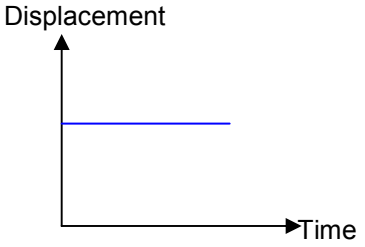
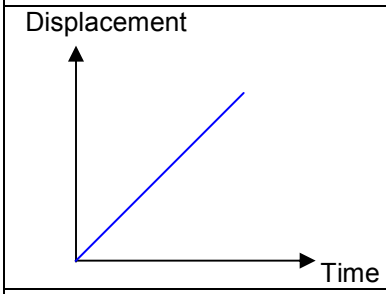
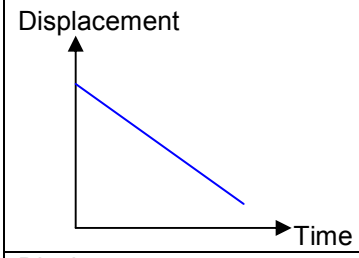
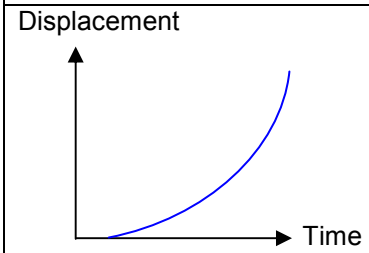
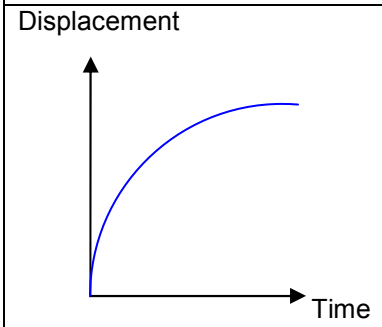
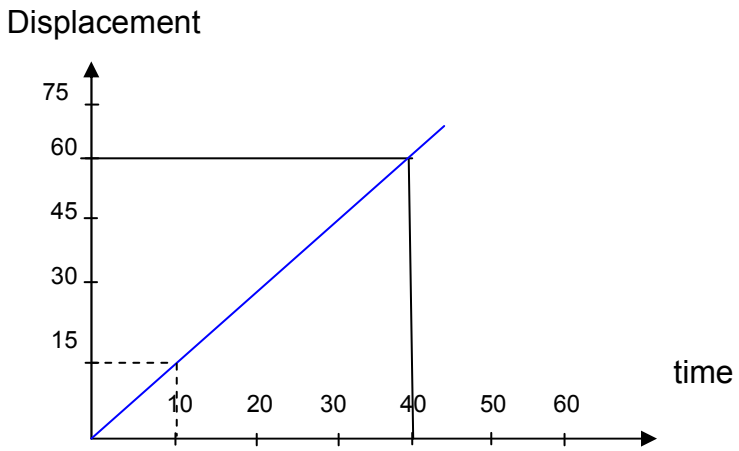
2.2 . ANALYSING MOTION GRAPHS

THE DISPLACEMENT-TIME GRAPHS	EXPLANATION
	Uniform displacement, zero velocity
	Displacement increases at constant rate, constant velocity
	Displacement decreases at a constant rate , Constant velocity.
	Increasing velocity
	Decreasing velocity

Application of the displacement –time graph



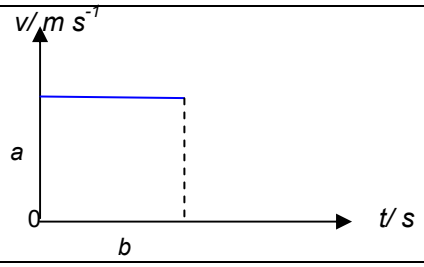
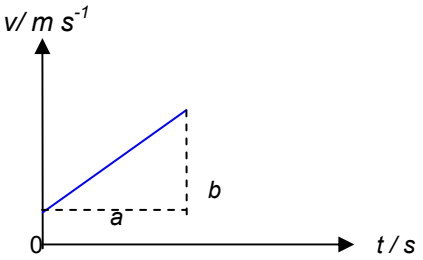
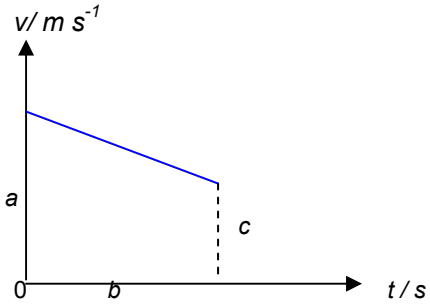
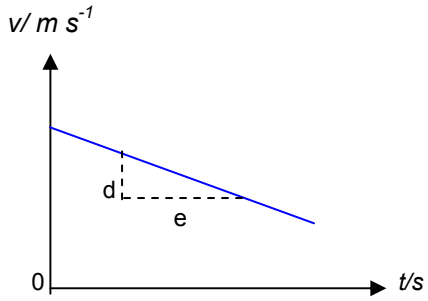
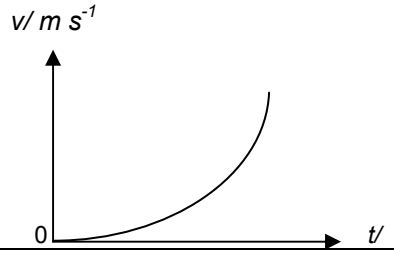
When t = 40 s , the displacement s = 60 m
When t = 10 s the displacement s = 15 m

