P118-152 (ESE)

Set-2

DECEMBER 2018 / END-SEM

F. Y. M. TECH. (MECHANICAL) (SEMESTER - I)

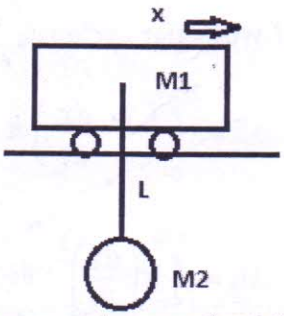
COURSE NAME: ADVANCED VIBRATIONS AND ACOUSTICS

COURSE CODE: MEPA11182

(PATTERN 2018)

SOLUTION –Set 2

Q.1) Draw FBD and write the displacement equations of the following system [3 marks]



Example 5.30 *Find the natural frequency of the system shown in Fig. 5.43.*

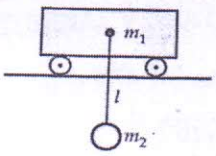


Fig. 5.43

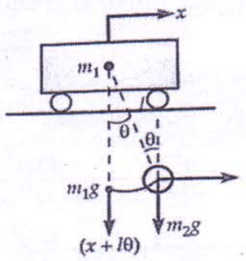


Fig. 5.44

Solution. Let us assume the whole system is moved to the right by x. The ball m_2 is displaced by θ as shown in Fig. 5.44. The total movement of ball m_2 is $x + l\theta$.

The equations of motion are :

For pendulum m_2, $\quad m_2(\ddot{x} + l\ddot{\theta}) = -T\theta \qquad (\sin\theta \simeq \theta)$

$$m_2(\ddot{x} + l\ddot{\theta}) + m_2 g\theta = 0 \quad \text{or} \quad \ddot{x} + l\ddot{\theta} + g\theta = 0 \qquad ...(1)$$

For mass m_1, $\quad m_1\ddot{x} = T\theta$

$$m_1\ddot{x} - m_2 g\theta = 0 \quad \text{or} \quad \ddot{x} = \frac{m_2}{m_1} g\theta \qquad \text{— 01 M} \qquad ...(2)$$

Putting the value of $\ddot{x}$ from Eqn. (2) in Eqn. (1), we get

$$\frac{m_2}{m_1} g\theta + l\ddot{\theta} + g\theta = 0 \qquad \text{— 02 M}$$

OR

b) What are different types of Damping? Determine the equation for energy dissipation in viscous damping.
[3 marks]

... types of damping ...

- Viscous damping
- Coulomb damping — 01 M
- Structural damping
- Non-linear, Slip or interfacial damping.

For a viscously damped system the force F is expressed as

$$F = c\dot{x} = c\frac{dx}{dt}$$

where

$$\dot{x} = \frac{dx}{dt}$$

Work done $$dW \equiv F\,.\,dx = \left(c\frac{dx}{dt}\right).\,dx$$

The rate of change of work per cycle *i.e.,*

Energy dissipated $$\Delta E = \int_0^{2\pi/\omega}\left(F\,.\frac{dx}{dt}\right)dt = \int_0^{2\pi/\omega} c\left(\frac{dx}{dt}\frac{dx}{dt}\right)dt$$

$$\Delta E = \int_0^{2\pi/\omega} c\left(\frac{dx}{dt}\right)^2 .\,dt$$ — 02 M

Q.2) a) Determine the lowest natural frequency of the following system [3 marks]

The static deflections at two points are given as

$$y_1 = M_1 g a_{11} + M_2 g a_{12} \quad \text{and} \quad y_2 = M_1 g a_{21} + M_2 g a_{22}$$

$$a_{11} = \frac{a^3}{3EI} = \frac{(.18)^3}{3\times 1.96\times 10^{11}\times 4\times 10^{-7}} = 2.479\times 10^{-8}$$

$$a_{22} = \frac{l^3}{3EI} = \frac{(0.3)^3}{3\times 1.96\times 10^{11}\times 4\times 10^{-7}} = 1.147\times 10^{-7}$$

$$a_{12} = a_{21} = \frac{a^2(3l-a)}{6EI} = \frac{(.18)^2(3\times .30-.18)}{6\times 1.96\times 10^{11}\times 4\times 10^{-7}} = 4.959\times 10^{-8}$$ — 01 M

