SAMPLE TEST 1
PHYS 111 FALL 2008

Name: _____

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 YOUR ANSWER.

Total Score: _____

1)

a) (15pts) We commonly use two equations that arise directly from the definitions of velocity and acceleration. Derive them starting with the definitions of velocity and acceleration using calculus and **list any assumptions that were made.**

assume constant acceleration

$a = \frac{dv}{dt}$,

$\int dv = \int a\,dt$

$v = at + v_0$

$\frac{dx}{dt} = v$

$\int dx = \int v\,dt$

$\int dx = \int (v_0 + at)\,dt$

$x = v_0 t + \frac{1}{2}at^2 + x_0$

b) (5 pts) Write down (or derive using basic trigonometric reltionships) the four relationships for conversion of a vector between Polar and Cartesian coordinates.

$\vec{A} = (A_x\hat{x} + A_y\hat{y})$

$A_x = |\vec{A}|\cos\theta$

$A_y = |\vec{A}|\sin\theta$

$|\vec{A}| = (A_x^2 + A_y^2)^{1/2}$

$\theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$

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2) Consider 3 vectors. Vector **A** is given by $4.00i + A_y j$, vector **B** has a magnitude of 6.00 and is pointing at an angle of 35.0° with respect to the x axis, and vector **C** is given by $C_x i + 7.00j$.

a. (10pts) Assuming that **A** + **B** = **C**, find the missing components A_y and C_x.
b. (5pts) Find the magnitude of **C**?
c. (5pts) Find the angle of **C** makes with respect to the x – axis?

a) $A_x + B_x = +C_x$

$4.0 + 6\cos 35 = +C_x$

$\boxed{C_x = 8.9}$

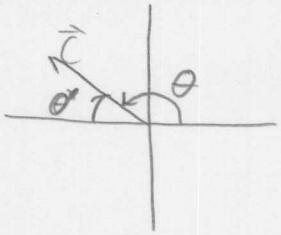
$A_y + B_y = C_y$

$A_y + 6\sin 35 = 7.0$

$\boxed{A_y = 3.56}$

b) $\boxed{|\vec{C}| = (8.9^2 + 7.0^2)^{1/2} = 11.3}$

c)



$\theta' = \tan^{-1}\left(\frac{7}{8.9}\right) = 38°$

$\boxed{\theta = 180 - \theta' = 142°}$

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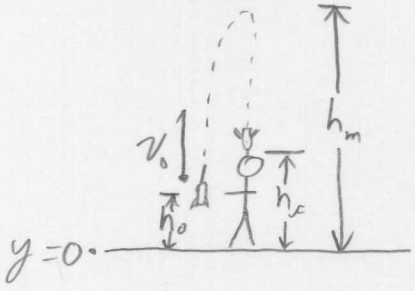
3 20pts) Wily coyote has purchased a new dart gun that he plans to use on roadrunner. Being somewhat uncoordinated he accidentally fires the gun straight up.. The gun was 0.50 m above the ground when it fired, the dart reached a maximum height of 50.50 m above the ground, and Wily is 1.00 m tall. What is the darts velocity when it hits him in the head?

Find the Dart's INITIAL velocity.
Using the initial velocity, find the dart's FINAL velocity as it hits him in the head.

a. (5pts) Draw a sketch of the situation showing ALL relevant variables and define the coordinate system.
b. (13pts) Using the kinematics equations, derive an expression for the WANTED term (the velocity of the dart) in terms of the GIVEN variables defined in part a.
c. (2pts) Using your expression from part b and numbers given in the problem statement, calculate the velocity of the dart.



GIVEN

$h_0 = 0.5\,m$

$h_m = 50.5\,m$

$h_f = 1.0\,m$

WANT

$v_0 = ?$

$v_f = ?$

Find v_0 by using the height h_m.

at $h = h_m$, $v = 0$

$y_f = y_0 + v_0 t + \frac{1}{2}at^2$

$h_m = h_0 + v_0 t - \frac{1}{2}gt^2$

$v_f = v_0 + at$

$0 = v_0 - gt$

$t = \frac{v_0}{g}$

$h_m - h_0 = \frac{v_0^2}{g} - \frac{1}{2}\frac{v_0^2}{g}$

$h_m - h_0 = \frac{1}{2}\frac{v_0^2}{g} \Rightarrow \boxed{v_0 = (2g(h_m - h_0))^{1/2}}$

