Department of Architecture Engineering degree

Full Mark: 35

Year: Second

Subject: Acoustics

Acoustics solutions

[1] Question One: (15 Mark)

1- A-

i- **Wavelength λ:** is the distance between consecutive corresponding points of the same phase, such as peaks, troughs, or zero crossings.

ii- **Wave impedance**: represents the opposition of the medium to the wave propagation

iii- **acoustic pressure** is the local pressure deviation from the ambient (average, or equilibrium) atmospheric pressure caused by a sound wave. Sound pressure can be measured using a microphone in air and a hydrophone in water. The SI unit for sound pressure p is the pascal (symbol: Pa).

iv- **Reflection.** Changing the direction of the wave.Waves *reflect partially* when resistance of medium increases

B-

i)The acoustic impedance amplitude =415

ii) The effective or *rms* pressure

$$I = \frac{1}{2}\frac{P^2}{\rho_o c}$$

$$= 4.81\text{x}10^{-3}\ \frac{W}{m^2}$$

P=1.41 pa

iv) The sound intensity level is given by

$$10\log_{10}\left(\frac{I}{I_{ref}}\right)$$

$$= 10\log_{10}\left(\frac{4.81\text{x}10^{-3}}{10^{-12}}\right)$$

$$= 96.8\ dB$$

b) What is the effective or *rms* pressure

$$P_{rms} = P_{eff} = \frac{P_{max}}{\sqrt{2}} = \frac{2}{\sqrt{2}} = 1.41\ \text{Pa}$$

c) What is the sound pressure level reference to 20μPa

$$\because SPL = 20\log_{10}\left(\frac{P}{P_{ref}}\right)$$

$$= 20\log_{10}\left(\frac{2}{20\times10^{-6}}\right) = 100\ dB$$

c-

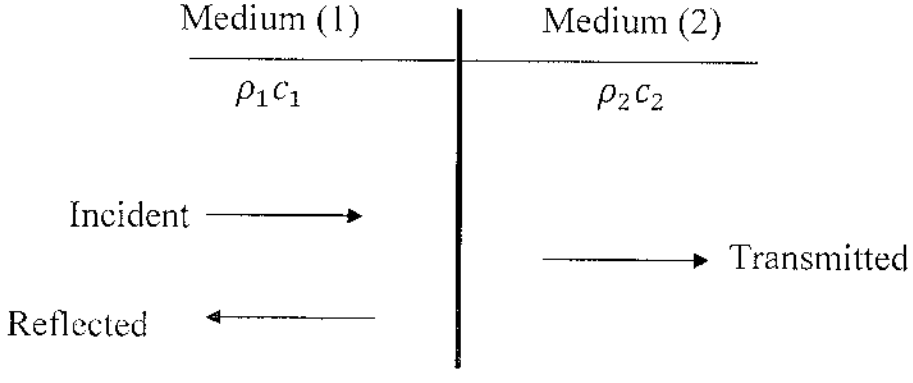


Fig. Plane wave transition between two mediums.

The sound pressure waves is represented in the two mediums by in medium (1)

$$P_i = P_i e^{j\omega(t-\frac{x}{c_1})} \qquad (1.a)$$

$$P_r = P_r e^{j\omega(t+\frac{x}{c_1})} \qquad (1.b)$$

, and in medium (2)

$$P_t = P_t e^{j\omega(t-\frac{x}{c_2})} \qquad (1.c)$$

The associated particle velocity of the incident, reflected and transmitted plane waves is given by in medium (1)

$$u_i = u_i e^{j\omega(t-\frac{x}{c_1})} \qquad (2.a)$$

$$u_r = u_r e^{j\omega(t+\frac{x}{c_1})} \qquad (2.b)$$

, and in medium (2)

$$u_t = u_t e^{j\omega(t-\frac{x}{c_2})}$$

At boundary

$$P_i + P_r = P_t \qquad (3)$$

$$u_i - u_r = u_t$$

$$\frac{P_i}{Z_1} - \frac{P_r}{Z_1} = \frac{P_t}{Z_2} \qquad (5)$$

By solving both equations (3) and (5), the relation between P_i and P_r is given by

$$R = \frac{P_r}{P_i} = \frac{Z_2 - Z_1}{Z_2 + Z_1} = \frac{\rho_2 c_2 - \rho_1 c_1}{\rho_2 c_2 + \rho_1 c_1}$$

Question Two: (20 Mark)

A) Discuss in details the most common problems in Architecture acoustics

sound reflection and sound transmission between rooms.

Reflection can be defined as the change in the direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated.

This phenomenon is useful for many applications such as medical applications (e.g. sonar). But it may cause some problems in speech intelligibility and hence needs special treatment when designing buildings.

Reflection of sound waves causes two different phenomena called ***reverberation*** *and* ***echo***

To overcome the problems of echo and reverberation, sound absorption phenomenon is used

B) Define the following items

i) Acoustic materials: Some artificial fabricated materials designed for sound absorption

ii) Reverberation time: the time taken for a signal to drop by 60dB.

iii) Cavity Absorption: absorption in air gaps between different layers

iv) Transmission loss: is the difference between sound levels in two rooms in opposite sides

C) write short notes about different factors affecting the absorption of acoustic materials.

1- Frequency

2- Material type

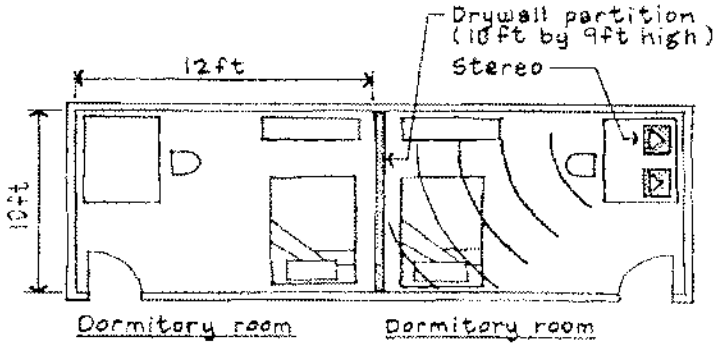
3- Porosity

4- Facings

5- Material thickness

6- Location and mounting methods

/- **D)** Find the TL for the 90 ft^2 common partition between the two adjoining dormitory rooms shown below. Ceiling height in the rooms is 9ft. Sound absorption coefficients are 0.04 for gypsum board walls and ceiling, and 0.69 for the carpeted floor. Absorption of the bed is 15 Sabins. Noise level in the receiving room should not exceed 22 dB. Likely noise level from a stereo in the source room is 82 dB.



First, find the absorption in the receiving room using the formula $a = \Sigma S\alpha$.

	Surface area (ft^2)		α		a
Walls	2(12 × 9)	= 216			
	2(10 × 9)	= 180			
Ceiling	10 × 12	= 120			
		516	× 0.04	=	21
Floor	10 × 12	= 120	× 0.69	=	83
Bed					15
				a_2 =	119 sabins

Next, find the required NR.

$NR = L_1 - L_2$

$NR = 82 - 22 = \boxed{60\ dB}$

Finally, find the required TL.

$$TL = NR - 10 \log \frac{a_2}{S}$$

$$= 60 - 10 \log \frac{119}{90}$$

$$= 60 - 10 \log (1.3) = 60 - 10 (0.1139)$$

$TL = 60 - 1 = \boxed{59\ dB}$