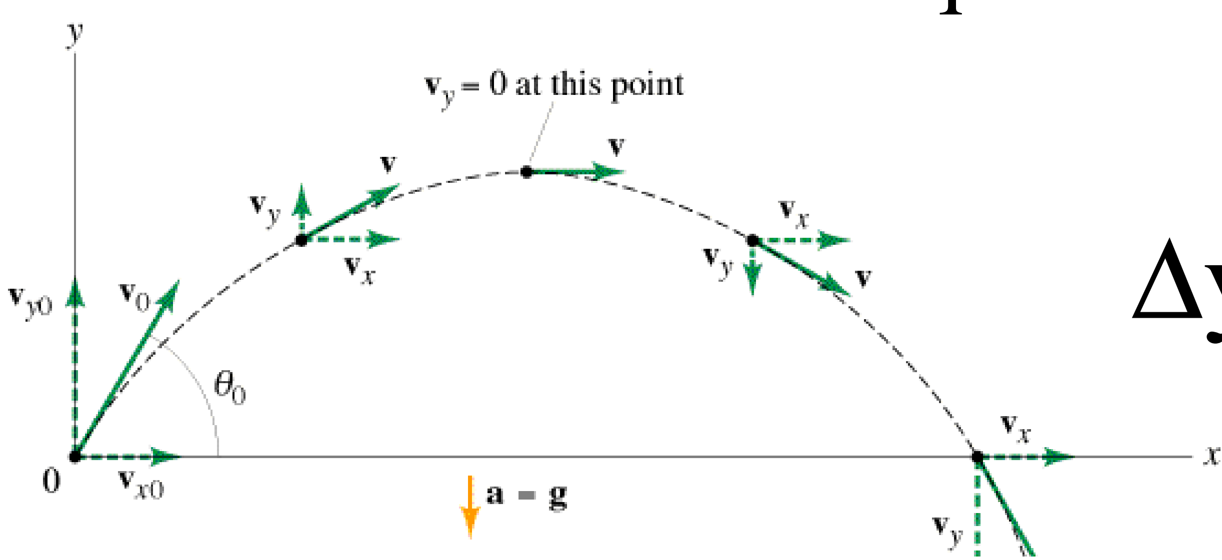
Problem Solving Day

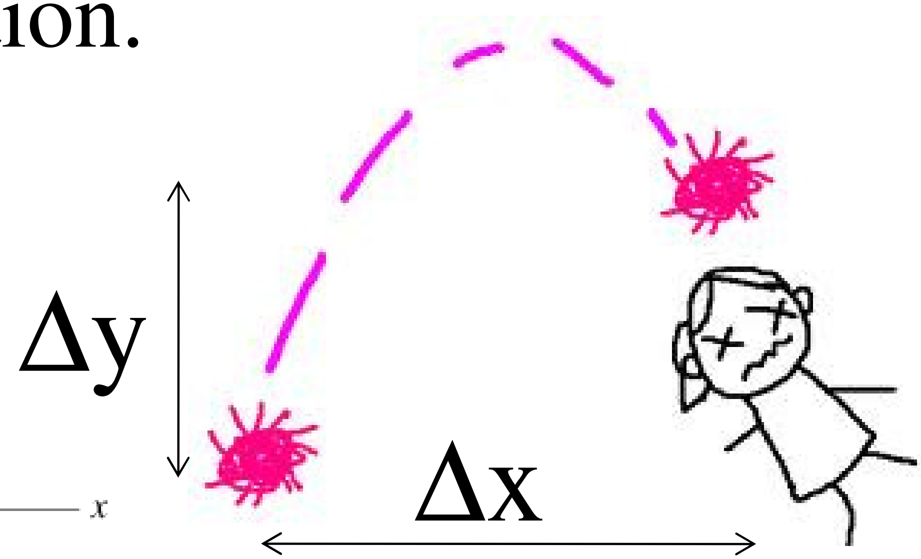
I've prepared projectile motion stuff, but I'm happy to talk about anything about vectors or a prior quiz.

