Chapter 30
Wave Optics

Newton's Corpuscular Theory

(1) Newton thought that light is made up of tiny, light and elastic particles called corpuscles which are emitted by a luminous body.

(2) The corpuscles travel with speed equal to the speed of light in all directions in straight lines.

(3) The corpuscles carry energy with them. When they strike retina of the eye, they produce sensation of vision.

(4) The corpuscles of different colour are of different sizes (red corpuscles larger than blue corpuscles).

(5) The corpuscular theory explains that light carry energy and momentum, light travels in a straight line, Propagation of light in vacuum, Laws of reflection and refraction

(6) The corpuscular theory fails to explain interference, diffraction and polarization.

(7) A major prediction of the corpuscular theory is that the speed of light in a denser medium is more than the speed of light in a rarer medium. The truth is that the speed of the light is smaller in a denser medium. Therefore, the Newton's corpuscular theory is wrong.

Huygen's Wave Theory

(1) Wave theory of light was given by Christian Huygen. According to this, a luminous body is a source of disturbance in a hypothetical medium ether. This medium pervades all space.

(2) It is assumed to be transparent and having zero inertia. The disturbance from the source is propagated in the form of waves through the space.

(3) The waves carry energy and momentum. Huygen assumed that the waves were longitudinal. Further when polarization was discovered, then to explain it, light waves were, assumed to be transverse in nature by Fresnel.

(4) This theory explains successfully, the phenomenon of interference and diffraction apart from other properties of light.

(5) The Huygen's theory fails to explain photo-electric effect, Compton's effect *etc*.

(6) The wave theory introduces the concept of wavefront.

Wavefront

(1) Suggested by Huygens

(2) The locus of all particles in a medium, vibrating in the same phase is called Wave Front (WF)

(3) The direction of propagation of light (ray of light) is perpendicular to the WF.

(4) Every point on the given wave front acts as a source of new disturbance called secondary wavelets which travel in all directions with the velocity of light in the medium.

(5) A surface touching these secondary wavelets tangentially in the forward direction at any instant gives the new wave front at that instant. This is called secondary wave front

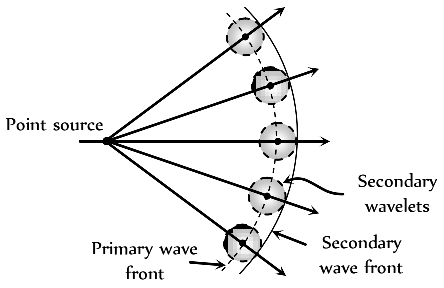
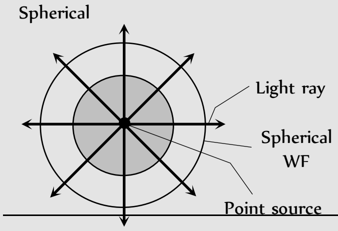
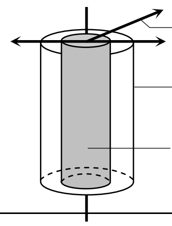
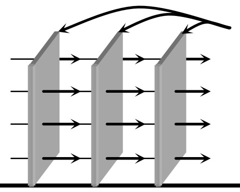


Fig. 30.1

Table 30.1 : Different types of wavefront

Type of wavefront	Intensity	Amplitude
Spherical 	$I \propto \frac{1}{r^2}$	$A \propto \frac{1}{r}$

Cylindrical 	$I \propto \frac{1}{r}$	$A \propto \frac{1}{\sqrt{r}}$
Plane 	$I \propto r^0$	$A \propto r^0$

Reflection and Refraction of Wavefront

Reflection

$BC = AD$

and $\angle i = \angle r$

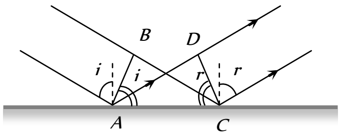


Fig. 30.2

Refraction

$\frac{BC}{AD} = \frac{v_1}{v_2} = \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

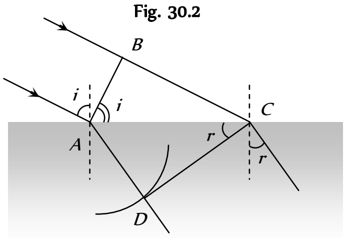


Fig. 30.3

Super Position of Waves

When two or more than two waves superimpose over each other at a common particle of the medium then the resultant displacement (y) of the particle is equal to the vector sum of the displacements (y_1 and y_2) produced by individual waves. *i.e.* $\vec{y} = \vec{y}_1 + \vec{y}_2$

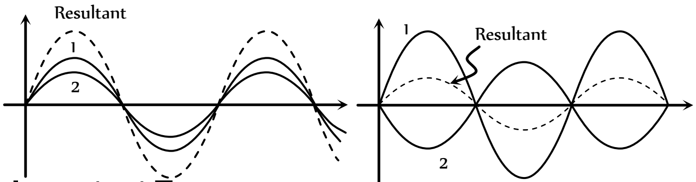


Fig. 30.4

Important Terms

(1) **Phase :** The argument of sine or cosine in the expression for displacement of a wave is defined as the phase. For displacement $y = a \sin \omega t$; term ωt = phase or instantaneous phase.

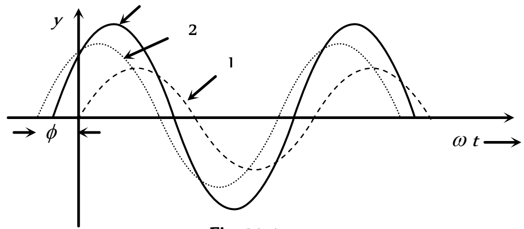
(2) **Phase difference (ϕ) :** The difference between the phases of two waves at a point is called phase difference *i.e.* if $y_1 = a_1 \sin\omega t$ and $y_2 = a_2 \sin(\omega t + \phi)$ so phase difference = ϕ

(3) **Path difference (Δ) :** The difference in path length's of two waves meeting at a point is called path difference between the waves at that point. Also $\Delta = \frac{\lambda}{2\pi} \times \phi$

(4) **Time difference (*T.D.*) :** Time difference between the waves meeting at a point is $T.D. = \frac{T}{2\pi} \times \phi$

Resultant Amplitude and Intensity

Let us consider two waves that have the same frequency but have a certain fixed (constant) phase difference between them. Their super position shown below



Let the two waves are

Fig. 30.5

$y_1 = a_1 \sin\omega t$ and $y_2 = a_2 \sin(\omega t + \phi)$

where $a_1, a_2 =$ Individual amplitudes,

ϕ = Phase difference between the waves at an instant when they are meeting a point.

(1) **Resultant amplitude :** The resultant wave can be written as $y = A \sin(\omega t + \theta)$

where A = resultant amplitude $= \sqrt{a_1^2 + a_2^2 + 2a_1a_2 \cos\varphi}$

(2) **Resultant intensity :** As we know intensity $\propto$ (Amplitude)

$\Rightarrow \quad I_1 = ka_1^2, I_2 = ka_2^2$ and $I = kA^2$ (k is a proportionality constant). Resultant intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

For two identical source $I_1 = I_2 = I_0 \Rightarrow I = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi$

$= 4I_0 \cos^2\frac{\phi}{2}$ $\quad [1 + \cos\theta = 2\cos^2\frac{\theta}{2}]$

Coherence

The phase relationship between two light waves can very from time to time and from point to point in space. The property of definite phase relationship is called coherence.

(1) **Temporal coherence :** In a light source a light wave (photon) is produced when an excited atom goes to the ground state and emits light.

(i) The duration of this transition is about 10^{-} to 10^{-} *sec.* Thus the emitted wave remains sinusoidal for this much time. This time is known as coherence time (τ).

(ii) Definite phase relationship is maintained for a length $L = c\tau_c$ called coherence length. For neon λ = 6328 Å, $\tau \approx 10^{-}$ *sec* and L = 0.03 *m*.

For cadmium λ = 6438 Å, $\tau = 10^{-}$ *sec* and L = 0.3 *m*

For Laser $\tau = 10^{-}$ *sec* and L = 3 *km*

(iii) The spectral lines width $\Delta\lambda$ is related to coherence length L and coherence time τ_c. $\Delta\lambda \approx \frac{\lambda^2}{c\tau_c}$ or $\Delta\lambda \approx \frac{\lambda^2}{L}$

(2) **Spatial coherence :** Two points in space are said to be spatially coherence if the waves reaching there maintains a constant phase difference

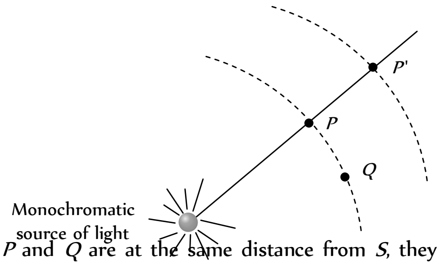


Fig. 30.6

Points P and Q are at the same distance from S, they will always be having the same phase. Points P and P' will be spatially coherent if the distance between P and P' is much less than the coherence length *i.e.* $PP' << c\tau_c$

(3) **Methods of obtaining coherent sources :** Two coherent sources are produced from a single source of light by two methods (i) By division of wavefront and (ii) By division of amplitude

(i) **Division of wave front :** The wave front emitted by a narrow source is divided in two parts by reflection, refraction or diffraction.

The coherent sources so obtained are imaginary. There produced in Fresnel's biprism, Llyod's mirror Youngs' double slit *etc.*

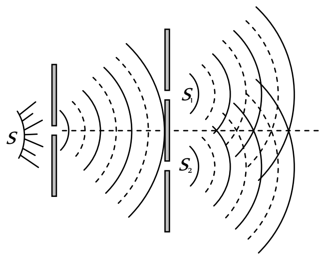


Fig. 30.7

(ii) **Division of amplitude :** In this arrangement light wave is partly reflected (50%) and partly transmitted (50%) to produced two light rays.

The amplitude of wave emitted by an extend source of light is divided in two parts by partial reflection and partial refraction.

The coherent sources obtained are real and are obtained in Newton's rings, Michelson's interferrometer, colours in thin films.

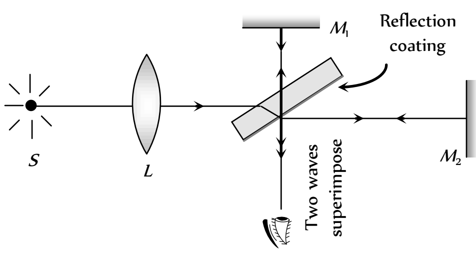
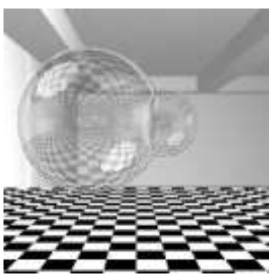


Fig. 30.8

Interference of Light

When two waves of exactly same frequency (coming from two coherent sources) travels in a medium, in the same direction simultaneously then due to their superposition, at some points intensity of light is maximum while at some other points intensity is minimum. This



phenomenon is called Interference of light. It is of following two types

(1) **Constructive interference :** When the waves meets a point with same phase, constructive interference is obtained at that point (*i.e.* maximum light)

(i) Phase difference between the waves at the point of observation $\phi = 0^o$ or $2n\pi$

(ii) Path difference between the waves at the point of observation $\Delta = n\lambda$ (*i.e.* even multiple of $\lambda/2$)

(iii) Resultant amplitude at the point of observation will be maximum $A_{max} = a_1 + a_2$

If $a_1 = a_2 = a_0 \Rightarrow A_{\max} = 2a_0$

(iv) Resultant intensity at the point of observation will be maximum $I_{\max} = I_1 + I_2 + 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

If $I_1 = I_2 = I_0 \Rightarrow I_{\max} = 4I_0$

(2) **Destructive interference :** When the wave meets a point with opposite phase, destructive interference is obtained at that point (*i.e.* minimum light)

(i) Phase difference $\phi = 180^o$ or $(2n-1)\pi$; n = 1, 2, ...

or $(2n+1)\pi$; $n = 0,1,2.....$

(ii) Path difference $\Delta = (2n-1)\frac{\lambda}{2}$ (*i.e.* odd multiple of $\lambda/2$)

(iii) Resultant amplitude at the point of observation will be minimum $A_{\min} = a_1 - a_2$

If $a_1 = a_2 \Rightarrow A_{\min} = 0$

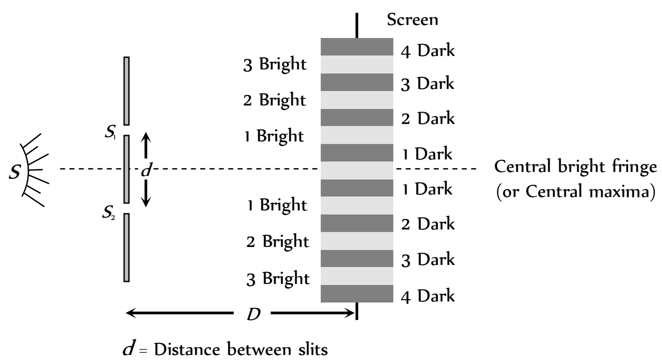
(iv) Resultant intensity at the point of observation will be minimum $I_{\min} = I_1 + I_2 - 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} - \sqrt{I_2}\right)^2$

If $I_1 = I_2 = I_0 \Rightarrow I_{\min} = 0$

(3) **Super position of waves of random phase difference :** When two waves (or more waves) having random phase difference between them super impose, then no interference pattern is produced. Then the resultant intensity is just the sum of the two intensities. $I = I_1 + I_2$

Young's Double Slit Experiment (YDSE)

Monochromatic light (single wavelength) falls on two narrow slits S_1 and S_2 which are very close together acts as two coherent sources, when waves coming from two coherent sources (S_1, S_2) superimposes on each other, an interference pattern is obtained on the screen. In YDSE alternate bright and dark bands obtained on the screen. These bands are called Fringes.



d = Distance between slits
D = Distance between slits and screen
λ = Wavelength of monochromatic light emitted from source

(1) Central fringe is always bright, because at central position $\phi = 0^o$ or $\Delta = 0$

(2) The fringe pattern obtained due to a slit is more bright than that due to a point.

(3) If the slit widths are unequal, the minima will not be complete dark. For very large width uniform illumination occurs.

(4) If one slit is illuminated with red light and the other slit is illuminated with blue light, no interference pattern is observed on the screen.

(5) If the two coherent sources consist of object and it's reflected image, the central fringe is dark instead of bright one.

Useful Results

(1) **Path difference :** Path difference between the interfering waves meeting at a point P on the screen is given by

$\Delta = \Delta_i + \Delta_f$; where Δ_i = initial path difference between the waves before the slits and Δ_f = path difference between the waves after emerging from the slits. In this case $\Delta_i = 0$ (Commonly used condition). So $\Delta = \Delta_f = \frac{xd}{D} = d \sin\theta$

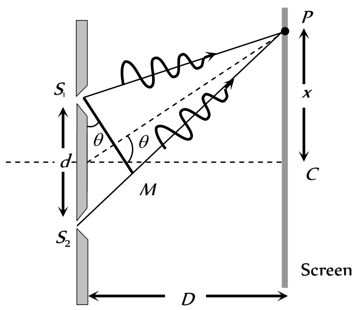


Fig. 30.10

where x is the position of point P from central maxima.

For maxima at P: $\Delta = n\lambda$; where n = 0, ± 1, ± 2, ...

and For minima at P: $\Delta = \frac{(2n-1)\lambda}{2}$; where n = ± 1, ± 2, ...

(2) **Location of fringe :** Position of n bright fringe from central maxima $x_n = \frac{n\lambda D}{d} = n\beta$; $n = 0, 1, 2 ....$

Position of n dark fringe from central maxima

$$x_n = \frac{(2n-1)\lambda D}{2d} = \frac{(2n-1)\beta}{2} \; ; \; n = 1, 2, 3 ....$$

(3) **Fringe width (β) :** The separation between any two consecutive bright or dark fringes is called fringe width. In *YDSE* all fringes are of equal width. Fringe width $\beta = \frac{\lambda D}{d}$.

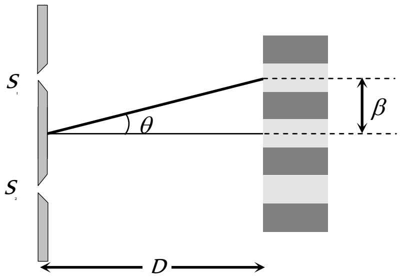


Fig. 30.11

and angular fringe width $\theta = \frac{\lambda}{d} = \frac{\beta}{D}$

(4) In YDSE, if n fringes are visible in a field of view with light of wavelength λ_1 , while n with light of wavelength λ_2 in the same field, then $n_1\lambda_1 = n_2\lambda_2$.

(5) **Separation (Δx) between fringes**

(i) Between n bright and m bright fringes $(n > m)$

$$\Delta x = (n - m)\beta$$

(ii) Between n bright and m dark fringe

(a) If $n > m$ then $\Delta x = \left(n - m + \frac{1}{2}\right)\beta$

(b) If $n < m$ then $\Delta x = \left(m - n - \frac{1}{2}\right)\beta$

(6) **Identification of central bright fringe :** To identify central bright fringe, monochromatic light is replaced by white light. Due to overlapping central maxima will be white with red edges. On the other side of it we shall get a few coloured band and then uniform illumination.

If the whole YDSE set up is taken in another medium then λ changes so β changes

e.g. in water $\lambda_w = \frac{\lambda_a}{\mu_w} \Rightarrow \beta_w = \frac{\beta_a}{\mu_w} = \frac{3}{4}\beta_a$

Condition for Observing Interference

(1) The initial phase difference between the interfering waves must remain constant. Otherwise the interference will not be sustained.

(2) The frequency and wavelengths of two waves should be equal. If not the phase difference will not remain constant and so the interference will not be sustained.

(3) The light must be monochromatic. This eliminates overlapping of patterns as each wavelength corresponds to one interference pattern.

(4) The amplitudes of the waves must be equal. This improves contrast with $I_{\max} = 4I_0$ and $I_{\min} = 0$.

(5) The sources must be close to each other. Otherwise due to small fringe width $\left(\beta \propto \frac{1}{d}\right)$ the eye can not resolve fringes resulting in uniform illumination.

Shifting of Fringe Pattern in YDSE

If a transparent thin film of mica or glass is put in the path of one of the waves, then the whole fringe pattern gets shifted towards the slit in front of which glass plate is placed.

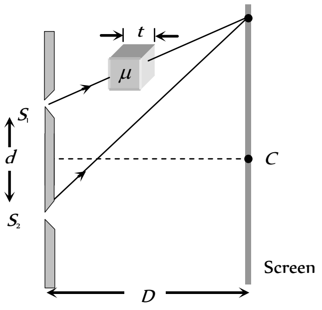


Fig. 30.12

(1) $\text{Fringe shift} = \frac{D}{d}(\mu-1)t = \frac{\beta}{\lambda}(\mu-1)t$

(2) Additional path difference $= (\mu-1)t$

(3) If shift is equivalent to n fringes then $n = \frac{(\mu-1)t}{\lambda}$ or $t = \frac{n\lambda}{(\mu-1)}$

(4) Shift is independent of the order of fringe (*i.e.* shift of zero order maxima = shift of n^{th} order maxima.

