would never produce opposite seasons at all. **Q12.** Each sign happens at the same time of year and leads to the next: hearing the quoll cries tells you the lilly pillies are ripening, and the falling fruit tells you it is time to mend cloaks and start the journey to the coast. Because the signs follow one another reliably, noticing one early sign predicts what comes next. **Q13.** Difference (any one): four equal phases against six seasons of different lengths; fixed calendar dates against signs read from Country. Usefulness: the indicators say what the local land and animals are actually doing, so they tell you when to travel, gather or hold back — information a date on a page does not carry. **Q14.** At the June solstice the northern hemisphere leans away from the Sun, so in Canada the Sun stays low and its rays arrive shallow — long shadows follow. At the same moment the Southern Hemisphere leans toward the Sun, so in Melbourne the noon Sun stands high, shadows are short, and the day is long.

Fully-worked solutions

Q1. (a) Earth's axis is tilted by about **23.4°** compared with upright. (b) The axis **keeps pointing the same way** in space all year — it does not swing around to follow the Sun. (c) One full circuit of the Sun takes **one year**.

Q2. (a) The noon Sun climbs highest at the **December solstice: 75.6°** above the horizon. (b) At both equinoxes the noon Sun reaches **52.2°**. (c) At the June solstice the **Southern Hemisphere is tilted away from the Sun**, so from Melbourne the Sun crosses the sky low; at the December solstice the lean is toward the Sun, so the Sun climbs high.

Q3. (a) About **14 h 37 min** of daylight at the December solstice. (b) About **9 h 23 min** at the June solstice. (c) 14 h 37 min − 9 h 23 min = **5 h 14 min** — more than five hours of daylight swing across the year.

Q4. (a) At a low angle the beam **spreads out over a wider patch** of ground. (b) The same energy now covers more ground, so the **intensity on each part of the patch drops**. (c) In Victoria's summer the noon sunlight is **more packed in**, because the **Southern Hemisphere leans toward the Sun**, so sunlight arrives high in the sky and close to straight on.

Q5. (a) **Winter** — Canada lies in the northern hemisphere, and the two hemispheres take turns. (b) The northern hemisphere is leaning **away from the Sun**. (c) **Winter** — the lean has swapped, so Victoria now leans away.

Q6. (a) The Bureau of Meteorology's D'harawal calendar names **six seasons**. (b) The Time of Marrai'gang falls in **April to June**. (c) Any two of the listed indicators: **quolls (marrai'gang) seeking mates** — their cries heard through the forests and woodlands; **lilly pilly fruit ripening** on the trees; and **wet weather becoming cooler**.

Q7. The claim fails on two facts *(1 mark each)*. Earth is closest to the Sun (about 147.1 million km) around **3 January** — yet the **northern hemisphere has winter then**, so closeness cannot guarantee warmth. And both hemispheres ride the **same Earth**, so at any moment they are exactly the **same distance from the Sun** while having opposite seasons

— a cause acting on the whole planet at once cannot explain a difference between its halves *(the tilt can, because the hemispheres lean opposite ways)*.

Q8. From December to February the Southern Hemisphere **leans toward the Sun** *(1 mark)*. That puts the noon Sun **high** in Melbourne's sky, so sunlight arrives at a steep angle and is **packed into small patches — high intensity** on the ground *(1 mark)*. The lean also makes the **days long** (up to about 14 h 37 min of daylight), so the ground gets many hours of that strong heating — and packed-in light over long days is Victoria's summer *(1 mark)*.

Q9. The equinox noon Sun (52.2°) sits **between** the December height (75.6°) and the June height (28.8°) *(1 mark)*. The rule is: the lower the Sun, the longer the shadow — so the equinox shadow must fall **between 0.26 m and 1.82 m** *(1 mark)* (working it out gives about 0.78 m, but the ordering alone follows from the Sun's height).

Q10. Strength (any one, *(1 mark)*): the torch shows that **the same light source spreads over more ground at a shallow angle**, so it is the angle alone — not a weaker torch — that lowers the intensity, exactly as the tilt does through the year. Falls short (any one, *(1 mark)*): a nearby torch's beam spreads out as it travels, while **the Sun's rays arrive at Earth almost parallel**; the **flat paper** does not show Earth's curved surface; or the setup shows **no day–night change and no orbit**.

Q11. Earth's real axis **keeps pointing the same way in space** all year, and that fixed lean is why each hemisphere spends half the year facing the Sun and half facing away *(1 mark)*. If the model's axis swung to face the lamp, every place on the globe would keep the same lean all the way around the circuit, so the model would show **no swap between the hemispheres and no opposite seasons** *(1 mark)*.

Q12. Each sign in the chain happens at the same time of year and points to the one after it: hearing the quolls' cries tells you the **lilly pillies are ripening**, and when the fruit **starts to fall** it is time to **mend cloaks and begin the annual journey to the coast** *(1 mark)*. Because the signs follow one another reliably year after year, noticing an early sign **predicts what is coming** on Country *(1 mark)*.

Q13. Difference (any one, *(1 mark)*): the Western calendar has **four roughly equal phases on fixed dates**, while the D'harawal calendar has **six seasons of different lengths, known by what Country is doing**. Usefulness *(1 mark)*: the indicators report what the **local** land, plants and animals are actually doing — when fruit is ripening, when to travel to the coast, when to hold back — so the calendar guides life on that Country in a way that dates on a page cannot.

Q14. At the June solstice the northern hemisphere **leans away from the Sun** *(1 mark)*, so in Canada the Sun stays **low** and its rays arrive shallow and spread out — and a low Sun throws **long shadows** *(1 mark)*. At the same moment the Southern Hemisphere **leans toward the Sun**, so in Melbourne the noon Sun stands **high, shadows are short, and the day is long** *(1 mark)*.

Sources

Web sources below were retrieved 2026-08-20.

- Bureau of Meteorology, "D'harawal calendar", 2026. bom.gov.au
- Bureau of Meteorology, "Climate statistics for Australian locations — Melbourne Olympic Park (station 086338)", n.d. bom.gov.au
- CSIRO, "Indigenous seasonal calendars", 2026. csiro.au
- Wikipedia, "Axial tilt", 2026. en.wikipedia.org
- Wikipedia, "Earth's orbit", 2026. en.wikipedia.org
- Wikipedia, "Melbourne", 2026. en.wikipedia.org
- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8U12` and its elaborations, 2026. vcaa.vic.edu.au

The Sun-path, day-length, noon-Sun-height and stick-shadow values in the Theory section and Worked Examples 1 and 2 are **computed from the geometry taught here** — Melbourne's latitude (37.8° S, Wikipedia, "Melbourne") and Earth's axial tilt (23.4°, Wikipedia, "Axial tilt") — using the standard relationships between tilt, Sun height and day length; they are not measured data. The Melbourne temperature values (January mean maximum 26.8 °C, July mean maximum 14.5 °C) are real climate statistics from the Bureau of Meteorology's Melbourne Olympic Park station. The

Earth–Sun distances (about 147.1 million km around 3 January; about 152.1 million km around 4 July) are as given in Wikipedia, “Earth’s orbit”.

Elaboration contexts used: `VC2S8U12.E01` (physical models or virtual simulations of how Earth’s tilt and position relative to the Sun cause differences in light intensity on Earth’s surface, resulting in seasons) and `VC2S8U12.E05` (Aboriginal and/or Torres Strait Islander Peoples’ seasonal calendars and how these can be used to predict seasonal change — the seasonal calendar of the people of D’harawal Country, south-west of Sydney).

Teacher-facing note — E05 delivery under D10/ICIP (not student text). The text of `VC2S8U12.E05` names “the cries of tiger quolls in search of mates”; the primary source (Bureau of Meteorology, “D’harawal calendar”) writes “the cries of the marrai’gang (quoll) seeking his mate”. Per §6’s sourcing rule this subtopic follows the primary source’s wording, and records the discrepancy here rather than papering over it. The D’harawal calendar is hosted by the Bureau of Meteorology with permission of the D’harawal Traditional Knowledge holders and Descendants Circle; per CSIRO, the seasonal calendars are the Indigenous Cultural and Intellectual Property (ICIP) of the communities who shared them, published with permission and conditions on use. Accordingly this subtopic teaches only the sourced indicator chain of the Time of Marrai’gang (April–June) with its permission line attached, and does not reproduce or redraw the calendar itself. The “six seasons” count is from the six named seasons on the Bureau’s page.

Earth, Moon and Sun: modelling the lunar cycle, solar and lunar eclipses, and the tides

What we teach here — VC2S8U12 (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"cyclic changes in the relative positions of Earth, the Sun and the Moon can be modelled to show how these cycles cause eclipses and influence predictable phenomena on Earth, including seasons and tides"* **This subtopic owns the phases/eclipses/tides clause only**: modelling the Earth–Moon–Sun positions to explain the lunar phases, eclipses and tides. The rest of the CD — modelling Earth–Sun positions to explain the seasons — belongs to the partner subtopic **14A** († split delivery, D6). 14A teaches the seasons mechanism; this subtopic does not teach it and does not repeat it (D9). **In our words:** the sky runs on repeats. The Sun always lights one half of the Moon, and as the Moon circles Earth the shape we see grows from a thin curve to a full round face and back again, every 29.5 days. When the Sun, the Moon and Earth line up exactly, shadows fall from one body onto another — those are eclipses — and because the Moon's path is tilted, exact line-ups come only now and then, not every month. And the Moon's pull of gravity, with some help from the Sun's, lifts the oceans twice a day in a rhythm you can predict ahead. Three bodies, their positions, and the patterns that repeat — that is the whole of this subtopic. **Achievement-standard extract served here (D13):** *"They model the Earth–Sun–Moon system's cyclic changes to explain the observable phenomena of seasons and tides."* 14A is the owner of VC2S8U12, so the extract appears in full in 14A's header; this subtopic cites it by reference to that header. **Elaborations drawn on:** VC2S8U12.E02 (examining the effect of the gravitational attraction of the Moon and Sun on Earth's oceans and describing how the positions of the Moon and Sun in relation to Earth result in tidal variations), VC2S8U12.E03 (using physical models or virtual simulations to explain the cyclic patterns of lunar phases and eclipses of the Moon and Sun), VC2S8U12.E04 (researching knowledges held by Aboriginal and/or Torres Strait Islander Peoples about the phases of the Moon and the connection between the lunar cycle and ocean tides — here, the Torres Strait Islander understanding of lunar cycles and neap tides enabling prediction of the safest periods to dive for lobster on the reef, delivered from the named published sources listed in Sources (D10)) and VC2S8U12.E06 (researching Aboriginal and/or Torres Strait Islander Peoples' oral traditions and cultural recordings of solar and lunar eclipses, and investigating similarities and differences with contemporary understandings — here, recorded accounts surveyed in Hamacher and Norris 2011, delivered from that named published source (D10)). **Authored from the CD text and the elaboration contexts (D12):** the CD names "eclipses" and "tides" among the predictable phenomena the cycles cause and influence but does not say how either works; E02 supplies the tide mechanism modelled here (the gravitational attraction of the Moon and Sun on the oceans; positions → tidal variations), E03 supplies the modelling activity for phases and eclipses, and E04 and E06 supply the contexts read in the final two theory sections. Scope is capped by D9: this subtopic stays inside the Earth–Sun–Moon system — nothing about other stars appears at all — and it does not teach the seasons mechanism, which is 14A's. **Maths interlock (D11):** the tide-time arithmetic in this subtopic practises time and duration from VC2M8M04 (Mathematics, Level 8).

