Equation Sheet – Physics 105 -- exam #2

Use |g|=9.8 m/s^2 unless otherwise stated in problem.

Some useful conversion factors:

1 inch = 2.54 cm 1 yd = 3 ft 1ft = 12 inch

Vectors: for θ measured from the +x axis: $A_x = |\vec{A}|\cos\theta$; $A_y = |\vec{A}|\sin\theta$; $|\vec{A}| = \sqrt{A_x^2 + A_y^2}$

$\theta = \tan^{-1}\frac{A_y}{A_x}$; $\vec{C} = \vec{A} + \vec{B} \Rightarrow C_x = A_x + B_x$, $C_y = A_y + B_y$

One-dimensional motion: $\Delta x = x - x_0 = v_o t + \frac{1}{2}at^2$, $v^2 = v_o^2 + 2a\Delta x$; $v = v_o + at$;

Projectile motion: $v_{ox} = v_o\cos\theta$; $v_{oy} = v_o\sin\theta$; $x = v_{ox}t$; $v_x = v_{ox}$

$\Delta y = y - y_0 = v_{oy}t - \frac{1}{2}gt^2$; $v_y = v_{oy} - gt$; $v_y^2 = v_{oy}^2 - 2g\Delta y$

FORCE AND MOTION $F_{net} = ma$ $F_g = mg$ $f_{s,max} = \mu_s N$ $f_k = \mu_k N$

<u>Uniform circular motion:</u> centripetal acceleration: $a = v^2/r$ centripetal force: $F = mv^2/r$

As a student at NJIT I (sign)_____, will conduct myself in a professional manner and will comply with the provisions of the NJIT Academic Honor Code. I also understand that I must subscribe to the following pledge on major work submitted for credit as described in the NJIT Academic Honor code: On my honor, I pledge that I have not violated the provisions of the NJIT Academic Honor Code.

The exam is closed book and closed notes. You are required to show all of your work. NO WORK MEANS NO CREDIT even if you answer is correct. Your work must be legible. If the grader can not follow and understand your work, it is wrong.

1. **(2 Points)** If we know an object is moving at constant velocity, we may assume:

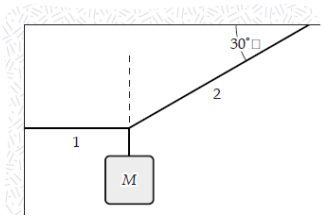
   a. the net force acting on the object is zero.
   b. there are no forces acting on the object.
   c. the object is accelerating.
   d. the object is losing mass.

2. **(2 Points)** If the only forces action on a 2.0 kg mass are $\vec{F}_1 = (3\hat{x} - 8\hat{y})$ N and $\vec{F}_1 = (5\hat{x} + 3\hat{y})$ N what is the magnitude of the acceleration?

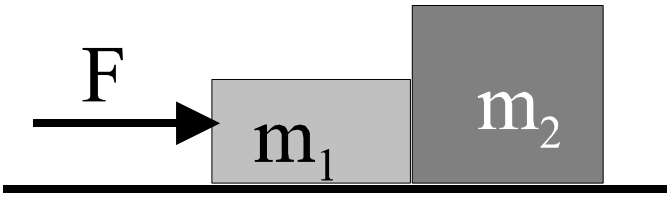
3. **(2 Points)** A roller-coaster car has a mass of 500 kg when fully loaded with passengers. The car passes over a hill of radius 15 m. At the top of the hill, the car has a speed of 8.0 m/s. What is the magnitude of the force of the track on the car at the top of the hill?

4. **(2 Points)** An airplane travels 80 m/s as it makes a horizontal circular turn which has a 800m radius. What is the magnitude of the resultant force on the 75-kg pilot of this airplane?

5. **(3 Points)** In the figure below if M = 2.0 kg, what is the tension in string 1?



