Lecturer: Robinson Murdock **Name**______________________________

Nov 7, 2000

Phys 121 — Fall 2000
Exam #2

1.	____________	(10)
2.	____________	(16)
3.	____________	(14)
4.	____________	(19)
5.	____________	(11)
6.	____________	(10)
MC	____________	(20)
Total	____________	(100)

$$g = 9.80\,\tfrac{\text{m}}{\text{s}^2} \qquad G = 6.67\times10^{-11}\,\tfrac{\text{N}\cdot\text{m}^2}{\text{kg}^2} = 6.67\times10^{-11}\,\tfrac{\text{m}^3}{\text{kg}\cdot\text{s}^2}$$

$$\mathbf{F} = m\mathbf{a} \qquad f_{\text{stat}}^{\text{max}} = \mu_{\text{stat}} F_N \qquad f_{\text{kin}} = \mu_{\text{kin}} F_N \qquad F_{\text{grav}} = G\frac{m_1 m_2}{r^2}$$

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

$$W = Fs\cos\theta \qquad \text{PE}_{\text{grav}} = mgh \qquad \text{KE} = \tfrac{1}{2}mv^2 \qquad \Delta E = \Delta\text{PE} + \Delta\text{KE} = W_{\text{non-cons}}$$

$$\mathbf{p} = m\mathbf{v} \qquad \mathbf{I} = \Delta\mathbf{p} \qquad \text{Isolated System: } \mathbf{P}_0 = \mathbf{P}_f$$

$$\omega = \omega_0 + \alpha t \qquad \theta = \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha\theta \qquad \theta = \tfrac{1}{2}(\omega_0 + \omega)t$$

$$s = r\theta \qquad v = r\omega \qquad a_c = \omega^2 r \qquad a_T = r\alpha$$

$$180\,\text{deg} = \pi\,\text{radian} \qquad 1\,\text{rev} = 360\,\text{deg} \qquad 1\,\text{min} = 60\,\text{sec} \qquad 1\,\text{km} = 10^3\,\text{m}$$

Multiple Choice

1. When a car successfully drives round a flat (non–banked) curve in a road at a constant speed, what forces are acting on the car?

a) Gravity, a normal force, and a force of static friction directed to the outside of the curve.

b) Gravity and a normal force only.

c) Gravity, a normal force, and a force of static friction directed to the inside of the curve.

d) Gravity, a normal force, and a force of static friction directed at a tangent to the curve.

2. While the car in Question #1 is driving round the curve a small package on the back seat slides across the seat and hits the door on the outside on the curve. This happens because:

a) A centrifugal force pushes the package across the seat toward the outside of the curve.

b) The package moves at a constant velocity, and the car does not.

c) The car moves at a constant velocity and the package does not.

d) The package contains a small furry mammal that has pushed its feet through the paper and scuttled across the seat.

3. Astronauts float inside the space shuttle when it is in orbit 250 miles above the surface of the Earth, because:

a) The force of gravity is very much weaker that far above the Earth.

b) They are outside the Earth's atmosphere.

c) The shuttle and its contents are in constant free fall at the acceleration due to gravity.

d) The force of gravity is balanced by the centrifugal force pushing them away from the Earth.

4. A wooden block slides down an inclined ramp at a constant velocity. Which of the following statements is true?

a) The force of gravity does no work on the block.

b) The frictional force does no work on the block.

c) All the forces acting on the block are conservative.

d) The total work done on the block by all forces is zero.

5. For the same block as in Question #4, which of the following statements is true?

a) The total mechanical energy of the block increases.

b) The total mechanical energy of the block decreases.

c) The total mechanical energy of the block is conserved.

d) The total mechanical energy of the block is zero.

6. On successive pitches, TTU's new Hungarian baseball pitcher Évåd Ķcödûrm delivers fast balls of 92 mph and 87 mph. Which statement *must* be true about these two pitches?

a) The force that Évåd exerted on the ball was greater for the faster pitch.

b) Évåd's hand was in contact with the ball for a slightly longer time period on the faster pitch.

c) The impulse exerted on the ball by Évåd was greater for the faster pitch.

d) Évåd moved his hand slightly faster in delivering the faster pitch.

