Mathematics Level 8

Chapter 4 — Measurement: time, rates and ratio

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

Significant effort has been made to ensure this content is legal. Please send any areas of concern to admin@vwx.au with appropriate document/legal references so errors can be verified and changes be made.

Contents

Time and duration: 12- and 24-hour time across multiple time zones

VC2M8M04 — solve problems involving time and duration, including using 12- and 24-hour time across multiple time zones

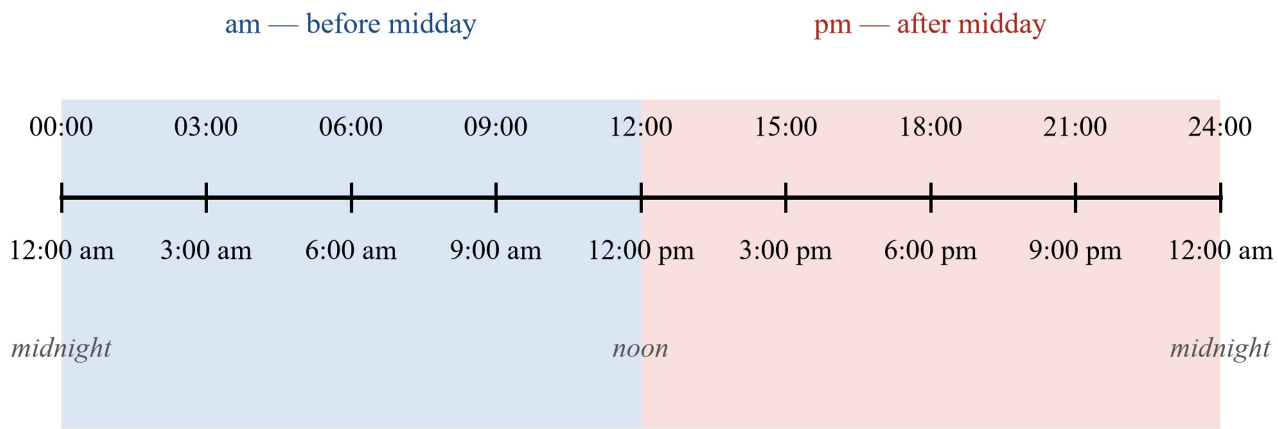
By the end of Level 8, students: solve problems of duration involving 12- and 24-hour cycles across multiple time zones.

When a Melbourne class joins a video call with a school in Perth, one side is eating lunch while the other is finishing breakfast — the same moment on two different clocks. This subtopic is about keeping those clocks straight.

Theory

One day, two ways of writing it

The **24-hour clock** writes the day as one count from 00:00 (midnight) up to 23:59, then starts again. The **12-hour clock** splits the day at midday and labels each half **am** (before midday) or **pm** (after midday). In this book the 24-hour form is written as 14:35 and the 12-hour form as 2:35 pm.



the same 24 hours, written two ways

A strip showing the 24 hours of one day, the am half shaded blue and the pm half shaded red, with every third hour labelled in both 12- and 24-hour time

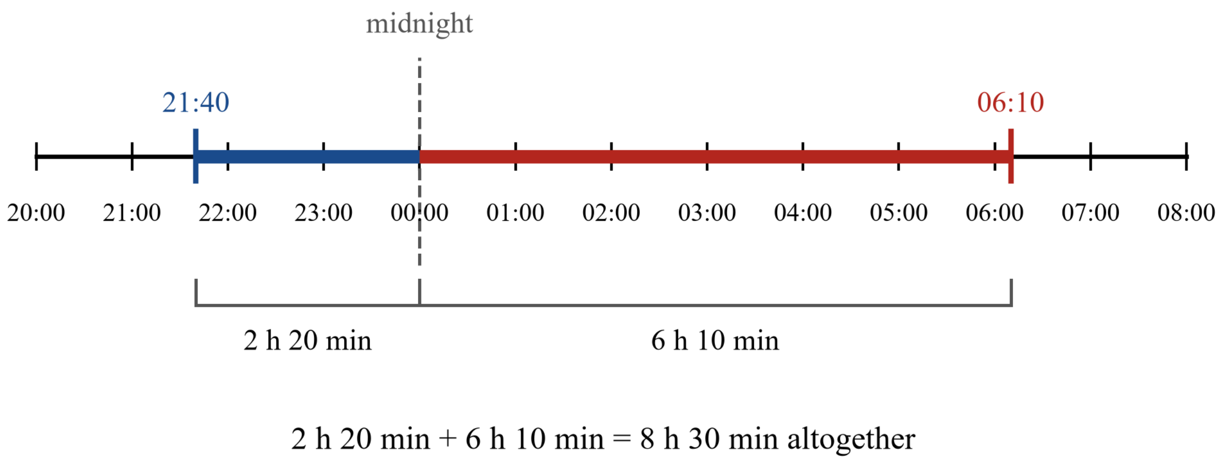
To swap between the two forms:

- **pm to 24-hour:** add 12 to the hours (2:35 pm is 14:35). 12:00 pm stays 12:00.
- **am to 24-hour:** keep the hours, writing a leading zero below 10 (7:05 am is 07:05). 12:00 am becomes 00:00.
- **24-hour to 12-hour:** hours above 12 lose 12 and take pm; hours below 12 take am.

Midday is **12:00** in 24-hour time and 12:00 pm; midnight is **00:00** and 12:00 am. The two names 12:00 am and 12:00 pm are easy to mix up, which is one reason timetables, flights and hospitals prefer the 24-hour clock.

How long did it take? Duration across midnight

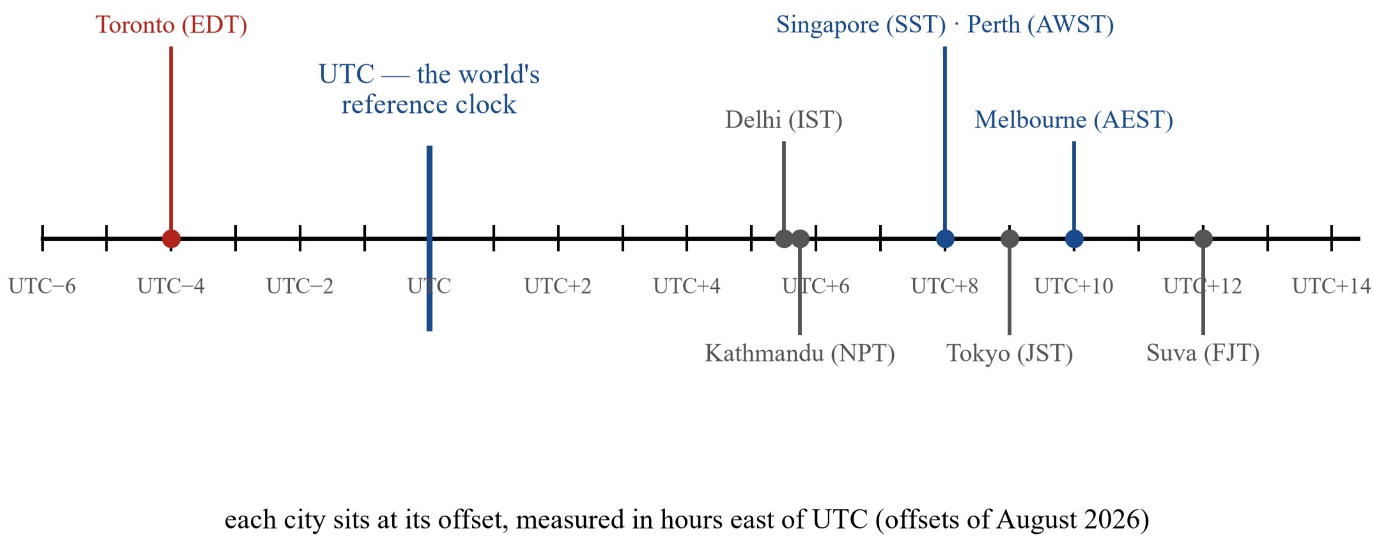
A **duration** is how much time passes between two moments. When the start and finish fall on the same day, count on in hours and minutes. When the finish falls after midnight, split the time at midnight and add the two parts — the figure below does this for a trip that leaves at 21:40 and arrives at 06:10.



A timeline from 20:00 to 08:00 with 21:40 to midnight drawn in blue (2 h 20 min) and midnight to 06:10 drawn in red (6 h 10 min), totalling 8 h 30 min

UTC — the clock every zone is measured from

Every place on Earth keeps a local clock, but all of them are measured from one shared clock, **UTC**. A zone is described by its **offset** — how many hours its clocks run ahead of UTC, or behind UTC (written with a minus sign). Perth sits at UTC+8, eight hours ahead; Toronto sits at UTC−5 in winter, five hours behind. Two zones that share an offset, like Perth and Singapore, always show the same time.



A number line from UTC−6 to UTC+14 with a dot for each city used in this subtopic: Toronto at −4 (its summer offset), Delhi at +5:30, Kathmandu at +5:45, Singapore and Perth at +8, Tokyo at +9, Melbourne at +10 and Suva at +12

To move a time from one zone to another, either **compare the offsets** (the zone further east is ahead by the gap between them) or **go through UTC**: step back to UTC, then step forward by the new zone's offset. Both routes always land on the same answer.

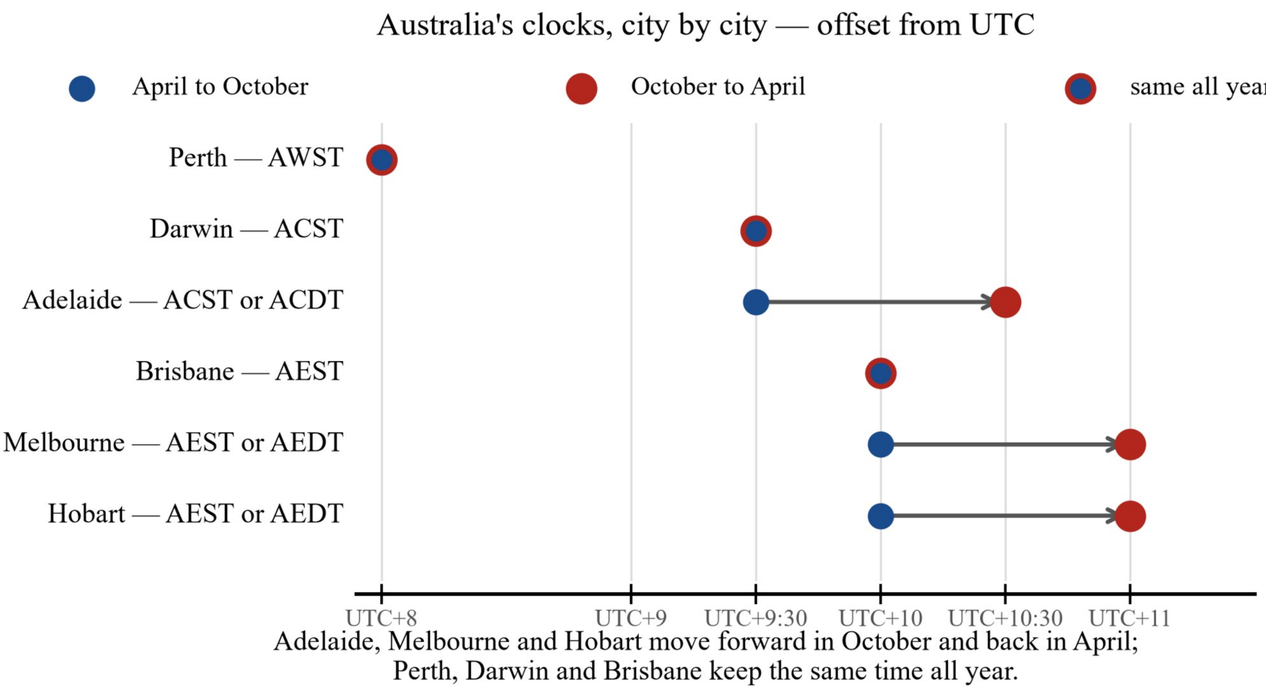
Australia's three standard times

Australia spans three standard offsets (Wikipedia "Time in Australia", retrieved 20 August 2026):

- **AWST** — Australian Western Standard Time, UTC+8, used in Western Australia;

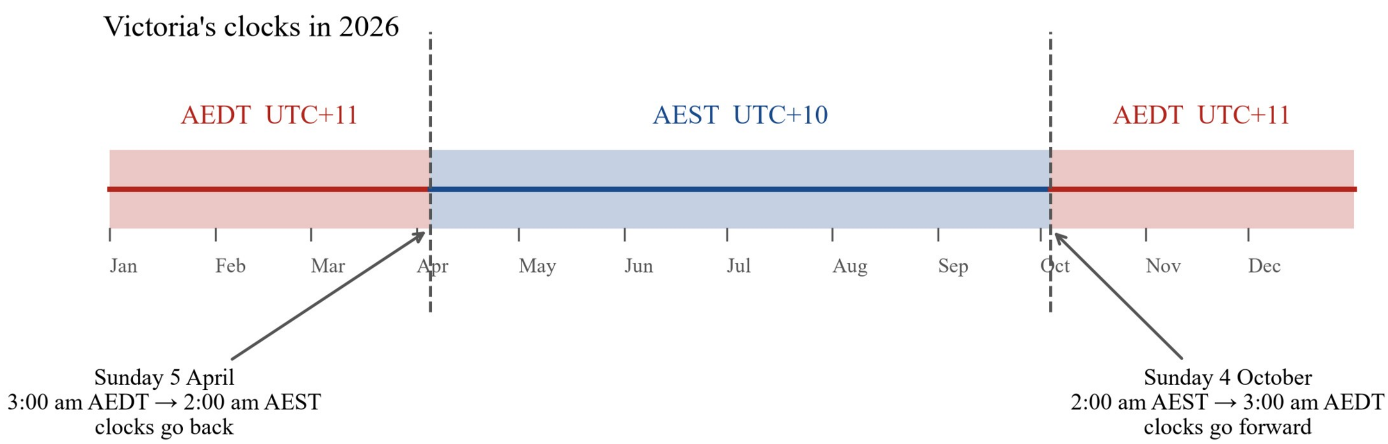
- **ACST** — Australian Central Standard Time, UTC+9:30, used in South Australia and the Northern Territory;
- **AEST** — Australian Eastern Standard Time, UTC+10, used in Queensland, New South Wales, Victoria, Tasmania and the ACT.

From April to October the country keeps these three times. From October to April, **daylight saving** moves some clocks one hour forward: Victoria, New South Wales, Tasmania and the ACT switch to **AEDT** (Australian Eastern Daylight Time, UTC+11), and South Australia switches to **ACDT** (Australian Central Daylight Time, UTC+10:30). Queensland, the Northern Territory and Western Australia do not use daylight saving, so their clocks never change. In Victoria the clocks go forward on the first Sunday in October and back on the first Sunday in April.



A dot plot of six Australian cities against their offset from UTC: Perth, Darwin and Brisbane keep one offset all year, while Adelaide, Melbourne and Hobart move one hour forward from October to April

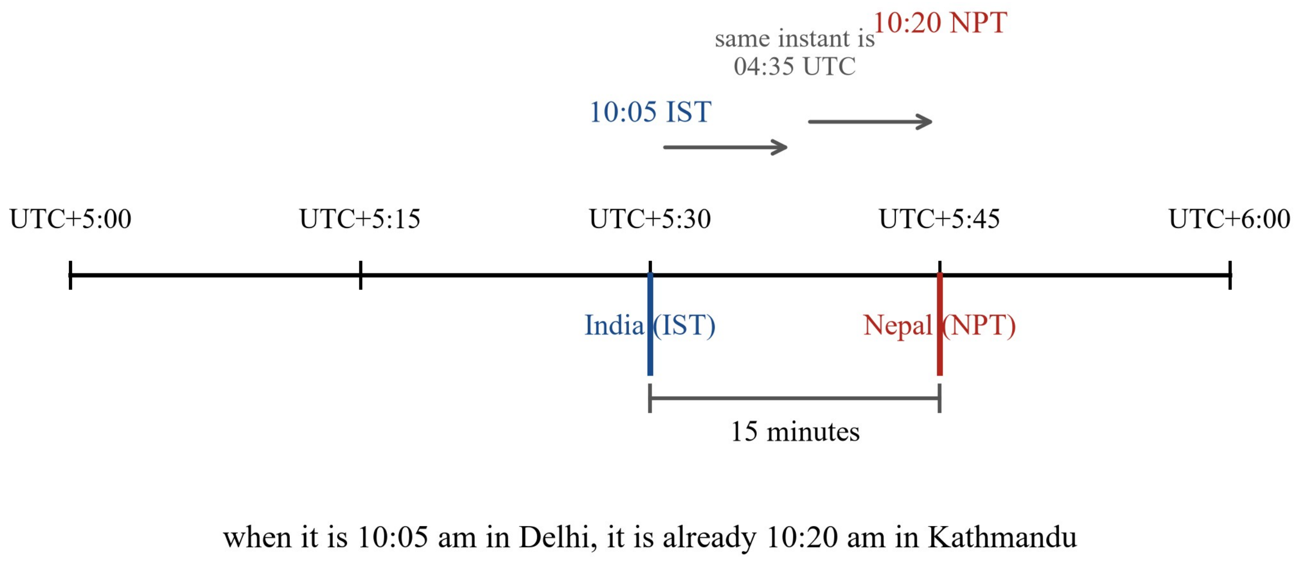
Because of this, the gap between two Australian cities depends on the date. Melbourne is 2 hours ahead of Perth from April to October, but 3 hours ahead from October to April. Any question with a date must first ask: *which side of the changeover is this date on?* The figure below shows Victoria's two changeover days in 2026, worked out from the first-Sunday rule.



A timeline of 2026 showing Victoria on AEDT until Sunday 5 April, on AEST from 5 April to 4 October, and on AEDT again from Sunday 4 October, with the two changeover moments labelled

Zones that are not whole hours

Not every offset is a whole hour. India keeps **IST** at UTC+5:30, and Nepal keeps **NPT** at UTC+5:45 — so Kathmandu is just 15 minutes ahead of Delhi. Half-hour and quarter-hour zones are easy to handle on the UTC route: move the hours first, then the minutes.



A number line from UTC+5:00 to UTC+6:00 in 15-minute steps with India at +5:30 and Nepal at +5:45, and the reading 10:05 IST is the same moment as 10:20 NPT

Words of this subtopic

Word	What it means here
12-hour time, 24-hour time	the two ways of writing the hours of one day; 2:35 pm is 14:35
UTC	the one clock every zone is measured from
offset	how many hours a zone runs ahead of UTC (behind UTC is written with a minus sign)
AWST	Australian Western Standard Time, UTC+8, all year
ACST, ACDT	Australian Central Standard Time, UTC+9:30; its daylight-saving time, UTC+10:30 (South Australia only)
AEST, AEDT	Australian Eastern Standard Time, UTC+10; its daylight-saving time, UTC+11
daylight saving	moving clocks one hour forward for the warmer months of the year
duration	how much time passes between two moments
layover	the wait between two flights of one journey
FJT, SST, JST, IST, NPT	the zone names of Fiji (UTC+12), Singapore (UTC+8), Japan (UTC+9), India (UTC+5:30) and Nepal (UTC+5:45)
EST, EDT	Toronto’s zone: Eastern Standard Time, UTC−5, in winter; Eastern Daylight Time, UTC−4, in summer

Worked examples

Example 1 — with help

Write each time in the other form.

