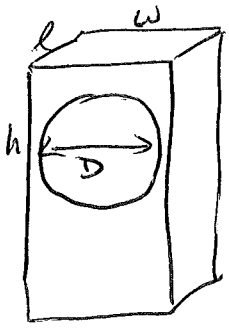
# Chapter 8

(2) $\ell \times w \times h = 40\text{cm} \times 55\text{cm} \times 44\text{cm}$

$t = 4\text{cm}$

$D = 22\text{cm}$




$c = 343\text{m/s}$

$\rho_o = 1.21\ \text{kg/m}^3$ $\quad V = 40\text{cm} \times 55\text{cm} \times 44\text{cm} = 96{,}800\ \text{cm}^3$

Unflanged: 20.5cm

Flanged opening – $L' = L + 1.7a$

$= 4\text{cm} + 1.7(11\text{cm}) = 22.7\text{cm}$

$A = \pi(11\text{cm})^2 = 121\pi\ \text{cm}^2 = 380\ \text{cm}^2$

(a) Helmholtz Resonator

$$Z = R + i\left(M\omega - \frac{1}{\omega C}\right)$$

Resonance when $X = 0 \Rightarrow M\omega - \frac{1}{\omega C} = 0$ $\quad \boxed{\omega = c\sqrt{\frac{A}{L'V}}}$

$$\omega = (343\text{m/s})\sqrt{\frac{121\pi\text{cm}^2}{(22.7\text{cm})(96{,}800\text{cm}^3)}} \times \frac{10^2\text{cm}}{1\text{m}}$$

Flanged $\quad \omega = 451\ \text{rad/s} = 71.8\ \text{Hz}$

unflanged $\quad \omega = 474\ \text{rad/s} = 75.6\ \text{Hz}$

(b)


$D = 22\text{cm}$

$m = 0.008\text{kg}$

$S_{spring} = 1100\ \text{N/m}$

$\omega_{cone} = \sqrt{\frac{k}{m}} = \sqrt{\frac{1100\ \text{N/m}}{0.008\text{kg}}} = 370.8\ \text{rad/s} = 59.0\ \text{Hz}$

unflanged $\quad m_{air} = \rho A \cdot L' = (1.21\ \text{kg/m}^3)(0.038\ \text{m}^2)(0.205\ \text{m}) = 0.00943$

$$S_{air} = \frac{\rho_o c^2 A^2}{V} = \frac{(1.21\ \text{kg/m}^3)(343\text{m/s})^2(.038\text{m}^2)^2}{0.0968\ \text{m}^3} = 2124\ \text{N/m}$$

$S_{total} = 1100\ \text{N/m} + 2124\ \text{N/m} = 3224\ \text{N/m}$

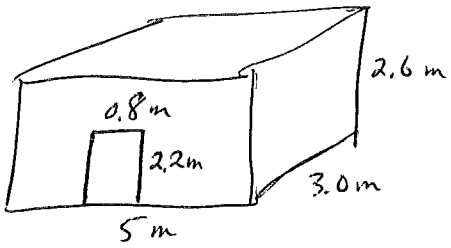
$m_{total} = 0.008\text{kg} + 0.00943 = 0.01743\ \text{kg}$

#2

$$\omega_0 = \sqrt{\frac{S}{m}} = \sqrt{\frac{3224\ N/m}{0.01743\ kg}} = 430\ rad/s = \boxed{68.4\ Hz}$$

(c) $$\omega_{sp} = \sqrt{\frac{S_{sp}}{m}} = \sqrt{\frac{1100 N/m}{0.028 kg}} = 370.8\ rad/s = \boxed{59.0 Hz}$$

(3)




$t = 12\ cm$

(a) $V = (5)(3)(2.6) = 39\ m^3$

$A = 0.8m \times 2.2m = 1.76\ m^2$

effective radius of opening $a = \sqrt{\frac{A}{\pi}} = \sqrt{\frac{1.76}{\pi}} = 0.748\ m$

unflanged $L' = 0.12m + 1.5(0.748m) = \boxed{1.242\ m}$

flanged $L' = 0.12m + 1.7(0.748m) = \boxed{1.392\ m}$

$$\omega_0 = c\sqrt{\frac{A}{L'V}} = (343 m/s)\sqrt{\frac{1.76\ m^2}{(1.242m)(39m^3)}} = 65.4\ rad/s$$

61.8 rad/s

$\boxed{10.4\ Hz}$ 9.83 Hz

(b) $$C = \frac{V}{\rho_0 c^2} = \frac{39 m^3}{(1.21 kg/m^3)(343 m/s)^2} = \boxed{2.74 \times 10^{-4}\ m^5/N}$$

