2.1 Motion

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Course	DP IB Physics
Section	2. Mechanics
Topic	2.1 Motion
Difficulty	Easy

To be used by all students preparing for DP IB Physics SL
Students of other boards may also find this useful

1

The correct answer is **A** because:

- $average\ speed = \frac{total\ distance\ travelled}{time\ taken}$
- Therefore, $average\ speed = \frac{200}{40} = 5\ m\ s^{-1}$

Remember when determining the **average speed** you must consider the **total distance** travelled and divide it by the **total time** taken.

2

The correct answer is **B** because:

- Acceleration $a = \frac{\Delta v}{\Delta t}$ where Δv and Δt are the change in speed and change in time respectively
- The initial speed $u = 0\ m\ s^{-1}$
- The final speed $v = 40\ m\ s^{-1}$
- Therefore:
  - $\Delta v = v - u = 40 - 0 = 40\ m\ s^{-1}$
- Therefore:
  - $a = \frac{40}{5} = 8\ m\ s^{-2}$

3

The correct answer is **D** because:

- The equation for acceleration is:
  - $a = \frac{\Delta v}{\Delta t}$ where Δv is the change in velocity and Δt is the change in time
- Therefore, this is defined in words as the **rate of change of velocity**

A is incorrect as	the length between two points is the **distance**. This is a **scalar** quantity, measured in metres, m
B is correct as	the length between two points in a certain direction is the **displacement**. This is a **vector** quantity, measured in metres, m
C is correct as	the rate of change of displacement is the **velocity**. This is a **vector** quantity, measured in metres per second, m s^{-1}

Be careful – the acceleration is also loosely defined as the rate of change of **speed**. But this is only when the **magnitude** of acceleration is important. You should remember the best definition of acceleration is the **rate of change of velocity**, because acceleration is a **vector** quantity and the 'rate' means that it changes with **time**.

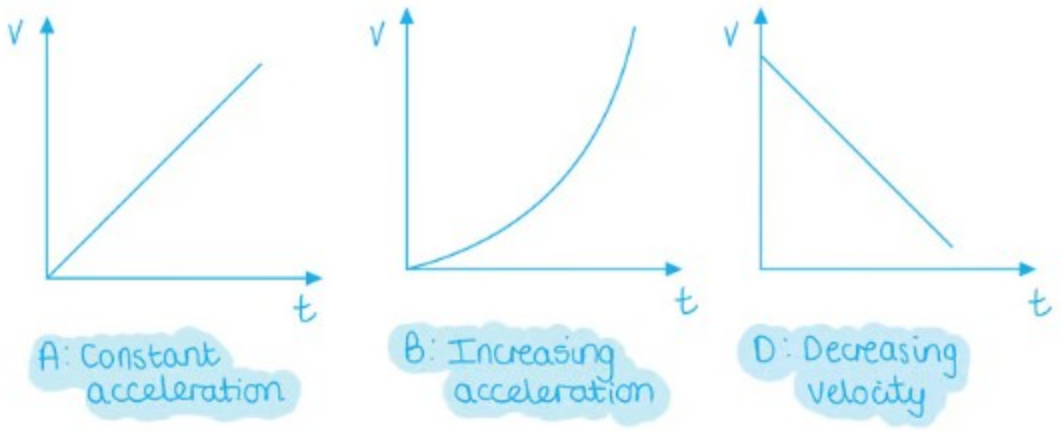
4

The correct answer is **C** because:

- The object's velocity is not changing between X and Y
  - This is because the velocity-time graph is a straight horizontal line
- Therefore, the object is moving with a constant velocity

A is incorrect as	constant acceleration would be represented by a positive slope. This would indicate the object increasing its velocity at a **constant** rate
B is incorrect as	increasing acceleration would be represented by a slope curving upwards. This would indicate the object increasing its velocity at an **increasing** rate
D is incorrect as	decreasing velocity would be represented by a line going downwards on a velocity-time graph

The graphs of the incorrect choices would have looked like:



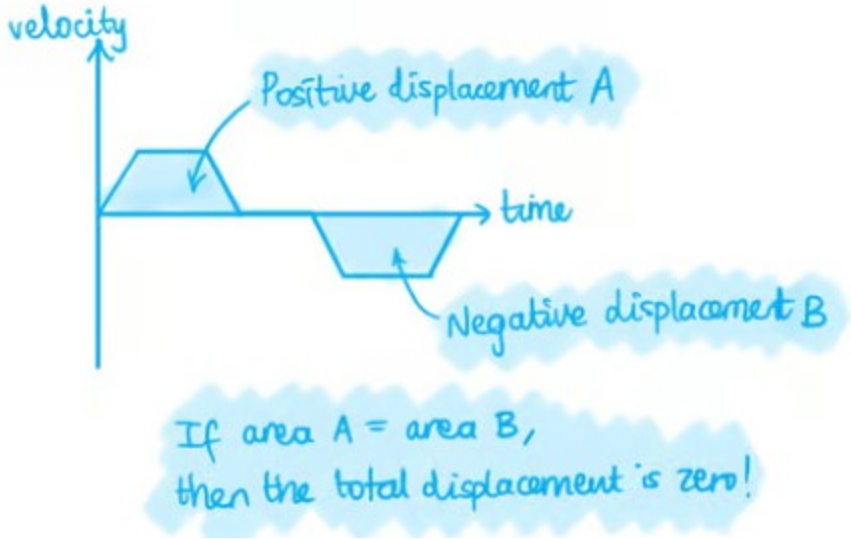
5

The correct answer is **B** because:

- The area between the line and the axis on a velocity-time graph represents the displacement
  - Hence, the total displacement is the total area

On a velocity-time graph, the area between the line and the axis represents the **displacement**, because velocity × time represents displacement.

In the graph shown in this question, there are two areas, labelled A and B as shown below:



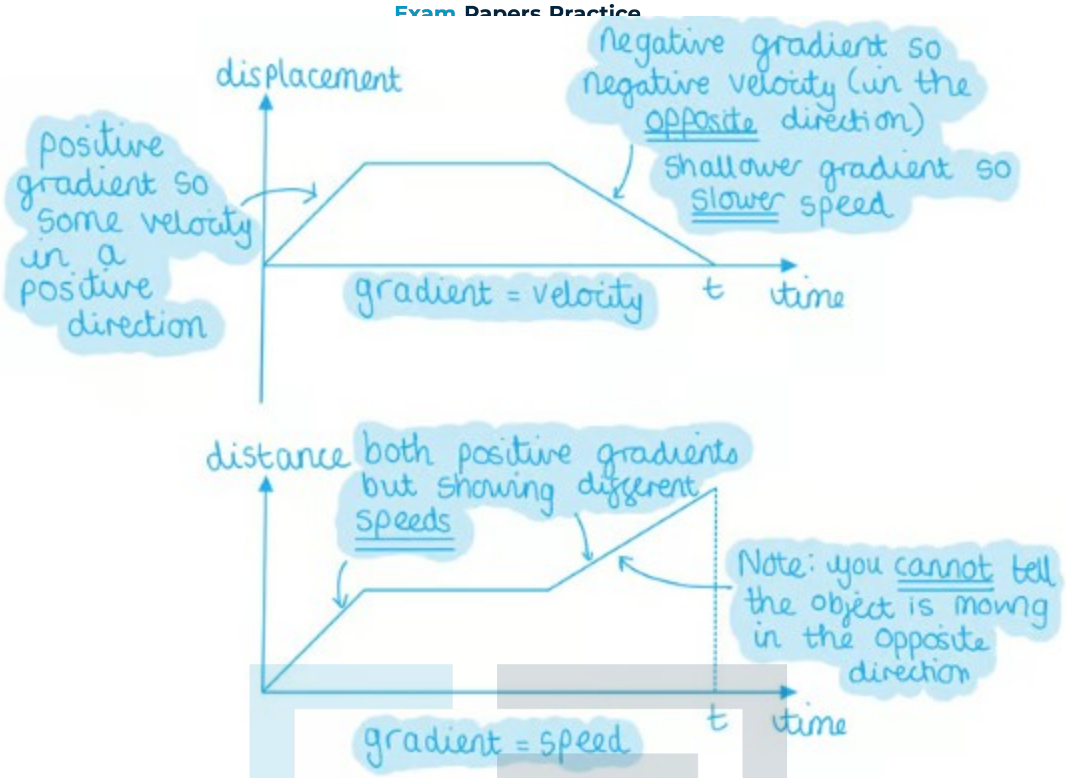
Notice that area A is positive, because it is above the axis (representing a positive displacement, which might mean **forwards**) and the area B is negative, because it is below the axis (representing a negative displacement, which might mean **backwards**). Hence, the total displacement could be zero, if both areas have the same magnitude. However, the distance, because it is a scalar quantity, would be the sum of the magnitudes of both areas and therefore not zero!