Word watch — *spring tide*, *phase*, *waxing* and *waning*. A **spring tide** is a tide with the biggest range — the highest high tides and the lowest low tides. It has nothing to do with the season called spring; here *spring* means to jump up. A **neap tide** is the opposite: a tide with the smallest range. A **phase** of the Moon is one of the shapes the lit part of the Moon makes as seen from Earth — not a stage of a plan. **Waxing** means growing: from new moon to full moon, the lit part we see gets bigger each night. **Waning** means shrinking: from full moon back to new moon, the lit part gets smaller. Neither word is about candle wax. A **gibbous** Moon is more than half lit but not full; a **crescent** Moon is a curved sliver, less than half lit. And **gravity**: the pull that every object with mass has on every other object. Earth's gravity pulls everything toward the ground; the Moon's gravity reaches all the way across space and tugs on Earth's oceans.

Theory

The Moon — Earth's travelling companion

The Moon is Earth's nearest neighbour in space, about **384 400 km** away on average. Its diameter is about **3 474 km** — a little less than a third of Earth's. The Moon travels around Earth in an orbit, and one full cycle of its changing shapes — say, from one full moon to the next — takes about **29.5 days**.

Two more facts matter for everything that follows. The Moon has no light of its own — like Earth, it is lit by the Sun, and at any moment the Sun lights exactly one half of it. And the Moon always shows us the same face: it spins around once in exactly the time it takes to go once around Earth, so the same side keeps facing us.

Source: Wikipedia, “Moon”, 2026. en.wikipedia.org — retrieved 2026-08-21.

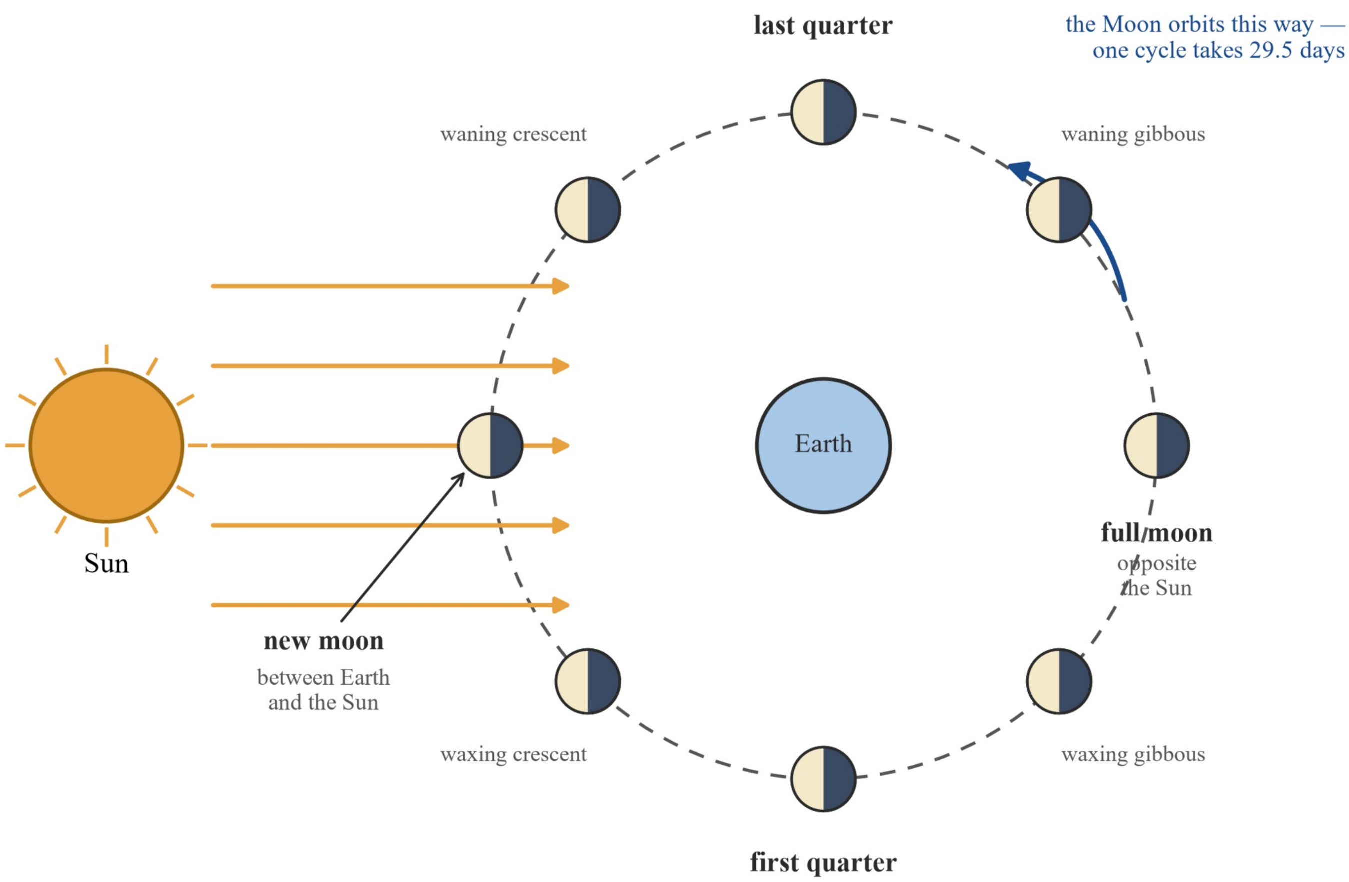
Why the Moon has phases

Because the Sun always lights one half of the Moon, what changes through the month is not the Moon itself but **how much of the lit half we can see**.

- When the Moon is **between Earth and the Sun**, the lit half faces away from us. We see almost nothing: **new moon**.
- About two weeks later the Moon is on the far side of Earth from the Sun, with Earth roughly in between. Now the whole lit half faces us: **full moon**.
- In between come the in-between shapes. At the two **quarter** positions we see half of the lit face — **first quarter** on the way up, **last quarter** on the way down. The curved slivers are **crescents**; the more-than-half shapes are **gibbous**.

The eight shapes, and the positions that make them, are shown below. One full trip around the cycle takes 29.5 days, so each step is about a week: new moon to first quarter about 7 days, to full moon about 15 days, to last quarter about 22 days, and back to new moon about 29.5 days.

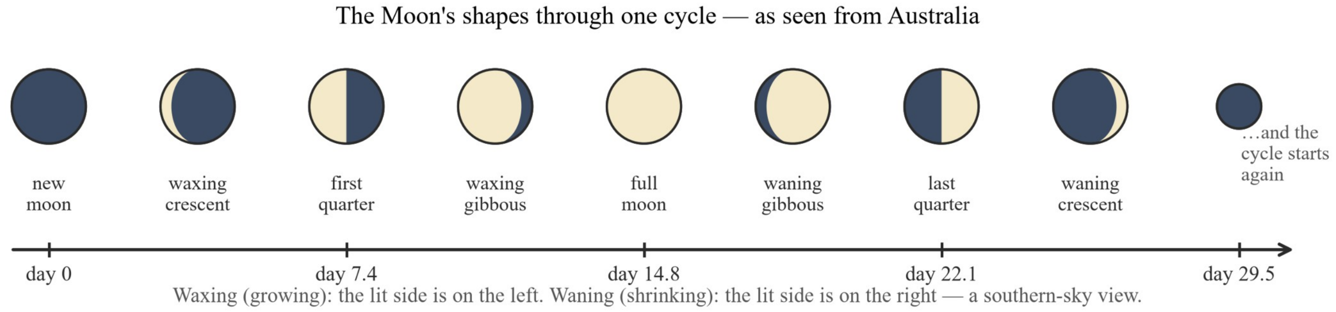
View from above the north pole — the Sun always lights one half of the Moon



Not to scale. The phase we see depends only on where the Moon is in its orbit around Earth.

Diagram viewed from above the north pole of the Moon at eight positions in its orbit around Earth, with the Sun far to the left lighting one half of the Moon at every position, and each position labelled with its phase: new moon, waxing crescent, first quarter, waxing gibbous, full moon, waning gibbous, last quarter and waning crescent

One detail matters for anyone actually watching the Moon from Victoria. From Australia, a **waxing** Moon — one that is growing toward full — has its lit side on the **left**. A **waning** Moon — one that is shrinking after full — has its lit side on the **right**. If you have ever seen it drawn the other way around, you were looking at a northern-hemisphere drawing: from the northern hemisphere the Moon appears the other way up. From here, left is waxing.



Row of eight Moon shapes as seen from Australia laid along the 29.5-day cycle from day 0 to day 29.5, showing the waxing Moons lit on the left and the waning Moons lit on the right

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Try it — modelling the phases with a lamp and a ball (`VC2S8U12.E03`)

You will need: a bright lamp with its shade off (the Sun), a small ball on a stick or string (the Moon), and a darkened room. Your own head stands in for Earth — you are the observer, standing on it.

1. Darken the room and put the lamp at head height. Stand facing it. The lamp is the Sun; your head is Earth.
2. Hold the ball at arm's length directly between your eyes and the lamp. This is the new moon position — the side of the ball facing you is in shadow.
3. Keep your eyes on the ball and move it slowly in a circle around your head, away from the lamp. Keep it the same distance from your head the whole way.
4. Stop at four positions: between you and the lamp; beside you; on the far side from the lamp; and beside you again. At each stop, describe the shape of the lit part you can see.
5. Check two things: on the far side from the lamp, the whole face you can see is lit (full moon); at the side positions, half the face you can see is lit (quarter moons).
6. To model eclipses: hold the ball exactly between your eyes and the lamp, so its shadow falls on your face (a solar eclipse); then turn your back to the lamp and hold the ball out in front of you inside the shadow your head throws (a lunar eclipse).

Safety: lamps get hot while they are on — switch off and let the lamp cool before packing away, and keep cords clear of the floor.

