Name______________________________

Phys 2010, NSCC
Exam #2 — Fall 2005

1.	________________	(20)
2.	________________	(20)
3.	________________	(10)
4.	________________	(8)
5.	________________	(14)
6.	________________	(10)
7.	________________	(18)
MC	________________	(10)
Total	________________	(110 (?))

Multiple Choice

Choose the best answer from among the four!

1. A mass m slides down a frictionless inclined plane. Its acceleration is $4.9\frac{\mathrm{m}}{\mathrm{s}^2}$ (This is $\frac{1}{2}g$.) What is the angle of incline of the slope?

$\boxed{\textbf{a)}}$ 30°

b) 45°

c) 60°

d) 90°

2. Mass B has twice the mass and twice the speed of mass A. How does the kinetic energy of B compare with that of A?

a) It is 2 times as large.

b) It is 4 times as large.

$\boxed{\textbf{c)}}$ It is 8 times as large.

d) It is the same.

3. A mass m moves 2.0 m along a line while a force of magnitude 3.0 N acts on the mass in a direction perpendicular to the direction of motion of the mass. The work done by the force is

a) $+6.0$ J

b) -6.0 J

$\boxed{\textbf{c)}}$ 0 J

d) -1.5 J

4. An "isolated" system is one where

$\boxed{\textbf{a)}}$ There is no net external force on the masses.

b) The masses are all moving at constant velocity.

c) The total kinetic energy of the masses is constant.

d) The masses exert no forces on each other.

5. 1 Joule is equal to

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

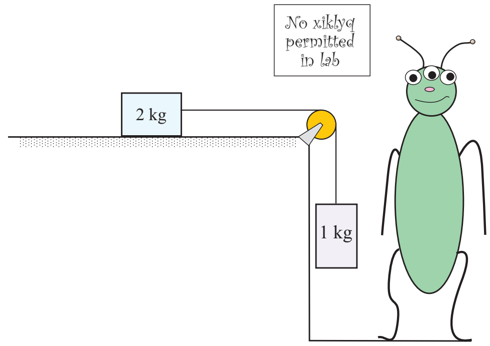
b) $1\,\frac{\mathrm{kg \cdot m^2}}{\mathrm{s^3}}$

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

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

Problems

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



1. On a strange planet (with a different value of g!) we perform the experiement pictured at the right; a 2.00-kg mass slides on a smooth horizontal table and it is connected by a string passing over an ideal pulley to a hanging 1.0-kg mass.

We find that, starting from rest, each mass moves 0.70 m in 0.5 s.

a) What is the acceleration of the masses? (4)

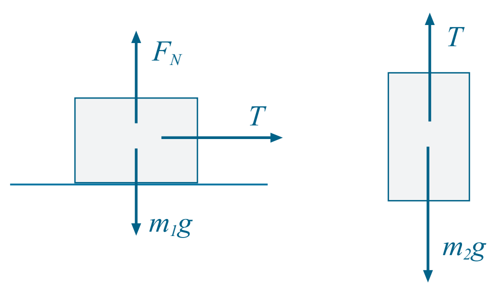
The masses start from rest, so for either one (the linear motion of each one is the same) we can use:

$$x = \tfrac{1}{2}at^2 \qquad \Longrightarrow \qquad a = \frac{2x}{t^2}$$

Plug in the numbers:

$$a = \frac{2(0.70\ \mathrm{m})}{(0.5\ \mathrm{s})^2} = 5.6\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

b) In the space given here, draw force diagrams (free–body diagrams) for both masses: (6)



c) What is the tension in the string? (4)

Apply Newton's 2nd law to the $2\ \mathrm{kg}$ mass and get:

$$T = m_1a \qquad \Longrightarrow \qquad T = (2.0\ \mathrm{kg})(5.6\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 11.2\ \mathrm{N}$$

d) What is the value of g on the planet? (6)

