AP Physics 1 Notes

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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 trignometric fucntions to get the x and y components. e.g. $\sin(\theta) = \frac{O}{H} \quad \Rightarrow \quad A_x = A\sin(\theta)$. Remember to use the corret 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
Velocity as a function of time	Relates final velocity to initial velocity, acceleration, and time.	$v_f = v_i + at$
Displacement as a function of time	Relates displacement to initial velocity, acceleration, and time.	$\Delta x = v_i t + \frac{1}{2}at^2$

	Description	Equation
Velocity as a function of displacement	Relates final velocity to initial velocity, acceleration, and displacement.	$v_f^2 = v_i^2 + 2a\Delta x$
Displacement as a function of average velocity	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
Position vs. Time	Velocity	-	Steeper slope = higher velocity, Zero slope = object at rest.
Velocity vs. Time	Acceleration	Displacement	Steeper slope = higher acceleration, Zero slope = constant velocity.
Acceleration vs. Time	-	Change in velocity	Area under the curve = Δv.

1.6 Free Fall

- **Acceleration due to gravity (g):** $g = 9.81$ 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
Horizontal displacement	$\Delta x = v_{x0}t$
Vertical displacement	$\Delta y = v_{y0}t - \frac{1}{2}gt^2$
Time of flight	$t = \frac{2v_{y0}}{g}$ (for symmetric projectile motion)

1.8 Relative Motion

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

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
First Law (Inertia)	An object at rest stays at rest, and an object in motion stays in motion unless acted upon by a net external force.	$\sum \vec{F} = 0 \Rightarrow \vec{a} = 0$
Second Law	The acceleration of an object is directly proportional to the net force and inversely proportional to its mass.	$\sum \vec{F} = m\vec{a}$
Third Law (Action-Reaction)	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
Gravitational Force	The force exerted by Earth (or any massive object) on another object.	$\vec{F}_g = m\vec{g}$
Normal Force	The force exerted by a surface to support an object. It acts perpendicular to the surface.	$\vec{F}_N$ is perpendicular to the surface.
Frictional Force	The force that opposes motion between two surfaces in contact.	- Static friction: $F_{f,\text{static}} \leq \mu_s F_N$ - Kinetic friction: $F_{f,\text{kinetic}} = \mu_k F_N$
Tension	The force exerted by a string, rope, or cable.	$\vec{T}$ acts along the direction of the string.
Applied Force	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
Parallel to Incline	The component of gravity acting down the incline.	$F_{g,\parallel} = mg \sin\theta$
Perpendicular to Incline	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
Static Friction	Prevents an object from moving when a force is applied.	$F_{f,\text{static}} \leq \mu_s F_N$
Kinetic Friction	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
Centripetal Force	Required for circular motion.	$F_c = \frac{mv^2}{r} = mr\omega^2$
Centripetal Acceleration	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.

Unit 8: Fluids

1. Properties of Fluids

- **Fluids**: Substances that can flow, including liquids and gases.
- **Density (ρ)**: Mass per unit volume, $\rho = \frac{m}{V}$.
- **Pressure (P)**: Force per unit area, $P = \frac{F}{A}$.

2. Pressure in Fluids

- **Pascal's Principle**: A change in pressure applied to an enclosed fluid is transmitted undiminished to all portions of the fluid and the walls of its container.
- **Hydraulic Systems**: Use Pascal's principle to multiply force. Example: Hydraulic lift.

3. **Buoyancy**
   - **Archimedes' Principle**: A body submerged in a fluid experiences a buoyant force equal to the weight of the fluid displaced by the body.
   - **Buoyant Force (F_b)**: $F_b = \rho_{fluid} \cdot V_{displaced} \cdot g$.

4. **Fluid Dynamics**
   - **Continuity Equation**: For an incompressible fluid, the product of cross-sectional area and velocity is constant along a streamline, $A_1 v_1 = A_2 v_2$.
   - **Bernoulli's Equation**: Relates pressure, velocity, and height in a moving fluid, derived from the conservation of energy: $P + \frac{1}{2}\rho v^2 + \rho g h =$ constant

5. **Applications of Fluid Dynamics**
   - **Venturi Effect**: Reduction in fluid pressure when a fluid flows through a constricted section of pipe.
   - **Airplane Wings**: Shape of wings creates different velocities above and below, generating lift due to pressure differences.