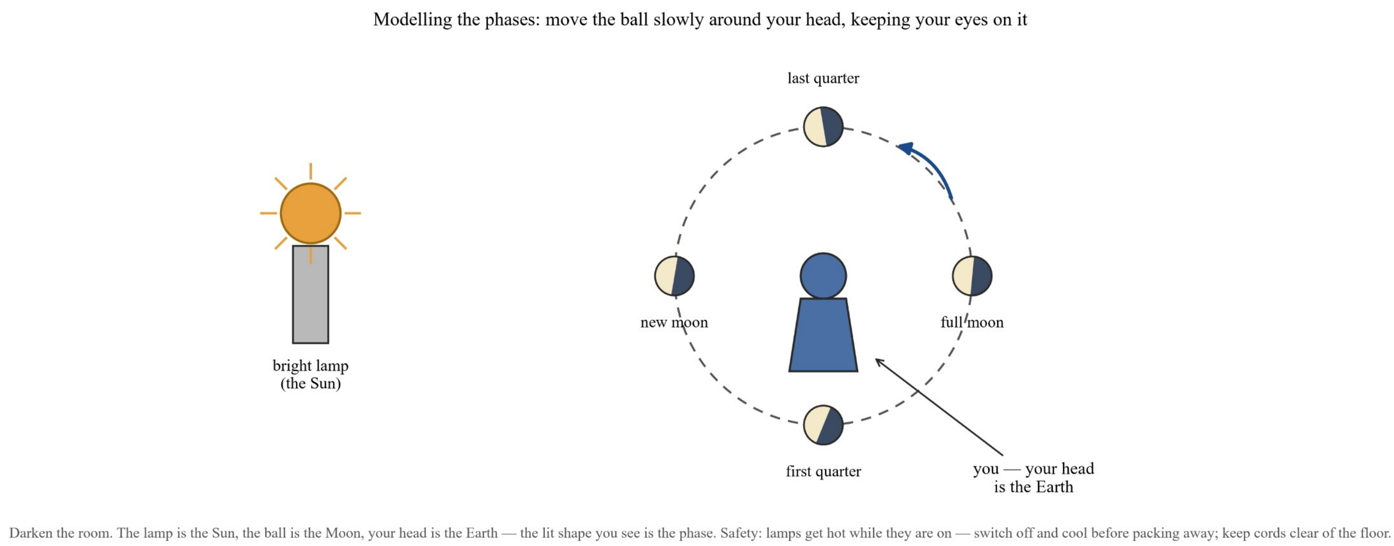


Diagram of the lamp-and-ball model of the phases, with a bright lamp as the Sun on the left, a person whose head is the Earth on the right, and the ball carried around the head on a dashed circular path marked with the new moon, quarter moon and full moon positions

What you did	What it models	What it stands for in nature
Lamp lighting one half of the ball	The Sun lighting one half of the Moon	Sunlight reaching the Moon from far away
Ball moved in a circle around your head	The Moon’s orbit around Earth	The Moon’s 29.5-day journey around Earth
Your head	Earth, with you standing on it as the observer	Where you stand when you look up at the night sky
The lit shape you can see on the ball	The phase of the Moon	New moon, quarter moons, full moon and the shapes between
Ball exactly between your eyes and the lamp	New moon lined up exactly — a solar eclipse	The Moon’s shadow falling on part of Earth
Ball inside the shadow your head throws	Full moon lined up exactly — a lunar eclipse	Earth’s shadow falling on the Moon

Every model has limits, and seeing them clearly is part of the skill. Ask yourself:

- The ball sits an arm’s length from your head, and the lamp sits a few metres away. The real Moon is about 384 400 km from Earth, and the real Sun is much farther away still. What does squeezing all those distances into one room change?
- Your ball circles your head in one flat plane. The real Moon’s path is tilted by about 5°. In your model, does every “new moon” make an eclipse? Does every new moon make one in nature?
- The lamp is close, so its light spreads out as it travels. The Sun is so far away that its light reaches the Moon almost in parallel rays. What difference does that make to the shadows?

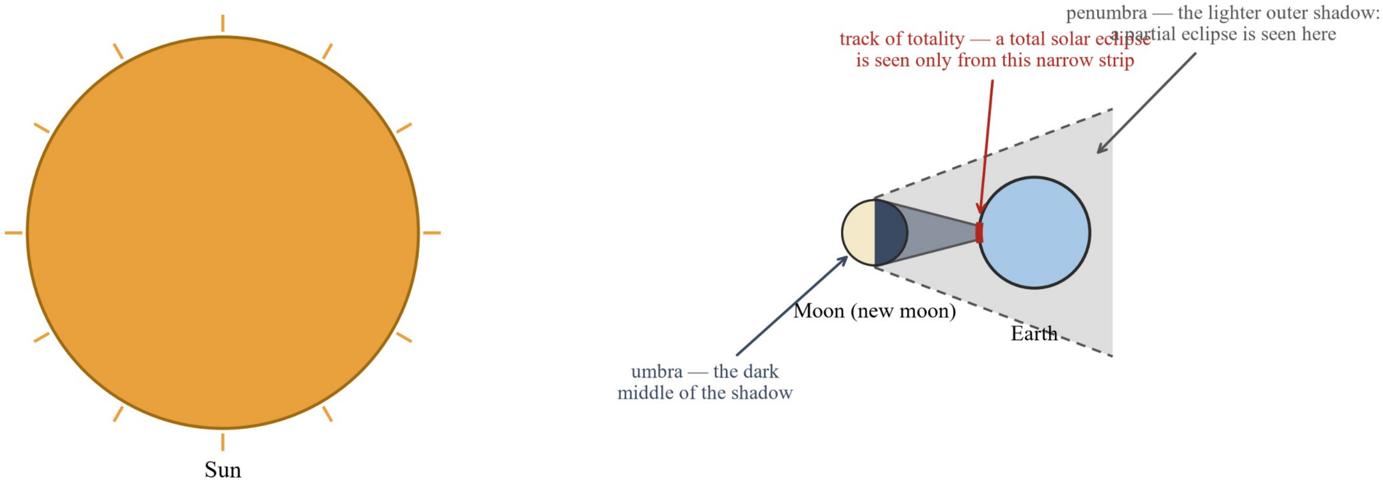
Solar eclipses — when the new moon’s shadow crosses Earth

A **solar eclipse** happens when a new moon passes exactly between the Sun and Earth, so the Moon’s shadow falls on part of Earth’s surface.

The shadow has two parts. The **umbra** is the dark middle, where the Moon covers the Sun completely — anyone standing in the umbra sees a **total solar eclipse**. Around it lies the **penumbra**, the lighter outer shadow, where the Moon covers only part of the Sun — people there see a **partial solar eclipse**. The umbra that reaches Earth is a tiny spot, so totality is seen only from a narrow strip of ground — the **track of totality** — while the partial eclipse is seen from a far wider region on either side of it. The strip is so narrow, and the line-up so exact, that a total solar eclipse returns to any one place on Earth only about every 360 to 410 years.

Source: Wikipedia, “Solar eclipse”, 2026. en.wikipedia.org — retrieved 2026-08-21.

A solar eclipse — the new moon passes between the Sun and Earth



Not to scale: sizes and distances are changed so the shadows can be seen.

Diagram of a solar eclipse showing the Sun, the new moon and Earth in line, with the Moon’s dark middle shadow, the umbra, and its lighter outer shadow, the penumbra, reaching Earth, and the narrow track of totality marked on Earth’s surface

Never look straight at the Sun, eclipsed or not, except during the brief minutes of totality — the Sun’s light can damage your eyes in seconds.

Lunar eclipses — when the full moon enters Earth’s shadow

A **lunar eclipse** happens when the Sun, Earth and a full moon line up, with Earth in the middle, so Earth’s shadow falls on the Moon.

The eclipsed Moon does not go completely dark. Even deep inside the umbra it stays dimly visible, usually glowing a coppery red. The cause is Earth’s atmosphere: sunlight passing through the thin ring of air around Earth is bent (refracted) into the shadow. The air also scatters the blue part of the light away — the same reason sunsets look red — so mostly red light reaches the Moon and lights it faintly. The total stage, with the Moon fully inside the umbra, can last up to about **107 minutes**. And unlike a total solar eclipse, a lunar eclipse is seen by everyone on Earth’s night side at the same time — the shadow is on the Moon, where all of them can see it.

Source: Wikipedia, “Lunar eclipse”, 2026. en.wikipedia.org — retrieved 2026-08-21.

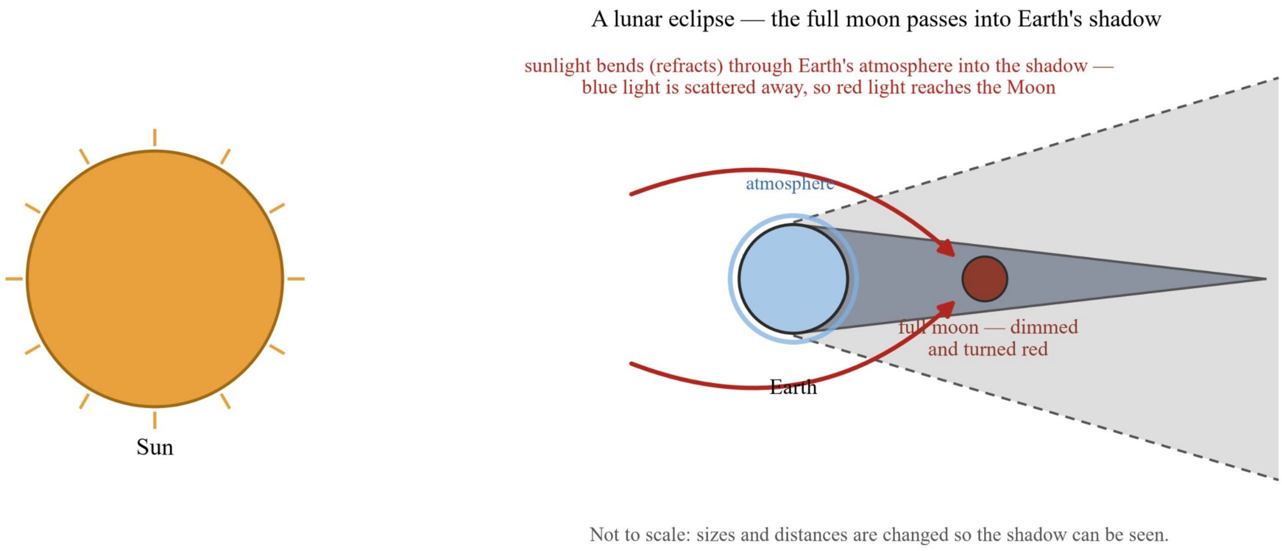


Diagram of a lunar eclipse showing the Sun, Earth and full moon in line, with the Moon dimmed and turned red inside Earth's shadow, and red sunlight bending through Earth's atmosphere into the shadow

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Why there is not an eclipse every month

If the Moon went around Earth in the same flat plane as Earth's path around the Sun, there would be a solar eclipse at every new moon and a lunar eclipse at every full moon. But the Moon's orbit is tilted by about **5°** compared with Earth's orbital plane. Most months, the new moon's shadow passes above or below Earth, and the full moon passes above or below Earth's shadow. Nothing is covered, and there is no eclipse.

An eclipse happens only when a new or full moon occurs near one of the two points where the Moon's orbit crosses Earth's orbital plane — points called **nodes**. The Sun, Earth and Moon then line up almost exactly. Because the line-up depends on the nodes, eclipses come in windows — **eclipse seasons** — roughly every six months, not every month.

