

CHAPTER 6 / 6E

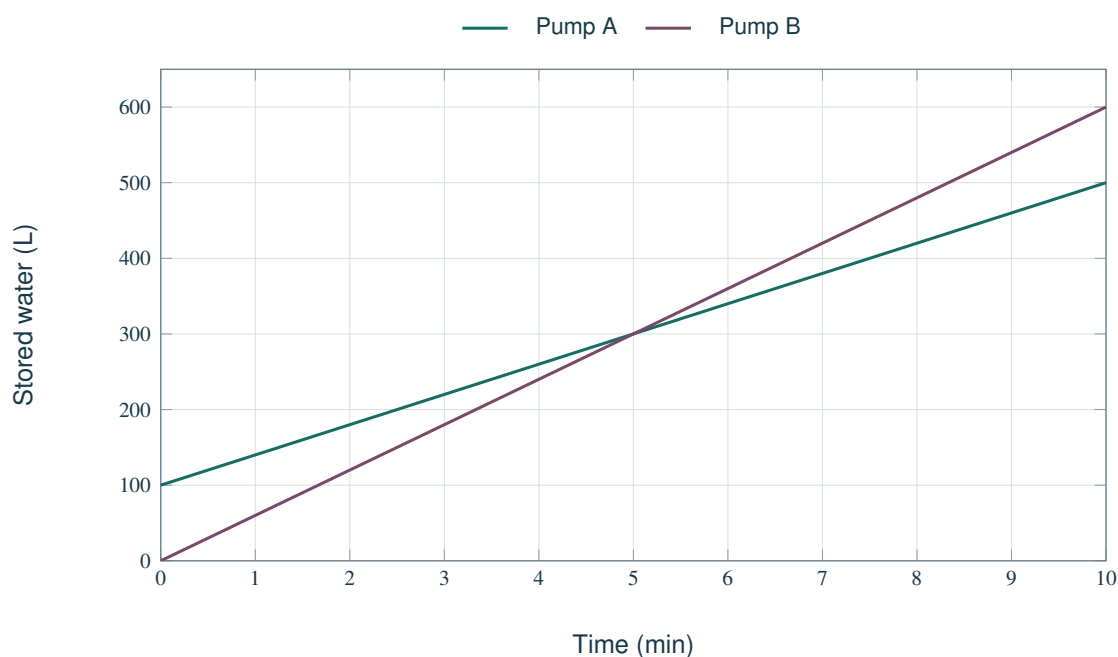
Rates from graphs

Name: _____ Class: _____ Date: _____

Use the gradient of a contextual graph as a rate. Keep the units attached, compare like with like, and distinguish a starting amount from a change.

What you will learn

- Calculate contextual rates from graph intervals.
- Convert units before comparing rates.
- Use positive and negative rates to plan an operation.

See the mathematics

Learning map: a higher starting amount is different from a greater rate of change.

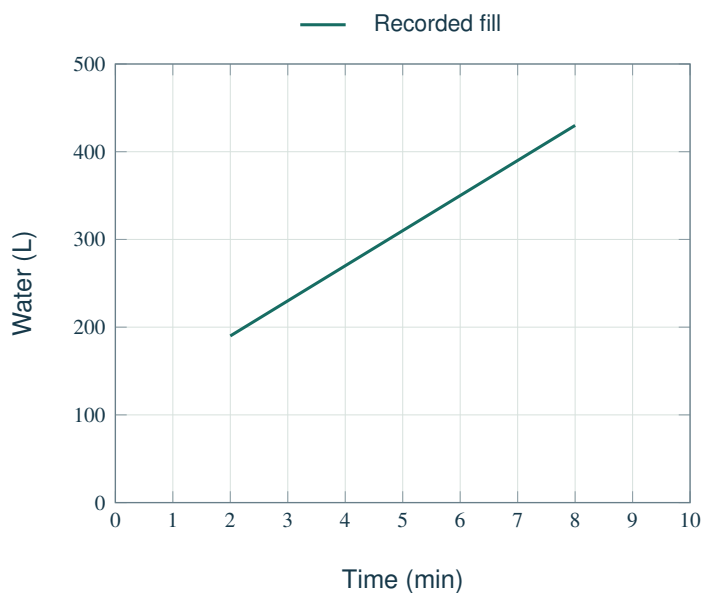
Key ideas

- Rate is $\frac{\text{change in vertical quantity}}{\text{change in horizontal quantity}}$.
- Rate units come from the vertical-axis unit divided by the horizontal-axis unit.
- A starting amount changes the graph's height but not its rate.
- Convert time or quantity units before comparing specifications or forecasting.