Working	Comment
(a) 4:05 pm → 4 + 12 = 16, so **16:05**	pm hours above 12 gain 12
(b) 21:40 → 21 − 12 = 9, so **9:40 pm**	hours above 12 lose 12 and take pm
(c) 00:15 → **12:15 am**	the first 15 minutes of the day are just after midnight
(d) midday is **12:00**; midnight is **00:00**	the two anchors of the 24-hour clock

Example 2 — with help

Find the duration.

Working	Comment
(a) 19:35 to 21:50 → 19:35 + 2 h = 21:35, + 15 min = 21:50, so **2 h 15 min**	same day: count on
(b) 21:40 to 06:10 → 21:40 to midnight is 2 h 20 min; midnight to 06:10 is 6 h 10 min; 2 h 20 min + 6 h 10 min = **8 h 30 min**	crosses midnight: split and add

Example 3 — with help

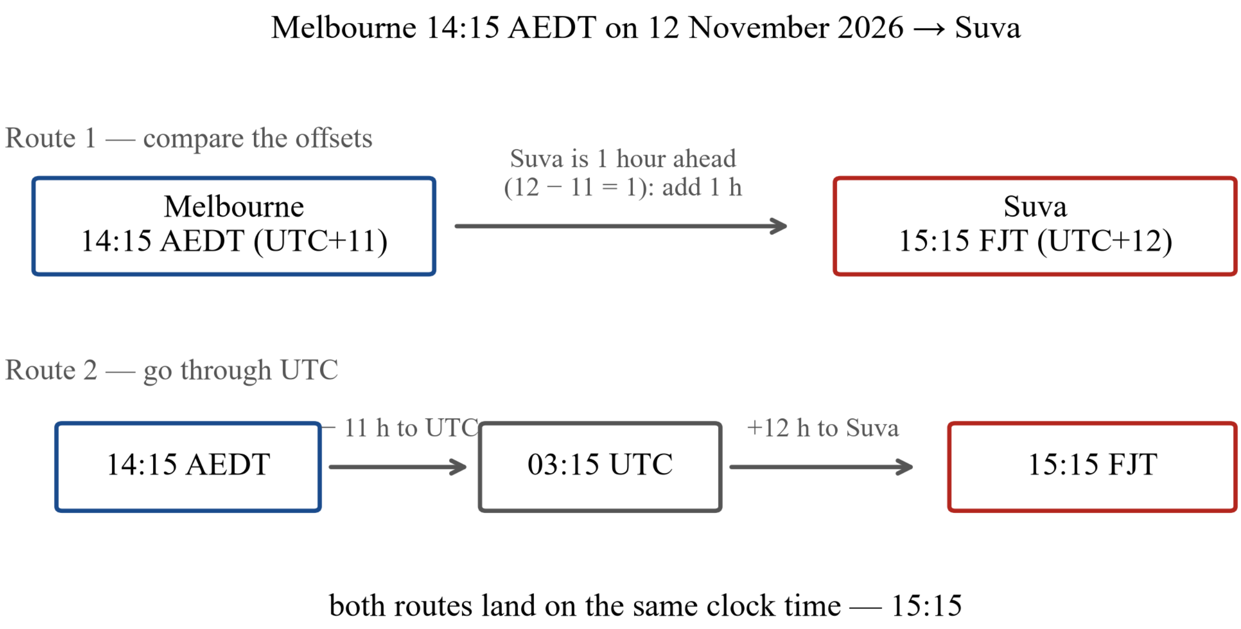
It is 6:30 pm in Melbourne on Sunday 18 January 2026. What time is it in Perth?

Working	Comment
Date check: 18 January 2026 is between 5 October 2025 and 5 April 2026, so Victoria is on AEDT, UTC+11	always check which side of the changeover the date sits
6:30 pm AEDT is 18:30; 18:30 − 11 h = 07:30 UTC	step back to UTC
07:30 + 8 h = 15:30 AWST, so **3:30 pm** in Perth	step forward by Perth's offset; WA never changes

Example 4 — with help

It is 2:15 pm in Melbourne on Thursday 12 November 2026. What time is it in Suva (Fiji)?

Working	Comment
Date check: 12 November 2026 is after 4 October, so Melbourne is on AEDT, UTC+11; Fiji keeps FJT, UTC+12, all year	one side of the pair still had to be checked
Route 1: Suva's offset is 1 hour more than Melbourne's (12 − 11 = 1), so 14:15 + 1 h = **15:15 FJT**	compare the offsets
Route 2: 14:15 − 11 h = 03:15 UTC; 03:15 + 12 h = 15:15 FJT	go through UTC — same answer



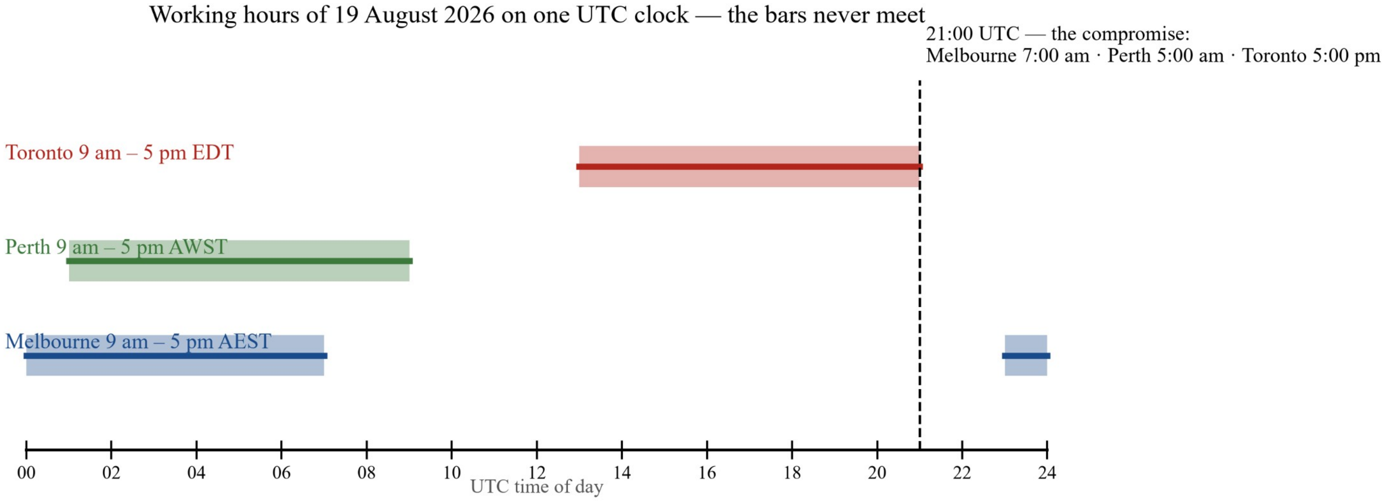
Two rows of boxes converting Melbourne 14:15 AEDT on 12 November 2026 to Suva time, one row comparing the offsets and one row going through UTC, both ending at 15:15 FJT

And going the other way: when it is 7:00 pm in Suva, 19:00 − 12 h = 07:00 UTC, and 07:00 + 11 h = 18:00, so **6:00 pm** in Melbourne.

Example 5 — with help

A teacher in Melbourne, an uncle in Perth and a friend in Toronto want one moment for a video call on Wednesday 19 August 2026, inside each city's working hours of 9 am to 5 pm. Is there such a moment?

Working	Comment
Date check: 19 August 2026 is between 5 April and 4 October, so Melbourne is on AEST, UTC+10; Perth is on AWST, UTC+8; Toronto is on its summer time EDT, UTC−4 (8 March to 1 November)	three offsets, all checked
Working hours on the UTC clock: Melbourne 23:00–07:00; Perth 01:00–09:00; Toronto 13:00–21:00	9 am to 5 pm in each zone, moved to UTC
Melbourne and Perth share 01:00–07:00 UTC, but Toronto's window sits nowhere near it — the three bars never meet, so **no moment works for all three**	read off the figure
A time all three can live with: 21:00 UTC is 5:00 pm in Toronto, 7:00 am next day in Melbourne and 5:00 am next day in Perth	early for Australia, but inside the working day for Toronto

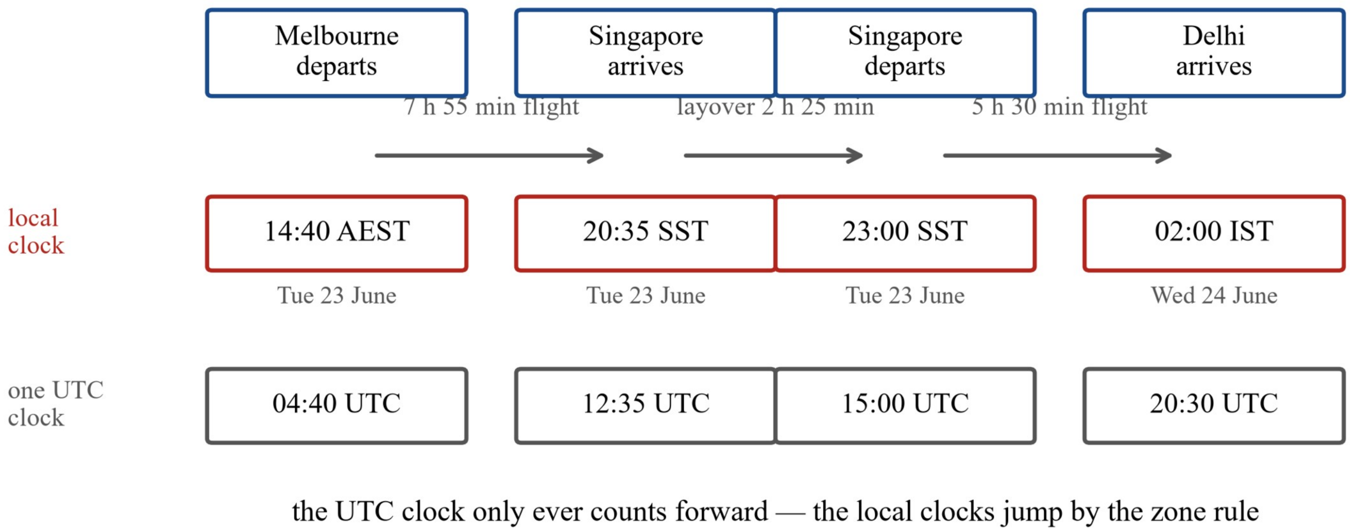


Three bars on a UTC timeline showing the 9-to-5 working hours of Melbourne, Perth and Toronto on 19 August 2026, with no hour inside all three bars, and 21:00 UTC marked as the pick

Example 6 — with help

A person leaves Melbourne at 2:40 pm on Tuesday 23 June 2026, flies 7 h 55 min to Singapore, waits 2 h 25 min, then flies 5 h 30 min on to Delhi. When do they arrive in Delhi, on Delhi's clock?

Working	Comment
Date check: 23 June 2026 is between 5 April and 4 October, so Melbourne is on AEST, UTC+10; Singapore (UTC+8) and India (UTC+5:30) never change	flights and layovers are durations — they tick along on the UTC clock
14:40 AEST − 10 h = 04:40 UTC	put the departure on the UTC clock
04:40 + 7 h 55 min = 12:35 UTC; in Singapore 12:35 + 8 h = 20:35 SST	first flight
12:35 + 2 h 25 min = 15:00 UTC (23:00 SST)	the layover
15:00 + 5 h 30 min = 20:30 UTC; in Delhi 20:30 + 5 h 30 min = 26:00, that is 02:00 next day	second flight
They land in Delhi at **2:00 am IST on Wednesday 24 June**	the local date has moved on too



A travel plan from Melbourne to Delhi through Singapore, with every event written on its local clock and on one UTC clock; the UTC clock only ever counts forward

Example 7 — on your own

Write 9:15 pm and 07:50 in the other form.

Example 8 — on your own

A film starts at 20:45 and runs 1 h 40 min. When does it finish, in 24-hour time?

Practice questions

With help

Q1. Write each time in the other form: (a) 3:20 pm; (b) 7:05 am; (c) 19:30; (d) 00:40.

Q2. Find the duration: (a) 09:20 to 13:45; (b) 6:50 pm to 8:05 pm.

Q3. It is midday in Melbourne on Wednesday 15 July 2026 (AEST). What time is it in: (a) Perth; (b) Adelaide; (c) Darwin; (d) Brisbane?

Q4. For each date, is Victoria on AEST or AEDT? (a) 26 January 2026; (b) 13 June 2026; (c) 31 December 2026; (d) 9 April 2026.

Q5. It is 2:30 pm in Melbourne on Wednesday 22 July 2026 (AEST). What time is it in Suva?

Q6. True or false? (a) 22:15 is 10:15 pm. (b) AEDT is UTC+10. (c) Perth is 2 hours behind Melbourne on every day of the year. (d) 00:00 is midnight. (e) Kathmandu is 15 minutes ahead of Delhi.

Q7. Write the offset of each zone: (a) AEST; (b) AEDT; (c) ACST; (d) AWST; (e) ACDT.

Q8. It is 9:00 am in Toronto on Wednesday 14 January 2026 (EST). What time and day is it in Melbourne?

On your own

Q9. Write each time in the other form: (a) 6:07 am; (b) 11:59 pm; (c) 12:05 am; (d) 17:02; (e) midnight; (f) midday.

Q10. It is 4:45 pm in Melbourne on Wednesday 22 July 2026 (AEST). Give the moment in: (a) UTC; (b) Suva; (c) Toronto.

Q11. It is 8:20 am in Perth on Thursday 5 March 2026. What time is it in: (a) Singapore; (b) Tokyo?

Q12. It is 10:05 am in Delhi on Wednesday 12 August 2026. What time is it in: (a) Kathmandu; (b) Melbourne?

Q13. A plane leaves Singapore at 22:15 SST and lands in Delhi after a flight of 5 h 30 min. What time and day is it in Delhi on landing?

Q14. It is 9:20 am in Melbourne on Monday 12 January 2026 (AEDT). What time and day is it in Toronto?

Q15. In Victoria, clocks jump from 2:00 am AEST to 3:00 am AEDT on Sunday 4 October 2026, and from 3:00 am AEDT back to 2:00 am AEST on Sunday 5 April 2026. (a) The clock shows 1:59 am on 4 October. What will it show one minute later? (b) A nurse works from midnight to 3:00 am by the clock on the night of 4 October. How many hours of real time does she work? (c) A guard works 3 h 30 min of real time from midnight on 5 April. What time does the clock show when he stops?

Q16. The border strip at Eucla (between WA and SA) keeps UTC+8:45 all year. It is midday at Eucla on Wednesday 20 May 2026. What time is it in: (a) Perth; (b) Melbourne?

Maths in real life

Q17. A stargazing stream goes live at 21:00 UTC on Wednesday 11 November 2026. What time and day is that in: (a) Melbourne; (b) Toronto; (c) Perth?

Q18. A person leaves Perth at 9:15 am on Wednesday 9 September 2026, flies 5 h 40 min to Singapore, waits 3 h 05 min, then flies 6 h 45 min on to Tokyo. When do they arrive in Tokyo, on Tokyo's clock?

Q19. A grand final screening starts in Melbourne at 7:30 pm on Saturday 14 November 2026. What time and day is that for a viewer in: (a) Perth; (b) Suva; (c) Toronto?

Q20. Pick two cities from the UTC number line figure. Write your own question that moves a time from one to the other, swap it with a partner, and check that you both get the same answer by the UTC route.

Answers

Example 7. 21:15; 7:50 am **Example 8.** 22:25 **Q1.** (a) 15:20 (b) 07:05 (c) 7:30 pm (d) 12:40 am **Q2.** (a) 4 h 25 min (b) 1 h 15 min **Q3.** (a) 10:00 am (b) 11:30 am (c) 11:30 am (d) midday **Q4.** (a) AEDT (b) AEST (c) AEDT (d) AEST **Q5.** 4:30 pm FJT (16:30) **Q6.** (a) T (b) F — AEDT is UTC+11 (c) F — 2 hours behind from April to October, 3 hours behind from October to April (d) T (e) T **Q7.** (a) UTC+10 (b) UTC+11 (c) UTC+9:30 (d) UTC+8 (e) UTC+10:30 **Q8.** 1:00 am on Thursday 15 January (AEDT) **Q9.** (a) 06:07 (b) 23:59 (c) 00:05 (d) 5:02 pm (e) 00:00 (f) 12:00 **Q10.** (a) 06:45 UTC (b) 18:45 FJT (c) 02:45 EDT **Q11.** (a) 8:20 am SST (b) 9:20 am JST **Q12.** (a) 10:20 am NPT (b) 2:35 pm AEST (14:35) **Q13.** 1:15 am IST the next day **Q14.** 5:20 pm on Sunday 11 January (EST) **Q15.** (a) 3:00 am AEDT (b) 2 hours — the clock hour from 2 to 3 does not exist that night (c) 2:30 am AEST **Q16.** (a) 11:15 am AWST (b) 1:15 pm AEST **Q17.** (a) 8:00 am on Thursday 12 November (AEDT) (b) 4:00 pm on Wednesday 11 November (EST) (c) 5:00 am on Thursday 12 November (AWST) **Q18.** 1:45 am JST on Thursday 10 September **Q19.** (a) 4:30 pm on Saturday 14 November (b) 8:30 pm on Saturday 14 November (c) 3:30 am on Saturday 14 November **Q20.** Answers will vary — the two routes must agree.

Fully-worked solutions

Example 7. 9:15 pm → 9 + 12 = 21 → 21:15. 07:50 is a morning time → 7:50 am.

Example 8. 20:45 + 1 h = 21:45, + 40 min = 22:25.

Q1. (a) 3 + 12 = 15 → 15:20. (b) Morning hours keep their number with a leading zero → 07:05. (c) 19 − 12 = 7 → 7:30 pm. (d) 00:40 is 40 minutes after midnight → 12:40 am.

Q2. (a) 09:20 + 4 h = 13:20, + 25 min = 13:45 → 4 h 25 min. (b) 6:50 pm + 1 h = 7:50 pm, + 15 min = 8:05 pm → 1 h 15 min.

Q3. Midday AEST is 02:00 UTC. (a) Perth +8 → 10:00 am. (b) Adelaide +9:30 → 11:30 am. (c) Darwin +9:30 → 11:30 am. (d) Brisbane +10 → midday. July is on the April-to-October side, so no city is on daylight saving.

Q4. Victoria runs AEDT from the first Sunday in October to the first Sunday in April (in 2026: 5 April and 4 October). (a) 26 January is inside that window → AEDT. (b) 13 June is between 5 April and 4 October → AEST. (c) 31 December is after 4 October → AEDT. (d) 9 April is four days after the 5 April change back → AEST.

Q5. 2:30 pm AEST is 14:30; 14:30 − 10 h = 04:30 UTC; Suva +12 → 16:30, that is 4:30 pm FJT. Fiji does not use daylight saving, so no further check is needed.

