solutions

(1

1. **(40 POINTS) In a Chabot College physics lab experiment, a piece of balsa wood is completely submerged under the water. The wood is *at rest* and is tethered by a string to the bottom of a container of water. The balsa wood has volume is 1.34×10^{-6} m^3 and density of 0.16×10^{3} kg/m^3. Water, on the other hand, has density 1.00×10^3 kg/m^3. Answer the following questions and show all work and reasoning.**

(a) (2 points) What is the direction of the buoyant force acting on the wood, *up or down* ? Circle *"up"* or *"down."*

(b) (1 points) What is the direction of the tension force acting on the wood, *up or down* ? Circle *"up"* or *"down."*

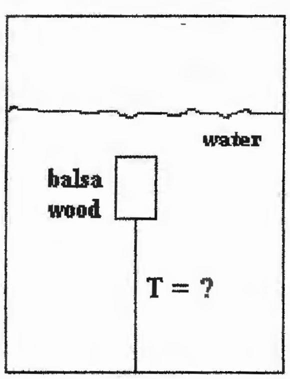
(c) (1 points) What is the direction of the force of gravity acting on the wood, *up or down* ? Circle *"up"* or *"down."*

(d) (18 points) What is the magnitude T of the tension in the string?

(e) (18 points) Suppose the string is cut and the piece of wood rises upward. What is the magnitude of the acceleration before the wood reaches the water surface?

d. $\Sigma F_y = B - T - mg = 0$

$$T = B - mg$$



$$T = (1000)Vg - (0.16\times10^{3})(1.34\times10^{-6})(9.8)$$

$$T = (1000)(1.34\times10^{-6})(9.8) - 2.144\times10^{-3}$$

$$T = (10^{4})(1.34\times10^{-6}) - 2.144\times10^{-3}$$

$$T = 1.34\times10^{-2} - 2.144\times10^{-3}$$

$$T = 1.34\times10^{-2} - 0.2144\times10^{-2}$$

$$T = 1.126\times10^{-2}\ (N)$$

(2

(e)

$$ma = B - mg$$

$$(160)(1.34\times10^{-6})\cdot a = B - mg$$

$$214.4\times10^{-6}\cdot a = (1000)(1.34\times10^{-6})(10) - (160)(1.34\times10^{-6})(10)$$

$$a = \frac{(1.34\times10^{4}\times10^{-6}) - (1600)(1.34\times10^{-6})}{214.4\times10^{-6}}$$

$$= \frac{1.34\times10^{-2} - 2144\times10^{-9}}{214.4\times10^{-6}}$$

$$= 1.34\times10^{-2} - 2.144\times10^{-3}$$

$$= \frac{1.34\times10^{-2} - 0.2144\times10^{-2}}{2.144\times10^{-4}}$$

$$= \frac{1.1256\times10^{-2}}{2.144\times10^{-4}}$$

$$\approx 0.52\times10^{2}\ m/s^{2}$$

$$\approx 52\ m/s^{2} \approx 50g$$

(f)

$$\frac{\forall_s}{\forall} = \frac{\rho_{wood}}{\rho_{water}} = \boxed{0.16}$$

13

2. (18 POINTS) You are a medical professional attempting to explore the problem of blood pressure drops in diseased, narrowed arteries. The arteries have approximately circular cross-section.

In a section of an artery, the diameter d_1 is 0.0050 m and the speed v_1 of the blood is 0.500 m/s. The section narrows into another segment of artery with diameter $d_2 = 0.0022$ m . The height relative to the laboratory floor does not change ($y_1 = y_2$) . The density of blood is 1.06×10^3 kg/m^3. NOTE: The diagram below shows dimensions and arrows qualitatively and may not be exactly at scale.

(a) (2 points) What is the circular cross-sectional area A_1 of the first section of artery?

$A_1 = \pi d_1^2/4 = \dfrac{\pi\cdot(5\times10^{-3})^2}{4} = \dfrac{\pi\cdot 25\times10^{-6}}{4} = 19.635\times10^{-6}$ m $= 1.9635\times10^{-5}$ m

(b) (2 points) What is the circular cross-sectional area A_2 of the second section ?

$A_2 = \dfrac{\pi(2.2\times10^{-3})^2}{4} = 3.80133\times10^{-6}$ m $= 0.380133\times10^{-5}$

(c) (5 points) What is the speed v_2 in the narrow section of artery?

