1 A	A beam of light composed of two wavelengths (λ_1= 589 nm and λ_2= 589.6 nm) is incident normally on a grating. The distance between the slits is d. The two lines, both of the fourth order, corresponding to the two wavelengths, have angular positions whose difference is 44', Then the value of d is. (Write the answer correct upto two decimal places) (2 Marks) Part-B Ans: 2.36 μm Range: 2.26 to 2.46 Hints: $d sin\theta_1 = m\lambda_1; d sin(\theta_1 + \alpha) = m\lambda_2 \rightarrow d^2 = \frac{m^2(\lambda_1^2+\lambda_2^2-2\lambda_1\lambda_2 cos\alpha)}{\sin^2\alpha} \rightarrow d = 2.36\ \mu m$
1 B	A beam of light composed of two wavelengths (λ_1= 589 nm and λ_2= 589.6 nm) is incident normally on a grating. The distance between the slits is d. The two lines, both of the eighth order, corresponding to the two wavelengths, have angular positions whose difference is 2.5°, Then the value of d is (2 Marks) (Write the answer correct upto two decimal places) Part-B Ans: 4.72 μm Range: 4.62 to 4.82 Hints: $d sin\theta_1 = m\lambda_1; d sin(\theta_1 + \alpha) = m\lambda_2 \rightarrow d^2 = \frac{m^2(\lambda_1^2+\lambda_2^2-2\lambda_1\lambda_2 cos\alpha)}{\sin^2\alpha} \rightarrow d = 4.72\ \mu m$
2 A	Three perfect linear polarizers are stacked normal to the central axis. A natural light of intensity I_0 is incident on the stack along the central axis . The first and last polarizers are crossed. If the middle polarizer is rotated at a rate of 5 rad/s about the central axis then the intensity of the emerging light oscillates with an angular frequency of (2 Marks) PART-B Ans: 20 rad/s Range: NA Hints: $I = I_2\cos^2(90-\theta) = I_1\cos^2(\theta)\sin^2(\theta) = \frac{I_{inc}}{2}\cos^2(\theta)\sin^2(\theta) \rightarrow I = \frac{I_{inc}}{16}(1-\cos(4\theta))$
2 B	Three perfect linear polarizers are stacked normal to the central axis. A natural light of intensity I_{inc} is incident on the stack along the central axis . The first and last polarizers are crossed. If the middle polarizer is rotated at a rate of 10 rad/s about the central axis then the Intensity of the emerging light oscillates with an angular frequency of (2 Marks) PART-B Ans: 40 rad/s Range: NA Hints: $I = I_2\cos^2(90-\theta) = I_1\cos^2(\theta)\sin^2(\theta) = \frac{I_{inc}}{2}\cos^2(\theta)\sin^2(\theta) \rightarrow I = \frac{I_{inc}}{16}(1-\cos(4\theta))$
3	If the orthogonal polarization components of a wave are given by $\overrightarrow{E_x}(z,t) = \hat{\imath}E_0\cos\left(\omega\left(t-\frac{z}{v}\right)\right)$ $\overrightarrow{E_y}(z,t) = \hat{\jmath}E_0\cos\left(\omega\left(t-\frac{z}{v}\right)-\frac{5\pi}{4}\right)$

	Then the state of polarization of the wave is (a) Ellipse (b) Circle (e) Linear at 135° with respect to x-axis (f) Linear at 45° with respect to x-axis PART-A Ans: (a) Ellipse (1 Mark)
4	The distance between the second and sixth minima of a single slit diffraction pattern is 0.4 mm. The screen is at a distance of 40 cm away from the slit. The wavelength of the incident light is 600 nm. The width of the slit (in mm) is (consider the angular positions of the minima are small) (1 Mark) (Write the answer correct upto two decimal places) PART-A Ans: 2.4 Range: 2.35 to 2.45 Hints: $6\theta - 2\theta = \frac{d_6 - d_2}{D} = \frac{0.4\ mm}{40cm} \rightarrow \theta = 0.25\ mrad \rightarrow a = \frac{\lambda}{\sin(\theta)} = 2.4\ mm$
5	The convex surface of a plano-convex lens of glass with a radius of curvature R=20 cm is placed on a glass plate. A certain ring observed in the reflected light has a radius *r*=2.0 mm. Watching this ring, the lens is shifted upwards by a distance *h*=7.5 μm. The new radius of the ring is (2 Marks) (Write the answer correct upto two decimal places) PART-B Ans: 1.0 mm Range: 0.98 mm to 1.02 mm Answer : $r' = 1.0\,\text{mm}$. $d_n = \frac{1}{2}\frac{r_n^2}{R}$, *and* $2d\mu = n\lambda$ $\Rightarrow \frac{r_n^2}{R} = n\lambda$, *and* $\frac{r'^2_n}{R} + 2\Delta h = n\lambda$, $r'^2_n = r_n^2 - 2R\Delta h$ $= 2.0\times 2.0\times 10^{-6} - 2\times 20\times 10^{-2}\times 7.5\times 10^{-6} = 1.0\times 10^{-6}\,\text{m}^2$ $r'_n = 1.0\,\text{mm}$
6	Light with a wavelength of 600 nm falls normally on the surface of a glass wedge (refractive index, n=1.5). A fringe pattern whose neighboring maxima on the surface of the wedge are separated by a distance 0.17 mm is observed in the reflected light. The angle between the wedge faces is (in minutes up to two decimal points) (1 Mark) (Write the answer correct upto two decimal places) PART-A Ans: 4.04

