Physics Notes

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Part I

AP Physics C

1 Kinematics

1.1 Describing Motion 1

1.1.1 Average Speed

- Average speed is the distance traveled over change in time
- It is a scaler
- Measured in meters/second.
- Magnitude of Velocity Vector

1.1.2 Average Velocity

- Average velocity is a vector.
- Measured in meters/second.

$$v_{avg} = \frac{\delta x}{\delta t} = \frac{x_f - x_i}{t_f - t_i}$$

1.1.3 Average Velocity

- Rate that velocity changes
- Is a vector
- Units are meters/second/second

$$a = \frac{\delta v}{\delta t} = \frac{dv}{dt}$$

1.1.4 Displacement

The displacement from t_0 to t_1 of a position function $x(t)$ with velocity function $v(t)$ is

$$\int_{t_0}^{t_1} v(t)dt$$

1.2 Describing Motion 2

1.2.1 Kinematic Equations

Variables	
v_0	Initial velocity
v	Final velocity
δx	Displacement
a	Acceleration
t	Time

- $v = v_0 + at$
- $x = x_0 + v_0 t + \frac{1}{2}at^2$
- $v^2 = v_0^2 + 2a\delta x$

1.2.2 Acceleration Due to Gravity

- Near the surface of Earth, objects accelerate at a rate of $9.8\frac{m}{s^2}$
- This is acceleration due to gravity (g)
- This can be approximated to $10\frac{m}{s^2}$
- As you move from Earth, acceleration decreases.

1.2.3 Objects Falling From Rest

- Objects starting from rest have $v_0 = 0$
- Typically down is the positive direction
- Acceleration is $+g$.

1.2.4 Objects Launched Upward

- Must examine the motion of object going up and down.
- Since object is going up, that is the positive direction.
- Acceleration is $-g$.
- At the highest point, $v = 0$.

1.3 Projectile Motion

A **projectile** is an object that is acted upon only gravity.

1.3.1 Independence of Motion

- Projectiles launched at an angle have motion in 2 dimensions.
  - Vertical - acceleration is gravity
  - Horizontal - 0 acceleration
- Vertical and Horizontal motion are treated separately

> **Note:** An object will travel the maximum horizontal distance with a launch angle of 45°

1.3.2 Steps for any Projectile Motion Problem

1. First, know that
$$a = \begin{bmatrix} 0 \\ -g \end{bmatrix}$$
2. Then find your v_0 as a vector
3. Find your x_0 as a vector
4. Substitute your vectors into the following formula
$$x(t) = -\frac{1}{2}at^2 + v_0t + x_0$$

1.3.3 Graphing Projectile Motion

In order to graph a path, solve for $y = f(x)$. Do this by solving for t in relation to x and then substitute into the y component.
For example:

$$\begin{aligned} x &= f(t) \\ y &= g(t) \\ \text{Find } y &= h(x) \\ t &= f^{-1}(x) \\ y = g(f^{-1}(x)) &= h(x) \\ \text{so } h(x) &= g(f^{-1}(x)) \end{aligned}$$

1.4 Circular And Relative Motion

1.4.1 Converting Linear to Angular Velocity

If we have an object moving counter clockwise around a point, let $\omega = \frac{d\theta}{dt}$. If we know that the object has velocity v and position s, we know that $s = r\theta$ where r is the radius of the circular path. By taking the derivative of both sides, $\dot{s} = r\dot{\theta}$. Now we can substitute to find the angular velocity.

$$\dot{s} = r\omega$$

2 Dynamics

2.1 Newton's First Law and Free Body diagrams

Newton's First Law

> An object at rest will remain at rest, and an object in motion will remain in motion, at constant velocity and in a straight line, unless acted upon by a net force.

2.1.1 Force

- A force is a push or pull on an object.
- Units of force are in Newtons (N).
- A newton is roughly the weight of an apple

$$1N = 1\frac{kg * m}{s^2}$$

Contract Force
A force that arises that from direct contact between objects.

- Tension
- Applied Force
- Friction

Field Force
Forces that act at a distance.

- Gravity
- Electrical
- Magnetic

2.1.2 Net Force

A net force is the vector sum of all the forces acting on an object.

$$F_{net} = \sum F$$

2.1.3 Equilibrium

- Static Equilibrium
  - Net force is 0
  - Net torque is 0
  - Object is at rest
- Mechanical Equilibrium
  - Net force is 0
  - Net torque is 0
- Translational Equilibrium
  - Net force is 0

2.1.4 Free Body Diagram

A Free Body Diagram (FBD) is a diagram that maps all of the forces that are applied to a single object.

2.2 Newton's 2nd and 3rd Laws of Motion

2.2.1 Newton's 2nd Law of Motion

- The acceleration of an object is in the direction of and directly proportional to the the net force applied, and inversely proportional to the object's mass.
- Valid only in *inertial reference frames*.

$$F_{net} = \sum F = ma$$

2.2.2 Mass vs. Weight

- Mass is the amount of stuff that something is made up of (independent of gravity)
- Weight is the force of gravity on an object. (dependent on gravity)

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