Distance-Time Graph – GCSE Physics

CONTENTS:

1. Introduction:

- Motion is the change in position of an object with respect to time.

- The three fundamental quantities that describe Motion are:

Distance   *Time*   *Speed*

- **Distance:** It is the total path length covered by an object, regardless of direction.

- **Time:** It is the duration over which Motion occurs.

- **Speed:** It tells us how fast an object moves.

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2. What is Speed and How is it Measure?

- **Speed** is the measure of how fast an object moves.
- It defined as the distance traveled per unit of time.
- It is a **Scalar Quantity.**
- **Speed** can be measured using the formula:

$$Speed = \frac{Distance}{Time}$$

Common SI Units:

- Meters per second (m/s)
- Kilometers per hour (km/h)
- Miles per hour (mph)

Example: If a bike travels 150 meters in 10 seconds, what's the speed of bike?

Solution:

Given:
- **Distance:** 150 m
- **Time Taken:** 10s

Using the formula,

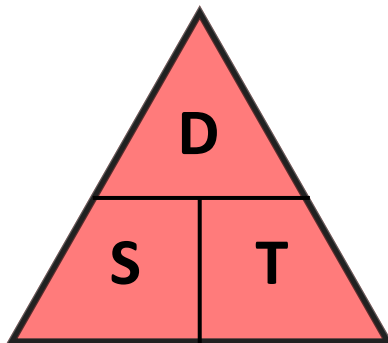$$Speed = \frac{Distance}{Time}$$

Putting the values and solve,

$$Speed = \frac{150}{10} = 15 \text{ m/s}$$

So, the speed of the bike is 15 meters per second (m/s)

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3. Speed, Distance and Time Triangle:

- The **Speed**, **Distance** and **Time Triangle** is an easy way to remember the relationship between speed, distance, and time.
- It helps in calculating one quantity when the other two are known.

- **D**= **Distance**
- **S**= **Speed**
- **T**= **Time**

How to use Triangle:

- **To Find Speed:** Cover "S" and the formula is,

$$Speed = \frac{Distance}{Time}$$

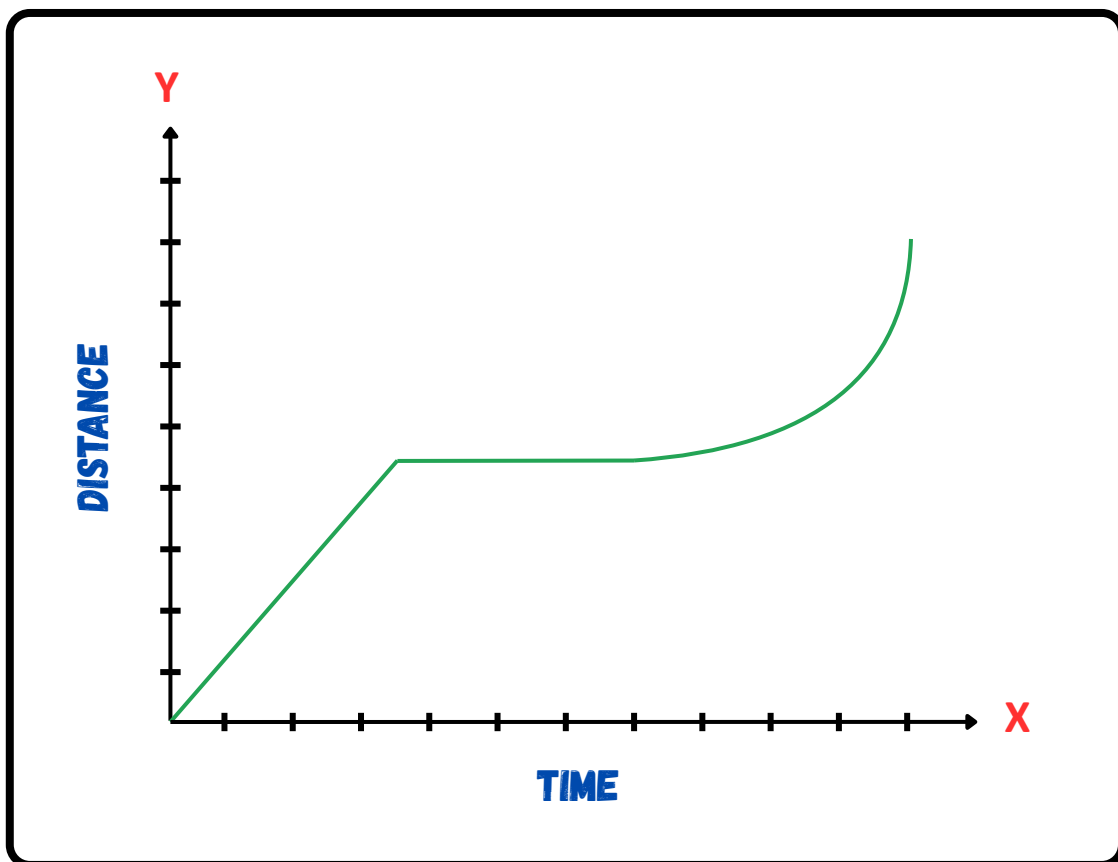- **To Find Distance:** Cover "D" and the formula is,

$$Distance = Speed \times Time$$

- **To Find Time:** Cover "T" and the formula is,

$$Time = \frac{Distance}{Speed}$$

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4. What is a Distance-Time Graph?