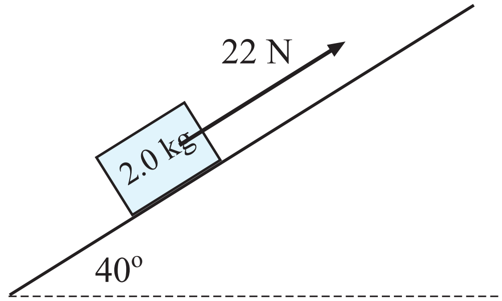
Apply Newton's 2nd law to the hanging mass (for motion in the downward direction) and get:

$$m_2g - T = m_2a \qquad \Longrightarrow \qquad m_2g = T + m_2a = 11.2\ \mathrm{N} + (1.0\ \mathrm{kg})(5.6\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 16.8\ \mathrm{N}$$

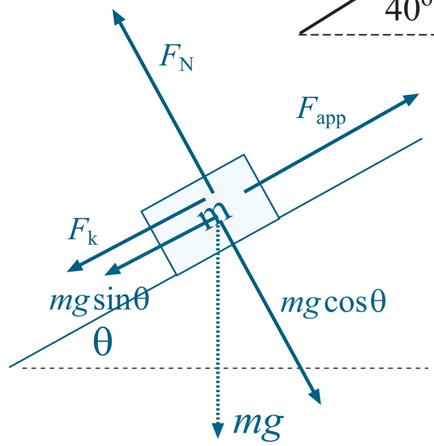
and then

$$g = \frac{(16.8\ \mathrm{N})}{m_2} = \frac{(16.8\ \mathrm{N})}{(1.0\ \mathrm{kg})} = 16.8\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

2. A 2.0 kg mass is pulled up a rough 40° incline by an applied force of 22 N. (This force is applied parallel to the incline, as shown.) The coefficient of kinetic friction for block and incline is 0.20.



a) Draw a diagram showing all the forces acting on the mass. (5)



b) What is the magnitude of the normal force from the surface? (4)

The normal force can be found from the forces perpendicular to the slope:

$$F_N - mg\cos\theta = 0 \qquad \Longrightarrow \qquad F_N = mg\cos\theta = (2.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2})\cos 40^\circ = 15.0\ \mathrm{N}$$

c) What is the magnitude of the friction force? (4)

$$F_{\mathrm{k}} = \mu_{\mathrm{k}} F_N \qquad \Longrightarrow \qquad F_{\mathrm{k}} = (0.20)(15.0\ \mathrm{N}) = 3.00\ \mathrm{N}$$

d) What is the magnitude of the total force acting on the mass? (5)

Using the force diagram we drew, we find:

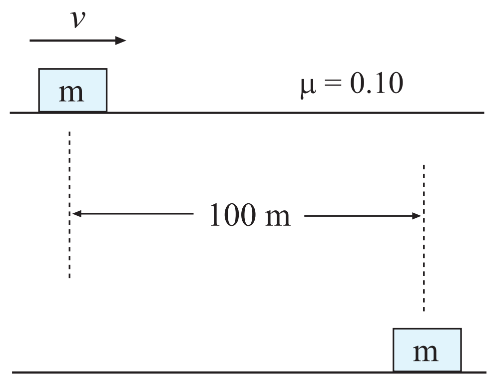
$$\begin{aligned} F_{\mathrm{net}} &= F_{\mathrm{app}} - mg\sin\theta - F_{\mathrm{k}} \\ &= 22\ \mathrm{N} - (2.0\ \mathrm{kg}(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2})\sin 40^\circ - 3.00\ \mathrm{N} = 6.4\ \mathrm{N} \end{aligned}$$

e) What is magnitude of the acceleration of the mass? (2)

From Newton's 2nd law,

$$a_x = F_{x,\mathrm{net}}/m = \frac{(6.4\ \mathrm{N})}{(2.0\ \mathrm{kg})} = 3.2\tfrac{\mathrm{m}}{\mathrm{s}^2}$$

3. A 1.0-kg mass is given a sudden kick to give it some initial speed v; it then slides for 100 m on a flat surface which has a coefficient of kinetic friction of 0.10. (And then it stops!)



a) What was the work done by friction as the mass slid on the surface? (5)