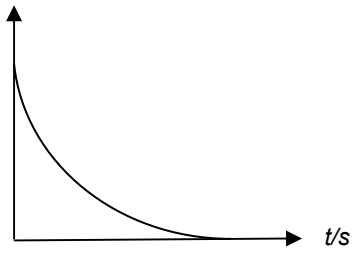
velocity = $\frac{60\text{ m} - 15}{40\text{ s} - 10\text{ s}}$ ➡ **(gradient of the graph)**

$= 1.5\text{ m s}^{-1}$

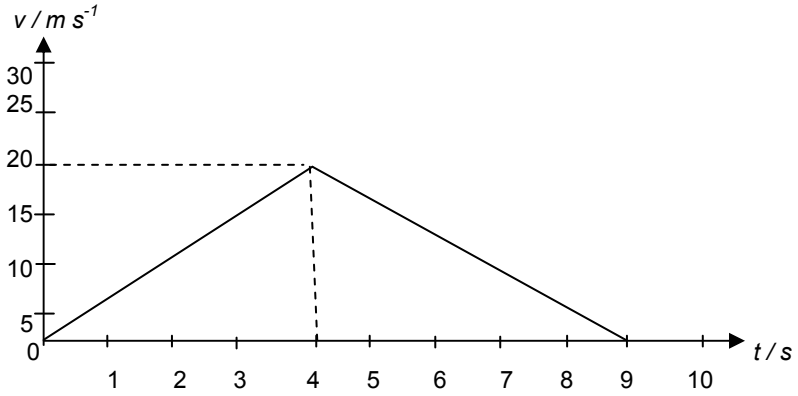
Therefore, **gradient of the graph represents the velocity** of the displacement-time graph.

The Velocity – Time Graph	**Explanation**

	Constant velocity Acceleration = 0 ➡ (the gradient is 0) Displacement = area under a graph = *a* x *b*
	Velocity increasing uniformly, Uniform acceleration. Acceleration = $\frac{b}{a}$ ➡ (gradient of the graph.) Displacement = area under a graph = ½ (*a* x *b*)
 	Decreasing velocity, uniform deceleration. Displacement = area under a graph = ½ (a + c) b Acceleration = gradient of graph = $-\frac{d}{a}$ (negative sign indicates deceleration) Deceleration = $\frac{d}{a}$ (no negative sign)
	The gradient of the graph changes and is always positive. The velocity increases non-uniformly Non-uniform acceleration
v/ m s-1	The gradient of the graph changes and

	is always negative . The velocity decreases non-uniformly. Non-uniform deceleration

Application of the velocity-time graph



How to find acceleration

Acceleration from 0 s to 4 s = the gradient of the graph from 0 to 4 s

$$= \frac{20 \text{ m s}^{-1} - 0}{4 \text{ s} - 0}$$

$$= \mathbf{5 \text{ m s}^{-2}}$$

Acceleration from 4 s to 9 s = the gradient of the graph from 4 s to 9 s

$$= \frac{0 - 20 \text{ m s}^{-1}}{9 - 4 \text{ s}}$$

$$= \frac{-4 \text{ m s}^{-2}}{}$$ (The negative value of acceleration indicates that the motion is getting slower.)

deceleration = $\underline{4 \text{ m s}^{-2}}$ (no negative sign)

How to find displacement or distance

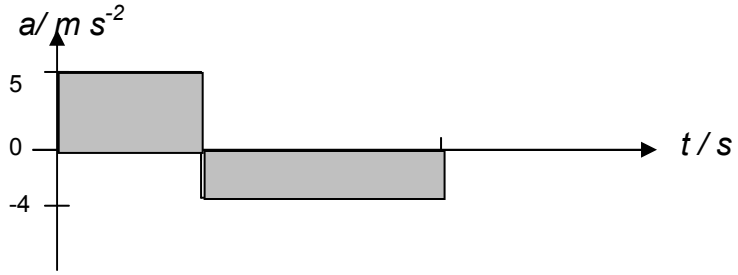
Displacement travelled from *t = 4 s to t = 9 s* = **area under a graph from *t = 4 s* to *t = 9 s***

= ½ (9 s – 4 s) (20 m s^{-1})

= <u>50 m</u>

How to draw a graph of acceleration-time graph using information from the graph velocity-time graph.

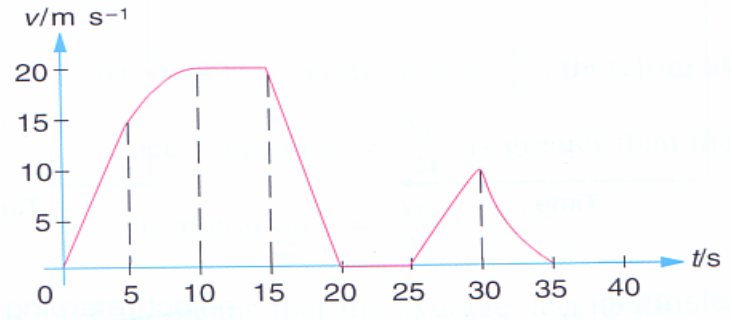
From the graph above the acceleration from **t = 0 to t = 4 s is 5 m s^{-2}** and the acceleration from **t = 4 s to t = 9 s is - 4 m s^{-2}**



*The gradient of velocity-time graph represents tacceleration of an object.
*The area under a graph represents the total distance travelled by the object.

