Name ……………………………………………

Motion Intervention Booklet

Motion Intervention Booklet

1 **Random uncertainties** have no pattern. They can cause a reading to be higher or lower than the "true value".
Systematic uncertainties have a pattern. They cause readings to be consistently too high or consistently too low.

2 The **uncertainty in repeat readings** is found from "half the range" and is given to 1 significant figure.

	Time / s			
	Trial 1	Trial 2	Trial 3	Mean
	1.23	1.20	1.28	

Mean time = $\frac{1.23 + 1.20 + 1.28}{3}$ = 1.23666666 => 1.24 (original data is to 2dp, so the mean is to 2 dp as well)

Range = 1.20 → 1.28. Uncertainty is ½ × (1.28 – 1.20) = ½ × 0.08 = ± 0.04 s

3 The speed at which a person can walk, run or cycle depends on many factors including: age, terrain, fitness and distance travelled.
The speed of a moving object usually changes while it's moving.
Typical values for speeds may be taken as:

walking:	**1.5**	**m/s**
running:	**3**	**m/s**
cycling:	**6**	**m/s**
sound in air:	**330**	**m/s**

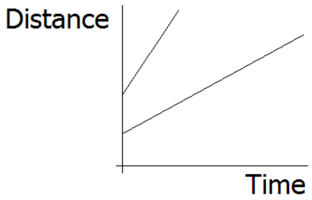
4 **Scalar quantities** have **magnitude only**. Speed is a scaler, eg speed = 30 m/s.
Vector quantities have **magnitude and direction**. Velocity is a vector, eg velocity = 30 m/s north.
Distance is how far something moves, it doesn't involve direction.
The **displacement** at a point is how far something is from the start point, in a straight line, including the direction. It doesn't make any difference how far the object has moved in order to get to that point.

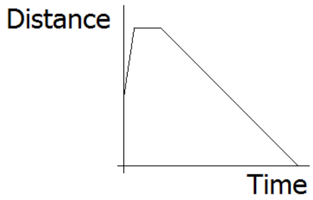
Scalars	Vectors	
Speed	Velocity	Momentum
Distance	Displacement	
Energy	Force	
Time	Acceleration	

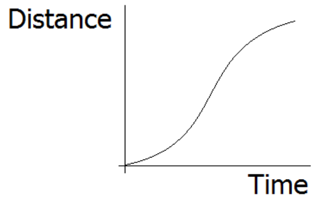
5 A object moving in a circle at a constant speed is not moving with a constant velocity.
The magnitude of the velocity is the same, but the direction of the velocity is changing, to the velocity is changing.

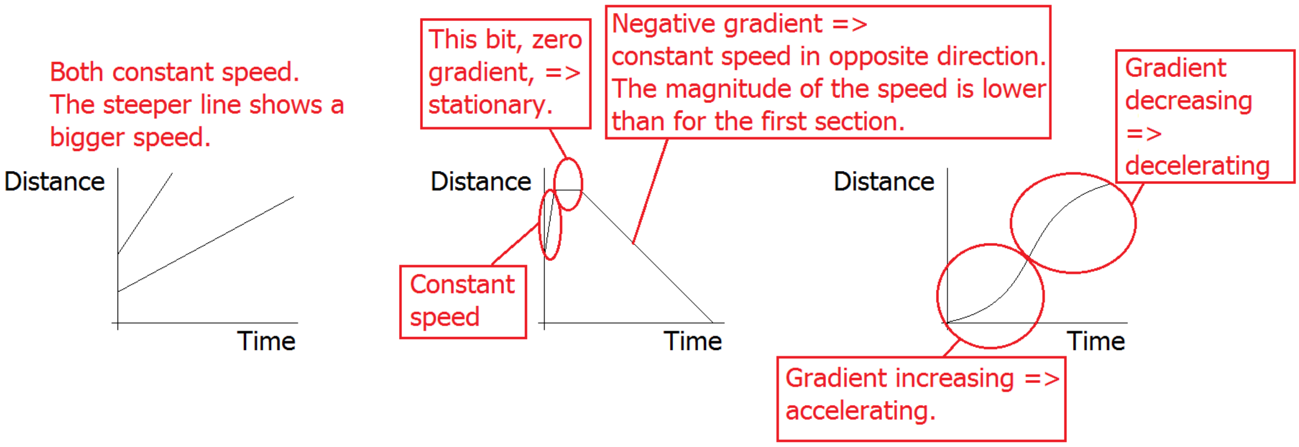
6a If an object moves along a straight line, the distance travelled can be represented by a distance-time graph.

The gradient of a distance-time graph represents speed.

