Speed, Distance, Acceleration

Higher Tier

Equations

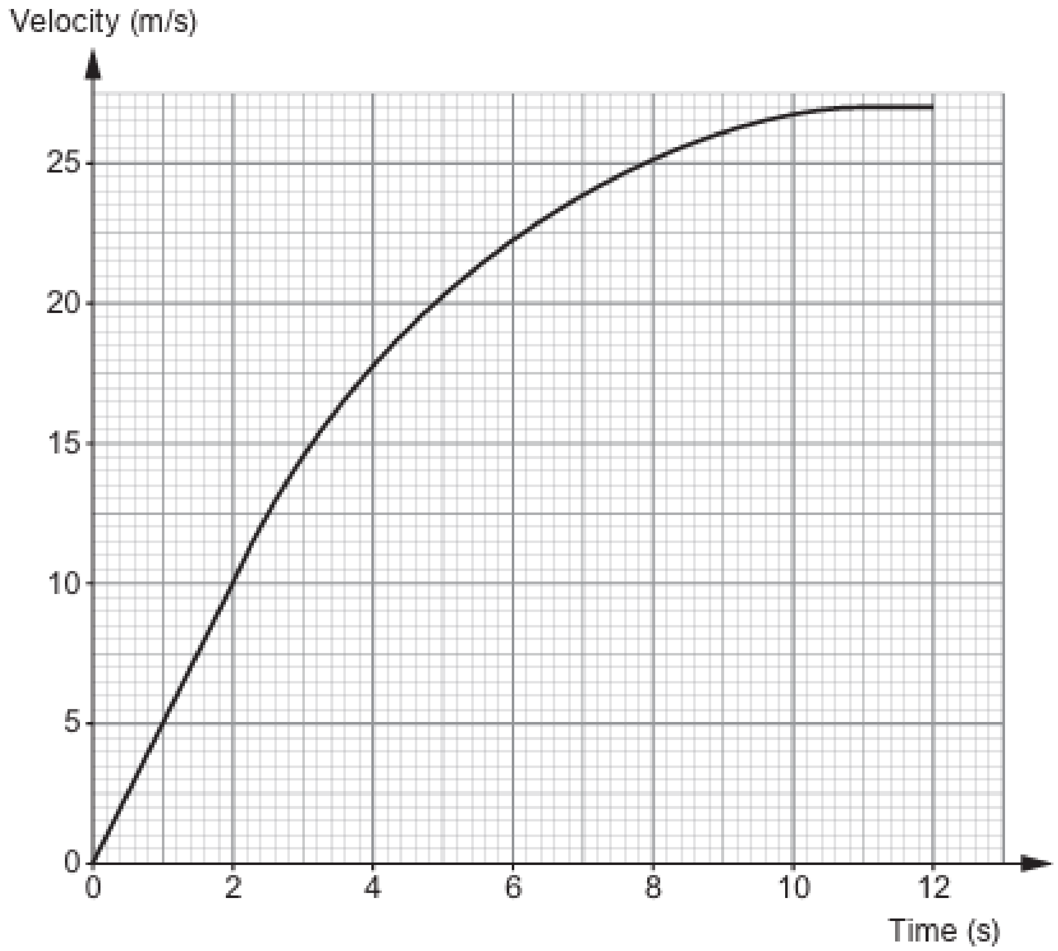
speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
distance travelled = area under a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
kinetic energy = $\frac{\text{mass} \times \text{velocity}^2}{2}$	$\text{KE} = \frac{1}{2} mv^2$
change in potential energy = mass × gravitational field strength × change in height	$\text{PE} = mgh$
force = spring constant × extension	$F = kx$
work done in stretching = area under a force-extension graph	$W = \frac{1}{2} Fx$

SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
µ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^{3}
M	1×10^{6}
G	1×10^{9}
T	1×10^{12}

Manufacturers test new cars on a level track. In order to find out how long it takes them to accelerate to 27 m/s (60 mph), the cars are driven in a straight line at maximum power and the speed recorded. Data for one car is shown on the graph below.



