Mathematics Level 9

End-of-book review

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.

End-of-year review

This is a school-designed paper. It is not a VCAA instrument. Achievement in the Victorian Curriculum is reported against the Level 9 achievement standard, not against a mark on this paper.

End-of-year review · All six strands · End-of-Level-9 check

Mathematics Level 9 (Year 9) · Victorian Curriculum 2.0

Codes assessed: `VC2M9N01` · `VC2M9A01` · `VC2M9A02` · `VC2M9A03` · `VC2M9A04` · `VC2M9A05` · `VC2M9A06` · `VC2M9A07` · `VC2M9M01` · `VC2M9M02` · `VC2M9M03` · `VC2M9M04` · `VC2M9M05` · `VC2M9SP01` · `VC2M9SP02` · `VC2M9SP03` · `VC2M9ST01` · `VC2M9ST02` · `VC2M9ST03` · `VC2M9ST04` · `VC2M9ST05` · `VC2M9P01` · `VC2M9P02` · `VC2M9P03`

Name: ______________________________ Date: ______________

Total marks	70
Parts	Part A — technology-free, **28 marks**. Part B — technology-active, **42 marks**. The two parts are **sat separately**.
Timing	Part A: 30 minutes. Part B: 45 minutes. This is a classroom check, not an exam; your teacher will tell you when each part begins and ends.
Equipment, Part A	No calculator and no digital tool of any kind. A ruler is optional. The grid, graph and tables you need are printed on the paper.
Equipment, Part B	A scientific calculator, plus the digital tools your teacher nominates from: a spreadsheet, a graphing tool, dynamic geometry software, or a programming language. **No CAS (computer algebra system) is permitted on any part of this paper.**
Instructions	Show your working — working earns marks even when a final number slips. Where a question asks you to *explain*, *justify* or *evaluate*, the reason is worth marks: a correct number with no reason does not score full marks. Exact answers (in surd or π form) are expected where the question asks for them; round only once, at the end.

This paper checks what you learned across all of Level 9: Number, Algebra, Space, Measurement, Statistics and Probability. Attempt every question.

Part A — technology-free (28 marks)

No calculator. No digital tools. Answer all questions.

Section A1 — Number (3 marks)

Question 1 — Rational and irrational numbers (3 marks)

(a) Classify each number as **rational** or **irrational**. A recurring decimal such as $0.444\ldots$, where the 4s repeat forever, counts by what it equals, not by how it looks. **(2 marks)**

i. $\sqrt{49}$

ii. $\sqrt{12}$

iii. $0.444\ldots$ (the 4s recur)

iv. π

(b) A circle has radius 3 cm. Find its area, first exactly in terms of π, then as a decimal correct to 2 decimal places. **(1 mark)**

Section A2 — Algebra (9 marks)

Question 2 — Exponent laws (2 marks)

(a) Write $2^3 \div 2^5$ as a single power, then evaluate it. Negative integer exponents are in scope at Level 9. **(1 mark)**

(b) Simplify $12x^5y^2 \div 4x^3y^6$, leaving only positive exponents in your answer. **(1 mark)**

Question 3 — Expanding and factorising (2 marks)

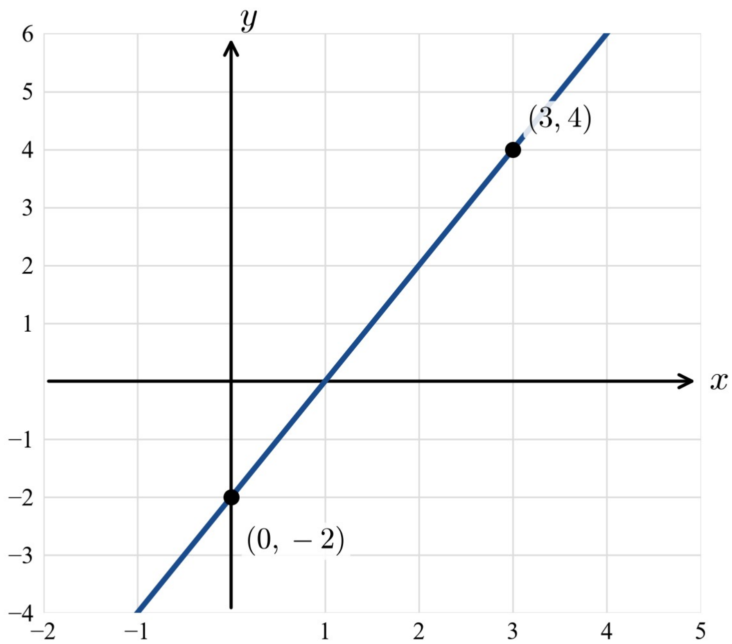
(a) Expand $(x-6)(x+9)$. **(1 mark)**

(b) Factorise $x^2 - 13x + 36$. **(1 mark)**

Question 4 — Linear relations (2 marks)

(a) Solve $5(x-3) = 2x + 9$. **(1 mark)**

(b) The straight line in the figure passes through the two marked points. Read its rule. **(1 mark)**



A straight line rising from left to right with two marked points, (0, −2) on the y-axis and (3, 4)

Question 5 — Gradient (1 mark)

Find the gradient of the line segment joining $(-1, 3)$ and $(4, -7)$. **(1 mark)**

Question 6 — Quadratic equations (2 marks)

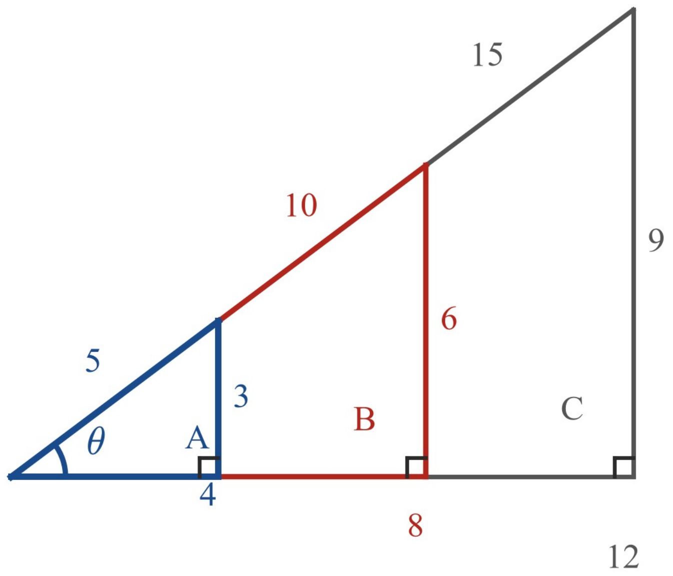
(a) Solve $x^2 - 7x + 10 = 0$ algebraically, using the **null factor law**: a product equals zero only when at least one of its factors equals zero. **(1 mark)**

(b) Explain why $x^2 + 9 = 0$ has no real solution. **(1 mark)**

Section A3 — Space (4 marks)

Question 7 — Trigonometric ratios in similar triangles (2 marks)

The figure shows three nested right-angled triangles, A, B and C, sharing the angle θ at the origin. Triangle A has sides 3, 4 and 5; triangle B has sides 6, 8 and 10; triangle C has sides 9, 12 and 15.



Three nested similar right-angled triangles A, B and C sharing the angle theta at the origin: A with sides 3, 4 and 5 in blue, B with sides 6, 8 and 10 in red, C with sides 9, 12 and 15 in grey, each with a small square at its right angle

(a) Find $\sin\theta$ from triangle A, then check that triangles B and C give the same value. **(1 mark)**

(b) Explain why all three triangles give the same value of $\sin\theta$. **(1 mark)**

Question 8 — Testing an algorithm (2 marks)

This algorithm classifies a triangle from its three side lengths:

1. Square each side length.
2. Compare the largest square with the sum of the other two squares.
3. If they are equal, the triangle is right-angled. If the largest square is smaller, the triangle is acute. If the largest square is bigger, the triangle is obtuse.

(a) Trace the algorithm for a triangle with sides 5, 7 and 9. What is the classification? **(1 mark)**

(b) Trace the algorithm for side lengths 2, 3 and 6. What goes wrong, and what check should the algorithm make before step 1? The **triangle inequality** says the sum of any two sides of a triangle must be greater than the third side. **(1 mark)**

Section A4 — Measurement (5 marks)

Question 9 — Volume and capacity of a cylinder (2 marks)

A cylinder has radius 5 cm and height 12 cm.