Q6. (a) T: 22 − 12 = 10. (b) F: AEDT is UTC+11; AEST is the +10 one. (c) F: 2 hours behind from April to October, but 3 hours behind while the east is on AEDT. (d) T. (e) T: 5:45 − 5:30 = 15 minutes.

Q7. (a) +10 (b) +11 (c) +9:30 (d) +8 (e) +10:30.

Q8. EST is UTC−5, so 9:00 am EST is 9 + 5 = 14:00 UTC. 14 January 2026 is between 5 October 2025 and 5 April 2026, so Melbourne is on AEDT: 14:00 + 11 h = 25:00 → 1:00 am on Thursday 15 January.

Q9. (a) 06:07. (b) 11 + 12 = 23 → 23:59. (c) 12:05 am is just after midnight → 00:05. (d) 17 − 12 = 5 → 5:02 pm. (e) 00:00. (f) 12:00.

Q10. 4:45 pm AEST is 16:45. (a) 16:45 − 10 h = 06:45 UTC. (b) 06:45 + 12 h = 18:45 FJT. (c) 06:45 − 4 h = 02:45 EDT (22 July is inside Toronto's 8 March to 1 November summer time).

Q11. Perth and Singapore share UTC+8 all year, so (a) 8:20 am SST. (b) Tokyo is one more hour east → 9:20 am JST. WA's clock never changes, so the March date needs no daylight saving check.

Q12. 10:05 am IST is 04:35 UTC. (a) 04:35 + 5 h 45 min = 10:20 am NPT. (b) 04:35 + 10 h = 14:35 AEST, that is 2:35 pm (12 August is on the April-to-October side).

Q13. 22:15 SST is 14:15 UTC. 14:15 + 5 h 30 min = 19:45 UTC. 19:45 + 5 h 30 min = 25:15 → 1:15 am IST on the next day.

Q14. 9:20 am AEDT − 11 h = 22:20 UTC, and stepping back those 11 hours crosses midnight, so the UTC moment sits on Sunday 11 January. Toronto is on EST in January: 22:20 − 5 h = 17:20 → 5:20 pm on Sunday 11 January.

Q15. (a) The clock jumps straight from 2:00 am to 3:00 am, so one minute after 1:59 am it shows 3:00 am AEDT. (b) The clock reads 3 hours, but the hour from 2 to 3 never happens: midnight to 2:00 am is 2 real hours, and the jump adds none → 2 hours. (c) Midnight to 3:00 am AEDT is 3 real hours (the change back happens at 3:00 am); the last 30 minutes run on AEST, when the clock reads 2:00 to 2:30 am → the clock shows 2:30 am AEST.

Q16. Midday at Eucla is 03:15 UTC (12:00 − 8 h 45 min). (a) Perth +8 → 11:15 am AWST. (b) Melbourne +10 → 13:15, that is 1:15 pm AEST (20 May is on the April-to-October side).

Q17. (a) 21:00 + 11 h = 32:00 → 8:00 am on Thursday 12 November AEDT (11 November is after 4 October). (b) 21:00 − 5 h = 16:00 → 4:00 pm on Wednesday 11 November EST (after 1 November). (c) 21:00 + 8 h = 05:00 → 5:00 am on Thursday 12 November AWST; Perth's clock is the same on both sides of the changeover.

Q18. 9:15 am AWST is 01:15 UTC. 01:15 + 5 h 40 min = 06:55 UTC; Singapore +8 → 14:55 SST. 06:55 + 3 h 05 min = 10:00 UTC (18:00 SST). 10:00 + 6 h 45 min = 16:45 UTC; Tokyo +9 → 25:45 → 1:45 am JST on Thursday 10 September.

Q19. 7:30 pm AEDT is 19:30; 19:30 − 11 h = 08:30 UTC (14 November is after 4 October, so AEDT). (a) 08:30 + 8 h = 16:30 → 4:30 pm Saturday in Perth. (b) 08:30 + 12 h = 20:30 → 8:30 pm Saturday in Suva. (c) 08:30 − 5 h = 03:30 → 3:30 am Saturday in Toronto (EST after 1 November).

Q20. Check by the UTC route: move the start time back to UTC, then forward by the other city's offset; both partners should land on the same clock time. Example: 3:00 pm in Tokyo is 06:00 UTC, and 06:00 + 8 h = 14:00, so 2:00 pm in Singapore — and the direct route agrees, since Singapore is 1 hour behind Tokyo.

Zone rules and offsets checked against Wikipedia's "Time in Australia", "Time in Fiji", "Eastern Time Zone", "Time in Singapore", "Nepal Standard Time" and "List of time zones by country", all retrieved 20 August 2026.

Rates

Content description `VC2M8M05`: recognise and use rates to solve problems involving the comparison of 2 related quantities of different units of measure

A car's speed, a shop's price per kilogram, a Saturday job's hourly pay, a cricket team's run rate and even the tax table are all the one idea: two quantities with different units, compared by division. By the end of this subtopic you will recognise a rate wherever it appears, build one by dividing, and run it in both directions - multiply to go forward, divide to go back.

Theory

What is a rate?

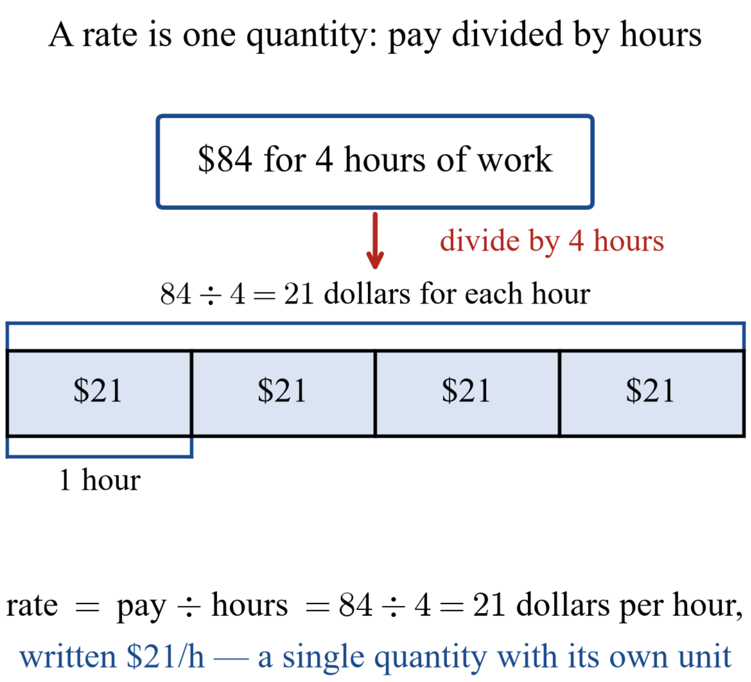
A **rate** compares two quantities measured in **different units**. You met ratios in Level 7 (`VC2M7N09`); a rate is a ratio where the two quantities carry different units, so the comparison makes a new kind of quantity with its own **compound unit**:

Rate	Compares	Unit
speed	distance with time	km/h (also written km per hour)
rate of pay	dollars with hours of work	\$/h
price rate	dollars with mass	\$/kg
recipe rate	cups of milk with cups of flour	cups per cup
run rate	runs with overs	runs per over
dilution rate	mL of concentrate with L of water	mL/L

Every rate is **one quantity** found by division:

$$\text{rate} = \text{quantity} \div \text{quantity}$$

Jana is paid \$84 for 4 hours of work. Dividing the pay across the hours shares it evenly, and each hour carries the same amount - that amount is the rate.



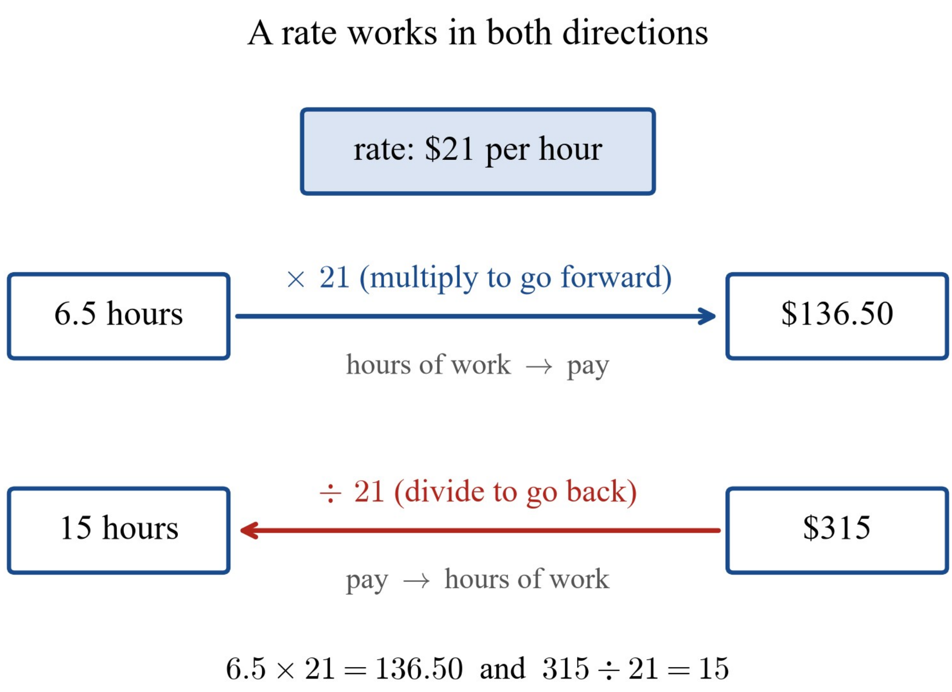
A bar model sharing $84 of pay evenly across 4 one-hour cells of $21 each, showing rate = pay ÷ hours = $21 per hour

The word **per** means "for each": $21 **per** hour is $21 for each hour of work. Because the rate is a single quantity with its own unit, it can be used on its own, long after the original $84 and 4 hours are forgotten.

A rate works in both directions

The same rate answers two kinds of question:

- **forward** - how many dollars for a known number of hours? Multiply by the rate.
- **backward** - how many hours of work earned a known number of dollars? Divide by the rate.



Two arrows from the rate $21 per hour: forward, 6.5 hours multiplied by 21 gives $136.50; backward, $315 divided by 21 gives 15 hours

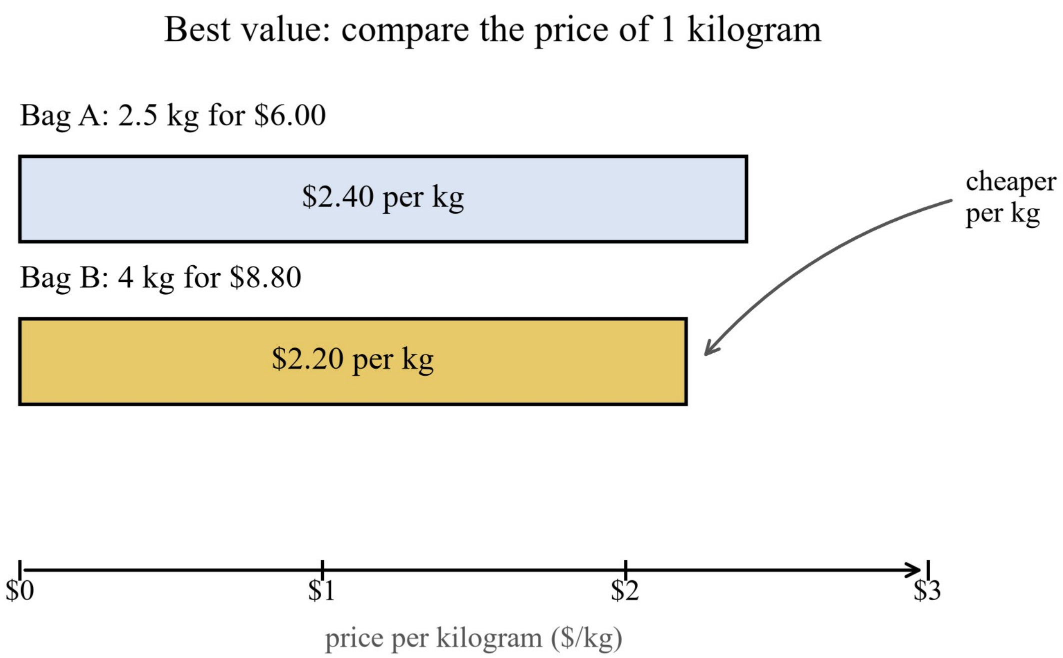
At $21 per hour: $6.5 \times 21 = 136.50$, so 6.5 hours of work earns $136.50; and $315 \div 21 = 15$, so $315 of pay came from 15 hours. One rate, two directions. This is the same two-way thinking 2C uses for the constant rate of change in a linear rule.

Recognising rates in the world

Rates hide in ordinary sentences. “The car travelled 60 km each hour” is a speed of 60 km/h. “Rice costs $2.40 a kilogram” is a price rate. “The bank adds $4 for every $100 in the account each year” is a rate of interest - 4% per year is the rate $4 per year per $100. “The recipe takes 2 cups of milk for each cup of flour” is a recipe rate. Average rates work the same way: a trip of 240 km in 4 hours averages $240 \div 4 = 60$ km/h, even though the car never held exactly 60 km/h the whole way.

Comparing by the unit rate - best buys

When two offers use different sizes, compare them **per 1 unit** - the **unit rate**. This is the Level 7 best-buy idea (`VC2M7N10`) written as a rate.



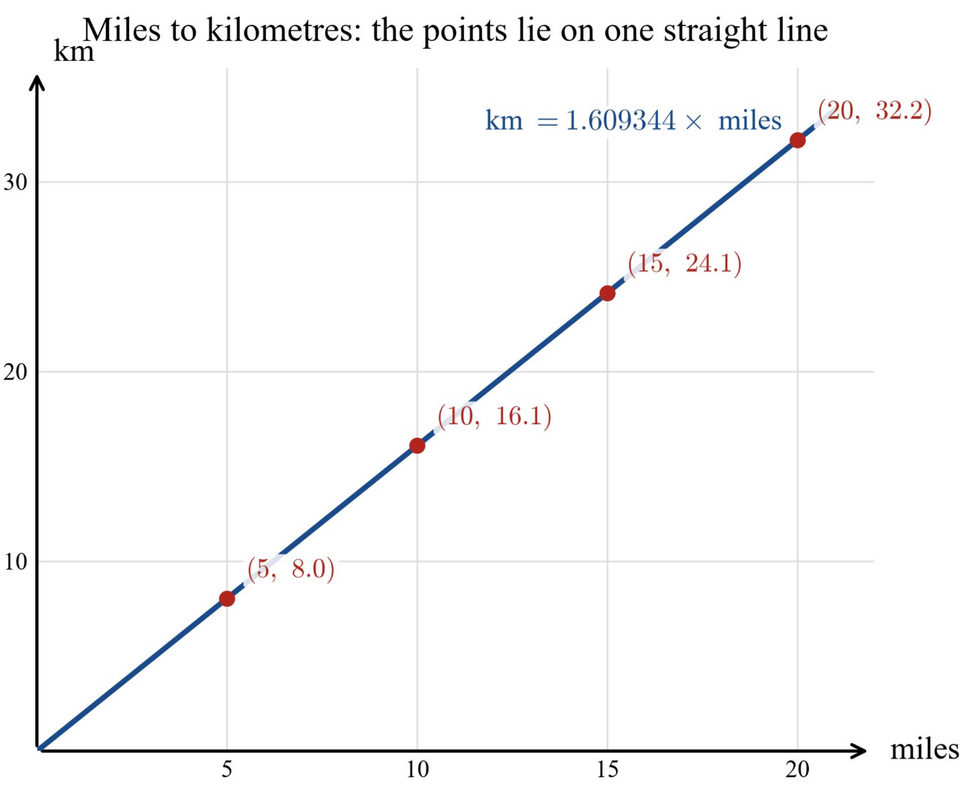
A bar chart comparing two bags: Bag A costs $2.40 per kilogram and Bag B costs $2.20 per kilogram, with Bag B shaded as the cheaper per kg

Bag A is 2.5 kg for $6.00: $6.00 \div 2.5 = 2.40$ per kg. Bag B is 4 kg for $8.80: $8.80 \div 4 = 2.20$ per kg. The bars make the comparison visible - the shorter price per kg is the better value, and the gap between the bars is the saving per kilogram.

Converting units by rate

A rate can convert a quantity from one unit to another.

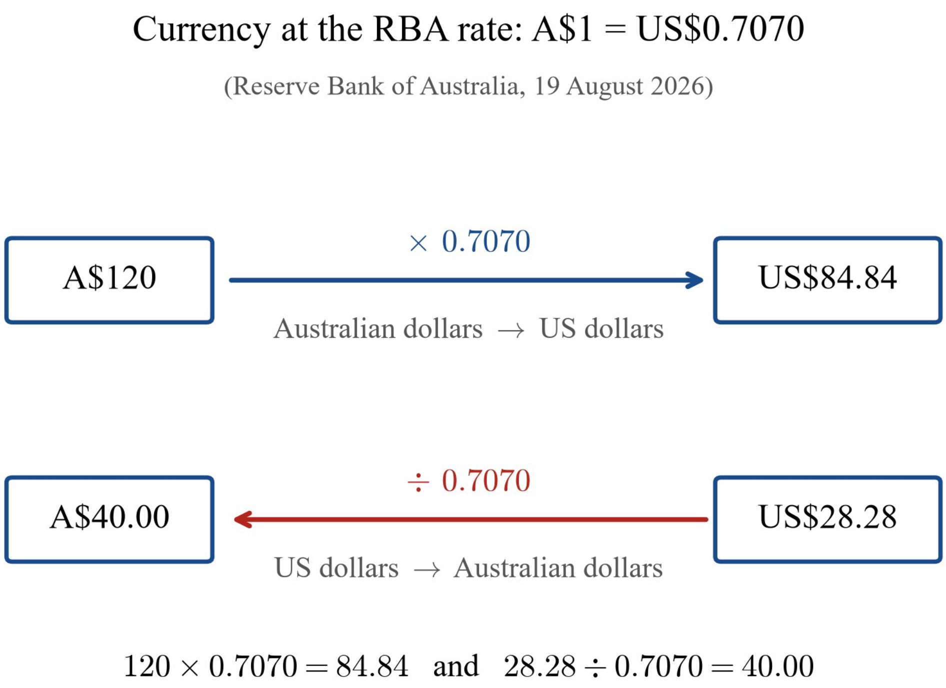
Miles to kilometres. One mile is exactly 1.609344 km, so the conversion rate is 1.609344 km per mile: multiply miles by the rate to get kilometres, divide to go back.



A graph of kilometres against miles with the points (5, 8.0), (10, 16.1), (15, 24.1) and (20, 32.2) lying on one straight line through the origin, labelled km = 1.609344 × miles

The points lie on one straight line through the origin - a constant rate always produces that picture (2C explains why).

Currency. An **exchange rate** converts dollars of one country into dollars of another. The Reserve Bank of Australia's rate on 19 August 2026 was A$1 = US$0.7070.