(a) Describe how the **acceleration** changes during the 12 s shown. [2]

....

....

....

(b) By drawing a suitable tangent and using:

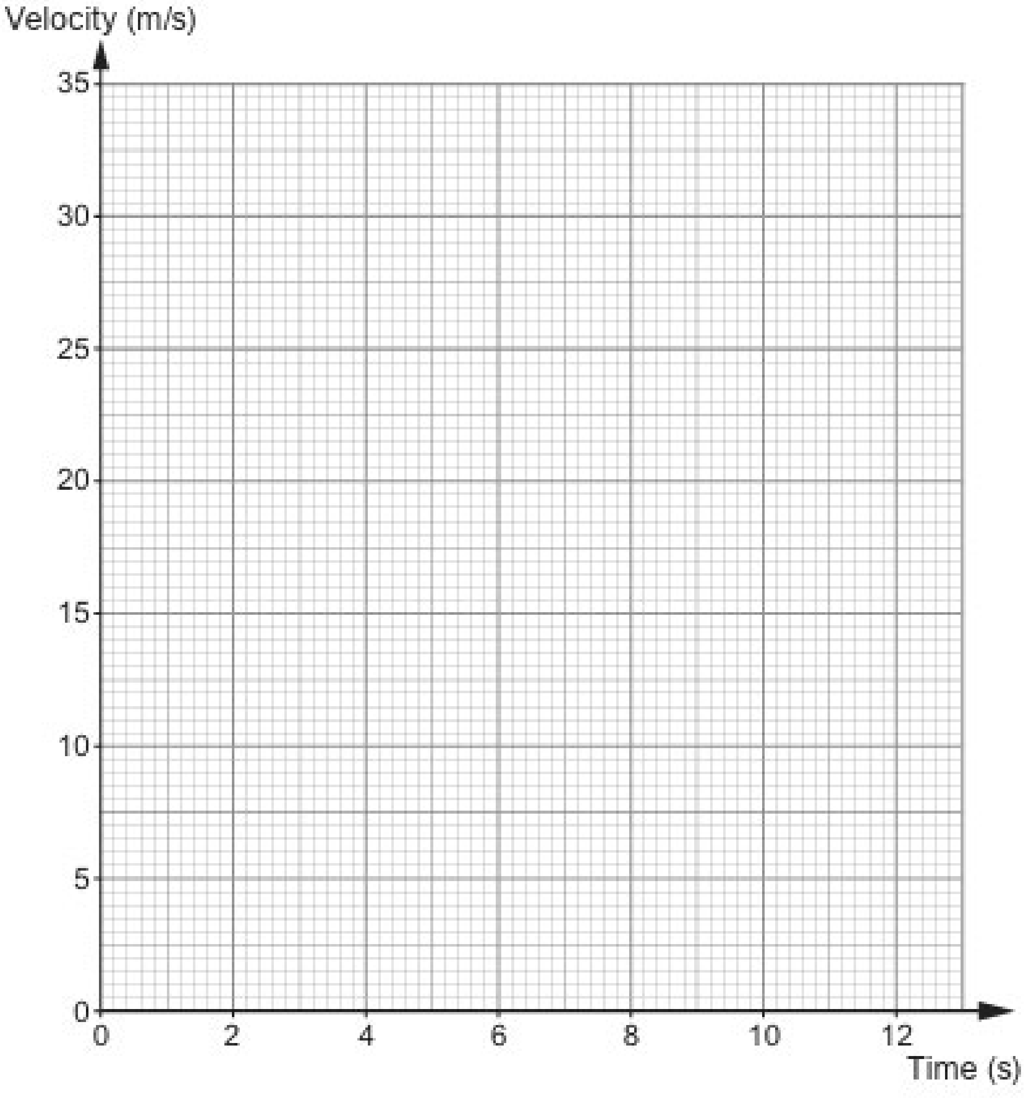
acceleration = gradient of a velocity-time graph

calculate the acceleration of the car at 5 s. Give a unit with your answer. [3]