7. In a collision between two objects where they do *not* stick together,

a) Momentum is conserved but kinetic energy is not.

b) Momentum is not conserved but kinetic energy *is*.

c) Both momentum and kinetic energy are conserved.

d) Momentum is conserved, but kinetic energy may or may not be conserved.

8. The script of the movie Superman XII has a 2×10^6 kg asteroid headed straight for Earth at a speed of $4000\,\frac{\text{m}}{\text{s}}$. To save the world, Superman ($m = 85\,\text{kg}$) flies straight toward the asteroid, head on, at a speed of $4000\,\frac{\text{m}}{\text{s}}$. He grabs the asteroid, reverses its direction and carries it back into space at a speed of $4000\,\frac{\text{m}}{\text{s}}$. As the science consultant on the movie, your verdict is:

a) This violates conservation of mechanical energy.

b) This violates conservation of momentum.

c) This is OK because kinetic energy is conserved.

d) This is OK because momentum is conserved.

9. On a merry-go-round ride at the fair, where should you sit to experience the greatest angular acceleration as the ride is speeding up?

a) As close to the center as possible.

b) Halfway out from the center.

c) As far from the center as possible.

d) It doesn't matter where you sit, all seats have the same angular acceleration.

10. On the very same merry–go–round, where should you sit to have the greatest tangential acceleration as the ride is speeding up?

a) As close to the center as possible.

b) Halfway out from the center.

c) As far from the center as possible.

d) It doesn't matter where you sit, all seats have the same tangential acceleration.

Problems

1. *Units? Units?* What are the appropriate MKS (SI, metric) units for the following quantities: (10)

a) Force

$N = \frac{kg\,m}{s^2}$

b) Angular Acceleration

rad/s^2 or $1/s^2 = s^{-2}$

c) Kinetic Energy

$J = \frac{kg\,m^2}{s^2}$

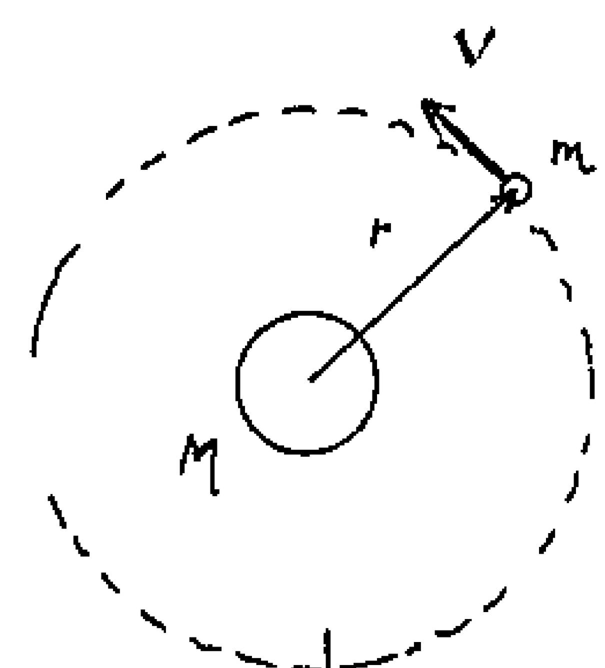
d) Momentum

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

e) Work

$J = \frac{kg \cdot m^2}{s^2}$

2. A planet of mass 1.90×10^{27} kg has a moon of mass 4.80×10^{22} kg. The moon has a circular orbit of radius 6.71×10^5 km.



a) What is the gravitational force on the moon as it orbits the planet? (4)

$M = 1.90\times10^{27}$ kg

$m = 4.80\times10^{22}$ kg

$r = 6.71\times10^{5}$ km $= 6.71\times10^{8}$ m

$$F = F_{grav} = G\frac{m_1 m_2}{r^2}$$

$$= \left(6.67\times10^{-11}\frac{N\cdot m^2}{kg^2}\right)\frac{(1.90\times10^{27}\,kg)(4.80\times10^{22}\,kg)}{(6.71\times10^{8}\,m)^2} = \boxed{1.35\times10^{22}\,N}$$

b) What is the speed of the moon as it orbits? *(Hint: Here, the centripetal force is the gravitational force.)* (7)

