SHORT QUESTIONS AND ANSWERS

Complete Video Lecture

Q No. 9.1: Under what conditions two or more sources of light behave as coherent sources?

Two or more sources can be considered as coherent if they fulfil the following conditions.

i. They must be monochromatic. Same colour corresponds to same wavelength.

ii. They can produce waves having a constant phase difference.

Practically a single source can be divided into more than one source to make them coherent.

Q No. 9.2: How is the distance between interference fringes affected by the separation between the slits of Young's experiment? Can fringes disappear? (SHW-2021)(GUJ-2021)(MUL-2019)(SGD-2016)(FED-2016)

The interference fringes gets thinner by increasing separation between the slits.

Reason

The separation between fringes can be determined as

$$\Delta y = \frac{\lambda L}{d} \quad \text{where} \quad \left\{ \begin{array}{lcl} \lambda & = & \text{Wavelength of wave} \\ L & = & \text{Distance between source and screen} \\ d & = & \text{Slit separation} \end{array} \right\}$$

As the separation between fringes is inversely proportional to "d"($\Delta y \propto \frac{1}{d}$), if we increase "d" for maximum, Δy will decrease and vice versa.

Disappearance of Fringes

If slits separation "d" is increased for maximum, Δy will approach to zero and fringes become indistinguishable.

Q No. 9.3: Can visible light produce interference fringes? Explain (BWP-2021) (DGK-2021) (BWP-2021) (DGK-2019) (SGD-2019) (RWP-2019) (FED-2018) (RWP-2018) (SHW-2018) (SGD-2017) (FSB-2017) (FSB-2016) (DGK-2016) (DGK-2016) (RWP-2016)

Yes, visible light can demonstrate interference.

Reason

Visible light is composed of seven individual colours which can interfere with corresponding colours, results into a fringe pattern. As these patterns are overlapped they cannot be observed properly.

Q No. 9.4: In the Young's experiment, one of the slits is covered with blue filter and other with red filter. What would be the pattern of light intensity on the screen? (FSB-2021) (RWP-2021)

No interference pattern of light intensity will be observed on the screen.

Reason

There will be two colour image of slits with constant intensity. As to observe interference, waves must be monochromatic having constant phase difference. In this case we have two sources of different colour (wavelength) hence they do not fulfil conditions for interference, resultantly it could not be observed.

Q No. 9.5: Explain whether the Young's experiment is an experiment for studying interference or diffraction effects of light. (BWP-2021) (DGK-2021) (MUL-2021) (GUJ-2021) (LHR-2019) (SHW-2019) (DGK-2018) (LHR-2018) (FED-2018) (SGD-2018) (RWP-2016) (SGD-2016)

Young's double slit experiment was designed to observe interference of light. Although when light passes through slits it will exhibit diffraction also so it can be used to study diffraction. On the whole interference effects are dominating over diffraction.

Q No. 9.6: An oil film spreading over a wet footpath shows colours. Explain how does it happen. (BWP-2019) (DGK-2019) (MUL2019) (GUJ-2019) (DGK-2018) (LHR-2018) (GUJ-2018)(DGK-2017) (RWP-2017) (LHR-2017) (LHR-2016)

An oil film spreading over a wet footpath acts like a thin film. Light is composed of seven different colours (wavelength). When it falls on oil film, at some points the thickness and angle of incidence corresponds to constructive interference and on some other point it will interfere destructively. Hence colours are can be seen on oil film.

Q No. 9.7: Could you obtain Newton's rings with transmitted light? If yes, would the pattern be different from that obtained with reflected light? (MUL-2021) (MUL-2021) (GUJ-2021) (GUJ-2019) (SHW-2018) (BWP-2017) (SHB-2016)

Yes, it is possible to observe Newton's rings with the transmitted light, fringe pattern will be opposite as observed with reflected light. As there is zero phase change in transmitted light, hence the central spot of Newton's ring will be bright instead of dark.

9.8: In the white light spectrum obtained with a diffraction grating, the third order image of a wavelength coincides with the fourth image of a second wavelength, calculate the ratio of the two wavelengths. (FSB-2021) (DGK-2021) (LHR-2021) (SHW-2021) (SGD-2021) (GUJ-2021) (BWP-2019) (LHR-2019) (SHW-2019) (MUL-2019) (RWP-2019) (SHW-2018) (DGK-2017) (RWP-2017) (RWP-2017) (SGD-2017) (FSB-2016) (BWP-2016) (LHR-2016) (RWP-2016)

The relation used for diffraction grating.

For 3rd order image

$$d\sin\theta = 3\lambda_1 \ldots\ldots\ldots (i)$$

For 4th order image

$$d\sin\theta = 4\lambda_2 \ldots\ldots\ldots (ii)$$

Comparing equation (i) & (ii)

$$3\lambda_1 = 4\lambda_2$$

$$\frac{\lambda_1}{\lambda_2} = \frac{4}{3}$$

Q No.9.9: How would you manage to get more orders of spectra using a diffraction grating?

The relation for diffraction grating is

$$d\sin\theta = m\lambda$$

$$\frac{d\sin\theta}{\lambda} = m$$

or

$$\frac{\sin\theta}{N\lambda} = m$$

$$m \propto d \text{ and } m \propto \sin\theta$$

$$m \propto \frac{1}{N}$$

$$m \propto \frac{1}{\lambda}$$

In order to get more orders (m)

(i) Increase grating element "d"

(ii) Decrease number of grating "N"

(iii) Use wave of smaller wavelength "λ"

Q No.9.10: Why are the polaroid sunglasses better than ordinary sunglasses? (MUL-2019) (FSB-2019) (FSB-2018) (LHR-2018) (RWP-2017) (LHR-2016) (SGD-2016)

Polaroid sunglasses are better because

(i) They reduce intensity of light.