o

$$y_1 = M_1 g a_{11} + M_2 g a_{12}$$
$$= 100\times 9.8\times 2.479\times 10^{-8} + 50\times 9.8\times 4.959\times 10^{-8} = .486\times 10^{-4}\ \text{m}$$
$$y_2 = M_1 g a_{21} + M_2 g a_{22}$$
$$= 100\times 9.8\times 4.959\times 10^{-8} + 50\times 9.8\times 1.147\times 10^{-7} = 10.48\times 10^{-5}\ \text{m}$$ — 01 M

ius

$$\omega_n = \sqrt{\frac{9.8[P_1 y_1 + P_2 y_2]}{(P_1 y_1^2 + P_2 y_2^2)}}$$

$$\omega_n = \sqrt{\frac{9.8\,[100\times 4.86\times 10^{-5} + 50\times 10.48\times 10^{-5}]}{100\times(4.86\times 10^{-5})^2 + 50\times(10.48\times 10^{-5})^2}} = 354.96\ \text{rad/sec}$$ — 01 M

OR

b) Explain Matrix iteration method with suitable example.
[3 marks]

6.6 MATRIX ITERATION METHOD

With the help of this method the natural frequencies and corresponding mode shapes are determined. Use of influence coefficients is made in the analysis. The method can best be understood by solving the problem of Fig. 6.5 by matrix iteration method.

(I.M.I., 2008 ; P.U. 05 ; KUK, 2012)

SOLUTION The equations for the above system in terms of influence coefficients can be written as

$$x_1 = a_{11}4mx_1\omega^2 + a_{12}2mx_2\omega^2 + a_{13}mx_3\omega^2$$
$$x_2 = a_{21}4mx_1\omega^2 + a_{22}2mx_2\omega^2 + a_{23}mx_3\omega^2$$
$$x_3 = a_{31}4mx_1\omega^2 + a_{32}2mx_2\omega^2 + a_{33}mx_3\omega^2$$

– 01 M

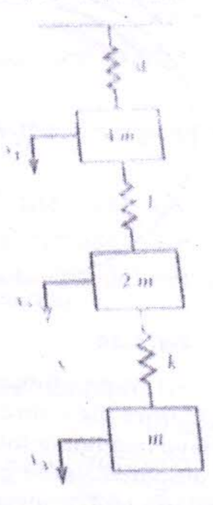
Influence coefficients are

$$a_{11} = a_{12} = a_{21} = a_{13} = a_{31} = \frac{1}{3k}$$

$$a_{22} = \frac{1}{3k} + \frac{1}{k} = \frac{4}{3k} = a_{23} = a_{32}$$

$$a_{33} = \frac{1}{3k} + \frac{1}{k} + \frac{1}{k} = \frac{7}{3k}$$

01 M



01 M

Fig. 6.5

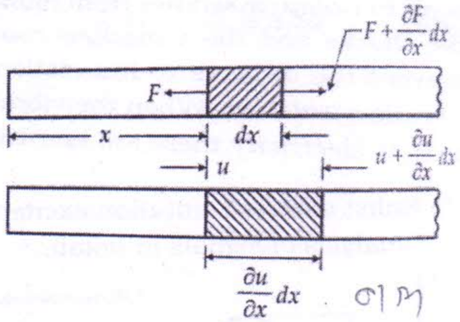
Q.3) a) Write the one dimensional wave equation for longitudinal vibration of bar with neat Sketch [2 Marks]

7.3 LONGITUDINAL VIBRATIONS OF BARS

Let us consider thin and uniform bar for longitudinal vibrations as shown in Fig. 7.2. The bar is subjected to axial forces. An element dx of the bar is considered here for analysis.