Worked examples / connect the calculation to the graph

1. A filling rate

A tank contains 190 L at 2 min and 430 L at 8 min. Find the fill rate.



$$1. \text{ Change in water} = 430 - 190 = 240 \text{ L};$$

$$\text{change in time} = 8 - 2 = 6 \text{ min.}$$

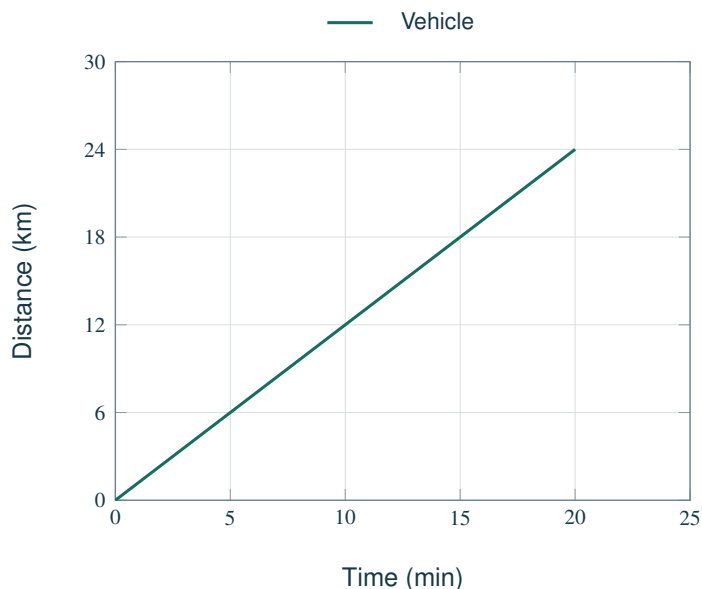
$$2. \text{ Rate} = \frac{240}{6} = 40 \text{ L/min.}$$

Result
40 L/min.

Worked example: the two measurements define the observed rate.

2. Convert a transport rate

A test vehicle travels 24 km in 20 min. Find its speed in km/min and km/h.



$$1. \text{ Speed} = \frac{24}{20} = 1.2 \text{ km/min.}$$

$$2. \text{ Multiply by 60 minutes per hour: } 1.2 \times 60 = 72 \text{ km/h.}$$

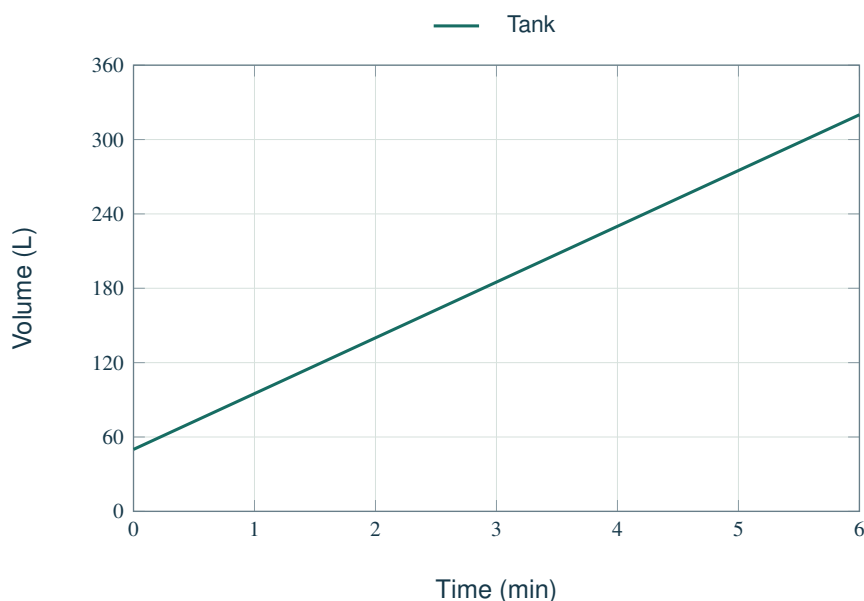
Result
1.2 km/min = 72 km/h.

Worked example: the graph uses minutes; the same journey can also be expressed per hour.

Rates and their units

Use the graph to record your thinking. Show calculations and include units where needed.

