Physics 218 Spring 2000 Exam III
(Sections 509-512)
(60 minutes)

***** INSTRUCTION *****

1. Write your LAST and FIRST names.
2. Write your ID number (last 4 digits).
3. Write your "registered" SECTION number.
4. DO NOT OPEN UNTIL INSTRUCTED TO DO SO.

Name (Last, First):__________________________ ID #: XXX-XX-_____

Section #:__________ Note: The recitation/laboratory schedule for each sec-
Row-Seat #:__________ tion is as follows:
509: M 9:10-10, 10:10-12PM
510: W 10:20-11:10, 11:20-1:10PM
511: T 9:35-10:25, 10:35-12:25PM
512: R 4:55-5:45PM, 5:55-7:45PM

- You may use a calculator.
- Mark your answers clearly by drawing BOXES around them.
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<th>Problem</th>
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Moment of inertia:

\[ I_{cm} = \frac{1}{2} MR^2 \text{ (solid cylinder)} \]
\[ = MR^2 \text{ (thin-walled hollow cylinder)} \]
\[ = \frac{2}{5} MR^2 \text{ (solid sphere)} \]
\[ = \frac{2}{3} MR^2 \text{ (thin-walled hollow sphere)} \]
\[ = \frac{1}{12} ML^2 \text{ (slender rod, axis through center)} \]
1. (25 points) Consider a solid cylinder (mass $M = 50.0 \text{ kg}$, height $H = 1.50 \text{ m}$, radius $R = 0.300 \text{ m}$) in a spin with revolution frequency of 0.600 revolutions per second. Note that very light rods of length $l = 0.800 \text{ m}$ (we ignore the mass of the rods) and particles of mass $m = 1.00 \text{ kg}$ are attached to the cylinder, as shown in Figure X. The spin is about an axis through the center of the cylinder.

   a. (5 pts) Find the magnitude of the angular velocity (in rad/s) of the spin.

   b. (5 pts) Find the moment of inertia of the system about the axis.

During the spin, the configuration of the rods are changed, as shown in Figure Y. Assume that the net torque associated with the external forces acting on the system is zero.

   c. (15 pts) Find the magnitude of the angular velocity (in rad/s) of the resultant spin.

\[ \text{Figure X} \quad \text{Figure Y} \]
2. (25 points) A uniform solid cylinder of mass $M_c = 2.00 \text{ kg}$ and radius $R = 0.300 \text{ m}$ rests on a horizontal table top. A light string is attached by a light yoke to a frictionless axle through the center of the cylinder, so that the cylinder can rotate about the axle. The string runs over a frictionless pulley. A block of mass $M_b = 6.00 \text{ kg}$ is suspended from the free end of the string. The cylinder rolls without slipping on the table top. The system is released from the rest and the block has a motion with a constant acceleration. The acceleration due to the earth’s gravity is $g = 9.80 \text{ m/s}^2$.

a. (4 pts) Draw the free body diagram for the cylinder. **Label carefully.**

b. (2 pts) Draw the free body diagram for the block. **Label carefully.**

c. (15 pts) Write equations of motion ($\vec{F} = m\vec{a}$ and $\tau = I\alpha$) for the cylinder and the block.

d. (4 pts) Find the magnitude of the downward acceleration of the block.
3. **(25 points)** A particle (mass $M = 1.00$ kg) is released from rest at $x = -3.00$ m while being acted on by a **conservative** force parallel to the $x$-axis. The potential energy function is given as $U(x) = (735 \text{ J/m}^2) x^2 - (70.0 \text{ J/m}^3) x^3$.

a. (10 pts) Find the force acting on the particle as a function of $x$.

b. (5 pts) Find value or values of $x$ corresponding to points of stable equilibrium. Also find value or values of $x$ corresponding to points of unstable equilibrium.

c. (5 pts) What is the largest value of the kinetic energy of the particle during its motion.

d. (5 pts) How much work is done when the particle moves from $x = -3$ m and $x = 0$ m.
4. (25 points) A 20.0-kg projectile is fired at an angle of 60.0° above the horizontal and with a speed of 240 m/s. At the highest point of its trajectory the projectile explodes into two fragments, one of which has a mass of 15.0 kg and falls vertically with an initial speed of 10.0 m/s. The acceleration due to the earth's gravity is \( g = 9.80 \text{ m/s}^2 \). Neglect air resistance.

a. (18 pts) How far from the point of firing does the other fragment strike if the terrain is level?

b. (3 pts) How much energy is released during the explosion?

c. (4 pts) Find the position \((x \text{ and } y)\) of the center of mass system of two fragments at time of 10 secs after the explosion.