

# QQQ – Mechanics Year 1 – Chapter 9 – Time-Series Graphs (Version 1)

**Total Marks: 23**

(23 = Platinum, 21 = Gold, 18 = Silver, 16 = Bronze)

1. The displacement–time graph, **Figure 1**, shows the first 5 seconds of the motion of a car which starts from rest and travels 12 metres.

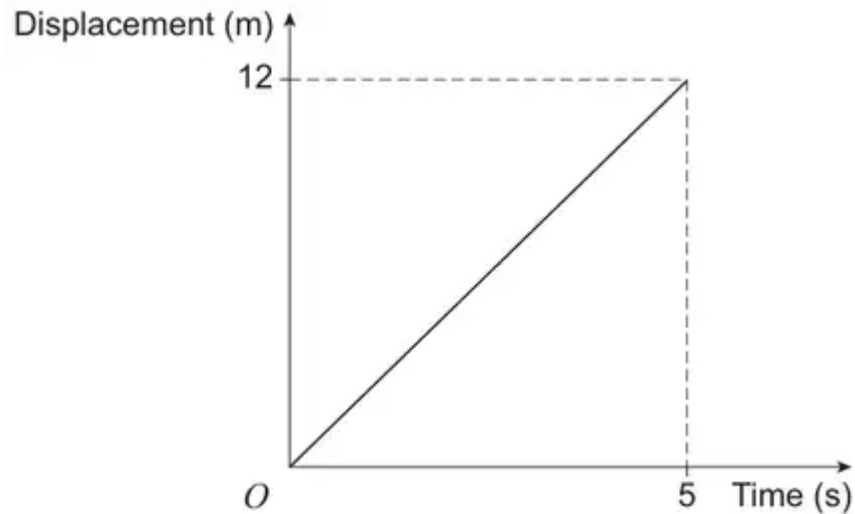


**Figure 1**

- (a) Find the speed of the car. **[1 mark]**
- (b) On **Figure 2**, draw a more realistic displacement–time graph to show the first 5 seconds of motion of the car. **[1 mark]**

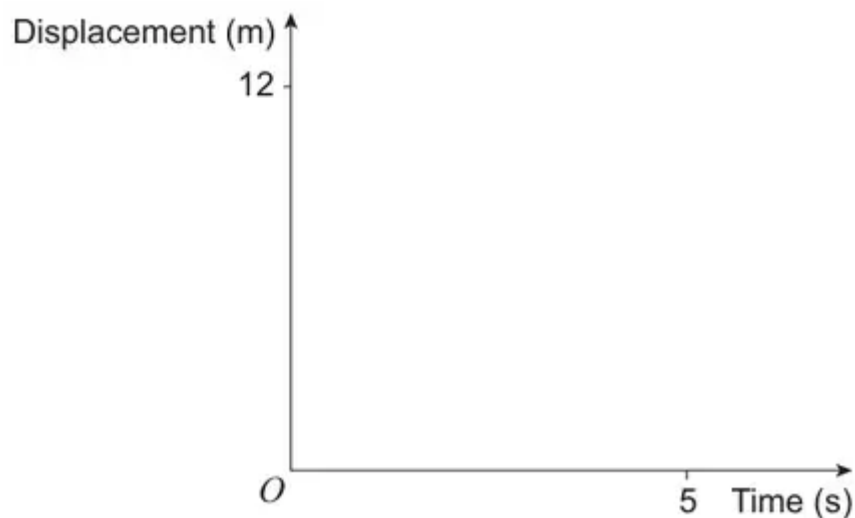


**Figure 2**

**(Total 2 marks)**

2. A car, initially at rest, moves with constant acceleration along a straight horizontal road.

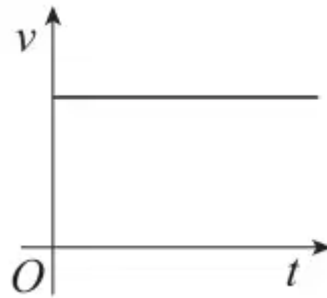
One of the graphs below shows how the car's velocity,  $v \text{ m s}^{-1}$ , changes over time,  $t$  seconds.

Identify the correct graph.

