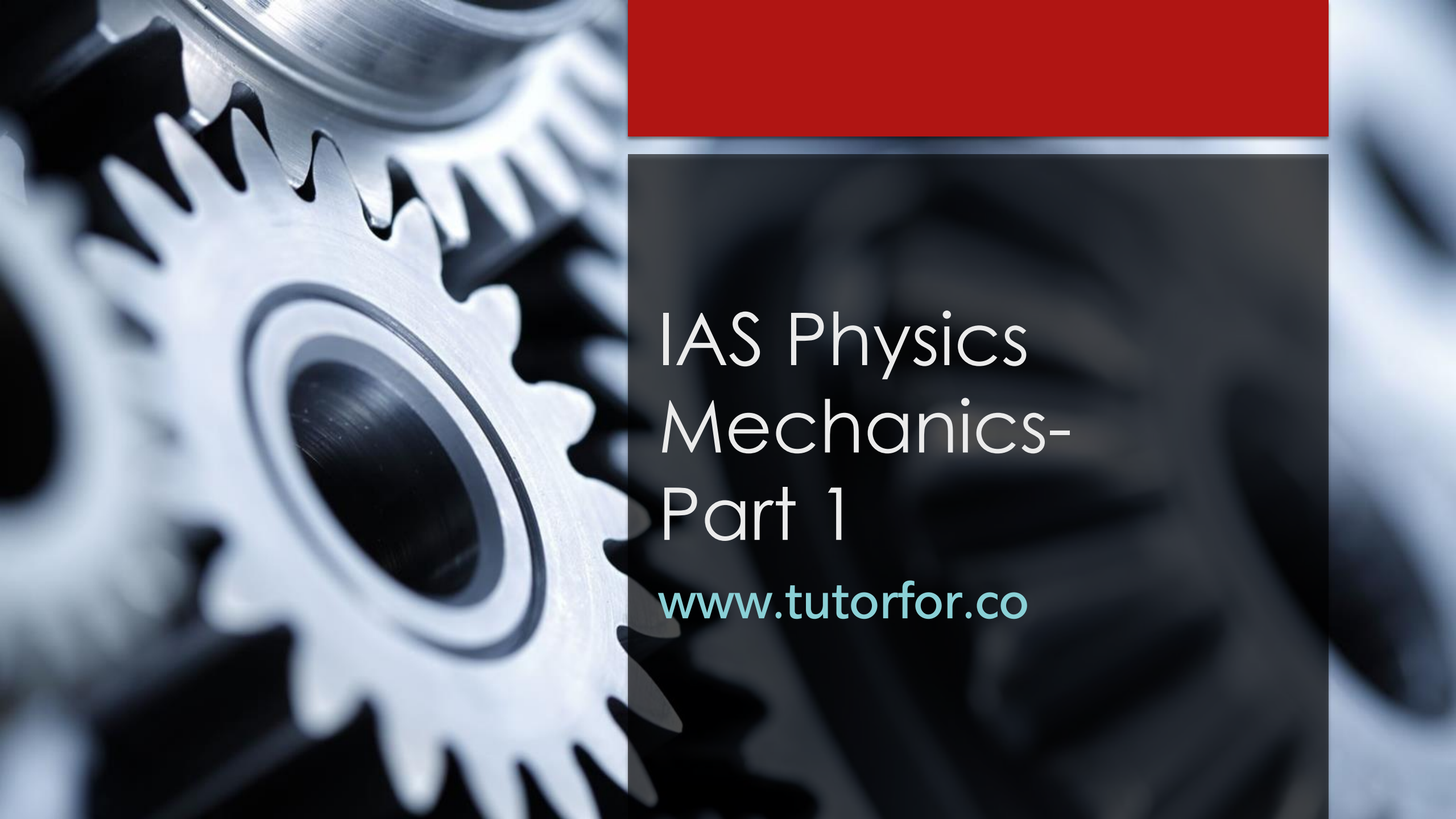

IAS Physics Mechanics- Part 1

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Objectives:

1	be able to use the equations for uniformly accelerated motion in one dimension: $s = \frac{(u+v)t}{2}$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
2	be able to draw and interpret displacement-time, velocity-time and acceleration-time graphs
3	know the physical quantities derived from the slopes and areas of displacement-time, velocity-time and acceleration-time graphs, including cases of non-uniform acceleration and understand how to use the quantities

Distance & Displacement

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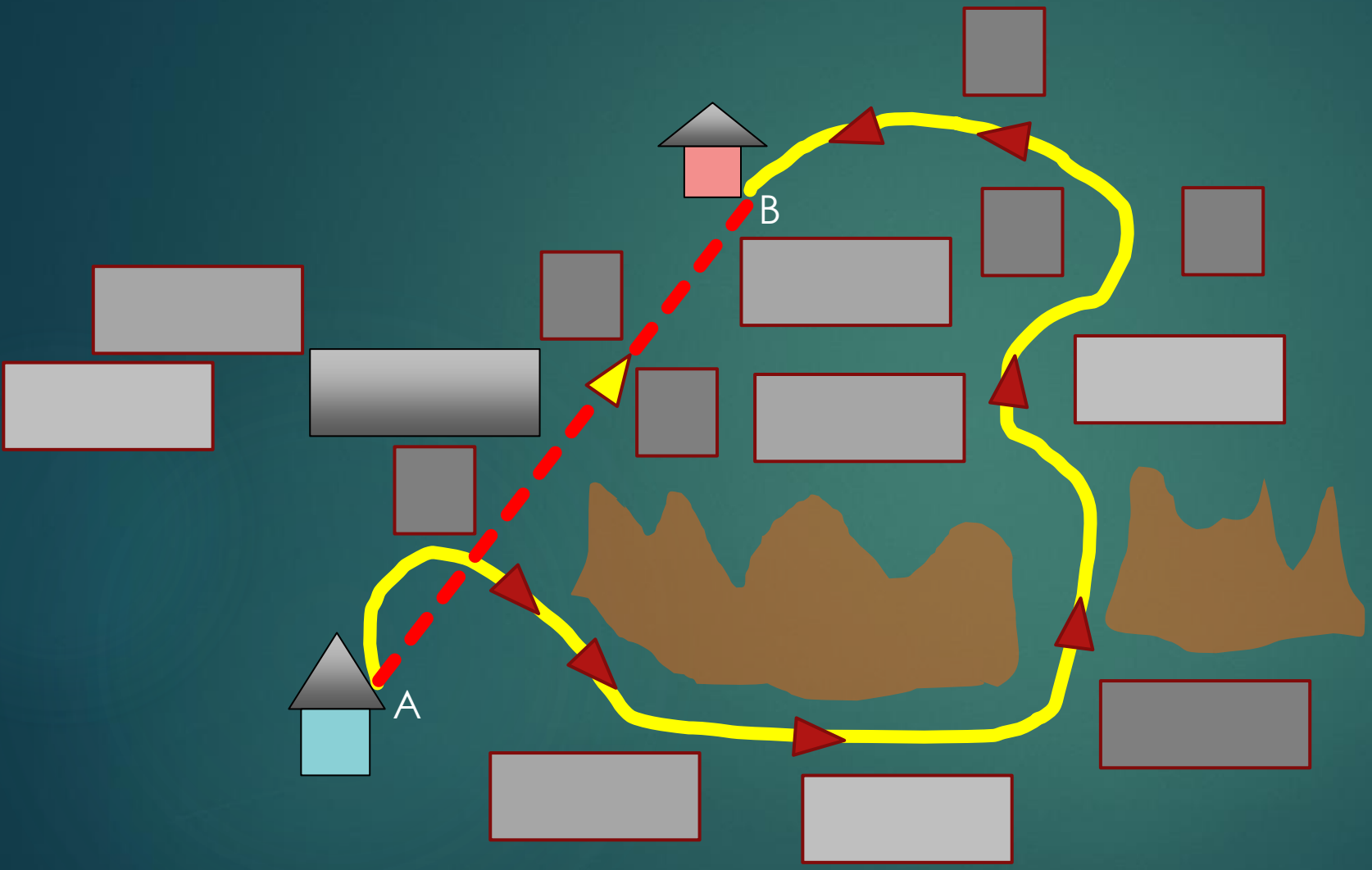
Distance & Displacement



The length of the path between two points is called the distance.

Distance has no specific direction.

Displacement is the distance(straight) travelled in a particular direction .

