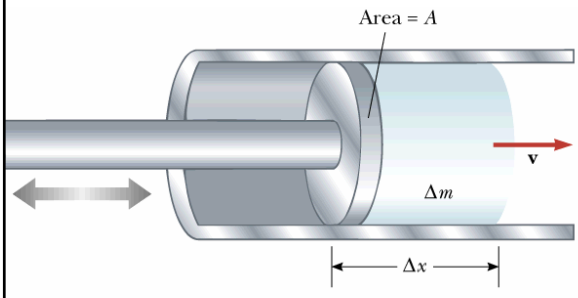
Sound Waves: lecture 9

- Sound – longitudinal wave that can be viewed as displacement or pressure fluctuations
- Ear drum vibrates with pressure variations relative to atmospheric pressure
- Audible range – 20 to 20,000 Hz

1

Pressure Description



$$\Delta V = A[y(x+\Delta x,t) - y(x,t)]$$

$$\frac{dV}{V} = \frac{\partial y(x,t)}{\partial x}$$

$$B = -V_o \frac{dP}{dV}$$

Using the definition of bulk modulus:

$$dP = p(x,t) = -B\frac{\partial y(x,t)}{\partial x}$$

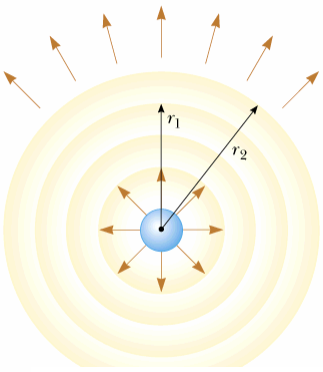
Evaluating this for a sinusoidal wave: $p(x,t) = BkA\cos(\omega t - kx)$

Pressure amplitude: $p_{\max} = BkA$

A is the displacement amplitude

2

Sound Intensity



Intensity – time average rate of transfer of energy per unit area

$$p(x,t)v_y(x,t) = B\omega kA^2\cos^2(\omega t - kx)$$

$$I = \frac{1}{2}B\omega kA^2 = \frac{1}{2}\sqrt{\rho B}\,\omega^2 A^2 = \frac{p_{\max}^2}{2\sqrt{\rho B}}$$

For a point source power falls off as the inverse square of distance

$$I = \frac{P}{4\pi r^2}$$

3

The Decibel Scale

- The sound intensity level is often measured in decibels and is defined by

$$\beta = (10\text{ dB})\log\frac{I}{I_o}$$

where $I_o = 10^{-12}$ W/m^2 is the reference intensity

- This is a convenient unit to measure the sound intensities detectable by the human ear which vary over many orders of magnitude

4