

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 ($\lambda = 6 \times 10^{-5} \text{ cm}$) 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 $\omega \ll \omega_0$ and (ii) its stiffness if $\omega \gg \omega_0$.

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

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

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