(5) Shift is independent of wavelength.

Fringe Visibility (*V*)

With the help of visibility, knowledge about coherence, fringe contrast an interference pattern is obtained.

$V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = 2\frac{\sqrt{I_1 I_2}}{(I_1 + I_2)}$ If $I_{min} = 0$, $V = 1$ (maximum) *i.e.*, fringe visibility will be best.

Also if $I_{max} = 0, V = -1$ and If $I_{max} = I_{min}, V = 0$

Missing Wavelength in Front of One Slit in YDSE

Suppose P is a point of observation infront of slit S_1 as shown

Missing wavelength at P

$$\lambda = \frac{d^2}{(2n-1)D}$$

By putting $n = 1, 2, 3....$

Missing wavelengths are

$$\lambda = \frac{d^2}{D}, \frac{d^2}{3D}, \frac{d^2}{5D}....$$

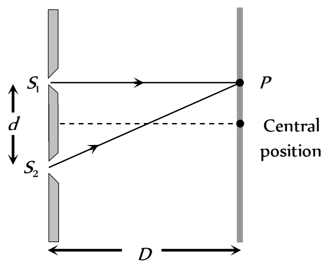
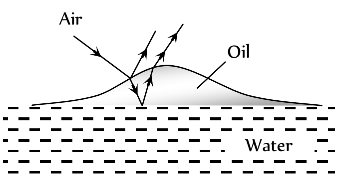


Fig. 30.13

Interference in Thin Films

Interference effects are commonly observed in thin films when their thickness is comparable to wavelength of incident light (If it is too thin as compared to wavelength of light it appears dark and if it is too thick, this will result in uniform illumination of film). Thin layer of oil on water surface and soap bubbles shows various colours in white light due to interference of waves reflected from the two surfaces of the film.



Oil film on water surface

Fig. 30.14

In thin films interference takes place between the waves reflected from it's two surfaces and waves refracted through it.

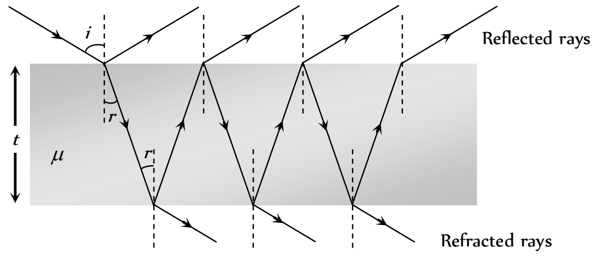


Fig. 30.15

(1) **Interference in reflected light :** Condition of constructive interference (maximum intensity)

$\Delta = 2\mu\ t\cos r = (2n-1)\frac{\lambda}{2}$.

For normal incidence $r = 0$ so $2\mu t = (2n-1)\frac{\lambda}{2}$

Condition of destructive interference (minimum intensity)

$\Delta = 2\mu t\cos r = (2n)\frac{\lambda}{2}$. For normal incidence $2\mu t = n\lambda$

(2) **Interference in refracted light :** Condition of constructive interference (maximum intensity)

$\Delta = 2\mu t\cos r = (2n)\frac{\lambda}{2}$. For normal incidence $2\mu t = n\lambda$

Condition of destructive interference (minimum intensity)

$\Delta = 2\mu t\cos r = (2n-1)\frac{\lambda}{2}$

For normal incidence $2\mu t = (2n-1)\frac{\lambda}{2}$

Lloyd's Mirror

A plane glass plate (acting as a mirror) is illuminated at almost grazing incidence by a light from a slit S_1. A virtual image S_2 of S_1 is formed closed to S_1 by reflection and these two act as coherent sources. The expression giving the fringe width is the same as for the double slit, but the fringe system differs in one important respect.

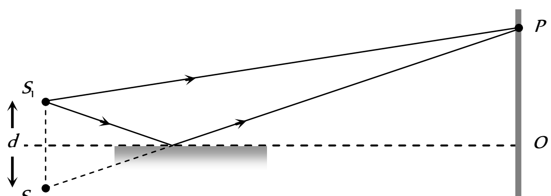


Fig. 30.16

The path difference $S_1P - S_2P$ is a whole number of wavelengths, the fringe at P is dark not bright. This is due to 180° phase change which occurs when light is reflected from a denser medium. At grazing incidence a fringe is formed at O, where the geometrical path difference between the direct and reflected waves is zero and it follows that it will be dark rather than bright.

Thus, whenever there exists a phase difference of a π between the two interfering beams of light, conditions of maximas and minimas are interchanged, *i.e.*, $\Delta x = n\lambda$ (for minimum intensity)

and $\Delta x = (2n-1)\lambda/2$ (for maximum intensity)

Fresnel's Biprims

(1) It is an optical device of producing interference of light Fresnel's biprism is made by joining base to base two thin prism of very small angle

(2) Acute angle of prism is about 1/2° and obtuse angle of prism is about 179°.

(3) When a monochromatic light source is kept in front of biprism two coherent virtual source S_1 and S_2 are produced.

(4) Interference fringes are found on the screen placed behind the biprism interference fringes are formed in the limited region which can be observed with the help eye piece.

(5) Fringe width is measured by a micrometer attached to the eye piece. Fringes are of equal width and its value is $\beta = \frac{\lambda D}{d}$

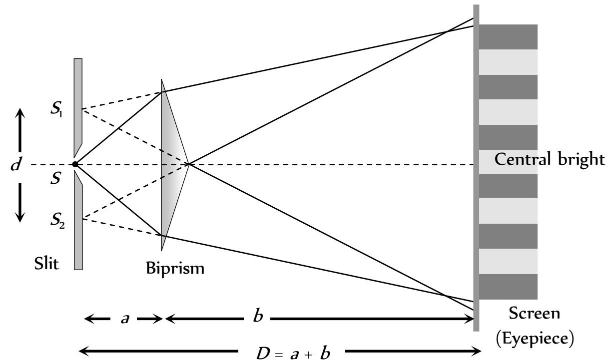


Fig. 30.17

(6) Let the separation between S_1 and S_2 be d and the distance of slits and the screen from the biprism be a and b respectively *i.e.* $D = (a + b)$. If angle of prism is α and refractive index is μ then $d = 2a(\mu - 1)\alpha$

$$\therefore \quad \lambda = \frac{\beta[2a(\mu-1)\alpha]}{(a+b)} \quad \Rightarrow \quad \beta = \frac{(a+b)\lambda}{2a(\mu-1)\alpha}$$

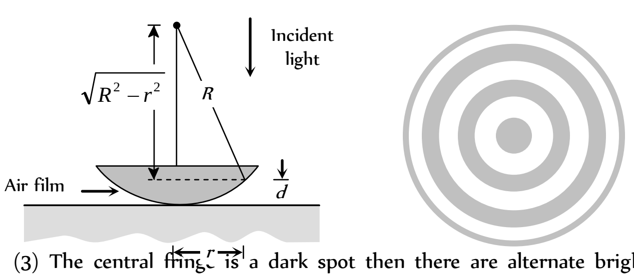
(7) If a convex lens is mounted between the biprism and eye piece. There will be two positions of lens when the sharp images of coherent sources will be observed in the eyepiece. The separation of the images in the two positions are measured. Let these be d_1 and d_2 then $d = \sqrt{d_1 d_2}$

$$\therefore \ \lambda = \frac{\beta d}{D} = \frac{\beta\sqrt{d_1 d_2}}{(a+b)}.$$

Newton's Rings

(1) If we place a plano-convex lens on a plane glass surface, a thin film of air is formed between the curved surface of the lens and plane glass plate.

(2) If we allow monochomatic light to fall normally on the surface of lens, then circular interference fringes of radius r can be seen in the reflected light. This circular fringes are called Newton rings.



(3) The central fringe is a dark spot then there are alternate bright and dark fringes (Ring shape).

Fig. 30.18

(4) Radius of n^{th} dark ring $r_m \simeq \sqrt{n\lambda R}$

n = 0, 1, 2, ..., R = Radius of convex surface

(5) Radius of n^{th} bright ring $r_n = \sqrt{\left(n + \frac{1}{2}\right)\lambda R}$

(6) If a liquid of ref index μ is introduced between the lens and glass plate, the radii of dark ring would be $r_n = \sqrt{\frac{n\lambda R}{\mu}}$

(7) Newton's ring arrangement is used of determining the wavelength of monochromatic light. For this the diameter of n^{th} dark ring (D_n) and $(n + p)^{th}$ dark ring (D_{n+p}) are measured then

$$D_{(n+p)}^2 = 4(n+p)\lambda R \text{ and } D_n^2 = 4n\lambda R \quad \Rightarrow \quad \lambda = \frac{D_{n+p}^2 - D_n^2}{4pR}$$

Doppler's Effect of Light

The phenomenon of apparent change in frequency (or wavelength) of the light due to relative motion between the source of light and the observer is called Doppler's effect.

If $\nu =$ actual frequency, $\nu' =$ Apparent frequency, v = speed of source *w.r.t* stationary observer, c = speed of light

(1) **Source of light moves towards the stationary observer :** When a light source is moving towards an observer with a relative velocity v then the apparent frequency (ν') is greater than the actual frequency (ν) of light. Thus apparent wavelength (λ') is lesser the actual wavelength (λ).

$$\nu' = \nu\sqrt{\frac{(1 + v/c)}{(1 - v/c)}} \text{ and } \lambda' = \lambda\sqrt{\frac{(1 - v/c)}{(1 + v/c)}}$$

For $v \ll c$:

(i) Apparent frequency $\nu' = \nu\left(1 + \frac{v}{c}\right)$ and

(ii) Apparent wavelength $\lambda' = \lambda\left(1 - \frac{v}{c}\right)$

(iii) Doppler's shift : Apparent wavelength < actual wavelength,

So spectrum of the radiation from the source of light shifts towards the violet end of spectrum. This is called violet shift

Doppler's shift $\Delta\lambda = \lambda . \frac{v}{c}$

(iv) The fraction decrease in wavelength $= \frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

(2) **Source of light moves away from the stationary observer :** In this case $\nu' < \nu$ and $\lambda' > \lambda$

$$\nu' = \nu\sqrt{\frac{(1 - v/c)}{(1 + v/c)}} \text{ and } \lambda' = \lambda\sqrt{\frac{(1 + v/c)}{(1 - v/c)}}$$

For $v \ll c$:

(i) Apparent frequency $\nu' = \nu\left(1 - \frac{v}{c}\right)$ and

(ii) Apparent wavelength $\lambda' = \lambda\left(1+\frac{v}{c}\right)$

(iii) Doppler's shift : Apparent wavelength > actual wavelength,

So spectrum of the radiation from the source of light shifts towards the red end of spectrum. This is called red shift

Doppler's shift $\Delta\lambda = \lambda.\frac{v}{c}$

(iv) The fractional increase in wavelength $=\frac{\Delta\lambda}{\lambda}=\frac{v}{c}$.

(3) **Doppler broadening :** For a gas in a discharge tube, atoms are moving randomly in all directions. When spectrum of light emitted from these atoms is analyzed, then due to Doppler effect (because some atoms are moving towards detector, some atoms are moving away from detector), the frequency of a spectral line is not observed as having one value, but is spread over a range

$$\pm\Delta\nu = \pm\frac{v}{c}\nu\,, \quad \pm\Delta\lambda = \pm\frac{v}{c}\lambda$$

This broadens the spectral line by an amount ($2\Delta\lambda$). It is called Doppler broadening. The Doppler broadening is proportional to v, which in turn is proportional to $\sqrt{T}$, where T is the temperature in Kelvin.

(4) **Radar :** Radar is a system for locating distant object by means of reflected radio waves, usually of microwave frequencies. Radar is used for navigation and guidance of aircraft, ships *etc*.,.

Radar employs the Doppler effect to distinguish between stationary and moving targets. The change in frequency between transmitted and received waves is measured. If v is the velocity of the approaching target, then the change in frequency is

$\Delta\nu = \frac{2v}{c}\nu$. (The factor of 2 arises due to refection of waves). For a receding target $\Delta\nu = -\frac{2v}{c}\nu$. (The minus sign indicates decrease in frequency).

(5) **Applications of Doppler effect**

(i) Determination of speed of moving bodies (aeroplane, submarine etc) in RADAR and SONAR.

(ii) Determination of the velocities of stars and galaxies by spectral shift.

(iii) Determination of rotational motion of sun.

(iv) Explanation of width of spectral lines.

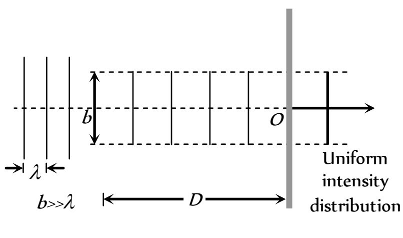
(v) Tracking of satellites.

(vi) In medical sciences in echo cardiogram, sonography *etc*.

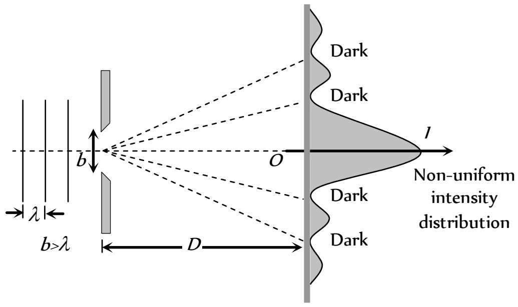
Diffraction of Light

The phenomenon of diffraction was first discovered by Girmaldi. It's experimental study was done by Newton's and young. The theoretical explanation was first given by Fresnel's.

(1) The phenomenon of bending of light around the corners of an obstacle/aperture of the size of the wave length of light is called diffraction.



(A) Size of the slit is very large compared to wavelength



(B) Size of the slit is comparable to wavelength

(2) The phenomenon resulting from the superposition of secondary wavelets originating from different parts of the same wave front is define as diffraction of light.

(3) Diffraction is the characteristic of all types of waves.

(4) Greater the wave length of wave higher will be it's degree of diffraction.

Types of Diffraction

(1) **Fresnel diffraction :** If either source or screen or both are at finite distance from the diffracting device (obstacle or aperture), the diffraction is called Fresnel type.

Common examples : Diffraction at a straight edge, narrow wire or small opaque disc *etc*.

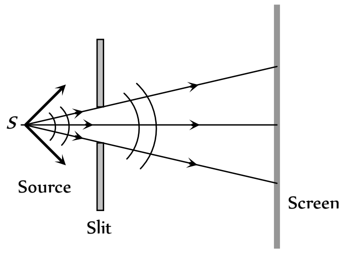


Fig. 30.20

(2) **Fraunhofer diffraction :** In this case both source and screen are effectively at infinite distance from the diffracting device.

Common examples : Diffraction at single slit, double slit and diffraction grating.

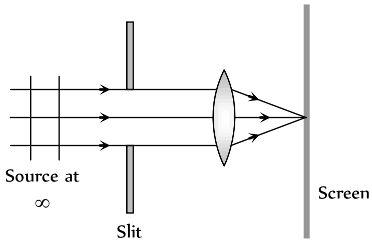
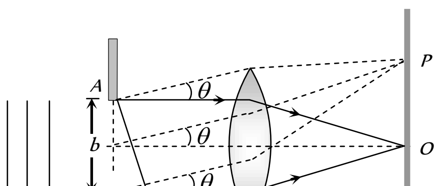


Fig. 30.21

Diffraction at Single Slit (Fraunhoffer Diffraction)

Suppose a plane wave front is incident on a slit AB (of width b). Each and every part of the expose part of the plane wave front (i.e. every part of the slit) acts as a source of secondary wavelets spreading in all directions. The diffraction is obtained on a screen placed at a large distance. (In practice, this condition is achieved by placing the screen at the focal plane of a converging lens placed just after the slit).



(1) The diffraction pattern consists of a central bright fringe (central maxima) surrounded by dark and bright lines (called secondary minima and maxima).

(2) At point O on the screen, the central maxima is obtained. The wavelets originating from points A and B meets in the same phase at this point, hence at O, intensity is maximum.

(3) **Secondary minima :** For obtaining n secondary minima at P on the screen, path difference between the diffracted waves $\Delta = b\sin\theta = n\lambda$

(i) Angular position of n secondary minima $\sin\theta \approx \theta = \frac{n\lambda}{b}$

(ii) Distance of n secondary minima from central maxima

$x_n = D.\theta = \frac{n\lambda D}{b} = \frac{n\lambda f}{b}$; where D = Distance between slit and screen. $f \approx D$ = Focal length of converging lens.

(4) **Secondary maxima :** For n secondary maxima at P on the screen.

Path difference $\Delta = b\sin\theta = (2n+1)\frac{\lambda}{2}$; where n = 1, 2, 3 .....

(i) Angular position of n secondary maxima

$$\sin \approx \theta \approx \frac{(2n+1)\lambda}{2b}$$

(ii) Distance of n secondary maxima from central maxima

$$x_n = D.\theta = \frac{(2n+1)\lambda D}{2b} = \frac{(2n+1)\lambda f}{2b}$$

(5) **Central maxima :** The central maxima lies between the first minima on both sides.

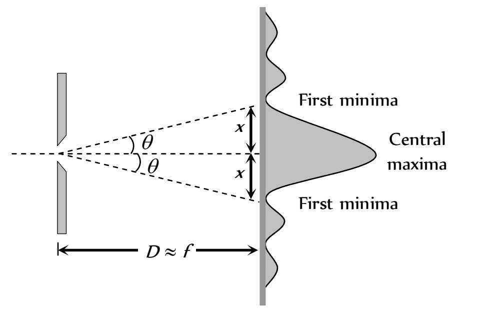
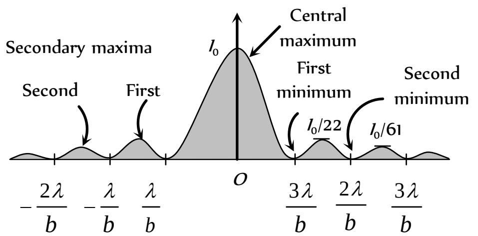


Fig. 30.23

(i) The Angular width d central maxima = $2\theta = \frac{2\lambda}{b}$

(ii) Linear width of central maxima $= 2x = 2D\theta = 2f\theta = \frac{2\lambda f}{b}$

(6) **Intensity distribution :** If the intensity of the central maxima is I_0 then the intensity of the first and second secondary maxima are found to be $\frac{I_0}{22}$ and $\frac{I_0}{61}$. Thus diffraction fringes are of unequal width and unequal intensities.



(i) The mathematical expression for in intensity distribution on the screen is given by

$I = I_0\left(\frac{\sin\alpha}{\alpha}\right)^2$ where α is just a convenient connection between the angle θ that locates a point on the viewing screening and light intensity I.

ϕ = Phase difference between the top and bottom ray from the slit width b.

Also $\alpha = \frac{1}{2}\phi = \frac{\pi b}{\lambda}\sin\theta$

(ii) As the slit width increases (relative to wavelength) the width of the control diffraction maxima decreases; that is, the light undergoes less flaring by the slit. The secondary maxima also decreases in width (and becomes weaker).

(iii) If $b >> \lambda$, the secondary maxima due to the slit disappear; we then no longer have single slit diffraction.

(iv) When the slit width is reduced by a factor of 2, the amplitude of the wave at the centre of the screen is reduced by a factor of 2, so the intensity at the centre is reduced by a factor of 4.

