1. (8 pts) A delectric motor of a table saw is consuming electricity at the rate of 500 W. It is turning a 120 mm radius saw blade at an angular speed of 3450 rpm. What is the tangential force, F, that acts on the saw blade?

\[ \text{Power} = 45 \text{ J/s} \quad \rho = 500 \text{ J/s} \]

\[ \omega = 3450 \text{ rpm} \]

\[ \theta = \frac{360}{2 \pi} \text{ rad} = 360 \text{ rad/s} \]

\[ F = \frac{\rho}{\omega} = \frac{500 \text{ J/s}}{360 \text{ rad/s}} = 1.39 \text{ N} \]

2. (8 pts) A disc is initially spinning at 33 rpm. 14 seconds later the disc is spinning at 45 rpm. How many revolutions did the disc make in the 14 seconds?

\[ \Delta \theta = (\omega_1 + \omega_2) \Delta t \\
\omega_1 = 33 \text{ rpm} \\
\omega_2 = 45 \text{ rpm} \\
\Delta t = 14 \text{ sec} \\
1 \text{ rpm} = \frac{2 \pi}{60} \text{ rad/s} \\
\Delta \theta = \frac{(33 + 45) \text{ rev}}{2} \cdot 14 \text{ sec} = 9.04 \text{ rev} \]
3. (14 pts) Determine the x-coordinate of the center of mass of this object. All dimensions are in cm. Use a coordinate system located at the lower left corner and assume uniform thickness and density.

\[ A_1 = 9 \text{cm} \times (13.5) \text{cm} = 121.5 \text{cm}^2 \]

\[ A_2 = (20.9) \text{cm} \times 13 \text{cm} = 276.7 \text{cm}^2 \]

\[ A_3 = \pi \times (4) \text{cm}^2 = 50.27 \text{cm}^2 \]

\[ X_{cm} = \frac{A_1 \times 4.5 \text{cm} + A_2 \times (9.5) \text{cm} - A_3 \times (30.6) \text{cm}}{A_1 + A_2 - A_3} = 10.28 \text{cm} \]

4. (14 pts) A solid cylinder starts from rest and rolls down an incline. At the bottom of the incline, the cylinder has a speed of 2.5 m/s. Determine the height, \( h \), of the incline. The cylinder has a mass of 0.3 kg and a diameter of 8 cm.

\[ mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 \]

\[ mgh = \frac{1}{2}mV^2 + \frac{1}{2}(\frac{1}{2}mr^2)(\frac{V}{r})^2 \]

\[ g = \frac{1}{2}V^2 + \frac{1}{2}V^2 = \frac{3}{2}V^2 \]

\[ h = \frac{3}{2}V^2 \times \frac{1}{g} = \frac{3}{2} \times \frac{2.5 \text{m/s}^2 \times 2}{9.81 \text{m/s}^2} = 0.478 \text{m} \]

5. (14 pts) A force \( \langle 2 \hat{i} - 6 \hat{j} + 6 \hat{k} \rangle \) is applied at point \( \langle 6 \hat{i} + 2 \hat{j} + 2 \hat{k} \rangle \). Determine the torque of the force about point \( \langle 6 \hat{i} + 2 \hat{j} + 2 \hat{k} \rangle \).

\[ \tau = \left[ \begin{array}{c} 2 \\ -6 \\ 6 \end{array} \right] \times \left[ \begin{array}{c} 6 \\ 2 \\ 2 \end{array} \right] = 3 \hat{i} - 6 \hat{j} + 3 \hat{k} \]

\[ \rightarrow \tau = (3 \hat{i} - 6 \hat{j} + 3 \hat{k}) \times \hat{l} \]

6. (14 points) Two forces act as shown on a merry-go-round. The mass moment of inertia of the merry-go-round is 93,000 kg·m². What is the magnitude of the angular acceleration of the merry-go-round?

\[ 0.0367 \text{ rad/s}^2 \]

\[ 2 \tau = I \alpha \]

\[ 500 \sin(60°) \times 1.5 + 250 \times 1.5 = 93,000 \times 120 \text{ rad}^2 \text{m}^2 \]

\[ \Rightarrow \tau = 0.0367 \text{ rad/s}^2 \]

\[ \Rightarrow \alpha = 0.0367 \times \frac{1}{5} \]
7. (14 pts) A figure skater with a mass moment of inertia of 0.9 kg m² is spinning at 5.9 rad/sec while her hands are close to her body. The figure skater raises her arms, so her mass moment of inertia changes to 1.26 kg m². Determine the percentage of kinetic energy that was lost.

\[ I_1 \omega_1 = I_2 \omega_2 \]

0.9 kg m² \cdot 5.9 \text{ rad/sec} = 1.26 \text{ kg m}^2 \cdot \omega_2 \Rightarrow \omega_2 = 4.248 \text{ rad/sec}

\[ KE_1 = \frac{1}{2} I_1 \omega_1^2 = \frac{1}{2} \cdot 0.9 \text{ kg m}^2 \cdot (5.9 \text{ rad/sec})^2 = 15.06 \text{ J} \]

\[ KE_2 = \frac{1}{2} I_2 \omega_2^2 = \frac{1}{2} \cdot 1.26 \text{ kg m}^2 \cdot (4.248 \text{ rad/sec})^2 = 11.28 \text{ J} \]

\[ \% \text{ Loss} = \frac{15.06 - 11.28}{15.06} \times 100 = 24.47 \%

8. (14 pts) The shaft of Professor Schletter's golf club can be modeled as a thin uniform rod with a mass of 0.14 kg and a length of 0.8 m. The golf club head has a mass of 0.22 kg and a mass moment of inertia of about its center of mass of 2000 g cm². Determine the mass moment of inertia of the golf club about the top of the shaft, point A.

\[ 0.209 \text{ kg m}^2 \] or \[ 2090000 \text{ g cm}^2 \]

2000 g cm² = 0.002 kg m², \[ 1 \text{ kg m}^2 \cdot \left( \frac{1 \text{ m}}{100 \text{ cm}} \right)^2 = 0.0002 \text{ kg m}^2 \]

\[ I_{\text{shaft}} = \frac{1}{3} ml^2 = \frac{1}{3} \cdot 0.14 \text{ kg} \cdot (0.4 \text{ m})^2 = 0.0298 \text{ kg m}^2 \]

\[ I_{\text{head}} = 0.0002 \text{ kg m}^2 + 0.3318 \text{ kg m}^2 = 0.1741 \text{ kg m}^2 \]

\[ I_{\text{total}} = 0.309 \text{ kg m}^2 \]

Please remain seated if there are less than 5 minutes to go in the exam so as not to disturb those still trying to finish. If you finish early you should go back and check your work.