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

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

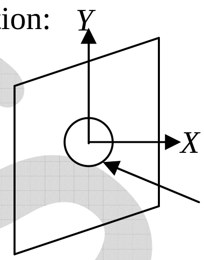
JEST 2015

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 $(\theta = 0^0)$

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