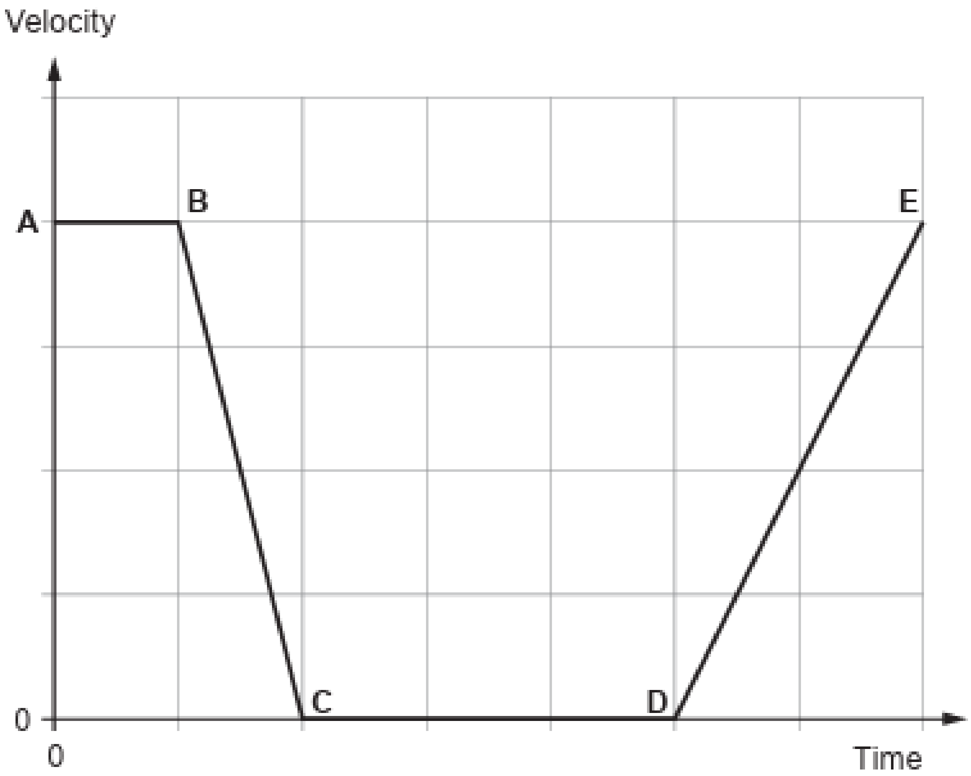
(c) Use an equation from page 2 to estimate the distance travelled by the car in the first 3 s. [2]

Distance = ... m

(d) Another car of the same power and mass but with a more streamlined shape is tested. **Sketch on the grid below** the velocity-time graph for this car. [2]



(a) Since 2017, new bi-modal electric/diesel trains have been introduced to run between Swansea and London.
A velocity-time graph for one of these trains is shown below.



Use information from page 2 to **compare** the distances travelled **and** accelerations for the parts of the journey labelled **AB**, **BC**, **CD** and **DE**. [6 QER]

(b) The diagram shows a 5-carriage bi-modal electric/diesel train.

The table below shows information about two types of bi-modal electric/diesel trains.

Train	Mass ($\times 10^5$ kg)	Maximum speed (m/s)	Standard acceleration (m/s^2)	Standard deceleration (m/s^2)	Emergency deceleration (m/s^2)
5 carriage	2.3	55.8	0.7	1.0	1.2
9 carriage	4.4	55.8	0.7	1.0	1.2

For the journey from Swansea to London **two** of the 5-carriage trains are joined, making a 10-carriage train.
The 10-carriage train has the same speed and acceleration as a 5-carriage train.

(i) State Newton's second law of motion as an equation. [1]

....

(ii) Use information from the table to answer the following questions.

