Name________________________

Mar. 29, 2007

# Phys 2010, NSCC
# Exam #2 — Spring 2007

| | | |
|---|---|---|
| **1.** | ________ | (6) |
| **2.** | ________ | (21) |
| **3.** | ________ | (11) |
| **4.** | ________ | (15) |
| **5.** | ________ | (8) |
| **6.** | ________ | (10) |
| **7.** | ________ | (7) |
| **8.** | ________ | (12) |
| **MC** | ________ | (10) |
| **Total** | ________ | (100) |

## Multiple Choice

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

**1.** When an object is undergoing uniform circular motion then

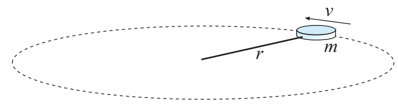
**a)** Its speed, velocity and acceleration are all constant.

**b)** Its speed and velocity are constant but its acceleration changes.

**c)** Its speed and acceleration are constant but its velocity changes.

$\boxed{\textbf{d)}}$ Its speed is constant but both its velocity and acceleration change.

**2.** A mass $m$ is attached to a string and moves on a frictionless table. It undergoes uniform circular motion with speed $v$ in a circle of radius $r$; the tension in the string is $T$. If we double its speed (but keep the radius the same) the string tension will be




- **a)** $T/2$
- **b)** $T$
- **c)** $2T$
- **d)** $4T$

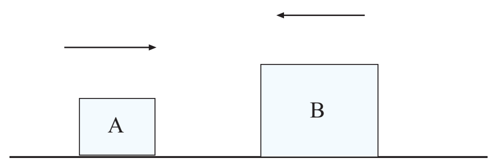
**3.** An elastic collision is one in which

- **a)** Energy is conserved.
- **b)** Momentum is conserved.
- **c)** One of the masses is initially at rest.
- **d)** Both of the masses are initially moving in the same direction.

**4.** Object B has twice the mass of object A and in moving at 3 times the speed. As compared with A, the kinetic energy of B is

- **a)** 3 times as large.
- **b)** 6 times as large.
- **c)** 18 times as large.
- **d)** 36 times as large.

**5.** When mass A undergoes a collision with a much larger mass B, during the collision




- **a)** The force of A on B is greater than the force of B on A.
- **b)** The force of B on A is greater than the force of A on B.
- **c)** The force of A on B has the same magnitude as the force of B on A.
- **d)** It is impossible to compare the forces unless we know the initial velocities.

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## Problems

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

**1.** What are the SI ("mks") units of: (6)

**a)** String tension

Newtons, N

**b)** Kinetic Energy

Joules, J

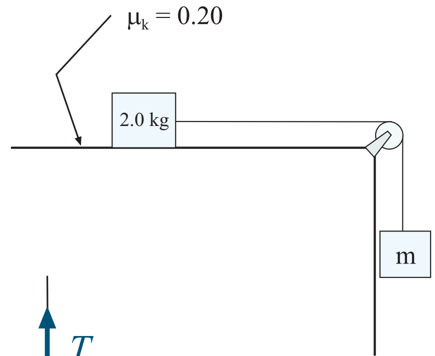
**c)** Gravitational potential energy

Joules, J

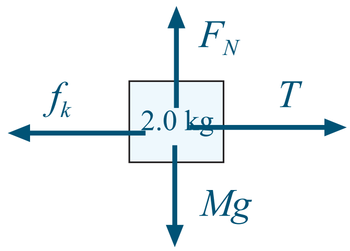
**d)** Momentum

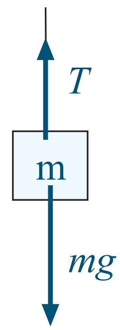
$\frac{\text{kg}\cdot\text{m}}{\text{s}}$

**2.** A 2.0 kg mass and a mass $m$ are connected by a light string which runs over an ideal pulley. The 2.0 kg mass slides on a rough horizontal surface for which the coefficient of friction is $\mu_k = 0.20$. When the masses are released it is found that the masses have a common acceleration of $3.00\frac{\mathrm{m}}{\mathrm{s}}$