Example :

The figure below shows the velocity-time graph of the car.



Describe the motion of the car .

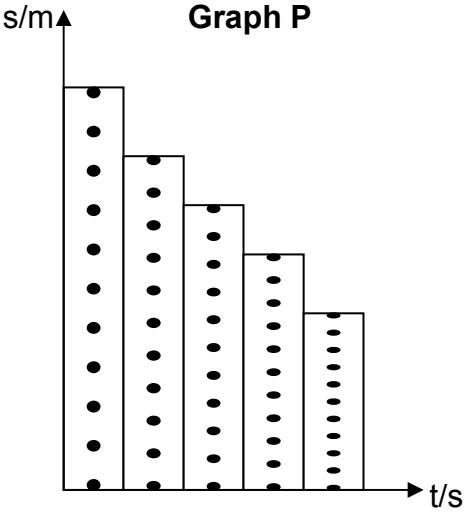
solution :

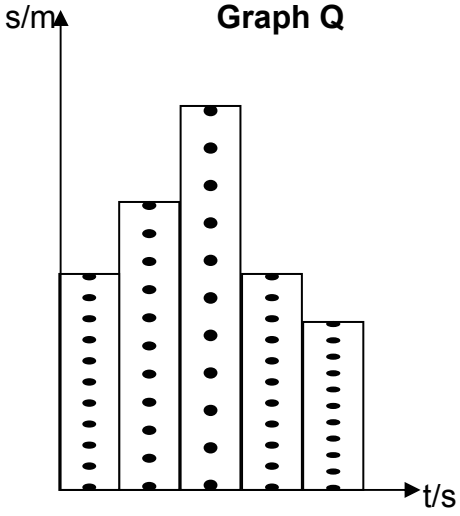
Time	Motion
0 s to 5 s	Velocity increases uniformly. Constant acceleration . Acceleration $a = \frac{15 - 0}{5} = 3 \text{ m s}^{-2}$
5 s to 10 s	Velocity increases from 15 m s^{-1} to 20 m s^{-1}. Acceleration decreases from 3 m s^{-2} to 0 m s^{-2}. The increase rate of velocity, though positive, is decreasing .
10 s to 15 s	Constant velocity. Zero acceleration.
15 s to 20 s	Velocity decreases uniformly from 20 m s^{-1} to 0 m s^{-1}. Deceleration $= \frac{20 - 0}{5} = 4 \text{ m s}^{-2}$
20 s to 25 s	Velocity is zero Car is at rest.
25 s to 30 s	Constant acceleration of $a = \frac{10 - 0}{5} = 2 \text{ m s}^{-2}$
30 s to 35 s	Velocity decreases non-uniformly from 10 m s^{-1} to 0 m s^{-1}. Non-uniform deceleration.

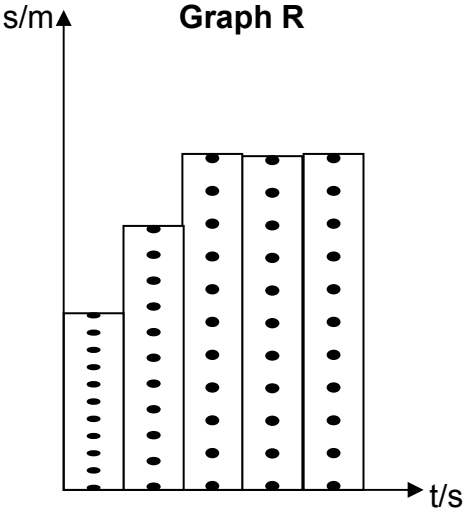
ACTIVITY

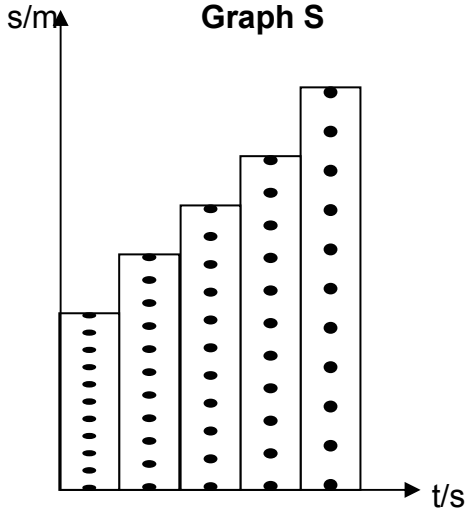
(50 MINUTES)

1.









The above graphs show tape cuttings, each of 10 ticks, arranged side-by-side and consecutively. Comment on the acceleration of each graph.

