Sample Test 1
Phys 111 Spring 2010

Name: Key

By writing my name above, I affirm that this test represents my work only, without aid from outside sources. In all aspects of this course I perform with honor and integrity.

Show your work on all of the problems – your approach to the problem is as important as (if not MORE) important than) your final answer.

Total Score: ________

1) (20pts) When we solve kinematics problems, we use two basic equations (one for velocity and one for position) that arise directly from the definitions of velocity and acceleration. Starting with the definitions of velocity and acceleration, derive these equations using calculus and **list any assumptions that were made.**

Assuming constant acceleration

$$\underline{a = \frac{dv}{dt}} \Rightarrow \int_0^t a\,dt = \int_{v_0}^{v} dv \Rightarrow a\int_0^t dt = \int_{v_0}^{v} dv$$

$$\Rightarrow at = v - v_0$$

$$\Rightarrow \boxed{v = v_0 + at}$$

$$\underline{v = \frac{dx}{dt}} \Rightarrow \int_0^t v\,dt = \int_{x_0}^{x} dx \Rightarrow \int_0^t (v_0 + at)\,dt = \int_{x_0}^{x} dx$$

$$\Rightarrow \int_0^t v_0\,dt + \int_0^t at\,dt = \int_{x_0}^{x} dx$$

$$\Rightarrow v_0 t + \tfrac{1}{2}at^2 = x - x_0$$

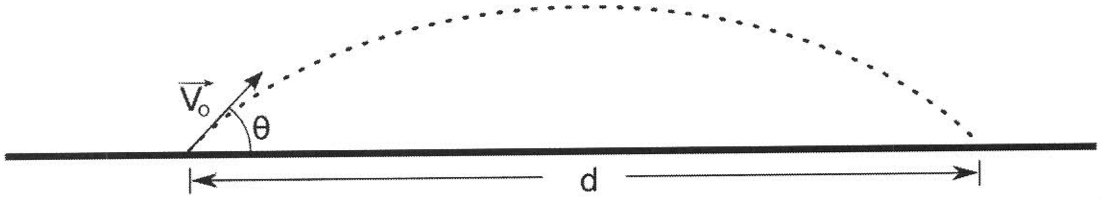
$$\Rightarrow \boxed{x = x_0 + v_0 t + \tfrac{1}{2}at^2}$$

Sample Test 1

Phys 111, Fall 2011, Section 1

2. Short questions, 4 points each.

2.1 A projectile is fired with an initial velocity $|V_O|$ at an angle θ as in the picture below.



Circle the correct expression for the x component of the projectile's velocity at the midpoint of its flight.

a) $V_x = |V_o| \sin(\theta)$

wrong trig.

$\boxed{\text{c) } V_x = |V_o| \cos(\theta)}$

b) $V_x = 0$

$V_y = 0$, not V_x

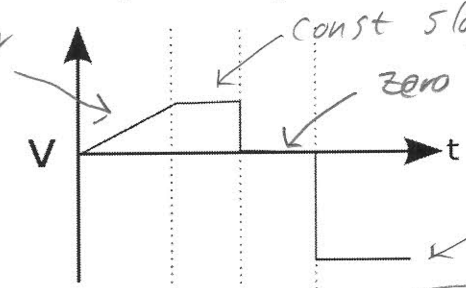
d) $V_x = \dfrac{1}{2}\dfrac{gd}{V_{oy}}$ ← not sure what that is ...

2.2) Circle the correct position versus time plot for the given velocity versus time plot.