	Range: 3.98 to 4.1 Ans: $\Delta x = \dfrac{\lambda}{2\alpha n_f} \Rightarrow \alpha = \dfrac{\lambda}{2\Delta x n_f}$ (in radian) $\alpha = \dfrac{600\times10^{-9}}{2\times0.17\times10^{-3}\times1.5} = \dfrac{60}{51}\times10^{-3}$ rad $= 4.04'$
7	In a Newton's rings arrangement, the radius of curvature of the curved surface is 27 cm. The radii of the 5th and 15th dark rings are 0.18 cm and 0.22 cm, respectively. The wavelength of incident light is (in nm) (1 Mark) (Write the answer correct upto two decimal places) PART-A Ans: 592.6 nm Range: 592 to 593 Answer: $\lambda = \dfrac{r_{m+n}^2 - r_m^2}{nR} = \dfrac{(0.22)^2-(0.18)^2}{10\times27}\times10^{-2} = \dfrac{0.4\times0.04}{270}\times10^{-2}$ $= \dfrac{16\times10^{-5}}{270} = 5925$ A
8	In the Newton's rings arrangement, if the incident light consists of two wavelengths, 580 nm and 582 nm, calculate the distance (from the point of contact) at which the rings will disappear. Assume that the radius of curvature of the curved surface is 30 cm. (1 Mark) (Write the answer correct upto two decimal places) PART-A Ans: 5.02 mm Range: 5.00 mm to 5.04 mm Answers: $m\lambda_2 = (m+1/2)\lambda_1 \Rightarrow m582 = (m+1/2)580$ $2m = 290 \Rightarrow m = 145,$ $r_m^2 = m\lambda R = 145\times580\times10^{-9}\times30\times10^{-2} = 25.2\times10^{-6} = 25.2\,\mu$m $r_m = 5\ mm$
9 A	A 5 cm long rectangular glass chamber is inserted into one arm of a Michelson interferometer having a 600 nm light source. This chamber is initially filled with some gas (refractive index 1.00024) but the gas is gradually pumped out using a vacuum pump until a near-perfect vacuum is achieved. How many fringes are moved during this process? (2 Mark) PART-B Ans: 40 Range: NA Answers: The OPD is $\Lambda = (n_{medium} - n_{vaccum})\, d = N\lambda / 2$. Hence, $N = 2d(n_{medium} - 1)/\lambda = 40$

9 B	A 5 cm long rectangular glass chamber is inserted into one arm of a Michelson interferometer using a 600 nm light source. This chamber is initially filled with some gas (refractive index 1.00027) but the gas is gradually pumped out using a vacuum pump until a near-perfect vacuum is achieved. How many fringes are moved during this process? (2 Mark) PART-B Ans: 45 Range: NA Answers: The OPD is $\Lambda = (n_{medium} - n_{vaccum})\, d = N \lambda / 2$. Hence, $N = 2\, d\, (n_{medium} - 1) / \lambda = 45$
10A	In a Michelson interferometer arrangement, if one of the mirrors is moved by a distance 0.08 mm, 250 fringes disappear from the field of view. The wavelength of the incident light is (in nm) (1 Mark) PART-A Ans: 640 nm Range: NA Answers: $2\, d \cos(\theta) = m_0 \lambda$; $2\, d = \Delta m \lambda$; $\lambda = 0.08 * 2 / 250 = 640$ nm
10B	In a Michelson interferometer arrangement, if one of the mirrors is moved by a distance 0.05 mm, 150 fringes disappear from the field of view. The wavelength of the incident light is (in nm) (1 Mark) (Write the answer correct upto two decimal places) PART-A Ans: 666.7 nm Range: 666 nm to 667 nm Answers: $2d \cos(\theta) = m_0 \lambda$; $2\, d = \Delta m \lambda$; $\lambda = 0.05 * 2 / 150 = 666$ nm
11	In a Michelson's interferometer the yellow sodium light composed of the two wavelengths $\lambda_1 = 589$ nm and $\lambda_2 = 589.6$ nm is employed. When one of the mirrors is moved away, the fringe pattern vanishes periodically. Find the displacement of the mirror between two successive positions of the sharpest pattern. (1 Marks). (Write the answer correct upto two decimal places) PART-A Ans: 0.29 mm Range: 0.28 mm to 0.3 mm Answers: $$\Delta d = \frac{\lambda^2}{2 * \Delta\lambda} \approx 0.29\, mm$$
12	In a Michelson interferometer experiment, it is found that for a source S, as one of the mirrors is moved away from the equal path length position of about 4 cm, the fringe system completely disappears. What is the coherence time of the radiation emerging from the source ? (in ns) [1 Marks] (Write the answer correct upto two decimal places)

