10 Wave Optics

10.1 (a) Find an expression for the total path difference and the condition for maximum intensity.

Path difference before slits: $\Delta L_1 = d \sin \alpha$. Path difference after slits: $\Delta L_2 = d \sin \beta$. Total path difference ΔL:

$$\Delta L = \Delta L_2 - \Delta L_1 = d(\sin \beta - \sin \alpha)$$

Condition for maximum intensity (constructive interference):

$$d(\sin \beta - \sin \alpha) = m\lambda, \quad \text{where } m = 0, \pm 1, \pm 2, \ldots$$

10.2 (b) Show that the angular separation between adjacent maxima is independent of α for small β.

For the m-th and $(m+1)$-th maxima:

$$\sin \beta_m = \sin \alpha + \frac{m\lambda}{d}$$
$$\sin \beta_{m+1} = \sin \alpha + \frac{(m+1)\lambda}{d}$$

The difference is:

$$\sin \beta_{m+1} - \sin \beta_m = \frac{\lambda}{d}$$

For small angles β, we can use the approximation $\sin \beta_{m+1} - \sin \beta_m \approx \Delta\beta \cos \beta$, where $\Delta\beta = \beta_{m+1} - \beta_m$.

$$\Delta\beta \cos \beta \approx \frac{\lambda}{d}$$

For small values of β, $\cos \beta \approx 1$. Therefore, the angular separation is:

$$\Delta\beta \approx \frac{\lambda}{d}$$

This expression is independent of the angle of incidence α.