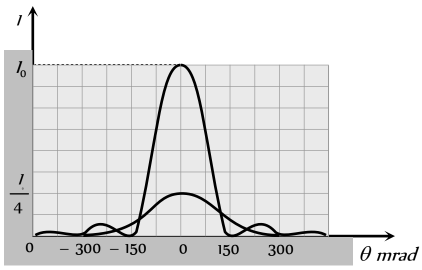


Fig. 30.25

Diffraction Gratings

One of the most useful tools in the study of light and of objects that emit and absorbs light is the diffraction grating.

(1) this device consists parallel slits of equal width and equal spacing called rulings, perhaps as many as several thousand per mm.

(2) The separation (d) between rulings is called grating spacing. (If N-rulings occupy a total width ω, then $d = \frac{\omega}{N}$)

(3) For light ray emerging from each slit at an angle θ, there is a path difference $d\sin\theta$, between each ray the one directly above. The d is called the grating element

$d = a + e$

where a = width of the slit

e = opaque part

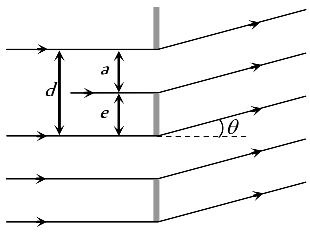


Fig. 30.26

(4) The condition for formation of bright fringe is $d \sin\theta = n\lambda$, where $n = 0, 1, 2, ...$ is called the order of diffraction.

Fresnel's Half Period Zone (HPZ)

According to Fresnel's the entire wave front can be divided into a large number of parts of zones which are known as Fresnel's half period zones (HPZ's).

The resultant effect at any point on screen is due to the combined effect of all the secondary waves from the various zones.

Suppose ABCD is a plane wave front. We desire to find it's effect at point P consider a sphere of radius $\left(d + \frac{\lambda}{2}\right)$ with centre at P, then this sphere will cut the wave front in a circle (circle 1). This circular zone is called Fresnel's first (I) HPZ.

A sphere of radius $b + 2\left(\frac{\lambda}{2}\right)$ with centre at P will cut the wave front in circle 2, the annular region between circle 2 and circle 1 is called second (II) HPZ.

The peripheral area enclosed between the n circle and $(n-1)^{th}$ circle is defined as n HPZ.

(1) **Radius of HPZ :** For n HPZ, it is given by

$$r_n = \sqrt{nd\lambda} \;\; \Rightarrow r_n \propto \sqrt{\lambda}$$

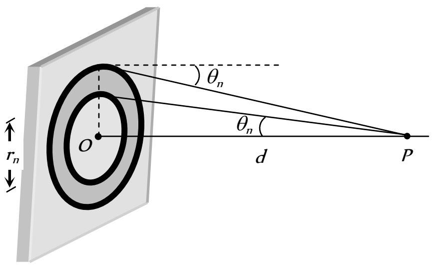


Fig. 30.28

(2) **Area of HPZ :** Area of n HPZ is given by

A_n = Area of n circle – Area of $(n-1)^{th}$ circle

$$= \pi(r_n^2 - r_{n-1}^2) = \pi d\lambda$$

(3) **Mean distance of the observation point P from n HPZ :** $d_n = \frac{r_n + r_{n-1}}{2} = b + \frac{(2n-1)\lambda}{4}$

(4) **Phase difference between the HPZ :** phase difference between the wavelets originating from two consecutive HPZ's and reaching the point P is π (or path difference is $\frac{\lambda}{2}$, time difference is $\frac{T}{2}$).

The phase difference between any two even or old number HPZ is 2π.

(5) **Amplitude of HPZ :** The amplitude of light at point P due to n HPZ is $R_n \propto \frac{A_n}{d_n}(1+\cos\theta_n)$; where A_n = Area of n HPZ, d_n = Mean distance of n HPZ

$(1+\cos\theta_n)$ = Obliquity factor.

On increasing the value of n, the value of R_n gradually goes on decreasing i.e. $R_1 > R_2 > R_3 > R_4 > ....\ .. > R_{n-1} > R_n$

(6) **Resultant Amplitude :** The wavelets from two consecutive HPZ's meets in opposite phase at P.

Hence Resultant amplitude at P

$$R = R_1 - R_2 + R_3 - R_4 + ...(-1)^{n-1} R_n$$

When $n = \infty$, then $R_{n-1} = R_n = 0$, therefore $R = \frac{R_1}{2}$

i.e. For large number of HPZ, the amplitude of light at point P due to whole wave front is half the amplitude due to first HPZ.

The ratio of amplitudes due to consecutive HPZ's is constant and is less than 1

$$\frac{R_n}{R_{n-1}} .... \frac{R_5}{R_4} = \frac{R_4}{R_3} = \frac{R_3}{R_2} = \frac{R_2}{R_1} = k \quad \text{(where } k < 1\text{)}$$

(7) **Resultant Intensity :** Intensity $\propto$ (amplitude)^2

For $n = \infty$, $I \propto \frac{R_1^2}{4} \propto \frac{I_1}{4}$

i.e. the resultant intensity due to whole wave front is $\frac{1}{4}th$ the intensity due to first HPZ.

Diffraction Due to a Circular Disc

When a disc is placed in the path of a light beam, then diffraction pattern is formed on the screen.

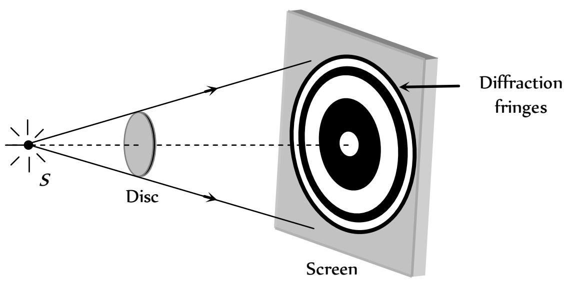


Fig. 30.29

(1) At the centre of the circular shadow of disc, there occurs a bright spot. This spot is called Fresnel's spot or Poisson's spot.

(2) The intensity of bright spot decreases, when the size of the disc is increased or when the screen is moved towards the disc.

(3) Circular alternate bright and dark fringes are formed around the bright spot with fringe width in decreasing order.

(4) Let r be the radius of the disc, d is the distance between screen and the disc and λ is the wavelength of light used.

If n HPZ are covered by disc then $nd\lambda = \pi r^2 \Rightarrow n = \frac{r^2}{d\lambda}$

(5) If the disc obstruct only first HPZ, the resultant amplitude at the central point $R = -R_2 + R_3 + ... \approx -\frac{R_2}{2}$.

So intensity is $\frac{kR_2^2}{4}$ which is slightly less than the intensity $\frac{k\,R_1^2}{4}$ due to whole wave front, when no obstacle is placed.

(6) The intensity at bright spot is given by $I = k\left[\frac{R_{n+1}}{2}\right]^2$

where n = Number of obstructed HPZ's

Diffraction Due to a Circular Aperture

When a circular aperture is placed in the path of a light beam, then following diffraction pattern is formed on the screen.

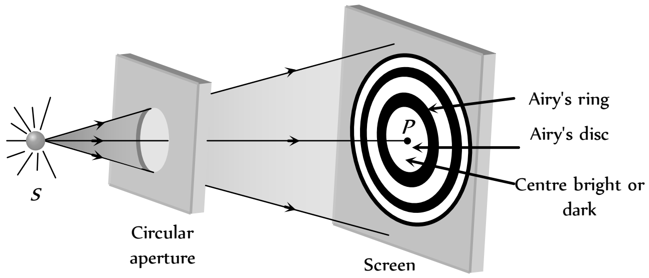
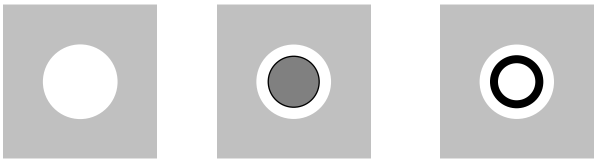


Fig. 30.30

(1) If only one HPZ is allowed by the aperture then the resultant amplitude at P would be R_1 which is twice the value of amplitude for the unobstructed wave front. The intensity would there fore be $4I$, where I represents the intensity at point P, due to unobstructed wave front.

(2) If the first two HPZ's are permitted by aperture than the resultant intensity at the centre point P will be very small (as $R_1 - R_2 \approx 0$). In this case the diffraction pattern consist of a bright circle of light with a dark spot.

(3) In general if number of HPZ's (n) passing through aperture is odd, then the central point will be bright and if n is even, central point will be dark.



(A) $n=1$, $r^2=b\lambda$ bright centre; (B) $n=2$, $r^2=2b\lambda$ dark centre; (C) $n=3$, $r^2=3b\lambda$ bright centre

Fig. 30.31

(4) The central bright disc is known as Airy's disc.

(5) In the non axial region bright and dark diffraction rings are obtained. The intensity of bright diffraction rings gradually goes on decreasing whereas that of dark diffraction goes on increasing.

(6) The first dark ring obtained around the central bright disc is known as Airy's ring.

Zone Plate

It is a diffracting device used to experimentally demonstrate the diffraction effect.

(1) It is formed on a glass plate by drawing a number of concentric circles on it whose radii are in the ratio of

$$\sqrt{1} : \sqrt{2} : \sqrt{3} .... \;.i.e.\, r \propto \sqrt{n}$$

For some specific distance from this plate the circles coincides with the HPZ's of the Fresnel's theory. (Alternate zones are made opaque).

(2) **Positive zone plate :** When odd zones are kept transparent to the light and even zones are made opaque, then it is called positive zone plate.

The resultant amplitude due to this zone plate in

$$R = R_1 + R_3 + R_5 + ... >> \frac{R_1}{2}$$

Thus, intensity of light tremendously increases.

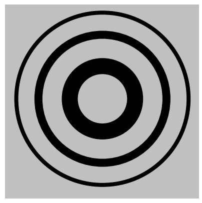


Fig. 30.32

(3) **Negative zone plate :** when even zones are kept transparent to light and odd zones are made opaque, then it is called negative zone plate.

The resultant amplitude due to this zone plate is

$$R = R_2 + R_4 + R_6 + ... >> \frac{R_1}{2}$$

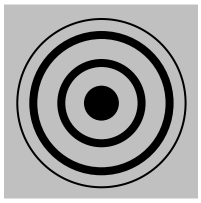


Fig. 30.33

(4) Zone plate behaves like a convex lens. For a plane wave front the image of source is formed at distance d *i.e.* d is equal to the principle focal length or first focal length $f_1 = d = \frac{r^2}{\lambda}$

(5) Multiple focii of zone plate are given by $f_p = \frac{r^2}{(2p-1)\lambda}$ where p = 1, 2, 3,......... represents the order of focii

(6) If the radius of n circle on zone plate is r_n then in terms of r_n.

Principal focal length $f_1 = \frac{r_n^2}{n\lambda}$

Other focal length $f_p = \frac{r_n^2}{(2p-1)n\lambda}$

(7) If a is the distance of the source from the zone plate then the distance b of the point where maximum intensity is observes is given by $\frac{1}{a} + \frac{1}{b} = \frac{n\lambda}{r_n^2}$

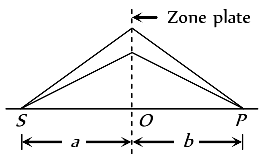


Fig. 30.34

Polarisation of Light

Light propagates as transverse EM waves. The magnitude of electric field is much larger as compared to magnitude of magnetic field. We generally prefer to describe light as electric field oscillations.

(1) **Unpolarised light :** In ordinary light (light from sun, bulb *etc.*) the electric field vectors are distributed in all directions in a light is called unpolarised light. The oscillation of propagation of light wave. This resolved into horizontal and vertical component.

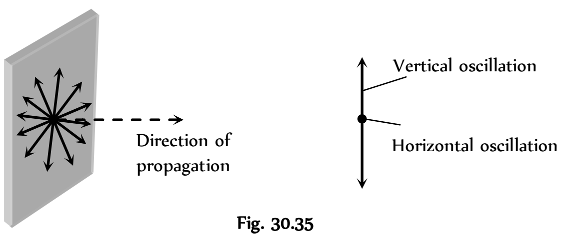


Fig. 30.35

(2) **Polarised light :** The phenomenon of limiting the vibrating of electric field vector in one direction in a plane perpendicular to the direction of propagation of light wave is called polarization of light.

(i) The plane in which oscillation occurs in the polarised light is called plane of oscillation.

(ii) The plane perpendicular to the plane of oscillation is called plane of polarisation.

(iii) Light can be polarised by transmitting through certain crystals such as tourmaline or polaroids.

(3) **Polaroids :** It is a device used to produce the plane polarised light. It is based on the principle of selective absorption and is more effective than the tourmaline crystal. or

It is a thin film of ultramicroscopic crystals of quinine idosulphate with their optic axis parallel to each other.

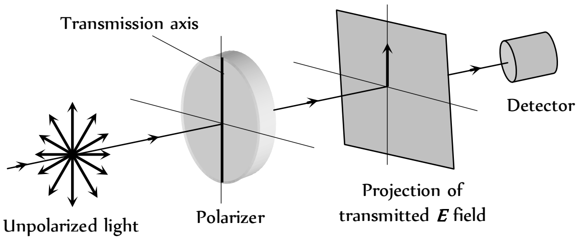
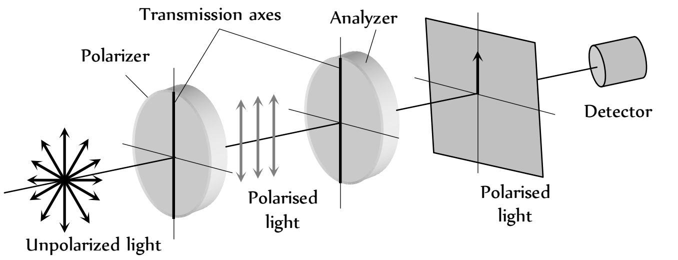


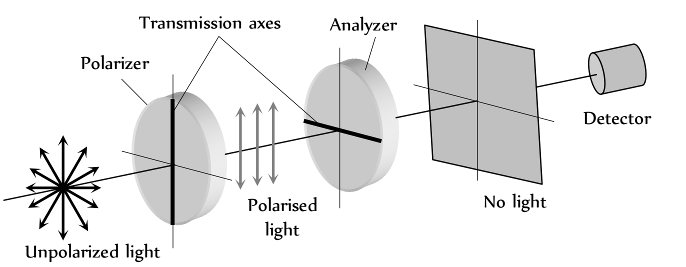
Fig. 30.36

(i) Polaroids allow the light oscillations parallel to the transmission axis pass through them.

(ii) The crystal or polaroid on which unpolarised light is incident is called polariser. Crystal or polaroid on which polarised light is incident is called analyser.



(A) Transmission axes of the polariser and analyser are parallel to each other, so whole of the polarised light passes through analyser



(B) Transmission axis of the analyser is perpendicular to the polariser, hence no light passes through the analyser

Fig. 30.37

(4) **Malus law :** This law states that the intensity of the polarised light transmitted through the analyser varies as the square of the cosine of the angle between the plane of transmission of the analyser and the plane of the polariser.

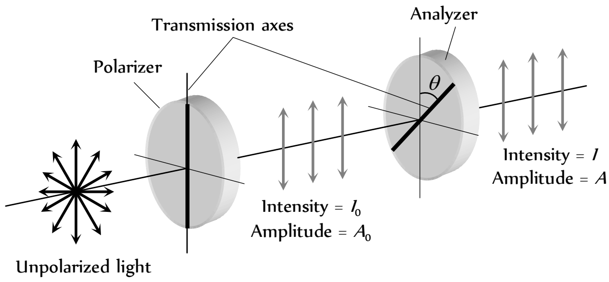


Fig. 30.38

(i) $I = I_0 \cos^2\theta$ and $A^2 = A_0^2\cos^2\theta \Rightarrow A = A_0\cos\theta$

If $\theta = 0^o$, $I = I_0$, $A = A_0$, If $\theta = 90^o$, $I = 0$, $A = 0$

(ii) If $I_i =$ Intensity of unpolarised light.

So $I_0 = \frac{I_i}{2}$ *i.e.* if an unpolarised light is converted into plane polarised light (say by passing it through a Polaroid or a Nicol-prism), its intensity becomes half. and $I = \frac{I_i}{2}\cos^2\theta$

Methods of Producing Polarised Light

(1) **Polarisation by reflection :** Brewster discovered that when a beam of unpolarised light is reflected from a transparent medium (refractive index =μ), the reflected light is completely plane polarised at a certain angle of incidence (called the angle of polarisation θ_p).

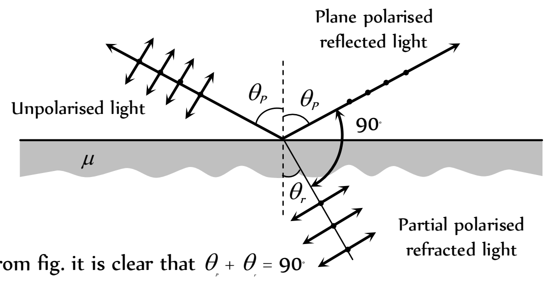


Fig. 30.39

From fig. it is clear that $\theta_p + \theta_r = 90^\circ$

Also $\mu = \tan\theta_p$ Brewster's law

(i) For $i < \theta_p$ or $i > \theta_p$

Both reflected and refracted rays becomes partially polarised

(ii) For glass $\theta_P \approx 57^o$, for water $\theta_P \approx 53^o$

(2) **By Dichroism :** Some crystals such as tourmaline and sheets of iodosulphate of quinine have the property of strongly absorbing the light with vibrations perpendicular to a specific direction (called transmission axis) transmitting the light with vibrations parallel to it. This selective absorption of light is called dichroism.

(3) **By double refraction :** In certain crystals, like calcite, quartz and tourmaline *etc*, incident unpolarized light splits up into two light beams of equal intensities with perpendicular polarization.

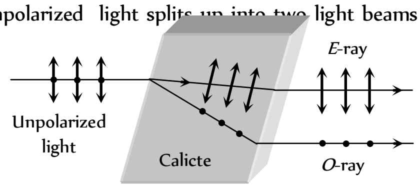


Fig. 30.40

(i) One of the ray is ordinary ray (*O*-ray) it obey's the Snell's law. Another ray's extra ordinary ray (*E*-ray) it doesn't obey's the Snell's law.

(ii) Along a particular direction (fixed in the crystal, the two velocities (velocity of *O*-ray v_o and velocity of *E*-ray v_e) are equal; this direction is known as the optic axis of the crystal (crystal's known as uniaxial crystal). Optic axis is a direction and not any line in crystal.

(iii) In the direction, perpendicular to the optic axis for negative crystal (calcite) $v_e > v_o$ and $\mu_e < \mu_o$.

For positive crystal $v_e < v_o$, $\mu_e > \mu_o$.

(4) **Nicol prism :** Nicol prism is made up of calcite crystal and in it *E*-ray is isolated from *O*-ray through total internal reflection of *O*-ray at canada balsam layer and then absorbing it at the blackened surface as shown in fig.

