

14.20 $T = 2\pi \sqrt{\frac{Vm}{Ba^2}}$ where B is the bulk modulus of air. For isothermal changes $B = P$.

14.21 (a) $5 \times 10^4 \text{ N m}^{-1}$; (b) 1344.6 kg s^{-1}

14.22 Hint: Average K.E. = $\frac{1}{T} \int_0^T \frac{1}{2} mv^2 dt$; Average P.E. = $\frac{1}{T} \int_0^T \frac{1}{2} kx^2 dt$

14.23 Hint: The time period of a torsional pendulum is given by $T = 2\pi \sqrt{\frac{I}{\alpha}}$, where I is the

moment of inertia about the axis of rotation. In our case $I = \frac{1}{2} MR^2$, where M is the mass of the disk and R its radius. Substituting the given values, $\alpha = 2.0 \text{ N m rad}^{-1}$.

14.24 (a) $-5\pi^2 \text{ m s}^{-2}$; 0; (b) $-3\pi^2 \text{ m s}^{-2}$; $0.4\pi \text{ m s}^{-1}$; (c) 0; $0.5\pi \text{ m s}^{-1}$

14.25 $\sqrt{x_0^2 + \frac{v_0^2}{\omega^2}}$

Chapter 15

15.1 0.5 s

15.2 8.7 s

15.3 $2.06 \times 10^4 \text{ N}$

15.4 Assume ideal gas law: $P = \frac{\rho RT}{M}$, where ρ is the density, M is the molecular mass, and

T is the temperature of the gas. This gives $v = \sqrt{\frac{\gamma RT}{M}}$. This shows that v is:

- (a) Independent of pressure.
- (b) Increases as \sqrt{T} .
- (c) The molecular mass of water (18) is less than that of N_2 (28) and O_2 (32).

Therefore as humidity increases, the effective molecular mass of air decreases and hence v increases.

- 15.5** The converse is not true. An obvious requirement for an acceptable function for a travelling wave is that it should be finite everywhere and at all times. Only function (c) satisfies this condition, the remaining functions cannot possibly represent a travelling wave.
- 15.6** (a) $3.4 \times 10^{-4} \text{ m}$ (b) $1.49 \times 10^{-3} \text{ m}$
- 15.7** $4.1 \times 10^{-4} \text{ m}$
- 15.8** (a) A travelling wave. It travels from right to left with a speed of 20 ms^{-1} .
(b) 3.0 cm , 5.7 Hz
(c) $\pi/4$
(d) 3.5 m
- 15.9** All the graphs are sinusoidal. They have same amplitude and frequency, but different initial phases.
- 15.10** (a) $6.4 \pi \text{ rad}$
(b) $0.8 \pi \text{ rad}$
(c) $\pi \text{ rad}$
(d) $(\pi/2) \text{ rad}$
- 15.11** (a) Stationary wave
(b) $l = 3 \text{ m}$, $n = 60 \text{ Hz}$, and $v = 180 \text{ m s}^{-1}$ for each wave
(c) 648 N
- 15.12** (a) All the points except the nodes on the string have the same frequency and phase, but not the same amplitude.
(b) 0.042 m
- 15.13** (a) Stationary wave.
(b) Unacceptable function for any wave.
(c) Travelling harmonic wave.
(d) Superposition of two stationary waves.
- 15.14** (a) 79 m s^{-1}
(b) 248 N
- 15.15** 347 m s^{-1}
- Hint : $v_n = \frac{(2n-1)v}{4l}$; $n = 1, 2, 3, \dots$ for a pipe with one end closed
- 15.16** 5.06 km s^{-1}

15.17 First harmonic (fundamental); No.

15.18 318 Hz

15.20 (i) (a) 412 Hz, (b) 389 Hz, (ii) 340 m s^{-1} in each case.

15.21 400 Hz, 0.875 m, 350 m s^{-1} . No, because in this case, with respect to the medium, both the observer and the source are in motion.

15.22 (a) 1.666 cm, 87.75 cm s^{-1} ; No, the velocity of wave propagation is -24 m s^{-1}

(b) All points at distances of $n\lambda$ ($n = \pm 1, \pm 2, \pm 3, \dots$) where $\lambda = 12.6 \text{ m}$ from the point $x = 1 \text{ cm}$.

15.23 (a) The pulse does not have a definite wavelength or frequency, but has a definite speed of propagation (in a non-dispersive medium).

(b) No

15.24 $y = 0.05 \sin(\omega t - kx)$; here $\omega = 1.61 \times 10^3 \text{ s}^{-1}$, $k = 4.84 \text{ m}^{-1}$; x and y are in m.

15.25 45.9 kHz

15.26 1920 km

15.27 42.47 kHz