6. SOUND WAVES

HOMEWORK SOLUTION

1. Given :

$n = 320\text{ Hz}$

$\lambda = 20\text{ m}$

To Find :

$V = ?$

Solution :

We know that velocity of wave is given by,

$$V = n\lambda$$
$$= 320 \times 2$$
$$= 6400\text{ m/s}$$

2. Given :

$$\lambda_1 = \frac{81}{174}\text{ m}$$

$$\lambda_2 = \frac{81}{175}\text{ m}$$

$V = 324\text{ m/s}$

To Find :

$|n_1 - n_2| = ?$

Solution :

$\lambda_1 > \lambda_2$ and since $n \propto \frac{1}{\lambda}$

$\therefore\ n_1 < n_2$

$$\therefore\ n_2 - n_1 = \frac{V}{\lambda_2} - \frac{V}{\lambda_1}$$

$$= V\left[\frac{V}{\lambda_2} - \frac{V}{\lambda_1}\right]$$

$$= 324\left[\frac{1}{\frac{81}{175}} - \frac{1}{\frac{81}{174}}\right]$$

$$= 324\left[\frac{175-174}{81}\right]$$

$$= \frac{324}{81}$$

$$= 4\text{ Hz}$$

3. Given :

$V = 350\text{ m/s}$

$n = 175\text{ Hz}$

To Find :

Distance between compression and adjacent rarefaction $= \frac{\lambda}{2} = ?$

Solution :

$$V = n\lambda$$

$$\therefore\ \lambda = \frac{V}{n}$$

$$= \frac{350}{175}$$

$$\lambda = 2\text{ m}$$

$\therefore$ Distance between compression and adjacent rarefaction $= \frac{\lambda}{2}$

$$= \frac{2}{2} = 1\text{ m}$$

4. Given :

$n_1 = 100\text{ Hz}$

$n_2 = 110\text{ Hz}$

To Find :

$V = ?$

Solution :

Since, $n_2 > n_1$

$\therefore\quad \lambda_2 < \lambda_1 \quad \therefore\ \lambda_1 - \lambda_2 = 0.3\text{ m}$ ... (given)

$$\therefore\ \lambda_1 < \lambda_2 = \frac{V}{n_1} - \frac{V}{n_2}$$

$$= V\left[\frac{n_2 - n_1}{n_1 n_2}\right]$$

$$\therefore \quad V = \frac{n_1.n_2(\lambda_1 - \lambda_2)}{(n_2 - n_1)}$$

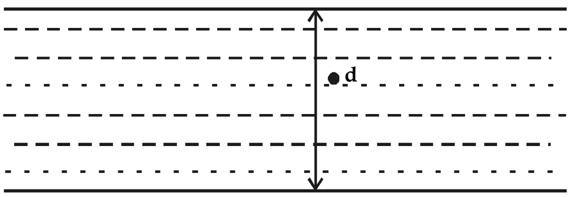
$$= \frac{100 \times 110 \times (0.3)}{(110 - 100)}$$

$$= \frac{100 \times 110 \times 0.3}{10}$$

$V = 330\ m/s$

5. Given :

$V = 1450\ m/s$



Return time of pulse = 2.4 sec

To Find :

$d = ?$

Solution :

$$\text{Velocity} = \frac{\text{Distance travelled by pulse}}{\text{time}}$$

$$\text{Velocity} = \frac{2d}{b}$$

$$1450 = \frac{2d}{2.4}$$

$$\therefore \quad d = \frac{1450 \times 2.4}{2}$$

$d = 1740\ m$

6. Given :

$\lambda_a = 0.68\ m$

$\lambda_g = 0.76\ m$

$V_a = 340\ m/s$

To Find :

$V_g = ?$

Solution :

Frequency of sound remains same even if the medium changes.

