PHYSICS 2110 – EXAM #1
February 16, 2012

KEY

SEAT NO.______________ NAME (PRINT)______________________

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. STANDARD SCIENTIFIC CALCULATORS MAY BE USED.

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

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	8:00 AM
Ayik	10:10 AM, 11:15 AM
Murdock	12:20 PM

PROBLEM	POINT VALUE	YOUR SCORE
1	7	
2	8	
3	9	
4	8	
5	18	
6	7	
7	8	
8	10	
9	15	
10	10	
TOTAL	100	

1. Antarctica is roughly a semicircular shape with radius R=2000 km. Average thickness of its ice cover is H=3000 m. Approximately how many cubic centimeters of ice does Antarctica contain? Ignore the curvature of the Earth.

In order to get credit, you must give your answer in scientific notation with two significant figures. (7 pts)

$$V = \left(\frac{1}{2}\pi R^2\right)(H) = \frac{1}{2}\, 3.14 \times (2\times10^8)^2 \times (3\times10^5)$$

$$V = 18.84\times10^{21} = \boxed{1.9\times10^{22}\,\text{cm}^3}$$

2. In each of the situations below, indicate the direction of both the velocity and acceleration vectors at the time in question. (2 pts each)

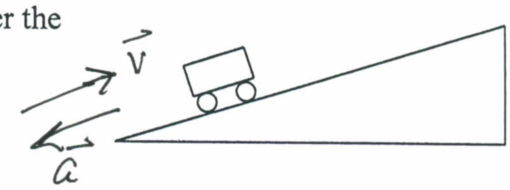
(a) An elevator is at rest and then starts moving upward. Consider the time just after it starts moving.

$\uparrow \vec{v} \qquad \uparrow \vec{a}$

(b) An elevator is at rest and then starts moving downward. Consider the time just after it starts moving.

$\downarrow \vec{v} \qquad \downarrow \vec{a}$

(c) A car is coasting (engine off) up a hill. Consider the time just before it reaches its highest point.



(d) Now consider the time just after the car reaches its highest point.

$\swarrow \vec{v}$

$\swarrow \vec{a}$

3. You drop a rock over the edge of a cliff from a height h above the ground at the bottom of the cliff. At a time t later, your friend throws over a rock downward from the same height with speed v_0. Both rocks hit the ground at the same time. Find the time t (your answer should be in terms of v_0, g, and h). (9 pts)

$\uparrow y$

1st rock: $V_{y0} = 0,\ a_y = -g,\ y_0 = 0$ time to ground $= t_1$

$$-h = 0 + 0(t_1) - \frac{1}{2} g t_1^2 \Rightarrow t_1 = \sqrt{\frac{2h}{g}}$$

2nd rock: $V_{y0} = -V_0,\ a_y = -g,\ y_0 = 0$ time to ground $= t_2$

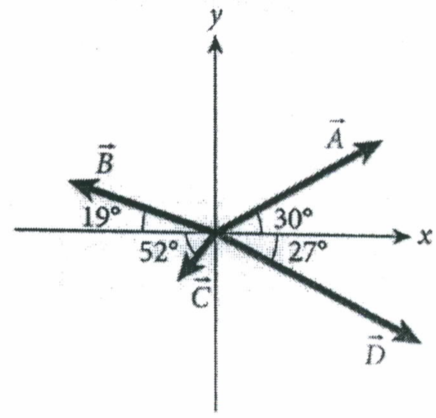
$$-h = 0 - v_0 t_2 - \frac{1}{2} g t_2^2 \Rightarrow \frac{1}{2} g t_2^2 + v_0 t_2 - h = 0$$ Apply quadratic formula:

$$\Rightarrow t_2 = \frac{-V_0 \pm \sqrt{V_0^2 + 2gh}}{g}$$ Only "+" sign gives positive t_2

$$\text{So } t_2 = \frac{-V_0 + \sqrt{V_0^2 + 2gh}}{g}$$

$$\text{Then } t = t_1 - t_2 = \sqrt{\frac{2h}{g}} - \frac{-V_0 + \sqrt{V_0^2 + 2gh}}{g}$$

