Indian Association for the Cultivation of Science
Kolkata 700032, India

First Year, Second Semester
2019-2020

PHS – 1201: ELECTRICITY, MAGNETISM & OPTICS

Assignment #1 - Geometrical Optics and Interference

UNDERSTANDING GEOMETRICAL OPTICS AND SOME FEATURES OF INTERFERENCE

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DUE : *13th March 2020*

INSTRUCTIONS

- You are free to discuss the questions among yourselves if you choose to do so. However, each one should write the answers independently at the end and submit it. You should be prepared to explain the steps and arguments in your answer if called upon to do so.
- Interpret the questions as a physicist; not as a mathematician. Make reasonable assumptions when required and mention them.
- Your answers can be brief and to the point, giving just the essential algebraic steps and arguments. The marks for each of the questions are given at the right end of the question. Total marks: **55**.
- I have tried to keep the questions clear, consistent with the notation used in the class and error-free. But if you have any difficulties on these counts, feel free to email me.

1. The left end of a long glass rod of index 1.6350 is polished to a convex spherical surface of radius 2.50 cm. A small object is located in the air and on the axis 9.0 cm from the vertex. Find (a) the primary and secondary focal lengths and (b) the image distance. **[3]**

2. A spherical surface with a radius of + 2.650 cm is polished on the end of a glass rod of index 1.560. Find its power when placed in (a) air, (b) water of index 1.3330, (c) oil of index 1.480, and (d) an organic liquid of index 1.780. **[5]**

3. An object located 12.0 cm in front of a thin lens has its image formed on the opposite side 42.0 cm from the lens. Calculate (a) the focal length of the lens and (b) the lens power. **[3]**

4. An equi-concave lens is to be made of flint glass of index 1.750. Calculate the radii of curvature if it is to have a power of - 3.0 Dioptre. **[3]**

5. An object is located 1.60 m from a white screen. A lens of what focal length will be required to form a real and inverted image on the screen with a magnification of - 6.0? **[3]**

6. Two lenses with focal lengths f_1 = + 5.0 cm and f_2 = + 10.0 cm are located 5.0 cm apart. If an object 2.50 cm high is located 15.0 cm in front of the first lens, find (a) the position and (b) the size of the final image. **[5]**

7. A double-convex lens is to be made of glass having a refractive index of 1.580. If one surface is to have twice the radius of the other and the focal length is to be + 6.0 cm, find the radii. **[3]**

8. An equi-convex lens 2 cm thick and having radii of curvature of 2 cm is mounted in the end of a water tank. An object in air is placed on the axis of the lens 5 cm from its vertex. Find the position of the final image. Assume refractive indices of 1.00, 1.50, and 1.33 for air, glass, and water, respectively. **[3]**

9. A parallel beam of light enters a clear plastic bead 2.50 cm in diameter and index 1.440. At what point beyond the bead are these rays brought to a focus? **[3]**

10. The left end of a long glass rod of index 1.620 is polished to a convex surface of radius + 1.20 cm and then submerged in water of index 1.3330. A small object 2.50 cm high is located in the water 10.0 cm in front of the vertex. Calculate (a) the primary and secondary focal lengths, (b) the power of the surface, (c) the image distance, and (d) the size of the image. **[5]**

11. Two lenses having focal lengths f_1= + 9.0 cm and f_1= -18.0 cm are placed 3.0 cm apart. If an object 2.50 cm high is located 20.0 cm in front of the first lens, calculate (a) the position and (b) the size of the final image. **[3]**

12. Consider two electromagnetic waves originating from two sources S_1 and S_2 given by:

$$\vec{E_1} = \vec{E_{01}}\ cos(\vec{k_1}.\vec{r} - \omega t - \epsilon_1)$$
$$\vec{E_2} = \vec{E_{02}}\ cos(\vec{k_2}.\vec{r} - \omega t - \epsilon_2)\ .$$

Hence find the following results: (a) Give an expression for the resultant field at a point P; (b) Obtain the expression for the phase difference and the intensity at that point; (c) If the two waves are parallel, derive an expression for the intensity; (d) If the amplitudes of the two waves are equal, and the waves are parallel, find the expression for the intensity; (e) The visibility of the fringes in an interference pattern is defined by

$$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}}\ .$$

Derive an expression for the visibility of the pattern resulting from the two coherent waves, assuming their fields to be parallel; (f) What is the visibility when the two field amplitudes are equal? **[10]**

13. A quasi-monochromatic beam of wavelength λ_0 illuminates Young's experiment, generating a fringe pattern having a 5.6-mm separation between consecutive dark bands. If the distance between the plane containing the apertures and the plane of observation is 10 m, and if the two sources are separated by 1.0 mm, what is the wavelength of the light? **[3]**

14. A double slit with a separation of 0.250 mm between centres is illuminated with green light of wavelength 570 THz from a cadmium-arc lamp. How far behind the slits must one go to measure the fringe separation and find it to be 0.80 mm between centres? **[3]**