Announcements – 11 Sep 2014

1. **A Cappella Auditions!** – Many of the groups in the BYU a cappella club are having a joint audition Tuesday at 7 pm, Varsity Theater. All parts needed, male and female. Prepare 60 seconds of music to sing. They will also do range checks and tonal memory checks.
   → Facebook page: www.facebook.com/acappellaclub

“Which of the problems from last night's HW assignment would you most like me to discuss in class today?”

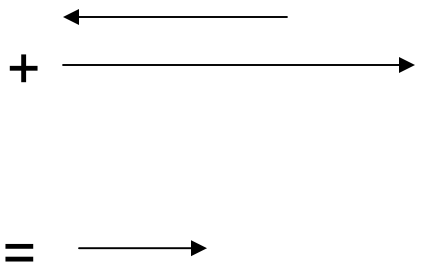
Adding vectors by components – review

Web demo:
http://phet.colorado.edu/sims/vector-addition/vector-addition_en.html

Relative velocities

From warmup (last time): A man on a treadmill is walking at 1.5 m/s to the left. The treadmill is going at 2 m/s to the right. If you are standing still, it looks like the man is moving:

a. 0.5 m/s left
b. 3.5 m/s left
c. stationary
d. 0.5 m/s right
e. 3.5 m/s right



Dr. Colton's "one size fits all" relative velocity equation

$$\vec{\mathbf{v}}_{13} = \vec{\mathbf{v}}_{12} + \vec{\mathbf{v}}_{23}$$

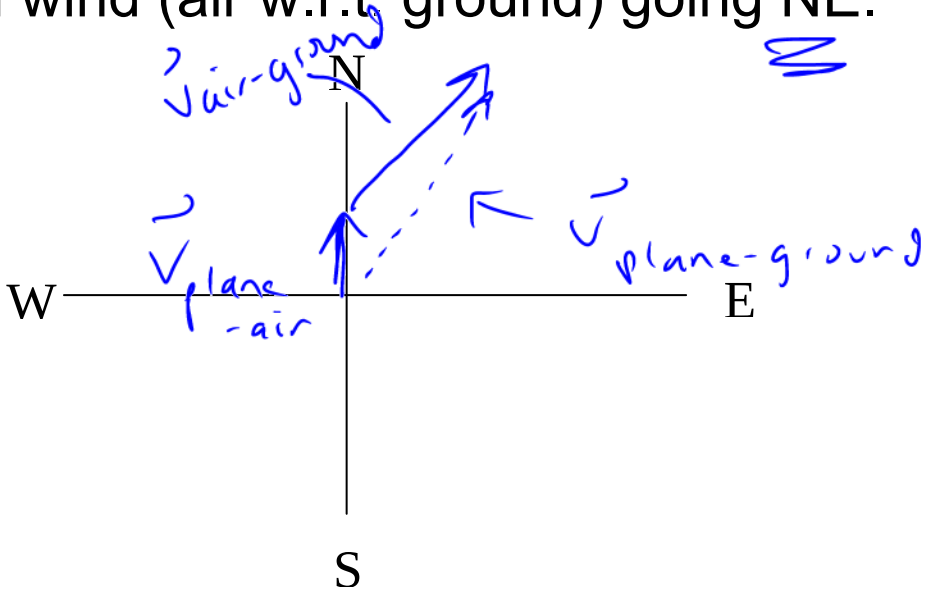
- Read v_{13} as "velocity of object 1 relative to object 3"
- These are vectors!

In this case

$$\vec{\mathbf{v}}_{man-ground} = \vec{\mathbf{v}}_{man-treadmill} + \vec{\mathbf{v}}_{treadmill-ground}$$

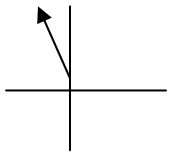
1 3 1 2 2 3

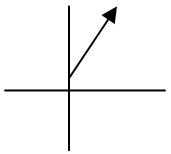
A jet pointed N at 100 mph airspeed (*v* of plane w.r.t. air) flies in a 200 mph wind (air w.r.t. ground) going NE.

