Important Derivations Wave Optics

Here are some of the important derivations in wave optics for Class 12 Physics (NCERT syllabus):

1. Derivation of Young's Double-Slit Experiment (YDSE)

This experiment demonstrates the interference of light, where two coherent light waves overlap to form a pattern of bright and dark fringes.
Derivation:

- Let d be the distance between the two slits, and D the distance from the slits to the screen.
- The path difference between the light waves reaching a point P on the screen is $\Delta x = d \sin\theta$.
- For small angles, $\sin\theta \approx \theta = \frac{y}{D}$, where y is the distance of the point from the central maximum.
- The condition for constructive interference (bright fringes) is:

$$d \sin\theta = n\lambda \quad \text{or} \quad y_n = \frac{n\lambda D}{d}$$

  where n is an integer (order of the fringe), and λ is the wavelength of light.
- The condition for destructive interference (dark fringes) is:

$$d \sin\theta = (n + \frac{1}{2})\lambda \quad \text{or} \quad y_n = \frac{(n + \frac{1}{2})\lambda D}{d}$$

2. Derivation of Fringe Width in YDSE

Fringe width (β) is the distance between two consecutive bright or dark fringes.

- From the formula for the position of bright fringes:

$$y_n = \frac{n\lambda D}{d}$$

  The fringe width is the distance between two consecutive bright fringes:

$$\beta = y_{n+1} - y_n = \frac{\lambda D}{d}$$

3. Condition for Diffraction through a Single Slit

In single-slit diffraction, a pattern of alternating bright and dark fringes is observed due to the spreading of light.
Derivation:

- The angular width of the central maximum can be derived using the condition that the path difference between light from opposite ends of the slit should be an integral multiple of the wavelength.
- The condition for the first minimum is:

$$a \sin \theta = \lambda$$

where a is the width of the slit.

- For small angles, $\theta \approx \frac{y}{D}$, so the angular width of the central maximum is:

$$\theta = \frac{\lambda}{a}$$

4. Brewster's Law

Brewster's law gives the condition for maximum polarization when light is incident on a transparent surface.

Derivation:

- The law states that when light is incident at the Brewster angle (θ_B), the reflected and refracted rays are perpendicular.
- Using Snell's law at the Brewster angle:

$$\tan \theta_B = \frac{n_2}{n_1}$$

where n_1 and n_2 are the refractive indices of the two media.

5. Polarization by Reflection

This derivation involves explaining how light becomes polarized upon reflection at a specific angle, which is Brewster's angle.

- At Brewster's angle, the reflected light is completely polarized perpendicular to the plane of incidence.

These are some key derivations in wave optics. Each of these forms a crucial part of the understanding of wave phenomena in light, as discussed in the Class 12 NCERT Physics curriculum.