Speed-time graphs

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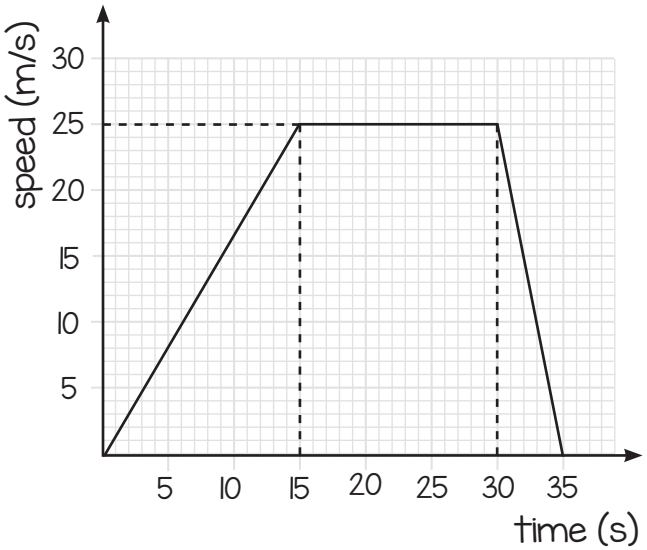
Speed-time graphs

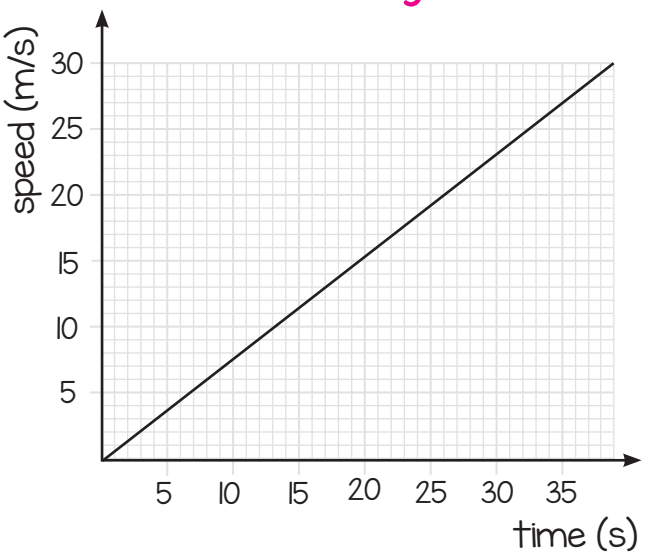
- A speed-time graph shows how the speed of a moving object varies with time.

Interpretation of a speed-time graph

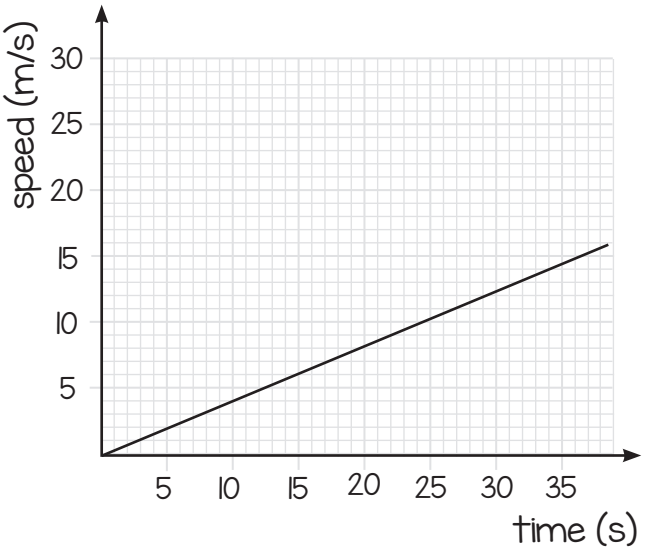
- The speed-time graph can give information about
  1. the speed,
  2. the acceleration,
  3. the distance travelled
  4. the time taken for a journey.



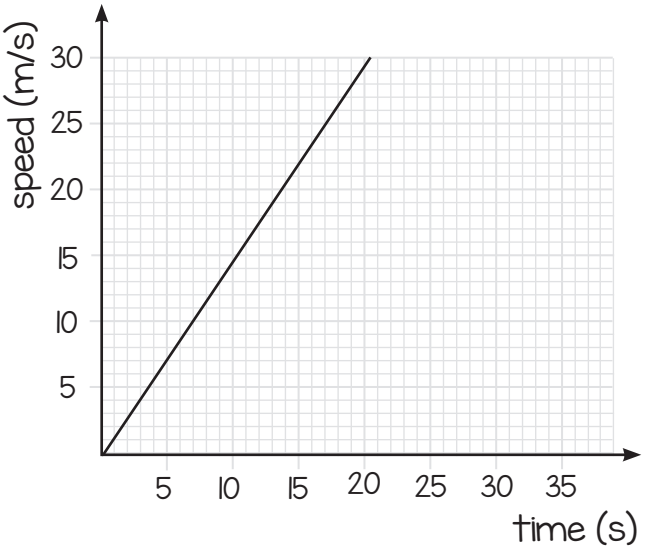
The graph above is a speed-time graph for the journey of a car. The speed of the car when time = 15 s is 25 m/s. The acceleration of the car in the first 15 s is 1.7 m/s. The distance travelled in the first 15 s is 190 m and the total time taken for the journey is 35 s



