2011

PHYSICS

(Major)

Paper : 1.2

Full Marks : 60

Time : 2½ hours

The figures in the margin indicate full marks for the questions

SECTION—I

(*Marks* : 40)

1. *(a)* Indicate the type of motion described by the equation

$$m\ddot{x} + R\dot{x} + kx = 0$$ 1

(b) Define group velocity. 1

(c) What is the ratio between the intensities of the fundamental and the third harmonic in a string plucked at the midpoint of its length? 1

(d) What simplification is obtained in the Fourier series if the function is even? 1

(e) A sine wave is travelling in a medium. What is the minimum distance between the two particles, always having same speed? 1

(f) What is the difference between transverse and longitudinal waves? 1

2. (a) Write down the expression of wave travelling in negative direction along x-axis and having an amplitude 0·02 m, frequency 440 Hz and velocity 330 ms^{-1}. 2

(b) In a one-dimensional motion of a mass 10 g, it is acted on by a restoring force 10 dyne/cm and a resisting force 2 dyne sec/cm. Find—

(i) whether the motion is aperiodic or oscillatory;

(ii) the resisting force per unit velocity which will make the motion critically damped. 2

3. Answer any *two* questions : 5×2=10

(a) Using the method of separation of variables, find the general solution of the differential wave equation in one dimension.

(b) Derive the expression of average energy density of a plane progressive wave.

(c) Calculate the average energy density in a plane progressive wave in air if the intensity level of sound is 140 dB relative to the threshold intensity of 10^{-12} watt/m^2. Given speed of sound in air = 330 m/s.

4. (a) Two simple harmonic motions act simultaneously on a particle at right angles to each other. Show that the path of the particle will be an ellipse when the two motions have the same period but different amplitudes and initial phases.

What happens when the phase difference between the motions is π? A Lissajous figure is produced by superposing a vertical and a horizontal simple harmonic motion. The pattern has 4 intersections with the vertical and 6 intersections with the horizontal. If the horizontal frequency is 2 kHz, what is the vertical frequency? 6+2+2=10

Or

Derive the expressions for the growth and the decay of the acoustic energy density with time in an enclosure. Give Sabine's definition of reverberation time. 8+2=10

(b) State Fourier's theorem. Analyse, with the help of Fourier's theorem, a square periodic wave given by

$$y = A \text{ (constant)} \quad \text{for} \quad 0 \le t \le \frac{T}{2}$$

$$= 0. \quad \text{for} \quad \frac{T}{2} \le t \le T$$

Also plot the Fourier synthesis with first four terms. 2+6+2=10

Or

Find the differential equation of transverse vibration of a stretched string. Find an expression for the energy eigen-modes for vibration of a string fixed at the two ends and plucked at the middle. 4+6=10

SECTION—II

(*Marks* : 20)

5. State Fermat's principle of least action. 1

6. *(a)* Define conjugate foci of a lens. 2

(b) What is achromatic doublet? 2

7. Answer any *one* question : 5

(a) Establish the refraction matrix for the refraction of a ray of light at a spherical surface separating media of refractive indices n_1 and n_2.

(b) Find the condition of achromatism of two thin lenses separated by a small distance.

8. Answer any *one* question : 10

(a) *(i)* Using Fermat's principle, establish the laws of refraction of light at a plane surface. 5

(ii) Obtain the conjugate foci relation for refraction at a single spherical surface with pole as origin. 5

(b) *(i)* What is distortion of image? Distinguish between the pin-cushion and barrel-shaped distortions. 1+2=3

(ii) What is meant by aplanatic surface? Show that spherical refracting surface is aplanatic with respect to certain position of the object. 2+5=7

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