Key

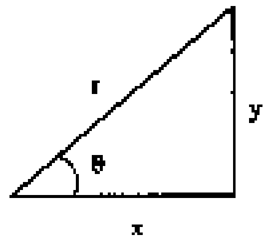
Physics 220 – Exam #3

November 16 **1999**

This exam consists of 12 problems on 7 pages. **Please check that you have them all.**

All of the formulas that you will need are given below. You may also use a calculator.

$\sin\theta = y/r$ $\cos\theta = x/r$ $\tan\theta = y/x$



average speed = $\frac{\text{distance traveled}}{\text{time}}$ $g = 9.8 \text{ m/s}^2$

average velocity = $\bar{v} = \frac{\text{displacement}}{\text{time}}$

instantaneous velocity = slope of position versus time
instantaneous acceleration = slope of velocity versus time

For constant acceleration:
$x = x_0 + v_0 t + \frac{1}{2}at^2$ $v = v_0 + at$ $v^2 = v_0^2 + 2a(x - x_0)$

$\vec{F} = m\vec{a}$ $F_{friction}^{max} = \mu_S N$ (static friction) $F_{friction} = \mu_K N$ (sliding friction)

$F_{gravity} = \frac{G m_1 m_2}{r^2}$ $G = 6.67 \times 10^{-11}$ Nm^2/kg^2

$a_c = v^2/r$ $KE = \frac{1}{2}mv^2$ $W = F\,d\,\cos\theta$ $PE_{gravity} = mgh$

power = work/Δt $\vec{p} = m\vec{v}$ Δp = impulse = $F\,\Delta t$

$F_{spring} = -kx$ $PE_{spring} = \frac{1}{2}kx^2$ $x = A\sin(\omega t)$ $v = A\omega\cos(\omega t)$

$\omega = \sqrt{k/m}$ $\omega = \sqrt{g/L}$ $\omega = 2\pi f$ $f = 1/T$

For constant angular acceleration:
$\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2$ $\omega = \omega_0 + \alpha t$ $\omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0)$

KE = $I\omega^2/2$ $L = I\omega$ $\tau = I\alpha$ $\theta = s/r$ $\omega = v/r$ $\alpha = a/r$ $\omega = \theta/t$

Pressure = Force/area $A_1 v_1 = A_2 v_2$ $P_1 + \rho g h_1 + \rho v_1^2/2 = P_2 + \rho g h_2 + \rho v_2^2/2$

Archimedes principle: buoyant force = weight of fluid displaced

1. You have just purchased an old-fashioned record player, which generates music from plastic disks. If the record player spins a record at 33 revolutions per minute (33 rpm), find the speed of a point on the outer edge of a record (diameter = 28 cm).

(a) 3.5 m/s
(b) 9.8 m/s
(c) 0.077 m/s
(d) 0.48 m/s
(e) 0.14 m/s

$\omega = 33 \frac{rev}{min} \times \frac{2\pi\, rad}{rev} \cdot \frac{1 min}{60}$

$= \frac{33(2\pi)}{60}$

$v = \omega \cdot r = \frac{33(2\pi)}{60} \cdot (0.14 m)$

$= 0.48\ m/s$

2. A bicycle wheel has a mass of approximately 1.5 kg and a radius of 65 cm. With the wheel initially at rest, a torque 0.75 N-m is then applied. What is the angular speed of the tire after 5 seconds? The moment of inertia of a wheel is mR^2.

(a) 12 rad/s
(b) 5.9 rad/s
(c) 3.8 rad/s
(d) 2.4 rad/s
(e) 12×10^{-4} rad/s

$\tau = I\alpha$

$\alpha = \frac{\tau}{I} = \frac{\tau}{mR^2}$

$= \frac{0.75}{1.5(0.65)^2} = 1.18\ rad/s^2$

$\omega = \omega_0 + \alpha t = 0 + (1.18) \cdot 5$

$= 5.9\ rad/s$

3. You want to use a simple pendulum as a clock. The pendulum consists of a ball of mass 3.5 kg attached to one end of a (massless) string of length 1.5 m, with the other end of the string attached to the ceiling. This pendulum will undergo simple harmonic motion. If one period of the motion is one "tick" of the pendulum clock, how long will each tick of the clock be?