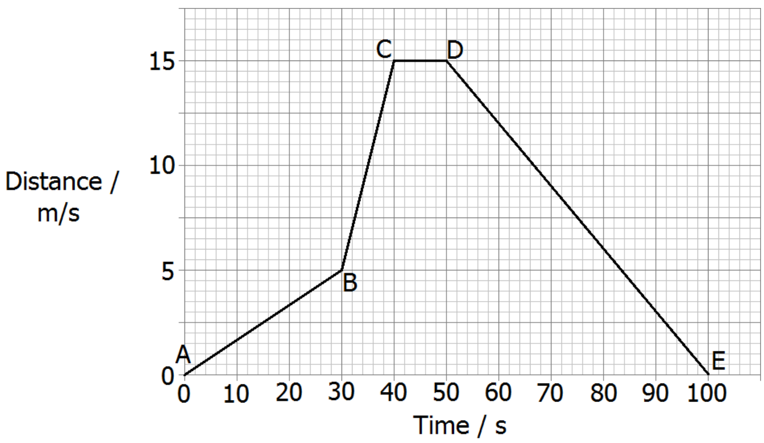








6b

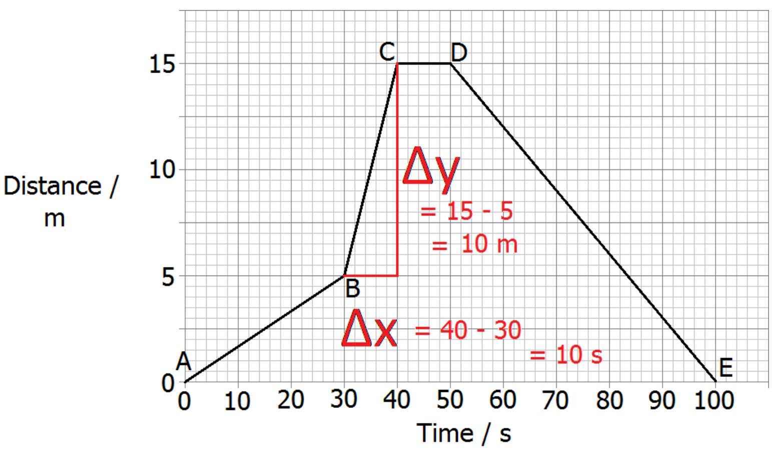


AB => constant speed

BC => greater constant speed

CD => stationary

DE=> constant speed, opposite direction to initial speed.



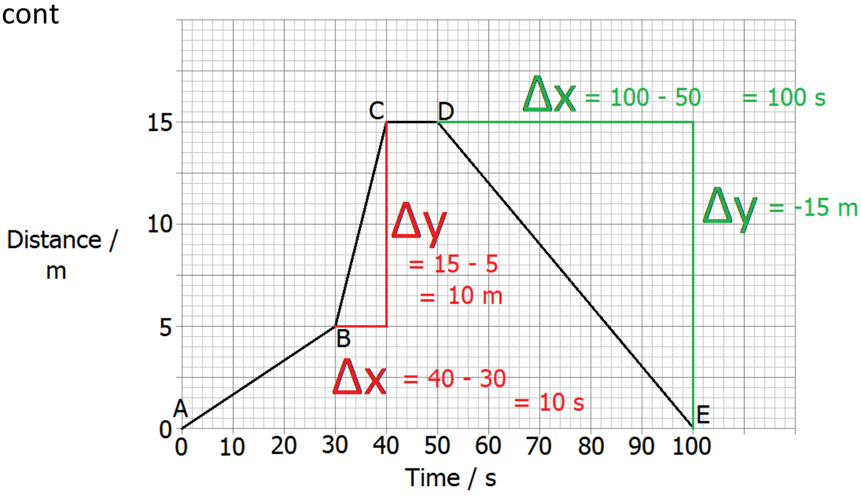
Velocity B → C

= gradient of BC part

$$= \frac{\Delta y}{\Delta x} = \frac{10\ m}{10\ s}$$

= 1 m/s.

6b cont



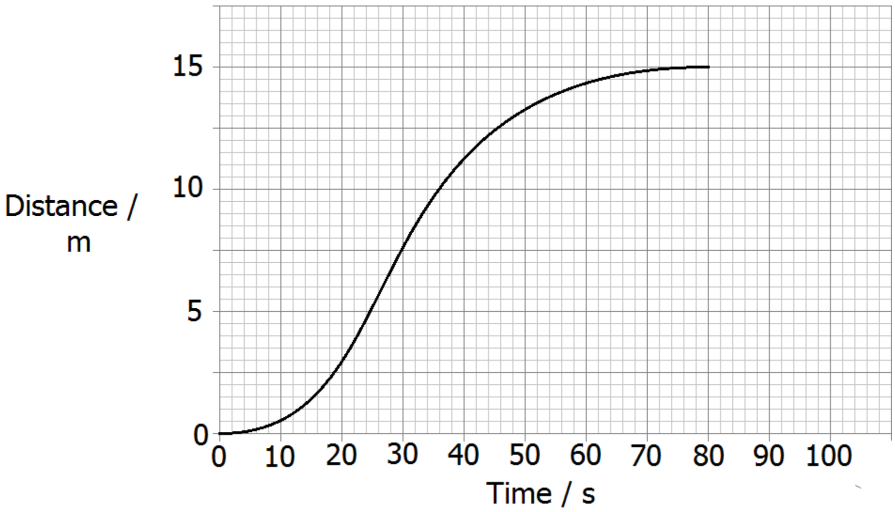
Velocity D → E

= gradient DE part

$= \frac{\Delta y}{\Delta x} = \frac{-15\ m}{50\ s}$

= - 0.30 m/s

7 **The distance-time graph** for an object that has **non-uniform motion** can be used to work out **average speed**.