$\boxed{v_0 = (2(9.8)(50))^{1/2} = 31.3\ m/s}$

Now, with v_0 in hand, Find v_f

$$y_f = y_0 + v_0 t + \tfrac{1}{2} a t^2 \qquad v_f = v_0 + at$$

$$h_f = h_0 + v_0 t - \tfrac{1}{2} g t^2 \qquad v_f = v_0 - gt$$

$$t = \frac{v_0 - v_f}{g}$$

$$h_f - h_0 = \frac{v_0(v_0 - v_f)}{g} - \frac{1}{2} g \frac{(v_0 - v_f)^2}{g^2}$$

$$= \frac{1}{g}\left[v_0^2 - v_0 v_f - \frac{1}{2}\left(v_0^2 - 2 v_0 v_f + v_f^2\right)\right]$$

$$= \frac{1}{g}\left[v_0^2 - \cancel{v_0 v_f} - \frac{1}{2} v_0^2 + \cancel{v_0 v_f} - \frac{1}{2} v_f^2\right]$$

$$h_f - h_0 = \frac{1}{2g}\left(v_0^2 - v_f^2\right)$$

$$\boxed{v_f = \left[v_0^2 - 2g(h_f - h_0)\right]^{1/2}}$$

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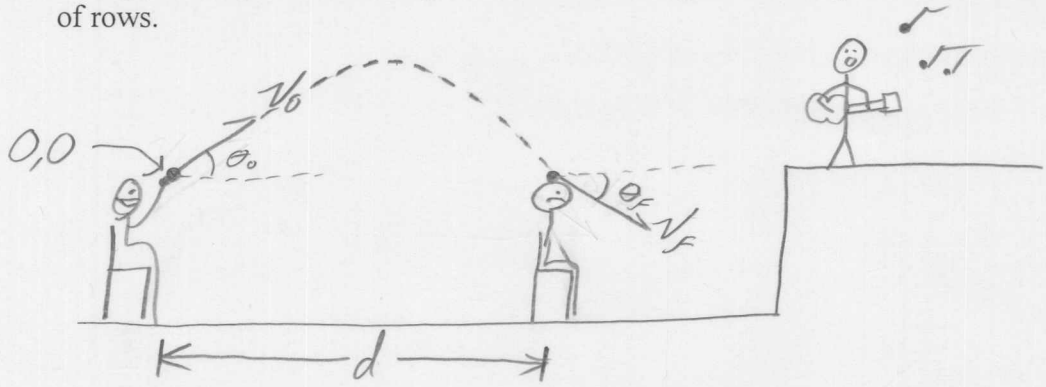
4 20pts) You are sitting in the middle of a field listening to a concert when a water balloon hits you from behind at a speed of 14 m/s coming in at an angle of -60° as measured off of the x axis. If the rows are separated by 1.5 m, how many rows behind you are the vandals sitting?

a. (5pts) Draw a sketch of the situation showing ALL relevant variables and define the coordinate system.
b. (13pts) Using the kinematics equations, derive an expression for the number of rows in terms of GIVEN variables defined in part a.
c. (2pts) Using your expression from part b and numbers given in the problem statement, calculate the number of rows.



GIVEN
$|\vec{v}_f| = 14\ m/s$
$\theta = -60°$
$r = 1.5\ m/row$

want
d in rows

$x_f = x_0 + v_{ox}t + \frac{1}{2}a_x t^2$

$d = 0 + v_{ox}t + 0$

$y_f = y_0 + v_{oy}t + \frac{1}{2}a_y t^2$

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

hmm... use velocity eqs

$v_{fx} = v_{ox} + at$

$|\vec{v}_f|\cos\theta_f = v_{ox} + 0$

$d = |\vec{v}_f|\cos\theta_f t$

$v_{fy} = v_{oy} + at$

$|\vec{v}_f|\sin\theta = v_{oy} - gt$

$v_{oy} = |\vec{v}_f|\sin\theta + gt$

$0 = |\vec{v}_f|\sin\theta + gt - \frac{1}{2}gt$

$0 = |\vec{v}_f|\sin\theta + \frac{1}{2}gt$

Continued ↓

Solve for t

$$t = -\frac{2|\vec{v}_0|\sin\theta}{g}$$

$$d = -\frac{2|\vec{v}_0|^2 \sin\theta\cos\theta}{g}$$

don't freak out!
Remember $\theta = -60$ so $\sin\theta$ will be negative and it will cancel the negative

$$d = -\frac{2(14)^2 \sin(-60)\cos(-60)}{9.8}$$

$$= 17.3\,m \cdot \frac{1}{1.5}\,\text{rows}/m = \boxed{11.5\,\text{rows}}$$