1206

B.Sc. (Hons.) PHYSICS/II Sem.   A

Paper—PHHT-204

(Oscillations and Waves)

Time : 3 Hours   *Maximum Marks* : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all

including Q. No. 1 which is compulsory.

1.   Attempt any *five* of the following :

(*a*)   Define simple harmonic motion (SHM). Show that the differential equation of motion for SHM is linear and homogeneous. Hence, prove that the principle of superposition holds for SHM.

(b)   A uniform spring of force constant 'K' is cut into two

pieces of lengths in the ratio 1 : 2. What is the force

constant of each piece in terms of K ?

(c)   Distinguish between plane and spherical waves and give

their mathematical representations.

(d)   The displacement of a simple harmonic oscillator of mass

m is given by :

$$r = A \sin(\omega t + \phi).$$

If r_1 and r_2 are the displacements of oscillator from mean

position and the corresponding velocities are v_1 and v_2,

respectively, show that frequency is given by :

$$f = \frac{1}{2\pi} \left\{ \frac{v_1^2 - v_2^2}{r_2^2 - r_1^2} \right\}^{1/2}.$$

(e)   Two tuning forks A and B of nearly equal frequencies

are employed in an optical experiment to produce

Lissajous figures. On slightly loading the fork A, it is observed that the cycle of change of figure slows down from 10 s to 20 s. If the frequency of B is 256 Hz, what will be the frequency of tuning fork A before and after loading ?

(f) The phase velocity of ripples of short wavelength 'λ' in water is given by :

$$v_p = \left(\frac{2\pi S}{\rho\lambda}\right)^{1/2},$$

where 'S' is the surface tension and 'ρ' the density of water. Show that the group velocity for a disturbance made up of wavelengths close to a given λ is equal to $\frac{3}{2}v_p$.

(g) What are the characteristic features of stationary waves ? Distinguish between stationary and travelling waves.

(h)   A smooth tunnel is bored through the earth along one

of its diameters and a ball is dropped into it. Show that

the ball will execute SHM with period $T = 2\pi\sqrt{\dfrac{R}{g}}$, where

R is radius of the earth and g is acceleration due to

gravity at the surface of the earth. Assume earth to be

a homogeneous sphere.   5×3=15

2.   (a)   Using the rotating vector representation, obtain the

resulting motion of a particle subjected simultaneously

to two SHM's in the same direction having equal

amplitudes and equal frequencies and differing in phase

by $\pi/4$.   10

(b)   Obtain an expression for the time period of vertical

oscillations of a liquid column in a uniform U tube. Neglect

viscous effects.   5

3. (a) What are Lissajous figures ? Two vibrations at right angles to each other are described by the equations $x_1 = 10 \cos(5\pi t)$, $y_1 = 10 \cos(10\pi t - \pi/4)$. Draw the Lissajous figure corresponding to the resulting motion.   10

(b) Two identical masses are connected with two identical massless springs and placed on a horizontal, frictionless surface as shown in the figure below. Determine the ratio of the normal mode frequencies of longitudinal oscillations of the masses.   5
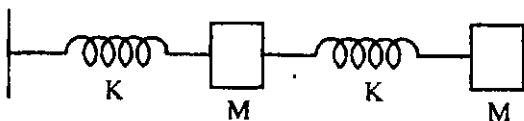
4. (a) Establish the equation of motion of a damped harmonic oscillator subjected to a resistive force that is proportional to the first power of its velocity. If the damping is less than critical, show that the motion of the system is oscillatory with its amplitude decaying exponentially with time.   10

(b) What do you understand by logarithmic decrement, relaxation time and quality factor of a weakly damped harmonic oscillator ? What is the relationship between them ? 5

5. (a) A long uniform string of linear density μ is stretched with a tension T'. Obtain an expression for the velocity of transverse waves on a long stretched string. 10

(b) Transverse waves are generated in two uniform steel wires A and B of diameters 10^{-3} m and 0.5×10^{-3} m, respectively; by attaching their free ends to a vibrating source of frequency 500 Hz. Find the ratio of wavelengths if they are stretched with the same tension. 5

6. (a) Obtain Newton's formula for the velocity of longitudinal waves in a column of a gas. What is Laplace's correction to Newton's formula ? 10

(b) The intensity of sound in a normal conversation is about 3×10^{-6} watt/m^2 and the frequency of normal human voice is about 1000 Hz. Find the amplitude of waves, assuming that the air is at standard conditions. 5

7.   (a)   Obtain an expression for the time period of a compound pendulum and show that the centres of suspension and oscillation of a compound pendulum are interchangeable. What length of the pendulum has its minimum time period ?   10

   (b)   A disc of 10 cm radius and mass 1 kg is suspended in a horizontal plane by a vertical wire attached to its centre. If the diameter of the wire is 1 mm and its length is 1.5 m and the time period of torsional vibrations of the disc is 5 s, find the rigidity modulus (η) of the material of the wire.   5