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

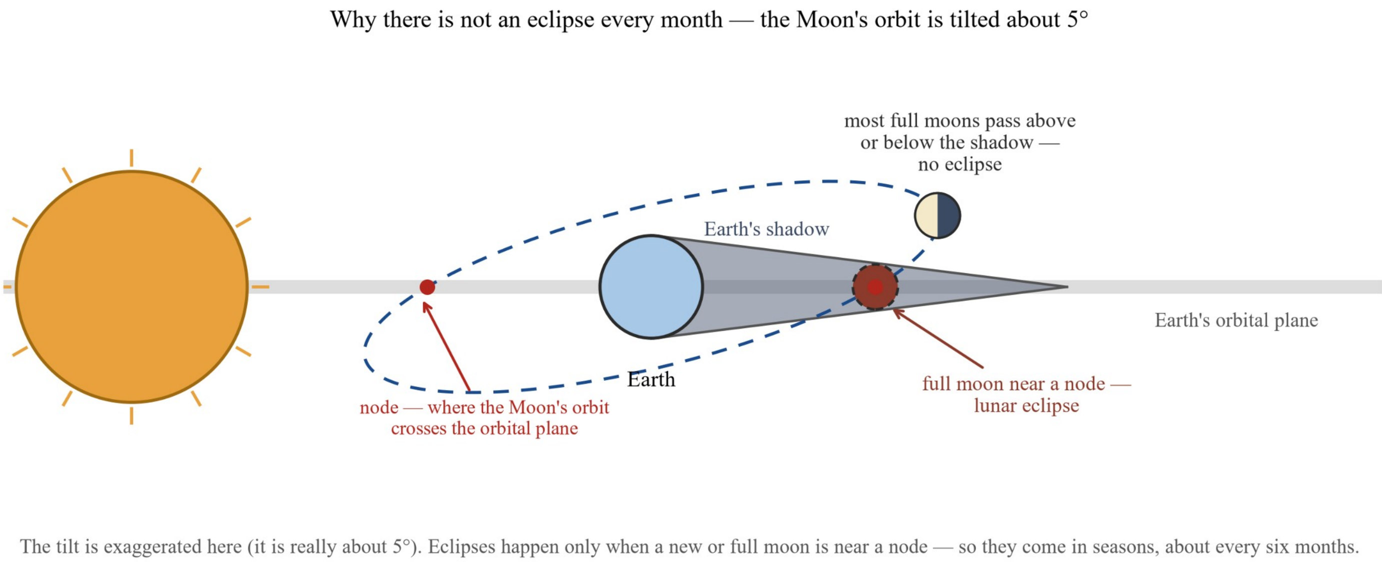

Diagram showing why there is not an eclipse every month, with the Moon's orbit drawn tilted to Earth's orbital plane, most full moons passing above or below Earth's shadow, and an eclipse happening only where a full moon sits near a node, one of the two points where the orbit crosses the plane

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Tides — the Moon's pull on the oceans (`VC2S8U12.E02`)

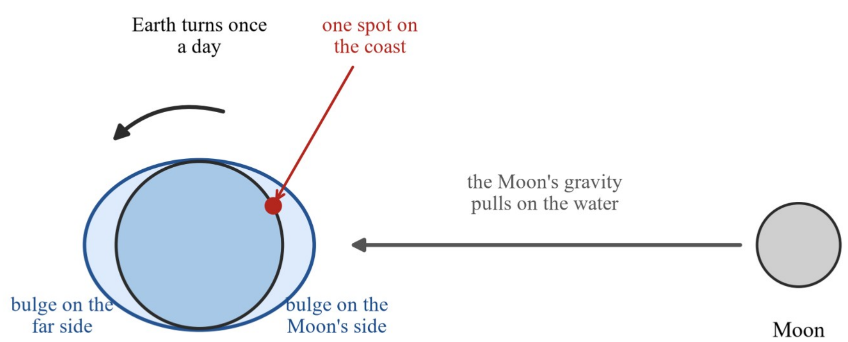
Gravity is the pull that every object with mass has on every other object. The Moon is much smaller than the Sun, but it is far closer to Earth — and its gravity reaches across the 384 400 km between them and tugs on Earth's oceans.

That tug raises two bulges in the water: one on the side of Earth facing the Moon, where the pull is strongest, and one on the far side, where the water is pulled the least. At the same time, Earth turns once a day underneath the bulges. A spot on the coast passes through a bulge → high tide; then out of it → low tide; then through the second bulge → high tide again. So most coasts have **two high tides and two low tides each day**.

The timing is set by the Moon. From one high tide to the next is about **12 h 25 min**. And because the Moon is moving along its own orbit at the same time as Earth turns, the Moon comes back to the same place in the sky only after about **24 h 50 min** — a full "tidal day". That is why each day's tides arrive about **50 minutes later** than the day before.

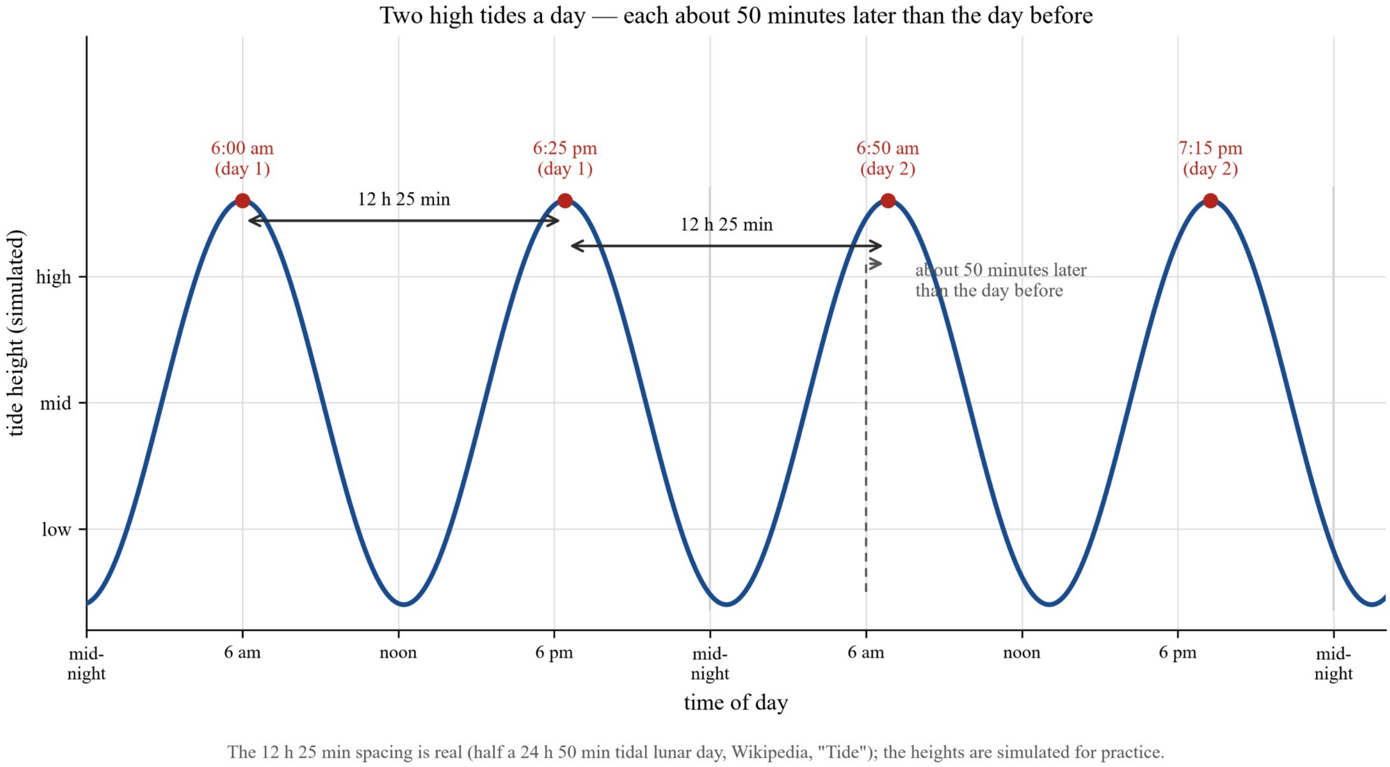
Source: Wikipedia, "Tide", 2026. en.wikipedia.org — retrieved 2026-08-21.

Two tidal bulges — Earth turns underneath them



The bulges are exaggerated — real tidal bulges are small compared with Earth. A coast passing through a bulge has a high tide; most coasts pass through two bulges a day.

Diagram of Earth with two exaggerated tidal bulges in the ocean, one on the side facing the Moon and one on the far side, with Earth turning once a day underneath them and one spot on the coast marked passing through both bulges



Graph of simulated tide heights over two days, with high tides at 6:00 am, 6:25 pm, 6:50 am and 7:15 pm, showing the real spacing of about 12 hours 25 minutes between high tides and the slip of about 50 minutes later each day

The tide heights in the graph above are simulated for practice; the spacings it shows — 12 h 25 min between high tides, about 50 minutes later each day — are the real ones.

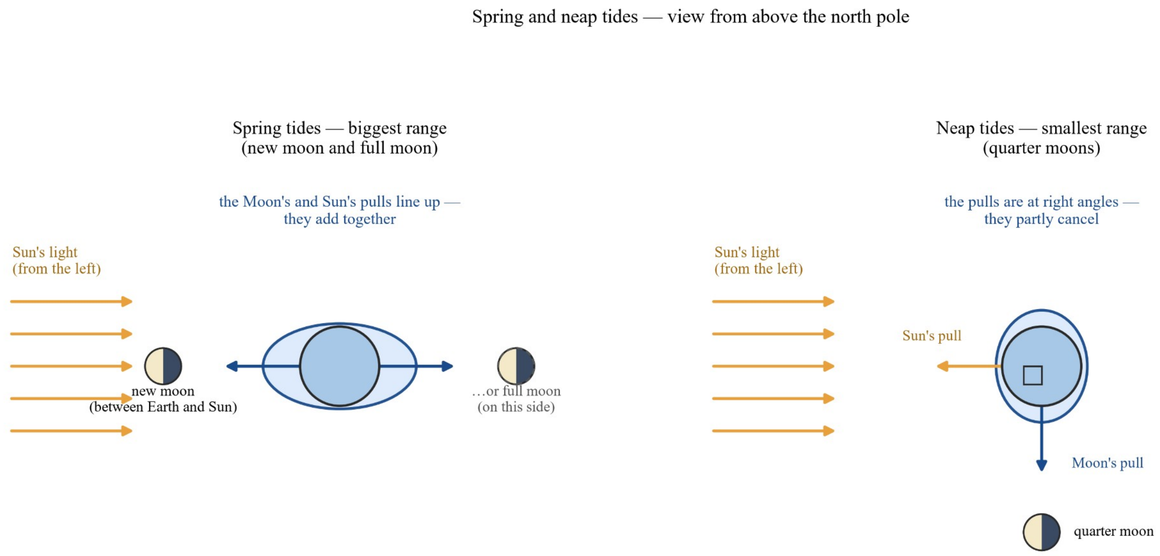
Spring tides and neap tides

The Sun pulls on Earth's oceans too. Even though the Sun is much farther away than the Moon, its tidal pull is still about **46%** of the Moon's. Whether the two pulls work together or against each other depends on the positions of the Sun, the Moon and Earth.

- At **new moon and full moon**, the three bodies are in a line. The Moon's pull and the Sun's pull point along the same line and add together. The bulges grow: high tides are at their highest, low tides at their lowest, and the range of the tide is at its biggest. These are **spring tides** — remember, the name means the water "springs up"; it has nothing to do with the season.
- At the **quarter moons**, the Moon is off to the side, and the two pulls act at right angles to each other. The Sun's pull works against the Moon's. The bulges shrink: the range of the tide is at its smallest. These are **neap tides**.

The pattern repeats about every two weeks: about **7 days** from a spring tide to the next neap tide, and about 7 days back to the next spring tide.

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



Two diagrams viewed from above the north pole: spring tides at new moon and full moon, where the pulls of the Moon and the Sun line up and add together, and neap tides at the quarter moons, where the pulls act at right angles and work against each other

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Moon, tides and the crayfish hunt (`VC2S8U12.E04`)

Aboriginal and Torres Strait Islander Peoples have long read the link between the Moon and the ocean that this subtopic models. One teaching comes from **David Bosun**, a Torres Strait Islander man of Moa Island, recorded in a 2018 video by Duane Hamacher and discussed in Brooker (2024): around the **quarter moon** — first or last quarter — crayfish (rock lobster) are plentiful on the reef, and it is a good time to dive for them.

The chain behind the teaching runs through the very tide physics above:

- At quarter moon, the pulls of the Moon and the Sun act at right angles, so the tides are **neap** — small range, gentle currents.
- Gentle tides do not stir up the reef, so the water stays clear — crystal clear.
- In clear, calm water, the crayfish leave their shelters and swim slowly, where they are easier to see and to spear.