If u is displacement at a distance x from left and it becomes $u + \frac{\partial u}{\partial x}dx$ at a distance $x + dx$. It is clear that the element dx has changed its position by an amount

$$\left(u + \frac{\partial u}{\partial x}dx - u\right) = \frac{\partial u}{\partial x}dx$$



01 M

So strain of the element is given by

$$\in = \frac{\frac{\partial u}{\partial x}.dx}{dx} = \frac{\partial u}{\partial x} \quad ...(7.3.1)$$

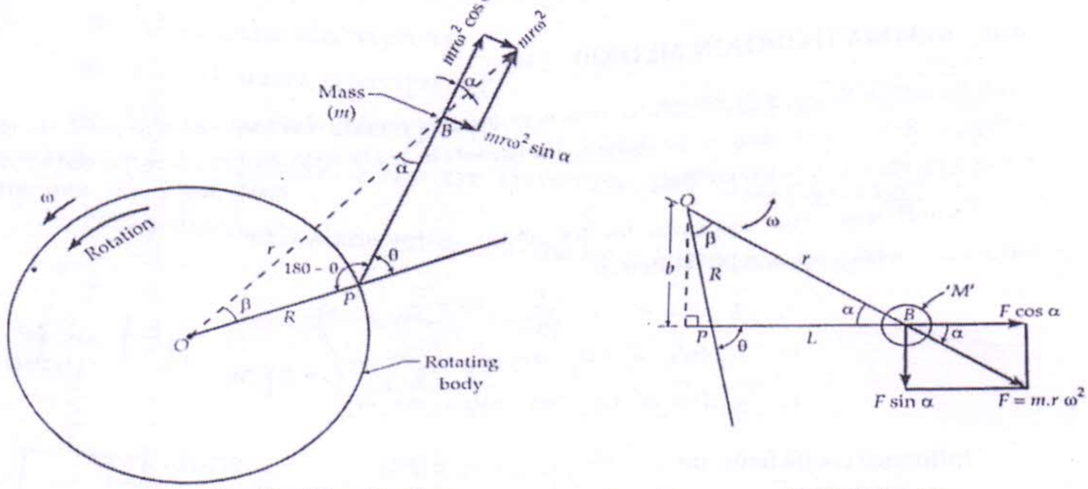
01 M

Fig. 7.2

OR

b) How the analysis of continuous system is different than multi degree freedon system [2 marks]

Q.4) a) Differentiate Vibration absorber and Vibration Isolators, Explain centrifugal pendulum absorber with neat sketch [6 marks]



(a) Centrifugal Pendulum Absorber. 02M (b) Force diagram

Fig. 5.16

A pendulum *PB* of length '*L*' is attached to a rotating member at point *P*, which is at a radius '*R*' from the centre of rotation *O*. The mass of the pendulum bob is '*m*' and the string is assumed to have negligible mass. This pendulum is subjected to a centrifugal force which is much greater as compared to the gravitational force so that the latter is considered negligible. The rotating body rotates with a angular velocity of 'ω' and due to this rotation a centrifugal force $m\omega^2 r$ is experienced by the pendulum.

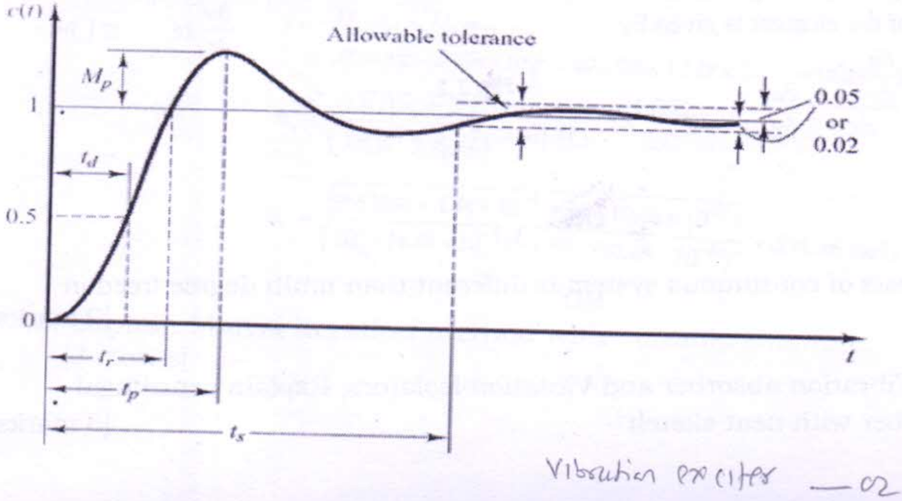
Let us assume that at any instant, the pendulum is displaced from the radial line by a small amount θ. The bob or mass at the tip of the pendulum is then at a distance '*r*' from the centre of rotation '*O*' and is subjected to a centrifugal force of 02 M