The SI unit of distance and displacement- metre(m)

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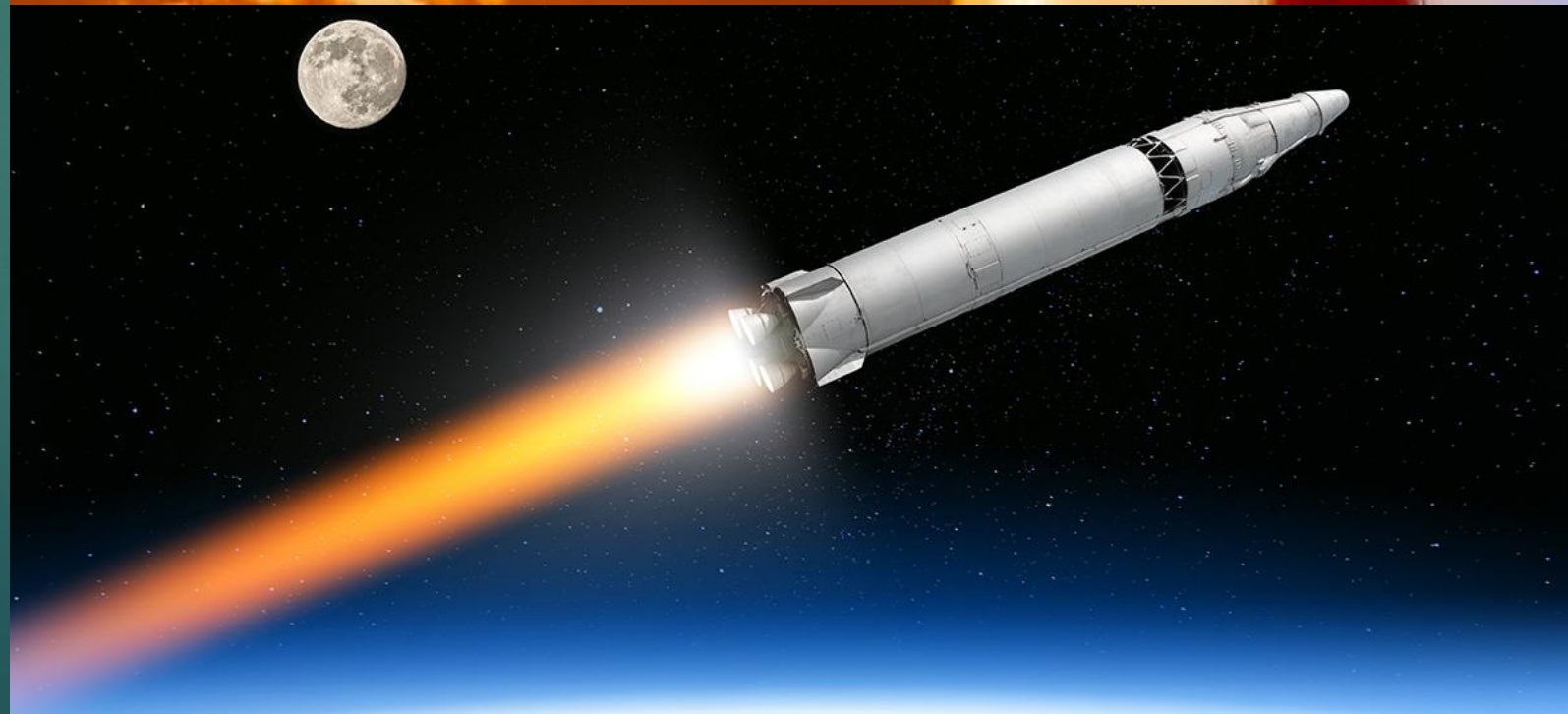
Vector quantities & scalar quantities



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Vector quantities & scalar quantities

- A vector quantity is a quantity that has both magnitude(size) and direction.

Ex: Displacement, Force, Momentum, Acceleration, Velocity

- A scalar quantity is a quantity that has only a magnitude(size) and no direction.

Ex: Distance, time, volume, speed, mass, temperature

The speed of an object at a particular moment in time is called instantaneous speed

Instantaneous speed

Average speed

The ratio between the total distance moved and the total time taken for a journey is called the average speed of an object.

$$Average\ speed = \frac{total\ distance\ moved}{total\ time\ taken}$$

$$v = \frac{s}{t}$$

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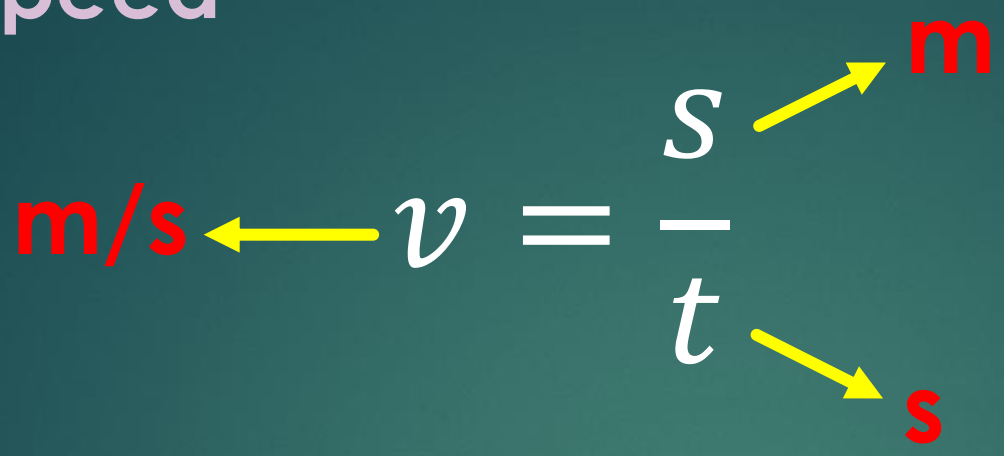
Units of speed



s-distance moved
t-time taken
v-speed

SI unit of speed is metre per second(m/s).

Other units for speed:

- kilometre per hour(km/h)
- centimetre per second(cm/s)
- millimetre per second(mm/s)

Concept learning:

A car travels 240 km in 3 hours. Find the average speed of the car in km/h .

$$v = \frac{S}{t} \qquad v = \frac{240\ km}{3\ h} = 80\ km/\text{h}$$

Unit conversions between km/h & m/s.

1 h = 60 x 60 s = 3600 s
1 km = 1000 m

Convert 1 km/h to m/s

$$\frac{1\ km}{1\ h} = \frac{1000\ m}{3600\ s} = \left(\frac{5}{18}\right) m/s = \frac{1}{3.6}\ m/s$$

- Divide the (km/h) speed value by 3.6 and write the answer in m/s.

Ex: Write 144 km/h in m/s

144 ÷ 3.6 = 40 m/s

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Unit conversions between km/h & m/s.

Convert 1 m/s to km/h

$$\frac{1\ m}{1\ s} = \frac{0.001\ km}{\left(\frac{1}{3600}\right) h} = 3.6\ km/h$$

- Multiply the (m/s) speed value by 3.6 and write the answer in km/h.

Ex: Write 10 m/s in km/h.

10 × 3.6 = 36 km/h

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Velocity & Acceleration

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Velocity

- The rate of change of displacement is called the velocity.
- Velocity is a vector quantity.
- SI unit- metre per second (m/s)

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Acceleration

- The rate of change of velocity is called the acceleration.
- Acceleration is a vector quantity.
- SI unit – metre per second square (m/s^2)
- Acceleration = $\frac{Change\ in\ velocity}{Time\ taken}$
- Acceleration = $\frac{(Final\ velocity - Initial\ velocity)}{Time\ taken}$

The equation works for uniform(constant) accelerations only.

$$a = \frac{(v-u)}{t}$$

$v - final\ velocity$
$u - intial\ velocity$
$a - acceleration$
$t - time\ taken$

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Deceleration

- Deceleration means slowing down. Ex: Applying brakes.
- The negative acceleration is called the deceleration.
- Same equation is used to calculate deceleration.

$$a = \frac{(v-u)}{t}$$

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Equations of motion

(Valid only for Uniform acceleration)

1) $s = \frac{(u+v)t}{2}$

$v = final\ velocity$
$u = initial\ velocity$
$s = displacement$
$a = acceleration$
$t = time\ taken$

2) $v = u + at$

3) $v^2 = u^2 + 2as$

4) $s = ut + \frac{1}{2}at^2$

Concept Learning Questions

1) A car accelerates uniformly from rest to a speed of 25 m/s in 10 seconds. Calculate the acceleration of the car.

2) An object is thrown vertically upward with an initial velocity of 20 m/s. How high does the object go before it starts coming back down? (Assume constant acceleration due to gravity, $g = 9.81\ m/s^2$)

Concept Learning Questions

3) A ball is dropped from a height of 40 meters. Calculate the time it takes for the ball to reach the ground. (Assume constant acceleration due to gravity, $g = 9.81\ m/s^2$)

4) A train decelerates from 40 m/s to 10 m/s in 20 seconds.Determine the displacement of the train during that time period.

