Chapter # 09 (Physical Optics)

Important Short Questions

1. Define wave front and a ray of light.

Ans: Wavefront:

The surface on which all the points of waves have same phase of vibration is known as wavefront. It has two types:

- Spherical wavefront
- Plane wavefront

Ray of light:

The line normal to the wavefront which shows the direction of propagation of light is called a ray of light.

2. State Huygens's Principle.

Ans: Huygens's Principle:

If the location of the wavefront at any instant t is known then Huygen's principle enables us to determine shape and location of the new wavefront at a later time $t + \Delta t$.

It has two parts:

- Every point of wavefront may be considered as a source of secondary wavelets which spread out in forward direction with a speed equal to the speed of propagation of the wave.
- The new position of the wavefront after a certain interval of time can be found by constructing a surface that touches all the secondary wavelets.

3. What are the condition for detectable interference?

Ans: Condition for detectable interference patter:

The condition for detectable interference:

- The interfering beams must be monochromatic.
- The interfering beams of light must be coherent.
- The sources should be narrow and very close to each other.
- The intensity of the two sources be comparable.

4. What is meant by coherent source? Give one example.

Ans: Coherent Source:

The monochromatic sources of light which emit waves, having a constant phase difference are called coherent sources.

Example:

The coherent light beam is used a monochromatic source to illuminate a screen containing two small closely spaced holes, usually in the shape of slits. The light emerging from two slits us coherent because a single source produces the original beam.

5. Prove that $\Delta y = \frac{\lambda L}{d}$.

Ans: Proof:

In order to find the distance between two adjacent bright fringes on the screen mth and (m + 1)th fringes are considered.

$$\text{Position of the mth fringe} = Y_m = (m)\left(\frac{\lambda L}{d}\right)$$

$$\text{Position of the (m + 1)th fringe} = Y_{m+1} = (m+1)\left(\frac{\lambda L}{d}\right)$$

$$\Delta Y = Y_{m+1} - Y_m$$

$$\Delta Y = (m+1)\left(\frac{\lambda L}{d}\right) - (m)\left(\frac{\lambda L}{d}\right)$$

$$\Delta Y = (m + 1 - m)\left(\frac{\lambda L}{d}\right)$$

$$\mathbf{\Delta Y = \frac{\lambda L}{d}}$$

Hence proved.

6. Why central spot of Newton's rings is dark?

Ans: Dark Central Spot:

At the point of contact of the lens and the glass plate, the thickness of the film is effectively zero but due to reflection at the lower surface of air film from denser medium, an additional path difference of $\lambda/2$ is (phase change of 180^0) introduced. Consequently, the centre of Newton's rings is dark due to destructive interference.

7. Define Michelson's experiment. Write its uses.

Ans: Michelson's Interferometer:

Michelson's interferometer is an instrument that can be used to measure distance with extremely high precision. Albert A. Michelson devised this instrument in 1881, using the idea of interference of light rays.

Uses:

- It is used for the determination of wavelength of light.
- Michelson's measure the length of the standard meter in terms of wavelength of red cadmium light and prove that

  Standard meter = 1553163.5 wavelength of light
- If light of wavelength λ = 400 nm is used, then it can measure the thickness upto 10^{-4} mm (or 100 nm).
- It is used to observe the interference of light.

8. What is difference between interference and diffraction?

Ans: Interference:

When two identical light waves travelling in the same direction are superimposed to each other in such a way that they reinforce each other at some points while at some points they cancel the effect of each other. Such phenomenon is called interference of light.

Condition for constructive interference:

Path difference = $m\lambda$ where m = 0,1,2,3,4,……

Condition for destructive interference:

Path difference = $\left(m + \frac{1}{2}\right)\lambda$ where m = 0,1,2,3,4,……

Diffraction:

The property of bending of light around the obstacle and spreading of light waves intro the geometrical shadow of an obstacle is called diffraction.

9. What is meant by optical rotation?

Ans: Optical Rotation:

When a plane of polarized light is passed through certain crystals. They rotate the plane of polarization. Quartz and sodium chloride crystals are typical examples, which are termed optically active crystals. A few millimeters thickness of such crystals will rotate the plane of polarization by many degrees. Certain organic substance, such as sugar and tartaric acid show optical rotation when they are in solution, this property of optical active substances can be used to determine the concentration in the solutions.

Exercise Short Questions

1. Under what conditions, the two sources of light behave as coherent sources?

Ans: Conditions for coherent sources: -

Two and more sources are said to be coherent if:

- The sources must emit waves of same wavelength (monochromatic).
- The waves emitted by the sources must have constant phase difference.