$$F = mr\omega^2 \qquad ...(5.12.1)$$

Difference between a Vibration Absorber and a Vibration Isolator

Vibration absorber is a spring mass system attached to the main vibratory system to absorb the vibrations whereas vibration isolators are materials like cork, rubber, felt, pad etc. which are used to isolate machines from foundation and support. These vibration isolation materials absorb the shocks and the vibrations caused by unbalanced forces set up in the machinery and thus prevent the damage to foundations or supports. Cork, rubber, felt, pad are known as passive vibration isolators. When the vibrations are isolated with the help of external or artificial devices such as electricity these are known as active vibration isolators. 02 M

b) Enlist different vibration exciters with its application. Describe time domain analysis of signals in detail. [8 marks]



02 M

Vibration exciter — 02 M

- In time-domain analysis the response of a dynamic system to an input is expressed as a function of time
- It is possible to compute the time response of a system if the nature of input and the mathematical model of the system are known
- Usually, the input signals to control systems are not known fully ahead of time
- Delay Time-The delay (t_d) time is the time required for the response to reach half the final value the very first time
- The rise time is the time required for the response to rise from 10% to 90%, 5% to 95%, or 0% to 100% of its final value.
- The peak time is the time required for the response to reach the first peak of the overshoot
- The maximum overshoot is the maximum peak value of the response curve measured from unity. If the final steady-state value of the response differs from unity, then it is common to use the maximum percent overshoot. It is defined by 04 M

OR

Q.5)a) What are the different methods to control undesirable vibrations? Explain the block diagram of FFT spectrum analyzer [6 marks] method-2 FFT-06 M

b) What is experimental modal analysis? Explain electrodynamic and hydraulic shaker used in vibration testing. 8M 04M 04M [8 marks]

Q.6) a) Calculate the sound pressure level if 1) rms pressure value is 30 µµPa.2) sound pressure level is 40 dB [6 marks]

Given: PrmsPrms = 30 µµPa, prefpref = 20 µµPa.

The sound pressure level formula is given by,

LpLp = 20 log10log10 (prmspref)(prmspref)

LpLp = 20 log10log10 (3020)(3020) — 03 M

LpLp = 3.52 dB

Therefore, the sound pressure level is **3.52** **dB.**

sound pressure level = 40 dB,

Given: sound pressure level = 40 dB, p_{ref} = 20 µPa.

The sound pressure level formula is given by,

$$L_p = 20\ log_{10}\left(\frac{p_{rms}}{p_{ref}}\right)$$

The pressure level is given as,

$$e^{\left(\frac{L_p}{20}\right)} = \left(\frac{p_{rms}}{p_{ref}}\right)$$

$$e^{\left(\frac{40}{20}\right)} = \frac{p_{rms}}{(20\times10^{-6})}$$

$$4.85 \times 10^8 = \frac{p_{rms}}{(20\times10^{-6})}$$ — 03 M

p_{rms} = 9.703 × 10^3 Pa.

Therefore, the pressure level is **9.703 × 10^3 Pa.**

b)

SOUND POWER CALCULATION

Sound power, denoted P, is defined by

$$P = \mathbf{f} \cdot \mathbf{v} = Ap\,\mathbf{u} \cdot \mathbf{v} = Apv$$

In a medium, the sound power is given by

$$P = \frac{Ap^2}{\rho c} \cos\theta,$$

Relationships with other quantities

Sound power is related to sound intensity:

$$P = AI,$$

Sound power is related sound energy density:

$$P = Acw,$$ — 02m

Sound power level definition

Sound power level (SWL) or **acoustic power level** is a logarithmic measure of the power of a sound relative to a reference value. Sound power level, denoted L_W and measured in dB, is defined by

$$L_W = \frac{1}{2}\ln\left(\frac{P}{P_0}\right)\,\mathrm{Np} = \log_{10}\left(\frac{P}{P_0}\right)\,\mathrm{B} = 10\log_{10}\left(\frac{P}{P_0}\right)\,\mathrm{dB},$$

where

P is the sound power;

P_0 is the *reference sound power*;

1 Np = 1 is the neper;

1 B = $\frac{1}{2}$ ln 10 is the bel; — 02m

1 dB = $\frac{1}{20}$ ln 10 is the decibel.

