Name ______________________________ Seat Number ______________

PHYSICS 2110
Exam I – Spring 2010

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	8:00 AM
Ayik	10:10 AM
Murdock	11:15 AM

YOU MUST SHOW YOUR WORK **AND** EXPLAIN YOUR REASONING TO RECEIVE CREDIT. ALL CELL PHONES AND OTHER COMMUNICATION DEVICES MUST BE TURNED OFF AND STORED OUT OF SIGHT. NO EXTRA PAPERS ARE ALLOWED OTHER THAN THE PROVIDED FORMULA SHEET.

Free-body diagrams are ***required*** for problems involving forces.

PROBLEM	POINT VALUE	YOUR SCORE
1	6	
2	10	
3	17	
4	5	
5	8	
6	12	
7	8	
8	8	
9	14	
10	12	
TOTAL	100	

1. Express the quantity $1.054\times10^{-34}\,\frac{kg\cdot m^2}{s}$ in units of $\frac{g\cdot cm^2}{s}$. (6 pts)

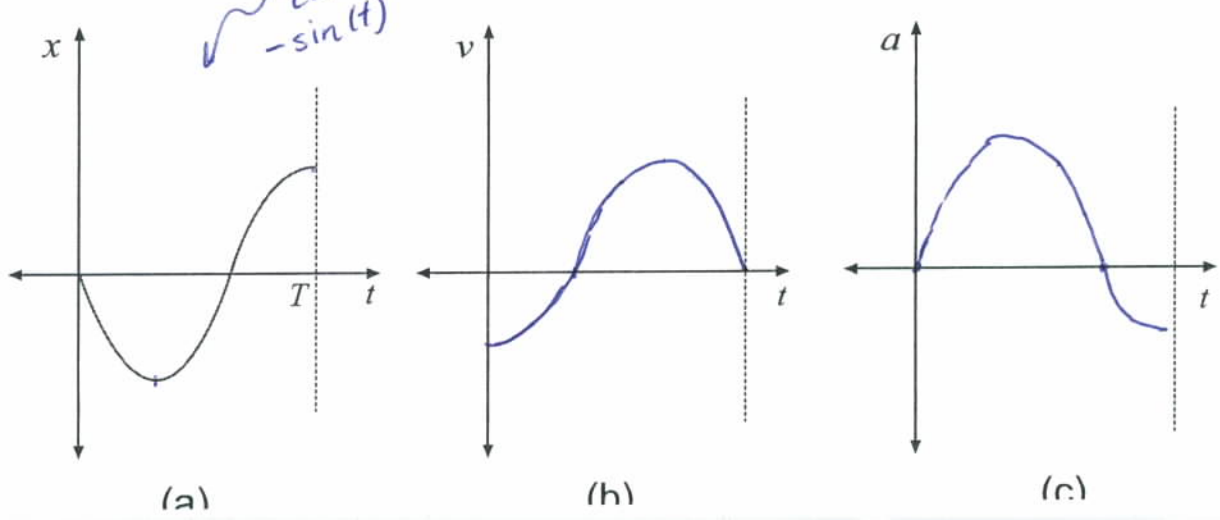
$$= 1.054\times10^{-34}\,\frac{kg\,m^2}{s}\cdot\left(\frac{1000\,g}{kg}\right)\cdot\left(\frac{100\,cm}{m}\right)^2$$

$$= 1.054\times10^{-27}\,\frac{g\,cm^2}{s}$$

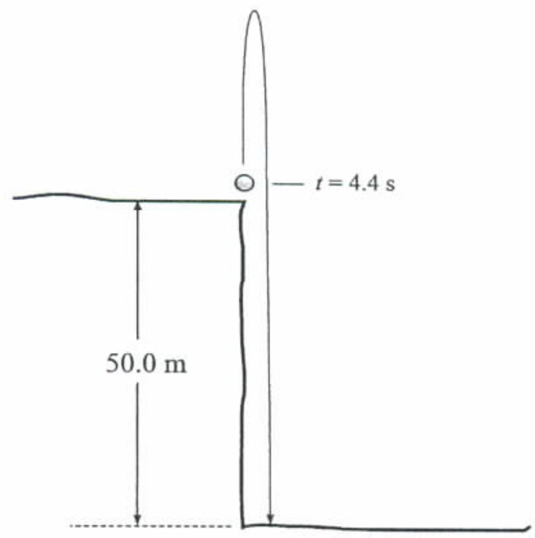
2. A particle moves along the x axis; the plot of x vs. t is given in (a) below.