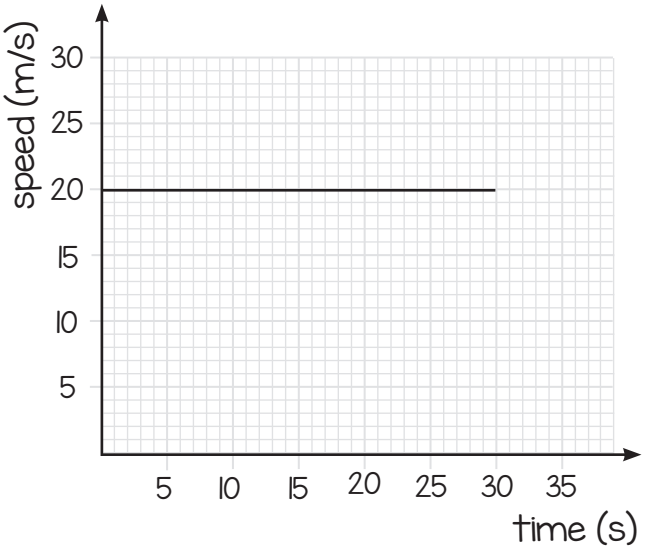
Constant acceleration



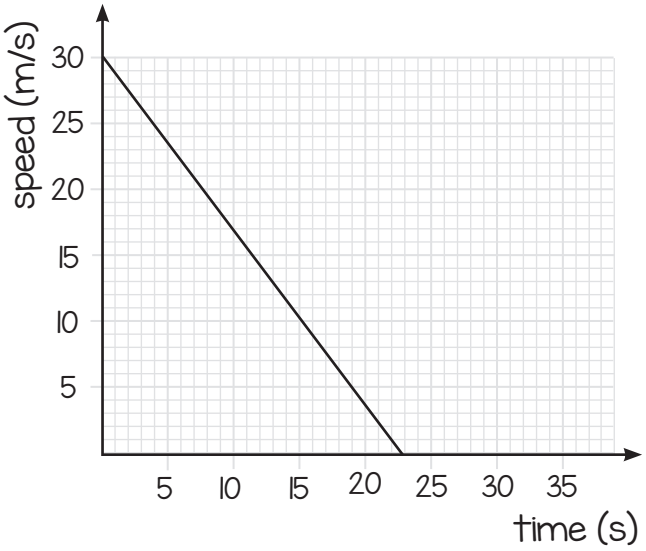
lower constant acceleration



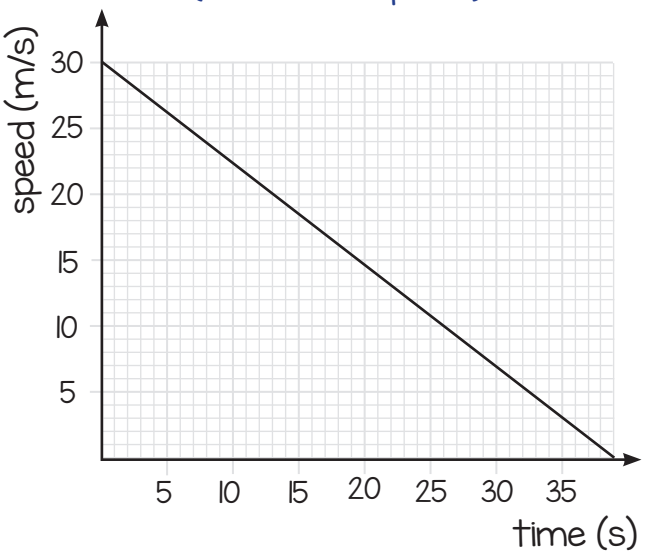
smaller constant acceleration



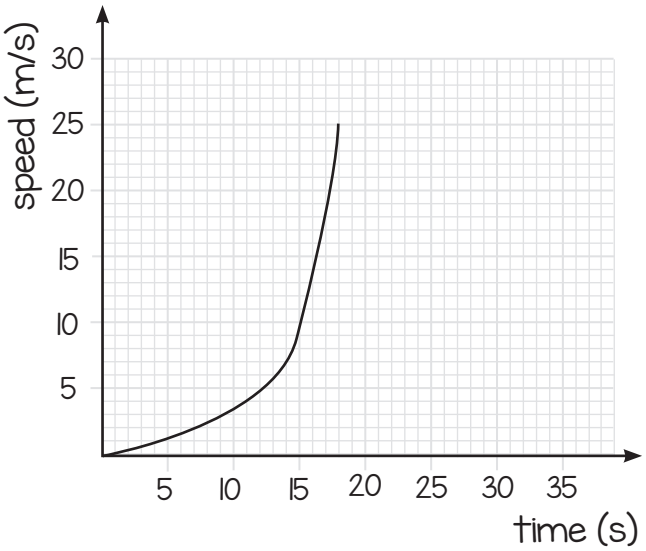
zero acceleration
(constant speed)



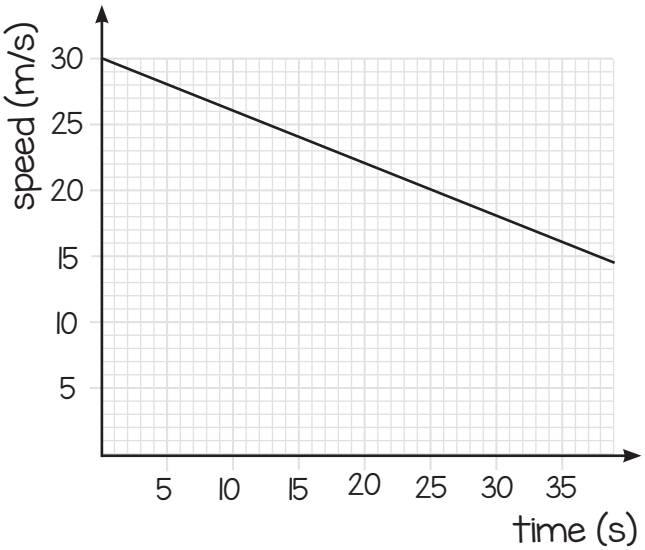
larger constant deceleration
(larger constant negative
acceleration)



