

GRAPHS OF MOTION

DRAW AND ANALYZE

Distance – Time Graph



Displacement– Time Graph

Velocity – Time Graph



Acceleration – Time Graph

Learning Objectives:

**Plot and interpret distance – time, displacement – time, velocity – time, and acceleration – time graphs
calculating the area under velocity – time graph to work out distance travelled for motion with constant velocity or constant acceleration.**

Recall

Define the following:

- a. Time**
- b. Distance**
- c. Displacement**
- d. Speed**
- e. Velocity**
- f. Acceleration**

Difference between Distance – time graph from Displacement – time graph

*** The position-time graph ($x-t$) is the same as displacement-time graph. This graph will tell you the exact change in position of a body (using the shortest path between the initial and final point), irrespective of the actual path used (that is called displacement), with respect to time.**

Difference between Distance – time graph from Displacement – time grap

A distance-time graph, on the other hand, will tell you the distance covered, that is the exact length of the actual path used to travel from initial point to final point, with respect to time.

Distance-Time Graph

Plot the following data of a car traveling on a straight road with a constant speed, which is indicated by the speedometer of the car. The driver measures the time the car takes to pass every successive kilometers stone on the side of the road. He finds that the car passes the first kilometers in 1 and $\frac{1}{2}$ min., the second kilometre in 3 min. and so on. Thus he notes the position of the car every one and a half minutes :

Distance-time table of the car

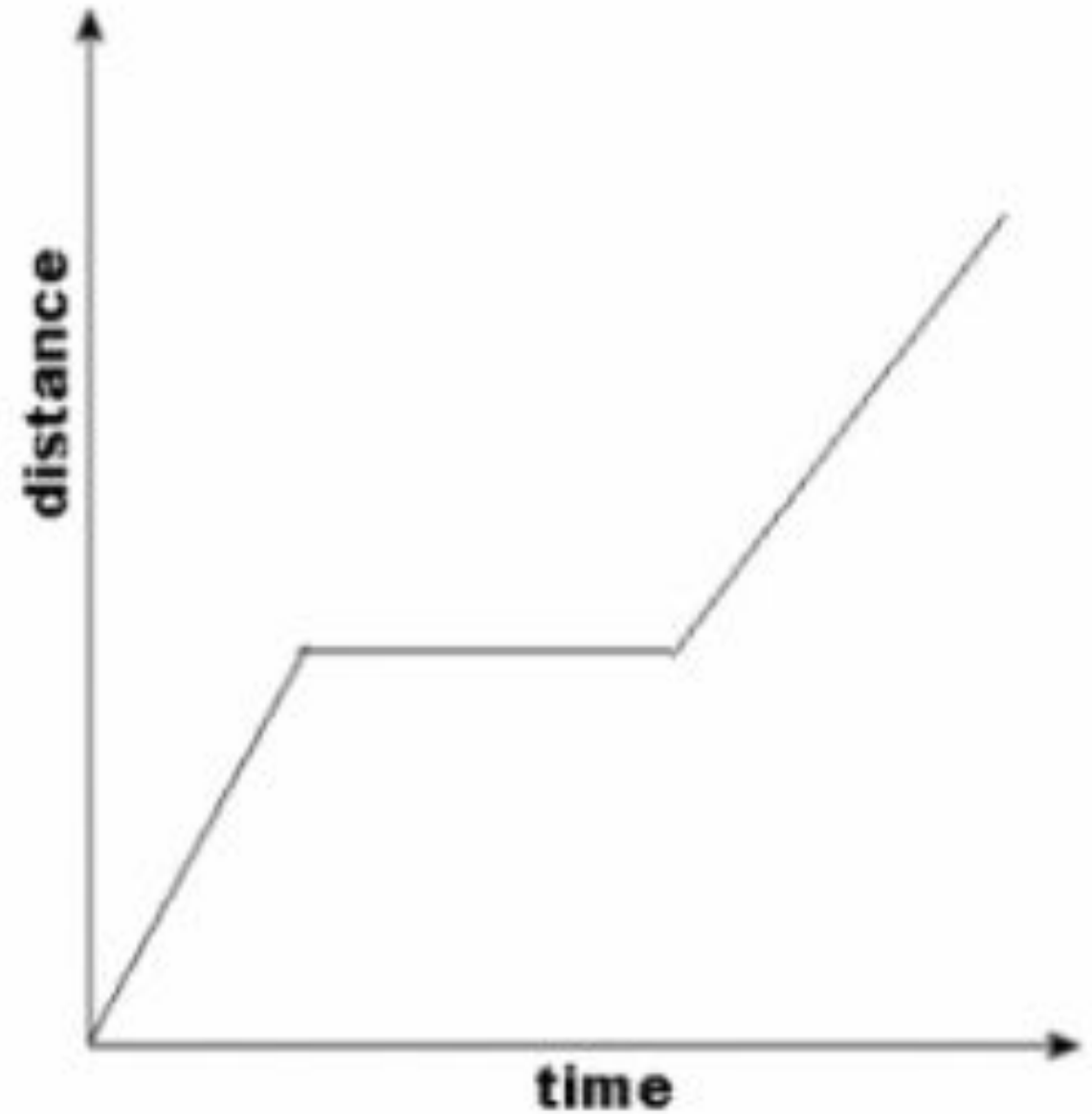
Distance (in km)	1	2	3	4	5	6
Time (in min)	1.5	3	4.5	6	7.5	9

Distance-time table of the car						
Distance (in km)	1	2	3	4	5	6
Time (in min)	1.5	3	4.5	6	7.5	9

Answer the following:

- 1. Describe the data table.**
- 2. After plotting the data in the table above, what does the graph look like?**
- 3. What does your answer in number 2 indicate about the motion of the car?**
- 4. How can you determine the instantaneous speed in the graph?**
- 5. What is the slope/ gradient of the graph?**
- 6. What is the unit of the slope of the graph? What physical quantity does it represent?**

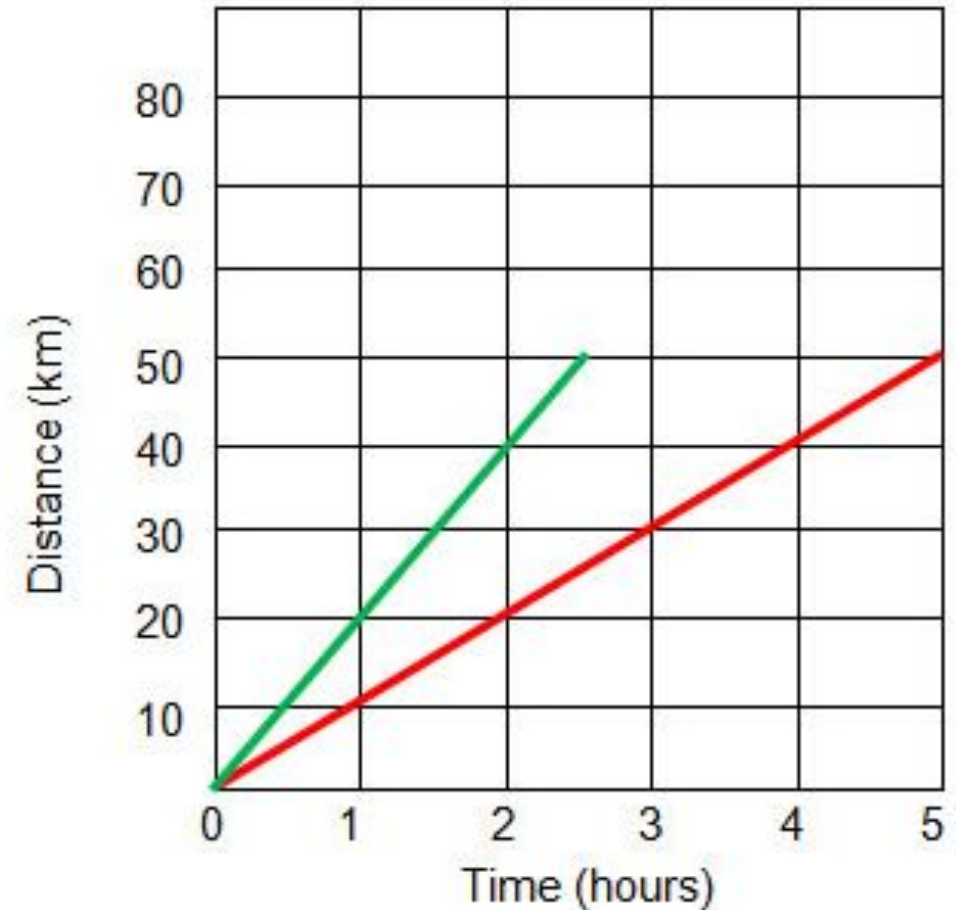
Describe the motion of the object having a graph like this.



As in uniform motion, the distance time graph would be a straight line, because the equal distance is covered in equal units of time.

The graph shows data from two moving objects.

1. Describe the two lines. What can you say about the speeds of the two objects?
2. What is the distance covered by both objects? How did you say that?
3. Which of the two objects covered the 50 km first? The second?
4. At what speed was the object represented by the red line moving?
5. At what speed was the object represented by the green line moving?
6. What can you conclude about the steepness of the line?

