Name ______________________________

Nov. 2, 2006

Phys 2010, NSCC
Exam #2 — Fall 2006

1.	____________	(14)
2.	____________	(18)
3.	____________	(12)
4.	____________	(12)
5.	____________	(11)
6.	____________	(12)
7.	____________	(12)
MC	____________	(10)
Total	____________	(100)

Multiple Choice

Choose the best answer from among the four! (2) each.

1. A Joule is the same thing as

a) $1\,\frac{\mathrm{kg \cdot m}}{\mathrm{s}}$

b) $1\,\frac{\mathrm{kg \cdot m}}{\mathrm{s^2}}$

$\boxed{\textbf{c)}}$ $1\,\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^2}}$

d) $1\,\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^3}}$

2. Recalling that velocity and acceleration are both *vectors*, when an object undergoes uniform circular motion

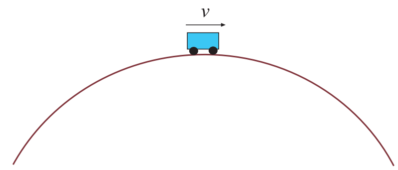
a) The velocity and acceleration are both constant

b) The velocity changes but the acceleration is constant.

c) The velocity is constant but the acceleration changes.

$\boxed{\textbf{d)}}$ The velocity and acceleration are both changing.

3. When a car is travelling over the top of a hill (and stays on the road), the normal force of the road on the car



a) Is equal to its weight.

$\boxed{\textbf{b)}}$ Is less than its weight.

c) Is greater than its weight.

d) Can be any one of the above.

4. A 2.0 kg mass moves in the $-x$ direction with a speed of $3.0\frac{\text{m}}{\text{s}}$. It bounces off of another object and is then moving in the $+x$ direction with a speed of $2.0\frac{\text{m}}{\text{s}}$. The magnitude of the mass's change in momentum is

a) $2.0\,\frac{\text{kg}\cdot\text{m}}{\text{s}}$

b) $5.0\,\frac{\text{kg}\cdot\text{m}}{\text{s}}$

$\boxed{\textbf{c)}}$ $10\,\frac{\text{kg}\cdot\text{m}}{\text{s}}$

d) $20\,\frac{\text{kg}\cdot\text{m}}{\text{s}}$

5. The total momentum of a system of masses will be conserved if

$\boxed{\textbf{a)}}$ There are no external forces on the system.

b) There are no forces between the masses.

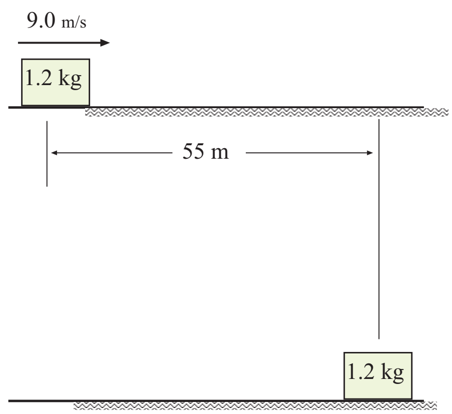
c) There are no friction–type forces

d) The KE is conserved.

Problems

Show your work and include the correct units with your answers!

1. A 1.2 kg mass is sliding on a flat horizontal surface at a speed of $9.00\frac{\mathrm{m}}{\mathrm{s}}$; because of the friction from the (uniform) surface it comes to a halt after sliding for 55 m.



a) What was the magnitude of the mass's acceleration as it was slowing? (5)

Use $v^2 = v_0^2 + 2ax$, with $v = 0$ and $v_0 = 9.0\frac{\mathrm{m}}{\mathrm{s}}$. Get:

$$a = \frac{v^2 - v_0^2}{2x} = \frac{0^2 - (9.0\frac{\mathrm{m}}{\mathrm{s}})^2}{2(55.0\ \mathrm{m})} = -0.736\frac{\mathrm{m}}{\mathrm{s}^2}$$

The magnitude of the mass's acceleration is $\boxed{0.736\frac{\mathrm{m}}{\mathrm{s}^2}}$.

b) What was the magnitude of the friction force which acted on the mass? (4)

The friction force is the only (horizontal) force on the mass as it slows down, so its magnitude is

$$F_{\mathrm{net}} = f_{\mathrm{k}} = ma = (1.2\ \mathrm{kg})(0.736\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 0.884\ \mathrm{N}$$

c) What is the coefficient of kinetic friction for the mass sliding on this surface? (5)

