Your Name: ________________________

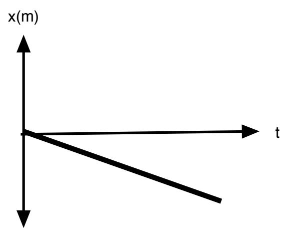
PHY203
Final Exam
Fri., 5/10/13

Part 1

Solutions

1. On the graphs below, fill in the appropriate sketches assuming 1D motion.

a. Sketch a plot consistent with constant negative velocity.



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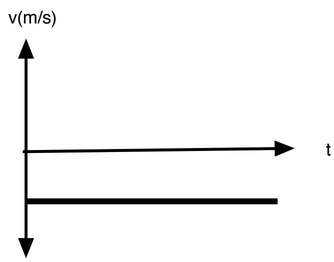
b. Sketch a plot consistent with constant negative velocity.



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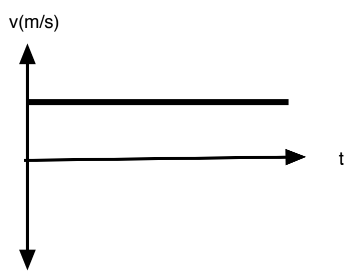
c. Sketch a plot consistent with zero acceleration.



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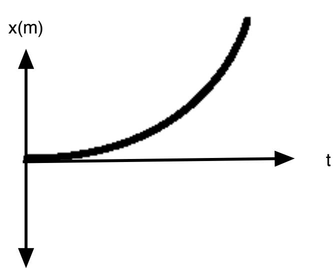
d. Sketch a plot consistent with constant, positive acceleration.



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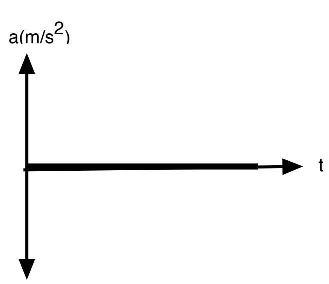
e. Sketch a plot consistent with non-zero constant, positive velocity.



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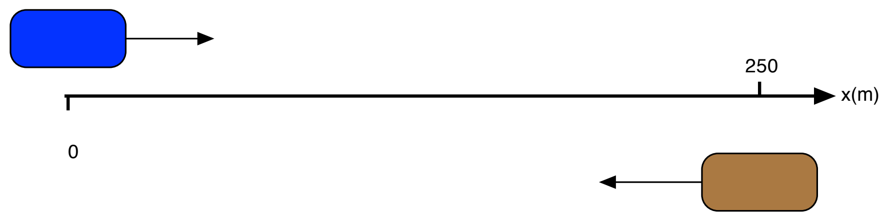


2. Two trains approach each other on parallel tracks. At a time of t=0 the train on the left is at rest and begins to accelerate at 2.50 m/s^2 to the right. At t=0 the train on the right is separated from the train on the left by 250 m and is traveling with a constant speed of 15.0 m/s and continues to travel at that speed to the left.

a. Using the coordinate system depicted above and assuming that the center of the train on the left is at x=0 at t=0, write an equation of motion (x vs. t) for the train on the left:

$x_l = 1/2(2.50\ m/s^2)t^2 = 1.25t^2$ **10**

b. Using the coordinate system depicted above and assuming that the center of the train on the right is at x=250 m at t=0, write an equation of motion (x vs. t) for the train on the right:

$x_r = 250\ m - (15.0\ m/s)t$ **10**

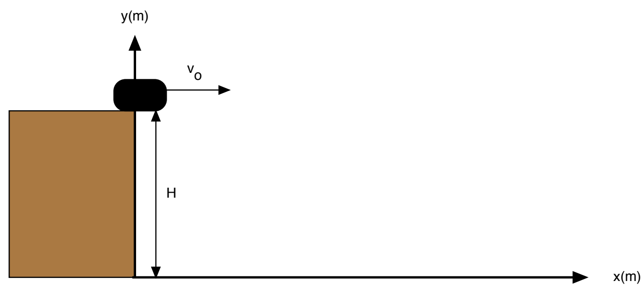
c. Combine these equations to find the time at which the centers of the trains are side-by-side.

