Instructions:

- Put name and section on exam and on equation sheet.
- Do not open the test until you are told to do so.
- Write your final answer in the box provided.
- If you finish with less than 5 minutes remaining, please stay seated until the exam is over.
- Stop work immediately when time is over; pass exams to the aisle; stay seated until all exams are collected.
- Turn in your equation sheet with your examination.

Guidelines:

- Assume 3 significant figures for all given numbers unless otherwise stated.
- Show all of your work – no work, no credit.
- Include units for all answers.
- Include directions for all vectors.

Mass Moments of Inertia:

\[ I_{\text{center}} = \frac{mL^2}{12} \]

\[ I_z = \frac{mr^2}{2} \]
\[ I_x = I_y = \frac{mr^2}{4} \]
1. (2 pts) Prof White is holding a rapidly spinning bicycle wheel so the axis is horizontal. The first time the rope is at the end of the axle. The second time the rope is near the hub. How does this affect the motion?
   A. Increase in wheel’s angular speed
   B. Decrease in wheel's angular speed
   C. Increase in precession speed
   D. Decrease in precession speed
   E. No change in either speed

2. (14 pts) The object shown has uniform density and thickness. Determine the x-coordinate of the center of mass. All units are inches.
3. (14 pts) A car starts from rest and is going around a 120 ft radius circular track. The car is increasing speed at a rate of 6 ft/s$^2$, and it will start to slip when the total acceleration is 12 ft/s$^2$. How much time elapses between when the car starts and when it begins to slip?

4. (14 pts) Four thin rods with a weight of 0.8 pounds and a length of 1.2 ft are welded to a uniform circular disk with a mass of 1.4 pounds and a radius of 0.3 ft. Determine the mass moment of inertia about the center of mass of the object.
5. (14 pts) Tania and Chris are trying to loosen a lug nut. They cannot decide which way to push on the wrench, so they push in opposite directions. What is to the total torque about point A (counterclockwise positive)?

6. (14 pts) A constant torque of 40 N·m is applied to a flywheel that has a mass moment of inertia of 60 kg·m². The flywheel starts from at rest. How much time is required to get the flywheel spinning fast enough so that is has 1500 J of stored energy?
7. (14 pts) A barrel is being rolled along the ground. What is the required speed, \( v \), so the barrel will roll over the hill with a speed of 2 ft/sec? The barrel is modeled as a hollow cylinder with \( I = mr^2 \).

8. (14 pts) A 0.058 kg tennis ball is thrown at a hammer that is held up by a hinge at point A. The tennis ball is thrown with a speed of +8 m/s. The hammer has an angular velocity of 0.20 rad/sec after the collision. What is the velocity of the tennis ball after the collision? The hammer has a mass of 6.0 kg and a mass moment of inertia of 3.5 kg·m².