Your Name: ______________________

PHY203
Exam #3
Chapters 8-10,14
Mon., 4/29/19

Solutions

Exam3S19

1. Two blocks are sliding on a frictionless floor (in the x-y plane). Block 1 has a mass of 2.50 kg and is traveling in the +x-direction with a speed of 7.50 m/s. Block 1 hits and sticks to block 2 which has a mass of 3.25 kg and is traveling in the -x direction with a speed of 3.00 m/s before the collision.

a. Find the momenta of blocks 1 and 2 before the collision in vector notation.

$\vec{p_1} = (2.50)(7.50)\hat{i}$

$= 18.8\,\hat{i}$ kg m/s

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$\vec{p_2} = -(3.25)(3)\hat{i}$

$= -9.75\hat{i}$ kg m/s

b. Find the velocity of the block 1-2 combination in vector notation after the collision.

$p_{tot} = 9.05 = (2.50 + 3.25)\,V$

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$\vec{V} = 1.57\hat{i}$ m/s

Soon after the collision the 2-block combination breaks apart into 3 blocks which fly off in different directions. Block A has a mass of 0.750 kg and flies off with a velocity vector of $(1.50\hat{\imath} - 2.50\hat{\jmath})m/s$. Block B has a mass of 3.50 kg and flies off with a velocity vector of $(-1.00\hat{\imath} + 2.00\hat{\jmath})m/s$.

c. Find the velocity in vector notation of the third block, C, after the breakup.

x: $9.05 = (.750)(1.50) + (3.50)(-1.00) + 1.50\,V_{cx}$

$V_{cx} = 7.62$ m/s

y: $0 = (.750)(-2.50) + (3.50)(2.00) + 1.50\,V_{cy}$

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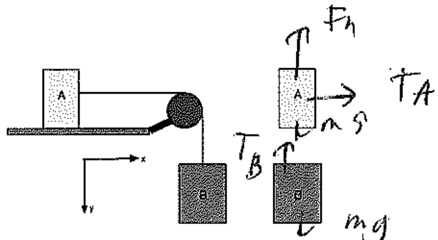
$V_{cy} = -3.42$ m/s

$\vec{V_c} = (7.62\hat{i} - 3.42\hat{j})$ m/s

$m_c = 5.75 - .750 - 3.50 = 1.50$ kg



2. Blocks A and B are connected by a light string and attached over a pulley and are initially at rest. Assume a frictionless surface under block A; the blocks have masses m_A and m_B. The pulley is a solid disk with radius R and mass M. The blocks are released.

a. Draw free body diagrams on the blocks shown above and on the right. 6

b. Write out Newton's 2nd Law for both blocks in the x- and y-directions.

A: x: $T_A = m_A a$

y: $m_A g - F_{N_A} = 0$ 15

B: y: $m_B g - T_B = m_B a$

c. Write out the torque equation for the pulley.

$T_B R - T_A R = I\alpha = I \frac{a}{R}$ 6

Take m_A = 5.50 kg, m_B = 7.50 kg, M = 4.00 kg, and R = 0.750 m.

d. Find the moment of inertia of the pulley about its axis.

$I = \frac{1}{2}(4.00)(0.750)^2 = 1.12\ kg\,m^2$ 3

e. Find the magnitude of the acceleration of the blocks.

$T_B - T_A = I\frac{a}{R^2} = \frac{1}{2}MR^2\frac{a}{R^2}$

Combine! 5

$m_B g = \left(m_A + m_B + \frac{M}{2}\right)a$

$a = \frac{7.50g}{\left(5.50 + 7.50 + \frac{4.00}{2}\right)} = 4.90\ \frac{m}{s^2}$

3. A hollow sphere is held at rest on a rough ramp. The sphere has a mass of 3.50 kg and a radius of 1.25 m. The center of the sphere is at a height of 5.50 m + the radius = 6.75 m above the ground.

a. Find the moment of inertia of the sphere about its center of mass.

$$I = \frac{2}{3} MR^2 = \frac{2}{3}(3.50)(1.25)^2 = 3.65\ kg\,m^2$$ 5

The sphere is released and rolls without slipping down the ramp.

b. Draw a free body diagram of the sphere rolling on the ramp.

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c. Use Conservation of Energy to find the kinetic energy of the sphere at the bottom of the ramp.

$$KE = mgh = (3.50)g(5.50)$$ 5

$$= 189\ J$$

d. Find the linear speed of the sphere at the bottom of the ramp.

$$189 = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

$$= \frac{1}{2}mv^2 + \frac{1}{2}\frac{2}{3}mr^2\frac{v^2}{r^2}$$ 10

$$= \frac{1}{2}mv^2\left(1 + \frac{2}{3}\right) = \frac{1}{2}(3.50)(1.67)v^2$$

$$v = 8.04\ m/s$$

e. The object runs into a spring with a spring constant of 500 N/m. Find the maximum compression of the spring.

$$189 = \frac{1}{2}kx^2 = \frac{1}{2}(500)x^2$$ 5

$$x = 0.869\ m$$

Exam3S19 alt

1. Two blocks are sliding on a frictionless floor (in the x-y plane). Block 1 has a mass of 3.50 kg and is traveling in the +x-direction with a speed of 6.50 m/s. Block 1 hits and sticks to block 2 which has a mass of 4.25 kg and is traveling in the -x direction with a speed of 3.00 m/s before the collision.

a. Find the momenta of blocks 1 and 2 before the collision in vector notation.

