[This question paper contains 2 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 9269 **J**

Unique Paper Code : 2223510026

Name of the Paper : Laser Physics and its Applications

Name of the Course : **B.Sc. Physical Science**

Semester : VI

Duration : 2 Hours Maximum Marks : 60

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **four** questions in all. Question **1** is compulsory.
3. Attempt **three** more questions from the rest.
4. Non-programmable scientific calculators are allowed.
5. Some useful constants, integrals and expressions are given at the end of question paper.

1. Answer any **five** parts :

   (a) Explain the role of coherence in laser action.

   (b) What is an optical resonator?

   (c) How does holography differ from conventional photography?

   (d) Differentiate between natural broadening and collisional broadening.

   (e) Why do lasers typically have narrow line widths compared to other light sources?

   (f) How are lasers used in industrial applications? Mention any two examples.

   (g) A laser emits light of wavelength 632.8 nm. Calculate the energy of one photon emitted by this laser. (5×3=15)

2. (a) Describe the processes of absorption, spontaneous emission, and stimulated emission in atoms.

P.T.O.

(b) In a laser medium, the number of atoms in the excited state N_2 is 5×10^{18} atoms/m^3 and in the lower laser level N_1 is 2×10^{18} atoms/m^3. The stimulated emission cross-section is $\sigma = 3\times10^{-20}$ m^2. Calculate the optical gain per meter of the laser medium.

(c) Define population inversion. Why is it necessary for sustained laser action? Illustrate your answer with the help of an energy level diagram for a three-level laser system. (5+5+5)

3. (a) Define optical amplification. Derive the condition for amplification of light in a laser medium and explain how it differs from spontaneous emission.

(b) A laser medium has a gain coefficient g = 0.4 cm^{-1}, and the total round-trip losses in the cavity are α = 0.3 cm^{-1}. Will laser oscillation occur in this medium?

(c) State the threshold condition for laser oscillation and explain its physical significance. (7+3+5)

4. (a) Explain how the energy band structure and carrier distribution in a GaAs semiconductor laser enable stimulated emission. How does population inversion occur, and why is GaAs particularly suitable for laser action?

(b) What is optical gain in a semiconductor laser? Derive the condition for net optical gain and explain how it is related to population inversion. (10+5)

5. (a) Explain how interferometry can be used to measure small distances or changes in position with a laser. Draw a labelled diagram of a typical Michelson interferometer setup and describe the working principle.

(b) In a Michelson interferometer, if 300 fringes shift when the movable mirror is displaced, calculate the distance moved by the mirror.
Given Laser wavelength λ = 600 nm (10+5)

Physical constants

$$\hbar = 1.054 \times 10^{-34}\ \text{Js}$$
$$h = 6.63 \times 10^{-34}\ \text{Js}$$
$$\textit{Rest mass of electron} = 9.1 \times 10^{-31}\text{Kg}$$
$$\textit{charge of electron} = 1.6 \times 10^{-19}\text{C}$$
$$\textit{Speed of light } c = 3\times10^{8}\ \textit{m/s}$$

(100)