Physics 2A: Lecture 3
Today's Agenda

- Kinematics in 2-D
  - Quick Recap of last lecture
  - Position
  - Velocity
  - Acceleration
- Special case: Constant acceleration in 2-D
  - Constant acceleration equations
  - Examples: Projectile motion

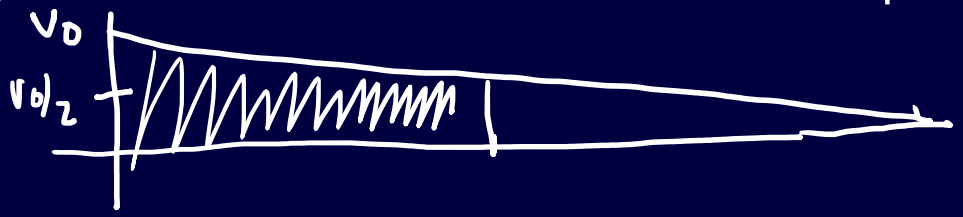
Clicker Question 0.1:

A car decelerates constantly from an initial velocity to a complete stop. As it does this it covers a total distance D. When the velocity of the car has decreased to half its initial velocity the remaining distance is

(a) greater than half the total distance D required to stop.
(b) half the total distance D required to stop.
(c) less than half the total distance D required to stop.

$v_0 = 50$ mph

$\frac{v_1}{2} = 25$ mph

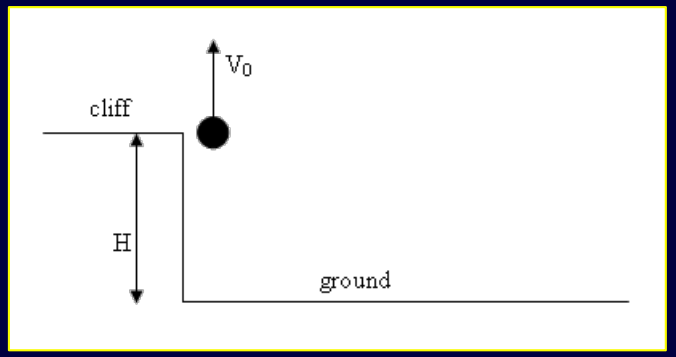


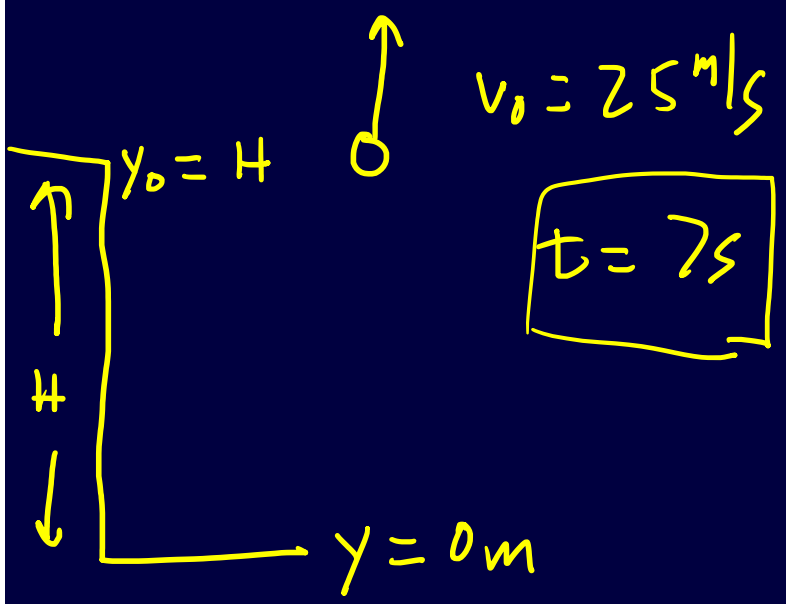
Clicker Question 0.2:

At t = 0 a ball is thrown straight upward from the edge of a cliff with initial velocity V_0 = 25 m/s. It lands on the ground at the base of the cliff 7 seconds later.

What is the height *H* of the cliff?

