Grade 10 Physics: Mechanics and Measurement

Comprehensive Instructional Material based on National Curriculum Guidelines

Physics Department

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Contents

1 The Nature of Physics and Scientific Inquiry

Physics is the study of matter, energy, and the fundamental forces that govern the universe. It is a science built upon observations, hypotheses, and rigorous experimentation.

1.1 The Scientific Process

Physical knowledge is not static; it evolves through a systematic approach:

1. **Observation:** Collecting data through human senses and precision instruments.
2. **Hypothesis:** Creating a testable explanation for an observed phenomenon.
3. **Experimentation:** Testing variables in a controlled environment to verify or refute theories.
4. **Mathematical Modeling:** Translating experimental results into formal laws.

1.2 International System of Units (SI)

To maintain precision and facilitate global communication, scientists use the **Système International (SI)** units.

Table 1: SI Base Units for Fundamental Quantities

Quantity	**Symbol**	**Unit Name**	**Unit Symbol**
Length	l, x	Meter	m
Mass	m	Kilogram	kg
Time	t	Second	s
Electric Current	I	Ampere	A
Temperature	T	Kelvin	K

2 Precision and Significant Figures

In physics, every measurement contains an element of uncertainty. The number of significant figures used indicates the precision of the measuring instrument.

2.1 Rules for Significant Figures

- **Rule 1:** All non-zero digits are significant.
- **Rule 2:** Zeros between non-zero digits are significant.
- **Rule 3:** Leading zeros are *not* significant.
- **Rule 4:** Trailing zeros are significant only if a decimal point is present.

2.2 Measurement Uncertainty

Results are typically reported as $\overline{x} \pm \Delta\overline{x}$. The absolute uncertainty $\Delta\overline{x}$ for a set of experimental trials is calculated as:

$$\Delta\overline{x} = \frac{x_{max} - x_{min}}{2}$$

3 Describing Motion: Kinematics in One Dimension

Kinematics describes the motion of objects using parameters such as position, velocity, and acceleration.

3.1 Position, Displacement, and Distance

- **Position (x):** Location relative to a reference point.
- **Displacement (Δx):** Change in position ($x_f - x_i$).
- **Distance (d):** Total path length traveled (scalar).

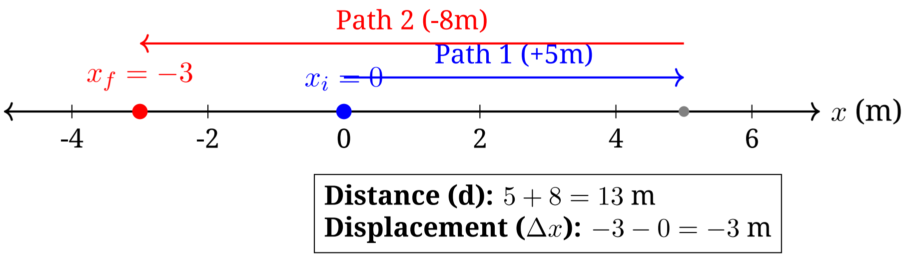

Figure 1: Comparison demonstrating path-dependent Distance and path-independent Displacement.

3.2 Velocity and Speed

Average Speed (v_{av}) is distance divided by time. **Average Velocity ($\overline{v}_{av}$)** is displacement divided by time.

$$\overline{v}_{av} = \frac{\Delta x}{\Delta t}$$

3.3 Acceleration

Acceleration (a) is the rate at which velocity changes over time.

$$a_{av} = \frac{v_f - v_i}{\Delta t}$$

4 Graphical Analysis of Linear Motion

Graphs provide a visual representation of motion parameters over time.

4.1 Position-Time Graphs ($x - t$)

The slope of a position-time graph represents the velocity. A steeper slope indicates a higher velocity.

4.2 Velocity-Time Graphs ($v - t$)

The slope of a $v - t$ graph represents acceleration, and the area under the curve represents displacement.

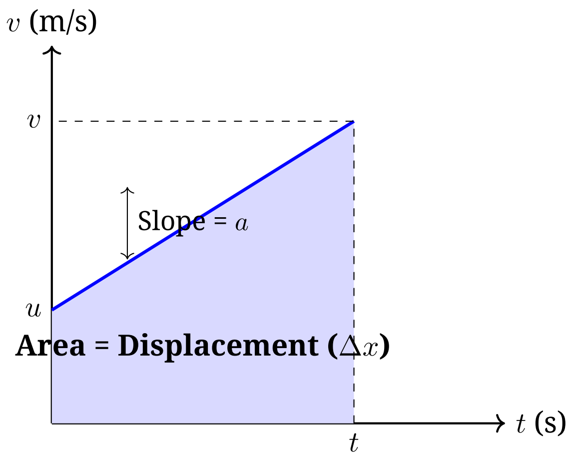

Figure 2: Using a Velocity-Time graph to derive acceleration and displacement.

4.3 Acceleration-Time Graphs ($a - t$)

The area under the curve in an $a - t$ graph represents the change in velocity (Δv).

5 The Equations of Constant Acceleration (SUVAT)

When acceleration is constant, we use the SUVAT equations to solve for unknown variables.

Table 2: The SUVAT Equations

Equation	**Relationship**
$v = u + at$	Velocity-Time
$\Delta x = ut + \frac{1}{2}at^2$	Displacement-Time
$v^2 = u^2 + 2a\Delta x$	Velocity-Displacement
$\Delta x = \left(\frac{u+v}{2}\right) t$	Average Velocity

6 Free Fall Motion

Free fall is motion under the sole influence of gravity ($g \approx 9.8\,m/s^2$ downwards).

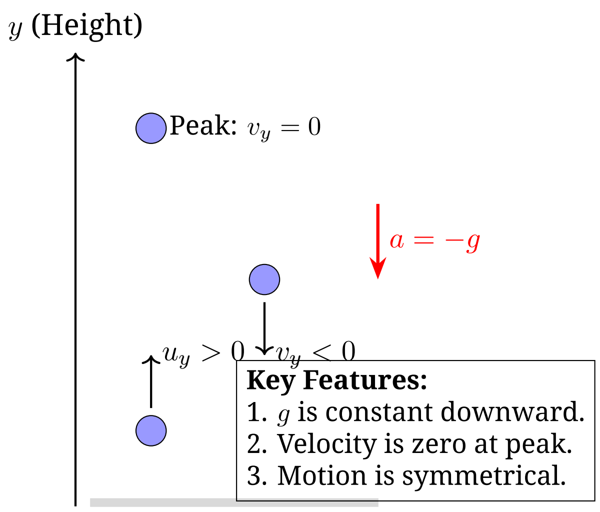

Figure 3: Visualizing the stages of vertical projectile motion under gravity.

7 Worked Examples

Example: A stone is dropped from a cliff 80m high. How long does it take to hit the ground? ($g = 10\,m/s^2$)
Solution: $u = 0$, $\Delta y = -80\,m$, $a = -10\,m/s^2$.

$$\Delta y = ut + \frac{1}{2}at^2 \implies -80 = 0 + \frac{1}{2}(-10)t^2$$

$$80 = 5t^2 \implies t^2 = 16 \implies t = 4\,\text{seconds.}$$

8 Review Exercises & Answers

1. Convert $36\,km/h$ to m/s. (*Answer:* $10\,m/s$)
2. A car slows from $20\,m/s$ to a stop in $5\,s$. Find a. (*Answer:* $-4\,m/s^2$)
3. A ball is thrown up at $19.6\,m/s$. Find time to peak. (*Answer:* $2\,s$)

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