Name:______________________________________ Pd._____

# 2016-17 AP Physics: Kinematics Study Guide

*The study guide will help you review all chapter concepts as well as prepare you for AP style test questions.*

## The Basics:

- Motion
  - Uniform
    - Constant acceleration
  - Non-Uniform
    - Changing acceleration
- Kinematic Variables:
  - Scalars: (only have magnitude)
    - Time
    - Speed
    - Distance
  - Vectors: (have magnitude and direction)
    - Displacement
      - $\Delta x$
      - Remember, position (can be x or y) is measuring the location with respect to an origin.
    - Velocity
      - $v = \frac{\Delta x}{t}$
    - Acceleration
      - $a = \frac{\Delta v}{t}$

**REMEMBER!!!**

Δ (Delta)

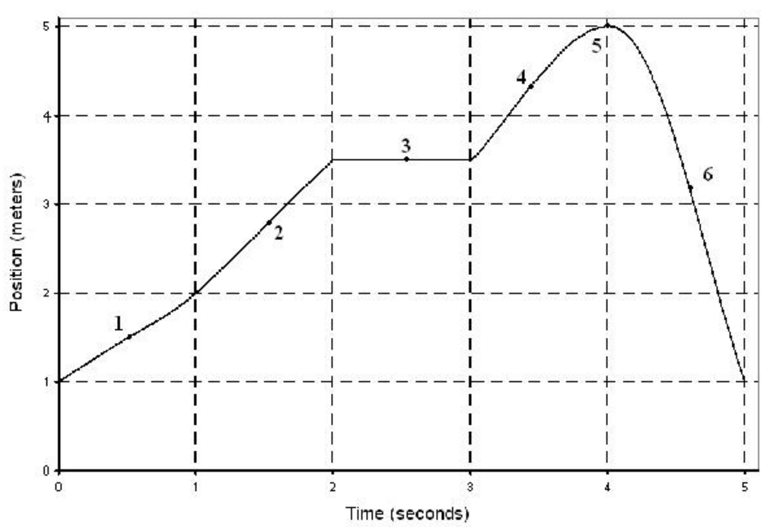
Delta means "the change in ___."
The variable after the delta is what we are finding the change in.

LIKE THIS:

$Change\ in\ Position \rightarrow \Delta x = x_f - x_i$

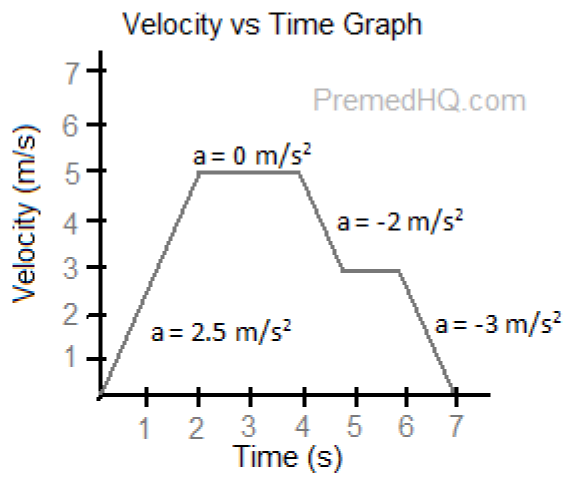
The change in a variable is always the final minus the initial.

- **Motion Graphs**
  - Position vs. Time Graphs




    - Staying still = any horizontal line
    - Constant velocity = any straight line with a non-zero slope
      - To find velocity, find the slope of the line
    - Acceleration = curved line

- Velocity vs. Time Graphs




  - Constant velocity = any horizontal line
  - Accelerated motion = any straight line with a non-zero slope
    - To find acceleration, find the slope of the line
  - Distance covered = area under the line
    - Displacement = adding the total area KEEPING negative area in mind
  - *NOT REQUIRED Any curved line on a V vs T graph is a change in acceleration (Jerk)*

- ## Our Kinematic Equations

  - $v_f = v_i + at$
  - $x_f = x_i + v_i t + \frac{1}{2}at^2$
  - $v_f^2 = v_i^2 + 2ad$
  - $\Delta x = \frac{1}{2}(v_i + v_f)t$

- As the AP Test will give you:

$$v_x = v_{x0} + a_x t$$

$$x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2$$

$$v_x^2 = v_{x0}^2 + 2a_x(x - x_0)$$

**SUB NOTATIONS!!!**

We use sub notations to distinguish from different variables with the same letter.

