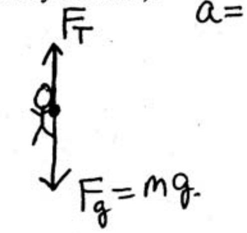
General Physics I (PHYS 203) Fall 2006 **Name:**________________________

Exam 2: October 17, 2006

Questions and Problems: Provide clear and logical answers to each of the following questions. In question 1 answer 3 of the 4 parts (a-d). Where calculations are required, neatly show all work. For full credit, problems that require the application of Newton's Laws must include a Free Body Diagram and systematic and clear labeling of the forces and their components. Be sure that your answers have the correct units. If you continue your work on another sheet of paper, be sure that it is clearly labeled.

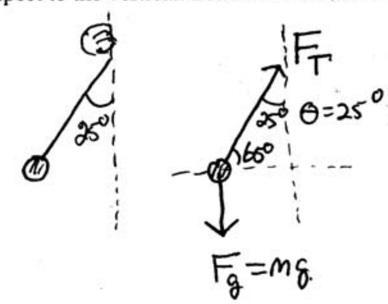
1a (15 points) An 85 kg Coast Guard rescuer is being lowered by an attached cable from a helicopter to the water. Over the first two seconds that they are being lowered their velocity changes from rest to 5.6 m/s downward. Determine the tension in the cable (i.e., the force on the person by the cable).

$$a = \frac{V_f - V_i}{t} = \frac{-5.6\,m/s - 0\,m/s}{2\,s} = -2.8\,m/s^2$$



$$\Sigma F_y = m\,a_y$$
$$F_T - mg = m\,a_y$$
$$F_T = m\,(g + a_y) = 85\,kg\,(9.8\,m/s^2 - 2.8\,m/s^2)$$
$$F_T = 595\,N$$

1b (15 points) Suppose that your are sitting on a plane and holding a string from which a bob is suspended. As the plane accelerates down the runway, the string makes an angle of 25° with respect to the vertical. Estimate the acceleration of the plane.



$$\Sigma F_y = 0$$
$$\therefore\ F_T \cos(25) = mg$$
$$F_T = \frac{mg}{\cos\theta}$$
$$\Sigma F_x = m\,a_x$$
$$F_T \sin\theta = m\,a_x$$
$$\cancel{a_x}\ \frac{mg}{\cos\theta}\sin\theta = m\,a_x$$
$$a_x = g\tan\theta$$
$$a_x = 9.8\,m/s^2 \tan(25^o) = 4.6\,\frac{m}{s^2}$$

1c (15 points) A sample is on the outer edge of a centrifuge of radius 0.2 m. It takes the centrifuge approximately 8 seconds to come up to speed. During this time the speed of the sample is given by v = 2.5 t. Determine the centripetal, tangential and total acceleration at t = 4s.

$$a_t = \frac{d|V|}{dt} = 2.5\ m/s^2$$

$$\text{or } a_t = \frac{V(5s) - V(3s)}{2s}$$

$$a_t = \frac{12.5\ m/s - 7.5\ m/s}{2s}$$

$$a_t = 2.5\ m/s^2$$

$$a_c = \frac{v^2}{r} = \frac{[V(4)]^2}{r}$$

$$a_c = \frac{(10\ m/s)^2}{.2\ m} = 500\ m/s^2$$

$$a_{total} = \left[a_t^2 + a_c^2\right]^{1/2}$$

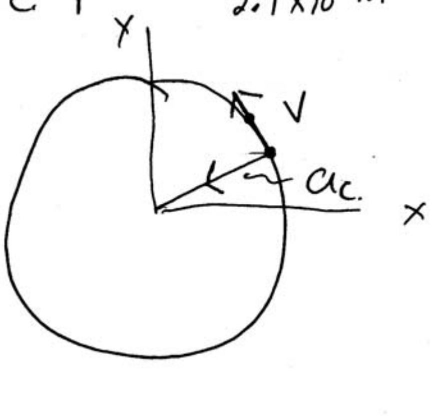
$$a_{total} = \left[(2.5\ m/s^2)^2 + (500\ m/s^2)^2\right]^{1/2}$$

$$a_{total} = 500.01\ m/s^2$$

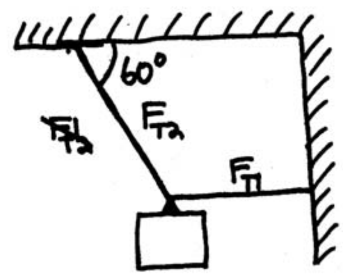
1d (15) A planet travels in a circular orbit of radius 2.10×10^9 m at a constant speed. At some time, the velocity of the planet is $\mathbf{v} = -153.5$ m/s $\mathbf{i}$ + 265.9 m/s $\mathbf{j}$ as described in a coordinate system with the origin at the center of the orbit. Determine the acceleration of the planet. Show the velocity and the acceleration of the object on a diagram of the orbit.