PART-A

Ans: 0.27
Range: 0.25 to 0.28

Answer:

$$c = \frac{2d}{\tau} \qquad d = 4\text{ cm} = 4 \times 10^{-2}\text{ m.}$$

$$= \frac{8 \times 10^{-2}}{\tau}$$

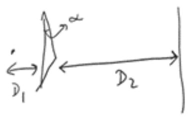
$$\therefore \tau = \frac{8 \times 10^{-2}}{3 \times 10^{8}}$$

$$= 2.667 \times 10^{-10}\text{ sec.}$$

13 In a Fresnel biprism experiment, the source emits red ($\lambda_{Red} = 800\ nm$) and blue ($\lambda_{Blue} = 400\ nm$) light which are independent of one another. The refractive index of the prism is given by the Cauchy's relation $n = A + \frac{B}{\lambda^2}$ where A = 1.5 and $B = 4\text{ X }10^{-3}\ \mu m^2$. If ω_{Red} and ω_{Blue} are the fringe widths of the red and blue light respectively, then the value of $\frac{2\,\omega_{Red}}{\omega_{Blue}}$ is : [Mention answer correct to two decimal places] [2 Marks] (Write the answer correct upto two decimal places) PART-B

Ans: 4.15
Range: 4.05 to 4.25

$$\mu = A + B/\lambda^2 \qquad A = 1.5,\ B = 4\times10^{-3}\ \mu m^2 = 4\times10^{3}\ nm^2$$



$$d_1 = 2D_1\alpha\left(A + B/\lambda_1^2 - 1\right)$$

$$d_2 = 2D_1\alpha\left(A + B/\lambda_2^2 - 1\right)$$

$$\omega_{red} = \frac{\lambda_{red}(D_1+D_2)}{2D_1\alpha\left(A + \frac{B}{\lambda_{red}^2} - 1\right)} \quad ; \quad \omega_{blue} = \frac{\lambda_{blue}(D_1+D_2)}{2D_1\alpha\left(A + B/\lambda_{blue}^2 - 1\right)}$$

$$\therefore \frac{2\omega_{red}}{\omega_{blue}} = \frac{2\lambda_{red}\cancel{(D_1+D_2)}}{\cancel{2D_1\alpha}\left(A + \frac{B}{\lambda_{red}^2} - 1\right)} \cdot \frac{\cancel{2D_1\alpha}\left(A + B/\lambda_{blue}^2 - 1\right)}{\lambda_{blue}\cancel{(D_1+D_2)}} = \frac{2\lambda_{red}}{\lambda_{blue}} \frac{\left(A + B/\lambda_{blue}^2 - 1\right)}{\left(A + \frac{B}{\lambda_{red}^2} - 1\right)}$$

$$= \frac{2\times800}{400}\left(\frac{0.5 + \frac{4\times10^3}{(400)^2}}{0.5 + \frac{4\times10^3}{(800)^2}}\right) = 4\left(\frac{0.525}{0.50625}\right) = 4.15$$

$$\boxed{\text{Answer}:\ 4.15}$$

14	A soap film is formed and is illuminated by white-light which is reflected by the soap film. Region 1 on it has cyan (Blue + Green) colour, region 2 has magenta (Red + Blue) colour and region 3 has yellow (Red + Green) colour. If the refractive index of the film is 1.4 and t_1, t_2 and t_3 represent the minimum thicknesses of region 1, region 2 and region 3, respectively then :  Soap film illuminated by white light (a) t_1 = (......) nm (b) t_2 = (......) nm (c) t_3 = (......) nm [λ_{Red} = 750 nm, λ_{Green} = 550 nm, λ_{Blue} = 450 nm] [2 Marks] (Write the answer correct upto two decimal places) PART-B Ans: t1 = 267.85 nm [Range = 265 to 270 nm] t2 = 196.42 nm [Range = 195 to 200 nm] t3 = 160.714 nm [Range = 158 to 163 nm] Answer:

3) Red colour interferes destructively in region 1.

$2\mu t = n\lambda$ [for destructive interference in reflection]

$\therefore 2 \times 1.4\, t = 750$

$t = 267.857$ nm

Region 2 green interferes destructively.

$\therefore 2\mu t = 550.$

$t = \frac{550}{2.8} = 196.428$ nm

Region 3 has blue colour which interferes destructively.

$\therefore t = \frac{450}{2.8} = 160.714$ nm.