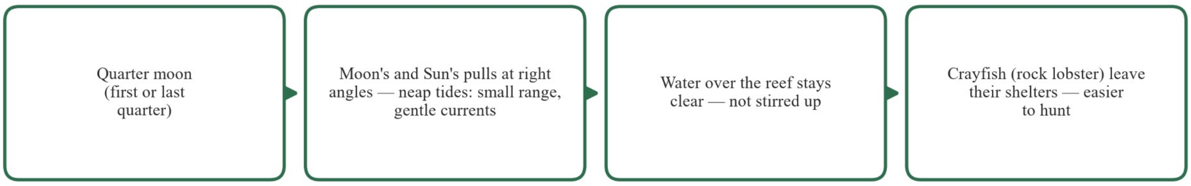
So the phase of the Moon works as a calendar: reading it tells you, days ahead, when the water over the reef will be calm and clear and the crayfish easiest to hunt — a prediction about the safest, best time to dive.

This knowledge belongs to its Torres Strait Islander owners. It is taught here as it was recorded from David Bosun, with the sources named.

Source: Hamacher, D., “Torres Strait astronomy with David Bosun” [video], YouTube, 2018. youtube.com — retrieved 2026-08-21.

Source: Brooker, E., “Archaeoastronomy: Comparing Astronomic Traditions of Torres Strait Islanders with Quantitative Evidence” (MA thesis, University of Oklahoma), 2024. shareok.org — retrieved 2026-08-21.

Moon, tides and the crayfish hunt — knowledge recorded from David Bosun, a Torres Strait Islander man of Moa Island



Source: recorded in Hamacher, "Torres Strait astronomy with David Bosun", 2018 (video), and discussed in Brooker, Archaeoastronomy, 2024. This knowledge belongs to its Torres Strait Islander custodians.

Flow diagram of four linked stages from the knowledge recorded from David Bosun: quarter moon, then neap tides with gentle currents, then clear water over the reef, then crayfish leaving their shelters and becoming easier to hunt

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Recorded Aboriginal accounts of eclipses (`VC2S8U12.E06`)

Aboriginal Peoples across Australia have watched and recorded eclipses in oral traditions — stories, songs and art handed down through the generations. A survey of about **50** recorded accounts (Hamacher and Norris, 2011) found two things that matter here.

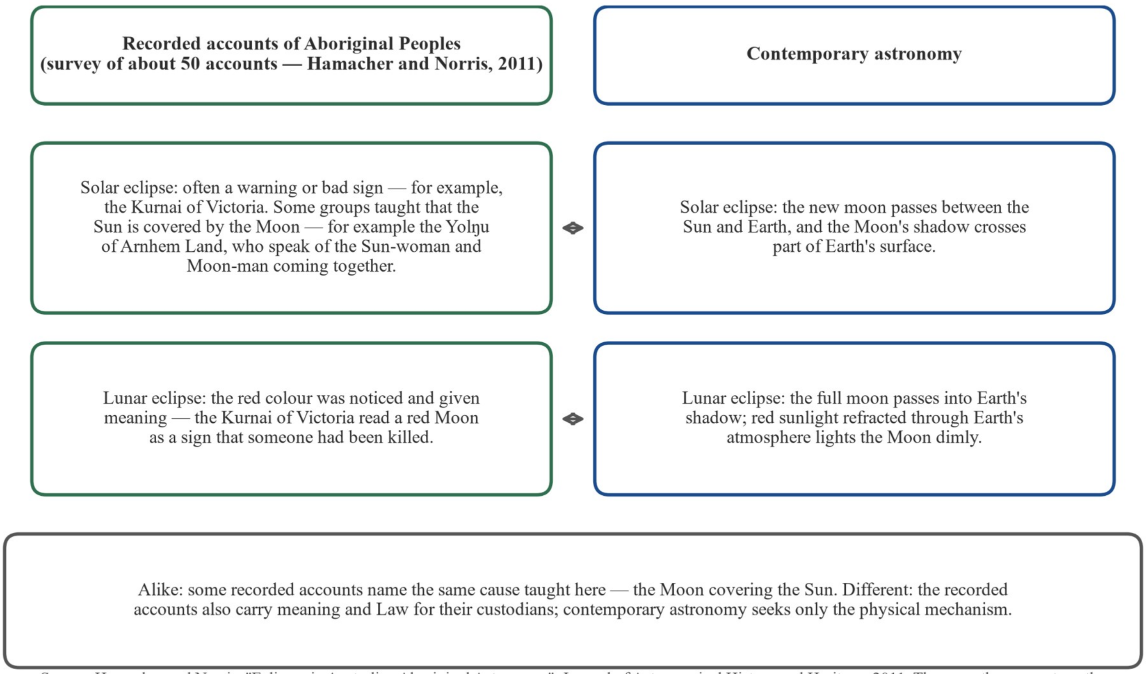
Many accounts read an eclipse as a warning or a bad sign. Among the **Kurnai** of south-eastern Victoria, a solar eclipse was feared, and a red eclipsed Moon was read as a sign that someone had been killed. And many groups worked out what was actually happening in the sky: the survey notes that many Aboriginal groups understood the motions of the Sun–Earth–Moon system and the link between the Moon’s phases and the tides. Some accounts taught that the Sun is covered by the Moon — for example, the **Yolŋu** of Arnhem Land speak of the Sun-woman and the Moon-man coming together.

How do these recorded accounts compare with the astronomy taught in this subtopic?

- **Alike:** both are built on careful watching of the same sky, and some recorded accounts name the same cause taught here — the Moon covering the Sun.
- **Different:** the recorded accounts also carry meaning and Law for their owners — warnings, responses, the roles of Elders — while today’s astronomy looks only for the physical cause: the positions of the Sun, the Moon and Earth, and the shadows they cast.

This is the knowledge as the sources record it; it belongs to its Aboriginal owners.

Source: Hamacher, D. and Norris, R., “Eclipses in Australian Aboriginal Astronomy”, Journal of Astronomical History and Heritage 14(2), 2011. arxiv.org — retrieved 2026-08-21.



Source: Hamacher and Norris, "Eclipses in Australian Aboriginal Astronomy", Journal of Astronomical History and Heritage, 2011. These are the accounts as the sources record them; they belong to their Aboriginal custodians.

Two-column comparison of recorded Aboriginal accounts of solar and lunar eclipses beside today's astronomy explanations, with a strip below noting how they are alike and how they are different

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The whole story in four sentences

The Sun always lights one half of the Moon, and as the Moon circles Earth every 29.5 days the lit part we see grows and shrinks — that cycle is the lunar phases, with the waxing side on the left as seen from Victoria. When the three bodies line up exactly at new moon, the Moon's shadow crosses Earth — a solar eclipse; when they line up exactly at full moon, Earth's shadow covers the Moon — a lunar eclipse — and because the Moon's orbit is tilted about 5°, exact line-ups come only in eclipse seasons, not every month. The Moon's gravity, with a pull from the Sun worth about 46% of its own, raises two bulges in the ocean, and Earth's daily turn under them gives most coasts two high tides a day, about 12 h 25 min apart and about 50 minutes later each day. When the two pulls line up (new and full moon) the tides are at their biggest — spring tides; when the pulls act at right angles (quarter moons) they are at their smallest — neap tides — a rhythm Torres Strait Islander Peoples have long read to plan the crayfish hunt.

Worked examples

Example 1 — scaffolded

At one coastal town, high tide is at **6:00 am** on day 1. The time from one high tide to the next is about **12 h 25 min**. *(Tide times here are simulated data for practice. The time-and-duration arithmetic is the* `VC2M8M04` *interlock (D11).)*

(a) At about what time is the next high tide?
(b) Low water comes about halfway between two high tides. At about what time is the low water between the two high tides in part (a)?
(c) At about what time is the high tide after that one — that is, on the morning of day 2?

Working	Comment
(a) 6:00 am + 12 h 25 min = **6:25 pm**.	Add hours to hours and minutes to minutes.
(b) Half of 12 h 25 min is about 6 h 12 min. 6:00 am + 6 h 12 min ≈ **12:12 pm** — just after midday.	Low water sits about halfway between the two high tides.
(c) 6:25 pm + 12 h 25 min = **6:50 am** on day 2.	Each day the tides arrive about 50 minutes later — 6:00 am, then 6:50 am the next morning.

Example 2 — scaffolded

The Moon's phase cycle takes **29.5 days**. On **2 March** there is a new moon — and a spring tide.

(a) On about what date is the next full moon, and what kind of tide — spring or neap — comes with it?
(b) On about what date is the first quarter moon, and what kind of tide comes with it?
(c) About how many days pass between a spring tide and the next neap tide?

Working	Comment
(a) Full moon comes about half a cycle later: 29.5 ÷ 2 ≈ 14.8, so about 15 days on — about **17 March**. The Sun, Earth and Moon are in line again, so it is a **spring tide**.	New moon → full moon is half the 29.5-day cycle.
(b) First quarter comes about a quarter of a cycle later: 29.5 ÷ 4 ≈ 7.4, so about 7 days on — about **9 March**. The pulls act at right angles, so it is a **neap tide**.	Quarter moons fall a quarter of the way around the cycle.
(c) About **7 days**.	Spring tides and neap tides alternate about every week through the cycle.

Example 3 — unscaffolded

A student in Melbourne watches the Moon and says: *"The lit side is on the right, so the Moon is waxing — it is growing toward full."* Evaluate this claim.

The claim is wrong for an observer in Victoria. From Australia, a **waxing** Moon — one growing toward full — has its lit side on the **left**; a Moon lit on the **right** is **waning**, shrinking after full. The student has applied the northern-hemisphere rule, where the sides are swapped. ∴ seen from Melbourne, a Moon lit on the right is waning, not waxing.

Example 4 — unscaffolded

Explain why a total lunar eclipse can be seen by everyone on Earth's night side at once, while a total solar eclipse is seen only from a narrow strip.

In a lunar eclipse, the shadow falls **on the Moon**: Earth stands between the Sun and the full moon, and Earth's umbra covers the Moon itself. Anyone on Earth's night side can see the Moon at that moment, so everyone there sees the same darkened, reddened Moon at the same time. In a solar eclipse, the shadow falls **on Earth**: the much smaller Moon stands between the Sun and Earth, and its umbra reaches Earth as only a tiny spot. Totality is seen only where that spot touches — the narrow track of totality — while people across the much wider penumbra see only a partial eclipse. ∴ the difference is where the shadow lands: a lunar eclipse puts the shadow on the Moon, in everyone's view; a solar eclipse puts a small shadow on Earth, in the way of only a few.

Practice questions

Scaffolded

Q1. Answer the following about the Moon. (a) About how far is the Moon from Earth, on average? (b) About how long does one full cycle of the Moon's shapes take? (c) Do we always see the same face of the Moon from Earth?

Q2. Answer the following about the lunar phases. (a) Name the phase when the Moon sits between Earth and the Sun. (b) About how long after new moon does full moon come? (c) Seen from Victoria, which side of a waxing Moon is lit — left or right?

Q3. Answer the following about solar eclipses. (a) During which phase can a solar eclipse happen? (b) What is the dark middle part of the Moon's shadow called? (c) Why is a total solar eclipse seen only from a narrow strip of Earth?

Q4. Answer the following about lunar eclipses. (a) During which phase can a lunar eclipse happen? (b) Why does the Moon in total eclipse look dim and red rather than going dark? (c) About how long can the total stage of a lunar eclipse last?

Q5. Answer the following about the tides. (a) How many high tides do most coasts get each day? (b) About how long passes from one high tide to the next? (c) Why does each tide arrive about 50 minutes later than the day before?

