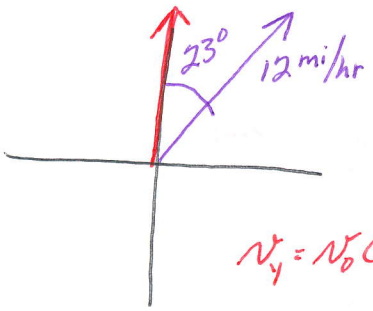
Level I Key Pd 1

VECTORS

AT VECTORS(11)

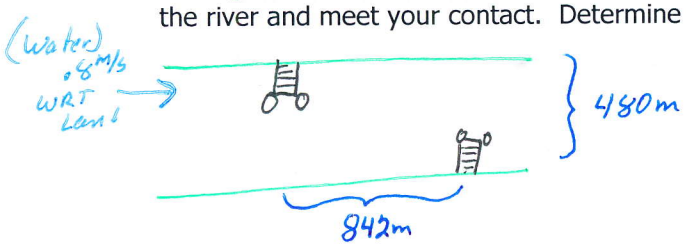
Directions: Solve the following problems. Show all work in a neat orderly fashion so that your response can be "read." Please circle your answer. Each problem is worth 5 points.

1. A 12 mi/hr wind is blowing at 23 degrees east of north. Determine the northern component of the wind.



$v_y = v_0 \cos(23°) = (12\ mi/hr)\cos(23°) = 11\ mi/hr$

2. It's a dark, foggy night with a new moon, and no ambient light from the distant city. As an agent with a top secret organization, you are instructed to silently cross a 480 m wide river in a kayak and land 842m upstream with only a compass and a "water speed" measuring instrument. No radio receivers or transmitting devices may be used (No GPS, cell phone, etc.). The river is flowing at a constant rate of 0.8 m/s WRT land. From the launch, you have 10 minutes to cross the river and meet your contact. Determine your speed and heading for an accurate landing.



time = 10 min = 600s

Crossing WRT Land

$\frac{480m}{600s} = .8\ m/s$ ↑

Crossing WRT Water (Same)

.8 m/s

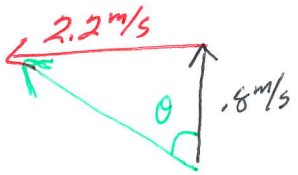
Upstream WRT Land

$\frac{842m}{600s} = 1.4\ m/s$ ←

Upstream WRT Water

← 1.4 m/s + .8 m/s (To Counter Current)

← 2.2 m/s



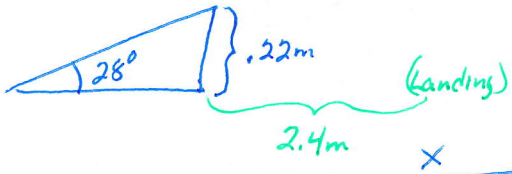
$\tan\theta = \frac{2.2\ m/s}{.8\ m/s}$

$\theta = \tan^{-1}\left[\frac{2.2\ m/s}{.8\ m/s}\right]$

$\theta = 70^{\circ}$ From Straight Across

2.34 m/s

3. While watching an RC car buzzing around, you wonder just how fast the car is traveling. There is a ramp that the car has been going over, and you notice the car consistently lands 2.4 m from the end of the ramp. The top of the ramp is 22 cm above the floor, and the ramp has an angle of incline of 28 degrees. How fast is the RC car traveling? Assume the speed of the car is constant.



y

$y = -.22m$

$t = ?$

$a = -9.8 m/s^2$

$v_{0y} = v_0 \sin\theta$

$y = v_{0y} t + \frac{1}{2} a t^2$

$y = v_0(\sin\theta)\, t + \frac{1}{2} a t^2$

x

$x = 2.4m$

$t = ?$

$v_{0x} = v_0 \cos\theta$

$a = \text{zero}$

$x = v_{0x} t + \frac{1}{2} a t^2$

$x = (\cos\theta)(v_0)\, t + \text{zero}$

$x = (v_0 \cos\theta)\, t$

$\frac{x}{v_0 \cos\theta} = t$

$y = v_0 \sin\theta \left[\frac{x}{v_0 \cos\theta}\right] + \frac{1}{2} a \left[\frac{x}{v_0 \cos\theta}\right]^2$

$y = \frac{v_0 \sin\theta\, x}{v_0 \cos\theta} + \frac{a x^2}{2 v_0^2 \cos^2\theta}$

