ACOUSTICS

LECTURE 1

Dr. Hatem Galal A Ibrahim

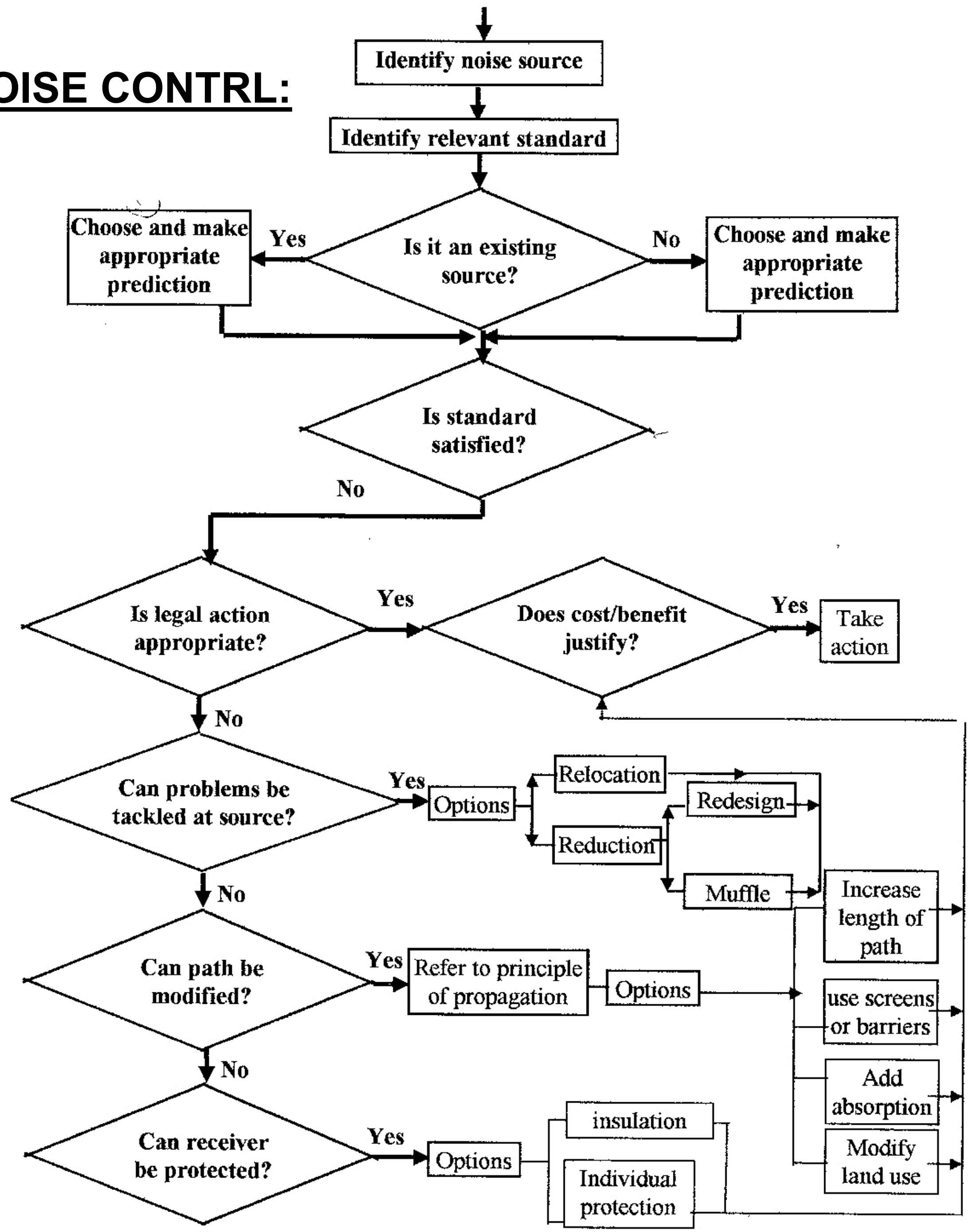
BASIC REFRENCES:

1- Environmental Acoustics, L.L.Doelle, McGraw-Hill Book company, 1972.

2- Design for Good Acoustics and Noise Control, J.E.Moore, The Macmillan Press Ltd., 1979.

3- Handbook of Noise Assessment, D.N.May, Litton Educational Publishing Inc., 1978.