4. The figure at the right shows 4 vectors with magnitudes given by A = 75, B = 59, C = 25, and D = 91. Their directions are indicated on the figure.



a) Write $\vec{C}$ in unit vector notation (4 pts)

$$\vec{C} = \left[-25\cos 52^\circ\right]\hat{i} + \left[-25\sin 52^\circ\,\hat{j}\right]$$

$$= -15\hat{i} - 20\hat{j}$$

b) Find the magnitude and direction of the vector $\vec{A} - 2.1\vec{D}$. (4 pts)

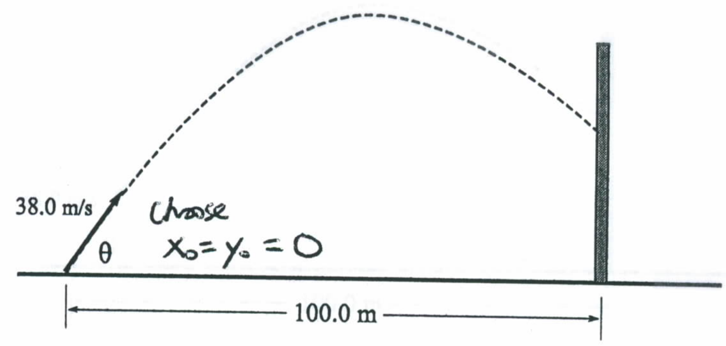
$$\vec{A} - 2.1\vec{D} = \left[75\cos 30^\circ\right]\hat{i} + \left[75\sin 30^\circ\right]\hat{j} - 2.1\left[91\cos 27^\circ\,\hat{i} - 91\sin 27^\circ\,\hat{j}\right]$$

$$= -110\hat{i} + 120\hat{j}$$

$$|\vec{A} - 2.1\vec{D}| = \sqrt{(-110)^2 + (120)^2} = 160$$

$\vec{A} - 2.1\vec{D}$ lies in 2nd quadrant and makes angle $\tan\phi = \dfrac{A_y - 2.1D_y}{A_x - 2.1D_x} \Rightarrow \phi = 50^\circ$ with negative x-axis

5. A projectile is fired from ground level toward a large wall which is 100.0 m from the point of firing. The projectile is fired at a speed of 38.0 m/s and strikes the wall 3.46 s later!



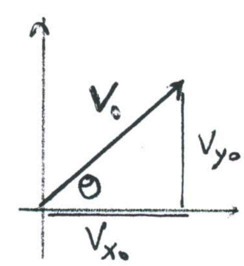
a) At what angle was the projectile fired? (6 pts)

x-eqn of motion is

$x = V_{x_0} t$ At impact $\rightarrow$ $100.0\,\text{m} = V_{x_0}(3.46\,\text{s})$

$\Longrightarrow V_{x_0} = 28.9\,\frac{\text{m}}{\text{s}}$

$\cos\theta = \dfrac{V_{x_0}}{V_0} = 0.761 \longrightarrow \theta = \boxed{40.5^\circ}$



b) At what height did it strike the wall? (5 pts)

$V_{y_0} = V_0 \sin\theta = (38.0\,\frac{\text{m}}{\text{s}})\sin 40.5^\circ = 24.7\,\frac{\text{m}}{\text{s}}$

what is y at $t = 3.46$ s ?

$y = V_{y_0} t - \frac{1}{2} g t^2 = (24.7\,\frac{\text{m}}{\text{s}})(3.46\,\text{s}) - \frac{1}{2}(9.80\,\frac{\text{m}}{\text{s}^2})(3.46\,\text{s})^2$

$= \boxed{26.7\,\text{m}}$

(5, continued)

c) What was the speed of the projectile when it struck the wall? (5 pts)

What were V_x and V_y when it hit (3.46 s)?