Distance-time graphs

The distance-time graph shows how the distance traveled by an object changes with time.

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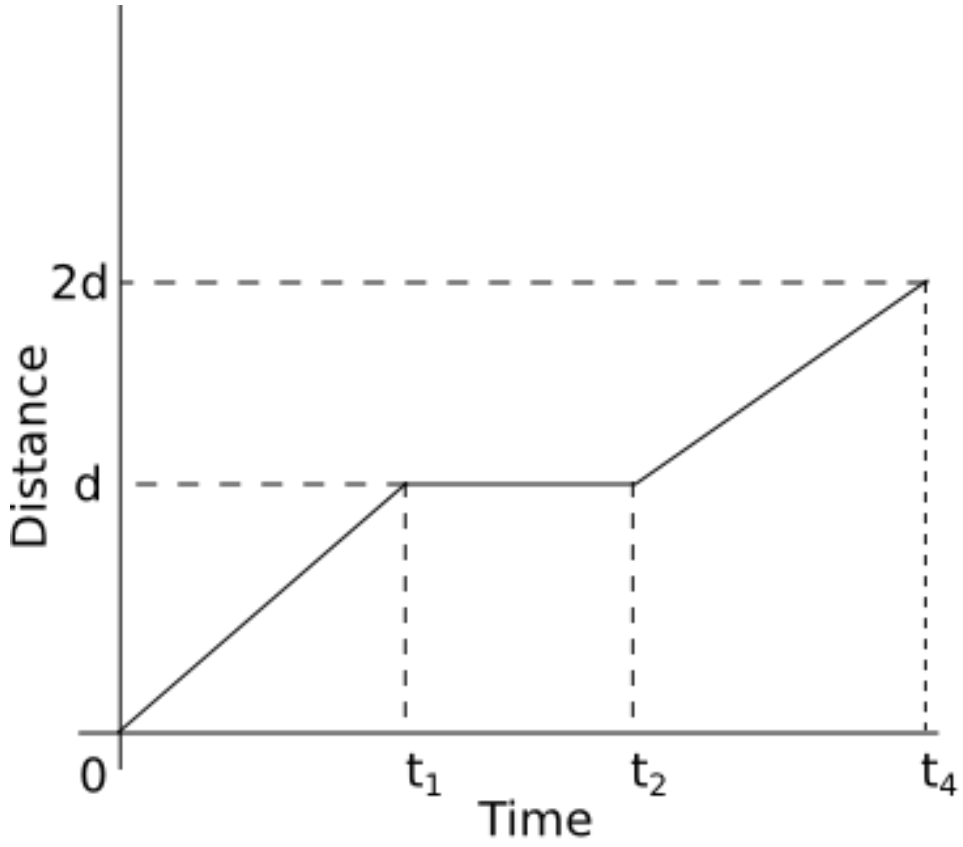
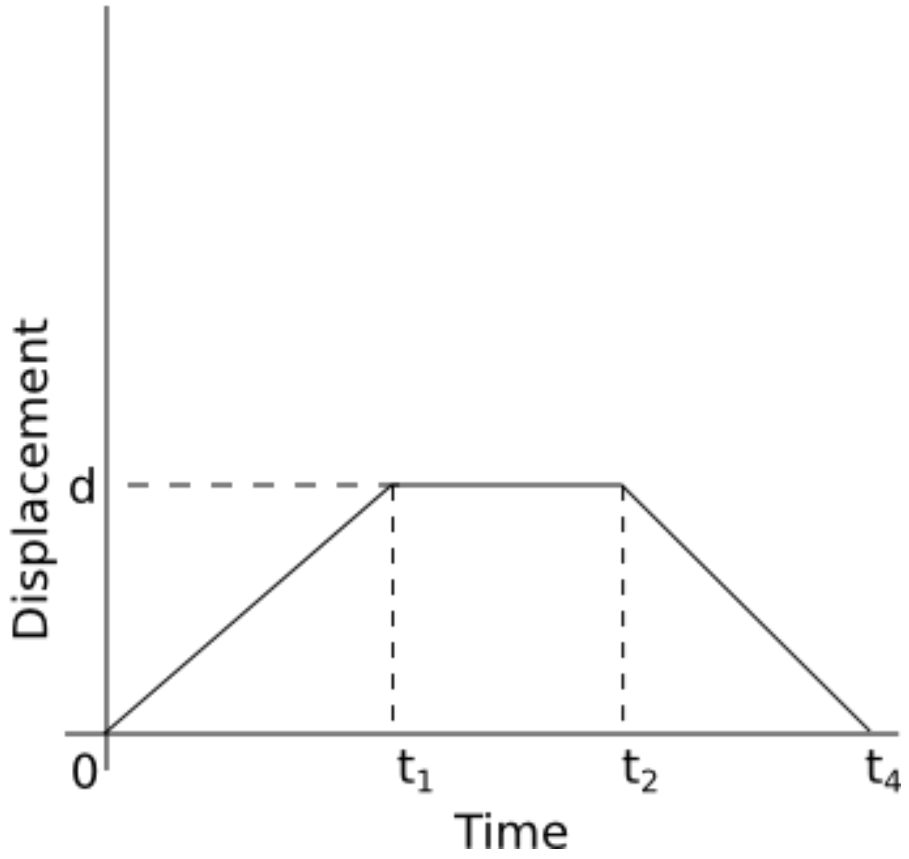
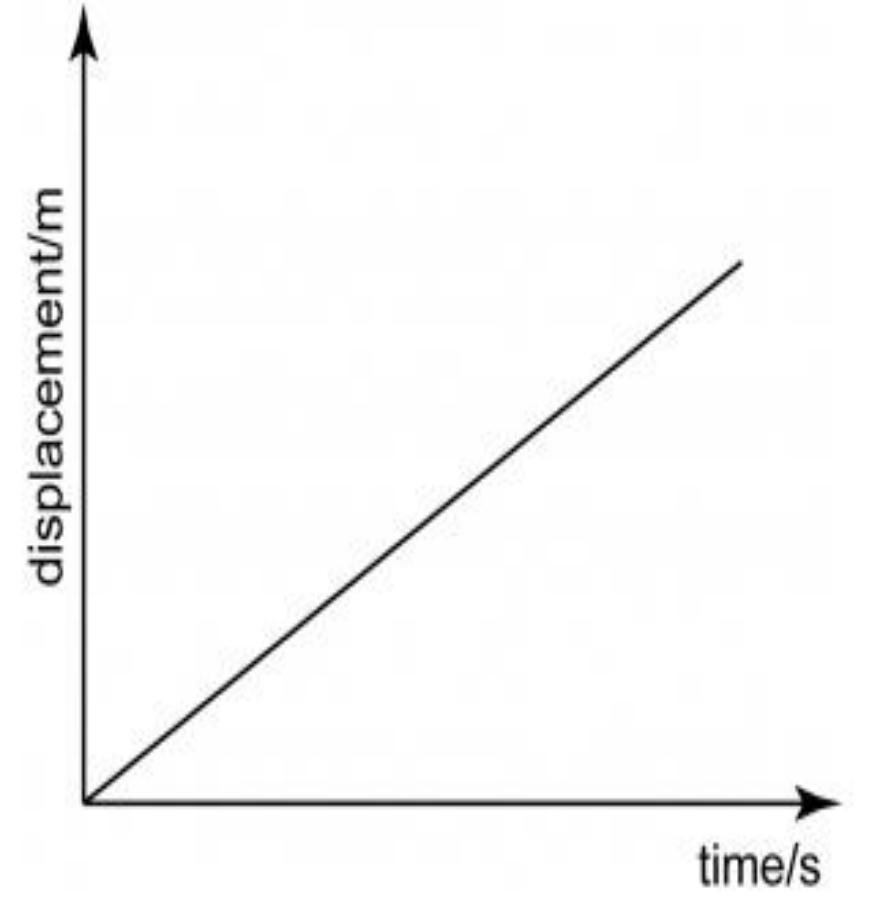
- Distance-time graph cannot decrease with time.
- A displacement-time graph could have parts of it in the negative portions of the y-axis, if the movement went in the opposite direction at some points in time.