(a) Find its volume, leaving your answer in exact form in terms of π. **(1 mark)**

(b) The cylinder is used as a container. Find its capacity in litres, correct to 2 decimal places. (1 L $=1000$ cm^3.) **(1 mark)**

Question 10 — Scientific notation (2 marks)

Scientific notation writes a number as $a \times 10^n$, where $1 \le a < 10$ and n is an integer.

(a) Write $0.000\,047\,3$ in scientific notation. **(1 mark)**

(b) Calculate $(4 \times 10^{-3}) \times (5 \times 10^{7})$, giving your answer in scientific notation. **(1 mark)**

Question 11 — Percentage error (1 mark)

A student estimates that a crowd contains 240 people. The actual count is 250. The **absolute error** of an estimate is the positive difference between the estimate and the actual value; the **percentage error** is the absolute error divided by the actual value, expressed as a percentage. Find the absolute error and the percentage error of the estimate. **(1 mark)**

Section A5 — Statistics (3 marks)

Question 12 — Comparing two distributions (2 marks)

SCENARIO — a made-up context with invented numbers and generic people. Two players' basketball scores over seven games are:

- Player A: $8, 12, 10, 22, 11, 9, 12$
- Player B: $13, 11, 14, 12, 10, 12, 12$

(a) Calculate the mean, median and range of each player's scores. **(1 mark)**

(b) Both players have the same mean. Compare the two distributions: which player is more consistent, and what effect does Player A's score of 22 have on their mean? **(1 mark)**

Question 13 — Choosing a display (1 mark)

A gardener measures the heights of 40 seedlings, in millimetres, and wants to show the shape of the distribution. Justify why a histogram is a better choice than a bar chart for these data. **(1 mark)**

Section A6 — Probability (4 marks)

Question 14 — Two-step chance experiment (2 marks)

A bag contains 3 red counters and 2 yellow counters. Two counters are drawn at random, one after the other, **without replacement** — the first counter is not put back before the second is drawn.

(a) Draw a tree diagram showing all outcomes and their probabilities. **(1 mark)**

(b) Find the probability that both counters drawn are red. **(1 mark)**

Question 15 — Probabilities from a two-way table (2 marks)

The two-way table shows the 31 days of July 2026 at Melbourne (Olympic Park). A day is *rainy* if at least 1 mm of rain fell, and *windy* if the strongest gust reached at least 40 km/h.

	Windy	Not windy	Total
Rainy	4	5	9
Not rainy	5	17	22
Total	9	22	31

Source: Bureau of Meteorology, "Daily Weather Observations for Melbourne (Olympic Park), Victoria, July 2026" (station 086338), prepared 14 August 2026. Retrieved 20 August 2026.

(a) One day is chosen at random. Find the probability that it was rainy but not windy. **(1 mark)**

(b) Use the data to predict the number of rainy days in a 62-day period at the same place. **(1 mark)**

Part B — technology-active (42 marks)

A scientific calculator is permitted throughout this part. Your teacher will tell you which digital tools are nominated for this sitting — a spreadsheet, a graphing tool, dynamic geometry software or a programming language. No CAS is permitted. Answer all questions.

Section B1 — Number (2 marks)

Question 16 — An irrational length (2 marks)

SCENARIO — a rectangular park measures 7 m by 9 m. A path runs straight along its diagonal.

(a) Show that the diagonal has length $\sqrt{130}$ m, and explain why $\sqrt{130}$ is irrational. **(1 mark)**

(b) Use your calculator to find the length of the diagonal, in metres, correct to 2 decimal places. **(1 mark)**

Section B2 — Algebra (10 marks)

Question 17 — Solving quadratics from a graph (3 marks)

Use a graphing tool for this question.

Graph $y=x^2-4x+3$.

(a) Use your graph to solve $x^2-4x+3=0$. **(1 mark)**

(b) Use your graph or the tool's numerical readout to solve $x^2-4x+3=2$, correct to 2 decimal places. **(1 mark)**

(c) Explain why $x^2-4x+3=-2$ has no solution. **(1 mark)**

Question 18 — Sliding and reflecting parabolas (3 marks)

Use a graphing tool for this question.

(a) Graph $y=x^2$, $y=(x-4)^2$ and $y=(x+1)^2$ on the same axes. Describe the effect of h in $y=(x-h)^2$ on the graph of $y=x^2$. **(1 mark)**

(b) Predict the direction of opening and the vertex of $y=-(x+3)^2+2$ before graphing it, then check your prediction with the graphing tool. **(1 mark)**

(c) Generalise: in $y=a(x-h)^2+b$, what does each of a, h and b control? **(1 mark)**

Question 19 — Modelling with simple interest (4 marks)

SCENARIO — **simple interest** is interest paid only on the starting amount. \$3500 is invested at 3.2% p.a. simple interest.

(a) Find the interest earned in one year. **(1 mark)**

(b) Write a rule for the balance A dollars after t years. **(1 mark)**

(c) Use a spreadsheet to extend your rule year by year. What is the balance after 8 years? **(1 mark)**

(d) Evaluate the model: give one reason why a real bank account might not follow this rule. **(1 mark)**

Section B3 — Space (5 marks)

Question 20 — Enlargement in dynamic geometry (5 marks)

Use dynamic geometry software for this question.

Draw a rectangle 4 cm by 3 cm. Enlarge it by **scale factor** $k=2$ — the number every length is multiplied by — about a centre you choose, and again by $k=3$. Measure the sides, perimeter, area and angles of each image.

(a) Copy and complete the table from your measurements. **(2 marks)**

	side lengths (cm)	perimeter (cm)	area (cm²)	angles
original	4 by 3	14	12	$90°$
$k=2$ image				
$k=3$ image				

(b) By what factor does the perimeter change under an enlargement of scale factor k? By what factor does the area change? **(1 mark)**

(c) What happens to the angles? Using the language of similarity, state the relationship between each image and the original rectangle. **(1 mark)**

(d) A solid is enlarged by scale factor $k=3$. By what factor does its volume change? **(1 mark)**

Section B4 — Measurement (9 marks)

Question 21 — A ramp (5 marks)

SCENARIO — a ramp rises 7 m over a horizontal run of 24 m. The angle between the ramp and the ground is θ.

(a) Use Pythagoras' theorem to find the length of the sloping surface of the ramp. **(1 mark)**

(b) Write down $\sin\theta$, $\cos\theta$ and $\tan\theta$, naming which side of the triangle is opposite, adjacent and hypotenuse with respect to θ. **(2 marks)**

(c) Use your calculator to find θ, correct to 1 decimal place. **(1 mark)**

(d) A similar ramp rises 10.5 m. Find its horizontal run. **(1 mark)**

Question 22 — Modelling direct proportion (4 marks)

SCENARIO — a pump fills a tank at a steady 12 L per minute. The volume of water in the tank after t minutes is $V=12t$ litres. Two quantities are in **direct proportion** when their ratio is constant.

(a) Explain why V is directly proportional to t. **(1 mark)**

(b) Use a spreadsheet to extend the rule. How long does the pump take to deliver 450 L? **(1 mark)**

(c) What does the constant 12 represent in this situation? **(1 mark)**

(d) Evaluate the model: give one reason why the real flow might not stay at 12 L/min as the tank fills. **(1 mark)**

Section B5 — Statistics (10 marks)

Question 23 — Estimating from a sample (3 marks)

Use a spreadsheet for this question.

The table shows the 2025 annual rainfall at eight of the 81 Victorian weather stations with complete records, taken from the Bureau of Meteorology's annual climate summary.

Station	Rainfall (mm)
Westmere	405.8
Mallacoota	1230.8
Essendon Airport	579.8
Coldstream	653.6
Melbourne Airport	459.0
Scoresby Research Institute	621.8

Station	Rainfall (mm)
Moorabbin Airport	543.4
Ballarat Aerodrome	585.0

Source: Bureau of Meteorology, Victoria in 2025 (Annual Climate Summary), 2026. Retrieved 20 August 2026.

(a) Use your spreadsheet to find the mean and the median of this sample. **(2 marks)**

(b) Treat these values as estimates of the population mean and median for all 81 stations. The actual population values are mean 642.4 mm and median 579.8 mm. Find the error of each estimate. **(1 mark)**

Question 24 — Sampling, representation and point of view (3 marks)

(a) Six random samples of eight stations, all drawn from the same 81 stations, have means ranging from 627.4 mm to 647.2 mm. Explain why the six sample means are different from one another. **(1 mark)**

(b) SCENARIO — a radio station polls its listeners about a new policy by phoning landline numbers during working hours. Give one reason why this sample may not represent the wider community. **(1 mark)**

(c) The average weekly earnings of full-time adults in Australia in May 2026 were $\$2285.90$ for males and $\$1964.50$ for females.