Average speed over 80 s:

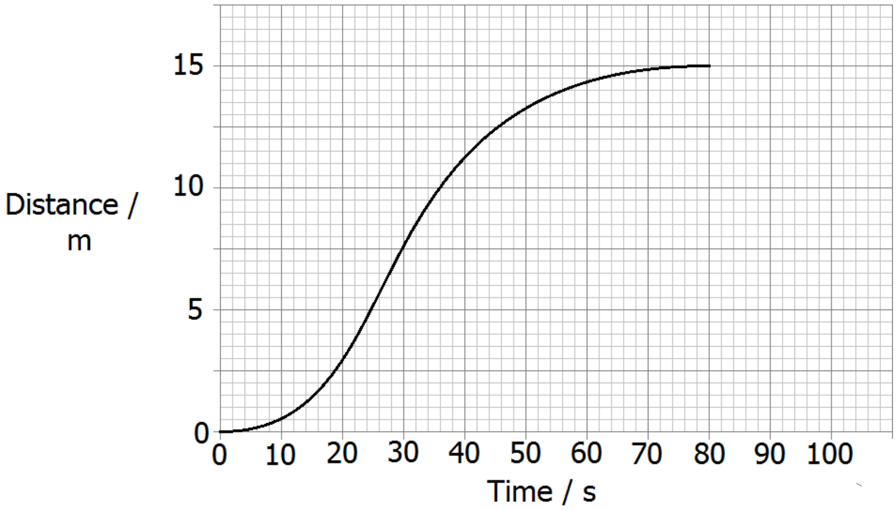
Speed = $\frac{\text{distance}}{\text{time}}$

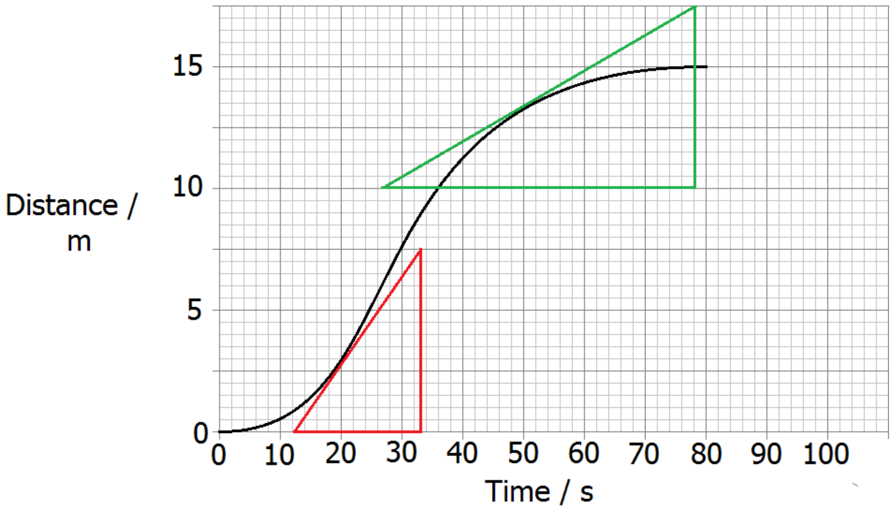
$= \frac{15\ m}{80\ s}$

= 0.19 m/s

8 HT ONLY

If an object is accelerating, its **speed at any particular instant** can be determined by drawing **a tangent** and measuring the gradient of the distance-time graph at that time.





Velocity at 20 seconds:

= gradient of tangent at 20 s

Δy = 7.5 m

Δx = 33 – 12
= 21 s

$= \frac{\Delta y}{\Delta x} = \frac{7.5 \text{ m}}{21 \text{ s}}$
= 0.35 m/s

Velocity at 50 seconds = gradient of tangent at 50 seconds.

Δy = 17.5 – 10

= 7.5 m

Δ x = 78 - 27

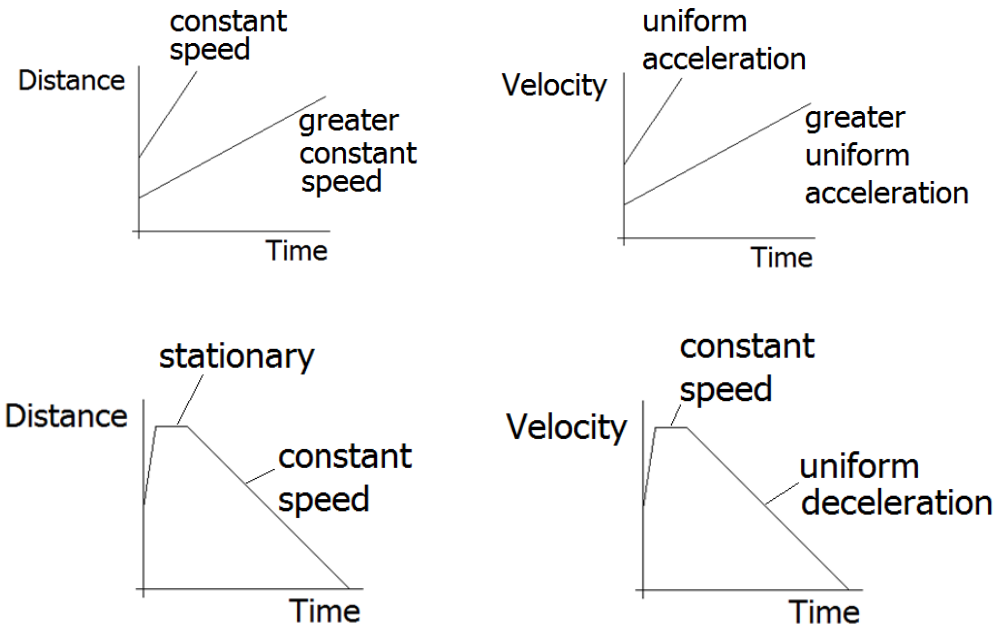
= 51 s

Gradient of tangent at 50 s = $\frac{\Delta y}{\Delta x} = \frac{7.5 \text{ m}}{51 \text{ s}}$
= 0.15 m/s

