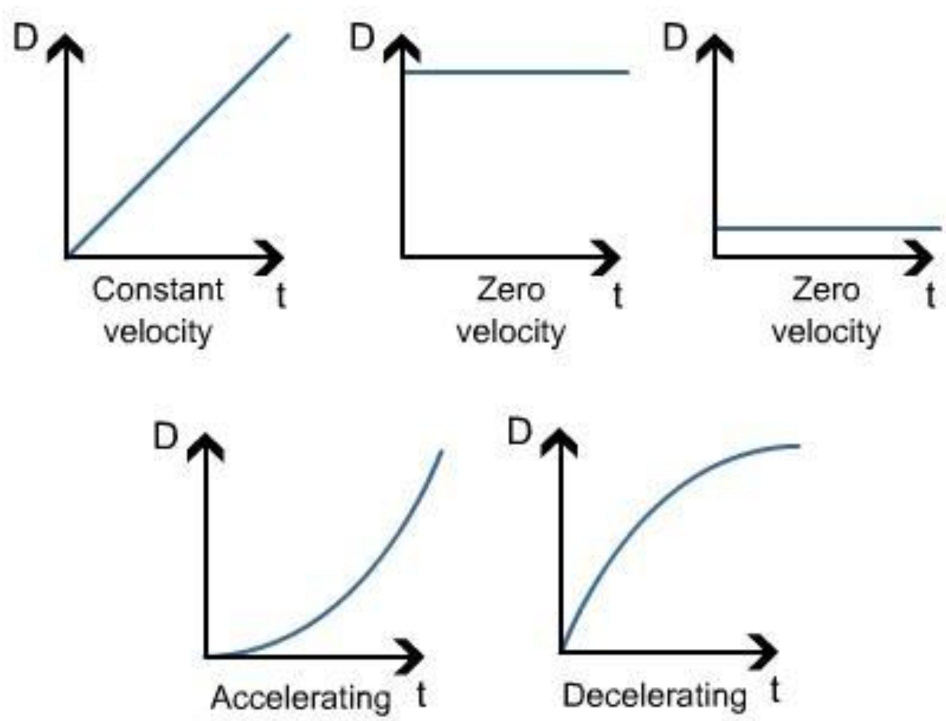
PHYSICS
KENAMATICS
FORM 5

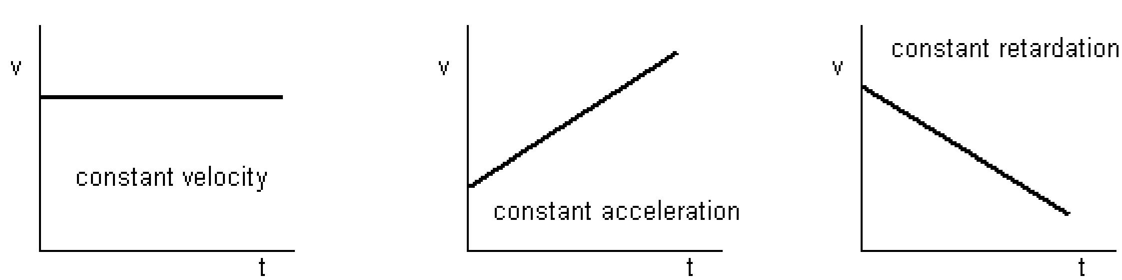
Kinematics refers to motion in a straight line.

There are several graphs that illustrate motion in a straight line:

1. Displacement-Time Graph
2. Distance-Time Graph
3. Velocity-Time Graph
4. Speed-Time Graph

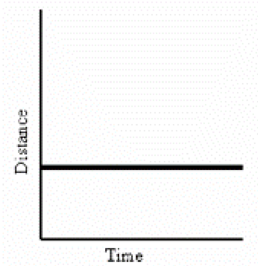
The graphs are illustrated below:



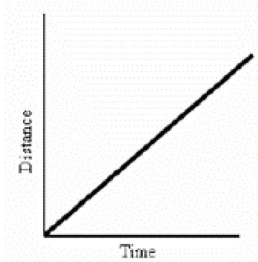


PHYSICS
KENAMATICS
FORM 5

Motion Graphs – Distance/Time Graphs

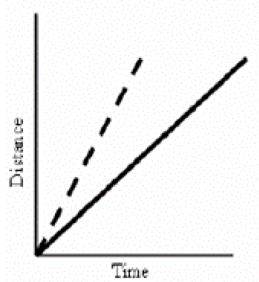


Time is increasing to the right, but its distance does not change. It is not moving. It is **At Rest**.



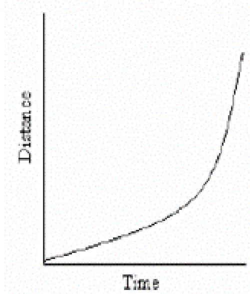
Time is increasing to the right, and the distance is increasing constantly with time. The object moves at a **constant speed.**

Constant speed is shown by a straight line on a graph.