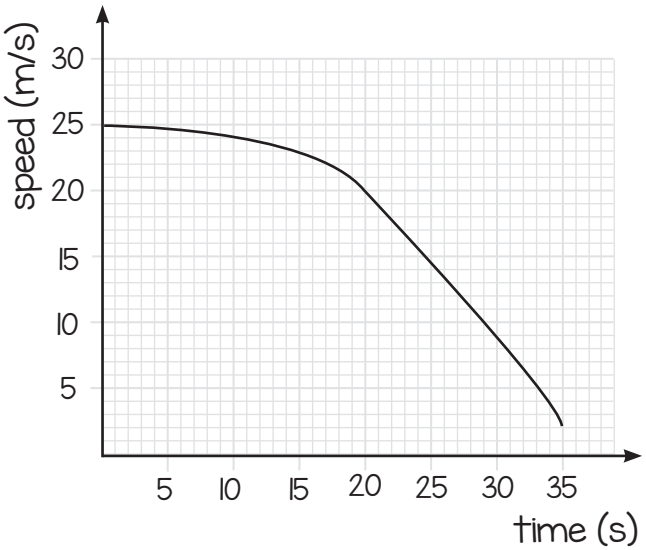
constant deceleration
(constant negative acceleration)



increasing acceleration



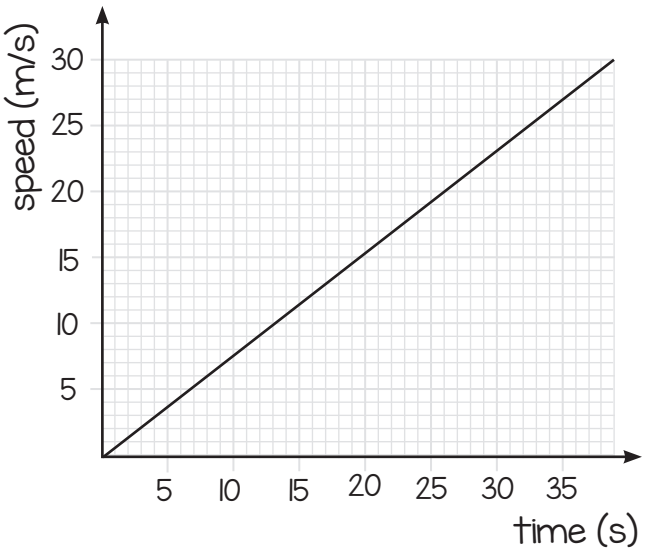
slower constant deceleration
(slower constant negative
acceleration)



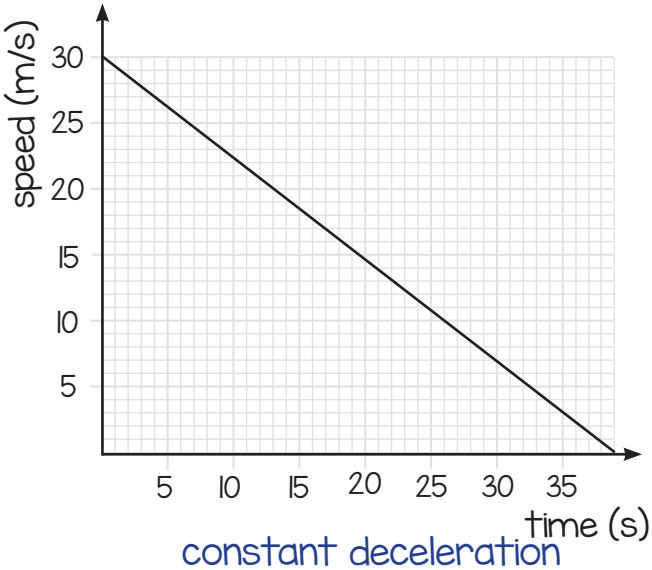
decreasing acceleration

Acceleration on a speed-time graph

- On a speed-time graph:

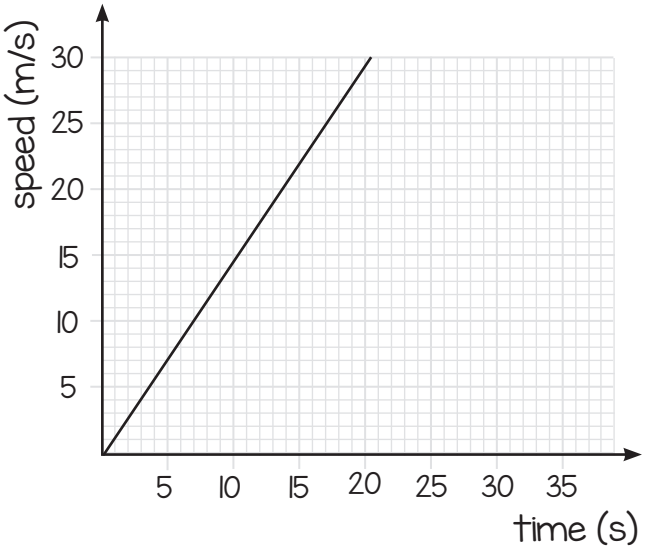


Constant acceleration

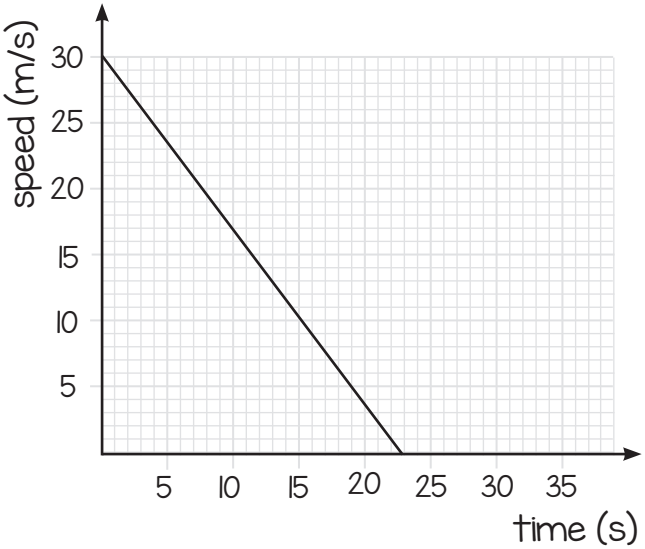


constant deceleration
(constant negative acceleration)

A straight non-horizontal line represents constant acceleration or deceleration. The slope of the line represents the magnitude of the acceleration.