**a)** Draw free-body diagrams (force diagrams) for the two masses. (5)




**b)** What is the magnitude of the friction force which acts on the sliding mass? (5)

The normal force on this mass must be

$$f_k = \mu_k F_N = \mu_k M g = (0.20)(2.0\ \mathrm{kg})(9.80\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 3.92\ \mathrm{N}$$

**c)** Using your force diagram for the sliding mass, find the tension in the string. (5)

Newton's 2nd law and the force diagram gives

$$F_{\mathrm{net}} = T - f_k = T - 3.92\ \mathrm{N} = Ma = (2.0\ \mathrm{kg})(3.0\tfrac{\mathrm{m}}{\mathrm{s}^2})$$

Solve for $T$:

$$T = 3.92\ \mathrm{N} + (2.0\ \mathrm{kg})(3.0\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 9.92\ \mathrm{N}$$

**d)** Using your diagram for for the hanging mass, find $m$. (Write down Newton's 2nd law and solve for $m$!) (6)

The forces in the downward direction add up to give:

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

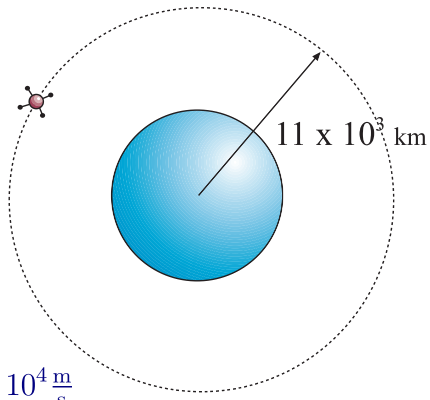
We need to solve for $m$, so:

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

Then we get:

$$m = \frac{(9.92\ \mathrm{N})}{(9.80\frac{\mathrm{m}}{\mathrm{s}^2} - 3.0\frac{\mathrm{m}}{\mathrm{s}^2})} = 1.46\ \mathrm{kg}$$

**3.** A satellite orbits a planet at a distance of $11 \times 10^3$ km from the planet's center. The period of the satellite's orbit is 1.14 hours.




**a)** What is the speed of the satellite? (5)

With

$$r = 11 \times 10^6 \text{ m} \qquad \text{and} \qquad T = 1.14 \text{ hours} = 4.10 \times 10^3 \text{ s}$$

we get:

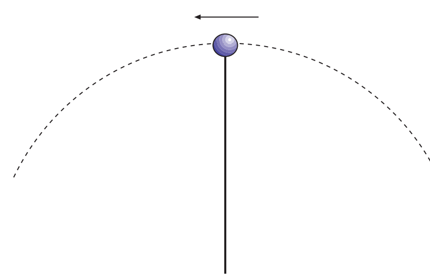
$$v = \frac{2\pi r}{T} = \frac{2\pi(11 \times 10^6 \text{ m})}{(4.10 \times 10^3 \text{ s})} = 1.68 \times 10^4 \tfrac{\text{m}}{\text{s}}$$

**b)** What is the magnitude and direction of the acceleration of the satellite? (6)

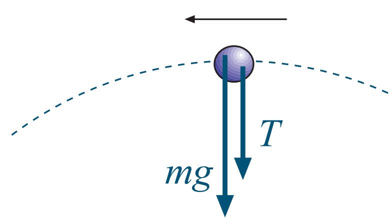
The acceleration of the satellite is its *centripetal* acceleration, which is directed toward the center of the orbit and has magnitude

$$a = a_c = \frac{v^2}{r} = \frac{(1.68 \times 10^4 \tfrac{\text{m}}{\text{s}})^2}{(11 \times 10^6 \text{ m})} = 24.4 \tfrac{\text{m}}{\text{s}^2}$$

**4.** A 0.600 kg swings at the end of a 1.20 m string in a vertical circle. We will consider the time when it is at the top of the circle. At this time the speed of the mass is $4.50 \tfrac{\text{m}}{\text{s}}$



