1. (2 pts) A square is made by joining two materials. Material 1 is twice as dense as material 2. Assuming that the diagram is drawn to scale and the object has a constant thickness, draw a dot at the location of the center of mass.

2. (2 pts) A motor spins at 800 rpm. 800 is the:
   A. period
   B. frequency
   C. angular velocity
   D. tangential acceleration
   E. normal acceleration

3. (2 pts) A car is going around a banked turn on a racetrack. The direction of the normal acceleration is:
   A. B. C. D.
   E. F. G. H.

4. (2 pts) The mass moment of inertia about the center of mass of the object is 4.2 kg·m². The mass moment of inertia about point A is:
   A. $I_a < 4.2$ kg·m²
   B. $I_a = 4.2$ kg·m²
   C. $I_a > 4.2$ kg·m²
   D. $I_a$ depends on the shape
5. (2 pts) A car starts from rest. The tangential acceleration of the car is 3 ft/s\(^2\), the normal acceleration is 4 ft/s\(^2\), and the total acceleration is 5 ft/s\(^2\). The speed of the car after 2 seconds is:

A. 6 ft/s  
B. 8 ft/s  
C. 10 ft/s

6. (2 pts) The cross product \( \mathbf{t} \times \mathbf{j} \) is:

A. \( \mathbf{t} \)  
B. \( \mathbf{j} \)  
C. \( \mathbf{k} \)  
D. \( -\mathbf{t} \)  
E. \( -\mathbf{j} \)  
F. \( -\mathbf{k} \)

7. (2 pts) Three solid spheres start from rest and the same elevation, and are simultaneously rolled down an incline. Which sphere will reach the bottom first?

A. Sphere 1  
B. Sphere 2  
C. Sphere 3  
D. Sphere 1 and 2 tie  
E. Sphere 2 and 3 tie  
F. Sphere 1 and 3 tie  
G. All spheres reach the bottom simultaneously

8. (2 pts) Which is a valid unit for angular momentum?

A. \( \text{kg} \cdot \text{m}^2 \cdot \text{s} \)  
B. \( \text{kg} \cdot \text{m/s} \)  
C. \( \text{kg} \cdot \text{m}^2 / \text{s} \)  
D. \( \text{N} \cdot \text{m/s} \)
9. (14 pts) The object shown has uniform density and thickness. If the x-coordinate of the center of mass is 5.4 cm, determine the location of the hole, $x_{\text{circle}}$.

\[
\begin{align*}
A_1 &= 8 \text{ cm} \times 6 \text{ cm} = 48 \text{ cm}^2 \\
A_2 &= 6 \times 10 \text{ cm} = 80 \text{ cm}^2 \\
A_3 &= \pi \cdot (2 \text{ cm})^2 = 12.57 \text{ cm}^2 \\
A_{\text{total}} &= A_1 + A_2 - A_3 = 85.43 \text{ cm}^2 \\
x_{\text{circle}} &= \frac{A_1 d_1 + A_2 d_2 - A_3 d_3}{A_{\text{total}}} \\
&= \frac{(18 \text{ cm}^2)(11 \text{ cm}) + (80 \text{ cm}^2)(4 \text{ cm}) - (12.57 \text{ cm}^2) x_{\text{circle}}}{85.43 \text{ cm}^2} \\
x_{\text{circle}} &= 4.51 \text{ cm}
\end{align*}
\]

10. (14 pts) Butch Jones (weight of 180 lb) is riding a 60 ft. radius Ferris Wheel that is spinning at a constant rate 4 rpm. Determine the normal force on Butch when the Butch is at the location shown. (FBD = KD required)

\[
N = 231 \text{ lb}
\]

\[
y: \quad V = \omega r = \left(\frac{4 \text{ rad}}{\text{min}}\right) \left(\frac{360 \text{ rad}}{2\pi \text{ rad}}\right) \left(\frac{1 \text{ min}}{60 \text{ sec}}\right) \left(60 \text{ ft/ sec}\right) = 25.13 \text{ ft/sec}
\]

\[
\alpha_n = \frac{V^2}{r} = \left(\frac{25.13 \text{ ft/sec}}{60 \text{ ft}}\right)^2 = 10.53 \text{ ft/s}^2
\]
11. (14 pts) A solid 4 kg disc is rotating about point A with an angular speed of 24 rad/sec. Determine the rotational kinetic energy of the disc.