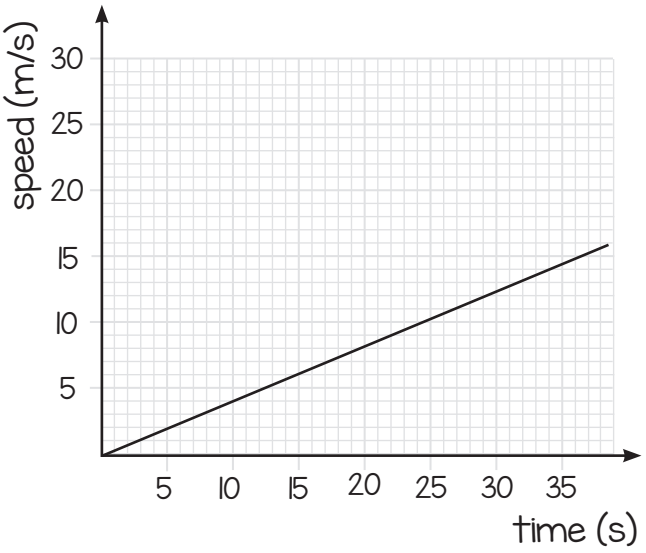


larger constant acceleration

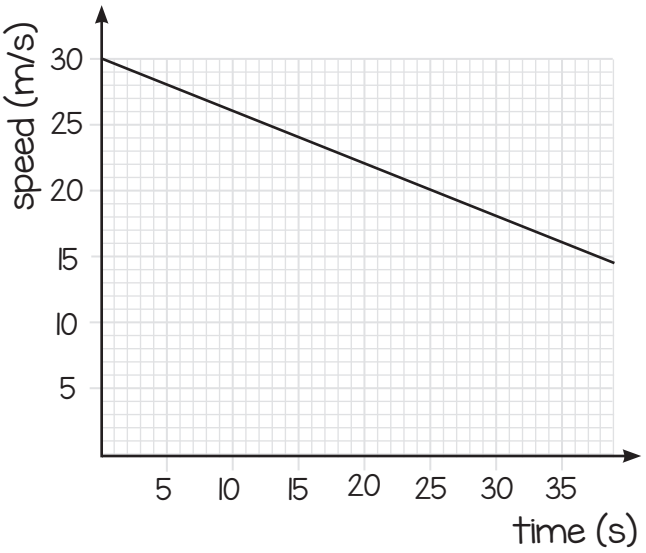


larger constant deceleration
(larger constant negative acceleration)

A steep slope like this shows large acceleration or deceleration. This means that the object's speed is changing rapidly. The magnitude of the acceleration is larger but still it is constant since the graph shows a straight line.

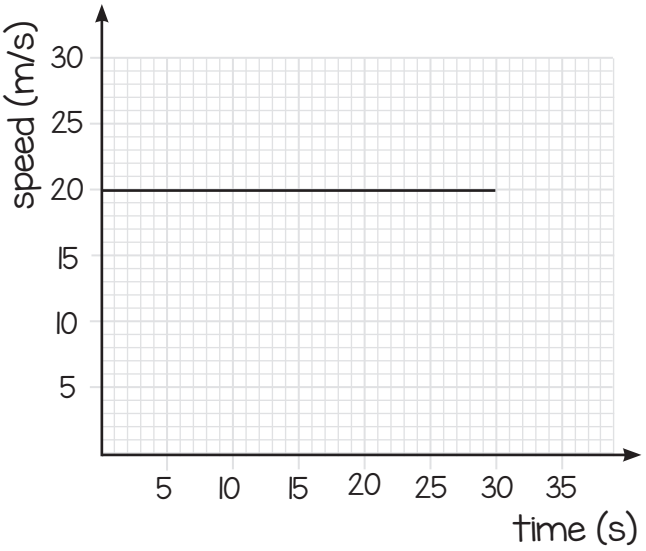


smaller constant acceleration



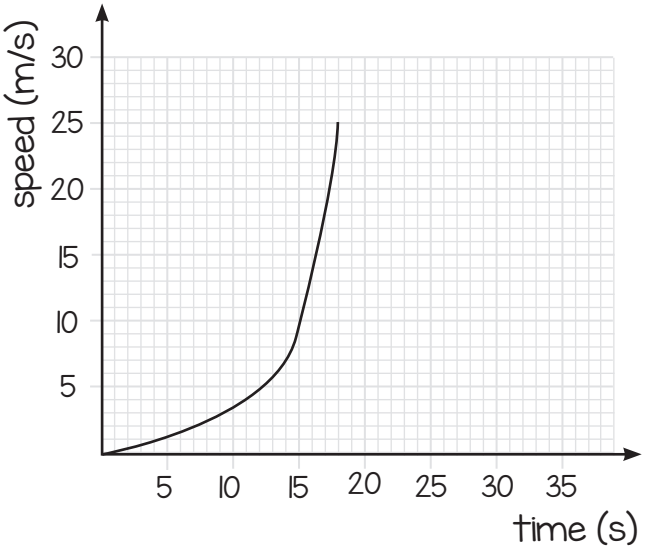
smaller constant deceleration (smaller constant negative acceleration)

A gentle slope like this shows smaller acceleration or deceleration. This means that the object's speed is changing gradually (not rapidly). The magnitude of the acceleration is smaller but still it is constant since the graph shows a straight line.