The magnitude of the friction force is

$$F_{\rm k} = \mu_{\rm k} F_N = \mu_{\rm k} mg$$

since the normal force is $F_N = mg$. Then the work done by (kinetic) friction is

$$W_{\rm k} = Fs\cos\theta = \mu_{\rm k} mgs(-1) = (0.10)(1.0\ \text{kg})(9.8\tfrac{\text{m}}{\text{s}^2})(100\ \text{m})(-1) = -98\ \text{J}$$

b) What was the initial speed v? (5)

The total work done (in this case, by friction) is the change in KE, so

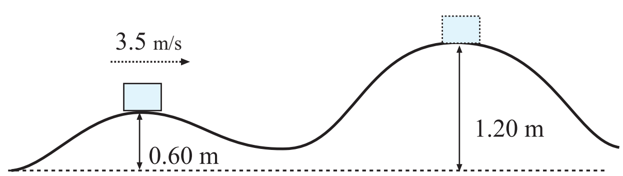
$$W_{\rm k} = \Delta(\text{KE}) = 0 - \tfrac{1}{2}mv^2 \qquad \Longrightarrow \qquad -\mu_{\rm k} mgs = -\tfrac{1}{2}mv^2$$

Where v is the initial speed. Then:

$$v^2 = \mu_{\rm k} gs = 2(0.10)(9.8\tfrac{\text{m}}{\text{s}^2})(100\ \text{m}) = 196\ \tfrac{\text{m}^2}{\text{s}^2} \qquad \Longrightarrow \qquad v = 14\tfrac{\text{m}}{\text{s}}$$

4. A mass m slides on a curvy but perfectly smooth surface. When it is at point A (which has a height of 0.60 m its speed is $3.5\frac{\text{m}}{\text{s}}$.

What is the speed of the mass when its gets to point B, which is at a height of 1.2 m? (8)



Since there is no friction, the total energy of the mass is conserved:

$$E_i = E_f \qquad \Longrightarrow \qquad \tfrac{1}{2}m(3.5\tfrac{\text{m}}{\text{s}})^2 + mg(0.60\ \text{m}) = \tfrac{1}{2}mv_f^2 + mg(1.2\ \text{m})$$

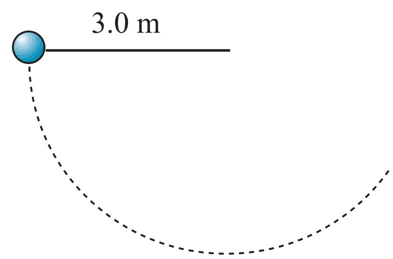
Cancel the m from all terms. Solve for v_f:

$$\tfrac{1}{2}v_f^2 = (9.8\tfrac{\text{m}}{\text{s}^2})(0.60\ \text{m} - 1.2\ \text{m}) + \tfrac{1}{2}(3.5\tfrac{\text{m}}{\text{s}})^2 = 0.245\ \tfrac{\text{m}^2}{\text{s}^2}$$

Then:

$$v_f^2 = 0.49\ \tfrac{\text{m}^2}{\text{s}^2} \qquad \Longrightarrow \qquad v_f = 0.70\tfrac{\text{m}}{\text{s}}$$

5. A 3.0-kg is attached to the end of a 3.0-m long string. It is held in the horizontal position (as shown) and released.



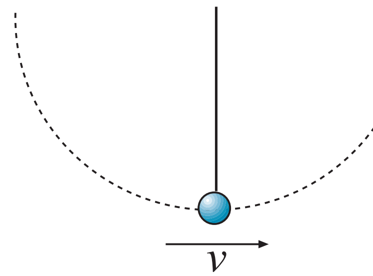
a) What is the speed of the mass as it passes through the lowest position? (6)

Energy is conserved (no friction; the force from the string does no work) so that:

$$E_i = E_f \qquad \Longrightarrow \qquad (3.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2})(3.0\ \mathrm{m}) = \tfrac{1}{2}(3.0\ \mathrm{kg})v_f^2$$

