Midterm 1

Physics 1B (Lec 5)

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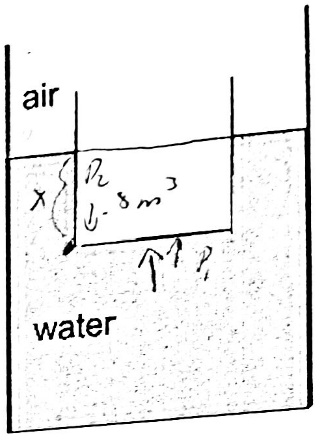
Time to complete the exam: 90 min

Each problem is worth 20 points. If a problem has parts (a) and (b), they are 10 points each. It is not sufficient to present the final answer. You need to show the solution and justify your steps at the level of detail that would be sufficient for your fellow classmate (or grader) to understand how you arrived at the final answer. Please write your solutions in the spaces below each question. You can use the back sides of the pages as scrap paper. Numerical answers need not have more significant figures than the numbers provided in the problem.

1	2	3	4	5	6	total
20	20	20	20	20	20	120

Problem 1. An open metal box with dimensions 1.00 m x 1.00 m x 1.00 m and mass 800 kg floats on the surface of the water ($\rho_w = 1.00\, g/cm^3$).



(a) What is the height of the box above the water line?

$$\frac{\rho_{obj}}{\rho_F} = \frac{V_{dsp}}{V_{obj}}$$

$$m_{obj} = V_{dsp}\,\rho_F$$

$$V_{dsp} = \frac{m_{obj}}{\rho_F}$$

$$V_{disp} = .8\ m^3$$

$$1 \cdot 1 \cdot x = .8\ m^3$$

$$x = .8\ m$$

$$1 - x = \boxed{.200\ m}$$

(b) What is the total force F of pressure acting on the bottom of the box, including the atmospheric pressure ($p_0 = 1.01 \times 10^5$ Pa) and the contribution from the water?

$$F = \frac{P}{A} \qquad A = 1\ m^2$$

$$P_1 = \rho g h \qquad P_2 = P_0$$

$$P_1 = P_0 + \rho g h$$

$$P_1 = 1.01\times10^5\ Pa + 1000(9.8\ .8)$$

$$P_1 = 1.01\times10^5\ Pa + 7.84\times10^3\ \text{Pascal}$$ from below

From above $P_2 = P_0 = 1.01\times10^5\ Pa$

$$P_{net} = P_1 - P_2 = 7.84\times10^3\ Pa$$

$$F = \frac{P_{net}}{A} \qquad F = \frac{7.84\times10^3\ Pa}{1\ m^2} = \boxed{7.84\times10^3\ N}$$

Problem 2. A paint with density 1.2 g/cm³ comes out of a paint gun with a speed 2 m/s. Neglecting friction and viscosity, what is the gauge pressure inside the hose?

$\rho = 1.2\ g/cm^3$

$v = 2\ m/s$

$\frac{1.2\ g}{cm^3} \cdot \frac{kg}{1000\ g} \cdot \frac{100\ cm}{m} \cdot \frac{100\ cm}{m} \cdot \frac{100\ cm}{m} = \frac{1200\ kg}{m^3}$

$P_1 - P_2 = \frac{1}{2}\rho v^2$ from bernoulli's equation

$= \frac{1}{2}(1200)(4) = 2.4 \times 10^3$ pascals

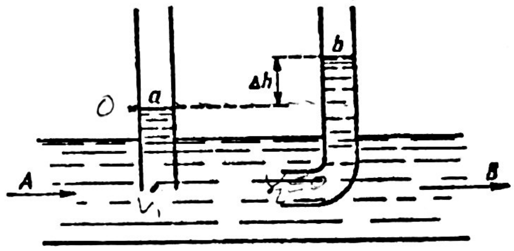
$P_1 + \frac{1}{2}\rho v_1^2 = P_2 + \frac{1}{2}\rho v_2^2$

$P_1 - P_2 = \frac{1}{2}\rho v_2^2$

gauge pressure

20/20

Problem 3. Water flows along a horizontal pipe AB, as shown in the figure. The difference between the levels of the liquid in tubes a and b is $\Delta h = 1$ cm. The diameters of tubes a and b are the same. Water density is $\rho = 1\ g/cm^3$. Determine the velocity of the water flowing along the pipe AB.