$$F_{cent} = \frac{m_{moon}v^2}{r} = F_{grav}, \quad \text{so} \quad v^2 = \frac{r\,F_{grav}}{m_{moon}} = \frac{(6.71\times10^{8}\,m)(1.35\times10^{22}\,N)}{(4.80\times10^{22}\,kg)}$$

$$= 1.89\times10^{8}\,m^2/s^2$$

$$\Rightarrow v = \boxed{1.37\times10^{4}\,m/s}$$

c) What is the circumference of the moon's orbit? (2)

$$C = 2\pi r = 2\pi(6.71\times10^{8}\,m) = \boxed{4.22\times10^{9}\,m}$$

d) What is the period of the orbit (time to go around once)? (3)

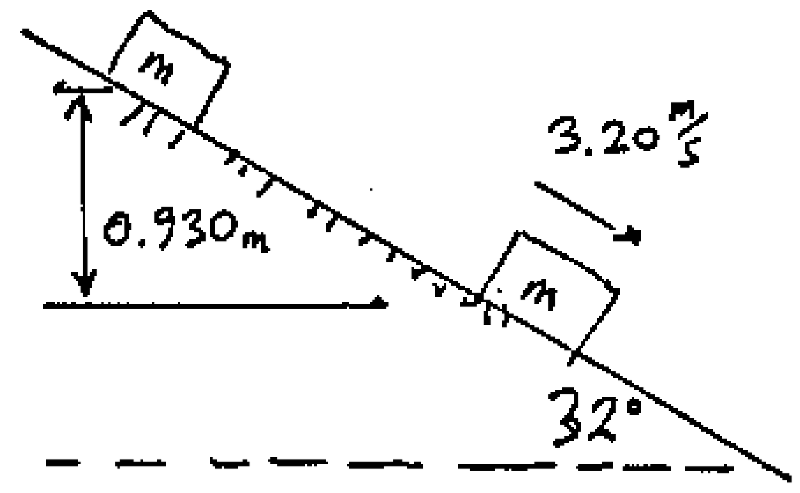
From parts (b) and (c), using $\text{Speed} = \frac{\text{Dist}}{\text{Time}}$

True for motion w/ uniform speed!

$$\text{Time} = \frac{\text{Dist}}{\text{Speed}} = \frac{4.22\times10^{9}\,m}{1.37\times10^{4}\,m/s} = \boxed{3.07\times10^{5}\,s}$$

$$= \boxed{3.55 \text{ days}}$$

3. A 1.20 kg mass slides down a *rough* 32° incline. It starts from rest and after its height has decreased by 0.930 m, its speed is 3.20 $\frac{m}{s}$.



a) What is the change in (gravitational) potential energy of the mass? (4)

$$\Delta PE_{grav} = \Delta(mgh) = mg\Delta h$$
$$= (1.20\,kg)(9.8\,\tfrac{m}{s^2})(-0.930\,m) = \boxed{-10.9\ J}$$

b) What is the change in kinetic energy of the mass? (4)

$$\Delta KE = KE_f - KE_o = \tfrac{1}{2}(1.20\,kg)(3.20\,\tfrac{m}{s})^2 - 0$$
$$= \boxed{6.14\ J}$$

c) What is the change in total mechanical energy of the mass? (3)

