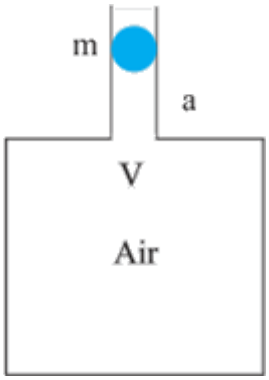
FlexiPrep

NCERT Class 11 Physics Solutions: Chapter 14 – Oscillations- Part 14

Question 14.20:

An air chamber of volume V has a neck area of cross section a into which a ball of mass m just fits and can move up and down without any friction. Show that when the ball is pressed down a little and released, it executes SHM. Obtain an expression for the time period of oscillations assuming pressure-volume variations of air to be isothermal



Answer:

Volume of the air chamber = V

Area of cross)section of the neck = a

Mass of the ball = m

The pressure inside the chamber is equal to the atmospheric pressure.

Let the ball be depressed by x units. As a result of this depression, there would be a decrease in the volume and an increase in the pressure inside the chamber.

Decrease in the volume of the air chamber, $\Delta V = ax$

$$\text{Volumetric strain} = \frac{\text{Change in volume}}{\textbf{Original volume}}$$

$$\frac{\Delta V}{V} = \frac{ax}{V}$$

$$\text{Bulk Modulus of air, } B = \frac{\text{Stress}}{\text{Strain}} = \frac{-p}{\frac{ax}{V}}$$

In this case, stress is the increase in pressure. The negative sign indicates that pressure increases with a decrease in volume.

$$p = \frac{-Bax}{V}$$

The restoring force acting on the ball,

$$F = p \times a$$

$$= \frac{-Bax}{V} \times a$$

$$\frac{-Ba^2x}{V} \ldots (i)$$

In simple harmonic motion, the equation for restoring force is:

$$F = -kx \ldots (ii)$$

Where, k is the spring constant

Comparing equations (i) and (ii), we get:

$$k = \frac{Ba^2}{V}$$

Time period,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$= 2\pi\sqrt{\frac{Vm}{Ba^2}}$$