

Your Name: _____

PHY203

Exam #3
Chapters 8-10
Fri., 4/10/09

Solutions

For problems 1-3:

Point masses are placed as follows along the x-axis: 1kg at $x=0$, 2kg at $x=1\text{m}$, and 3kg at $x=2\text{m}$, all connected by a massless rod.

1. Find the moment of inertia about the x-axis:

- a. **0 kgm^2** $I = 0$ for point masses on x-axis
 b. 1.33 kgm^2
 c. 2.33 kgm^2
 d. 8.0 kgm^2
 e. 14.0 kgm^2

2. Find the moment of inertia about the y-axis:

- a. 0 kgm^2 $I = \sum(mr^2) = (1\text{kg})(0\text{m})^2 + (2\text{kg})(1.0\text{m})^2 + (3\text{kg})(2.0\text{m})^2$
 b. 1.33 kgm^2
 c. 2.33 kgm^2
 d. 8.0 kgm^2
 e. **14.0 kgm^2**

3. Assuming the rod-mass combination is rotating about the y-axis with an angular speed of 5rad/s , find the magnitude of the angular momentum:

- a. $1.6 \text{ kgm}^2/\text{s}$ $L = I\omega = (14 \text{ kgm}^2)(5\text{rad/s})$
 b. $2.8 \text{ kgm}^2/\text{s}$
 c. $40.0 \text{ kgm}^2/\text{s}$
 d. **$70.0 \text{ kgm}^2/\text{s}$**
 e. none of the above

For problems 4 and 5:

Let the vector $\mathbf{A} = 5\mathbf{i} - 4\mathbf{j}$, $\mathbf{B} = -3\mathbf{i} + 2\mathbf{k}$, $\mathbf{C} = 3\mathbf{j}$, and $\mathbf{D} = -6\mathbf{j}$

3. Find the vector $\mathbf{C} \times \mathbf{D}$:

- a. $-18\mathbf{i}$ $\mathbf{C} \times \mathbf{D} = (3\mathbf{j}) \times (-6\mathbf{j}) = -18(\mathbf{j} \times \mathbf{j}) = 0$
 b. $-18\mathbf{j}$
 c. $-18\mathbf{k}$
 d. $+18\mathbf{k}$
 e. **none of the above (0)**

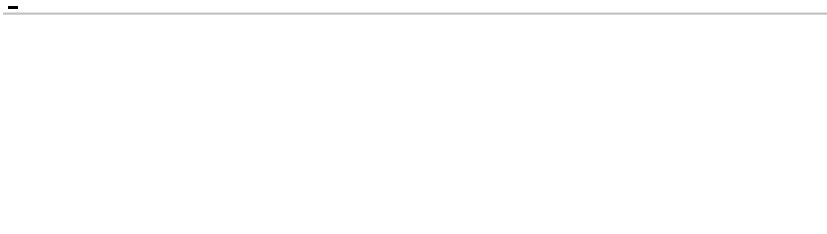
4. Find the vector $\mathbf{D} \times \mathbf{A}$:

- a. $-24\mathbf{i} - 30\mathbf{k}$ $\mathbf{D} \times \mathbf{A} = (-6\mathbf{j}) \times (5\mathbf{i} - 4\mathbf{j}) = -30(\mathbf{j} \times \mathbf{i}) - 24(\mathbf{j} \times \mathbf{j}) = -30(-\mathbf{k}) - 0$
 b. $+24\mathbf{i} - 30\mathbf{k}$

- c. $+24\mathbf{i} + 30\mathbf{k}$
- d. $-30\mathbf{k}$
- e. $+30\mathbf{k}$

For problems 6-10:

Two pucks collide on a frictionless horizontal surface, as shown below. Before the collision, puck 1 (mass=4kg) is traveling in the positive x-direction with a speed of 3.5m/s and puck 2 (mass=3kg) is traveling in the negative x-direction with a speed of 2.5m/s. After the collision, puck 1 travels off at an angle of 30° with respect to the x-axis and a speed of 3m/s.