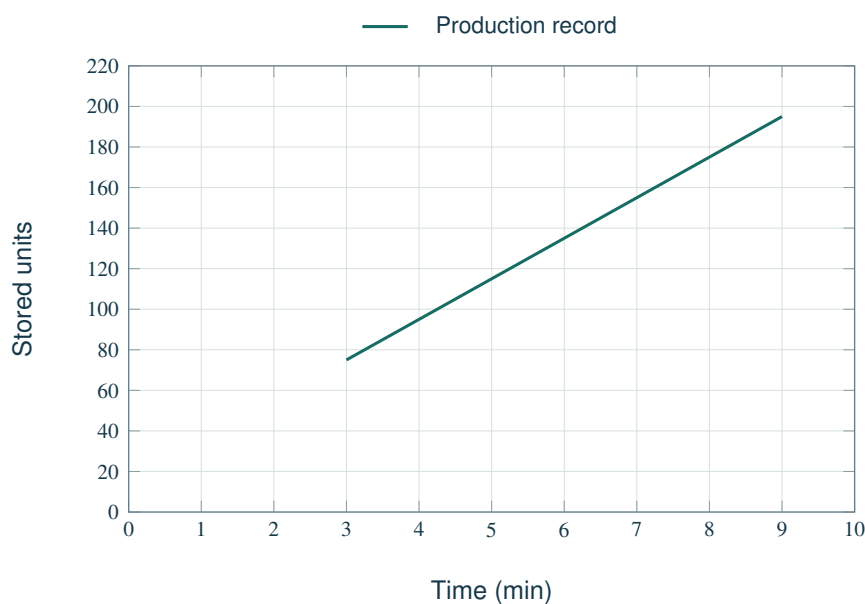
1. The graph shows a tank filling. Find the rate between 2 and 6 minutes, and state the correct units.



WORKING / DECISION

Read the quantities, scales and labelled line before answering.

2. A production graph records 75 units at 3 min and 195 units at 9 min. Find the production rate. Explain why $\frac{195}{9}$ is not the correct calculation.



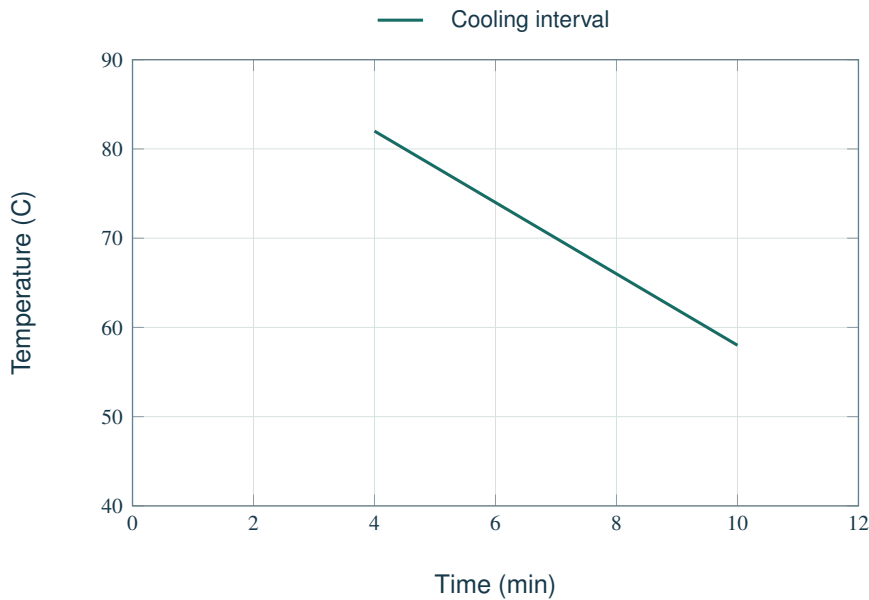
WORKING / DECISION

The rate comes from the recorded interval. The line need not start at the origin.

Rates and their units

Use the graph to record your thinking. Show calculations and include units where needed.

