Physics 211-02: Third Exam
5-13-03
Version A

Name: ________________________________
(Print Clearly)

Instructions:
Read through each problem first. If you don't get a problem, move on to another. All problems are worth 10 points unless otherwise noted. Circle the answer that best matches your answer. Partial credit may be considered if you have shown sufficiently clear work next to the problem.
1. A 3.0 kg object moving 8.0 m/s in the positive x direction has a one-dimensional elastic collision with an object (mass = $M$) initially at rest. After the collision the object of unknown mass has a velocity of 6.0 m/s in the positive x direction. What is $M$?

   a. 7.5 kg  
   b. 6.0 kg  
   c. 5.0 kg  
   d. 4.2 kg  
   e. 8.0 kg

2. A 70 kg man who is ice skating north collides with a 30 kg boy who is ice skating west. Immediately after the collision, the man and boy are observed to be moving together with a velocity of 2.0 m/s, in a direction 37° north of west. What was the magnitude of the boy's velocity before the collision?

   a. 8.5 m/s  
   b. 5.3 m/s  
   c. 3.7 m/s  
   d. 6.7 m/s  
   e. 1.0 m/s

Total Score: _______________
3. A uniform rod of mass $M = 1.2$ kg and length $= 0.80$ m is free to pivot about one end as shown. If a force $(F = 5.0 \text{ N}, \theta = 40^\circ)$ acts as shown, what is the resulting angular acceleration about the pivot point?

![Diagram of a uniform rod with a force applied at an angle]

- a. $16 \text{ rad/s}^2$
- b. $12 \text{ rad/s}^2$
- c. $14 \text{ rad/s}^2$
- d. $10 \text{ rad/s}^2$
- e. $33 \text{ rad/s}^2$

4. The rigid body shown is rotated about an axis perpendicular to the paper and through the point $P$. If $M = 0.40$ kg, $a = 30 \text{ cm}$, and $b = 50 \text{ cm}$, how much work is required to take the body from rest to an angular speed of $5.0 \text{ rad/s}$? Neglect the mass of the connecting rods and treat the masses as particles.

![Diagram of a rigid body with masses at points $3M$ and $M$]

- a. $2.9 \text{ J}$
- b. $1.6 \text{ J}$
- c. $3.1 \text{ J}$
- d. $3.4 \text{ J}$
- e. $2.6 \text{ J}$

Page score: ___________
5. Two blocks, $m_1 = 1$ kg and $m_2 = 2$ kg, are connected by a light string as shown in the figure. If the radius of the pulley is 1 m and its moment of inertia is 5 kg m$^2$, the acceleration of the system is

- a. $(1/6)g$
- b. $(3/8)g$
- c. $(1/8)g$
- d. $(1/2)g$
- e. $(5/8)g$

6. A skater extends her arms horizontally, holding a 5 kg mass in each hand. She is rotating about a vertical axis with an angular velocity of one revolution per second. If she drops her hands to her sides, what will the final angular velocity (in rev/s) be if her moment of inertia (not including her arms and the 5 kg masses) remains approximately constant at 5 kg m$^2$, and the distance of the masses from the axis changes from 1 m to 0.1 m?

- a. 3
- b. 6
- c. 9
- d. 4
- e. 7
7. A body oscillates with simple harmonic motion along the x-axis. Its displacement varies with time according to the equation $x(t) = 5.0 \sin (\pi t + \pi/3)$. The acceleration (in m/s²) of the body at $t = 1.0$ s is approximately

a. 3.5  
b. 49  
c. 14  
d. 4.3  
e. 43

8. The figure shows a uniform rod (length $L = 1.0$ m, mass = 2.0 kg) suspended from a pivot a distance $d = 0.25$ m above its center of mass. The angular frequency (in rad/s) for small oscillations is approximately

a. 1.0  
b. 2.5  
c. 4.1  
d. 1.5  
e. 3.5
Conceptual Problems this page only: (5 pts. Each)

9. The law of conservation of momentum applies to a collision between two bodies if:
   a. they exert equal and opposite forces on each other.
   b. they exert forces on each other respectively proportional to their masses.
   c. they exert forces on each other respectively proportional to their velocities.
   d. they exert forces on each other respectively inversely proportional to their masses.
   e. their accelerations are proportional to their masses.

10. Five objects of mass \( m \) move at velocity \( v \) at a distance \( r \) from an axis of rotation perpendicular to the page through point A, as shown below. The one that has zero angular momentum about that axis is:

![Diagram](image)

11. Which of the following quantities is conserved for a planet orbiting a star in a circular orbit? Only the planet itself is to be taken as the system; the star is not included.
   a. Momentum and energy.
   b. Energy and angular momentum.
   c. Momentum and angular momentum.
   d. Momentum, angular momentum and energy.
   e. None of the above.
Moments of Inertia of select objects:

- **Hoop or cylindrical shell**
  \[ I_{CM} = MR^2 \]

- **Solid cylinder or disk**
  \[ I_{CM} = \frac{1}{2} MR^2 \]

- **Long thin rod with rotation axis through center**
  \[ I_{CM} = \frac{1}{12} ML^2 \]

- **Solid sphere**
  \[ I_{CM} = \frac{2}{5} MR^2 \]

- **Hollow cylinder**
  \[ I_{CM} = \frac{1}{2} M(R_1^2 + R_2^2) \]

- **Rectangular plate**
  \[ I_{CM} = \frac{1}{12} M(a^2 + b^2) \]

- **Long thin rod with rotation axis through end**
  \[ I = \frac{1}{3} ML^2 \]

- **Thin spherical shell**
  \[ I_{CM} = \frac{2}{3} MR^2 \]

Page score: ____________
Key:

1. C
2. B
3. D
4. E
5. C
6. A
7. E
8. C
9. A
10. D