Q2. Explain how Michelson Interferometer can be used to measure the wavelength of a monochromatic light.

Draw fig. 2.1 from Q1

The two mirrors M_1 and M_2 are adjusted such that a circular fringes are observed. Let d_1 be the initial thickness between M_1 and M'_2 (image of M_2 as seen through the telescope) corresponding to a dark fringe of the order n_1. Let M_1 be moved through a distance x and the number of dark fringes that appear at the centre be m. Therefore, the final thickness between M_1 and M'_2 is $d_2 = d_1 + x$ ……….(a)

and the corresponding order of fringe is $n_2 = n_1 + m$ ………….(b)

We have, $2d_1 = n_1\lambda$ …………………………(c) here, $\theta = 0^0$ and $\cos\theta = 1$

$2d_2 = n_2\lambda$ …………………………(d)

From (c) & (d), $2(d_2 - d_1) = (n_2 - n_1)\lambda$

$2x = m\lambda$, using (a) & (b)

$$\lambda = \frac{2x}{m}$$

Thus, knowing the values of x and m, we can measure λ.

Q3. Explain how Michelson Interferometer can be used to measure small difference in wavelengths.

Draw fig. 2.1 from Q1

Suppose a source of light S emits two close wavelengths λ_1 and λ_2, where $\lambda_1 > \lambda_2$. When the apparatus is adjusted for a circular fringes, each wavelength will produce its own system of fringes which will be very close to each other. By adjusting M_1, a position is found where the fringes are very bright and distinct. In this position, the bright fringes due to λ_1 coincide with the bright fringes due to λ_2. Now, M_1 is moved further till the visibility of the fringes becomes almost zero. In this position, the dark fringes due to λ_1 fall on the bright fringes due to λ_2 and hence the fringes become almost invisible.

Again by further moving M_1, the bright fringes due to λ_1 fall on the bright fringes due to λ_2 and the visibility of the fringes again increases and the fringes become bright and distinct.

Let x be the distance moved by the mirror M_1 for two consecutive states of maximum brightness and distinctness. In moving from one state of maximum brightness to the next consecutive brightness, the number of fringes (m_2) crossing the field of view of λ_2 is one more than the number of fringes (m_1) crossing the field of view of λ_1.

i.e. $m_2 = m_1 + 1$ …………………… (a)

therefore, $m_1 = \frac{2x}{\lambda_1}$ and $m_2 = \frac{2x}{\lambda_2}$

putting m_1 & m_2 in (a), we have

$$\frac{2x}{\lambda_2} = \frac{2x}{\lambda_1} + 1$$

$$\frac{\lambda_1 - \lambda_2}{\lambda_1\lambda_2} = \frac{1}{2x}$$

Since $\lambda_1 \approx \lambda_2$, we can write $\lambda_1 = \lambda_2 = \lambda$, also $\lambda_1 - \lambda_2 = \Delta\lambda$

$$\therefore \Delta\lambda = \frac{\lambda^2}{2x}$$

Thus, knowing the values of λ and x, we can measure Δλ.