Conditions of Maxima and Minima

For maximum intensity (i.e maxima), the path difference should be equal to $n\lambda$, i.e.,

$$2\mu t\cos r + \frac{\lambda}{2} = n\lambda$$

or, $$2\mu t\cos r = (2n-1)\frac{\lambda}{2}$$

where $n = 1, 2, 3, \ldots$

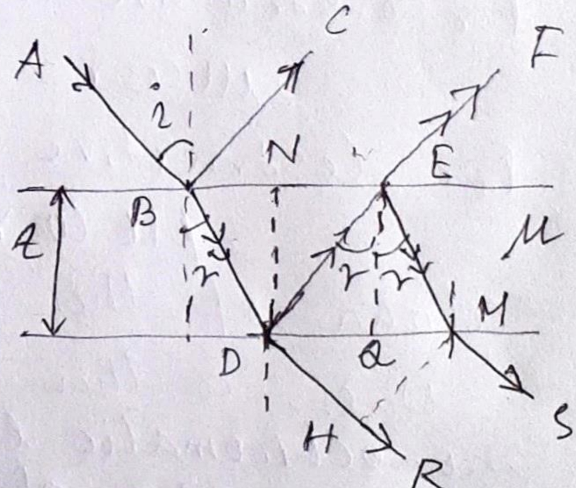
For minimum intensity (i.e minima), the path difference should be equal to $(2n+1)\frac{\lambda}{2}$ i.e

$$2\mu t\cos r + \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2}$$

or, $$2\mu t\cos r = n\lambda$$

Interference in thin films for Transmitted ~~reflected~~ light

Let us consider a thin film of uniform thickness t and refractive index μ. Further let a ray AB of monochromatic light of wavelength λ is incident on it at an angle i as shown in the figure. This ray after refraction at B follows the path BD. At D, it is partially reflected along DE and partially refracted along DR. At point E, the ray is partly reflected along EM and then it is partly refracted along MS.



Let us now calculate the optical path difference between DR and MS. Draw a normal MH on DR. As the paths beyond MH are equal.

$\therefore$ Path difference = Path DEM in film − Path DH in air

$= \mu(DE + EM) - DH = 2\mu DE - DH$ [As $DE = EM$]

In right angled ΔDEQ,

$$\frac{EQ}{DE} = \cos r \text{ or, } DE = \frac{EQ}{\cos r} = \frac{t}{\cos r}$$

Also, in right angled ΔDEQ

$$\frac{DQ}{EQ} = \tan r, \text{ or, } DQ = EQ \tan r = t \tan r$$

Again in right angled ΔDMH

$$\frac{DH}{DM} = \sin i \text{ or, } DH = DM \sin i = (DQ + QM) \sin i$$

or, $DH = 2\, DQ \sin i$ (As $DQ = QM$)

$\therefore$ $DH = 2t \tan r \sin i$

$\therefore$ Path difference $= \frac{2\mu t}{\cos r} - 2t \tan r \frac{\sin i}{\sin r} \times \sin r$

$$= \frac{2\mu t}{\cos r} - \frac{2\mu t}{\cos r} \sin^2 r = \frac{2\mu t}{\cos r}(1 - \sin^2 r) = 2\mu t \cos r$$

Condition for maxima

For constructive interference, the path difference $= n\lambda$

$\therefore$ $2\mu t \cos r = n\lambda$, $n = 0, 1, 2, 3 \ldots$

For destructive interference path difference $= (2n-1)\frac{\lambda}{2}$

$$2\mu t \cos r = (2n-1)\frac{\lambda}{2}$$

Colour of thin films

When a thin film is illuminated by monochromatic light, it will appear bright if the condition of maxima i.e $2\mu t \cos r = (2n-1)\frac{\lambda}{2}$ is satisfied and dark if the condition of minima $2\mu t \cos r = n\lambda$ is satisfied. When white light is incident on the film, it will appear coloured when the condition of maxima for various wavelengths is satisfied. For a particular value of t and r, only certain wavelengths satisfy the condition of maxima. Therefore, only these colours will be present in the reflected light and film will appear coloured.