Source: Australian Bureau of Statistics, Average Weekly Earnings, Australia, May 2026, 2026. Retrieved 20 August 2026.

A media article redraws these two values as a bar chart with the vertical axis starting at $\$1900$ instead of zero. Explain how this representation promotes a point of view, and say how the chart should be fixed. **(1 mark)**

Question 25 — Planning a statistical investigation (4 marks)

SCENARIO — you plan an investigation of the question: *How do Year 9 students at your school travel to school, and does travel time vary?*

(a) State the population, and give one numerical variable and one categorical variable the investigation would record. **(1 mark)**

(b) Describe a sampling method you could use to select the students. **(1 mark)**

(c) Give one weakness or possible bias of your method. **(1 mark)**

(d) Say how you would report your methods and findings, and to whom. **(1 mark)**

Section B6 — Probability (6 marks)

Question 26 — Simulating a combined event (6 marks)

SCENARIO — a community fair runs a game: a player spins two fair spinners — one with ten equal sectors numbered 1 to 10, and one with six equal sectors numbered 1 to 6 — and adds the two numbers. The player wins if the total is 13 or more.

(a) Explain why simulating the game is more practical than listing all possible outcomes by hand. **(1 mark)**

(b) Design a simulation for one trial: state what each random number represents and how a win is decided. **(2 marks)**

(c) *Use a spreadsheet or a programming language for this part.* Run your simulation for 100 trials. Record the number of wins, and calculate the **relative frequency** of a win — the number of wins divided by the number of trials. **(1 mark)**

(d) The exact probability of a win is $\frac{10}{60}=\frac{1}{6}\approx 0.167$. Compare your relative frequency with this value, and say what you would expect to happen to the relative frequency if the simulation were run for many more trials. **(2 marks)**

End of review — total 70 marks

Marking guide

Teacher-facing. The End-of-year review is a classroom check, not an exam: Part A runs 30 minutes and Part B runs 45 minutes, and the two parts are sat separately (TOC §7.3). Part A is technology-free — no calculator and no digital tool of any kind. Part B is technology-active — a scientific calculator, plus teacher-nominated tools chosen from a spreadsheet, a graphing tool, dynamic geometry software or a programming language. No CAS on either part (D9). The paper is cumulative and assesses no new content: every CD below was already assessed in its chapter test, T1–T7 (TOC §7). The three full-cycle CDs (`VC2M9A06`, `VC2M9M05`, `VC2M9ST05`) carry 4-mark interpret-the-model or interpret-the-finding items here (Q19, Q22, Q25); the full cycle is assessed by rubric tasks X1–X3, not by this timed paper. Where a CD requires reasoning, reasoning is marked separately from the answer and a correct number with no reason does not score full marks (Q6b, Q7b, Q8b, Q12b, Q13, Q16a, Q17c, Q19d, Q20c, Q21d, Q22a, Q22d, Q24a–c, Q25c, Q26a). All parts carry whole marks.

Mark map

Part	Section	Strand	Questions	Marks	Codes assessed
A	A1	Number	Q1	3	`VC2M9N01`
A	A2	Algebra	Q2–Q6	9	`VC2M9A01` `VC2M9A02` `VC2M9A03` `VC2M9A04` `VC2M9A05`
A	A3	Space	Q7–Q8	4	`VC2M9SP01` `VC2M9SP03`
A	A4	Measurement	Q9–Q11	5	`VC2M9M01` `VC2M9M02` `VC2M9M04`
A	A5	Statistics	Q12–Q13	3	`VC2M9ST03` `VC2M9ST04`
A	A6	Probability	Q14–Q15	4	`VC2M9P01` `VC2M9P02`
			Part A total	**28**	
B	B1	Number	Q16	2	`VC2M9N01`
B	B2	Algebra	Q17–Q19	10	`VC2M9A05` `VC2M9A07` `VC2M9A06`
B	B3	Space	Q20	5	`VC2M9SP02`
B	B4	Measurement	Q21–Q22	9	`VC2M9M03` `VC2M9M05`
B	B5	Statistics	Q23–Q25	10	`VC2M9ST01` `VC2M9ST02` `VC2M9ST05`
B	B6	Probability	Q26	6	`VC2M9P03`
			Part B total	**42**	
			Review total	**70**	**all 24 CDs**

`VC2M9N01` appears in both parts, as the CD requires — problems solved without digital tools (Q1) and with them (Q16). `VC2M9A05` is sampled twice, algebraically in Part A (Q6) and graphically/numerically in Part B (Q17).

Allocating marks, question by question

Q	CD	Mark allocation
1	`VC2M9N01`	(a) 2 for all four classifications:

Q	CD	Mark allocation
		$\sqrt{49}=7$ rational; $\sqrt{12}$ irrational; $0.444\ldots=\frac{4}{9}$ rational; π irrational. Award 1 for exactly three correct. (b) 1 for both 9π cm² exactly and ≈ 28.27 cm².
2	VC2M9A01	(a) 1 for $2^3 \div 2^5 = 2^{-2} = \frac{1}{4}$; the single power 2^{-2} and its value are both required. Negative integer exponents are in scope: the CD governs over the raw achievement-standard extract's “positive integers” (D6). (b) 1 for $\frac{3x^2}{y^4}$ with only positive exponents.
3	VC2M9A02	(a) 1 for $x^2+3x-54$. (b) 1 for $(x-4)(x-9)$; accept $(x-9)(x-4)$.
4	VC2M9A03	(a) 1 for $x=8$ with working shown (expanding to $5x-15=2x+9$ then gathering terms). (b) 1 for $y=2x-2$, read from the marked points $(0,-2)$ and $(3,4)$.
5	VC2M9A04	1 for gradient -2: rise $-7-3=-10$, run $4-(-1)=5$, gradient $-10 \div 5=-2$.
6	VC2M9A05	(a) 1 for factorising to $(x-2)(x-5)=0$ and stating both solutions $x=2$, $x=5$ by the null factor law. (b) 1 for an explanation that holds — $x^2 \geq 0$ for every real x, so $x^2+9 \geq 9$ and can never equal 0. A bare “no solution” with no reason earns 0.
7	VC2M9SP01	(a) 1 for $\sin\theta=\frac{3}{5}$ from triangle A and the checks $\frac{6}{10}$ and $\frac{9}{15}$, all 0.6. (b) 1 for similarity reasoning — the three triangles have equal corresponding angles, so they are similar and the ratio of corresponding sides (opposite ÷ hypotenuse) is the same in each. The answer “they are similar” alone earns the mark only if tied to the ratio.
8	VC2M9SP03	(a) 1 for the trace: $5^2+7^2=25+49=74$, and

Q	CD	Mark allocation
		$74 < 9^2 = 81$, so the triangle is obtuse. (b) 1 for: $2 + 3 = 5 < 6$, so no triangle exists with these side lengths; the algorithm must check the triangle inequality before classifying.
9	VC2M9M01	(a) 1 for $V = \pi \times 5^2 \times 12 = 300\pi$ cm³. (b) 1 for $300\pi \approx 942.48$ cm³ and capacity 0.94 L (2 d.p.).
10	VC2M9M02	(a) 1 for 4.73×10^{-5}. (b) 1 for 2×10^5: coefficients $4 \times 5 = 20$, exponents $-3 + 7 = 4$, then $20 \times 10^4 = 2 \times 10^5$.
11	VC2M9M04	1 for both: absolute error $250 - 240 = 10$; percentage error $10 \div 250 = 4\%$.
12	VC2M9ST03	(a) 1 for all six measures: A — mean 12, median 11, range 14; B — mean 12, median 12, range 4. (b) 1 for a comparison that names consistency and the outlier — Player B is more consistent (range 4 against 14); Player A’s 22 is an outlier and pulls A’s mean above A’s median.
13	VC2M9ST04	1 for a justification that names the data type and what the display shows — heights are numerical (continuous) data, and a histogram groups them into classes so the shape of the distribution can be seen; a bar chart is for categorical data. “A histogram is better” with no reason earns 0.
14	VC2M9P01	(a) 1 for a complete tree: first draw red $\frac{3}{5}$ / yellow $\frac{2}{5}$; after a red, second draw red $\frac{2}{4}$ / yellow $\frac{2}{4}$; after a yellow, second draw red $\frac{3}{4}$ / yellow $\frac{1}{4}$. (b) 1 for $\frac{3}{5} \times \frac{2}{4} = \frac{6}{20} = \frac{3}{10}$.
15	VC2M9P02	(a) 1 for $\frac{5}{31}$ (the rainy-and-not-windy cell). (b) 1 for $62 \times \frac{9}{31} = 18$ rainy days.
16	VC2M9N01	(a) 1 for $7^2 + 9^2 = 49 + 81 = 130$, so the diagonal is $\sqrt{130}$ m, with an irrationality argument that holds —