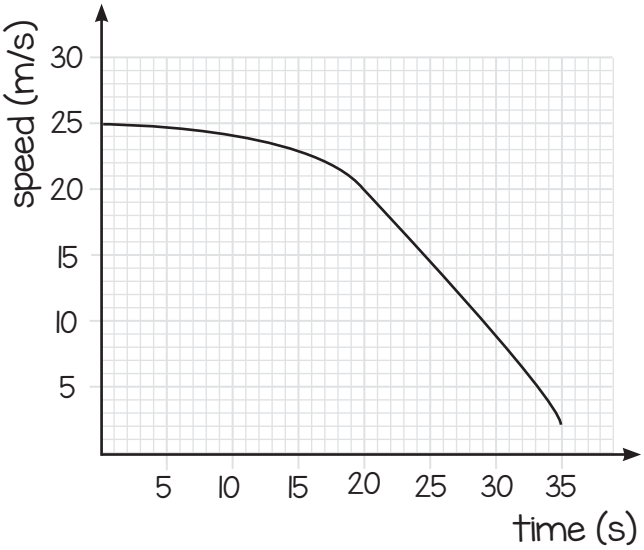
zero acceleration (constant speed)

A flat horizontal line like this shows that the acceleration is zero – i.e. the object is moving with a constant speed.



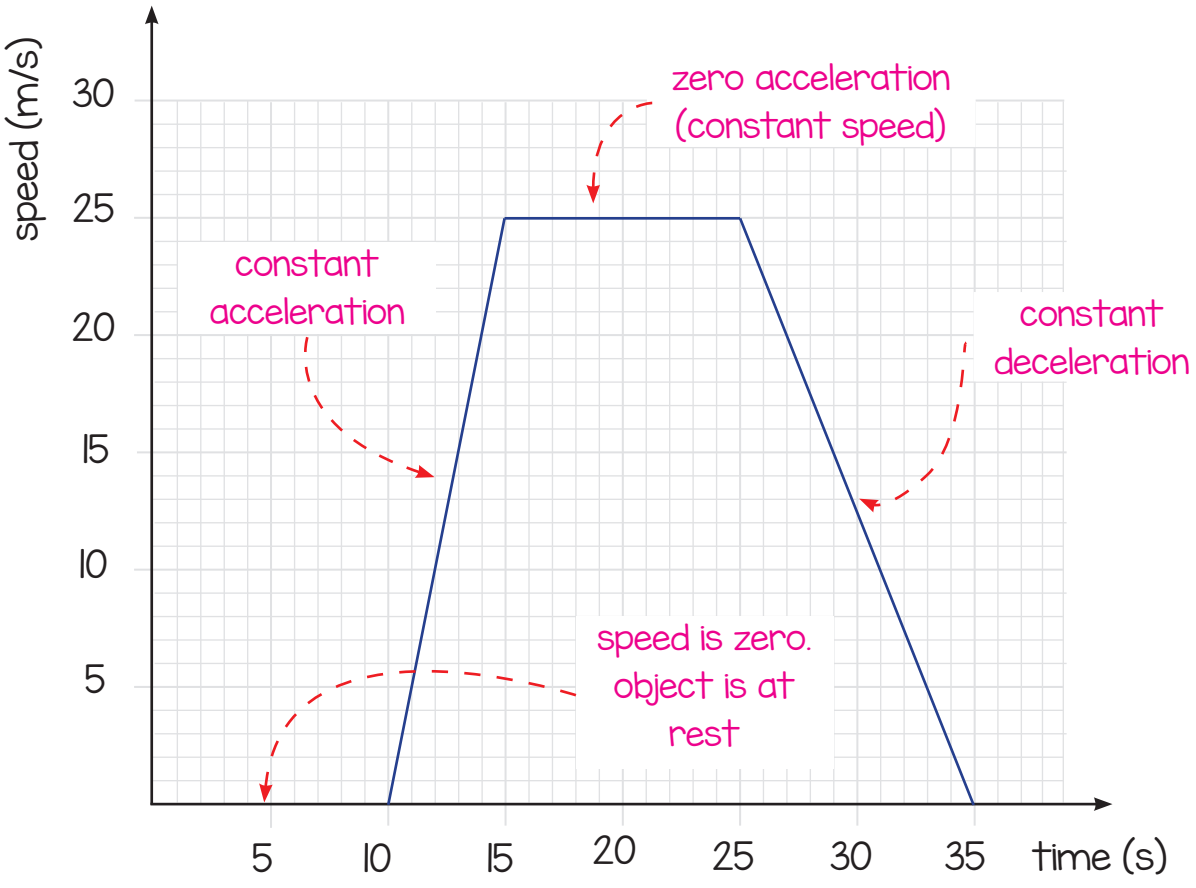
increasing acceleration

Since this line is no longer straight, the acceleration is no longer constant. But since the velocity is increasing rapidly, this curve shows increasing acceleration.



