Stopping Distances – GCSE Physics

CONTENTS:

1. Introduction:

- The **Total distance** a vehicle covers from the moment a driver identifies a hazard until the vehicle comes to a complete stop, is known as **Stopping Distances**.
- This concept is important,
    - To Prevent Accidents
    - To Be a More Aware Driver
    - To Drive Safely in Different Conditions
    - Understand how long it really takes to stop

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2. What is Stopping Distance?

- **Stopping Distance** is how for a car moves between the driver noticing something in front of them and the car coming to a stop.
- It's affected by two main features,

1. Thinking Distance:

- The Distance the vehicle travels while the driver reacts and decides to brake.
- It depends on reaction time (**typically 0.5–2 seconds**).
- Affected by driver alertness, distractions, fatigue, and intoxication.

2. Braking distance:

- The Distance the vehicle travels after the brakes are applied until it fully stops.
- It depends on speed, road conditions, vehicle weight, and brake efficiency.
- Affected by wet/icy roads, worn tires, or faulty brakes.

So,

Stopping Distance = Thinking Distance + Braking Distance

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3. Factors that affect stopping distance.

- **Speed** — Higher speeds mean longer stopping distances.

- **Driver reaction time** — Affected by tiredness, distractions, alcohol, or drugs.

- **Road conditions** — Wet, icy, or uneven roads increase braking distance.

- **Vehicle condition** — Things like brake quality and tire grip matter too.

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4. How to Calculate Stopping Distance.

- It involves two components: **Thinking Distance** and **Braking Distance.**
- The Total Stopping Distance is the sum of these two.

$$\text{Stopping Distance} = \text{Thinking Distance} + \text{Braking Distance}$$

Where,

Thinking Distance:

- The distance traveled while the driver reacts before applying the brakes is called the **Thinking Distance.**

$$\text{Thinking Distance} = \text{Speed} \times \text{Reaction Time}$$

- Speed = Vehicle speed (Typically in m/s).
- Reaction time = Around **0.7** to **1.5** seconds, depending on the driver and conditions.

Braking Distance:

- The distance traveled while the vehicle decelerates to a stop after the brakes are applied is called the **Braking distance.**

$$\text{Braking Distance} = \frac{v^2}{2a}$$

- v = Speed in m/s.
- a = Deceleration in m/s² (depends on brakes, road surface, tires, weather, etc.)

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5. Solved Examples

Problem1: If a car is traveling at 72 km/h. The driver has a reaction time of 1.5 seconds, and the car decelerates at 6 m/s² when the brakes are applied. Calculate the Total Stopping Distance.

Solution:

Step#1: Convert speed to m/s

$$\text{Speed} = \frac{72 \times 100}{3600} = 20\text{m/s}$$

Step#2: Calculate Thinking Distance

$$\text{Thinking Distance} = \text{Speed} \times \text{Reaction Time}$$

$$= 20\text{m/s} \times 1.5\text{s} = 30\text{m}$$

Step#3: Calculate Braking Distance

$$\text{Braking Distance} = \frac{v^2}{2a}$$

$$= \frac{200^2}{2 \times 6} = \frac{400}{12} = 33.33\text{m}$$

Step#4: Calculate Total Stopping Distance

$$\text{Stopping Distance} = \text{Thinking Distance} + \text{Braking Distance}$$

$$= 30\text{m} + 33.33\text{m} = 63.33\text{m}$$

Total Stopping Distance is **63.33m.**

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Problem2: A motorcycle is moving at 54 km/h. The rider's reaction time is 1.2 seconds. The motorcycle decelerates at 7 m/s² after braking. Find the Total Stopping Distance.

Solution:

Step#1: Convert speed to m/s

$$\text{Speed} = \frac{54 \times 1000}{3600} = 15\text{m/s}$$

Step#2: Calculate Thinking Distance

$$\text{Thinking Distance} = \text{Speed} \times \text{Reaction Time}$$

$$= 15\text{m/s} \times 1.2\text{s} = 18\text{m}$$

Step#3: Calculate Braking Distance

$$\text{Braking Distance} = \frac{v^2}{2a}$$

$$= \frac{15^2}{2 \times 7} = \frac{225}{14} = 16.07\text{m}$$

Step#4: Calculate Total Stopping Distance

$$\text{Stopping Distance} = \text{Thinking Distance} + \text{Braking Distance}$$

$$= 18\text{m} + 16.07\text{m} = 34.07\text{m}$$

Total Stopping Distance is **34.07m.**

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Problem3: A truck travels at 90 km/h. The driver reacts in 2 seconds. The truck decelerates at 5 m/s². Find the total stopping distance.

Solution:

Step#1: Convert speed to m/s

$$\text{Speed} = \frac{90 \times 1000}{3600} = 25\text{m/s}$$

Step#2: Calculate Thinking Distance

$$\text{Thinking Distance} = \text{Speed} \times \text{Reaction Time}$$

$$= 25\text{m/s} \times 2\text{s} = 50\text{m}$$

Step#3: Calculate Braking Distance

$$\text{Braking Distance} = \frac{v^2}{2a}$$

$$= \frac{25^2}{2 \times 5} = \frac{625}{10} = 62.5\text{m}$$

Step#4: Calculate Total Stopping Distance

$$\text{Stopping Distance} = \text{Thinking Distance} + \text{Braking Distance}$$

$$= 50\text{m} + 62.5\text{m} = 112.5\text{m}$$

Total Stopping Distance is **112.5m.**

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6. FAQs

1. What is stopping distance?

Stopping distance is the total distance a vehicle travels from the moment the driver perceives a hazard until the vehicle comes to a complete stop. It includes thinking distance (reaction time) and braking distance.

2. What factors affect stopping distance?

- Speed (most critical, braking distance $\propto$ speed^2)
- Road conditions (wet, icy, or dry surfaces)
- Tire condition & brake efficiency
- Driver reaction time (affected by fatigue, distractions, alcohol)

3. How does speed impact stopping distance?

Higher speeds exponentially increase braking distance (e.g., doubling speed quadruples braking distance).

Example:

At 30 mph, stopping distance ≈ 23 meters (75 ft)

4. What is the difference between thinking and braking distance?

Thinking distance = Distance covered during driver's reaction time.

Braking distance = Distance needed to stop after brakes are applied.

5. What's the formula for braking distance?

$$\text{Braking Distance} = \frac{v^2}{2a}$$