2. How is the distance between interference fringes affected by the separation between the slits of Young's experiment? Can fringe disappear?

Ans: By increasing the separation between slits fringe spacing is decreased and vise verse.

Explanation: -

The fringe spacing is given by,

$$\Delta y = \frac{\lambda L}{d}$$

This equation shows that the distance between fringes (Δy) is inversely proportional to the separation between the slits (d).

Fringe can disappear: -

When separation between the slits is made large enough, the fringes will be so close that they cannot be distinguished from one another and pattern will disappear.

3. Can the visible light produce interference fringes? Explain.

Ans: Yes, visible light (White light) can produce the interference fringes.

Explanation: -

White light consists of seven colours. Each spectral colour produces its own interference fringe pattern. These patterns overlap to give resultant coloured interference pattern.

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4. In Young's experiment, one of the slits is covered with blue filter and other with red filter. What would be the pattern of light intensity on the screen?

Ans: No, interference pattern of bright and dark fringes is formed on screen.

Reason: -

Blue filter gives blue light and red light gives red light. For interference, the two waves must have same frequency, and constant phase difference. As in this case red and blue light have different wavelengths. Therefore, no interference take place and we will observe two coloured images on the screen with constant intensity.

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5. Explain whether Young's experiment is an experiment for studying interference or diffraction effects of light.

Ans: Basically, it is an experiment to study the interference of light though it involves diffraction.

Explanation: -

As the light passes through the slits it bends around the slit (Diffraction). Then these diffracted rays superpose each other to produce the interference pattern effect of light. But in this experiment, we only study the interference effect of light.

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6. An oil film spreading over a wet footpath shows colours? Explain how does it happen?

Ans: This happens due to the interference of light waves.

Reason: -

Oil film spread over a wet foot path acts like a thin film. A light beam is incident on the upper surface. Some part of light is reflected from the upper surface and rest of light is reflected from the lower surface of thin film of oil. The two reflected coherent beams superpose and an interference pattern of different colours is obtained.

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7. Could you obtain Newton's rings with transmitted light? If yes, would the pattern be different from that obtained with reflected light?

Ans: Yes, the Newton's ring can be obtained by transmitted light.

Reason: -

The pattern obtained from transmitted light is exactly opposite to that of reflected light. There is no phase change in this case. Every dark ring is converted into bright ring and vice versa. So, the centre of Newton's ring is bright.

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8. In white light spectrum obtained with diffraction grating, the third order image of wavelength coincides with fourth order image of second wavelength. Calculate the ratio of the two wavelengths?

Ans: For first wavelength $d\sin\theta = 3\lambda_1$ _____ (1)

For second wavelength $d\sin\theta = 4\lambda_2$ _____ (2)

Comparing equations (1) and (2), we get.

$$3\lambda_1 = 4\lambda_2$$

$$\frac{\lambda_1}{\lambda_2} = \frac{4}{3}$$

Hence, the ratio is 4 : 3

9. How would you manage to get more orders of spectra using grating?

Ans: As we know that,

$$d\sin\theta = n\lambda$$

$$n = \frac{d\sin\theta}{\lambda}$$

- For maximum value of n, $\sin\theta = 1$, $\theta = 90^o$.
- For a given diffraction, the grating element is constant.

$$n \propto \frac{1}{\lambda}$$

Hence, by decreasing the wavelength we can obtain more order of spectra.

10. Why Polaroid sunglasses are better than ordinary sun glasses?

Ans: Polaroid sunglasses are better than sunglasses. Because:

- They reduce the glare of light.
- Snow and rough road is partially polarized and produce glare, therefore the glare is reduced by the polaroid sunglasses.
- They protect the eyes from harmful and bright rays of sun light.

11. How would you distinguish between unpolarized and plane polarized light?

Ans: Ordinary light (Unpolarized light) has a number of planes of vibrations on the other hand in polarized light, vibration is confined in one plane only. The unpolarized and polarized light can be distinguished by using a polarized light.

- If the transmitted light is plane polarized, it becomes dimmer and disappear at certain orientation.
- If the transmitted light is unpolarized, it becomes dim but not completely blocked at any orientation.

12. Fill in the blanks.

Ans:

(i) According to **Huygens's principle**, each point on a wave front act as a source of secondary **wavelets**.

(ii) In Young's experiment, the distance between two adjacent bright fringes for violet light **smaller** than that for green light.

(iii) The distance between bright fringes in the interference pattern **increases** as the wavelength of the light used increases.

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