The normal force of the surface on the block is just the weight of the block,

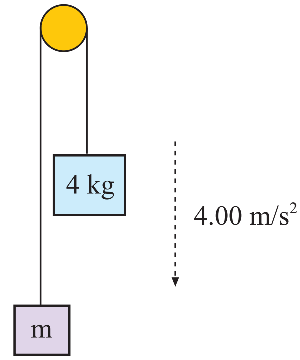
$$F_N = mg = (1.2\ \mathrm{kg})(9.80\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 11.8\ \mathrm{N}$$

so using the answer to (b), the coefficient of kinetic friction is

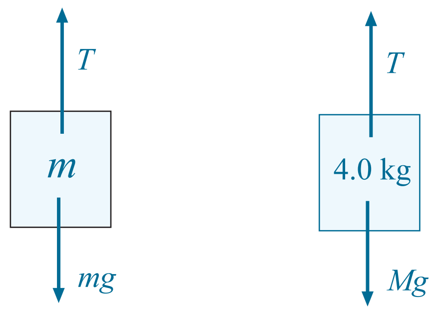
$$\mu_{\mathrm{k}} = \frac{f_k}{F_N} = \frac{(0.884\ \mathrm{N})}{(11.8\ \mathrm{N})} = 0.075$$

2. Two masses are suspended from the ends of an ideal string; the string runs over an ideal pulley, as shown. The larger mass is 4.00 kg.

When the masses are released, the larger mass accelerates downward at $4.00\frac{\mathrm{m}}{\mathrm{s}^2}$. (And the other mass accelerates upward at the same rate.)



a) Draw two force (free–body) diagrams showing the forces on both masses. (5)



b) Find the tension in the string. (6)

Considering the forces on the 4.0 kg mass in the *downward* direction, Newton's 2nd law gives

$$Mg - T = Ma \qquad \Longrightarrow \qquad T = Mg - Ma = M(g-a) = (4.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2} - 4.0\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 23.2\ \mathrm{N}$$

c) Write down Newton's 2nd law for the smaller mass (with m unknown) and solve it to find the value of m. (7)

For the smaller mass, consider forces in the upward direction (since that is the direction of its acceleration) and get

$$T - mg = ma \qquad \Longrightarrow \qquad T = mg + ma = m(g+a) \qquad \Longrightarrow \qquad m = \frac{T}{(g+a)}$$

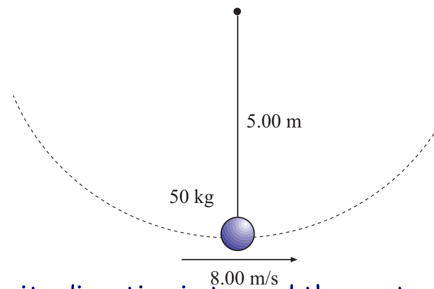
Plug in the numbers:

$$m = \frac{(23.2\ \mathrm{N})}{(9.8\frac{\mathrm{m}}{\mathrm{s}^2} + 4.0\frac{\mathrm{m}}{\mathrm{s}^2})} = 1.68\ \mathrm{kg}$$

3. A 50 kg mass is swinging from the end of a cable which is 5.0 m in length.

At the bottom of the swing, the speed of the mass is $8.00\frac{\mathrm{m}}{\mathrm{s}}$.

a) At this point, what is the magnitude and direction of the acceleration of the mass? (5)



The acceleration is the *centripetal* acceleration of the motion; its direction is toward the center of the circle (upward) and its magnitude is

$$a_c = \frac{v^2}{r} = \frac{(8.00\frac{\mathrm{m}}{\mathrm{s}})^2}{(5.0\ \mathrm{m})} = 12.8\frac{\mathrm{m}}{\mathrm{s}^2}$$

b) What is the tension in the cable? (7)

Apply Newton's second law: The forces are tension T upward and gravity mg downward:

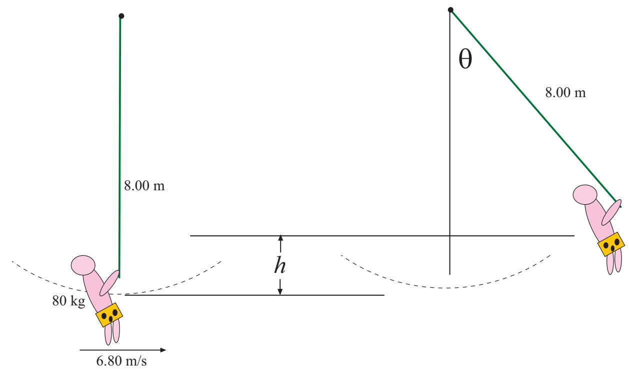
$$F_{\mathrm{net}} = T - mg = ma_c$$

Solve for T:

$$T = mg + ma_c = m(g + a_c) = (50.0\ \mathrm{kg})(9.8\frac{\mathrm{m}}{\mathrm{s}^2} + 12.8\frac{\mathrm{m}}{\mathrm{s}^2}) = 1.13 \times 10^3\ \mathrm{N}$$

4. Another swinging problem: Tarzan (mass 80 kg) is swinging from a vine which has a length of 8.0 m. At the bottom of the swing, his speed is $6.80\frac{\text{m}}{\text{s}}$.

a) When he attains maximum height on his swing, what is his height, as measured from the bottom of the swing? (6)



Use energy conservation: Energy at bottom of swing is all kinetic and energy at top of swing is all potential:

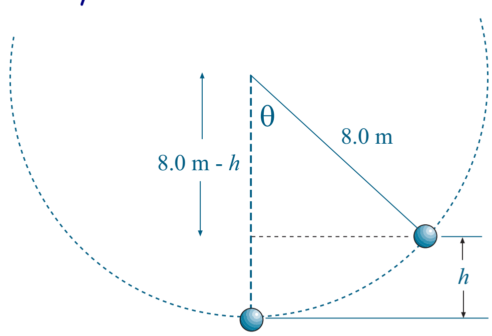
$$\tfrac{1}{2}mv^2 = mgh$$

Solve for h:

$$h = \frac{v^2}{2g} = \frac{(6.80\frac{\text{m}}{\text{s}})^2}{2(9.8\frac{\text{m}}{\text{s}^2})} = 2.36\ \text{m}$$

b) At maximum height, what angle does the vine make with the vertical? (6)

Draw a picture showing the geometry:



Then with $h = 2.36\ \text{m}$, we get

$$\cos\theta = \frac{(8.0\ \text{m} - 2.36\ \text{m})}{8.0\ \text{m}} = 0.705 \qquad \Longrightarrow \qquad \theta = 45.2^\circ$$

5. a) How much work is required to lift a 400 kg piano by 20.0 m? (6)

One needs to apply the weight of piano in the upward direction over a distance of 20.0 m, thus:

$$W = Fs(1) = mgs = (400 \text{ kg})(9.8\tfrac{\text{m}}{\text{s}^2})(20.0 \text{ m}) = 7.84 \times 10^4 \text{ J}$$

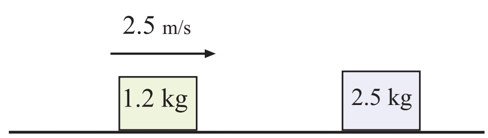
b) If this job is accomplished in 3.0 minutes what power is necessary to lift the piano ? (5)

The time to do the work is $3.0 \text{ min} = 1800 \text{ s}$, so the power necessary is

$$P = \frac{W}{t} = \frac{(7.84 \times 10^4 \text{ J})}{(1800 \text{ s})} = 43.5 \tfrac{\text{J}}{\text{s}} = 43.5 \text{ W}$$

6. In a simple one-dimensional collision between two ideal carts, a cart of mass 1.2 kg moves at a speed of $2.5\frac{\text{m}}{\text{s}}$ toward a stationary 2.5 kg mass.

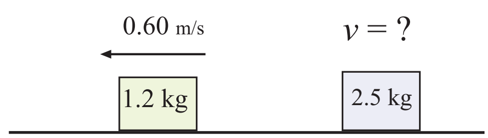
After the collision, the 1.2 kg mass is moving in the opposite direction with a speed of $0.60\frac{\text{m}}{\text{s}}$.



a) Find the velocity of the 2.5 kg mass after the collision. (7)

Total momentum is conserved in the collision:

$$(1.2 \text{ kg})(2.5\tfrac{\text{m}}{\text{s}}) + 0 = (1.2 \text{ kg})(-0.60\tfrac{\text{m}}{\text{s}}) + (2.5 \text{ kg})v$$