$V_2 = A_1V_1/A_2 = (1.9635/0.380133)\cdot 0.500\ \frac{m}{s} = \boxed{2.583\ \frac{m}{s}}$

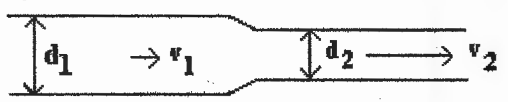
5

(d) (7 points) What is the pressure difference $P_1 - P_2$ between the two sections?

(e) (2 points) *Short answer in sentence form or math form; just clearly explain your work:* It was mentioned in class a drop in pressure could lead to the collapse of the narrow section of artery. Explain. What would be one major consequence of such a collapse?

$$P_1 + \tfrac{1}{2}(1060)V_1^2 = P_2 + \tfrac{1}{2}(1060)V_2^2$$

$$P_1 - P_2 = \tfrac{1}{2}(1060)(V_2^2 - V_1^2)$$



$$= (530)(2.583^2 - 0.500^2)$$

$$= 3.4036\times10^3\ Pa$$

$$= 0.034036\times10^5\ Pa \approx 0.034\ ATM$$

(e) LOW PRESSURE CAUSES ARTERY WALLS TO IMPLODE due TO INWARD DIRECTED NET FORCE: ARTERY WILL COLLAPSE TO ZERO INTERNAL DIAMETER.

(4

3. (40 points)

A simple harmonic oscillator consists of a block of mass m = 2.10 kg attached to a *horizontal* spring of force constant k= 110 N/m. When t = 0, the position and horizontally directed velocity of block are: x_0 = 0.140 m and v_0 = 3.500 m/s, in that order.

(a) $\frac{1}{2}kA^2 = \frac{1}{2}mv_0^2 + \frac{1}{2}kx_0^2$

The position as a function of time has the form:

$\frac{1}{2}(110)A^2 = \frac{1}{2}(2.1)(3.5)^2 + \frac{1}{2}(110)(0.140)^2$

$= 12.8625 + 1.078 \rightarrow A = 0.503(m)$

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

(b) $V_{MAX} = A\omega = (0.503)\sqrt{\frac{k}{m}} = (0.503)\sqrt{\frac{110}{2.1}} = 3.64\frac{m}{s}$

AT $X = 0$

(a) (17 points) Find amplitude A.

(b) (2 points) What is the maximum value of the speed? What is the value of x when block has this maximum speed?

(c) (2 points) What is the maximum value of the acceleration? What is the value of x when block has this maximum acceleration?

(d) (3 points) What is the maximum value of the potential energy? What are the *two* values of x where block has this maximum potential energy?

(e) (16 points) What is ϕ ? In what quadrant is the angle?

(c) $a_{max} = A\omega^2 = (0.503)\cdot\frac{k}{m} = (0.503)\cdot\frac{110}{2.1}$

$= 26.35\ m/s^2$ at $x = -A$.

(d.) $\frac{1}{2}kA^2 = \frac{1}{2}(110)(0.503)^2 = 13.92\ J$ at

$x = \pm A$

(e.) $\left.\begin{array}{l} x_0 = A\cos\phi > 0 \\ v_0 = -\omega A\sin\phi > 0 \end{array}\right\}$ $\cos\phi > 0$ and $\sin\phi < 0$

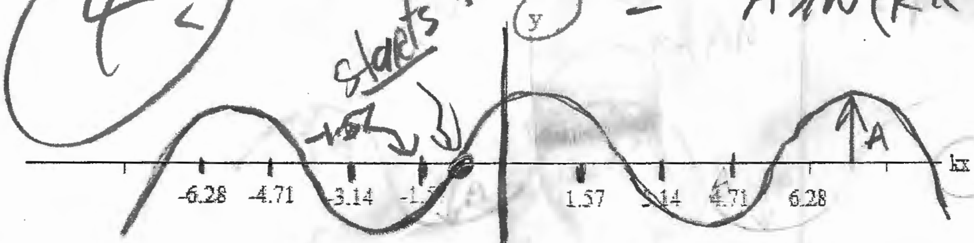
QUADRANT 4

$\rightarrow \phi = -\cos^{-1}\left(\frac{0.140}{0.500}\right) = -73.7^\circ$

$= -1.29$ RAD

15

(4.) $y = A\sin(kx + 48.59^\circ)$



shift sine function left

NOTE: $y = y(x, t)$

(a.) $y(0,0) = A\sin\Phi = 0.015 \rightarrow \sin\Phi > 0$

$\frac{dy}{dt} = -\omega A\cos\Phi < 0 \rightarrow \cos\Phi > 0$

QUADRANT I: $\Phi = \sin^{-1}\left(\frac{0.015}{0.02}\right) = 48.59^\circ$
$= 0.849$ RAD

