

# Ap Physics 1 Notes

nimblestart - February 2025

## Unit 1: Kinematics

Kinematics is the study of motion without considering the forces that cause it. It focuses on describing motion using quantities like displacement, velocity, and acceleration.

### 1.1 Scalars and Vectors

- **Scalar:** A quantity with magnitude only (e.g., speed, distance, mass).
- **Vector:** A quantity with both magnitude and direction (e.g., velocity, displacement, acceleration, force).
- **Component Vectors:** If a vector is at an angle use trigonometric functions to get the x and y components. e.g.  $\sin(\theta) = \frac{O}{H} \Rightarrow A_x = A \sin(\theta)$ . Remember to use the correct angle and appropriate Trig function.

### 1.2 Distance, and Speed

- **Distance:** Distance is how far something moves and it includes the path travelled.
- **Speed:** Distance/Time

### 1.3 Displacement, Velocity, and Acceleration

Quantity	Description	Equation
Displacement	The straight-line distance from where the object started to where it ended. The change in position of an object.	$\Delta \vec{x} = \vec{x}_f - \vec{x}_i$
Average Velocity	The rate of change of displacement over a time interval.	$\vec{v}_{\text{avg}} = \frac{\Delta \vec{x}}{\Delta t}$
Instantaneous Velocity	The velocity of an object at a specific moment in time.	$\vec{v} = \frac{d\vec{x}}{dt}$
Average Acceleration	The rate of change of velocity over a time interval.	$\vec{a}_{\text{avg}} = \frac{\Delta \vec{v}}{\Delta t}$
Instantaneous Acceleration	The acceleration of an object at a specific moment in time.	$\vec{a} = \frac{d\vec{v}}{dt}$

### 1.4 Equations of Motion (UAM - Uniformly Accelerated Motion)

	Description	Equation
<b>Velocity as a function of time</b>	Relates final velocity to initial velocity, acceleration, and time.	$v_f = v_i + at$
<b>Displacement as a function of time</b>	Relates displacement to initial velocity, acceleration, and time.	$\Delta x = v_i t + \frac{1}{2}at^2$
<b>Velocity as a function of displacement</b>	Relates final velocity to initial velocity, acceleration, and displacement.	$v_f^2 = v_i^2 + 2a\Delta x$

	Description	Equation
<b>Displacement as a function of average velocity</b>	Relates displacement to average velocity and time.	$\Delta x = \frac{1}{2}(v_i + v_f)t$

These equations apply when acceleration is constant.

## 1.5 Graphical Analysis of Motion

Graph	Slope Represents	Area Represents	Key Observations
<b>Position vs. Time</b>	Velocity	-	Steeper slope = higher velocity, Zero slope = object at rest.
<b>Velocity vs. Time</b>	Acceleration	Displacement	Steeper slope = higher acceleration, Zero slope = constant velocity.
<b>Acceleration vs. Time</b>	-	Change in velocity	Area under the curve = $\Delta v$ .

## 1.6 Free Fall

- **Acceleration due to gravity ( $g$ ):**  $g = 9.81 \text{ m/s}^2$  (downward direction is negative).
- In free fall, the only force acting on the object is gravity (ignoring air resistance).
- Equations of motion apply with  $a = -g$ .

## 1.7 Projectile Motion

Projectile motion is the motion of an object launched into the air, subject only to gravity.

### Key Points:

- The horizontal and vertical motions are independent.
- **Horizontal motion:** Constant velocity ( $a_x = 0$ ).
- **Vertical motion:** Constant acceleration ( $a_y = -g$ ).

### Equations:

Quantity	Equation
<b>Horizontal displacement</b>	$\Delta x = v_{x0}t$
<b>Vertical displacement</b>	$\Delta y = v_{y0}t - \frac{1}{2}gt^2$
<b>Time of flight</b>	$t = \frac{2v_{y0}}{g}$ (for symmetric projectile motion)

## 1.8 Relative Motion

- The motion of an object as observed from a different frame of reference.
- **Relative velocity:**  $\vec{v}_{\text{A relative to B}} = \vec{v}_A - \vec{v}_B$

## Unit 2: Dynamics

Dynamics is the study of forces and how they affect the motion of objects. It builds on the concepts of kinematics by introducing the causes of motion.

