

City College

Internal Examination 2021-2022
Physics (Hons.) CBCS Semester 5
Paper: PHSA DSE A1 (b)
Topic: Laser and Fiber Optics
Full Marks: 20; Time: 1 Hour

Answer any ten questions from the following:

[$2 \times 10 = 20$]

1. What is spatial and temporal coherence?
2. The Krypton line ($\lambda = 605.8 \text{ nm}$) has a coherence length of $\sim 20 \text{ cm}$. Calculate the line width and the frequency stability.
3. The ratio of population of two energy level is 1.06×10^{-30} . Find the wavelength of the light emitted at 27°C .
4. For the $2P \rightarrow 1S$ transition in the hydrogen atom calculate ω . Assuming the spontaneous emission lifetime of the $2P$ state to be 1.6 ns , calculate the Einstein B coefficient. Assume $n_0 \approx 1$.
5. Consider a laser with plane mirrors having reflectivities of 0.9 each and of length 50 cm filled with the gain medium. Neglecting scattering and other cavity losses, estimate the threshold gain coefficient required to start laser oscillation.
6. Calculate the ratio of stimulated to spontaneous for the wavelength 5893 \AA at 27°C , $k_b T = 0.025 \text{ eV}$.
7. Calculate the spontaneous lifetime of level 3 for the atomic system as shown below:

$$\begin{array}{l} 3 \text{ — } E_3 = 3 \text{ eV} \\ 2 \text{ — } E_2 = 1 \text{ eV} \\ 1 \text{ — } E_1 = 0 \text{ eV} \end{array}$$

The A coefficient of the various transitions are given by $A_{32} = 7 \times 10^7 \text{ s}^{-1}$, $A_{31} = 10^7 \text{ s}^{-1}$ and $A_{21} = 10^8 \text{ s}^{-1}$

8. State whether resonators made with the following mirror pairs are stable or not?
 - a. $R_1 = \infty$, $R_2 = 20 \text{ cm}$, $d = 25 \text{ cm}$
 - b. $R_1 = 20 \text{ cm}$, $R_2 = 20 \text{ cm}$, $d = 40 \text{ cm}$
 - c. $R_1 = 20 \text{ cm}$, $R_2 = -20 \text{ cm}$, $d = 15 \text{ cm}$.
9. Define Q factor and cavity lifetime.
10. What is numerical aperture of an optical fibre? Write its value in terms of fractional refractive index change.
11. Distinguish between step index fibre and graded index fibre structure
12. What are the sources of attenuation in an optical fibre?

13. In the case of multimode graded index fibre, using power law profile, show that a parabolic index fibre can accommodate nearly 25 modes.
14. A step-index fibre is made with a core of refractive index 1.5, a diameter of $29.5 \mu\text{m}$ and a fractional difference index of 0.0007. When it is operated at a wavelength of $1.3 \mu\text{m}$ find the V-number and the number of modes that the fibre will support.
15. Explain the basic principle of point holography.

Answer scripts must be emailed to sem5hcityphysics@gmail.com within 30 minutes of the end of the examination