Your Name: ________________________

PHY203
Exam #3
Chapters 9-11,15
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Mon., ~~[illegible]~~ April 29, 2024

Solutions

1. A 1.50 kg disk (A) sliding in the +x-direction on a horizontal, frictionless surface with an initial speed of 5.00 m/s collides with a 2.50 kg disk (B) that had been at rest.

a. List the known quantities before the collision:

Parameter	Known Value
M_A	1.50 kg
v_A	5.00 $\hat{i}$ m/s
M_B	2.50 kg
v_B	0

b. Find the linear momenta (um) of disk A before the collision and write it in vector notation. **10**

$$\vec{p_A} = (1.50)(5.00)$$

$$= 7.50 \text{ kg m/s } \hat{i}$$

c. Assuming the disks stick together after the collision, find the velocity of the 2-disk system in vector notation. **10**

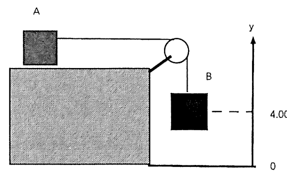
$$\vec{V_{AB}} = \frac{\vec{P_{AB}}}{m_{AB}} = \frac{7.50}{4.00} = 1.88 \text{ m/s } \hat{i}$$

d. Show that the collision is inelastic. **10**

$$K_i = \frac{1}{2}(1.50)(5.00)^2 = 18.75 \text{ J}$$

$$K_f = \frac{1}{2}(4.00)(1.88)^2 = 7.07 \text{ J}$$

$$K_i \neq K_f \Rightarrow \text{Inelastic collision}$$

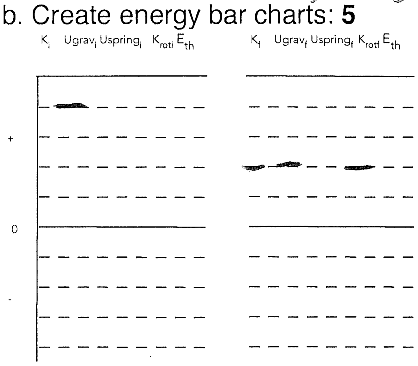


2. One block of mass m_A = 3.00 kg starts from rest and then is released so that it slides across a smooth table. It is attached by a string to a second block, mass m_B = 7.00 kg, which is hanging over a pulley. Assume the string is very light and that the pulley is a solid disk that it is frictionless. The pulley has mass M = 5.00 kg and radius R = 0.500 m. We want to find the speed of the blocks after the blocks have traveled 2.50 m. Assume block B starts at a height of 4.00 m.

a. List the known quantities before the blocks start to move below:

Parameter	Known Value
h	4.00 m
R	0.500 m
M_A	3.00 kg
M_B	7.00 kg
M_{pulley}	5.00 kg

b. Create energy bar charts: **5**



c. Find the initial energy of the block B before the blocks start moving. **10**

$U_{gB} = mgh = (7.00)(g)(4.00) = 275$ J

d. Find the moment of inertia of the pulley. **5**

$I = \frac{1}{2}MR^2 = \frac{1}{2}(5.00)(0.500)^2 = 0.625$ kg m^2

e. Using Conservation of Energy, find the speed of the blocks after they have travelled 2.50 m. **20**

$275 = \frac{1}{2}(10)v^2 + (7)g(1.5) + \frac{1}{2}I\omega^2$

$= 5v^2 + 103 + \frac{1}{2}(\frac{1}{2}M\cancel{R^2})\frac{v^2}{\cancel{R^2}}$

$172 = v^2[5 + \frac{M}{4}] = v^2[5 + 1.25]$

$v = 5.25$ m/s

3. A block of mass m=3.50 kg is attached to a spring with spring constant k=650 N/m and is stretched by a distance D=0.250 m in the +x-direction and released at t=0.

a. Find the angular frequency. **5**

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{650}{3.50}} = 13.6 \text{ rad/s}$$

b. Write out an equation giving the x-position of the block as a function of time. **5**

$$x = (0.250)\cos(13.6t)$$

c. Find the maximum acceleration of the block **5**

$$a = -\omega^2 A \cos\omega t$$

$$a_{max} = \omega^2 A = (13.6)^2(0.250)$$

$$= 46.4 \text{ m/s}^2$$

d. Find the velocity of the block the first time the block is at a position of x = -0.150 m. **15**

$$x = -.150 = (0.250)\cos(13.6t)$$

$$13.6t = \cos^{-1}\left[\frac{-.150}{.250}\right] = \cos^{-1}(-0.600)$$

$$= 2.21$$

$$t = 0.163$$

$$v = -\omega A \sin\omega t$$

$$= -(13.6)(0.250)\sin((13.6)(0.163))$$

$$= -2.72 \text{ m/s}$$

1. A 2.50 kg disk (A) sliding in the +x-direction on a horizontal, frictionless surface with an initial speed of 6.00 m/s collides with a 2.00 kg disk (B) that had been at rest.

