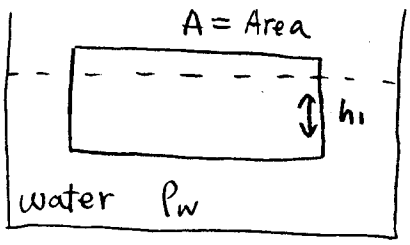
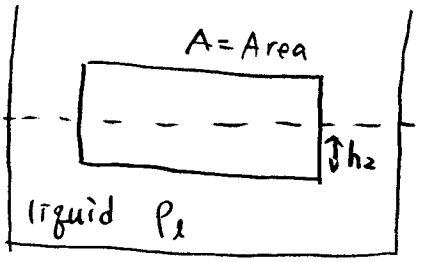
Q1.

(20pts)





$h_1 = 5.6$ cm

$\rho_w = 10^3$ kg/m^3

$h_2 = 4.6$ cm

Buoyant force B is Mg for both.

$$B = \rho_w (h_1 A) g = \rho_l (h_2 A) g$$

$$\therefore \rho_l = \frac{h_1}{h_2} \rho_w = \frac{5.6}{4.6} \times 10^3 = 1.217 \times 10^3 \text{ kg/m}^3$$

Q2.

$$x(t) = A e^{-\frac{b}{2m}t} \cos \omega t$$

$A = 0.2$ m, $k = 4$ N/m, $m = 0.25$ kg, $b = 0.015$ kg/s

$$\omega = \sqrt{\frac{k}{m} - \left(\frac{b}{2m}\right)^2} = 4 \text{ (rad/s)}$$

$$A(t) = A e^{-\frac{b}{2m}t} = 0.2\, e^{-0.03t} \text{ (m)}$$

(a) (4pts) $T = \frac{2\pi}{\omega} = 1.57$ (s)

(b) (6pts) $A(t) = 0.2\, e^{-0.03t}$ (m)

(c) (10pts)

$$A(t) = A(0)\cdot e^{-1}$$

$$\Rightarrow \quad e^{-0.03t} = e^{-1}$$

$$\Rightarrow \quad t = \frac{1}{0.03} = 33.3 \quad (s)$$

$$t = nT$$

$$\Rightarrow \quad n = \frac{t}{T} = \frac{33.3}{1.57} \approx 21$$

$\therefore$ 21 oscillations

Q3.

$$\mu = 5\times10^{-2}\ (kg/m) \quad , \quad T = 80\ (N) \quad \Rightarrow \quad V = \sqrt{\frac{T}{\mu}} = 40\ (m/s)$$

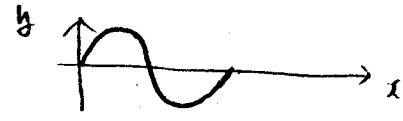
$$A = 0.06\ (m) \quad , \quad f = 60\ (Hz)$$

$$\Rightarrow \begin{cases} \lambda = \dfrac{V}{f} = 0.67\ (m) \\ k = \dfrac{2\pi}{\lambda} = 9.42\ (rad/m) \\ \omega = 2\pi f = 376.8\ (rad/s) \end{cases}$$

(a) (6pts)

$$y(x,t) = A\sin(kx - \omega t)$$

$$= 0.06\sin(9.42x - 376.8t) \quad (m)$$



(b) (7pts) $P = \frac{1}{2}\mu(\omega A)^2 V$

$= 511.12 \quad (W)$

(c) (7pts) $1000 = \frac{1}{2}\mu\omega^2 V A^2$

$\Rightarrow A = \sqrt{\frac{1000}{\frac{1}{2}\mu\omega^2 V}} = 0.08 \quad (m)$

Q4.

$\rho_{Fe} = 7.86 \times 10^3 \ kg/m^3$, $V_{Fe} = 5950 \ m/s$

$\rho_{air} = 1.29 \ kg/m^3$, $V_{air} = 343 \ m/s$

$I = 2 \times 10^{-6} \ W/m^2$, $f = 1000 \ Hz$

(a) (4pts) $\beta = 10 \log\left(\frac{I}{I_0}\right) = 10 \log\left(\frac{2\times10^{-6}}{10^{-12}}\right) = 63 \ (dB)$

(b) (4pts) $\lambda = \frac{V}{f}$

$\lambda_{Fe} = \frac{5950}{1000} = 5.950 \ (m)$

$\lambda_{air} = \frac{343}{1000} = 0.343 \ (m)$

(c) 4pts

$$I = \frac{1}{2}\rho\omega^2 V s_{max}^2$$

$$= \frac{1}{2}\rho(2\pi f)^2 V s_{max}^2$$

$$s_{max} = \sqrt{\frac{I}{2\pi^2 \rho f^2 V}}$$

$$\begin{cases} s_{Fe} = 0.47 \times 10^{-10}\ m \\ s_{air} = 1.5 \times 10^{-8}\ m \end{cases}$$

(d) 4pts

$s_{Fe} \approx r_B$, $s_{air} \gg r_B$

Air has much room for moving (vibrating) than the iron since air is gas and iron is solid.

(e) 4pts

$$\begin{cases} \frac{\lambda_{Fe}}{s_{Fe}} = \frac{5.950}{0.47 \times 10^{-10}} = 11.9 \times 10^{10} \\ \frac{\lambda_{air}}{s_{air}} = \frac{0.343}{1.5 \times 10^{-8}} = 22.9 \times 10^{6} \end{cases}$$

Q.5.

20pts. Frequency of the whistle, $f_w = 21\,kHz$

Maximum frequency you can hear, $f_h = 20\,kHz$

Since f_h is smaller than f_w,

observer (= you) should go away from the source

(= friend). If you move with speed v,

$$f_h = \frac{V_{sound} - V}{V_{sound}} f_w$$

$$\Rightarrow 20 = \left(1 - \frac{V}{343}\right) 21$$

$$\therefore V = \frac{343}{21}.$$

$$= 16.3 \quad (m/s)$$

$$= 58.8 \quad (km/h)$$