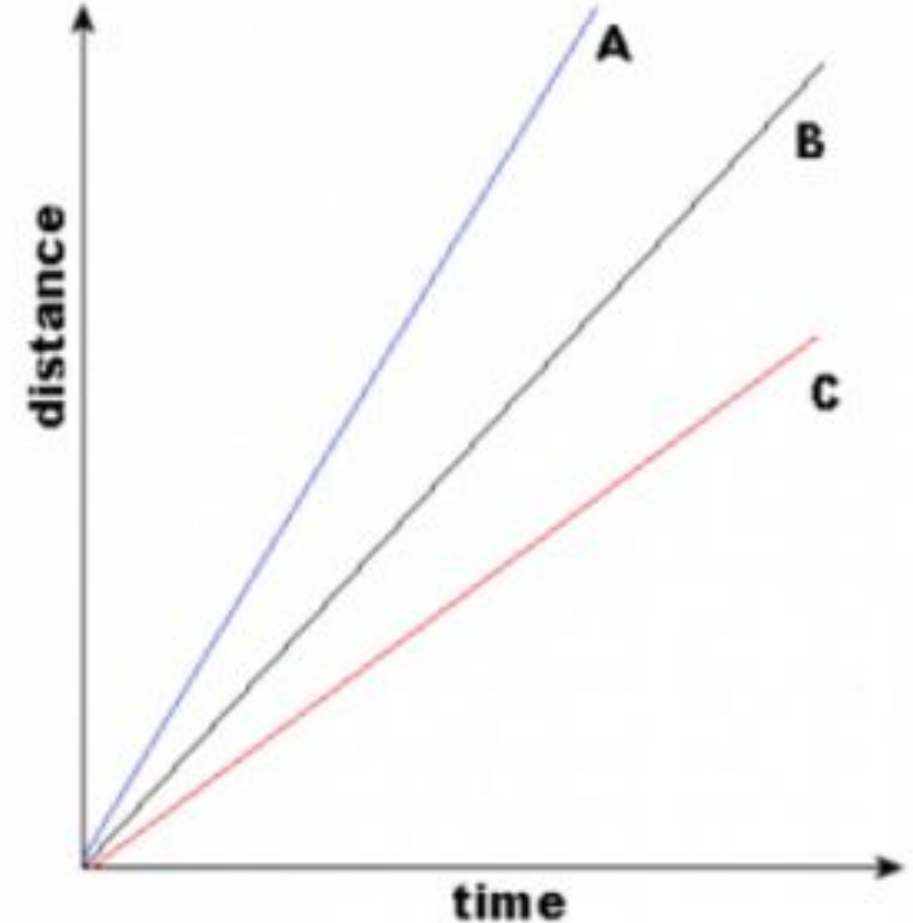


As in uniform motion, the distance time graph would be a straight line, because the equal distance is covered in equal units of time.

*** You can see that there are three bodies A, B and C, all of them are in uniform motion then why do they have different slopes?**

**** From graph in the right, what conclusion can you make regarding the speeds of the three bodies?**

***** Which has the highest speed (fastest) and which has the least speed (slowest)?**



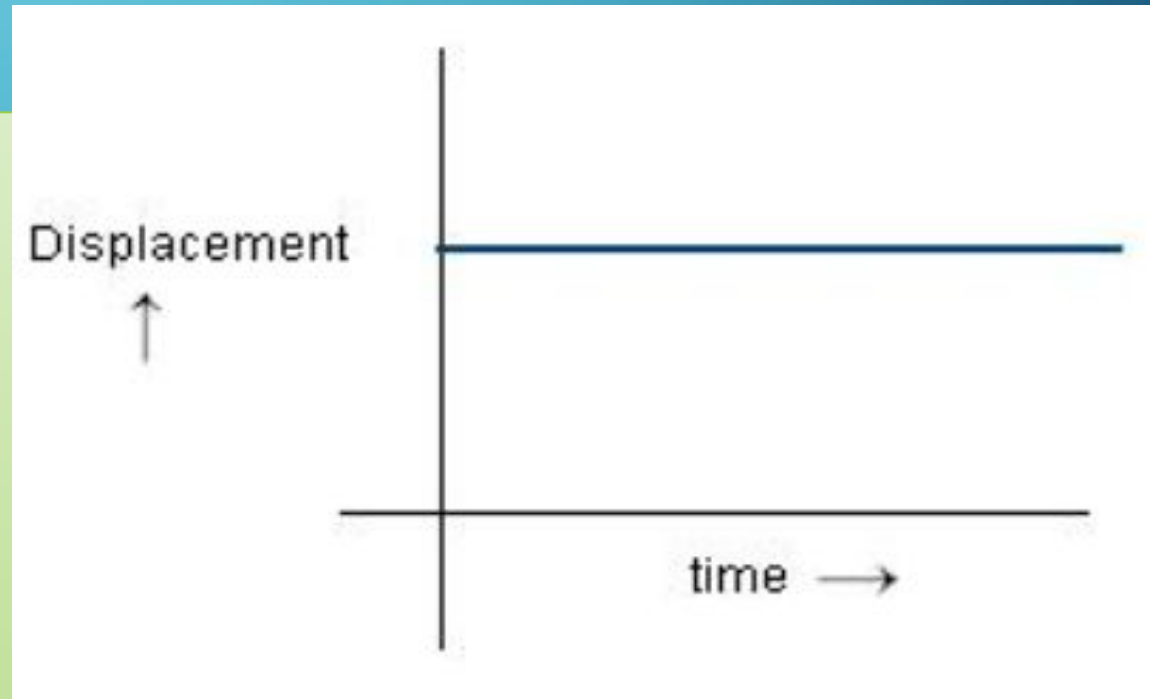
Position-time Graphs or Displacement - Time Graphs

Distance-Time Graphs give you speed, but speed is never negative so you can only have a positive slope in a distance-time graph.

Position-Time graphs show displacement, have direction, and from which you can calculate velocity.

Questions:

1. What does the slope of a displacement -time graph indicates?
2. Describe the graph.
3. What is the slope of the graph?
4. What does it tell about the velocity of the object described by that graph?