(c) $$M = \frac{\rho_0 L'}{A} = \frac{(1.21 kg/m^3)(1.242m)}{1.76\ m^2} = \boxed{0.854\ kg/m^4}$$

1.392 → 0.957

(d) $$Z = R + i\left(M\omega - \frac{1}{\omega C}\right) = 0 + i\left(\left(0.854\ \frac{kg}{m^4}\right)(60\pi s^{-1}) - \frac{1}{(60\pi s^{-1})(2.74 \times 10^{-4}\ m^5/N)}\right)$$

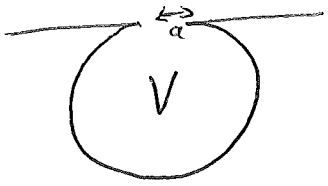
$\omega = (30Hz)(2\pi) = 60\pi$

$$= \boxed{i(141.6)\ \frac{Ns}{m^5}}$$

#3

(7) $A = 35\text{ cm} \times 35\text{ cm} = 0.1225\text{ m}^2$

$a = 9\text{ cm}$




(a) $f = 30\text{Hz} \Rightarrow \omega = 60\pi\text{ rad/s}$

$A_g = \pi a^2 = \pi (.09\text{m})^2 = 0.0254\text{ m}^2$

flanged $L' = L + 1.7a = 0 + 1.7(0.09\text{m}) = 0.153\text{ m}$

$$\omega = c\sqrt{\frac{A_g}{L'V}} \Rightarrow \left(\frac{\omega}{c}\right)^2 = \frac{A_g}{L'V} \Rightarrow V = \frac{A_g}{L'}\left(\frac{c}{\omega}\right)^2$$

$$V = \frac{(0.0254\text{ m}^2)}{(0.153\text{m})}\left(\frac{343\text{m/s}}{60\pi\text{ rad/s}}\right)^2 = \boxed{0.55\text{ m}^3}$$

0.5497

(b) $f = 45\text{Hz} \quad \omega = 90\pi\text{ rad/s}$

$$T_{P45} = \left[1 + \frac{c^2}{4A^2\left(\frac{\omega L'}{A_g} - \frac{c^2}{\omega V}\right)^2}\right]^{-1}$$

$$T_{P45} = \left[1 + \frac{(343\text{m/s})^2}{4(0.1225\text{m}^2)^2\left(\frac{90\pi(0.153\text{m})}{0.0254\text{m}^2} - \frac{(343\text{m/s})^2}{(90\pi)(0.55\text{m}^3)}\right)^2}\right]^{-1} = 0.313$$

~~0.00483~~ ~~$4.83 \times 10^{-1}$~~

31.3%

$f = 60\text{Hz} \quad \omega = 120\pi\text{ rad/s}$

$T_{P60} =$ ~~$8.68 \times 10^{-2}$~~ 0.597

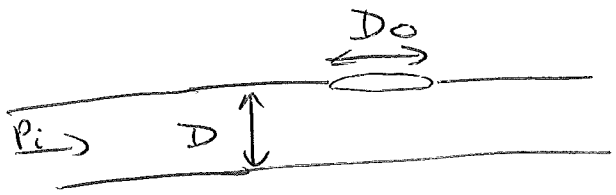
59.7%

(9) $f = 400\,Hz$

$P = 0.2\,W$

$D = 5\,cm$

$D_o = 1.2\,cm$




$$k = \omega/c = \frac{400(2\pi)}{343\ m/s} = 7.33\ rad/m$$

$$A = \pi(0.005m)^2 = 1.96\times10^{-3}\ m^2$$

$$L' = L + 1.5a = 0 + 1.5(0.006\,m) = 0.009\,m$$

$$T_{pg} = \frac{2(7.33\ rad/m)^2(1.96\times10^{-3})\ 7.33\,rad/m}{\pi\left[\left(\frac{2(1.96\times10^{-3}m^2)(0.009m)}{\pi(6\times10^{-3})^2}\right)^2+1\right]}$$

$$T_{pg} = 0.0108 \qquad P_{pg} =$$

$$T_p = \frac{1}{\left(\frac{\pi a^2}{2AkL'}\right)^2+1} = \frac{1}{\left[\frac{\pi(0.006m)^2}{2(1.96\times10^{-3}m^2)(7.33rad/m)(0.009m)}\right]^2+1}$$

$$T_p = 0.839$$

$$R_p = 1 - T_{pg} - T_p = 1 - 0.0108 - 0.839 = 1 - 0.8498$$

$$R_p = 0.1302$$