M.Sc. Semester–II (CBCS Scheme) Examination

PHYSICS

2-PHY-4 (II) Laser Fundamentals & Applications

Time : Three Hours] [Maximum Marks : 80

Note :— All questions are compulsory and carry equal marks.

1. (a) A semiconductor laser operates at a free-space wavelength of 790 nm, and has a longitudinal coherence length of 1 mm. Determine the linewidth in terms of both frequency and wavelength. 6

   (b) Draw and write the expression of time dependent decay of the electric field produced by an oscillating electron when the loss of energy due to radiation is taken into account. 6

   (c) Write the principle of detailed balance. 4

OR

   (p) Define gain coefficient. What is the relationship between gain coefficient and stimulated emission cross section ? 4

   (q) Explain the following statement, "In the visible spectrum, the dominance of stimulated emission over spontaneous emission normally happens only in stars". 6

   (r) A particular atom has two energy levels with a transition wavelength of 420 nm. At 297 K there are 2.5×10^{21} atoms in the lower state. Calculate how many atoms are in the upper state. 6

2. (a) Which are the two factors that determine if a two-mirror laser can reach saturation intensity and why ? 6

   (b) A laser amplifier with a length of 0.12 m and a gain of 60 m^{-1} has a 100% reflecting mirror at the laser wavelength coated on one end of the laser rod. For a rod diameter of 5 mm, what would be the half angle of the diverging beam exiting from the amplifier ? Would the beam reach the saturation intensity as it emerges from the rod after having made a double pass through the rod ? 6

   (c) Draw a graph showing growth and saturation of laser beam as a function of amplifier length. 4

OR

   (p) Prove mathematically that the population inversion is not possible in a two level system. 6

   (q) Compare the pumping requirement of Nd:YAG laser with that for Ruby laser. Whether number of laser level plays a role here ? 6

   (r) What are the different laser pumping mechanisms ? Briefly write principle of each of them. 4

3. (a) Draw the various possible laser cavity configurations possible. 7

   (b) Estimate the mode number and mode spacing for an Ar ion laser oscillating at 514 nm in a cavity of length 1 m. Assume n = 1. 5

   (c) Write a short note on spectral hole burning. 4

OR

(p) In context with the ideal Gaussian beam, define (i) Beam waist (ii) Rayleigh range. Draw a diagram showing Gaussian beam parameters mentioned above. 6

(q) Obtained an ABCD matrix for a beam translating from point 1 to point 2. 6

(r) Write out the mode distributions at the mirrors for the TEM_{00} and TEM_{01} in terms of the transverse variables x, y and $\rho = \sqrt{x^2 + y^2}$. 4

4. (a) Compare the mode-locked pulse width Δt_p and the separation between pulses Δt_{sep} for a dye laser operating over its entire gain bandwidth (570 nm-640 nm) with cavity mirror separation by 2 m. The Index of refraction of a laser dye in typical solvent is 1.4. 6

(b) How Kerr Lens Mode-Locking (KLM) is achieved ? 6

(c) Write four applications of femtosecond laser. 4

OR

(p) What are the requirements to produce the necessary high inversion density needed for Q-Switching ? 6

(q) Draw a diagram depicting the evolution of a Q-Switched laser pulse. 6

(r) Write four applications of nanosecond laser. 4

5. (a) Write the general excitation mechanism in dye laser in detail. 6

(b) What are the different types of laser structures used for the CO_2 laser ? Draw and briefly explain all of them. 8

(c) Comment on the emission linewidths of a radiating Nd ion doped into a YAG crystal and Glass material. 2

OR

(p) Describe the structure and working of Double Heterostructure semiconductor Laser. 6

(q) Draw and explain the energy level diagram of Helium Neon laser (red wavelength). 6

(r) Why Argon ion laser is relatively inefficient ? At which wavelength(s) this laser operates ? 4