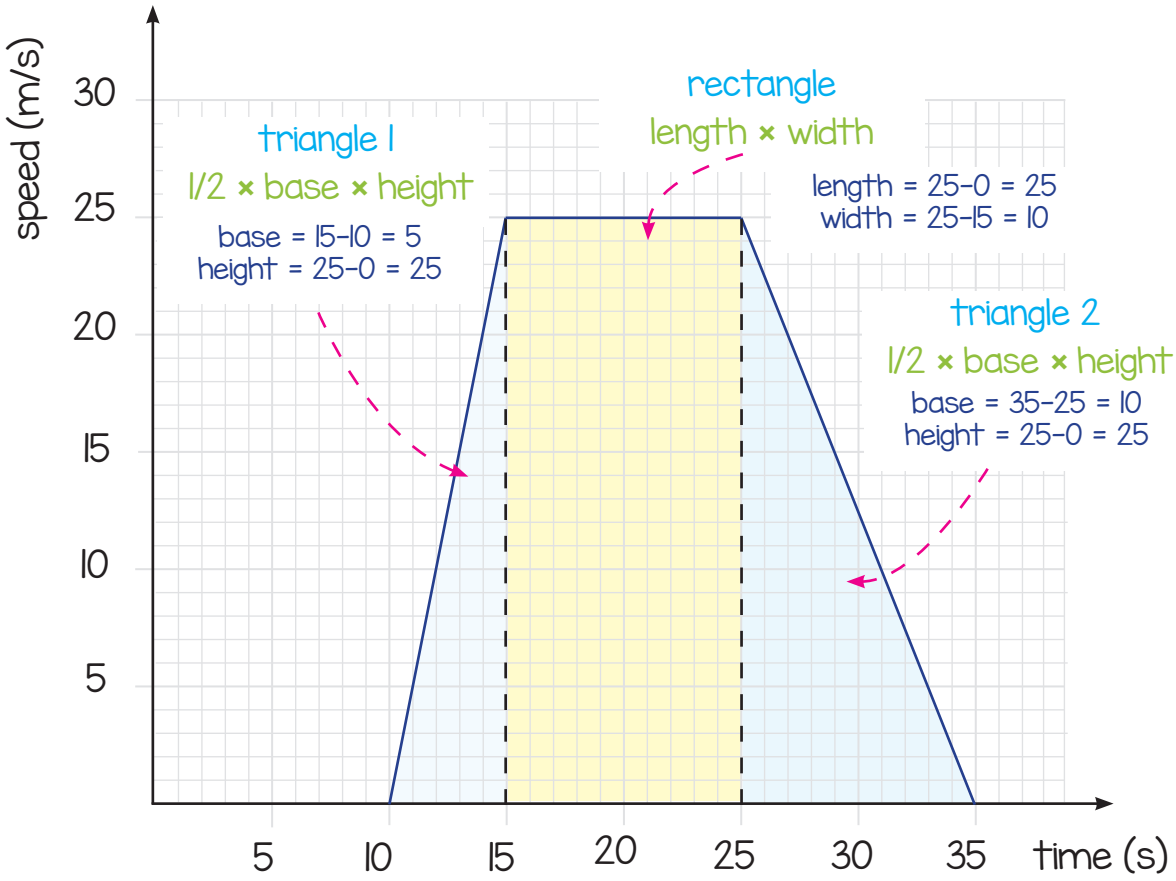
decreasing acceleration

Since this line is no longer straight, the acceleration is no longer constant. But since the velocity is decreasing rapidly, this curve shows decreasing acceleration.



Calculating distance from speed-time graphs

The distance travelled can be calculated from a speed-time graph by calculating the area under the graph.



- If the area under the graph is in the shape of a triangle (the object is accelerating or decelerating), then the area can be calculated using the formula:

$$\text{area} = \frac{1}{2} \times \text{base} \times \text{height}$$

- If the area under the graph is in the shape of a rectangle) (constant velocity), then the area can be calculated using the formula:

$$\text{area} = \text{length} \times \text{width}$$

For the graph above, the total distance travelled by the object is equal to:

area of triangle 1 + area of the rectangle + area of triangle 2

$$\left(\frac{1}{2}\times 5\times 25\right)+(10\times 25)+\left(\frac{1}{2}\times 10\times 25\right)$$

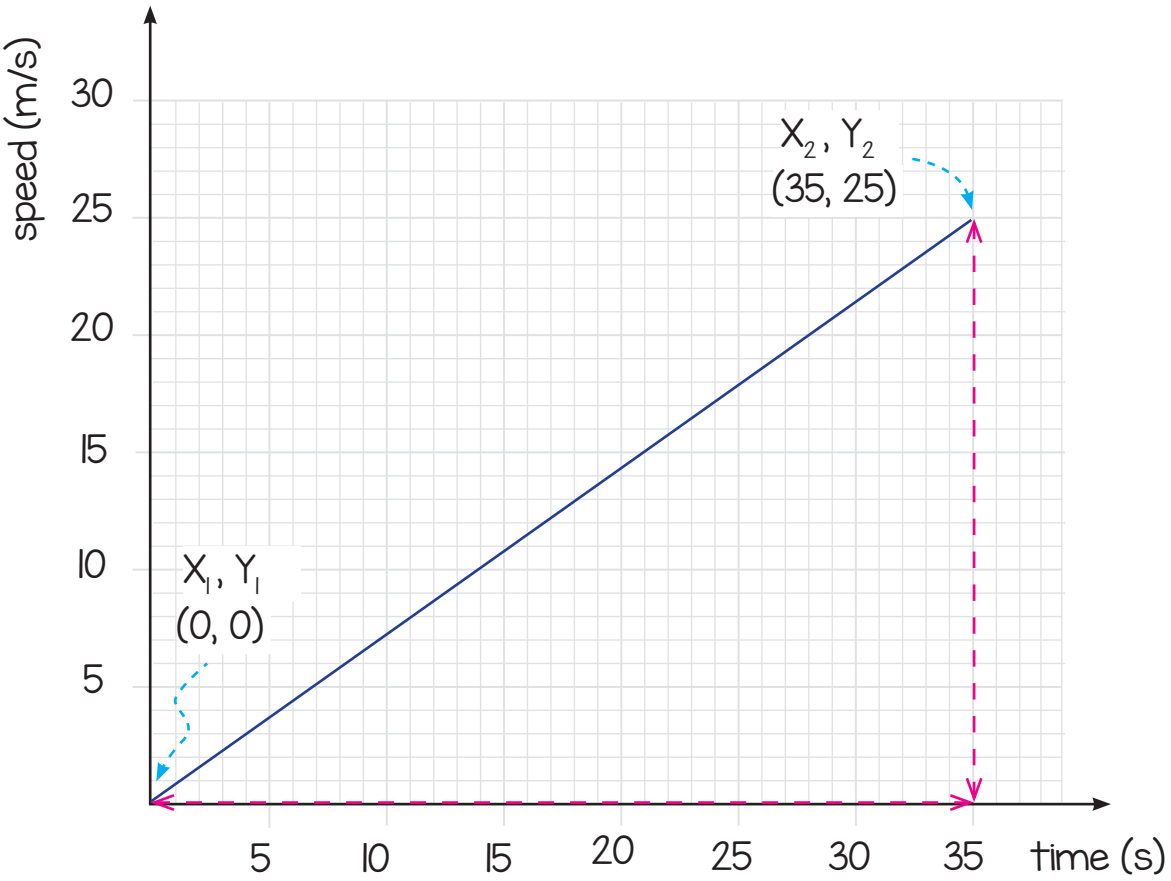
$$62.5+250+125 \;= 437.5 \cong 440$$

$$\therefore \text{total distance travelled} = 440 \text{ m}$$

Calculating acceleration from speed-time graphs

The acceleration of an object can be calculated from the gradient of a speed-time graph.