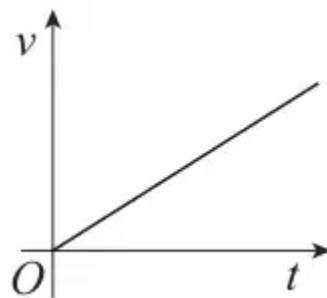
Tick (✓) **one** box.

[1 mark]

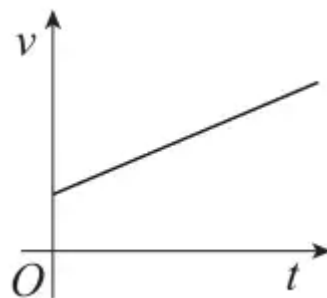
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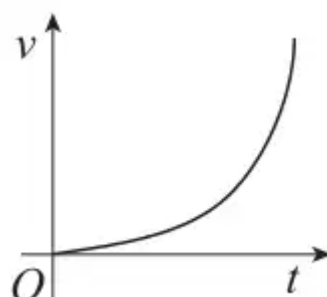
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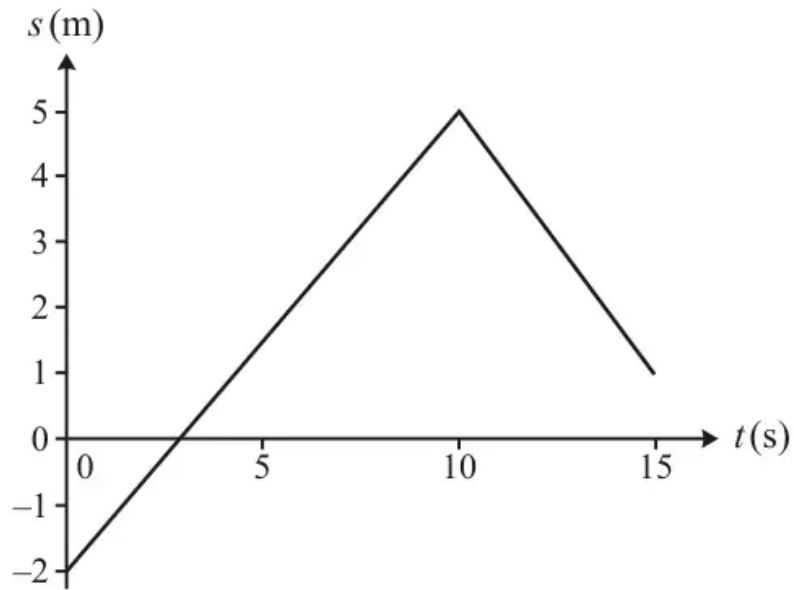


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(Total 1 marks)

**3.** A particle moves along a straight line. The displacement  $s$  m at time  $t$  s is shown in the displacement-time graph below. The graph consists of straight line segments joining the points  $(0, -2)$ ,  $(10, 5)$  and  $(15, 1)$ .