The commonly used reference sound power in air is

$$P_0 = 1\ \mathrm{pW}.$$

The proper notations for sound power level using this reference are $L_{W/(1\ \mathrm{pW})}$ or L_W (re 1 pW), but the suffix notations dB SWL, dB(SWL), dBSWL, or $\mathrm{dB_{SWL}}$ are very common, even if they are not accepted by the SI.

The reference sound power P_0 is defined as the sound power with the reference sound intensity I_0 = 1 pW/m^2 passing through a surface of area A_0 = 1 m^2:

$$P_0 = A_0 I_0,$$

hence the reference value P_0 = 1 pW

Relationship with sound pressure level — 02m

The generic calculation of sound power from sound pressure is as follows:

$$L_W = L_p + 10\log_{10}\left(\frac{A_S}{A_0}\right)\,\mathrm{dB},$$

where: A_S defines the area of a surface that wholly encompasses the source. This surface may be any shape, but it must fully enclose the source.

In the case of a sound source located in free field positioned over a reflecting plane (i.e. the ground), in air at ambient temperature, the sound power level at distance *r* from the sound source is approximately related to sound pressure level (SPL) by

$$L_W = L_p + 10\log_{10}\left(\frac{2\pi r^2}{A_0}\right)\ \mathrm{dB},$$

Derivation of this equation:

$$\begin{aligned} L_W &= \frac{1}{2}\ln\left(\frac{P}{P_0}\right) \\ &= \frac{1}{2}\ln\left(\frac{AI}{A_0 I_0}\right) \\ &= \frac{1}{2}\ln\left(\frac{I}{I_0}\right) + \frac{1}{2}\ln\left(\frac{A}{A_0}\right). \end{aligned}$$

For a *progressive* spherical wave, — 02M

$$z_0 = \frac{p}{v},$$

$A = 4\pi r^2$, (the surface area of sphere)

where z_0 is the characteristic specific acoustic impedance.

Consequently,

$$I = pv = \frac{p^2}{z_0},$$

and since by definition $I_0 = p_0^2/z_0$, where p_0 = 20 μPa is the reference sound pressure,

$$\begin{aligned} L_W &= \frac{1}{2}\ln\left(\frac{p^2}{p_0^2}\right) + \frac{1}{2}\ln\left(\frac{4\pi r^2}{A_0}\right) \\ &= \ln\left(\frac{p}{p_0}\right) + \frac{1}{2}\ln\left(\frac{4\pi r^2}{A_0}\right) \\ &= L_p + 10\log_{10}\left(\frac{4\pi r^2}{A_0}\right)\ \mathrm{dB}. \end{aligned}$$

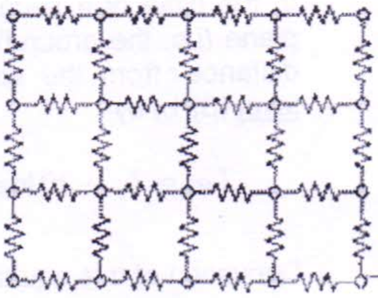
The sound power estimated practically does not depend on distance. The sound pressure used in the calculation may be affected by distance due to viscous effects in the propagation of sound unless this is accounted for.

OR

Q.7) a) [6 marks]

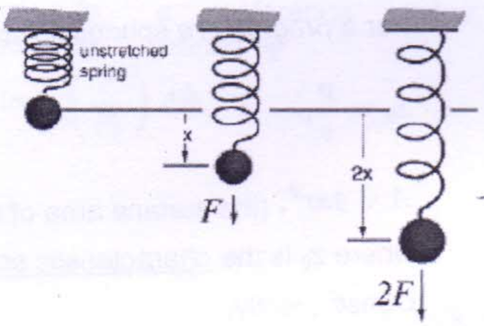
Sound Propagation in Elastic Materials

In the previous pages, it was pointed out that sound waves propagate due to the vibrations or oscillatory motions of particles within a material. An ultrasonic wave may be visualized as an infinite number of oscillating masses or particles connected by means of elastic springs. Each individual particle is influenced by the motion of its nearest neighbor and both inertial and elastic restoring forces act upon each particle.



