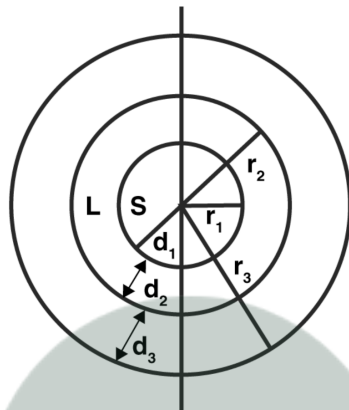


## Exemplar Solutions for Class 11 Physics Chapter 14 – Waves

### Long Answer Questions

**32.** The earth has a radius of 6400 km. The inner core of 1000 km radius is solid. Outside it, there is a region from 1000 km to a radius of 3500 km which is in molten state. Then again from 3500 km to 6400 km the earth is solid. Only longitudinal (P) waves can travel inside a liquid. Assume that the P wave has a speed of 8 km/s in solid parts and of 5 km/s in liquid parts of the earth. An earthquake occurs at some place close to the surface of the earth. Calculate the time after which it will be recorded in a seismometer at a diametrically opposite point on the earth if wave travels along diameter?

**Answer:** Path analysis along diameter:



- Solid region 1:  $6400 - 3500 = 2900$  km
- Liquid region:  $3500 - 1000 = 2500$  km
- Solid region 2: 1000 km
- Solid region 3: 1000 km (inner core)
- Solid region 4: 2500 km (other side of liquid)
- Solid region 5: 2900 km (other side to surface)

Total solid distance =  $2 \times (1000 + 2900) = 7800$  km Total liquid distance =  $2 \times 2500 = 5000$  km

Time in solid =  $7800/8 = 975$  s Time in liquid =  $5000/5 = 1000$  s Total time =  $975 + 1000 = 1975$  s = 32 minutes 55 seconds

**33.** If  $c$  is r.m.s speed of molecules in a gas and  $v$  is the speed of sound waves in the gas, show that  $c/v$  is constant and independent of temperature for all diatomic gases.

**Answer:** For an ideal gas:

- RMS speed of molecules:  $c = \sqrt{3RT/M}$
- Speed of sound:  $v = \sqrt{\gamma RT/M}$

Therefore:  $c/v = \sqrt{3RT/M} / \sqrt{\gamma RT/M} = \sqrt{3/\gamma}$

For diatomic gases:  $\gamma = 7/5 = 1.4$

$c/v = \sqrt{3/1.4} = \sqrt{15/7} = \text{constant}$

Since this ratio depends only on  $\gamma$  (which is constant for all diatomic gases) and not on temperature  $T$ ,  $c/v$  is constant and temperature-independent for all diatomic gases.

**34.** Given below are some functions of  $x$  and  $t$  to represent the displacement of an elastic wave: a)  $y = 5 \cos(4x) \sin(20t)$

b)  $y = 4 \sin(5x - t/2) + 3 \cos(5x - t/2)$

c)  $y = 10 \cos[(252-250)\pi t] \cos[(252+250)\pi t]$

d)  $y = 100 \cos(100\pi t + 0.5x)$

State which of these represent: a) a travelling wave along  $-x$  direction

b) a stationary wave

c) beats

d) a travelling wave along  $+x$  direction

**Answer:** a) Travelling wave in  $-x$  direction: d)  $y = 100 \cos(100\pi t + 0.5x)$  (Positive coefficient of  $x$  indicates  $-x$  direction)

b) Stationary wave: a)  $y = 5 \cos(4x) \sin(20t)$  (Product of space and time functions)

c) Beats: c)  $y = 10 \cos[(252-250)\pi t] \cos[(252+250)\pi t]$  (Product of two close frequencies)

d) Travelling wave in  $+x$  direction: b)  $y = 4 \sin(5x - t/2) + 3 \cos(5x - t/2)$  (Can be written as single wave with negative coefficient of  $x$ )

**35.** In the given progressive wave  $y = 5 \sin(100\pi t - 0.4\pi x)$  where  $y$  and  $x$  are in m,  $t$  is in s.

What is the: a) amplitude

b) wavelength

c) frequency

d) wave velocity

e) particle velocity amplitude

**Answer:** Comparing with  $y = A \sin(\omega t - kx)$ :

a) Amplitude:  $A = 5$  m

b)  $k = 0.4\pi$  rad/m Wavelength:  $\lambda = 2\pi/k = 2\pi/(0.4\pi) = 5$  m

c)  $\omega = 100\pi$  rad/s Frequency:  $f = \omega/2\pi = 100\pi/2\pi = 50$  Hz

d) Wave velocity:  $v = \omega/k = 100\pi/0.4\pi = 250$  m/s

e) Particle velocity:  $v_y = \partial y/\partial t = 5 \times 100\pi \cos(100\pi t - 0.4\pi x)$  Particle velocity amplitude =  $500\pi$  m/s

**36.** For the harmonic travelling wave  $y = 2 \cos 2\pi(10t - 0.0080x + 3.5)$  where  $x$  and  $y$  are in cm and  $t$  is in second. What is the phase difference between the oscillatory motion at two points separated by a distance of: a) 4 m

b) 0.5 m

c)  $\lambda/2$

d)  $3\lambda/4$

e) What is the phase difference between the oscillation of a particle located at  $x = 100$  cm at  $t = T$  and  $t = 5s$ ?

**Answer:** From the wave equation:  $k = 2\pi \times 0.0080 = 0.016\pi$  rad/cm

Phase difference =  $k\Delta x$

a)  $\Delta x = 4 \text{ m} = 400 \text{ cm}$   $\Delta\phi = 0.016\pi \times 400 = 6.4\pi \text{ rad}$

b)  $\Delta x = 0.5 \text{ m} = 50 \text{ cm}$

$\Delta\phi = 0.016\pi \times 50 = 0.8\pi \text{ rad}$

c) For  $\lambda/2$  separation:  $\Delta\phi = \pi \text{ rad}$  (general result)

d) For  $3\lambda/4$  separation:  $\Delta\phi = 3\pi/2 \text{ rad}$

e) For temporal phase difference at fixed position:  $\omega = 2\pi \times 10 = 20\pi \text{ rad/s}$   $T = 2\pi/\omega = 0.1 \text{ s}$

Phase difference between  $t = T$  and  $t = 5\text{s}$ :  $\Delta\phi = \omega(5 - 0.1) = 20\pi \times 4.9 = 98\pi \text{ rad}$