\[ KE = \frac{1}{2} I \omega^2 \]

Solid disc
\[ I_{cm} = \frac{1}{2} m r^2 = \frac{1}{2} (4 \text{ kg})(0.3 \text{ m})^2 = 0.18 \text{ kg m}^2 \]

Parallel Axis Theorem
\[ I = I_{cm} + ra^2 = 0.18 \text{ kg m}^2 + (4 \text{ kg})(0.2\text{ m})^2 = 0.34 \text{ kg m}^2 \]

\[ KE = \frac{1}{2} (0.34 \text{ kg m}^2)(24 \text{ rad/s})^2 = 97.9 \text{ J} \]

12. (14 pts) A 70 N force is applied to a disc as shown. The disc starts from rest. Determine the rotational speed after 4 seconds.

\[ \omega_2 = 53.6 \text{ rad/s} \]

\[ \tau = 3 \text{ sec} \quad I = 1.6 \text{ kg m}^2 \quad \omega_i = 0 \quad \phi_i = 0 \]

\[ \alpha = \frac{\tau}{I} = \frac{-21.45 \text{ kg m}^2}{1.6 \text{ kg m}^2} = -13.41 \text{ rad/s}^2 \]

\[ \Delta \phi = \omega_1 \Delta t + \frac{1}{2} \alpha \Delta t^2 = 0 + \frac{1}{2} (-13.41 \text{ rad/s})^2 (4 \text{ sec})^2 \]

\[ \Delta \phi = -107.28 \text{ rad} \]

\[ \Delta \phi = \frac{\omega_1 + \omega_2}{2} \Delta t \]

\[ -107.28 \text{ rad} = 0 + \frac{\omega_2}{2} (4 \text{ sec}) \]

\[ \omega_2 = -53.6 \text{ rad/sec} \]

\[ \tau = 70 \text{ N}(\cos 40^\circ)(0.4 \text{ m}) \]

\[ \tau = -21.45 \text{ Nm} \]

-4 I = \frac{1}{2} m r^2 \quad \text{P.A.T.}

-4 Parallel Axis Theorem

-4 KE = \frac{1}{2} I \omega^2

-2 Answer & Units

-2 Forget \( \frac{1}{2} \) in KE

-8 KE = \frac{1}{2} (m) \omega^2

-4 Solve \( \tau \) without distance

-7 Did not solve for \( \Delta \phi \) and \( \omega_2 \)

-2 Solve \( \tau \) using wrong distance

-7 Did not solve for \( \Delta \phi \) and \( \omega_2 \)

\[ \omega_2 = \omega_1 + \Delta \phi \]

\[ \omega_2 = 0 + (-13.41 \text{ rad/s}) = -53.6 \text{ rad/sec} \]
13. (14 pts) Determine the net torque about point A. Assume each block = 1 ft. Use CCW as positive.

\[ \sum M_A = 3 \left[ 26 \text{ lb}(2 \text{ ft}) \right] - 42 \text{ lb}(5 \text{ ft}) - 51 \text{ lb} \cdot \sin 20(2 \text{ ft}) + 51 \text{ lb} \cdot \cos 20(3 \text{ ft}) \]

\[ = -49.11 \text{ ft} \cdot \text{lb} \]

14. (14 pts) A uniform 0.4 kg board is hung so it pivots about its center. A 0.003 kg bullet is shot through the board. The bullet approaches at 250 m/s and leaves at 140 m/s. Determine the angular speed of the board after the collision.

\[ \mathbf{5.5 \text{ rad/s}} \]

Perfectly Inelastic Collisions

\[ L_{Bul} + L_{Boa} = L_{Bul}' + L_{Boa}' \]

\[ m_{Bul} V_{Bul} r = m_{Bul} V_{Bul}' r + I_{Boa} \omega_{Boa}' \]

\[ (0.003 \text{ kg})(250 \text{ m/s})(0.2 \text{ m}) = (0.003 \text{ kg})(140 \text{ m/s})(0.2 \text{ m}) + (0.012 \text{ kg m}^2) \omega_{Boa}' \]

\[ \omega_{Boa}' = 5.5 \text{ rad/s} \]

Math/Calc Error - 1