Birla Institute of Technology & Science-Pilani, K. K. Birla Goa Campus

First Semester 2022-2023

PHY F213	Mid Semester Examination (Closed Book)	Maximum Marks: 40
Optics	Duration: 1.5 hours	Date: 31 October 2022

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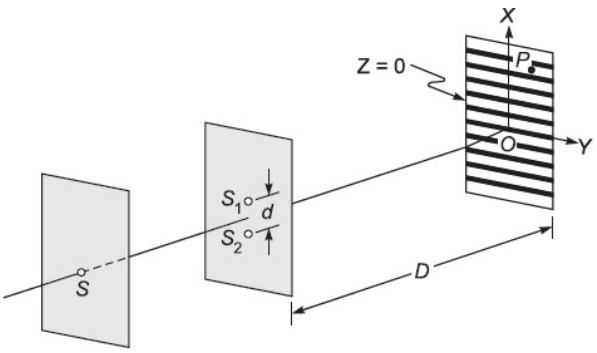
1. Consider a Young's double slit experiment (figure below). The distance between the slits S_1 and S_2 is d and the screen is kept at a large distance D from the slits. The electric field at a point P on the screen due to source S_1 is $\overrightarrow{\mathbf{E}_1}$ and that due to source S_2 is $\overrightarrow{\mathbf{E}_2}$.



   (a) In general the net electric field $\overrightarrow{\mathbf{E}}$ at any point P on the screen (in terms of $\overrightarrow{\mathbf{E}_1}$ and $\overrightarrow{\mathbf{E}_2}$) can be expressed as ——

   (b) In an experiment carried out using a monochromatic source of wavelength λ, the net electric field $\overrightarrow{\mathbf{E}}$ at any point P on the screen close to axis is found to be equal to $|\overrightarrow{\mathbf{E}_1}|^2 + |\overrightarrow{\mathbf{E}_2}|^2$. Explain what this implies and how this result is related to the spatial and/or temporal coherence of the source. Comment on the relation between the angular size of the source S and the slit separation d.

   (c) If the experiment is carried out using white light, only a few (colored) fringes are visible. Assuming that the visible spectrum extends from 400 nm to 700 nm, explain this phenomenon qualitatively on the basis of coherence length. (2 + 4+ 4 marks)

2. Consider the interference pattern formed by a thin film when illuminated by light source. Write down type of fringes (straight line/circular/any other) observed in the following cases. (a) Plane parallel film (b) A film with nonparallel surfaces (a wedge) when illuminated by (i) a plane wave (ii) point source (iii) An extended source. State in each of these cases whether the fringes are local or non-local. (10 marks)

3. In a Michelson interferometer experiment to determine the wavelength of a laser, if one of the mirrors is moved by a distance of 0.08 mm, 250 fringes cross the field of view. Further it is found that when the mirror is moved away from the equal path-length position by a distance of 5 cm the fringe pattern disappears all together. What is spectral width ($\Delta\nu$) of the source? Calculate the spectral purity (monochromaticity) of the source. (10 marks)

4. A He-Ne laser consists of a mixture of He and Ne gas in a narrow discharge tube placed between a pair of plane mirrors. The the laser transition ($\lambda_0 \approx 600$ nm) takes place between two levels of Ne named E6 and E3. The fluorescence emission from E6 to E3 has a spectral width of 1300 MHz. Comparing the laser cavity to a Fabry-Perot etalon, list all possible longitudinal mode frequencies in a laser cavity of length 30 cm. How will you alter the cavity so that the laser oscillates with a single longitudinal mode? (10 marks)

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