The steeper dashed line indicates a larger distance moved in a given time. In other words, **higher speed**.

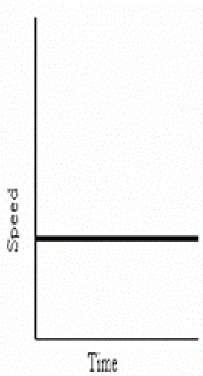
Both lines are straight, so both speeds are constant.



The line on this graph is curving upwards. This shows an **increase in speed**, since the line is getting steeper.

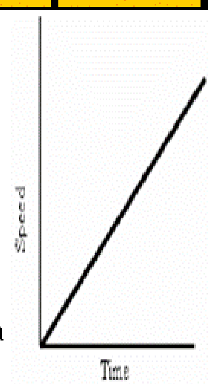
In a given time the distance the object moves gets larger. t is **accelerating.**

Motion Graphs – Speed/Time Graphs

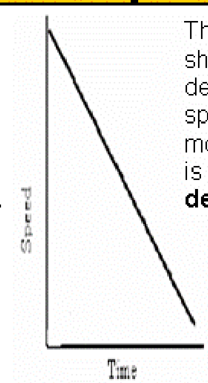


A straight horizontal line on a speed-time graph means that speed is constant. It is not changing over time.

There is movement at a constant speed.

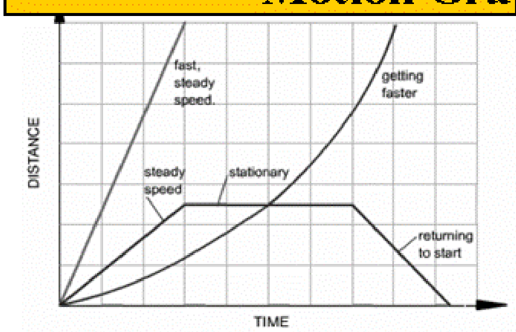


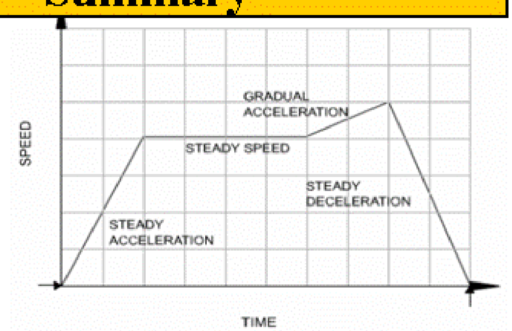
This graph shows increasing speed. The moving object is **accelerating.**



This graph shows decreasing speed. The moving object is **decelerating.**

Motion Graphs – Summary





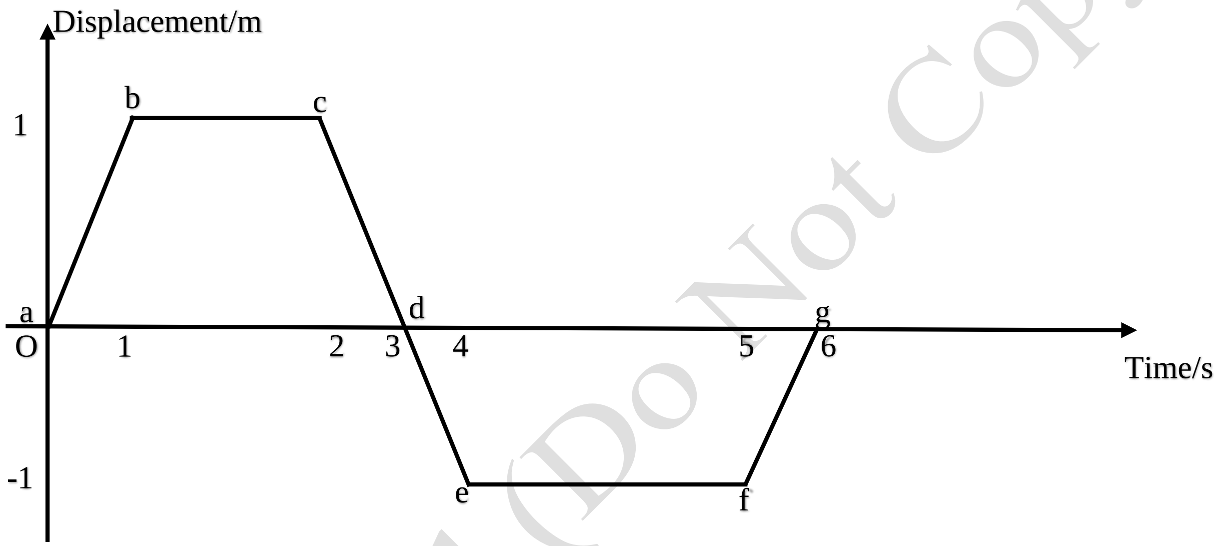
PHYSICS
KENAMATICS
FORM 5

Displacement-Time Graph

Displacement represents distance in a particular direction and is a vector quantity.