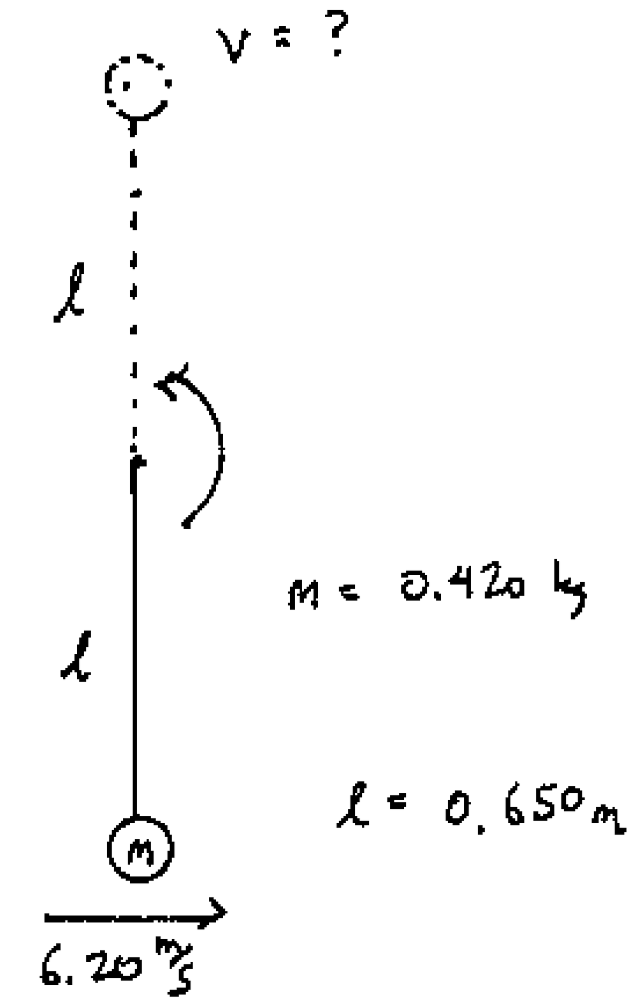
$$\Delta E = \Delta PE + \Delta KE = -10.9\,J + 6.14\,J = \boxed{-4.79\ J}$$

d) What was the work done by friction on the mass? (3)

$$W_{fric} = W_{\text{non-conservative}} = \Delta E = \boxed{-4.79\ J}$$

4. A small 0.420 kg mass hangs from a 0.650 m–long string. The mass is suddenly given a horizontal velocity of magnitude 6.20 $\frac{m}{s}$, which is sufficient to make it swing up to the vertical position, as shown.

No frictional forces act on the mass–string system.



a) When the mass is in the upper position, what is its height above the first position? (1)

Height above bottom position

$$= 2l = 2(0.650\,m) = \boxed{1.30\,m}$$

b) When the mass is in the upper position, what is its speed? (7)

Mech. energy is conserved, so if bottom position has h = 0 then

$$\frac{1}{2}m(6.20\tfrac{m}{s})^2 = mg(1.30\,m) + \frac{1}{2}mv^2$$

Cancel m, mult by 2

$$(6.20\tfrac{m}{s})^2 = 2g(1.30\,m) + v^2$$

$$v^2 = (6.20\tfrac{m}{s})^2 - 2(9.80\tfrac{m}{s^2})(1.30\,m) = 13.0\,\tfrac{m^2}{s^2}$$

$$\boxed{v = 3.60\,\tfrac{m}{s}}$$

c) What is the *net force* on the mass when it is in the upper position? (Hint: The mass is moving in a circular path...) (4)

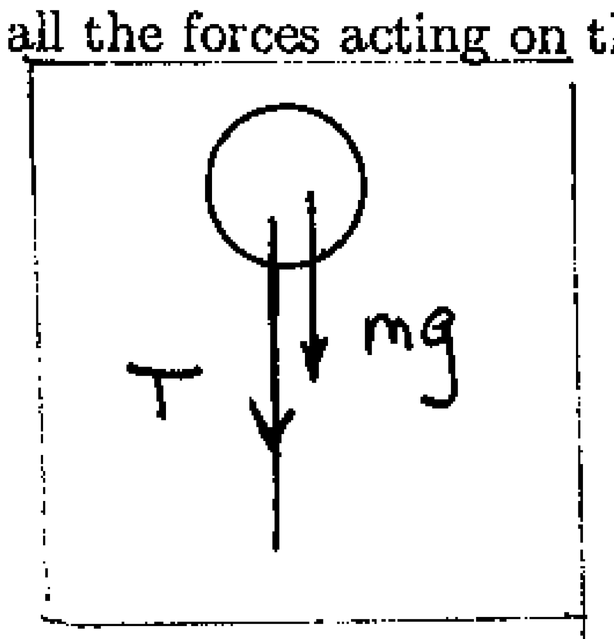
Net force must equal $\frac{mv^2}{r}$ w/ direction downward (toward center of circle).

$$F = F_{cent} = \frac{(0.420\,kg)(3.60\tfrac{m}{s})^2}{(0.650\,m)} = \boxed{8.37\,N}$$

d) Draw a free–body diagram showing all the forces acting on the mass at the upper position. (4)

T is string tension.

mg is weight of mass.



