

## Studying for the Projectile Motion Retest.

A note before you start...

There are a couple of tricky questions on the retest. They are mostly as tricky as on the first test.

However, there are not that many tricky questions. Most of the questions are very basic and straight forward vector and projectile motion questions. That's all there is to it. You have to know the basics and know them perfectly.

These pages are designed to give you enough practice that you can master these problems. The keys are on the following page to each set of problems.

Included:

Page 2—Vector Basics—How to put x and y components back together to find the resultant's magnitude and direction. Don't skip this page. Most of you make mistakes doing this process.

Page 3—key

Page 4—Projectile Motion Concepts. These were supposed to be easy points on the test, but ended up killing many of you.

Page 5—key

Page 6—Relative Motion. Work in x and y independently.

Page 7—key

Page 8—Adding Vectors. I used my Excel calculator program to crunch all these numbers for you. There is no reason why you should miss the adding vector problem, but many of you do anyway.

There are enough problems that if you can do all of these you will be perfect (and bored).

Page 9—key

Page 10—Projectile Motion Problems—Again, there are enough to choke you with. Work 'em until you are a "Projectile Master".

Page 11—key

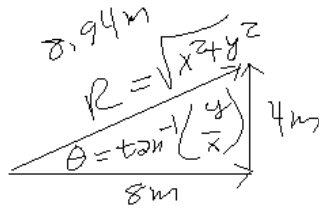
And there is a final thought on the last page.—Mr. Murray

## Vector Basics

1. If an object moves the following amounts, find the object's total displacement (magnitude and direction). Double check your direction by figuring out what quadrant it is in.
  - A. 8 m east and 4 m north.
  - B. 4 m west and 9 m south.
  - C. 6 m west and 8 m north
  - D. 7 m south and 4 m east.
2. A person walks 45 m at  $65^\circ$  and then turns to  $325^\circ$  and walks 122 m. Find the person's total displacement (magnitude and direction).

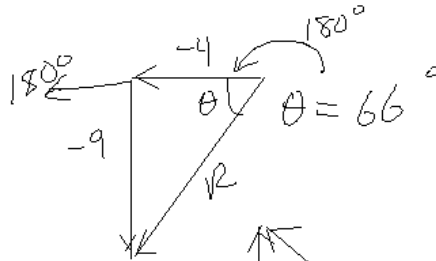
1. 8 m east 4 m north:

①  $R = 8.94$  at  $26.6^\circ$



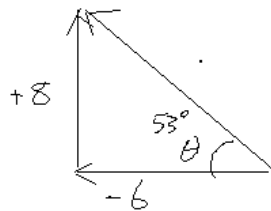
2. 4 m west 9 m south:

$R = 9.85$  m at  $246^\circ$



3. 6 m west 8 m north:

$R = 10$  m at  $127^\circ$



IV: 7 m south and 4 m <sup>east</sup> ~~west~~:  $R = 8.06$  m at  $-60.3^\circ$

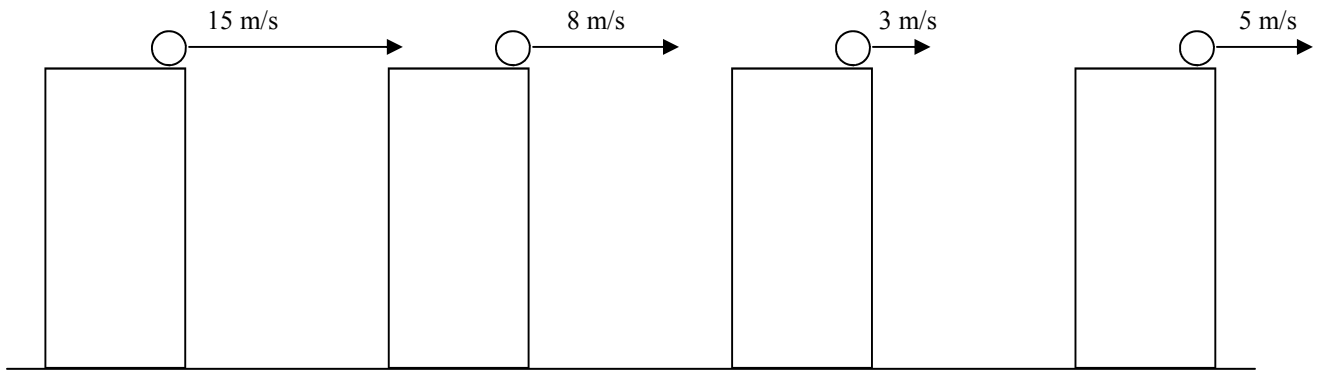
E. A person walks 45 m at 65 degrees then turns to 325 degrees and walks 122 meters. Find the total displacement of the person.