$y = x \tan\theta + \frac{a x^2}{2 v_0^2 \cos^2\theta}$

$y - x\tan\theta = \frac{a x^2}{2 v_0^2 \cos^2\theta}$

$(2 v_0^2 \cos^2\theta)(y - x\tan\theta) = a x^2$

$2 v_0^2 \cos^2\theta = \frac{a x^2}{(y - x\tan\theta)}$

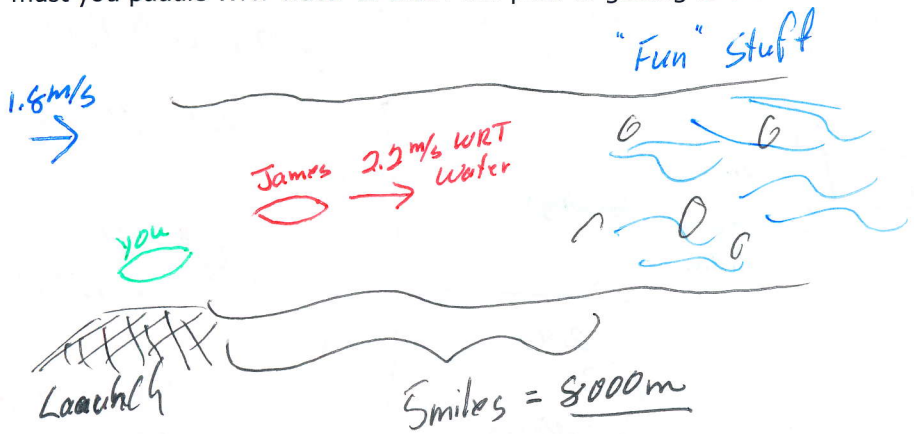
$v_0^2 = \frac{a x^2}{2\cos^2\theta (y - x\tan\theta)}$

$v_0 = \sqrt{\frac{(-9.8 m/s^2)(2.4m)^2}{(2)(\cos^2(28°))(-.22m - (2.4m)\tan 28)}}$

$\tan(28°)$

$v_0 = 4.92 m/s$

4. You and your friend James are planning a kayak trip down a river. The first 5 miles of the river are rather calm and boring with the river flowing a constant and steady 1.8 m/s. After the first 5 miles, the pace picks up and there are rapids and chutes to play in. James gets his boat in the water and takes off a 2.2 m/s WRT water in an attempt to beat you to the "fun" stuff. How fast must you paddle WRT water to catch him prior to getting to the fun stuff? 4 min



Time For James To Get To Fun Stuff

$$\frac{8000\text{m}}{(2.2\text{m/s} + 1.8\text{m/s})} = 2000\text{s}$$

You Need To Get To "Fun Stuff" In 2000s

$$2{,}000\text{s} - \left(\frac{4\text{min}}{4}\right)\left(\frac{60\text{s}}{\text{min}}\right)$$

$$\frac{8000\text{m}}{1760\text{s}} = 4.55\text{ m/s}$$ WRT Land

$$(4.55\text{ m/s} - 1.8\text{ m/s}) = 2.75\text{ m/s or faster}$$

5. You are driving along at a constant 28 m/s. Just as you pass a police officer, he pulls out and accelerates at $3 m/s^2$ until he catches you. How long does it take the officer to catch you?

police WRT Land

$v_0 = Zero$

$a = 3 m/s^2$

$t = ?$

you

$v_0 = 28 m/s$

$a = Zero$

$t = ?$

All Motion WRT "you"

police

$v_0 = -28 m/s$

$a = 3 m/s^2$

$t = ?$

$x = 0$

(Return To Starting Position)

you

$v_0 = Zero$

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

$0 = \left(-28 \frac{m}{s}\right) t + \left(\frac{1}{2}\right)\left(3 \frac{m}{s^2}\right) t^2$

$(28 m/s) t = (1.5 m/s^2) t^2$

$28 m/s = (1.5 m/s^2) t$

$\frac{28 m/s}{1.5 m/s^2} = t$

$18.7 s = t$

6. A pitching machine throws with a constant 32 m/s. At what angle would the pitching machine need to be setup up so the ball travels a distance of 45 m. Assume the height of the "pitching" and the height of "catching" height are the same.

$$x = \frac{v_0^2 \sin(2\theta)}{g}$$

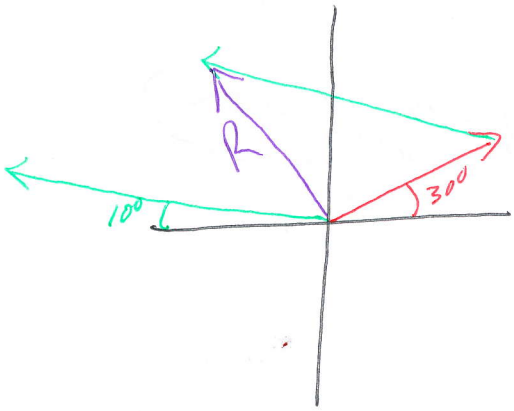
$$\frac{\sin^{-1}\left(\frac{xg}{v_0^2}\right)}{2} = \theta$$

$$\frac{\sin^{-1}\left(\frac{(45\,m)(9.8\,m/s^2)}{(32\,m/s)^2}\right)}{2} = \theta$$

$$12.8^\circ = \theta$$

7. "Sketch" the addition of the following two vectors:
   a. 4 m at 30 degrees north of east
   b. 8 m at 10 degrees north of west.

   In your sketch, show the original vectors drawn on an axis, the translation of the vectors, and the resultant of the addition of the two vectors. The purpose of the sketch is for you to demonstrate your ability to add vectors without taking the time to accurately draw the vectors to scale.



8. A projectile is fired at 38 m/s at an angle of 68 degrees. Determine the velocity at the top of the path.

@ Top

Y

v_y = zero

X

$v_x = v_0 \cos\theta = (38\ m/s)(\cos 68^\circ)$

$v_x = v_{Total} = 14.2\ m/s$