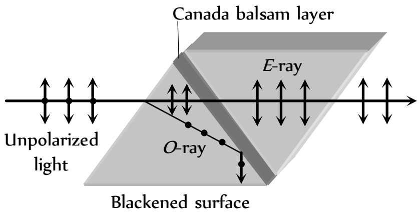


Fig. 30.41

The refractive index for the *O*-ray is more that for the *E*-ray. The refractive index of Canada balsam lies between the refractive indices of calcite for the *O*-ray and *E*-ray

(5) **By Scattering :** It is found that scattered light in directions perpendicular to the direction of incident light is completely plane polarised while transmitted light is unpolarised. Light in all other directions is partially polarised.

(6) **Optical activity and specific rotation :** When plane polarised light passes through certain substances, the plane of polarisation of the light is rotated about the direction of propagation of light through a certain angle. This phenomenon is called optical activity or optical rotation and the substances optically active.

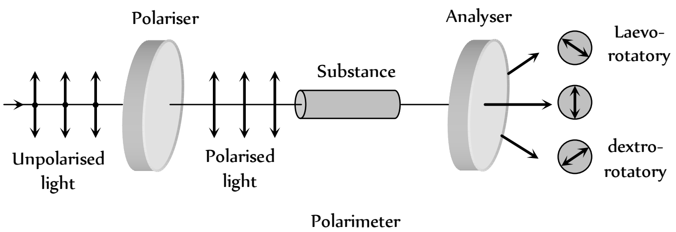


Fig. 30.42

If the optically active substance rotates the plane of polarisation clockwise (looking against the direction of light), it is said to be *dextro-rotatory* or *right-handed.* However, if the substance rotates the plane of polarisation anti-clockwise, it is called *laevo-rotatory* or *left-handed.*

The optical activity of a substance is related to the asymmetry of the molecule or crystal as a whole, *e.g.,* a solution of cane-sugar is dextro-rotatory due to asymmetrical molecular structure while crystals of quartz are dextro or laevo-rotatory due to structural asymmetry which vanishes when quartz is fused.

Optical activity of a substance is measured with help of polarimeter in terms of 'specific rotation' which is defined as the rotation produced by a solution of length 10 *cm* (1 *dm*) and of unit concentration (*i.e.* 1 *g*/cc) for a given wavelength of light at a given temperature. *i.e.* $[\alpha]_{t^oC}^{\lambda} = \dfrac{\theta}{L \times C}$

where θ is the rotation in length L at concentration C.

(7) **Applications and uses of polarisation**

(i) By determining the polarising angle and using Brewster's law, *i.e.* $\mu = \tan\theta$, refractive index of dark transparent substance can be determined.

(ii) It is used to reduce glare.

(iii) In calculators and watches, numbers and letters are formed by liquid crystals through polarisation of light called liquid crystal display (LCD).

(iv) In CD player polarised laser beam acts as needle for producing sound from compact disc which is an encoded digital format.

(v) It has also been used in recording and reproducing three-dimensional pictures.

(vi) Polarisation of scattered sunlight is used for navigation in solar-compass in polar regions.

(vii) Polarised light is used in optical stress analysis known as 'photoelasticity'.

(viii) Polarisation is also used to study asymmetries in molecules and crystals through the phenomenon of 'optical activity'.

(ix) A polarised light is used to study surface of nucleic acids (DNA, RNA)

Electromagnetic Waves

A changing electric field produces a changing magnetic field and vice versa which gives rise to a transverse wave known as electromagnetic wave. The time varying electric and magnetic field are mutually perpendicular to each other and also perpendicular to the direction of propagation of this wave.

The electric vector is responsible for the optical effects of an EM wave and is called the *light vector*.

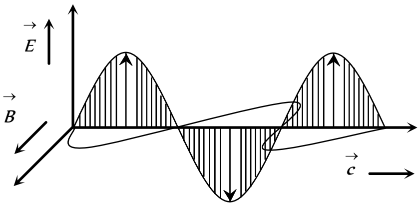


Fig. 30.43

(1) $\vec{E}$ and $\vec{B}$ always oscillates in phase.

(2) $\vec{E}$ and $\vec{B}$ are such that $\vec{E} \times \vec{B}$ is always in the direction of propagation of wave.

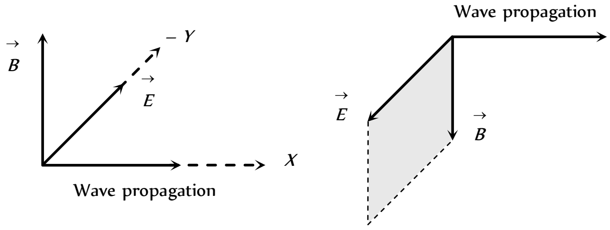


Fig. 30.44

(3) The EM wave propagating in the positive *x*-direction may be represented by

$$E = E_y = E_0 \sin(kx - \omega t)$$

$$B = B_z = B_0 \sin(kx - \omega t)$$

where E (or E_y), B (or B_z) are the instantaneous values of the fields, E_0, B_0 are amplitude of the fields and K = angular wave number $= \dfrac{2\pi}{\lambda}$.

Maxwell's Contribution

(1) **Ampere's Circuital law :** According to this law the line integral of magnetic field along any closed path or circuit is μ_0 times the total current threading the closed circuit *i.e.,* $\oint \vec{B}.\vec{dl} = \mu_0 i$

(2) **Inconsistency of Ampere's law :** Maxwell explained that Ampere's law is valid only for steady current or when the electric field does not change with time. To see this inconsistency consider a parallel plate capacitor being charged by a battery. During the charging time varying current flows through connecting wires.

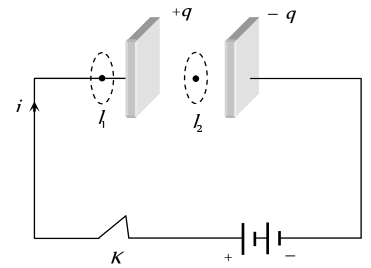


Fig. 30.45

Applying Ampere's law for loop and l $\oint_{l_1} \vec{B}.\vec{dl} = \mu_0 i$

But $\oint_{l_2} \vec{B}.\vec{dl} = 0$ (Since no current flows through the region between the plates). But practically it is observed that there is a magnetic field between the plates. Hence Ampere's law fails

i.e. $\oint_{l_1} \vec{B}.\vec{dl} \neq \mu_0 i$.

(3) **Modified Ampere's Circuital law or Ampere- Maxwell's Circuital law :** Maxwell assumed that some sort of current must be flowing between the capacitor plates during charging process. He named it displacement current. Hence modified law is as follows

$$\oint \vec{B}.\vec{dl} = \mu_0(i_c + i_d) \text{ or } \oint \vec{B}.\vec{dl} = \mu_0\left(i_c + \varepsilon_0 \frac{d\phi_E}{dt}\right)$$

where i_c = conduction current = current due to flow of charges in a conductor and

i_d = Displacement current = $\varepsilon_0 \frac{d\phi_E}{dt}$ = current due to the changing electric field between the plates of the capacitor

(4) **Maxwell's equations**

(i) $\oint_s \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$ (Gauss's law in electrostatics)

(ii) $\oint_s \vec{B}.\vec{ds} = 0$ (Gauss's law in magnetism)

(iii) $\oint \vec{B}.\vec{dl} = -\frac{d\phi_B}{dt}$ (Faraday's law of EMI)

(iv) $\oint \vec{B}\,\vec{dl} = \mu_o\left(i_c + \varepsilon_o \frac{d\phi_E}{dt}\right)$ (Maxwell- Ampere's Circuital law)

History of EM Waves

(1) **Maxwell :** Was the first to predict the EM wave.

(2) **Hertz :** Produced and detected electromagnetic waves experimentally at wavelengths of 6 *m*.

(3) **J.C. Bose :** Produced EM waves of wavelength ranging from 5 *mm* to 25 *mm*.

(4) **Marconi :** Successfully transmitted the EM waves up to a few *kilometer*. Marconi discovered that if one of the spark gap terminals is connected to an antenna and the other terminal is Earthed, the electromagnetic waves radiated could go upto several kilometers.

Experimental Setup for Producing EM Waves

Hertz experiment based on the fact that a oscillating charge is accelerating continuously, it will radiate electromagnetic waves continuously. In the following figure

(1) The metallic plates (P_1 and P_2) acts as a capacitor.

(2) The wires connecting spheres S_1 and S_2 to the plates provide a low inductance.

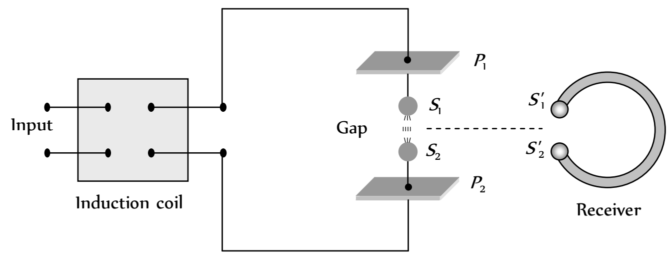


Fig. 30.46

(3) When a high voltage is applied across metallic plates these plates get discharged by sparking across the narrow gap. The spark will give rise to oscillations which in turn send out electromagnetic waves. Frequency of these wave is given by $\nu = \frac{1}{2\pi\sqrt{LC}}$

The succession of sparks send out a train of such waves which are received by the receiver.

Source, Production and Nature of EM Waves

(1) A charge oscillating harmonically is a source of EM waves of same frequency.

(2) A simple *LC* oscillator and energy source can produce waves of desired frequency $\left(\nu = \frac{1}{2\pi\sqrt{LC}}\right)$.

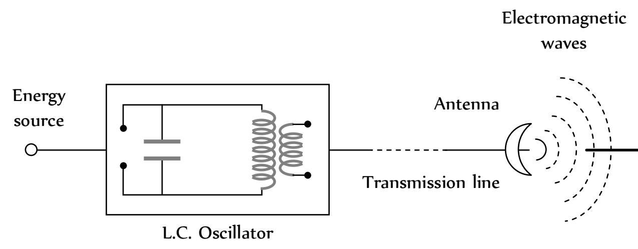


Fig. 30.47

(3) The EM Waves are transverse in nature. They do not require any material medium for their propagation.

Properties of EM Waves

(1) **Speed :** In free space it's speed

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = \frac{E_0}{B_0} = 3 \times 10^8 m/s.$$

In medium $v = \frac{1}{\sqrt{\mu\varepsilon}}$; where μ_0 = Absolute permeability, ε = Absolute permittivity.

(2) **Energy :** The energy in an EM waves is divided equally between the electric and magnetic fields.

Energy density of electric field $u_e = \frac{1}{2}\varepsilon_0 E^2$, Energy density of magnetic field $u_B = \frac{1}{2}\frac{B^2}{\mu_0}$

The total energy per unit volume is $u = u_e + u_m = \frac{1}{2}\varepsilon_0 E^2 + \frac{1}{2}\frac{B^2}{\mu_0}$.

Also $u_{av} = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{B_0^2}{2\mu_0}$

(3) **Intensity (*I*) :** The energy crossing per unit area per unit time, perpendicular to the direction of propagation of EM wave is called intensity.

i.e. $I = \frac{\text{Total EM energy}}{\text{Surface area} \times \text{Time}} = \frac{\text{Total energy density} \times \text{Volume}}{\text{Surface area} \times \text{Time}}$

$\Rightarrow I = u_{av} \times c = \frac{1}{2}\varepsilon_0 E_0^2 c = \frac{1}{2}\frac{B_0^2}{\mu_0}.c \frac{Watt}{m^2}$.

(4) **Momentum :** EM waves also carries momentum, if a portion of EM wave of energy *u* propagating with speed *c*, then linear momentum $= \frac{\text{Energy}(u)}{\text{Speed }(c)}$

If wave incident on a completely absorbing surface then momentum delivered $p = \frac{u}{c}$. If wave incident on a totally reflecting surface then momentum delivered $-p = \frac{2u}{c}$.

(5) **Poynting vector** $(\vec{S})$. **:** In EM waves, the rate of flow of energy crossing a unit area is described by the Poynting vector.

(i) It's unit is $Watt/m^2$ and $\vec{S} = \frac{1}{\mu_o}(\vec{E} \times \vec{B}) = c^2\varepsilon_0(\vec{E} \times \vec{B})$.

(ii) Because in EM waves $\vec{E}$ and $\vec{B}$ are perpendicular to each other, the magnitude of $\vec{S}$ is $|\vec{S}| = \frac{1}{\mu_0} E B \sin 90^o = \frac{EB}{\mu_0} = \frac{E^2}{\mu C}$.

(iii) The direction of $\vec{S}$ does not oscillate but it's magnitude varies between zero and a maximum $\left(S_{\max} = \frac{E_0 B_0}{\mu_0}\right)$ each quarter of a period.

(iv) Average value of poynting vector is given by

$$\overline{S} = \frac{1}{2\mu_0} E_0 B_0 = \frac{1}{2}\varepsilon_0 E_0^2 c = \frac{cB_0^2}{2\mu_0}$$

The direction of the poynting vector $\vec{S}$ at any point gives the wave's direction of travel and direction of energy transport the point.

(6) **Radiation pressure :** Is the momentum imparted per second pre unit area. On which the light falls.

For a perfectly reflecting surface $P_r = \frac{2S}{c}$; *S* = Poynting vector; *c* = Speed of light

For a perfectly absorbing surface $P_a = \frac{S}{c}$.

(7) **Wave impedance (*Z*) :** The medium offers hindrance to the propagation of wave. Such hindrance is called wave impedance and it is given by $Z = \sqrt{\frac{\mu}{\varepsilon}} = \sqrt{\frac{\mu_r}{\varepsilon_r}}\sqrt{\frac{\mu_0}{\varepsilon_0}}$

For vacuum or free space $Z = \sqrt{\frac{\mu_0}{\varepsilon_0}} = 376.6\,\Omega$.

EM Spectrum

The whole orderly range of frequencies/wavelengths of the EM waves is known as the EM spectrum.

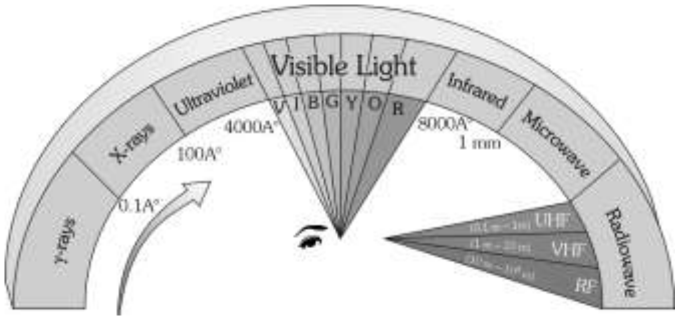


Fig. 30.48

Table 30.2 : Uses of EM spectrum

Radiation	Uses
γ-rays	Gives informations on nuclear structure, medical treatment *etc.*
X-rays	Medical diagnosis and treatment study of crystal structure, industrial radiograph.
UV- rays	Preserve food, sterilizing the surgical instruments, detecting the invisible writings, finger prints etc.
Visible light	To see objects
Infrared rays	To treat, muscular strain for taking photography during the fog, haze etc.
Micro wave and radio wave	In radar and telecommunication.

Earth's Atmosphere

The gaseous envelope surrounding the earth is called it's atmosphere. The atmosphere contains 78% N_2, 21% O_2, and traces of other gases (like helium, krypton, CO_2 etc.)

(1) **Division of earth's atmosphere :** Earth atmosphere has been divided into regions as shown.

(i) Troposphere : In this region, the temperature decreases with height from 290 *K* to 220 *K*.

(ii) Stratosphere : The temperature of stratosphere varies from 220 *K* to 200 *K*.

(iii) Mesosphere : In this region, the temperature falls to 180 *K*.

(iv) Ionosphere : Ionosphere is partly composed of charged particles, ions and electrons, while the rest of the atmosphere contains neutral molecules.

(v) Ozone layer absorbs most of the ultraviolet rays emitted by the sun.

(vi) Kennelly heaviside layer lies at about 110 km from the earth's surface. In this layer concentration of electron is very high.

(vii) The ionosphere plays a vital role in the radio communication.

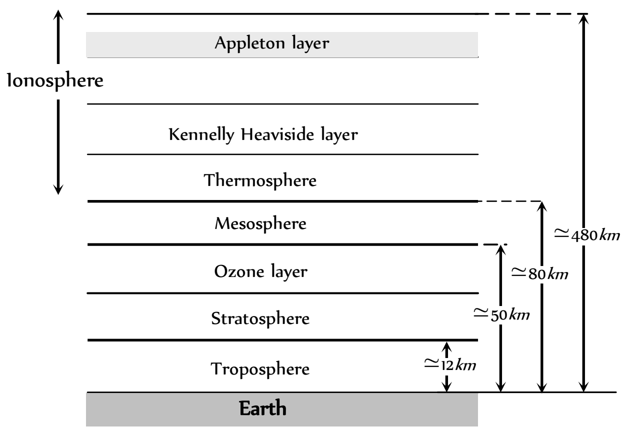


Fig. 30.49

(2) **Green house effect :** The warming of earth's atmosphere due to the infrared radiations reflected by low lying clouds and carbon dioxide in the atmosphere of earth is called green house effect.

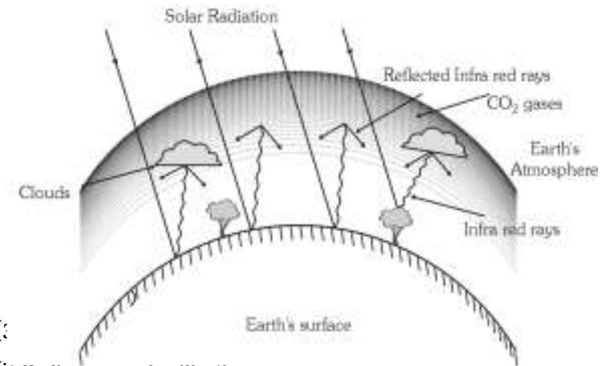


Fig. 30.50

(3

(i) **Radio waves classification**

(a) Very low frequency (VLF) $\rightarrow$ 10 KHz to 30 KHz

(b) Low frequency (LF) $\rightarrow$ 30 KHz to 300 KHz

(c) Medium frequency (MF) or medium wave (MW) $\rightarrow$ 300 KHz to 3000 KHz

(d) High frequency (HF) or short wave (SW) $\rightarrow$ 3 MHz to 30 MHz

(e) Very high frequency (VHF) $\rightarrow$ 30 MHz to 300 MHz

(f) Ultra high frequency (UHF) $\rightarrow$ 300 MHz to 3000 MHz

(g) Super high frequency or micro waves $\rightarrow$ 3000 MHz to 300, 000 MHz

(ii) **Amplitude modulated transmission :** Radio waves having frequency less than or equal to 30 MHz form an amplitude modulation band (or AM band). The signals can be transmitted from one place to another place on earth's surface in two ways

(a) Ground wave propagation : The radio waves following the surface of the earth are called ground waves.

(b) Sky wave propagation : The amplitude modulated radio waves which are reflected back by the ionosphere are called sky waves.

(iii) **Frequency modulated (FM) transmission :** Radio waves having frequencies between 80 MHz and 200 MHz form a frequency modulated bond. T.V. signals are normally frequency modulated.

