# PHYS11 CH:1-3: Introduction to Physics and 1D Kinematics

## From Core Concepts to Equations of Motion

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# Learning Objectives I

After this lesson, you will be able to:

- Define physics and its role as a fundamental science.
- Describe the scientific method.
- Differentiate between physical quantities, units, accuracy, and precision.
- Explain the rules for significant figures in calculations.
- Distinguish between distance and displacement, and speed and velocity.
- Analyze motion using position vs. time and velocity vs. time graphs.
- Define acceleration as the rate of change of velocity.
- Apply kinematic equations to solve problems involving one-dimensional motion with constant acceleration.

# What is Physics? (Sec 1.1)

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- **Modern Physics** includes two revolutionary theories:
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  - **Quantum Mechanics:** Describes the behavior of subatomic particles.
- Physics provides the fundamental principles that underlie all other sciences, including chemistry, biology, and geology.

# The Scientific Method (Sec 1.2)

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- **Theory:** A scientific explanation that is supported by a large body of experimental results. A theory is a powerful and well-substantiated explanation.
    - Example: The Theory of General Relativity
- **Law:** A concise description of a universally true aspect of the universe. Laws often take the form of mathematical equations.
    - Example: Newton's Second Law of Motion ($F = ma$)

# Physical Quantities and Units (Sec 1.3)

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- The four fundamental units for this course are:
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- The metric system uses powers of 10 for easy conversion between different scales (e.g., 1 kilometer $= 10^3$ meters).

# Accuracy and Precision (Context)

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- **Precision:** How close a series of measurements are to each other.
  - Are your measurements repeatable?

An ideal measurement is both accurate and precise. Let's visualize this idea.

# Visualizing Accuracy and Precision

[Image of four targets showing: (a) High accuracy, high precision; (b) Low accuracy, high precision; (c) High accuracy, low precision; (d) Low accuracy, low precision]

*The classic target analogy for accuracy and precision.*

# Significant Figures (Sec 1.3)

Significant figures in a measurement express the precision of the measuring tool. When performing calculations, the result cannot be more precise than the least precise measurement. **Rules for Calculations:**

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- **Addition/Subtraction:** The final answer must have the same number of decimal places as the measurement with the fewest decimal places.

# Distance vs. Displacement (Context)

Understanding the difference between distance and displacement is crucial for describing motion.

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- **Distance (Scalar):** The total length of the path traveled. It has magnitude only.
  - "How much ground an object has covered."
- **Displacement (Vector):** The change in an object's position. It has both magnitude and direction.
  - "How far out of place an object is."
  - Equation: $\Delta\vec{d} = \vec{d}_f - \vec{d}_0$ (final position - initial position)

# Visualizing Distance and Displacement

[Diagram showing a winding path from point A to point B. The path length is labeled as 'distance'. A straight arrow from A to B is labeled as 'displacement'.]

*Distance is the path taken; displacement is the straight-line change in position.*

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  - An object's velocity can change even if its speed is constant (e.g., a car turning a corner).
- **Average Velocity (Vector):** Displacement divided by the time interval.
  - $\vec{v}_{avg} = \frac{\Delta \vec{d}}{\Delta t} = \frac{\vec{d}_f - \vec{d}_0}{t_f - t_0}$

# Position vs. Time Graphs (Context)

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- The vertical axis (y-axis) is position ($\vec{d}$).
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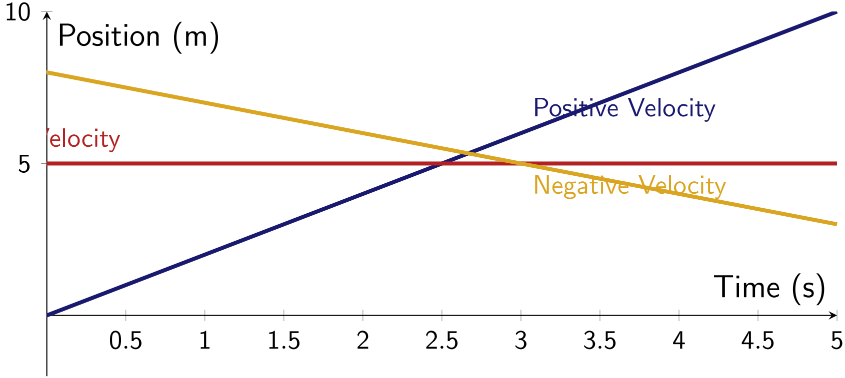
- A **straight line** means constant velocity.
- A **horizontal line** means zero velocity (the object is at rest).
- A **curved line** means the velocity is changing (acceleration).