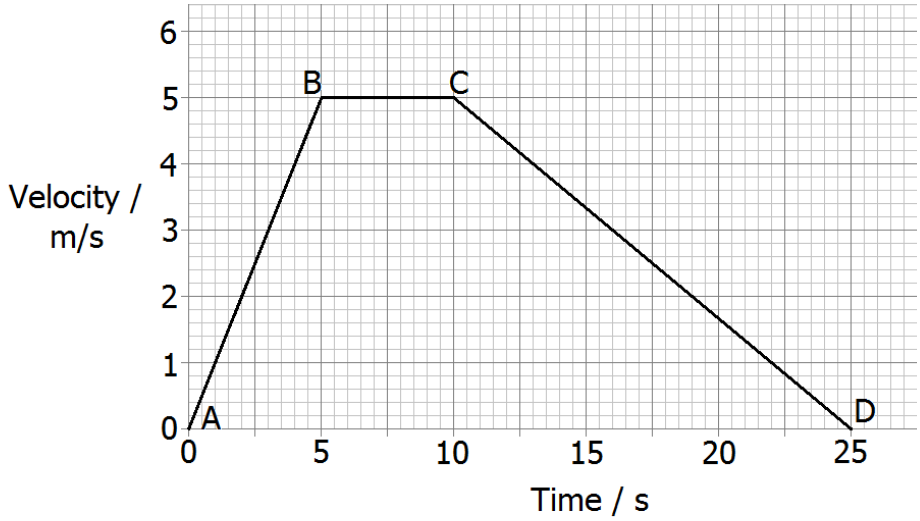
[NB: really the tangents drawn above should be longer and the triangles for working out the gradients should be bigger. They're drawn smaller on here so that they don't overlap with each other.]

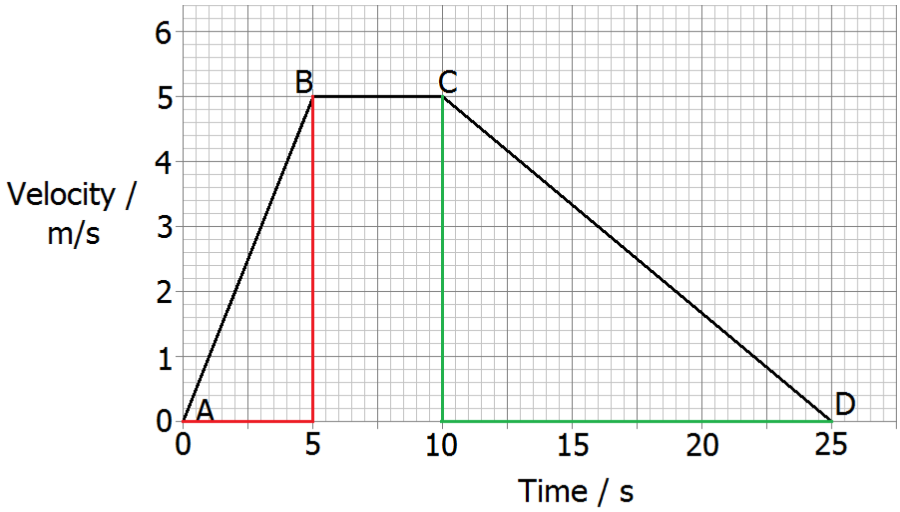
9 The **acceleration** of an object is how much its velocity changes per second.
"An acceleration of 5 m/s^2" means "the velocity changes by 5 m/s every second".
The SI unit for acceleration is metre per second squared …
… (or metre per second per second), m/s^2.
The SI unit for change in velocity is metre per second, m/s.
The SI unit for time is the second, s.

10 The gradient of a velocity-time graph represents acceleration.



10 cont





Acceleration A → B:

= gradient AB part:

$\Delta y = 5$ m/s

$\Delta x = 5$ s

gradient $= \frac{\Delta y}{\Delta x} = \frac{5 \text{ m/s}}{5 \text{ s}}$

$= 1 \text{ m/s}^2$

Acceleration C → D: = gradient of CD part: $\Delta y = -5$ m/s.

$\Delta x = 15$ s

gradient $= \frac{\Delta y}{\Delta x} = \frac{-5 \text{ m/s}}{15 \text{ s}}$

$= -0.33 \text{ m/s}^2$

11 HT ONLY

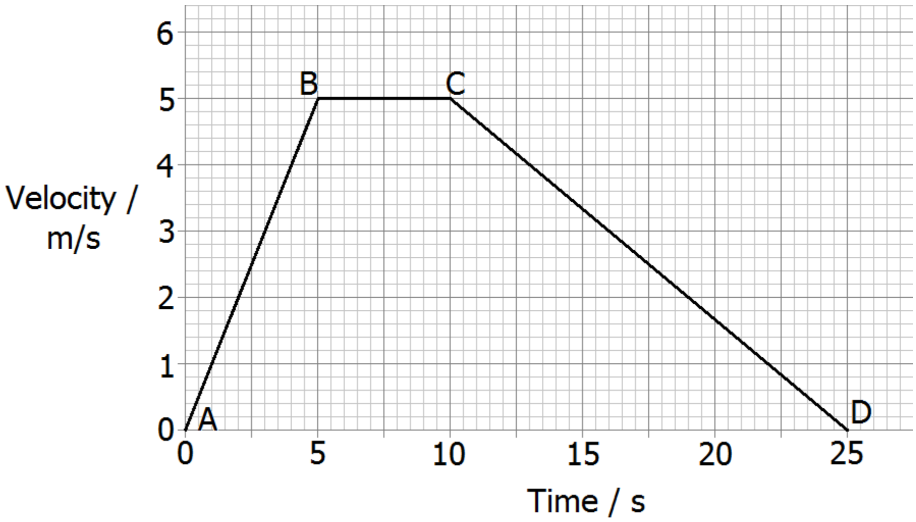
The area under a velocity-time graph gives the distance travelled (or the displacement, depending how it is calculated).