$V_{air} = n.\lambda_a$

$340 = n \times 0.68$

$\therefore n = 500\ Hz$

$= 500 \times 0.76$

$= 380\ m/s$

$\therefore V_g = 380\ m/s$

7. Given :

$n_1 = 606\ Hz$

$n_2 = 612\ Hz$

To Find :

$V = ?$

Solution :

We know that, $n \propto \dfrac{1}{\lambda}$

$\therefore n_2 > n_1$

$\therefore \lambda_2 > \lambda_1$

$$\therefore \lambda_1 - \lambda_2 = 0.5 \times 10^{-2} = V\left[\frac{1}{n_1} - \frac{1}{n_2}\right]$$

$$= V\left[\frac{n_2 - n_1}{n_1.n_2}\right]$$

$$= V\left[\frac{6}{606 \times 612}\right]$$

$\therefore V = 309.06\ m/s$

8. Given :

$T = \dfrac{1}{200}$ sec

$V = 330\ m/s$

To Find :

$\lambda = ?$

Solution :

$V = n\lambda$

$$\therefore \lambda = \frac{V}{n}$$

$= VT$

$$= 330 \times \frac{1}{200} = \frac{33}{20} = 1.65\ m$$

$\therefore \lambda = 1.65\ m$

9. Given :

$V_2 = 2V_1$

$\therefore$ Where 'V_1' the velocity of sound in air at $T_1 = 273$ K

To Find :

$T_2 = ?$

Solution :

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{V_2}}$$

$$\therefore \frac{V_1}{2V_1} = \sqrt{\frac{273k}{T_2}}$$

$$\therefore \sqrt{T_2} = \sqrt{273k} \times 2$$

$$\therefore T_2 = 1092\text{ K} \quad \text{or} \quad 819^0\text{C}$$

10. Given :

$\rho = 1.298\ kg/m^3$

$n = 512$ Hz

$\lambda = 66.5\ cm = 0.665\ m$

$V = 340.48\ m/s$

$P = 1.013 \times 10^5\ N/m^2$

To Find :

$\gamma = ?$

Solution :

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

$$\therefore \gamma = \frac{V^2 \rho}{P}$$

$$= \frac{(340 \times 48)^2 \times 1.293}{1.013 \times 10^5}$$

$$\therefore \gamma = 1.4797$$

11. Given :

At, $T_1 = 273$ k

Velocity of gas 'V_1'

To Find :

T_2 at $V_2 = V_1 + 10\ \%\ V_1$

Solution :

$$V_2 = V_1 + 10\%\ V_1$$

$$= V_1 + \frac{10}{100} V_1$$

$$V_2 = 1.1\ V_1$$

$$\frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{V_1}{1.1 \times V_1} = \sqrt{\frac{273}{T_2}}$$

$$\therefore T_2 = (1.1)2 \times 273 = 330.33\text{ k}$$

$$T_2 = 57.33^0\text{C} \quad \text{or} \quad 330.33\text{ k}$$

12. Given :

At, $T_1 = 273$ k

$V_1 = 331\ m/s$

To Find :

$T_2 = ?$ ... at $V_2 = 350\ m/s$

Solution :

$$V \propto \sqrt{T}$$

$$\therefore \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$$

$$\frac{331}{350} = \sqrt{\frac{273}{T_2}}$$

$$\therefore T_2 = \frac{(350)^2 \times 273}{(331)^2}$$

$$= 305.241\text{ k} \quad \text{or} \quad 32.241^0\text{C}$$

13. Given :

$$\left.\begin{array}{l} P = 105\ N/m^2 \\ \rho = 0.09\ kg/m^3 \end{array}\right\} \text{at } t = 0^0\text{C}$$

$\gamma = 1.4$

To Find :

$V = ?$

Solution :

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

$$= \sqrt{\frac{1.4 \times 10^5}{0.09}}$$

$$V = 1247\ m/s$$

14. Given :

$\lambda_1 = 27$ m at $t_1 = 27^0C$ (300 k)

$t_2 = 37^0C$ (310 k)