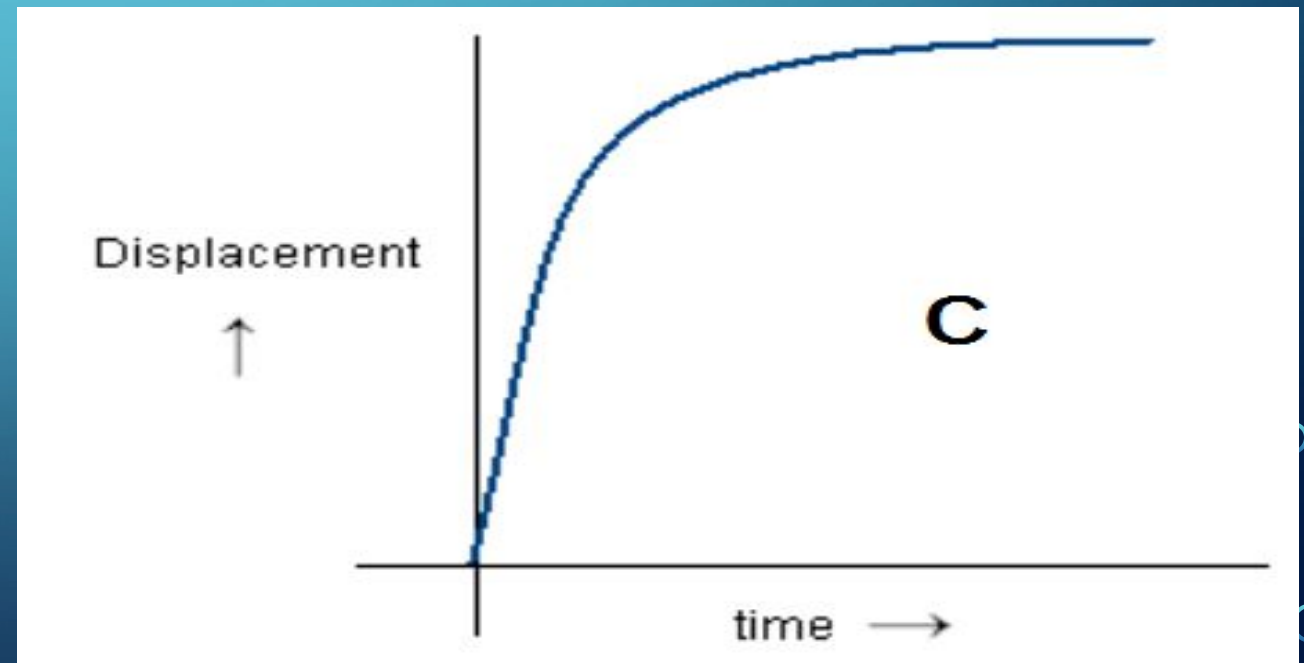
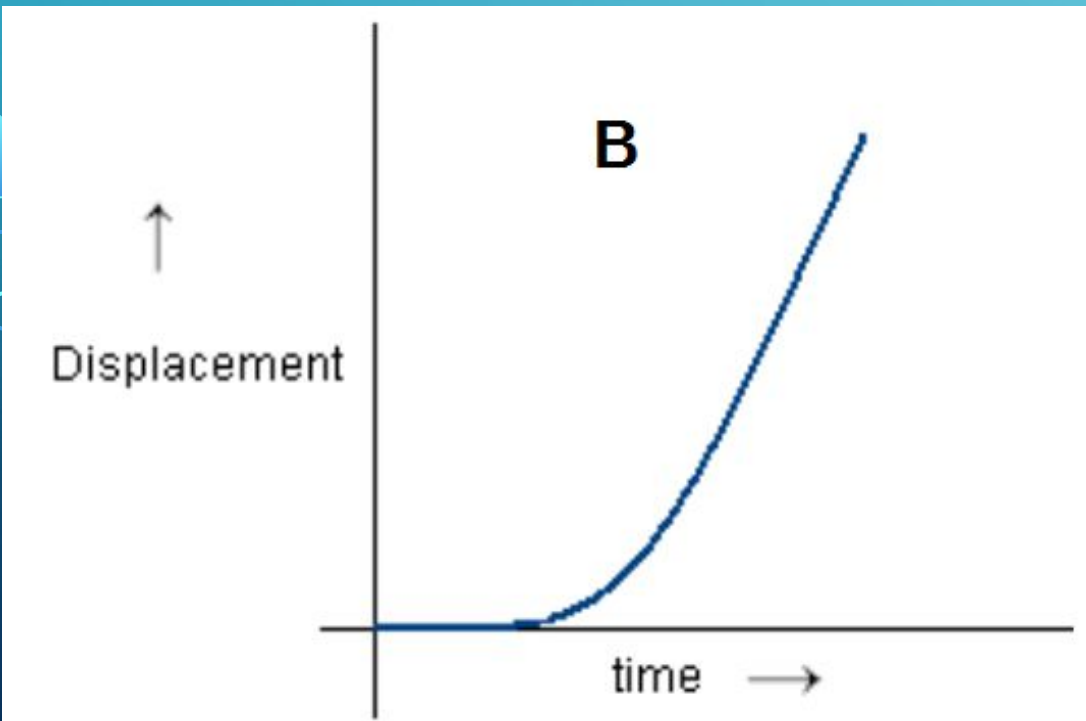
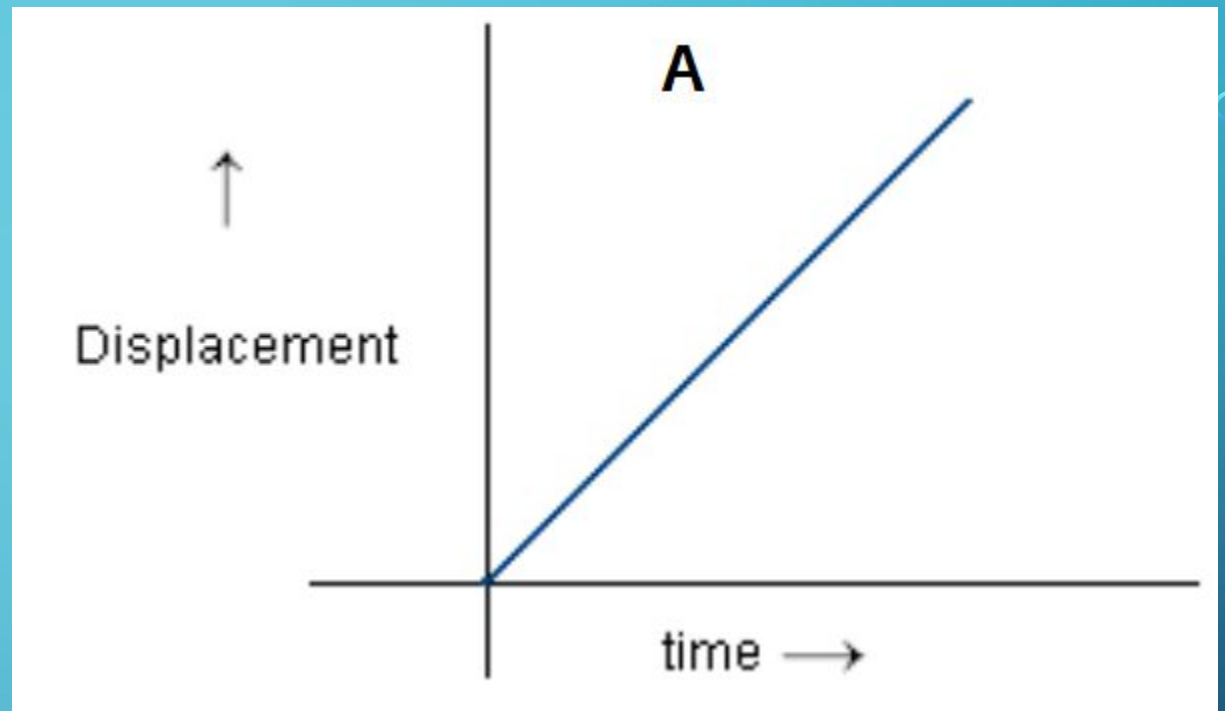


Describe these graphs':

1. line

2. slope

3. velocity

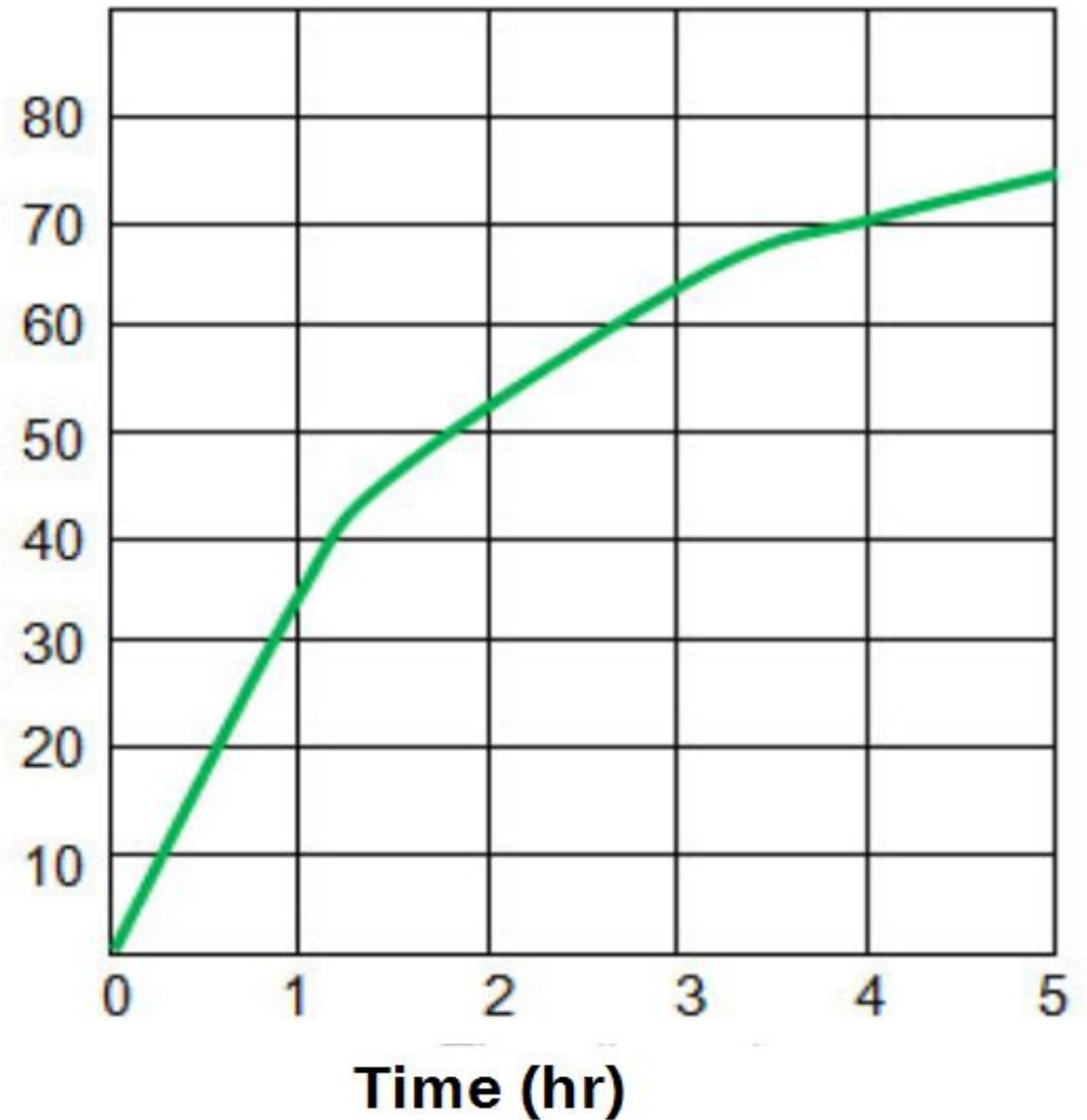


Some more displacement - time graphs exercises.