You can see in Grant AP Physics, we use the sub notations with "i" and "f." These stand for initial and final respectively.

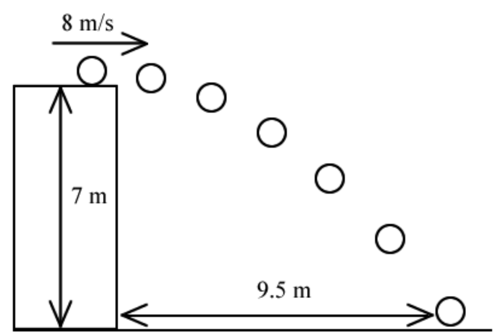
However, the AP Test will use a sub notation such as "0." This stands for initial, and there is no sub notation for final.

We both use sub notations like "x" and "y," occasionally, to distinguish in which direction our variable is.

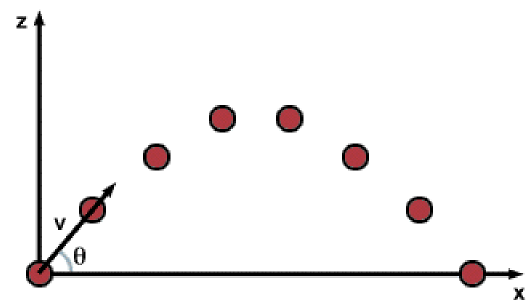
- ## Projectile Motion

  - Free fall
    - Any object in free fall is only being acted on by gravity
    - If it is dropped from rest, use:
      - $t = \sqrt{\frac{2h}{9.8}}$
    - If it is thrown up and returns to its original height, use:
      - $t = \frac{2v_{iy}}{9.8}$

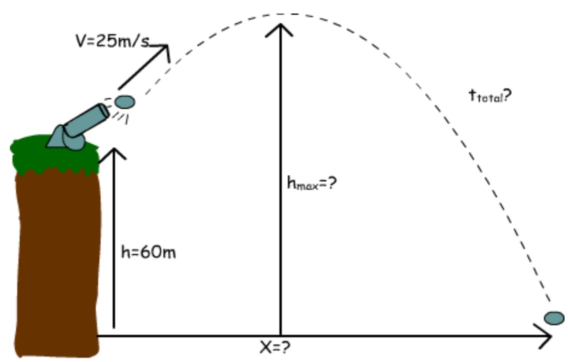
- Type 1 (Horizontal projectiles)
  - Launched with a 0 degree angle.
  - Vertical motion depends on gravity ($9.8 m/s^2$) and initial height (find t like finding an object dropped from rest)
    - $t = \sqrt{\frac{2h}{9.8}}$
  - Horizontal motion depends on BOTH velocity in the x direction, and time of flight
    - $\Delta x = v_x t$




- Type 2 (Horizontal and vertical components)
  - Vertical motion depends on gravity, initial height, AND initial velocity. (find time like you would find an object thrown up and returns to its original height)
    - $t = \frac{2v_{iy}}{9.8}$
  - Horizontal motion depends ONLY on horizontal velocity and time
    - $\Delta x = v_x t$




- Type 3 ($y_i \neq y_f$)
  - Same as a type 2 projectile except the final height is not the same as the initial height
  - Find t by:
    - $\Delta y = v_{iy} t + \frac{1}{2} a_y t^2$
  - Find x by:
    - $\Delta x = v_x t$




**REMEMBER!!!!**

The **quadratic equation** must be used to solve for variables in second degree polynomials! It goes like this:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

For functions that look like this:

$$0 = ax^2 + bx + c$$

For Physics it looks like this:

(now we solve for t instead of x) $0 = \frac{1}{2}(a)t^2 + v_i t + (-\Delta x)$

## Review Questions:

1. An object is sitting motionless for days on end, what is its acceleration?

2. An object is falling down without air friction, what is its acceleration?

3. An object is being tossed upward without air friction, what is the acceleration?

4. An object is moving in a circle at a constant speed. Does it have an acceleration?

5. If you walk 5 meters forward, and then 7 meters backwards, what is the distance you traveled? What is your displacement?

6. A train moves to the right at 30 m/s for 5 minutes, then it moves to the left at 30 m/s for 5 minutes. What is the average speed? What is the average velocity?