(4) **T.V. Signals**

(i) T.V. signals are normally frequency modulated. So T.V. signals can be transmitted by using tall antennas.

(ii) Distance covered by the T.V. signals $d=\sqrt{2hR}$

(h = Height of the antenna, R = Radius of earth)

(iii) Area covered $A=\pi d^2=2\pi hR$

(iv) Population covered = Area × Population density.

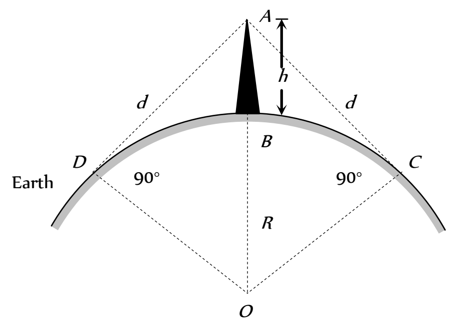


Fig. 30.51

Tips & Tricks

✍ In interference redistribution of energy takes place in the form of maxima and minima.

✍ Average intensity : $I_{av}=\dfrac{I_{\max}+I_{\min}}{2}=I_1+I_2=a_1^2+a_2^2$

✍ Ratio of maximum and minimum intensities :

$$\frac{I_{\max}}{I_{\min}}=\left(\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}\right)^2=\left(\frac{\sqrt{I_1/I_2}+1}{\sqrt{I_1/I_2}-1}\right)^2$$

$$=\left(\frac{a_1+a_2}{a_1-a_2}\right)^2=\left(\frac{a_1/a_2+1}{a_1/a_2-1}\right)^2 \text{ also } \sqrt{\frac{I_1}{I_2}}=\frac{a_1}{a_2}=\left(\frac{\sqrt{\frac{I_{\max}}{I_{\min}}}+1}{\sqrt{\frac{I_{\max}}{I_{\min}}}-1}\right)$$

✍ If two waves having equal intensity ($I_1=I_2=I$) meets at two locations P and Q with path difference Δ_1 and Δ_2 respectively then the ratio of resultant intensity at point P and Q will be

$$\frac{I_P}{I_Q} = \frac{\cos^2 \frac{\phi_1}{2}}{\cos^2 \frac{\phi_2}{2}} = \frac{\cos^2\left(\frac{\pi\Delta_1}{\lambda}\right)}{\cos^2\left(\frac{\pi\Delta_2}{\lambda}\right)}$$

✍ The angular thickness of fringe width is defined as $\delta = \frac{\beta}{D} = \frac{\lambda}{d}$, which is independent of the screen distance *D*.

✍ Central maxima means the maxima formed with zero optical path difference. It may be formed anywhere on the screen.

✍ All the wavelengths produce their central maxima at the same position.

✍ The wave with smaller wavelength from its maxima before the wave with longer wavelength.

✍ The first maxima of violet colour is closest and that for the red colour is farthest.

✍ Fringes with blue light are thicker than those for red light.

✍ In an interference pattern, whatever energy disappears at the minimum, appears at the maximum.

✍ In YDSE, the nth maxima always comes before the nth minima.

✍ In YDSE, the ratio $\frac{I_{\max}}{I_{\min}}$ is maximum when both the sources have same intensity.

✍ For two interfering waves if initial phase difference between them is ϕ and phase difference due to path difference between them is ϕ. Then total phase difference will be

$$\phi = \phi_0 + \phi' = \phi_0 + \frac{2\pi}{\lambda}\Delta .$$

✍ Sometimes maximm number of maximas or minimas are asked in the question which can be obtained on the screen. For this we use the fact that value of sin θ (or cos θ) can't be greater than 1. For example in the first case when the slits are vertical

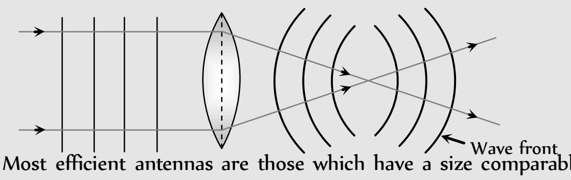
$$\sin\theta = \frac{n\lambda}{d} \qquad \text{(for maximum intensity)}$$

$$\because \sin\theta \not> 1 \quad \therefore \frac{n\lambda}{d} \not> 1 \qquad \text{or} \qquad n \not> \frac{d}{\lambda}$$

Suppose in some question d/λ comes out say 4.6, then total number of maximuas on the screen will be 9. Corresponding to $n = 0, \pm 1, \pm 2, \pm 3$ and ± 4.

✍ ***Shape of wave front***

If rays are parallel, wave front is plane. If rays are converging wave front is spherical of decreasing radius. If rays are diverging wave front is spherical of increasing radius.



✍ Most efficient antennas are those which have a size comparable to the wavelength of the of electromagnetic wave they emit or receive.

✍ A substance (like calcite quartz) which exhibits different properties in different direction is called an anisotopic substance.

Ordinary Thinking

Objective Questions

Wave Nature and Interference of Light

1. By corpuscular theory of light, the phenomenon which can be explained is
(a) Refraction (b) Interference
(c) Diffraction (d) Polarisation

2. According to corpuscular theory of light, the different colours of light are due to
(a) Different electromagnetic waves
(b) Different force of attraction among the corpuscles
(c) Different size of the corpuscles
(d) None of the above

3. Huygen's conception of secondary waves [CPMT 1975]
(a) Allow us to find the focal length of a thick lens
(b) Is a geometrical method to find a wavefront
(c) Is used to determine the velocity of light
(d) Is used to explain polarisation

4. The idea of the quantum nature of light has emerged in an attempt to explain [CPMT 1990]
(a) Interference
(b) Diffraction
(c) Radiation spectrum of a black body
(d) Polarisation

5. Two coherent sources of light can be obtained by [MH CET 2001]
(a) Two different lamps
(b) Two different lamps but of the same power
(c) Two different lamps of same power and having the same colour
(d) None of the above

6. By Huygen's wave theory of light, we cannot explain the phenomenon of [CPMT 1989; AFMC 1993, 99; MP PET 1995, 2003; RPMT 2003; BCECE 2003; Pb PMT 2004]
(a) Interference (b) Diffraction
(c) Photoelectric effect (d) Polarisation

7. The phenomenon of interference is shown by [MNR 1994; MP PMT 1997; AIIMS 1999, 2000; JIPMER 2000; UPSEAT 1994, 2000]
(a) Longitudinal mechanical waves only
(b) Transverse mechanical waves only
(c) Electromagnetic waves only
(d) All the above types of waves

8. Two coherent monochromatic light beams of intensities I and $4I$ are superposed. The maximum and minimum possible intensities in the resulting beam are [IIT-JEE 1988; RPMT 1995; AIIMS 1997; MP PMT 1997; MP PET 1999; BHU 2002; KCET 2000, 05]
(a) $5I$ and I (b) $5I$ and $3I$
(c) $9I$ and I (d) $9I$ and $3I$

9. Light appears to travel in straight lines since [RPMT 1997; CPMT 1987, 89, 90, 2001; AIIMS 1998, 2002; KCET 2002; BHU 2002; DCE 2003]
(a) It is not absorbed by the atmosphere
(b) It is reflected by the atmosphere
(c) Its wavelength is very small
(d) Its velocity is very large

10. The idea of secondary wavelets for the propagation of a wave was first given by [Orissa PMT 2004]
(a) Newton (b) Huygen
(c) Maxwell (d) Fresnel

11. By a monochromatic wave, we mean [AFMC 1995]
(a) A single ray
(b) A single ray of a single colour
(c) Wave having a single wavelength
(d) Many rays of a single colour

12. The similarity between the sound waves and light waves is [KCET 1994]
(a) Both are electromagnetic waves
(b) Both are longitudinal waves
(c) Both have the same speed in a medium
(d) They can produce interference

13. The ratio of intensities of two waves is 9 : 1. They are producing interference. The ratio of maximum and minimum intensities will be MP PET 1999; AMU (Engg.) 1999; AIIMS 2000]
(a) 10 : 8 (b) 9 : 1
(c) 4 : 1 (d) 2 : 1

14. A wave can transmit ...... from one place to another [CPMT 1984]
(a) Energy (b) Amplitude
(c) Wavelength (d) Matter

15. If the ratio of intensities of two waves is 1 : 25, then the ratio of their amplitudes will be [CPMT 1984]
(a) 1 : 25 (b) 5 : 1
(c) 26 : 24 (d) 1 : 5

16. Two identical light sources S_1 and S_2 emit light of same wavelength λ. These light rays will exhibit interference if [MP PMT 1993]
(a) Their phase differences remain constant
(b) Their phases are distributed randomly
(c) Their light intensities remain constant
(d) Their light intensities change randomly

17. Wave nature of light follows because [MP PMT 1993]
(a) Light rays travel in a straight line
(b) Light exhibits the phenomena of reflection and refraction
(c) Light exhibits the phenomenon of interference

(d) Light causes the phenomenon of photoelectric effect

18. If L is the coherence length and c the velocity of light, the coherent time is [MP PMT 1996]

(a) cL (b) $\frac{L}{c}$

(c) $\frac{c}{L}$ (d) $\frac{1}{Lc}$

19. If the amplitude ratio of two sources producing interference is 3 : 5, the ratio of intensities at maxima and minima is [MP PMT 1996]

(a) 25 : 16 (b) 5 : 3

(c) 16 : 1 (d) 25 : 9

20. Colours of thin films result from [CPMT 1972, 83, 96; RPMT 1997; DCE 2002; AIIMS 2005]

or

On a rainy day, a small oil film on water show brilliant colours. This is due to [MP PET 2004]

(a) Dispersion of light (b) Interference of light

(c) Absorption of light (d) Scattering of light

21. For constructive interference to take place between two monochromatic light waves of wavelength λ, the path difference should be [MNR 1992; UPSEAT 2001]

(a) $(2n-1)\frac{\lambda}{4}$ (b) $(2n-1)\frac{\lambda}{2}$

(c) $n\lambda$ (d) $(2n+1)\frac{\lambda}{2}$

22. Two sources of waves are called coherent if [NCERT 1984; MNR 1995; RPMT 1996, 97; CPMT 1997; UPSEAT 1995, 2000; Orissa JEE 2002; RPET 2003; MP PMT 1996, 2004]

(a) Both have the same amplitude of vibrations

(b) Both produce waves of the same wavelength

(c) Both produce waves of the same wavelength having constant phase difference

(d) Both produce waves having the same velocity

23. Soap bubble appears coloured due to the phenomenon of [AFMC 1995, 97; RPET 1997; CBSE PMT 1999; Pb PET 2001]

(a) Interference (b) Diffraction

(c) Dispersion (d) Reflection

24. Which of the following statements indicates that light waves are transverse [MP PMT 1995; AFMC 1996]

(a) Light waves can travel in vacuum

(b) Light waves show interference

(c) Light waves can be polarized

(d) Light waves can be diffracted

25. If two light waves having same frequency have intensity ratio 4 : 1 and they interfere, the ratio of maximum to minimum intensity in the pattern will be [BHU 1995; MP PMT 1995; DPMT 1999; CPMT 2003]

(a) 9 : 1 (b) 3 : 1

(c) 25 : 9 (d) 16 : 25

26. Evidence for the wave nature of light cannot be obtained from

(a) Reflection (b) Doppler effect

(c) Interference (d) Diffraction

27. Two light sources are said to be coherent if they are obtained from

(a) Two independent point sources emitting light of the same wavelength

(b) A single point source

(c) A wide source

(d) Two ordinary bulbs emitting light of different wavelengths

28. Wavelength of light of frequency $100\,Hz$ [CBSE PMT 1999]

(a) $2\times10^{6}m$ (b) $3\times10^{6}m$

(c) $4\times10^{6}m$ (d) $5\times10^{6}m$

29. Two waves having intensity in the ratio 25 : 4 produce interference. The ratio of the maximum to the minimum intensity is

(a) 5 : 2 (b) 7 : 3

(c) 49 : 9 (d) 9 : 49

30. Wavefront means [RPMT 1997, 98]

(a) All particles in it have same phase

(b) All particles have opposite phase of vibrations

(c) Few particles are in same phase, rest are in opposite phase

(d) None of these

31. Wavefront of a wave has direction with wave motion [RPMT 1997]

(a) Parallel (b) Perpendicular

(c) Opposite (d) At an angle of θ

32. Which one of the following phenomena is not explained by Huygen's construction of wavefront [CBSE PMT 1992]

(a) Refraction (b) Reflection

(c) Diffraction (d) Origin of spectra

33. Interference was observed in interference chamber when air was present, now the chamber is evacuated and if the same light is used, a careful observer will see [CBSE PMT 1993; DPMT 2000; BHU 2002]

(a) No interference

(b) Interference with bright bands

(c) Interference with dark bands

(d) Interference in which width of the fringe will be slightly increased

34. The ratio of intensities of two waves are given by 4 : 1. The ratio of the amplitudes of the two waves is [CBSE PMT 1993]

(a) 2 : 1 (b) 1 : 2

(c) 4 : 1 (d) 1 : 4

35. For the sustained interference of light, the necessary condition is that the two sources should [DPMT 1996; RPMT 1998, 2003]

(a) Have constant phase difference

(b) Be narrow

(c) Be close to each other

(d) Of same amplitude

36. If the ratio of amplitude of two waves is 4 : 3, then the ratio of maximum and minimum intensity is [AFMC 1997]

(a) 16 : 18 (b) 18 : 16

(c) 49 : 1 (d) 94 : 1

37. Which of the following is conserved when light waves interfere [MNR 1998]

(a) Intensity (b) Energy

(c) Amplitude (d) Momentum

38. Intensity of light depends upon [RPMT 1999]

(a) Velocity (b) Wavelength

(c) Amplitude (d) Frequency

39. Ray diverging from a point source from a wave front that is [RPET 2000]

(a) Cylindrical (b) Spherical

(c) Plane (d) Cubical

40. Ratio of amplitude of interfering waves is 3 : 4. Now ratio of their intensities will be [RPET 2000]

(a) $\frac{16}{9}$ (b) 49 : 1

(c) $\frac{9}{16}$ (d) None of these

41. Two coherent sources have intensity in the ratio of $\frac{100}{1}$. Ratio of (intensity) max/(intensity) min is [RPET 2000]

(a) $\frac{1}{100}$ (b) $\frac{1}{10}$

(c) $\frac{10}{1}$ (d) $\frac{3}{2}$

42. If two waves represented by $y_1 = 4\sin\omega t$ and $y_2 = 3\sin\left(\omega t + \frac{\pi}{3}\right)$ interfere at a point, the amplitude of the resulting wave will be about [MP PMT 2000]

(a) 7 (b) 6

(c) 5 (d) 3.5

43. The two waves represented by $y_1 = a\sin(\omega t)$ and $y_2 = b\cos(\omega t)$ have a phase difference of [MP PMT 2000]

(a) 0 (b) $\frac{\pi}{2}$

(c) π (d) $\frac{\pi}{4}$

44. In a wave, the path difference corresponding to a phase difference of ϕ is [MP PET 2000]

(a) $\frac{\pi}{2\lambda}\phi$ (b) $\frac{\pi}{\lambda}\phi$

(c) $\frac{\lambda}{2\pi}\phi$ (d) $\frac{\lambda}{\pi}\phi$

45. Two coherent sources of intensities, I_1 and I_2 produce an interference pattern. The maximum intensity in the interference pattern will be [UPSEAT 2001; MP PET 2001]

(a) $I_1 + I_2$ (b) $I_1^2 + I_2^2$

(c) $(I_1 + I_2)^2$ (d) $(\sqrt{I_1} + \sqrt{I_2})^2$

46. Newton postulated his corpuscular theory on the basis of [UPSEAT 2001; KCET 2001]

(a) Newton's rings

(b) Colours of thin films

(c) Rectilinear propagation of light

(d) Dispersion of white light

47. The dual nature of light is exhibited by [KCET 1999; AIIMS 2001; BHU 2001; MH CET 2003; BCECE 2004]

(a) Photoelectric effect

(b) Refraction and interference

(c) Diffraction and reflection

(d) Diffraction and photoelectric effect

48. Two beams of light having intensities I and $4I$ interfere to produce a fringe pattern on a screen. The phase difference between the beams is $\frac{\pi}{2}$ at point A and π at point B. Then the difference between the resultant intensities at A and B is [IIT JEE (Screening) 2001]

(a) $2I$ (b) $4I$

(c) $5I$ (d) $7I$

49. Coherent sources are those sources for which [RPET 2001]

(a) Phase difference remain constant

(b) Frequency remains constant

(c) Both phase difference and frequency remains constant

(d) None of these

50. Wave nature of light is verified by [RPET 2001]

(a) Interference (b) Photoelectric effect

(c) Reflection (d) Refraction

51. Two waves are represented by the equations $y_1 = a\sin\omega t$ and $y_2 = a\cos\omega t$. The first wave [MP PMT 2001]

(a) Leads the second by π

(b) Lags the second by π

(c) Leads the second by $\frac{\pi}{2}$

(d) Lags the second by $\frac{\pi}{2}$

52. Light waves producing interference have their amplitudes in the ratio 3 : 2. The intensity ratio of maximum and minimum of interference fringes is [EAMCET 2001]

(a) 36 : 1 (b) 9 : 4

(c) 25 : 1 (d) 6 : 4

53. Laser beams are used to measure long distance because [DCE 2001]

(a) They are monochromatic

(b) They are highly polarised

(c) They are coherent

(d) They have high degree of parallelism

54. Two coherent sources of different intensities send waves which interfere. The ratio of maximum intensity to the minimum intensity is 25. The intensities of the sources are in the ratio

(a) 25 : 1 (b) 5 : 1
(c) 9 : 4 (d) 25 : 16

55. The frequency of light ray having the wavelength 3000 Å is [DPMT 2002]

(a) 9×10^{13} *cycles/sec* (b) 10^{15} *cycles/sec*
(c) 90 *cycles/sec* (d) 3000 *cycles/sec*

56. Two waves have their amplitudes in the ratio 1 : 9. The maximum and minimum intensities when they interfere are in the ratio

(a) $\frac{25}{16}$ (b) $\frac{16}{26}$
(c) $\frac{1}{9}$ (d) $\frac{9}{1}$

57. Huygen's principle of secondary wavelets may be used to [KCET 2002]

(a) Find the velocity of light in vacuum
(b) Explain the particle behaviour of light
(c) Find the new position of the wavefront
(d) Explain photoelectric effect

58. What is the path difference of destructive interference [AIIMS 2002]

(a) $n\lambda$ (b) $n(\lambda+1)$
(c) $\frac{(n+1)\lambda}{2}$ (d) $\frac{(2n+1)\lambda}{2}$

59. If an interference pattern have maximum and minimum intensities in 36 : 1 ratio then what will be the ratio of amplitudes

(a) 5 : 7 (b) 7 : 4
(c) 4 : 7 (d) 7 : 5

60. Intensities of the two waves of light are I and $4I$. The maximum intensity of the resultant wave after superposition is

(a) 5 I (b) 9 I
(c) 16 I (d) 25 I

61. As a result of interference of two coherent sources of light, energy is [MP PMT 2002; KCET 2003]

(a) Increased
(b) Redistributed and the distribution does not vary with time
(c) Decreased
(c) Redistributed and the distribution changes with time