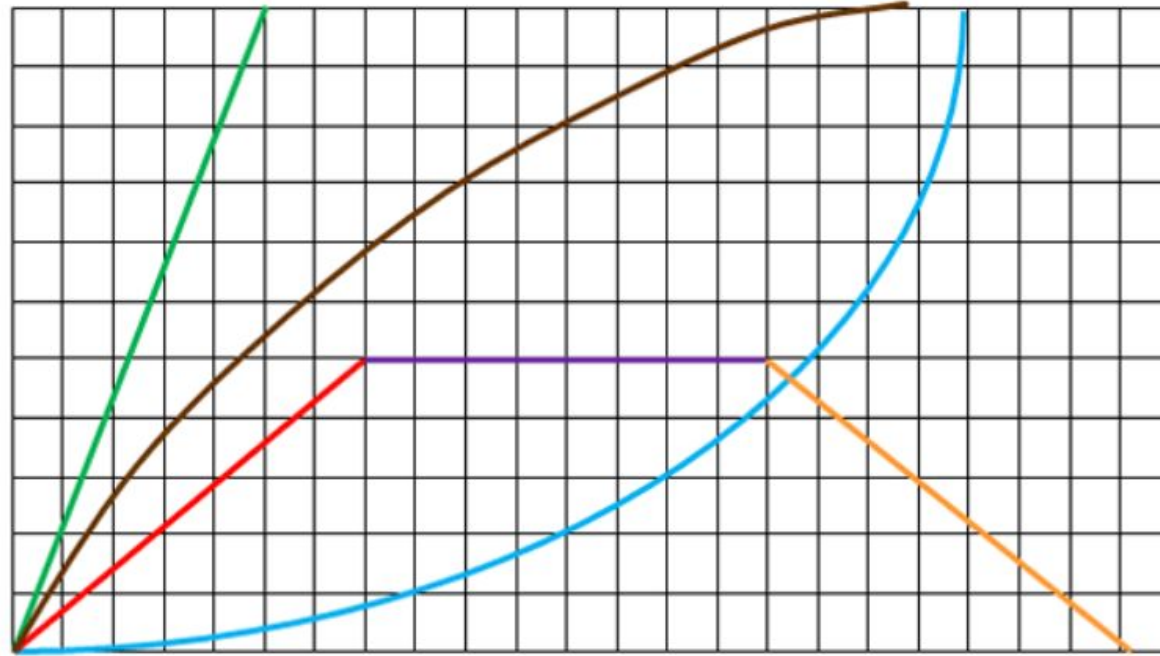
Displacement
(km)

1. What is the displacement of the car travel in the first hour?

2. How far did the car travel in the last hour?



Displacement



Time

1. What does displacement-time graph tells us?

2. Describe the motion of the following lines:

A . green line

B. brown line

C. red line

D. violet line

E. orange line

F. light blue line

Answers:

1. D- t graphs tell us how far from an object has moved with time.
2. A. fast and steady/ constant speed
B. decreasing velocity over time
C. steady/ constant velocity
D. stationary / at rest
E. returning to start with a constant velocity
F. increasing velocity over time

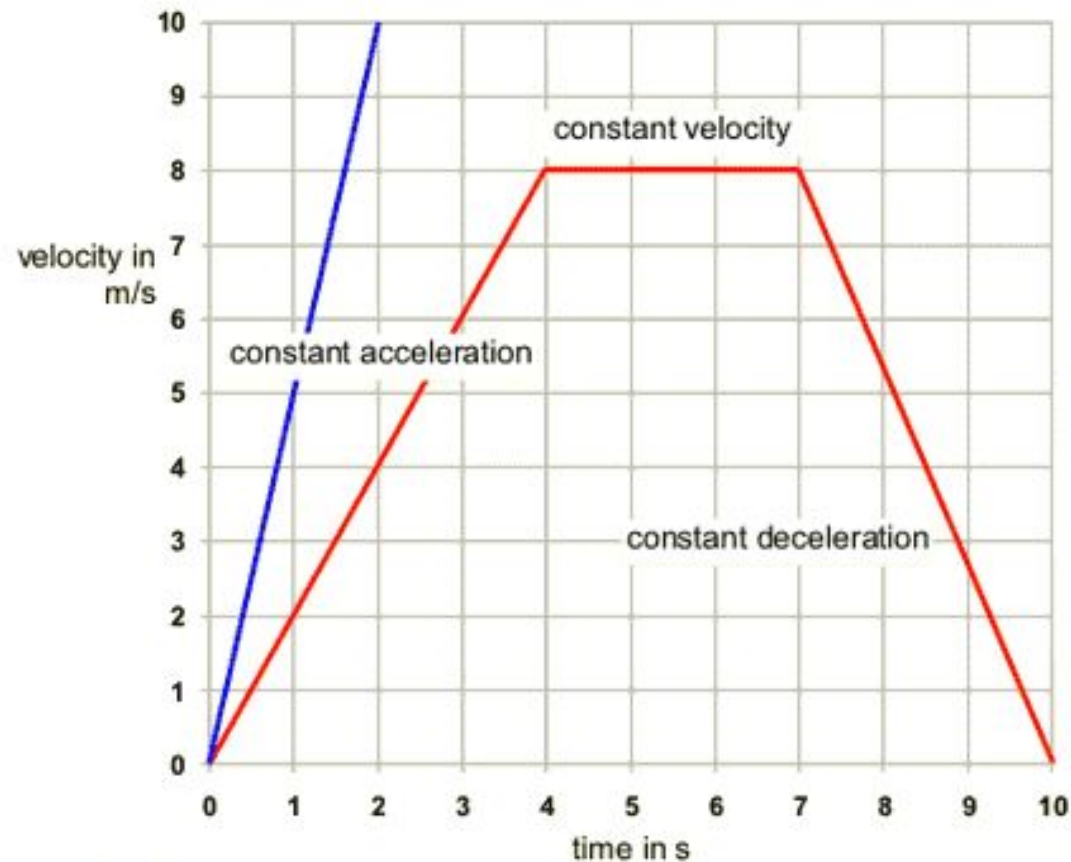
Velocity-time graphs

- * The velocity of an object is its speed in a particular direction. This means that two cars traveling at the same speed, but in opposite directions, have different velocities. One velocity will be positive, and the velocity in the other direction will be negative.**
- * The vertical axis of a velocity-time graph is the velocity of the object and the horizontal axis is the time taken from the start.**
- * When an object is moving with a constant velocity, the line on the graph is horizontal. When an object is moving with a steadily increasing velocity, or a steadily decreasing velocity, the line on the graph is straight, but sloped. The following diagram shows some typical lines on a velocity-time graph..**

Velocity-time graphs

Answer the following:

1. What is the unit of the slope of a V-t graph?



2. Describe the line, slope and motion of the object projected by line A, B, C and D.

3. Which of the 4 lines has the greatest acceleration? Which has the least?

Velocity-time graphs

- More exercises

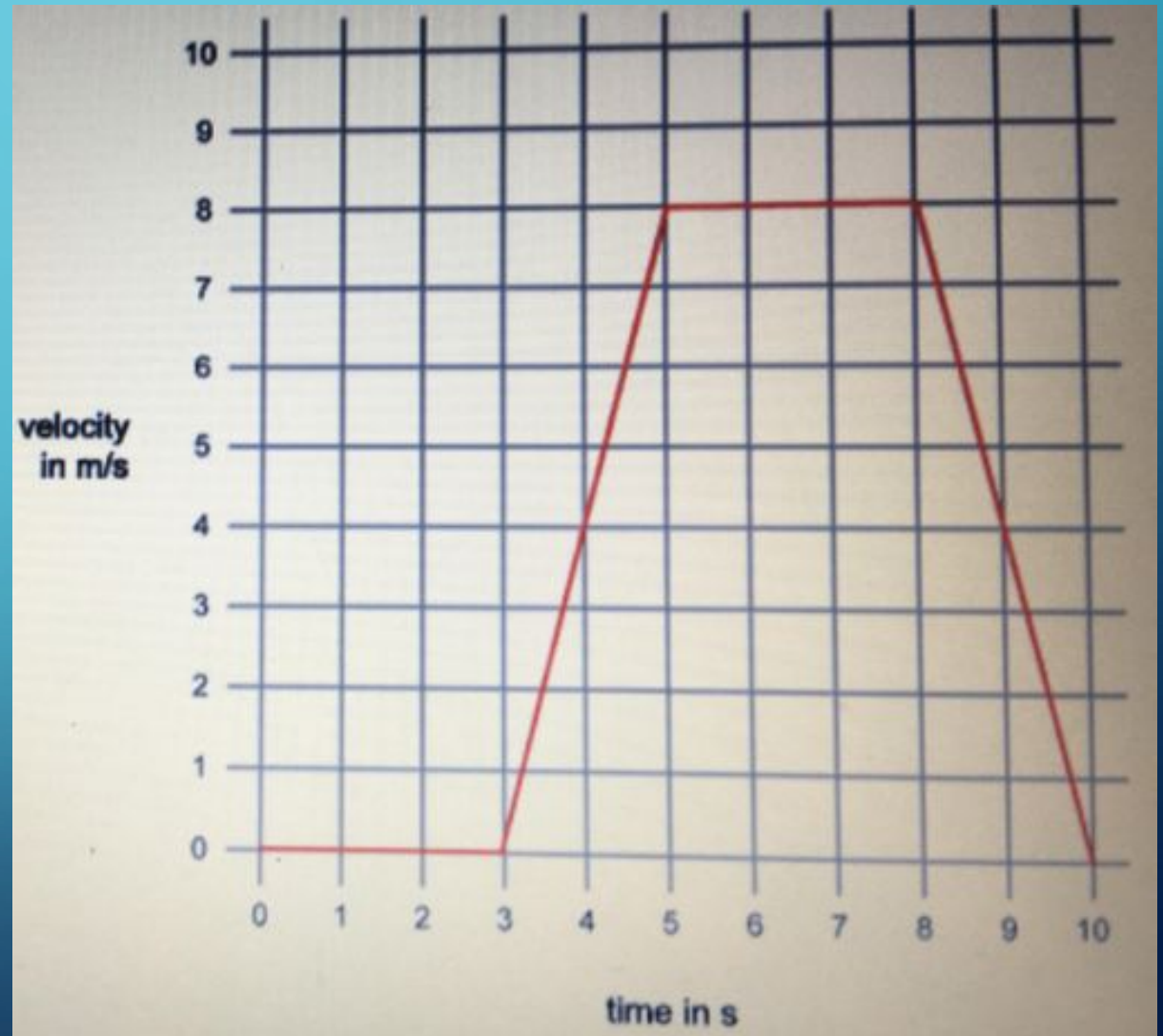
1. An object's motion is seen in the graph in the right.