# Visualizing Position vs. Time



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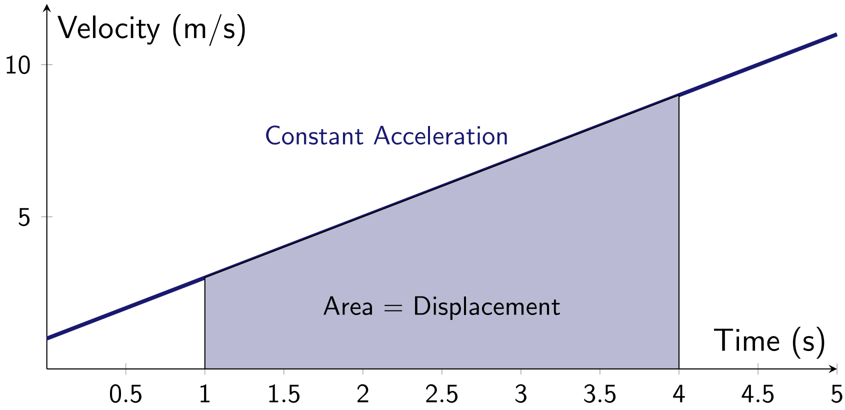
- The slope of the line gives the acceleration.
  - Slope $= \frac{\text{rise}}{\text{run}} = \frac{\Delta \vec{v}}{\Delta t} = \vec{a}$
- The area under the line gives the displacement.
  - Area $=$ height $\times$ width $= \vec{v} \times t = \Delta \vec{d}$

# Visualizing Velocity vs. Time



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- Average acceleration is calculated as:

$$\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_0}{t_f - t_0}$$

- The standard unit for acceleration is **meters per second squared ($m/s^2$)**.

# Essential Equations (for constant acceleration)

These are the kinematic equations that relate displacement ($d$), time ($t$), initial velocity ($v_0$), final velocity ($v$), and acceleration ($a$).

1. **Velocity from acceleration:**

$$v = v_0 + at$$

*Use when you don't know displacement.*

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4. **Displacement from average velocity:**

$$d = d_0 + \left(\frac{v_0 + v}{2}\right) t$$

# Example Problem (I do)

**Problem:** A sports car accelerates from rest to 27 m/s in 9.0 s. What is its average acceleration?

**G - Givens:**

- $v_0 = 0$ m/s ("from rest")
- $v = 27$ m/s
- $\Delta t = 9.0$ s

**U - Unknown:**

- $a = ?$

**E - Equation:**

$$a = \frac{\Delta v}{\Delta t} = \frac{v - v_0}{\Delta t}$$

**S - Substitute:**

$$a = \frac{27 \text{ m/s} - 0 \text{ m/s}}{9.0 \text{ s}}$$

**S - Solve:**

$$a = 3.0 \text{ m/s}^2$$

# Guided Practice (We do)

**Problem:** A dragster starts from rest and accelerates at a constant 10.0 m/s² for 4.0 s. How far does it travel in this time?

**G - Givens:**

- $v_0 = 0$ m/s
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Use the GUESS method and the kinematic equations to solve.

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**Answers:**

- Part A: $a = -5.0$ m/s²
- Part B: $d = 22.5$ m

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    - **Position-Time Graph:** Slope is velocity.
    - **Velocity-Time Graph:** Slope is acceleration, area is displacement.
- For motion with **constant acceleration**, we can use the kinematic equations to predict the future state of an object.