METHODOLOGY OF NOISE CONTRL:



Definition of Terms and Symbols

Decibles (dB):

The range of sensitivity of the ear is very wide. It will detect a sound pressure of 0.00002 Pa (the threshold of hearing), and will withstand a pressure of 20 Pa. If the absolute units used above were used for sound measurement the range of numbers would be very large. Furthermore, the ear appears to respond to a fractional change in sound pressure, for example: the change from 0.1 to 0.2 Pa sounds about the same as the change from 1 to 2 Pa and not the same from 1 to 1.1 Pa.

A logarithmic scale corresponds more closely with the way we hear sounds. The unit that is derived from a logarithmic scale is the decibel (dB).

Frequency:

The number of complete vibration that the source makes in the medium in 1 second (abbreviated by cycle/second or Hz.)

Speed of Sound (C):

The speed of sound can be calculated from the following equation:

$C = 331.4 + 0.6\ t$

Where t is the temperature in Celsius (C^{o}) and C is the sound speed in m/sec.

If $t = 20^{oc}$ then C= 343.4 m/s

Sound Power (W):

The power of a source is the amount of sound energy it generates per second, can be expressed in watts.

Sound Power Level (SWL):

It given by:

$$SWL = 10 \log_{10} W/W_o \text{ dB}$$

Where:

W = power of the sound source in watts

W_o = reference power = 10^{-12} w

Sound Intensity (I):

The sound intensity is the sound energy passing through unit area per second. The unit is Watt/m^2.

Sound Intensity Level (IL):

The sound intensity of a sound, in decibels, is 10 times the logarithm to the base 10 of the ratio of the intensity of this sound to reference intensity.

$IL = 10 \log_{10} I/I_{ref}$

Where $I_{ref} = 10^{-12}$ watt/m^2

Static Pressure (P_0):

The static pressure at a point in the medium is the pressure that would exist at that point with no sound waves present. P_o equals approximately 10^5 newtons/m^2, figure (1.1).

Instantaneous Sound Pressure ((P_t):

The instantaneous sound pressure at a point is the incremental change from the static pressure at a given instant caused by the presence of a sound wave, figure (1.1).

Effective Sound Pressure (P):

The effective sound pressure at a point is the root-mean-square (rms) value of the instantaneous sound pressure, over a time interval at that point as shown in figure (1.1).