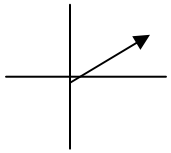


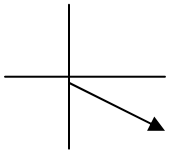
$\vec{V}_{plane-ground} = \vec{V}_{plane-air} + \vec{V}_{air-ground}$

Clicker quiz: What is the jet's true bearing (velocity with respect to the ground)?

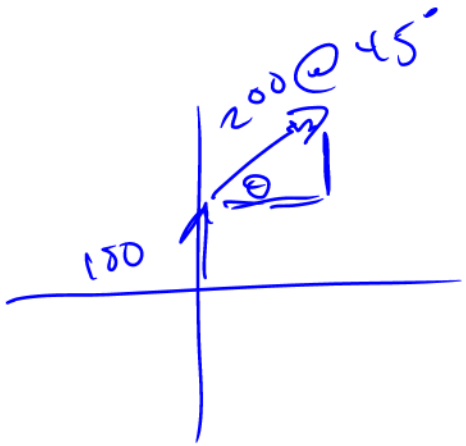
a. 

b. 

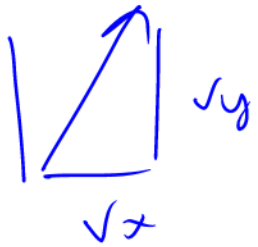
c. 

d. 

Question: How would you figure out the jet's total velocity (magnitude)?



	x	y
V_1	0	100
V_2	$200\cos 45°$	$200\sin 45°$
tot	V_x	V_y

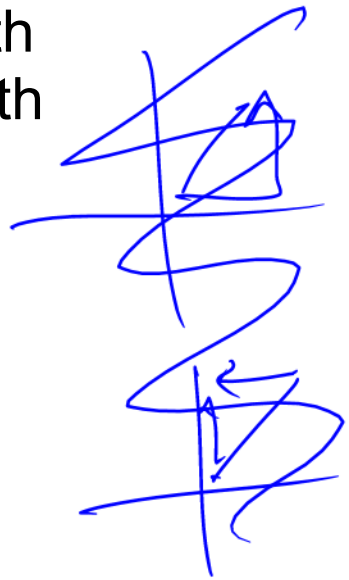


pyth theorem

Clicker quiz

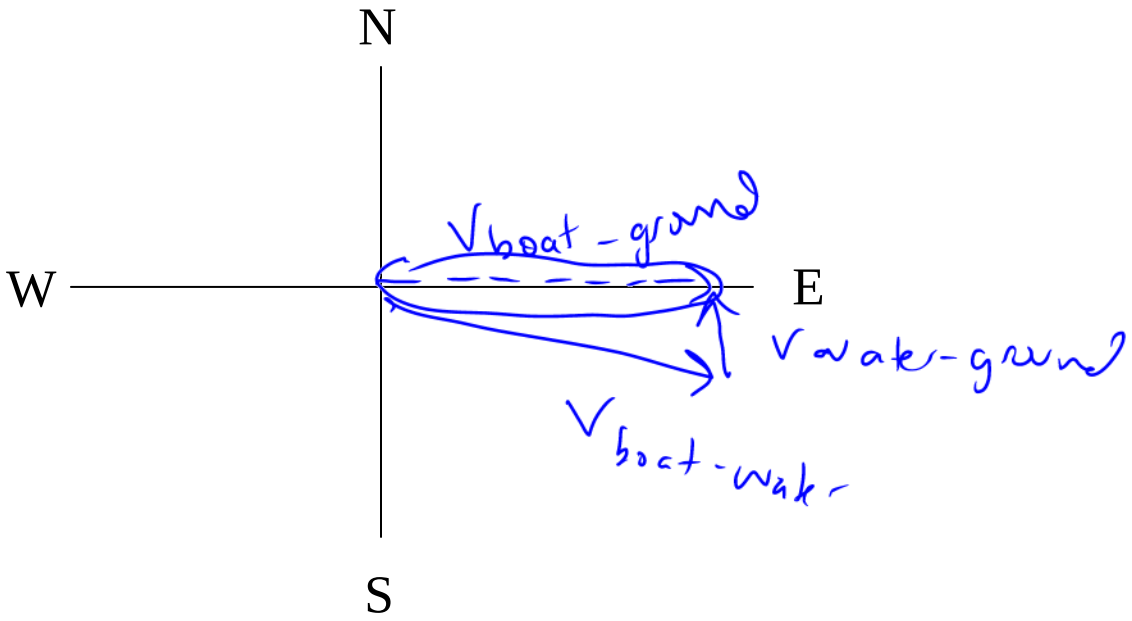
A captain wants her boat to sail exactly **E** on a map, with a speed relative to the *earth* of 10 mph. What direction should she point her boat if there is a 5 mph current to the **N**?

