Optics

JEST 2013

Q1. The equation describing the shape of curved mirror with the property that the light from a point source at the origin will be reflected in a beam of rays parallel to the x-axis is (with a as some constant)

(a) $y^2 = ax + a^2$ (b) $2y = x^2 + a^2$ (c) $y^2 = 2ax + a^2$ (d) $y^2 = ax^3 + 2a^2$

Ans.: (c)

JEST 2014

Q2. A spherical air bubble is embedded in a glass slab. It will behave like a

(a) Cylindrical lens (b) Achromatic lens (c) Converging lens (d) Diverging lens

Ans.: (c)

Q3. The resolving power of a grating spectrograph can be improved by

(a) recording the spectrum in the lowest order

(b) using a grating with longer grating period

(c) masking a part of the grating surface

(d) illuminating the grating to the maximum possible extent

Ans.: (d)

Solution: $\Rightarrow R\cdot P = \frac{\Delta\lambda}{\lambda} = nN$, where N - Number of slit and n - order of diffraction.

Q4. Three sinusoidal waves have the same frequency with amplitude A, $A/2$ and $A/3$ while their phase angles are 0, $\pi/2$ and π respectively. The amplitude of the resultant wave is

(a) $\frac{11A}{6}$ (b) $\frac{2A}{3}$ (c) $\frac{5A}{6}$ (d) $\frac{7A}{6}$

Ans.: (c)

Solution: $y_1 = A\sin(\omega t + 0)$, $y_2 = \frac{A}{2}\sin\left(\omega t + \frac{\pi}{2}\right)$, $y_3 = \frac{A}{3}\sin(\omega t + \pi)$

Hence, $y = y_1 + y_2 + y_3 = A\sin\omega t + \frac{A}{2}\cos\omega t - \frac{A}{3}\sin\omega t = \frac{2A}{3}\sin\omega t + \frac{A}{2}\cos\omega t$

$$A' = \sqrt{\left(\frac{2A}{3}\right)^2 + \left(\frac{A}{2}\right)^2} = \sqrt{\frac{4A^2}{9} + \frac{A^2}{4}} = \sqrt{\frac{25A^2}{36}} = \frac{5A}{6}$$

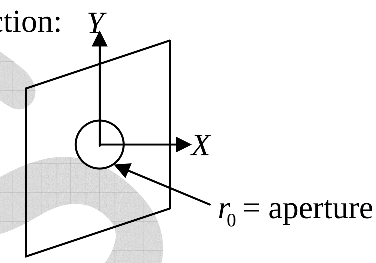
JEST 2015

Q5. Let λ be the wavelength of incident light. The diffraction pattern of a circular aperture of dimension r_0 will transform from Fresnel to Fraunhofer region if the screen distance z is,

(a) $z >> \frac{r_0^2}{\lambda}$ (b) $z >> \frac{\lambda^2}{r_0}$ (c) $z << \frac{\lambda^2}{r_0}$ (d) $z << \frac{r_0^2}{\lambda}$

Ans.: (a)

Solution: Fraunhofer made an approximation on the quadratic phase function:



$$e^{i\frac{k\left(x_0^2+y_0^2\right)}{2z}} = e^{i\frac{kr_0^2}{2z}} \approx 1$$

If $z >> \frac{kr_0^2}{2} \Rightarrow z >> \frac{\pi r_0^2}{\lambda} \Rightarrow z >> \frac{r_0^2}{\lambda}$

For this reason Fraunhofer diffraction is also called Far-field diffraction, whereas for Fresnel diffraction, the condition is

$z >> \lambda$ called near-field diffraction.

JEST 2017

Q6. A thin air film of thickness d is formed in a glass medium. For normal incidence, the condition for constructive interference in the reflected beam is (in terms of wavelength λ and integer $m = 0,1,2,...$)

(a) $2d = (m - 1/2)\lambda$ (b) $2d = m\lambda$

(c) $2d = (m-1)\lambda$ (d) $2\lambda = (m - 1/2)d$

Ans. : (a)

Solution: Condition for constructive interference is,

$$2\mu d\cos\theta = \left(m - \frac{1}{2}\right)\lambda, \text{ where } m = 1,2,3.......$$

for thin airfilm $(\mu = 1)$ and normal incidence $\left(\theta = 0^0\right)$

$$2d = \left(m - \frac{1}{2}\right)\lambda$$

JEST 2019

Q7. A collimated white light source illuminates the slits of a double slit interference setup and forms the interference pattern on a screen. If one slit is covered with a blue filter, which one of the following statements is correct?

(a) No interference pattern is observed after the slit is covered with the blue filter

(b) Interference pattern remains unchanged with and without the blue filter

(c) A blue interference pattern is observed

(d) The central maximum is blue with coloured higher order maxima

Ans. : (c)

Solution: Because to form stationary interference pattern light from two coherent source should be of same frequency and wavelength.

Q8. The refractive index (n) of the entire environment around a double slit interference setup is changed from $n=1$ to $n=2$. Which one of the following statements is correct about the change in the interference pattern?

(a) The fringe pattern disappears

(b) The central bright maximum turns dark, i.e. becomes a minimum

(c) Fringe width of the pattern increases by a factor 2

(d) Fringe width of the pattern decreases by a factor 2

Ans. : (d)

Solution: $\beta = \frac{D}{2d}\left(\frac{\lambda}{n}\right)$

Q9. White light of intensity I_0 is incident normally on a filter plate of thickness d. The plate has a wavelength (λ) dependent absorption coefficient $\alpha(\lambda) = \alpha_0\left(1-\frac{\lambda}{\lambda_0}\right)$ per unit length. The band pass edge of the filter is defined as the wavelength at which the intensity, after passig through the filter, is $I = \frac{I_0}{\rho}, \alpha_0, \lambda_0$ and ρ are constants. The reflection coefficient of the plate may be assumed to be independent of λ. Which one of the following statements is true about the bandwidth of the filter?

(a) The bandwidth is linear dependent on λ_0

(b) The bandwidth is independent of the plate thickness d

(c) The bandwidth is linearly dependent on α_0

(d) The bandwidth is dependent on the ratio α_0 / d

Ans. : (a)

Solution: For example C-band and L-band in fiber optics communication, the central wavelength λ_c of band pass is $\lambda_c = \lambda_0\sqrt{1-\frac{\sin^2\theta}{n^{+2}}}$

Where $\lambda_0 =$ central wavelength at normal incidence

$n^* =$ filter effective index of refraction

$\theta =$ angle of incidence

Here this result is applicable only for very low absorption.

Q10. An optical line of wavelength $5000\overset{0}{A}$ in the spectrum of light from a star is found to be red-shifted by an amount of $2\overset{0}{A}$. Let v be the velocity at which the star is receding. Ignoring relativistic effects, what is the value of $\frac{c}{v}$?

Ans. : 2500

Solution: $\frac{c}{v} = \frac{\lambda_0}{\Delta\lambda} = \frac{5000}{2} = 2500$.

Q11. In the Young's double slit experiment (screen distance $D = 50\,cm$ and $d = 0.1\,cm$), a thin mica sheet of refractive index $n = 1.5$ is introduced in the path of one of the beams. If the central fringe gets shifted by 0.2, what is the thickness (in micrometer) of the mica sheet?

Ans. : 8

Solution: $x_0 = \frac{D}{d}(\mu - 1)t$

$$0.2 = \frac{50}{0.1}(1.5-1)t$$

$$t = \frac{0.2\times 0.1}{50\times 0.5}cm = 8\times 10^{-4}\,cm = 8\mu m.$$