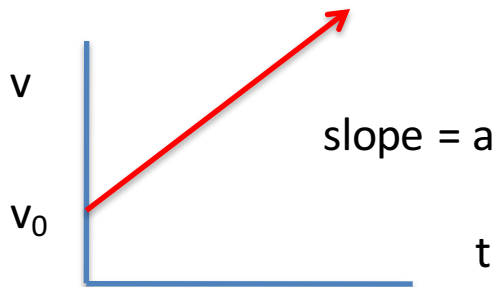


Kinematics

Formulas for Constant Acceleration

Deriving the Kinematics Formulas

- For constant acceleration, the slope on a v vs. t graph is constant.



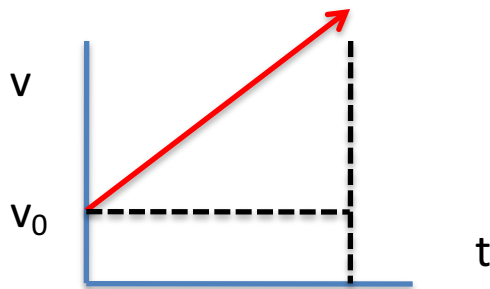
$$y = mx + b$$

$$y = at + v_0$$

Rearranging:

$$v = at + v_0$$

- Area under curve = displacement



$x =$ area of rectangle + area of triangle

$$x = v_0t + \frac{1}{2}(t)(v - v_0)$$

multiply last term by t/t & plug in for a :

$$x = \frac{1}{2}at^2 + v_0t + x_0$$

- Solve for t in the first equation, and plug into the second equation to get an equation with no time in it.

$$v^2 - v_0^2 = 2a(x - x_0)$$

Formulas for Constant Acceleration

1. $v = at + v_0$

2. $s - s_0 = \bar{v}t = \left(\frac{v+v_0}{2}\right)t$

3. $s = \frac{1}{2}at^2 + v_0t + s_0$

4. $v^2 - v_0^2 = 2a(s - s_0)$

Notes:

1. If time is not involved in the problem, use equation 4.
2. If time is involved in the problem as a given value or as the unknown, use equation 1 or 3.

Ex1: A truck comes to rest over a distance of 120 m. If it slowed down at a rate of 2.4 m/s^2 , how fast was it going initially?

Ex2: A car accelerates from 10 m/s to 25 m/s in 6 s. How far does it travel?

Ex3: A boat is initially 81 m from a dock. Starting from rest, it accelerates towards the dock for 12 s. If its final position is 25 m from the dock, solve for its acceleration.

Ex4: A ball starts from rest and rolls down a hill. It travels 9 m in 7 seconds. How far does it travel in 14 seconds?

Ex5: A car traveling at 20 m/s slams on its breaks and skids 40 m. What would be the stopping distance if it were traveling at 50 m/s?

One Dimensional Motion: Recipe

1. Draw a cartoon with the coordinate axis at ground level.
 2. Label the diagram with the given information.
 3. Pick the proper equation and solve!
- **Free-fall: In the air, no friction, no parachutes. On earth, $a = -10 \text{ m/s}^2$.**
 - **The acceleration is always (-) because gravity *always* pulls down.**

Example: Brad throws an orange straight up at 60 m/s.

- a) Find the total time airborne

- b) Find the time to the apex

- c) Find the location at the zenith

- d) Find the velocity with which it hits the ground

- e) Find the time at which the speed is 20 m/s

Intuitions for Free Fall

- Any object in the air whose motion is influenced only by gravity, $a = -10 \text{ m/s}^2$.
- -10 m/s^2 tells us that the velocity is changing in chunks of -10 m/s each second.
- If the object has initial upward velocity, gravity will take some time to stop the object and then give it negative velocity as it returns to earth.
- The position of the object is not as straightforward as the velocity.
- If an object is dropped from rest, the distance fallen each second is proportional to the odd numbers. Therefore, the total distance fallen is proportional to the sum of the odd integers.
- Note: Equation 3 is quadratic ($y = at^2 + \dots$)
- Warning: **Please do not** use $\text{distance} = (\text{rate})(\text{time})$.
- Use equations 2 or 3.