**a)** Draw a force diagram showing the forces acting on the mass here. (3)




**b)** What is the magnitude and direction of the net force on the mass? (6)

Net force is toward the center of the circle of its motion, which here is $\boxed{\text{downward}}$. The magnitude of the (centripetal) force is

$$F_c = \frac{mv^2}{r} = \frac{(0.600 \text{ kg})(4.50 \tfrac{\text{m}}{\text{s}})^2}{(1.20 \text{ m})} = 10.1 \text{ N}$$

**c)** What is the tension in the string when the mass is at the top position? (6)

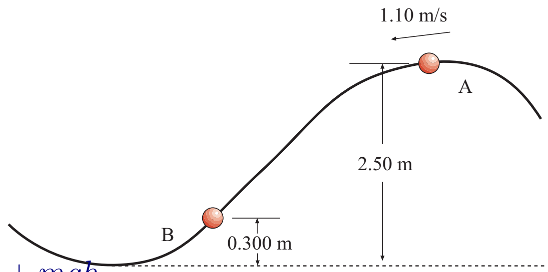
The net downward force on the mass is

$$F_{net} = T + mg = F_c = 10.2 \text{ N}$$

Solve for $T$:

$$T = 10.2 \text{ N} - mg = 10.1 \text{ N} - (0.600 \text{ kg})(9.80 \tfrac{\text{m}}{\text{s}^2}) = 4.2 \text{ N}$$

**5.** A bead slides on a frictionless wire, as shown at the right. If at point A (2.50 m above the lowest point) it has a speed of $1.10\frac{\text{m}}{\text{s}}$, what is its speed at point B (0.300 m above the lowest point)? (8)




Mechanical energy is conserved:

$$\tfrac{1}{2}mv_A^2 + mgh_A = \tfrac{1}{2}mv_B^2 + mgh_B$$

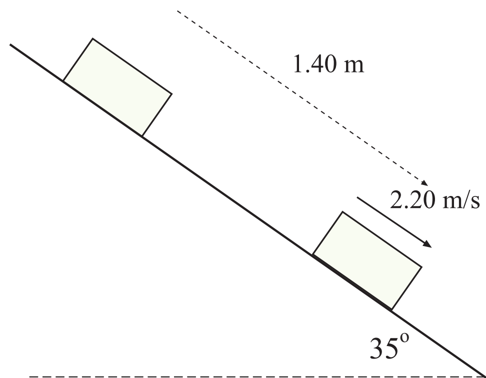
The factor of $m$ can be cancelled here. Then:

$$\Longrightarrow \qquad \tfrac{1}{2}(1.10\tfrac{\text{m}}{\text{s}})^2 + g(2.50\text{ m}) = \tfrac{1}{2}v_B^2 + g(0.300\text{ m})$$

Solve for $v_B$; multiply both sides by 2, get:

$$v_B^2 = (1.10\tfrac{\text{m}}{\text{s}})^2 + 2g(2.50\text{ m} - 0.300\text{ m}) = 44.3\,\tfrac{\text{m}^2}{\text{s}^2} \qquad \Longrightarrow \qquad v_B = 6.7\tfrac{\text{m}}{\text{s}}$$

**6.** A 1.5 kg mass slides 1.4 m down a 35.0° incline, starting from rest. At the end of its slide it has a speed of $2.20\frac{\text{m}}{\text{s}}$.




**a)** What was the change in potential energy for the mass? (5)

The change in height of the mass is

$$\Delta y = -(1.4\text{ m})\sin 35^\circ = -0.803\text{ m}$$

So the change in potential energy is

$$\Delta\text{PE} = mg\Delta y = (1.5\text{ kg})(9.80\tfrac{\text{m}}{\text{s}^2})(-0.803\text{ m}) = -11.8\text{ J}$$