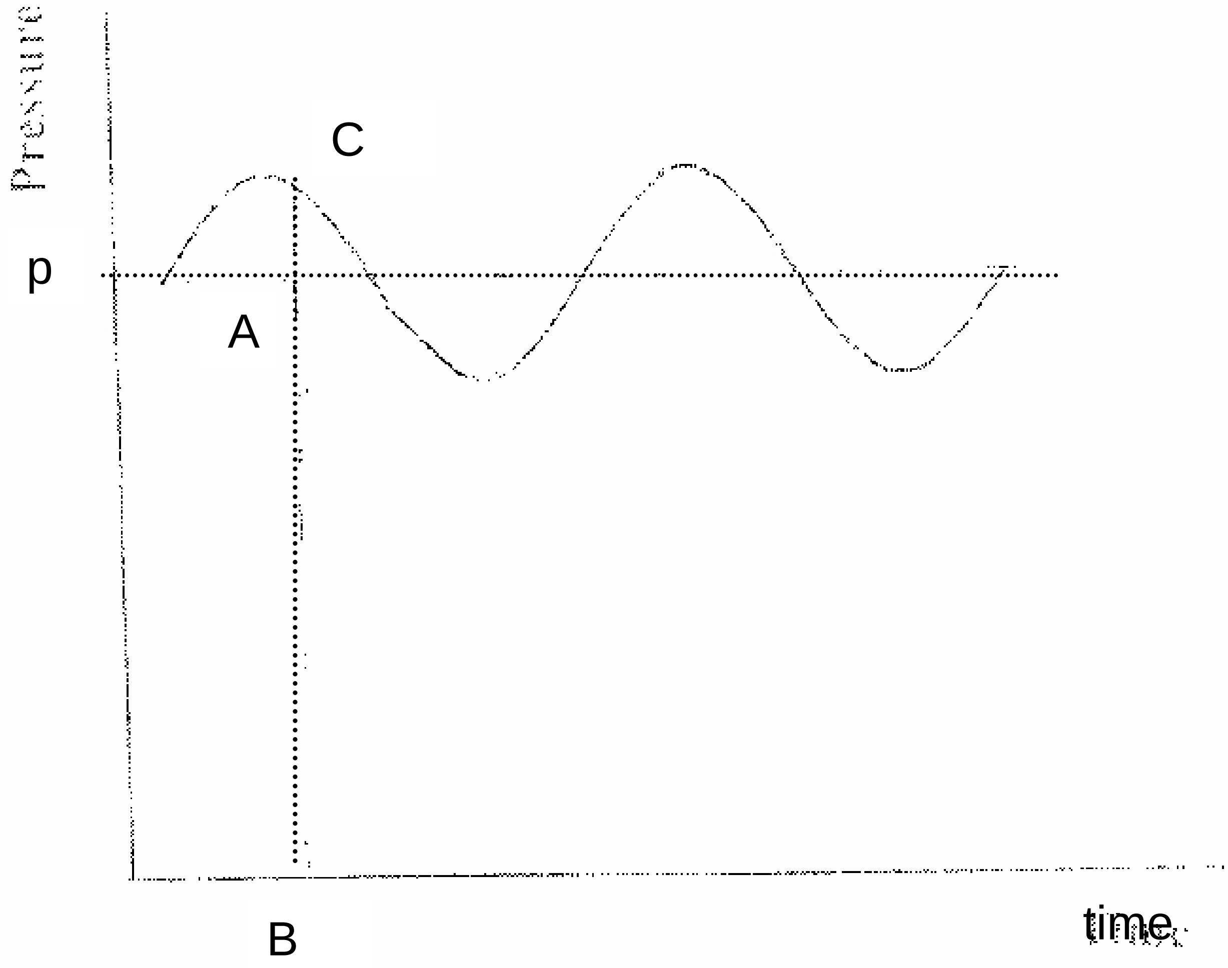


Figure (1.1): Static and soun pressure

Static pressure = AB Sound pressure = AC Instateneous pressure = BC

Sound Pressure Level (SPL):

The sound pressure level of a sound< in decibls is 20 times the logarithm to the base 10 of the ratio of the measured effective sound pressure of this sound to a reference soundpressure.

$SPL = 20 \log_{10} p/p_{ref}$ dB

where $p_{ref} = 2x10^{-4}$ microbar ($2x10^{-5}$ newton/m^2)

Loudness:

The strength of sound as determined by the ear depends not only on the pressure of sound< but also on its frequency spectrum. Loudness can be described in terms of another subjective characteristic of sound, the so – called loudness level, which itself is defined in terms of the sound pressure and frequency of a pure tone. The loudness level, in phone, of a sound is numerically equal to the sound pressure level, in decibels, of 1000 cycle reference tone which is judged by listeners to equal in loudness, see figure (1.2)