$\vec{p}_1 = (3.50)(6.50)\hat{i} =$
$= 22.8\,\hat{i}$ kg m/s

$\vec{p}_2 = -(4.25)(3.00)$
$= -12.8\,\hat{i}$ kg m/s

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b. Find the velocity of the block 1-2 combination in vector notation after the collision.

$p_{tot} = 10.0 = (3.50 + 4.25)\,v$

$\vec{v} = 1.29\,\hat{i}$ m/s

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Soon after the collision the 2-block combination breaks apart into 3 blocks which fly off in different directions. Block A has a mass of 3.00 kg and flies off with a velocity vector of $(1.50\hat{\imath} - 2.50\hat{\jmath})m/s$. Block B has a mass of 2.50 kg and flies off with a velocity vector of $(-1.00\hat{\imath} + 2.00\hat{\jmath})m/s$.

c. Find the velocity in vector notation of the third block, C, after the breakup.

$m_c = 3.50 + 4.25 - 3.00 - 2.50 = 2.25$ kg

x: $10.0 = (3.00)(1.50) + 2.50(-1.00) + 2.25\,v_{cx}$

$v_{cx} = 3.56\,\hat{i}$ m/s

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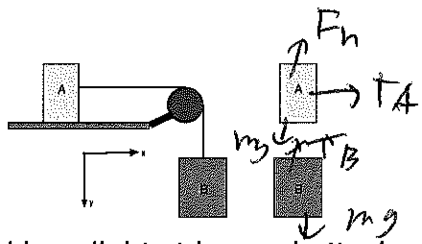
y: $0 = (3.00)(-2.50) + (2.50)(2.00) + 2.25\,v_{cy}$

$v_{cy} = 1.11\,\hat{j}$ m/s

$\vec{v}_c = (3.56\hat{i} + 1.11\hat{j})$ m/s



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a. Draw free body diagrams on the blocks shown above and on the right.

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b. Write out Newton's 2nd Law for both blocks in the x- and y-directions.

A: x: $T_A = m_A a$

y: $m_A g - F_{NA} = 0$ 15

B: y: $m_B g - T_B = m_B a$

c. Write out the torque equation for the pulley.

$T_B R - T_A R = I\alpha = I \frac{a}{R}$ 6

Take m_A = 6.50 kg, m_B = 8.50 kg, M = 5.00 kg, and R = 0.750 m.

d. Find the moment of inertia of the pulley about its axis.

$I = \frac{1}{2}(5.00)(0.750)^2 = 1.41 \text{ kg m}^2$ 3

e. Find the magnitude of the acceleration of the blocks.

$T_B - T_A = \frac{1}{2} M R^2 \frac{a}{R^2}$

combine: 5

$m_B g = (m_A + m_B + \frac{M}{2}) a$

$a = \frac{8.50g}{(6.50 + 8.50 + \frac{5.00}{2})} = 4.76 \frac{m}{s^2}$

3. A hollow sphere is held at rest on a rough ramp. The sphere has a mass of 3.25 kg and a radius of 1.25 m. The center of the sphere is at a height of 4.50 m + the radius = 5.75 m above the ground.

a. Find the moment of inertia of the sphere about its center of mass.

$$I = \frac{2}{3} M R^2 = \frac{2}{3}(3.25)(1.25)^2 = 3.39 \text{ kg m}^2$$ 5

The sphere is released and rolls without slipping down the ramp.

b. Draw a free body diagram of the sphere rolling on the ramp.

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c. Use Conservation of Energy to find the kinetic energy of the sphere at the bottom of the ramp.

$$KE = mgh = (3.25)g(4.50)$$ 5
$$= 143 \text{ J}$$

d. Find the linear speed of the sphere at the bottom of the ramp.

$$143 = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$
$$= \frac{1}{2}mv^2 + \frac{1}{2}\frac{2}{3}m r^2 \frac{v^2}{r^2}$$ 10
$$= \frac{1}{2}mv^2\left(1 + \frac{2}{3}\right) = \frac{1}{2}(3.25)v^2(1.67)$$
$$v = 7.26 \text{ m/s}$$

e. The object runs into a spring with a spring constant of 600 N/m. Find the maximum compression of the spring.

$$143 = \frac{1}{2}kx^2 = \frac{1}{2}(600)x^2$$ 5
$$x = 0.690 \text{ m}$$