Case I: Constant acceleration

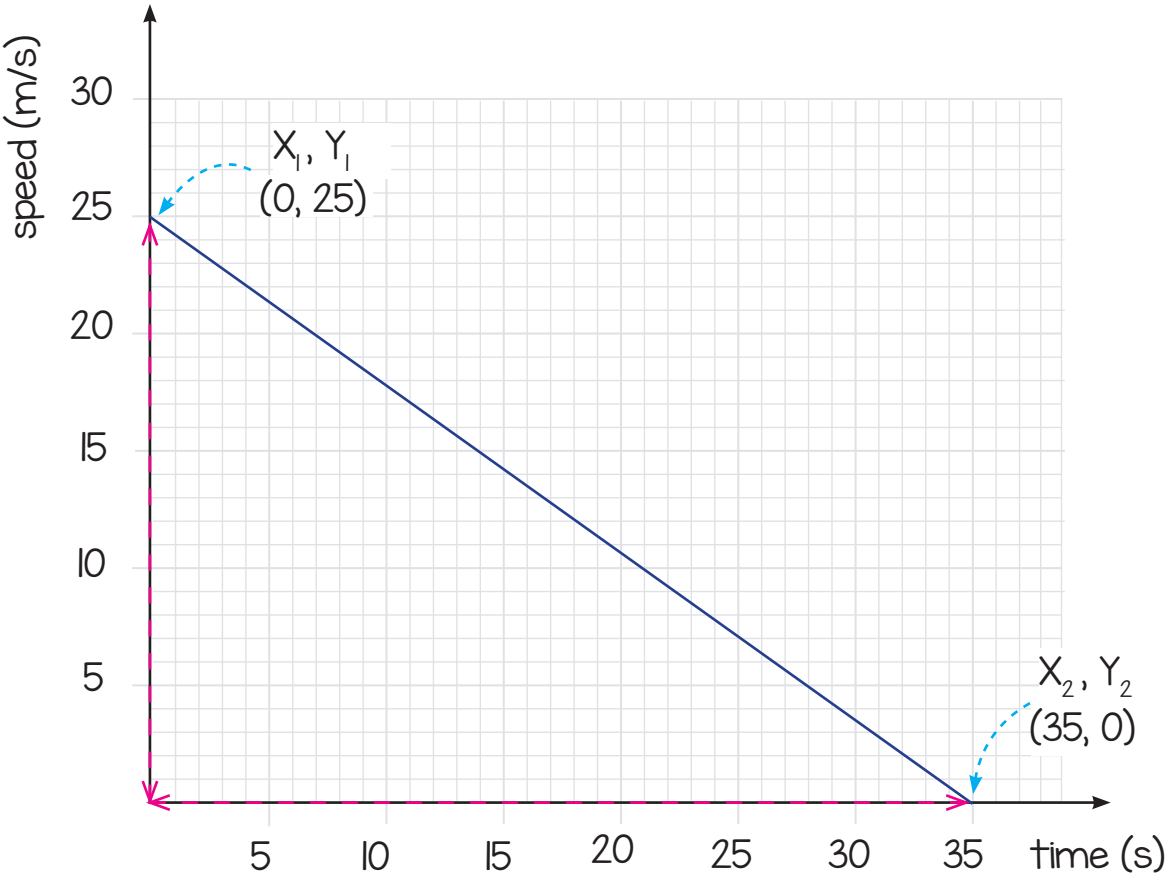


$$\text{acceleration} = \text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{gradient} = \frac{25-0}{35-0} = \frac{25}{35} = 0.7 \text{ m/s}^2$$

It is better to use the entire slope - as shown in the example above- whenever possible, to calculate the gradient. Remember to draw the dotted/dashed lines on the graph to show your working.