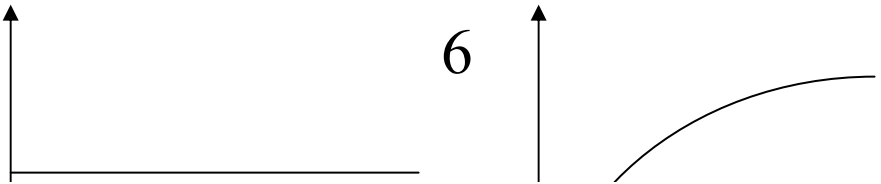
(i) Graph P : _____

(ii) Graph Q : _____

(iii) Graph R : _____

(iv) Graph S : _____

2. From the four displacement – time graphs shown below, comment on the velocity of each graph.



s/m Graph A s/m Graph B

(i) (ii)

t/s t/s

s/m Graph C s/m Graph D

(iii) (iv)

t/s t/s

(i) Graph A : _____

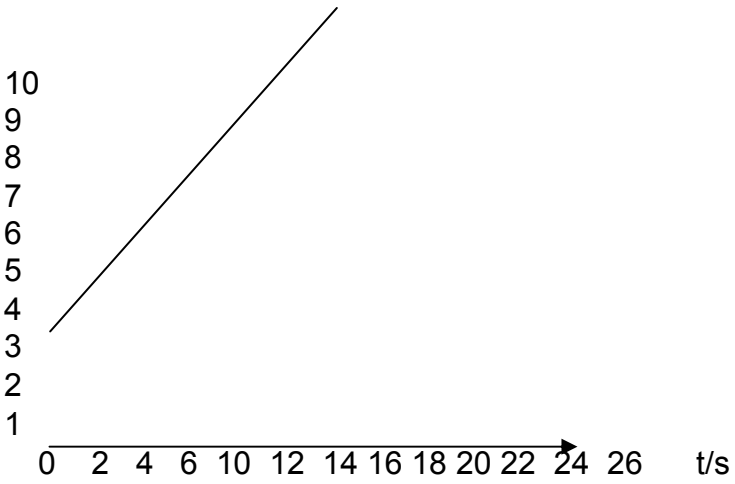
(ii) Graph B : _____

(iii) Graph C : _____

(iv) Graph D : _____

s/m

3.

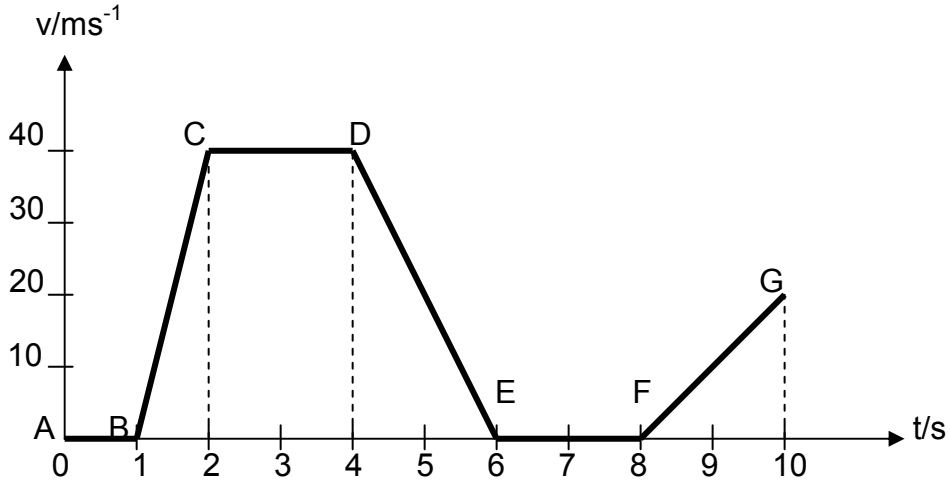


The figure above shows a graph of displacement s against t for an object.

(a) Calculate the gradient (m)of the graph.

(b) The gradient of a displacement – time graph represents_____.

(c) Write an equation which relates s and t.

4. 

The above figure shows a typical speed – time graph of an object.

(a) From A to B, the object is at_____ .

(b) The slope BC shows the object is _____

(c) From C to D , the object travels at _____ speed.

(d)Calculate the acceleration between the fourth and the sixth second.

Acceleration = gradient of the graph

$$= \frac{(y_E - y_D)}{(x_E - x_D)}$$

=

(If a is negative, the object is said to undergo retardation)

(e)At _____, the object comes to stop and remains at rest for a

further_____seconds before accelerating again.

(f) what is the acceleration from F to G?

Acceleration = gradient of the graph

$$= \frac{(y_G - y_F)}{(x_G - x_F)}$$

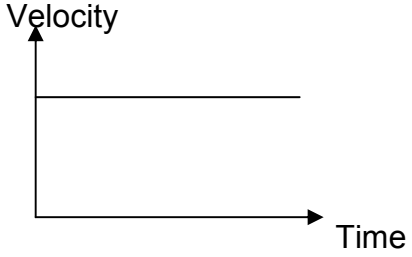
=

ASSESSMENT
(40 MINUTES)

OBJECTIVE QUESTION

1. What information would you expect to find from a given velocity-time graph?
   A The velocity.
   B The velocity and acceleration.
   C The velocity and displacement.
   D The velocity,displacement and acceleration.

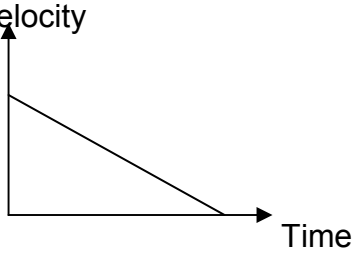
2. The following velocity-time graph shows the motion of an object.