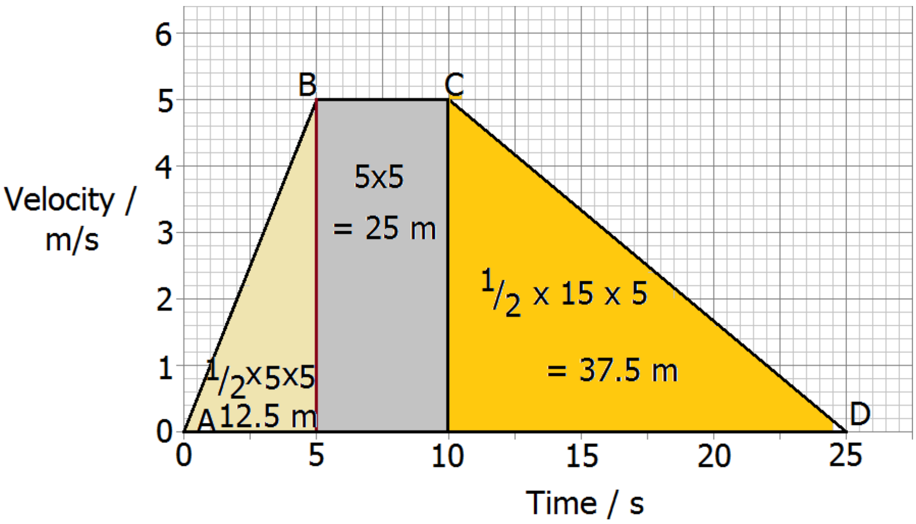
The area under a graph may be determined by using

(1) area of a rectangle = length × width

(2) area of a triangle = ½ × base × height

(3) (if the area's under a curve) counting the squares, working out what distance each square represents, and multiplying them together.





Distance moved AB:
= area under AB
= ½ × 5 × 5
= 12.5 m

Distance moved BC:
= area under BC
= 5 × 5
= 25 m

Distance moved CD:
= area under CD:
= ½ × 15 × 5
= 37.5 m

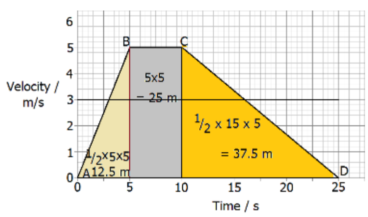
Total distance moved
= 12.5 + 25 + 37.5
= 75 m

Average speed over the 25 of movement:

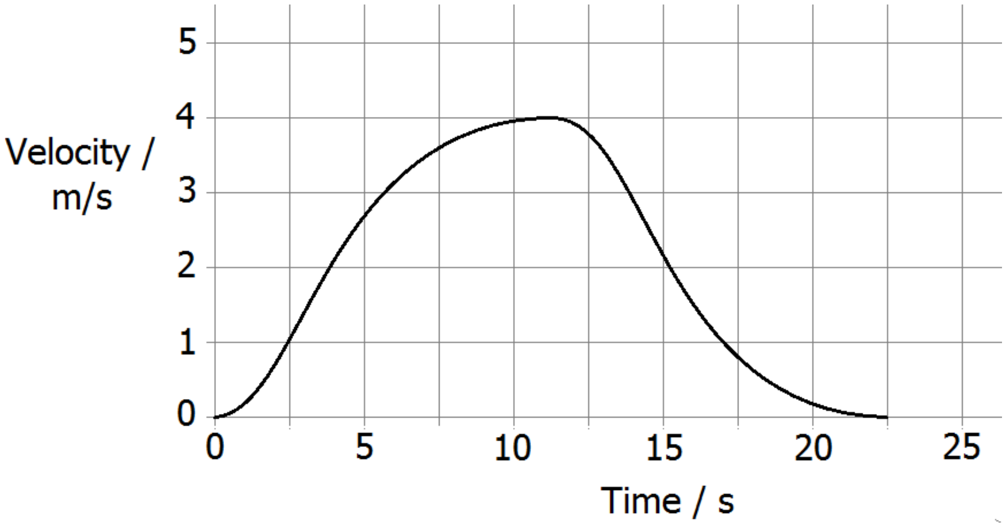
Average speed = $\frac{\text{distance moved}}{\text{time}}$ = $\frac{75\text{ m}}{25\text{ s}}$

= 3 m/s

ie a constant 3 m/s would have covered the same distance in the same time.



(3) (if the area's under a curve) counting the squares, working out what distance each square represents, and multiplying them together.