(a) 6.28 s

(b) 0.15 s

(c) 0.39 s

(d) 1.0 s

(e) 2.5 s

$$\omega = \sqrt{\frac{g}{l}} = 2\pi f = \frac{2\pi}{T}$$

$$T = 2\pi\sqrt{\frac{l}{g}} = 2\pi\sqrt{\frac{1.5}{9.8}} = 2.5\,s$$

4. A watermelon is thrown horizontally from the roof of a building. If the building is 25 m tall, and the initial speed of the watermelon is 12.0 m/s, how far from the base of the building does the watermelon land?

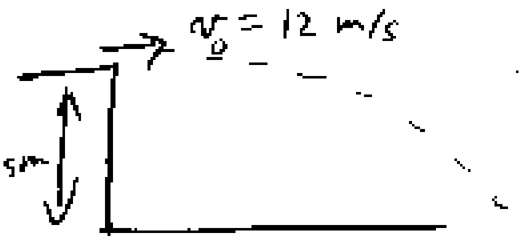
(a) 2.3 m

(b) 27 m

(c) 12 m

(d) 39 m

(e) 61 m



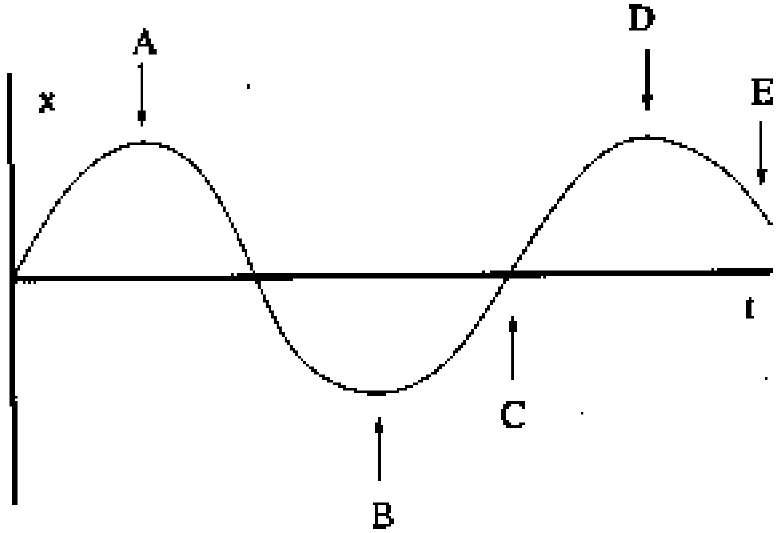
$$y = y_0 - \frac{1}{2} g t^2$$

$$0 = 25 - \frac{1}{2} g t^2$$

$$t = \sqrt{\frac{2(25)}{g}} = \sqrt{\frac{50}{g}}$$

$$x = v_0 t = v_0\sqrt{\frac{50}{g}} = 12\sqrt{\frac{50}{g}} = 27\,m$$

5. The figure below shows the position as a function of time for an object undergoing simple harmonic motion. One complete period of the motion corresponds to which interval?