Common Strategy for Projectile Motion Problems

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 at an angle

One step problem,

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.

x	y
$a_x=0$	$a_y= -9.8\ m/s^2$

Always know this line

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

$-15 = (16 \sin 60)\ t + 1/2\ (-9.8)\ t^2$

Quadratic eq. $(at^2+bt+c=0)$: $a=-4.9$, $b=13.86$, $c=-\Delta y = 15$ m

$t=[-b \pm (b^2-4ac)^\wedge \tfrac{1}{2}\ ]/(2a)$

$=[-13.86\pm(191.8-4*-4.9*15)^\wedge \tfrac{1}{2}\ ]/(-9.8)$

$t= 1.41 \pm 2.25= -0.84$ 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}=16cos60º) 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.)

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

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

$$v_{fy} = -22 \text{ m/s}$$

Should be negative since moving opposite from positive y direction

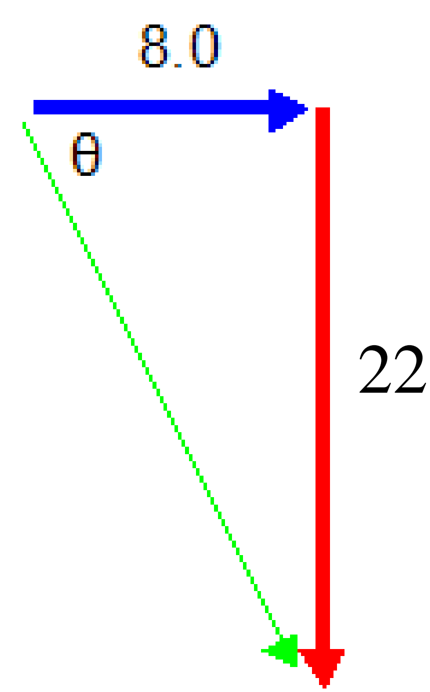
Part D/E: Velocity when hits (Combination!)

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.

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

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

$c = 23.4$ m/s



$\tan\Theta$ = opp/adj

= (22 m/s) / (8m/s)

$\Theta = \tan^{-1}(22/8) = 70°$

The object is moving at 23.4 m/s at an angle of 70° below the horizontal when it hits the ground.

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?

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.

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.

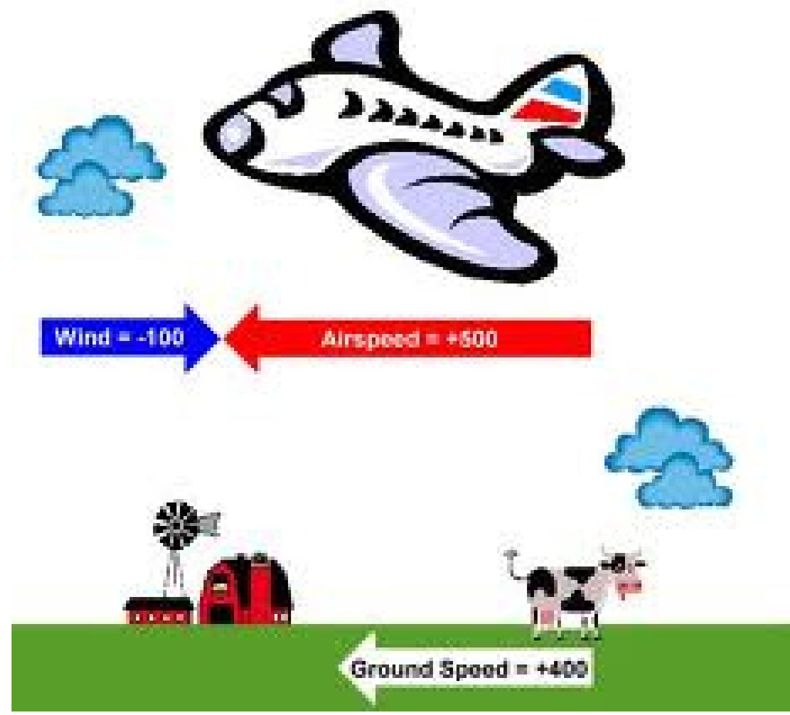
(c) Find the velocity components of the ball when it reaches the wall.

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

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 $a_y=0$)



Physics Cannon Demo

https://www.youtube.com/watch?v=TbWiMsfr_DQ