Q6. Answer the following about the crayfish knowledge recorded from David Bosun (Hamacher, 2018, video; Brooker, 2024). (a) Around which phase of the Moon are crayfish plentiful on the reef? (b) Why does the water over the reef stay clear at that phase? (c) What do the crayfish do at that time that makes them easier to hunt?

Unscaffolded

Q7. A student says: *"The tides are caused only by the Moon — the Sun has nothing to do with them."* Evaluate this claim. In your answer, use the size of the Sun's tidal pull and what happens at spring and neap tides. *(2 marks)*

Q8. Explain why spring tides — the tides with the biggest range — happen at both new moon **and** full moon. In your answer, link the positions of the Sun, the Moon and Earth to the size of the tides. *(3 marks)*

Q9. Use the ideas of umbra and penumbra to explain why a total solar eclipse is seen from only a narrow strip of Earth, while a partial solar eclipse is seen from a much wider region. *(2 marks)*

Q10. Explain why there is not a lunar eclipse at every full moon. In your answer, use the tilt of the Moon's orbit and the idea of the nodes. *(2 marks)*

Q11. At one beach, high tide is at **3:20 pm**. (a) At about what time is the next high tide? (b) At about what time is the high tide after that one? *(2 marks)*

Q12. In the Try-it lamp-and-ball model of the phases, the ball is held at arm's length from your head. State one strength of this model for explaining the phases, and one way it falls short of the real Earth–Moon–Sun system. *(2 marks)*

Q13. Explain how knowledge of the link between the lunar cycle and the tides lets Torres Strait Islander Peoples plan the crayfish hunt, as recorded from David Bosun. In your answer, follow the chain from the phase of the Moon to the hunt. *(2 marks)*

Q14. Recorded Aboriginal accounts of eclipses and today's astronomy both describe the same events in the sky. State one way they are alike and one way they are different, using examples from this subtopic. *(3 marks)*

Answers

Q1. (a) About 384 400 km. (b) About 29.5 days. (c) Yes — the Moon always shows us the same face. **Q2.** (a) New moon. (b) About 15 days (half of the 29.5-day cycle). (c) The left side. **Q3.** (a) New moon. (b) The umbra. (c) The umbra reaching Earth is a tiny spot, so totality is seen only from the narrow strip it crosses. **Q4.** (a) Full moon. (b) Sunlight bends through Earth's atmosphere into the shadow; the air scatters the blue light away, so red light reaches the Moon. (c) Up to about 107 minutes. **Q5.** (a) Two. (b) About 12 h 25 min. (c) The Moon moves along its orbit while Earth turns, so it returns to the same place in the sky only after about 24 h 50 min. **Q6.** (a) Around the quarter moon — first or last quarter. (b) Quarter moons bring neap tides — small range and gentle currents — so the water is not stirred up. (c) They leave their shelters and swim slowly. **Q7.** The claim is wrong: the Sun's tidal pull is about 46% of the Moon's, and spring and neap tides show its effect — at new and full moon the two pulls line up and add (spring tides), while at the quarter moons they act at right angles and work against each other (neap tides). **Q8.** At new moon the Moon sits between Earth and the Sun, and at full moon Earth sits between the Sun and the Moon — at both, the three are in a line. The Moon's pull and the Sun's pull then act along the same line and add together, so the tidal bulges grow and the range is biggest. **Q9.** The umbra — the dark middle of the Moon's shadow — reaches Earth as a tiny spot, so totality is seen only along the narrow strip it crosses; the penumbra — the lighter outer shadow — covers a far wider region, where only part of the Sun is covered. **Q10.** The Moon's orbit is tilted about 5° to Earth's orbital plane, so at most full moons the Moon passes above or below Earth's shadow; a lunar eclipse happens only when the full moon is near a node, where the two planes cross. **Q11.** (a) About 3:45 am. (b) About 4:10 pm. **Q12.** Strength (any one): it shows that the phases come from position alone — the same lamp lights half the ball, and the shape seen changes only as the ball moves around the head. Falls short (any one): all distances are squeezed — the real Moon is about 384 400 km away; the model orbit is flat, while the real orbit is tilted about 5°, so in the model every "new moon" eclipses; the lamp is close, so its light spreads, while sunlight arrives almost parallel. **Q13.** Quarter moon → the pulls act at right angles → neap tides with gentle currents → the water stays clear → the crayfish leave their shelters and swim slowly, easy to hunt; reading the Moon predicts this days ahead. **Q14.** Alike (any one): both rest on careful watching of the same sky; some recorded accounts name the same cause taught here — the Moon covering the Sun (Yolŋu). Different: the recorded accounts also carry meaning and Law for their owners — warnings and responses, like the Kurnai reading a red Moon as a sign — while today's astronomy looks only for the physical cause.

Fully-worked solutions

Q1. (a) The Moon is about **384 400 km** from Earth, on average. (b) One full cycle of the Moon's shapes — from one full moon to the next — takes about **29.5 days**. (c) **Yes**: the Moon spins once in the same time it takes to orbit Earth once, so the **same face always points toward Earth**.

Q2. (a) **New moon** — the lit half faces away from Earth, so we see almost nothing. (b) Full moon comes about half a cycle after new moon: $29.5 \div 2 \approx 14.8$, so **about 15 days**. (c) Seen from Victoria, a waxing Moon is lit on the **left** — the right-side-lit picture is the northern-hemisphere view.

Q3. (a) A solar eclipse can happen only at **new moon**, when the Moon passes between the Sun and Earth. (b) The dark middle of the shadow is the **umbra**. (c) The umbra reaching Earth is a **tiny spot** — the Moon is much smaller than Earth — so totality is seen only from the **narrow strip** that spot crosses, the track of totality.

Q4. (a) A lunar eclipse can happen only at **full moon**, when Earth is between the Sun and the Moon. (b) Sunlight passing through Earth's atmosphere is **bent (refracted) into the shadow**, and the air **scatters the blue light away**, so mostly **red** light reaches the Moon and lights it dimly. (c) The total stage can last **up to about 107 minutes**.

Q5. (a) Most coasts get **two high tides** (and two low tides) each day, as Earth turns under two tidal bulges. (b) From one high tide to the next is about **12 h 25 min**. (c) The Moon is moving along its orbit while Earth turns, so it returns to the same place in the sky only after about **24 h 50 min** — that is why the tides slip about **50 minutes later** each day.

Q6. (a) Around the **quarter moon** — first or last quarter. (b) Quarter moons bring **neap tides**: the pulls of the Moon and the Sun act at right angles, the range is small and the currents gentle, so the water over the reef is **not stirred up and stays clear**. (c) The crayfish **leave their shelters and swim slowly**, so they are easier to see and to spear.

Q7. The claim is wrong *(1 mark)*: the Sun's tidal pull is about **46% of the Moon's**, so the Sun has plenty to do with the tides. The evidence is in the two kinds of tide *(1 mark)*: at new and full moon the two pulls **line up and add**, giving spring tides with the biggest range, while at the quarter moons the pulls act **at right angles and work against each other**, giving neap tides with the smallest range — the Sun's pull changes the outcome.

Q8. At new moon the Moon sits **between Earth and the Sun**; at full moon Earth sits **between the Sun and the Moon** *(1 mark)*. In both positions the three bodies are **in a line**, so the Moon's pull and the Sun's pull act **along the same line and add together** *(1 mark)*. The added pull raises bigger bulges, so high tides reach highest, low tides reach lowest, and the **range of the tide is biggest** — spring tides *(1 mark)*.

Q9. The **umbra** — the dark middle of the Moon's shadow where the Sun is fully covered — reaches Earth as a **tiny spot**, so a total eclipse is seen only from the **narrow strip** that spot crosses *(1 mark)*. The **penumbra** — the lighter outer shadow where only part of the Sun is covered — spreads over a **far wider region** of Earth, so a partial eclipse is seen from a much wider area *(1 mark)*.

Q10. The Moon's orbit is **tilted about 5°** to Earth's orbital plane, so at most full moons the Moon passes **above or below Earth's shadow** and nothing is eclipsed *(1 mark)*. A lunar eclipse happens only when the full moon falls **near a node** — one of the two points where the Moon's orbit crosses Earth's orbital plane — so the three bodies can line up exactly *(1 mark)*.

Q11. (a) 3:20 pm + 12 h 25 min = **about 3:45 am** *(1 mark)*. (b) 3:45 am + 12 h 25 min = **about 4:10 pm** — both fall on the day after the 3:20 pm tide, since the tides arrive about 50 minutes later each day *(1 mark)*.

Q12. Strength (any one, *(1 mark)*): the model shows that the phases come from **position alone** — the same lamp lights one half of the ball the whole time, and the shape seen changes only as the ball moves around the head, exactly as the real phases come from the Moon's position in its orbit. Falls short (any one, *(1 mark)*): the **distances are squeezed** — the real Moon is about 384 400 km away and the Sun much farther; the model orbit is **flat**, while the real one is tilted about 5°, so in the model every "new moon" eclipses when in nature eclipses are rare; or the nearby lamp's light **spreads out**, while sunlight arrives at the Moon almost parallel.

Q13. The chain runs: at **quarter moon** the pulls of the Moon and the Sun act at right angles, so the tides are **neap** — small range, gentle currents *(1 mark)*; gentle tides do not stir the reef, so the **water stays clear**, the crayfish leave their shelters and swim slowly, and the hunt is safe and rewarding — reading the Moon **predicts** this days ahead *(1 mark)*.

Q14. Alike (any one, *(1 mark)*): both are built on **careful watching of the same sky**, and some recorded accounts name **the same cause taught here** — the Moon covering the Sun, as in the Yolŋu account of the Sun-woman and Moon-man coming together. Different *(2 marks)*: the recorded accounts also **carry meaning and Law for their owners** — warnings and responses, like the Kurnai of Victoria reading an eclipse with fear and a red Moon as a sign that someone had been killed *(1 mark)* — while today's astronomy looks **only for the physical cause**: the positions of the Sun, the Moon and Earth and the shadows they cast *(1 mark)*.

Sources

Sources below were retrieved 2026-08-21.

- Brooker, E., "Archaeoastronomy: Comparing Astronomic Traditions of Torres Strait Islanders with Quantitative Evidence", MA thesis, University of Oklahoma, 2024. shareok.org
- Hamacher, D., "Torres Strait astronomy with David Bosun" [video], YouTube, 2018. youtube.com
- Hamacher, D. and Norris, R., "Eclipses in Australian Aboriginal Astronomy", Journal of Astronomical History and Heritage 14(2), 2011. arxiv.org
- Wikipedia, "Lunar eclipse", 2026. en.wikipedia.org
- Wikipedia, "Moon", 2026. en.wikipedia.org
- Wikipedia, "Solar eclipse", 2026. en.wikipedia.org
- Wikipedia, "Tide", 2026. en.wikipedia.org
- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8U12` and its elaborations, 2026. vcaa.vic.edu.au

The tide heights in the tide graph are **simulated for practice** (as labelled); the timings it shows are real — the 12 h 25 min spacing of high tides and the 24 h 50 min tidal lunar day are from Wikipedia, “Tide”, and the daily slip of about 50 minutes follows from them. The day numbers along the phase strip (7.4, 14.8, 22.1) are computed by dividing the 29.5-day cycle (Wikipedia, “Moon”) into quarters; the worked-example and practice-question tide times are simulated data for practice. The Moon’s distance (384 400 km) and diameter (3 474 km) are from Wikipedia, “Moon”; the Sun’s tidal pull at about 46% of the Moon’s and the about-7-day spacing of spring tides and neap tides are from Wikipedia, “Tide”; the up-to-107-minute lunar totality is from Wikipedia, “Lunar eclipse”; and the 360-to-410-year return of a total solar eclipse at a given place is from Wikipedia, “Solar eclipse”.