(b.) Positive x: $kx - \omega t + \Phi = $ constant

$\frac{d(kx - \omega t + \Phi)}{dt} = 0 \Rightarrow k\frac{dx}{dt} - \omega = 0$

$dx/dt = \frac{\omega}{k} > 0 \Rightarrow$ moves right in the positive x-direction.

(c.) PLOT $y(x, 0) = A\sin(kx + 48.59^\circ)$
$48.59^\circ = 0.85$ radians; $y(x, 0)$ STARTS at 0.85 RADIANS. NOTE: $48.59 \approx \pi/4$ on graph

(d.) $\frac{dy}{dt} = -\omega A\cos(kx - \omega t + \Phi)\Big|_{\substack{t=0\\x=0}} = -\omega A\cos\Phi$

$V_y = -\omega A\cos 48.59^\circ$
$= (-2\pi f)\cdot(0.02)\cdot\cos 48.59^\circ = (-6.28)\cdot(246)(0.02)\cos 48.59$
$= -20.44$ m/s $\Rightarrow$ Particle moves DOWN

6.

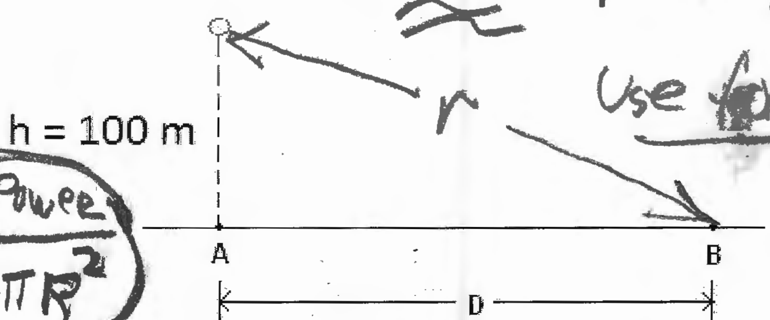
5. (Extra Credit) (Tentatively 10 points) On Chinese New Year, a fireworks shell explodes a distance h = 100 m above the ground, creating a colorful display of sparks and a loud sound. Person A standing at point A directly below the explosion detects a sound level of 110 db. Person B stands a distance D to the right of person A and detects a sound level of 100 dB.

(a) (6 points) What is the distance D?

(b) (4 points) How much *sooner* does person A hear the sound before person B? Could the two people, using only their ears, distinguish the two arrival times? Explain. Assume the speed of sound is 345 m/s on this warm January night.

NOTE: $r^2 = h^2 + D^2$

Use FORMULA $dB = 10\log\frac{I}{I_0}$



$I = \frac{Power}{4\pi R^2}$

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

(a) $110\,dB - 100\,dB = 10\log\frac{I_A}{I_0} - 10\log\frac{I_B}{I_0}$

$10 = 10\log\frac{I_A}{I_B}$

$1 = \log\frac{I_A}{I_B} \Rightarrow \frac{I_A}{I_B} = 10$

$\Rightarrow \frac{\cancel{Power}}{\cancel{4\pi} h^2} = 10\cdot\frac{\cancel{Power}}{\cancel{4\pi}(h^2+D^2)}$

$h^2 + D^2 = 10\cdot h^2 \Rightarrow D = \sqrt{9}\cdot h$

$= 3\cdot h = \boxed{300\,m}$

(5) continued

(b.)

$$\Delta t = \frac{r - h}{345\,m/s}$$

$$\Delta t = \frac{\sqrt{10}\,h - h}{345\,m/s}$$

$$\Delta t = \frac{(\sqrt{10} - 1)\,h}{345\,m/s}$$

$$\Delta t = \boxed{0.627\,(s)}$$