I. Use an equation from page 2 to calculate the resultant force needed to accelerate the 10-carriage train. [2]

Resultant force = ... N

II. Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

to calculate the time taken to accelerate the 10-carriage train from rest to its maximum speed. [2]

Time = ... s

(a) When a car stops the overall stopping distance is made up of two distances: the thinking distance and the braking distance.
Increasing speed increases both the thinking distance and the braking distance.

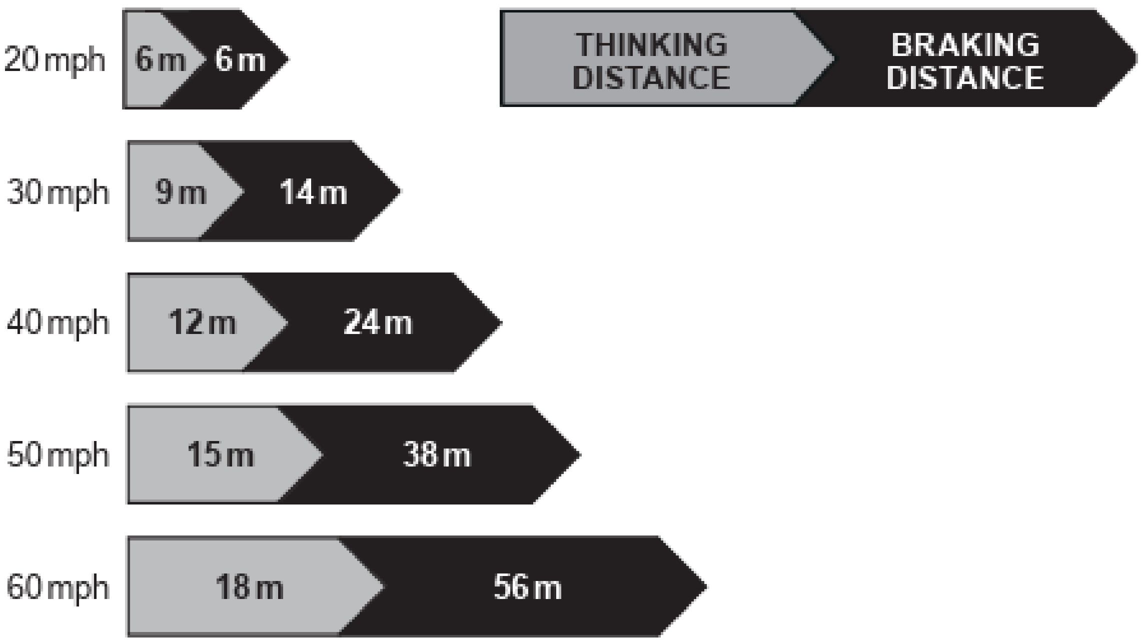
(i) State **one** factor, other than speed, which increases the thinking distance. [1]

....

(ii) State **one** factor, other than speed, which increases the braking distance. [1]

....

(b) The diagram gives information about stopping distances at different speeds.



On a dangerous road, it is proposed to reduce the speed limit from 40 mph to 20 mph.

Bethan makes the following 3 suggestions.

1. The thinking distance will halve.
2. The braking distance will halve.
3. The overall stopping distance will halve.

Explain whether you agree with each suggestion.
Include data from the diagram to support your answer. [3]