In the spaces provided, make sketches of the curves for v vs t and a vs t for the same time interval as the first graph. (You just need to give the *appearance* of these curves.) (10pts)

sim to curve of −sin(t)



3. A ball is flung straight upward at the edge of a cliff; it returns to its starting height 4.4 seconds later and then continues to fall, striking the ground 50.0 m below the starting point. Ignore air resistance!



a) What was the initial speed of the ball? (5 pts)

With $y_0 = 0$,

$y(4.4s) = 0 = v_0(4.4s) - \frac{1}{2}g(4.4s)^2$

Solve for v_0:

$v_0 = \frac{g}{2}(4.4s) = \boxed{21.6\,\frac{m}{s}}$

b) How long after the toss did it strike the ground? (6 pts)

Solve for t when $y = -50\,m$

$-50m = (21.6\frac{m}{s})t - \frac{1}{2}(9.8\frac{m}{s^2})t^2 \Longrightarrow 4.9t^2 - 21.6t - 50 = 0$

$t = \frac{21.6 \pm \sqrt{(21.6)^2 + 4(4.9)(50)}}{(9.8)} = 6.08\,s$ or $-1.68\,s \longrightarrow \boxed{t = 6.08\,s}$

c) What was the speed of the ball when it struck the ground? (6 pts)

$v^2 = v_0^2 + 2a(y - y_0) \longrightarrow v^2 = (21.6\frac{m}{s})^2 + 2(-9.8\frac{m}{s^2})(-50m)$

$\longrightarrow v = -38.0\frac{m}{s} \longrightarrow \boxed{|v| = 38.0\,\frac{m}{s}}$

4. A bow hunter shoots an arrow almost straight up (at an angle of 85° above horizontal) at a goose flying overhead. However, he misses, and the arrow lands 30.2 m away after being in the air for 15.0 s. What was the acceleration of the arrow at its highest point? (5 pts)

$\vec{g}$: $9.80\,m/s^2$ downward

5. A sprinter runs at 9.2 m/s around a circular track with an acceleration with magnitude 3.8 m/s^2.

(a) What is the radius of the track? (4 pts)

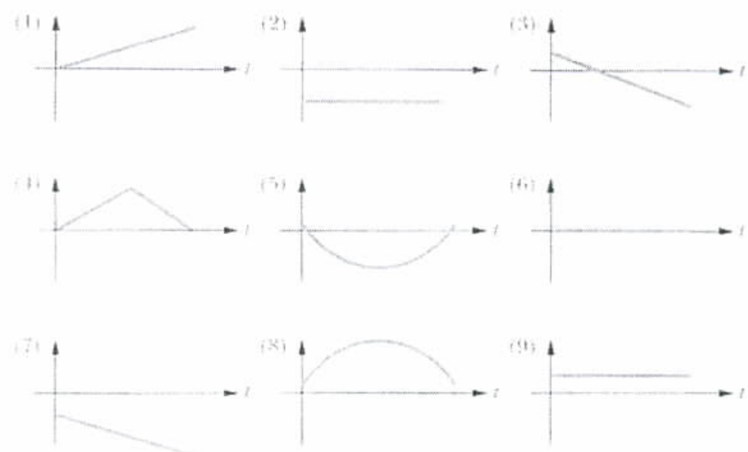
$a = \frac{v^2}{r} \Rightarrow r = \frac{v^2}{a} = \frac{(9.2\,m/s)^2}{3.8\,m/s^2} = 22\,m$

(b) How long does it take the sprinter to complete one lap? (4 pts)

$T = \frac{d}{v} = \frac{2\pi r}{v} = \frac{2\pi(22\,m)}{9.2\,m/s} = 15\,s$

6. A popgun is angled so that it shoots a small dense ball through the air as shown. Note that the directions of positive x- and y-coordinates are also indicated on the figure.

Various graphs are shown here. Note that the horizontal axis is time in each case.



For each quantity listed here, indicate the letter of the graph that ***could*** provide a correct description of the ball's motion. If none of the graphs could work, write N. (2 pts each)

(a) y 8 $\quad y = y_0 + V_{0y} t + \frac{1}{2} a_y t^2 \quad a_y < 0,\ V_{0y} > 0$

(b) x 3 $\quad x = x_0 + V_{0x} t + \frac{1}{2} a_x t^2 \quad V_{0x} < 0,\ a_x = 0,\ x_0 > 0$

(c) v_x 2 $\quad V_x = V_{0x} + a_x t \quad a_x = 0,\ V_{0x} < 0$

(d) v_y 3 $\quad V_y = V_{0y} + a_y t \quad a_y < 0,\ V_{0y} > 0$

(e) a_x 6 $\quad a_x = 0$

(f) a_y 2 $\quad a_y = \text{const} < 0$

7. Some rental cars have a GPS unit installed. This allows the rental car company both to check where you are at all times and to know your speed at any time. One of these rental cars is driven by an employee in the company's lot. During the time interval from t = 0 s to t = 10 s, the position vector as a function of time is

$$\vec{r}(t) = [24.4m - (12.3m/s)t + (2.43m/s^2)t^2]\hat{\imath} + [74.4m + (1.80m/s^2)t^2 - (0.130m/s^3)t^3]\hat{\jmath}$$

What is the speed of this car at t = 5.20 s? (8 pts)