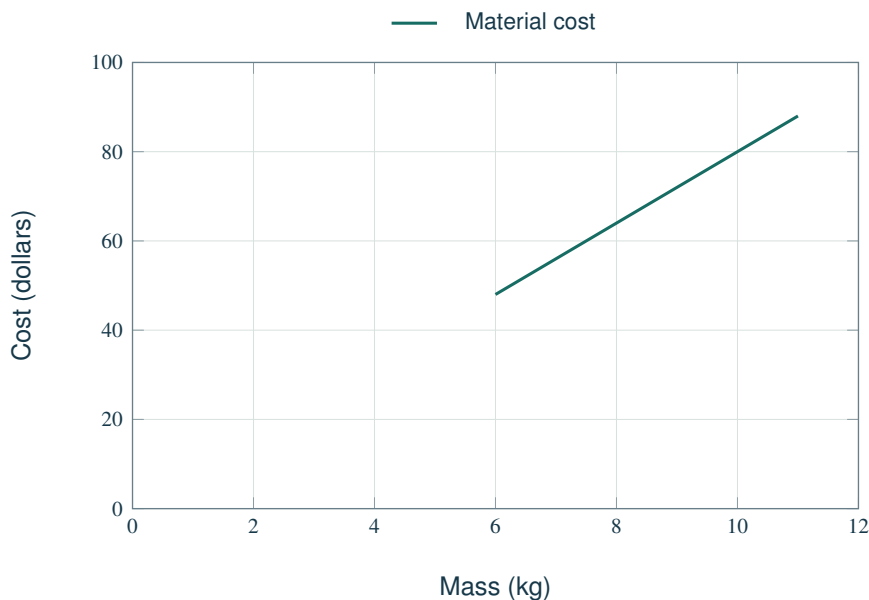
3. A chamber cools from 82°C at 4 min to 58°C at 10 min. Find its signed rate of temperature change.



WORKING / DECISION

Use the temperature and time scales to interpret the signed change.

4. The cost of material rises from \$48 for 6 kg to \$88 for 11 kg. Find the cost per additional kilogram.



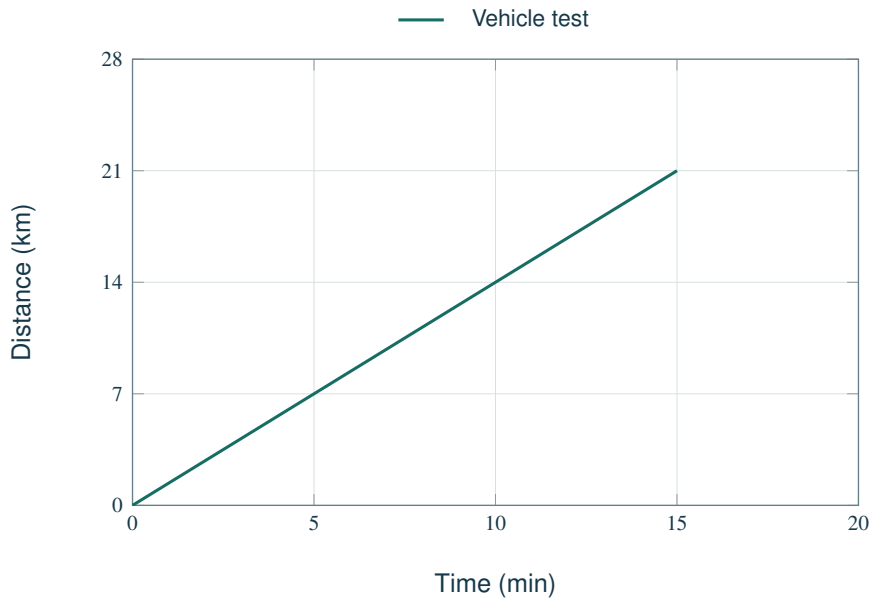
WORKING / DECISION

Compare changes in cost and mass across the same interval.

Convert and compare

Use the graph to record your thinking. Show calculations and include units where needed.

