Your Name ____________________

PY132 Physics of Motion
Third **PRACTICE** Exam

Real exam: 2:00-3:00 PM, Monday, December 11, 2006, SCI-115

This is a closed book exam, with no notes allowed. You may use (but not share) a calculator. Do not talk or otherwise communicate with the other students. This exam is governed by the CAS Academic Conduct Code

Show the mathematical steps that lead you to your answers. Without them, a "right" answer is unjustified. With them, a "wrong" answer may be worth partial credit.

$g = 10\, m/s^2$

$PE_{grav} = mgh$

$PE_{spring} = \frac{1}{2}kx^2$, $F_{spring} = -kx$, $\omega_0 = \sqrt{k/m}$

$\omega_0 = \sqrt{g/L}$

$x(t) = A\cos(\omega t)$

$v(t) = -\omega A \sin(\omega t)$

$a(t) = -\omega^2 A\cos(\omega t)$

$v = \sqrt{T/\mu}$

$\beta = 10\log_{10}\frac{I}{I_0}$

$v_{sound} = 340\, m/s^2$

$P = P_0 + \rho g h$

$P_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = const = P_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2$

$V = \frac{4}{3}\pi r^3$, $A = 4\pi r^2$

$\log AB^C = \log A + C\log B$

$\vec{F} = m\vec{a}$

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

$w = Fd$

$KE = \frac{1}{2}mv^2$

$v = f\lambda$

$f = 1/T$

$\omega = 2\pi f$

$I_0 = 10^{-12}\, W/m^2$

$v_1 A_1 = v_2 A_2$

1. ________ /40 + 2. ________ /20 + 3. ________ /20 + 4. ________ /20

= Total ________ /100

[1.1] You compress by 3 centimeters a massless spring that obeys Hooke's Law with spring constant k=10 N/m. A mass of 0.1 kg attached onto the end that can slide back and forth on a frictionless surface.

(a) To compress the spring the first centimeter, does it take **[more], [less], [the same]** amount of work as it does to compress the spring the third centimeter?

(b) Calculate the motion of the mass after you release the spring: find the amplitude and frequency of oscillation.

(a) less. Work is force times distance, and the force required for the first centimeter is less than for the third centimeter by Hooke's Law: F = -kx. The more you compress or stretch a spring the harder it resists!

(b) The motion is Simple Harmonic Motion. The amplitude is the same as the maximum compression (3 centimeters). The angular frequency is given by the formula: $\omega_0 = \sqrt{k/m}$ = 10 rad/s. The frequency is found from $\omega=2\pi f$ giving f = 1.6 Hz.

[1.2] A fluid flows through the pipe drawn below with velocity v in the main section that has cross sectional area A. The constricted section has cross sectional area $A/4$.

(a) What is the velocity in the constricted section, v_2 in terms of v_1?

(b) Fluid will rise into the small vertical tubes, which act as pressure gauges. As measured from the bottom of each tube, which column of liquid will be higher?

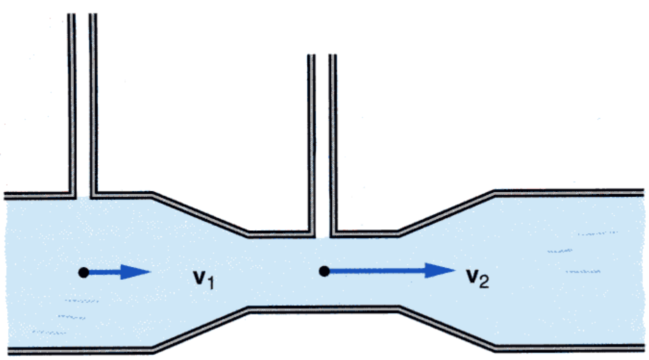


figure 9.23 Vertical open pipes can serve as pressure gauges.