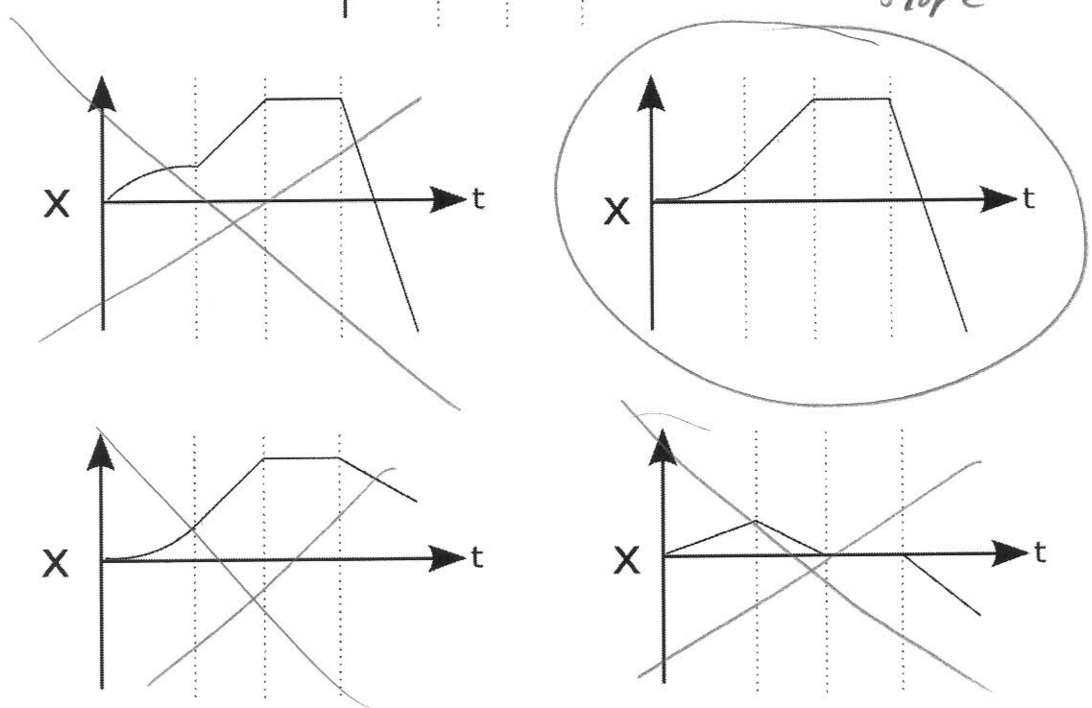
Increasing slope

Const slope (Positive)

zero slope



Large negative slope



SAMPLE TEST 1

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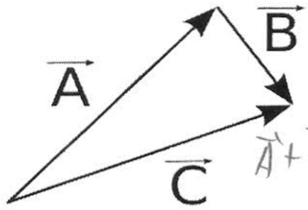
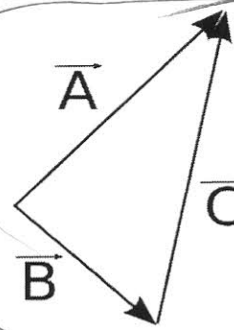
2.3 Which diagram correctly illustrates the vector equation $\boxed{A - B = C}$ $\Rightarrow \vec{A} = \vec{B} + \vec{C}$

a)



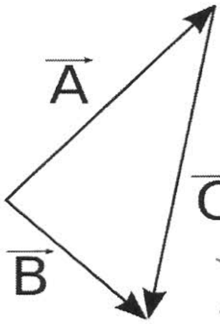
$\vec{A} + \vec{B} = \vec{C}$

b)



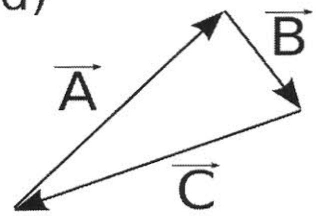
$\vec{B} + \vec{C} = \vec{A}$

c)



$\vec{A} + \vec{C} = \vec{B}$

d)



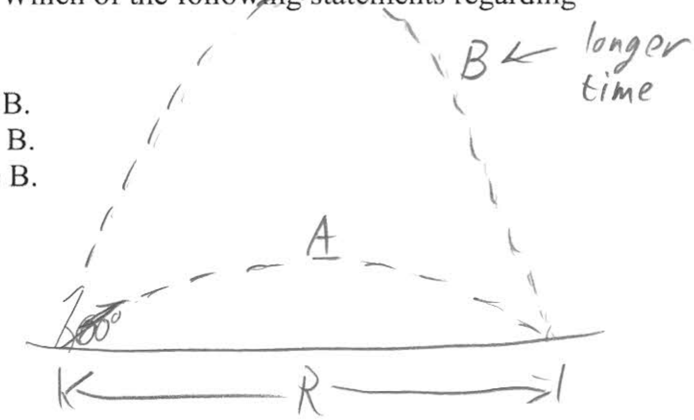
? $\vec{A} + \vec{B} + \vec{C} = 0$

2.4 If I throw a ball straight up, in the absence of air resistance, its velocity *vector* when it hits my hand is:

a) equal to the initial velocity vector
b) greater in magnitude than the initial velocity vector
c) equal in magnitude to the initial velocity vector but opposite in direction.
d) less in magnitude than the initial velocity vector

2.5 A projectile launched at an angle of 30° (projectile A) has the same range as a projectile launched with the same initial velocity at an angle of 60° (projectile B). Which of the following statements regarding their total flight time is true?

a) Projectile A has a longer flight time than Projectile B.
b) Projectile A has a the same flight time as Projectile B.
c) Projectile A has a shorter flight time than Projectile B.
d) Not enough information.



