Physics Department
Physics 218 Final Exam
December 18, 1991

NAME:__________
SECTION:_______

Instructions

1) Do not open this exam until you are instructed to do so. Meanwhile, write your name and section number above. Allowed section numbers are 525, 526, 527 or 528.

2) There are six problems worth a total of 150 points on this exam. The point value for each problem is noted on the problem page.

3) Write your answers to each problem on the question page or the facing page. If you need more room and use extra work sheets be sure to indicate that you have done so. Write your name clearly on each sheet.

4) Remember most of the credit is given for correctness in setting up the problem, so if you are pressed for time, indicate the numbers you would like to evaluate in the expression and leave the calculations for later.

5) If you are unable to answer a question whose result is needed in a subsequent part of the problem, make an assumption for the needed result, indicating clearly what you are doing and then continue.

6) Partial credit will be given, however your work must be shown and clearly labeled if you expect to receive it.

7) You have 120 minutes to complete this exam. Good luck and have a very pleasant holiday.
PROBLEM 1 (25 points)

A point mass of 2 kg is acted on by a force of $F_{\text{total}} = 4.0 \text{ Nt} \mathbf{i} + 3.0 \text{ Nt} \mathbf{j}$. At $t=1$ second the mass is observed to have a velocity of 2.0 m/sec $\mathbf{i}$.

(A) What is the acceleration experienced by this mass?

(B) Find the velocity of this particle for anytime $t$.

(C) Find the position of this particle in the $x,y$ plane for any time $t$ if at $t=0$ seconds it is located at $x = 1$ m and $y = 2$ m.

(D) Find the work done by this force on the point mass during the interval from $t = 1$ sec to $t = 2$ sec.
A rifle is positioned next to a wooden block of mass $M$ which is suspended on two ropes of length $L$ attached to the center of the block at each end as shown in the figure above. The rifle fires a bullet of mass $m$ with a velocity $v_0$ horizontally at time $t = 0$. Following the collision, the bullet imbeds itself in the wooden block and the pendulum begins to swing. Answer the following in terms of $M, m, L, g, v_0$:

(A) After the bullet becomes imbedded in the block, what is the velocity of the bullet-block system?

(B) What is the largest angle that the pendulum will make with the vertical?

(C) What is the time it takes for the pendulum to swing back to its original position?
PROBLEM 3 (25 points)

A hoop of mass, \( M \) and radius, \( R \), rolls without slipping across a horizontal surface toward an incline. The center-of-mass of the hoop is initially moving to the right with a velocity, \( v_0 \). The coefficients of friction between the hoop and the surface are \( \mu_s \) and \( \mu_k \) respectively. In terms of the quantities, \( M \), \( R \), \( g \), \( v_0 \), \( \mu_s \) and \( \mu_k \), answer the following:

(A) What is the angular velocity of the hoop about its center as it rolls along the horizontal surface?

(B) What is the kinetic energy of the hoop as it rolls along the horizontal surface?

(C) Find the maximum height above the horizontal surface that the hoop can roll before turning around and rolling back down.
PROBLEM 4 (25 points)

Sketched above is a simple beam arrangement which can be used for lifting objects. The beam itself is uniform and has a weight of 1000 Nt and makes an angle of 37° with the vertical and has a total length of 10 m. The beam is fastened at the wall by a hinge as shown. Assume that the lifting cable can withstand any load without breaking, but the horizontal reinforcing cable will break under a tension of 5000 Nt. There is a pulley located at the very end of this beam where the lifting cable is attached. Answer the following.

(A) When lifting a weight of 3000 Nt with this system what is the vertical force being supplied by the hinge to the end of the beam?

(B) When lifting this same 3000 Nt weight, what is the tension in the horizontal support cable?

(C) What is the horizontal force being supplied by the hinge on the beam under these same conditions?

(D) What is the maximum weight which this device can lift?
PROBLEM 5 (25 points)

(A) A fly of mass, $m$, sits on the rim of a spinning bicycle wheel that has a radius $R$ and a mass $M$. Initially the wheel-fly system is rotating with an angular velocity of $\omega_0$ in the counterclockwise direction. If the fly walks to the center of the wheel along a radial spoke with a constant velocity, $v_0$, find the angular velocity of the system at any time, $t$, after the fly has started walking.

(B) Two children are playing catch as they ride to school in their school bus. They toss a ball back and forth between themselves as they sit on opposite sides of the bus at a distance of 2 meters with a velocity of 1 m/sec. How long does it take the ball to travel between the two students? What is the velocity of the ball as it is flying between the two students relative to an observer standing on the curb outside the bus as the bus goes by at 30 m/sec?
PROBLEM 6 (25 points)

A block of mass $m$ sits on a frictionless horizontal surface connected by two springs with spring constants $k_r$ and $k_l$ between two walls as shown in the figure above. This block is displaced from its equilibrium position by a distance $x_0$ and then released. In terms of the constants given ($k_r, k_l, m, x_0$) answer the following:

(A) Draw the force diagram for the block after it has been displaced from its equilibrium position by a distance $x_0$.

(B) What is the total force exerted on the mass when it has been displaced the distance $x_0$ to the right of its equilibrium position?

(C) What is the form of the general solutions for the equations of motion for simple harmonic motion? (I want the functions which satisfy $F = ma$).

(D) What is the "natural" angular frequency $\omega$ for this mass and spring system?