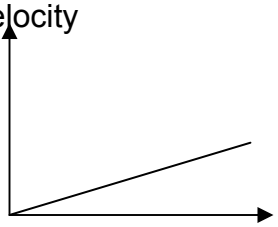
   For the duration shown, the object is
   A moving with constant acceleration.
   B moving with increasing velocity.
   C moving at constant speed.
   D stationary (not moving)

3. Which of the following velocity-time graphs shows an object slowing down with a non-uniform acceleration?

A velocity

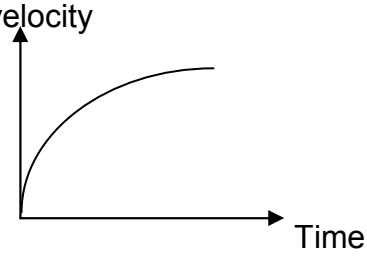


B velocity

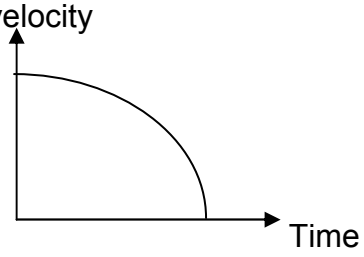


Time

C velocity

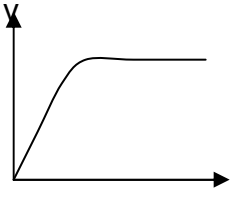


D velocity

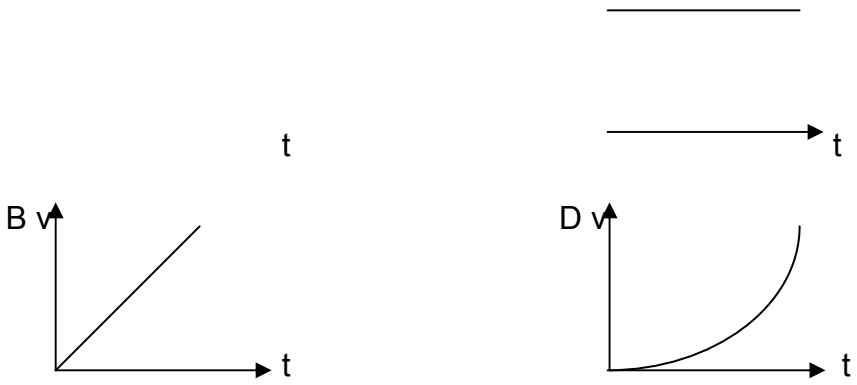


4. Which of the following velocity-time graphs shows constant acceleration?

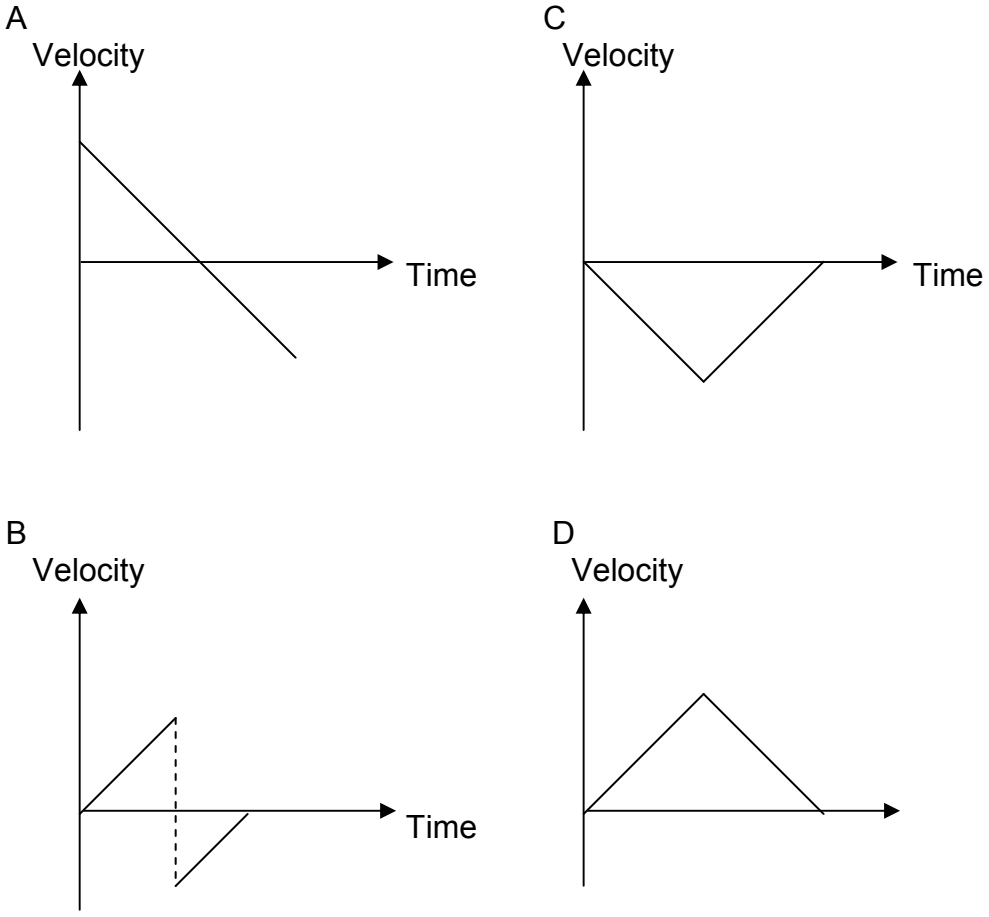
A v



C v



5. An elastic rubber ball is dropped freely onto a hard and smooth floor.Which of the following velocity-time graphs shows the relationship between the velocity of the ball with time?



STRUCTURED QUESTION

1.

A car starts from rest at time t = 0s and moves along a straight road.
Figure 1.1 shows the velocity time graph of the car from t = 0 to 200s.