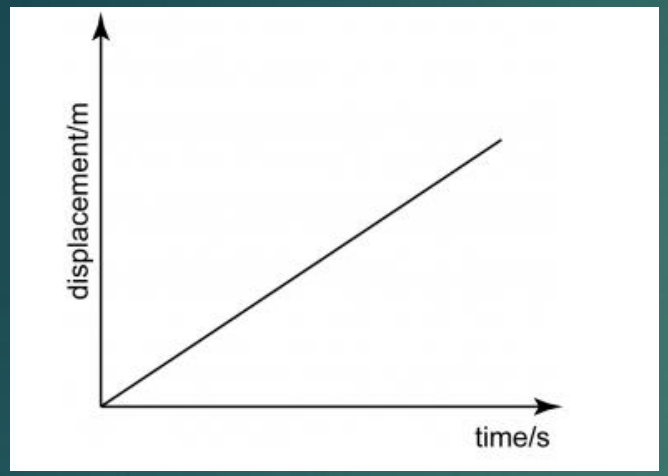


Displacement time(s-t) graphs.



- In a Displacement-Time Graph, the gradient of the graph is equal to the velocity of motion.
- Therefore, if the gradient of the graph is positive, the velocity is positive, and if the gradient of the graph is negative, the velocity is negative.
- A negative velocity indicates that the object moves in the opposite direction.

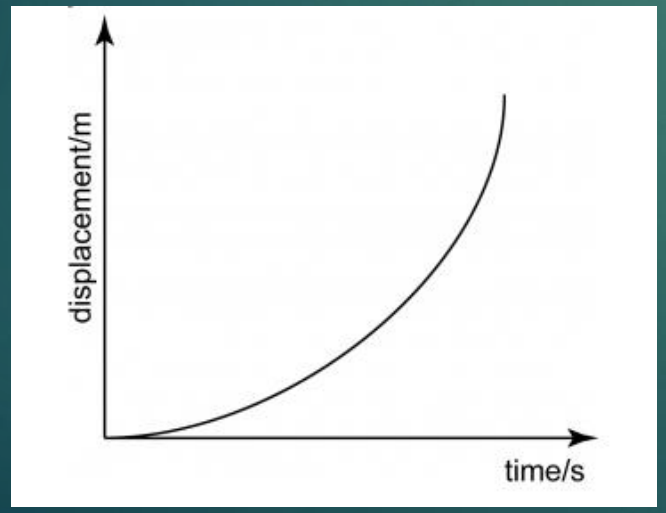
Displacement-time(s-t) graphs



Uniform(positive) velocity:

Graph: A straight line inclined to the time axis.

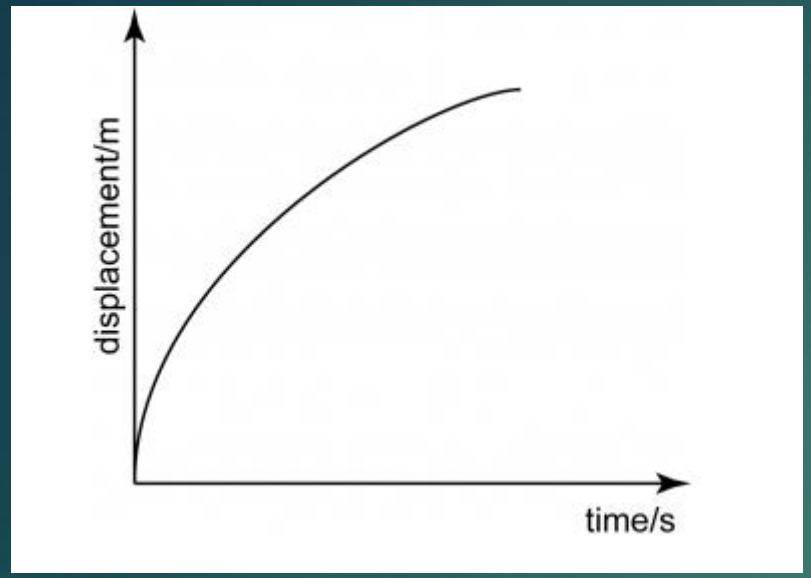
Characteristics: Constant slope indicates constant velocity. The steeper the slope, the greater the velocity.



Uniformly Accelerated Motion:

Graph: A curved line.

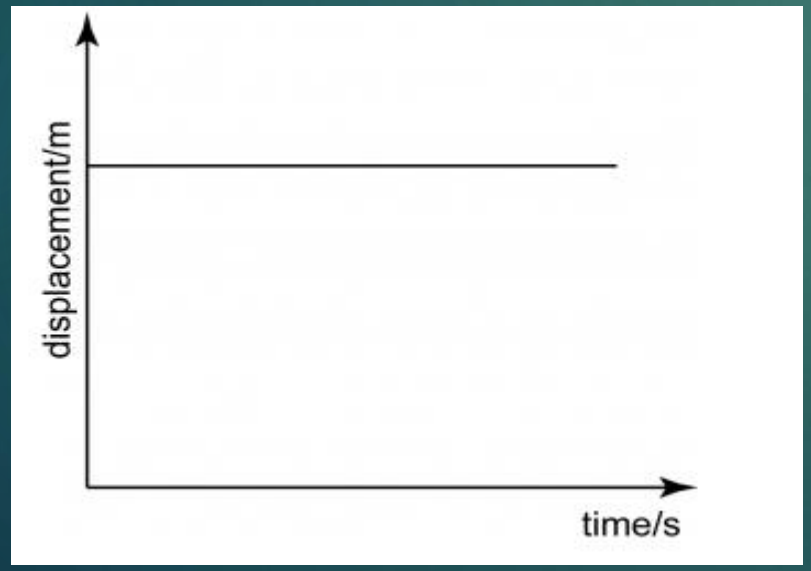
Characteristics: Increasing slope indicates acceleration. The steeper the slope, the greater the acceleration.



Uniformly Decelerated Motion:

Graph: A curved line

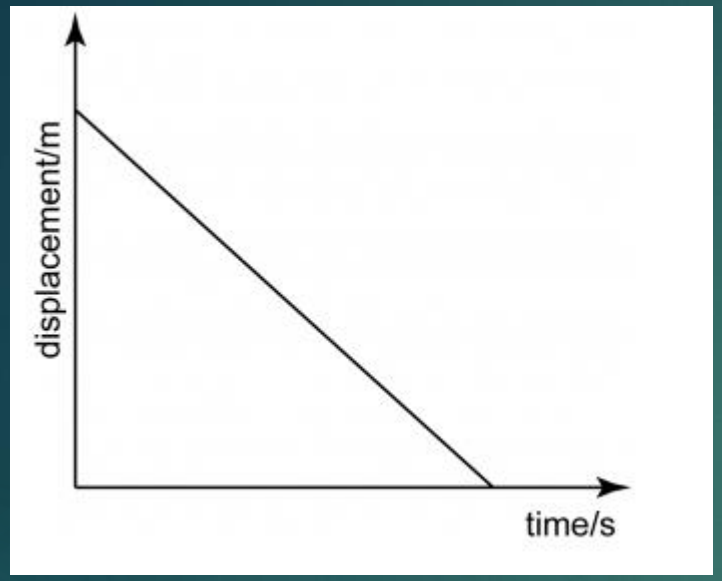
Characteristics: Decreasing slope indicates deceleration. The steeper the slope, the greater the deceleration.



Motion at Rest:

Graph: A horizontal line along the displacement axis.

Characteristics: The object is not moving; displacement remains constant with time



The graph is a non-horizontal straight line, with a negative gradient.

The negative value of gradient indicates that the object moves in the opposite direction.