(a) *H* = 46 m
(b) *H* = 53 m
(c) *H* = 65 m
(d) *H* = 76 m
(e) *H* = 82 m





$$y_F = y_0 + v_0 t + \frac{1}{2} a t^2$$

$$y_F = H + 25\ m/s\ t - \frac{1}{2} g t^2$$

$$0 = H + 25\ m/s\,(7s) - \frac{1}{2} g (7s)^2$$

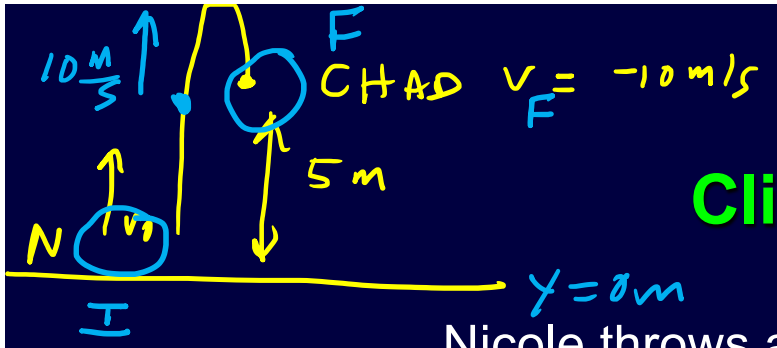
$$\frac{1}{2} g (7s)^2 - 25 \frac{m}{s} 7s = H = 65m$$

$y_0 = H$

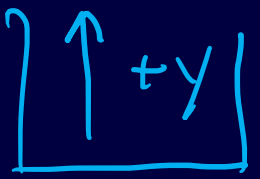
$y_F = 0\ m$

$v_0 = +25\ m/s$

$a = -9.81\ m/s^2$



time ?



$\Delta y = y_F - y_0 = 5m - 0m = 5m$

Clicker Question 0.3:

Nicole throws a ball straight up. Chad watches the ball from a window 5.0 m above where Nicole released it. The ball passes Chad on the way up, and it has a speed of 10m/s as it passes him on the way back down.

How fast did Nicole throw the ball?

(a) 14 m/s
(b) 22 m/s
(c) 10 m/s
(d) 17 m/s
(e) 26 m/s

$y_0 = 0m$

$y_F = 5m$

$v_0 = ?$

$a = -g$

$-9.81 \, m/s^2$

$v_F^2 = v_0^2 + 2a\Delta y$

$v_0^2 = v_F^2 - 2a\Delta y$

$v_0^2 = (-10 \, m/s)^2 - 2(-g)[5m]$

$v_0 = \pm 14 \, m/s$

Clicker Question 1

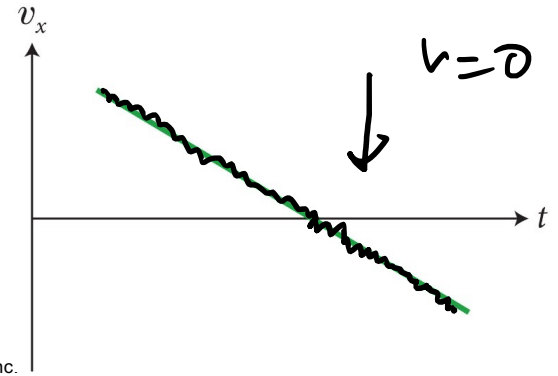
Based on the $v(t)$ curve in the figure, which of the following statements is necessarily true for the time interval shown?

A. Acceleration is a constant.

B. The object passes through the position $x = 0$.

C. The object's velocity is never zero.

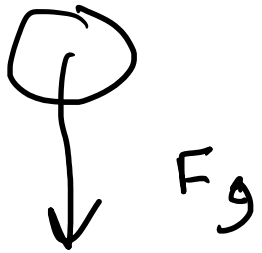
D. The object is always moving in the same direction.



Clicker Question 2

A ball is thrown downward (not dropped) from the top of a tower. After being released, its downward acceleration will be