(a)
$$A_1 v_1 = A_2 v_2$$
$$A v_1 = \frac{A}{4} v_2$$
$$v_2 = 4 v_1$$

(b) High velocity = low pressure; Bernoulli's Principle. So the first tube (v_1) will be higher.

$$P_1 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = const = P_2 + \tfrac{1}{2}\rho v_2^2 + \rho g y_2$$

[1.3] In the Palazzo dei Conservatori in Rome, one finds fragments from the giant statue of Emperor Constantine. The foot shown in the foreground is 6-feet long.

If the original statue sprang to life and took a step, how "long" would the step be? Answer in units of both distance and time, showing your work and assumptions.

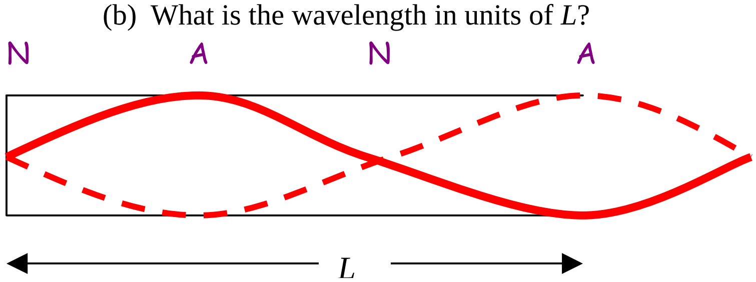
My foot is about one foot long, and my normal stride is about 2 feet long, so the statue would stride about 6x2 = 12 feet in distance.

The pendulum period for my stride is about 1.5 seconds (one step is half that). The pendulum period goes like sqrt(L/g). Assuming all the body parts scale up in size, the statue has a leg 6x longer and his pendulum period will be sqrt(6) times longer. Sqrt(6) x 0.75 sec = 1.8 seconds.

[1.4] Here is a hollow tube, of length L, closed at one end. If you blow across it hard enough, you can excite the next harmonic (2^{nd} harmonic), which is higher pitched than the fundamental frequency (1^{st} harmonic).

(a) Sketch the 2nd harmonic standing wave in this tube, indicating the nodes and antinodes.

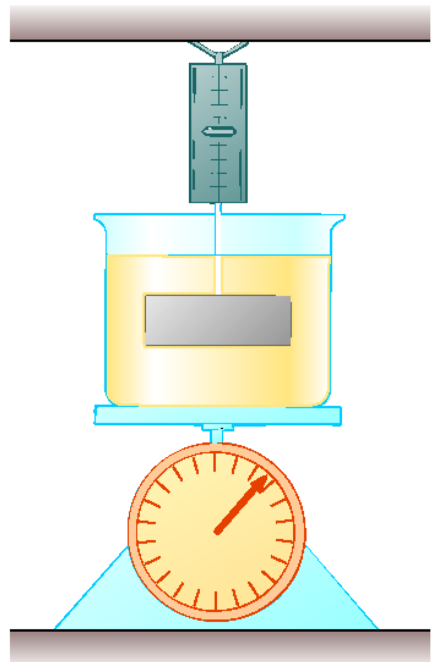
(b) What is the wavelength in units of L?



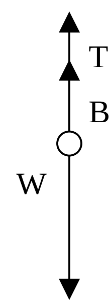
(b) $\lambda = 4/3\ L$

Problem 2 [20 points]

A 1.00-kg beaker containing 2.00 kg of oil (density = 916 kg/m^3) rests on a scale. A 2.00-kg block of iron (density = 7860 kg/m^3) is suspended from a spring scale and is completely submerged in the oil. Find the equilibrium readings of both scales.



Free body diagram:



It looks like I need to find the buoyancy, so I need the volume of liquid displaced, so I need the volume.

$$V = \frac{m_{iron}}{\rho_{iron}} = \frac{2.00 \text{ kg}}{7.86 \times 10^3 \text{ kg/m}^3} = 2.54 \times 10^{-4} \text{ m}^3,$$

The buoyancy is:

$$B = (\rho_{oil} V) g = (916 \text{ kg/m}^3)(2.54 \times 10^{-4} \text{ m}^3)(9.80 \text{ m/s}^2) = 2.28 \text{ N}$$

so the tension in the upper scale (which gives the reading) is:

T = W – B = 19.6 N – 2.28 N = <u>17.32 N</u>

Then, by Newton's Third Law (action-reaction), the bottom scale reads: N = W_{beaker} + W_{oil} + B, the weight of the beaker and oil plus the reaction to the buoyant force:

W = 9.8 N + 19.6 N + 2.28 N = <u>31.68 N</u>

Problem 3 [20 points]

A simple pendulum consists of a ball of mass 5 kg hanging from a uniform string of mass 0.060 kg and length *L*. The period of oscillation of the pendulum is 2.0 s.