a. a little bit north of east
b. a little bit east of north
c. a little bit south of east
d. a little bit east of south



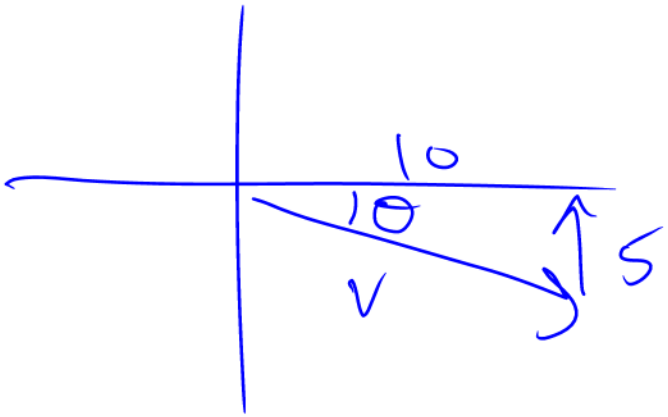
Hint: Start with an approximate picture

$$\mathbf{v}_{\text{boat-earth}} = \mathbf{v}_{\text{boat-water}} + \mathbf{v}_{\text{water-earth}}$$



Worked Problem

How fast will the boat have to go, and what's the exact heading?



$$V = \sqrt{5^2 + 10^2}$$

$$= \boxed{11.18 \text{ m/s}}$$

$$\tan\theta = \frac{\text{opp}}{\text{adj}}$$

$$\tan\theta = 5/10$$

$$\theta = \tan^{-1}(5/10) = \boxed{26.6^\circ} \text{ South of east}$$

Answer: 11.18 m/s, 26.6° south of east

Demo: Cart & ball

Clicker quiz: What will happen?

A. Ball will land in front of cart
B. Ball will land in back of cart
C. Ball will land in cart

Demo: “Shooter & dropper” (2 balls: one shot & one dropped)

Clicker quiz: What will happen?

A. Dropped ball will land first
B. Shot ball will first
C. Two balls will land at same time

2D Motion: Basic Concept

Motions in perpendicular directions are **independent**

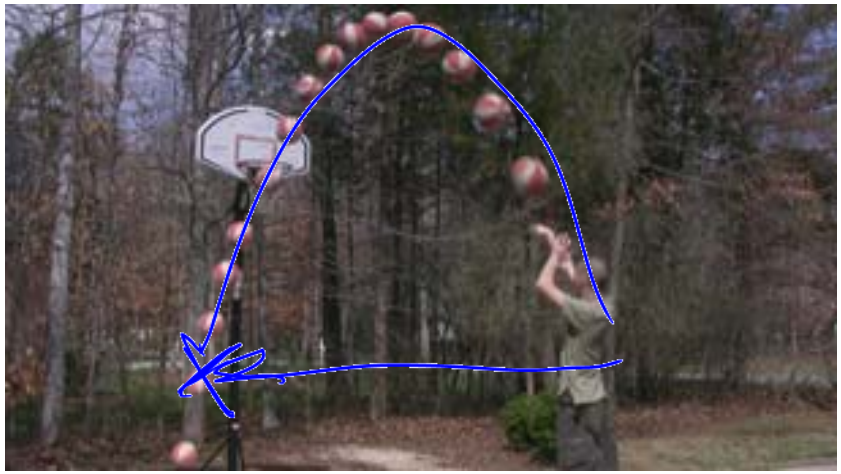
From warmup

Which geometrical shape does a 2D projectile follow?

a. line
b. circle
c. ellipse
d. parabola
e. hyperbola

Why is that?