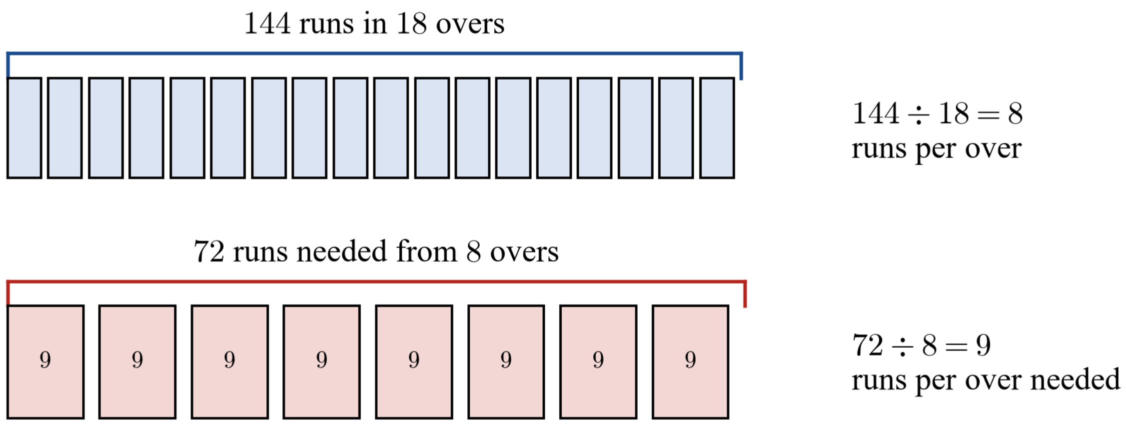
Two arrows at the Reserve Bank of Australia rate A$1 = US$0.7070: forward, A$120 multiplied by 0.7070 gives US$84.84; backward, US$28.28 divided by 0.7070 gives A$40.00

Forward: $120 \times 0.7070 = 84.84$, so A$120 buys US$84.84. Backward: $28.28 \div 0.7070 = 40.00$, so a US$28.28 item costs A$40.00. Again one rate, two directions.

Rates in action: run rates, dilution and fuel

Cricket. A **run rate** is runs per over. A team's 144 runs in 18 overs is a rate of $144 \div 18 = 8$ runs per over. If that team now needs 72 runs from the last 8 overs, the **required rate** is $72 \div 8 = 9$ runs per over - higher than the rate so far, so the batters must score faster.

Run rate: runs scored per over

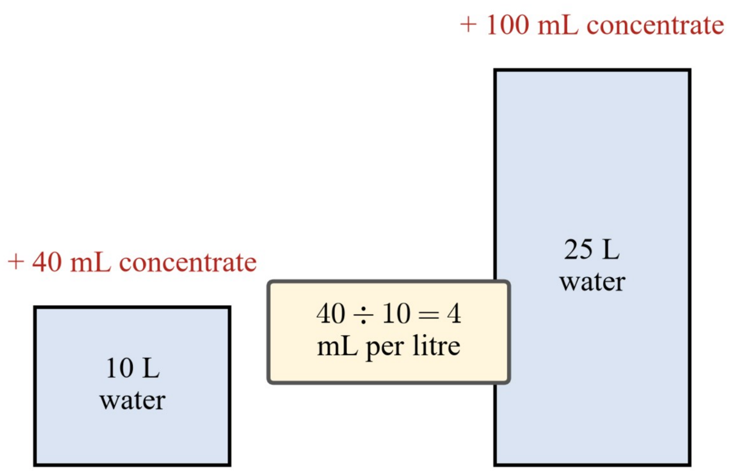


The required rate (9 per over) is higher than the rate so far (8 per over)

A bar model in two rows: 144 runs in 18 overs gives 8 runs per over; 72 runs needed from 8 overs gives a required rate of 9 per over

Dilution. A label that says "add 40 mL of concentrate to every 10 L of water" gives a rate of $40 \div 10 = 4$ mL of concentrate per litre of water. The rate scales to any size of container - that is what makes it a rate. (Dilution is also a Science idea - you will meet the same rate in Science when solutions are mixed.)

Dilution: a rate of concentrate per litre of water



Same rate, any size: $4 \times 25 = 100$ mL for 25 L of water. Water volumes are drawn to scale; concentrate amounts are labelled.

Two containers drawn to scale: 10 L of water takes 40 mL of concentrate, and 25 L of water takes 100 mL, both at the rate 40 ÷ 10 = 4 mL per litre

Fuel. Petrol consumption compares litres of fuel with distance. A car that travels 196 km on 14 L manages $196 \div 14 = 14$ km per litre; another that travels 180 km on 12 L manages $180 \div 12 = 15$ km per litre. Same kind of comparison as the best-buy bars - the higher km per litre is the more efficient car.

A tax table is a list of rates

The resident tax table for the financial year 2026-27 (Australian Taxation Office) is nothing new: each bracket carries a rate, and each rate applies **only to the part of your income inside that bracket**. Rates like these are called **marginal** rates.

Resident tax rates 2026–27: the rate that applies to each part of your income

The rates are marginal rates: each rate applies only to the part of your income inside that bracket.

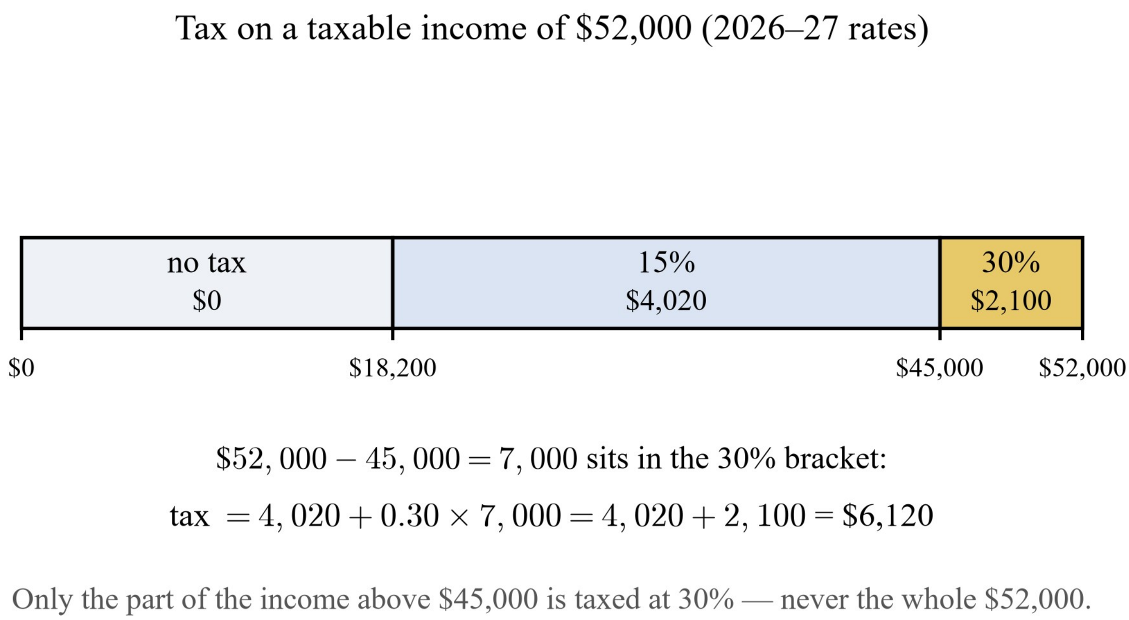
The first $18,200 is tax-free; the table does not include the Medicare levy.

Source: Australian Taxation Office, resident tax rates 2026–27; retrieved 20 August 2026.

A horizontal bar of the 2026–27 resident tax brackets from $0 to $190,000 and over, labelled 0%, 15%, 30%, 37% and 45%, noting each marginal rate applies only to the part of income in that bracket

To find the tax on a **taxable income** of $52,000, split the income at the bracket edges and apply each bracket's rate to its slice:

- the first $18,200: rate 0% → $0;
- the next $26,800 (from $18,200 to $45,000): rate 15% → $0.15 \times 26,800 = 4,020$;
- the last $7,000 (from $45,000 to $52,000): rate 30% → $0.30 \times 7,000 = 2,100$.



A worked bar splitting $52,000 into three slices: no tax on the first $18,200, $4,020 at 15% on the middle slice, and $2,100 at 30% on the top slice, totalling $6,120

Total tax $= 0 + 4,020 + 2,100 = 6,120$. Notice what the table does **not** say: it does not tax the whole $52,000 at 30%. Only the part above $45,000 carries the 30% rate. In this subtopic the tax table is used exactly like this - look up the brackets, apply the rates - and only for the named year 2026-27. (1F takes the modelling of tax further; the table here does not include the Medicare levy.)

Review card

4B Rates — what this subtopic built

A rate compares two quantities with different units: km/h, $/kg, mL per L.

rate = quantity ÷ quantity.
Multiply to go forward; divide to go back.

Rates convert units:
miles → km, A$ → US$.

A tax table is a list of rates:
find the bracket, apply its rate.

All of these are the one idea: two quantities measured together, compared by division.

A summary card with four tiles: a rate compares two quantities with different units such as km/h, /kg and mL per L; rate = quantity ÷ quantity, multiply forward and divide back; rates convert u to US$; a tax table is a list of rates

Words of this subtopic

Word	What it means here
rate	a comparison of two quantities with different units, found by division
per	"for each"; $21 per hour means $21 for each hour
compound unit	the unit a rate carries, built from two units: km/h, $/kg, mL/L
unit rate	the rate per 1 unit, used to compare offers of different sizes
rate of pay	dollars earned per hour of work
run rate	runs scored per over in cricket; the required rate is what the team needs from the overs left
dilution	mixing concentrate into water at a rate of mL of concentrate per L of water
concentrate	the strong chemical or cordial that is diluted with water
exchange rate	the rate that converts money of one country into money of another
taxable income	the part of a person's income that tax is worked out on
bracket	one slice of the income scale in a tax table, carrying its own rate
marginal rate	a rate that applies only to the part of the income inside its bracket

Worked examples

Example 1 — with help

Jana is paid $84 for 4 hours of work at a constant rate.

(a) Find her rate of pay.
(b) How much does she earn for 6.5 hours at this rate?
(c) One week she earns $315. How many hours did she work?
(d) Write the rate with its unit, and say why a rate is one quantity, not two.

Working	Comment
(a) $84 \div 4 = 21$	rate = pay ÷ hours.
(b) $21 \times 6.5 = 136.50$	Multiply by the rate to go forward.
(c) $315 \div 21 = 15$	Divide by the rate to go back.
(d) $21/h - the pay shared over the hours becomes a single quantity with its own unit.	Division collapses two quantities into one.

∴ (a) $21 per hour; (b) $136.50; (c) 15 hours. Review: the model assumes every hour is paid at the same rate - no penalty rates or overtime - so it suits ordinary hours only.

Example 2 — with help

Rice is sold in two bags. Bag A is 2.5 kg for $6.00. Bag B is 4 kg for $8.80. Which bag is the better value?

Working	Comment
Bag A: $6.00 \div 2.5 = 2.40$ per kg	Unit rate for A.
Bag B: $8.80 \div 4 = 2.20$ per kg	Unit rate for B.
$2.20 < 2.40$	The lower price per kg wins.

∴ Bag B is the better value at $2.20 per kg, saving 20c on every kilogram. Review: unit rates give a fair comparison only when the goods are the same quality - the cheaper per kg is the better value *as rice*, not necessarily the better rice.

Example 3 — with help

A cricket team has scored 144 runs in 18 overs.

(a) Find the team's run rate.
(b) The team needs 72 more runs from the last 8 overs. Find the required run rate.
(c) Compare the two rates. What must the batters do?

Working	Comment
(a) $144 \div 18 = 8$ runs per over	Run rate = runs ÷ overs.
(b) $72 \div 8 = 9$ runs per over	Required rate = runs needed ÷ overs left.
(c) 9 per over is more than 8 per over.	The scoring must speed up.

∴ (a) 8 runs per over; (b) 9 runs per over; (c) the required rate is higher than the rate so far, so the batters must score faster than they have.

Example 4 — on your own

One mile is exactly 1.609344 km.

Source: NIST Special Publication 811, Appendix B. Retrieved 20 August 2026.

(a) Convert 5 miles to kilometres. Give the exact answer, then round to 2 decimal places.
(b) A sign says the next town is 10 km away. Estimate the distance in miles using 1.6 km per mile, then state the exact value $10 \div 1.609344 = 6.21371\ldots$ to 2 decimal places. Is your estimate too high or too low? Why?

The rate is 1.609344 km per mile: multiply miles by the rate to get kilometres, and divide kilometres by the rate to get miles.

(a) $5 \times 1.609344 = 8.04672$, exactly; 8.05 km to 2 decimal places.

(b) Estimate: $10 \div 1.6 = 6.25$ miles. Exact: 6.21 miles to 2 decimal places. The estimate is too high, because dividing by 1.6 divides by a number a little smaller than 1.609344, and dividing by a smaller number gives a bigger answer.

∴ (a) 8.04672 km, about 8.05 km; (b) estimate 6.25 miles, exact 6.21 miles; the estimate is high for the reason above.

Example 5 — on your own

On 19 August 2026 the Reserve Bank of Australia's exchange rate was A$1 = US$0.7070.

Source: Reserve Bank of Australia, *Exchange Rates*. Retrieved 20 August 2026.

(a) How many US dollars does A$120 buy at this rate?

(b) A souvenir costs US$28.28. What is that in Australian dollars?

(c) Which is worth more, one Australian dollar or one US dollar? Explain using the rate.

(d) $120 \times 0.7070 = 84.84$: US$84.84.

(e) $28.28 \div 0.7070 = 40.00$: A$40.00.

(f) A$1 buys only US$0.7070 - less than one US dollar - so one US dollar is worth more than one Australian dollar. (Backwards: US$1 ≈ A$1.41.)

∴ (a) US$84.84; (b) A$40.00; (c) the US dollar, because A$1 converts to less than US$1. Review: exchange rates move every business day, so an answer worked at this rate is true for 19 August 2026 only.

Example 6 — on your own

A garden spray label says: mix 40 mL of concentrate with every 10 L of water.

(a) Find the rate of concentrate per litre of water.

(b) A sprayer holds 25 L of water. How much concentrate is needed?

(c) You have 200 mL of concentrate left. How many litres of water does it treat?

(d) $40 \div 10 = 4$: the rate is 4 mL of concentrate per litre of water.

(e) $4 \times 25 = 100$: 100 mL of concentrate.

(f) $200 \div 4 = 50$: 50 L of water.

∴ (a) 4 mL/L; (b) 100 mL; (c) 50 L. Review: the label rate keeps the mixture at the same strength at any size - doubling the water without doubling the concentrate would halve the rate and weaken the spray.

Example 7 — on your own

Use the resident tax rates for 2026-27 shown in the theory (Australian Taxation Office, retrieved 20 August 2026) to find the tax on a taxable income of $52,000.

(a) Which brackets does $52,000 reach into?

(b) Work the tax on each slice and add them.

(c) Explain in one sentence why the tax is not 30% of $52,000.

(d) $52,000 fills the 0% bracket ($0-$18,200), the 15% bracket ($18,200-$45,000), and part of the 30% bracket ($45,000-$135,000).

(e) Slice 1: $0. Slice 2: $45,000 - 18,200 = 26,800$; $0.15 \times 26,800 = 4,020$. Slice 3: $52,000 - 45,000 = 7,000$; $0.30 \times 7,000 = 2,100$. Total: $0 + 4,020 + 2,100 = 6,120$.

(f) The rates are marginal: 30% applies only to the $7,000 above $45,000, never to the whole income.

∴ The tax on $52,000 is $6,120. Review: the table used is the named 2026-27 table; a different year has different edges and rates, so always check which year a tax question names.

Practice questions

Work these questions by hand. The numbers are chosen so that no calculator is needed - the skill here is building and using the rate, not the arithmetic.

With help

Q1. Which of these are rates? For each rate, give its unit.

a. a car travelling 60 km in each hour
b. $5 in a money box
c. cheese costing $2.50 for each kilogram
d. a recipe using 3 cups of flour for each cup of milk

Q2. Work out each rate.

a. $96 for 8 hours of work
b. 240 km in 4 hours
c. $13.50 for 3 kg
d. 45 runs in 9 overs

Q3. Use the rate $21 per hour.

a. Find the pay for 5 hours.
b. Find the pay for 2.5 hours.
c. How many hours of work earn $189?
d. How many hours of work earn $94.50?

Q4. A pancake recipe uses 2 cups of milk for each cup of flour.

a. How much milk for 4 cups of flour?
b. How much milk for 2.5 cups of flour?
c. You pour 7 cups of milk. How much flour does it need?

Q5. Find the better value in each pair. Show the unit rates.

a. Bottle X: 2 L for $5.00, or Bottle Y: 3 L for $6.90
b. Pack X: 500 g for $4.50, or Pack Y: 2 kg for $16.00

Q6. Car P travels 196 km on 14 L of petrol. Car Q travels 180 km on 12 L.

a. Find each car's rate in km per litre.
b. Which car uses its fuel more efficiently?

Q7. Use 1 mile ≈ 1.6 km.

a. Convert 5 miles to km.
b. Convert 12 miles to km.
c. Convert 40 km to miles.

Q8. Use the rate A$1 = US$0.70.

a. Convert A$50 to US dollars.
b. Convert A$120 to US dollars.

c. Convert US$56 to Australian dollars.

On your own

Q9. A painter is paid $27 per hour.

a. Write the rate with its unit.
b. Find the pay for 6 hours.
c. Find the pay for 7.5 hours.
d. One job earns $351. How many hours did it take?

Q10. Potting mix is sold as 3 kg for $7.50 or 5 kg for $12.00.

a. Find the price per kg of each bag.
b. Which bag is the better value, and by how much per kg?

Q11. A team scores 96 runs in 12 overs.

a. Find the run rate.
b. At this rate, how many runs would the team score in 20 overs?
c. How many overs would 128 runs take at this rate?

Q12. On 19 August 2026 the Reserve Bank of Australia's exchange rate for the New Zealand dollar was A$1 = NZ$1.2042.

Source: Reserve Bank of Australia, *Exchange Rates*. Retrieved 20 August 2026.

a. Convert A$250 to New Zealand dollars.
b. A jersey costs NZ$60.21. What is that in Australian dollars?
c. Which is worth more, one Australian dollar or one New Zealand dollar? Explain.

Q13. A cordial label says: mix 25 mL of concentrate with every 5 L of water.

a. Find the rate of concentrate per litre of water.
b. How much concentrate for 12 L of water?
c. How many litres of water does 150 mL of concentrate treat?

Q14. Use the resident tax rates for 2026-27 (Australian Taxation Office, retrieved 20 August 2026).

a. Find the tax on a taxable income of $31,500.
b. Find the tax on a taxable income of $150,000.

Q15. A sprinter runs 100 m in 20 seconds.

a. Find the rate in metres per second.
b. At this rate, how far does the sprinter run in 90 seconds?
c. At this rate, how long does 120 m take?

Q16. A pool fills at a constant rate of 250 L per hour.

a. How much water goes in during 6 hours?
b. How many hours does a 4000 L pool take to fill at this rate?

Q17. A cyclist covers 42 km in 3 hours. A runner covers 10 km in 40 minutes.

a. Find the cyclist's rate in km/h.
b. Find the runner's rate in km/h. (Hint: 40 minutes is two-thirds of an hour, so think about what 60 minutes would take.)
c. Who is faster?