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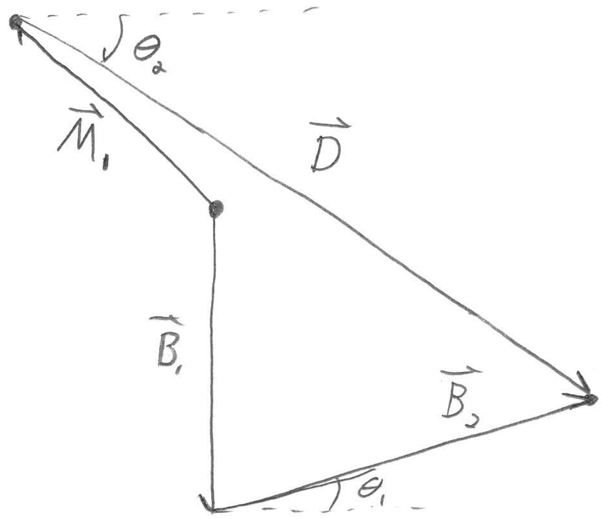
2) It's Sunday afternoon and you have just arrived at the park with your dog Bowser. Ignoring the leash law, Bowser takes off chasing rabbits and squirrels. You started out together but soon part ways. Bowser chases a rabbit due south for 25 yards and then chases a squirrel along a line 10° north of east for 30 yards. In the meantime, your leisurely stroll takes you to a point 10 yards north and 15 yards west of your starting point.

a) Find the x and y components of the displacement vector between you and Bowser.
b) Calculate the magnitude and direction of the vector you found in part a.



$\vec{B}_1 = 0\hat{\imath} - 25\hat{\jmath}$ yards

$|\vec{B}_2| = 30$ yards

$\theta = 10^\circ$

$\vec{M}_1 = -15\hat{\imath} + 10\hat{\jmath}$ yards

$D_x = ?\ ,\ D_y = ?$

$\vec{B}_1 + \vec{B}_2 = \vec{M}_1 + \vec{D} \Rightarrow \vec{D} = \vec{B}_1 + \vec{B}_2 - \vec{M}_1$

a)

x: $D_x = B_{1x} + B_{2x} - M_{1x}$

$D_x = 0 + |\vec{B}_2|\cos\theta - M_{1x}$

$D_x = (30)\cos(10) + 15 = \boxed{45\text{ yards}}$

y: $D_y = B_{1y} + B_{2y} - M_{1y}$

$= B_{1y} + |B_2|\sin\theta - M_{1y}$

$D_y = -25 + (30)\sin(10) + 10 = \boxed{-9.8\text{ yards}}$

continued ↓

Test 1 problem 2 continued

b) $|\vec{D}| = (D_x^2 + D_y^2)^{1/2}$

$= (45^2 + -9.8^2)^{1/2}$

$= \boxed{46 \text{ yards}}$

$\tan\theta_2 = \left(\frac{D_y}{D_x}\right) \Rightarrow \theta_2 = \tan^{-1}\left(\frac{D_y}{D_x}\right)$

$\theta_2 = \tan^{-1}\left(\frac{-9.8}{45}\right) = \boxed{-12^\circ}$

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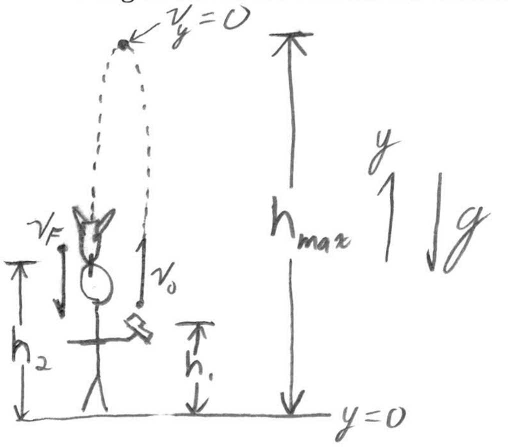
3) Wily coyote has purchased a new dart gun that he plans to use on roadrunner. Being somewhat uncoordinated he accidentally fires the gun straight up. The gun was 0.50 m above the ground when it fired, the dart reached a maximum height of 50.50 m above the ground, and Wily is 1.00 m tall. What is the darts velocity when it hits him in the head?

a) Find an expression for the Dart's INITIAL velocity. Plug in the numbers and find a numerical value.
b) Using the initial velocity, find an expression for the dart's FINAL velocity as it hits him in the head. Plug in numbers and find a numerical value.



$h_1 = 0.50 m$

$h_2 = 1.00 m$

$h_{max} = 50.50 m$

$V_0 = ?, \quad V_F = ?$

a) We can find the dart's initial velocity by knowing it's maximum height and realizing that $V_y = 0$ at that point.

$$y_F = y_0 + V_{0y} t + \tfrac{1}{2} a_y t^2 \qquad V_y = V_{0y} + a_y t$$

$$h_{max} = h_1 + V_{0y} t - \tfrac{1}{2} g t^2 \qquad 0 = V_{0y} - g t$$

$$h_{max} = h_1 + V_{0y} \frac{V_{0y}}{g} - \tfrac{1}{2} \cancel{g} \frac{V_{0y}^2}{g^{\cancel{2}}} \qquad \Rightarrow t = \frac{V_{0y}}{g}$$