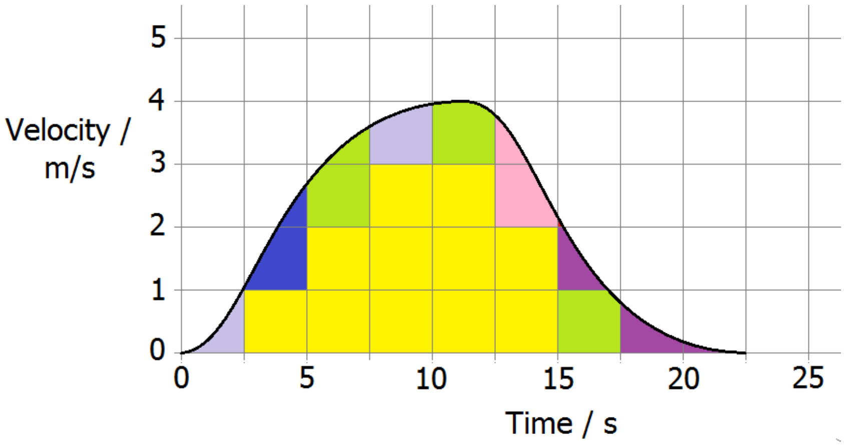


Distance moved in during the motion? **Average speed?**

Distance moved
= area under the curve.

11 "whole squares"
&
"bits of squares"
equivalent to 5 whole.

=> 16 squares.



Each square has an "area" of 2.5 seconds × 1 m/s = 2.5 m.

So distance moved = area under curve = 16 × 2.5 = 40 m.

Average speed = $\frac{\text{distance moved}}{\text{time}} = \frac{40\text{ m}}{22.5\text{ s}}$ = 1.78 m/s

12 The **equations** used in this topic are:

distance = speed × time $s = vt$

acceleration = $\frac{\text{change in velocity}}{\text{time taken for change}}$ $a = \frac{\Delta v}{t}$

$(\text{final velocity})^2 – (\text{initial velocity})^2 = 2 \times \text{acceleration} \times \text{distance}$ $v^2 – u^2 = 2as$

12a A car increases speed from 10 m/s to 20 m/s in 5 seconds.
Calculate its acceleration.

12b A car has an initial speed of 25 m/s then decelerates to a stop in 5 seconds.
Calculate its deceleration.

12c A car accelerates from rest to 15 m/s over a distance of 30 m.
Calculate its acceleration.

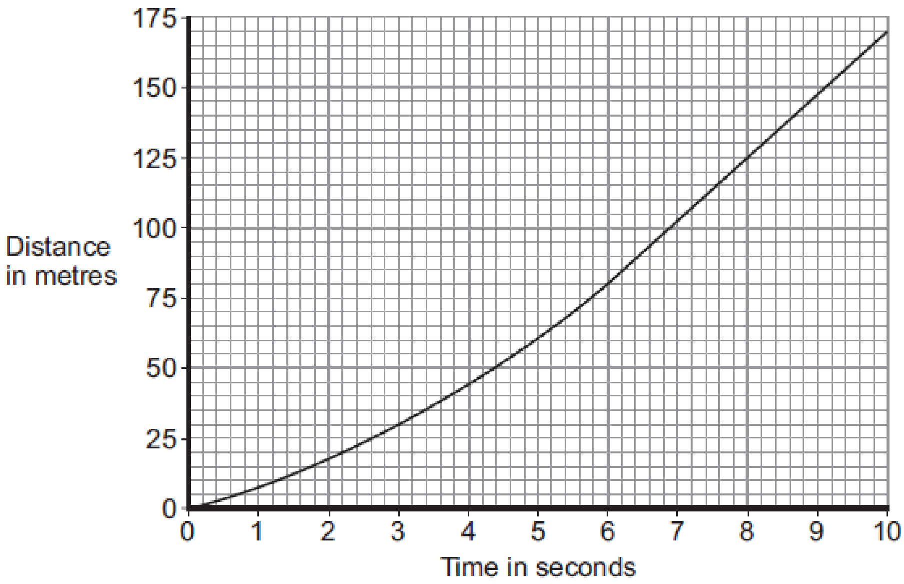
12d A car is moving at 30 m/s when its brakes are applied and it decelerates uniformly at 0.2 m/s^2 over a distance of 50 m.
Calculate the speed of the car after its deceleration.

GCSE Style Questions

Q13 PH2HP June '15 q4

Figure 4 shows the distance–time graph for the car in the 10 seconds before the driver applied the brakes.

Figure 4



13a) Use **Figure 4** to calculate the maximum speed the car was travelling at.
Show clearly how you work out your answer.

[2 marks]

13b) Describe the motion of the car over the first 6 seconds.