When the pendulum hangs vertically with no motion, you pluck the string.

(a) Is the wave that travels along the string [**transverse**] or [**longitudinal**]?

(b) Find the speed of the wave that travels along the string.

(c) If you quadruple the length of the pendulum, what is the period?

(d) If instead, you change the mass to 10 kg, what is the period?

(a) it is a transverse wave (a plucked string)

(b) v = sqrt(tension/linear-mass-density). It looks like I need to find L. I can find this from the period of oscillation when it is swinging:

$$T = \frac{1}{f} = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{L}{g}} = 2\pi\sqrt{\frac{\mathrm{L}}{10\mathrm{m/s}}} = 2\,\mathrm{sec} \Rightarrow L = 1.01\ \mathrm{meters}$$

μ = 0.060 kg/1.01m = 0.059 kg/m
v = sqrt(50 N / 0.059 kg/m) = <u>29.1 m/s</u>

(c) if L changes to 4L then period T changes to <u>2T= 4 seconds</u> (see above formula).

(d) the period does not depend on mass, only g and L. <u>No change</u>.

This end is shaking the rope like the standing wave demonstration in class. The end is not free, but is driven to generate the wave moving towards the fixed end. So the system is like two fixed ends of a plucked string.

Problem 4 [20 points] (DO BOTH PARTS)

[4.1] A certain rope has a length of 8 meters and a mass of 2.4 kg. It is fixed at one end and pulled with a tension of 30 N. The other end is moved up and down with a frequency of 2.5 Hz.

- **(a)** What is the speed of the waves?
- **(b)** How many waves fit on the rope at this frequency? Is the wave pattern that is formed a standing wave?
- **(c)** To make the fundamental vibration of the rope (please sketch it), at what frequency should you shake it?

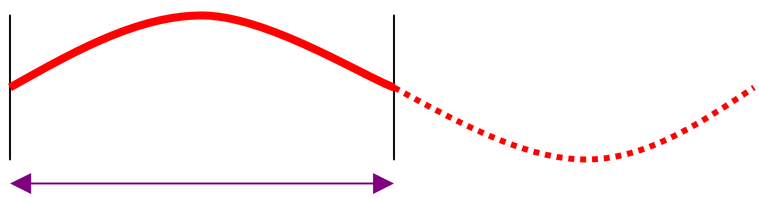
(a) $v = \sqrt{T/\mu}$ μ = 2.4kg/8m = 0.3 kg/m

v = sqrt(30 N/0.3 kg/m) = 10 m/s

(b) v=fλ λ = (10m/s) / 2.5 s^{-1} = 4 m therefore, 2 waves fit and the pattern is a standing wave

(c) there will be one antinode and λ = 2L = 16 meters

f = v/λ = 0.625 Hz



[4.2] Two fire alarm buzzers, ACME and BUZZCO, are compared. BUZZCO is advertised to emit 20 times the sound power as ACME (in watts).

(a) If ACME gives 60 dB on a decibel meter 10 meters away, what will the dB meter read for BUZZCO at the same distance?
(b) To a human, about how much louder will BUZZCO be perceived compared with ACME?

$$\beta_{ACME} = 10\log\frac{I_{ACME}}{I_0} = 60 \text{ dB}$$

$$\beta_{BUZZCO} = 10\log\frac{20\times I_{ACME}}{I_0} = 10\log 20 + 10\log\frac{I_{ACME}}{I_0} = 13\text{dB}+60\text{dB}=73\text{dB}$$

(a) 73 dB

(b) a little more than twice as loud, since 10 dB is perceived as twice as loud