Your Name: ______________________

PHY203
Exam #3
Chapters 8-10,14
Mon., 12/10/18

Solutions

Exam3F18

1. Two blocks are sliding on a frictionless 1D track. Block A has a mass of 3.50 kg and is initially traveling in the +x direction with a speed of 15.5 m/s. Block B which has a mass of 2.25 kg and is traveling in the -x direction with a speed of 4.00 m/s before the collision.

a. Find the momenta of blocks A and B before the collision in vector notation.

$$\vec{p_A} = (3.50)(15.5)\,\hat{i} = 54.2\ \frac{kg\,m}{s}\,\hat{i}$$

$$\vec{p_B} = -(2.25)(4.00)\,\hat{i} = -9.00\ \frac{kg\,m}{s}\,\hat{i}$$

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b. Find the kinetic energy of blocks A and B before the collision.

$$K_A = \frac{1}{2}(3.50)(15.5)^2 = 420\ J$$

$$K_B = \frac{1}{2}(2.25)(4.00)^2 = 18\ J$$

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c. Assume the blocks collide in an inelastic collision and stick together. Find the velocity of the A-B block combination in vector notation after the collision.

$$p_{tot} = 54.2 - 9.00 = 45.2$$

$$45.2 = (3.50 + 2.25)\,v_f$$

$$\vec{v_f} = 7.86\ \frac{m}{s}\,\hat{i}$$

8

d. Assume the blocks collide elastically. We want to find the velocities of the blocks in vector notation after the collision. Write out the equations you need to solve with appropriate numbers and variables <u>but don't solve them</u>. No answer is needed.

$$p_{tot} = 45.2 = (3.50)\,v_A + (2.25)\,v_B$$

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$$K_{tot} = 438 = \frac{1}{2}(3.50)\,v_A^2 + \frac{1}{2}(2.25)\,v_B^2$$

2. A hollow sphere of mass 6.50 kg and radius 1.50 m is rotating at a constant angular speed of 17.0 rad/s in a clockwise direction as viewed from above.

a. Find the moment of inertia and the angular momentum of the sphere in vector notation taking the +z-direction as "up" and perpendicular to the disk.

$I = \frac{2}{3}(6.50)(1.50)^2 = 9.75\ kg\,m^2$ 4

$\vec{L} = (9.75)(17.0)(-\hat{k})$

$= -166\,\hat{k}\ kg\frac{m^2}{s}$ 6

b. Find the kinetic energy of the rotating sphere.

$K = \frac{1}{2}(9.75)(17.0)^2 = 1.41\times10^3\ J$ 5

A force of 35.0 N is applied to the edge of the sphere at a 35.0° angle as shown above.

c. Find the torque in vector notation on the sphere due to the applied force.

$\tau = (1.50)(35.0)\sin(35.0) = 3.01$

$\vec{\tau} = 3.01\ Nm\,\hat{k}$ 7

d. Find the angular velocity in vector notation after the force has been applied for 3.00 s.

$\omega = -17.0 + \alpha t \qquad \alpha = \frac{3.01}{9.75} = 3.09$ 8

$\vec{\omega} = [-17.0 + (3.09)(3)]\hat{k} = -7.73\ \frac{rad}{s}\,\hat{k}$

e. Find the number of revolutions the sphere makes in 20.0 s.

$\theta = 0 - 17.0(20.0) + \frac{1}{2}(3.09)(20.0)^2$

$= \frac{278\ rad}{2\pi} = 44.2\ rev.$ 10

3. A wheel is rolling without slipping on a horizontal surface with a linear speed of 17.5 m/s. It rolls up a rough ramp which makes an angle of 55.0° with respect to the horizontal. The wheel consists of a thin rim with mass 3.50 kg at a radius of 1.50 m and 6 spokes of length 1.50 m and mass 0.450 kg apiece.

a. Find the moment of inertia of the wheel through its axis.

$I = (3.50)(1.50)^2 + 6\left(\frac{1}{3}\right)(.450)(1.50)^2$ 5

$= 9.90 \text{ kg m}^2$

b. Find the kinetic energy of the wheel as it is rolling on the horizontal surface.

$K = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$ $m = 3.50 + 6(.450)$

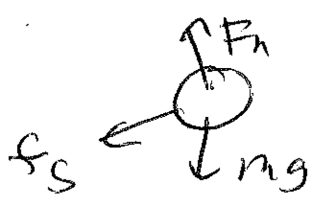
$= 6.20$

$= \frac{1}{2}(6.20)(17.5)^2 + \frac{1}{2}(9.90)\left(\frac{17.5}{1.5}\right)^2$ 10

$= 1.62 \times 10^3 \text{ J}$

$\omega = \frac{17.5}{1.5} = 11.7$

b. Sketch a free body diagram of the wheel as it rolls without slipping up the ramp.



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c. Use Conservation of Energy to find the kinetic energy of the wheel after it has rolled a distance of 7.50 m along the ramp.