6

The correct answer is **C** because:

- The gradient of a displacement-time graph represents the change in displacement divided by the change in time
- Since $velocity = \frac{displacement}{time}$ then the gradient of a displacement-time graph is equal to the velocity

Note that displacement is a **vector**, so the gradient of a displacement-time graph is also a **vector**, i.e. velocity, **not** speed. Hence, the gradient of a displacement-time graph can be negative, representing velocity in the opposite direction. Distance-time graphs have a gradient that represent the **speed** of an object, so you cannot get any information about the object's direction of motion. This is shown below, with two graphs describing the same motion on a displacement-time graph and a distance-time graph:



7

The correct answer is **A** because:

- The given SUVAT quantities are listed below:
  - s = not given
  - $u = 10\ \text{m s}^{-1}$
  - v = ?
  - $a = 2\ \text{m s}^{-2}$
  - $t = 5\ \text{s}$
- Therefore, the equation that includes each of the quantities, initial velocity u, final velocity v, acceleration a, and time t, is:
  - $v = u + at$
- Substituting the quantities in to this equation gives:
  - $v = 10 + (2 \times 5) = 10 + 10 = 20$
- Hence, $v = 20\ \text{m s}^{-1}$
- Therefore, the correct answer is **A**

Remember whenever you spot a question which gives **constant acceleration** for a period of time, think "SUVAT". Notice that displacement s is **not** given in the question, so we can just ignore it (and any of the SUVAT equations involving it).

You are given each SUVAT equation in your data booklet, so using the framework as shown in this example will help you structure your work very clearly and increase the likelihood of calculating the right value!

8

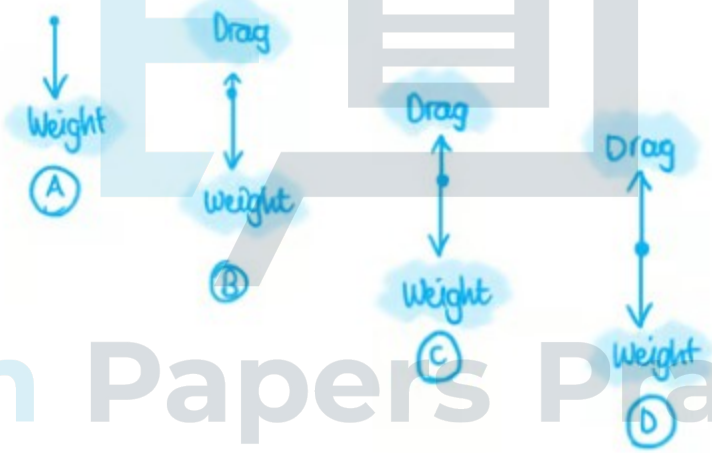
The correct answer is **D** because:

- Terminal velocity is reached when the upward force of drag on the skydiver = the downward force of weight
- Therefore, there is no further acceleration (acceleration = 0 m s^{-2}) because the resultant force is zero
- Acceleration is given by:
  - Acceleration = $\frac{change\ in\ velocity}{change\ in\ time}$
- This means that acceleration is the **gradient** of the velocity-time graph
  - The gradient of the graph is 0 at terminal velocity
- This is the horizontal part of the graph (i.e. velocity is constant) at point **D**