Interpret the graph. A. Describe the slope and motion of the object for the first 3 seconds.

B. Then, motion for the next 2 seconds (from $t=3$ to $t=5$).

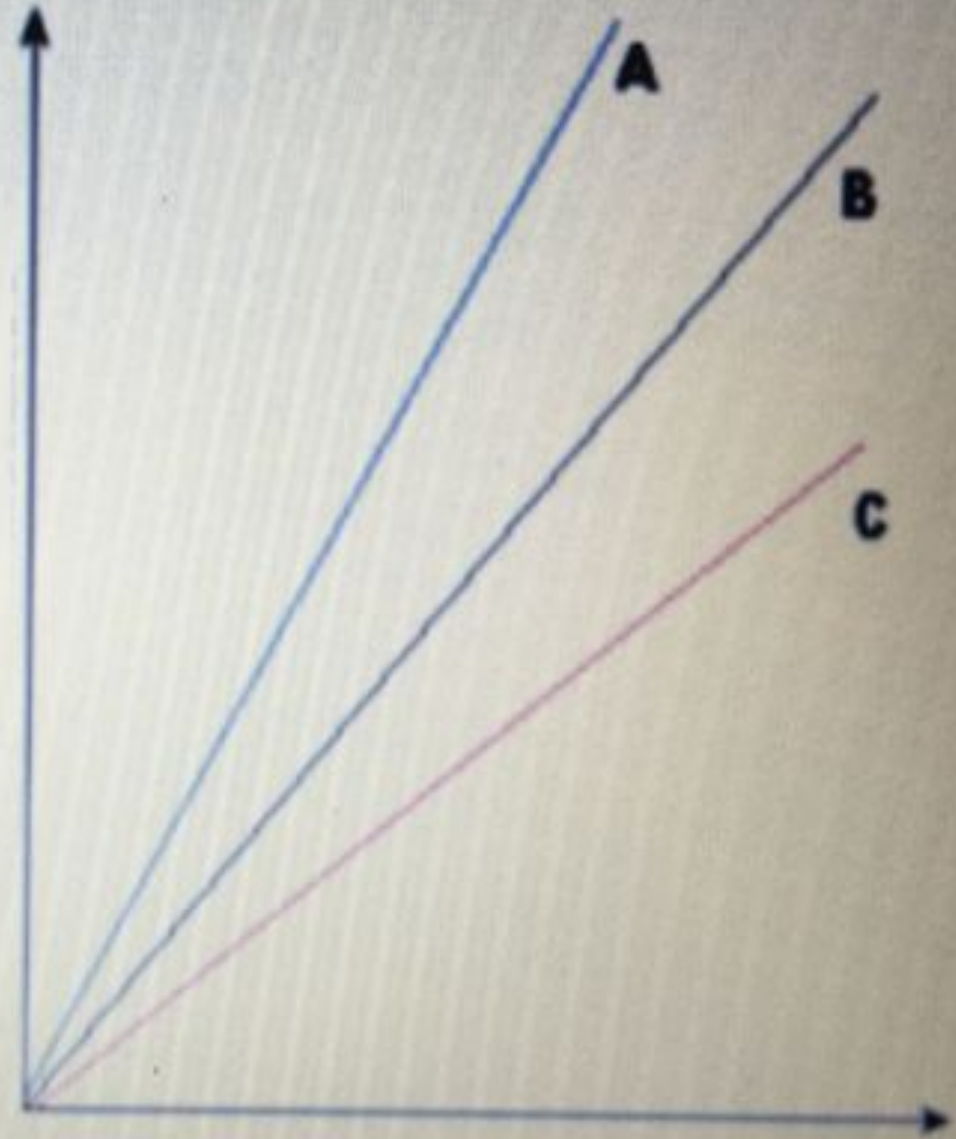
C. Next from $t=5$ to $t=8$.

D. What about for the last 2 seconds?



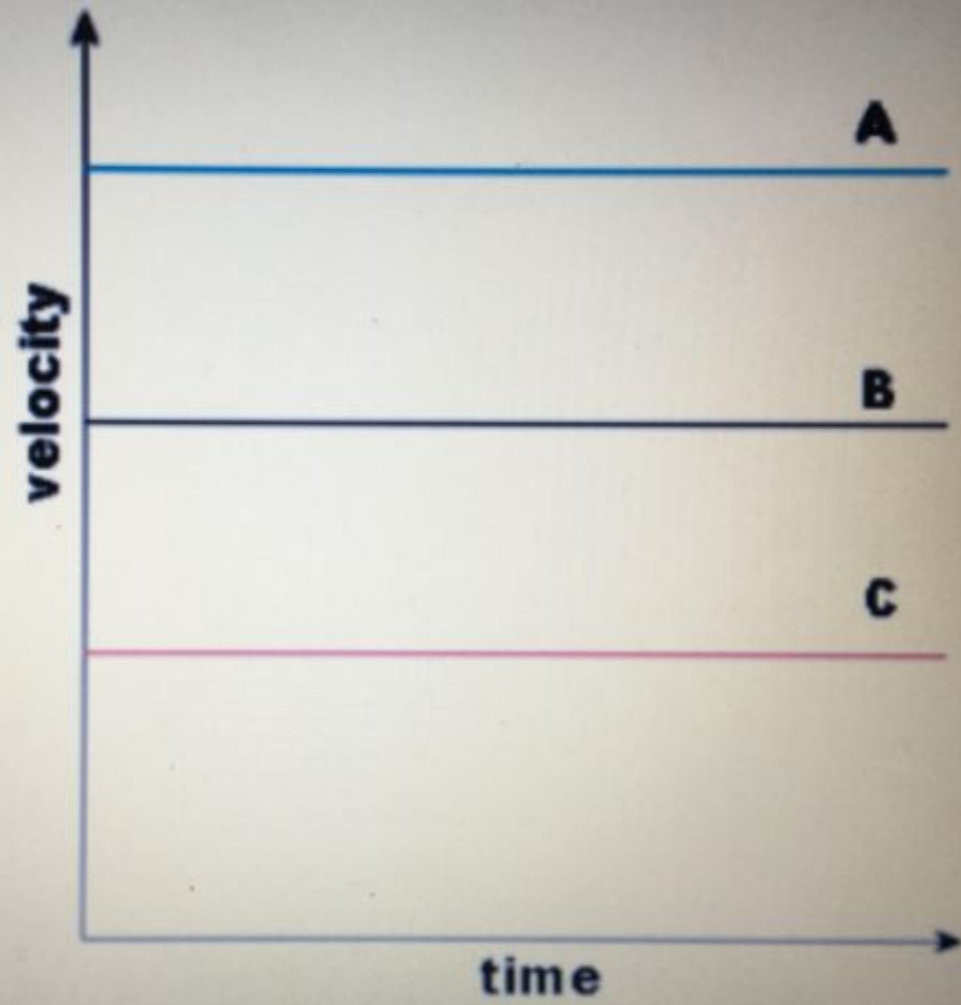
2. Draw the velocity – time graph for this displacement -time graph.