A mass on a spring has a single resonant frequency determined by its spring constant **k** and its mass **m**. The spring constant is the restoring force of a spring per unit of length. Within the elastic limit of any material, there is a linear relationship between the displacement of a particle and the force attempting to restore the particle to its equilibrium position. This linear dependency is described by **Hooke's Law**.

In terms of the spring model, Hooke's Law says that the restoring force due to a spring is proportional to the length that the spring is stretched, and acts in the opposite direction. Mathematically, Hooke's Law is written as **F =-kx**, where **F** is the force, **k** is the spring constant, and **x** is the amount of particle displacement. Hooke's law is represented graphically it the right. Please note that the spring is applying a force to the particle that is equal and opposite to the force pulling down on the particle.



b) What is acoustics Impedance? Correlate it with acoustic energy and reflection coefficient [8 marks]

$$p(x,t) = \hat{p}(x)\,e^{i\omega t} = p^{+}\,e^{i\omega t - ikx} + p^{-}\,e^{i\omega t + ikx}$$

where $k = \omega/c_0$. p^{+} is the amplitude of the wave incident at $x = 0$ from $x < 0$ and p^{-} is the amplitude of the wave reflected at $x = 0$ by an impedance Z. Using the linearized momentum conservation law $\rho_0(\partial v/\partial t) = -\partial p/\partial x$ we find:

$$\hat{v}(x) = \frac{1}{\rho_0 c_0}\left(p^{+}\,e^{-ikx} - p^{-}\,e^{ikx}\right).$$

If we define the reflection coefficient R at $x = 0$ as:

$$R = p^{-}/p^{+}$$

we see that because $Z = \hat{p}(0)/\hat{v}(0)$:

$$R = \frac{Z - \rho_0 c_0}{Z + \rho_0 c_0}$$

In two dimensions we have a similar result. Consider a plane wave (amplitude p^+), propagating in the direction $(\cos\vartheta, \sin\vartheta)$ where ϑ is the angle with the positive x-axis (*c.f.* Fig. 3.6), and approaching from $y < 0$ an impedance wall at $y = 0$. Here it reflects into a wave (amplitude p^-) propagating in the direction $(\cos\vartheta, -\sin\vartheta)$. The pressure field is given by

$$\hat{p}(x, y) = e^{-ikx\cos\vartheta}\left(p^+ e^{-iky\sin\vartheta} + p^- e^{iky\sin\vartheta}\right).$$

The y-component of the velocity is

$$\hat{v}(x, y) = \frac{\sin\vartheta}{\rho_0 c_0} e^{-ikx\cos\vartheta}\left(p^+ e^{-iky\sin\vartheta} - p^- e^{iky\sin\vartheta}\right).$$

so we have for the impedance

$$Z = \frac{\hat{p}(x, 0)}{\hat{v}(x, 0)} = \frac{\rho_0 c_0}{\sin\vartheta}\frac{p^+ + p^-}{p^+ - p^-} = \frac{\rho_0 c_0}{\sin\vartheta}\frac{1 + R}{1 - R},$$

04 m

and for the reflection coefficient

$$R = \frac{Z\sin\vartheta - \rho_0 c_0}{Z\sin\vartheta + \rho_0 c_0}$$

Q.8) a) [6 marks]

Masking System Types

There are several types of masking systems.

- **Portable systems**. These systems are small and can be installed on a temporary basis. They are controlled and powered centrally. They are used for Secret Privacy in rental rooms, and can be used for demonstration purposes elsewhere.
- **Self-contained systems**. These are typically one, or several, single units that contain all the features necessary to create masking sound. Each unit is powered by standard line voltage and there is no centralized control, but they are portable. They are used in homes, on desk tops, and can be carried in luggage for privacy in hotel rooms. 02m
- **Centralized systems**. They can be of any size but are preferably used in large, permanent installations. They can contain the advanced features noted above, are centrally powered, and centrally controlled.
- **Distributed systems**. These systems can be of any size but are distinguished from centralized systems by the fact that they may be centrally controlled, but the power to speakers is distributed throughout the area.