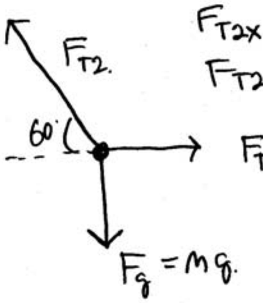
$$V = (V_x^2 + V_y^2)^{1/2} = \left[(153.5\ m/s)^2 + (265.9\ m/s)^2\right]^{1/2} = 307\ m/s$$

$$a_c = \frac{v^2}{r} = \frac{(307\ m/s)^2}{2.1 \times 10^9\ m} = 4.5 \times 10^{-5}\ m/s^2$$



2 (15 points) The figure shows a 10.0 kg mass supported by two cables. Determine the tension in each of the cables.





$F_{T2x} = F_{T2} \cos\theta$

$F_{T2y} = F_{T2} \sin\theta$

$\Sigma F_y = 0$

$F_{T2} \sin\theta - mg = 0$

$F_{T2} = \dfrac{mg}{\sin\theta} = 113\ N$

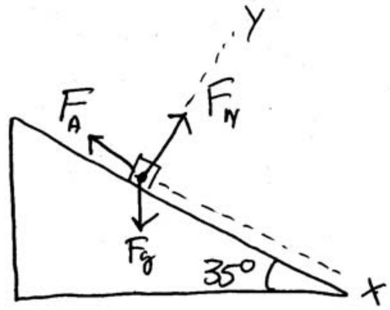
$\Sigma F_x = 0$

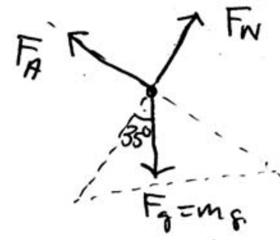
$F_{T1} - F_{T2} \cos\theta = 0$

$F_{T1} = F_{T2} \cos\theta = 113\ N \cos(60) = 56.5\ N$

Mass of skier = 70 kg.

3 (15 points) An air resistance force opposes the motion of a skier as she moves down a 35° incline. The skier travels at constant velocity. Determine the air resistance and normal forces acting on the skier as she moves at constant velocity. If we may neglect air resistance, how fast will the skier be moving after 4 seconds?





$$\Sigma F_y = ma_y = 0$$

$$F_N - F_g \cos\theta = 0$$

$$F_N = mg\cos\theta = 70\,kg\,(9.8\,m/s^2)\cos(35°)$$

$$F_N = 562\ N$$

$$\Sigma F_x = ma_x = 0 \quad \text{constant velocity.}$$

$$-F_A + mg\sin\theta = 0$$

$$F_A = mg\sin\theta = 70\,kg\,(9.8\,m/s^2)\sin(35°) = 393\,N$$

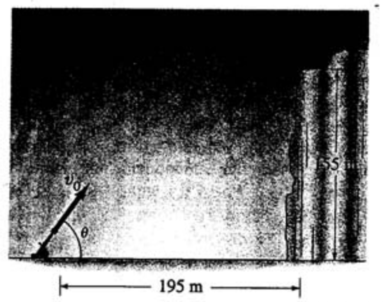
is $F_A = 0$.

$$mg\sin\theta = ma_x$$

$$a_x = g\sin\theta = 9.8\,m/s^2 \sin(35) = 5.62\,m/s^2$$

$$V_{fx} = V_{ix} + at = 5.62\,m/s^2\ 4\,s. = 22.5\,m/s$$

4 (25 points) A projectile is launched from ground level to the top of a cliff which is 195 m away and 155 m high (see figure). If the projectile lands on top of the cliff 7.6 s after it is fired, find the initial velocity of the projectile. Express the velocity in unit vector (**i**, **j**, component) notation. Determine the magnitude and direction of the initial velocity. Determine the vertical component of the velocity just before the object hits the ground.