6. Find the momentum of puck #2 before the collision.
- a. $-7.5\mathbf{i}$ kgm/s $\mathbf{p}_2 = (3\text{kg})(-2.5\text{m/s}\mathbf{i})$
 - b. $-2.5\mathbf{i}$ kgm/s
 - c. $+2.5\mathbf{i}$ kgm/s
 - d. $+7.5\mathbf{i}$ kgm/s
 - e. none of the above
7. Find the total momentum of system before the collision.
- a. $+1.0\mathbf{i}$ kgm/s $\mathbf{p}_0 = (4\text{kg})(3.5\text{m/s}\mathbf{i}) + (3\text{kg})(-2.5\text{m/s}\mathbf{i})$
 - b. $+6.5\mathbf{i}$ kgm/s
 - c. $+15.9\mathbf{i}$ kgm/s
 - d. $+21.5\mathbf{i}$ kgm/s
 - e. 15.9 kgm/s
8. What is the total momentum of system after the collision?
- a. less than before the collision same: conservation of linear momentum
 - b. **the same as before the collision**
 - c. more than before the collision
 - d. not enough information is given
9. Find the final x-component of the velocity of puck #2 after the collision.
- a. -5.1m/s $6.5\text{kgm/s} = (4\text{kg})(v_{1x}) + (3\text{kg})(v_{2x})$
 - b. -1.3m/s $= (4\text{kg})(3\text{m/s})(\cos 30^\circ) + (3\text{kg})(v_{2x})$
 - c. $+0.1\text{m/s}$ $= (10.4\text{kgm/s} + (3\text{kg})(v_{2x}))$
 - d. $+1.3\text{m/s}$
 - e. $+5.6\text{m/s}$
10. Find the final y-component of the velocity of puck #2 after the collision.
- a. -2.0m/s $0 = (4\text{kg})(v_{1y}) + (3\text{kg})(v_{2y})$
 - b. -1.5m/s $= (4\text{kg})(3\text{m/s})(\sin 30^\circ) + (3\text{kg})(v_{2y})$
 - c. $+1.5\text{m/s}$ $= (6.0\text{kgm/s} + (3\text{kg})(v_{2y}))$
 - d. $+2.0\text{m/s}$
 - e. none of the above
11. A spoked wheel is rolling without slipping, as shown below. The wheel can be modeled as a hollow cylinder of mass 5kg and diameter 1.0m with 4 spokes of mass 1.5kg each that can be modeled as thin rods of length 0.5m. The translational speed of the center of mass of the wheel is 3.5m/s as it approaches the 40° ramp. (Use $g=9.81 \text{ m/s}^2$.)



- a. Find the moment of inertia of the wheel about the axis through the center of the wheel.

$$\begin{aligned}
 I &= Mr^2 + 4\left(\frac{1}{3}mL^2\right) = (5\text{kg})(0.5\text{m})^2 + 4\left(\frac{1}{3}\right)(1.5\text{kg})(0.5\text{m})^2 \\
 &= (1.25 \text{ kgm}^2) + (0.5 \text{ kgm}^2) \\
 &= 1.75\text{kgm}^2
 \end{aligned}$$

- b. Find the angular speed of the wheel before it reaches the ramp.

$$w = v/R = (3.5\text{m/s})/(0.5\text{m}) = 7\text{rad/s}$$

- c. Find the total Kinetic Energy of the wheel before it reaches the ramp.

$$\begin{aligned}
 K &= (1/2)mv^2 + (1/2)Iw^2 = (1/2)(5.0 + 4 \times 1.5)\text{kg}(3.5\text{m/s})^2 + \\
 &\quad (1/2)(1.75 \text{ kgm}^2)(7\text{rad/s})^2 \\
 &= 67.4\text{J} + 42.9\text{J} = 110.3\text{J}
 \end{aligned}$$

- d. Assuming the wheel continues to roll without slipping, find the distance along the ramp the wheel travels before coming to rest.

$$\begin{aligned}
 110.3\text{J} &= mgh = mgD/(\sin 40^\circ) = (11\text{kg})(9.81\text{m/s}^2)D/(0.642) \\
 D &= 1.59\text{m}
 \end{aligned}$$