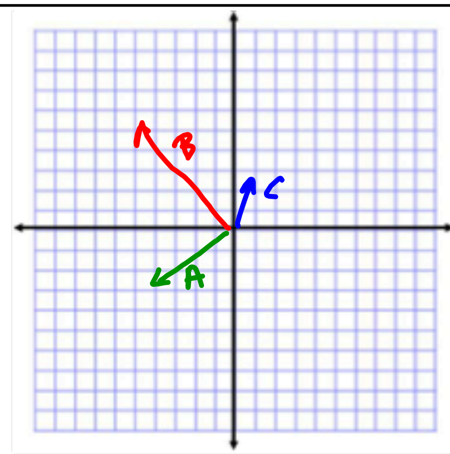
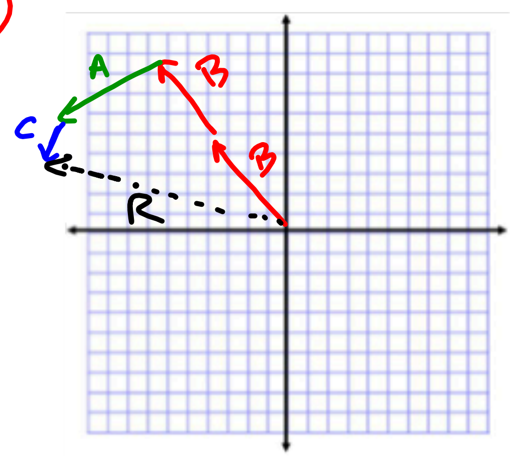
Warm-Up: September 21st



- Given vectors:
  - A (4.00, 217°) → (-3.2, -2.4)
  - B (7.80, 126°) → (-4.6, 6.3)
  - C (2.78, 62.0°) → (1.31, 2.45)

  - Give the magnitude and direction of the resultant of 2B + A - C

(-13.7, 7.76)
↓
(15.71, 150.4°)



$$R_x = 2(B_x) + A_x - C_x = -13.7$$

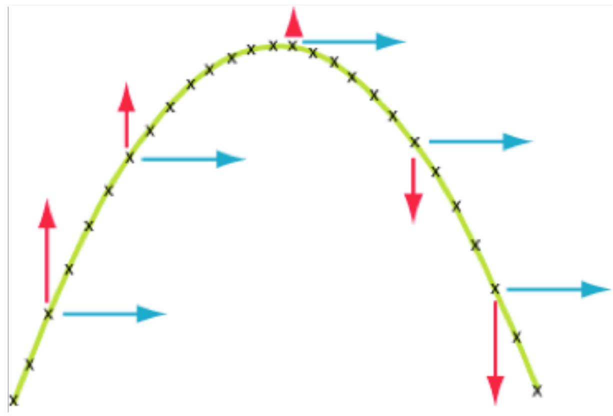
$$R_y = 2(B_y) + A_y - C_y = 7.76$$

Projectile Motion

- This is the motion or trajectory of a object in which the **only acceleration present is the acceleration of gravity.**
  - Curved motion is accomplished by:
    - Motion in the x-direction

      combined with…
    - Motion in the y-direction

Kinematics in TWO Dimensions



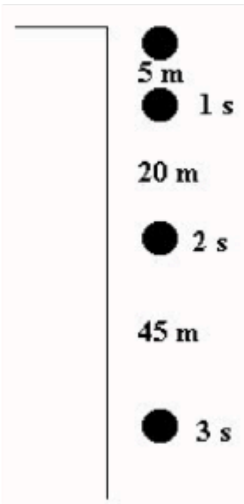
- A projectile moves in 2-dimensions
- Which means it has 2 components and a resultant vector
- **Horizontal and Vertical Components**

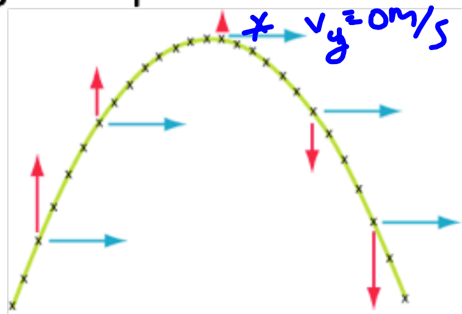
x- and y- components

- If gravity is the only acceleration...it affects motion...
  Vertical

- Acceleration changes the velocity of an object

- Changes in vertical velocity are due to the acceleration of gravity. Both the magnitude and direction of the velocity are changed. *Change is exponential