In a displacement-time graph, displacement is given on the y-axis and time is given on the x-axis.

The gradient of any line segment in a displacement-time graph gives the velocity.



a	–	Object is at origin
ab	–	Object moved 1m in a particular direction
b	–	Object is 1m away from origin
bc	-	Object did not move
c	-	Object is still 1m away from the origin
cd	-	Object moved back to the origin
d	-	Object is back to the origin
de	-	Object moved 1m away from the origin in the opposite direction
e	-	Object moved away from the origin
ef	-	Object is stationary
f	-	Object is 1m away from the origin
fg	-	Object returned to the origin.

By finding the gradient of any of the following line segments, velocity can be found:

ab - Constant velocity

bc - Zero velocity

cd - Constant velocity in the opposite direction

de - Constant velocity in the opposite direction

ef - Zero velocity

fg - Constant velocity

$$Velocity = \frac{displacement}{time}$$

$$Velocity = \frac{distance\ in\ a\ given\ direction}{time}$$

$$Velocity = \frac{m}{s}$$

Practical example:

Imagine a car going around a roundabout with a speedometer reading 30km/hr. The speed is constant (30km/hr). Since the direction of the car is always changing, then the velocity will also change. The velocity is not a constant.

Acceleration

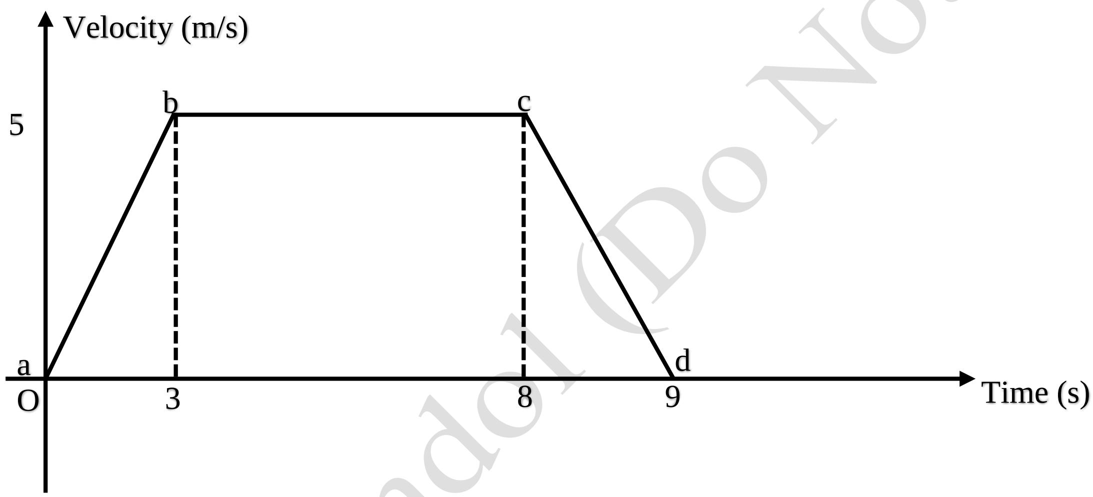
Acceleration is defined as the rate of change of velocity. The change in $\frac{velocity}{time\ taken}$ for this change will yield the acceleration.

$$Acceleration = \frac{change\ in\ velocity}{change\ in\ time}$$

$$Acceleration = \frac{ms^{-1}}{s} = ms^{-2}$$

Therefore acceleration has the units m/s^2 or ms^{-2}.

If velocity increases then acceleration will have a positive value. Likewise, if velocity decreases then acceleration will have a negative value and is known as deceleration.



In a velocity-time graph, the gradient of any of the line segments gives acceleration:

ab - Constant acceleration

bc - Zero acceleration (constant velocity)

cd - Constant deceleration

The shape 'abcd' is that of a trapezium and the area under the graph represents distance moved.

Hence the area of the trapezium gives the distance moved.

$$Area\ of\ Trapezium = \frac{1}{2} \times (sum\ of\ parallel\ sides) \times height$$

$$Area\ of\ Trapezium = \frac{1}{2} \times (9 + 5) \times 5$$

$$Area\ of\ Trapezium = \frac{1}{2} \times (14) \times 5$$

$$Area\ of\ Trapezium = \frac{1}{2} \times 70$$

$$Area\ of\ Trapezium = 35$$

Therefore the distance covered is 35m.

PHYSICS
KENAMATICS
FORM 5

Questions:

1. A car starts from rest, accelerates at $8m/s$ for 10 seconds and then a further 20 seconds. Draw a velocity time graph and find the total distance travelled.
2. A car starts from rest accelerating $1m/s^2$ for 10 seconds. It then continues at a steady speed for 20 seconds and decelerates to rest in 5 seconds. Draw a velocity-time graph. Find the distance travelled and hence find the average speed.

Further Reading:

1. http://www.physicsclassroom.com/Physics-Tutorial/1-D-Kinematics