http://en.wikipedia.org/wiki/Parabola



http://www.aapt.org/Programs/contests/pc08.cfm

Dr. Stokes' flash animation: baseball velocity components
http://stokes.byu.edu/teaching_resources/baseball_flash.html

Equations

Projectile $a_x = 0$ $a_y = -g$

x-direction

$$v_x = v_{0x} + a_x t \longrightarrow v_x = v_{0x}$$

$$x = x_0 + v_{0x} t + \tfrac{1}{2} a_x t^2 \longrightarrow x = x_0 + v_{0x} t$$

$$v_{fx}^{\,2} = v_{0x}^{\,2} + 2 a_x \Delta x$$ boring

y-direction

$$v_y = v_{0y} + a_y t \longrightarrow v_y = v_{0y} - gt$$

$$y = y_0 + v_{0y} t + \tfrac{1}{2} a_y t^2 \longrightarrow y = y_0 + v_{0y} t - \tfrac{1}{2} g t^2$$

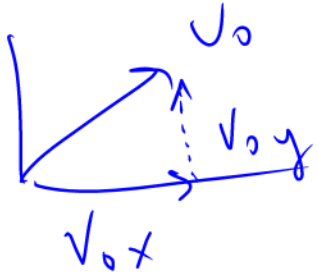
$$v_{fy}^{\,2} = v_{0y}^{\,2} + 2 a_y \Delta y \longrightarrow v_{fy}^{\,2} = v_{0y}^{\,2} - 2 g \Delta y$$

2-D Projectile motion:

$a_x = 0$ $\quad$ $a_y = -g$

(= –9.8 m/s^2)

projectile: an object in free fall



Warmup Questions

I throw a ball at an upward angle across a flat field. Neglecting air resistance, at what part of its path does the ball have its *minimum* speed?

a. right before it hits the ground
b. halfway to the top
c. at the top of its path
d. right after it leaves my hand
e. There's not enough information to say

I throw a ball at an upward angle across a flat field. Neglecting air resistance, at what part of its path does the ball have its *maximum* speed?

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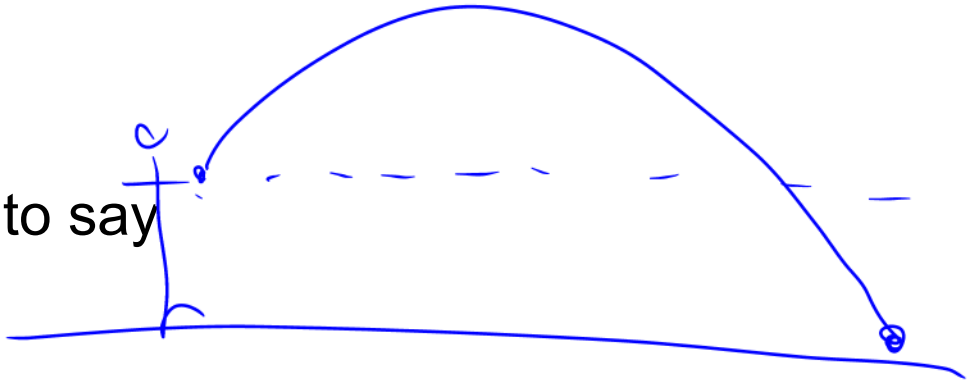
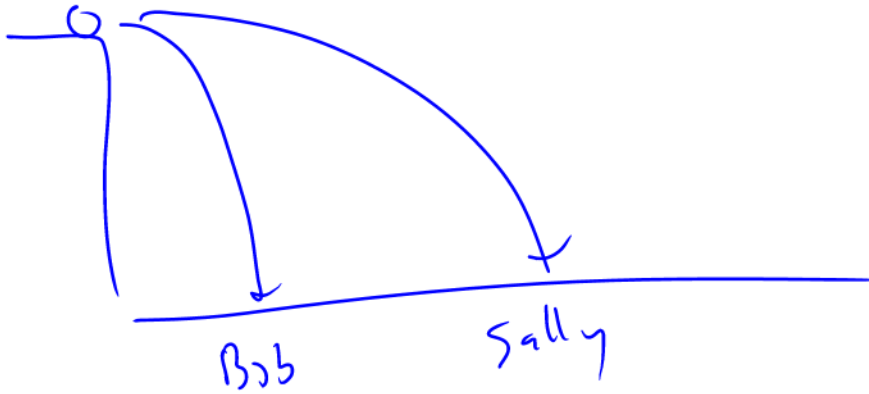


Clicker Quizzes

Sally and Bob each throw a rock horizontally from a cliff. Sally throws her rock hard. Bob throws his more easily.