Applications of Sound Masking

- Commercial Facilities
  Applications relate to acoustical privacy within an office, there have been applications where sound masking was used to create privacy from sounds exterior to the office. Examples are privacy from elevated freeway traffic, continual siren use in cities, sound from the floor above, and local construction noise. Sound masking is used in court rooms to prevent jurors from hearing attorney conversations with the judge at his bench. 04m

- Medical Facilities

  Sound masking has been used beneficially in a number of locations. Patient rooms, corridors, and nursing areas of hospitals are prime locations. Sound masking can be used in retirement and rehabilitation centers. It is also beneficial in medical suites or patient contact areas of medical insurance providers. Pharmacies can also provide confidential privacy at contact areas with sound masking.
- Secure Facilities

  For secure facilities, the listener is presumed to be deliberate and may make use of sophisticated technical listening devices. Many government facilities have made use of structural solutions, i.e., rooms (room-within-a-room) that are shielded from vibration, acoustical, and electromagnetic surveillance. Unfortunately, not all secret conversations take place in such rooms. A less obvious weakness in secure rooms is that modern listening devices can be placed in locations that the building structure cannot protect against (inside wall cavities or remote detection of window vibration). Another weakness in rooms of this type is that designers may presume speech is on a controlled, but low, level. Public address systems, speaker phones, and audio/video presentations require additional protection.

b) Write short Notes on 1)Equal loudness levels 2) Pitch and Beats [8 marks]

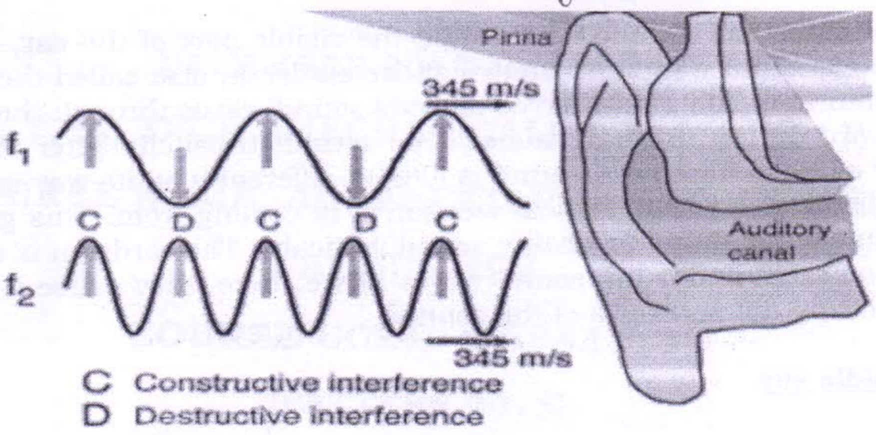
Pitch:

Pitch is a perceptual property of sounds that allows their ordering on a frequency-related scale or more commonly, pitch is the quality that makes it possible to judge sounds as "higher" and "lower" in the sense associated with musical melodies. Pitch can be determined only in sounds that have a frequency that is clear and stable enough to distinguish from noise. Pitch is a major auditory attribute of musical tones, along with duration, loudness, and timber.

Pitch may be quantified as a frequency, but pitch is not a purely objective physical property; it is a subjective psychoacoustical attribute of sound. Historically, the study of pitch and pitch perception has been a central problem in psychoacoustics, and has been instrumental in forming and testing theories of sound representation, processing, and perception in the auditory system. —02M.

Beats

Beats are formed when two waves with different frequency approaches to ear. When we listen two waves that have different frequencies, we hear the amplitude increasing and decreasing as the function of time this type of variation in amplitude called a beat. —02M loudness – 02M. + fig – 2 marks



In above figure point C is constructive interference and point D is destructive interference. The sounds constructive and destructive interference causes the sound to be alternatively soft and loud.