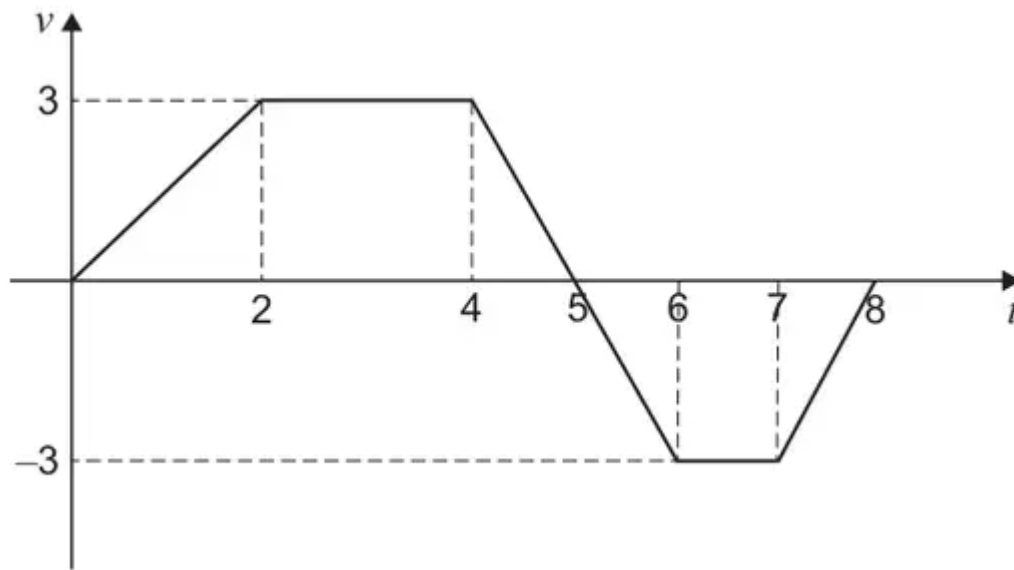


**(a)** Find the distance travelled by the particle in the first 15 s. **[2]**

**(b)** Calculate the velocity of the particle between  $t = 10$  and  $t = 15$ . **[2]**

**(Total 4 marks)**

4. A graph indicating how the velocity,  $v \text{ m s}^{-1}$ , of a particle changes with respect to time,  $t$  seconds, is shown below.



(a) Find the total distance travelled by the particle over the 8 second period shown.

**[3 marks]**

(b) A student claims that

“The displacement of the particle is less than the distance travelled.”

State the range of values of  $t$  for which this claim is true.

**[1 mark]**

**(Total 4 marks)**

5.

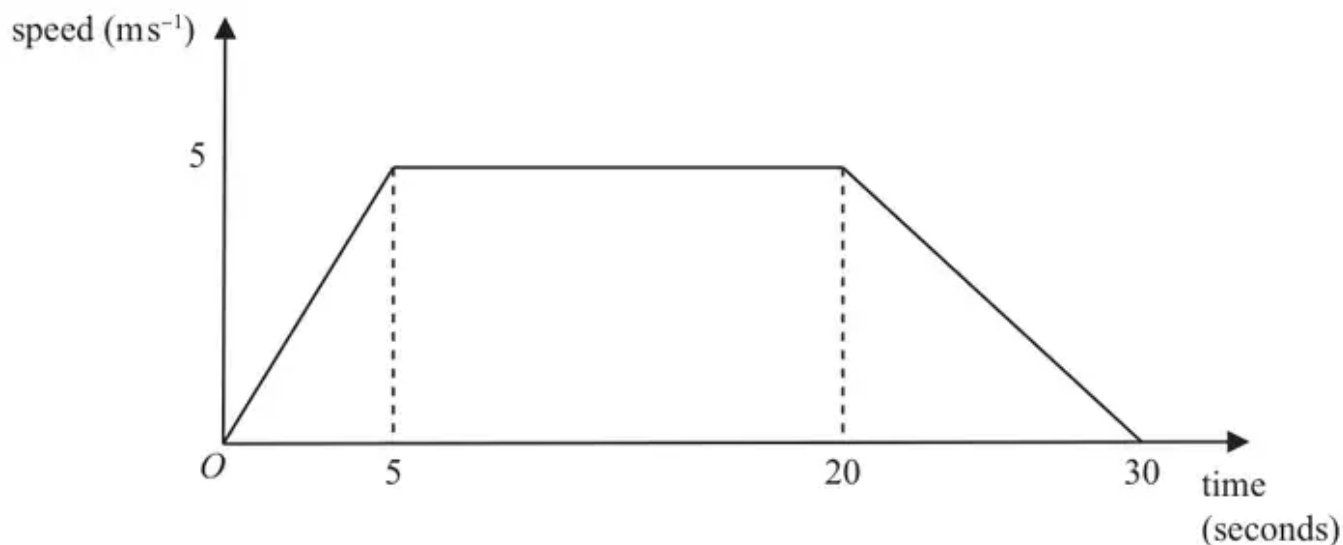


Figure 1

Figure 1 shows the speed-time graph for the journey of a car moving in a long queue of traffic on a straight horizontal road.

At time  $t = 0$ , the car is at rest at the point  $A$ .

The car then accelerates uniformly for 5 seconds until it reaches a speed of  $5 \text{ m s}^{-1}$

For the next 15 seconds the car travels at a constant speed of  $5 \text{ m s}^{-1}$

The car then decelerates uniformly until it comes to rest at the point  $B$ .