$45$  at  $65^\circ$        $x_1 = 45 \cos 65^\circ = 19.02$  m       $y_1 = 45 \sin 65^\circ = 40.78$  m

$122$  m at  $325^\circ$        $x_2 = \cos = 99.94$  m       $y_2 = \sin = -69.98$  m

$x_t = 118.95$  m       $y_t = -29.19$  m

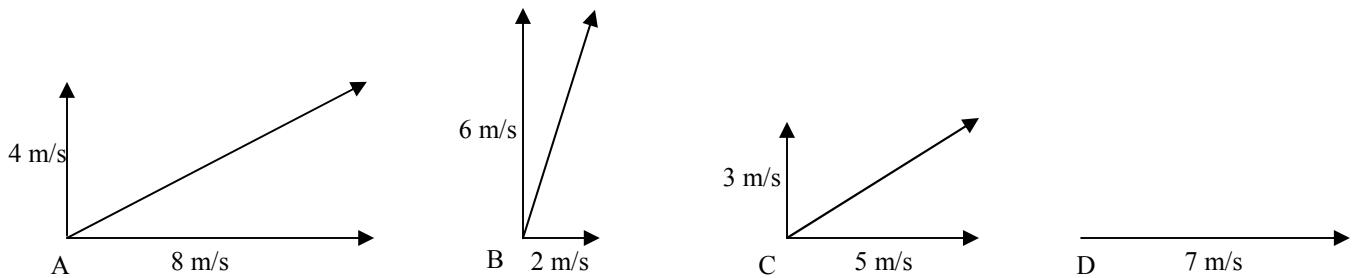
$R = 122.48$  m  
at  $-13.79^\circ$



Four objects are shot horizontally off of tables of the same height.

A. Rank them from greatest time to least time in the air.

B. Rank them from greatest to least range (how far away they land).

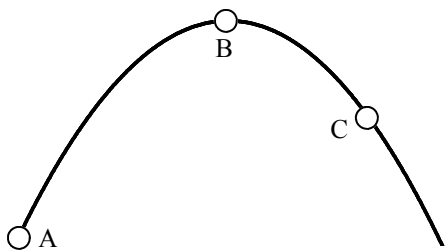


Four objects are shot at different speeds and angles. The x and y components are given.

A. Rank them from most time in the air to least time in the air.

B. Rank them from greatest initial velocity to least.

C. Rank them from greatest range to least range.



1. The diagram shows a projectile shot from ground to ground. For the following questions answer positions A, B, C, the same, or some combination.

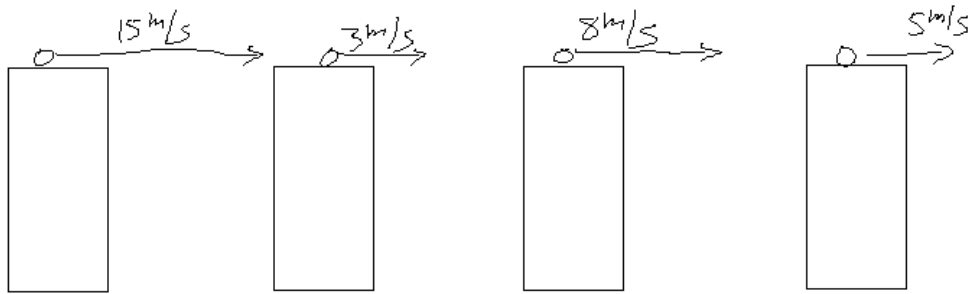
- A. \_\_\_\_\_ Where the speed (total speed) is greatest.
- B. \_\_\_\_\_ Where the vertical acceleration is least.
- C. \_\_\_\_\_ Where the net force is greatest.
- D. \_\_\_\_\_ Where the vertical speed is greatest.
- E. \_\_\_\_\_ Where the horizontal speed is smallest.
- F. \_\_\_\_\_ Where the horizontal acceleration is zero.
- G. \_\_\_\_\_ Where the direction is zero degrees.
- H. \_\_\_\_\_ Where the total speed equals the vector addition of the vertical and horizontal speeds.