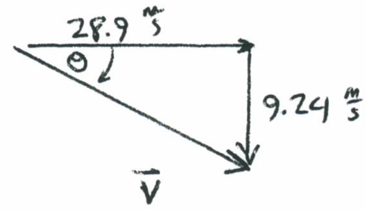
$$V_x = V_{x0} = 28.9\ \tfrac{m}{s}$$

$$V_y = V_{y0} + a_y t = (24.7)\tfrac{m}{s} - (9.80\tfrac{m}{s^2})(3.46\,s) = -9.24\ \tfrac{m}{s}$$

$$V = \sqrt{V_x^2 + V_y^2} = \sqrt{(28.9\tfrac{m}{s})^2 + (-9.24\tfrac{m}{s})^2} = \boxed{30.3\ \tfrac{m}{s}}$$

d) What was the direction of the projectile's motion when it struck the wall? (2 pts)

Velocity vector at $t = 3.46\,s$ has direction:

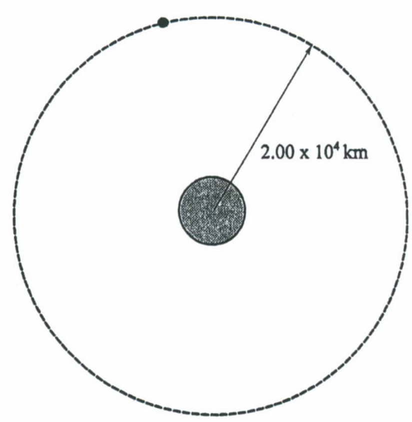


$$\tan\theta = \frac{-9.24}{28.9} = -0.320$$

$$\rightarrow \boxed{\theta = -17.7^\circ}$$

That is, 17.7° degrees below the horizontal

6. A satellite goes around the Earth in a circular orbit at constant speed at a distance of 2.000×10^4 km from the Earth's center. The magnitude of the satellite's acceleration is $1.00\ \frac{m}{s^2}$.



a) What is the speed of the satellite? (4 pts)

$$a = a_c = \frac{v^2}{r} \Rightarrow v^2 = ra$$

$$\rightarrow v^2 = ra = (2.00\times10^7 m)(1.00\ \tfrac{m}{s^2})$$

$$= 2.00\times10^7\ \tfrac{m^2}{s^2}$$

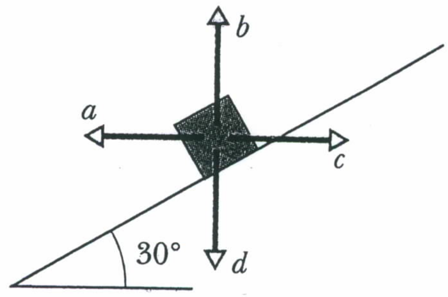
$$v = \boxed{4.47\times10^3\ \tfrac{m}{s}}$$

b) How long does it take the satellite to make one complete revolution? (3 pts)

$$v = \frac{2\pi r}{T} \qquad T = \frac{2\pi r}{v}$$

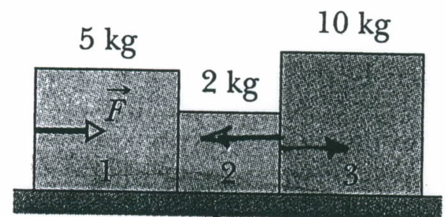
$$T = \frac{2\pi(2.00\times10^7 m)}{4.47\times10^3\ \tfrac{m}{s}} = \boxed{2.81\times10^4 s} = \boxed{7.8\ h}$$

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



$\boxed{d, c, a, b}$

b) The figure shows three blocks being pushed across a frictionless floor by a horizontal force $\vec{F}$. The common acceleration of the blocks is $\vec{a} = 2.0\hat{i}\ m/s^2$. What are the magnitude and direction of the force $\vec{F}_{23}$ on block 2 from block 3? (4 pts)

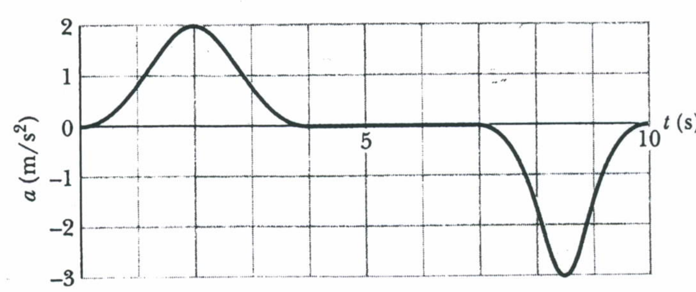


$\vec{F}_{23} = -\vec{F}_{32}$

$\vec{F}_{32} = 10\vec{a} = 20.0\hat{i}\ N$

$\vec{F}_{23} = \boxed{-20.0\hat{i}\ N}$

8. A 50.0 kg passenger rides in an elevator that starts from rest on the ground floor and rises to the top floor. The figure shows the acceleration of the elevator as a function of time. Positive values mean that the acceleration is directed upward. Determine



a) The direction and magnitude of the force on the passenger from the floor when the force has its maximum magnitude. (5 pts)

