PHY 231C – EXAM 2 **Form 1** **July 15, 2003**

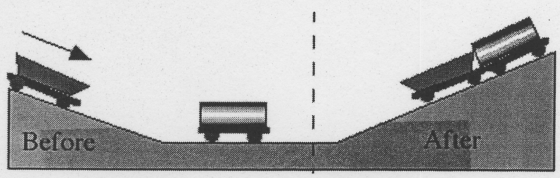
All your answers should appear on the bubble sheets. Please fill in the circles on the sheets using a number 2 pencil. Use the margins or the backs of your exam pages for scratch paper. You may take these exam pages with you when you leave.

Unless stated otherwise, all mechanics problems below assume the environment is on Earth's surface. Use 10 m/s^2 for the acceleration of gravity.

Density of fresh water: 1000 kg/m^3

1. If two objects collide elastically, then:
   a. Total kinetic energy is conserved, but total momentum is not conserved
   b. Total momentum is conserved, but total kinetic energy is not conserved
   c. Total kinetic energy and total momentum are both conserved
   d. Neither total kinetic energy nor total momentum are conserved

2. A railroad car of mass 22500 kg is released from rest in a railway switchyard and rolls to the bottom of a slope H_i =18 m below its original height. At the low point, it collides with and sticks to another car of mass 22000 kg. The two cars roll together up another slope and climb up to a height H_f above the low point, where they come to a stop before rolling back. Ignore the effects of friction and calculate H_f
   a. 9.10 m
   b. 4.60 m
   c. 18.0 m
   d. 35.6 m
   e. 4.40 m



Before

$mgH_i = \frac{1}{2}mV_i^2$

$V_i = \sqrt{2gH_i}$

Collision

$\vec{P}_i = \vec{P}_f$

$m_1 V_i = (m_1+m_2)V_f$

$V_f = \frac{m_1}{m_1+m_2} V_i$

$V_f = \frac{m_1}{m_1+m_2}\sqrt{2gH_i}$

After

$\frac{1}{2}(m_1+m_2)V_f^2 = (m_1+m_2) g H_f$

$H_f = \frac{1}{2g} V_f^2$

$= \frac{1}{\cancel{2g}}\left(\frac{m_1}{m_1+m_2}\right)^2(\cancel{2g}H_i)$

$= \left(\frac{m_1}{m_1+m_2}\right)^2 H_i$

$= \left(\frac{22500\,kg}{44500\,kg}\right)^2 (18\,m) = 4.60\,m$

3. A drunk driver strikes a parked car. During the collision the cars become entangled and skip to a stop together. The drunk driver's car has a total mass of 790 kg, and the parked car has a total mass of 874 kg. If the cars slide 47 m before coming to rest, how fast was the drunk driver going? The coefficient of sliding friction between the tires and the road is 0.47.

a. 44.3 m/s
b. 21.0 m/s
c. 10.0 m/s
d. 64.6 m/s
e. 30.7m/s

$$\vec{P}_i = \vec{P}_f$$

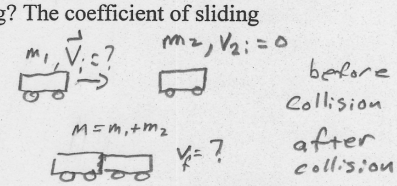
$$m_1 V_i = (m_1 + m_2) V_f$$

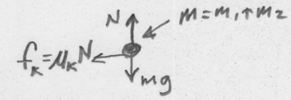
$$V_i = \frac{m_1 + m_2}{m_1} V_f$$

$$V_i = \frac{m_1 + m_2}{m_1} \sqrt{2 \mu_k g x}$$

$$V_i = \frac{790\text{kg} + 874\text{kg}}{790\text{kg}} \sqrt{2(.47)(10\tfrac{\text{m}}{\text{s}^2})(47\text{m})}$$

$$= 44.3 \text{ m/s}$$





$$N = mg$$

$$f_k = ma$$

$$-\mu_k N = (m_1 + m_2) a$$

$$-\mu_k \cancel{(m_1 + m_2)} g = \cancel{(m_1 + m_2)} a$$

$$a = -\mu_k g$$

$$V^2 = V_0^2 + 2ax \qquad \text{here } V_0 = V_f$$

$$0 = V_f^2 + 2ax$$

$$V_f^2 = -2ax \Rightarrow V_f = \sqrt{-2ax}$$

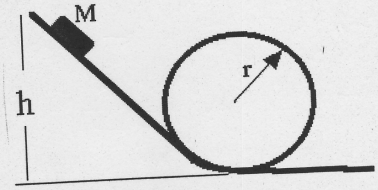
$$= \sqrt{2 \mu_k g}$$

4. Consider the following statements, which is incorrect?

a. If one planet has eight times the period of another, it must have four times the orbital radius.
b. If two planets have the same mass, but the second one has four times the gravity the second one must also have half the radius.
c. There is only one possible radius for the circular orbit of a satellite around the earth with a period of 24 hours.
d. An object traveling in a circle with constant speed has zero acceleration.
e. The value of G, the constant in Newton's Law of Gravity does not depend on which planetary system we are trying to study.