Q	CD	Mark allocation
		130 is not a perfect square ($121<130<144$), so $\sqrt{130}$ cannot be written as a fraction. (b) 1 for 11.40 m (2 d.p.), from a calculator.
17	VC2M9A05	(a) 1 for $x=1$ and $x=3$, read where the graph cuts the x-axis. (b) 1 for $x\approx0.27$ and $x\approx3.73$ (2 d.p.), where the graph meets $y=2$. (c) 1 for an explanation that holds — the lowest point of the parabola is its turning point $(2,-1)$, so the least value of y is -1, and the graph never reaches $y=-2$. No quadratic formula or completing the square is expected or rewarded; the reasoning is graphical.
18	VC2M9A07	(a) 1 for: h slides the parabola horizontally without changing its shape — $y=(x-4)^2$ has vertex $(4,0)$, a slide 4 right; $y=(x+1)^2$ has vertex $(-1,0)$, a slide 1 left. (b) 1 for the prediction opens downward with vertex $(-3,2)$, verified against the graph. (c) 1 for: a sets the direction (and width) of opening, h the horizontal slide (the vertex's x -coordinate), b the vertical slide (the vertex's y-coordinate); the vertex is (h,b).
19	VC2M9A06	(a) 1 for $3500\times0.032=\$112$. (b) 1 for $A=3500+112t$. (c) 1 for $\$4396$ after 8 years, with the spreadsheet working shown or described. (d) 1 for an evaluation point that holds — real accounts pay interest on the growing balance (compound interest), or pay rates that change over time, so the constant $\$112$ per year is a simplification.
20	VC2M9SP02	(a) 2 for both rows: $k=2$ — 8 by 6, perimeter 28, area 48, angles $90°$; $k=3$ — 12 by 9, perimeter 42, area 108, angles $90°$; 1 mark per row, accept small measurement tolerances from the software. (b) 1 for: perimeter $\times k$; area $\times k^2$. (c) 1 for: the angles are unchanged; corresponding angles are equal and corresponding sides are in the ratio k , so each image is similar to the

Q	CD	Mark allocation
		original. (d) 1 for: volume $\times k^3 = \times 27$.
21	VC2M9M03	(a) 1 for $\sqrt{7^2+24^2}=\sqrt{625}=25$ m. (b) 2 for all three ratios with the sides named — with respect to θ: opposite 7 m, adjacent 24 m, hypotenuse 25 m; $\sin\theta=\frac{7}{25}$, $\cos\theta=\frac{24}{25}$, $\tan\theta=\frac{7}{24}$; award 1 for two correct ratios. (c) 1 for $\theta=\tan^{-1}\left(\frac{7}{24}\right)\approx 16.3°$. (d) 1 for scale factor $10.5\div 7=1.5$ and run $24\times 1.5=36$ m. This item stays right-angled throughout; the phrasing is “the angle between the ramp and the ground”, never an angle of elevation (D3).
22	VC2M9M05	(a) 1 for: $\frac{V}{t}=12$ for every t, a constant ratio, so V is directly proportional to t. (b) 1 for $450\div 12=37.5$ minutes, from the spreadsheet. (c) 1 for: 12 is the flow rate — 12 litres per minute — and it is the constant of proportionality. (d) 1 for an evaluation point that holds — in practice the flow slows as the tank fills (pressure drops), so the constant rate is a simplification.
23	VC2M9ST01	(a) 2: 1 for the sample mean 634.9 mm; 1 for the sample median 582.4 mm. (b) 1 for both errors: mean estimate out by $642.4-634.9=7.5$ mm; median estimate out by $582.4-579.8=2.6$ mm.
24	VC2M9ST02	(a) 1 for sampling variation — each sample is a different subset of the 81 stations, so the means vary from sample to sample. (b) 1 for a bias that holds — a daytime landline poll misses people without landlines and people away from home during working hours, so it over-represents people at home in the day. (c) 1 for: starting the axis at $\$1900$ makes the visible difference between the bars far larger than the true difference of $\$321.40$ in proportion to the values, exaggerating the gap to promote a

Q	CD	Mark allocation
		point of view; the fix is to start the vertical axis at 0.
25	`VC2M9ST05`	(a) 1 for a population (all Year 9 students at the school), one numerical variable (e.g. travel time in minutes, or distance in km) and one categorical variable (e.g. mode of transport). (b) 1 for any workable method — e.g. select three classes at random from the Year 9 roll and survey every student in them. (c) 1 for a weakness that attaches to the stated method — e.g. only students present on the day are covered, or whole classes from one area may share a transport pattern. (d) 1 for a report plan naming an audience and a form — e.g. a short report with one display for the Year 9 coordinator. The formulate/evaluate/report verbs of the CD are evidenced here in shortened form; the full cycle belongs to task X1.
26	`VC2M9P03`	(a) 1 for: there are $10 \times 6 = 60$ equally likely outcomes, too many to list reliably by hand in the time; a simulation estimates the probability quickly and can be repeated as often as needed. (b) 2: 1 for the generators — one random integer from 1 to 10 for the first spinner and one from 1 to 6 for the second; 1 for the decision rule — add them, record a win if the total is 13 or more. (c) 1 for a 100-trial run with the number of wins recorded and the relative frequency computed as wins $\div 100$; the win count varies by run — accept the student's own figures provided the arithmetic is consistent. (d) 2: 1 for the comparison with the exact value $\frac{1}{6} \approx 0.167$; 1 for the long-run statement — as the number of trials grows, the relative frequency settles closer to the exact probability.

Diagnostic mapping to the Level 9 achievement standard

The paper is sectioned by strand so each section's mark can be read against the Level 9 achievement standard. The sentences below are the **corrected anchors of TOC §4**, quoted verbatim — not the raw `achievement_standard` field of `maths_9.json`, which is defective in the places marked (D6, D7).

Strand	Questions	Achievement-standard sentence (corrected anchor, §4)
Number	Q1, Q16	AS 1 — “Students recognise and use rational and irrational numbers to solve problems.”
Algebra	Q2	AS 2 — “Students apply the exponent laws to numerical expressions with positive integers and the zero exponent, and extend to variables.” **D6 note:** the raw extract’s “positive integers” is a defect in the authority file; the content description (“integer exponents”) governs, so negative integer exponents are in scope and are assessed in Q2.
Algebra	Q3	AS 3 — “They expand binomial products and factorise monic quadratic expressions.”
Algebra	Q4, Q5	AS 4 — “They find the distance between 2 points on the Cartesian plane, sketch linear graphs and find the gradient and midpoint of a line segment.”
Algebra	Q6, Q17	AS 6 — “They graph quadratic functions and use null factor law to solve monic quadratic equations with integer roots algebraically.”
Algebra	Q19	AS 5 — “Students use mathematical modelling to solve problems involving change, including simple interest in financial contexts and change in other applied contexts, choosing to use linear and quadratic functions.” **D7 note:** the authority file carries this sentence on `VC2M9M05`; it belongs to `VC2M9A06`, and §4 anchors it here.
Algebra	Q18	AS 7 — “Students investigate and describe the effects of variation of parameters on functions and relations, using digital tools where appropriate, and make connections between their graphical and algebraic representations.”
Space	Q7	AS 9 — “They solve problems involving ratio, similarity and scale in two-dimensional situations.” — and restored AS 11: “Students apply Pythagoras’ theorem and use trigonometric ratios to solve problems involving right-angled triangles.” **D7 note:** AS 11 is

Strand	Questions	Achievement-standard sentence (corrected anchor, §4)
		claimed by no CD in the raw authority file; §4 restores it to 4A and 5C. Without this, the trigonometry outcome cannot be reported at all.
Space	Q20	AS 14 — “Students apply the enlargement transformation to images of shapes and objects, and interpret results.”
Space	Q8	AS 15 — “They design, use and test algorithms based on geometric constructions or theorems.”
Measurement	Q9	AS 8 — “Students apply formulas to solve problems involving the surface area and volume of right prisms, cylinders and composite shapes.”
Measurement	Q10	AS 13 — “Students express small and large numbers in scientific notation.”
Measurement	Q21	AS 9 — “They solve problems involving ratio, similarity and scale in two-dimensional situations.” — and restored AS 11: “Students apply Pythagoras’ theorem and use trigonometric ratios to solve problems involving right-angled triangles.” (D7, as above.)
Measurement	Q11	AS 10 — “They determine percentage errors in measurements.”
Measurement	Q22	AS 12 — “They use mathematical modelling to solve practical problems involving direct and indirect proportion, ratio and scale, evaluating the model and communicating their methods and findings.” **D7 note:** the authority file carries this sentence on `VC2M9A06`; it belongs to `VC2M9M05`, and §4 anchors it here.
Statistics	Q12, Q13	AS 16 — “Students compare and analyse the distributions of multiple numerical data sets, choose representations, describe features of these data sets using summary statistics and the shape of distributions, and consider the effect of outliers.”
Statistics	Q23, Q24, Q25	AS 17 — “They explain how sampling techniques and representation can be used to support or question conclusions or to

Strand	Questions	Achievement-standard sentence (corrected anchor, §4)
		promote a point of view.”
Probability	Q14	AS 18 — “Students determine sets of outcomes for two-step chance experiments and represent these in various ways.”
Probability	Q15	AS 19 — “They assign probabilities to the outcomes of two-step chance experiments.”
Probability	Q26	AS 20 — “They design and conduct experiments or simulations for combined events using digital tools.”