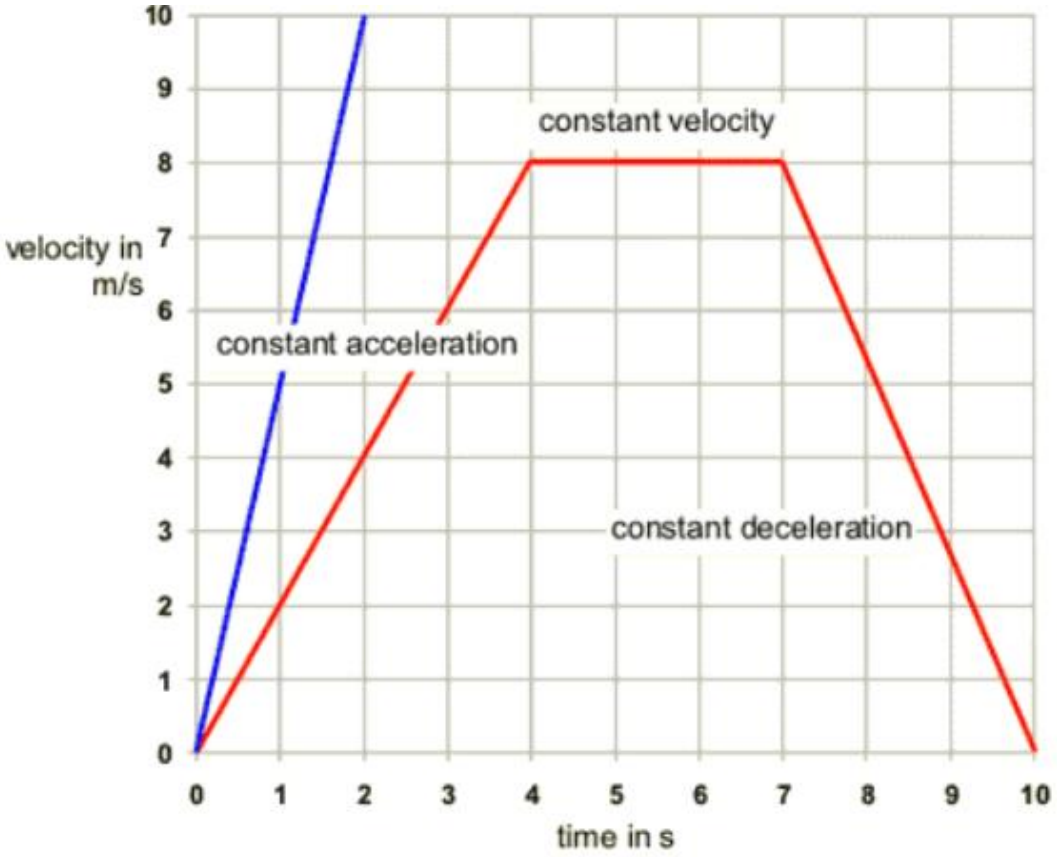
Therefore, this graph represents a motion with uniform velocity in opposite direction.

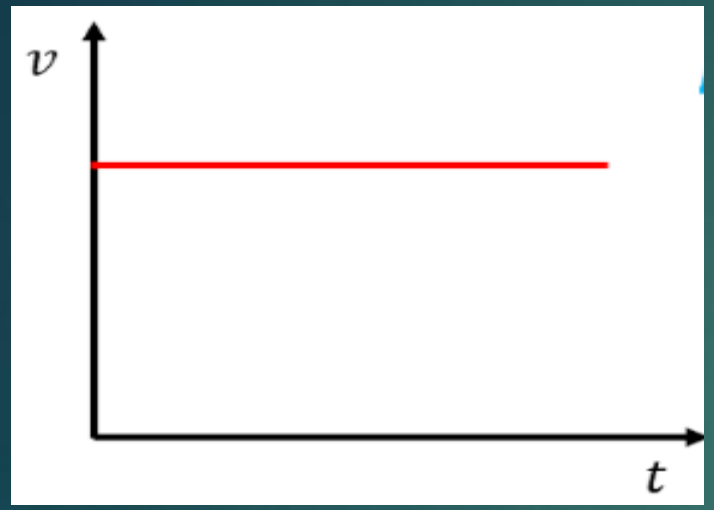
Velocity-time graphs (v-t graphs)

Velocity-time(v-t) graphs

- The gradient of the velocity-time graph gives a value of the changing rate in velocity, which is the acceleration of the object.

- The area below the velocity-time graph gives a value of the object's displacement.

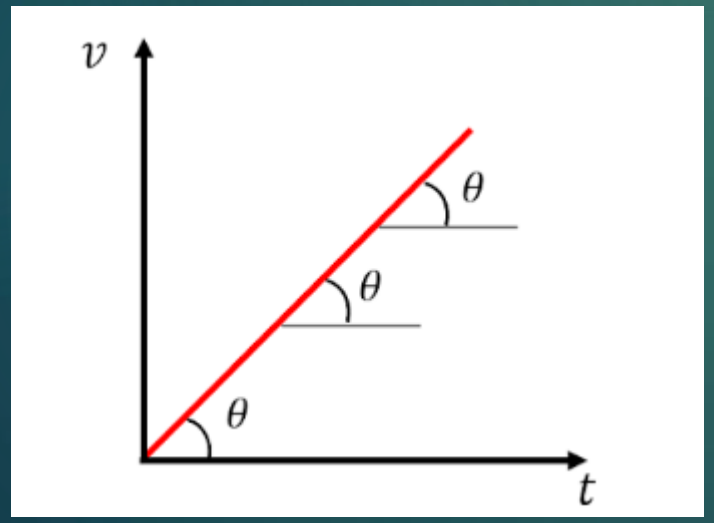




Constant Velocity:

Graph: A straight line parallel to the time axis.

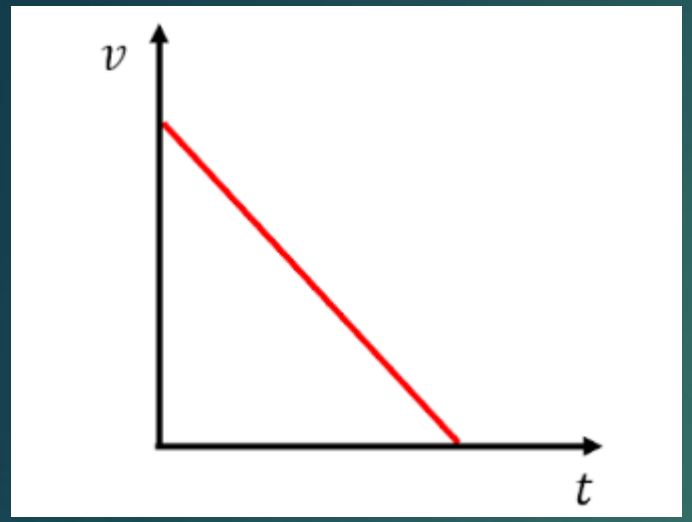
Characteristics: Constant slope indicates constant velocity. The steeper the slope, the greater the velocity.



Uniform Acceleration:

Graph: A straight line sloping upwards.

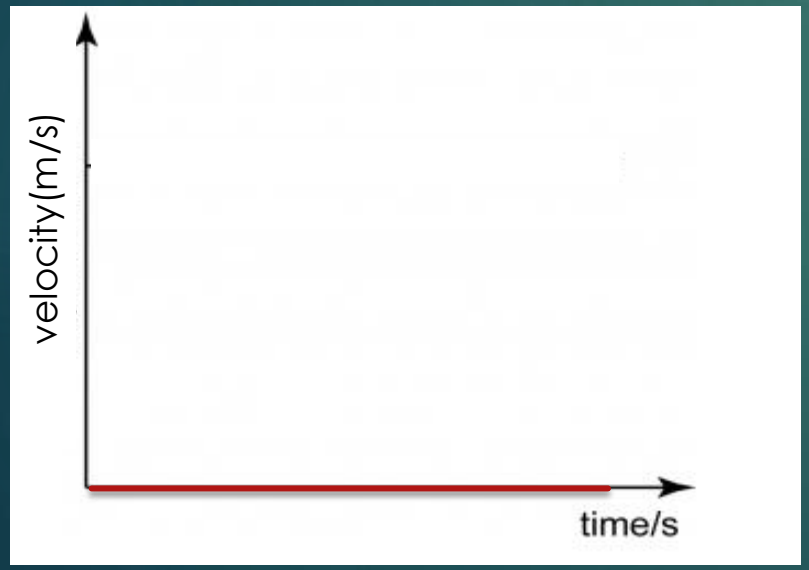
Characteristics: Increasing slope indicates acceleration. The steeper the slope, the greater the acceleration.



Uniform Deceleration:

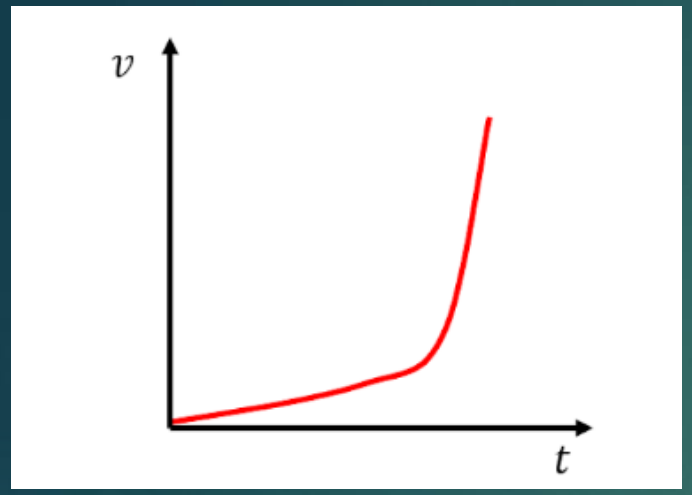
Graph: A straight line sloping downwards.

