LAST NAME.....STUDENT NUMBER.....

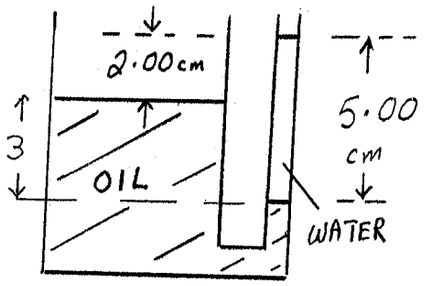
FIRST NAME.....SIGNATURE.....

PHYSICS 101 Section 103 MID-TERM EXAMINATION

Lecturer: J. E. Eldridge, Thursday October 24 2002

Answer all questions, on both sides of the sheet. Write answers in the space provided. Working must be shown. Maximum mark is 100.

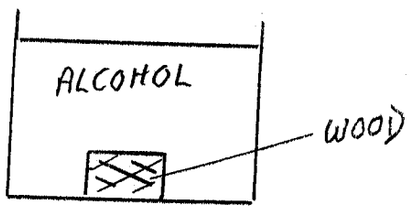
1. The large vessel contains oil. Water ($\rho = 1000$ kg / m^3) is poured into the tube on the side and equilibrium is reached as shown. Calculate the density of the oil. (10 marks)



Using ρgh ; $1000g * 5cm = \rho g * 3cm$

$\rho = \frac{5000}{3} = 1667$ kg/m^3

2. A 0.480 kg piece of wood sinks and has an apparent mass of 0.047 kg in alcohol ($\rho = 790$ kg / m^3). (Use masses rather than forces in the problem). (15 marks)



What is the buoyancy mass acting on the wood ?

$M_{APP} = M - M_{BUOY}$ $\therefore M_{BUOY} = 0.48 - 0.047$

$= 0.433$ kg

What is the volume of the piece of wood ?

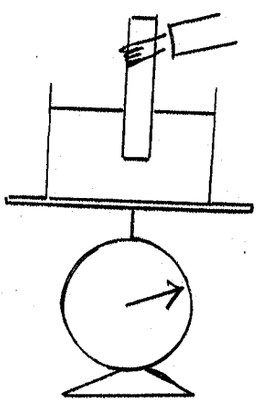
$M_{BUOY} = \rho_{ALC} * V_{WOOD}$

$\therefore V_{WOOD} = 0.433 / 790 = 0.000548$ m^3

Calculate the density of the wood.

$\rho_{WOOD} = \frac{M}{V} = \frac{0.48}{0.000548} = 875.9$ kg/m^3

3. A container of water sits on a scale and the scale reading is 20.00 N. What is the reading if a piece of wood is held in the water, without touching the sides, and with 0.50 x 10^{-3} m^3 submerged ? (15 marks)



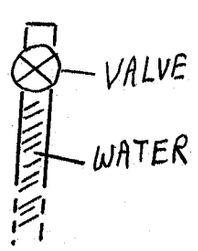
Scale now reads $20N + F_B$.

F_B = weight water displaced

$= 0.5 * 10^{-3}$ m^3 $* 1000$ kg/m^3 $* g$

$= 4.9$ N $\therefore$ Reading $= 24.9$ N

4. A vertical pipe contains water under a gauge pressure of 1.0 atmosphere (1.013 x 10^5 N/m^2). The valve is initially closed. (15 marks)



Write down the three terms in the Bernoulli equation to find the velocity of the water at the pipe exit when the valve is opened.

$P + \frac{1}{2}\rho v^2 + \rho gh$

$(1.013 * 10^5 + P_0) + 0 + 0 = P_0 + \frac{1}{2}\rho v^2 + 0$

$1.013 * 10^5 = \frac{1000}{2} v^2$ $v = 14.23$ m/s

Write the three terms again to find the maximum height which the water will reach.

$(1.013 * 10^5 + P_0) + 0 + 0 = P_0 + 0 + \rho gh$

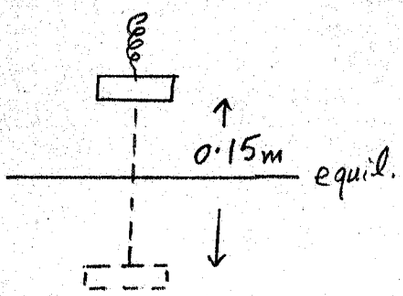
$h = \frac{1.013 * 10^5}{1000 * 9.8} = 10.33$ m.

What velocity will the water have when it falls back to the level of the pipe exit ?

$V = -14.23$ from symmetry of problem and equations

5. A 2.00 kg mass is held at the bottom of an unstretched spring, and then released. It falls 15.0 cm before stopping and bouncing back. (25 marks).

Using energy considerations, calculate the spring force constant, k.



mgh = Grav. P.E $= \frac{1}{2}kx^2$ = Spring P.E.

$mgx = \frac{1}{2}kx^2$ and $k = \frac{2mg}{x}$

$= \frac{2 * 2 * 9.8}{0.15} = 261.33$ N/m

What is the angular frequency of the oscillation ?

$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{261.33}{2}} = 11.43$ r/s

What is the amplitude of the oscillation ?

$A = 0.075$ m

What is the maximum velocity of the mass and where does this occur ?

$V_{MAX} = A\omega = 0.857$ m/s at equil. pt 0.075m from start.

OR use energy $\frac{1}{2}mV_M^2 + \frac{1}{2}kA^2 + (mg * 0.075) =$ Total energy $= mg * 0.15$

$V_M^2 + 0.735 + 1.47 = 2.94$ $V_M^2 = 0.735$ $V_M = 0.857$ m/s

How long does it take to fall from the top to the bottom for the first time ?

$T = \frac{2\pi}{\omega} = \frac{2\pi}{11.43} = 0.5497$ sec

Time $= \frac{T}{2} = 0.2749$ sec

6. A 440 Hz longitudinal wave in air has a speed of 345 m/s. (20 marks)

What is the wavelength ? $\lambda = \frac{V}{f} = \frac{345}{440} = 0.784$ m

How much time is required for the phase to change by 90° at a given point in space ?

$T = \frac{1}{f} = 2.273$ msec. Time $= \frac{T}{4} = 0.568$ msec

At a particular instant, what is the phase difference (in degrees) between two points 4.4 cm apart ?

$\phi = \frac{2\pi x}{\lambda} = \frac{360°}{0.784} * 0.044 = 20.2°$

Write the equation for the wave, as a cosine function, if its amplitude is 0.020 cm, and at t = 0 and x = 0, the displacement is – 0.020 cm.

$k = \frac{2\pi}{\lambda} = 8.01$ $\omega = 2\pi F = 2764$

At $t=0$, $x=0$ $-0.02 = +0.02 \cos\phi$ $\therefore \phi = \pi$

$\therefore d = +0.02$ cm $\cos(8.01x \pm 2764t \pm \pi)$

or -0.02 cm $\cos(8.01x \pm 2764t)$.