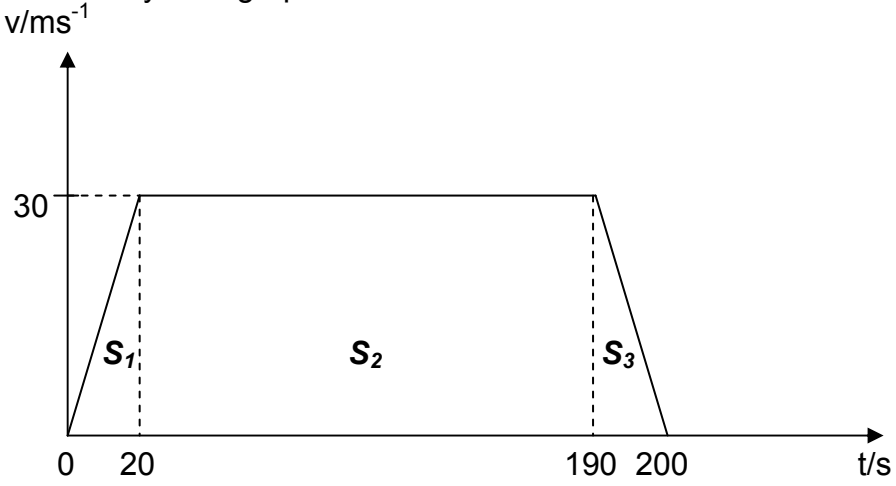


Figure 1.1

(a) Describe the motion of the car from t = 0 s to t = 200 s.

(3marks)

(b) Find the acceleration of the car in
(i) the first 20 second,

(1 mark)

(ii) the last 10 s.

(1 mark)

(c) Find the distance travelled by the car when the car is
(i) Accelerating S_1,

(1 mark)

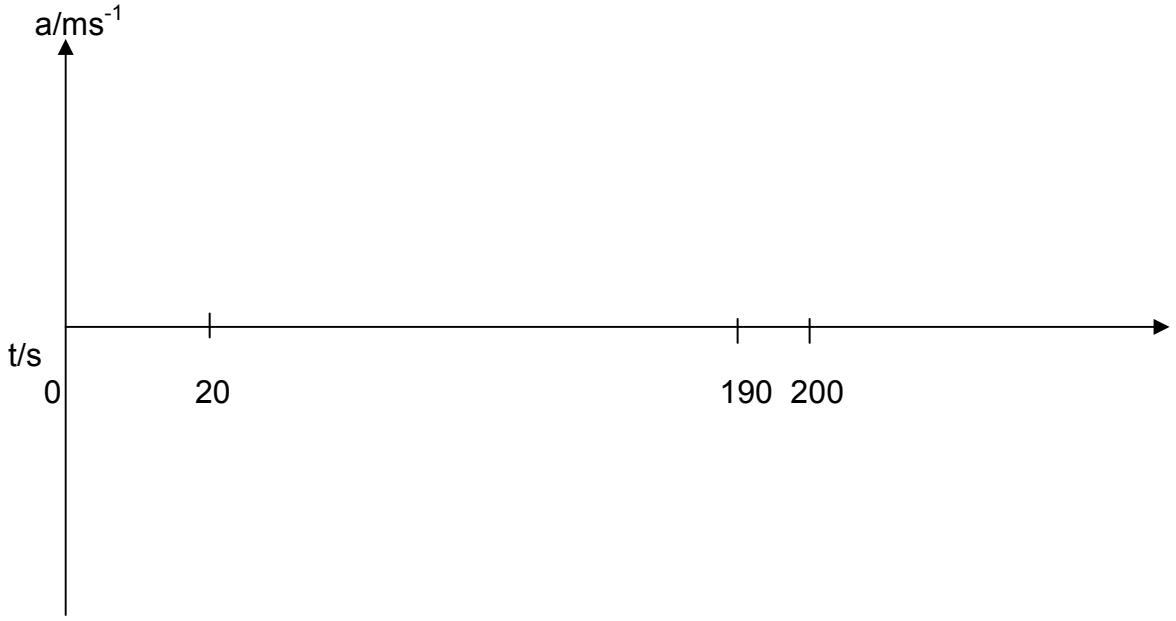
(ii) moving with constant velocity S_2,

(1 mark)

(iii) decelerating S_3.

(1 mark)

(d) draw an acceleration-time graph of the car from t=0s to t=200s.



(3 marks)

2.

A student conducted an experiment to investigate the motion of his father's car along a horizontal straight road. Using a stopwatch and the car's tachometer, the student recorded the time and the distance travelled by the car. Figure 2.1 shows the graph obtained from the experiment.