62. To demonstrate the phenomenon of interference, we require two sources which emit radiation [AIEEE 2003]

(a) Of the same frequency and having a define phase relationship
(b) Of nearly the same frequency
(c) Of the same frequency
(d) Of different wavelengths

63. When a beam of light is used to determine the position of an object, the maximum accuracy is achieved if the light is [AIIMS 2003]

(a) Polarised (b) Of longer wavelength
(c) Of shorter wavelength (d) Of high intensity

64. If the distance between a point source and screen is doubled, then intensity of light on the screen will become [UPSEAT 2002] [RPET 1997; RPMT 1999]

(a) Four times (b) Double
(c) Half (d) One-fourth

65. Huygen wave theory allows us to know [AFMC 2004]

(a) The wavelength of the wave
(b) The velocity of the wave
(c) The amplitude of the wave
(d) The propagation of wave fronts [KCET 2002]

66. The wave theory of light was given by [J & K CET 2004; KCET 2005]

(a) Maxwell (b) Planck
(c) Huygen (d) Young

67. The phase difference between incident wave and reflected wave is 180° when light ray [RPMT 1998, 2001]

(a) Enters into glass from air
(b) Enters into air from glass
(c) Enters into glass from diamond
(d) Enters into water from glass

68. Which of the following phenomena can explain quantum nature of light [RPMT 2001]

(a) Photoelectric effect (b) Interference
(c) Diffraction (d) Polarisation

69. Which of the following is not a property of light [AFMC 2005]

(a) It requires a material medium for propagation [AFMC 2002]
(b) It can travel through vacuum
(c) It involves transportation of energy
(d) It has finite speed [MP PET 2002]

70. What causes changes in the colours of the soap or oil films for the given beam of light [AFMC 2005]

(a) Angle of incidence (b) Angle of reflection
(c) Thickness of film (d) None of these

71. Select the right option in the following [KCET 2005]

(a) Christian Huygens a contemporary of Newton established the wave theory of light by assuming that light waves were transverse
(b) Maxwell provided the compelling theoretical evidence that light is transverse wave
(c) Thomas Young experimentally proved the wave behaviour of light and Huygens assumption
(d) All the statements give above, correctly answers the question "what is light"

72. Two waves of intensity I undergo Interference. The maximum intensity obtained is [BHU 2005]

(a) $I/2$ (b) I
(c) $2I$ (d) $4I$

Young's Double Slit Experiment

1. Young's experiment establishes that

[CPMT 1972; MP PET 1994, 98; MP PMT 1998]

(a) Light consists of waves
(b) Light consists of particles
(c) Light consists of neither particles nor waves
(d) Light consists of both particles and waves

2. In the interference pattern, energy is

(a) Created at the position of maxima
(b) Destroyed at the position of minima
(c) Conserved but is redistributed
(d) None of the above

3. Monochromatic green light of wavelength $5\times10^{-7}\,m$ illuminates a pair of slits 1 *mm* apart. The separation of bright lines on the interference pattern formed on a screen 2 *m* away is

(a) 0.25 *mm* (b) 0.1 *mm*
(c) 1.0 *mm* (d) 0.01 *mm*

4. In Young's double slit experiment, if the slit widths are in the ratio 1 : 9, then the ratio of the intensity at minima to that at maxima will be [MP PET 1987]

(a) 1 (b) 1/9
(c) 1/4 (d) 1/3

5. In Young's double slit interference experiment, the slit separation is made 3 fold. The fringe width becomes

[CPMT 1982, 89]

(a) 1/3 *times* (b) 1/9 *times*
(c) 3 *times* (d) 9 *times*

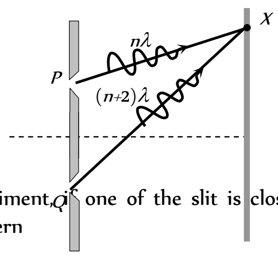
6. In a certain double slit experimental arrangement interference fringes of width 1.0 *mm* each are observed when light of wavelength 5000 Å is used. Keeping the set up unaltered, if the source is replaced by another source of wavelength 6000 Å, the fringe width will be [CPMT 1988]

(a) 0.5 *mm* (b) 1.0 *mm*
(c) 1.2 *mm* (d) 1.5 *mm*

7. Two coherent light sources S_1 and S_2 (λ= 6000 Å) are 1*mm* apart from each other. The screen is placed at a distance of 25 *cm* from the sources. The width of the fringes on the screen should be

(a) 0.015 *cm* (b) 0.025 *cm*
(c) 0.010 *cm* (d) 0.030 *cm*

8. The figure shows a double slit experiment *P* and *Q* are the slits. The path lengths *PX* and *QX* are $n\lambda$ and $(n+2)\lambda$ respectively, where *n* is a whole number and λ is the wavelength. Taking the central fringe as zero, what is formed at *X*



(a) First bright
(b) First dark
(c) Second bright
(d) Second dark

9. In Young's double slit experiment, one of the slit is closed fully, then in the interference pattern

(a) A bright slit will be observed, no interference pattern will exist
(b) The bright fringes will become more bright
(c) The bright fringes will become fainter
(d) None of the above

10. In Young's double slit experiment, a glass plate is placed before a slit which absorbs half the intensity of light. Under this case

(a) The brightness of fringes decreases
(b) The fringe width decreases
(c) No fringes will be observed
(d) The bright fringes become fainter and the dark fringes have finite light intensity

11. In Young's experiment, the distance between the slits is reduced to half and the distance between the slit and screen is doubled, then the fringe width

[IIT 1981; MP PMT 1994; RPMT 1997; KCET 2000; CPMT 2003; AMU (Engg.) 2000; DPMT 2003; UPSEAT 2000, 04; Kerala PMT 2004]

(a) Will not change (b) Will become half
(c) Will be doubled (d) Will become four times

[CPMT 1977; DPMT 1999]

12. The maximum intensity of fringes in Young's experiment is *I*. If one of the slit is closed, then the intensity at that place becomes I_0. Which of the following relation is true ?

[NCERT 1982; MP PMT 1994, 99; BHU 1998; RPMT 1996; RPET 1999; AMU (Engg.) 1999]

(a) $I = I_0$
(b) $I = 2I_0$
(c) $I = 4I_0$
(d) There is no relation between I and I_0

13. In the Young's double slit experiment, the ratio of intensities of bright and dark fringes is 9. This means that [IIT 1982]

(a) The intensities of individual sources are 5 and 4 units respectively
(b) The intensities of individual sources are 4 and 1 units respectively
(c) The ratio of their amplitudes is 3
(d) The ratio of their amplitudes is 2

14. An oil flowing on water seems coloured due to interference. For observing this effect, the approximate thickness of the oil film should be

[DPET 1987; JIPMER 1997; RPMT 2002, 04]

(a) 100 Å (b) 10000 Å
(c) 1 *mm* (d) 1 *cm*

[CPMT 1990]

15. The Young's experiment is performed with the lights of blue (λ = 4360 Å) and green colour (λ = 5460 Å), If the distance of the 4th fringe from the centre is *x*, then [CPMT 1987]

(a) *x* (Blue) = *x* (Green) (b) *x* (Blue)> *x* (Green)
(c) *x* (Blue) < *x* (Green) (d) $\frac{x(Blue)}{x(Green)}=\frac{5460}{4360}$

16. In the Young's double slit experiment, the spacing between two slits is 0.1 *mm*. If the screen is kept at a distance of 1.0 *m* from the slits and the wavelength of light is 5000 Å, then the fringe width is [MP PMT 1993; R

(a) 1.0 *cm* (b) 1.5 *cm*
(c) 0.5 *cm* (d) 2.0 *cm*

17. In Young's double slit experiment, if *L* is the distance between the slits and the screen upon which interference pattern is observed, *x* is

the average distance between the adjacent fringes and d being the slit separation. The wavelength of light is given by

(a) $\frac{xd}{L}$ (b) $\frac{xL}{d}$

(c) $\frac{Ld}{x}$ (d) $\frac{1}{Ldx}$

18. In a Young's double slit experiment, the central point on the screen is **[MP PMT 1996]**

(a) Bright (b) Dark

(c) First bright and then dark (d) First dark and then bright

19. In a Young's double slit experiment, the fringe width is found to be 0.4 *mm*. If the whole apparatus is immersed in water of refractive index 4/3 without disturbing the geometrical arrangement, the new fringe width will be **[CBSE PMT 1990]**

(a) 0.30 *mm* (b) 0.40 *mm*

(c) 0.53 *mm* (d) 450 *micron*

20. Young's experiment is performed in air and then performed in water, the fringe width **[CPMT 1990; MP PMT 1994; RPMT 1997; Kerala PMT 2004]**

(a) Will remain same (b) Will decrease

(c) Will increase (d) Will be infinite

21. In double slits experiment, for light of which colour the fringe width will be minimum **[MP PMT 1994]**

(a) Violet (b) Red

(c) Green (d) Yellow

22. In Young's experiment, light of wavelength 4000 Å is used to produce bright fringes of width 0.6 *mm*, at a distance of 2 meters. If the whole apparatus is dipped in a liquid of refractive index 1.5, then fringe width will be **[MP PMT 1994]**

(a) 0.2 *mm* (b) 0.3 *mm*

(c) 0.4 *mm* (d) 1.2 *mm*

23. In Young's double slit experiment, the phase difference between the light waves reaching third bright fringe from the central fringe will be (λ =6000 Å) **[MP PMT 1994]**

(a) Zero (b) 2π

(c) 4π (d) 6π

24. In Young's double slit experiment, if the widths of the slits are in the ratio 4 : 9, the ratio of the intensity at maxima to the intensity at minima will be **[Manipal MEE 1995]**

(a) 169 : 25 (b) 81 : 16

(c) 25 : 1 (d) 9 : 4

25. In Young's double slit experiment when wavelength used is 6000 Å and the screen is 40 *cm* from the slits, the fringes are 0.012 *cm* wide. What is the distance between the slits **[MP PMT 1995; Pb PET 2002]**

(a) 0.024 *cm* (b) 2.4 *cm*

(c) 0.24 *cm* (d) 0.2 *cm*

26. In two separate set - ups of the Young's double slit experiment, fringes of equal width are observed when lights of wavelengths in the ratio 1 : 2 are used. If the ratio of the slit separation in the two cases is 2 : 1, the ratio of the distances between the plane of the slits and the screen in the two set - ups is **[MP PET 1993]**

(a) 4 : 1 (b) 1 : 1

(c) 1 : 4 (d) 2 : 1

27. In an interference experiment, the spacing between successive maxima or minima is **[MP PET 1996]**

(a) $\frac{\lambda d}{D}$ (b) $\frac{\lambda D}{d}$

(c) $\frac{dD}{\lambda}$ (d) $\frac{\lambda d}{4D}$

(Where the symbols have their usual meanings)

28. If yellow light in the Young's double slit experiment is replaced by red light, the fringe width will **[MP PMT 1996]**

(a) Decrease

(b) Remain unaffected

(c) Increase

(d) First increase and then decrease

29. In Young's double slit experiment, the fringe width is $1\times10^{-4}\,m$ if the distance between the slit and screen is doubled and the distance between the two slit is reduced to half and wavelength is changed from $6.4\times10^{7}\,m$ to $4.0\times10^{-7}\,m$, the value of new fringe width will be

(a) $0.15\times10^{-4}\,m$ (b) $2.0\times10^{-4}\,m$

(c) $1.25\times10^{-4}\,m$ (d) $2.5\times10^{-4}\,m$

30. In Young's experiment, one slit is covered with a blue filter and the other (slit) with a yellow filter. Then the interference pattern

(a) Will be blue (b) Will be yellow

(c) Will be green (d) Will not be formed

31. Two sources give interference pattern which is observed on a screen, D distance apart from the sources. The fringe width is $2w$. If the distance D is now doubled, the fringe width will

(a) Become $w/2$ (b) Remain the same

(c) Become w (d) Become $4w$

32. In double slit experiment, the angular width of the fringes is 0.20° for the sodium light (λ =5890 Å). In order to increase the angular width of the fringes by 10%, the necessary change in the wavelength is **[MP PMT 1997]**

(a) Increase of 589 Å (b) Decrease of 589 Å

(c) Increase of 6479 Å (d) Zero

33. In a biprism experiment, by using light of wavelength 5000 Å, 5 *mm* wide fringes are obtained on a screen 1.0 *m* away from the coherent sources. The separation between the two coherent sources is

(a) 1.0 *mm* (b) 0.1 *mm*

(c) 0.05 *mm* (d) 0.01 *mm*

34. The slits in a Young's double slit experiment have equal widths and the source is placed symmetrically relative to the slits. The intensity at the central fringes is I. If one of the slits is closed, the intensity at this point will be

[MP PMT 1999; Orissa JEE 2004; Kerala PET 2005]

(a) I (b) $I/4$

(c) $I/2$ (d) $4I$

35. A thin mica sheet of thickness $2\times10^{-6}\,m$ and refractive index $(\mu=1.5)$ is introduced in the path of the first wave. The wavelength of the wave used is 5000 Å. The central bright maximum will shift [CPMT 1999]

(a) 2 fringes upward (b) 2 fringes downward

(c) 10 fringes upward (d) None of these

36. In a Young's double slit experiment, the fringe width will remain same, if (D = distance between screen and plane of slits, d = separation between two slits and λ = wavelength of light used)

(a) Both λ and D are doubled

(b) Both d and D are doubled

(c) D is doubled but d is halved

(d) λ is doubled but d is halved

37. In Young's double slit experiment, the slits are 0.5 *mm* apart and interference pattern is observed on a screen placed at a distance of 1.0 *m* from the plane containing the slits. If wavelength of the incident light is 6000 Å, then the separation between the third bright fringe and the central maxima is

(a) 4.0 *mm* (b) 3.5 *mm*

(c) 3.0 *mm* (d) 2.5 *mm*

38. In Young's double slit experiment, 62 fringes are seen in visible region for sodium light of wavelength 5893 Å. If violet light of wavelength 4358 Å is used in place of sodium light, then number of fringes seen will be [RPET 1997]

(a) 54 (b) 64

(c) 74 (d) 84

39. In Young's double slit experiment, angular width of fringes is 0.20° for sodium light of wavelength 5890 Å. If complete system is dipped in water, then angular width of fringes becomes

(a) 0.11° (b) 0.15°

(c) 0.22° (d) 0.30°

40. In Young's double slit experiment, the distance between the slits is 1 *mm* and that between slit and screen is 1 meter and 10th fringe is 5 *mm* away from the central bright fringe, then wavelength of light used will be [RPMT 1997]

(a) 5000 Å (b) 6000 Å

(c) 7000 Å (d) 8000 Å

41. In Young's double slit experiment, carried out with light of wavelength λ = 5000 Å, the distance between the slits is 0.2 *mm* and the screen is at 200 *cm* from the slits. The central maximum is at x =0. The third maximum (taking the central maximum as zeroth maximum) will be at x equal to

[CBSE PMT 1992; MH CET 2002]

(a) 1.67 *cm* (b) 1.5 *cm*

(c) 0.5 *cm* (d) 5.0 *cm*

42. In a Young's experiment, two coherent sources are placed 0.90 *mm* apart and the fringes are observed one metre away. If it produces the second dark fringe at a distance of 1 *mm* from the central fringe, the wavelength of monochromatic light used would be

[CBSE PMT 1992; KCET 2004]

(a) $60\times10^{-4}\,cm$ (b) $10\times10^{-4}\,cm$

(c) $10\times10^{-5}\,cm$ (d) $6\times10^{-5}\,cm$

43. In Young's double slit experiment, the distance between the two slits is 0.1 *mm* and the wavelength of light used is $4\times10^{-7}\,m$. If the width of the fringe on the screen is 4 *mm*, the distance between screen and slit is

[Bihar CMEET 1995]

(a) 0.1 *mm* (b) 1 *cm*

(c) 0.1 *cm* (d) 1 *m*

44. In Young's double slit experiment, the distance between sources is 1 *mm* and distance between the screen and source is 1 *m*. If the fringe width on the screen is 0.06 *cm*, then λ = [Bihar MEE 1995]

(a) 6000 Å (b) 4000 Å

(c) 1200 Å (d) 2400 Å

45. In Young's double slit experiment, a mica slit of thickness t and refractive index μ is introduced in the ray from the first source S. By how much distance the fringes pattern will be displaced [RPMT 1996, 97; JIPM

[AMU 1995]

(a) $\frac{d}{D}(\mu-1)t$ (b) $\frac{D}{d}(\mu-1)t$

(c) $\frac{d}{(\mu-1)D}$ (d) $\frac{D}{d}(\mu-1)$

46. In Young's double slit experiment using sodium light (λ = 5898 Å), 92 fringes are seen. If given colour (λ = 5461 Å) is used, how many fringes will be seen

[CPMT 1989; RPET 1996; JIPMER 2001, 02]

(a) 62 (b) 67

(c) 85 (d) 99

47. If a torch is used in place of monochromatic light in Young's experiment what will happens [RPET 1997]

[MH CET 1999; KCET 1999]

(a) Fringe will appear for a moment then it will disappear

(b) Fringes will occur as from monochromatic light

(c) Only bright fringes will appear

(d) No fringes will appear

48. When a thin metal plate is placed in the path of one of the interfering beams of light [KCET 1999]

(a) Fringe width increases (b) Fringes disappear

(c) Fringes become brighter (d) Fringes becomes blurred

49. In Young's experiment, the distance between slits is 0.28 *mm* and distance between slits and screen is 1.4 *m*. Distance between central bright fringe and third bright fringe is 0.9 *cm*. What is the wavelength of used light [KCET 1999]

(a) 5000 Å (b) 6000 Å

(c) 7000 Å (d) 9000 Å

50. Two parallel slits 0.6 *mm* apart are illuminated by light source of wavelength 6000 Å. The distance between two consecutive dark fringes on a screen 1 *m* away from the slits is

(a) 1 *mm* (b) 0.01 *mm*

(c) 0.1 *m* (d) 10 *m*

51. In young's double slit experiment with a source of light of wavelength 6320Å, the first maxima will occur when [Roorkee 1999]

(a) Path difference is 9480 Å

(b) Phase difference is 2π radian

(c) Path difference is 6320 Å

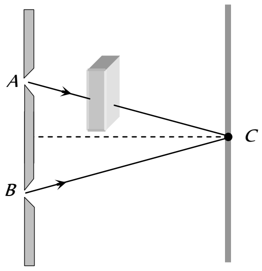
(d) Phase difference is π radian

52. If a transparent medium of refractive index $\mu = 1.5$ and thickness $t = 2.5 \times 10^{-5}$ *m* is inserted in front of one of the slits of Young's Double Slit experiment, how much will be the shift in the interference pattern? The distance between the slits is 0.5 *mm* and that between slits and screen is 100 *cm*

(a) 5 *cm* (b) 2.5 *cm*

(c) 0.25 *cm* (d) 0.1 *cm*

53. In Young's experiment, monochromatic light is used to illuminate the two slits *A* and *B*. Interference fringes are observed on a screen placed in front of the slits. Now if a thin glass plate is placed normally in the path of the beam coming from the slit [UPSEAT 1993, 2000; AIIMS 1999, 2004]