Case 2: Constant deceleration

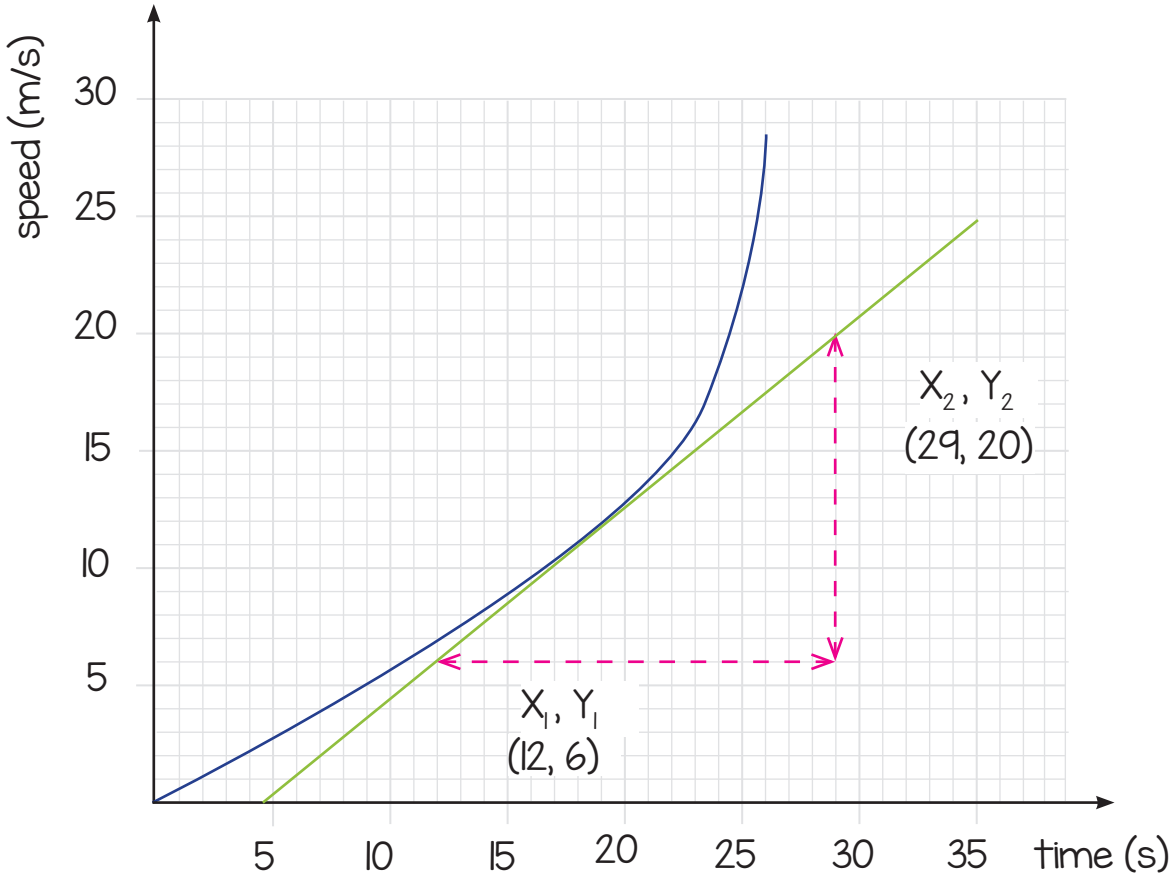


$$\text{acceleration} = \text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{gradient} = \frac{0-25}{35-0} = \frac{-25}{35} = -0.7 \text{ m/s}^2$$

The acceleration is negative. (i.e. the object is decelerating).

Case 3: increasing acceleration

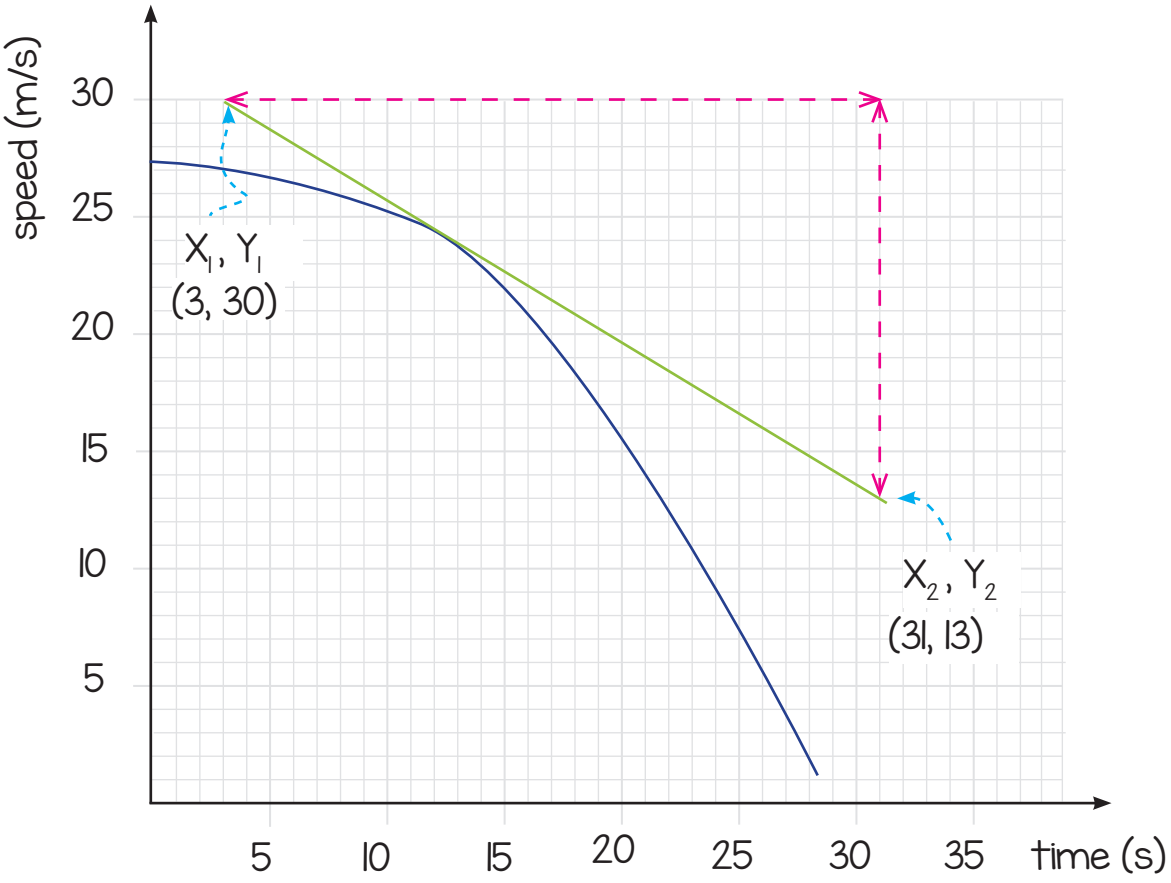


$$\text{acceleration} = \text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{gradient} = \frac{20-6}{29-12} = \frac{14}{17} = 0.8 \text{ m/s}^2$$

When the graph is a curve, a tangent can be drawn and used to calculate the gradient of the graph. This skill is among the mathematical skills required for the physics 0625 syllabus. It is rare to find questions that require this skill, however, students must be prepared for any such questions.

Case 4: Increasing deceleration



$$\text{acceleration} = \text{gradient} = \frac{y_2 - y_1}{x_2 - x_1}$$

$$\text{gradient} = \frac{13 - 30}{31 - 3} = \frac{-17}{28} = -0.6 \text{ m/s}^2$$

The acceleration is negative. (i.e. the object is decelerating).

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If any mistake (including typing mistakes) are noticed
by anyone, kindly let me know by emailing to
adiyy.muhammad@gmail.com