$1/2(2.50\ m/s^2)t^2 = 250\ m - (15.0\ m/s)t$ **10**

Solve quadratic eq.; longer time is correct:
t = 9.36 s

d. Find the position at which the centers of the trains are side-by-side.

$x = 1/2(2.50\ m/s^2)(9.36\ s)^2 = 110\ m$ **5**



3. A rock is pushed off a horizontal cliff of height, H=200 m with an initial speed of v_o=15.0 m/s. (Ignore air resistance.)

a. Sketch the path of the rock on the figure above. **5**

b. Just after the rock leaves the cliff, find the acceleration of the rock and express it in vector notation using the coordinate system in the figure:

a = (0 **i** + -9.81 **j**) m/s^2 **5**

c. Just after the rock leaves the cliff, find the velocity of the rock and express it in vector notation using the coordinate system in the figure:

v = (15.0 **i** + 0 **j**) m/s **5**

d. Find the time it takes for the rock to hit the ground.

Use kinematic eq. A: **10**

$0 = 200\text{ m} + (0)t + 1/2(-9.81\text{ m/s}^2)t^2$
$t = 6.39\text{ s}$

e. Find the y-component of velocity (magnitude and sign) just before the rock hits the ground using the coordinate system in the figure.

Use kinematic eq. B or C (with previous answer):

$v_y^2 = 0 + 2(-9.81\text{ m/s}^2)(200\text{ m})$ **10**
$v_y = -62.6\text{ m/s}$

f. Find the magnitude of the velocity just before the rock hits the ground.

$v^2 = (v_{x0}^2 + v_{y0}^2)^{1/2} = ((15.0\text{m/s})^2 + (-62.6\text{m/s})^2)^{1/2} = 64.4\text{ m/s}$ **5**

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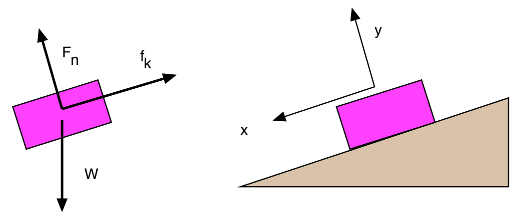
PHY203
Final Exam #2
Fri., 5/10/13

Part 2

Solutions



1. A block of mass, m=5.00 kg, is sliding down a ramp with a coefficient of kinetic friction of 0.300.
a. On the figure to the right above, draw a free-body diagram (sketch and label all the forces on the block). **5**

b. Assuming that the ramp makes an angle of 40° with respect to the horizontal direction, find the magnitude of the normal force.

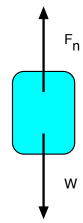
y-direction:
$$F_n - mg\cos\theta = 0$$
$$F_n = mg\cos\theta = (5.00)(9.81)\cos(40^\circ) = 37.6\,\text{N}$$
10

c. Find the magnitude of the frictional force on the block.

$$f_k = \mu_k F_n = (0.300)(37.6N) = 11.3N$$
5

d. Find the magnitude of the acceleration of the block.

x-direction:
$$mg\sin\theta - f_k = ma$$
$$a = \frac{mg\sin\theta - f_k}{m} = \frac{(5.00)(9.81)\sin(40^\circ) - 11.3N}{5.00} = 4.05\frac{m}{s^2}$$
20



2. A block of mass 7.00 kg is placed on a bathroom scale on the floor of an elevator.

a. On the figure above, draw a free-body diagram (sketch and label all the forces on the block). **5**

b. Find the reading on the scale before the elevator starts to move.

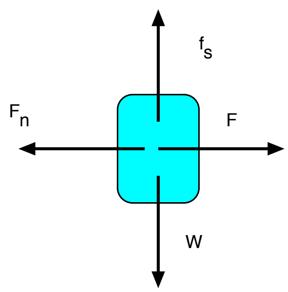
$\text{Scale Reading} = F_n = mg = (7.00)(9.81) = 68.7\text{N}$ **5**

c. Later on, the elevator is traveling at a constant speed of 5.50 m/s. Find the reading on the scale.