**b)** How much work was done by friction? (5)

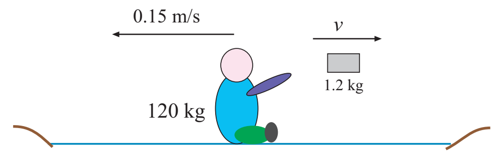
The change in kinetic energy was

$$\Delta\text{KE} = \tfrac{1}{2}v_f^2 - 0 = \tfrac{1}{2}(1.5\text{ kg})(2.2\tfrac{\text{m}}{\text{s}})^2 = 3.63\text{ J}$$

so the work done by the friction force was

$$W_{\text{fric}} = W_{\text{nc}} = \Delta\text{PE} + \Delta\text{KE} = -11.8 + 3.63\text{ J} = -8.17\text{ J}$$

**7.** A big fat guy of mass 120 kg is sitting in the middle of a frozen lake, holding a 1.2 kg physics book. He is presently at rest, but he wants to get himself moving at a speed of $0.150\frac{\text{m}}{\text{s}}$. With what speed should he throw the physics book? (7)

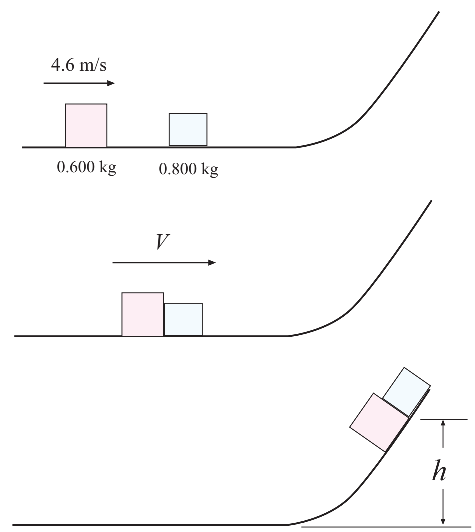



If the fat guy's final velocity is $-0.150\frac{\text{m}}{\text{s}}$ (we'll say he goes in the $-x$ direction) then by momentum conservation before and after the throwing,

$$0 = (120\ \text{kg})(-0.150\tfrac{\text{m}}{\text{s}}) + (1.2\ \text{kg})v_b \qquad \Longrightarrow \qquad v_b = 15.0\tfrac{\text{m}}{\text{s}}$$

He needs to throw the book at a speed of $\boxed{15.0\frac{\text{m}}{\text{s}}}$

**8.** A 0.600 kg mass slides on a frictionless track and collides with a stationary 0.800 kg mass. The masses stick together and then move up a sloped part of the track. The combined mass attains a maximum height $h$.




**a)** What is the speed of the combined mass just after the collision? (6)

Momentum is conserved in the collision, so since (from the picture!) the initial speed of the incoming mass is $4.60\frac{\text{m}}{\text{s}}$,

$$(0.600\ \text{kg})(4.60\tfrac{\text{m}}{\text{s}}) = (0.600\ \text{kg} + 0.800\ \text{kg})V$$

Solve for $V$,

$$V = 1.97\tfrac{\text{m}}{\text{s}}$$

**b)** What is the height $h$? (6)

Energy is conserved as the combined mass goes up the ramp, so

$$\tfrac{1}{2}(1.4\ \text{kg})(1.97\tfrac{\text{m}}{\text{s}})^2 = (1.4\ \text{kg})gh$$

Solve for $h$, get:

$$h = 0.198\ \text{m}$$

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

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

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

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

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

$$F = G\frac{m_1 m_2}{r^2} \qquad G = 6.67\times10^{-11}\,\tfrac{\mathrm{N\cdot m^2}}{\mathrm{kg^2}} \qquad f_{\mathrm{s}}^{\mathrm{Max}} = \mu_s F_N \qquad f_{\mathrm{k}} = \mu_{\mathrm{k}} F_N$$

$$v = \frac{2\pi R}{T} \qquad a_c = \frac{v^2}{r} \qquad F_c = \frac{mv^2}{r} \qquad W_{\mathrm{total}} = \Delta\mathrm{KE}$$

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

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

$$\mathbf{J} = \Delta\mathbf{p} \qquad \mathbf{F}_{\mathrm{av}} = \frac{\Delta\mathbf{p}}{\Delta t} \qquad x_{\mathrm{CM}} = \frac{m_1x_1 + m_2x_2 + \cdots}{m_1 + m_2 + \cdots}$$