PHYS12 CH:1.1-1.4, 2.1-2.8

Progression from Physics 11 to Physics 12: Advanced Kinematics

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Learning Objectives

Reviewing the Fundamentals of Motion

After this lesson, you will be able to:

- Define position, displacement, distance, velocity, speed, and acceleration.
- Differentiate between vector and scalar quantities.
- Analyze one-dimensional motion under constant acceleration.
- Apply the kinematic equations to solve problems involving motion.
- Interpret position-time and velocity-time graphs to describe motion.
- Describe the motion of objects in free-fall.

Physics 11 to Physics 12 Progression

Building on Your Foundation

- Physics 11 Foundation: Basic kinematic concepts, graphical analysis, and problem-solving methods

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Building on Your Foundation

- Physics 11 Foundation: Basic kinematic concepts, graphical analysis, and problem-solving methods
- Physics 12 Enhancement: More complex applications, vector analysis, and real-world scenarios
- Key Progression Areas:
  - Multi-dimensional motion analysis
  - Vector decomposition and composition
  - Advanced problem-solving strategies
  - Real-world applications and limitations

Position (x) The location of an object at a particular time. It is a vector quantity.

Key Concepts

Position, Displacement, and Distance

Position (x) The location of an object at a particular time. It is a vector quantity.

Displacement (Δx) The change in an object's position. It is a vector pointing from the initial position (x_0) to the final position (x_f).

$$\Delta x = x_f - x_0$$

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Distance Traveled The total length of the path traveled between two positions. It is a scalar quantity and is always positive.

Concept Visualization

Context: Displacement vs. Distance

Imagine walking from your home to school.

- The winding path you take along sidewalks represents the distance traveled.
- A straight line drawn directly from your home to the school represents your displacement.

These two values are often different. Displacement only cares about the start and end points, not the path taken.

Concept Visualization

Displacement vs. Distance Traveled

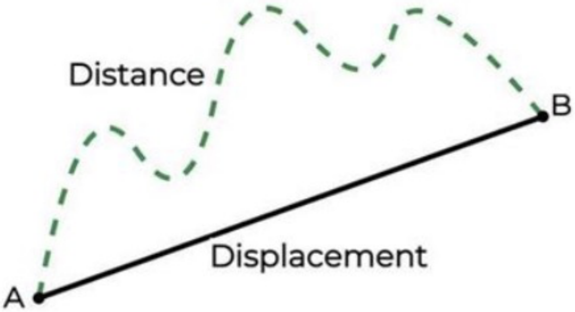

Figure: Displacement is the shortest path, while distance is the actual path taken.

Key Concepts

Scalars vs. Vectors

In physics, we use two types of quantities to describe the world:

Scalar

- A quantity described by **magnitude** (a numerical value) only.
- Examples:
  - Distance (5 m)
  - Speed (10 m/s)
  - Time (15 s)
  - Mass (2 kg)

Vector

- A quantity described by both **magnitude and direction**.
- Examples:
  - Displacement (5 m, East)
  - Velocity (10 m/s, North)
  - Acceleration (9.8 m/s^2, Down)
  - Force (20 N, Up)

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Acceleration (a) The rate at which velocity changes. A vector.

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_f - v_0}{t_f - t_0}$$

Deceleration is simply acceleration in the direction opposite to the velocity.

Key Concepts
Free Fall

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- The sign of acceleration depends on your chosen coordinate system. Conventionally, "up" is positive, which makes acceleration $a = -g = -9.80\,\mathrm{m/s^2}$.

Essential Equations

For Motion with Constant Acceleration

These equations are the foundation for solving problems in 1D kinematics. They are only valid when acceleration a is constant.

$$v = v_0 + at$$

$$\Delta x = v_0 t + \frac{1}{2}at^2$$

$$v^2 = v_0^2 + 2a\Delta x$$

$$\Delta x = \frac{v_0 + v}{2}t$$

Variables

- Δx: displacement (m)
- t: elapsed time (s)
- v_0: initial velocity (m/s)
- v: final velocity (m/s)
- a: constant acceleration (m/s^2)