(a) The fringes will disappear

(b) The fringe width will increase

(c) The fringe width will increase

(d) There will be no change in the fringe width but the pattern shifts

54. The fringe width in Young's double slit experiment increases when

(a) Wavelength increases

(b) Distance between the slits increases

(c) Distance between the source and screen decreases

(d) The width of the slits increases

55. In a double slit experiment, instead of taking slits of equal widths, one slit is made twice as wide as the other. Then in the interference pattern [IIT-JEE (Screening) 2000]

(a) The intensities of both the maxima and the minima increase

(b) The intensity of maxima increases and the minima has zero intensity

(c) The intensity of maxima decreases and that of the minima increases

(d) The intensity of maxima decreases and the minima has zero intensity

56. Two slits, 4 *mm* apart, are illuminated by light of wavelength 6000 Å. What will be the fringe width on a screen placed 2 *m* from the slits [MP PET 2000]

(a) 0.12 *mm* (b) 0.3 *mm*

(c) 3.0 *mm* (d) 4.0 *mm*

57. In the Young's double slit experiment, for which colour the fringe width is least [UPSEAT 2001, MP PET 2001]

(a) Red (b) Green

(c) Blue (d) Yellow

58. In a Young's double slit experiment, the separation of the two slits is doubled. To keep the same spacing of fringes, the distance *D* of the screen from the slits should be made [JIPMER 1999]

[MNR 1998; AMU (Engg.) 2001]

(a) $\frac{D}{2}$ (b) $\frac{D}{\sqrt{2}}$

(c) $2D$ (d) $4D$

59. Young's double slit experiment is performed with light of wavelength 550 *nm*. The separation between the slits is 1.10 *mm* and screen is placed at distance of 1 *m*. What is the distance between the consecutive bright or dark fringes [Pb. PMT 2000]

(a) 1.5 *mm* (b) 1.0 *mm*

(c) 0.5 *mm* (d) None of these

60. In Young's experiment, the ratio of maximum to minimum intensities of the fringe system is 4 : 1. The amplitudes of the coherent sources are in the ratio [AIIMS 1999]

[RPMT 1996; MP PET 2000; RPET 2001; MP PMT 2001]

(a) 4 : 1 (b) 3 : 1

(c) 2 : 1 (d) 1 : 1

61. An interference pattern was made by using red light. If the red light changes with blue light, the fringes will become [BHU 2001]

(a) Wider (b) Narrower

(c) Fainter (d) Brighter

62. If a white light is used in Young's double slit experiments then a very large number of coloured fringes can be seen [KCET 2001]

(a) With first order violet fringes being closer to the central white fringes

(b) First order red fringes being closer to the central white fringes

(c) With a central white fringe [MP PMT 2000]

(d) With a central black fringe

63. In a Young's double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 *nm* is used. If the wavelength of light is changed to 400 *nm*, number of fringes observed in the same segment of the screen is given by [IIT-JEE (Screening) 2001]

(a) 12 (b) 18

(c) 24 (d) 30

64. In the Young's double slit experiment with sodium light. The slits are 0.589 *m* a part. The angular separation of the third maximum from the central maximum will be (given $\lambda = 589$ *mm*)

(a) $\sin^{-1}(0.33 \times 10^{8})$ (b) $\sin^{-1}(0.33 \times 10^{-6})$

(c) $\sin^{-1}(3 \times 10^{-8})$ (d) $\sin^{-1}(3 \times 10^{-6})$

65. In Young's double slit experiment, the distance between the two slits is made half, then the fringe width will become [RPMT 1999; BHU 2002]

(a) Half (b) Double

(c) One fourth (d) Unchanged

66. In Young's double slit experiment, the central bright fringe can be identified [KCET 2002]

(a) By using white light instead of monochromatic light

(b) As it is narrower than other bright fringes

(c) As it is wider than other bright fringes

(d) As it has a greater intensity than the other bright fringes

67. In Young's double slit experiment, the wavelength of the light used is doubled and distance between two slits is half of initial distance, the resultant fringe width becomes [AIEEE 2002]

(a) 2 *times* (b) 3 *times*
(c) 4 *times* (d) 1/2 *times*

68. In a Young's double slit experiment, the source illuminating the slits is changed from blue to violet. The width of the fringes

(a) Increases (b) Decreases
(c) Becomes unequal (d) Remains constant

69. In Young's double slit experiment, the intensity of light coming from the first slit is double the intensity from the second slit. The ratio of the maximum intensity to the minimum intensity on the interference fringe pattern observed is [KCET 2002]

(a) 34 (b) 40
(c) 25 (d) 38

70. If the sodium light in Young's double slit experiment is replaced by red light, the fringe width will [MP PMT 2002]

(a) Decrease
(b) Increase
(c) Remain unaffected
(d) First increase, then decrease

71. In Young's double slit experiment the wavelength of light was changed from 7000 Å to 3500 Å. While doubling the separation between the slits which of the following is not true for this experiment [Orissa JEE 2002]

(a) The width of the fringes changes
(b) The colour of bright fringes changes
(c) The separation between successive bright fringes changes
(d) The separation between successive dark fringes remains unchanged

72. When a thin transparent plate of thickness t and refractive index μ is placed in the path of one of the two interfering waves of light, then the path difference changes by [MP PMT 2002]

(a) $(\mu+1)t$ (b) $(\mu-1)t$
(c) $\frac{(\mu+1)}{t}$ (d) $\frac{(\mu-1)}{t}$

73. In Young's double-slit experiment, an interference pattern is obtained on a screen by a light of wavelength 6000 Å, coming from the coherent sources S_1 and S_2. At certain point P on the screen third dark fringe is formed. Then the path difference $S_1P - S_2P$ in microns is [EAMCET 2003]

(a) 0.75 (b) 1.5
(c) 3.0 (d) 4.5

74. In a Young's double slit experiment, the slit separation is 1 *mm* and the screen is 1 *m* from the slit. For a monochromatic light of wavelength 500 *nm*, the distance of 3rd minima from the central maxima is [Orissa JEE 2003]

(a) 0.50 *mm* (b) 1.25 *mm*
(c) 1.50 *mm* (d) 1.75 *mm*

75. In Young's double-slit experiment the fringe width is β. If entire arrangement is placed in a liquid of refractive index *n*, the fringe width becomes [KCET 2003]

(a) $\frac{\beta}{n+1}$ (b) $n\beta$
(c) $\frac{\beta}{n}$ (d) $\frac{\beta}{n-1}$

76. In an interference experiment, third bright fringe is obtained at a point on the screen with a light of 700 *nm*. What should be the wavelength of the light source in order to obtain 5th bright fringe at the same point [KCET 2003] [KCET 2002]

(a) 500 *nm* (b) 630 *nm*
(c) 750 *nm* (d) 420 *nm*

77. If the separation between slits in Young's double slit experiment is reduced to $\frac{1}{3}rd$, the fringe width becomes *n* times. The value of *n* is [MP PET 2003]

(a) 3 (b) $\frac{1}{3}$
(c) 9 (d) $\frac{1}{9}$

78. A double slit experiment is performed with light of wavelength 500 *nm*. A thin film of thickness 2 μm and refractive index 1.5 is introduced in the path of the upper beam. The location of the central maximum will [AIIMS 2003]

(a) Remain unshifted
(b) Shift downward by nearly two fringes
(c) Shift upward by nearly two fringes
(d) Shift downward by 10 fringes

79. The two slits at a distance of 1 *mm* are illuminated by the light of wavelength $6.5\times10^{-7}\,m$. The interference fringes are observed on a screen placed at a distance of 1*m*. The distance between third dark fringe and fifth bright fringe will be [NCERT 1982; MP PET 1995; BVP 2003]

(a) 0.65 *mm* (b) 1.63 *mm*
(c) 3.25 *mm* (d) 4.88 *mm*

80. In a Young's double-slit experiment the fringe width is 0.2 *mm*. If the wavelength of light used is increased by 10% and the separation between the slits is also increased by 10%, the fringe width will be

(a) 0.20 *mm* (b) 0.401 *mm*
(c) 0.242 *mm* (d) 0.165 *mm*

81. Two coherent sources of intensity ratio 1 : 4 produce an interference pattern. The fringe visibility will be [J & K CET 2004]

(a) 1 (b) 0.8
(c) 0.4 (d) 0.6

82. In Young's double slit experiment the amplitudes of two sources are 3*a* and a respectively. The ratio of intensities of bright and dark fringes will be [J & K CET 2004]

(a) 3 : 1 (b) 4 : 1
(c) 2 : 1 (d) 9 : 1

83. In Young's double slit experiment, distance between two sources is 0.1 *mm*. The distance of screen from the sources is 20 *cm*. Wavelength of light used is 5460 Å. Then angular position of the first dark fringe is [DCE 2002]

(a) 0.08° (b) 0.16°

(c) 0.20° (d) 0.313°

84. In a Young's double slit experiment, the slit separation is 0.2 *cm,* the distance between the screen and slit is 1*m*. Wavelength of the light used is 5000 Å. The distance between two consecutive dark fringes (in *mm*) is

[DCE 2004]

(a) 0.25 (b) 0.26

(c) 0.27 (d) 0.28

85. A light of wavelength 5890 Å falls normally on a thin air film. The minimum thickness of the film such that the film appears dark in reflected light [Pb. PMT 2003]

(a) $2.945\times10^{-7}m$ (b) $3.945\times10^{-7}m$

(c) $4.95\times10^{-7}m$ (d) $1.945\times10^{-7}m$

86. In Young's double slit experiment, a minimum is obtained when the phase difference of super imposing waves is

[MH CET 2004]

(a) Zero (b) $(2n-1)\,\pi$

(c) $n\pi$ (d) $(n+1)\,\pi$

87. In Fresnel's biprism $(\mu = 1.5)$ experiment the distance between source and biprism is 0.3 *m* and that between biprism and screen is 0.7*m* and angle of prism is 1°. The fringe width with light of wavelength 6000 Å will be

[RPMT 2002]

(a) 3 *cm* (b) 0.011 *cm*

(c) 2 *cm* (d) 4 *cm*

88. In Young double slit experiment, when two light waves form third minimum, they have [RPMT 2003]

(a) Phase difference of 3π (b) Phase difference of $\frac{5\pi}{2}$

(c) Path difference of 3λ (d) Path difference of $\frac{5\lambda}{2}$

89. In Fresnel's biprism experiment, on increasing the prism angle, fringe width will [RPMT 2003]

(a) Increase

(b) Decrease

(c) Remain unchanged

(d) Depend on the position of object

90. If prism angle $\alpha = 1°$, $\mu = 1.54$, distance between screen and prism $(b) = 0.7\,m$, distance between prism and source $a = 0.3\,m$, $\lambda = 180\pi\ nm$ then in Fresnal biprism find the value of β (fringe width) [RPMT 2002]

(a) $10^{-4}\,m$ (b) $10^{-3}\,mm$

(c) $10^{-4}\times\pi m$ (d) $\pi\times10^{-3}\,m$

91. If Fresnel's biprism experiment as held in water inspite of air, then what will be the effect on fringe width [RPMT 1997, 98]

(a) Decrease (b) Increase

(c) No effect (d) None of these

92. What is the effect on Fresnel's biprism experiment when the use of white light is made [RPMT 1998]

(a) Fringe are affected

(b) Diffraction pattern is spread more

(c) Central fringe is white and all are coloured

(d) None of these

93. What happens to the fringe pattern when the Young's double slit experiment is performed in water instead or air then fringe width

(a) Shrinks (b) Disappear

(c) Unchanged (d) Enlarged

94. In Young's doubled slit experiment, the separation between the slit and the screen increases. The fringe width

[BCECE 2005]

(a) Increases (b) Decreases

(c) Remains unchanged (d) None of these

95. In Young's double slit experiment, the aperture screen distance is 2*m*. The fringe width is 1 *mm*. Light of 600 *nm* is used. If a thin plate of glass (μ = 1.5) of thickness 0.06 *mm* is placed over one of the slits, then there will be a lateral displacement of the fringes by

(a) 0 *cm* (b) 5 *cm*

(c) 10 *cm* (d) 15 *cm*

96. In which of the following is the interference due to the division of wave front [UPSEAT 2005]

(a) Young's double slit experiment

(b) Fresnel's biprism experiment

(c) Lloyd's mirror experiment

(d) Demonstration colours of thin film

97. Two slits are separated by a distance of 0.5 *mm* and illuminated with light of $\lambda = 6000$ Å. If the screen is placed 2.5 *m* from the slits. The distance of the third bright image from the centre will be

(a) 1.5 *mm* (b) 3 *mm*

(c) 6 *mm* (d) 9 *mm*

Doppler's Effect of Light

1. The observed wavelength of light coming from a distant galaxy is found to be increased by 0.5% as compared with that coming from a terrestrial source. The galaxy is

[MP PMT 1993, 2003]

(a) Stationary with respect to the earth

(b) Approaching the earth with velocity of light

(c) Receding from the earth with the velocity of light

(d) Receding from the earth with a velocity equal to $1.5\times10^{6}\,m/s$

2. A star producing light of wavelength 6000 Å moves away from the earth with a speed of 5 *km/sec*. Due to Doppler effect the shift in wavelength will be $(c = 3\times10^{8}\,m/\sec)$

[MP PMT 1990]

(a) 0.1 Å (b) 0.05 Å

(c) 0.2 Å (d) 1 Å

3. If the shift of wavelength of light emitted by a star is towards violet, then this shows that star is

[RPET 1996; RPMT 1999]

(a) Stationary
(b) Moving towards earth
(c) Moving away from earth
(d) Information is incomplete

4. Assuming that universe is expanding, if the spectrum of light coming from a star which is going away from earth is tested, then in the wavelength of light

(a) There will be no change
(b) The spectrum will move to infrared region
(c) The spectrum will seems to shift to ultraviolet side
(d) None of the above

5. Doppler's effect in sound in addition to relative velocity between source and observer, also depends while source and observer or both are moving. Doppler effect in light depend only on the relative velocity of source and observer. The reason of this is

(a) Einstein mass - energy relation
(b) Einstein theory of relativity
(c) Photoelectric effect
(d) None of these

6. A rocket is moving away from the earth at a speed of $6\times10^{7} m/s$. The rocket has blue light in it. What will be the wavelength of light recorded by an observer on the earth (wavelength of blue light = 4600 Å)

(a) 4600 Å (b) 5520 Å
(c) 3680 Å (d) 3920 Å

7. A spectral line λ = 5000 Å in the light coming from a distant star is observed as a 5200 Å. What will be recession velocity of the star

(a) $1.15\times10^{7} cm/\sec$ (b) $1.15\times10^{7} m/\sec$
(c) $1.15\times10^{7} km/\sec$ (d) 1.15 *km/sec*

8. The apparent wavelength of the light from a star moving away from the earth is 0.01% more than its real wavelength. Then the velocity of star is [CPMT 1979]

(a) 60 *km/sec* (b) 15 *km/sec*
(c) 150 *km/sec* (d) 30 *km/sec*

9. A star emits light of 5500 Å wavelength. Its appears blue to an observer on the earth, it means [DPMT 2002]

(a) Star is going away from the earth
(b) Star is stationary
(c) Star is coming towards earth
(d) None of the above

10. The velocity of light emitted by a source *S* observed by an observer *O*, who is at rest with respect to *S* is *c*. If the observer moves towards *S* with velocity *v*, the velocity of light as observed will be

(a) $c + v$ (b) $c - v$
(c) c (d) $\sqrt{1-\frac{v^2}{c^2}}$

11. In the context of Doppler effect in light, the term 'red shift' signifies

(a) Decrease in frequency
(b) Increase in frequency
(c) Decrease in intensity
(d) Increase in intensity

12. The sun is rotating about its own axis. The spectral lines emitted from the two ends of its equator, for an observer on the earth, will show [MP PMT 1994]

(a) Shift towards red end
(b) Shift towards violet end
(c) Shift towards red end by one line and towards violet end by other
(d) No shift

13. A star is moving away from the earth with a velocity of 100 *km/s*. If the velocity of light is $3\times10^{8} m/s$ then the shift of its spectral line of wavelength 5700 Å due to Doppler's effect will be [MP PET/PMT 1988]

(a) 0.63 Å (b) 1.90 Å
(c) 3.80 Å (d) 5.70 Å

14. If a source of light is moving away from a stationary observer, then the frequency of light wave appears to change because of

(a) Doppler's effect
(b) Interference
(c) Diffraction
(d) None of these

15. A star emitting radiation at a wavelength of 5000 Å is approaching earth with a velocity of $1.5\times10^{6} m/s$. The change in wavelength of the radiation as received on the earth, is

(a) 25 Å (b) Zero
(c) 100 Å (d) 2.5 Å

16. A star emitting light of wavelength 5896 Å is moving away from the earth with a speed of 3600 *km / sec*. The wavelength of light observed on earth will

[MP PET 1995, 2002]

(a) Decrease by 5825.25 Å
(b) Increase by 5966.75 Å
(c) Decrease by 70.75 Å
(d) Increase by 70.75 Å

($c = 3\times10^{8} m/\sec$ is the speed of light)

17. A star moves away from earth at speed 0.8 *c* while emitting light of frequency $6\times10^{14} Hz$. What frequency will be observed on the earth (in units of 10^{14} *Hz*) (*c* = speed of light) [NCERT 1980]

(a) 0.24 (b) 1.2
(c) 30 (d) 3.3

18. A light source approaches the observer with velocity 0.8 *c*. The doppler shift for the light of wavelength 5500 Å is

[MP PET 1996]

(a) 4400 Å (b) 1833 Å

(c) 3167 Å (d) 7333 Å

19. Light coming from a star is observed to have a wavelength of 3737 Å, while its real wavelength is 3700 Å. The speed of the star relative to the earth is [Speed of light $3\times10^{8} m/s$] **[MP PET 1997]**

(a) $3\times10^{5} m/s$ (b) $3\times10^{6} m/s$

(c) $3.7\times10^{7} m/s$ (d) $3.7\times10^{6} m/s$

20. In the spectrum of light of a luminous heavenly body the wavelength of a spectral line is measured to be 4747 Å while actual wavelength of the line is 4700 Å. The relative velocity of the heavenly body with respect to earth will be (velocity of light is $3\times10^{8} m/s$)

(a) $3\times10^{5} m/s$ moving towards the earth

(b) $3\times10^{5} m/s$ moving away from the earth

(c) $3\times10^{6} m/s$ moving towards the earth

(d) $3\times10^{6} m/s$ moving away from the earth

21. The wavelength of light observed on the earth, from a moving star is found to decrease by 0.05%. Relative to the earth the star is

(a) Moving away with a velocity of $1.5\times10^{5} m/s$

(b) Coming closer with a velocity of $1.5\times10^{5} m/s$

(c) Moving away with a velocity of $1.5\times10^{4} m/s$

(d) Coming closer with a velocity of $1.5\times10^{4} m/s$

22. A star is going away from the earth. An observer on the earth will see the wavelength of light coming from the star **[MP PMT 1999]**

(a) Decreased

(b) Increased

(c) Neither decreased nor increased

(d) Decreased or increased depending upon the velocity of the star

23. A star is moving towards the earth with a speed of 4.5×10^{6} *m/s*. If the true wavelength of a certain line in the spectrum received from the star is 5890 Å, its apparent wavelength will be about $[c = 3\times10^{8} m/s]$ **[MP PMT 1999]**