A. greater than g.
B. exactly g.
C. smaller than g.

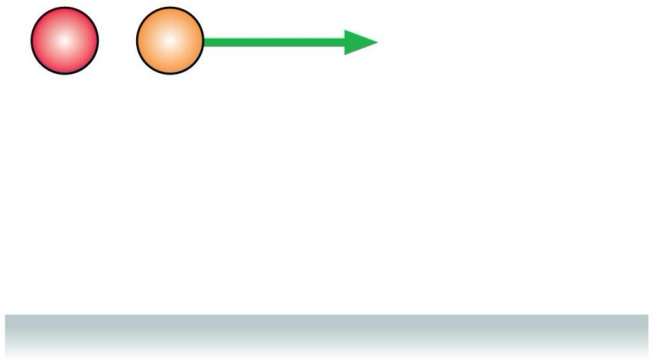


Student Comments

- Correct: The vertical acceleration will not change due to initial velocity.
- Correct: If the ball is thrown, the downward acceleration will be exactly g. The throw force will not affect acceleration (after its released), only giving the ball initial velocity.
- Incorrect: The force would be greater than g because although the force of gravity is acting on the ball, there's also the additional force with which the ball was thrown which will cause the ball to fall at a rate faster than that of just gravity.

Clicker Question 3:

A heavy red ball is released from rest 2.0 m above a flat, horizontal surface. At exactly the same instant, a yellow ball with the same mass is fired horizontally at 3.0 m/s. Which ball hits the ground first?



A. The red ball hits first.

B. The yellow ball hits first.

C. They hit at the same time.

Student Comments

- Correct: We need to look at the y component of the ball and not the x component. When we look at the y component, both initial velocities are at 0 and this means they will land int the same time.
- Correct: Horizontal velocity has nothing to do with the vertical velocity. Therefore by these rules the balls will hit at the same time as they have the same acceleration and starting velocity at the start.
- Correct: Since they are starting in the same position in both x and y directions, on the second ball the initial speed in the x direction is 3 m/s and has only an acceleration due to gravity in the negative y direction. If we define the starting point for both balls as 0m and the final position -2m, we can use the kinematic equation for finding final position to solve for the time it takes the ball to reach the ground. When we calculate this we come out with ~0.6386s for the ball being fired at 3m/s. And we will use the same equation for the ball in free fall to calculate this and we get the same time of ~0.6386s.
- Incorrect: since the velocity of the red ball is less than the yellow ball, it in theory should start losing speed sooner, and drop faster
- Incorrect: Even though both balls have equal masses, since the red ball is only moving in the y-direction I figured it would hit the ground first because the yellow ball has to move in both the x and y directions before falling to the ground.

Motion in a plane with constant acceleration

2-D model

- We can treat each direction as if the other did not exist. So basically we have 2 1-D cases.

- Demos

Where to get help

- Lectures (podcast posted the afternoon of each lecture)
- Discussions (LAs will offer extra sections if requested)
- Office hours
  - Andrew: Tuesday and Thursday from 2-3pm
  - Wanda: Wednesday and Thursday 4-5pm
  - Raj: Wednesday and Friday 9-10am
  - Sharath: Wednesday and Thursday 10-11am
- Supplemental Instruction
  - Erica Yang
  - Wednesdays and Thurdays 11-12:20
  - https://ucsd.zoom.us/j/92155353023
- PIAZZA