Q18. A bank account pays simple interest at 4% per year: the rate is $4 per year for every $100 in the account.

a. How much interest does $500 earn in one year?
b. How much interest does it earn in 3 years at this rate?

Maths in real life

Q19. The resident tax rates for 2026-27 (Australian Taxation Office, retrieved 20 August 2026) are: 0% on the first $18,200; 15% from $18,200 to $45,000; 30% from $45,000 to $135,000; 37% from $135,000 to $190,000; 45% over $190,000.

a. A taxable income of $61,000 reaches into which brackets?
b. Work out the tax on $61,000.
c. Explain why the tax is much less than 30% of $61,000.

Q20. On 19 August 2026 the Reserve Bank of Australia's exchange rate was A$1 = US$0.7070.

Source: Reserve Bank of Australia, *Exchange Rates*. Retrieved 20 August 2026.

a. A family exchanges A$500 for a US holiday. How many US dollars do they get?
b. Back home, they have US$141.40 left. How many Australian dollars is that?
c. Does one US dollar buy more or less than one Australian dollar? Show how the rate tells you.

Q21. Road signs give speeds in km/h, but stopping distances are easier to think about in metres per second. Remember 1 km = 1000 m and 1 hour = 3600 s.

a. Show that 60 km/h is about 16.7 m/s (1 decimal place).
b. Show that 100 km/h is about 27.8 m/s.
c. A driver takes about 1.5 s to react. At each speed, how far does the car travel in that 1.5 s before the brakes even start to work? Comment.

Q22. Make your own. Find three rates from your own life - a price per kg at the shops, a tap's flow in L per minute, a walking speed in km/h, or one you choose. Write each as a rate with its unit, then use one of them to predict a different amount (a different mass, time or distance). Swap with a partner and check each other's rates.

Answers

Q1. a. Rate; km/h. b. Not a rate - one quantity only, no comparison. c. Rate; $/kg. d. Rate; cups of flour per cup of milk.

Q2. a. $12/h. b. 60 km/h. c. $4.50/kg. d. 5 runs per over.

Q3. a. $105. b. $52.50. c. 9 hours. d. 4.5 hours.

Q4. a. 8 cups. b. 5 cups. c. 3.5 cups.

Q5. a. X $2.50/L, Y $2.30/L - Y. b. X $9.00/kg, Y $8.00/kg - Y.

Q6. a. P: 14 km per litre; Q: 15 km per litre. b. Car Q.

Q7. a. 8 km. b. 19.2 km. c. 25 miles.

Q8. a. US$35. b. US$84. c. A$80.

Q9. a. $27/h. b. $162. c. $202.50. d. 13 hours.

Q10. a. $2.50/kg and $2.40/kg. b. The 5 kg bag, by 10c per kg.

Q11. a. 8 runs per over. b. 160 runs. c. 16 overs.

Q12. a. NZ$301.05. b. A$50.00. c. The Australian dollar - A$1 buys more than one New Zealand dollar.

Q13. a. 5 mL/L. b. 60 mL. c. 30 L.

Q14. a. $1,995. b. $36,570.

Q15. a. 5 m/s. b. 450 m. c. 24 s.

Q16. a. 1500 L. b. 16 hours.

Q17. a. 14 km/h. b. 15 km/h. c. The runner.

Q18. a. $20. b. $60.

Q19. a. The 0%, 15% and 30% brackets. b. $8,820. c. Because only the part of the income above $45,000 is taxed at 30% - the first $18,200 carries no tax and the middle slice is taxed at 15%.

Q20. a. US$353.50. b. A$200.00. c. More: A$1 buys only US$0.7070, so the US dollar is the stronger one (US$1 ≈ A$1.41).

Q21. a. $60,000 \div 3600 = 16.7$ m/s. b. $100,000 \div 3600 = 27.8$ m/s. c. About 25 m at 60 km/h and about 42 m at 100 km/h - before the brakes do anything.

Q22. Answers will vary. Check: each rate compares two different units and is found by division, and the predicted amount uses the rate in the right direction.

Fully-worked solutions

Q1. A rate compares two quantities with different units.

a. 60 km in each hour compares distance with time - a rate, **km/h**.
b. $5 is one quantity with one unit - **not a rate**.
c. $2.50 foreachkilogramcomparespricewithmass - arate,$**/kg**.
d. 3 cups of flour for each cup of milk compares two volumes used together - a rate, **cups of flour per cup of milk**.

Q2. a. $96 \div 8 = 12$: **$12/h**. b. $240 \div 4 = 60$: **60 km/h**. c. $13.50 \div 3 = 4.50$: **$4.50/kg**. d. $45 \div 9 = 5$: **5 runs per over**.

Q3. a. $21 \times 5 = 105$: **$105**. b. $21 \times 2.5 = 52.50$: **$52.50**. c. $189 \div 21 = 9$: **9 hours**. d. $94.50 \div 21 = 4.5$: **4.5 hours**.

Q4. The rate is 2 cups of milk per cup of flour: multiply cups of flour by 2 to get milk, divide milk by 2 to get flour.

a. $2 \times 4 = 8$: **8 cups of milk**.
b. $2 \times 2.5 = 5$: **5 cups of milk**.
c. $7 \div 2 = 3.5$: **3.5 cups of flour**.

Q5. a. X: $5.00 \div 2 = 2.50$ per L; Y: $6.90 \div 3 = 2.30$ per L. **Bottle Y.** b. X: 500 g for $4.50 is $9.00 per kg; Y: $16.00 \div 2 = 8.00$ per kg. **Pack Y.**

Q6. a. P: $196 \div 14 = 14$ km per litre; Q: $180 \div 12 = 15$ km per litre. b. **Car Q** travels further on each litre, so it is the more efficient car.

Q7. a. $5 \times 1.6 = 8$: **8 km**. b. $12 \times 1.6 = 19.2$: **19.2 km**. c. $40 \div 1.6 = 25$: **25 miles**.

Q8. a. $50 \times 0.70 = 35$: **US$35**. b. $120 \times 0.70 = 84$: **US$84**. c. $56 \div 0.70 = 80$: **A$80**.

Q9. a. **$27/h**. b. $27 \times 6 = 162$: **$162**. c. $27 \times 7.5 = 202.50$: **$202.50**. d. $351 \div 27 = 13$: **13 hours**.

Q10. a. $7.50 \div 3 = 2.50$ per kg; $12.00 \div 5 = 2.40$ per kg. b. **The 5 kg bag**, cheaper by $2.50 - 2.40 = 0.20$, **10c per kg**.

Q11. a. $96 \div 12 = 8$: **8 runs per over**. b. $8 \times 20 = 160$: **160 runs**. c. $128 \div 8 = 16$: **16 overs**.

Q12. a. $250 \times 1.2042 = 301.05$: **NZ$301.05**. b. $60.21 \div 1.2042 = 50.00$: **A$50.00**. c. **The Australian dollar.** A$1 buys NZ$1.2042 - more than one New Zealand dollar - so the Australian dollar is worth more.

Q13. a. $25 \div 5 = 5$: **5 mL per litre**. b. $5 \times 12 = 60$: **60 mL**. c. $150 \div 5 = 30$: **30 L**.

Q14. a. $31,500 fills the 0% bracket and part of the 15% bracket: $31,500 - 18,200 = 13,300$; $0.15 \times 13,300 = 1,995$. Tax: **$1,995**.

b. $150,000 fills four brackets. 0% slice: $0. 15% slice: $26,800 → $4,020. 30% slice: $135,000 - 45,000 = 90,000$; $0.30 \times 90,000 = 27,000$. 37% slice: $150,000 - 135,000 = 15,000$; $0.37 \times 15,000 = 5,550$. Total: $4,020 + 27,000 + 5,550 = 36,570$. Tax: **$36,570**.

Q15. a. $100 \div 20 = 5$: **5 m/s**. b. $5 \times 90 = 450$: **450 m**. c. $120 \div 5 = 24$: **24 s**.

Q16. a. $250 \times 6 = 1500$: **1500 L**. b. $4000 \div 250 = 16$: **16 hours**.

Q17. a. $42 \div 3 = 14$: **14 km/h**. b. In 40 minutes the runner covers 10 km, so in 20 minutes, 5 km, and in 60 minutes, $10 + 5 = 15$ km: **15 km/h**. c. $15 > 14$: **the runner** is faster.

Q18. a. $500 is five lots of $100, so $5 \times 4 = 20$: **$20** in one year. b. $20 \times 3 = 60$: **$60** in 3 years.

Q19. a. $61,000 fills the 0% bracket, the 15% bracket and part of the 30% bracket.

b. 0% slice: $0. 15% slice: $26,800 → $4,020. 30% slice: $61,000 - 45,000 = 16,000$; $0.30 \times 16,000 = 4,800$. Total: $4,020 + 4,800 = 8,820$. Tax: **$8,820**.

c. The 30% rate is marginal - it touches only the $16,000 above $45,000. The first $18,200 is tax-free and the next $26,800 is taxed at 15%, so the total is far less than 30% of the whole.

Q20. a. $500 \times 0.7070 = 353.50$: **US$353.50**. b. $141.40 \div 0.7070 = 200.00$: **A$200.00**. c. **More.** A$1 converts to only US$0.7070, so one Australian dollar buys less than one US dollar; turning the rate around, US$1 ≈ $1 \div 0.7070 = 1.41$ Australian dollars.

Q21. a. 60 km/h is $60,000$ m per 3600 s: $60,000 \div 3600 = 16.66\ldots$, about **16.7 m/s**. b. 100 km/h is $100,000 \div 3600 = 27.77\ldots$, about **27.8 m/s**. c. 60 km/h: $16.7 \times 1.5 = 25.05$, about **25 m**. 100 km/h: $27.8 \times 1.5 = 41.7$, about **42 m**. Comment: in the same 1.5 s of reaction time the faster car travels about 17 m further before braking even begins - a strong argument for slower speeds where people are about.

Q22. Answers will vary. Example: a tap fills a 9 L bucket in 30 s, a rate of $9 \div 30 = 0.3$ L/s. Prediction: in 2 minutes (120 s) the tap delivers $0.3 \times 120 = 36$ L. Check: the rate compares two different units (litres with seconds), is found by division, and the prediction multiplies by the rate to go forward.

Modelling with ratios and rates, including distance–time at constant speed

Content description VC2M8M07: use mathematical modelling to solve practical problems involving ratios and rates, including distance-time problems for travel at a constant speed and financial contexts; formulate problems; interpret and communicate solutions in terms of the situation, reviewing the appropriateness of the model

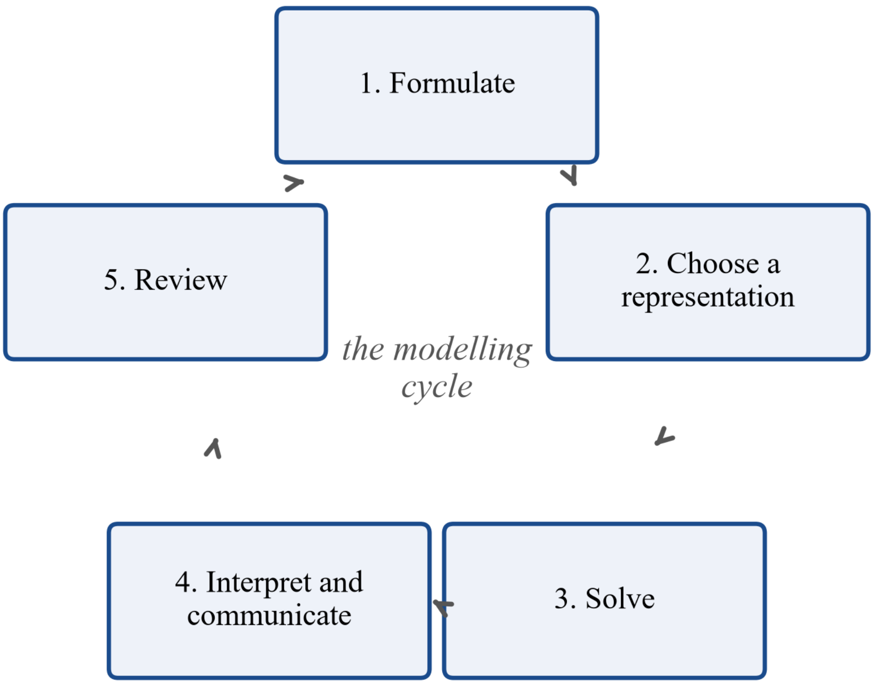
A road trip, a map, a photograph of an ant, a pay slip and a holiday budget all raise the same kind of question: how does one quantity change when another changes? By the end of this subtopic you will model situations like these with rates — speed in km/h, scale on a map, magnification in a photo, dollars per hour, tax per dollar earned — and you will know how to check, in words, whether your model really fits the situation.

Theory

The modelling cycle

In 2C you met mathematical modelling: building mathematics **from** a situation, solving, and then interpreting and reviewing. Every worked example and every full modelling question in this subtopic runs the same five steps, shown in the diagram below.

Modelling runs in a cycle — review leads back to the start



Flow diagram of the five-step modelling cycle: formulate, choose a representation, solve, interpret and communicate, and review, with arrows running in a ring

1. **Formulate.** Decide what the question is really asking. Choose letters for the quantities and write the relationship between them — often a rate connecting two different units.
2. **Choose a representation.** A rule, a table, a graph, a scale drawing or a diagram — pick the one that suits the question.
3. **Solve.** Do the mathematics: multiply or divide by the rate, substitute into the rule, or read from a graph.
4. **Interpret and communicate.** State the answer **in terms of the situation**, with the right units. "$t = 3$" is not an answer; "the trip takes 3 hours" is.
5. **Review.** Ask whether the answer and the model make sense: does the size fit? For how long, or for which values, does the model actually describe real life?

Rates you already know

Last year you compared quantities with **ratios** (`VC2M7N09`): a ratio like $1:4$ compares two amounts of the *same kind of thing*, such as 1 part cordial to 4 parts water. A **rate** is a comparison of two quantities in *different units*, expressed per one unit of the second quantity:

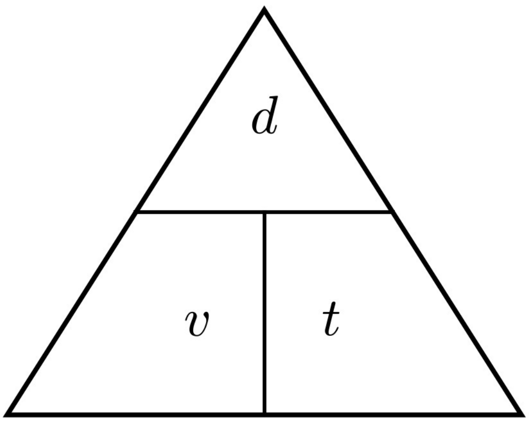
- a car covers 80 km **per hour** — 80 km/h;
- a job pays 19 dollars **per hour** — \$19/h;
- a map shows 1 cm **per** 250 000 cm of real distance — scale 1:250 000.

In every case the rate answers the question "how many of this for **each one** of that?" Multiplying by the rate goes one way; dividing goes back:

$$\text{amount} = \text{rate} \times \text{number of units}, \text{number of units} = \text{amount} \div \text{rate}$$

Speed, distance and time

The rate you have used for years is **speed**: the distance travelled per unit of time. The three quantities fit in a triangle — cover the one you want:



distance on top: cover it to read each rule

speed = distance ÷ time

$$v = \frac{d}{t}$$

distance = speed × time

$$d = v \times t$$

time = distance ÷ speed

$$t = \frac{d}{v}$$

Formula triangle with distance d on top and speed v and time t below, beside the three rules: speed equals distance divided by time, distance equals speed times time, time equals distance divided by speed

$$v = \frac{d}{t} \quad d = v \times t \quad t = \frac{d}{v}$$

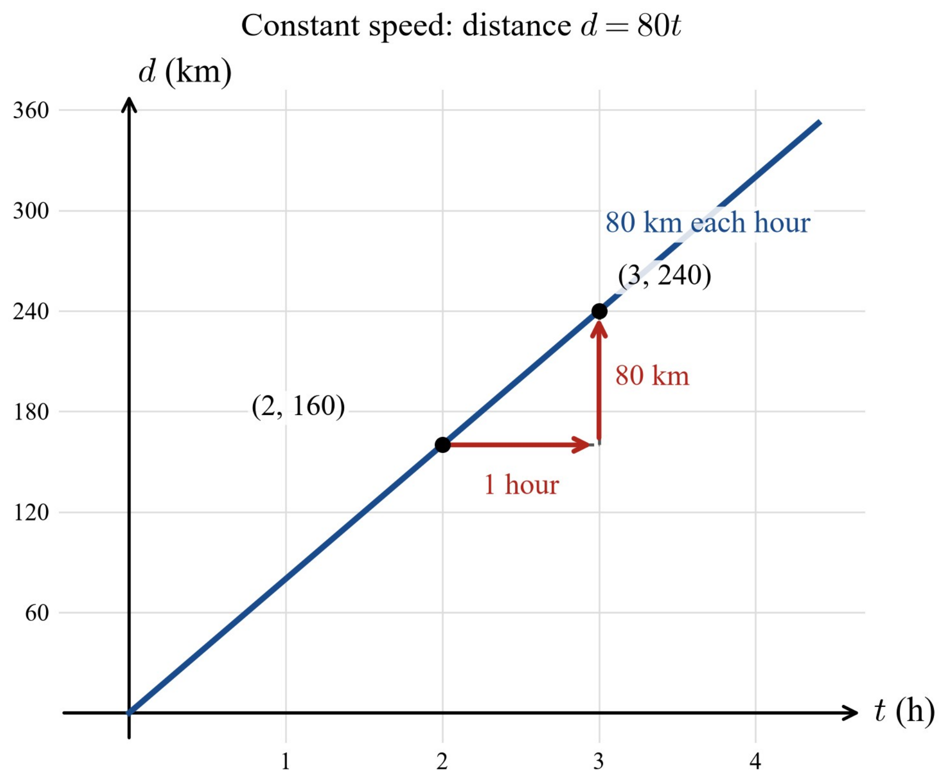
with d in km, t in hours and v in km/h. **Change minutes to hours first**: 30 min is 0.5 h, 45 min is 0.75 h, 1 h 15 min is 1.25 h.

