Roll No. 2401007034 Total Pages : 06

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December 2024

B.Tech. (First Semester)

Waves and Optics (BSC101C)

Time : 3 Hours] *[Maximum Marks : 75*

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other. Non-programable calculator is allowed.

Part A

1. (a) Describe the simple harmonic motion through phasor representation method. 1.5

(b) All Simple Harmonic Motions (SHMs) are periodic but all periodic motions are not SHM. Explain with example. 1.5

(c) Write the differential equations for damped and forced oscillations with proper explanation of the symbols. 1.5

(d) What are the group and phase velocities ? Explain with examples. 1.5

(e) Explain the term standing wave ratio. 1.5

(f) What is matrix method and why is it used in paraxial optics ? 1.5

(g) What do you mean by Brewster's angle ? Give an example, where an optical instrument is used at Brewster's angle placed. 1.5

(h) What do you understand by evanescent wave ? Give two examples, where these waves generally occur. 1.5

(i) What are the absent spectra ? Write atleast one condition for the occurrence of absent spectra. 1.5

(j) What do you mean by the term population inversion ? What are different methods used for population inversion in lasers ? 1.5

Part B

2. (a) What do you mean of free damped oscillations ? Deduce the differential equation for one dimensional damped oscillator and obtain the general solution of the equation. Show that the displacement of critically damped oscillator decays exponentially with time. 8

(b) A uniform spring of spring constant k is cut into two pieces whose lengths are in the ratio of 1 : 3. What is the force constant of each piece in terms of k ? 3

(c) What do you mean by logarithmic decrement of a weakly damped harmonic oscillator ? 4

3. (a) What do you mean by standing wave ? Derive the expression that describes a standing wave on a stretched string of length L fixed between two rigid supports. Also discuss the normal modes of vibrations upto 2nd overtones. 10

(b) Sound waves are produced under water are incident normally on water-air interface. If the speed of sound in water is 1600 m/s and in air is 400 m/s. Calculate the percentage of incident sound energy transmitted out into air. Density of air is 1.3 kg/m^3. 5

4. (a) State and explain Fermat's principle of least time as applied to light rays and with the help of it prove the laws of reflection and refraction. 7

(b) Prove that the least possible distance between an object and its real image in a convex lens is four times the focal length of the lens. 3

(c) Obtain the Gauss's formula relating u, v and f for an extended object placed in front of a concave mirror of radius of curvature r. 5

5. (a) What are Newton's rings and how are they formed ? How would you employ this phenomenon for measuring the wavelength of light and refractive index of a liquid. Give the necessary theory. 12

(b) Calculate the angle between the central image of a lamp filament ($\lambda = 6 \times 10^{-5}$ cm) and its first diffracted image produced by the fabric with 160 threads per centimeter. 3

6. (a) Discuss the principal, construction and working with labeled energy level diagram of solid-state ruby laser. 10

(b) What are the three and four level systems ? Which of these is more efficient and why. Give two-two examples of both kinds of systems. 5

7. (a) Show that the steady state behaviour of the oscillator is independent of (i) its mass if $\omega << \omega_0$ and (ii) its stiffness if if $\omega >> \omega_0$. 6

(b) Discuss the theory of Fraunhoffer diffraction from a circular aperture and obtain the conditions for maxima and minima of diffraction pattern produced by it. 6

(c) Explain any *two* properties of laser beams from (i) monochromaticity, (ii) coherence and (iii) directionality with suitable diagrams. 3