To Do This Week

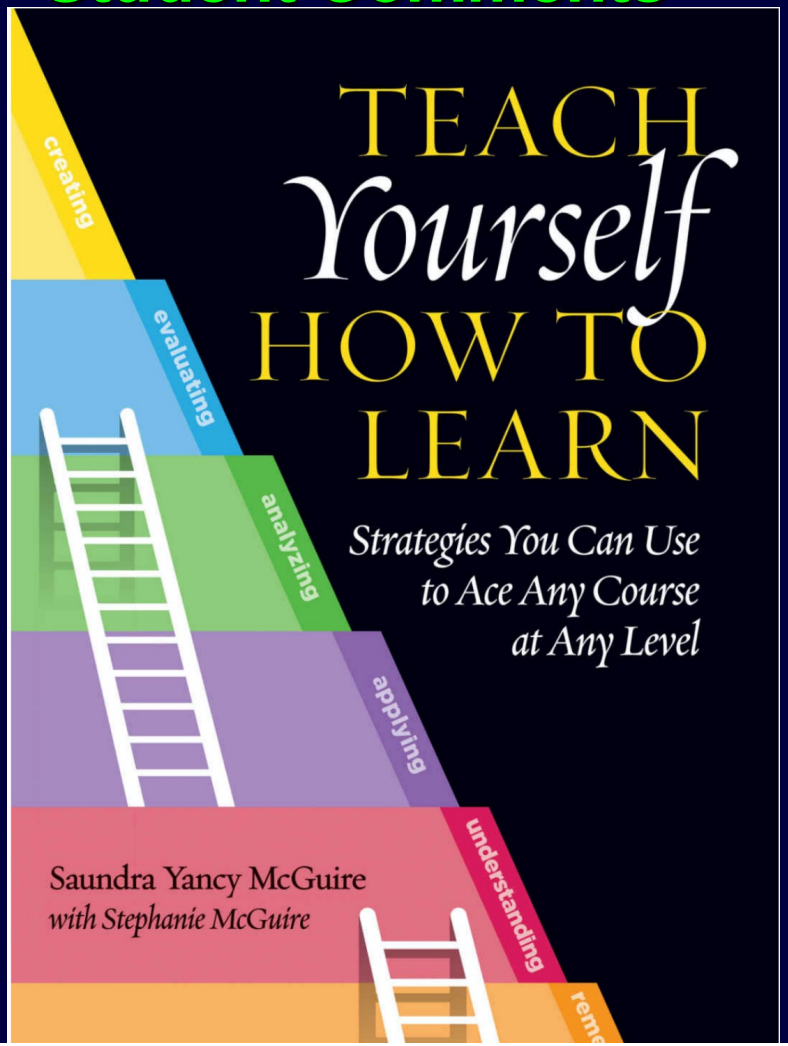
- PCQ for Tuesday class due 8am Tuesday morning
- Pre-Course Assessment test due Wednesday at 11:59 (found on assignments in canvas)
- Integrity Pledge (upload signed pdf to gradescope)
- Set-up Mastering physics (first assignment due Friday at midnight)

Student Comments

- What are some resources that we could use to help us practice?
- I have a hard time knowing how to apply each equation, I get stuck for a long time trying to work out which one to use
- I feel like everyone else knows what is going on and I feel like I don't

- Andrew's Tip: Try to practice everyday (2 hrs/day)
- Andrew's Tip: Practice doing problems under test-like situations
- Andrew's Tip: If there's something you don't get, get help!
- Andrew's Tip: Sleep helps to organize information into LTM, super important especially on exam day
- Andrew's Tip: Helps to mix it up, Physics then Bio

Student Comments

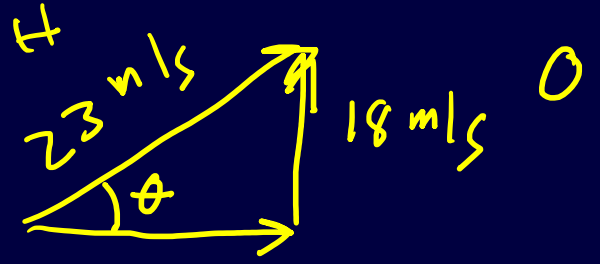


The ability to do physics comes from practice, repetition, and struggling with the ideas until you “own” them and apply them yourself in new situations

No one is born knowing physics

Constant acceleration in 2-D

- x-direction
  - $x = x_0 + v_{0x}t + \frac{1}{2} a_x t^2$
  - $v_x = v_{0x} + a_x t$
  - $v_x^2 = v_{0x}^2 + 2a_x(\Delta x)$
- y-direction
  - $y = y_0 + v_{0y}t + \frac{1}{2} a_y t^2$
  - $v_y = v_{0y} + a_y t$
  - $v_y^2 = v_{0y}^2 + 2a_y(\Delta y)$



$23\frac{m}{s}\cos 52 = 0$

$\sin\theta = \frac{O}{H}$

$\theta = \sin^{-1}\left[\frac{O}{H}\right]$

$= \sin^{-1}\left[\frac{18}{23}\right]$

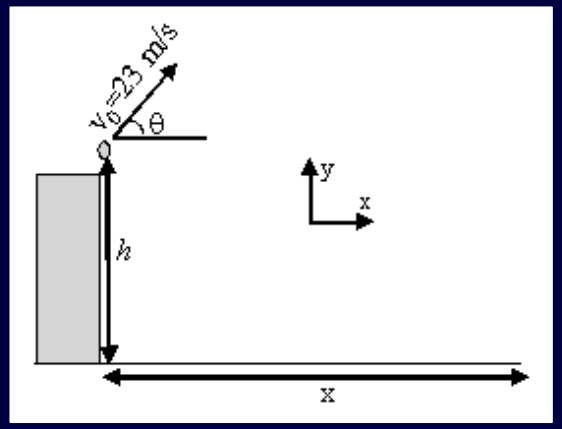
$= 52°$

Clicker Question 4:

A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

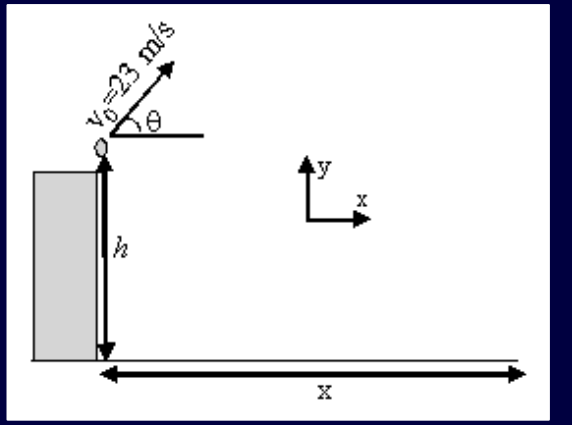
(a) What angle did the student throw the ball?

(a) $\theta = 24°$
(b) $\theta = 37°$
(c) $\theta = 52°$.



A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

What angle did the student throw the ball?



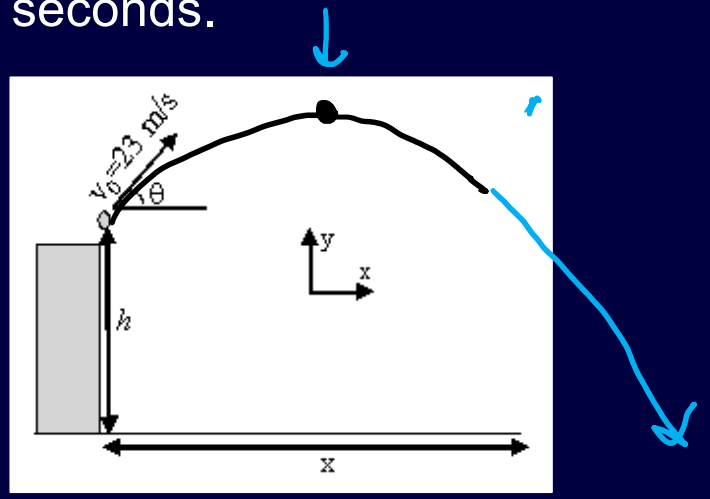
Clicker Question 5:

A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

$V_y = 0$

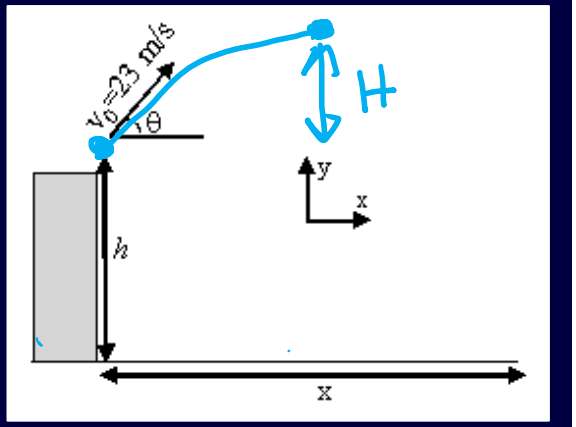
(B) How long does it take for the ball to reach its maximum height?

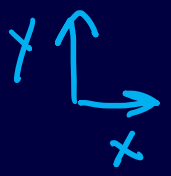
(a) 1.8 s
(b) 2.3 s
(c) 3.1 s



A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

How long does it take for the ball to reach its maximum height?