Graph of s against t

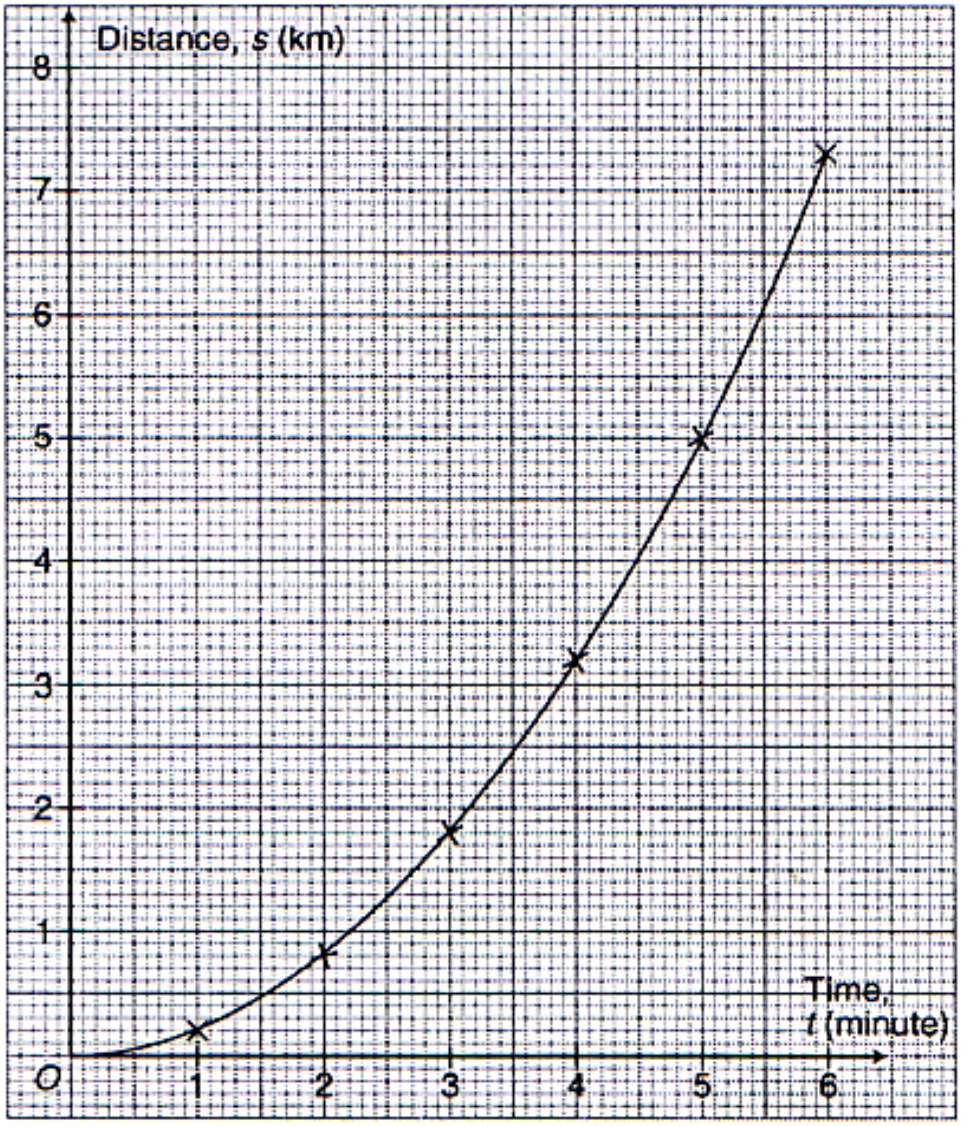


Figure 2.1

(a) Calculate the gradient of the graph at the fourth minute.

(2 marks)

(b) State the physical quantity represented by the gradient of the graph.

(1 mark)

(c)Sketch a distance-time graph to show the motion of constant velocity.

(1 mark)

ANSWER KEY
(ACTIVITY)

1(i) Graph P : Uniform deceleration.

(ii) Graph Q : Acceleration followed by deceleration.

(iii)Graph R : Uniform acceleration until zero acceleration.

(iv)Graph S : Uniform acceleration.

2(i) Graph A : Velocity always zero.

(ii) Graph B : Moves with decreasing velocity until zero.

(iii)Graph C : Moves with increasing velocity.

(iv)Graph D : Moves with uniform velocity in the opposite direction.

3.(a) Gradient of the graph $m = \frac{8}{16}$

$= 0.5 ms^{-1}$

(b) velocity

(c) $Y = mX + c$
Y = Displacement (s)
m= 0.5
x = Time (t)
c = 0
The equation is $s = 0.5t$.

4.(a) rest
(b) accelerating uniformly
(c) constant / uniform speed
(d) $\frac{0-40}{6-4} = -20 ms^{-2}$
(e) E,2
(f) $10 ms^{-2}$

ANSWER KEY
(ASSESSMENT)

OBJECTIVE.

1. D
2. C
3. D
4. B
5. B

STRUCTURED

1.

(a)The graph shows that the car starts from rest and accelerates uniformly until its velocity reaches a valueof 30 ms^{-1} in 20 s.Then the car moves with constant velocity for 170s. In the last 10 s, the car slows down and decelerates uniformly until it comes to a stop.