Characteristics: Decreasing slope indicates deceleration. The steeper the slope, the greater the deceleration.



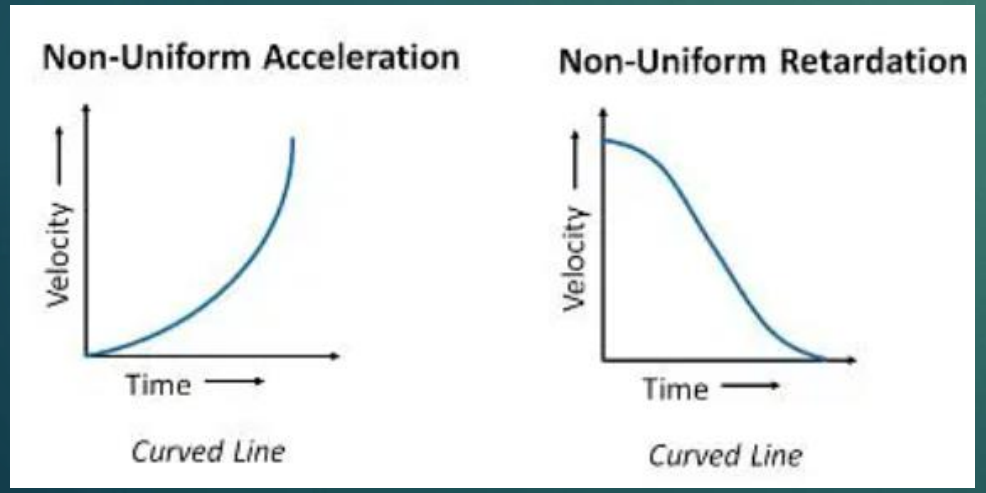
Motion at Rest:

- **Graph:** A horizontal line along the velocity axis.
- **Characteristics:** The object is not accelerating; velocity remains constant with time.

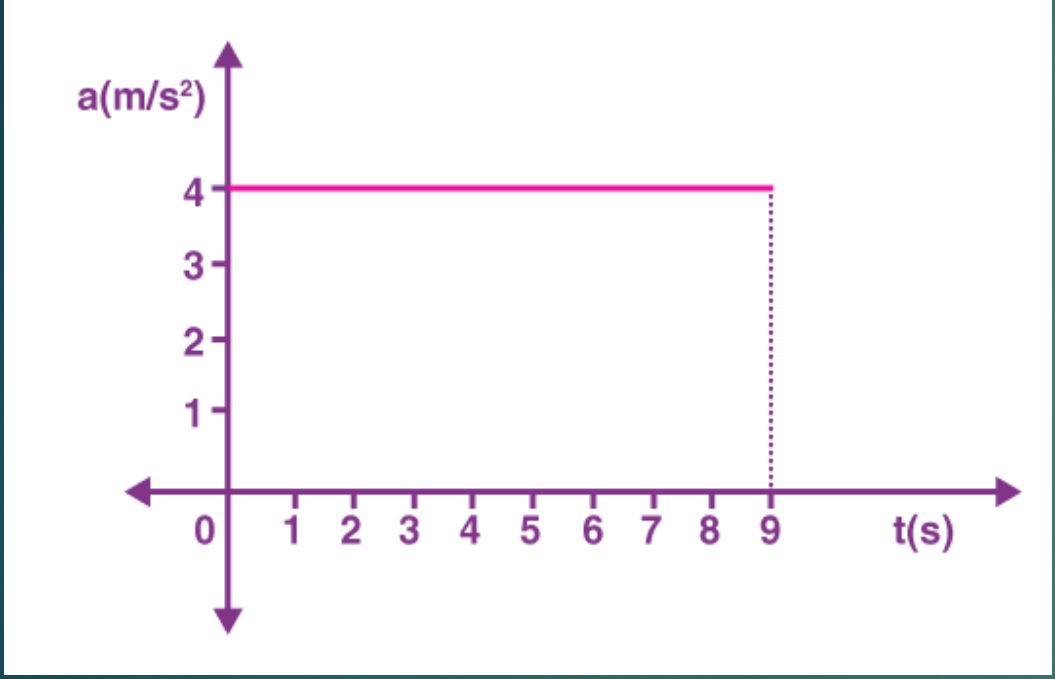


Changing(non uniform) Acceleration:

Graph: A curve that is not a straight line, indicating changes in acceleration.
Characteristics: Reflects varying accelerations or decelerations during the motion.