Four objects are shot horizontally off of equal height tables.

A. rank them from greatest time in the air to least time in the air.

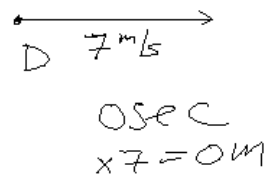
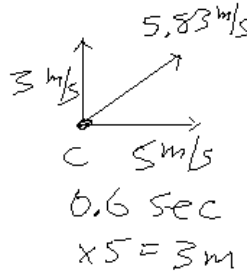
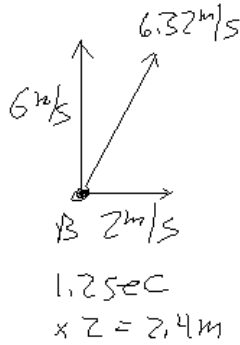
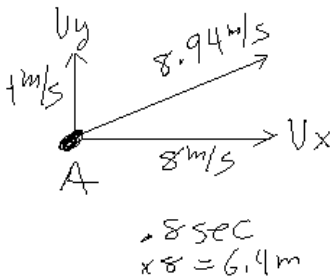
Same for all

they fall from the same heights, so have same time to ground.



B. Rank them from greatest range to least range.

Since they all have the same height and time, the one with the fastest horizontal speed goes farther. SO: 15, 8, 5, 3.



Four objects are shot. The x and y components of their velocities are shown.

A. Rank them from most time in the air to the least time in the air.

One with the greatest y component is in the air the longest. SO: B, A, C, D

D has no y-component so is shot straight into the ground.

B. Rank them from greatest initial velocity to least. The actual initial velocity is the vector addition

(pythagorean theorem) of the two components. See diagrams.

C. Rank them from greatest to least range. : A, C, B, D

Since you have the x velocity of each, all you need is the time in the air for each. Ex. for A. (round g, for speed)

$$v_f = v_i + at$$

$$-4 = 4 - 10t$$

$$-8 = -10t$$

$$t = .8 \text{ sec}$$

$$\text{then } S = \frac{D}{T}$$

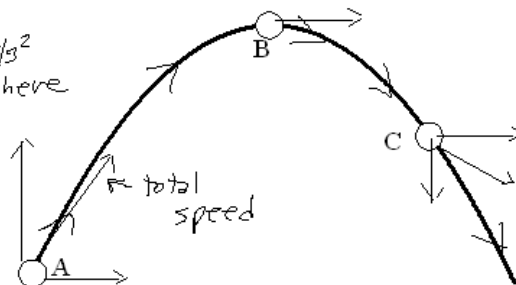
in x-dir, so

$$D = ST$$

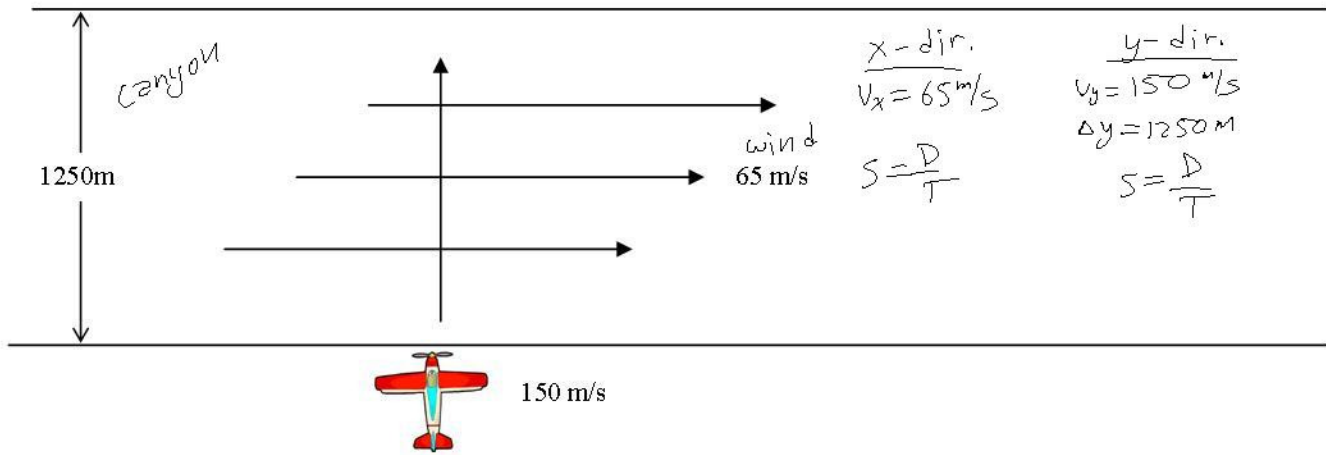
$$= 8(.8) = 6.4 \text{ m}$$

The picture shows three positions on the path of a projectile. Answer which position is correct for the following statements. There can be more than one answer or no answers.

