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Intensity and Loudness of Sound

Intensity: — The intensity of sound at any point is defined as the amount of sound energy falling per second on unit area placed at that point normal to the direction of travel of the sound. Thus intensity is a definite measurable quantity.

If the source radiates uniformly in all direction, the intensity of sound varies inversely as the square of the distance from the source.

'Bel' is a unit which expresses the intensity of sound. The absolute sound intensity is measured in $watt/(meter)^3$. When ever the sound intensity increases by a factor of 10, it is said to have increased by 1 bel, when it increases by a factor of 100 it is said to have increased by 2 bels and so on. If two sounds have intensities I_1 and I_2 $(I_2 > I_1)$ then the intensity level I_2 is said to exceed that of I_1 by

$$log_{10}(I_2/I_1) \ bel$$

In practice bel is too large a unit and therefore the decibel (db) is used which is one tenth of a bel. Thus the intensity level of I_2 above I_1 is

$$10 \ log_{10}(I_2/I_1) \ decibel$$

If I is the intensity of sound and I_o the minimum audible intensity of $10^{12} \ watt/m^3$ then

the intensity level in decibel is

$$= 10 \log_{10}(I/I_0) \text{ decibel}$$

This definition holds good whatever be the frequency of the sound.

Loudness:— Loudness is the degree of sensation produced in the ear. It is purely a subjective quantity depending on the intensity of sound and also on the sensitiveness of the listener's ear under the particular conditions. It has been found experimentally that the sensation of Loudness L is proportional to the logarithm of intensity I of the sound

$$\therefore L = K \log_{10}(I)$$

'phon' is a unit which expresses the loudness of sound. The loudness depends upon the sensitivety of the listner's ear. A standard sound tone of adjustable intensity and of frequency 1000Hz is produced by a valve oscillator placed directly infront of a listner who listens with both ears. The listner adjusts the intensity of this tone until he judges it to be equally as loud as the given sound whose loudness is to be measured, the two sound being heard alternately. The intensity of the standard tone is then measured. If this is n decible above the threshold value, then the loudness of the given sound is said to be n phon.

If I be the intensity of the standard tone when its loudness is judged equal to that of the given sound, and I_0 be the minimum audible intensity, then the intensity level of I above I_0 is

$$10 \log_{10}(I/I_0) \text{ decible}.$$

Thus the loudness of the given sound is

$$10 \log_{10}(I/I_0) \text{ phon}.$$