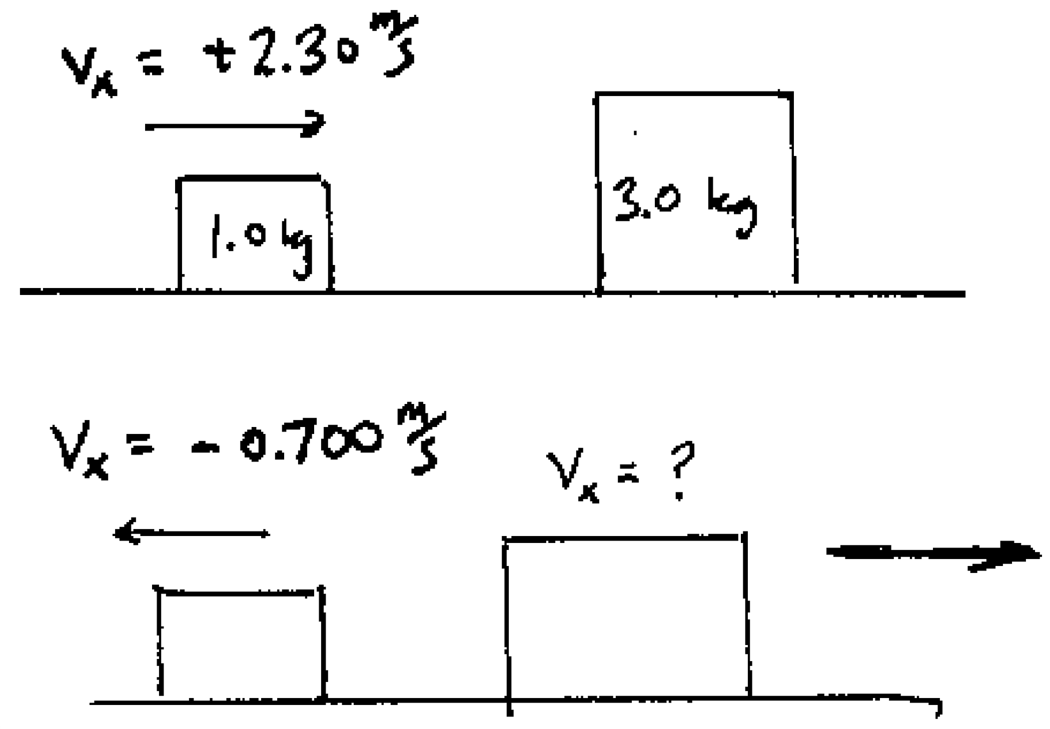
d) Find the tension in the string when the mass is at the upper position. (3)

Combining parts (c) and (d),

$$F_{cent} = 8.37\,N$$
$$= T + mg$$

$$\rightarrow \quad T = 8.37\,N - mg = 8.37\,N - (0.420\,kg)(9.8\,\tfrac{m}{s^2})$$
$$= \boxed{4.26\,N}$$

5. On a horizontal, frictionless track, a 1.0 kg mass is moving to the right with speed 2.30 $\frac{m}{s}$ toward a stationary 3.0 kg mass.
Immediately after the ensuing collision, the 1.0 kg mass is moving to the left with speed 0.700 $\frac{m}{s}$.



a) What is the *velocity* (i.e. give magnitude and direction) of the 3.0 kg mass immediately after the collision? (8)

Linear momentum is conserved:

$$(1.0\,kg)(2.30\,\tfrac{m}{s}) + 0 = (1.0\,kg)(-0.700\,\tfrac{m}{s}) + (3.0\,kg)V_x$$

Solve for V_x:

$$(3.0\,kg)V_x = (1.0\,kg)(2.30\,\tfrac{m}{s}) + (1.0\,kg)(0.700\,\tfrac{m}{s}) = 3.0\,\tfrac{kg \cdot m}{s}$$

$$\rightarrow \boxed{V_x = 1.00\,\tfrac{m}{s}}$$

// Mass moves $\boxed{\text{to the right}}$ w/ speed 1.00 m/s

b) How much kinetic energy was lost in the collision? (3)