Elaboration contexts used: `VC2S8U12.E02` (examining the effect of the gravitational attraction of the Moon and Sun on Earth’s oceans and describing how the positions of the Moon and Sun in relation to Earth result in tidal variations), `VC2S8U12.E03` (using physical models or virtual simulations to explain the cyclic patterns of lunar phases and eclipses of the Moon and Sun), `VC2S8U12.E04` (researching knowledges held by Aboriginal and/or Torres Strait Islander Peoples about the phases of the Moon and the connection between the lunar cycle and ocean tides — the Torres Strait Islander understanding of lunar cycles and neap tides enabling prediction of the safest periods to dive for lobster on the reef) and `VC2S8U12.E06` (researching Aboriginal and/or Torres Strait Islander Peoples’ oral traditions and cultural recordings of solar and lunar eclipses, and investigating similarities and differences with contemporary understandings).

Teacher-facing note — E04 and E06 delivery under D10/ICIP (not student text). Per D10, Aboriginal and Torres Strait Islander content is taught only from named published sources, with attribution. E04 is delivered from the quarter-moon crayfish teaching recorded from **David Bosun**, a Torres Strait Islander man of Moa Island, in Hamacher’s 2018 video “Torres Strait astronomy with David Bosun” and discussed in Brooker’s 2024 thesis (ch. 7, §7.2); the CD elaboration writes “reef-dive for lobster” while the recorded source says “crayfish (rock lobster)” — per §6’s sourcing rule this subtopic follows the source’s wording and records the discrepancy here. E06 is delivered from Hamacher and Norris (2011), a survey of about 50 recorded accounts of eclipses; the Kurnai accounts of south-eastern Victoria are as recorded there (after Massola, 1968), and the Yolŋu Sun-woman/Moon-man account is as recorded there. Per CSIRO’s framing of Indigenous seasonal knowledge, such knowledge is the Indigenous Cultural and Intellectual Property (ICIP) of the communities who hold it; accordingly this subtopic teaches only the sourced content, names its sources, and does not reproduce, extend or redraw beyond them.

Test A

Topic 6 test — Earth and space sciences · Chapter 14 · Covers Chapter 12, Chapter 13 and Chapter 14 (subtopics 12A, 12B, 13A, 13B, 13C, 13D, 14A and 14B)

> This is a school-designed paper. It is not a VCAA instrument. Levels 7 and 8 carry no VCAA examination and no external assessment (D14); this paper is a school-based assessment instrument of this book's own design, graded against the achievement-standard extracts of `VC2S8U09`, `VC2S8U10`, `VC2S8U11` and `VC2S8U12`, with the inquiry-strand marks attached to the chapters' own practical work (`VC2S8I02`, `VC2S8I04` and `VC2S8I05`) per D7. Achievement at Levels 7 and 8 is reported against the Victorian Curriculum achievement standard on teacher judgement; the marks here are one source of evidence towards that judgement.

About this test

Covers	Chapter 12 — Earth and space sciences A: the dynamic Earth, Chapter 13 — Earth and space sciences B: rocks, minerals and Earth's resources, and Chapter 14 — Earth and space sciences C: the Earth–Sun–Moon system; subtopics 12A, 12B, 13A, 13B, 13C, 13D, 14A and 14B
Content descriptions	`VC2S8U09` (13C and 13D) · `VC2S8U10` (12A and 12B) · `VC2S8U11` (13A and 13B) · `VC2S8U12` (14A and 14B)
Total marks	**40** — Test A 10 marks, Test B 30 marks
Inquiry marks	**10 of 40** — Q11(a)–(d), (f) and Q16 (paper minimum: 5)
Suggested time	45 minutes

How to run this test

- A scientific calculator is permitted for this paper. No formula sheet. No reading time.
- **Untimed completion** — the suggested time is a guide only. A student may take all the time they need.
- **Reading support** — any item may be read aloud to a student who asks. Reading is not being assessed.
- Answer every question in the spaces provided. Show your working wherever you calculate.

Choose the best answer for each of the 10 questions. Each question is worth 1 mark.

Q1. A renewable resource is one that: *(1 mark)*

A. Never runs out

B. Replenishes naturally on a human timescale

C. Cannot be used

D. Is artificial

Q2. The PRIMARY cause of seasons is: *(1 mark)*

A. Earth's axial tilt as it orbits the Sun

B. Earth's changing distance from the Sun

C. Changes in the Sun's brightness

D. Earth's rotation on its axis

Q3. Earthquake-resistant buildings often use: *(1 mark)*

A. Rigid frames bolted directly to bedrock

B. Heavy unreinforced concrete walls

C. Tall narrow towers without cross-bracing

D. Flexible structures with base isolation

Q4. Why is timber considered renewable in principle? *(1 mark)*

A. Trees take millions of years to regrow like fossil fuels

B. Timber is manufactured in factories, not grown

C. Trees regrow within decades, a meaningful human timescale

D. Forests regrow instantly after harvesting

Q5. Granite, with interlocking crystals, is which type? *(1 mark)*

A. Sedimentary

B. Igneous

C. Metamorphic

D. A single mineral, not a rock

Q6. The 'Ring of Fire' is a: *(1 mark)*

A. Star pattern

B. Volcanic museum

C. Equator pattern

D. Pacific Ocean rim with active plate boundaries

Q7. Spring tides (largest tidal range) occur when: *(1 mark)*

A. Sun, Earth and Moon are aligned (new or full Moon)

B. The Moon is at first quarter

C. Earth's axis tilts

D. It is springtime

Q8. Why is groundwater sometimes classified as 'partly renewable'? *(1 mark)*

A. All water on Earth replenishes instantly through the water cycle

B. Groundwater is replaced as fast as it is pumped out

C. Aquifers recharge over years to centuries — slow on human timescales

D. Groundwater comes from rivers and never runs low

Q9. Why is the rock cycle described as cyclic? *(1 mark)*

A. Only sedimentary rocks can change into other rock types

B. Rocks change once and then remain in their new form

C. All rocks must first melt into magma before changing

D. Each rock type can transform into the others through ongoing processes

Q10. Why are earthquakes common at transform boundaries? *(1 mark)*

A. Magma rises and pushes the crust upward

B. Plates slide past each other, building stress that releases as quakes

C. Plates collide and one is forced under the other

D. Plates pull apart and new crust forms

Test B

Answer every question in the spaces provided. Show your working wherever you calculate. Questions 11–16 are worth 30 marks.

The questions are worth 30 marks in total:

Question	Assesses	Marks
11	Interpreting sourced Victorian seismicity data (`VC2S8I05`, `VC2S8U10`)	8
12	Plate boundaries, subduction and earthquake-resistant design (`VC2S8U10`)	6
13	Rock groups, formation and the rock cycle (`VC2S8U11`)	5
14	Resources: renewable or not, benefits and risks (`VC2S8U09`)	4
15	Seasons from Earth's tilt (`VC2S8U12`)	3
16	Inquiry: variables in the torch test; strengths and limits of a model (`VC2S8I02`, `VC2S8I04`)	4
	Total	**30**

Q11. The table below is real data about seismicity in and near Victoria. Use it to answer the questions. *(8 marks)*

Recorded earthquakes in Victoria and the national context

Record	Detail
Earthquake of 2021	North of Rawson, Victoria; magnitude 5.9
Earthquake of May 2023	Near Sunbury, Victoria; first measured at magnitude 3.8, later upgraded to 4.0; more than 20 000 felt reports were received, from as far north as Bendigo and as far south as Hobart
Victoria's five-year record	In the five years before the May 2023 earthquake, Victoria had four other earthquakes of magnitude 3 or larger, including the Rawson earthquake
Australia-wide	About 100 earthquakes of magnitude 3 or larger are recorded each year; on average, an earthquake of magnitude 6.0 or larger happens about every 10 years

Source: Geoscience Australia, "Recent seismic activity in Australia", 2023. ga.gov.au — retrieved 2026-08-19.

Source: Geoscience Australia, "Melbourne residents woken by 3.8 magnitude earthquake", 2023. ga.gov.au — retrieved 2026-08-19.

(a) State the magnitude of the 2021 earthquake north of Rawson. *(1 mark)*

(b) The Sunbury earthquake was first measured at magnitude 3.8 and later upgraded to 4.0. By how much did the measured magnitude increase? Show your working. *(1 mark)*

(c) How much larger is the magnitude of the Rawson earthquake (5.9) than the first measurement of the Sunbury earthquake (3.8)? Show your working. *(1 mark)*

(d) State one observation from the table about where the Sunbury earthquake was felt. *(1 mark)*

(e) Melbourne is far from any plate boundary. Explain why earthquakes can still happen in Victoria. *(2 marks)*

(f) A student says: *"Victoria is far from a plate boundary, so it cannot have a large earthquake."* Use data from the table to evaluate this claim. *(2 marks)*

Q12. The Andes mountains of South America were built where the rock of the ocean floor bends down and slides beneath the continent, and volcanoes stand along their length. *(6 marks)*

(a) What is the name for one plate sinking beneath another? *(1 mark)*

(b) State the deep feature on the sea floor that marks where the plate bends down. *(1 mark)*

(c) Explain why a line of volcanoes forms on the continent above the sinking plate. *(2 marks)*

(d) State one design feature that helps a building survive earthquake shaking, and explain how it protects the people inside. *(2 marks)*

Q13. Basalt and granite both formed from melted rock. Basalt forms from lava that cooled quickly; its crystals are too small to see. Granite forms from magma that cooled slowly underground; its interlocking crystals are large enough to see. *(5 marks)*

(a) State the difference between magma and lava. *(1 mark)*

(b) Use cooling rate to explain why granite's crystals are large while basalt's crystals are too small to see. *(2 marks)*

(c) Limestone is a sedimentary rock. When limestone is subjected to great heat and pressure without melting, it becomes marble. To which rock group does marble belong? *(1 mark)*

(d) State one process that turns loose sediment into sedimentary rock. *(1 mark)*

Q14. Victoria's Latrobe Valley holds enormous deposits of brown coal, formed from forests that grew and died tens of millions of years ago. *(4 marks)*

(a) State whether brown coal is a renewable or a non-renewable resource, and give the reason in terms of regeneration time. *(2 marks)*

(b) Energy production from brown coal has both benefits and risks for sustainability. State one benefit and one risk. *(2 marks)*

Q15. *(3 marks)*

(a) Explain why Victoria and Canada have opposite seasons at the same time. *(2 marks)*

(b) State the season in Victoria at the June solstice. *(1 mark)*

Q16. The chapters' practical work. *(4 marks)*

In 14A's torch test, a student holds a torch at the same height above graph paper, changes the angle at which the beam arrives, and counts the squares the light spot covers. The torch stands in for the Sun, and the graph paper stands in for a patch of Victoria's ground.

(a) State (i) the independent variable and (ii) the dependent variable in the torch test. *(2 marks)*

In 12A's cardboard-and-sand model of the plate boundaries, damp sand spread over two cardboard sheets stands in for the rock layers on two plates, and the sheets are pushed together, pulled apart and slid sideways past each other.