7. If an object is being accelerated at a rate of 6 $m/s^2$ for 15 seconds, how much does the velocity increase between 11 and 12 seconds?

8. If a ball is thrown in the air with an initial velocity of 25 m/s, how high does the ball get?

    a. How is the height affected when the initial velocity is cut in half?

    b. …if initial velocity doubles?

9. A hotwheels car rolls off of a lab table 0.92m high. It hits the ground about 2m away from the edge of the table.
    a. How long was the car in the air?

    b. What was the car's initial velocity?

10. An object slows from 100 m/s to 90 m/s while covering a distance of 50 m. How many seconds does this take?

11. An object moves from 20 m to 100 m while accelerating from 5 m/s to 8 m/s. How long does this take?

12. A train is moving according to the equation $X = 3t^2 + 5t - 9$. A bus moves according to the equation $X = -2t^2 + 4t + 10$.

    a. What is the initial location of the train?

    b. What is the initial location of the bus?

    c. What is the initial velocity of the bus?

    d. What is the initial velocity of the train?

    e. Which way is the bus moving?

    f. Which way is the train moving?

    g. What is the acceleration of the bus?

    h. What is the acceleration of the train?

    i. Is the train speeding up or slowing?

    j. Is the bus speeding up or slowing?

    k. When does the train pass the bus?

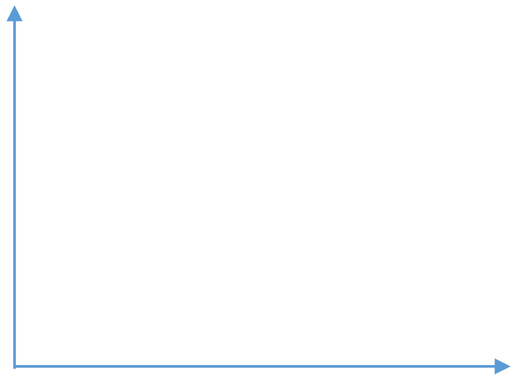
13. An object is thrown upward, from ground level, with an initial speed of 60 m/s. At the same time (t=0) a second object is thrown downward with an initial speed of 15 m/s at a height of 75 m from the ground. At what height do the objects pass each other?

14. Draw a particle model for the motion of an object with a constant speed.

15. Draw a particle model for the motion of an object with a slower constant speed than in #14.

16. Draw a particle model for the motion of an object speeding up then slowing down.

17. Draw a position vs time graph for an object that object that starts at rest 5m in front of a motion detector. After 1 second, the object moves at a constant velocity towards the detector. At 3 seconds, when the object is 1 m away, the object stops moving towards the detector and immediately accelerates away from it.

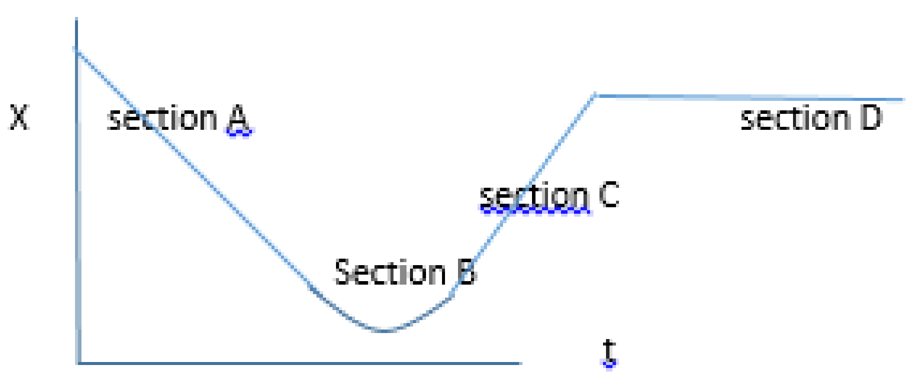


18. A ball is thrown straight up into the air. Write an expression for the time it takes the ball to get to the half-way point (half the time of flight). Write an expression for the final velocity of the ball at any given time.