Six sentences are shared by more than one CD (AS 4 → 2A, 2B; AS 9 and AS 11 → 4A, 5C; AS 16 → 6A, 6B; AS 17 → 6C, 6D, 6E), which is VCAA’s own granularity, not a duplication. A rubric or reporting line built from the raw authority field would report the wrong outcome for 3C and 5E and would not report the trigonometry outcome at all (D7) — use the table above.

Score

Part / strand	Marks
Part A — technology-free	/28
Part B — technology-active	/42
Strand — Number (A1 + B1)	/5
Strand — Algebra (A2 + B2)	/19
Strand — Space (A3 + B3)	/9
Strand — Measurement (A4 + B4)	/14
Strand — Statistics (A5 + B5)	/13
Strand — Probability (A6 + B6)	/10
End-of-year review total	**/70**

A strand mark that falls well below the chapter-test marks for the same strand points to retention, not to missing coverage — every CD here was taught and assessed earlier in the year. The review is the Year 9 exit check and the readiness check for `_build10`; its Number, Algebra and Measurement sections are the ones a Year 10 teacher should read first (TOC §7.3).

Solutions

Teacher-facing. Part A is technology-free and Part B is technology-active, sat separately, exactly as stated on the paper. The mark allocation for every part is in the Marking guide above. Figures appear here only where they add to the worked solution; a figure whose labels already contain an answer is never used in the question text.

Answer key

Q	Part	Answer	Marks
1	(a)	$\sqrt{49}=7$ rational; $\sqrt{12}$ irrational; $0.444\ldots=\frac{4}{9}$ rational; π irrational	2
1	(b)	9π cm² exactly; ≈ 28.27 cm²	1
2	(a)	$2^{-2}=\frac{1}{4}$	1
2	(b)	$\frac{3x^2}{y^4}$	1
3	(a)	$x^2+3x-54$	1
3	(b)	$(x-4)(x-9)$	1
4	(a)	$x=8$	1
4	(b)	$y=2x-2$	1
5	—	-2	1
6	(a)	$x=2$ or $x=5$	1
6	(b)	$x^2\geq 0$ for all real x, so x^2+9 can never be 0	1
7	(a)	$\sin\theta=\frac{3}{5}=\frac{6}{10}=\frac{9}{15}=0.6$	1
7	(b)	The triangles are similar, so the side ratios are equal	1
8	(a)	$74<81$, so obtuse	1
8	(b)	$2+3=5<6$: no triangle; check the triangle inequality first	1
9	(a)	300π cm³	1
9	(b)	0.94 L	1
10	(a)	4.73×10^{-5}	1
10	(b)	2×10^{5}	1
11	—	Absolute error 10; percentage error 4%	1
12	(a)	A: mean 12, median 11, range 14; B: mean 12, median 12, range 4	1
12	(b)	B is more consistent; A’s outlier 22 pulls the mean above the median	1
13	—	Numerical data in classes; a histogram shows the	1

Q	Part	Answer	Marks
		shape of the distribution	
14	(a)	Tree with branches $\frac{3}{5}$, $\frac{2}{5}$, then $\frac{2}{4}$/$\frac{2}{4}$ and $\frac{3}{4}$/$\frac{1}{4}$	1
14	(b)	$\frac{3}{10}$	1
15	(a)	$\frac{5}{31}$	1
15	(b)	18 rainy days	1
16	(a)	$7^2+9^2=130$; 130 is not a perfect square, so $\sqrt{130}$ is irrational	1
16	(b)	11.40 m	1
17	(a)	$x=1$, $x=3$	1
17	(b)	$x\approx0.27$, $x\approx3.73$	1
17	(c)	Minimum value is -1 at $x=2$; the graph never reaches -2	1
18	(a)	h slides the parabola horizontally; vertices $(4,0)$ and $(-1,0)$	1
18	(b)	Opens downward; vertex $(-3,2)$	1
18	(c)	a: direction/width; h: horizontal slide; b: vertical slide; vertex (h,b)	1
19	(a)	$\$112$	1
19	(b)	$A=3500+112t$	1
19	(c)	$\$4396$	1
19	(d)	Real accounts compound or vary the rate	1
20	(a)	$k=2$: 8 by 6, $P=28$, $A=48$, $90°$; $k=3$: 12 by 9, $P=42$, $A=108$, $90°$	2
20	(b)	Perimeter $\times k$; area $\times k^2$	1
20	(c)	Angles unchanged; each image is similar to the original	1
20	(d)	Volume $\times 27$	1
21	(a)	25 m	1
21	(b)	$\sin\theta=\frac{7}{25}$; $\cos\theta=\frac{24}{25}$; $\tan\theta=\frac{7}{24}$	2
21	(c)	$16.3°$	1

Q	Part	Answer	Marks
21	(d)	36 m	1
22	(a)	$\frac{V}{t}=12$, a constant ratio	1
22	(b)	37.5 minutes	1
22	(c)	The flow rate, 12 L/min	1
22	(d)	The flow slows in practice (pressure drops)	1
23	(a)	Mean 634.9 mm; median 582.4 mm	2
23	(b)	Mean error 7.5 mm; median error 2.6 mm	1
24	(a)	Sampling variation — different samples give different means	1
24	(b)	Misses people without landlines and people out during the day	1
24	(c)	Axis from $\$1900$ exaggerates the gap; start the axis at 0	1
25	(a)	Population: all Year 9 students; e.g. travel time (numerical), mode of transport (categorical)	1
25	(b)	E.g. three randomly chosen Year 9 classes, all students in them	1
25	(c)	E.g. only students present that day are covered	1
25	(d)	E.g. a short report with a display, to the Year 9 coordinator	1
26	(a)	60 outcomes is too many to list reliably; a simulation is faster	1
26	(b)	Random integers 1–10 and 1–6; win if the sum is ≥ 13	2
26	(c)	Student's own run: wins out of 100; relative frequency = wins $\div$ 100	1
26	(d)	Close to $\frac{1}{6}\approx 0.167$; more trials, the relative frequency settles toward it	2

Worked solutions

Q1. (a) $\sqrt{49}=7$, a whole number, so it is **rational**. $\sqrt{12}$ lies between $\sqrt{9}=3$ and $\sqrt{16}=4$ and 12 is not a perfect square, so $\sqrt{12}$ is **irrational**. $0.444\ldots=\frac{4}{9}$, a fraction, so it is **rational** — recurring decimals always equal a fraction. π cannot be written as a fraction, so it is **irrational**.

(b) $A=\pi r^2$

$A=\pi\times 3^2$

$A=9\pi$ cm² exactly

$9\pi\approx 28.2743\ldots$

$\therefore$ $A=9\pi$ cm² exactly, ≈ 28.27 cm² to 2 decimal places.

Q2. (a) Divide powers of the same base by subtracting the exponents:

$2^3\div 2^5=2^{3-5}=2^{-2}$

$2^{-2}=\frac{1}{2^2}=\frac{1}{4}$

$\therefore$ $2^3\div 2^5=2^{-2}=\frac{1}{4}$.

(b) Divide the coefficients and subtract the exponents of each letter:

$12\div 4=3$, $x^5\div x^3=x^2$, $y^2\div y^6=y^{-4}=\frac{1}{y^4}$

$\therefore$ $12x^5y^2\div 4x^3y^6=\frac{3x^2}{y^4}$.

Q3. (a) Multiply every term of the second bracket by every term of the first:

$(x-6)(x+9)=x^2+9x-6x-54$

$\therefore$ $(x-6)(x+9)=x^2+3x-54$.

