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Music, Ph and Engin

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Preface to the S

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1.5 VELOCITY OF PROPAGATION OF A SOUND WAVE

The preceding examples have shown that a sound wave travels with a definite finite velocity. The velocity of propagation, in centimeters per second, of a sound wave in a gas is given by

$$c = \sqrt{\frac{\gamma p_0}{\rho}} \quad (1.1)$$

where γ = ratio of specific heats for a gas, 1.4 for air

p_0 = static pressure in the gas, in dynes per square centimeter

ρ = density of the gas, in grams per square centimeter

If the pressure is increased, the density is also increased. Therefore, there is no change in velocity due to a change in pressure. But this is true only if the temperature remains constant. Therefore, the velocity can be expressed in terms of the temperature. The velocity of sound, in centimeters per second, in air is given by

$$c = 33,100 \sqrt{1 + 0.00366t} \quad (1.2)$$

where t = the temperature in degrees centigrade.

1.6 FREQUENCY OF A SOUND WAVE

Referring to the Sec. 1.4 on Sound Generators, it will be seen that these generators produce similar recurrent waves. A complete set of these recurrent waves constitute a cycle. These recurrent waves are propagated at a definite velocity. The number of recurrent waves or cycles which pass a certain observation point per second is termed the frequency of the sound wave.

1.7 WAVELENGTH OF A SOUND WAVE

The wavelength of a sound wave is the distance the sound travels to complete one cycle. The frequency of a sound wave is the number of cycles which pass a certain observation point per second. Thus it will be seen that the velocity of propagation of a sound wave is the product of the wavelength and the frequency, which may be expressed as follows:

$$c = \lambda f \quad (1.3)$$

where c = velocity of propagation, in centimeters per second

λ = wavelength, in centimeters

f = frequency, in cycles per second

1.8 PRESSURE IN A SOUND WAVE

A sound wave consists of pressures above and below the normal undisturbed pressure in the gas (see Secs. 1.3 and 1.4).

The instantaneous sound pressure at a point is the total instantaneous

SOUND WAVES

pressure at that point minus the normal atmospheric pressure.

The effective sound pressure of the instantaneous sound pressure is frequently shown. The unit is the dyne per square centimeter.

The sound pressure in a distance from the sound source.

1.9 PARTICLE DISPLACEMENT

The passage of a sound wave or molecules in the gas from the absence of a sound wave in speech and music. For example, in normal conversation from the speaker, the particle of an inch. The particle frequency of the sound wave the process of being displaced termed the particle velocity.

The relation between sound

where p = sound pressure,
 ρ = density of air, in
 c = velocity of sound
 u = particle velocity

The amplitude or displacement of a sound wave is

where d = particle amplitude
 u = particle velocity
 f = frequency, in cycles

1.10 INTENSITY OR POWER

From the foregoing sections in a sound wave. The sound of a sound wave.

The intensity of a sound sound energy transmitted per a unit area normal to this per second per square centimeter

The intensity, in ergs per second per square centimeter, of a plane sound wave is

$$I = \frac{p^2}{\rho c} = pu = \rho cu^2 \quad (1.6)$$

where p = sound pressure, in dynes per square centimeter

u = particle velocity, in centimeters per second

c = velocity of propagation of sound, in centimeters per second

ρ = density of the medium, in grams per cubic centimeter

The intensity level, in decibels, of a sound is ten times the logarithm to the base 10 of the ratio of the intensity of this sound to the reference intensity. Decibels will be described in the section which follows.

TABLE 1.1: THE RELATION BETWEEN DECIBELS AND POWER AND CURRENT OR VOLTAGE RATIOS

Power ratio	Decibels	Current or voltage ratio	Decibels
1	0	1	0
2	3.0	2	6.0
3	4.8	3	9.5
4	6.0	4	12.0
5	7.0	5	14.0
6	7.8	6	15.6
7	8.5	7	16.9
8	9.0	8	18.1
9	9.5	9	19.1
10	10	10	20
100	20	100	40
1,000	30	1,000	60
10,000	40	10,000	80
100,000	50	100,000	100
1,000,000	60	1,000,000	120

1.11 DECIBELS

In acoustics the ranges of intensities, pressures, and particle velocities are so large that it is convenient to use a condensed scale of smaller numbers termed decibels. The abbreviation db is used for the term decibel. The bel is the fundamental division of a logarithmic scale for expressing the ratio of two amounts of power, the number of bels denoting such a ratio being the logarithm to the base 10 of this ratio. The decibel is one-tenth of a bel. For example, with P_1 and P_2 designating two amounts of power and n the number of decibels denoting their ratio, then

$$n = 10 \log_{10} \frac{P_1}{P_2} \text{ decibels} \quad (1.7)$$

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When the conditions are such that ratios (or the analogous quantities such as pressures and particle velocities) are the square ratios, the number of decibels by which the ratio is expressed by the following formulas:

$$n = 20 \log_{10} \frac{i_1}{i_2}$$

$$n = 20 \log_{10} \frac{e_1}{e_2}$$

where i_1/i_2 and e_1/e_2 are the given current or voltage ratios.

For relation between decibels and power ratios, see Table 1.1.

1.12 DOPPLER EFFECT IN SOUND WAVES

The Doppler effect is the phenomenon of the observed frequency of a sound wave in the time rate of change in the length of the wave and the point of observation. The most common effect is due to the relative motion of the source and the observer. The most common examples are the change in the frequency of whistles of passing automobiles or locomotives.

When the source and observer are moving toward each other, the frequency observed by the listener is higher than the frequency of the sound source. If the source and observer are moving away from each other, the frequency is lower.

The frequency at the observation point is

$$f_o = \frac{v}{v - v_s}$$

where v = velocity of sound in the medium

v_o = velocity of the observer

v_s = velocity of the source

f_s = frequency of the source

All the velocities must be expressed in the same units.

No account is taken of the effect of the medium in Eq. (1.10). In order to be correct, the velocity v in the medium must be replaced by the velocity in the direction in which the sound is traveling. In substitution in Eq. (1.10), the result is

$$f_o = \frac{v + u}{v - v_s}$$

Equation (1.11) shows that the wavelength is

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