Q1: Which spends the longest time falling?

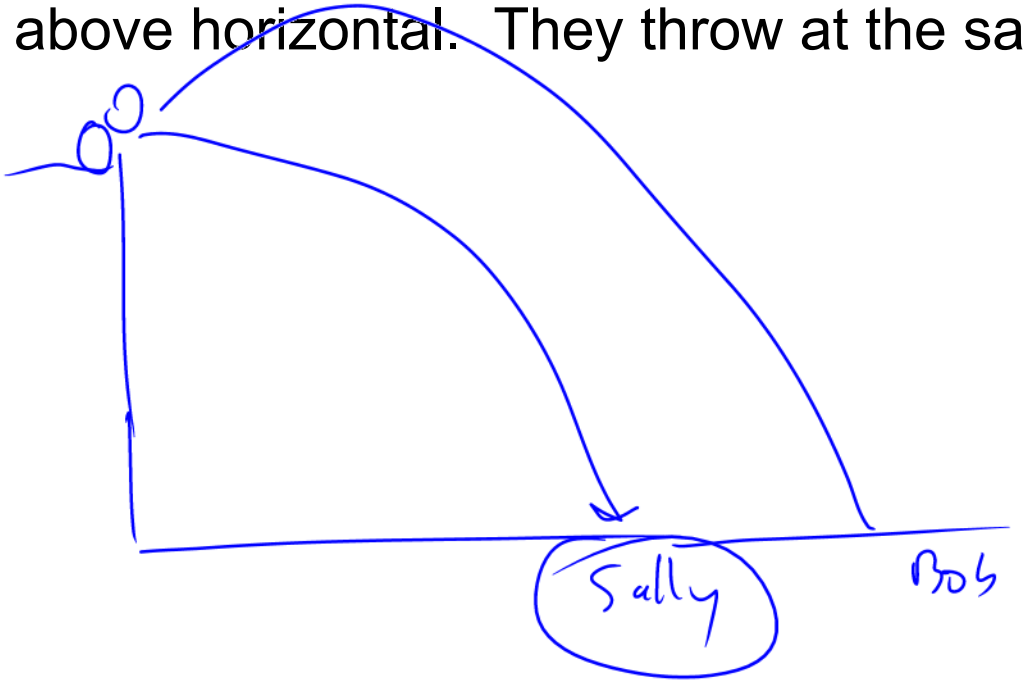
a. Sally's
b. Bob's
c. same

Q2: Which rock is going fastest (vector magnitude) just before it hits the ground?

a. Sally's
b. Bob's
c. same

Question

Sally throws a rock horizontally from a cliff. Bob throws his at an angle above horizontal. They throw at the same speed. Whose hits first?



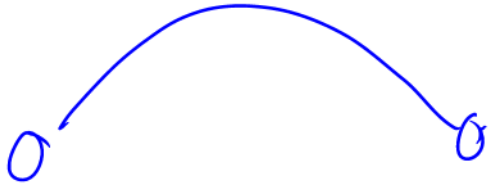
Demo: Monkey gun

Clicker quiz: What will happen?

A. Bullet will pass over monkey
B. Bullet will pass under monkey
C. Bullet will hit monkey

Warmup question

A ball is thrown upwards at an angle. Ralph thought that since the ball is still moving upwards for a while after it is thrown, it must have some upwards acceleration in the air after it leaves my hand that continues to propel the ball. I told him "No, that's not quite what is happening." Can you help Ralph understand what *is* happening?



"Think-pair-share"

- Think about it for a bit
- Talk to your neighbor, find out if he/she thinks the same as you
- Be prepared to share your answer with the class if called on

Clicker: I am now ready to share my answer if randomly selected.

a. Yes

Note: you are allowed to "pass" if you would really not answer.

