Physics 161: Exam #3

Write your name and seat number in the upper right hand corner. Please write neatly, and state your assumptions and definitions clearly. A labeled sketch will often make this easier! Remember, vectors have magnitude and direction.

1. **5 points** A 0.16-kg baseball is thrown with a speed of 40 m/s. It is hit straight back at the pitcher with a speed of 80 m/s. What is the magnitude of the impulse exerted on the ball by the bat?

   (a) 16 N s
   (b) 64 N s
   (c) 19 N s
   (d) 3.2 N s
   (e) 64 N s

   **10 points. Why?**

2. **20 points.** A U-238 nucleus (mass = 238 units) decays, transforming into an alpha particle (mass = 4 units) and a residual thorium nucleus (mass = 234 units). If the uranium nucleus was at rest, and the alpha particle has a speed of $1.5 \times 10^7$ m/s, determine the recoil speed of the thorium nucleus.
3. (See the illustration on the board.) A ball of mass $m$ travelling at a velocity $v_0$ collides head-on with a system of identical balls glued together with massless glue. (There are $N$ balls each of mass $m$ glued together, and they are initially at rest.) After the collision, the ball of mass $m$ is moving with velocity $-v_0$. The collision is perfectly elastic.

(a) **15 points** Find the recoil velocity $u$ of the system of $N$ balls, in terms of $v_0$.

(b) **15 points** Find the number of balls $N$ in the system.
4. **25 points.** (See the illustration on the board.) The pulley shown on the board has radius $R$ and moment of inertia $I$. One end of the mass $m$ is connected to a spring of force constant $k$, and the other end is fastened to a cord wrapped around the pulley. The pulley axle and the incline are frictionless. If the pulley is wound counterclockwise so that the spring is stretched a distance $d$ from its unstretched position and is then released from rest, find the angular speed $\omega$ of the pulley when the spring is again unstretched.
5. **5 points** A uniform rod (mass = 2.0 kg, length = 0.60 m) is free to rotate about a frictionless pivot at one end. The rod is released from rest in the horizontal position. What is the magnitude of the angular acceleration of the rod at the instant it is 60° below the horizontal?

(a) 15 rad/s²
(b) 12 rad/s²
(c) 18 rad/s²
(d) 29 rad/s²
(e) 23 rad/s²

**20 points. Why?**
6. **5 points each.** Given these vectors: \( \mathbf{A} = 6\mathbf{j} + 3\mathbf{k}, \mathbf{B} = -\mathbf{i}, \mathbf{C} = \frac{1}{7}\mathbf{j} - \mathbf{k}, \) and \( \mathbf{D} = 10\mathbf{k}, \) evaluate the following:

(a) \( \mathbf{i} \cdot \mathbf{j} \)

(b) \( \mathbf{i} \times \mathbf{k} \)

(c) \( \mathbf{i} \cdot (\mathbf{k} \times \mathbf{j}) \)

(d) \( \mathbf{A} \cdot \mathbf{B} \)

(e) \( \mathbf{C} \times \mathbf{D} \)

(f) \( (\mathbf{A} \times \mathbf{B}) \cdot (\mathbf{C} \times \mathbf{D}) \)

(g) \( \mathbf{A} \cdot \mathbf{C} \)

(h) What is the angle between \( \mathbf{A} \) and \( \mathbf{C} \)?

(i) \( \mathbf{A} \times (\mathbf{A} \times \mathbf{B}) \)
7. Two massless ropes are attached to a pulley (shown above) whose moment of inertia is $I$. The upper rope is attached at radius $R_2$, and a mass $m$ hangs from a rope attached at radius $R_1$. Application of the force $F = T_2$ (leftward) causes the mass to rise with acceleration of magnitude $a$. Gravity points downward.

20 points (a) Find the ratio $T_2/T_1$. Your answer should depend only on $R_1, R_2, I, m, g$, and $a$.

10 points (b) If the mass rises with constant speed, what is $T_2/T_1$?
Physics 161: Practice Exam (for second midterm)

8. **5 points** Five particles, each of which has a mass of 0.24 kg, are fixed at positions that are equally spaced along a meter stick with one of these particles at each end. What is the moment of inertia about an axis that is perpendicular to the meter stick (which has negligible mass) and through the center of mass of this rigid body?

   (a) 0.15 kg m²
   (b) 0.20 kg m²
   (c) 0.25 kg m²
   (d) 0.30 kg m²
   (e) 0.35 kg m²

**15 points. Why?**