$1.62 \times 10^3 = mgH + K_f$

$H = 7.50 \sin(55.0)^\circ = 6.14$ 10

$1.62 \times 10^3 = (6.20)g(6.14) + K_f$

$K_f = 1.25 \times 10^3 \text{ J}$

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1. Two blocks are sliding on a frictionless 1D track. Block A has a mass of 4.50 kg and is initially traveling in the +x direction with a speed of 16.5 m/s. Block B which has a mass of 3.25 kg and is traveling in the -x direction with a speed of 5.00 m/s before the collision.

a. Find the momenta of blocks A and B before the collision in vector notation.

$$\vec{p_A} = (4.50)(16.5)\,\hat{i} = 74.2\ \mathrm{kg\frac{m}{s}}\,\hat{i}$$

$$\vec{p_B} = -(3.25)(5.00)\,\hat{i} = -16.2\ \mathrm{kg\frac{m}{s}}\,\hat{i}$$

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b. Find the kinetic energy of blocks A and B before the collision.

$$K_A = \frac{1}{2}(4.50)(16.5)^2 = 613\ \mathrm{J}$$

$$K_B = \frac{1}{2}(3.25)(5.00)^2 = 40.6\ \mathrm{J}$$

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c. Assume the blocks collide in an inelastic collision and stick together. Find the velocity of the A-B block combination in vector notation after the collision.

$$p_{tot} = 74.2 - 16.2 = 58.0$$

$$58.0 = (4.50 + 3.25)v_f$$

$$\vec{v_f} = 7.48\ \mathrm{\frac{m}{s}}\,\hat{i}$$

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d. Assume the blocks collide elastically. We want to find the velocities of the blocks in vector notation after the collision. Write out the equations you need to solve with appropriate numbers and variables <u>but don't solve them</u>. No answer is needed.

$$p_{tot} = 58.0 = (4.50)v_A + (3.25)v_B$$

$$K_{tot} = 654 = \frac{1}{2}(4.50)v_A^2 + \frac{1}{2}(3.25)v_B^2$$

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2. A hollow sphere of mass 7.50 kg and radius 2.50 m is rotating at a constant angular speed of 19.0 rad/s in a clockwise direction as viewed from above.

a. Find the moment of inertia and the angular momentum of the sphere in vector notation taking the +z-direction as "up" and perpendicular to the disk.

$I = \frac{2}{3}(7.50)(2.50)^2 = 31.2 \text{ kg m}^2$ 4

$\vec{L} = (31.2)(19.0)(-\hat{k})$

$= -594\,\hat{k}\ \frac{\text{kg m}^2}{\text{s}}$ 6

b. Find the kinetic energy of the rotating sphere.

$K = \frac{1}{2}(31.2)(19.0)^2 = 5.63 \times 10^3 \text{ J}$ 5

A force of 45.0 N is applied to the edge of the sphere at a 35.0° angle as shown above.

c. Find the torque in vector notation on the sphere due to the applied force.

$\tau = (2.50)(45.0)\sin(35.0) = 64.5$ 7

$\vec{\tau} = 64.5 \text{ Nm } \hat{k}$

d. Find the angular velocity in vector notation after the force has been applied for 3.00 s.

$\omega = -19.0 + \alpha t \qquad \alpha = \frac{64.5}{31.2} = 2.07$

$\vec{\omega} = \{-19.0 + 2.07(3)\}\hat{k} = -10.8\,\hat{k}\ \frac{\text{rad}}{\text{s}}$ 8

e. Find the number of revolutions the sphere makes in 20.0 s.

$\theta = 0 - 19.0(20.0) + \frac{1}{2}(2.07)(20.0)^2$

$= \frac{34.0 \text{ rad}}{2\pi} = 5.41 \text{ rev.}$ 10

3. A wheel is rolling without slipping on a horizontal surface with a linear speed of 19.5 m/s. It rolls up a rough ramp which makes an angle of 55.0° with respect to the horizontal. The wheel consists of a thin rim with mass 4.50 kg at a radius of 1.50 m and 6 spokes of length 1.50 m and mass 0.650 kg apiece.

a. Find the moment of inertia of the wheel through its axis.

$$I = (4.50)(1.50)^2 + 6\left(\tfrac{1}{3}\right)(.650)(1.50)^2$$

$$= 13.0 \text{ kg m}^2$$

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b. Find the kinetic energy of the wheel as it is rolling on the horizontal surface.

$$K = \tfrac{1}{2} m v^2 + \tfrac{1}{2} I \omega^2 \qquad m = 4.50 + 6(.650) = 8.40$$

$$= \tfrac{1}{2}(8.40)(19.5)^2 + \tfrac{1}{2}(13.0)\left(\frac{19.5}{1.5}\right)^2$$

$$= 2.70 \times 10^3 \text{ J}$$

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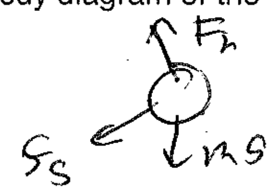
b. Sketch a free body diagram of the wheel as it rolls without slipping up the ramp.



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c. Use Conservation of Energy to find the kinetic energy of the wheel after it has rolled a distance of 9.50 m along the ramp.

$$2.70 \times 10^3 = mgH + K_f$$

$$H = 9.50 \sin 55.0° = 7.78$$

$$2.70 \times 10^3 = (8.40)g(7.78) + K_f$$

$$K_f = 2.06 \times 10^3 \text{ J}$$

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