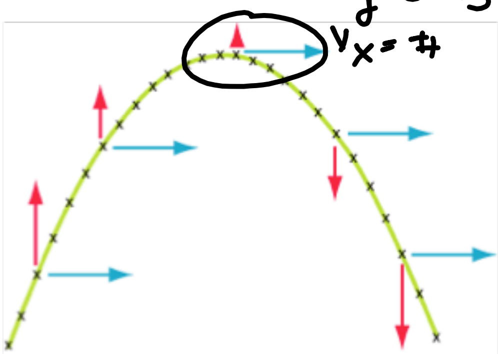
On the way up:
Magnitude: slowing down / decreasing
Direction: Upwards

On the way down:
Magnitude: increasing / getting faster
Direction: downwards

Horizontal Velocity Component

- Gravity does not affect horizontal motion.
- Therefore, the x-component of the velocity **NEVER** changes, covers equal displacements in equal time periods.

$V_y = 0\,m/s$
$V_x = \#$



In other words, the horizontal velocity is CONSTANT.

Projectile Motion - Kinematics

- Separate kinematics can be used...

Kinematic Formulas
For x-components

$$\underbrace{v_x = v_{ox}}\ \cancel{+a_x t}$$

$$x = \frac{1}{2}(v_x + v_{ox})t$$

$x = \frac{1}{2}(v_x + v_x)t$

$x = \frac{1}{2}(2v_x)\cdot t$

$x = v_x \cdot t$

$v = \frac{\Delta x}{\Delta t}$

$x = v \cdot t$

$$x = v_{ox}t + \cancel{\frac{1}{2}a_x t^2}$$

$x = v_x \cdot t$

$$v_x^2 = v_{ox}^2 \cancel{+2a_x x}$$

Kinematic Formulas
For y-components

$$v_y = v_{oy} + a_y t$$

$$y = \frac{1}{2}(v_y + v_{oy})t$$

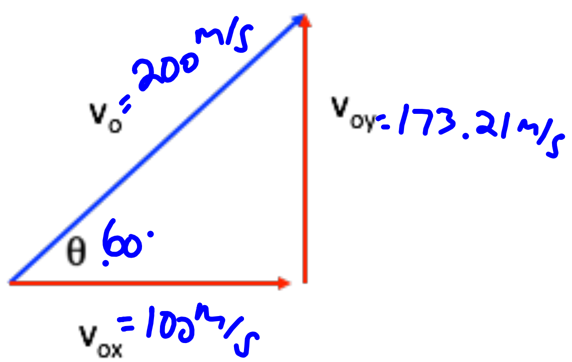
$$y = v_{oy}t + \frac{1}{2}a_y t^2$$

$$v_y^2 = v_{oy}^2 + 2a_y y$$

- *ONLY acceleration gravity. (a_y = -9.8 m/s²)
- *Therefore, $a_x = 0$ m/s²
- *x-velocity is constant, $v_x = v_{ox}$

Full Projectiles

Since the projectile was launched at a angle, the velocity MUST be broken into components