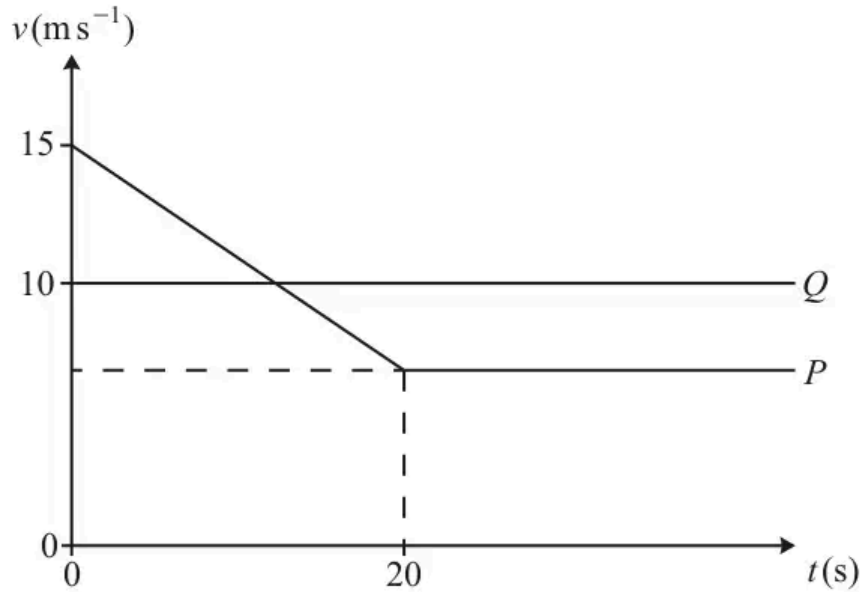
The total journey time is 30 seconds.

(a) Find the distance  $AB$ . (3)

(b) Sketch a distance-time graph for the journey of the car from  $A$  to  $B$ . (3)

**(Total 6 marks)**

6.



The velocity-time graph represents the motion of two cyclists  $P$  and  $Q$  who are travelling along a straight, horizontal road. At time  $t = 0$ , the cyclists pass the same point on the road with  $P$  cycling at  $15 \text{ m s}^{-1}$  and  $Q$  cycling at  $10 \text{ m s}^{-1}$ .

From time  $t = 0$ ,  $P$  cycles with constant deceleration  $0.4 \text{ m s}^{-2}$  for 20 seconds and  $Q$  cycles at a constant velocity of  $10 \text{ m s}^{-1}$ . From  $t = 20$  onwards,  $P$ 's velocity remains constant.

(a) Find the value of  $t$  when  $P$  and  $Q$  have the same velocity. [2]

(b) Determine the value of  $t$  when  $Q$  overtakes  $P$ . [4]

**(Total 6 marks)**

## Solutions

1.

### Mark scheme (a)

| Scheme                                                         | Marks | AO   |
|----------------------------------------------------------------|-------|------|
| Obtains $2.4 \text{ m s}^{-1}$<br>ACF<br>Condone missing units | B1    | 1.1b |
|                                                                | (1)   |      |

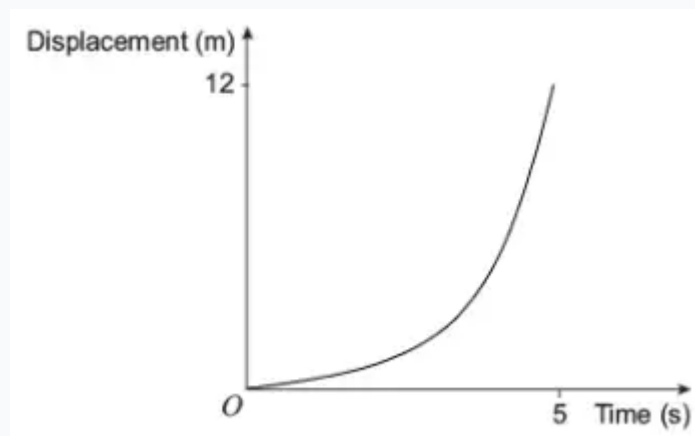
#### Typical solution

$2.4 \text{ m s}^{-1}$

### Mark scheme (b)

| Scheme                                                                                         | Marks     | AO   |
|------------------------------------------------------------------------------------------------|-----------|------|
| Draws a graph which is convex at the origin and reaches or passes through approximately (5,12) | B1        | 3.5c |
|                                                                                                | (1)       |      |
|                                                                                                | (2 marks) |      |

#### Typical solution

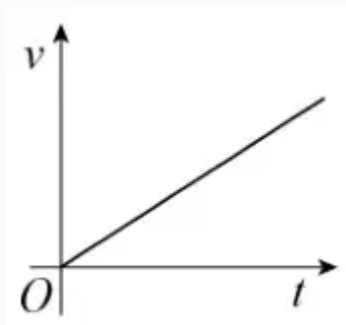


2.

| Scheme | Marks | AO |
|--------|-------|----|
|--------|-------|----|

|                        |                 |      |
|------------------------|-----------------|------|
| Circles correct graph. | B1              | 2.2a |
|                        | <b>(1 mark)</b> |      |

### Typical solution



3.