Graphical Analysis of Motion

Context: Position vs. Time Graph

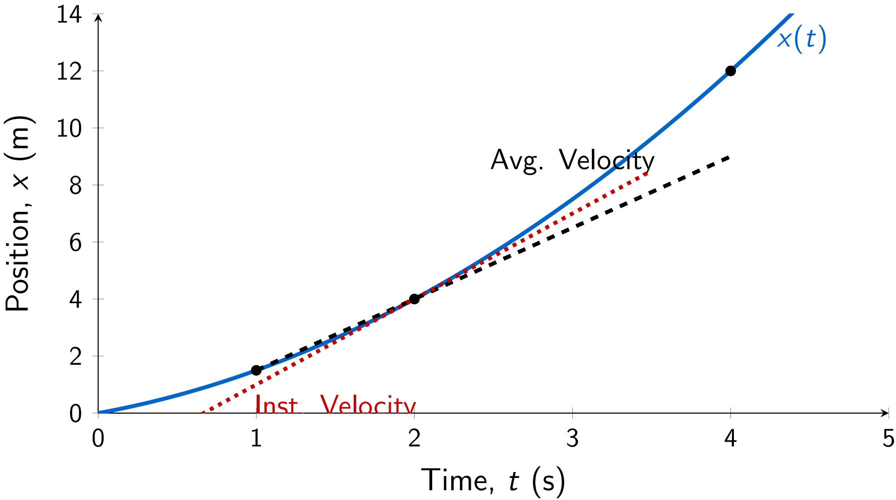
A graph of an object's position (x) as a function of time (t) provides a wealth of information about its motion.

- The slope of the line reveals the object's velocity.
- A straight line means constant velocity.
- A curved line means the velocity is changing (i.e., there is acceleration).

On the next slide, we will visualize the difference between average velocity (slope between two points) and instantaneous velocity (slope at a single point).

Graphical Analysis of Motion

Visualization: Position vs. Time



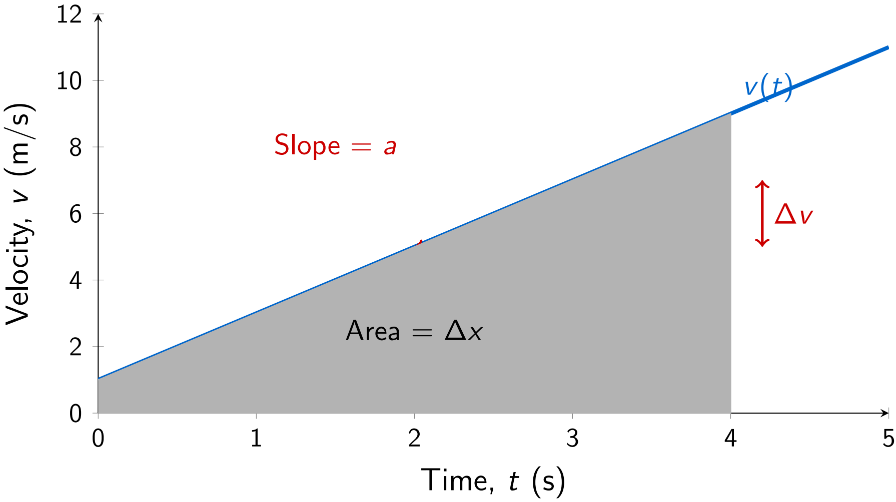
A graph of velocity (v) versus time (t) also tells a detailed story.

- The slope of the line is the object's **acceleration**.
- The area under the curve is the object's **displacement** (Δx).

Next, we will see these two concepts illustrated for an object with constant positive acceleration.

Graphical Analysis of Motion

Visualization: Velocity vs. Time



Problem Solving

The GUESS Method

We will use a structured method to solve physics problems.

- **G** - Givens: List all known quantities from the problem, with variables and units. Define your coordinate system (e.g., up is positive).
- **U** - Unknown: Identify what quantity you need to find.
- **E** - Equation: Choose a kinematic equation that relates your givens and unknown.
- **S** - Substitute: Plug your known values into the equation, including units.
- **S** - Solve: Calculate the answer and make sure it has the correct units and significant figures.

I Do: Freeway Acceleration - Problem Setup

Problem based on Ch. 2, Problem 24

Problem

A car enters a freeway, accelerating from rest at a rate of $2.40\,\mathrm{m/s^2}$ for $12.0\,\mathrm{s}$. How far does the car travel in this time?