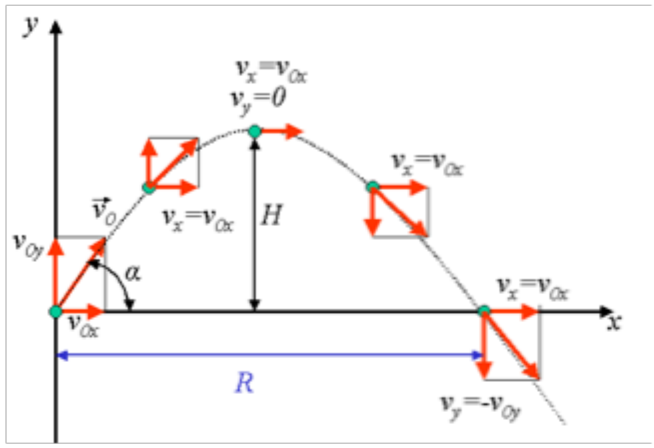


$$v_{ox} = v_o \cos\theta =$$

$$v_{oy} = v_o \sin\theta$$

Full Projectiles

- Set y = 0 m where the motion begins

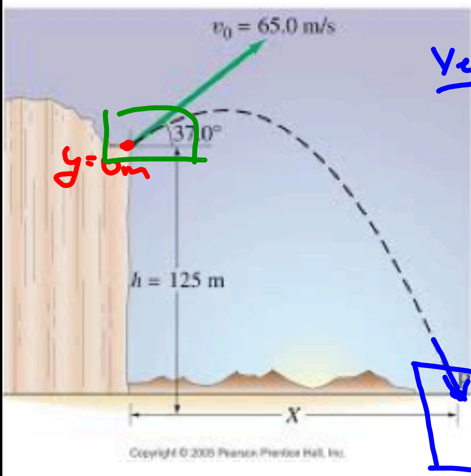


- If it begins and ends at ground level, the "y" displacement is ZERO: y = 0 m

Example 6

A projectile is shot from the edge of a cliff 125 m above ground level with an initial velocity of 65.0 m/s at an angle of 37.0° with respect to the horizontal. Find the following:

- A. How much time does it take the projectile to reach the bottom (point P)?
- B. What is the horizontal range (x) of the projectile?
- C. What are the horizontal and vertical components of the final velocity at point P?
- D. What is the magnitude and angle of this final velocity?



Final Velocity

$V_x = 51.91$ m/s

θ

$V_y = -63.1$ m/s

(51.91, -63.1)

→ (81.7, -50.55)

$V_y = ?$

$V_{oy} = 39.12$ m/s

$a_y = -9.8$ m/s²

$t = 10.43$ s

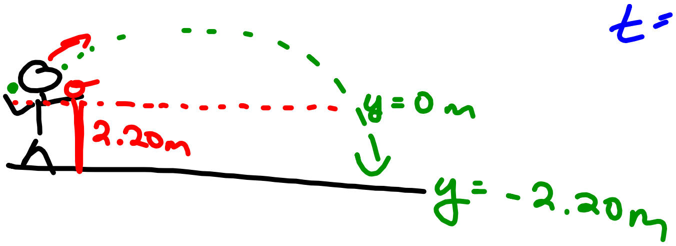
$V_y = V_{oy} + a_y t$

$V_y = 39.12 + (-9.8)(10.43)$

$V_y = -63.1$ m/s

Example 7

A shotputter throws the shot with a initial speed of 15.5 m/s at an angle of 34.0° with respect to the horizontal. Calculate the horizontal distance traveled by the shot if it leaves the athlete's hand 2.20 m above the ground.



$t = 1.99\ s$

$x = 25.7\ m$

Example 8 and 9

Example 8:

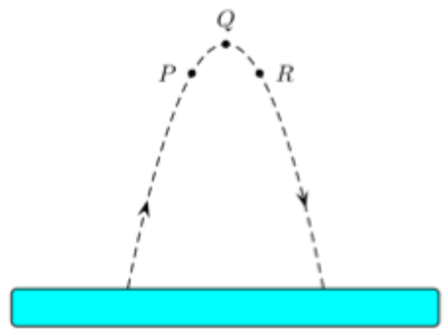
A ball is thrown and follows the parabolic path shown. Air resistance is negligible. Point Q is the highest point of the path. P and R are both the same height above the ground. How do the speeds of the projectile compare?

A. $v_P < v_Q < v_R$

B. $v_R < v_Q < v_P$

C. $v_Q < v_R < v_P$

D. $v_Q < v_P = v_R$



Example 9:

Which arrow best describes the acceleration of the projectile at point P?

A. ➔

B. ↗

C. ↑

D. ↓

E. ↘

Example 10

The diagram below shows four cannons firing shells with different masses at different angles of elevation. The horizontal component of the shell's velocity is the same in all four cases. In which case will the shell have the **greatest range** if air resistance is neglected?

A. Cannon A

B. Cannon B and C

C. Cannon D

D. All will be equal in range

$X = V_x \cdot t$

$y = V_{oy} t + 1/2 a t^2$

$0 = V_{oy} t - 4.9 t^2$

$0 = (V_{oy} - 4.9 t)$

$t =$