## 2.1 Newton's Laws of Motion

Law	Description	Equation/Key Points
<b>First Law (Inertia)</b>	An object at rest stays at rest, and an object in motion stays in motion unless acted upon by a net external force.	$\sum \vec{F} = 0 \Rightarrow \vec{a} = 0$
<b>Second Law</b>	The acceleration of an object is directly proportional to the net force and inversely proportional to its mass.	$\sum \vec{F} = m\vec{a}$
<b>Third Law (Action-Reaction)</b>	For every action, there is an equal and opposite reaction.	$\vec{F}_{12} = -\vec{F}_{21}$

## 2.2 Types of Forces

Force	Description	Equation/Key Points
<b>Gravitational Force</b>	The force exerted by Earth (or any massive object) on another object.	$\vec{F}_g = m\vec{g}$
<b>Normal Force</b>	The force exerted by a surface to support an object. It acts perpendicular to the surface.	$\vec{F}_N$ is perpendicular to the surface.
<b>Frictional Force</b>	The force that opposes motion between two surfaces in contact.	- Static friction: $F_{f,\text{static}} \leq \mu_s F_N$ - Kinetic friction: $F_{f,\text{kinetic}} = \mu_k F_N$
<b>Tension</b>	The force exerted by a string, rope, or cable.	$\vec{T}$ acts along the direction of the string.
<b>Applied Force</b>	A force applied to an object by an external agent (e.g., pushing or pulling).	$\vec{F}_{\text{applied}}$

## 2.3 Free Body Diagrams

- A diagram showing all the forces acting on an object.
- Steps to Draw:
  1. Identify the object of interest.
  2. Draw all forces acting on the object as vectors.
  3. Label each force (e.g.,  $\vec{F}_g$ ,  $\vec{F}_N$ ,  $\vec{F}_f$ ).
  4. Break forces into components if necessary (e.g., on an incline).

## 2.4 Inclined Planes

Forces on an object on an inclined plane can be broken into components parallel and perpendicular to the surface.

Force Component	Description	Equation
<b>Parallel to Incline</b>	The component of gravity acting down the incline.	$F_{g,\parallel} = mg \sin \theta$
<b>Perpendicular to Incline</b>	The component of gravity acting perpendicular to the incline.	$F_{g,\perp} = mg \cos \theta$

## 2.5 Friction

Friction opposes motion and depends on the normal force and the coefficient of friction.

Type of Friction	Description	Equation
<b>Static Friction</b>	Prevents an object from moving when a force is applied.	$F_{f,\text{static}} \leq \mu_s F_N$
<b>Kinetic Friction</b>	Acts on an object in motion.	$F_{f,\text{kinetic}} = \mu_k F_N$

## 2.6 Centripetal Force

The net force directed toward the center of a circular path that causes circular motion.

Concept	Description	Equation
<b>Centripetal Force</b>	Required for circular motion.	$F_c = \frac{mv^2}{r} = mr\omega^2$
<b>Centripetal Acceleration</b>	The acceleration directed toward the center of the circle.	$a_c = \frac{v^2}{r} = r\omega^2$

## 2.7 Translational Equilibrium

- An object is in translational equilibrium when the net force acting on it is zero.
- **Condition:**  $\sum \vec{F} = 0$
- **Implications:** The object is either at rest or moving with constant velocity.

## 2.8 Action-Reaction Pairs

- Forces always occur in pairs. For every action, there is an equal and opposite reaction.
- **Example:** When you push a wall, the wall pushes back on you with an equal force.

## 2.9 Applications of Newton's Laws

- **Atwood's Machine:** A system of two masses connected by a string over a pulley.
- **Pulleys:** Used to change the direction of a force.
- **Elevators:** Analyze forces when an elevator accelerates upward or downward.