(b) State one thing this model shows well about real plate boundaries, and one limit of the model. *(2 marks)*

Marking guide

This guide is written so a teacher without a science background can mark the paper. Accept the student's own words wherever the meaning matches the answer given here. Spelling and grammar are not marked. Test A (the multiple-choice paper) is marked in "Section A — answers" below; Test B (the short and structured response paper) is marked in "Section B — answers and marking". Every item traces to the achievement-standard extracts of the four CDs in §4's rows for `VC2S8U09`, `VC2S8U10`, `VC2S8U11` and `VC2S8U12`; the inquiry-strand marks attach to the chapters' own practical work per D7.

Inquiry-strand marks on this paper: 10 of 40 — Q11(a)–(d), (f) (`VC2S8I05`) and Q16 (`VC2S8I02`, `VC2S8I04`). The paper minimum is 5.

Section A — answers

Every multiple-choice item is drawn from the MCQ bank keyed to this paper's content descriptions; the bank item ids keep the §4 join. No vocabulary repair was needed. One presentational normalisation applies to all ten items: the bank stores every item with its correct option in position A; the option texts are printed unchanged but redistributed across the letters so that the key is not uniform. No stem, option text, code or difficulty was changed. Difficulty mix: three easy (D1), four medium (D2), three hard (D3).

Q	Answer	CD	Bank item
1	**B** — Replenishes naturally on a human timescale	`VC2S8U09`	`VC2S8U09.E01.S01.D1.V01`
2	**A** — Earth's axial tilt as it orbits the Sun	`VC2S8U12`	`VC2S8U12.E01.S01.D1.V01`
3	**D** — Flexible structures with base isolation	`VC2S8U10`	`VC2S8U10.E02.S01.D1.V01`
4	**C** — Trees regrow within decades, a meaningful human timescale	`VC2S8U09`	`VC2S8U09.E02.S01.D2.V01`
5	**B** — Igneous	`VC2S8U11`	`VC2S8U11.E01.S01.D2.V01`
6	**D** — Pacific Ocean rim with active plate boundaries	`VC2S8U10`	`VC2S8U10.E01.S01.D2.V01`
7	**A** — Sun, Earth and Moon are aligned (new or full Moon)	`VC2S8U12`	`VC2S8U12.E02.S01.D2.V01`
8	**C** — Aquifers recharge over years to centuries — slow on human timescales	`VC2S8U09`	`VC2S8U09.E01.S01.D3.V01`
9	**D** — Each rock type can transform into the others through ongoing processes	`VC2S8U11`	`VC2S8U11.E02.S01.D3.V01`
10	**B** — Plates slide past each other, building stress that releases as quakes	`VC2S8U10`	`VC2S8U10.E01.S01.D3.V01`

Section B — answers and marking

Q11 *(8 marks)* — interpreting sourced Victorian seismicity data. Parts (a)–(d) and (f) are inquiry (`VC2S8I05`: reading, processing and evaluating supplied data); part (e) is understanding (`VC2S8U10`: intraplate earthquakes, rehearsing 12A). The data in the table are real Geoscience Australia records as cited; the source lines appear under the table on the paper.

(a) Magnitude 5.9. *1 mark*

(b) 4.0 − 3.8 = 0.2. *1 mark* Accept “an increase of 0.2” or “0.2 magnitude units”.

(c) 5.9 − 3.8 = 2.1. *1 mark*

(d) Any one of: more than 20 000 felt reports were received; it was felt as far north as Bendigo; it was felt as far south as Hobart. *1 mark*

(e) *2 marks.* Victoria sits in the middle of the Australian plate, and as the plate pushes into its neighbours, forces build up inside the plate *(1 mark)*; when an old crack in the crust — a fault — slips suddenly, the stored energy shakes the ground, an intraplate earthquake *(1 mark)*.

(f) *2 marks.* The claim is not supported *(1 mark)*; the table shows a magnitude 5.9 earthquake happened north of Rawson, inside Victoria, in 2021 — and four other earthquakes of magnitude 3 or larger in the five years before May 2023 — all far from any boundary *(1 mark)*. Accept the widely felt Sunbury earthquake as the cited data point, provided the student reads it from the table.

Q12 *(6 marks)* — understanding: plate boundaries and what they build (`VC2S8U10`; rehearses 12A’s subduction clause and `.E02` engineering).

(a) Subduction. *1 mark*

(b) A trench. *1 mark*

(c) The sinking plate helps melt rock above it *(1 mark)*; the melted rock (magma) rises through the continent and erupts as volcanoes *(1 mark)*.

(d) *1 mark* for any one design feature taught in 12A, *1 mark* for the matching protection. Accept: flexible frames of steel or timber (they bend and sway without snapping); cross-bracing (diagonal supports stop the frame wobbling sideways out of shape); base isolation (flexible bearings absorb the shaking, so the ground can move underneath while the building above stays almost still); retrofitting (strengthening older buildings already standing — for example unreinforced masonry — so they do not collapse). The protection must match the feature named.

Q13 *(5 marks)* — understanding: the rock cycle (`VC2S8U11`; rehearses 13A).

(a) Magma is melted rock while it is underground; lava is melted rock that has reached the surface. *1 mark*

(b) Granite’s magma cooled slowly underground, giving its crystals time to grow large; basalt’s lava cooled quickly, so its crystals stayed too small to see. *2 marks* — 1 mark for each cooling-rate link.

(c) Metamorphic. *1 mark*

(d) Compaction or cementation. *1 mark*

Q14 *(4 marks)* — understanding: renewable and non-renewable resources, benefits and risks (`VC2S8U09`; rehearses 13C’s timescale test and 13D’s weighing).

(a) Non-renewable *(1 mark)*; it took tens of millions of years to form, so it cannot regenerate within any human timescale *(1 mark)*.

(b) *1 mark* for any one benefit taught in 13D, *1 mark* for any one risk taught in 13D. Accept benefits: the fuel is local and cheap; coal stations can run day and night in any weather, so the supply is steady; the stations and mines employ people in the Latrobe Valley. Accept risks: burning coal releases carbon dioxide (a greenhouse gas) and other gases and particles that can affect health; mining clears land and changes the landscape; ash waste is left behind; coal is non-renewable; the mines carry risks such as the 2014 Hazelwood mine fire.

Q15 *(3 marks)* — understanding: seasons (`VC2S8U12`; rehearses 14A).

(a) Earth’s axis is tilted, and the tilt keeps pointing the same way all year *(1 mark)*; so when the Southern Hemisphere leans toward the Sun, the northern hemisphere leans away — the two halves take turns, giving opposite seasons at the same time *(1 mark)*. Accept answers that also note distance cannot be the cause, because Victoria and Canada ride the same Earth at the same distance from the Sun.

(b) Winter. *1 mark*

Q16 *(4 marks)* — inquiry, from the chapters' own practical work (D7). Part (a) rehearses 14A's torch test (`VC2S8I02`: variables in a planned investigation); part (b) rehearses 12A's cardboard-and-sand model (`VC2S8I04`: strengths and limits of representations).

(a)

(i) The independent variable is the angle at which the beam arrives — how steep or shallow the light falls on the paper. *1 mark* (ii) The dependent variable is the number of squares the light spot covers — how far the beam spreads. *1 mark* The fixed torch height is a controlled variable — not credited either way.

(b) Shows well (any one): pushing the sheets together crumples the sand upwards, as rock crumples into fold mountains at a convergent boundary; pulling the sheets apart opens a gap, as a rift opens at a divergent boundary; sliding the sheets sideways offsets the mark in the sand, as a fault slips in an earthquake. *1 mark* Limit (any one): the sand is not solid rock, and the cardboard is nothing like kilometres of solid plate; the demonstration takes seconds while real plates move far too slowly to watch; the model is cold, so it cannot show melting, magma or volcanoes; the push comes from hands, not from convection, slab pull or ridge push. *1 mark*

Section B subtotal: 30 marks.

Data provenance and sources. Every multiple-choice item is drawn from the MCQ bank keyed to `VC2S8U09`–`VC2S8U12` and printed with stem and option texts unchanged (option order redistributed — see the Section A note); the bank item ids above keep the §4 join. Q11's table is **real data**: Geoscience Australia's records of Victorian and Australian seismicity, sourced through subtopic 12A, with both source lines printed under the table on the paper (retrieved 2026-08-19). No other item uses real data; Q12's Andes context and Q14's Latrobe Valley brown coal are drawn from 12A, 13C and 13D. Elaboration contexts drawn on: `VC2S8U09.E02` (regeneration timescales), `VC2S8U10.E02` (impacts and engineering) and `VC2S8U10.E03` (modelling boundaries), `VC2S8U11.E02` (rock-cycle processes), `VC2S8U12.E01` (tilt and seasons) and `VC2S8U12.E02` (tides).

Teacher-facing note (not student text). Marking is strictly point-based per §7: every mark above is tied to a stated point, and no holistic judgement is applied at any level. This paper carries no Aboriginal and Torres Strait Islander content (CONTENT_POLICY Rule 1): the elaborations that carry that content (`VC2S8U10.E06`, `VC2S8U11.E05`, `VC2S8U12.E04–.E06`) are contexts only and are not drawn on. The only calculations on the paper are the two magnitude differences in Q11(b)–(c), for which a scientific calculator is permitted; no graphing is required. Q11's table is fixed data — mark against the table as printed.

Traceability

Item	Marks	CD	Achievement-standard evidence	Inquiry
Q1, Q4, Q8	3	`VC2S8U09`	resources distinguished as renewable and non-renewable by regeneration timescale	0
Q3, Q6, Q10	3	`VC2S8U10`	plate tectonics applied to explain earthquakes and their distribution	0
Q5, Q9	2	`VC2S8U11`	rock properties related to their formation	0
Q2, Q7	2	`VC2S8U12`	Earth–Sun–Moon cycles modelled to	0

Item	Marks	CD	Achievement-standard evidence	Inquiry
			explain seasons and tides	
Q11(a)–(d), (f)	6	`VC2S8I05`	supplied data read, processed and evaluated	6
Q11(e)	2	`VC2S8U10`	intraplate earthquakes explained	0
Q12	6	`VC2S8U10`	subduction, trenches, volcanoes and earthquake-resistant design explained	0
Q13	5	`VC2S8U11`	rock groups, formation processes and the rock cycle explained	0
Q14	4	`VC2S8U09`	sustainable use evaluated; benefits and risks compared	0
Q15	3	`VC2S8U12`	seasons explained from Earth's tilt	0
Q16(a)	2	`VC2S8I02`	variables identified in a planned investigation	2
Q16(b)	2	`VC2S8I04`	strengths and limits of a representation	2
Total	**40**			**10**

Achievement-standard extracts served (D13), verbatim from the authority file: `VC2S8U09` — *"They distinguish between renewable and non-renewable resources, evaluate the sustainable use of different resources, and compare the benefits and risks of resource extraction and energy production."*; `VC2S8U10` — *"They apply the theory of plate tectonics to explain geological phenomena including volcanoes, earthquakes, mountain formation and the distribution of earthquakes and volcanic zones around the globe."*; `VC2S8U11` — *"They explain how the properties of rocks relate to their formation and influence their use."*; `VC2S8U12` — *"They model the Earth–Sun–Moon system's cyclic changes to explain the observable phenomena of seasons and tides."* Inquiry extracts: `VC2S8I02` — *"They plan a range of reproducible scientific investigations, document procedures…"*; `VC2S8I04` — *"They select and construct appropriate representations to organise and process data and information."*; `VC2S8I05` — *"They analyse and connect data and information to identify and explain patterns, trends, relationships and anomalies."*