Constant velocity so same as part b. = 68.7 N **10**

d. The elevator stops on the fifth floor, then it accelerates at a rate of 3.5 m/s^2 as it heads to the 10th floor. Find the reading on the bathroom scale.

$$F_n - mg = ma$$
$$\text{Scale Reading} = F_n = mg + ma = 68.7\text{N} + (7.00)(3.5) = 93.2N$$
15



3. A block of m = 5.50 kg is being pushed against the wall with a force of F=90.0 N, as shown above. The static frictional coefficient between the block and the wall is μ_s.

a. On the figure to the right above, draw a free-body diagram (sketch and label all the forces on the block). **5**

b. Find the magnitude of the normal force between the wall and the block.

Normal Force = F = 90.0 N **5**

c. Assuming the block is just about to slide, find μ_s.

$$f_{s\max} - W = 0 = \mu_s F_n - W$$
$$\mu_s = \frac{W}{F_n} = \frac{54.0}{90.0} = 0.600$$

15

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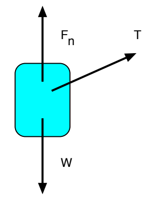
PHY203
Final Exam #3
Fri., 5/10/13

Part 3

Solutions



1. A 5.50 kg block initially at rest is attached to rope and is pulled with a constant force of 40.0 N at an angle of 35^o over a distance of 4.00 m on a frictionless surface.

a. On the figure on the right above, draw a free body diagram of the block as it is being pulled. **5**

b. Calculate how much work is done by the rope (magnitude and sign).

$W = F_x d$ or $F \cdot d = F\cos(\theta) = (40.0)\cos(35^o)(4.00) = 131J$ **10**

c. Calculate how much work is done by gravity (magnitude and sign).

F_g is perpendicular to displacement so W = 0 **5**

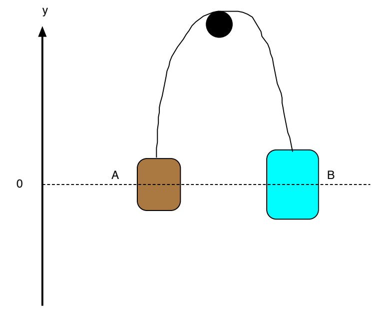
d. Using work and energy, find the speed of the block after it has been pulled for 4.00 m.

$$K_f = \frac{1}{2} m v_f^2 = W = 131$$
$$v_f = 6.90 m/s$$

10

e. If the pull took 3.00 s, find the power exerted by the rope.

P = W/t = (131)/(3.00) = 43.7 W **5**



2. Two blocks are attached by a light string, as shown above. Initially they are at rest at the same height. We'll call this height y=0. Block A has a mass of 2.50 kg; block B has a mass of 3.50 kg.

a. The blocks are released. After a later time the blocks have moved 2.00 m. Which of the blocks has the greater height?

Block A **5**

b. To find the speed of the blocks after they have traveled 2.00 m, which principle will work best? (Circle the best answer.)

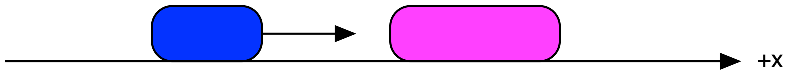
Conservation of Momentum **Conservation of Energy** Impulse-Momentum theorem **5**

c. Use the principle you circled above to find the speed of the blocks after they have traveled 2.00 m.

$$E = 0 = m_A gh + m_A gh + \frac{1}{2}m_A v^2 + \frac{1}{2}m_B v^2$$

$$0 = [(2.50)(2.00) + (3.50(-2.00)]g + \frac{1}{2}(2.50 + 3.50)v^2$$ **20**

$$v = 2.56 m/s$$



3. A disk with a mass of 0.500 kg slides along the ice. It hits and sticks to a second disk initially at rest with a mass of 0.750 kg. The two disks travel together right after the collision at a speed of 3.50 m/s.

a. Is this collision elastic or inelastic? Explain briefly.

