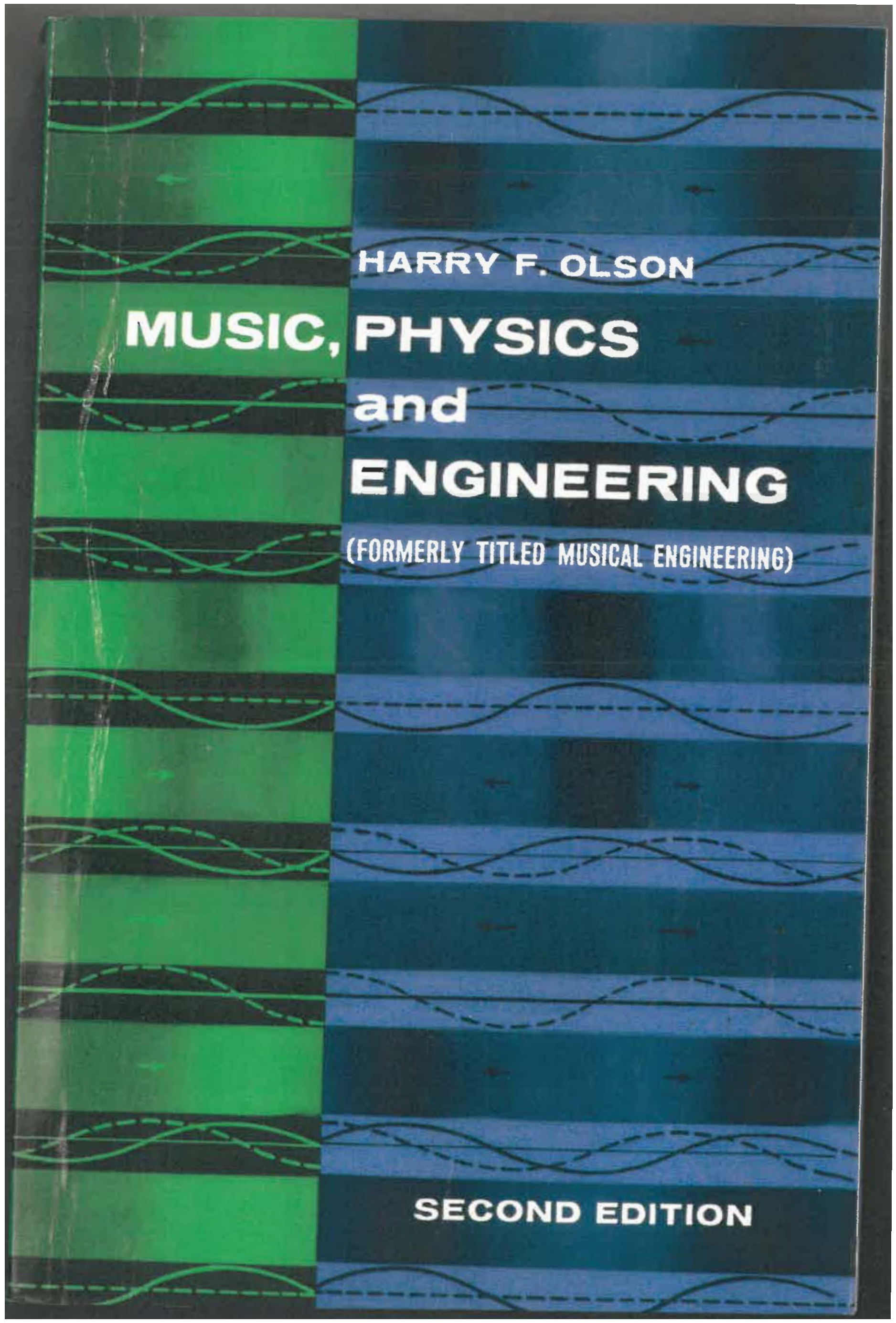

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Preface to the S

Many and varied advances
13 years since the appeara
developments have been m
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The most recent, significa
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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

$$c = \sqrt{\frac{\gamma p_0}{\rho}} \tag{1.1}$$

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

$$c = 33{,}100\sqrt{1 + 0.00366t} \tag{1.2}$$

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:

$$c = \lambda f \tag{1.3}$$

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

pressure at that point minu
the normal atmospheric pr
The effective sound pres
of the instantaneous sound
The unit is the dyne per sq
pressure" is frequently sho
The sound pressure in a
distance from the sound so

1.9 PARTICLE DISPLACEMEN

The passage of a sound
or molecules in the gas fro
the absence of a sound w
sound wave in speech and
For example, in normal co
from the speaker, the part
of an inch. The particle
frequency of the sound wa
the process of being displ
termed the particle velocit
The relation between sou

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

The amplitude or displac
absence of a sound wave is

where d = particle amplitu
u = particle velocity
f = frequency, in cy

1.10 INTENSITY OR POWER

From the foregoing sections
in a sound wave. The sou
of a sound wave.
The intensity of a sound
sound energy transmitted p
a unit area normal to this
per second per square centi

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

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

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

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

When the conditions are such that rati
(or the analogous quantities such as p
and particle velocities) are the square
ratios, the number of decibels by whicl
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 curre
For relation between decibels and po
see Table 1.1.

1.12 DOPPLER EFFECT IN SOUND WAV

The Doppler effect is the phenomeno
observed frequency of a sound wave in
time rate of change in the length of the
and the point of observation. The mo
effect is due to the relative motion of th
are the change in the frequency of
whistles of passing automobiles or loco
When the source and observer are
quency observed by the listener is hi
the sound source. If the source and
other, the frequency is lower.
The frequency at the observation p

$f_0 = \frac{v -}{v -}$

where v = velocity of sound in the me
v_0 = velocity of the observer
v_s = velocity of the source
f_s = frequency of the source
All the velocities must be expressed
No account is taken of the effect
medium in Eq. (1.10). In order to b
velocity v in the medium must be repla
velocity in the direction in which the
substitution in Eq. (1.10), the result i

$f_0 = \frac{v + u}{v + u}$

Equation (1.11) shows that the wi

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