a. List the known quantities before the collision:

Parameter	Known Value
M_A	2.50 kg
v_A	6.00 m/s $\hat{i}$
M_B	2.00 kg
v_B	0

b. Find the linear momentum of disk A before the collision and write it in vector notation. **10**

$$\vec{p}_A = (2.50)(6.00)\,\hat{i}$$
$$= 15.0\ \text{kg m/s}\ \hat{i}$$

c. Assuming the disks stick together after the collision, find the velocity of the 2-disk system in vector notation. **10**

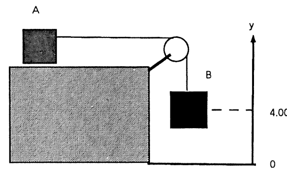
$$15.0 = (2.50 + 2.00)\,v_f$$
$$\vec{v}_f = 3.33\ \text{m/s}\ \hat{i}$$

d. Show (quantitatively) that the collision is inelastic. **10**

$$K_i = \frac{1}{2}(2.50)(6.00)^2 = 45.0\ \text{J}$$

$$K_f = \frac{1}{2}(4.50)(3.33)^2 = 25.0\ \text{J}$$

$$K_i \neq K_f \Rightarrow \text{inelastic}$$

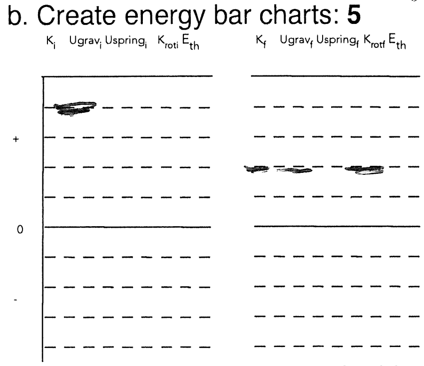


2. One block of mass m_A = 3.50 kg starts from rest and then is released so that it slides across a smooth table. It is attached by a string to a second block, mass m_B = 6.50 kg, which is hanging over a pulley. Assume the string is very light and that the pulley is a solid disk that it is frictionless. The pulley has mass M = 5.00 kg and radius R = 0.600 m. We want to find the speed of the blocks after the blocks have traveled 2.50 m. Assume block B starts at a height of 4.00 m.

a. List the known quantities before the blocks start to move below:

Parameter	Known Value
h	4.00 m
R	0.600 m
M_A	3.50 kg
M_B	6.50 kg
M_{pulley}	5.00 kg

b. Create energy bar charts: **5**



c. Find the initial energy of the block B before the blocks start moving. **10**

$$U_{gB} = mgh = (6.50)g(4.00) = 255 J$$

d. Find the moment of inertia of the pulley. **5**

$$I = \frac{1}{2}MR^2 = \frac{1}{2}(5.00)(.600)^2 = 0.900 \text{ kg m}^2$$

e. Using Conservation of Energy, find the speed of the blocks after they have travelled 2.50 m. **20**

$$255 = \frac{1}{2}(3.50 + 6.50)v^2 + 6.50g(1.50) + \frac{1}{2}I\omega^2$$

$$= 5v^2 + 95.6 + \frac{1}{2}\left(\frac{1}{2}M\cancel{R^2}\right)\frac{v^2}{\cancel{R^2}}$$

$$= v^2\left(5 + \frac{5}{4}\right) + 95.6$$

$$v^2 = \frac{159}{5 + 1.25} = 25.5$$

$$v = 5.05 \text{ m/s}$$

3. A block of mass m=4.50 kg is attached to a spring with spring constant k=800 N/m and is stretched by a distance D=0.350 m in the +x-direction and released at t=0.

a. Find the angular frequency. **5**

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{800}{4.50}} = 13.3 \text{ rad/s}$$

b. Write out an equation giving the x-position of the block as a function of time. **5**

$$x = (0.350)\cos(13.3t)$$

c. Find the maximum acceleration of the block **5**

$$a = -A\omega^2 \cos \omega t$$

$$a_{max} = A\omega^2 = (.350)(13.3)^2$$

$$= 62.2 \text{ m/s}^2$$

d. Find the velocity of the block the first time the block is at a position of x = -0.250 m. **15**

$$x = -.250 = .350 \cos(13.3t)$$

$$\cos(13.3t) = -0.714$$

$$13.3t = 2.37 \quad \text{or} \quad t = 0.178 \text{ s}$$

$$v = -A\omega \sin \omega t$$

$$= -(.350)(13.3) \sin(2.37)$$

$$= -3.25 \text{ m/s}$$