(b) Find two numbers that multiply to 36 and add to -13: they are -4 and -9.

$\therefore$ $x^2-13x+36=(x-4)(x-9)$.

Check by expanding: $(x-4)(x-9)=x^2-9x-4x+36=x^2-13x+36$ ✓

Q4. (a) Expand, then gather the x-terms:

$5x-15=2x+9$

$5x-2x=9+15$

$3x=24$

$\therefore$ $x=8$.

Check: $5(8-3)=5\times 5=25$ and $2\times 8+9=25$ ✓

(b) The line crosses the y-axis at $(0,-2)$, so the constant term is -2. From $(0,-2)$ to $(3,4)$ the rise is $4-(-2)=6$ over a run of 3, so the gradient is $6\div 3=2$.

$\therefore$ The rule is $y=2x-2$.

Q5. Rise $=-7-3=-10$; run $=4-(-1)=5$.

Gradient $=-10\div 5$

$\therefore$ The gradient is -2.

Q6. (a) Factorise, then apply the null factor law:

$x^2-7x+10=(x-2)(x-5)$

$(x-2)(x-5)=0$

A product is zero only when a factor is zero, so $x-2=0$ or $x-5=0$.

$\therefore$ $x=2$ or $x=5$.

(b) For every real number x, $x^2\geq 0$. Adding 9 gives $x^2+9\geq 9$, so x^2+9 can never equal 0.

$\therefore$ The equation has no real solution.

Q7. (a) In triangle A the side opposite θ is 3 and the hypotenuse is 5:

$\sin\theta=\dfrac{3}{5}=0.6$

Triangle B: $\dfrac{6}{10}=0.6$ ✓ Triangle C: $\dfrac{9}{15}=0.6$ ✓

$\therefore$ $\sin\theta=\dfrac{3}{5}=\dfrac{6}{10}=\dfrac{9}{15}=0.6$.

(b) Each larger triangle is an enlargement of triangle A, so all three have the same angles — they are similar. In similar triangles, corresponding sides are in the same ratio, so opposite ÷ hypotenuse is the same fraction in every one of them.

$\therefore$ The ratio depends only on the angle θ, not on the triangle's size.

Q8. (a) Squares: $5^2=25$, $7^2=49$, $9^2=81$.

$25+49=74$

$74<81$: the largest square is bigger than the sum of the other two.

$\therefore$ A triangle with sides 5, 7, 9 is **obtuse**.

(b) With sides 2, 3, 6: $2+3=5$, and $5<6$ — the two short sides cannot even reach across, so **no triangle exists** with these lengths. The algorithm's squares test would still run and print "obtuse", which is meaningless here.

$\therefore$ The algorithm must check the triangle inequality first: the sum of any two sides must be greater than the third.

Q9. (a) $V=\pi r^2 h$

$V=\pi\times 5^2\times 12$

$\therefore$ $V=300\pi$ cm³.

(b) $300\pi\approx 942.4778$ cm³

Capacity $=942.4778\div 1000$ L

$\therefore$ Capacity ≈ 0.94 L to 2 decimal places.

Q10. (a) Move the decimal point 5 places right to reach 4.73:

$\therefore\ 0.000\,047\,3 = 4.73 \times 10^{-5}$.

(b) Multiply the coefficients and add the exponents:

$(4 \times 10^{-3}) \times (5 \times 10^{7}) = (4 \times 5) \times 10^{-3+7} = 20 \times 10^{4}$

$20 \times 10^{4} = 2 \times 10^{5}$

$\therefore\ (4 \times 10^{-3}) \times (5 \times 10^{7}) = 2 \times 10^{5}$.

Q11. Absolute error $= |240 - 250| = 10$

Percentage error $= \dfrac{10}{250} \times 100\,\%$

$\therefore$ Absolute error 10; percentage error $4\,\%$.

Q12. (a) Player A, in order: $8, 9, 10, 11, 12, 12, 22$.

Mean $= (8 + 12 + 10 + 22 + 11 + 9 + 12) \div 7 = 84 \div 7 = 12$

Median $= 11$ (the 4th of 7 values) · Range $= 22 - 8 = 14$

Player B, in order: $10, 11, 12, 12, 12, 13, 14$.

Mean $= (13 + 11 + 14 + 12 + 10 + 12 + 12) \div 7 = 84 \div 7 = 12$

Median $= 12$ · Range $= 14 - 10 = 4$

(b) The means are equal, but Player B’s scores cluster within 4 points while Player A’s spread over 14. Player A’s 22 is an outlier: it drags A’s mean (12) above A’s median (11), while B’s mean and median agree.

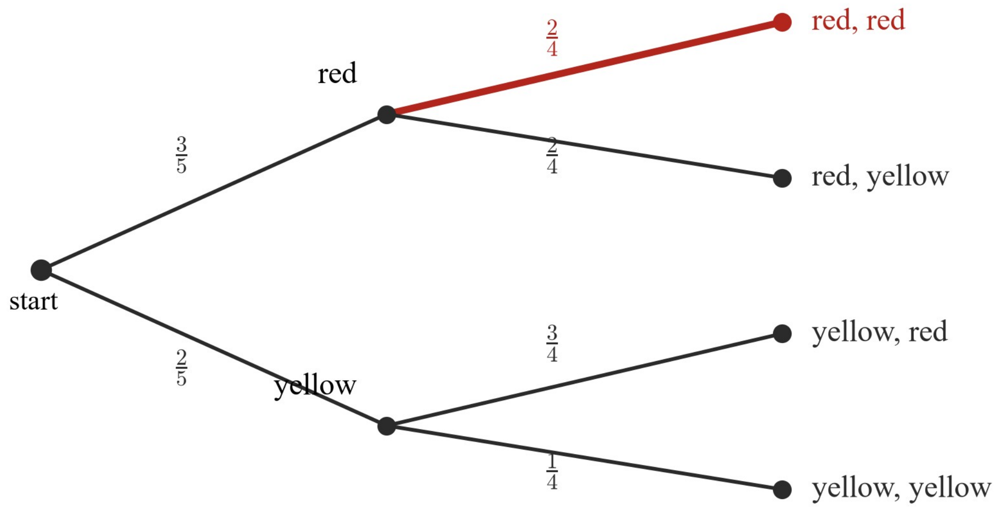
$\therefore$ Player B is the more consistent scorer; the outlier inflates Player A’s mean.

Q13. Seedling heights are numerical (continuous) data, and there are 40 of them. A histogram groups the heights into equal-width classes and shows how many fall in each, so the shape of the distribution — where most seedlings sit, and whether the values lean one way — is visible at a glance. A bar chart is for categorical data: 40 separate height values would give 40 thin bars with no shape to read.

$\therefore$ A histogram is the better choice.

Q14. (a) Without replacement, the second-draw probabilities change: after a red is drawn, only 2 of the 4 remaining counters are red; after a yellow, 3 of the 4 remaining are red.

Without replacement: one counter is gone for the second draw



Highlighted path: $P(\text{red, red}) = \frac{3}{5} \times \frac{2}{4} = \frac{3}{10} = 0.3$

A two-step tree for drawing without replacement: first draw red 3/5 or yellow 2/5, then from a red first draw 2/4 red and 2/4 yellow and from a yellow first draw 3/4 red and 1/4 yellow, with the red-red path highlighted

(b) Multiply along the red–red path:

$$P(\text{two reds}) = \frac{3}{5} \times \frac{2}{4} = \frac{6}{20}$$

$$\therefore P(\text{two reds}) = \frac{3}{10}.$$

Q15. (a) Rainy but not windy is the single cell where the *rainy* row meets the *not windy* column: 5 days out of 31.

$$\therefore P(\text{rainy but not windy}) = \frac{5}{31}.$$

(b) The data show 9 rainy days out of 31:

$$\text{Prediction} = 62 \times \frac{9}{31} = 18$$

$\therefore$ Expect about 18 rainy days in a 62-day period.