Displacement

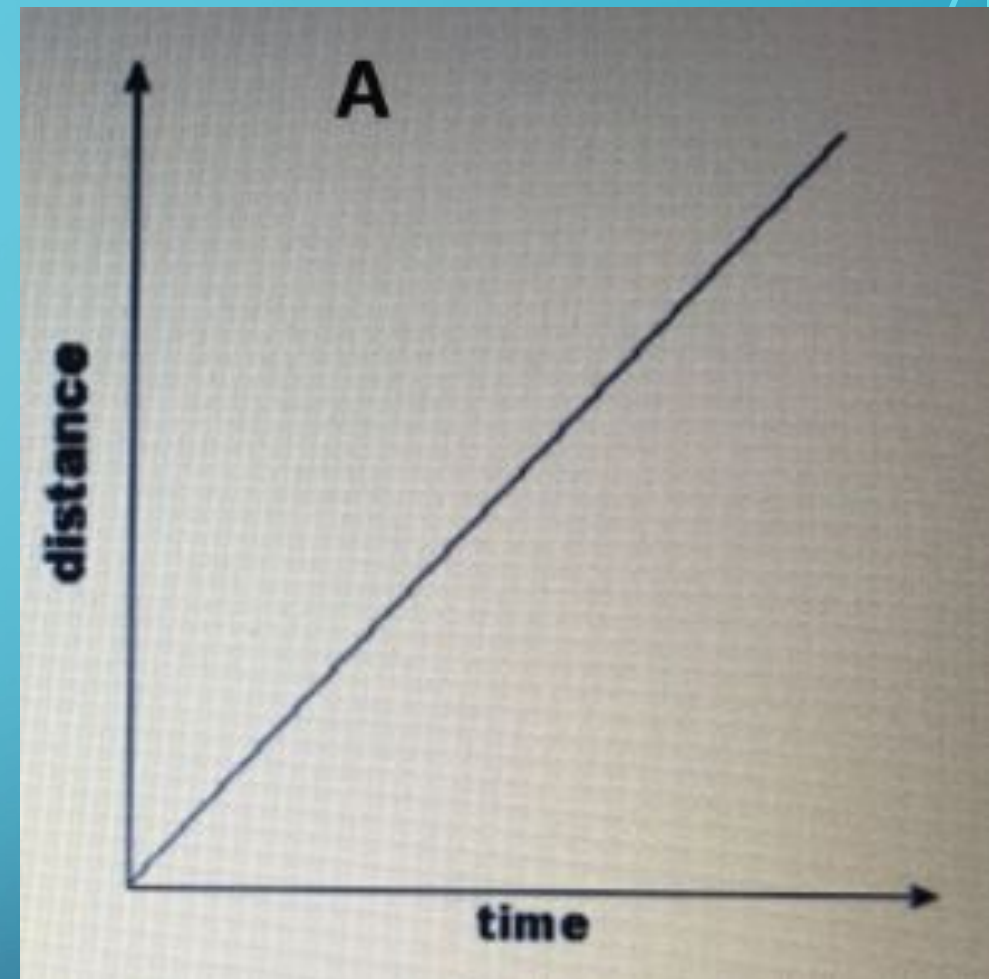
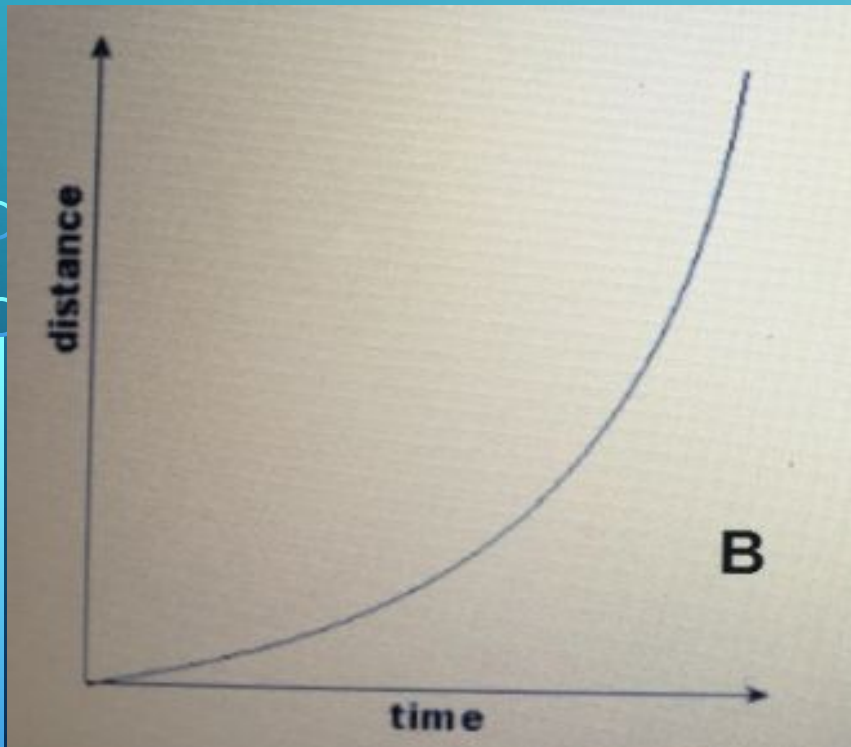


Time

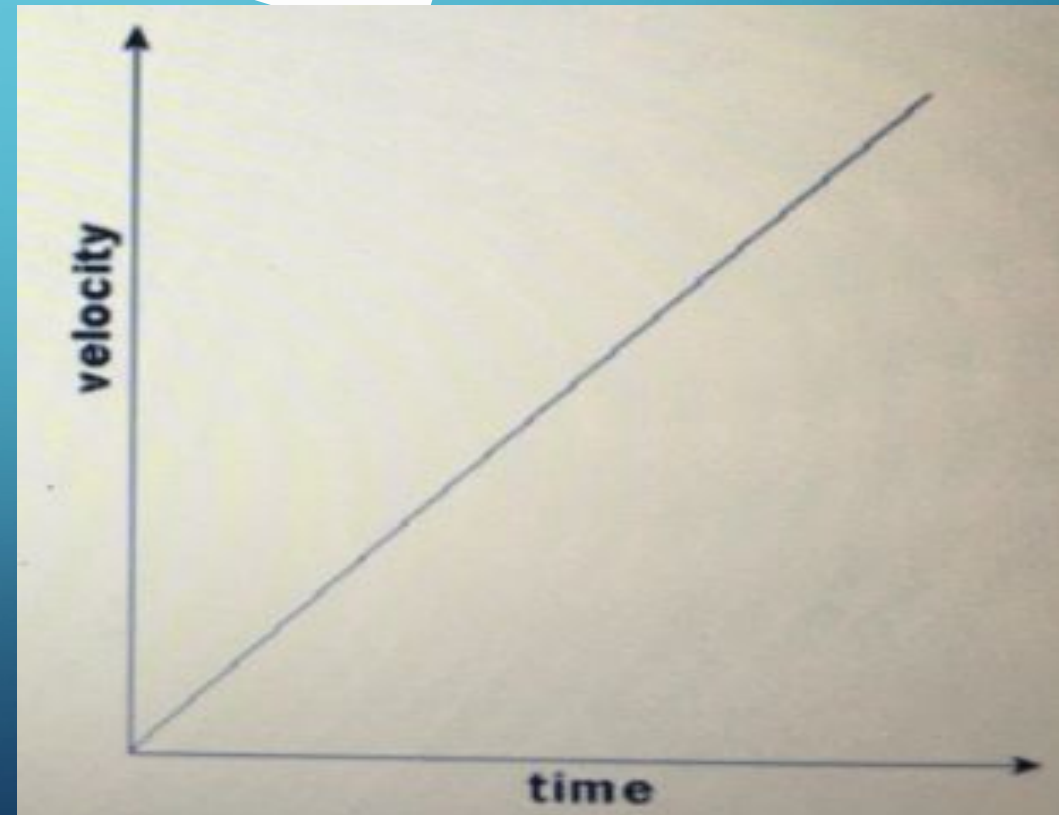
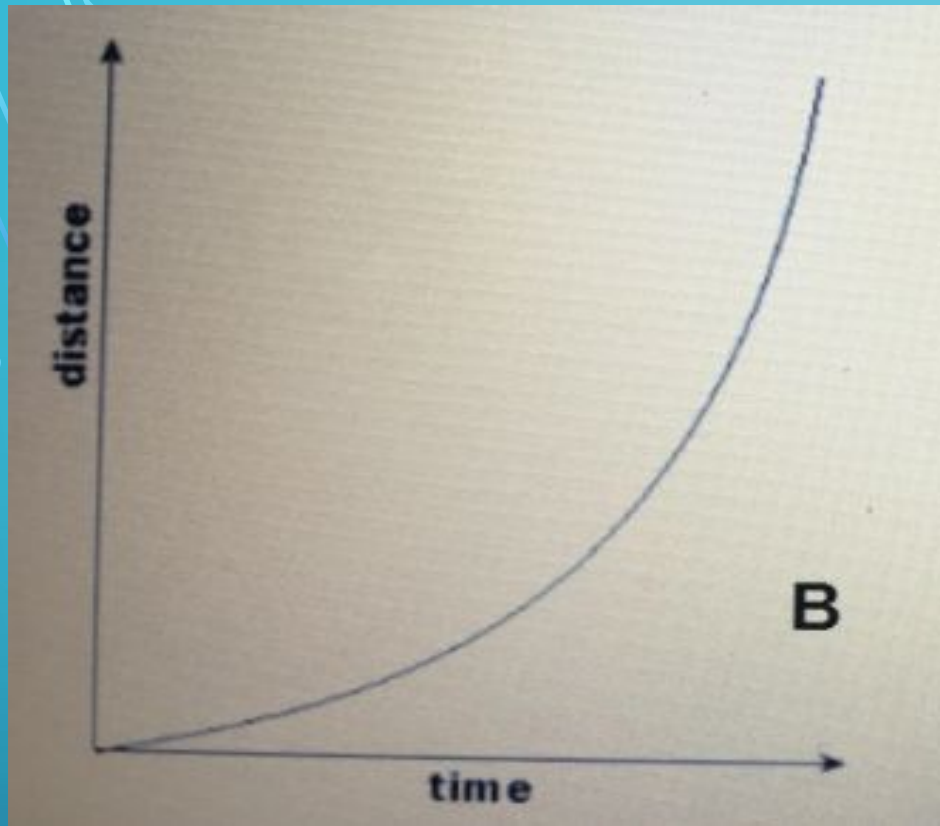
ANSWER



Which of the following graphs show a graph for a uniformly accelerated motion that the distance is changing exponentially indicating that the velocity is changing at a constant rate or there is constant acceleration?



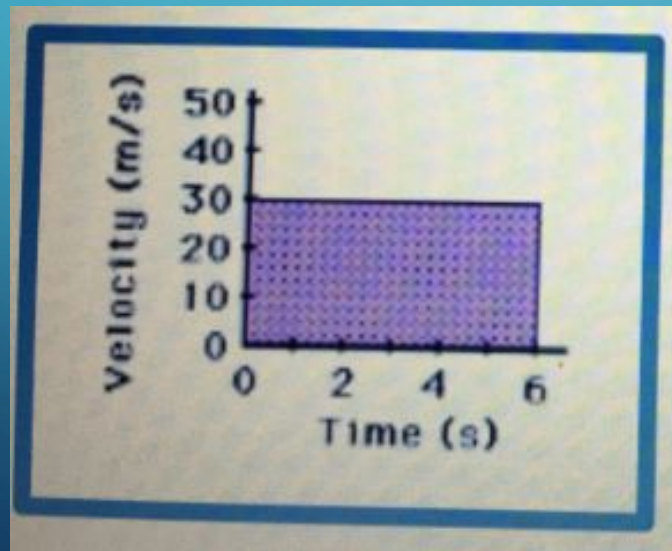
Draw the velocity – time graph of the graph showing uniformly accelerated motion.