$v_y = 0$

$x_0 = 0$

$y_0 = h$

$v_{0x} = 23\ m/s \cdot \cos 52 = 14.2\ m/s$

$v_{0y} = 18\ m/s$

$a_x = 0$

$a_y = -9.81\ m/s^2 = -g$

(1) $y_F = y_0 + v_{0y} t - \frac{1}{2} g t^2$

$y_F = h + 18\ m/s\ t - \frac{1}{2} g t^2$

(2) $v_y = v_{iy} + a t$

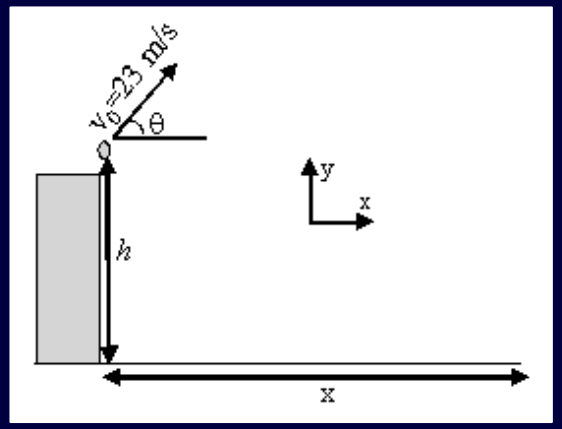
$0 = 18\ m/s - g t$

$t = \frac{18\ m/s}{g} = 1.83\ s$

Clicker Question 6:

A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

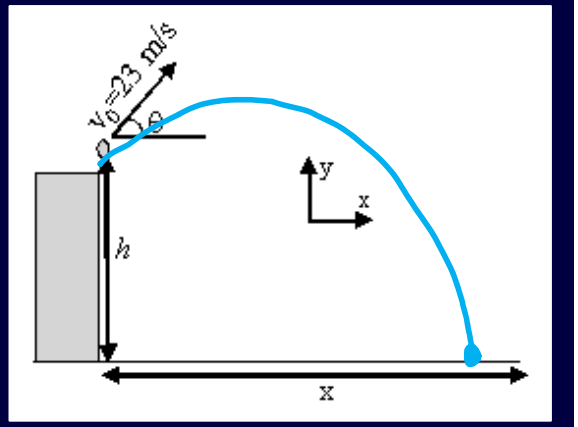
(c) What height *h* was the ball thrown from?



(a) 9.1 m
(b) 10.8 m
(c) 13.1 m

A student throws a ball off a cliff. When the ball leaves the student's hand it is traveling with a speed of 23 m/s, and the vertical component of the balls velocity is 18 m/s. The ball hits the ground after 4.2 seconds.

What height *h* was the ball thrown from?



$t = 4.2\,s$

$y_f = 0m$

$y = h + 18\,m/s\,t - \frac{1}{2}gt^2$

$0 = h + 18\,m/s\,(4.2s) - \frac{1}{2}g(4.2s)^2$

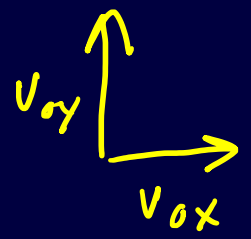
$h = \frac{1}{2}g(4.2s)^2 - 18\,m/s\,(4.2s) = 10.8m$

Clicker Question 7:

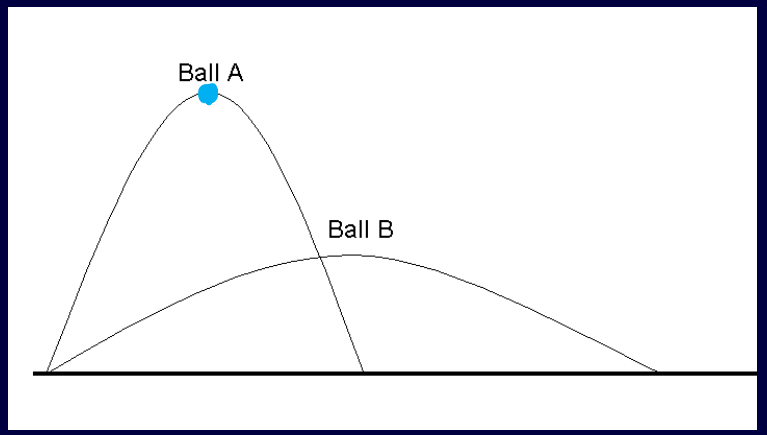
$v_f^2 = v_{oy}^2 - 2g\Delta y$

$0 = v_{oy}^2 - 2g\Delta y$

$\uparrow \Delta y = \frac{v_{oy}^2}{2g} \uparrow$



Two balls are launched at the same time. The balls follow the paths below. Which ball is in the air the longest?



$v_{fy} = v_{oy} - gt$

$0 = v_{oy} - gt$

$\uparrow t = \frac{v_{oy}}{g} \uparrow$

(A) Ball A

(B) Ball B

(C) They are in the air the same amount of time

(D) Not enough information