Q16. (a) The diagonal splits the rectangle into two right-angled triangles with legs 7 m and 9. By Pythagoras' theorem:

$$d^2 = 7^2 + 9^2 = 49 + 81 = 130$$

$$d = \sqrt{130} \text{ m}$$

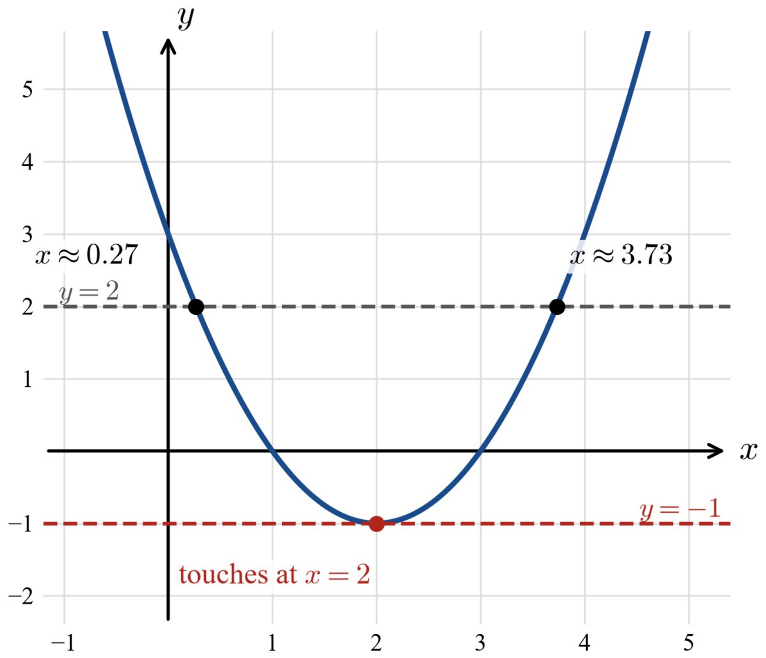
130 is not a perfect square — $11^2 = 121 < 130 < 144 = 12^2$ — so $\sqrt{130}$ cannot equal any fraction.

$\therefore$ The diagonal is $\sqrt{130}$ m, an irrational length.

(b) $\sqrt{130} = 11.4017\ldots$

$\therefore$ The diagonal is 11.40 m to 2 decimal places.

Q17. The parabola $y=x^2-4x+3$ cuts the x-axis at $x=1$ and $x=3$, meets the line $y=2$ at $x\approx 0.27$ and $x\approx 3.73$, and has its turning point — its lowest value — at $(2,-1)$.



The parabola y = x squared minus 4x plus 3 cut by the horizontal line y = 2 at x approximately 0.27 and x approximately 3.73, and touched by the horizontal line y = minus 1 at x = 2

(a) The solutions of $x^2-4x+3=0$ are the x-values where the graph meets $y=0$.

$\therefore$ $x=1$ or $x=3$.

(b) The solutions of $x^2-4x+3=2$ are the x-values where the graph meets $y=2$.

$\therefore$ $x\approx 0.27$ or $x\approx 3.73$, correct to 2 decimal places.

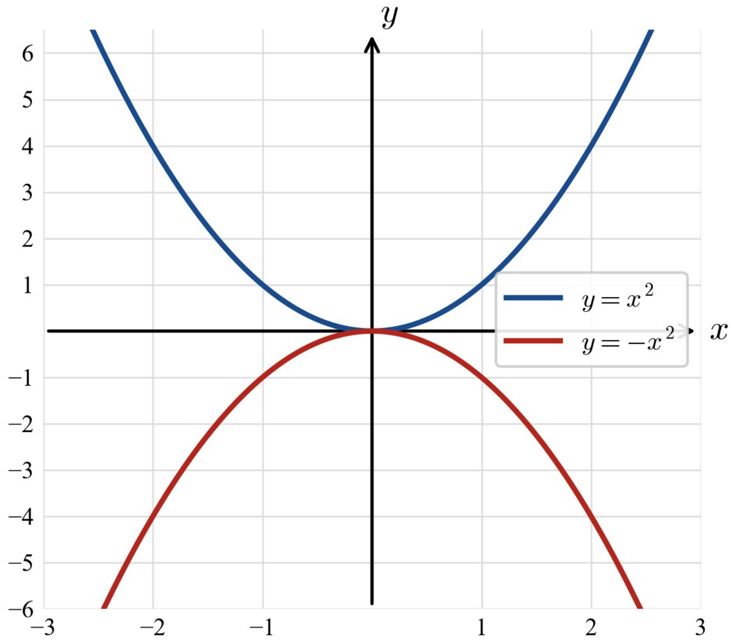
(c) The turning point $(2,-1)$ is the graph's lowest point, so the least value of x^2-4x+3 is -1. Since $-2<-1$, the graph never reaches $y=-2$.

$\therefore$ $x^2-4x+3=-2$ has no solution.

Q18. (a) The three graphs have identical shape; only their position differs. $y=(x-4)^2$ is $y=x^2$ slid 4 to the right — vertex $(4,0)$; $y=(x+1)^2$ is $y=x^2$ slid 1 to the left — vertex $(-1,0)$.

$\therefore$ h in $y=(x-h)^2$ slides the parabola horizontally and moves the vertex to $(h,0)$; the shape never changes.

(b) The minus sign in front reflects $y=(x+3)^2$ in the x-axis — the same reflection that carries $y=x^2$ to $y=-x^2$ — so the parabola opens downward; the slides put its vertex at $(-3,2)$. The graphing tool confirms both.



y = x-squared opening upward and y = minus x-squared opening downward, mirror images of each other in the x-axis

∴ Opens downward; vertex $(-3,2)$.

(c) ∴ In $y=a(x-h)^2+b$: a sets the direction (and width) of opening, h the horizontal slide, b the vertical slide — the vertex is (h,b).

Q19. (a) One year's interest $=3500\times0.032$

∴ $\$112$ per year.

(b) Simple interest adds the same $\$112$ every year to the starting $\$3500$:

∴ $A=3500+112t$.

(c) A spreadsheet extended year by year ($t=0$ to 8, each row adding 112) gives $A=3500+112\times8=3500+896$.

∴ The balance after 8 years is $\$4396$.

(d) Real accounts pay interest on the growing balance (compound interest), or their rates change over time, so the balance would not rise by exactly the same amount each year.

∴ The constant-$\$112$ growth is the model's simplification; the model is a guide, not a promise.

Q20. (a) Under an enlargement, every length is multiplied by k and angles are unchanged:

	side lengths (cm)	perimeter (cm)	area (cm²)	angles
original	4 by 3	14	12	$90°$
$k=2$ image	8 by 6	28	48	$90°$
$k=3$ image	12 by 9	42	108	$90°$

(b) $14\rightarrow28\rightarrow42$ is $\times2$ then $\times3$: perimeter $\times k$. $12\rightarrow48\rightarrow108$ is $\times4$ then $\times9$: area $\times k^2$.

∴ Perimeter $\times k$; area $\times k^2$.

(c) Every angle stays $90°$. Corresponding angles are equal and corresponding sides are in the ratio k, so each image is similar to the original rectangle.

∴ Angles unchanged; image similar to object.

(d) Volume grows by k^3: $3^3 = 27$.

∴ The volume is multiplied by 27.

Q21. (a) The rise and the run are the two shorter sides of a right-angled triangle; the sloping surface is the hypotenuse:

$\text{slope}^2 = 7^2 + 24^2 = 49 + 576 = 625$

$\text{slope} = \sqrt{625} = 25$

∴ The sloping surface is 25 m long.

(b) With respect to θ, the side opposite is the rise (7 m), the adjacent side is the run (24 m) and the hypotenuse is the slope (25 m):

∴ $\sin\theta = \dfrac{7}{25}$, $\cos\theta = \dfrac{24}{25}$, $\tan\theta = \dfrac{7}{24}$.

(c) $\theta = \tan^{-1}\left(\dfrac{7}{24}\right) = 16.26\ldots°$

∴ $\theta \approx 16.3°$.

(d) A similar ramp has the same shape, so its sides are in the same ratio. Scale factor $= 10.5 \div 7 = 1.5$:

$\text{run} = 24 \times 1.5 = 36$

∴ The horizontal run is 36 m.

Q22. (a) $\dfrac{V}{t} = \dfrac{12t}{t} = 12$ for every value of t — a constant ratio.

∴ V is directly proportional to t.

(b) $450 \div 12 = 37.5$; a spreadsheet extended row by row reaches 450 L at $t = 37.5$ min.

∴ The pump takes 37.5 minutes.

(c) ∴ The constant 12 is the flow rate — 12 litres per minute — which is the constant of proportionality.

(d) As the tank fills, the pump works against a rising head of water and the pressure drops, so the real flow rate would fall below 12 L/min.

∴ The constant rate is the model's simplification; the model over-estimates late volumes.