(a) (i)$a = \frac{30 - 0}{20}$

$= 1.5\ ms^{-2}$

(ii) $a = \frac{0-30}{10}$

$= -3.0 ms^{-2}$

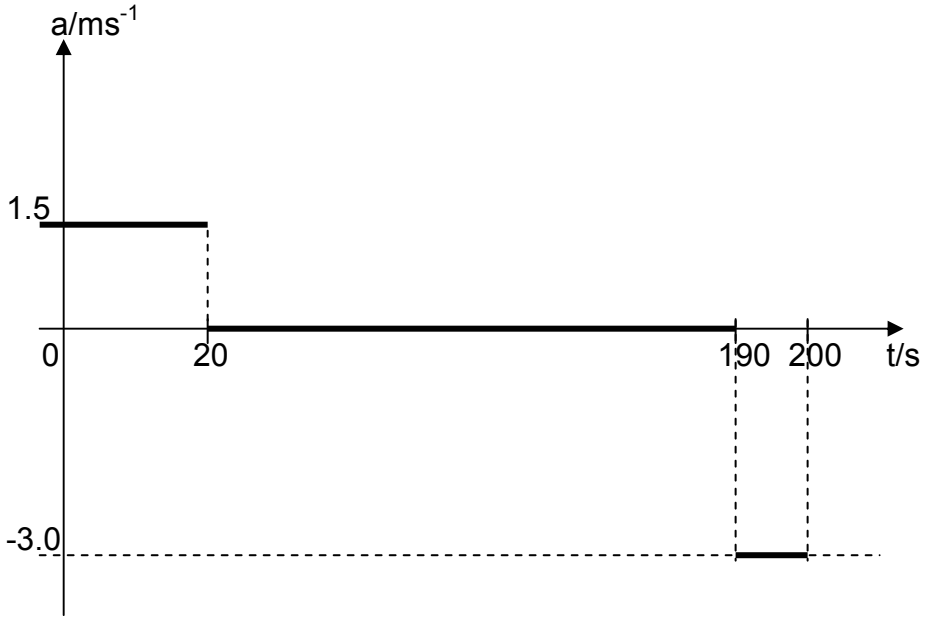
(The negative sign shows deceleration)

(b) (i) Distance, $s_1 = ½ \times 20 \times 30 = 300m$

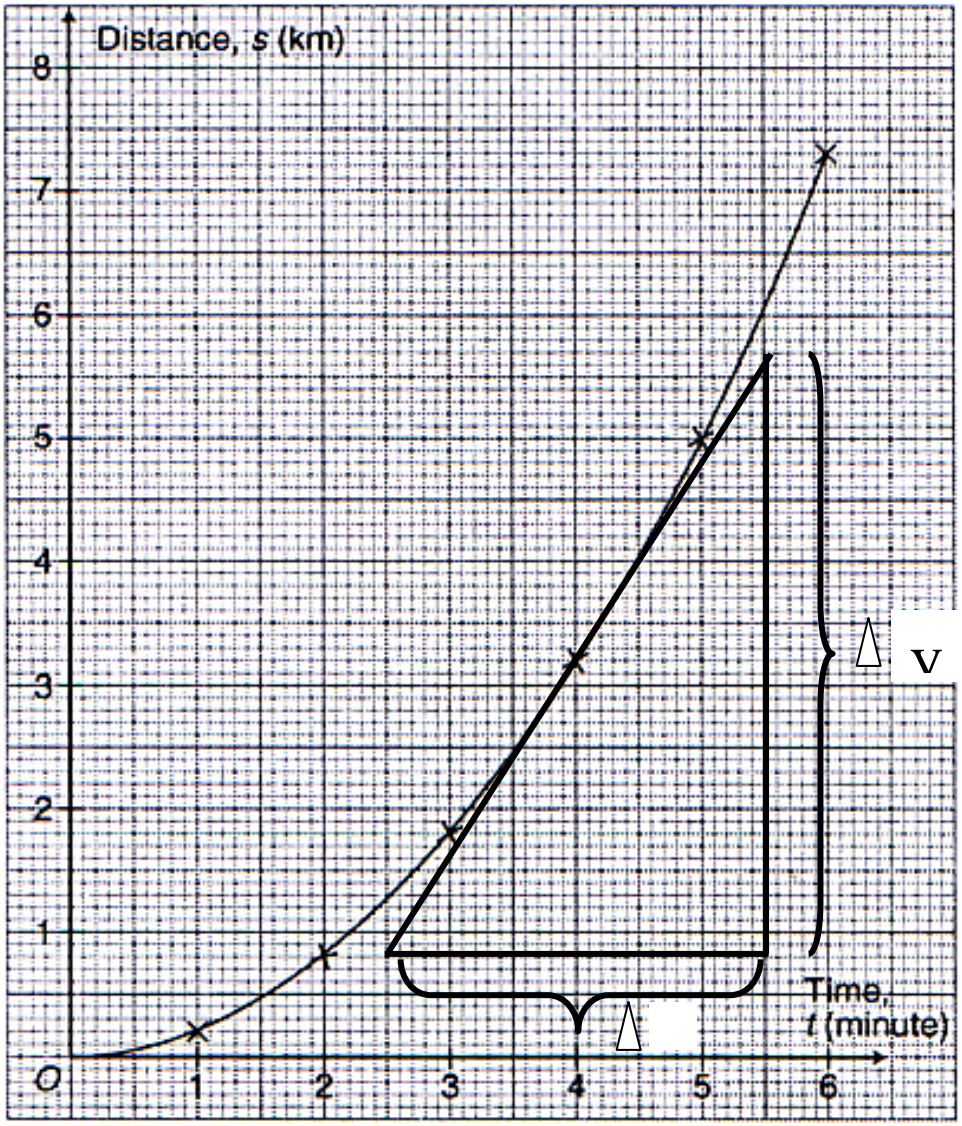
(ii)Distance, $s_2 = 20 \times 170 = 5100m$

(iii)Distance, $s_3 = ½ \times 10 \times 30 = 150m$

(c)



2. Graph of s against t



(a)Gradient of graph = $\frac{(5.6-0.8)}{(5.5-2.5)}$

= 4.8 km/3.0 minutes

= 26.7 ms^{-1}

(b) The gradient of the graph represents the velocity of the car.

(c)