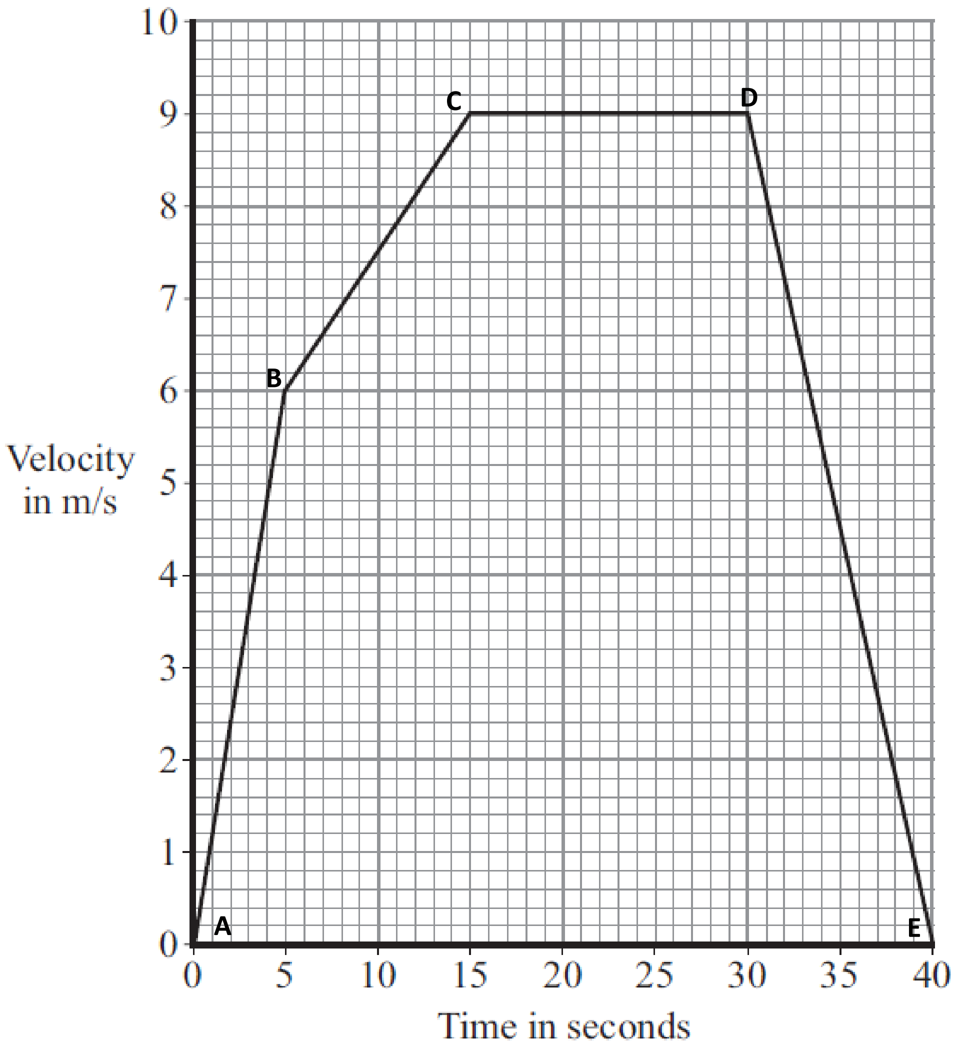
.... [1]

13c) Use the graph to determine the speed of the car at 2 seconds.

[3]

Q14 PHY2H Jan '10 q2

(b) The graph shows how the velocity of the cyclist changes with time.



b) Describe the motion of the cyclist at the different stages of her journey.

AB: ....

BC: ....

CD: ....

DE: .... [4]

ci) Calculate the acceleration of the cyclist between 5 seconds and 15 seconds.

[3]

cii) Calculate the distance travelled by the cyclist in the 40 second journey shown.

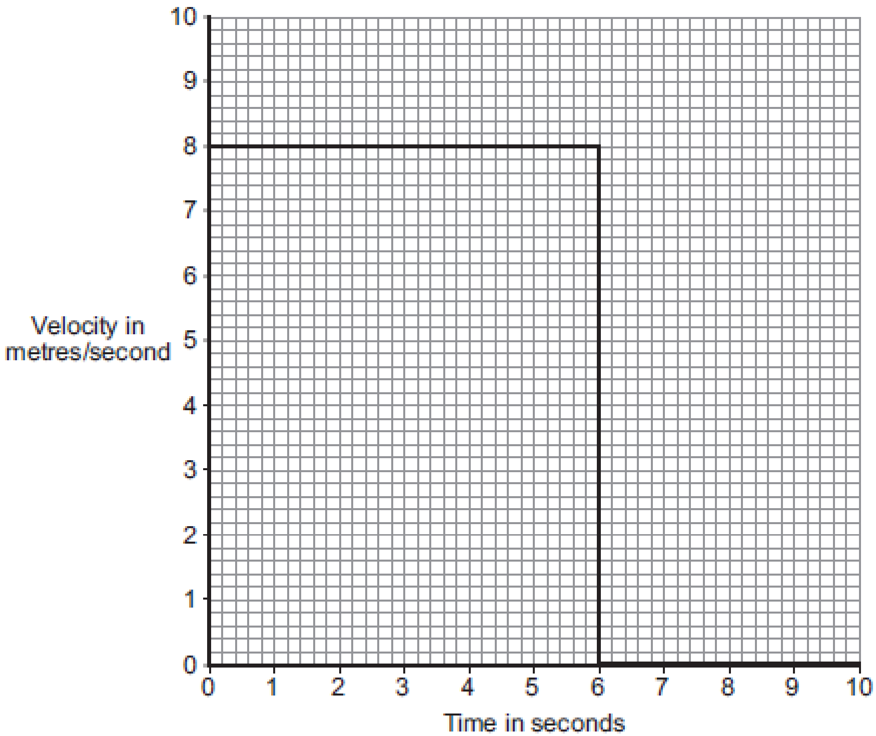
[3]

ciii) Calculate the cyclist's average speed over the whole journey.

[2]

Q15 PHY2H June '11 q5

The diagram shows the velocity-time graph for an object over a 10 second period.



(a) Use the graph to calculate the distance travelled by the object in 10 seconds.

Show clearly how you work out your answer.