Find velocity components

$$x_f = x_i + v_{xi} t$$

$$v_{xi} = \frac{x_f - x_i}{t} = \frac{195\text{ m}}{7.6\text{ s}} = 25.6\,\frac{\text{m}}{\text{s}}$$

$x_i = 0$
$x_f = 195\text{ m}$
$v_{xi} = ?$
$v_{xf} = ?$
$a_x = 0$
$t = 7.6\text{ s}$

$y_i = 0$
$y_f = 155$
$v_{yi} = ?$
$v_{yf} = ?$
$a_y = -9.8\text{ m/s}^2$
$t = 7.6\text{ s}$

~~v_y~~

$$y_f = y_i + v_{yi} t + \tfrac{1}{2} a_y t^2$$

$$v_{yi} = \frac{y_f - y_i - \frac{1}{2} a_y t^2}{t}$$

$$v_{yi} = \frac{155\text{ m} - \frac{1}{2}(-9.8\text{ m/s}^2)(7.6\text{ s})^2}{7.6\text{ s}}$$

$$v_{yi} = 57.6\text{ m/s}$$

$$v_{yf} = v_{yi} + a_y t$$

$$v_{yf} = 57.6\text{ m/s} - (9.8\text{ m/s}^2)(7.6\text{ s})$$

$$v_{yf} = -16.8\text{ m/s}$$

$$\vec{v}_i = 25.6\text{ m/s}\,\hat{i} + 57.6\text{ m/s}\,\hat{j}$$

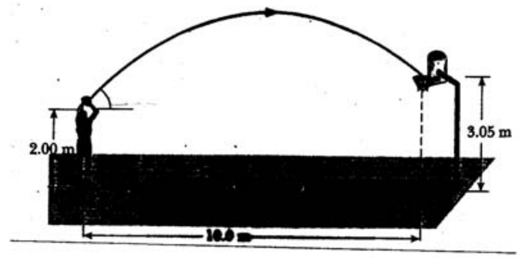
$$v_i = \left((25.6\text{ m/s})^2 + (57.6\text{ m/s})^2\right)^{1/2}$$

$$v_i = 63.0\text{ m/s} ✓$$

$$\theta = \tan^{-1}\left(\frac{57.6\text{ m/s}}{25.6\text{ m/s}}\right) = 66^\circ ✓$$

$$v_{yf} = -16.8\text{ m/s}$$

4 (25 points) A basketball player who is 2.00 m tall is standing on the floor 10.0 m from the basket as shown in the figure. If the ball is in the air for 1.22 seconds, determine the initial velocity of the basket ball. Express the velocity in unit vector (**i**, **j**, component). Determine the magnitude and direction of the initial velocity. Determine the vertical component of the velocity of the ball just as it enters the hoop.



$X_i = 0$

$X_f = 10\,m$ $a_x = 0$

$V_{xi} = ?$ $t = 1.22s$

$V_{xf} = ?$

$Y_i = 2m$ $a_y = -9.8\,m/s^2$

$Y_f = 3.05m$

$V_{yi} = ?$ $t = 1.22\,s$

$V_{yf} = ?$

$$V_{xi} = V_{xf} = \frac{X_f - X_i}{t}$$

$$V_{xi} = \frac{10\,m - 0m}{1.22s} = \boxed{8.20\,m/s}$$

$$Y_f = Y_i + V_{yi}t + \frac{1}{2}a_y t^2$$

$$V_{yi} = \frac{Y_f - Y_i - \frac{1}{2}a_y t^2}{t}$$

$$V_{yi} = \frac{1.05\,m + 4.9\,m/s^2(1.22s)^2}{1.22s}$$

$$\boxed{V_{yi} = 6.84\,m/s}$$

$$V_{yf} = V_{yi} + a_y t$$

$$V_{yf} = 6.84 - 9.8\,m/s^2(1.22s)$$

$$\boxed{V_{yf} = -5.12\,m/s}$$

$$\vec{V}_i = 8.20\,m/s\,\hat{i} + 6.84\,m/s\,\hat{j}$$

$$V_i = \left((8.20\,m/s)^2 + (6.84\,m/s)^2\right)^{1/2}$$

$$\boxed{\begin{array}{l} V_i = 10.7 \\ \theta = \tan^{-1}\left(\frac{6.84\,m/s}{8.2\,m/s}\right) = 39.8 \end{array}}$$