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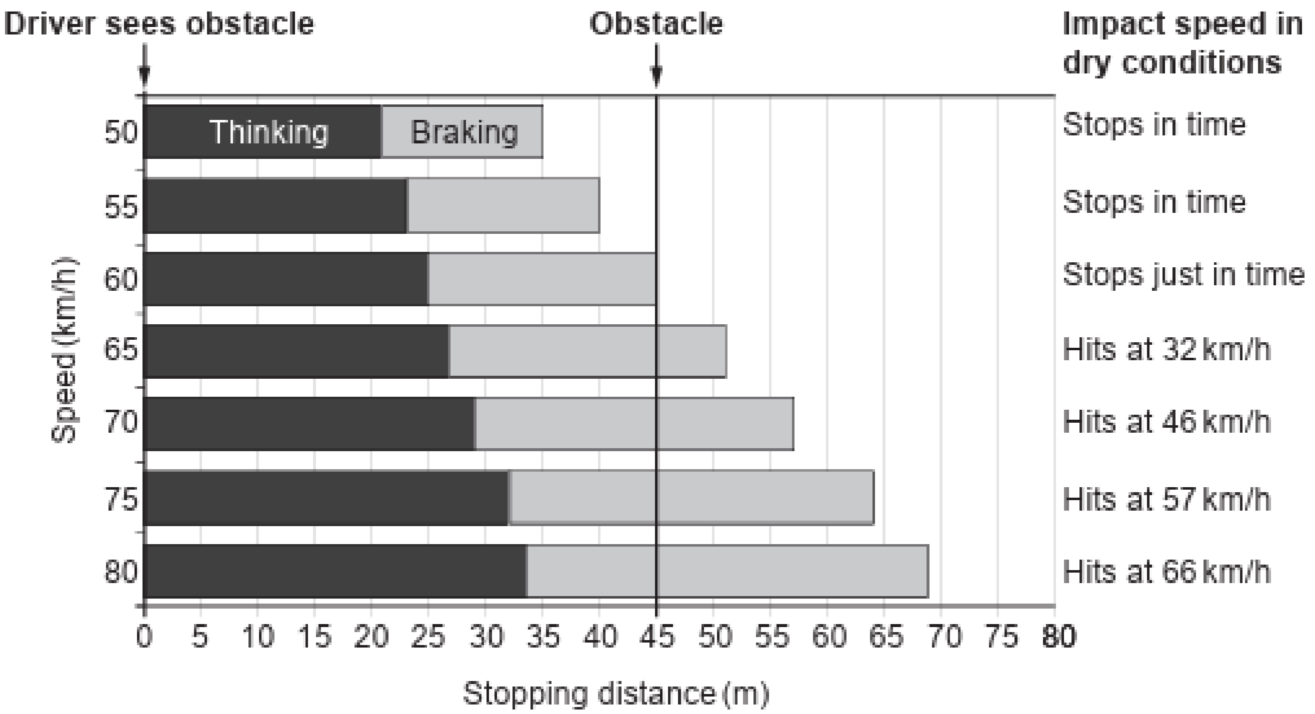
The chart below is used by traffic collision investigators. It gives the thinking, braking and stopping distances of cars driven at different speeds by an alert driver on a dry road.

An alert driver notices an obstacle 45 m away on the road ahead. The position of this obstacle is represented by the dark vertical line. If there is a collision, the chart also shows the impact speed with the obstacle.



(a) State how the following information in the chart for a speed of 70 km/h would compare if the tyre treads on the car are worn below the legal limit. [3]

(i) Thinking distance

....

(ii) Braking distance

....

(iii) Impact speed

....

(b) Use the information opposite to answer the following questions about a car travelling at 60 km/h which **decelerates to a stop**.
(10 km/h = 2.8 m/s)

