

Exam 3 Review Problems

Name: Solution

1. Explain the relationship between angular acceleration and centripetal acceleration. Give an example of having only one of these quantities non-zero and an example where an object has a non-zero value for both of these.

Angular acceleration is $\alpha = \frac{\Delta\omega}{\Delta t}$ it tells you how the angular velocity is changing. Centripetal acceleration is $a_c = \frac{v^2}{r} = \omega^2 r$ which tells you the acceleration required to make an object travel in a circle. Any object in circular motion has centripetal acceleration but only an object that's speeding up in circular motion also has angular acceleration.

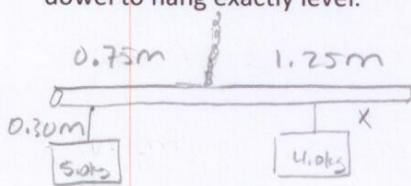
2. List all the linear quantities that we are able to determine mathematically after this semester's studies. Now determine all the angular quantities we are able to determine and match them up with their linear analog.

Position	x	\rightarrow	angular displacement	θ
Velocity	v	\rightarrow	angular velocity	ω
Acceleration	a	\rightarrow	angular acceleration	α
Force	F	\rightarrow	Torque	T
Momentum	P	\rightarrow	Angular momentum	L
mass	m	\rightarrow	moment of inertia	I
Centripetal acceleration a_c				

3. A store owner wants to hang two signs in a window and decides to use a long wooden dowel that he has handy and a chain. He only has enough chain to attach the dowel in one spot. He screws in a hook and hangs the dowel from the ceiling. He immediately realizes that he's attached the chain off center but figures it'll be easy enough to fix by attaching the signs in spots that balance the whole thing out.

The dowel is 2.0 meters long, has a mass of 1.0 kg and has been suspended at a point located 0.75 meters from the left end. He then attaches the first sign, which is 5.0 kg, 0.30 meters from the left end. The second sign has a mass of 4.0 kg?

- a. Using center of gravity find the distance from the right end that the second sign has to be hung for the dowel to hang exactly level.



I will use the right end as my origin - 0m.
 $X_{cm} = 1.25\text{m}$ for it to balance

$$X_{cm} = \frac{M_1 X_1 + M_2 X_2 + \dots}{M_1 + M_2 + \dots}$$

$$1.25\text{m} = \frac{1.0\text{kg} \cdot 1.0\text{m} + 5.0\text{kg} \cdot 1.70\text{m} + 4.0\text{kg} \cdot x}{10.0\text{kg}}$$

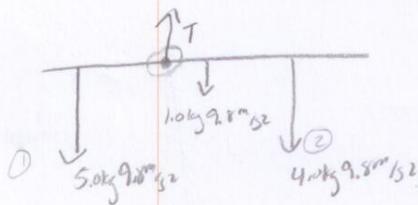
$$12.5\text{kgm} = 1\text{Kgm} + 8.5\text{Kgm} + 4.0\text{kg} \cdot x$$

$$12.5\text{kgm} - 9.5\text{kgm} = 4.0\text{kg} \cdot x$$

$$\frac{3.0\text{kgm}}{4.0\text{kg}} = x = \boxed{0.75\text{m}}$$

- b. Using Torque find the distance from the right end that the second sign has to be hung for the dowel to hang exactly level.

I will pick the axis of rotation to be the point of suspension.

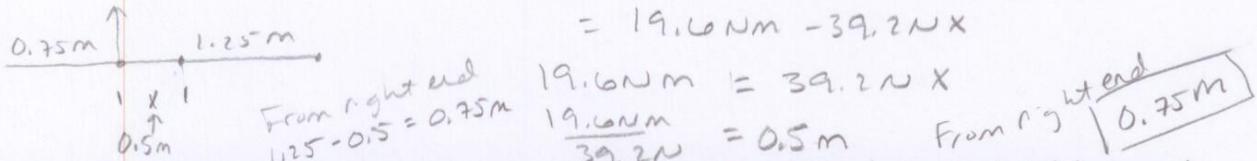


$$\sum \tau = w_1 x_1 + w_2 x_2 + w_0 x_0 = 0$$

$$= 5.0\text{kg} 9.8\text{m/s}^2 \cdot 0.45\text{m} + 4.0\text{kg} 9.8\text{m/s}^2 \cdot x + 1.0\text{kg} 9.8\text{m/s}^2 \cdot 0.25$$

$$= 22.05\text{Nm} - 39.2\text{N}x - 2.45\text{Nm} = 0$$

$$= 19.6\text{Nm} - 39.2\text{N}x$$



$$19.6\text{Nm} = 39.2\text{N}x$$

$$\frac{19.6\text{Nm}}{39.2\text{N}} = 0.5\text{m}$$

From rig^{ht} end / 0.75m

4. Two vehicles collide head on. Initially the first vehicle is traveling at 10.0 m/s due North and the second vehicle, which is twice the mass of the first, is traveling due South at 20.0 m/s. After the collision, the first vehicle is traveling at 17.0 m/s due South.