Acceleration-time(a-t) graphs

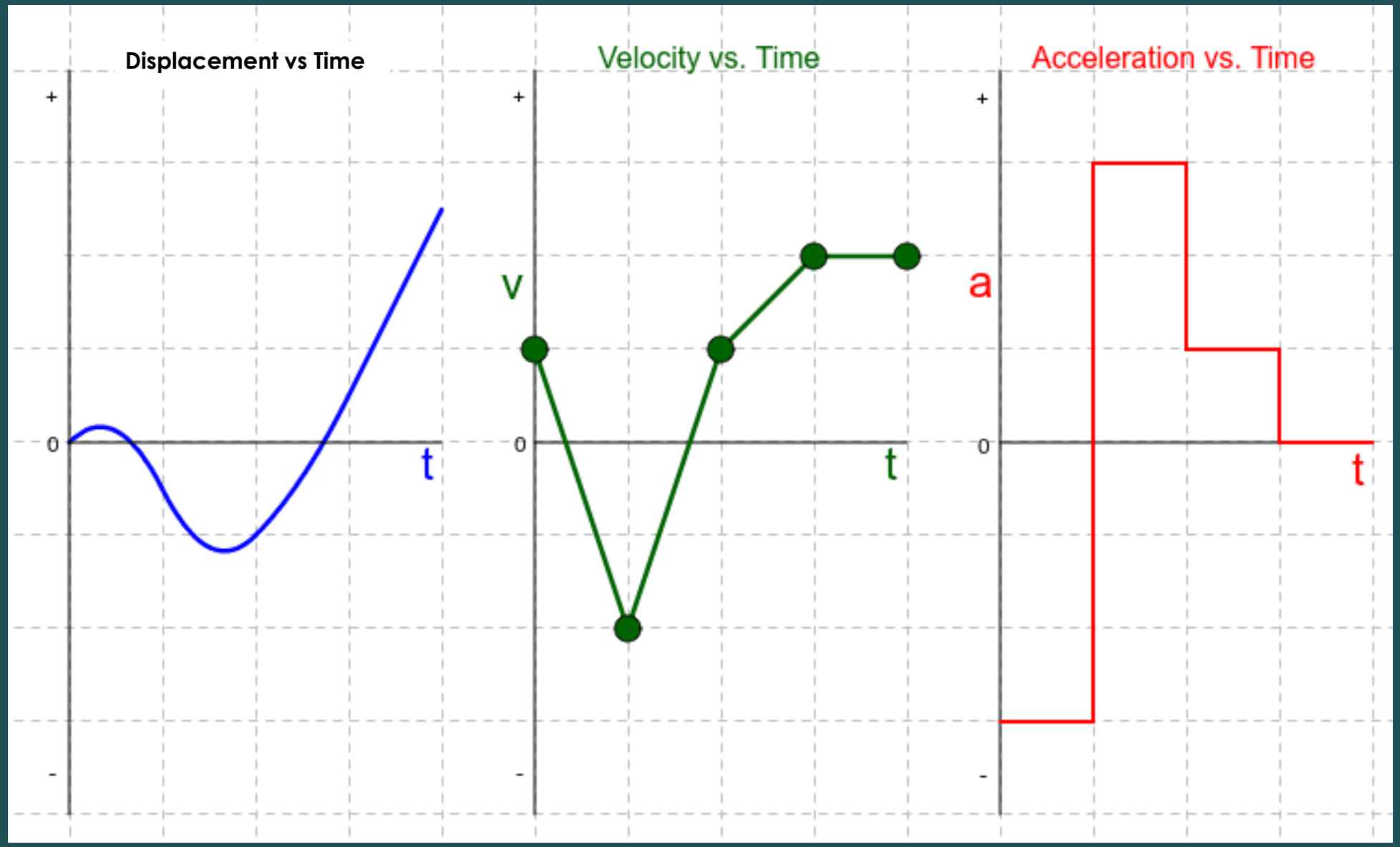


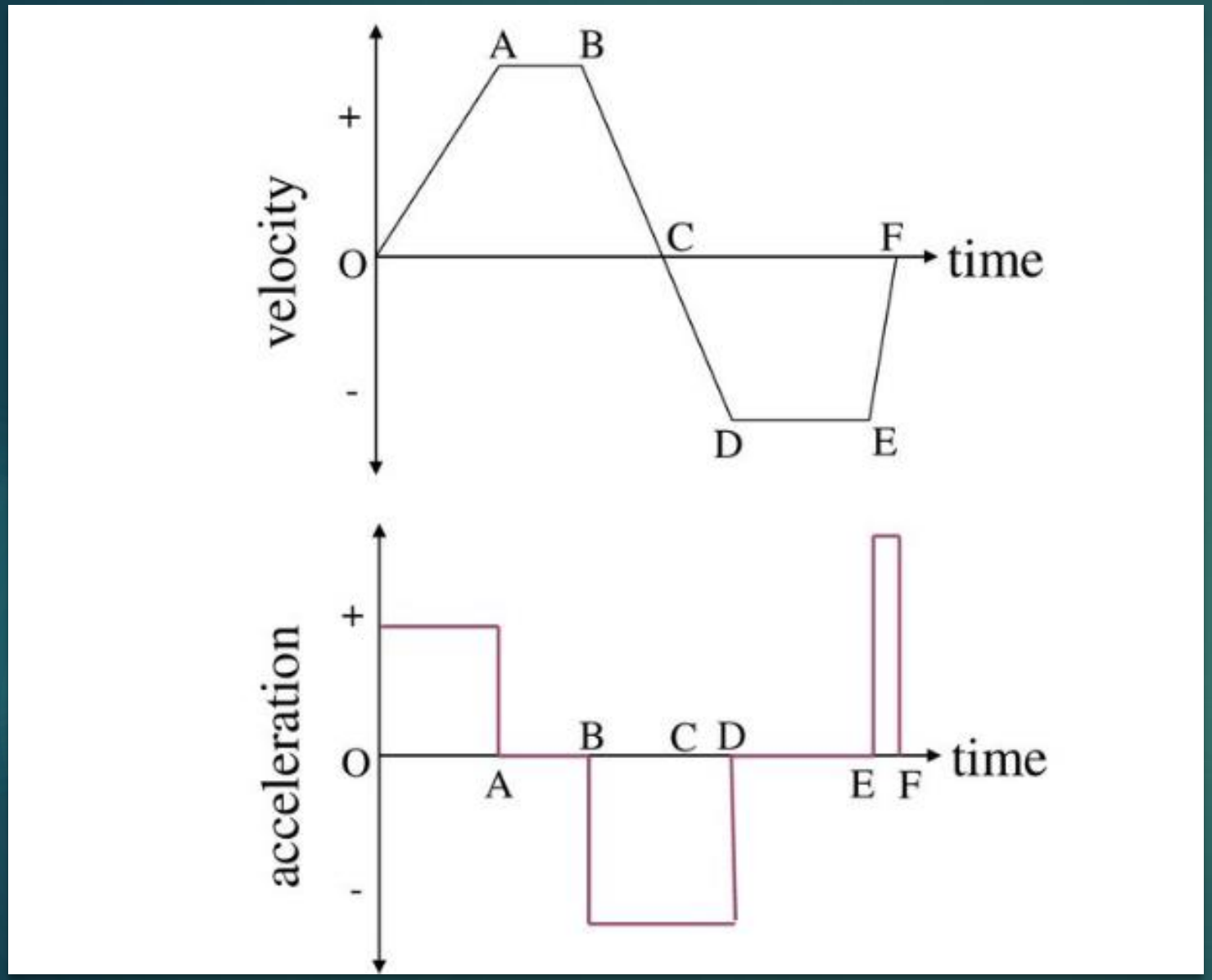
Constant Acceleration:

Graph: A horizontal line along the acceleration axis.

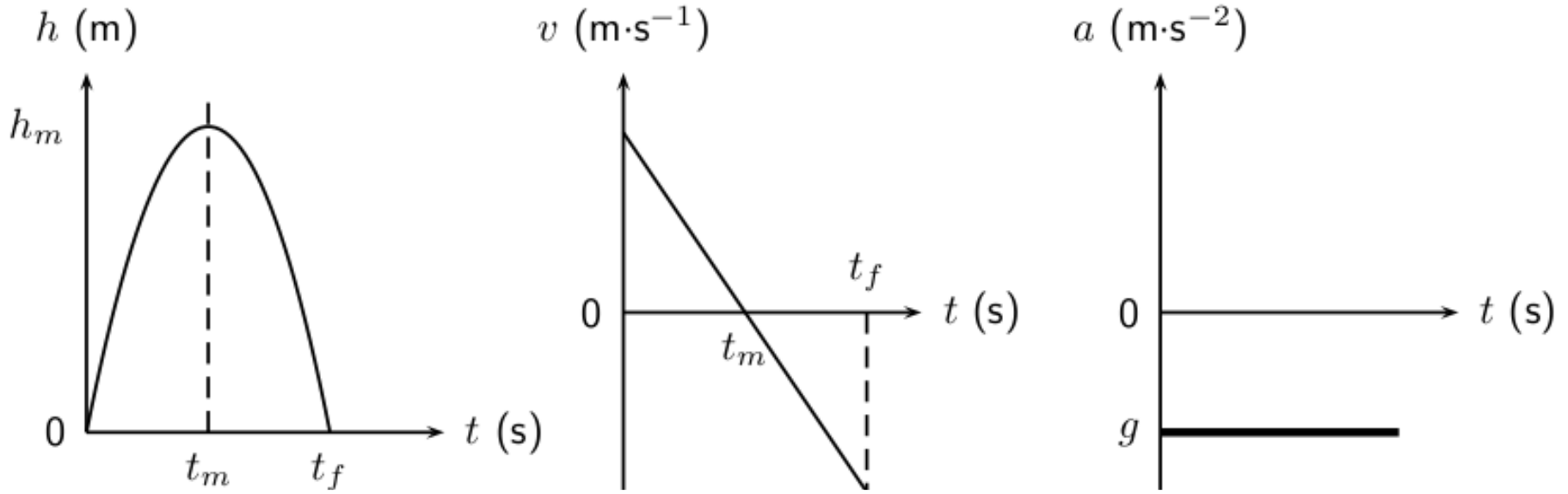
Characteristics: Acceleration remains constant over time.

Graph Conversions





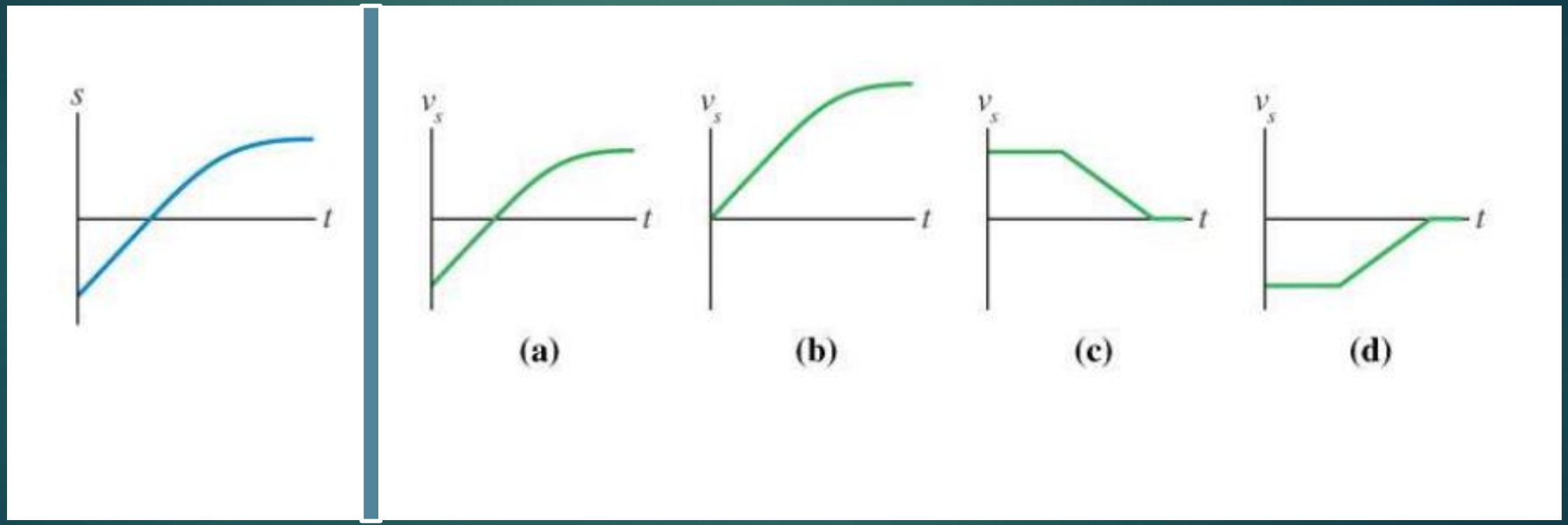
V-t graphs into a-t graphs:



Projectile motion-vertical motion graphs

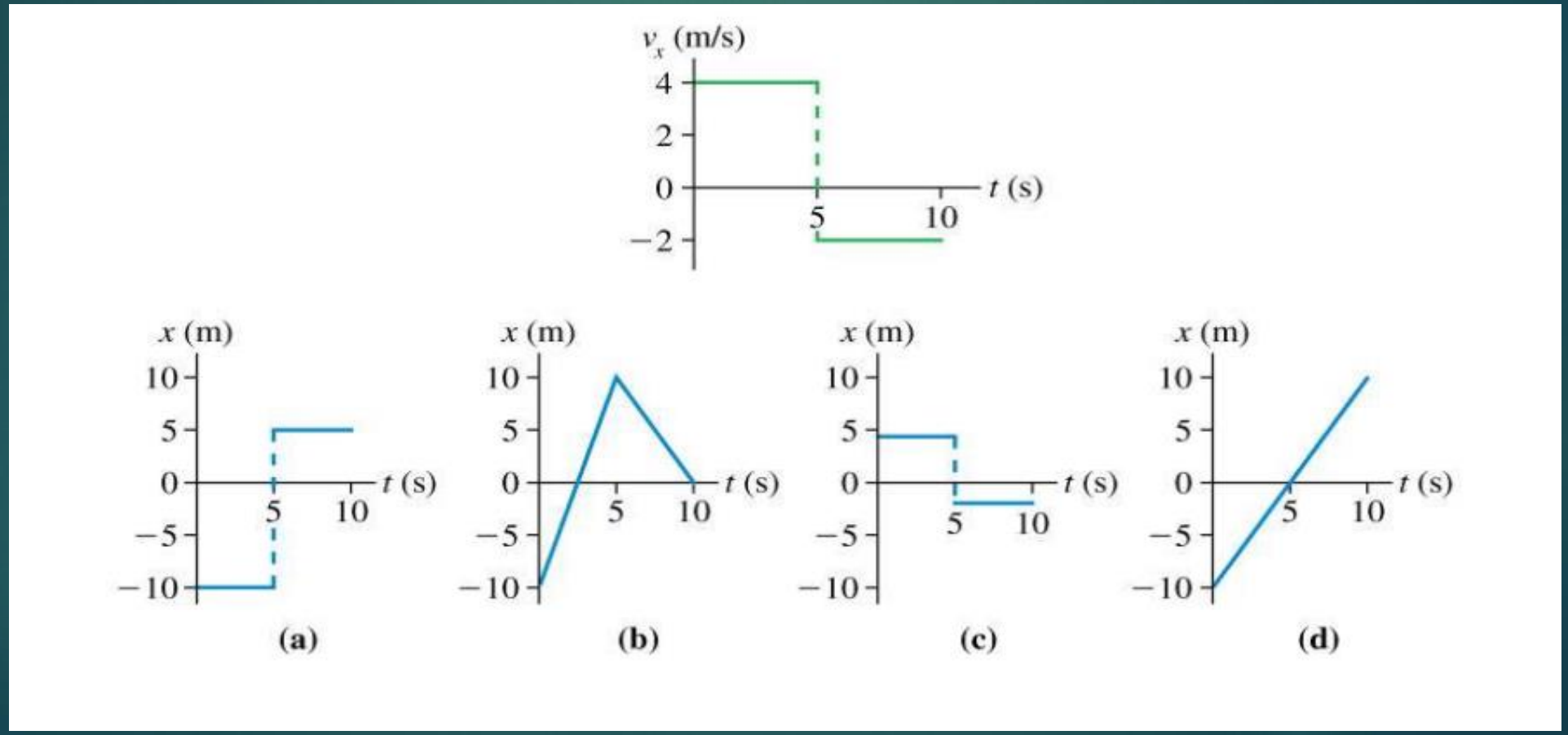
Concept Learning Questions.

1) Which velocity-versus-time graph goes with this displacement-versus-time graph on the left?



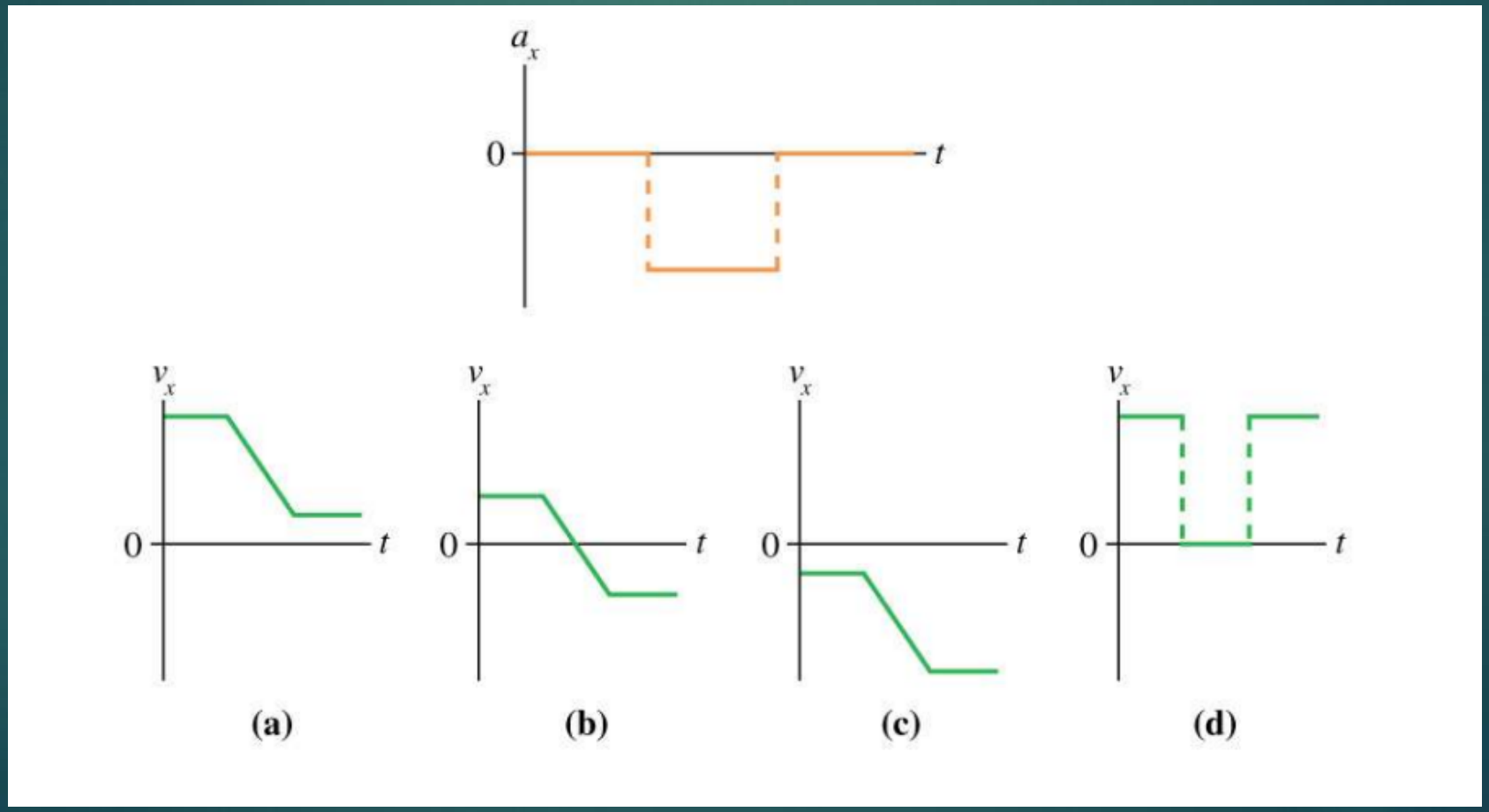
Concept Learning Questions.

2) Which position-versus-time graph goes with this velocity versus-time graph on the left? The particle's position at t = 0 s is x = –10 m .



Concept Learning Questions.

3) Which velocity-versus-time graph or graphs goes with this acceleration-versus-time graph? The particle is initially moving to the right and eventually to the left.



Concept Learning Questions.

4) The ball rolls up the ramp, then back down. Which is the correct acceleration graph?