- A. A Where the speed (total speed) is greatest.
- B. same Where the vertical acceleration is least.  $g = 9.8 \text{ m/s}^2$
- C. same Where the net force is greatest. =  $F_w$  every where
- D. A Where the vertical speed is greatest.
- E. same Where the horizontal speed is smallest.  $v_x$  is const.
- F. same Where the horizontal acceleration is zero.
- G. B Where the direction is zero degrees.
- H. same Where the total speed equals the vector addition of the vertical and horizontal speeds. see prev. section







A plane has a speed of 150 m/s and is flying directly north ( $90^\circ$ ). It comes to a canyon that is orientated exactly east/west and has a width of 1250 m. The wind in the canyon is blowing directly east ( $0^\circ$ ) and blowing 65 m/s.

A. How long does it take for the plane to cross the canyon?

y-dir only

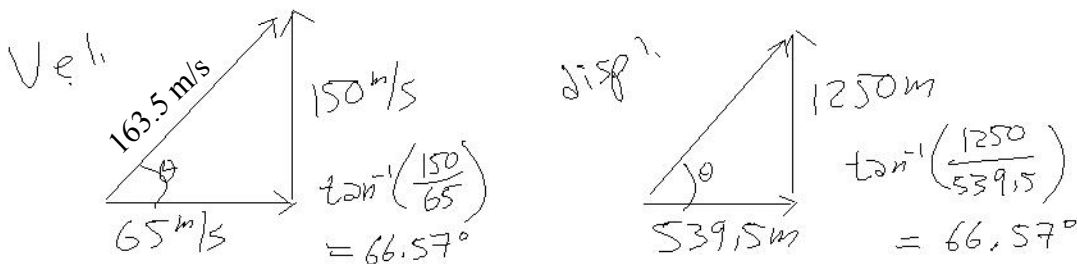
$$T = \frac{D}{S} = \frac{1250}{150} = 8.3 \text{ sec}$$

B. How far down the canyon is the plane pushed?

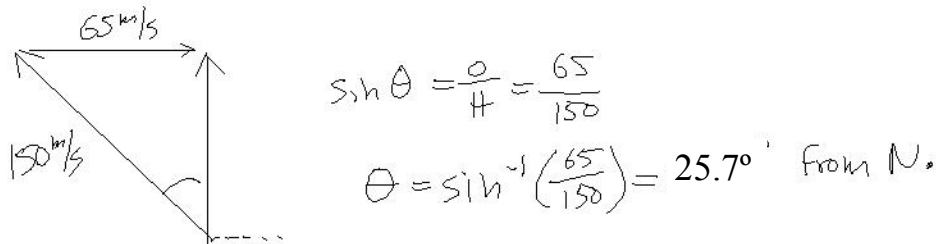
x-dir.

$$D = V_x t = 65(8.3) = 539.5 \text{ m}$$

C. What direction and speed does he actually fly?



D. Which direction does he need to fly to end up directly across the canyon?



**Vector Problems:**

1. I walk 35 m at  $32^\circ$ . How far east and north do I go?
2. A plane flies 980 miles at  $76^\circ$ . How far east and north did it fly?
3. A porcupine waddles 13 meters at a direction of  $16^\circ$ . How far east and north did it walk?
4. A boat moves 812 km at  $230^\circ$ . Give the how far the boat moved in the x and y directions.
5. A slingshot throws a ball 72 yards at an angle of  $310^\circ$ . Give the x and y components of its displacement.
6. A salamander scampers 22.6 m to avoid a rattle snake. If the slimy amphibian moved at a direction of  $125^\circ$ , how far did it move in the x and y directions from its initial position?