$V = |\vec{V}|$

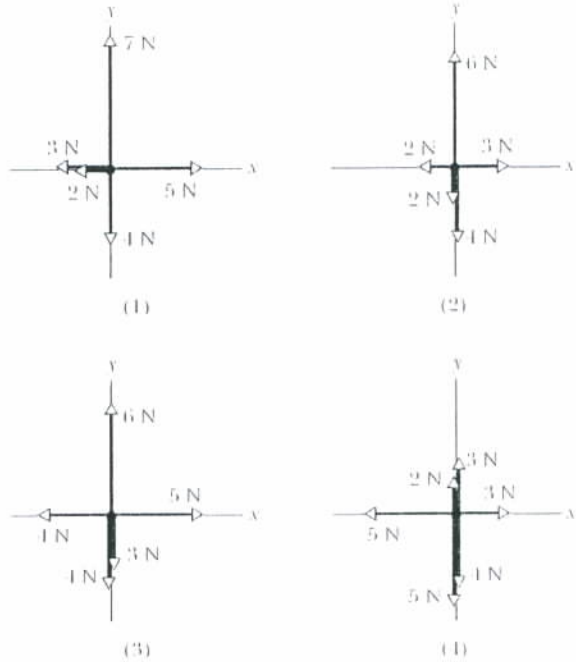
$\vec{V} = \frac{d\vec{r}}{dt} = [-12.3m/s + 4.86m/s^2\, t]\hat{i} + [3.60m/s^2 t - .390\, m/s^3 t^2]\hat{j}$

$\vec{V}(t=5.2s) = [12.9\hat{i} + 8.17\hat{j}]\, m/s$

$V = \sqrt{(12.9m/s)^2 + (8.2m/s^2)^2} = 15.3\ m/s$

8.

(a) The figure gives free-body diagrams for four situations in which an object is pulled by several forces across a frictionless floor, as seen from overhead. In each situation, state the direction of acceleration by naming either a quadrant or a direction along an axis. (4 pts)



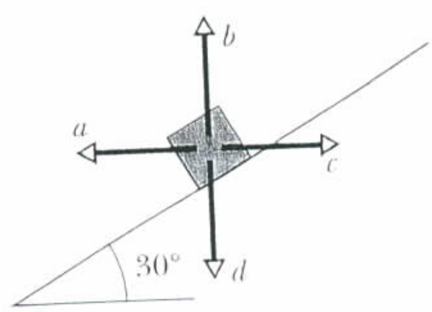
1 → +y

2 → +x

3 → 4. quadrant

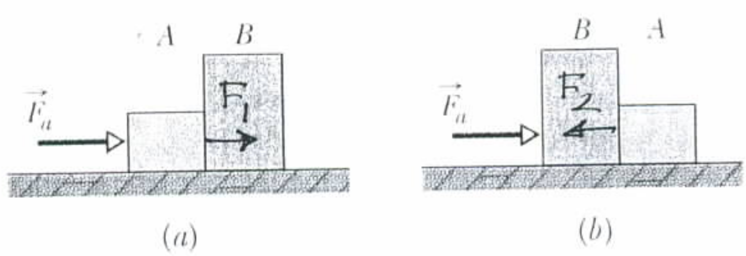
4 → 3. quadrant

(b) The figure shows four choices for direction of a force of magnitude F to be applied to a block on an inclined plane. The directions are either horizontal or vertical. Rank the choices according to the magnitude of the normal force on the block from the plane, greatest first. For choices a and b, the force is not enough to lift the block off the plane. (4 pts)



d, c, a, b

9. In figure (a), a constant horizontal force $\vec{F}_a$ is applied to block A. Block A pushes against block B with a 20.0 N force directed horizontally to the right. In figure (b), the same force $\vec{F}_a$ is applied to block B. Now block A pushes on block B with a 10.0 N force directed horizontally to the left. The blocks have a combined mass of 12.0 kg.



(a) Find the magnitude of the acceleration of the blocks. (8 pts)

$F_1 = 20 = m_B a$

$-F_2 = 10 = m_A a$

$20 + 10 = (m_A + m_B) a = 12 a$

$a = \frac{30}{12} = \boxed{2.50 \, m/s^2}$

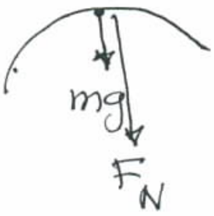
(b) What is the magnitude of the force $\vec{F}_a$? (6 pts)

$F_a = (m_A + m_B) a = 12 * 2.5$

$\boxed{F_a = 30 \text{ N}}$

10. In a 1901 circus performance, Allo "Dare Devil" Diavolo introduced a stunt of riding a bicycle in a loop-the-loop. The combined mass of Diavolo and the bicycle is 50.0 kg. The loop is a circle with a radius R = 5.00 m.

(a) If the speed of Diavolo at the top of the loop is 10.0 m/s, what is the normal force acting on the bicycle? (6 pts)



$$F_N + mg = m\frac{v^2}{r}$$

$$F_N = -mg + m\frac{v^2}{r} = -50*9.8 + 50*\frac{(10)^2}{5}$$

$$\boxed{F_N = 510.\ N}$$

(b) What is the least speed Diavolo could have at the top of the loop to remain in contact with the loop? (6 pts)

$$V_c = \sqrt{rg}$$

$$V_c = \sqrt{5 \times 9.8} = \boxed{7.00\ m/s}$$