T = repeat time

(a) The time between A and B

(b) The time between A and C

(c) The time between A and D

(d) The time between A and E

(e) The time between B and D

6. In the figure for problem 5 (above), at what point is the velocity of the object largest?

(a) A

(b) B

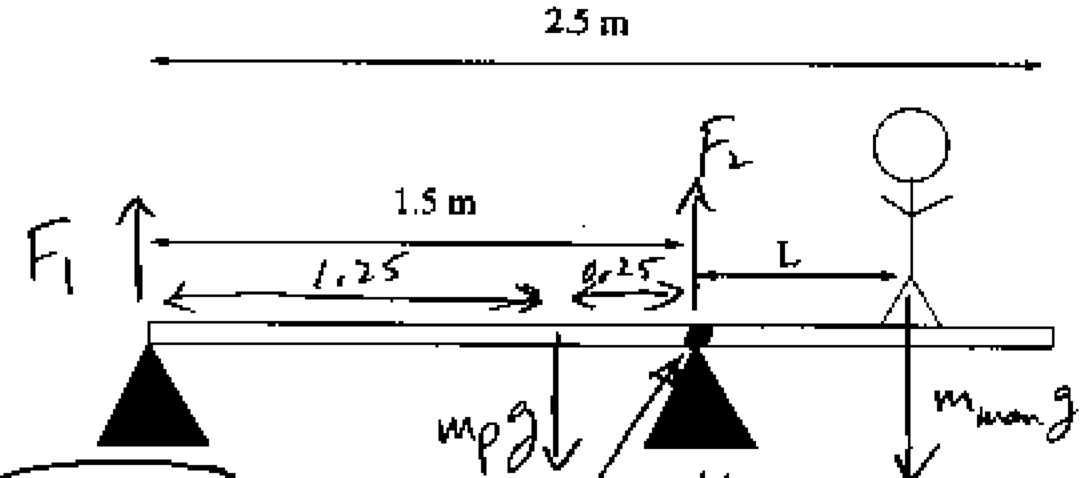
(c) C

(d) D

(e) E

v = slope of x-t graph

7. A man stands on a plank as shown below. The mass of the plank is 50 kg, and the mass of the man is 90 kg. Find the maximum value of L at which the man can stand without having the plank tip. Assume that the mass of the plank is distributed uniformly.



(a) 0.14 m

(b) 0.25 m

(c) 0.86 m

(d) 0.45 m

(e) 0.67 m

$F_1 = 0$

$\Sigma \tau = 0 = m_{man} g \cdot L - m_p g (0,25)$

$L = \frac{m_p}{m_{man}} (0,25) = \frac{50}{90} (0,25) = 0.14\,m$

8. A box of valuable metal is sitting on the bottom of a lake. If the box has a density of 5000 kg/m^3 and a volume of 5.0 m^3, what is the minimum force required to raise the box to the surface? $\rho_{water} = 1000$ kg/m^3.

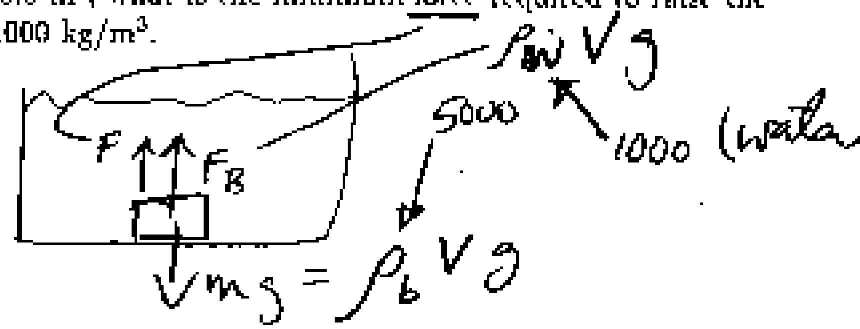
(a) 2.5×10^5 N

(b) 4.9×10^3 N

(c) 2.9×10^5 N

(d) 3.9×10^4 N

(e) 2.0×10^5 N



$F = mg - F_B = \rho_b V g - \rho_w V g$

$= (\rho_b - \rho_w) V g = (5000 - 1000) \cdot 5 \cdot (9,8)$

$= 2.0 \times 10^5\,N$

9. A tennis ball is hit to a player, who hits it back in the opposite direction. If the ball (of mass 0.12 kg) has an initial speed of 37 m/s, and is returned with a speed of 25 m/s, what is the magnitude of the impulse imparted to the ball?

