PHYSICS 218 Exam 2
Fall, 2005 Sections 807-809

Do not fill out the information below until instructed to do so!

Name:________________________
Signature:____________________
Student ID:___________________
E-mail:_______________________
Section Number:______________

- You have the full class period to complete the exam.
- Formulae are provided on the last page. You may NOT use any other formula sheet.
- When calculating numerical values, be sure to keep track of units.
- You may use this exam or come up front for scratch paper.
- Be sure to put a box around your final answers and clearly indicate your work to your grader.
- All work must be shown to get credit for the answer marked. If the answer marked does not obviously follow from the shown work, even if the answer is correct, you will not get credit for the answer.
- Clearly erase any unwanted marks. No credit will be given if we can’t figure out which answer you are choosing, or which answer you want us to consider.
- Partial credit can be given only if your work is clearly explained and labeled.

Put your initials here after reading the above instructions:
Problem 1: (25 points)

A gymnast of mass $m$ climbs a vertical rope attached to the ceiling. You can ignore the mass of the rope.

a) (5 points) Draw the free body diagram for the gymnast

b) (5 points) Calculate the tension in the rope if the gymnast climbs it at a constant velocity $v$.

c) (5 points) If the gymnast hangs from the rope without moving, what is the tension then.

d) (10 points) Calculate the tension in the rope if the gymnast climbs the rope at an acceleration $a$

\[ F_T - mg = 0 \quad \text{since} \quad a = 0 \]

\[ \Rightarrow \quad T = mg \]

c) Same as in b)

d) \[ T - mg = ma \]

\[ \Rightarrow \quad T = mg + ma \]
Problem 2: (20 points)

A block of mass $m_A$ is placed against the vertical front of a cart as shown in the figure below.

a) (5 points) Draw the free body diagram of block A

b) (10 points) What acceleration must the cart have in order that block A does not fall if the coefficient of static friction is $\mu_s$?

c) (5 points) If a block of mass $m_B$ is glued to block A, how will the needed acceleration change?

(b) Newton's 2nd Law

\[
\begin{align*}
\text{x: } & F_N = ma \\
\text{y: } & \mu_f N - m_A g = 0 \\
\Rightarrow & m = \frac{m_A g}{m_A a} = \frac{g}{a} \\
\mu &= \frac{g}{a}
\end{align*}
\]
Part 3: Spring Problem (25 points)

A small block of mass $m$ is attached to a cord passing through a hole in a frictionless table as shown in the figure below. The block is originally revolving at a distance $R_1$ from the hole at a speed $v_0$. The cord is then pulled from below, shortening the radius of the circle to $R_2$. The final speed is $v_f = v_0 \frac{R_1}{R_2}$

a) (10 points) What is the tension $T$ in the cord in the original situation

b) (15 points) How much work did the person do

\[ W = \Delta KE = \frac{1}{2} m v_f^2 - \frac{1}{2} m v_0^2 = \frac{1}{2} m \left( \frac{R_1^2}{R_2^2} \right) v_0^2 \]
Part 4: Skiing down a round hill (30 points)

A skier starts at the top of a very large, frictionless snowball, with a very small initial speed, and skis straight down the slope as shown in the figure below. At what point (angle \( \alpha \)) does she lose contact with the snowball and fly off at a tangent? (You need to use conservation of energy (15 points) and Newton's 2nd law of circular motion drawing the free body diagram (5 points) and writing and solving the equations (10 points)).

\[
\begin{align*}
\text{Newton's second law:} & \quad mg \cos \theta - FN = \frac{m v^2}{R} \\
\text{at point } \alpha & \quad \tan \alpha = \frac{mg \sin \alpha}{m a} \\
\text{Using conservation of energy at } & \text{ you at the center of the circle:} \\
mgR = \frac{1}{2} m v^2 + mg R \cos \theta & \implies v^2 = 2gR(1 - \cos \theta) \\
\text{Putting this in the radial Newton's 2nd law at } \alpha & \implies mg \cos \theta - FN = 2gR(1 - \cos \theta) \\
FN = 0 \text{ when it fly off.} & \implies \\
\cos \theta = 2 & \implies \cos \theta = \frac{2}{3} \\
\theta = \cos^{-1} \left( \frac{2}{3} \right) & = 48^\circ
\end{align*}
\]