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G - Givens

- Direction of motion: positive
- $\vec{a} = +2.40\,\mathrm{m/s^2}$, $t = 12.0\,\mathrm{s}$
- $\vec{v}_0 = 0\,\mathrm{m/s}$ (starts from rest)

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U - Unknown

- $\Delta\vec{x} = ?$ (displacement)

E - Equation

- Select: $\Delta x = v_0 t + \frac{1}{2}at^2$
- Already solved for displacement

S - Substitute

- Plug values with units:

$$\Delta x = (0\,\mathrm{m/s})(12.0\,\mathrm{s}) + \frac{1}{2}(2.40\,\mathrm{m/s^2})(12.0\,\mathrm{s})^2$$

I Do: Freeway Acceleration - Solution

S - Substitute

- Plug values with units:

$$\Delta x = (0\,\mathrm{m/s})(12.0\,\mathrm{s}) + \frac{1}{2}(2.40\,\mathrm{m/s^2})(12.0\,\mathrm{s})^2$$

S - Solve

- Calculate with unit analysis:

$$\Delta x = 0 + \frac{1}{2}(2.40\,\mathrm{m/s^2})(144\,\mathrm{s^2})$$

$$\Delta x = (1.20\,\mathrm{m/s^2})(144\,\mathrm{s^2}) = 172.8\,\mathrm{m}$$

- Apply sig figs: 173 m
- $\boxed{173\,\mathrm{m}}$

We Do: Dolphin's Jump

Problem based on Ch. 2, Problem 45

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- $\vec{v}_0 = +13.0\,\mathrm{m/s}$,
  $\vec{a} = -9.80\,\mathrm{m/s^2}$
- At max height: $\vec{v} = 0\,\mathrm{m/s}$

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- $\Delta\vec{y} =$? (height)

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U - Unknown

- $\Delta\vec{y} = ?$ (height)

E - Equation

- Select: $v^2 = v_0^2 + 2a\Delta y$
- Rearrange: $\Delta y = \frac{v^2 - v_0^2}{2a}$

S - Substitute

- Plug values: $\Delta y = \frac{(0)^2 - (13.0)^2}{2(-9.80)}$

S - Substitute

- Plug values: $\Delta y = \frac{(0)^2-(13.0)^2}{2(-9.80)}$

S - Solve

- Calculate: $\Delta y = \frac{0-169}{-19.6} = \frac{-169}{-19.6}$
- $\Delta y = 8.62\,\text{m}$
- $\boxed{8.62\,\text{m}}$

You Do: Swan's Takeoff

Problem based on Ch. 2, Problem 31

Problem

A swan on a lake accelerates from rest at an average rate of $0.350\,\mathrm{m/s^2}$ to take off. It must reach a velocity of $6.00\,\mathrm{m/s}$ to get airborne.

1. How far does it travel before becoming airborne?
2. How long does this take?

Your Turn

Use the GUESS method to solve this problem on your own.

- List your givens and what you need to find for each part.
- Choose the appropriate equation for each part.
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Solution Check: Your final answers should be (a) ≈ 51.4 m and (b) ≈ 17.1 s.

Reading Homework

Foundational Physics Concepts

Please review these foundational sections for our next class:

- **Section 1.5**: Physical Quantities and Units
- **Section 1.6**: Vector Addition and Subtraction
- **Section 1.7**: Vector Components
- **Section 1.8**: Relative Velocity

Focus on: Understanding vector operations and relative motion concepts.

These will be essential for our upcoming 2D motion unit.

Summary

Key Takeaways from 1D Kinematics

- **Scalars vs. Vectors**: Distance and speed are scalars; displacement, velocity, and acceleration are vectors (direction matters!).

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- **Scalars vs. Vectors**: Distance and speed are scalars; displacement, velocity, and acceleration are vectors (direction matters!).
- **Constant Acceleration**: The kinematic equations are powerful tools, but they only apply when acceleration is constant. Free-fall is a key example ($a = -g$).
- **Graphical Analysis**: Graphs provide a visual understanding of motion.
  - Slope of position-time graph $\rightarrow$ velocity
  - Slope of velocity-time graph $\rightarrow$ acceleration
  - Area under velocity-time graph $\rightarrow$ displacement

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  - Slope of position-time graph $\rightarrow$ velocity
  - Slope of velocity-time graph $\rightarrow$ acceleration
  - Area under velocity-time graph $\rightarrow$ displacement
- **Problem Solving**: A structured approach like the GUESS method is crucial for success.

Homework: Physics 11 Review

Essential Preparation for Advanced Topics

To ensure success in Physics 12, please review these fundamental concepts from Physics 11:

- **Chapter 1 Review**: Units, measurements, and significant figures
- **Chapter 2 Review**: Kinematic equations and problem-solving methods
- **Graphical Analysis**: Position-time and velocity-time graphs
- **Vector Basics**: Adding and subtracting vectors graphically

Focus on: Mastering the GUESS method and understanding the difference between scalars and vectors. These skills will be critical for our upcoming 2D motion unit.