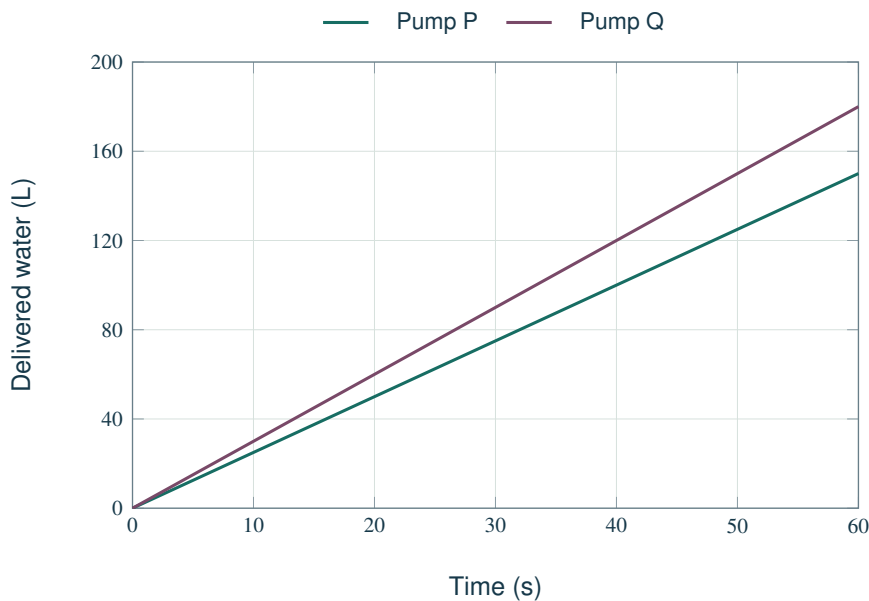
5. A vehicle travels 21 km in 15 min. Find its speed in km/min and km/h.



WORKING / DECISION

The graph uses minutes. Report the same speed in each requested unit.

6. Pump P delivers 2.5 L/s. Pump Q delivers 180 L/min. Which pump has the greater rate and by how much in L/min?



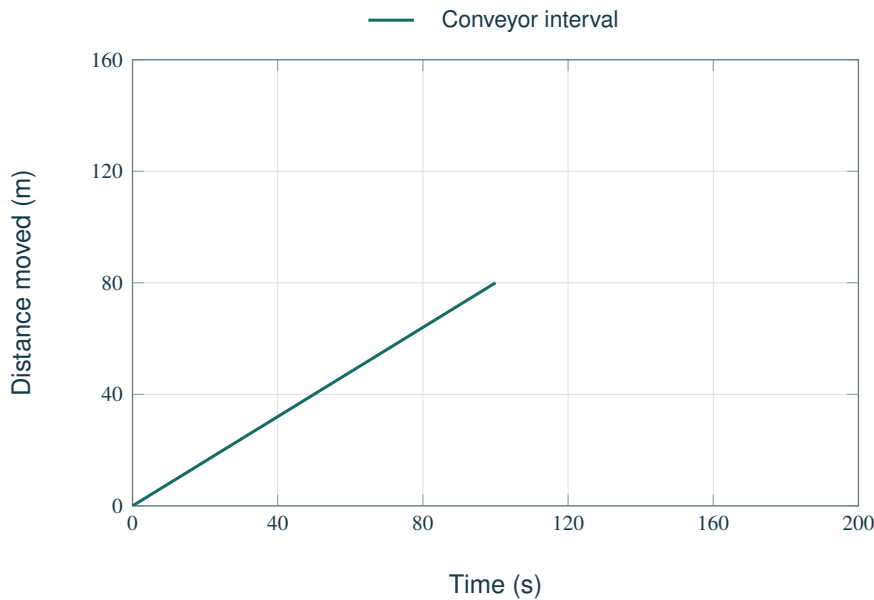
WORKING / DECISION

Both pump outputs are shown on the same time scale for comparison.

Convert and compare

Use the graph to record your thinking. Show calculations and include units where needed.

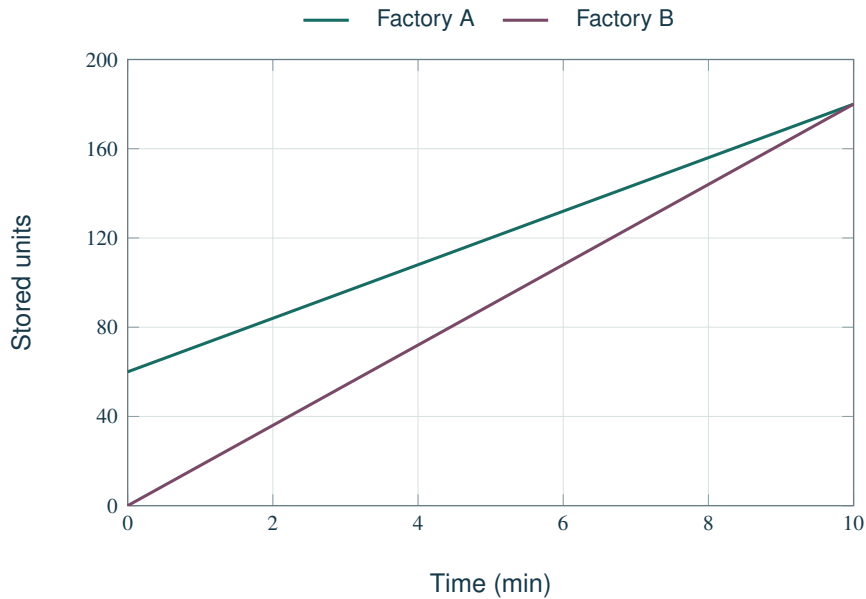
7. A conveyor moves at 0.8 m/s. Express this rate in m/min and find the time required to move an item 144 m.



