Q1

Given:

- Distance between slits (d) = 0.8 mm = 0.8×10^{-3} m
- Distance to screen (L) = 1.6 m
- Distance between the second-order maxima (Δy) = 5 mm = 5×10^{-3} m

The distance between two second-order maxima is given by:

$$\Delta y = 2 \cdot y_m = 2 \cdot \frac{m\lambda L}{d}$$

where m is the order of the maximum (for second-order maxima, $m = 2$), λ is the wavelength, L is the distance to the screen, and d is the distance between the slits.

Rearranging for λ:

$$\Delta y = 2 \cdot \frac{2\lambda L}{d} \implies \lambda = \frac{\Delta y \cdot d}{4L}$$

Substituting the given values:

$$\lambda = \frac{(5 \times 10^{-3}\,\mathrm{m}) \cdot (0.8 \times 10^{-3}\,\mathrm{m})}{4 \cdot 1.6\,\mathrm{m}}$$

$$\lambda = \frac{4 \times 10^{-6}\,\mathrm{m}^2}{6.4\,\mathrm{m}} = 6.25 \times 10^{-7}\,\mathrm{m}$$

Therefore, the wavelength of the light is:

$$\lambda = 625\,\mathrm{nm}$$

Q2

Given:

- Wavelength of laser light (λ) = 600 nm = 600×10^{-9} m
- Distance between slits (d) = 1 cm = 1×10^{-2} m
- Order of the maximum (m) = 3
- Distance to the screen (L) = 5 m

(a) Angle of the 3rd Order Maximum

The angle for the m-th order maximum is given by the diffraction equation:

$$d \sin \theta_m = m\lambda$$

For the 3rd order maximum ($m = 3$):

$$\sin \theta_3 = \frac{3\lambda}{d}$$

Substituting the given values:

$$\sin \theta_3 = \frac{3 \times 600 \times 10^{-9}\,\text{m}}{1 \times 10^{-2}\,\text{m}}$$

$$\sin \theta_3 = 1.8 \times 10^{-4}$$

$$\theta_3 = \arcsin(1.8 \times 10^{-4}) \approx 0.0103^\circ$$

(b) Distance between the 0th Order and 3rd Order Maximum on the Screen

The position y_m of the m-th order maximum on the screen is given by:

$$y_m = L \tan \theta_m$$

For small angles, $\tan \theta_m \approx \sin \theta_m$, so:

$$y_3 = L \sin \theta_3$$

Substituting the values:

$$y_3 = 5\,\text{m} \times 1.8 \times 10^{-4}$$

$$y_3 = 0.9\,\text{mm}$$

Therefore, the distance between the 0th order and the 3rd order maximum is:

$$y_3 = 0.9\,\text{mm}$$

Q3

Given:

- Wavelength of green light (λ) = 525 nm = 525×10^{-9} m

For destructive interference, the path difference should be:

$$\Delta = (m + 0.5)\lambda$$

where m is the order of the interference (for minimum thickness, $m = 0$).

In a thin film, the path difference is:

$$\Delta = 2tn$$

where t is the thickness of the film and n is the refractive index of the film.

For destructive interference, we set the path difference to:

$$2tn = (0.5)\lambda$$

Solving for the minimum thickness t:

$$t = \frac{0.5\lambda}{2n} = \frac{\lambda}{4n}$$

Assuming the refractive index n cancels out for minimum thickness:

$$t = \frac{0.5\lambda}{2}$$

Substituting the given wavelength:

$$t = \frac{0.5 \times 525 \times 10^{-9}\,\text{m}}{2}$$

$$t = 131.25 \times 10^{-9}\,\text{m} = 131.25\,\text{nm}$$

Therefore, the minimum thickness of oil that will produce destructive interference in green light is:

$$t = 131.25\,\text{nm}$$

Q4

Given:

- Mirror displacement (d) = 0.382 mm = 0.382×10^{-3} m
- Number of fringes (N) = 1700

Each time the pattern reproduces itself corresponds to a full round trip for the light. Therefore, one fringe corresponds to a displacement of one wavelength. Since the light travels to the mirror and back, the total path length is doubled:

$$\Delta x = 2d$$

The total path difference for 1700 fringes is:

$$N\lambda = 2d$$

Solving for the wavelength (λ):

$$\lambda = \frac{2d}{N}$$

Substituting the given values:

$$\lambda = \frac{2 \times 0.382 \times 10^{-3}\,\mathrm{m}}{1700}$$

$$\lambda = \frac{0.764 \times 10^{-3}}{1700}$$

$$\lambda = 4.494 \times 10^{-7}\,\mathrm{m} = 449.4\,\mathrm{nm}$$

Therefore, the wavelength of the light is:

$$\lambda = 449.4\,\mathrm{nm}$$

The color corresponding to this wavelength is violet.

Q5

Given two waves represented by cosine functions:

$$y_1 = A\cos(\omega t + \phi_1)$$

$$y_2 = A\cos(\omega t + \phi_2)$$

Resultant Wave

The resultant wave is the sum of the two waves:

$$y_{\text{resultant}} = y_1 + y_2$$

Substituting the given functions:

$$y_{\text{resultant}} = A\cos(\omega t + \phi_1) + A\cos(\omega t + \phi_2)$$

Using trigonometric identities, we can simplify the resultant wave:

$$y_{\text{resultant}} = A(\cos(\omega t + \phi_1) + \cos(\omega t + \phi_2))$$

Magnitude of the New Amplitude

The magnitude of the new amplitude can be found by using the trigonometric identity for the sum of cosines:

$$A_{\text{new}} = A\left(\cos(\phi_1 - \phi_2) + 1\right)$$

Thus, the magnitude of the new amplitude is:

$$A_{\text{new}} = A\left(\cos(\phi_1 - \phi_2) + 1\right)$$