Solve for v:

$$(2.5 \text{ kg})v = 3.72 \tfrac{\text{kg}\cdot\text{m}}{\text{s}} \quad \Longrightarrow \quad v = 1.49\tfrac{\text{m}}{\text{s}}$$

b) How much energy was lost in this collision? (5)

The total KE initially is:

$$\text{KE}_0 = \tfrac{1}{2}(1.2 \text{ kg})(2.5\tfrac{\text{m}}{\text{s}})^2 = 3.75 \text{ J}$$

The total KE after the collision is

$$\text{KE}_f = \tfrac{1}{2}(1.2 \text{ kg})(0.60\tfrac{\text{m}}{\text{s}})^2\tfrac{1}{2}(2.5 \text{ kg})(1.49\tfrac{\text{m}}{\text{s}})^2 = 2.99 \text{ J}$$

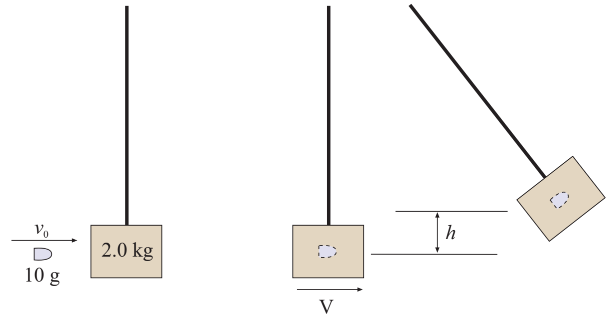
The change in KE was

$$\Delta\text{KE} = 2.99 \text{ J} - 3.75 \text{ J} = -0.76 \text{ J}$$

So $\boxed{0.76 \text{ J}}$ of KE was lost.

7. A ballistic pendulum is used to find the bullet's speed: A 10 g bullet is fired into a block of mass 2.0 kg; it is found that the block rises to a maximum height of 0.60 m (above its original height).

a) What was the speed of the bullet/block combination just after the bullet was embedded? (6)



Energy is conserved after the bullet sticks in the block; this gives

$$\tfrac{1}{2}(M+m)V^2 = (M+m)gh \qquad \Longrightarrow \qquad V^2 = 2gh \qquad \Longrightarrow \qquad V = \sqrt{2gh}$$

which gives

$$V = \sqrt{2(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2})(0.60\ \mathrm{m})} = 3.43\tfrac{\mathrm{m}}{\mathrm{s}}$$

b) What was the original speed of the bullet? (6)

Momentum was conserved in the collision, so:

$$mv_0 = (M+m)V \qquad \Longrightarrow \qquad v_0 = \frac{(M+m)}{m}V$$

Plug in the numbers:

$$v_0 = \frac{(2.0\ \mathrm{kg} + 0.010\ \mathrm{kg})}{(0.010\ \mathrm{kg})}(3.42\tfrac{\mathrm{m}}{\mathrm{s}}) = 698\tfrac{\mathrm{m}}{\mathrm{s}}$$

You must show all your work and include the right units with your answers!

$$A_x = A\cos\theta \qquad A_y = A\sin\theta \qquad A = \sqrt{A_x^2 + A_y^2} \qquad \tan\theta = A_y/A_x$$

$$v_x = v_{0x} + a_x t \qquad x = v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x x \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$g = 9.80\tfrac{\mathrm{m}}{\mathrm{s}^2} \qquad R = \frac{2v_0^2 \sin\theta\cos\theta}{g} \qquad \mathbf{F}_{\mathrm{net}} = m\mathbf{a} \qquad \mathrm{Weight} = mg$$

$$F = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times 10^{-11}\tfrac{\mathrm{N\cdot m^2}}{\mathrm{kg^2}} \qquad f_{\mathrm{s}}^{\mathrm{Max}} = \mu_s F_N \qquad f_{\mathrm{k}} = \mu_{\mathrm{k}} F_N$$

$$v = \frac{2\pi R}{T} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r}$$

$$\mathrm{PE_{grav}} = mgh \qquad \mathrm{KE} = \tfrac{1}{2}mv^2 \qquad E = \mathrm{PE} + \mathrm{KE} \qquad \Delta E = W_{\mathrm{nc}} \qquad P = \frac{W}{t}$$

$$\mathbf{p} = m\mathbf{v} \qquad \text{For isolated system} \quad \mathbf{p}_{\mathrm{Tot}} \quad \text{is conserved}$$