WORKING / DECISION

Continue the conveyor’s recorded movement yourself to plan the requested journey.

8. The graph shows stored output from two factories. Find each production rate and identify the faster producer, even if it begins with less stock.



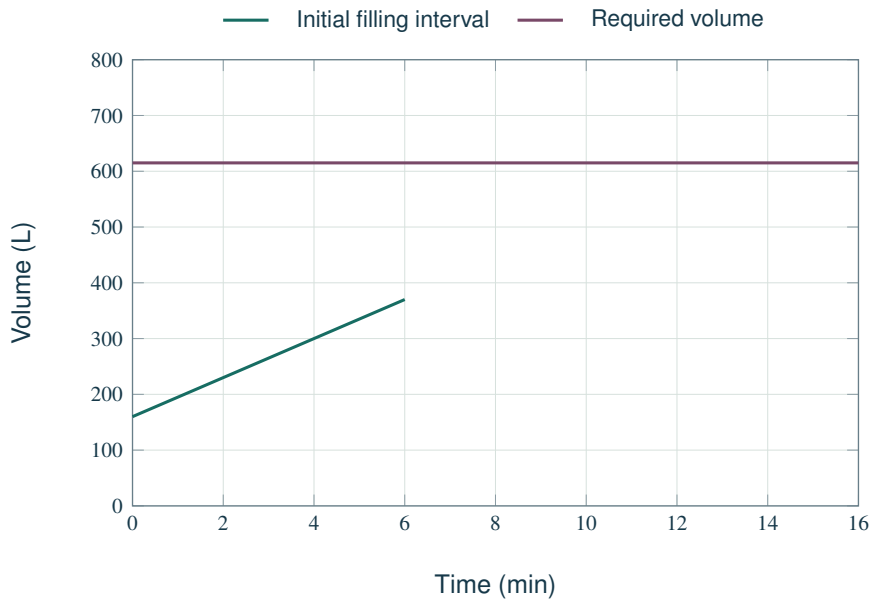
WORKING / DECISION

Read the quantities, scales and labelled line before answering.

Build an operating plan

Use the graph to record your thinking. Show calculations and include units where needed.

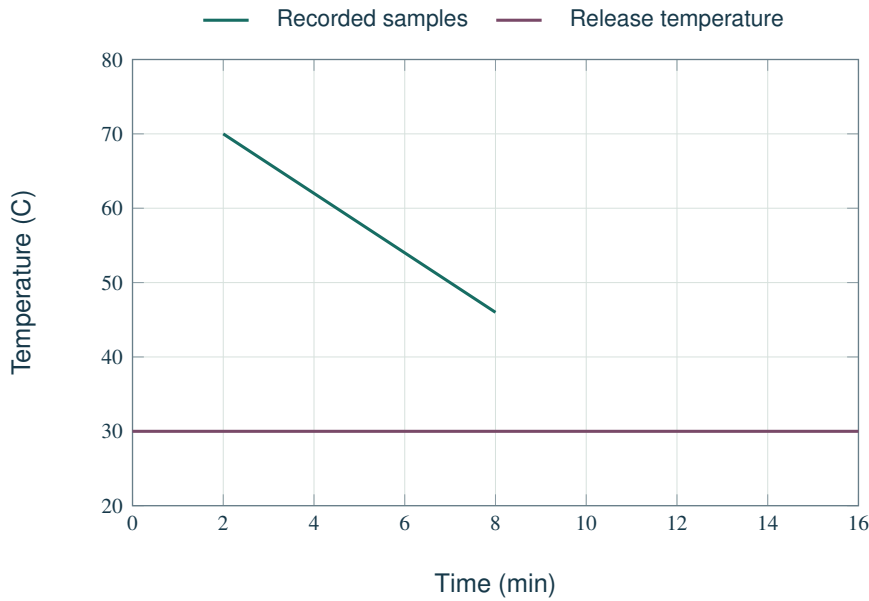
9. A reservoir contains 160 L at time zero and fills at 35 L/min. At what time will it contain 615 L?



