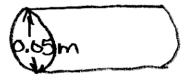
3. $\mathcal{E}_0 = 10^{-5}\,m$ $f = 400\,Hz$



cross section of the rod $= \pi r^2 = \pi(0.025m)^2 = 1.96\times10^{-3}\,m^2$

$\omega = 2\pi(400s^{-1}) = 2.51\times10^3\,rad/s$

for steele $\rho_v = 7800\,kg/m^3$ $Y = 20\times10^{10}\,N/m^2$ $c_w = 5.1\times10^3\,m/s$
(see pg 80)

a) displacement wave

$\mathcal{E} = \mathcal{E}_0 \sin(kx - \omega t)$

$$k = \frac{\omega}{c_w} = \frac{2.51\times10^3\,rad/s}{5.1\times10^3\,m/s} = 0.493\,m^{-1}$$

$\mathcal{E} = (10^{-5}m)\sin(0.493m^{-1}x - 2.51\times10^3 rad/s\, t)$

b) $\frac{1}{2}\rho_v \omega^2 \mathcal{E}_0^2 A$ Eq. 5.9

$= \frac{1}{2}(7800\,kg/m^3)(2.51\times10^3 rad/s)^2(10^{-5}m)^2(1.96\times10^{-3}m^2)$

$= 4.82\times10^{-3}\,J/m$

c) $\frac{1}{2}\rho_v \omega^2 \mathcal{E}_0^2 A c_w$ Eq 5.10

$= (4.82\times10^{-3}\,J/m)(5.1\times10^3\,m/s)$

$= 24.5W$

d) 24.5W

4. $\mathcal{E} = \mathcal{E}_0 \sin(kx - \omega t)$

a) $\frac{d\mathcal{E}}{dt} = -\omega \mathcal{E}_0 \cos(kx - \omega t)$

$= -0.025 \cos(0.49 m^{-1} x - 2.51 \times 10^3 \, rad/s \, t)$

b) Eq. 5.22 $F = AY \frac{\partial \mathcal{E}}{\partial t} = AYk\mathcal{E}_0 \cos(kx - \omega t)$

Y for steele $= 20 \times 10^{10}$ N/m

$F = 1.93 \times 10^3 N \cos(0.49 m^{-1} x - 2.51 \times 10^3 \, rad/s \, t)$

c) $E = \rho_v \omega^2 \mathcal{E}_0^2 A \cos(kx - \omega t)$

$= 9.6 \times 10^{-3} \cos(0.49 m^{-1} x - 2.5 \times 10^3 \, rad/s \, t)$

5. a) H_2 is diatomic so $\gamma = 7/5$

the molecular mass of diatomic hydrogen = 2

$\therefore \rho_v = 6 \times 10^{23} \times 2 \times 1.67 \times 10^{-27} kg \times \frac{10^3 L}{22.4 L} m^{-3} = 0.09 \, kg/m^3$

(see example 4 in your book)

$$C_w = \sqrt{\frac{\gamma P}{\rho_v}} = \sqrt{\frac{7(1.0 \times 10^5 N/m^2)}{5(0.09 kg/m^3)}} = 1250 \, m/s$$

b) Argon is monotonic with an atomic weight of 40 thus is will be 20 times denser than H_2

$\Rightarrow \rho_v = 1.8 \, kg/m^3$ and $\gamma = 5/3$

$$C_w = \sqrt{\frac{5(1.0 \times 10^5 N/m^2)}{3(1.8 kg/m^3)}} = 304 \, m/s$$

6. a) $c_w = \left(\frac{\gamma R T}{M_{mol}}\right)^{1/2}$ eq. 5.43

$$\frac{dc_w}{dT} = \frac{1}{2}\left(\frac{\gamma R T}{M_{mol}}\right)^{-1/2} \frac{\gamma R}{M_{mol}} \approx \frac{\Delta c_w}{\Delta T}$$

$$= \frac{1}{2}\frac{1}{c_w}\frac{c_w^2}{T} = \frac{1}{2}\frac{1}{T}c_w$$

$$\Delta c_w = \frac{1}{2}\frac{\Delta T}{T}c_w$$

b) At 0°C $c_w = 330\,m/s$ (Example 4a)

0°C = 273 K

$$\Delta c_w = \frac{27}{273\,K}\left(\frac{1}{2}\right)(330\,m/s) = 16.3\,m/s$$

c) at 27°C the speed of sound is approximately

346.3 m/s

the accepted value is

$$c_w = \sqrt{\frac{(7/5 \times 8.3\,J/K \times 300\,K)}{0.029\,kg}} = 346.7\,m/s$$

so this approximation is very close

7. if the explosion is a length L away, the time it takes for the sound to reach the swimmer in air is $L/c_{w\,air}$ and in water $L/c_{w\,water}$

we know $\frac{L}{c_{w\,air}} - \frac{L}{c_{w\,water}} = 25$ L = 880 m

8. $I = 1\times10^{-7}\ W/m^2$ $T = 20°C$ $P = 1atm$ $\nu = 400Hz$

$\omega = 2.5\times10^{3} rad/s$

a) $I = \frac{1}{2}\rho_r \omega^2 \mathcal{E}_0^2 c_w$ Eq 5.44

see example 6

$$\Rightarrow \mathcal{E}_0 = \left(\frac{2I}{\rho_r \omega^2 c_w}\right)^{1/2}$$

$$= \left(\frac{2(1\times10^{-7}W/m^2)}{(1.20kg/m^3)(2.5\times10^3 m/s)^2(343m/s)}\right)^{1/2}$$

$$= 8.82\times10^{-9}m$$

b) $\gamma P k \mathcal{E}_0$ $k = \frac{\omega}{c_w} = \frac{2.5\times10^3 rad/s}{343m} = 7.29m^{-1}$

$\gamma = 7/5$ for air $1atm = 1.013\times10^5 N/m^2$

$$= \frac{7}{5}(1.013\times10^5 N/m^2)(7.29m^{-1})(8.89\times10^{-9}m)$$

$$= 9.2\times10^{-3} N/m^2$$

c) Eq. 5.45 $I_0 = 1\times10^{-12}W/m^2$

$$dB = 10\log_{10}(I/I_0) = 10\log_{10}(10^{-7}/10^{-12}) = 50dB$$