$\rho = 1000\ \frac{kg}{m^3}$

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

$P_2 - P_1 = \frac{1}{2}\rho (v_1^2 - v_2^2)$

$98 = \frac{1}{2}\, 1000\, v_1^2$

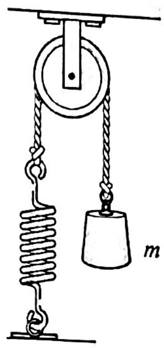
$v_1 = .442\ m/s$

$P_1 = \rho g h_1$ $P_2 = \rho g h_2$

$P_2 - P_1 = \rho g \Delta h$

$= 1000\,(9.8)(.01) = 98\ Pa$

Problem 4. A mass m=10 kg is attached to a spring with a spring constant k=300 N/m as shown in the figure. The mass is released with zero velocity from the position in which the spring was unstretched. Find the amplitude of the resulting small oscillations.



$F = -kx$

$x = \frac{10(9.8)}{300}$

$x = .326\ m$

$mgx = \frac{1}{2}kx^2$

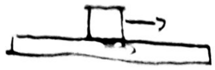
$\frac{1}{2}kx^2 - mgx = 0$ solve for x w/ calculator

$x = .653\ m \div 2 = .33\ m$

divide b/c the max distance it will stretch is .653 m so amplitude = ½ of that b/c Amplitude is max distance from the equilibrium point

Problem 5. A horizontal platform vibrates horizontally with an amplitude 10 cm and a frequency $f = 0.5$ Hz. When a small block is placed on top of the platform, the frequency and the amplitude remain the same. What is the minimum value μ that the coefficient of static friction must have for the block to oscillate with the platform without sliding? *(Hint: the force of friction on the block of mass m cannot exceed $(\mu\, mg)$.)*

$A = .1m$, $f = .5\ s^{-1}$



$F_f < \mu mg$

$f = \frac{1}{T} = \frac{\omega}{2\pi}$

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

$\mu mg = m\vec{a}$

$\mu g = a$

$x = A \sin(\omega t + \phi)$

$v = \omega A \cos(\omega t + \phi)$

$a = -\omega^2 A \sin(\omega t + \phi)$

a_{max}

$f = \frac{\omega}{2\pi}$

$.5 = \frac{\omega}{2\pi}$

$\omega = \pi$

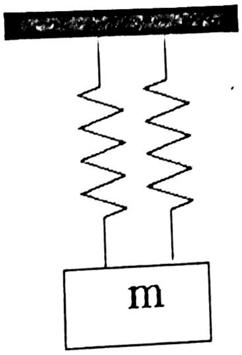
$\mu g = -\omega^2 A$

$\mu = \frac{-\omega^2 A}{g} = \frac{\pi^2 (.1)}{9.8}$

$\mu = .100 \ \frac{N}{Kg \frac{m}{s^2}}$

$T = \frac{2\pi}{\omega}$

Problem 6. (a)Two identical springs with a spring constant k=30 N/m are connected as shown in the figure. The horizontal bar is massless. A mass m=1 kg is attached as shown. Find the period of small oscillations.



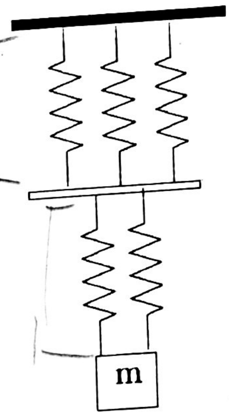
$T = 2\pi\sqrt{\frac{m}{K}}$ $K = K_1 + K_1$

$K = 30 + 30 \ \frac{N}{m}$

$T = 2\pi\sqrt{\frac{1}{60}}$

$T = .811$ seconds

(b) Find the period of small oscillations for five identical springs with k= 30 N/m connected to mass m=1 kg as shown. (The horizontal bar is massless.)



k_0

k_1

$\frac{1}{K_T} = \frac{1}{K_0} + \frac{1}{K_1}$. $k_0 = k+k+k = 90$

$K_1 = k+k = 60$

$\frac{1}{K_T} = \frac{1}{90} + \frac{1}{60}$ N/m

$\frac{1}{K_T} = \frac{1}{36}$ $k = 36 \ \frac{N}{m}$

$T = 2\pi\sqrt{\frac{m}{K_T}}$

$T = 2\pi\sqrt{\frac{1}{36}}$

$T = 1.05$ seconds

20/20