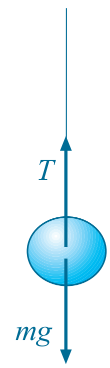
Then:

$$v_f^2 = 58.8\,\tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v_f = 7.7\tfrac{\mathrm{m}}{\mathrm{s}}$$



b) What is the tension in the string as it passes through the lowest position? *Draw a force diagram for the mass at this position.* (8)

The forces acting on the mass at the bottom of the swing are as shown at the right. But the net force is *not zero*, since the mass is in circular motion with a speed as found in part (a). The net force toward the center of the circle is



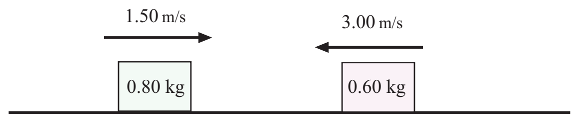
$$F_{\mathrm{cent}} = T - mg = \frac{mv^2}{R}$$

and so the tension is

$$T = mg + \frac{mv^2}{R} = (3.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2}) + \frac{(3.0\ \mathrm{kg})(7.7\tfrac{\mathrm{m}}{\mathrm{s}})^2}{(3.0\ \mathrm{m})} = 88.2\ \mathrm{N}$$

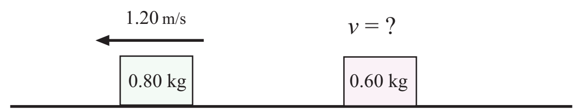
6. Two masses (0.80 kg and 0.60 kg) move toward each other on a smooth track with *speeds* of $1.5\frac{\mathrm{m}}{\mathrm{s}}$ and $3.0\frac{\mathrm{m}}{\mathrm{s}}$ respectively, as shown.

After the collision, the 0.80 kg mass is moving with a speed of $1.20\frac{\mathrm{m}}{\mathrm{s}}$ *to the left*.



a) Find the final velocity of the 0.60 kg mass. In which direction is it moving? (6)

Linear momentum is conserved in the collision ($P_i = P_f$), so



$$(0.80\ \mathrm{kg})(1.5\tfrac{\mathrm{m}}{\mathrm{s}}) + (0.60\ \mathrm{kg})(-3.0\tfrac{\mathrm{m}}{\mathrm{s}}) = (0.80\ \mathrm{kg})(-1.20\tfrac{\mathrm{m}}{\mathrm{s}}) + (0.60\ \mathrm{kg})v_f$$

Solve for v_f and get:

$$v_f = 0.60\tfrac{\mathrm{m}}{\mathrm{s}}$$

This is a positive number, so after the collision the $0.60\ \mathrm{kg}$ mass is moving $\boxed{\text{to the right}}$.

b) How much kinetic energy was lost (or gained) in this collision? (4)

Before the collision the total kinetic energy was:

$$\mathrm{KE}_i = \tfrac{1}{2}(0.80\ \mathrm{kg}(1.5\tfrac{\mathrm{m}}{\mathrm{s}})^2 + \tfrac{1}{2}(0.60\ \mathrm{kg})(3.0\tfrac{\mathrm{m}}{\mathrm{s}})^2 = 3.60\ \mathrm{J}$$

After the collision, using the result from (a), the KE was

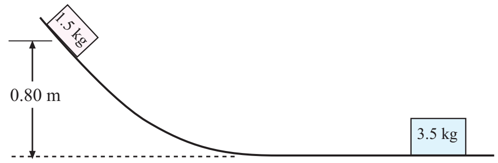
$$\mathrm{KE}_f = \tfrac{1}{2}(0.80\ \mathrm{kg}(1.2\tfrac{\mathrm{m}}{\mathrm{s}})^2 + \tfrac{1}{2}(0.60\ \mathrm{kg})(0.60\tfrac{\mathrm{m}}{\mathrm{s}})^2 = 0.68\ \mathrm{J}$$

which is less (much less) than the original KE; thus,

$$3.60\ \mathrm{J} - 0.68\ \mathrm{J} = 2.9\ \mathrm{J}$$

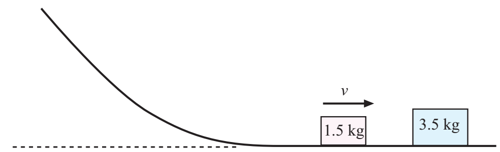
of energy was lost.

