## The pace of learning

- When you first start problem solving (or any skill), you are likely to start out pretty slowly and focus on your approach and accuracy.
- I (and probably many of you) could go through these questions a lot more quickly, but my job is to teach approaches that make it easier to understand. That is a slower process.
- It is the same reason why I do one step of algebra at a time. (Faster will be confusing to some.)
- Drawing a picture might help you prevent mistakes.
- Only practice helps with speed and accuracy. Not my practice (I could go fast), but yours.

## Common Mistakes in Projectile Motion

- Forgetting the Chapter 2 formulas apply when acceleration is constant (so after object is launch and before it hits something else)
- Mixing up the x and y component information in Chapter 2 formulas
- Forgetting to split up the initial velocity if it's not horizontal
- If the initial velocity is horizontal, forgetting that means that  $v_{oy} = 0$
- If something reaches its max height, then  $v_{fy} = 0$

Midterm Review Sessions Monday, September 23

4pm in G09 (the floor below your labs) Prof. Ybarra

7pm in this room (B51) Prof. Holcomb

### Problem Solving Day

I've prepared projectile motion stuff, but I'm happy to talk about any other problem solving too or questions about the upcoming test.



# The Long Jump

A long jumper leaves the ground at an angle of 20 degrees to the horizontal at a speed of 11 m/s.

- (a) How long does it take for him to reach maximum height?
- (b) What is the maximum height?
- (c) How far does he jump? (Is this the same setup as for parts a and b?)

# At an altitude of 1000 m, you drop something from a plane traveling at 60 m/s.



- How long does it take to reach the ground?
- Horizontally, how far is the object displaced from the position the plane was above when the object was dropped?

### Sighting a rifle

A rifle is sighted at a specific distance and won't work perfectly if you change the shooting range significantly. Let's consider why.



## Physics for Pilots

An airplane is approaching a runway. The pilot measures her horizontal speed to be 400 mph. The altimeter indicates that the plane is dropping at a constant speed of 10 feet/s. If the plane is at a height of 3000 feet and the start of the runway is 28 miles away (horizontally), does the pilot need to make any adjustments to her descent?



Similar strategy to homework, but not projectile motion (this case a<sub>v</sub>=0)



#### Physics Cannon Demo

https://www.youtube.com/watch?v=TbWiMsfr DQ

# <u>Common Strategy for Projectile</u> <u>Motion Problems</u>

Find how far something moves vertically in free fall as it goes horizontally a distance x

The time will be the same for x and y parts of the question.



#### Throwing something off of a cliff One step problem, at an angle Two steps

I throw a ball off the edge of a 15 m tall cliff. I threw it at 16 m/s at an angle of 60 degrees from the horizontal.

A. Determine how much time it takes to fall to cliff bottom.
B. Determine how far from the base of the cliff it hits the ground. (Need the time first)

C. Determine how fast it is moving vertically when it hits the ground. (y component of final velocity, easiest one this time!)
D. Determine what its magnitude of velocity is just before it hits the ground.

**E. Determine** the angle that it hits the ground from the horizontal.

#### Two ways to do this. One less obvious but easier mathematically. Part A: Time to Fall (Think Vertical)

I throw a ball off the edge of a 15.0m tall cliff. I threw it at 16 m/s at an angle of 60 degrees from the horizontal.

As we have more information on the vertical side of the column, it's only possible to find time using y info. Always know this line  $a_x=0$   $a_y=-9.8 \text{ m/s}^2$  $\Delta y = v_{ov}t + 1/2 a_v t^2$  $-15 = (16 \sin 60) t + 1/2 (-9.8) t^2$ Quadratic eq. (at<sup>2</sup>+bt+c=0): a=-4.9, b=13.86, c=- $\Delta y = 15$  m  $t=[-b \pm (b^2-4ac)^{1/2}]/(2a)$ = $[-13.86 \pm (191.8 - 4 \times -4.9 \times 15)^{1/2}]/(-9.8)$  $t=1.41 \pm 2.25 = -0.84$  s or 3.66 s

# Part B: How far from cliff base (Think Horizontal)

We know it was in the air for 3.66 s (from the previous question), and it was moving at a constant speed of 8.0m/s ( $v_{ox}$ =16cos60°) in the x-direction the whole time, so...

$$v_{avg} = \Delta x/t$$
 or  $\Delta x = v_{ox}t + \frac{1}{2}a_x t^2$  where  $a_x = 0$   
 $\Delta x = v_x t = (8 \text{ m/s})(3.66 \text{ s})$   
 $\Delta x = 29 \text{ m}$   
It will move 29m horizontally, so it hits the ground 29m

away from the base of the cliff.

# Part C: Vertical speed at the bottom (Think Vertical)

It has been accelerating down the whole time. We know that gravity is causing this acceleration, so we can figure out how fast it is going (vertically) when it hits the ground. (Also possible to do without time, but squares in formula.)

$$v_{fy} = v_{iy} + a t$$

$$v_{fy} = 16 \sin 60^{\circ} - 9.8 \ge 3.66$$

 $v_{fy} = -22 \text{ m/s}$ Should be negative since moving opposite from positive y direction

# Part D/E: Velocity when hits (Combination!)

It's total velocity is found by using the horizontal and vertical components of the final velocity and the Pythagorean theorem and tangent function to find the result.

$$c^{2} = a^{2} + b^{2}$$

$$= (8.0m/s)^{2} + (22m/s)^{2}$$

$$c = 23.4 \text{ m/s}$$

$$\tan\Theta = \text{opp/adj}$$

$$= (22 \text{ m/s}) / (8m/s)$$

$$\Theta = \tan^{-1}(22/8) = 70^{\circ}$$
The object is moving at 23.4 m/s at an angle of 70° below the horizontal when it hits the ground.

A home run is hit in such a way that the baseball just clears a wall 21 m high, located 130 m from home plate. The ball is hit at an angle of 35° to the horizontal, and air resistance is negligible. (Assume that the ball is hit at a height of 1.0 m above the ground.)

- (a) Find the initial speed of the ball.
- (b) Find the time it takes the ball to reach the wall.

(c) Find the velocity components of the ball when it reaches the wall.

(d) Find the speed of the ball when it reaches the wall.