WORKING / DECISION

Extend your own filling plan to the required-volume line.

10. A cooling chamber records 70°C at 2 min and 46°C at 8 min. Assuming the same rate continues, when will it reach 30°C from process start?



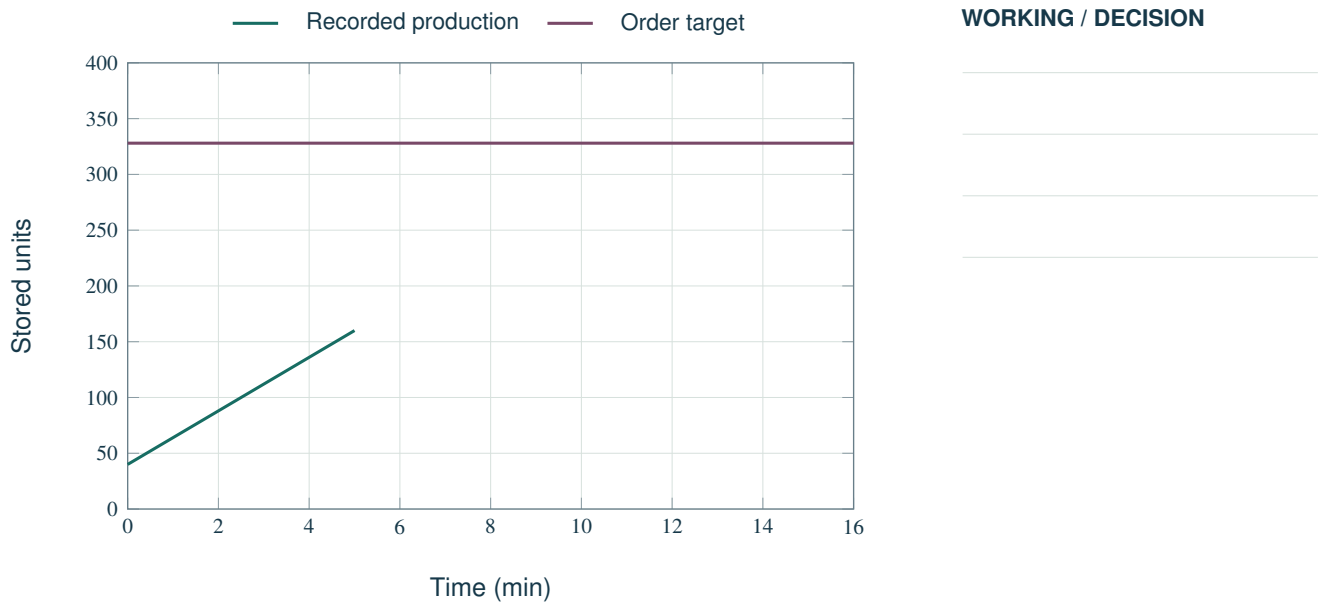
WORKING / DECISION

Only the recorded cooling interval is drawn. Add your proposed release point.