7. A 1.5 kg mass moves on a frictionless curved surface on which it can slide down to smooth flat part (where a 3.5 kg mass is sitting at reset).

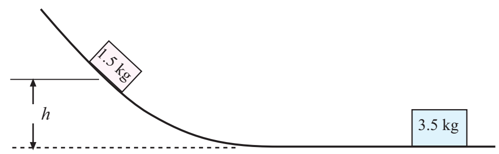


a) If it is released from a height of 0.80 m, what is its speed when it reaches the flat part? (6)

Total energy is conserved, so $E_i = E_f$ or in this case, if v is the speed when the $1.5\ \mathrm{kg}$ mass arrives at the bottom, then $mgh = \frac{1}{2}mv^2$, and this gives



$$v^2 = 2gh = 2(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2})(0.80\ \mathrm{m}) = 15.7\,\tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v = 4.0\tfrac{\mathrm{m}}{\mathrm{s}}$$



b) If the 1.5-kg mass makes an *elastic* (head-on) collision with the 3.5-kg mass, what is the final velocity of the 1.5-kg mass? (8)

Use the formulae which apply for a 1--D elastic collision where the second mass was initially at rest. If v' is the final velocity of m_1 we get:

$$v' = \frac{(m_1 - m_2)}{(m_1 + m_2)}v_{1i} = \frac{(1.5\ \mathrm{kg} - 3.5\ \mathrm{kg})}{(1.5\ \mathrm{kg} + 3.5\ \mathrm{kg})}(4.0\tfrac{\mathrm{m}}{\mathrm{s}}) = -1.58\tfrac{\mathrm{m}}{\mathrm{s}}$$

So the $1.5\ \mathrm{kg}$ mass has a speed of $1.6\frac{\mathrm{m}}{\mathrm{s}}$ and is moving to the left after the collision (as we expected, otherwise the next part wouldn't make any sense!).

c) The 1.5-kg mass slides back up the slope. What is the maximum height attained by this mass on its return trip? (4)

Again, energy is conserved so if h' is the height attained by the mass on the return trip, then $\frac{1}{2}mv'^2 = mgh'$, so

$$\tfrac{1}{2}v'^2 = gh' \qquad \Longrightarrow \qquad h' = \frac{v'^2}{2g} = \frac{(1.58\frac{\mathrm{m}}{\mathrm{s}})^2}{2(9.8\frac{\mathrm{m}}{\mathrm{s}^2})} = 0.127\ \mathrm{m}$$

The mass attains a height of $\boxed{0.13\ \mathrm{m}}$ on its return trip.

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

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

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

$$v_y = v_{0y} + a_y t \qquad y = v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad v_y^2 = v_{0y}^2 + 2a_y y \qquad y = \tfrac{1}{2}(v_{0y} + v_y)t$$

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

$$F = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times 10^{-11}\,\tfrac{\mathrm{N\cdot m^2}}{\mathrm{kg^2}}$$

$$F_{\mathrm{s}}^{\mathrm{Max}} = \mu_{\mathrm{s}} F_N \qquad F_{\mathrm{k}} = \mu_{\mathrm{k}} F_N \qquad v = \frac{2\pi R}{T} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r}$$

$$4\pi^2 r^3 = GMT^2$$

$$W = Fs\cos\theta \qquad \mathrm{KE} = \tfrac{1}{2}mv^2 \qquad \mathrm{PE}_{\mathrm{grav}} = mgy \qquad E = \mathrm{KE} + \mathrm{PE}$$

$$\Delta E = W_{\mathrm{fric,\,misc}}$$

$$\mathbf{p} = m\mathbf{v}$$

$$v_{1f} = \left(\frac{m_1 - m_2}{m_1 + m_2}\right)v_{1i} \qquad v_{2f} = \left(\frac{2m_1}{m_1 + m_2}\right)v_{1i}$$