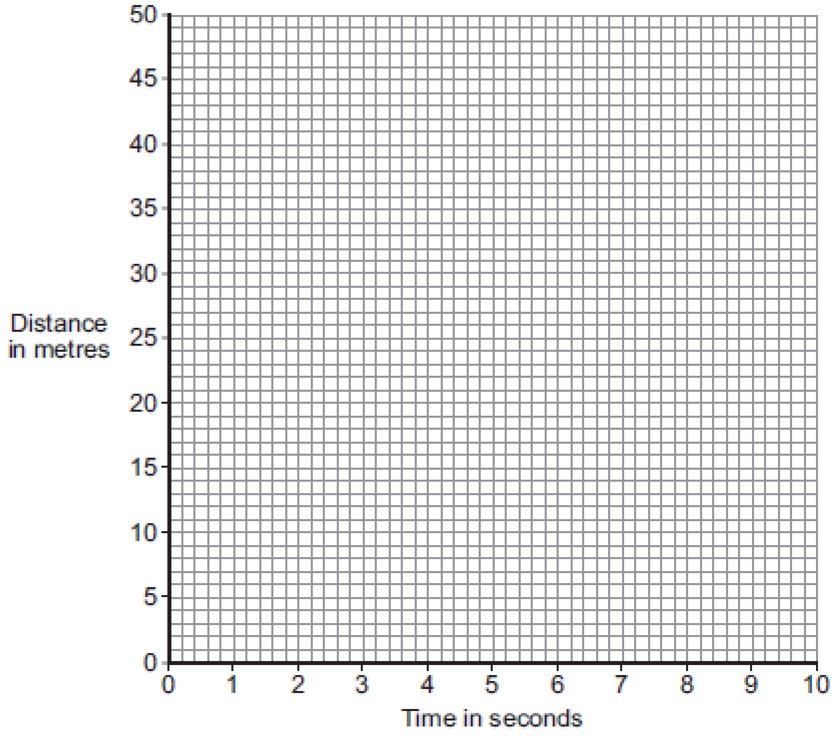
....

....

Distance = ... m

(2 marks)

(b) Complete the distance-time graph for the object over the same 10 seconds.



(2 marks)

Q16 A car moving at 15 m/s brakes, and decelerates uniformly to a stop in 2.2 s.

16a) Calculate the deceleration of the car.

[3]

16b) Use your answer to part (a) to calculate the distance moved by the car during its braking (the “braking distance”).

[3]

16ci) Another car decelerated from 15 m/s to a stop with a uniform deceleration of 5.8 m/s^2.
Calculate the time it took for the car to come to a stop.

16cii) While the car was braking, its average speed was 7.5 m/s.
Use your answer to part (ci) to calculate the braking distance for this car.

[3]

ANSWERS

12a $\Delta v = 20 - 10 = 10$ m/s $\quad a = \frac{\Delta v}{\Delta t} = \frac{10 \text{ m/s}}{5 \text{ s}} = 2 \text{ m/s}^2$

12b $\Delta v = -25$ m/s $\quad a = \frac{\Delta v}{\Delta t} = \frac{-25 \text{ m/s}}{5 \text{ s}} = -5 \text{ m/s}^2$

12c $v^2 - u^2 = 2as$

$15^2 - 0^2 = 2 \times a \times 30$

$225 = 60 \times a$

$a = \frac{225}{60}$

$a = 3.75 \text{ m/s}^2$

12d $v^2 - u^2 = 2as$

$v^2 - 30^2 = 2 \times -0.2 \times 30$

$v^2 - 900 = -12$

$v^2 = 900 - 12$

$v^2 = 888 \quad v = \sqrt{888} \quad v = 29.8$ m/s

13a Max speed is the steepest bit.
The steepest bit is the straight bit from 7 s to 10 s.

$v = \text{gradient} = \frac{\Delta y}{\Delta x} = \frac{170 - 100}{10 - 6.9} = \frac{70}{3.1} = 22.6$ m/s

13b acceleration (you can't tell if it's uniform or not)

13c) tangent at 2 seconds has gradient $\frac{40 \text{ m}}{4\text{s}}$ => 10 m/s

14b AB: uniform acceleration
BC: lower/smaller uniform acceleration than AB
CD: constant velocity
DE: uniform deceleration

14ci acceleration = gradient = $\frac{6}{5}$ = 1.2 m/s^2

14cii distance moved = area under $= (\frac{1}{2} \times 5 \times 6) + (\frac{1}{2} \times 10 \times 3) + (\frac{1}{2} \times 10 \times 9) + (3 \times 15) + (25 \times 6)$

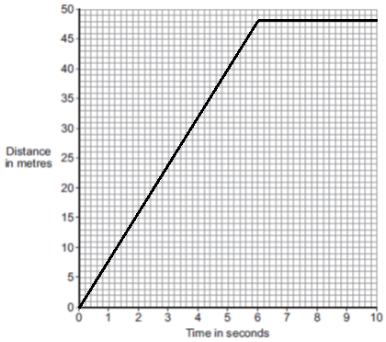
$= 15 + 15 + 45 + 45 + 150$

$= 270$ m

14ciii average speed = $\frac{\text{distance moved}}{\text{time}} = \frac{270 \text{ (or answer to 14cii)}}{40} = 6.75$ m/s

15a Area under = 8 × 6 = 48 m

15b



constant speed from 0,0 → 6s, 48 m

then stationary (zero speed)

16a $a = \frac{\Delta v}{t} = \frac{-15\ m/s}{2.2\ s} = (-)6.82\ m/s^2$

16b $v^2 - u^2 = 2as$

$0^2 - 15^2 = 2 \times -6.82 \times s$

$-225 = -13.64 \times s$

$s = -\frac{225}{-13.64}$

$s = 16.5\ m$

16ci $a = \frac{\Delta v}{t}$ $\quad -5.8 = \frac{-15\ m/s}{t}$ $\quad t = \frac{-15}{-5.8} = 2.6\ s$

16cii $s = v \times t$

$s = 7.5 \times 2.6$

$s = 19.5\ m$