- A **Distance-Time Graph** is a graphical representation of how distance changes over time.
- It helps visualize the motion of an object.


Features of a Distance-Time Graph:
- X-axis (Horizontal) → Represents **Time** (seconds, minutes, hours).
- Y-axis (Vertical) → Represents **Distance** (meters, kilometers).
- Slope of the Graph → Represents **Speed**.
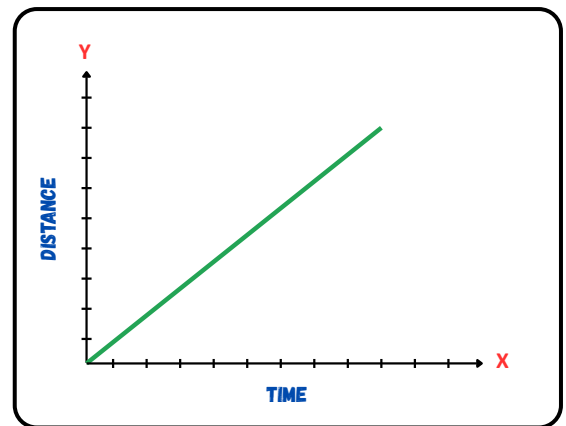
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Distance-Time graphs for various types of body motion:

- In Distance-Time Graph, the **Gradient** of the line at any point tell us the **Speed** of the object is travelling.
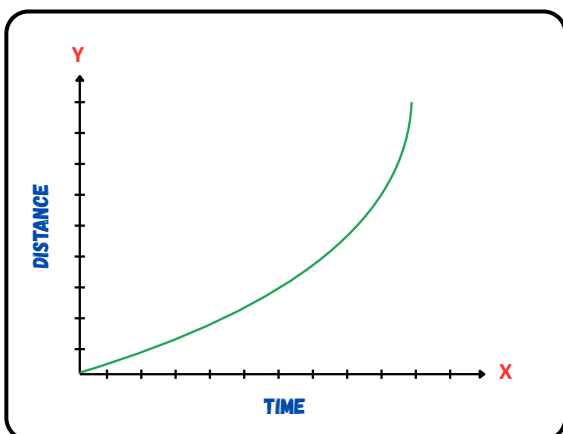- Mathematically,

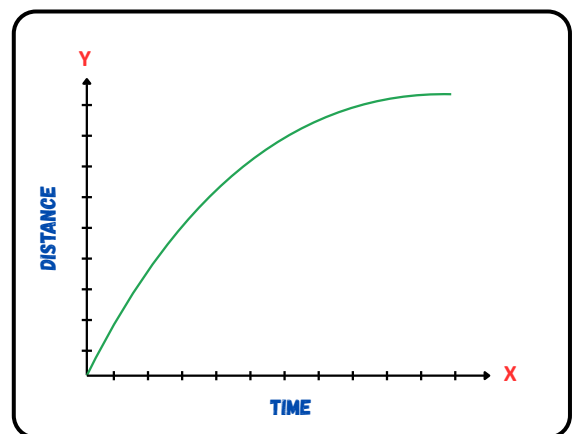$$\text{Gradient} = \frac{\text{Change in Distance}}{\text{Change in Time}}$$
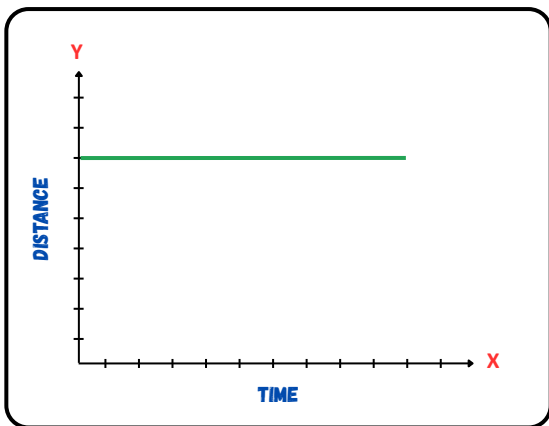
- For Stationary Body

  Speed = 0

- For Uniform Motion

  $$\text{Speed} = \frac{\text{Change in Distance}}{\text{Change in Time}}$$

- For Non-Uniform Motion

  Speed = Increasing

- For Non-Uniform Motion

  Speed = Decreasing

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5. How to Calculate Speed from Distance-Time Graph?