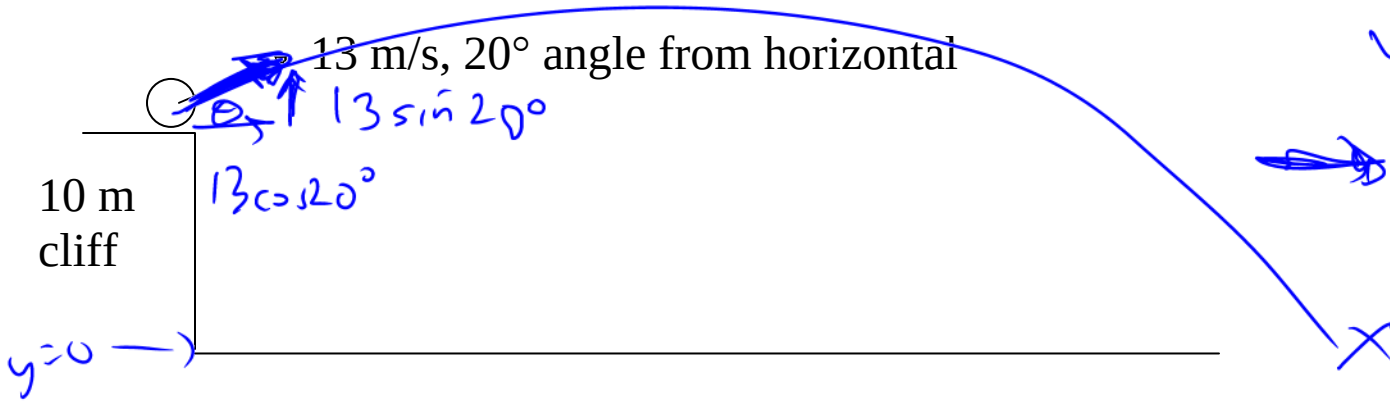
Range problems

Usually use the **y-equations** to figure out the **time** it takes

→Then use the **x-equations** to figure out **how far** it has traveled in that time

Exception: Sometimes the nature of the problem means the x-equations determine the time it takes—for example, if the projectile runs into a wall

Worked Problem: Where does the ball hit? How fast is it going then?



$v_{fy} = v_{0y} - gt$

$y = y_0 + v_{0y}t - \frac{1}{2}gt^2$

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

Step 1: find the time

$0 = 10 - 13\sin 20° t + \frac{1}{2}(9.8)t^2$

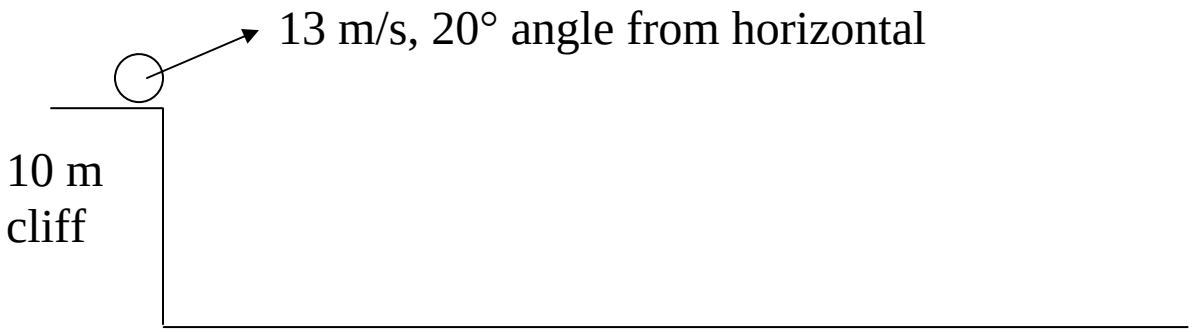
$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$t = \frac{+13\sin 20° \pm \sqrt{(13\sin 20°)^2 - 4\left(\frac{1}{2}\cdot 9.8\right)(-10)}}{2\left(\frac{1}{2}\cdot 9.8\right)}$

$t = 1.95\,s$

Answer: t = 1.9526 s

Worked Problem, cont.: Where does the ball hit? How fast is it going then?