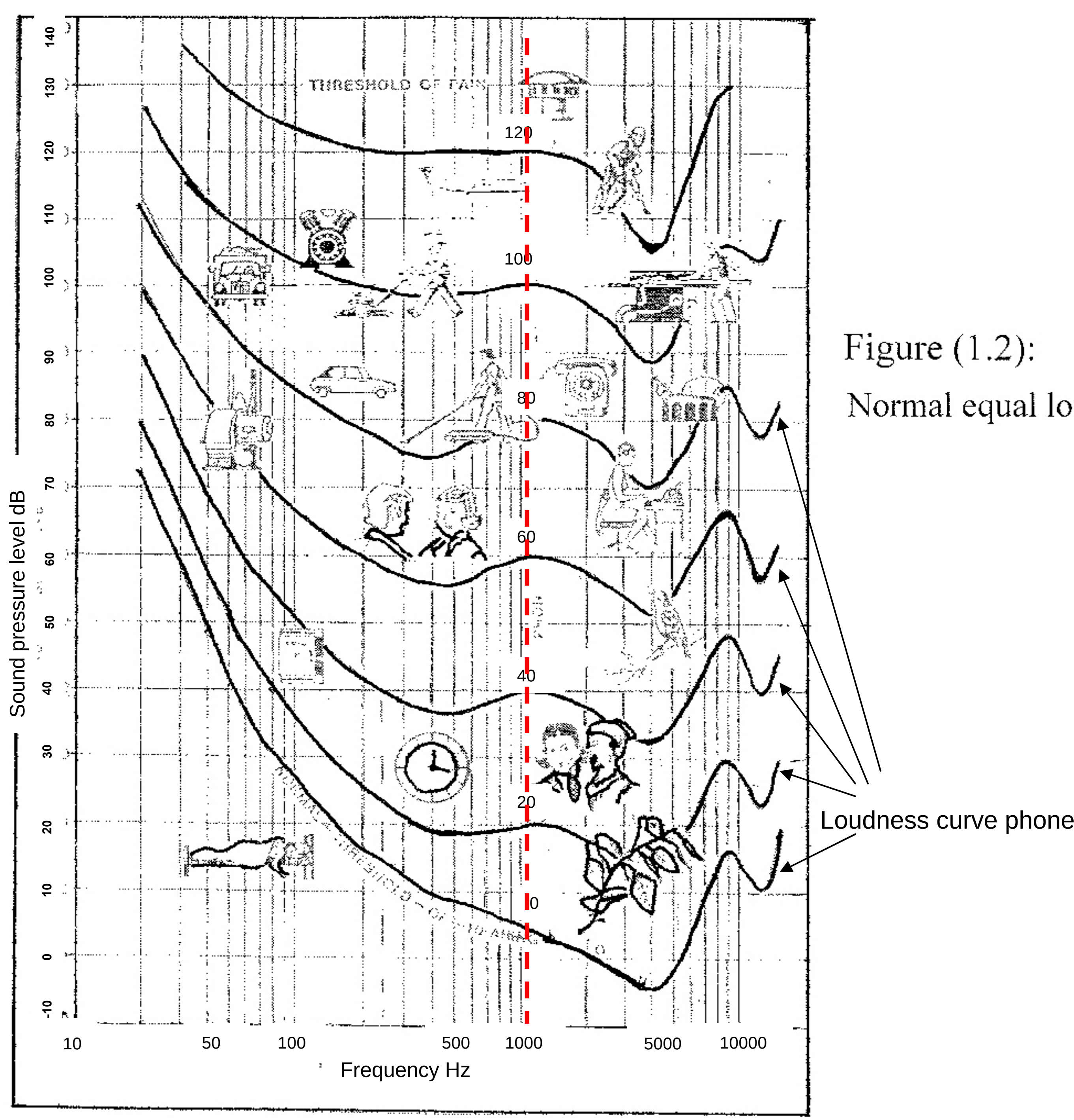


Figure (1.2):

Normal equal loudness contours for pure tone.

Weighting Networks:

Weighting networks have been agreed, which account for the variation in sensitivity of the ear with both frequency and level. These are the A, B, C and D Weighting networks.

* A used below 55 dB
* B used for level between 55 and 85 dB
* C used above 85 dB
* D used for aircraft noise.

The frequency response of these weighting networks is given in figure (1.3).