6. **(7 Points)** A force **F** of 14 N is applied to two boxes shown in the figure below (on a frictionless surface). For this problem m_1=3kg and m_2=6 kg.



a. Draw a free body for each mass.

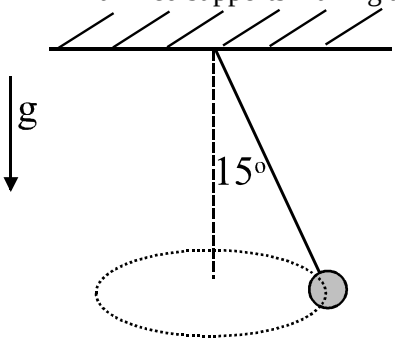
b. What is the acceleration of the boxes?

c. What is the magnitude of the force of box 2 on box 1?

d. What is the NET force of box 1 on box 2?

e. Based on the result of (d), one can use this net force to calculate the acceleration of m_2 using $F_{net} = m_2 a_2$. Using the net force on box 2 (your answer to part (d)), calculate the acceleration a_2 of box 2 and compare it to the result of (b). EXPLICITLY STATE which acceleration is bigger or smaller. HINT: Do you EXPECT the accelerations to be different?

7. (7 points). A 10 kg mass is tied to a cable 0.24 meters in length and the mass rotates (in a horizontal plane) from a fixed supports making an angle of 15^0 relative to vertical as seen in the figure below.



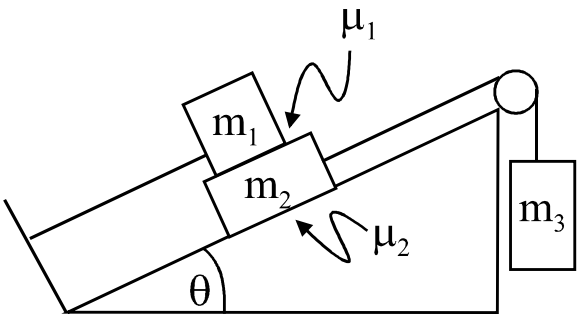
a. Draw a free body diagram for the mass.

b. Determine the tension in the cable.

c. Determine the velocity of the mass (in the horizontal circle).

d. How does the velocity change if the mass is 20 kg instead of 10 kg?

8. **(15 Points)** Three masses m_1 , m_2 , and m_3 are attached using strings and a pulley as shown in the figure below. The plane is inclined at an angle ɵ. Consider the case where the masses m_2 and m_3 are accelerating while mass m_1 is held fixed by the lower cable. The friction coefficients are given in the figure.



a. Draw the free-body diagrams for the three masses showing all forces acting on each mass.

b. Write down all components of Newton's equation (ie. $\sum \vec{F} = m\vec{a}$) for mass m_1 based on the diagrams in (a). Keep in mind that m_1 is FIXED.

c. Write down all components of Newton's equation (ie. $\sum \vec{F} = m\vec{a}$) for mass m_2 based on the diagrams in (a). Keep in mind that m_2 is accelerating.

d. Write down all components of Newton's equation (ie. $\sum \vec{F} = m\vec{a}$) for mass m_3 based on the diagrams in (a). Keep in mind that m_3 is accelerating.

e. Using the equations from parts (b), (c), and (d), find the accelerations of m_2 and of m_3 in terms of the masses, the gravitational acceleration *g*, angle of incline ɵ, and the coefficients of friction μ_1 and μ_2. Your answer should ONLY depend on these values.

f. As a short hand notation, going forward in the problem you can refer to this complicated formula for the acceleration as a_3. In terms of a_3, the masses, the gravitational acceleration *g* and angle of incline ɵ, and the coefficients of friction, find the tension in the string which is connected to mass m_3.

g. What is the DIRECTION of the frictional force which acts on mass m_1?

h. In terms of the masses, the gravitational acceleration *g*, the angle of incline ɵ, and the coefficients of friction, find the MAGNITUDE of the friction force which acts on mass m_1.