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Exam. Code : 103202
Subject Code : 1310

B.A./B.Sc. Semester—II

PHYSICS

Paper—B

(Vibration and Waves)

Time Allowed—3 Hours] [Maximum Marks—35

Note :— The question paper has *five* sections. Attempt *all* questions in Section A and *one* question each from Sections—B, C, D and E.

SECTION—A

1. (a) A particle is executing simple harmonic motion with angular frequency, ω and amplitude, a. Plot a graph between the velocity of particle and ωt.

(b) Give one practical application of Lissajous figures.

(c) Define quality factor, Q of an oscillator.

(d) Find the resonant frequency of a LC circuit containing C = 1, μF and L = 10 H.

(e) A mass stands on a platform, which vibrates simple harmonically in a vertical direction at a frequency of 5 Hz. Show that the mass loses contact with the platform when the displacement exceeds 10^{-2} m.

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(f) Plot graphs between phase angle ϕ, between displacement(x) and force(F) against angular frequency, ω of the driving force.

(g) A transverse mechanical wave propagates from one medium to another. Write down the expression for reflection coefficient of amplitude. $1\times7=7$

SECTION—B

2. (a) Find the trajectory of a particle under the superposition of two perpendicular simple harmonic motion of time periods in the ratio 1 : 2. 4

(b) Consider a simple pendulum oscillating with angular frequency, ω and amplitude, A. Derive expressions for its kinetic and potential energies as functions of time. 3

3. (a) A mass, M is connected via a spring to fixed wall. If the spring constant is s, obtain its equation of motion and solve it to get an expression for velocity. 4

(b) A simple pendulum swings with a displacement amplitude a. Find the different values of the phase constant, φ for the solution, $x = a \cos(\omega t + \varphi)$ if it is starting point from rest is (i) $x = a$ and (ii) $x = -a$. 3

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SECTION—C

4. (a) Write down the equation of motion of heavily damped one dimensional oscillator NOT driven by any external force and obtain an expression for its displacement magnitude x as function of time. 4

(b) A capacitance C with a charge q_0 at t = 0 discharges through a resistance, R. Use the voltage equation q/C + IR = 0 to show that relaxation time of this process is RC. 3

5. (a) Define logarithmic decrement, δ. 3

(b) The angular frequency, ω of the damped oscillator of mass, m is given by :

$$\omega^2 = \frac{s}{m} - \frac{r^2}{4m^2} = \omega_0^2 - \frac{r^2}{4m^2}$$

where s, is the spring constant and r is the damping coefficient.

If $\omega_0^2 - \omega^2 = 10^{-6}\ w_0^2$, then show that quality factor of this oscillator, Q = 500 and the logarithmic decrement, δ = π/500. 4

SECTION—D

6. (a) Obtain and solve the equation of motion of a forced mechanical oscillator with damping. 4

(b) Plot graphs between phase angle, ϕ, between velocity (v) and force(F) against angular frequency, ω of the driving force. 3

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7. (a) Define normal coordinates and degrees of freedom. 3

(b) Consider two particles of equal mass, m coupled by a spring of stiffness, s. Write down the equation of motion of this system in terms of normal coordinates and solve it to obtain frequencies of its normal modes. 4

SECTION—E

8. (a) Consider a string of length, l with fixed ends. Find the frequencies, ω_n of its normal modes of transverse vibration and the vertical displacement $y_n(x, t)$ of the string in its n^{th} mode. 4

(b) Define characteristic impedance of a string and explain how it determines the transmission coefficient of energy when a wave propagates from one medium to another. 3

9. (a) Sound waves are incident on a water-ice interface. If the acoustic impedance for water = 1.43×10^6 kg m^{-2} s^{-1} and for ice = 3.49×10^6 kg m^{-2} s^{-1}. Show that 82.3% of the energy is transmitted when the waves are incident normally at the interface. 4

(b) Using graphs between, ω and k, explain the conditions for normal dispersion, no dispersion and anomalous dispersion of waves propagating in a medium. 3

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