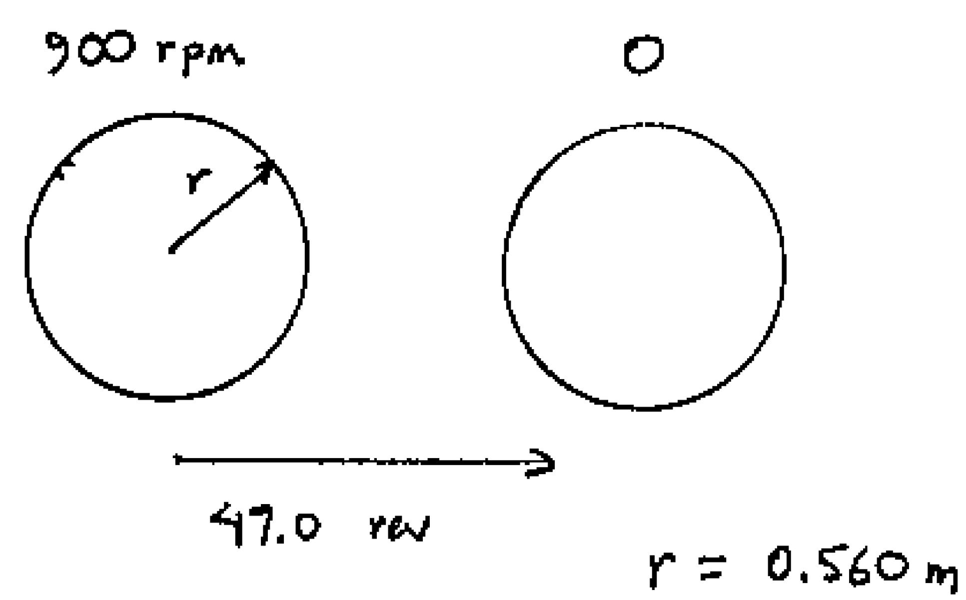
$$KE_0 = \tfrac{1}{2}(1.0\,kg)(2.3\,\tfrac{m}{s})^2 + 0 = 2.64\ J$$

$$KE_f = \tfrac{1}{2}(1.0\,kg)(0.70\,\tfrac{m}{s})^2 + \tfrac{1}{2}(3.0\,kg)(1.00\,\tfrac{m}{s})^2 = 1.74\ J$$

$$\Delta KE = 1.74\ J - 2.64\ J = -0.90\ J$$

$$\boxed{0.90\ J\ \ KE\ \text{lost}}$$

6. A wheel of radius 0.560 m is initially turning at a rate of 900 revolutions per minute. As it slows to a halt (with a constant angular deceleration), it makes 47.0 revolutions.



a) Find the initial angular speed of the wheel in radians per second. (3)

$$\omega_0 = 900\,\tfrac{rev}{min} \cdot \left(\tfrac{2\pi\ rad}{rev}\right)\left(\tfrac{1\ min}{60\ s}\right) = \boxed{94.2\,\tfrac{rad}{s}}$$

b) What was the magnitude of the angular acceleration of the wheel as it was stopping? (5)

Ang disp $\theta = 47.0\ rev \cdot \left(\frac{2\pi\ rad}{rev}\right) = 295\ rad$

Since $\omega = 0$ [final ang vel] we can use : $\omega^2 = \omega_0^2 + 2\alpha\theta$ to get

$$0 = (94.2\,\tfrac{rad}{s})^2 + 2\alpha(295\ rad)$$

$$\alpha = -\frac{(94.2\,\frac{rad}{s})^2}{2(295\,rad)} = -15.0\,\tfrac{rad}{s^2}$$

$$\boxed{|\alpha| = 15.0\,\tfrac{rad}{s}}$$

c) How long did it take the wheel to stop? (2)

Use $\omega = \omega_0 + \alpha t$

$$\Rightarrow 0 = 94.2\,\tfrac{rad}{s} + (-15.0\,\tfrac{rad}{s^2})\,t$$

$$\rightarrow t = \frac{-94.2\,\frac{rad}{s}}{(-15.0\,\frac{rad}{s^2})} = \boxed{6.2\ s}$$