Build an operating plan

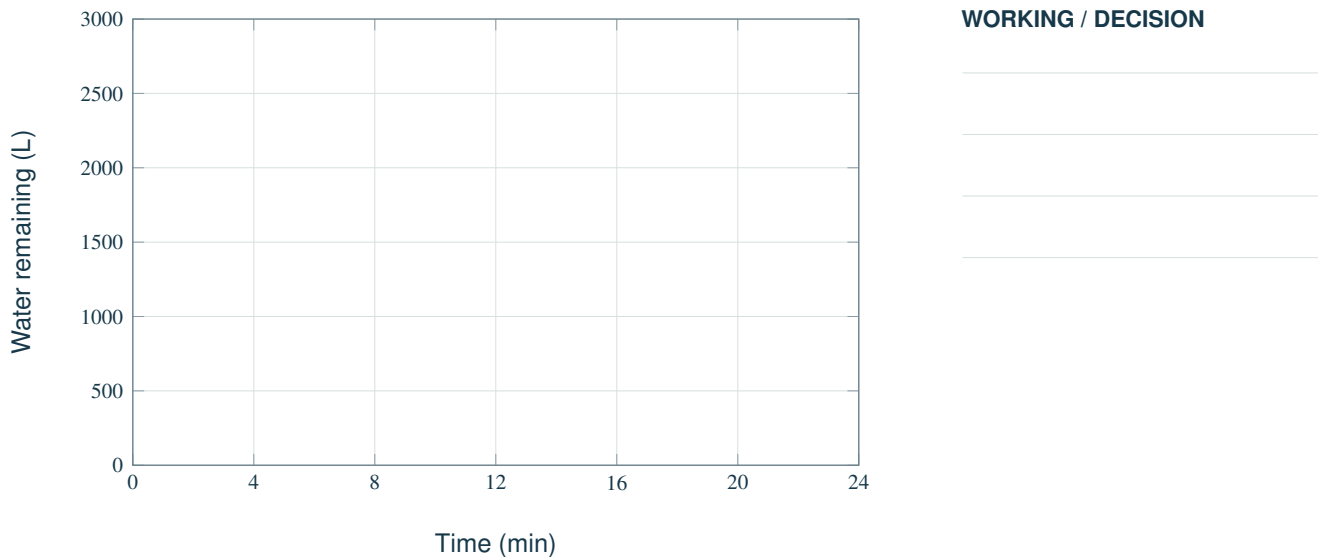
Use the graph to record your thinking. Show calculations and include units where needed.

11. A stock graph begins with 40 units and rises at 24 units/min. An order needs 328 units. Find the completion time. How many units were newly produced?



Distinguish existing stock from newly made units when you extend this line.

12. A basin holds 2700 L and must be empty in 20 min. Budget: \$75. Pump A costs \$40 at 120 L/min. B costs \$65 at 2.5 L/s. C costs \$90 at 12 kL/h. Select a valid pump and give the emptying time.



Sketch a drainage plan for each candidate after making the units consistent. Mark the deadline.

6E / Worked answers

Teacher appendix. Equivalent exact forms are accepted. Use the reasoning to check student work.

1. 45 L/min.

- The volume changes from 140 L to 320 L: a gain of 180 L.
 - Time changes by 4 min; rate = $\frac{180}{4} = 45$ L/min.
-

2. 20 units/min; it ignores the non-zero starting amount.

- Use changes: $\frac{195-75}{9-3} = \frac{120}{6} = 20$.
 - The model has 15 units already present at time zero.
-

3. -4°C/min .

- Temperature change = $58 - 82 = -24^{\circ}\text{C}$.
 - Time interval is 6 min, so rate = $\frac{-24}{6} = -4^{\circ}\text{C/min}$.
-

4. \$8/kg.

- Cost change = $88 - 48 = \$40$; mass change = $11 - 6 = 5$ kg.
 - Rate = $\frac{40}{5} = \$8/\text{kg}$.
-

5. 1.4 km/min; 84 km/h.

- $\frac{21}{15} = 1.4$ km/min.
 - $1.4 \times 60 = 84$ km/h.
-

6. Q is faster by 30 L/min.

- P delivers $2.5 \times 60 = 150$ L/min.
 - $180 - 150 = 30$ L/min.
-

6E / Worked answers

Teacher appendix. Equivalent exact forms are accepted. Use the reasoning to check student work.

7. 48 m/min; 3 min.

- $0.8 \times 60 = 48 \text{ m/min.}$
 - $\text{Time} = \frac{144}{48} = 3 \text{ min.}$
-

8. A: 12 units/min; B: 18 units/min. B is faster.

- A gains $180 - 60 = 120$ units in 10 min.
 - B gains 180 units in 10 min; compare rates 12 and 18.
-

9. 13 minutes.

- Required increase = $615 - 160 = 455 \text{ L.}$
 - $\text{Time} = \frac{455}{35} = 13 \text{ min.}$
-

10. 12 minutes from process start.

- Cooling rate = $\frac{46-70}{8-2} = -4^\circ\text{C/min.}$
 - From 46°C it needs $\frac{16}{4} = 4$ more min; $8 + 4 = 12$.
-

11. 12 minutes; 288 new units.

- New production required = $328 - 40 = 288$ units.
 - $\text{Time} = \frac{288}{24} = 12 \text{ min.}$
-

12. Pump B; 18 minutes.

- A needs $\frac{2700}{120} = 22.5$ min, too long. B gives 150 L/min and needs $\frac{2700}{150} = 18$ min.
 - C gives 200 L/min but exceeds the \$75 budget.
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