Distance–time graphs at constant speed

In 2B you built tables and graphs of linear relations, and in 2C you wrote rules like $C = 95 + 70n$, reading off the initial value and the constant rate of change. A trip at a **constant speed** is the same relation with initial value 0: after t hours at v km/h, the distance is

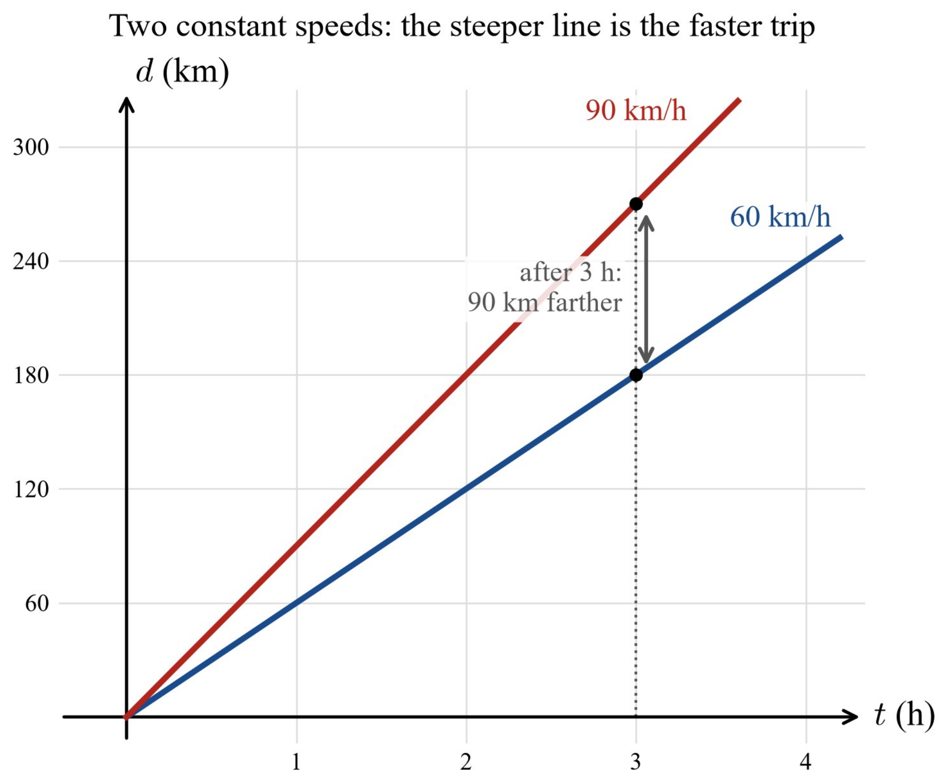
$$d = v \times t$$

so a car holding 80 km/h gives $d = 80t$.

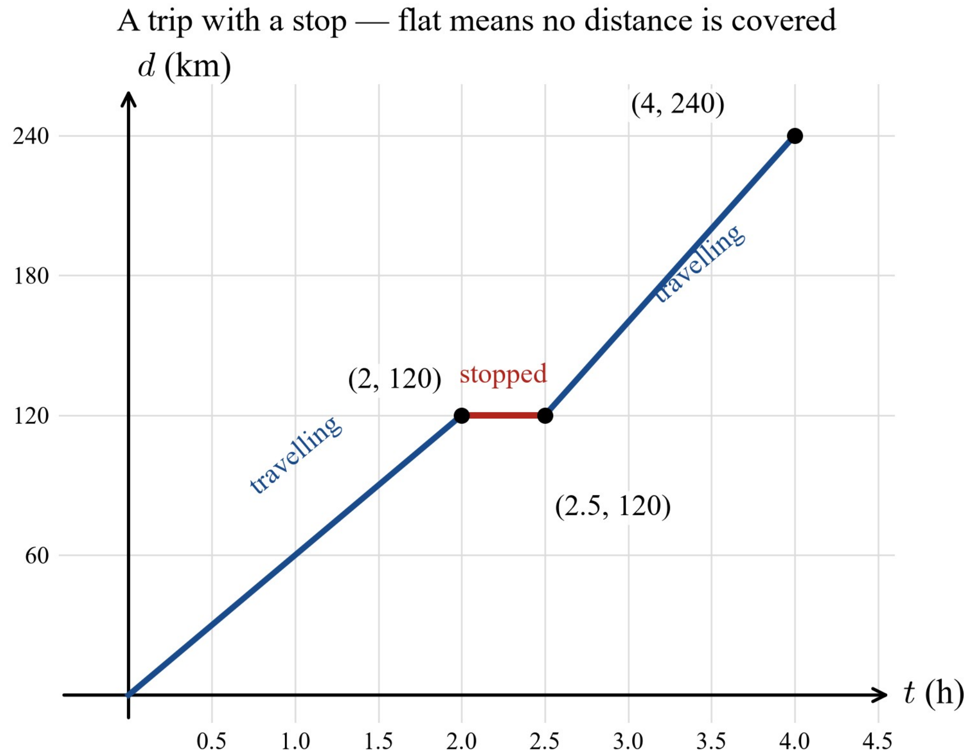


Distance–time graph of a straight line through the origin rising 80 km for each hour, with the points (2, 160) and (3, 240) marked and a red step showing the 80 km rise in 1 hour

Read the graph: for each extra hour, the distance rises by 80 km — the rise per hour **is** the speed. On a distance–time graph, the **steepness** of the line tells you the speed: steeper means faster, and a flat section means no distance is being covered at all.



Distance–time graph of two straight lines through the origin, the steeper red line at 90 km/h above the blue line at 60 km/h, with a marker showing the 90 km gap between them after 3 hours



Distance–time graph of a trip with a stop: a rising line to the point (2, 120), a flat section to (2.5, 120), then a rising line to (4, 240)

Average speed is the whole trip treated as one rate:

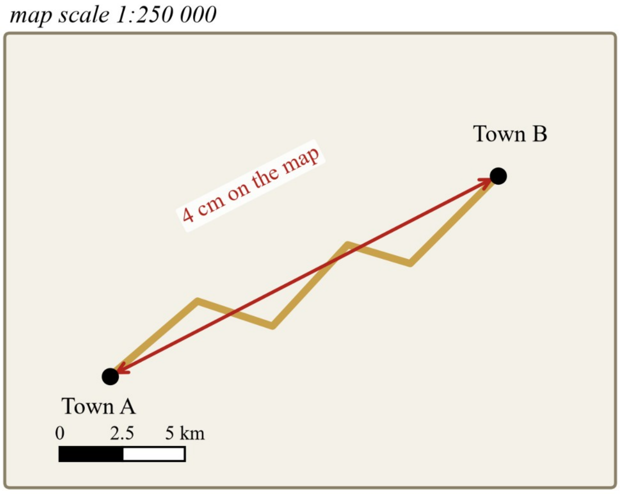
$$\text{average speed} = \text{total distance} \div \text{total time}$$

The third graph covers 240 km in 4 h, so its average speed is $240 \div 4 = 60$ km/h — even though part of the trip was driven at 80 km/h and part of the time the car was stopped. An average is a summary, not a story: it hides the stops and the speed changes.

Scales on maps and plans

A **scale** of $1 : n$ means 1 unit on the drawing stands for n of the same units in real life. A map at 1:250 000 says 1 cm on the map is 250 000 cm on the ground — and 250 000 cm is 2500 m, which is 2.5 km, so on this map 1 cm means 2.5 km.

map scale 1:250 000



From map distance to real distance

1 cm on the map $=$ 250 000 cm in real life

4 cm on the map $= 4 \times 250\,000$ cm

$= 1\,000\,000$ cm

$= 10\,000$ m $=$ 10 km

The two towns are 10 km apart.

Stylised map at scale 1:250 000 with two towns 4 cm apart and a scale bar, beside the working that turns 4 cm on the map into 10 km in real life

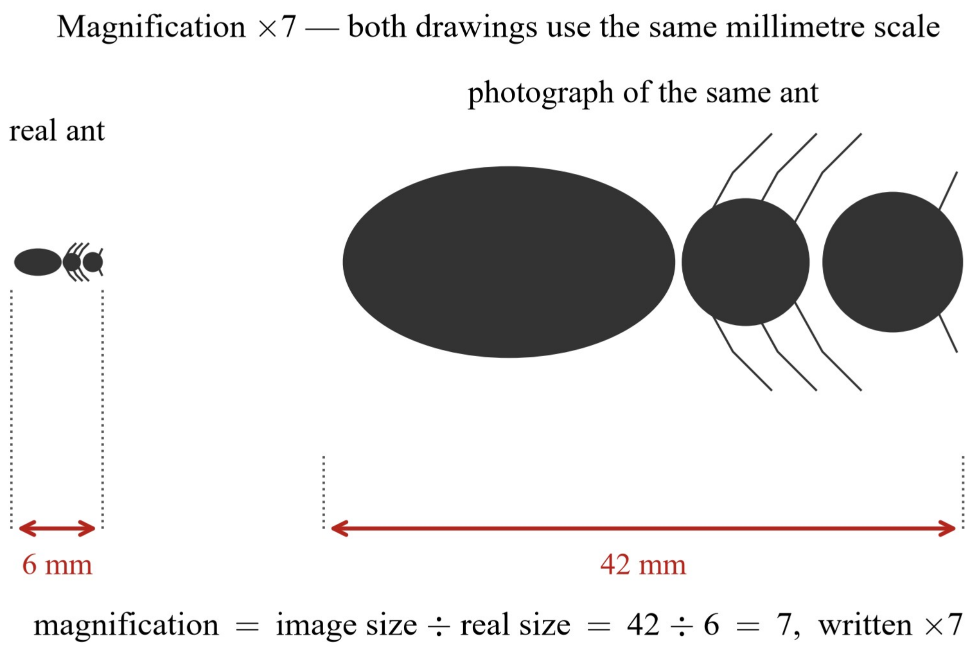
The rule is one multiplication, as long as the units match:

$$\text{real distance} = \text{drawing distance} \times n$$

Plans of houses and school grounds work the same way at much smaller n, such as 1:100 or 1:200.

Magnification

A scale can also make things **bigger**. A photograph or a microscope image states its **magnification** as a multiplier, written $\times 7$: every length in the image is 7 times the matching length on the real object.



Drawing of a 6 mm ant and a 42 mm photograph of the same ant on one shared millimetre scale, with dimension lines showing that the photograph is 7 times as long

$$\text{magnification} = \text{image size} \div \text{real size}$$

so image size = magnification × real size, and real size = image size ÷ magnification. The ant is 6 mm long; its photograph is 42 mm long; $42 \div 6 = 7$, so the photograph is at magnification $\times 7$ — and that is why both drawings in the figure above look different in size: they are drawn to the same millimetre scale.

Exchange rates

An **exchange rate** is a rate between two currencies. Banks quote it as the amount of foreign money one Australian dollar buys. On 19 August 2026 the Reserve Bank of Australia's indicative rate was

$$1\,\text{AUD} = 0.7070\,\text{USD}$$

Source: Reserve Bank of Australia, *Exchange Rates* (Table F11.1), rate for 19 August 2026. Retrieved 20 August 2026.

To change AUD into USD, multiply by the rate; to change USD back into AUD, divide:

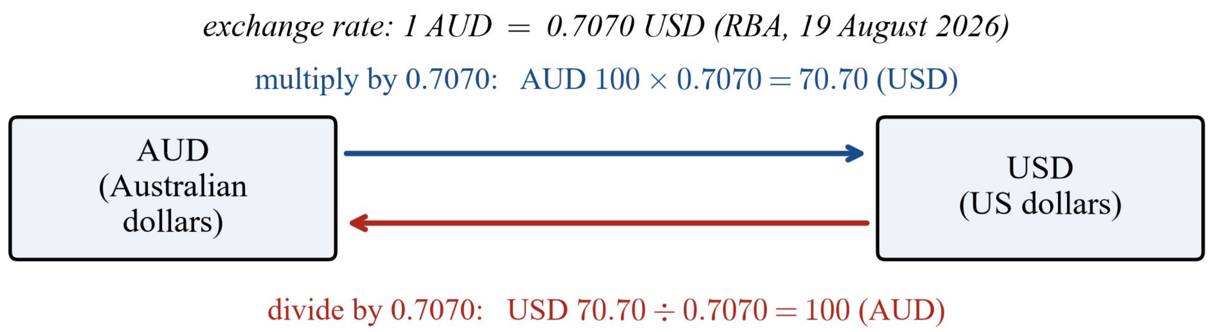


Diagram with an AUD box and a USD box: a blue arrow from AUD to USD labelled multiply by 0.7070, and a red arrow back labelled divide by 0.7070, with the worked amounts AUD 100 becoming USD 70.70 and back

Exchange rates move every trading day, so any budget built on a rate is a guide for the day the rate was read, not a promise for the day of the trip.

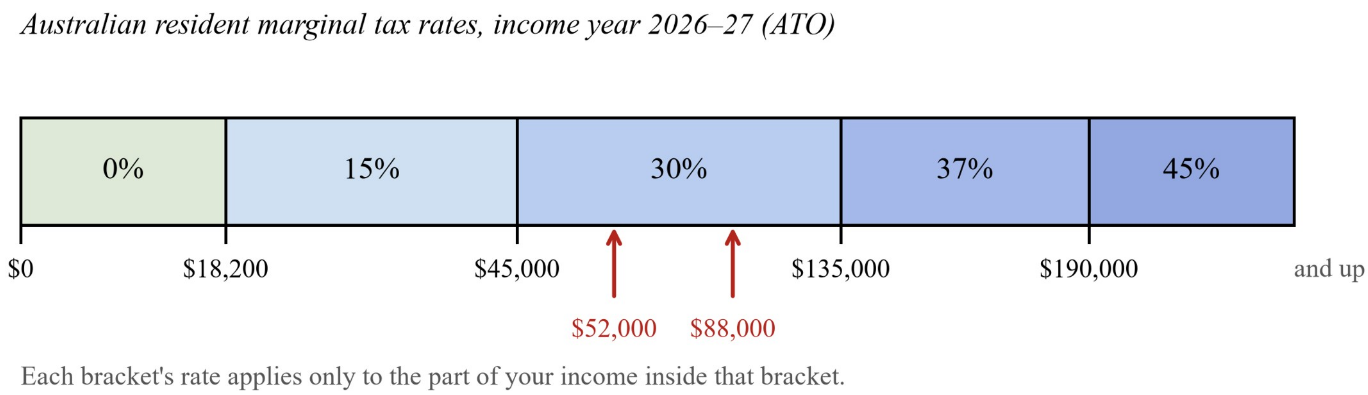
Rates of pay and tax brackets

Money is full of rates. A job paid at $19/h gives pay $P = 19h$ for h hours — the model you built in 2C. Comparing two pay options means comparing their rates, including any fixed amounts: a job with a lower hourly rate plus a travel allowance can pay more on a short shift and less on a long one.

Income tax uses several rates at once. The Australian Taxation Office publishes **marginal tax rates**: income is cut into slices (brackets), and each slice is taxed at its own rate. For residents in the income year 2026–27:

Taxable income	Tax on this income
$0 – $18,200	Nil — the tax-free threshold
$18,200 – $45,000	15c for each $1 over $18,200
$45,000 – $135,000	$4,020 plus 30c for each $1 over $45,000
$135,000 – $190,000	$31,020 plus 37c for each $1 over $135,000
$190,000 and over	$51,370 plus 45c for each $1 over $190,000

Source: Australian Taxation Office, *Tax rates – Australian residents*, income year 2026–27. Retrieved 20 August 2026. The rates do not include the Medicare levy.



Strip diagram of the 2026–27 tax brackets 0%, 15%, 30%, 37% and 45% with thresholds $0, $18,200, $45,000, $135,000 and $190,000, and sample incomes of $52,000 and $88,000 marked in the 30% bracket

Someone earning $52,000 pays **no** tax on the first $18,200, 15% on the slice from $18,200 to $45,000, and 30% only on the slice above $45,000:

- $15\,\% \times 26\,800 = 4\,020$
- $30\,\% \times (52\,000 - 45\,000) = 30\,\% \times 7\,000 = 2\,100$
- total: $4\,020 + 2\,100 = 6\,120$

Being “in the 30% bracket” does **not** mean 30% of all income is tax — only the top slice is taxed at 30%.

Reviewing the model

Rates are models, and every model has a range where it works. Before you accept a modelled answer, ask three questions:

1. Does the answer fit the situation — the right size and the right units?
2. Does the rate really stay constant — for how long, and over which values?
3. What has been left out of the model — stops and slow-downs, extra rates and deductions, or a rate (like an exchange rate) that changes from day to day?

An average speed of 60 km/h does not mean the speedometer read 60 all day; a tax calculation without the Medicare levy is not the final bill; a holiday budget in US dollars is only as good as the day’s rate. Saying so **is part of the mathematics**.

4C in six cards

4C in six cards

Speed, distance, time

$v = d \div t, \quad d = v \times t, \quad t = d \div v$

units: km, h, km/h — change minutes to hours first

Constant speed is a linear rule

$d = v \times t$: starts at 0; rate of change $=$ speed

steeper line $=$ faster; flat section $=$ stopped

Scales on maps and plans

scale $1{:}n$ — 1 unit on the drawing $=$ n units in real life

real distance $=$ drawing distance $\times\, n$

Magnification

magnification $=$ image size $\div$ real size, written $\times 7$

image size $=$ magnification $\times$ real size

Exchange rates

foreign amount $=$ AUD $\times$ rate

rate is in foreign dollars per 1 AUD; divide to go back

Review the model

averages hide stops and slow-downs; real pay can carry

extra rates and deductions; tables and rates change

Six summary cards: speed, distance and time rules; constant speed as a linear rule where steeper means faster and flat means stopped; scales on maps and plans; magnification; exchange rates; and reviewing the model

Words of this subtopic

Word	What it means here
rate	a comparison of two quantities in different units, per one unit of the second: 80 km/h, \$19/h, 1 cm per 250 000 cm

Word	What it means here
speed	the rate of distance per unit of time: $v = d \div t$
average speed	total distance ÷ total time for a whole trip; a summary that hides stops and speed changes
distance–time graph	a graph of distance against time; at constant speed the points lie on a straight line, steeper means faster, flat means stopped
scale	a ratio $1:n$ on a map or plan: 1 unit on the drawing stands for n units in real life
magnification	the multiplier, written $\times 7$, by which every length in an image is larger than the real object: image size ÷ real size
exchange rate	the amount of foreign money one Australian dollar buys; multiply to change AUD into the foreign currency, divide to change back
tax-free threshold	the amount of income ($18,200 in 2026–27) on which residents pay no income tax
bracket	one slice of income in a marginal tax table; the bracket's rate applies only to the income inside that slice

Worked examples

Example 1 — with help

A family drives 390 km in 5 h, holding a constant speed on a country highway.

(a) Find the speed.
(b) At the same speed, how long would 234 km take?
(c) Write a rule for the distance d km after t hours, and say what the number in the rule means.
(d) Review: is a constant speed a good model for this trip?

Working	Comment
$v = 390 \div 5 = 78$	speed = distance ÷ time; the units are km/h.
$t = 234 \div 78 = 3$	time = distance ÷ speed.
$d = 78t$	The distance grows by 78 km for each hour.

∴ (a) the speed is 78 km/h; (b) 234 km takes 3 h; (c) $d = 78t$, and 78 is the speed — the distance added for each hour of travel. Review: on an open highway a steady speed is a fair model for long stretches, but real trips slow for towns, traffic and stops, so 78 km/h is best read as the average picture of the trip.

Example 2 — with help

A cyclist rides at a constant 24 km/h.

(a) How far does the cyclist ride in 45 minutes?
(b) How long does it take to ride 30 km? Give your answer in hours and minutes.

Working	Comment
45 min $= 0.75$ h	Change minutes to hours **first** — the speed is per hour.
$d = 24 \times 0.75 = 18$	distance = speed × time.
$t = 30 \div 24 = 1.25$	time = distance ÷ speed.
1.25 h $= 1$ h 15 min	0.25 h is a quarter of an hour, which is 15 min.

∴ (a) the cyclist rides 18 km in 45 minutes; (b) 30 km takes 1 h 15 min. Review: a real ride slows for hills and lights, so the rule fits a flat, steady ride — or describes the whole ride as an average.