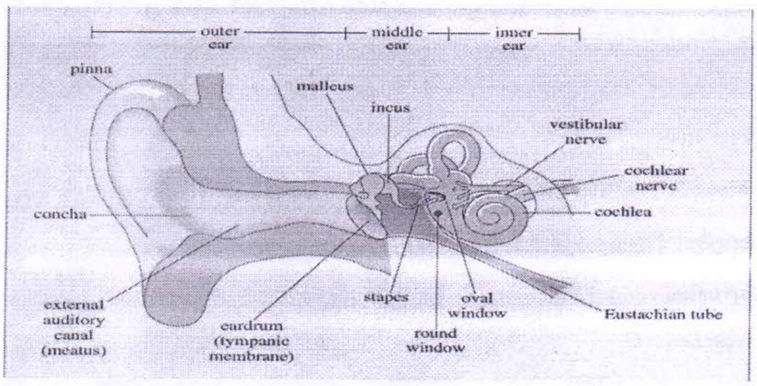
OR

Q.9) a) Describe mechanism of hearing and its consideration in psychoacoustics[6 marks]

MECHANISM OF HEARING:-

Hearing, or **auditory perception**, is the ability to perceive sounds by detecting vibrations, changes in the pressure of the surrounding medium through time, through an organ such as the ear. The academic field concerned with hearing is auditory science. Sound may be heard through solid, liquid, or gaseous matter.[2] It is one of the traditional five senses; partial or total inability to hear is called hearing loss.

In humans and other vertebrates, hearing is performed primarily by the auditory system: mechanical waves, known as vibrations are detected by the ear and transduced into nerve impulses that are perceived by the brain (primarily in the temporal lobe). Like touch, audition requires sensitivity to the movement of molecules in the world outside the organism. Both hearing and touch are types of mechanosensation. There are three main components of the human ear: the outer ear, the middle ear, and the inner ear. — 02M



— 02M

Schematic diagram of human ear

Outer ear

The outer ear includes the pinna, the visible part of the ear, as well as the ear canal which terminates at the eardrum, also called the tympanic membrane. The pinna serves to focus sound waves through the ear canal toward the eardrum. Because of the asymmetrical character of the outer ear of most mammals, sound is filtered differently on its way into the ear depending on what vertical location it is coming from. This gives these animals the ability to localize sound vertically. The eardrum is an airtight membrane, and when sound waves arrive there, they cause it to vibrate following the waveform of the sound.

Middle ear

The middle ear consists of a small air-filled chamber that is located medial to the eardrum. Within this chamber are the three smallest bones in the body, known collectively as the ossicles which include the malleus, incus, and stapes (also known as the hammer, anvil, and stirrup, respectively). They aid in the transmission of the vibrations from the eardrum into the inner ear, the cochlea. The purpose of the middle ear ossicles is to overcome the impedance mismatch between air waves and cochlear waves, by providing impedance matching. Also located in the middle ear are the stapedius muscle and tensor tympani muscle, which protect the hearing mechanism through a stiffening reflex. The stapes transmits sound waves to the inner ear through the oval window, a flexible membrane separating the air-filled middle ear from the fluid-filled inner ear. The round window, another flexible membrane, allows for the smooth displacement of the inner ear fluid caused by the entering sound waves.

b) Calculate the sound intensity level in decibels for a sound wave traveling in air having a pressure amplitude of 0.659 Pa [8 marks]

Strategy

We are given Δp, so we can calculate I using the equation $I = (\Delta p)^2/(2\rho v_w)^2$. Using I, we can calculate β straight from its definition in $\beta\ (\text{dB}) = 10 \log_{10}(I/I_0)$.

Solution

(1) Identify knowns:

Sound travels at 331 m/s in air at $0C$.

Air has a density of $1.29 kg/m^3$ at atmospheric pressure and $0C$.

(2) Enter these values and the pressure amplitude into $I = (\Delta p)^2/(2v_w)$:

$$I = \frac{(\Delta p)^2}{2v_w} = \frac{(0.656Pa)^2}{2(1.29\ \text{kg/m}^3)(331\ \text{m/s})} = 5.0410^{-4}\ \text{W/m}^2.$$

(3) Enter the value for I and the known value for I_0 into $\beta\ (\text{dB}) = 10 \log_{10}(I/I_0)$. Calculate to find the sound intensity level in decibels:

$$10 log_{10}(5.0410^8) = \ldots 8.70)\ dB = 87 dB.$$