(ii) They protect eyes from harmful radiation.

(iii) They polarize light.

Q No.9.11: How would you distinguish between un-polarized and plane-polarized lights?

To check this, we place a polaroid in the path of light and rotate it.

- If the intensity of light remains unchanged during rotation of polaroid then it is an unpolarised light.
- For a polarized light, its intensity will vary with the rotation of polaroid from maximum to minimum.

Q No.9.12: Fill in the blanks.

(i) According to **Huygen's** principle, each point on a wavefront acts as a source of secondary **wavelet.**

(ii) In Young's experiment, the distance between two adjacent bright fringes for violet light is **less** than that for green light.

(iii) The distance between bright fringes in the interference pattern **increases** as the wavelength of incident light increases.

(iv) A diffraction grating is used to make a diffraction pattern for yellow light and then for red light. The distances between the red spots will be **greater** than that for yellow light.

(v) The phenomenon of polarization of light reveals that light waves are **transverse** waves.

(vi) A polaroid is a commercial **polarizing material.**

(vii) A polaroid glass **reduces** glare of light produced at a road surface.

Result $\boxed{\text{Wavelength} = \lambda = 516\ \text{nm}}$

Q No. 9.7 Sodium light (λ= 589 nm) is incident normally on a grating having 3000 lines per centimeter. What is the highest order of the spectrum obtained with this grating?

Given

Wavelength of sodium light $= \lambda = 589\ \text{nm} = 589 \times 10^{-9}\text{m}$

Grating element $= N = 3000\ \frac{\text{lines}}{\text{cm}} = 3000 \times 10^{2}\ \frac{\text{lines}}{\text{m}}$

Incident angle $= \theta = 90^\circ$

To Find

Order of spectrum $= m = ?$

Solution

$d\sin\theta = m\lambda$

$$\lambda = \frac{d\sin\theta}{\lambda} = \frac{\sin\theta}{N\lambda} = \frac{\sin 90^\circ}{3 \times 10^{5} \times 589 \times 10^{-9}}$$

Result $\boxed{m = 5.66 \longrightarrow 5^{th}\ \text{order spectrum}}$

9.8 Blue light of wavelength 480 nm illuminates a diffraction grating. The second order image is formed at an angle of 30° from the central image. How many lines in a centimeter of the grating have been ruled? (RWP-2017)

Given

Wavelength of blue light $= \lambda = 480\ \text{nm} = 480 \times 10^{-9}\text{m}$

Order of spectrum $= m = 2$

Incident angle $= \theta = 30^\circ$

To Find

Grating element $= N = ?$

Solution

$$d\sin\theta = m\lambda$$

$$\frac{1}{N}\sin\theta = m\lambda$$

$$N = \frac{\sin\theta}{m\lambda} = \frac{\sin 30^{\circ}}{2 \times 248 \times 10^{-9}} = 5.2 \times 10^{5} \times \frac{\text{lines}}{\text{m}}$$

Result $\boxed{\text{Grating element} = N = 5.2 \times 10^{3}\frac{\text{lines}}{\text{cm}}}$

Q No. 9.9 X-ray of wavelength 0.150 nm are observed to undergo a first order reflection at a Bragg angle of 13.3° from a quartz (SiO_2) crystal. What is the interplanar spacing of the reflecting planes in the crystal?

Given

Wavelength of X-rays = 0.150 nm = 0.150×10^{-9}m

Order = n = 1

Incident angle = θ = 13.3°

To Find

Interplaner spacing = d = ?

Solution

Using Bragg's Equation.

$$2\,d\sin\theta = n\lambda$$

$$d = \frac{n\lambda}{2\sin\theta} = \frac{1 \times 0.150 \times 10^{-9}}{2\sin\theta\, 13.3} = 0.326 \times 10^{-9}\text{m}$$

Result $\boxed{d = 0.326\text{ nm}}$

Q No. 9.10 An X-ray beam of wavelength λ undergoes a first order reflection from a crystal when its angle of incidence to a crystal face is 26.5°, and an x-ray beam of wavelength 0.0097 nm undergoes a third order reflection when its angle of incidence to that face is 60.0°. Assuming that the two beams reflect from the same family of planes, calculate (a) the interplanar spacing of the planes and (b) the wavelength.

Given

Wavelenght of X-rays = $\lambda = \lambda_1$

Order of reflection = $n_1 = 1$

Angle of incidence = θ_1 26.5°

Wavelenght of Second X-rays = λ_2= 0.097 nm = 0.097×10^{-9}

Order of reflection = $n_2 = 3$

Angle of incidence = $\theta_2 = 60^{\circ}$

To Find

Interplaner spacing = d = ?

Wavelenght of X-rays = λ_1 = ?

Solution

using Bragg's equation

$$2d\sin\theta = n\lambda$$

For 2nd X-ray

$$2d\sin\theta_2 = n_2\lambda_2$$

$$d = \frac{n_2\lambda_2}{2d\sin\theta_2} = \frac{3 \times 0.097 \times 10^{-9}}{2d\sin 60^{\circ}}$$

$d = 0.1680 \times 10^{-9} m$

Result $\boxed{d = 0.1680 \text{ nm}}$

For 1st X-ray

$2d\sin\theta_1 = n_1\lambda_1$

$$\lambda_1 = \frac{2d\sin\theta_1}{n_1} = \frac{2 \times 0.1680 \times 10^{-9} \times \sin 26.5^\circ}{1}$$

$\lambda_1 = 0.1498 \times 10^{-9} m$

$\lambda_1 = 0.15 \times 10^{-9} m$

Result $\boxed{\lambda_1 = 0.15 \text{ nm}}$