Plug into position eq.

$$\Rightarrow h_{max} = h_1 + \frac{V_{0y}^2}{g} - \frac{1}{2}\frac{V_{0y}^2}{g}$$

$$\Rightarrow h_{max} = h_1 + \frac{1}{2}\frac{V_{0y}^2}{g} \Rightarrow \boxed{V_{0y} = \left[2g\left(h_{max} - h_1\right)\right]^{1/2}} = \left[2(9.8)(50.5 - 0.5)\right]^{1/2}$$

$$\boxed{V_{0y} = 31.3 \ m/s}$$

continued ↓

b) Now we can assume we know V_{oy} and solve for V_F

$$V_F = V_{oy} + at \qquad y = y_0 + V_{oy}t + \tfrac{1}{2}at^2$$

$$① \; V_F = V_{oy} - gt \qquad ② \; h_2 = h_1 + V_{oy}t - \tfrac{1}{2}gt^2$$

awe rats... quadratic in t...

Best to just buck up!

Rewrite ② and apply the quadratic formula.

From ②: $0 = (h_1 - h_2) + V_{oy}t - \tfrac{1}{2}gt^2$

$$t = \frac{+V_{oy} \pm \sqrt{V_{oy}^2 + 2(h_1 - h_2)g}}{+g}$$

In this case, let's find numbers for t

$$t = \frac{1}{9.8}\left[31.3 \pm \left((31.3)^2 + (2)(0.5 - 1.0)(9.8)\right)^{1/2}\right]$$

$t = 1.6 \times 10^{-2}$, $\boxed{6.37 \text{ seconds}}$

Passing his head on the way <u>up</u>

on the way back down.

So! $V_F = 31.3 - (9.8)(6.37)$

$$\boxed{V_F = -31.1 \text{ m/s}}$$

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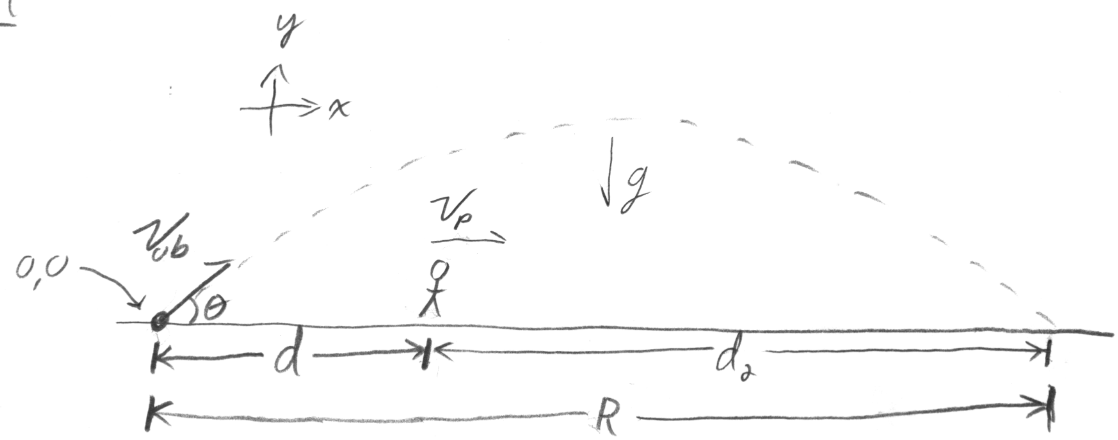
5) A soccer ball is kicked with an initial speed of v_0 at an upward angle of θ. A player a distance d away in the direction of the kick starts running at the same moment.

What must her speed be to meet the ball and catch it just before it hits the ground?

Given	Want
v_{ob}	v_p
θ	
d	



Ball

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

① $\boxed{R = 0 + v_{ob}\cos\theta\, t + 0}$

$$y = y_0 + v_{0y}t + \tfrac{1}{2}at^2$$

$$0 = 0 + v_{ob}\sin\theta\, t - \tfrac{1}{2}gt^2$$

$\Rightarrow \boxed{t = \frac{1}{g}2v_{ob}\sin\theta}$ ②

player

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

$R = d + v_p t \Rightarrow \boxed{v_p = \frac{R-d}{t}}$ ③

Substitute: ② → ①

④ $\boxed{R = \frac{1}{g}2v_{ob}^2\sin\theta\cos\theta}$

continued

↓

Extra Space for #5

substitute (2) and (4) into (3)

$$v_p = \frac{\frac{1}{g} 2 v_{ob}^2 \sin\theta \cos\theta - d}{\frac{1}{g} 2 v_{ob} \sin\theta}$$

$$\Rightarrow \boxed{v_p = v_{ob}\cos\theta - \frac{gd}{2 v_{ob} \sin\theta}}$$