Inelastic-the disks stick together **5**

b. Find the speed of the first disk just before the collision.

$$(0.500)v = (0.500 + 0.750)(3.50) = 4.375$$
$$v = 8.75 m/s$$

15

c. Assuming the coefficient of kinetic friction between the disks and the ice is 0.0500, use work and energy to find how far the disks travel before coming to rest.

$$K = \frac{1}{2}mv^2 = W_f = \mu_k F_n d = \mu_k mgd$$
$$\frac{1}{2}(3.50)^2 = (0.0500)(9.81)d$$
$$d = 12.5m$$

15

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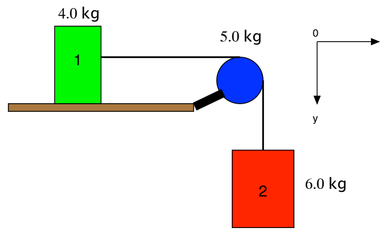
PHY203
Final Exam #4
Fri., 5/10/13

Part 4

Solutions



1. 2 blocks are attached by a thin string which hangs over a pulley (assumed to be a solid cylinder) with a radius of 0.500 m. Assume the table is frictionless. At first the blocks are held in place.

a. Find the moment of inertia of the pulley.

$$I = \frac{1}{2}MR^2 = \frac{1}{2}(5.0\,\text{kg})(0.5\,\text{m})^2 = 0.625\ \text{kgm}^2$$ **10**

b. Now the blocks are released. Use conservation of energy to find the speed of the blocks after the 6.0 kg block has fallen 2.50 m.

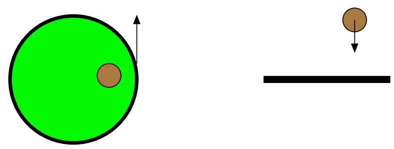
E_i=0 if measure h from the initial position of 6 kg block; 4 kg block and pulley do not change height.

Therefore:

$$0 = \frac{1}{2}(m_1 v^2 + m_2 v^2) + \frac{1}{2}I\omega^2 + mgh$$
$$= \frac{1}{2}[4.00 + 6.00]v^2 + \frac{1}{2}(0.625)(\frac{v}{R})^2 + (6.00)g(-2.50)$$ **20**
$$v = 4.85m/s$$

c. Find the angular speed of the pulley at this point.

$$\omega = \frac{v}{r} = \frac{4.85}{0.50} = 9.70rad/s$$ **5**



2. A disk of mass 1.50 kg and radius 0.500 m is rotating counterclockwise as viewed from with an angular speed of 3.50 rad/s.
a. Find the angular momentum of the disk and express it in vector notation. Take the z-axis in the positive direction out of the paper.

I = $\frac{1}{2}MR^2 = \frac{1}{2}(1.50\,\text{kg})(0.5\,\text{m})^2 = 0.1875\ \text{kgm}^2$ **10**

L = Iω= (0.1875)(3.50)=(0.656 kgm^2/s)**k**

b. A ball of mass 0.750 kg is dropped onto the disk from above and lands and sticks at a distance of 0.400 m from the axis of rotation of the disk. Assume the ball is traveling at a speed of 2.00 m/s in the vertical direction just before it lands. Find the angular momentum of the ball/disk system just after the collision in vector notation.

same as a. = 0.656 kgm^2/s **k** **5**

c. Find the magnitude of the angular speed of the ball/disk system after the collision.

conservation of angular momentum:

$$0.656 = (I_{disk} + M_b R_b^2)\omega'$$
$$= [0.1875 + (0.750)(0.400)^2]\omega'$$ **15**
$$\omega' = 2.13 rad/s$$

3. A block of mass 1.50 kg is attached to a spring. The block is stretched and released. The equation of motion of the block is as follows (with x in meters):

$x(t) = (0.750)\cos(6.00\pi t)$

a. Find the amplitude of the system.

A = 0.750 m **5**

b. Find the angular frequency of the oscillating block.

$\omega = 6.00\pi = 18.8$ rad/s **5**

c. Find the period of the system.

$$T = \frac{2\pi}{\omega} = \frac{2\pi}{18.8} = 0.333s$$ **5**

d. Find the spring constant of the spring.

$$\omega = \sqrt{\frac{k}{m}}$$ **5**

$$k = m\omega^2 = (1.50)(18.8)^2 = 530 N/m$$

e. Find the total energy of the system.

$$E = \frac{1}{2}kA^2 = \frac{1}{2}(530)(0.750)^2 = 149J$$ **5**

f. Find the time at which the block is first at a position of x = -0.500 m.

$-0.500 = (0.750)\cos(6.00\pi t)$ **10**

t = 0.122 s