5. Let's design a roller coaster. It should consist of a long ramp leading into a loop. The loop should have a radius r of 7.5 m. Assuming that friction can be neglected here, what should be the minimum height h of the ramp (in m) with respect to the bottom of the loop so that the cars don't fall off the track at the top of the loop?

a. 18.75 m
b. 15.00 m
c. 35.50 m
d. 30.00 m
e. Not enough information is given



Top of ramp   top of Loop

$\cancel{m}gh = \cancel{m}g(2r) + \frac{1}{2}\cancel{m}v^2$

$h = 2r + \frac{1}{2}\frac{v^2}{g}$

$h = 2r + \frac{1}{2}\frac{gr}{g}$

$h = 2.5r$

$= 2.5(7.5) = 18.75\,m$

AT Top of Ramp for the case of minimum h

$\Sigma F = ma$

$mg = m\left(\frac{v^2}{r}\right)$

$g = \frac{v^2}{r}$

or $v^2 = gr$

6. A solid sphere, a hollow sphere, a solid cylinder and a hollow cylinder are released from rest at the top of a ramp. All four objects have the same mass and radius. Which will reach the bottom of the ramp LAST?
   a. hollow sphere
   b. solid sphere
   c. solid cylinder
   d. hollow cylinder
   e. they will all reach the bottom at the same time

7. The wheel of an exercise cycle undergoes a constant angular acceleration such that the angular speed goes from zero to 3.0 revolutions per second in 4 seconds. The wheel is a hoop having a radius 0.50 meters and a mass of 5.0 kg. Calculate the net torque on the wheel. (HINT: to find the moment of inertia of the wheel, assume all the mass is concentrated on the rim).
   a. 0.94 N-m
   b. 2.95 N-m
   c. 3.75 N-m
   d. 5.89 N-m
   e. 23.6 N-m

$$\Sigma \tau = I\alpha$$

$$\tau = (mr^2)\frac{\Delta\omega}{\Delta t}$$

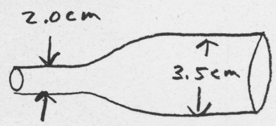
$$= (5.0\,kg)(0.5\,m)^2\left[\frac{3\frac{rev}{sec} \times \frac{2\pi\,rad}{rev}}{4\,sec}\right]$$

$$= 5.89\ N\text{-}m$$

8. A figure skater is spinning on the ice with her arms stretched out. The magnitude of her angular velocity increases when she brings her arms in close to her body. The best explanation for this is:
   a. A net torque acting on the skater causes the increase in angular velocity.
   b. When the skater brings her arms in close to her body, this increases her moment of inertia. Because the net torque on her is negligible, her angular momentum is conserved and her angular velocity must also increase.
   c. When the skater brings her arms in close to her body, this decreases her moment of inertia. Because the net torque on her is negligible, her angular momentum is conserved and her angular velocity must increase.
   d. When the skater brings her arms in close to her body, this decreases her moment of inertia. Because rotational kinetic energy is always conserved, her angular velocity must increase.
   e. When the skater brings her arms in close to her body, this increases her moment of inertia. Because rotational kinetic energy is always conserved, her angular velocity must also increase.

9. A horizontal tube carries water in a non-turbulent flow condition. The diameter of the tube changes from 2.0 cm to 3.5 cm and the flow rate is 1.9 x10^{-5} m^3/s. What is the velocity of the water when the diameter is 3.5 cm?

a. 4.93 x 10^{-3} m/s
b. 1.97 x 10^{-2}m/s
c. 6.90 x 10^{-4} m/s
d. 9.02 x 10^{-2} m/s
e. 5.97 x 10^{-1} m/s



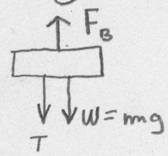
$$F = VA$$

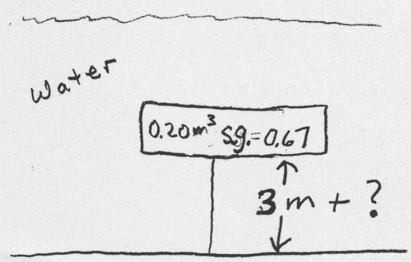
$$V = \frac{F}{A} = \frac{F}{\pi\left(\frac{d}{2}\right)^2} = \frac{1.9\times10^{-5}\,m^3/s}{\pi\left(\frac{3.5\times10^{-2}m}{2}\right)^2}$$

$$V = 0.0197\,m/s$$

10. A 0.20 m^3 piece of low density wood (specific gravity = 0.67) is anchored to the bottom of a fresh water pond. It is held in place by a 3.0 meter long, 5mm diameter steel wire. Young's modulus for steel is 2.0 x 10^{11} N/m^2. What is the change in length of the steel wire?

a. 7.75 mm
b. 2.56 mm
c. 1.53 mm
d. 1.03 mm
e. 0.504 mm





$$\Sigma F = 0$$

$$F_B - T - mg = 0$$

$$T = F_B - mg$$

$$= \rho_{water}Vg - \rho_{wood}Vg$$

$$= Vg(\rho_{wat.} - \rho_{wood})$$

$$= (.2\,m^3)\left(10\frac{m}{s^2}\right)\left(1000\frac{Kg}{m^3} - .67\left(1000\frac{kg}{m^3}\right)\right)$$

$$= 660N$$

$$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\frac{F}{A}}{\frac{\Delta L}{L}} \quad \text{here } F = T$$

$$\text{OR} \quad \Delta L = \frac{T \cdot L}{A \cdot Y}$$

$$\Delta L = \frac{(660N)(3\,m)}{\left(\pi\left(\frac{5\times10^{-3}m}{2}\right)^2\right)(2.0\times10^{11}\,N/m^2)}$$

$$= 5.04\times10^{-4}m = 0.504mm$$