Example 3 — with help

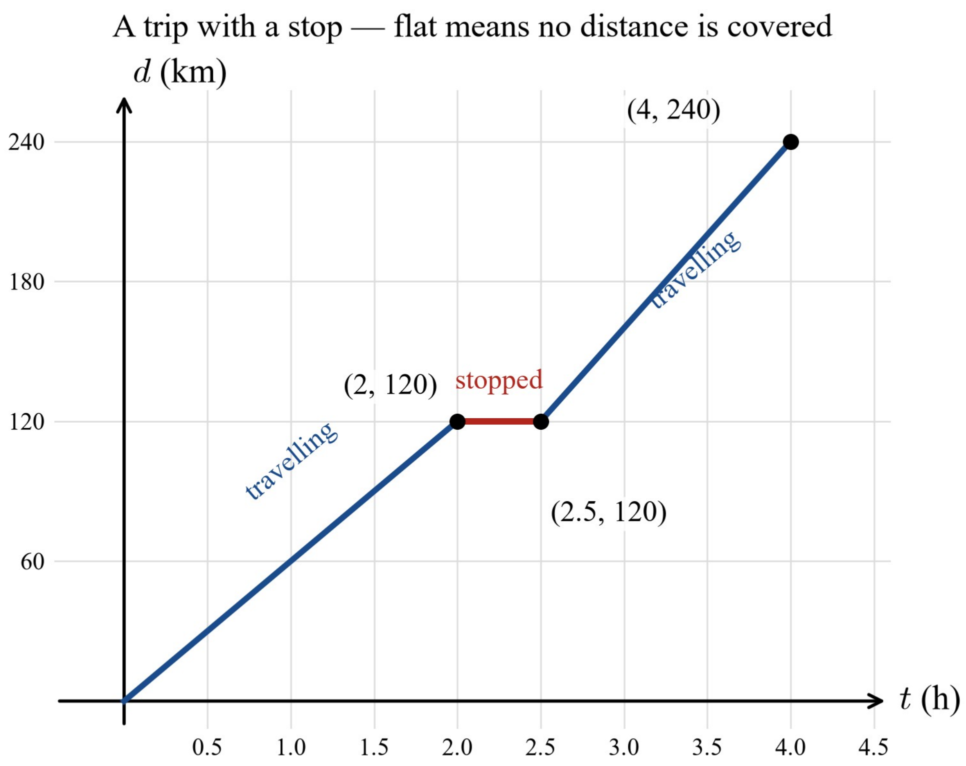
(a) A plan of a school is drawn at scale 1:200. A corridor measures 6.4 cm on the plan. How long is the corridor in real life? Give your answer in metres.
(b) An ant is 6 mm long. A photograph of the ant is 42 mm long. Find the magnification.
(c) A beetle 9 mm long is photographed at the same magnification. How long is the beetle in the photograph?

Working	Comment
$6.4\times 200=1280$ cm	real = drawing × n.
1280 cm $=12.8$ m	100 cm in each metre.
$42\div 6=7$	magnification = image ÷ real, written $\times 7$.
$9\times 7=63$ mm	image = magnification × real.

∴ (a) the corridor is 12.8 m long; (b) the magnification is $\times 7$; (c) the beetle is 63 mm long in the photograph. Review: a scale or a magnification assumes the drawing is accurate everywhere — a stretched photo would not keep the same multiplier in every direction.

Example 4 — on your own

The distance–time graph below shows a car trip with a stop.



Distance–time graph of a trip with a stop: a rising line to the point (2, 120), a flat section to (2.5, 120), then a rising line to (4, 240)

(a) Find the speed during the first 2 hours.
(b) Describe what happens between $t=2$ and $t=2.5$.
(c) Find the speed after the stop.
(d) Find the average speed for the whole trip.
(e) Explain in one sentence why the average speed is not the same as either driving speed.

The first section rises 120 km in 2 h, so the speed is $120\div 2=60$ km/h.

(b) The line is flat: the distance does not change, so the car is **stopped** for half an hour.

(c) After the stop the line rises from 120 km to 240 km in $4-2.5=1.5$ h: $120\div1.5=80$ km/h.

(d) Whole trip: $240\div4=60$ km/h.

∴ (a) 60 km/h; (b) the car is stopped for 0.5 h; (c) 80 km/h; (d) 60 km/h. (e) The average treats the whole 4 h — including the stop — as one steady rate, so it must sit below the faster driving speed; averages hide stops and slow-downs.

Example 5 — on your own

On 19 August 2026 the Reserve Bank of Australia's indicative exchange rate was 1 AUD = 0.7070 USD.

(a) A family changes AUD $300 into US dollars. How much is that, in USD?

(b) At the end of the trip, USD $70.70 is changed back into Australian dollars. How much is that, in AUD?

(c) Review: the family budgets for the trip using this rate in August. Give one reason the budget may not match what the money actually buys in December.

(d) Multiply by the rate: $300\times0.7070=212.10$.

(e) Divide by the rate: $70.70\div0.7070=100$.

∴ (a) AUD $300 becomes USD $212.10; (b) USD $70.70 becomes AUD $100. (c) Exchange rates move every trading day, so the December rate will almost certainly differ from the August rate — the budget is a guide, not a promise.

Example 6 — on your own

Use the 2026–27 resident tax rates in the table above (Australian Taxation Office). Two part-time workers have taxable incomes of $52,000 and $88,000.

(a) Show that the tax on $52,000 is $6,120.

(b) Find the tax on $88,000.

(c) The second income is $36,000 more than the first. Check that the difference in tax is 30% of $36,000, and explain in words why that is exactly what you would expect.

(d) Review: name one thing this model leaves out.

(e) Slice the income: 0 on the first $18,200; $15\%\times26\,800=4\,020$ on the next slice; $30\%\times7\,000=2\,100$ on the top slice. Total: $4\,020+2\,100=6\,120$.

(f) Same first two slices ($4,020$), then $30\%\times\left(88\,000-45\,000\right)=30\%\times43\,000=12\,900$. Total: $4\,020+12\,900=16\,920$.

(g) $16\,920-6\,120=10\,800$, and $30\%\times36\,000=10\,800$ ✓. Both incomes sit between $45,000 and $135,000, so every extra dollar of the $36,000 is in the 30% slice — the extra tax is 30% of the extra income.

∴ (a) $6,120; (b) $16,920; (c) the difference is $10,800, exactly 30% of the $36,000 gap, because the whole gap lies inside the 30% bracket. (d) Sample: the model leaves out the Medicare levy (2%), and real tax returns also include deductions and offsets — so the table gives the base tax, not the final bill.

Practice questions

Work these questions by hand. The numbers are chosen so that no calculator is needed — the skill here is the modelling, not the arithmetic.

With help

Q1. Find the speed in km/h.

a. 240 km in 3 h

b. 90 km in 1.5 h
c. 7 km in 30 min
d. 100 km in 1 h 15 min

Q2. Use the speed–distance–time triangle.

a. How far does a car travelling at 90 km/h go in 2 h?
b. How long does it take to travel 120 km at 80 km/h?
c. How far does a cyclist travelling at 60 km/h go in 45 min?
d. How long, in minutes, does it take to travel 10 km at 25 km/h?

Q3. Match each trip with its rule.

i. A train holds 90 km/h.
ii. A walker holds 5 km/h.
iii. A ferry holds 25 km/h.

Rules: $d = 5t \cdot d = 25t \cdot d = 90t$

Q4. Copy and complete the table, changing between minutes and hours.

minutes	30	45	90	▢	▢
hours	▢	▢	▢	1.25	2.4

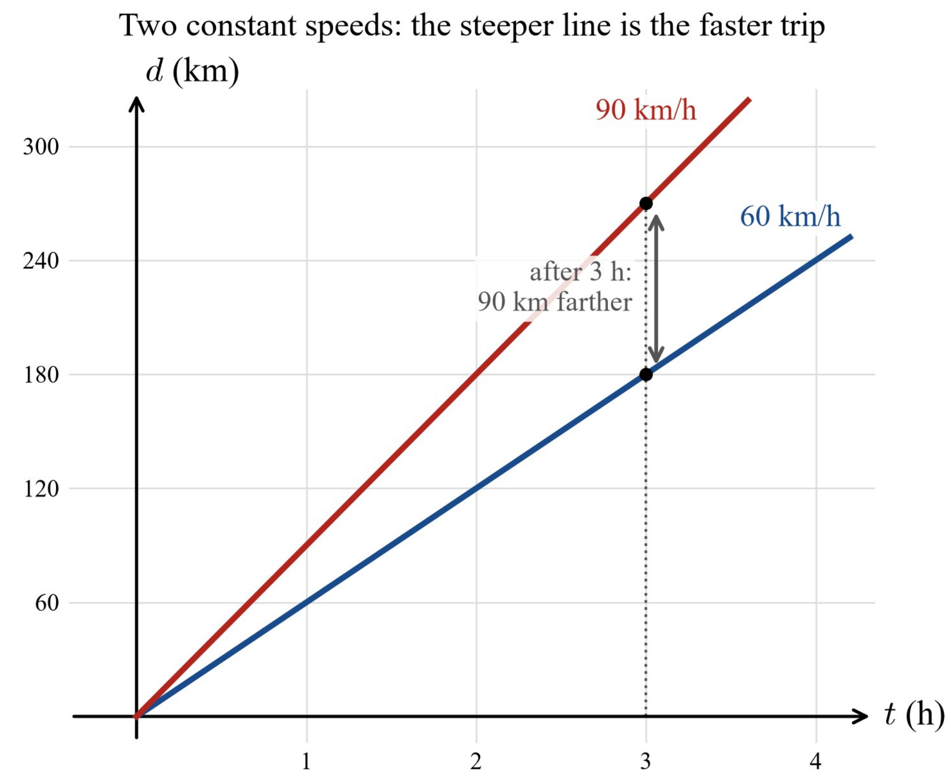
Q5. Scales.

a. A map has scale 1:100 000. Two villages are 5 cm apart on the map. How far apart are they in real life? Give your answer in km.
b. A room is drawn on a plan at scale 1:50. A wall measures 12 cm on the plan. How long is the wall in real life? Give your answer in m.

Q6. Magnification.

a. A flea 5 mm long is photographed at magnification $\times 4$. How long is the flea in the photograph?
b. A photograph at magnification $\times 4$ shows a ladybird 36 mm long. How long is the ladybird in real life?

Q7. Read the graph.



Distance–time graph of two straight lines through the origin, the steeper red line at 90 km/h above the blue line at 60 km/h, with a marker showing the 90 km gap between them after 3 hours

a. Which line shows the faster trip? How can you tell without calculating?
b. Read from the graph: after 3 h, how much farther has the faster trip gone?
c. Check your reading by calculating the distance each trip covers in 3 h.

Q8. Cordial is mixed at a ratio of 1 part cordial to 4 parts water.

a. How much water is mixed with 250 mL of cordial?
b. How much cordial is needed for 2 L of water?
c. How much made-up drink does 300 mL of cordial produce?

On your own

Q9. A driver travels at 70 km/h for 2 h, then at 100 km/h for 1 h.

a. Find the distance covered in each part, and the total distance.
b. Find the average speed for the whole trip.
c. The mean of 70 and 100 is 85. Explain why the average speed is **not** 85 km/h.

Q10. A map has scale 1:250 000.

a. Two towns are 8 cm apart on the map. How far apart are they in real life, in km?
b. Two landmarks are 15 km apart in real life. How far apart are they on the map, in cm?

Q11. Magnification.

a. A spider 12 mm long is photographed at magnification $\times 8$. How long is the spider in the photograph?
b. A photograph at magnification $\times 8$ shows a grasshopper 96 mm long. How long is the grasshopper in real life?

Q12. The Reserve Bank of Australia's indicative rate on 19 August 2026 was 1 AUD = 0.7070 USD.

a. Change AUD $250 into US dollars.
b. A souvenir costs USD $141.40. What is that in Australian dollars?

Q13. A family plans a trip and sets a spending money budget of USD $353.50. The rate they use is 1 AUD = 0.7070 USD.

a. How many Australian dollars do they set aside?
b. Review: give one reason the amount they actually need on the trip may differ from your answer.

Q14. Which is the better value? Show the rate per 100 g for each.

a. 500 g of cheese for $12.00
b. 750 g of the same cheese for $16.50

Q15. A table of a bushwalk is shown.

t (h)	0	1	2	3	4
d (km)	0	4	8	12	16

a. Show that the relation is linear, and state the rate of change with its units.
b. Write a rule for d in terms of t.
c. Use the rule to predict the distance after 6 h.
d. Review: give one reason the prediction may not match a real 6-hour bushwalk.

Q16. Two phone plans. Plan A costs a flat $30 a month with unlimited calls. Plan B costs $18 a month plus 25c per call. Let n be the number of calls in a month.

a. Write a rule for the monthly cost of each plan.
b. Find the cost of each plan for 20 calls and for 60 calls.
c. For how many calls do the two plans cost the same? What is that cost?
d. Which plan is cheaper for a light user (about 20 calls a month)? Which is cheaper for a heavy user (about 60 calls)?
e. In words, explain why the cheaper plan depends on how many calls you make.

Q17. A school excursion travels 135 km by coach at a constant 90 km/h, leaving at 9:00.

a. How long does the trip take?
b. What time does the coach arrive? Use 24-hour time.
c. The return trip over the same 135 km takes 2 h. Find the average speed on the return.
d. Review: give one reason the outward trip is unlikely to hold exactly 90 km/h the whole way.

Q18. Full modelling cycle. Two Saturday jobs are offered.

- Café work: paid $16 per hour, a 5-hour shift.
- Delivery work: paid $12 per hour for a 4-hour shift, plus $5 per delivery.

a. **Formulate:** write a rule for the pay in each job. Let h stand for hours and n for deliveries.
b. **Choose a representation and solve:** how many deliveries make the delivery job pay more than the café job?
c. **Interpret and communicate:** state your answer in terms of the jobs, in a full sentence.
d. **Review:** give two reasons the real pay might differ from your model.

Maths in real life

Q19. Australian resident income tax rates, 2026–27 (Australian Taxation Office, retrieved 20 August 2026): no tax on the first $18,200; 15c for each $1 over $18,200 up to $45,000; then $4,020 plus 30c for each $1 over $45,000 up to $135,000.

a. Find the tax on a taxable income of $30,000.
b. Find the tax on a taxable income of $50,000.
c. Explain in words why a person earning $50,000 does **not** pay 30% of $50,000.
d. Review: name one thing the table leaves out of a real tax bill.

Q20. The Reserve Bank of Australia's indicative exchange rate on 19 August 2026 was 1 AUD = 0.7070 USD (retrieved 20 August 2026). A family budgets for a holiday in the United States.

a. They change AUD $1,000. How many US dollars do they receive?
b. Their first hotel night costs USD $353.50. What is that in Australian dollars at this rate?
c. Review: the family builds the whole budget on the 19 August rate. Give one reason the budget is a guide rather than a promise.

Q21. On the V/Line Geelong line, the weekday service that leaves Southern Cross Station in Melbourne at 10:30 arrives at Geelong at 11:31. The rail distance along the line is 80.75 km.

Sources: V/Line, *Geelong line timetable*, effective 1 February 2026, vline.com.au; rail distance from the Victorian Department of Transport and Planning GTFS open data (DataVic). Both retrieved 20 August 2026.

a. How many minutes does the trip take?
b. The trip takes a little more than 1 hour. Use this to estimate the average speed, and show your estimate is about 80 km/h.
c. Check with an exact calculation: average speed $= 80.75 \times 60 \div 61$. Give your answer to the nearest km/h, and compare it with your estimate.
d. Review: give one reason the average speed is not the speed the train showed at any one moment.

Q22. Make your own. Choose **one** of these and write a full question of your own, with numbers that work out exactly: a map-scale question, a magnification question, or a speed–distance–time question. Write the question, solve it, and add one review sentence about where your model could fail. Swap with a partner and check each other's working.

Answers

Q1. a. 80 km/h. b. 60 km/h. c. 14 km/h. d. 80 km/h.

Q2. a. 180 km. b. 1.5 h. c. 45 km. d. 24 min.

Q3. i → $d = 90t$; ii → $d = 5t$; iii → $d = 25t$.

Q4. minutes 30, 45, 90, 75, 144; hours 0.5, 0.75, 1.5, 1.25, 2.4.

Q5. a. 5 km. b. 6 m.

Q6. a. 20 mm. b. 9 mm.

Q7. a. The red line — it is steeper. b. 90 km. c. $60 \times 3 = 180$ km and $90 \times 3 = 270$ km; $270 - 180 = 90$ km ✓.

Q8. a. 1000 mL (1 L). b. 500 mL. c. 1500 mL (1.5 L).

Q9. a. 140 km, then 100 km; total 240 km. b. 80 km/h. c. Sample: the two speeds were held for different times (2 h and 1 h), so the average must be worked from total distance and total time, not from the two speeds alone.

Q10. a. 20 km. b. 6 cm.

Q11. a. 96 mm. b. 12 mm.

Q12. a. USD $176.75. b. AUD $200.

Q13. a. AUD $500. b. Sample: the exchange rate moves every trading day, so the rate on the day of spending will differ from the planning rate.

Q14. a. $2.40 per 100 g. b. $2.20 per 100 g — option b is the better value.

Q15. a. Differences are 4 each hour; rate 4 km/h. b. $d = 4t$. c. 24 km. d. Sample: a real walk slows for rests and terrain, so 4 km/h is an average at best.

Q16. a. Plan A: 30; Plan B: $18 + 0.25n$. b. A: $30, $30; B: $23, $33. c. 48 calls; $30. d. Plan B for 20 calls; Plan A for 60 calls. e. Sample: Plan B starts cheaper but each call adds 25c, so it overtakes Plan A once calls pass 48.

Q17. a. 1.5 h. b. 10:30. c. 67.5 km/h. d. Sample: the coach must slow for towns, traffic and stops.

Q18. a. Café: $P = 16h$, so $16 \times 5 = 80$; delivery: $P = 12h + 5n$, so $48 + 5n$. b. $n = 7$ deliveries (7 pays $83 against $80; 6 pays $78). c. Sample: "The delivery job pays more than the café job only when at least 7 deliveries are made in the shift." d. Sample: some shifts have few deliveries; unpaid waiting time can cut the hours actually paid.

Q19. a. $1,770. b. $5,520. c. Sample: only the slice above $45,000 is taxed at 30%; the first $18,200 is tax-free and the middle slice at 15%. d. Sample: the Medicare levy (and any deductions or offsets).

Q20. a. USD $707.00. b. AUD $500. c. Sample: exchange rates change every trading day.

Q21. a. 61 min. b. 61 min is close to 1 h, so about 80.75 km is covered in about 1 h — an average speed of about 80 km/h. c. $80.75 \times 60 \div 61 = 4845 \div 61 \approx 79.4$, so 79 km/h to the nearest km/h — matching the estimate. d. Sample: the train stops at stations and slows and speeds up along the way, so its real speed changes the whole trip.

Q22. Answers will vary. Check: the scale or rate is applied by one multiplication or division, the units are handled correctly, and the review names a real way the model could fail.