$F_N - mg = ma$

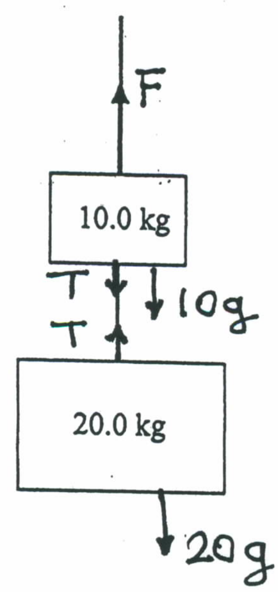
$F_N = m(g+a) = 50(9.8+2.0) = \boxed{590\ N}\ \uparrow$

b) The direction and magnitude of the force on the passenger from the floor when the force has its minimum magnitude. (5pts)

$F_N - mg = -ma$

$F_N = m(g-a) = 50(9.8-3.0) = \boxed{340N}\ \uparrow$

9. Two masses (10.0 kg and 20.0 kg) are connected by a string and are pulled upwards with a force F by a string connected to the top mass, as shown. The tension in the string connecting the masses is T= 200.0 N.



a) What is the magnitude of the pulling force F of the top string ? (10 pts)

$$F - 10g - T = 10a$$

$$T - 20g = 20a \rightarrow a = \frac{T-20g}{20}$$

$$F - 10g - T = \frac{T}{2} - 10g$$

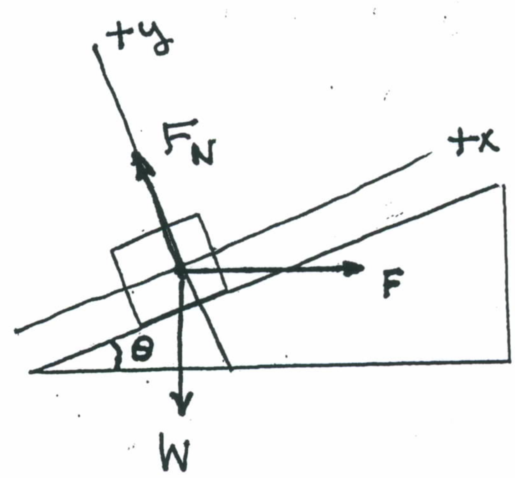
$$F = \frac{3}{2}T = \boxed{300\ N}$$

b) Under the conditions of part (a), what is the magnitude of the acceleration of the masses? (5 pts)

$$200 - 20 \times 9.8 = 20a$$

$$a = \frac{200-196}{20} = \boxed{0.2\ m/s^2}$$

10. A crate of mass $m = 10.0kg$ is pushed at a constant speed up a frictionless ramp by a horizontal force $\vec{F}$. The angle that the ramp makes with horizontal is θ.



a) Calculate the magnitude F of the pushing force in terms of the angle θ. (5 pts)

$$\Sigma F_x = F\cos\theta - mg\sin\theta = 0$$

$$F = mg\frac{\sin\theta}{\cos\theta} = \boxed{98\tan\theta\ N}$$

b) Calculate the magnitude of the force on the crate from the ramp in terms of the angle θ. (5 pts)

$$\Sigma F_y = F_N - mg\cos\theta - F\sin\theta = 0$$

$$F_N = mg\cos\theta + mg\frac{\sin\theta}{\cos\theta}\sin\theta$$

$$F_N = mg\left(\frac{\cos^2\theta + \sin^2\theta}{\cos\theta}\right) = \boxed{\frac{98}{\cos\theta}\ N}$$