(a) 3.0 N-s
(b) 4.4 N-s
(c) 7.4 N-s
(d) 1.4 N-s
(e) zero

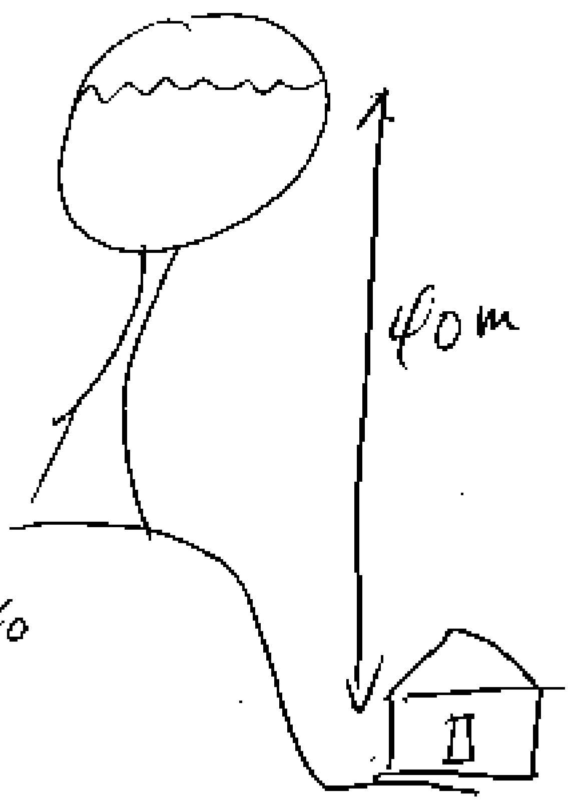
Impulse $= \Delta p = m v_f - m v_i$

$= 0.12(25 + 37)$!!!

$= 7.4$ N-s

10. Consider a water tower which is on top of a large hill overlooking your house. If the level of the water in the tower is 40 m above your house, what will be the ABSOLUTE pressure (not the gauge pressure) of the water in the pipes of your house? Assume that you (and your neighbors) have your faucets all closed, so that no water is flowing, and that the top of the water tower is open to the atmosphere. $\rho_{water} = 1000$ kg/m^3; $P_{atm} = 1.0 \times 10^5$ Pa.

(a) 4.9×10^5 Pa
(b) 9.8×10^5 Pa
(c) 2.9×10^5 Pa
(d) 1.0×10^5 Pa
(e) 3.9×10^5 Pa



$P = P_0 + \rho g h$

$= 1.0 \times 10^5 + 1000(9.8)40$

$= 4.9 \times 10^5$ Pa

11. The pool of water shown below has sprung a leak. If the diameter of the leak is very small, find the velocity with which the water is spraying out of the leak. $\rho_{water} = 1000\ \text{kg/m}^3$; $\rho_{air} = 1.3\ \text{kg/m}^3$; $P_{atm} = 1.0 \times 10^5$ Pa.

(a) 7.0 m/s

(b) 2.2 m/s

(c) 5.0 m/s

(d) 25 m/s

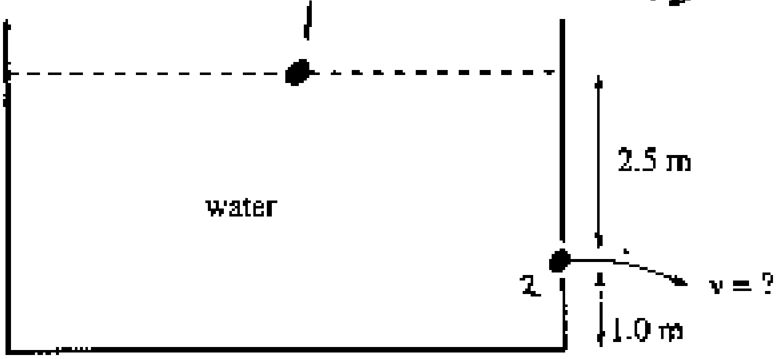
(e) 0.67 m/s

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$

$\approx 0 + \rho g (2.5) = \frac{1}{2}\rho v_2^2 + 0$

$P_1 \approx P_2$

$v_2 = \sqrt{\frac{2\rho g (2.5)}{\rho}} = \sqrt{2 \cdot g (2.5)} = 7.0\ \text{m/s}$



12. The spring constant for a dart gun is 2200 N/m. This spring is compressed a distance L, and the bullet is fired. If the bullet (mass 0.0020 kg) leaves the gun with a speed of 40 m/s. Find L.

(a) 0.067 m

(b) 0.0020 m

(c) 0.038 m

(d) 0.73 m

(e) 0.0015 m

Mechanical energy is conserved.

$PE_i + KE_i = PE_f + KE_f$

$\frac{1}{2}kL^2 + 0 = 0 + \frac{1}{2}mv_f^2$ $(v_i = 0)$

The End

$L = \sqrt{\frac{m v_f^2}{k}} = \sqrt{\frac{.002}{2200} \cdot 40^2} = 0.038\ \text{m}$