To Find :

$\lambda_2 = ?$ at $t_2 = 37^0C$ (310 k)

Solution :

We know that,

$V \propto \sqrt{T}$

$\therefore \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}} = \sqrt{\frac{300}{310}} = 0.98359$

$\therefore V_1 = 0.98359\ V_2$

$\frac{V_1}{V_2} = \frac{\lambda_1}{\lambda_2}$ $\{\because V = n\lambda \text{ and 'n' ramains same}\}$

$\frac{0.98359\ V_2}{V_2} = \frac{27}{\lambda_2}$

$\therefore \lambda_2 = 27.45$ m

15. Given :

$V_1 = 340$ m/s at $t_1^0 = 16^0C$

To Find :

$V_2 = ?$ at $t_2 = 88^0C$

Solution :

Now we know that,

$V \propto \sqrt{T}$

$\therefore \frac{V_1}{V_2} = \sqrt{\frac{T_1}{T_2}}$

$\frac{340}{V_2} = \sqrt{\frac{(16+273)}{(88+273)}}$

$\begin{Bmatrix} T = t_1 + 273 = 16 + 273 = 289\,k \\ T = t_2 + 273 = 88 + 273 = 361\,k \end{Bmatrix}$

$\therefore V_2 = \frac{340}{\sqrt{0.8005}}$

$\therefore V_2 = 380$ m/s

16. Given :

$E = 20 \times 10^8$ N/m²

$\rho_w = 1000$ kg/m²

To Find :

$V = ?$

Solution :

$V = \sqrt{\frac{E}{\rho_w}}$

$= \sqrt{\frac{20 \times 10^8}{1000}}$

$V = 1.41 \times 10^3$ m/s

17. Given :

$V_1 = 331$ m/s at $t = 0^0C$ (273 k)

To Find :

$V = ?$ at $t = 30^0C$ (303 k)

Solution :

We know that,

$V \propto \sqrt{T}$

$\therefore \frac{V_1}{V_2} = \frac{\sqrt{T_1}}{\sqrt{T_2}}$

$\frac{331}{V_2} = \sqrt{\frac{273}{303}}$

$\therefore V_2 = 331 \times \sqrt{\frac{303}{273}}$

$\therefore V_2 = 348.7$ m/s

18. Given :

$V_1 = 332$ m/s at

$t = 0^0C$ or 273 k

$\rho_{CO_2} = 1.6\ \rho_{air}$

$\gamma_{air} = 1.41$

$\gamma_{CO_2} = 1.31$

To Find :

$V_{CO_2} = ?$ at $t = 100^0C$ or (375 k)

Solution :

$$V \propto \sqrt{\frac{\gamma P}{\rho}}$$

$$\frac{V_{air_1}}{V_{air_2}} = \frac{\sqrt{T_1}}{\sqrt{T_2}}$$

$$\therefore \frac{332}{V_{air_2}} = \sqrt{\frac{273}{373}}$$

$$\therefore V_{air_2} = 332 \times \sqrt{\frac{373}{373}}$$

$$\therefore V_{air_2} = 388.07 \text{ m/s}$$

Since,

$$V = \sqrt{\frac{\gamma P}{\rho}}$$

$$\therefore \frac{V_{CO_2}}{V_{air_2}} = \sqrt{\frac{\gamma_{CO_2}\rho_{air}}{\rho_{CO_2}\gamma_{air}}}$$

$$= \sqrt{\frac{1.31}{1.41} \times \frac{\rho_{air}}{1.5\rho_{air}}}$$

$$= \sqrt{\frac{1.31}{1.41} \times \frac{1}{1.5}}$$

$$= 0.7870$$

$$\therefore V_{CO_2} = 0.7870 \times V_{air_2}$$

$$= 0.7870 \times 388.07$$

$$V_{CO_2} = 305.4 \text{ m/s} \quad \text{at} \quad t = 100^0\text{C}$$