**Vector Addition:** Add the following pairs of vectors. All answers must have magnitude and direction.

7. 340m at  $12^\circ$ , then 733m at  $335^\circ$ . Find total displacement.
8. 182 m at  $34^\circ$ , then 89m at  $97^\circ$ .
9. 1.47 feet at  $7^\circ$ , then 2.38m at  $342^\circ$ .
10. 366 yards at  $83^\circ$ , then 472 yards at  $28^\circ$ .
11. 135 miles at  $154^\circ$ , then 87 miles at  $286^\circ$ .
12. 56 inches at  $17^\circ$ , then 27 inches at  $189^\circ$ .

Answers:

**Vector Problems:**

- I walk 35 m at  $32^\circ$ . How far east and north do I go?  
 $X = 29.86\text{m}$        $Y = 18.55\text{m}$
- A plane flies 980 mph at  $76^\circ$ . How fast did it fly east and north?  
 $V_x = 237.08\text{ mph}$        $V_y = 950.89\text{ mph}$
- A porcupine waddles 13 meters at a direction of  $16^\circ$ . How far east and north did it walk?  
 $X = 12.50\text{ m}$        $Y = 3.58\text{ m}$
- A boat moves 812 km at  $230^\circ$ . Give the how far the boat moved in the x and y directions.  
 $X = -521.94\text{km}$        $Y = -622.03\text{ km}$
- A slingshot throws a ball 72 yards at an angle of  $310^\circ$ . Give the x and y components of its displacement.  
 $X = 46.28\text{ yards}$        $Y = -55.16\text{ yards}$
- A salamander scampers 22.6 cm/sec to avoid a rattle snake. If the slimy amphibian moved at a direction of  $125^\circ$ , how fast did it move in the x and y directions from its initial position?  
 $V_x = -12.96\text{ cm/sec}$        $V_y = 18.51\text{ cm/sec}$

**Vector Addition:** Add the following pairs of vectors. All answers must have magnitude and direction.

7. 340m at  $12^\circ$ , then 733m at  $335^\circ$ .

	X	Y		
V1	332.57	70.69		
V2	664.32	-309.78	Mag	Direction
Totals	996.87	-239.09	1025.2m	$-13.49^\circ$

8. 182 m at  $34^\circ$ , then 89m at  $97^\circ$ .

	X	Y		
V1	150.88	101.77		
V2	-10.85	88.34	Mag	Direction
Totals	140.04	190.11	236.12m	$53.62^\circ$

9. 1.47 feet at  $7^\circ$ , then 2.38m at  $342^\circ$ .

	X	Y		
V1	1.459	.179		
V2	2.26	-.735	Mag	Direction
Totals	3.722	-0.556	3.76ft	$-8.5^\circ$

10. 366 yards at  $83^\circ$ , then 472 yards at  $28^\circ$ .

	X	Y		
V1	44.60	363.27		
V2	416.75	221.59	Mag	Direction
Totals	461.36	584.86	744.92	$51.7^\circ$

11. 135 miles at  $154^\circ$ , then 87 miles at  $286^\circ$ .

	X	Y		
V1	-121.34	59.18		
V2	23.98	-83.63	Mag	Direction
Totals	-97.36	-24.45	100.38	$194^\circ$

12. 56 inches at  $17^\circ$ , then 27 inches at  $189^\circ$ .

	X	Y		
V1	53.55	16.37		
V2	-26.67	-4.22	Mag	Direction
Totals	26.89	12.15	29.50	$24.3^\circ$

### Basic Projectile Motion Problems:

- Shot ground to ground at an angle of  $34^\circ$  above the horizontal and a velocity of 56m/s.
  - Find total range.
  - How high did it go?
- Shot ground to ground with 712 m/s at  $60^\circ$ .
  - How high does it go?
  - How far away does it land?
- A bicyclist is riding 12 m/s across a flat roof 8.5m above the ground.
  - How much hang time did he have when he leaves the building?
  - How far away does he land?
- A football is kicked with a velocity of 14 m/s and an angle of  $48^\circ$ .
  - How high does it go?
  - How far down field does it land?
- Shot horizontally from 125cm up. Lands 1.5 m away. How fast does it leave the projectile launcher?
- Dropped from a plane going 120 m/s at an altitude of 280m. The plane is moving horizontally.
  - How much time for it to hit the ground.
  - How far away will it land from where it was dropped?
- I'm laying on the ground and my lunch decides to be resurrected. I blow chunks at an angle of  $75^\circ$  and 3.4m/s.
  - How high up do they go?
  - How far away do they land?
  - How nasty do they smell?
  - Why are you still reading this?
- Bubba Joe has a really bad cold, but no hankie. So, in true down-home style, he turns his head up and blows his nose. Turns out he blows exactly horizontally (and you said he had no talent). He hits a poor, undeserving toad that is just sitting on a rock, 2.6m away. If Bubba Joes nostril is exactly 1.86 m from the ground, how fast did the green globs of goo leave his breathing passages?
- Disgusted with his last attempt at a witty, but still academically useful projectile motion question, Mr. Murray crumples up his paper and throws it 3.1 m/s and  $35^\circ$  toward the recycle bin (even tired, he is still environmentally conscious). Pretending he is throwing from the floor and to the floor, how high up does it go and how far away does it land?
- It is Friday evening and I am very tired right now. So I am only going to launch one more thing: a final thought. This is exacting work. There is no room for error. Do not assume that by getting one problem right, you will get every one. Work hard. Repeat the problems until you can do them easily and with no errors. - Mr. Murray

