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السابعة	**رقم المحاضرة**
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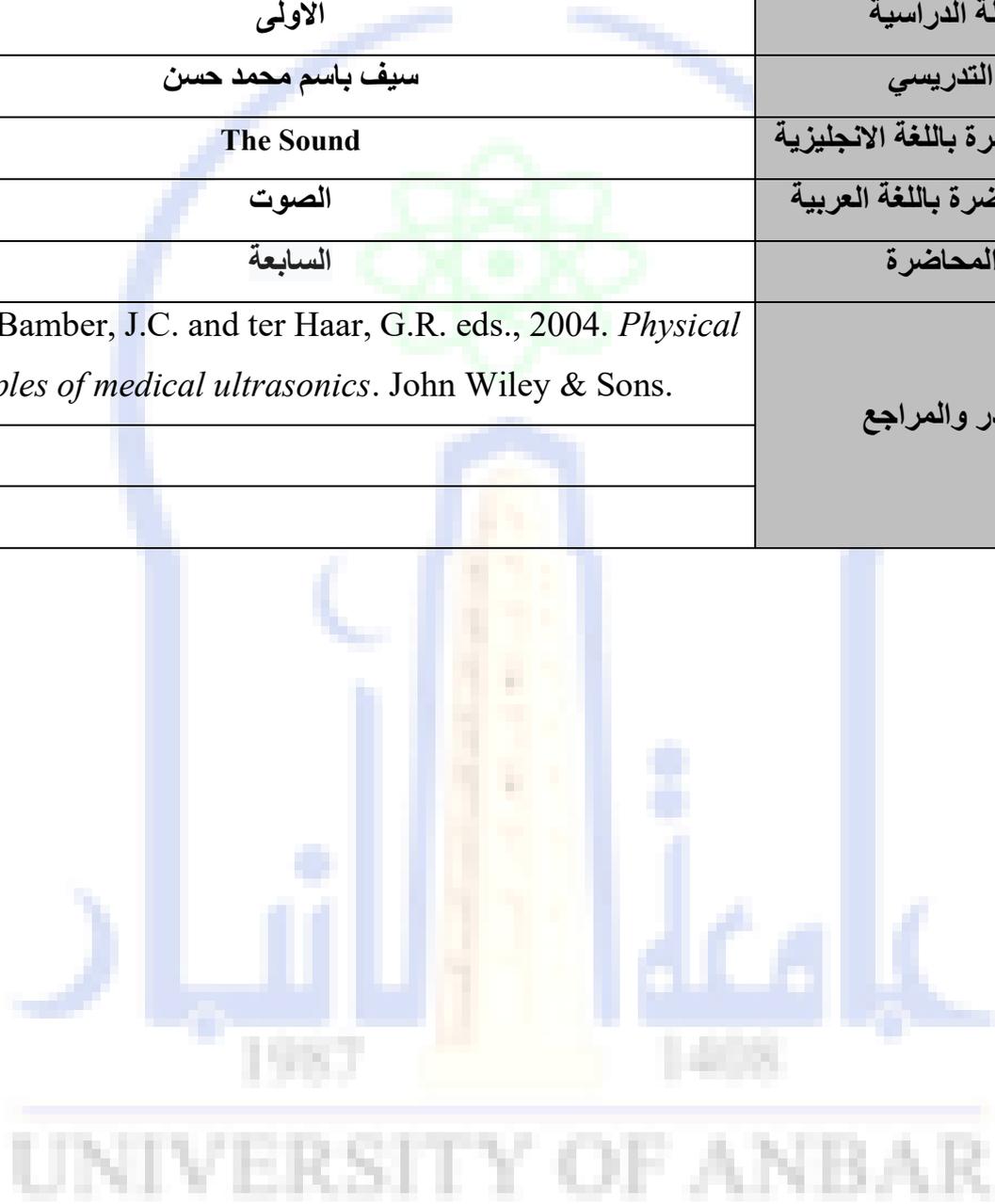
Medical Physics

Lecture (7)

The Sound

BY

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The audible sound range defined as (20Hz 20KHz) older people

lose the ability to hear frequencies above 10 KHz. The frequencies range above 20 K Hz called ultrasound.

GENERANL PROPERTIES OF SOUND

Sound wave is mechanical waves,

The vibrations cause local increases and decreases in pressure relative to atmospheric pressure.

