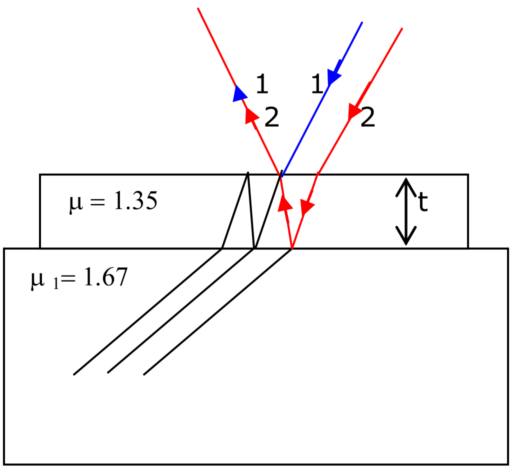
Q- A thin film of index of refraction of 1.35 is placed over a glass plate of refractive index 1.67. You shine white light on the film and notice that the only two visible colors in the reflected light are 400 and 525 nm. Determine the thickness of the film.

The question is based on the concept of the interference through thin films. When light incident on a thin film of a transparent media a part is directly reflected and comes back (blue) while the rest part is refracted and after reflection from the lower surface again refracted and comes back to the same medium (red). These two beams are having a path difference and hence interfere with each other.



Let the thickness of the film is t. If the incidence is near normal the additional path traveled by the light coming after refraction reflection and refraction is 2t in the film and hence equivalent path difference will be 2μt.

As both reflections are from the denser medium there will be no additional phase difference or path difference is to be considered. For the interference to be constructive, this path difference must be equal to nλ where n is an integer and λ is the wavelength of the light.

Let for the light of wavelength λ_1= 400 nm the interference is corresponding to maxima of order n_1 then we have

$$n_1\lambda_1 = 2\mu t \qquad \text{---------------------------} \ (1)$$

For the second light for the same thickness of the film the order of the maxima will be different and let it be n_2 then we have

$$n_2\lambda_2 = 2\mu t \qquad \text{---------------------------} \ (2)$$

Equating from the two equations we have

$$n_1\lambda_1 = n_2\lambda_2$$

Or $$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{525}{400} = \frac{21}{16}$$

As the order of maxima cannot be a fraction, the thickness of the film is such that n_1 = 21 and n_2 = 16

Substituting the value of n_1 in equation 1 the thickness of the film is given by

$$t = \frac{n_1\lambda_1}{2\mu} = \frac{21*400*10^{-9}}{2*1.35} = 3.11*10^{-6}\,m$$

For the second wave we have the same thickness again as

$$t = \frac{n_2\lambda_2}{2\mu} = \frac{16*525*10^{-9}}{2*1.35} = 3.11*10^{-6}\,m$$

This is the minimum thickness. Other thicknesses will be with the ratio 42/32 and so on.