A is incorrect as	this the **instantaneous** moment as the skydiver leaves the plane. Their initial velocity is zero, and their initial instantaneous acceleration is maximum, since the only force acting on them is the weight force. Therefore, the resultant force is maximum
B is incorrect as	the skydiver has some velocity, so there is a drag force acting on them. At point B, the drag force is still much smaller than the weight force, so the acceleration is still large. because the resultant force on them is still large. They are not yet at terminal velocity

C is incorrect as	the skydiver has a larger velocity, so the drag force on them has increased. At point C, the drag force is now almost as large as the weight force, so the acceleration is very small since the resultant force is very small. They are not yet at terminal velocity

This summary is sketched out below as a free body diagram, showing the weight force on the skydiver (constant) and the drag force, increasing as the skydiver's velocity increases. Eventually, the drag force equals the weight force in magnitude, and there is no more resultant force and hence no more acceleration. This is terminal velocity.



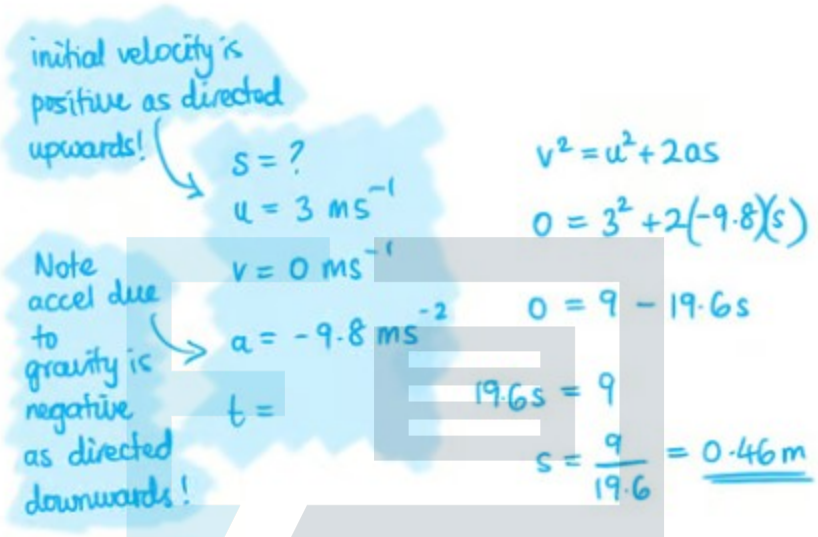
9

The correct answer is **C** because:

- The known SUVAT quantities are listed below:
  - s = ? (we want to calculate this)
  - $u = +3\ \text{m s}^{-1}$ (given in the question)
  - $v = 0\ \text{m s}^{-1}$ (the final velocity is zero at maximum height because the ball comes to rest)
  - $a = -9.8\ \text{m s}^{-2}$ (we know the ball is only accelerating under gravity, which is directed downwards)
  - t = not given

- Therefore, the equation that includes each of the quantities, displacement s, initial velocity u, final velocity v, and acceleration a is:
  - $v^2 = u^2 + 2as$
- Therefore, the correct answer is **C**

If you were permitted to use a calculator to actually calculate the maximum height, the calculation would look as shown below:



10

The correct answer is **B** because:

- The area under an acceleration-time graph represents a product of acceleration and time
- Since $acceleration = \frac{change\ in\ velocity}{time\ taken}$ then:
  - acceleration × time = change in velocity
- Hence, the area under the graph represents the change in velocity

A is incorrect as	while you can deduce the change in velocity from an acceleration-time graph, this is not deduced from the gradient of the line. This is because the gradient of the line is given by $\frac{change\ in\ acceleration}{time\ taken}$ which is does not represent the change in velocity
C & **D** are incorrect as	you cannot deduce the change in displacement from an acceleration time graph. Only information about the change in velocity can be deduced