ANSWER

Determining the Area on a v-t Graph

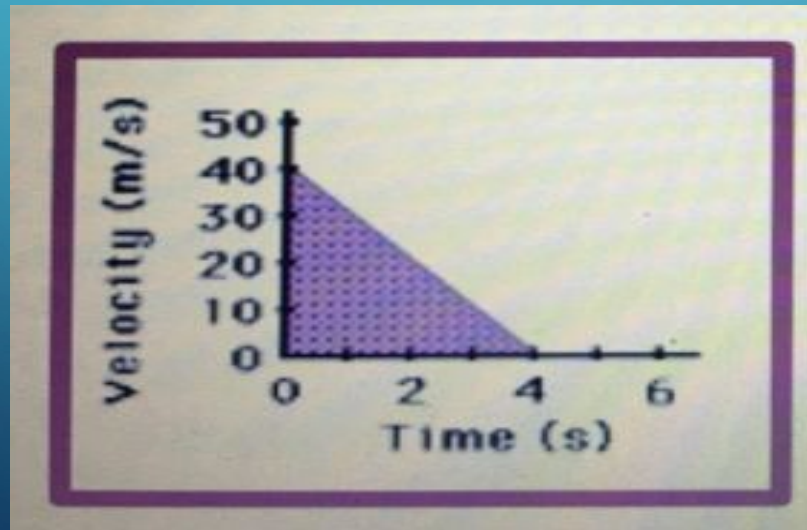
The shaded area is representative of the displacement during from 0 seconds to 6 seconds. This area takes on the shape of a rectangle can be calculated using the following equation.



Rectangle
 $\text{Area} = b \cdot h$

Determining the Area on a v-t Graph

The shaded area is representative of the displacement during from 0 seconds to 4 seconds. This area takes on the shape of a triangle can be calculated using the following equation.

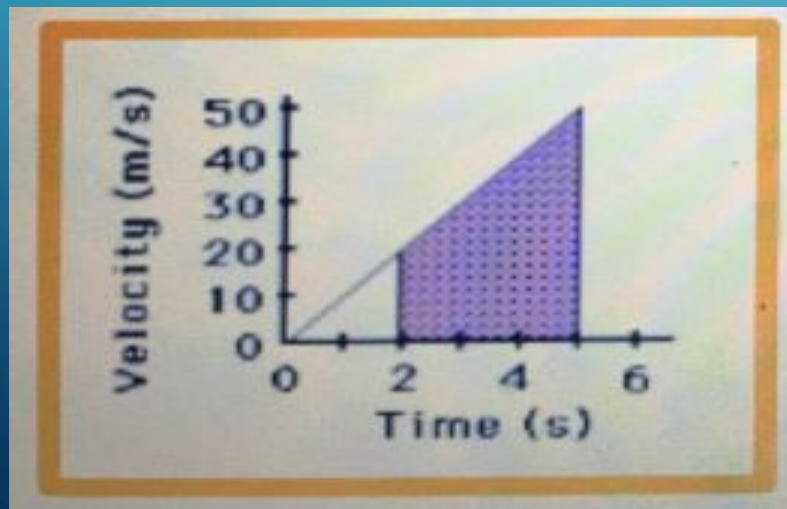


Triangle

$$\text{Area} = \frac{1}{2} \cdot b \cdot h$$

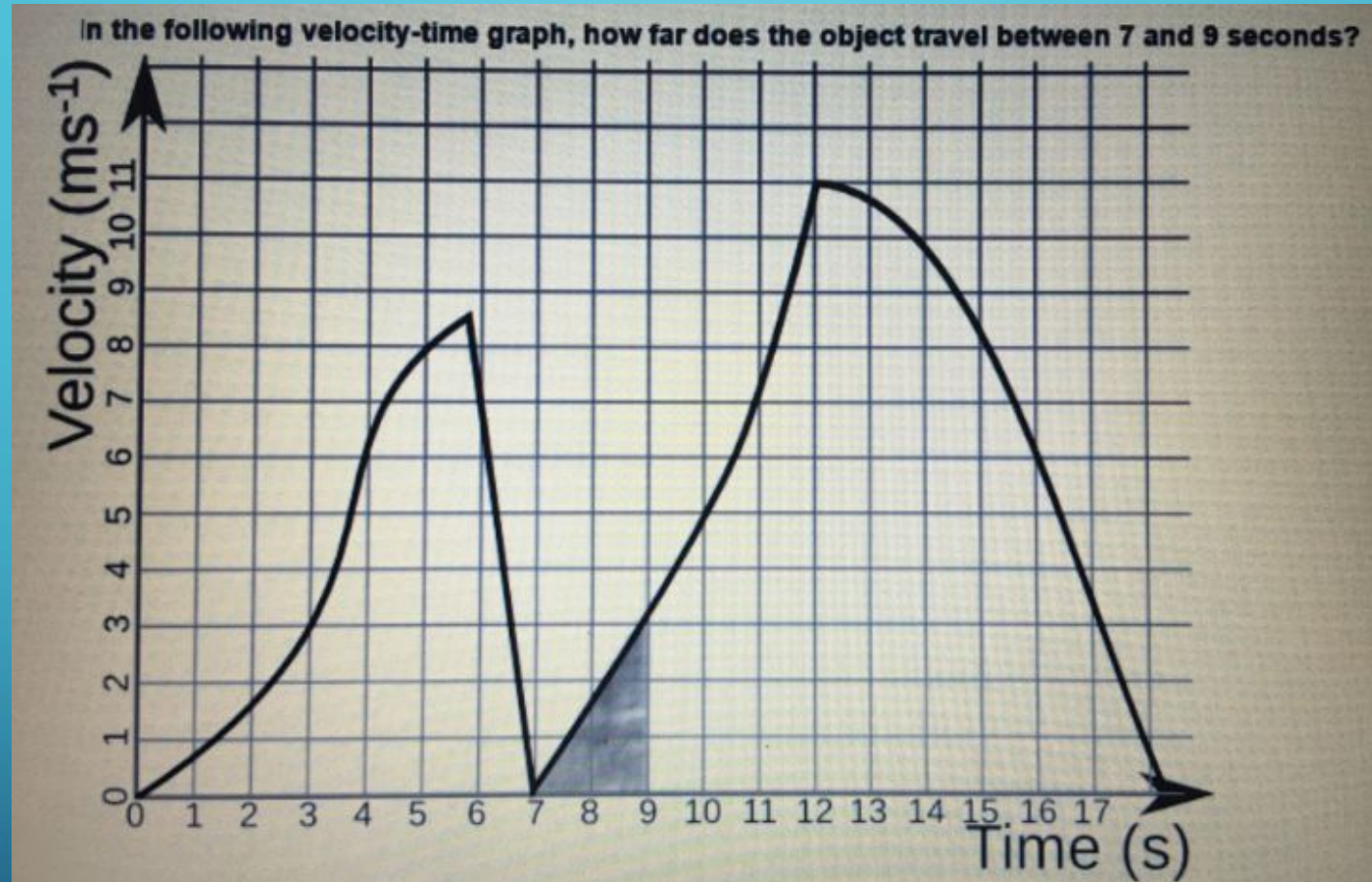
Determining the Area on a v-t Graph

The shaded area is representative of the displacement during from 2 seconds to 5 seconds. This area takes on the shape of a trapezoid can be calculated using the appropriate equation.



Trapezoid
Area = $\frac{1}{2} \cdot b \cdot (h_1 + h_2)$

SAMPLE PROBLEM ON GETTING THE DISPLACEMENT IN A VELOCITY – TIME GRAPH



Distance travelled is equal to the area under the graph. Between 7 and 9 seconds, this is the shaded area of the graph. So, calculate the area of the triangle:

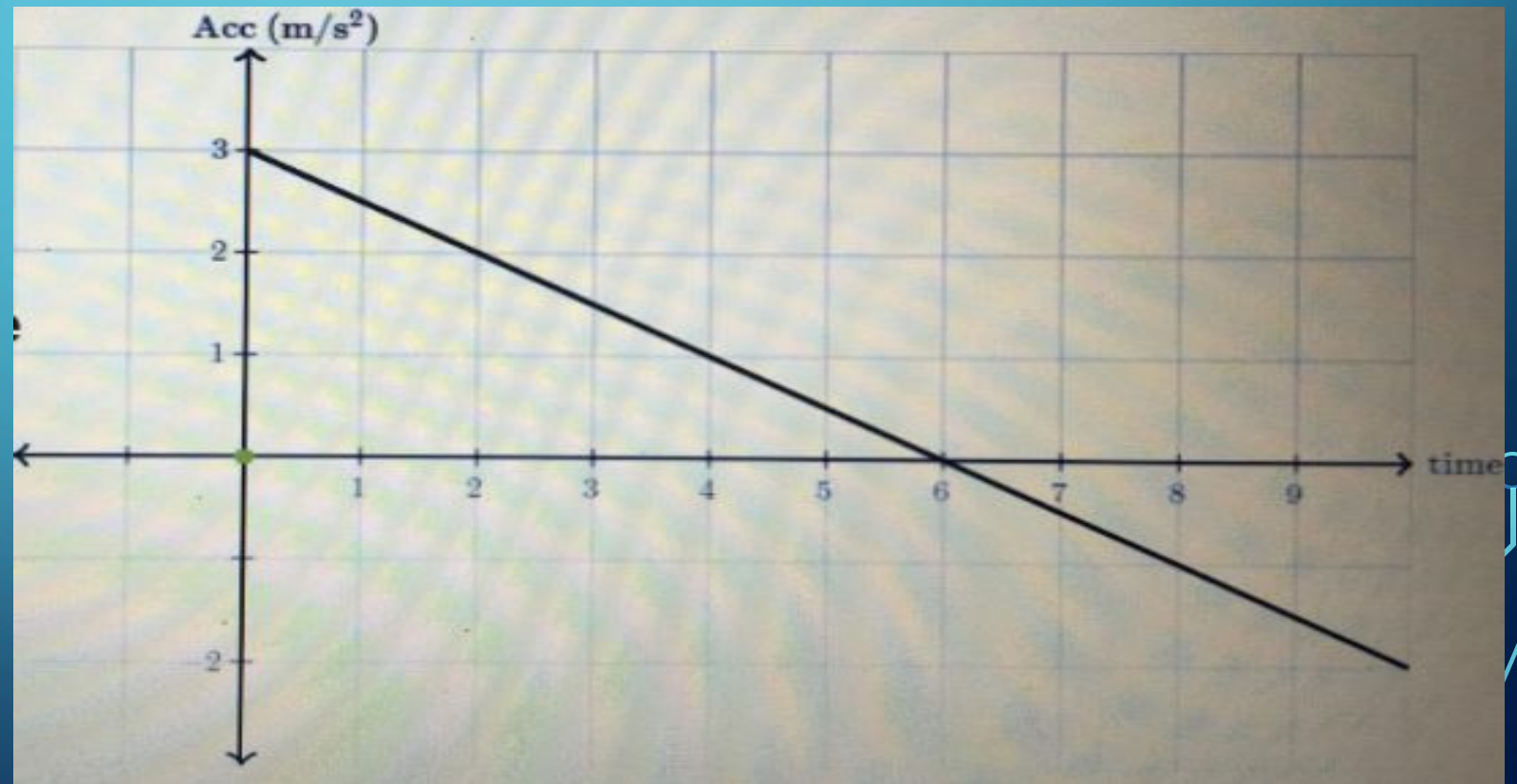
$$A = \frac{bh}{2} = \frac{2 \times 3}{2} = 3\text{m}$$

What are acceleration vs. time graphs?

What does the vertical axis represent on an acceleration graph?

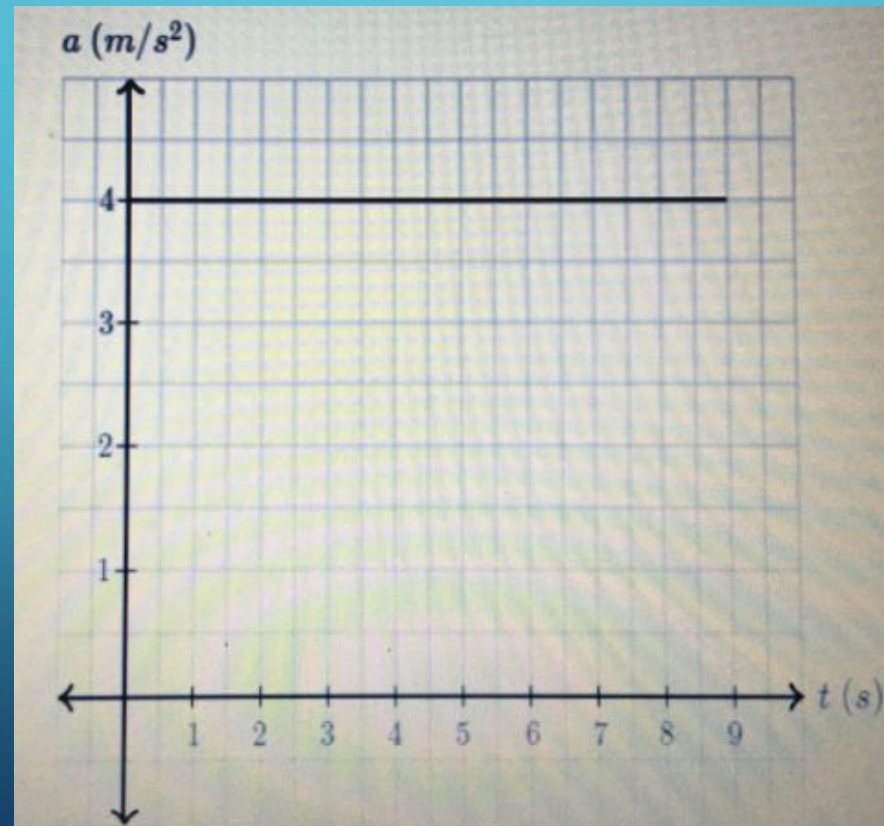
Concept check:

According to the graph, what is the acceleration at time $t = 4 \text{ s}$?



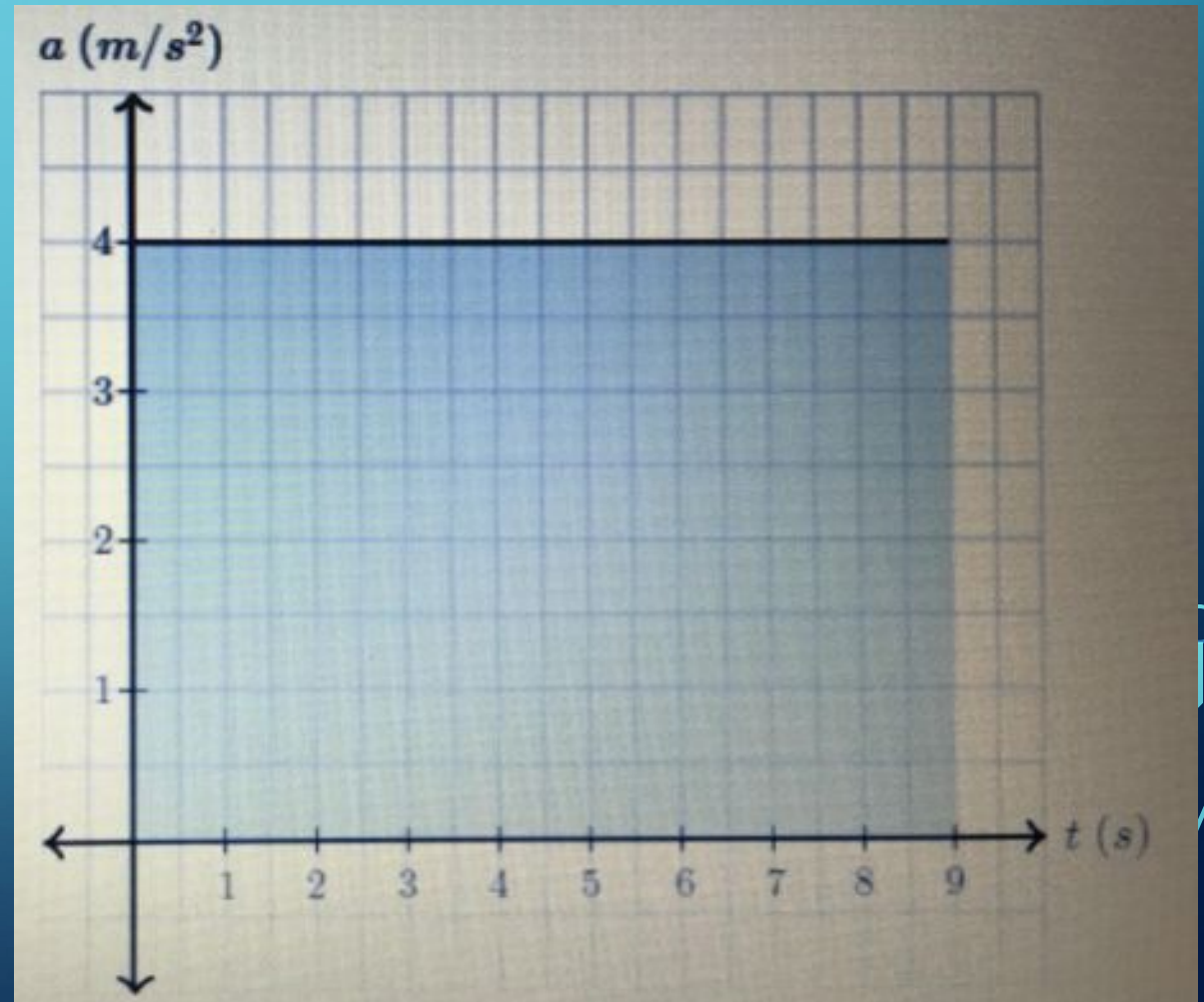
What does the area represent on an acceleration graph?

Consider the example graph below which shows a constant acceleration of 4 m/s^2 for a time of 9 s.



The area can be found by multiplying height times width. The height of this rectangle is $4 \frac{\text{m}}{\text{s}^2}$, and the width is 9 s. So, finding the area also gives you the change in velocity.

$$\text{area} = 4 \frac{\text{m}}{\text{s}^2} \times 9 \text{ s} = 36 \frac{\text{m}}{\text{s}}$$



QUESTION:

How do we get the change in velocity (area) of this acceleration – time graph?