- a. Determine the final velocity of the second vehicle?

- b. What is the impulse delivered to each vehicle?

$$(2) \downarrow 20.0\text{m/s} \quad a) m_1 = m, v_{1i} = 10.0\text{m/s}, v_{1f} = -17.0\text{m/s}$$

$$m_2 = 2m, v_{2i} = -20.0\text{m/s}, v_{2f} = ?$$

before

$$\uparrow 10.0\text{m/s} \quad a) m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$(1) \quad m_1 10.0\text{m/s} + 2m(-20.0\text{m/s}) = m(-17.0\text{m/s}) + 2m v_{2f}$$

$$\begin{aligned} (2) \quad v_{2f} &=? \\ after & X \\ 0 \downarrow 17.0\text{m/s} \end{aligned}$$

$$10.0\text{m/s} - 40.0\text{m/s} = -17.0\text{m/s} + 2m v_{2f}$$

$$-30.0\text{m/s} + 17.0\text{m/s} = 2m v_{2f}$$

$$-13\text{m/s} = 2m v_{2f}$$

$$-\frac{13\text{m/s}}{2m} = v_{2f} = \boxed{-6.5\text{m/s}}$$

$$b) \vec{J} = m \Delta \vec{v}$$

$$J_1 = m_1 (v_{1f} - v_{1i})$$

$$= m (-17.0\text{m/s} - 10.0\text{m/s})$$

$$\boxed{J_1 = -27.0\text{m/s} \cdot m}$$

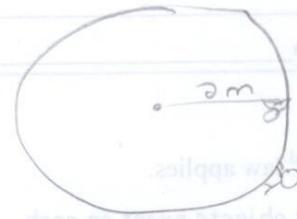
$$J_2 = m_2 (v_{2f} - v_{2i})$$

$$= 2m (-6.5\text{m/s} - -20\text{m/s})$$

$$= 2m (13.5\text{m/s})$$

$$\boxed{J_2 = 270\text{m/s} \cdot m}$$

4.



$$F = 250 \text{ N}$$

$$\Delta t = 1.5 \text{ s}$$

$$\alpha = 1.1 \text{ rad/s}^2$$

$$\omega_i = 0 \text{ rad/s}$$

$$\text{a. } \omega_f = ?$$

$$\omega_f = \omega_i + \alpha t$$

$$\omega_f = 0 + 1.1 \text{ rad/s}^2 (1.5 \text{ s})$$

$$= \boxed{1.65 \text{ rad/s}}$$

- b. This is a two part problem. During the first part the Merry-go-round is accelerating. During the second part it is spinning at a constant angular speed.

Part 1

$$\theta_i = 0 \text{ rad}$$

$$\theta_f = ?$$

$$\omega_i = 0 \text{ rad/s}$$

For part a

$$\omega_f = ? \quad 1.65 \text{ rad/s}$$

$$\alpha = 1.1 \text{ rad/s}^2$$

$$\Delta t = 1.5 \text{ s}$$

Part 2

$$\theta_i = \theta_f \text{ Part 1}$$

$$\theta_f = ?$$

$$\omega_i = \omega_f \text{ part 1} = 1.65 \text{ rad/s}$$

$$\omega_f = 1.65 \text{ rad/s} \quad \text{because } \alpha = 0$$

$$\alpha = 0 \text{ rad/s}^2$$

$$\Delta t = (60 - 1.5 \text{ s}) = 58.5 \text{ s}$$

$$\theta_f = \theta_i + \omega_i \Delta t + \frac{1}{2} \alpha \Delta t^2$$

$$= 0 + 0 \cdot 1.5 \text{ s} + \frac{1}{2} 1.1 \text{ rad/s}^2 (1.5 \text{ s})^2$$

$$= 1.24 \text{ rad}$$

$$\theta_f = \theta_i + \omega_i \Delta t + \frac{1}{2} \alpha \Delta t^2$$

$$\theta_f = 1.24 \text{ rad} + 1.65 \text{ rad/s} \cdot 58.5 \text{ s} + \frac{1}{2} 0 \text{ rad/s}^2 \cdot 58.5 \text{ s}^2$$

$$= 1.24 \text{ rad} + 96.5 \text{ rad}$$

$$= \boxed{97.7 \text{ rad}}$$