Fully-worked solutions

Q1. Use $v = d \div t$, changing minutes to hours first.

a. $240 \div 3 = 80$: **80 km/h**.
b. $90 \div 1.5 = 60$: **60 km/h**.

c. 30 min $= 0.5$ h; $7 \div 0.5 = 14$: **14 km/h**.
d. 1 h 15 min $= 1.25$ h; $100 \div 1.25 = 80$: **80 km/h**.

Q2. a. $d = 90 \times 2 = 180$: **180 km**.

b. $t = 120 \div 80 = 1.5$: **1.5 h**.

c. 45 min $= 0.75$ h; $d = 60 \times 0.75 = 45$: **45 km**.

d. $t = 10 \div 25 = 0.4$ h; $0.4 \times 60 = 24$: **24 min**.

Q3. The number multiplying t is the speed in km/h.

i → $d = 90t$; ii → $d = 5t$; iii → $d = 25t$.

Q4. Divide minutes by 60 to get hours; multiply hours by 60 to get minutes. 30 min $= 0.5$ h; 45 min $= 0.75$ h; 90 min $= 1.5$ h; 1.25 h $= 75$ min; 2.4 h $= 144$ min.

minutes	30	45	90	75	144
hours	0.5	0.75	1.5	1.25	2.4

Q5. a. $5 \times 100\,000 = 500\,000$ cm $= 5000$ m $= 5$ km: **5 km**.

b. $12 \times 50 = 600$ cm $= 6$ m: **6 m**.

Q6. a. image = magnification × real $= 4 \times 5 = 20$: **20 mm**.

b. real = image ÷ magnification $= 36 \div 4 = 9$: **9 mm**.

Q7. a. The **red** line. On a distance–time graph, steeper means faster — the red line rises more quickly, so it is the faster trip.

b. At $t = 3$ the red line is 90 km above the blue line: **90 km**.

c. Blue: $60 \times 3 = 180$ km. Red: $90 \times 3 = 270$ km. Difference: $270 - 180 = 90$ km, matching the reading in (b) ✓.

Q8. a. Water is 4 parts for every 1 part cordial: $250 \times 4 = 1000$ mL — **1 L**.

b. $2000 \div 4 = 500$: **500 mL** of cordial.

c. Made-up drink is $1 + 4 = 5$ parts: $300 \times 5 = 1500$ mL — **1.5 L**.

Q9. a. First part: $70 \times 2 = 140$ km. Second part: $100 \times 1 = 100$ km. Total **240 km**.

b. Total time $= 2 + 1 = 3$ h; average speed $= 240 \div 3 = 80$: **80 km/h**.

c. The mean of the two speeds, 85, would only be right if both speeds were held for the **same** time. Here 70 km/h was held for 2 h and 100 km/h for only 1 h, so the average is pulled towards 70 — work averages from total distance and total time.

Q10. a. $8 \times 250\,000 = 2\,000\,000$ cm $= 20\,000$ m $= 20$ km: **20 km**.

b. 15 km $= 1\,500\,000$ cm; $1\,500\,000 \div 250\,000 = 6$: **6 cm**.

Q11. a. $8 \times 12 = 96$: **96 mm**.

b. $96 \div 8 = 12$: **12 mm**.

Q12. a. $250 \times 0.7070 = 176.75$: **USD $176.75**.

b. $141.40 \div 0.7070 = 200$: **AUD $200**.

Q13. a. Work backwards by dividing: $353.50 \div 0.7070 = 500$: **AUD $500**.

b. Exchange rates change every trading day, so the rate when the family actually changes money will not be exactly 0.7070 — the budget may need more (or fewer) Australian dollars.

Q14. a. $12.00 \div 5 = 2.40$ per 100 g.

b. $16.50 \div 7.5 = 2.20$ per 100 g.

∴ option **b** is the better value: \$2.20 against \$2.40 per 100 g.

Q15. a. $4 - 0 = 4$, $8 - 4 = 4$, $12 - 8 = 4$, $16 - 12 = 4$: constant differences, so the relation is linear with rate of change **4 km/h**.

b. $d = 4t$.

c. $d = 4 \times 6 = 24$: **24 km**.

d. Sample: a real bushwalk includes rests, climbs and rough ground, so a steady 4 km/h is an average picture, not a minute-by-minute account.

Q16. a. Plan A: cost $= 30$. Plan B: cost $= 18 + 0.25n$.

b. 20 calls: A 30; B $18 + 5 = 23$. 60 calls: A 30; B $18 + 15 = 33$.

c. Same cost: $18 + 0.25n = 30$, so $0.25n = 12$ and $n = 48$. Both plans cost **\$30 at 48 calls**.

d. 20 calls: **Plan B** (\$23 against \$30). 60 calls: **Plan A** (\$30 against \$33).

e. Plan B starts \$12 cheaper but adds 25c to every call; after 48 calls those 25c amounts have repaid the \$12 gap, and from then on Plan A's flat rate is cheaper. The cheaper plan depends on your calling habits.

Q17. a. $t = 135 \div 90 = 1.5$: **1.5 h**.

b. 9:00 plus 1 h 30 min is **10:30**.

c. $135 \div 2 = 67.5$: **67.5 km/h**.

d. Sample: the coach slows for towns, roundabouts and traffic, and stops to pick passengers up, so 90 km/h can only be an average over the open stretches.

Q18. a. **Formulate.** Café: $P = 16h$, and the shift is 5 h, so the café pays $16 \times 5 = 80$. Delivery: $P = 12h + 5n$, and the shift is 4 h, so the delivery job pays $12 \times 4 + 5n = 48 + 5n$.

b. **Choose a representation and solve.** The delivery job pays more when $48 + 5n > 80$, so $5n > 32$, so $n > 6.4$. Check: $n = 6$ pays 78 (less than 80); $n = 7$ pays 83 (more than 80).

c. **Interpret and communicate.** The delivery job pays more than the café job only when at least **7 deliveries** are made in the shift.

d. **Review.** Sample: a quiet Saturday may bring fewer than 7 deliveries, and time spent waiting between deliveries is still paid at only \$12/h — the model assumes the hours and the per-delivery rate hold exactly.

Q19. a. Income over the threshold: $30\,000 - 18\,200 = 11\,800$. Tax: $15\,\% \times 11\,800 = 1\,770$: **\$1,770**.

b. First slice above the threshold: $45\,000 - 18\,200 = 26\,800$ at 15% gives $4,020$. Top slice: $50\,000 - 45\,000 = 5\,000$ at 30% gives $1,500$. Total: $4\,020 + 1\,500 = 5\,520$: **\$5,520**.

c. The 30% rate applies only to the slice of income above \$45,000. The first \$18,200 is tax-free and the next \$26,800 is taxed at 15% — so the tax is far less than 30% of the whole income (\$5,520 against \$15,000).

d. Sample: the Medicare levy of 2% is not in the table, and real returns include deductions and offsets.

Q20. a. $1\,000 \times 0.7070 = 707.00$: **USD \$707.00**.

b. $353.50 \div 0.7070 = 500$: **AUD \$500**.

c. Sample: the rate is the 19 August rate; rates move every trading day, so by the time the family travels and spends, the true rate will differ and the budget with it.

Q21. a. From 10:30 to 11:31 is **61 minutes**.

b. 61 min is a little more than 1 h, so the train covers its 80.75 km in a little more than an hour — the average speed is a little under 80.75 km/h, that is, **about 80 km/h**.

c. Speed = distance ÷ time $= 80.75 \div \frac{61}{60} = 80.75 \times 60 \div 61$. Now $80.75 \times 60 = 4845$, and $4845 \div 61$:

$61 \times 79 = 4819$, leaving 26, so the quotient is about 79.4. To the nearest km/h the average speed is **79 km/h**, which agrees with the estimate in (b).

d. Sample: the train stops at stations on the way and accelerates and brakes between them, so its real speed is always changing — 79 km/h treats the whole trip as one steady rate, which is a summary, not the driver's display at any one moment.

Q22. Answers will vary. Example: a map at scale 1:50 000 shows a walking track as 8 cm long. Real length: $8 \times 50\,000 = 400\,000$ cm = 4 km. Review: the map distance is the straight-line measure, while the track on the ground winds, so 4 km is a guide for planning, not a promise for your pedometer.

Test

Mathematics Level 8 — Chapter test T4: Measurement — time, rates and ratio

Read each question carefully, and show your working for every question.

Marks: 15

Time: 20 minutes in total: about 5 minutes to read through the paper, then about 15 minutes of writing (about 1 minute per mark). This is a classroom check, not an exam.

Equipment: nothing beyond pen, pencil and paper is needed for this test.

Calculators and digital tools: not permitted. None of the Chapter 4 content descriptions names a digital tool, and every number on this paper is chosen to work by hand.

Q1. Circle the letter of the right answer. A **rate** compares two quantities measured in different units, like km/h. **[1 mark]**

Which of these is a rate?

A	B	C	D
$5 in a money box	240 km travelled in 4 hours	a rope 12 m long	a group of 15 students

Q2. Time and time zones **[5 marks]**

A coach leaves Melbourne at 22:20 on Tuesday 14 July 2026 and arrives at a coastal town at 06:50 the next morning. Mia is making the poster for the trip.

You may use: AEST is UTC+10, AWST is UTC+8 and AEDT is UTC+11.

Source: Wikipedia, "Time in Australia", retrieved 20 August 2026.

a. Write each time on the poster in the other form. **[1 mark]**
(i) the departure time, 22:20, in 12-hour form
(ii) the arrival time, 6:50 am, in 24-hour form

b. Find the duration of the coach trip. **[1 mark]**

c. In 2026, Victoria's clocks change on Sunday 5 April and Sunday 4 October. Is Victoria on AEST or on AEDT on each date? **[1 mark]**
(i) 14 July 2026
(ii) 28 December 2026

d. Mia's friend lives in Perth, which uses AWST all year. What time is it in Perth when the coach leaves Melbourne? Show the offsets or the steps you used. **[2 marks]**

Q3. Rates **[4 marks]**

Dev has a Saturday job at a garden shop. He is paid $144 for 6 hours of work, at a constant **rate of pay** — the dollars earned for each hour of work.

a. Find Dev's rate of pay. Give the unit. **[1 mark]**

b. At this rate, how much does Dev earn for 3.5 hours of work? **[1 mark]**

c. The shop sells bird seed in two bags. Bag A is 2.5 kg for $7.00. Bag B is 4 kg for $10.00. A customer asks which bag is the better value. Work out the **unit rate** — the price per 1 kg — for each bag, and say which bag Dev should recommend. **[2 marks]**

Q4. Worked response — a trip at constant speed **[5 marks]**

A family drives 210 km along a country road. They hold a **constant speed** of 84 km/h — one speed kept the whole way.

a. Find how long the drive takes. Give your answer in hours and minutes. **[1 mark]**

b. The family leaves at 09:45. At what time do they arrive? Use 24-hour time. **[1 mark]**

c. How far have they travelled after 1.5 hours? **[1 mark]**

d. Write a rule for the distance d km after t hours at this speed. What does the number in your rule mean? **[1 mark]**

e. Review: give one reason the constant-speed rule may not describe the real trip exactly. **[1 mark]**

Solutions

Marking guide

Administration (per TOC §7). This is a classroom check, not an exam. The total time is 20 minutes: about 5 minutes reading plus about 1 minute per mark (15 minutes of writing). No equipment is needed beyond pen, pencil and paper (§7 names no equipment for T4). **Calculator status follows D10**: none of the three Chapter 4 CDs (`VC2M8M04`, `VC2M8M05`, `VC2M8M07`) names a digital tool, so no calculator or other digital tool is permitted on this paper. Every number is chosen to be workable by hand.

Marks by item and CD. Only Chapter 4 CDs are assessed (§4). Each of the three subtopics carries exactly 5 marks (§7 marking rule: 5 marks per subtopic).

Item	CD code	Subtopic	Type	Marks
Q1	`VC2M8M05`	4B	MCQ (A–D)	1
Q2	`VC2M8M04`	4A	Short answer	5
Q3	`VC2M8M05`	4B	Short answer / worked response	4
Q4	`VC2M8M07`	4C	Worked response (modelling cycle)	5
			Total	**15**

MCQ total: 1 of 15 marks — sparingly per §7, used only because recognising a rate is genuinely a selection skill (the *recognise* verb of `VC2M8M05`). Reasoning is not separately marked on this paper: §7 reserves separate reasoning marks for T3, T5 and T6 only.

Rubrics, by CD. The achievement-standard extracts are quoted verbatim from `maths_8.json`; `VC2M8M05` and `VC2M8M07` share one extract.

`VC2M8M04` (4A) — 5 marks (Q2a 1, Q2b 1, Q2c 1, Q2d 2). *"They solve problems of duration involving 12- and 24-hour cycles across multiple time zones."* Observable actions:

- swaps between 12- and 24-hour time in both directions — 10:20 pm and 06:50 (1 mark, both parts correct);
- finds a duration that crosses midnight by splitting at midnight — 1 h 40 min + 6 h 50 min = 8 h 30 min (1 mark);
- decides which side of the changeover a date sits on — AEST on 14 July, AEDT on 28 December (1 mark, both parts correct);
- moves a time from Melbourne to Perth, through UTC or by comparing offsets, with the date check done — 20:20 AWST, that is 8:20 pm (2 marks: 1 for a valid method with the correct offsets and date check, 1 for the correct Perth time).

`VC2M8M05` (4B) — 5 marks (Q1 1, Q3a 1, Q3b 1, Q3c 2). *"They use mathematical modelling to solve practical problems involving ratios, percentages and rates in measurement and financial contexts."* Observable actions:

- recognises the rate among single quantities — B, the comparison of km with hours (1 mark);
- builds a rate by division, with its compound unit — $24/h (1 mark);
- multiplies forward by the rate — $84 (1 mark);
- compares two offers by their unit rates and selects the better value — $2.80/kg against $2.50/kg, Bag B (2 marks: 1 for both unit rates, 1 for the correct choice with a comparison shown).

`VC2M8M07` (4C) — 5 marks (Q4a–e, 1 each). *"They use mathematical modelling to solve practical problems involving ratios, percentages and rates in measurement and financial contexts."* Observable actions, following the modelling cycle the CD names:

- solves for time by dividing distance by speed, and gives hours and minutes — 210 ÷ 84 = 2.5 h, that is 2 h 30 min (1 mark);
- adds the duration to the start time — 12:15 (1 mark);
- multiplies by the rate to find a part-way distance — 126 km (1 mark);
- formulates the constant-speed rule and names the number in it — $d = 84t$; 84 is the speed in km/h, the distance added for each hour (1 mark);
- reviews the appropriateness of the model — names a real way a constant speed fails, such as slowing for towns, traffic or stops (1 mark).

MCQ key. Q1 **B**. One mark for the correct letter; no part marks.

General marking notes.

- Q2a and Q2c: the mark needs both parts right.
- Q2b: accept any valid route — splitting at midnight or counting on — with the correct total duration.
- Q2d: accept either route: through UTC (22:20 − 10 h = 12:20 UTC; 12:20 + 8 h = 20:20) or by comparing offsets (Perth is 2 hours behind while Melbourne is on AEST). The method mark requires the correct offsets and the recognition that 14 July is on the AEST side of the changeover. Award the method mark for consistent follow-through if Q2c(i) was answered wrongly.
- Q3a: the unit ($/h, or "dollars per hour") is needed for the mark.
- Q3c: both unit rates must be worked out; a bare choice with no unit rates earns
    0. The choice mark requires the comparison to be shown or stated.
- Q4a: accept 2.5 h or 2 h 30 min.
- Q4d: accept $d = 84t$ or $d = 84 \times t$. The stated meaning must refer to the speed — km per hour, or the distance added each hour; "84 is a number" is not sufficient.
- Q4e: accept any genuine reason — slowing for towns, traffic, rest stops or road conditions. A bare "it is not right" with no reason earns 0.

Fully worked solutions

Q1. A rate compares two quantities measured in different units, found by division. Options A, C and D are each one quantity with one unit — nothing is being compared. Option B compares kilometres with hours: $240 \div 4 = 60$ km/h. ∴ B.

Q2. a. (i) Hours above 12 lose 12 and take pm: $22 - 12 = 10$, so **10:20 pm**. (ii) Morning hours keep their number with a leading zero below 10: **06:50**. ∴ (i) 10:20 pm; (ii) 06:50.

b. The trip crosses midnight, so split at midnight and add. 22:20 to midnight is 1 h 40 min; midnight to 06:50 is 6 h 50 min; 1 h 40 min $+ 6$ h 50 min = 8 h 30 min. ∴ The trip takes **8 h 30 min**.

c. Victoria is on AEDT from the first Sunday in October (4 October 2026) to the first Sunday in April (5 April 2026), and on AEST at all other times. (i) 14 July 2026 sits between 5 April and 4 October → **AEST**. (ii) 28 December 2026 sits after 4 October → **AEDT**. ∴ (i) AEST; (ii) AEDT.

d. From (c)(i), Melbourne is on AEST, UTC+10, on 14 July 2026; Perth uses AWST, UTC+8, all year. Through UTC: $22:20 - 10$ h $= 12:20$ UTC; $12:20 + 8$ h $= 20:20$ AWST. Check by comparing offsets: while Melbourne is on AEST, Perth is 2 hours behind, and $22:20 - 2$ h $= 20:20$ — the same answer. ∴ It is **20:20 AWST — 8:20 pm on Tuesday 14 July** — in Perth.

Q3. a. Rate of pay = pay ÷ hours: $144 \div 6 = 24$. ∴ **$24/h** ($24 per hour).

b. Multiply by the rate to go forward: $24 \times 3.5 = 84$. ∴ **$84**.

c. Bag A: $7.00 \div 2.5 = 2.80$ per kg. Bag B: $10.00 \div 4 = 2.50$ per kg. Since $2.50 < 2.80$, ∴ **Bag B** is the better value, at $2.50 per kg — 30c per kg cheaper — and that is the bag Dev should recommend.

Q4. a. Time = distance ÷ speed: $t = 210 \div 84 = 2.5$. Now 0.5 h is half an hour, 30 min. Check: $84 \times 2.5 = 210$ ✓ ∴ The drive takes **2 h 30 min**.

b. $09:45 + 2$ h 30 min: $09:45 + 2$ h $= 11:45$, and 30 more minutes gives 12:15. ∴ They arrive at **12:15**.

c. Distance = speed × time: $d = 84 \times 1.5 = 126$. ∴ After 1.5 hours they have travelled **126 km**.

d. At a constant speed the distance grows by 84 km for each hour, so the rule is ∴ $d = 84t$. The number **84 is the speed in km/h** — the distance added for each hour of travel.

e. Review: a real trip slows for towns, traffic and rest stops, so the speed is not held exactly the whole way; 84 km/h is best read as the average picture of the trip, and the rule fits the open stretches rather than every minute.

Answer key

Q1. B

Q2. a. (i) 10:20 pm (ii) 06:50 · b. 8 h 30 min · c. (i) AEST (ii) AEDT · d. 20:20 AWST (8:20 pm Tuesday)

Q3. a. $24/h · b. $84 · c. Bag B ($2.80/kg against $2.50/kg)

Q4. a. 2 h 30 min · b. 12:15 · c. 126 km · d. $d = 84t$ — 84 is the speed in km/h · e. any genuine reason (slowing for towns, traffic or stops)