Step 2: use the time

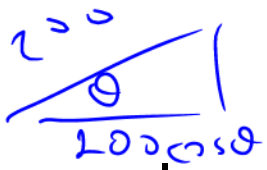
$$x = \cancel{x_0} + v_{0x} t$$

$$= (13 \cos 20^\circ) \times (1.95\,s)$$

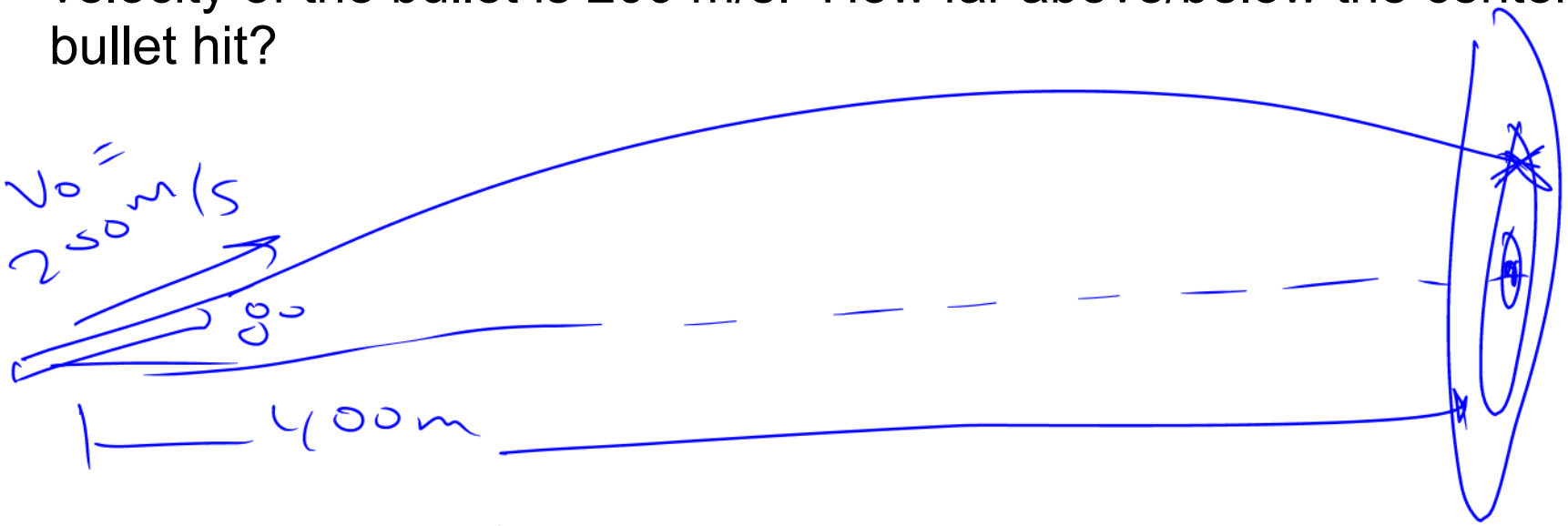
$$= 23.85\,m$$

Answers: t = 1.9526 s, x = 23.85 m, v_{fx} = 12.22 m/s, v_{fy} = 14.69 m/s, $v_{f,tot}$ = 19.10 m/s

Worked Problem



A rifle at the same height as a very large target tries to hit the center, 400 m away. The rifle is shot at 8º above the horizontal. The initial velocity of the bullet is 200 m/s. How far above/below the center does the bullet hit?



$$x = x_0 + v_{0x} t$$

$$400 = 0 + (200\cos 8°)\, t$$

$$t = \frac{400}{200\cos 8°} = 2.02\ \text{s}$$

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

$$y_f = 0 + (200\sin 8°)(2.02) - \frac{1}{2}(9.8)(2.02)^2$$

$$= 36.2\ \text{m}$$

Answers: t = 2.02 s, y = 36.23 m

Maximum range

Warmup question: Neglecting air resistance, at what angle should you throw a ball on a flat field in order to get the maximum range? (also neglecting height of person)

a. 30°
b. 45°
c. 60°
d. It depends on the initial speed

Caveats…