Q23. (a) The eight values in a spreadsheet sum to 5079.2:

Mean $= 5079.2 \div 8 = 634.9$ mm

In order the values are $405.8, 459.0, 543.4, 579.8, 585.0, 621.8, 653.6, 1230.8$ — eight values, so the median is the mean of the 4th and 5th:

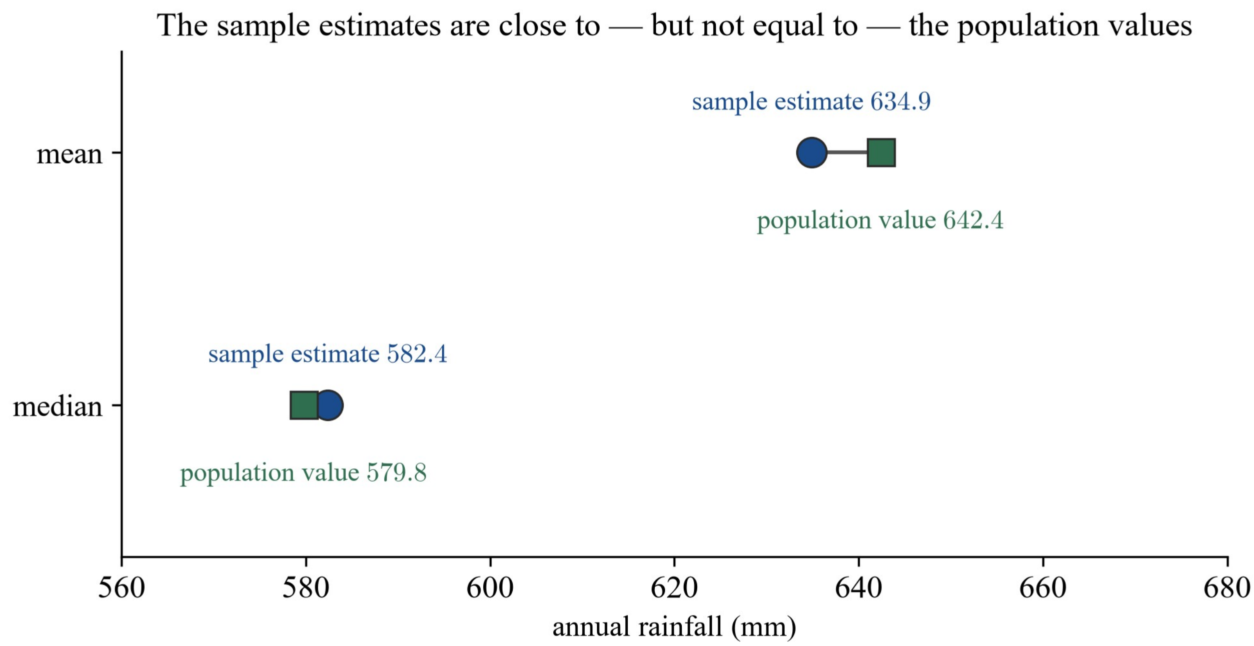
Median $= (579.8 + 585.0) \div 2 = 582.4$ mm

∴ Sample mean 634.9 mm; sample median 582.4 mm.

(b) Mean error $= 642.4 - 634.9 = 7.5$ mm

Median error $= 582.4 - 579.8 = 2.6$ mm

∴ The estimates land within a few millimetres of the population values and hit neither exactly — estimation always carries an error.



Dumbbell chart comparing the sample estimates (mean 634.9 mm, median 582.4 mm) with the population values (mean 642.4 mm, median 579.8 mm).

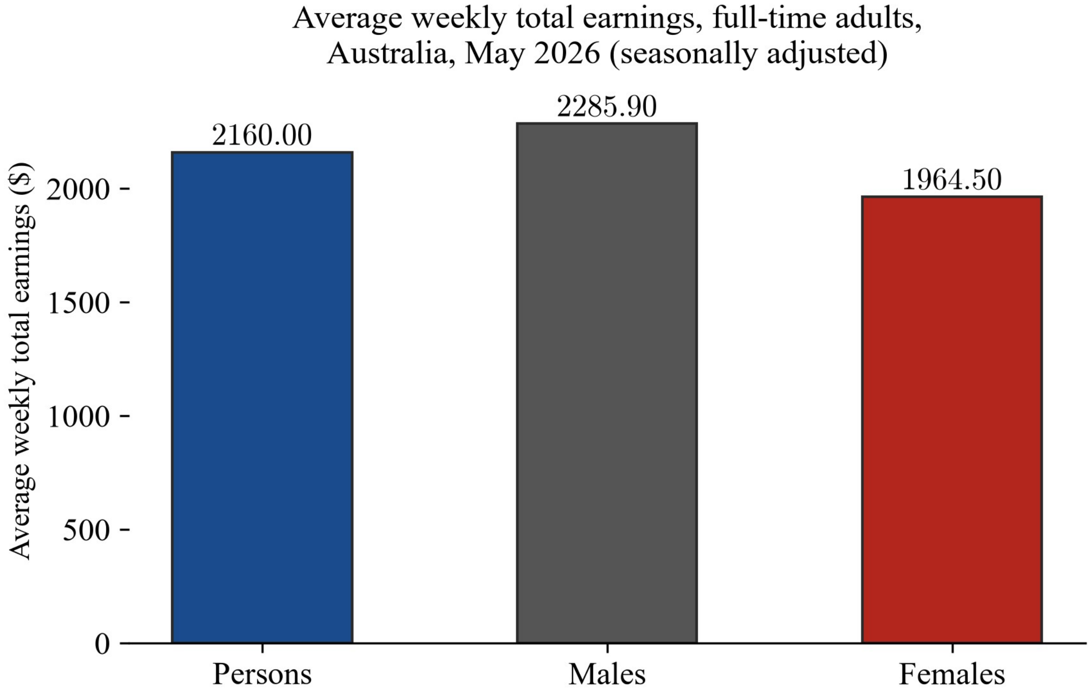
Q24. (a) Each sample is a different subset of the 81 stations, and which stations land in a sample is decided by chance. Different samples contain different rainfalls, so their means differ — this is sampling variation, not an error in the method.

∴ The six means vary because the samples vary.

(b) Only people who own a landline and are home during working hours can answer. People without landlines, and people at work or away in the day — most working adults and many younger people — can never be selected.

∴ The sample over-represents people at home in the day and is biased.

(c) The true difference is $\$2285.90 - \$1964.50 = \$321.40$. With the axis starting at $\$1900$, the visible bar lengths are about $\$386$ and $\$65$ — the taller bar looks about six times the shorter one, far more than the real gap, so the chart exaggerates the difference to promote a point of view. Starting the vertical axis at 0 makes the bars read honestly.



Bar graph of average weekly total earnings for full-time adults, Australia, May 2026, seasonally adjusted: 2160.00 dollars for persons, 2285.90 dollars for males and 1964.50 dollars for females.

∴ The truncated axis exaggerates the gap; the fix is to start the axis at 0.

Q25. (a) ∴ Population: all Year 9 students at the school. Numerical variable: travel time in minutes (or distance in km). Categorical variable: mode of transport (walk, bike, car, bus, train, …).

(b) ∴ For example: select three classes at random from the Year 9 roll and survey every student in those classes.

(c) ∴ For example: students absent on the day are not covered; or classes drawn from one part of the timetable may share a transport pattern, leaning the sample one way.

(d) ∴ For example: a short report with one display, giving the method, the results and one limitation, to the Year 9 coordinator.

Q26. (a) There are $10 \times 6 = 60$ equally likely outcomes. Listing all 60 reliably by hand is slow and error-prone; a simulation produces an estimate quickly and can be repeated as often as needed.

∴ Simulation is the practical method.

(b) ∴ One trial: generate one random integer from 1 to 10 (the first spinner) and one from 1 to 6 (the second spinner); add them; record a win if the total is 13 or more, otherwise a loss.

(c) A spreadsheet with 100 rows of the two random integers and a running count of wins gives, for example, 17 wins and relative frequency $17 \div 100 = 0.17$. Results vary from run to run — accept any consistent figures.

∴ Wins and relative frequency as recorded by the student.

(d) The exact probability counts the winning pairs: with the second spinner showing 6, the first needs 7 or more — 4 pairs; 5 needs 8 or more — 3 pairs; 4 needs 9 or more — 2 pairs; 3 needs 10 — 1 pair; 2 and 1 win with nothing. That is $4+3+2+1=10$ winning pairs out of 60:

$$P(\text{win}) = \frac{10}{60} = \frac{1}{6} \approx 0.167$$

A 100-trial run lands somewhere near 0.167 but rarely on it — 100-trial estimates spread. Running many more trials narrows the spread: the long-run relative frequency settles toward the exact value.

$\therefore$ The simulation's relative frequency should sit near $\frac{1}{6}$, and more trials bring it closer still.