The pressure increases called compressions, and decreases called rarefaction.

Compression and rarefaction can be described by density changes and by displacement

The relationship between the frequency of vibration f , the wavelength λ , and velocity V of the sound wave is

$$V = \lambda f$$

Energy is carried by the wave as potential and kinetic energy. The intensity (I) of a sound wave energy passing through (1m2 /s). Or watts per square meter for plane wave (I) is given by:

$$I = \frac{1}{2} \rho V A^2 (2\pi f)^2 = \frac{1}{2} Z(AW)^2$$
$$I = P_o^2 / 2Z$$

Where ρ: is the density of the medium   V: is the velocity of sound f: is the frequency W: is the angular frequency which equals $2\pi f$ A: is the maximum displacement amplitude of atoms from equilibrium position Z : equals ρ V, is the acoustic impedance.

Where **Po** is the maximum change in pressure.

Example.1

a- The maximum sound intensity that the ear can tolerate at (1000 Hz) isapproximately (1W/m2). What is the maximum displacement in aircorresponding to this intensity?

b- The faintest sound intensity the ear can hear at 1000 Hz is approximately(10 exp -12 w/m2) . what is (A) under these conditions?

C- Calculate the sound pressure for cases (a) and (b)

For comparing the intensities of two waves (I2/I1) . This was named after Alexander bell . The intensity ratio in bells equal to log 10 (I2/I1) , and (1 bel= 10 dB) it is common to use the describe comparing two sound intensities. Since I is proportional to P 2 , the pressure ratio between two sound levels can be expressed as

$$10 \log_{10} (P_2^2/P_1^2), \text{ or } 20 \log_{10} (P_2/P_1)$$

This can be used to compare any two sound pressures in the same medium. For two sounds with pressures that differ by factor (2) we get

$$20 \log_{10} (P_2/P_1) = 20 \log_{10} 2 = 20(0.301) = 6 \text{ dB}$$

H.w

The sound intensity levels of (104 W/m2) can cause damage of the eardrum diaphragm. What is the displacement of the diaphragm at such intensity adopting an average frequency (1000Hz) ? Where the acoustic impedance for tissue equal (1.64x104 Kg/m2 s) ?.

When a sound wave hits the body, part of the wave is reflected(R) and part is transmitted(T) into the body.

R : is the reflected pressure amplitude . Ao :is the incident pressure amplitude .

The ratio of (R/Ao) depends on acoustic impedance of the two media ,(Z1) and (Z2) . The relationship is

$$\frac{R}{A_o} = \frac{Z_2 - Z_1}{Z_1 + Z_2}$$

R : is the reflected pressure amplitude . Ao :is the incident pressure amplitude

The ratio of the transmitted pressure amplitude T to the incident wave amplitude Ao is

$$\frac{T}{A_o} = \frac{2Z_2}{Z_1 + Z_2}$$

H.W: Calculate the ratios of the pressure amplitudes of the reflected and transmitted sound waves from air to muscle (Z1=430kg/m2 .sec), and (Z2=1.64x106 kg/m2.sec).

$$\frac{R}{A_o} = \frac{Z_2 - Z_1}{Z_1 + Z_2} = \frac{1.64x10^6 - 430}{1.64x10^6 + 430} = 0.9995$$

$$\frac{T}{A_o} = \frac{2Z_2}{Z_1 + Z_2} = \frac{2(1.64x10^6)}{1.64x10^6 + 430} \approx 1.9995$$

When a wave hits an angle (Θ_i) to a boundary between two media

$$\frac{sin\Theta_1}{V_1} = \frac{sin\Theta_2}{V_2}$$

V1 and V2 are the velocities of sound in two media, Θ_1 is the angle of theincident wave, Θ_2 is the angle of the refracted sound wave. Because sound can be refracted, acoustic lenses can be constructed to focus sound waves. When sound wave passes through tissue, there is some loss of energy due to frictional effects. The absorption of energy in the tissue cause a reduction in the amplitude of sound wave. The amplitude (A) at a depth (X) cm in

$$A = A_o e^{-\alpha x}$$

medium is related to initial amplitude Ao (x=0) by the exponential equation

Where α , is the absorption coefficient for the medium. Since the intensity is proportional to the square of the amplitude, its dependence with depth is :

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