Steps to Calculate Speed from the Graph:

Step#1: Observe the Graph.

Step#2: Identify Two Points on the Graph.

Step#3: Find the Change in Distance (Δd).

Step#4: Find the Change in Time (Δt).

Step#5: Calculate the Speed using formula,

$$Speed = \frac{\Delta d}{\Delta t}$$

- *Case 1:* For **Stationary body**, it observed that the object is not moving. Since distance remains the same over time, Δd=0.

- *Case 2:* For **Uniform body**, the graph is a straight line and the speed is constant.

- *Case 3:* For **Non-Uniform body**, speed varies over time, so find instantaneous speed by calculating the slope of the tangent at a given point.

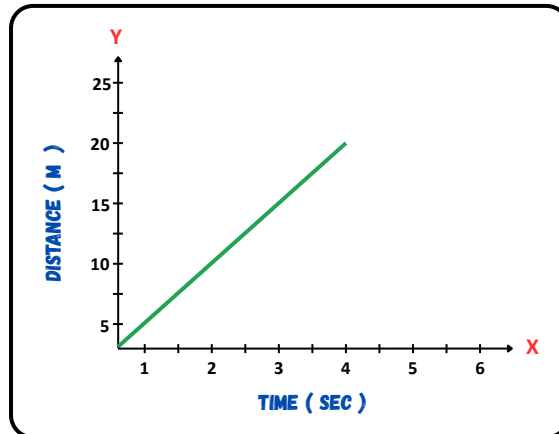$$\text{Average Speed} = \frac{\text{Total Distance Covered}}{\text{Total Time Taken}}$$

If Curved upwards → **Acceleration** (speed increasing).
If Curved downwards → **Deceleration** (speed decreasing).

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Example:

Problem: The distance-time graph of an object shows a slope at 20 meters for 4 seconds. What is the speed of the object?

Solution:

Step#1: Observe the Graph,

The Body is in Uniform Motion.

Step#2: Identify Two Points on the Graph,

- At t_1=0s, d_1=0m.
- At t_2=4s, d_2=20m.

Step#3: Change in Distance (Δd),

Δd= 20m−0m = 20m

Step#4: Change in Time (Δt).

Δt= 4s−0s = 4s

Step#5: Calculate the Speed ,
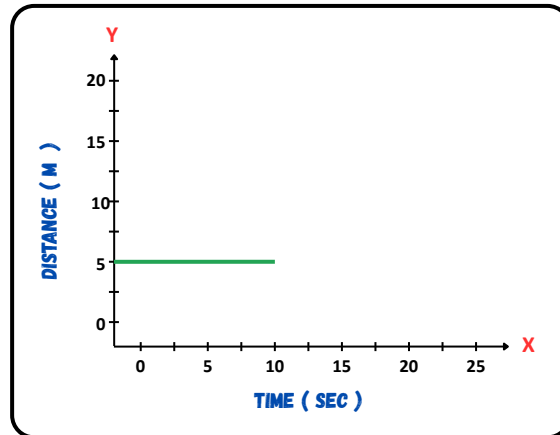
Speed = $\frac{20}{4}$ = 5m/s

Speed is 5m/s.

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Example:

Problem: The Distance-Time Graph of an object shows a flat horizontal line at 5 meters for 10 seconds. What is the speed of the object?

Solution:

Step#1: Observe the Graph,

The line is horizontal in the graph, so Distance does not change over time.

Step#2: Identify Two Points on the Graph,

- At t_1=0s, d_1=5m.
- At t_2=10s, d_2=5m.

Step#3: Change in Distance (Δd),

$$\Delta d = 5m - 5m = 0m$$

Step#4: Change in Time (Δt).

$$\Delta t = 10s - 0s = 10s$$

Step#5: Calculate the Speed ,

$$\text{Speed} = \frac{0}{10} = 0m/s$$

Speed is 0m/s.

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7. FAQs:

Q1. How to calculate speed from a distance time graph?
Use the formula: Speed = Distance ÷ Time. On a graph, calculate the slope by dividing the vertical change (distance) by the horizontal change (time).

Q2. How to find the distance in a velocity time graph?
Calculate the area under the graph line. Use basic shapes like rectangles and triangles to measure the area, which gives you the distance.

Q3. What does a horizontal line on a distance-time graph mean?
It means the object is stationary — it is not moving.

Q4. What does a steeper line mean on a distance time graph?
A steeper line shows a higher speed — the object is moving faster.

Q5. Can distance-time graphs show changes in speed?
Yes, when the slope changes or becomes curved (not shown in this example), it indicates acceleration or deceleration.

Q6. What's the difference between distance-time and velocity-time graphs?
• Distance-time graph: Shows how far something has travelled
• Velocity-time graph: Shows how fast it's moving — area under graph = distance.

Q7. How do I improve at reading graphs for exams?
Practice regularly, look at real exam questions, and use worksheets. Pay attention to axes labels, slope changes, and units.