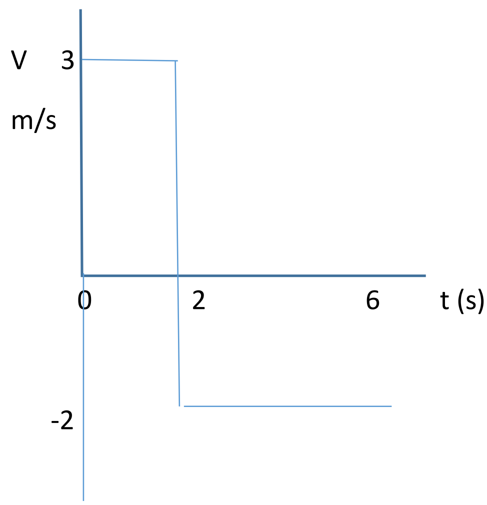
19. The equation for range of a projectile where $y_f$=$y_i$ is $R = \frac{v_i^2}{g} sin2\theta$. A cannon always launches the ball with the same initial velocity. Besides 36° what other angle would allow the cannoneers to shoot the same distance?

20. A football is kicked at an angle and travels 50 yards down field and attains a height of 30 yards. A soccer ball is kicked at an angle and travels 40 yards down field and attains a height of 45 yards. Which was in the air longer?

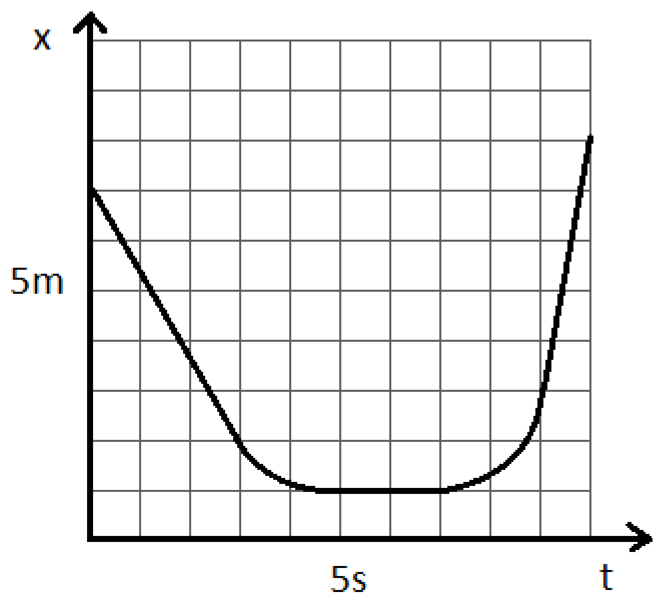
21. Look at the graph below. How would you describe the motion in section A? in section B? in section C? Section D?

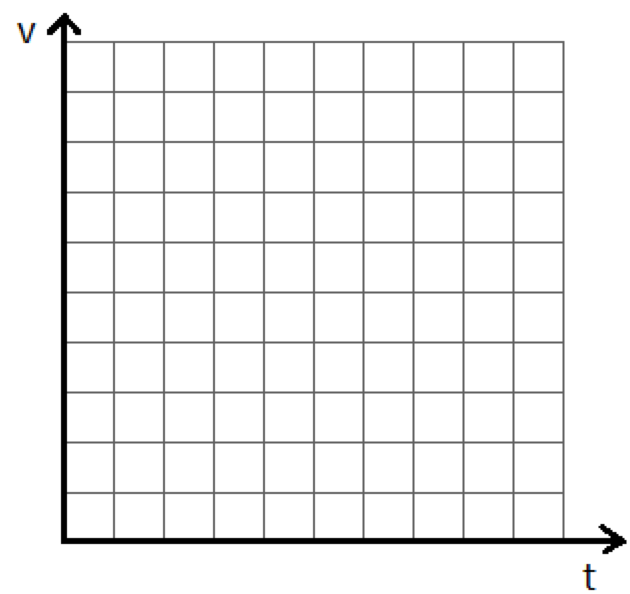


22. Find the total displacement of the object graphed below:




23. Using the following position vs. time graph. Create a velocity vs. time graph.




a. Find the acceleration from 7 to 9 s.

b. Find The total distance traveled and the total displacement from t=0 to t=10.

c. Which direction is the average acceleration for the entire duration of the motion?

24. A bouncy ball is thrown at a wall with a speed of 15 m/s. It bounces straight back from the wall with a speed of 10 m/s. The bouncy ball was in contact with the wall for 0.05 s.

a. What was the change in velocity of the bouncy ball?

b. Find the acceleration of the bouncy ball during the interaction with the wall.

c. If the ball hit an interesting bump on the wall, and took off with an angle of $10^0$ to the horizontal and bounced 3 meters high on the wall, how far would the ball go before hitting the ground? Assume air resistance is negligible.