Module 1 · Week 1 · Lesson

# Motion in a Straight Line

PH11-8

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## ORIENTATION

**Lesson goal:** build accurate physics fluency for motion in a straight line and use that fluency to support clear HSC-style scientific writing.

This page is materialised into the MentorMind course shell from existing teaching, textbook, and eduKG material. Use it as the main lesson surface; use the tutor for targeted repair, worked examples, and concise writing feedback.

## SYLLABUS INQUIRY QUESTION

- How is the motion of an object moving in a straight line described and predicted?

**From The Feynman Lectures on Physics, Vol I, Chapter 8:**

Motion becomes predictable when the change of velocity is treated as a measurable quantity rather than a mystery. The model does not explain why an object moves; it shows how to calculate its motion.

## LEARNING OBJECTIVES

- Distinguish scalars from vectors in one-dimensional motion.
- Define displacement, velocity, and acceleration with SI units.
- Interpret average and instantaneous quantities.
- Apply constant-acceleration ideas to straight-line motion.

## CONTENT

### Scalars and vectors in one dimension

A scalar has magnitude only. A vector has magnitude and direction. In straight-line motion, the direction is represented by a positive or negative sign along a chosen axis.

### Describing motion

Displacement describes the change in position. Velocity describes the rate of change of displacement. Acceleration describes the rate of change of velocity.

$$v_{avg} = \frac{\Delta s}{\Delta t}, \quad a = \frac{\Delta v}{\Delta t}$$

### Interactive: Motion Diagram

Explore how objects move under constant acceleration. The dots show position at equal time intervals, and the arrows show velocity at each instant.

**Observe:**

- The dots get closer together as the object slows down
- The velocity arrows get shorter over time
- The negative acceleration reduces velocity until the object momentarily stops

### Instantaneous values

Instantaneous velocity is the slope of a displacement-time graph at a point. It represents motion at a single instant rather than over an interval.

Hover over the position-time graph below to see the instantaneous velocity at any point. The tangent line shows the slope (velocity) at that instant.

**Key observations:**

- The curve is a parabola (constant acceleration)
- The gradient (slope) at any point equals the instantaneous velocity
- Where the curve is steepest, velocity is greatest
- At the maximum point, the gradient (and velocity) is zero

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## WORKED EXAMPLES

### Example 1: Average velocity

A cyclist moves from 120 m to 20 m in 25 s along a straight road.

1. Displacement: $\Delta s = 20 - 120 = -100$ m.
2. Average velocity: $v_{avg} = -100/25 = -4.0$ m/s.
3. The negative sign indicates motion in the chosen negative direction.

#### Example 2: Acceleration from velocity change

A car slows from 18 m/s to 6 m/s in 4.0 s.

1. Change in velocity: $\Delta v = 6 - 18 = -12$ m/s.
2. Acceleration: $a = -12/4.0 = -3.0$ m/s$^2$.
3. The negative sign indicates deceleration.

#### Example 3: Constant acceleration displacement

A trolley starts at 2.0 m/s and accelerates at 0.50 m/s$^2$ for 6.0 s.

1. Use $s = ut + \frac{1}{2}at^2$.
2. Substitute: $s = 2.0(6.0) + 0.5(0.50)(6.0)^2$.
3. $s = 12 + 9 = 21$ m.

#### Interactive Example: Velocity-Time Analysis

The velocity-time graph shows how velocity changes over time. The **area under the curve** equals displacement.

**Hover over the graph to see:**

- Time (t)
- Velocity (v) at that instant
- Displacement (s) from the start

**Observe:**

- The shaded blue area represents positive displacement
- The shaded red area (when $v < 0$) represents displacement in the negative direction
- The gradient of the line equals the acceleration

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### COMMON MISCONCEPTIONS

- **Misconception:** Speed and velocity are interchangeable. **Correction:** Velocity includes direction; speed does not.

- **Misconception:** A negative velocity means the object is slowing down. **Correction:** It only indicates direction relative to the axis.

- **Misconception:** Zero acceleration means zero velocity. **Correction:** Zero acceleration means velocity is constant.

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PRACTICE QUESTIONS

**Easy (2 marks)**

A runner moves from 40 m to 10 m in 10 s. Calculate average velocity.

- Correct displacement and sign (1)
- Correct division and units (1)

**Answer:** $v_{avg} = (10 - 40)/10 = -3.0$ m/s

**Medium (4 marks)**

A train travels at 12 m/s, then accelerates uniformly to 20 m/s in 16 s. Find the acceleration and describe its direction.

- Correct change in velocity (1)
- Correct acceleration calculation (2)
- Direction statement (1)

**Answer:** $a = (20 - 12)/16 = 0.50$ m/s$^2$ in the direction of motion

**Hard (5 marks)**

An object moves with constant acceleration. It travels 8.0 m in the first 2.0 s and 18.0 m in the next 2.0 s. Determine the initial velocity and acceleration.

- Correct setup using two displacement equations (2)
- Correct solution for acceleration (2)
- Correct initial velocity with units (1)

**Hint:** Use $s = ut + \frac{1}{2}at^2$ for each interval.

**Answer:** $u = 2.5$ m/s, $a = 2.5$ m/s$^2$

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#### MULTIPLE CHOICE QUESTIONS

Test your understanding with these interactive questions:

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#### SUMMARY

- Straight-line motion uses signed quantities to encode direction.
- Displacement, velocity, and acceleration define the kinematic model.
- Instantaneous values come from gradients on graphs.
- Constant acceleration allows predictive equations of motion.

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#### SELF-ASSESSMENT

**Check your understanding:**

After studying this section, you should be able to:

- [ ] Explain the difference between distance and displacement
- [ ] Calculate average velocity from position data
- [ ] Read instantaneous velocity from an s-t graph
- [ ] Interpret the meaning of negative velocity and acceleration
- [ ] Predict motion using constant acceleration equations

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#### SCIENTIFIC WRITING AND EXAM SUPPORT

When answering questions from this lesson, separate:

- the physical quantity being discussed,
- the model or law being applied,
- the mathematical relationship, including units,
- the conclusion in words.

For explanation questions, write in the pattern: **claim -> physics reason -> consequence**. For calculation questions, state the formula, substitute with units, calculate, then interpret the answer.

#### MAINTENANCE LOOP

One-minute retrieval:

1. State the key law, model, or relationship used in this lesson.
2. Identify one common misconception that would lead to a wrong answer.
3. Write one sentence that links the calculation or evidence back to the physical meaning.

#### STUDENT WORKING