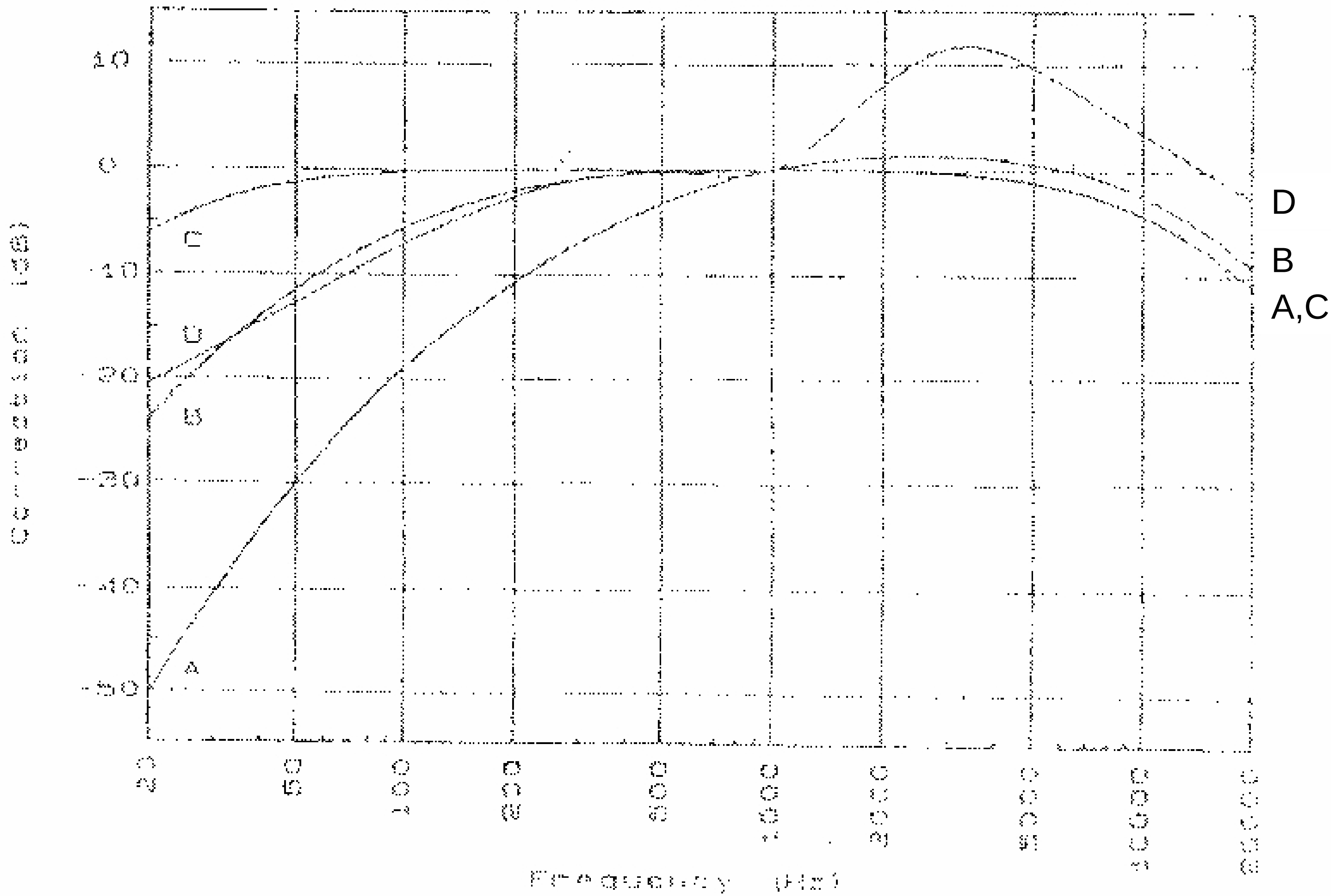


Figure (1.3): Frequency response of A, B, C and D weighting networks.

Propagation of Sound:

Sound has its origin in vibrating bodies. Consider a body is vibrating in air, as it moves in an outward direction it pushes a layer of air along with it. This layer of air is compressed and its density and temperature are correspondingly increased. Since the pressure in this layer is higher than that in the undisturbed surrounded atmosphere, the particles in it tend to move in the outward direction and transmit their motion to the next, and so on. As the vibrating body moves inward, the layer of rarefaction follows the layer of compression. The succession of outwardly traveling layers of compression and rarefaction is called wave motion.

The speed of propagation is determined by compressibility and density of the medium.

Audible Range:

Sound can be divided into three categories:

* Infra – sound means sound waves where the number of vibration per second is too low to be heard as “REAL” sound.

* Hearing – sound means sound waves where the number of vibrations per second is detected by the human ear.

* Ultra – sound means sound waves where the number of vibrations per second is too high to be detected by the human ear.

The approximate value range of the previous categories is shown in figure (1.4)