### Mark scheme (a)

| Scheme               | Marks      | AO   |
|----------------------|------------|------|
| Distance $2 + 5 + 4$ | M1         | 1.1a |
| $= 11 \text{ m}$     | A1         | 1.1b |
|                      | <b>[2]</b> |      |

### Notes

**M1:** adding distances in two or three sections

**A1:** cao

### Mark scheme (b)

| Scheme                             | Marks      | AO   |
|------------------------------------|------------|------|
| velocity $= \frac{5 - 1}{10 - 15}$ | M1         | 1.1a |
| $v = -0.8 \text{ m s}^{-1}$        | A1         | 1.1b |
|                                    | <b>[2]</b> |      |

### Notes

**M1:** Allow sign errors but not wrong way up. So

**A1:** Oe. Mark final answer

4.

**Mark scheme (a)**

| Scheme                                                                             | Marks      | AO   |
|------------------------------------------------------------------------------------|------------|------|
| Finds any area from the graph                                                      | M1         | 3.1a |
| Obtains a fully correct expression for total area above or below axis<br>PI by 4.5 | A1         | 1.1b |
| Obtains 16.5 m<br>Condone missing units                                            | A1         | 1.1b |
|                                                                                    | <b>(3)</b> |      |

**Typical solution**

Area above axis = 10.5

Area below axis = 6

Total distance travelled = 16.5 m

**Mark scheme (b)**

| Scheme                                                                                                       | Marks            | AO   |
|--------------------------------------------------------------------------------------------------------------|------------------|------|
| Obtains $t > 5$<br>Ignore any upper bound of inequality provided it is 8 or more<br>Do not accept $t \geq 5$ | R1               | 2.2a |
|                                                                                                              | <b>(1)</b>       |      |
|                                                                                                              | <b>(4 marks)</b> |      |

**Typical solution**

$$t > 5$$

5.

**Mark scheme (a)**

| Scheme                       | Marks | AO   |
|------------------------------|-------|------|
| Complete method to find $AB$ | M1    | 3.1b |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                    |            |      |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------|
| $= \left(\frac{1}{2} \times 5 \times 5\right) + (5 \times 15) + \left(\frac{1}{2} \times 5 \times 10\right)$<br>or $= \frac{1}{2}(30 + 15) \times 5$<br>or $= \left(\frac{1}{2} \times 5 \times 5\right) + \frac{1}{2}(25 + 15) \times 5$<br>or $= \frac{1}{2}(20 + 15) \times 5 + \left(\frac{1}{2} \times 5 \times 10\right)$<br>or $= (30 \times 5) - \left(\frac{1}{2} \times 5 \times 5\right) - \left(\frac{1}{2} \times 5 \times 10\right)$ | A1         | 1.1b |
| $= 112.5 \text{ (m)}$                                                                                                                                                                                                                                                                                                                                                                                                                              | A1         | 1.1b |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>(3)</b> |      |