### Basic Projectile Motion Problems:

- Shot ground to ground at an angle of  $34^\circ$  above the horizontal and a velocity of 56m/s.
  - Find total range.  $V_x = 46.43$ ;  $V_y = 31.315$  m/s  $t = 6.391$  sec  $\Delta x = 296.71$ m
  - How high did it go?  $\Delta y = 50.03$  m
- Shot ground to ground with 712 m/s at  $60^\circ$ .
  - How high does it go?  $V_x = 616.61$ m/s  $V_y = 356$ m/s  $\Delta y = 19398.36$ m
  - How far away does it land?  $t = 125.84$ sec  $\Delta x = 44798.7$ m
- A bicyclist is riding 12 m/s across a flat roof 8.5m above the ground.
  - How much hang time did he have when he leaves the building?  $t = 1.317$ sec
  - How far away does he land?  $\Delta x = 15.80$ m
- A football is kicked with a velocity of 14 m/s and an angle of  $48^\circ$ .
  - How high does it go?  $V_x = 10.4$ m/s  $V_y = 9.368$ m/s  $\Delta y = 5.523$ m
  - How far down field does it land?  $t = 2.123$ sec  $\Delta x = 19.89$ m
- Shot horizontally from 125cm up. Lands 1.5 m away. How fast does it leave the projectile launcher?  
Convert to meters so  $\Delta x = 1.5$ m and  $\Delta y = -1.25$ m.  $t = 0.505$ sec (y-dir) so  $V_x = V = 2.97$ m/s
- Dropped from a plane going 120 m/s at an altitude of 280m. The plane is moving horizontally.
  - How much time for it to hit the ground.  $V_y = 0$  m/s (horiz.)  $V_x = 120$  m/s  $t = 7.559$
  - How far away will it land from where it was dropped?  $\Delta x = 907.08$ m
- I'm laying on the ground and my lunch decides to be resurrected. I blow chunks at an angle of  $75^\circ$  and 3.4m/s.
  - How high up do they go?  $V_x = 3.284$ m/s  $V_y = .88$ m/s  $\Delta y = 0.55$ m
  - How far away do they land?  $t = 0.67$  sec  $\Delta x = 0.59$  m
  - How nasty do they smell? Like a fine bouquet of rot. Mmmmm.
  - Why are you still reading this? Because you are a sicko, too.
- Bubba Joe has a really bad cold, but no hankie. So, in true down-home style, he turns his head up and blows his nose. Turns out he blows exactly horizontally (and said he had no talent). He hits a poor, undeserving toad that is just sitting on a rock, 2.6m away. If Bubba Joes nostril is exactly 1.86 m from the ground, how fast did the green globs of goo leave his breathing passages?  
 $V_y = 0$ m/s.  $\Delta y = -1.86$  m From y-direction  $t = 0.616$ sec  $V_x = V = 4.22$  m/s
- Disgusted with his last attempt at a witty, but still academically useful projectile motion question, Mr. Murray crumples up his paper and throws it 3.1 m/s and  $35^\circ$  toward the recycle bin (even tired, he is still environmentally conscious). Pretending he is throwing from the floor and to the floor, how high up does it go and how far away does it land?  
 $V_y = 1.778$  m/s  $V_x = 2.539$ m/s;  $t = 0.363$  sec  $\Delta x = 0.92$  m
- It is Friday evening and I am very tired right now. So I am only going to launch one more thing: a final thought. This is exactly work. There is no room for error. Do not assume that by getting one problem right, you will get every one. Work hard. Repeat the problems until you can do them easily and with no errors. - Murray