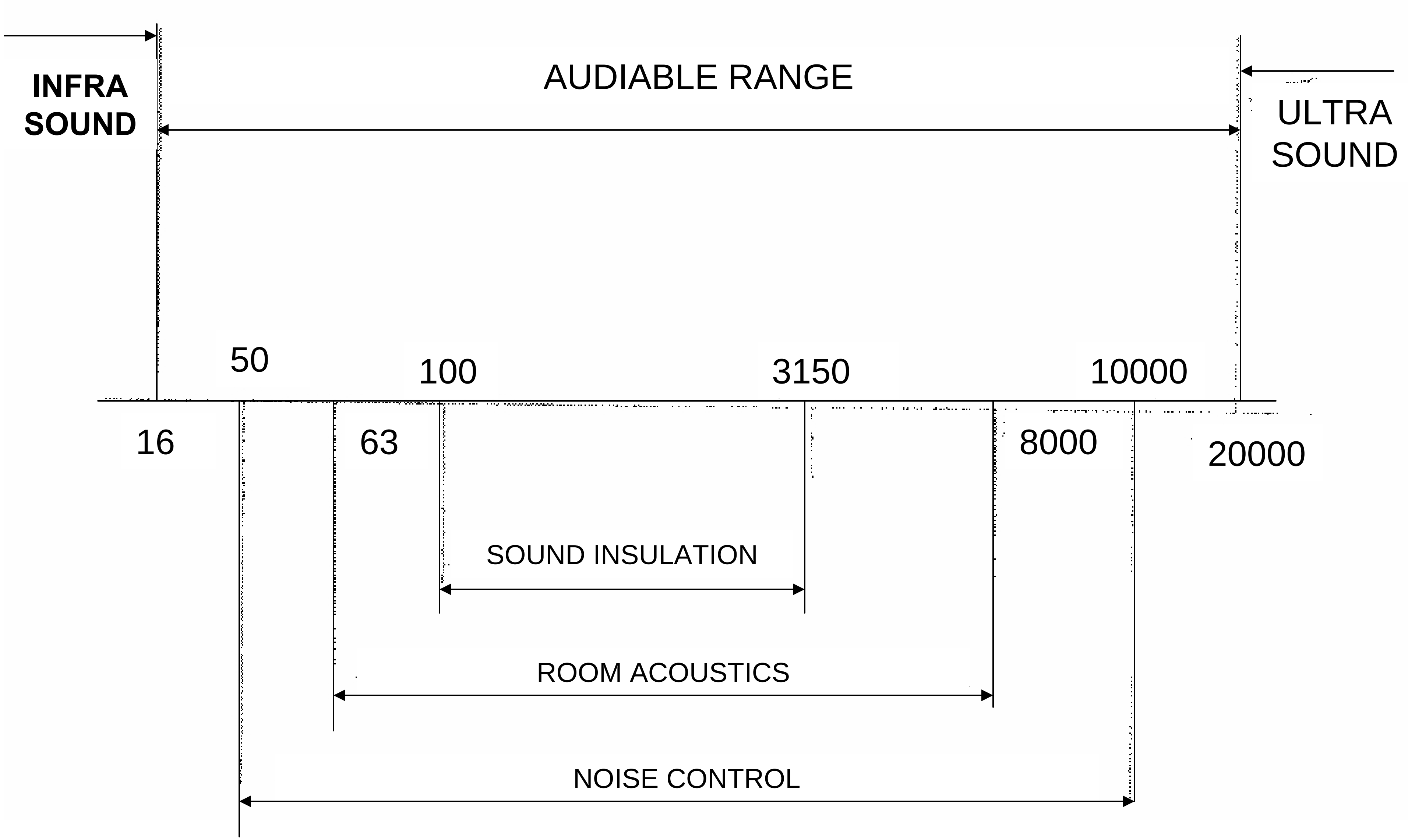


Figure (1.4): Audiable range

Wave Length:

The distance that a sound wave traveles during each complete cycle of vibration. It is denoted by the Greek Letter Lambda λ as shown in figure (1.5).

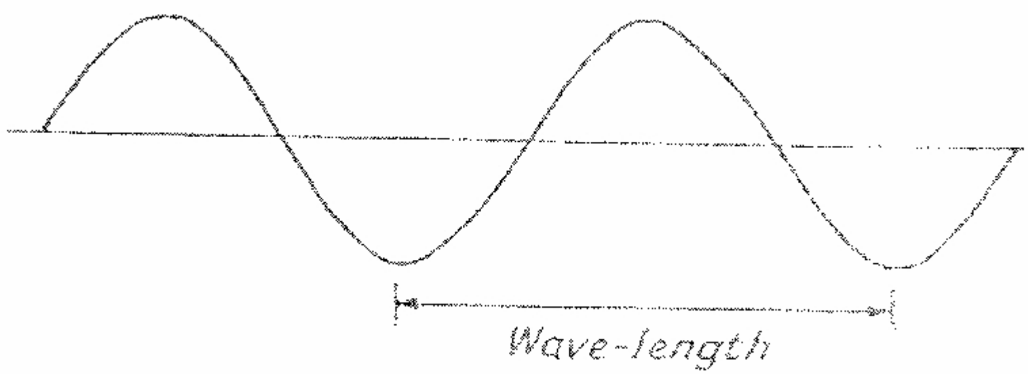


Figure (1.5): Wave length.

Wavelength λ, frequency f and the velocity of sound C are related by the following equation:

$C = \lambda . F$

تمت بحمد الله