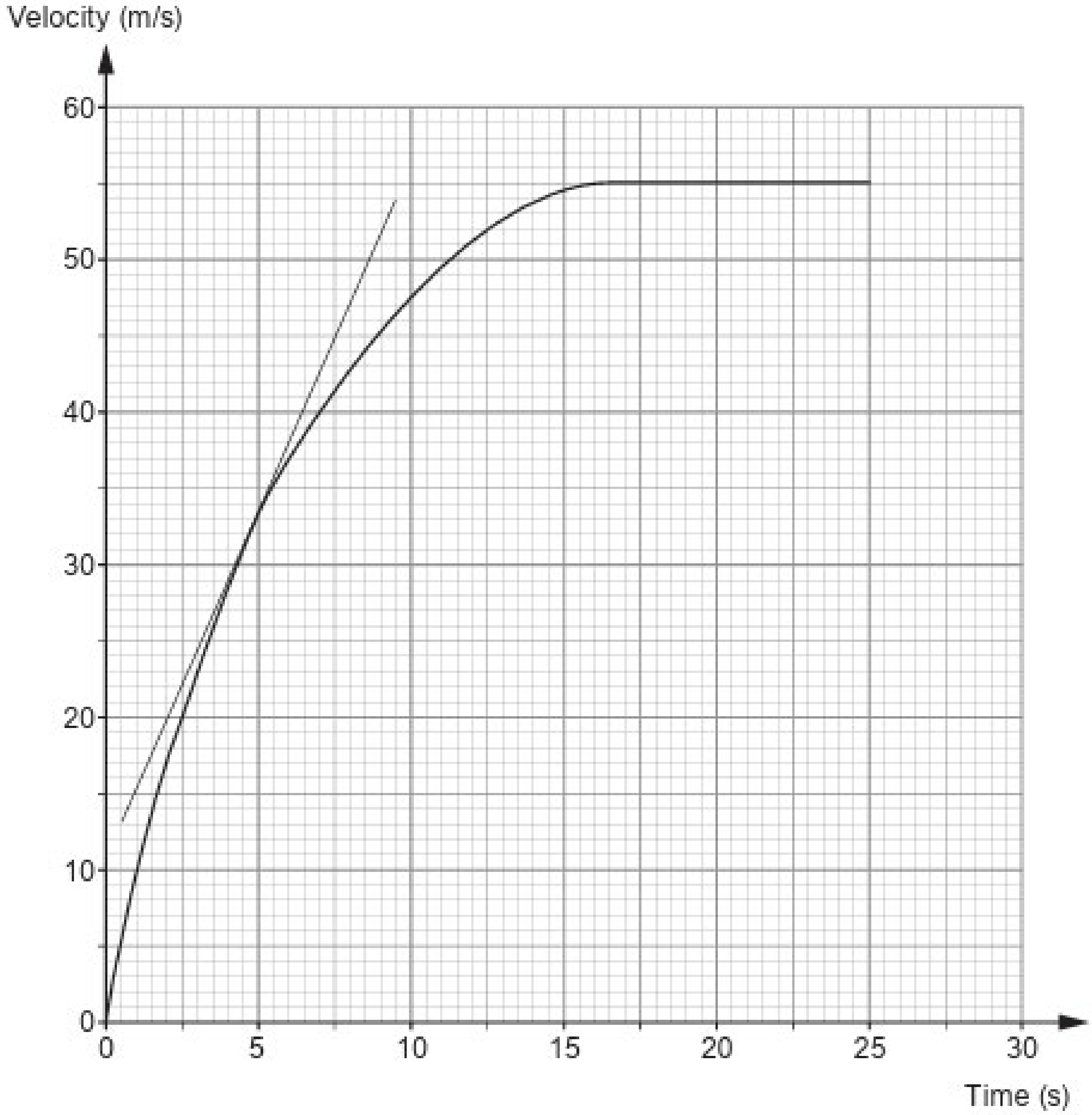
(i) **Complete** the following table. [4]

Initial speed (km/h)	Initial speed (m/s)	Thinking distance (m)	Braking distance (m)	Stopping distance (m)
60	....	....	....	....

(ii) Using the information in the table, calculate the **thinking time** of the driver. [3]

thinking time = ... s

(b) The velocity-time graph below shows the motion of a skydiver.
A tangent has been drawn at 5 seconds.



(i) Acceleration can be calculated by measuring the gradient of a velocity-time graph.
Calculate the acceleration of the skydiver at **5 s** by using the tangent shown. [3]

Acceleration = ... m/s^2

(ii) Describe how the acceleration changes over the 25 s shown. [2]

....

....

....

(iii) Use the graph and an equation from page 2 to estimate the distance travelled by the skydiver in the **first 5 s**. [3]

Distance travelled = ... m

End of questions