### Notes

**M1** Complete method to find the total area under the graph, with the correct structure

triangle + rectangle + triangle

or trapezium

or triangle + trapezium

or trapezium + triangle

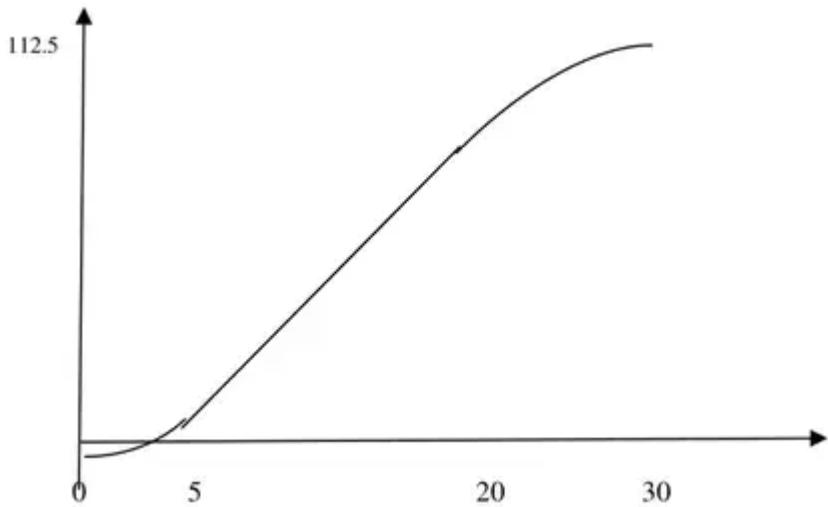
or rectangle – triangle – triangle

**N.B.** They may use *suvat* on one or more of the sections.

**A1** Correct unsimplified expression for the distance  $AB$

**A1** Accept 110 or better

### Mark scheme (b)

| Scheme                                                                               | Marks            | AO   |
|--------------------------------------------------------------------------------------|------------------|------|
|  | B1               | 1.1b |
|                                                                                      | B1               | 1.1b |
|                                                                                      | B1               | 1.1b |
|                                                                                      | <b>(3)</b>       |      |
|                                                                                      | <b>(6 marks)</b> |      |

### Notes

**SC:** If there is a single straight line with a positive gradient, allow B1B0B0, unless it's absolutely clear that it is for the first section only.

If there are just two straight lines, both with positive gradient, allow B1B0B0.

**B1** One section correct. Straight section should be straight with positive gradient. Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative.

**B1** Two sections correct. Straight section should be straight with positive gradient. Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative. Continuous graph but condone incorrect transition between sections.

**B1** All three sections correct and 5, 20, 30 and **their** 112.5 shown. Straight section should be straight with positive gradient. Curves should look like curves with first one having increasing gradient and second one decreasing gradient but staying non-negative. Continuous graph but condone incorrect transition between sections.

**N.B.** Subtract 1 mark from any earned if there is a continuous vertical line at the end.

Ignore any figs when awarding the first two B marks except for the **SC** mentioned above.

6.

### Mark scheme (a)

| Scheme                                | Marks | AO  |
|---------------------------------------|-------|-----|
| $(v_P =) 15 - 0.4t$                   | M1    | 3.4 |
| $15 - 0.4t = 10 \Rightarrow t = 12.5$ | A1    | 1.1 |
|                                       | [2]   |     |

### Notes

**M1:** Attempt to find a linear expression for the velocity of  $P$  for  $t < 20$  so

Condone  $a = 0.4$

May see  $y = 15 - 0.4x$

**A1:** Condone  $x = 12.5$

### Mark scheme (b)

| Scheme                                                 | Marks | AO  |
|--------------------------------------------------------|-------|-----|
| Speed of $P$ at $t = 20$ is given by $15 + (-0.4)(20)$ | M1    | 1.1 |

|                                                                                                                                                  |      |     |
|--------------------------------------------------------------------------------------------------------------------------------------------------|------|-----|
| Distance travelled by $Q$ is given by $10t$                                                                                                      | B1   | 3.4 |
| $10t = \frac{1}{2}(15 + '7')(20) + '7'(t - 20)$<br>$10t = \frac{1}{2}(15 - '7')(20) + '7't$<br>$10T + 20(10) = '7'T + \frac{1}{2}(15 + '7')(20)$ | A1FT | 3.4 |
| $t = 26.7$                                                                                                                                       | A1   | 1.1 |
|                                                                                                                                                  | [4]  |     |

### Notes

**M1:** Attempt to find speed of  $P$  at  $t = 20$

May be seen on the diagram but needs to be seen or used in **(b)**

If correct speed is 7

**B1:** Possibly seen in subsequent working oe

Condone  $10x$

**A1FT:** Correct equation with their speed of  $P$  at  $t = 20$

Condone any inequality rather than equation here

Condone  $x$

Where  $T$  is the time from 20s until  $Q$  overtakes  $P$

Condone  $t$

**A1:** Allow 26.7 or better (26.6666...)

Condone exact value  $\frac{80}{3}$  or  $26\frac{2}{3}$