(a) 5890 Å (b) 5978 Å

(c) 5802 Å (d) 5896 Å

24. Due to Doppler's effect, the shift in wavelength observed is 0.1 Å for a star producing wavelength 6000 Å. Velocity of recession of the star will be

(a) 2.5 *km/s* (d) 10 *km/s*

(c) 5 *km/s* (d) 20 *km/s*

25. A rocket is going away from the earth at a speed of 10^{6} *m/s* If the wavelength of the light wave emitted by it be 5700 Å, what will be its Doppler's shift **[RPMT 1996]**

(a) 200 Å (b) 19 Å

(c) 20 Å (d) 0.2 Å

26. A rocket is going away from the earth at a speed 0.2*c*, where *c* = speed of light. It emits a signal of frequency $4\times10^{7} Hz$. What will be the frequency observed by an observer on the earth

(a) $4\times10^{6} Hz$ (b) $3.2\times10^{7} Hz$

(c) $3\times10^{6} Hz$ (d) $5\times10^{7} Hz$

27. If a star is moving towards the earth, then the lines are shifted towards **[AIIMS 1997]**

(a) Red (b) Infrared

(c) Blue (d) Green

28. When the wavelength of light coming from a distant star is measured it is found shifted towards red. Then the conclusion is **[MP PMT/PET 1998]**

(a) The star is approaching the observer

(b) The star recedes away from earth

(c) There is gravitational effect on the light

(d) The star remains stationary

29. A heavenly body is receding from earth such that the fractional change in λ is 1, then its velocity is **[DCE 2000]**

(a) C **[MP PMT/PET 1998]** (b) $\frac{3C}{5}$

(c) $\frac{C}{5}$ (d) $\frac{2C}{5}$

30. The 6563 Å line emitted by hydrogen atom in a star is found to be red shifted by 5 Å. The speed with which the star is receding from the earth is **[Pb. PMT 2002]**

(a) 17.29×10^{9} *m/s* (b) 4.29×10^{7} *m/s*

(c) 3.39×10^{5} *m/s* (d) 2.29×10^{5} *m/s*

31. Three observers *A*, *B* and *C* measure the speed of light coming from a source to be v_A, v_B and v_C. The observer *A* moves towards the source, the observer *C* moves away from the source with the same speed. The observer *B* stays stationary. the surrounding space is vacuum every where. Then **[KCET 2002]**

(a) $v_A > v_B > v_C$ (b) $v_A < v_B < v_C$

(c) $v_A = v_B = v_C$ (d) $v_A = v_B > v_C$

32. Light from the constellation Virgo is observed to increase in wavelength by 0.4%. With respect to Earth the constellation is

(a) Moving away with velocity 1.2×10^{6} *m/s*

(b) Coming closer with velocity 1.2×10^{6} *m/s*

(c) Moving away with velocity 4×10^{6} *m/s*

(d) Coming closer with velocity 4×10^{6} *m/s*

33. It is believed that the universe is expanding and hence the distant stars are receding from us. Light from such a star will show

(a) Shift in frequency towards longer wavelengths

(b) Shift in frequency towards shorter wavelength

(c) No shift in frequency but a decrease in intensity

(d) A shift in frequency sometimes towards longer and sometimes towards shorter wavelengths

Diffraction of Light

1. A slit of width a is illuminated by white light. For red light (λ = 6500 Å), the first minima is obtained at $\theta = 30^o$. Then the value of a will be [MP PMT 1987; CPMT 2002]

(a) 3250 Å (b) $6.5 \times 10^{-4}\, mm$

(c) 1.24 *microns* (d) $2.6 \times 10^{-4}\, cm$

2. The light of wavelength 6328 Å is incident on a slit of width 0.2 *mm* perpendicularly, the angular width of central maxima will be [MP PMT 1987; Pb. PMT 2002]

(a) 0.36^o (b) 0.18^o

(c) 0.72^o (d) 0.09^o

3. The bending of beam of light around corners of obstacles is called [NCERT 1990; AFMC 1995; RPET 1997; RPMT 1997; CPMT 1999; JIPMER 2000]

(a) Reflection (b) Diffraction

(c) Refraction (d) Interference

4. The penetration of light into the region of geometrical shadow is called [CPMT 1999; JIPMER 2000]

(a) Polarisation (b) Interference

(c) Diffraction (d) Refraction

5. A slit of size 0.15 *cm* is placed at 2.1 *m* from a screen. On illuminated it by a light of wavelength 5×10^{-5} *cm*. The width of central maxima will be [RPMT 1999]

(a) 70 *mm* (b) 0.14 *mm*

(c) 1.4 *mm* (d) 0.14 *cm*

6. A diffraction is obtained by using a beam of red light. What will happen if the red light is replaced by the blue light [KCET 2000; BHU 2001]

(a) Bands will narrower and crowd full together

(b) Bands become broader and further apart

(c) No change will take place

(d) Bands disappear

7. What will be the angle of diffracting for the first minimum due to Fraunhoffer diffraction with sources of light of wave length 550 *nm* and slit of width 0.55 *mm*

(a) 0.001 *rad* (b) 0.01 *rad*

(c) 1 *rad* (d) 0.1 *rad*

8. Angular width (β) of central maximum of a diffraction pattern on a single slit does not depend upon [DCE 2000; 01]

(a) Distance between slit and source

(b) Wavelength of light used

(c) Width of the slit

(d) Frequency of light used

9. A single slit of width 0.20 *mm* is illuminated with light of wavelength 500 *nm*. The observing screen is placed 80 *cm* from the slit. The width of the central bright fringe will be [AMU (Med.) 2002]

(a) 1 *mm* (b) 2 *mm*

(c) 4 *mm* (d) 5 *mm*

10. Yellow light is used in single slit diffraction experiment with slit width 0.6 *mm*. If yellow light is replaced by *X*-rays then the pattern will reveal [IIT-JEE (Screening) 1999; MP PMT 2002; KCET 2003]

(a) That the central maxima is narrower

(b) No diffraction pattern

(c) More number of fringes

(d) Less number of fringes

11. Which statement is correct for a zone plate and a lens [RPMT 2002]

(a) Zone plate has multi focii whereas lens has one

(b) Zone plate has one focus whereas lens has multiple focii

(c) Both are correct

(d) Zone plate has one focus whereas a lens has infinite

12. In Fresnel diffraction, if the distance between the disc and the screen is decreased, the intensity of central bright spot will

(a) Increase (b) Decrease

(c) Remain constant (d) None of these

13. A plane wavefront $(\lambda = 6 \times 10^{-7} m)$ falls on a slit $0.4\, mm$ wide. A convex lens of focal length $0.8\, m$ placed behind the slit focusses the light on a screen. What is the linear diameter of second maximum [RPMT 2001]

(a) $6\, mm$ (b) $12\, mm$

(c) $3\, mm$ (d) $9\, mm$

14. A zone plate of focal length $60\, cm$, behaves as a convex lens, If wavelength of incident light is $6000\ Å$, then radius of first half period zone will be [RPMT 2001]

(a) $36 \times 10^{-8} m.$ (b) $6 \times 10^{-8} m.$

(c) $\sqrt{6} \times 10^{-8} m.$ (d) $6 \times 10^{-4} m.$

15. Radius of central zone of circular zone plate is $2.3\, mm$. Wavelength of incident light is $5893\ Å$. Source is at a distance of $6\, m$. Then the distance of first image will be [RPMT 2001]

(a) $9\, m$ (b) $12\, m$

(c) $24\, m$ (d) $36\, m$

16. Red light is generally used to observe diffraction pattern from single slit. If blue light is used instead of red light, then diffraction pattern [Pb. PMT 2001] [RPMT 2001; BCECE 2005; CPMT 2005]

(a) Will be more clear (b) Will contract

(c) Will expanded (d) Will not be visualized

17. In the experiment of diffraction at a single slit, if the slit width is decreased, the width of the central maximum [KCET 2001]

(a) Increases in both Fresnel and Fraunhofer diffraction

(b) Decreases both in Fresnal and Fraunhofer diffraction

(c) Increases in Fresnel diffraction but decreases in Fraunhofer diffraction

(d) Decreases in Fresnel diffraction but increases is Fraunofer diffraction.

18. Conditions of diffraction is [RPET 2001]

(a) $\frac{a}{\lambda} = 1$ (b) $\frac{a}{\lambda} >> 1$

(c) $\frac{a}{\lambda} << 1$ (d) None of these

19. Light of wavelength $589.3\,nm$ is incident normally on the slit of width $0.1\,mm$. What will be the angular width of the central diffraction maximum at a distance of $1\,m$ from the slit

(a) $0.68°$ (b) $1.02°$

(c) $0.34°$ (d) None of these

20. The phenomenon of diffraction of light was discovered by [KCET 2000]

(a) Hygens (b) Newton

(c) Fresnel (d) Grimaldi

21. The radius r of half period zone is proportional to [RPMT 1998, 2002]

(a) $\sqrt{n}$ (b) $\frac{1}{\sqrt{n}}$

(c) n^2 (d) $\frac{1}{n}$

22. In a diffraction pattern by a wire, on increasing diameter of wire, fringe width [RPMT 1998]

(a) Decreases

(b) Increases

(c) Remains unchanged

(d) Increasing or decreasing will depend on wavelength

23. What will be the angular width of central maxima in Fraunhoffer diffraction when light of wavelength $6000\,Å$ is used and slit width is $12 \times 10^{-5}\,cm$. [RPMT 2004]

(a) 2 *rad* (b) 3 *rad*

(c) 1 *rad* (d) 8 *rad*

24. When a compact disc is illuminated by a source of white light. Coloured 'lanes' are observed. This is due to [DCE 2003; AIIMS 2004]

(a) Dispersion (b) Diffraction

(c) Interference (d) Refraction

25. The diffraction effect can be observed in [J & K CET 2004]

(a) Only sound waves

(b) Only light waves

(c) Only ultrasonic waves

(d) Sound as well as light waves

26. If we observe the single slit Fraunhoffer diffraction with wavelength λ and slit width *e*, the width of the central maxima is 2θ. On decreasing the slit width for the same λ [UPSEAT 2004]

(a) θ increases

(b) θ remains unchanged

(c) θ decreases

(d) θ increases or decreases depending on the intensity of light

27. When light is incident on a diffraction grating the zero order principal maximum will be [KCET 2004]

(a) One of the component colours

(b) Absent

(c) Spectrum of the colours

(d) White

28. A beam of light of wavelength 600 *nm* from a distant source falls on a single slit 1 *mm* wide and the resulting diffraction pattern is observed on a screen 2 *m* away. The distance between the first dark fringes on either side of the central bright fringe is [IIT-JEE 1994; KCET 2004]

(a) 1.2 *mm* (b) 1.2 *cm*

(c) 2.4 *cm* [BHU (Med.) 1999] (d) 2.4 *mm*

29. In order to see diffraction the thickness of the film is [J&K CEE 2001]

(a) 100 Å (b) 10,000 Å

(c) 1 *mm* (d) 1 *cm*

30. Diffraction effects are easier to notice in the case of sound waves than in the case of light waves because [RPET 1978; KCET 1994, 2000]

(a) Sound waves are longitudinal

(b) Sound is perceived by the ear

(c) Sound waves are mechanical waves

(d) Sound waves are of longer wavelength

31. Direction of the first secondary maximum in the Fraunhofer diffraction pattern at a single slit is given by (a is the width of the slit) [KCET 1999]

(a) $a\sin\theta = \frac{\lambda}{2}$ (b) $a\cos\theta = \frac{3\lambda}{2}$

(c) $a\sin\theta = \lambda$ (d) $a\sin\theta = \frac{3\lambda}{2}$

32. A parallel monochromatic beam of light is incident normally on a narrow slit. A diffraction pattern is formed on a screen placed perpendicular to the direction of incident beam. At the first maximum of the diffraction pattern the phase difference between the rays coming from the edges of the slit is

(a) 0 (b) $\frac{\pi}{2}$

(c) π (d) 2π

33. Diffraction and interference of light suggest [CPMT 1995; RPMT 1998]

(a) Nature of light is electro-magnetic

(b) Wave nature

(c) Nature is quantum

(d) Nature of light is transverse

34. A light wave is incident normally over a slit of width $24 \times 10^{-5}\,cm$. The angular position of second dark fringe from the central maxima is 30°. What is the wavelength of light

(a) 6000 Å (b) 5000 Å

(c) 3000 Å (d) 1500 Å

35. A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 *mm*. The light is focused by a convex lens on a screen placed on the focal plane. The first minimum will be formed for the angle of diffraction equal to [CBSE PMT 1993]

(a) 0° (b) 15°

(c) 30° (d) 60°

36. The condition for observing Fraunhofer diffraction from a single slit is that the light wavefront incident on the slit should be

(a) Spherical (b) Cylindrical
(c) Plane (d) Elliptical

37. To observe diffraction the size of an obstacle [CPMT 1982]

(a) Should be of the same order as wavelength
(b) Should be much larger than the wavelength
(c) Have no relation to wavelength
(d) Should be exactly $\frac{\lambda}{2}$

38. In the far field diffraction pattern of a single slit under polychromatic illumination, the first minimum with the wavelength λ_1 is found to be coincident with the third maximum at λ_2. So

(a) $3\lambda_1 = 0.3\lambda_2$ (b) $3\lambda_1 = \lambda_2$
(c) $\lambda_1 = 3.5\lambda_2$ (d) $0.3\lambda_1 = 3\lambda_2$

39. Light of wavelength λ = 5000 Å falls normally on a narrow slit. A screen placed at a distance of 1 *m* from the slit and perpendicular to the direction of light. The first minima of the diffraction pattern is situated at 5 *mm* from the centre of central maximum. The width of the slit is

(a) 0.1 *mm* (b) 1.0 *mm*
(c) 0.5 *mm* (d) 0.2 *mm*

40. The width of the *n* *HPZ* will be

(a) $\sqrt{nb\lambda}$ (b) $\sqrt{b\lambda}\,[\sqrt{n}-\sqrt{n-1}]$
(c) $(\sqrt{n}-\sqrt{n-1})$ (d) $\frac{\sqrt{b\lambda}}{[\sqrt{n}-\sqrt{n-1}]}$

41. A single slit of width *a* is illuminated by violet light of wavelength 400 *nm* and the width of the diffraction pattern is measured as *y*. When half of the slit width is covered and illuminated by yellow light of wavelength 600 *nm*, the width of the diffraction pattern is

(a) The pattern vanishes and the width is zero
(b) $y/3$
(c) 3*y*
(d) None of these

Polarization of Light

1. A polariser is used to [CPMT 1999]

(a) Reduce intensity of light
(b) Produce polarised light
(c) Increase intensity of light
(d) Produce unpolarised light

2. Light waves can be polarised as they are

[CBSE PMT 1993; KCET 1994; AFMC 1997; J & K CET 2002; CPMT 2005]

(a) Transverse (b) Of high frequency
(c) Longitudinal (d) Reflected

3. Through which character we can distinguish the light waves from sound waves [CBSE PMT 1990; RPET 2000, 02]

(a) Interference (b) Refraction
(c) Polarisation [MP PMT 1987] (d) Reflection

4. The angle of polarisation for any medium is 60°, what will be critical angle for this [UPSEAT 1999]

(a) $\sin^{-1}\sqrt{3}$ (b) $\tan^{-1}\sqrt{3}$
(c) $\cos^{-1}\sqrt{3}$ (d) $\sin^{-1}\frac{1}{\sqrt{3}}$

5. The angle of incidence at which reflected light is totally polarized for reflection from air to glass (refraction index *n*) is

(a) $\sin^{-1}(n)$ (b) $\sin^{-1}\left(\frac{1}{n}\right)$
(c) $\tan^{-1}\left(\frac{1}{n}\right)$ (d) $\tan^{-1}(n)$

6. Which of following can not be polarised [Kerala PMT 2001]

(a) Radio waves (b) Ultraviolet rays
(c) Infrared rays (d) Ultrasonic waves

7. A polaroid is placed at 45° to an incoming light of intensity I_0. Now the intensity of light passing through polaroid after polarisation would be [CPMT 1995]

(a) I_0 (b) $I_0/2$
(c) $I_0/4$ (d) Zero

8. Plane polarised light is passed through a polaroid. On viewing through the polaroid we find that when the polariod is given one complete rotation about the direction of the light, one of the following is observed [MNR 1993]

(a) The intensity of light gradually decreases to zero and remains at zero
(b) The intensity of light gradually increases to a maximum and remains at maximum
(c) There is no change in intensity
(d) The intensity of light is twice maximum and twice zero

9. Out of the following statements which is not correct

[KCET 2005] [CPMT 1991]

(a) When unpolarised light passes through a Nicol's prism, the emergent light is elliptically polarised
(b) Nicol's prism works on the principle of double refraction and total internal reflection
(c) Nicol's prism can be used to produce and analyse polarised light
(d) Calcite and Quartz are both doubly refracting crystals

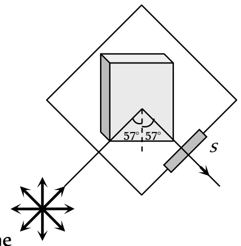
10. A ray of light is incident on the surface of a glass plate at an angle of incidence equal to Brewster's angle ϕ. If μ represents the refractive index of glass with respect to air, then the angle between reflected and refracted rays is

[CPMT 1989]

(a) $90+\phi$ (b) $\sin^{-1}(\mu\cos\phi)$
(c) 90° (d) $90^o - \sin^{-1}(\sin\phi/\mu)$

11. Figure represents a glass plate placed vertically on a horizontal table with a beam of unpolarised light falling on its surface at the polarising angle of 57° with the normal. The electric vector in the reflected light on screen *S* will vibrate with respect to the plane of incidence in a

[CPMT 1988]



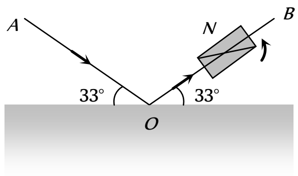
(a) Vertical plane

(b) Horizontal plane

(c) Plane making an angle of 45· with the vertical

(d) Plane making an angle of 57· with the horizontal

12. A beam of light *AO* is incident on a glass slab $(\mu = 1.54)$ in a direction as shown in figure. The reflected ray *OB* is passed through a Nicol prism on viewing through a Nicole prism, we find on rotating the prism that [CPMT 1986]



(a) The intensity is reduced down to zero and remains zero

(b) The intensity reduces down some what and rises again

(c) There is no change in intensity

(d) The intensity gradually reduces to zero and then again increases

13. Polarised glass is used in sun glasses because [CPMT 1981]

(a) It reduces the light intensity to half an account of polarisation

(b) It is fashionable

(c) It has good colour

(d) It is cheaper

14. In the propagation of electromagnetic waves the angle between the direction of propagation and plane of polarisation is

(a) 0· (b) 45·

(c) 90· (d) 180·

15. The transverse nature of light is shown by [CPMT 1972, 74, 78; RPMT 1999; AFMC 2001; AIEEE 2002; MP PET 2004; MP PMT 2000, 04; UPSEAT 2005]

(a) Interference of light (b) Refraction of light

(c) Polarisation of light (d) Dispersion of light

16. A calcite crystal is placed over a dot on a piece of paper and rotated, on seeing through the calcite one will be see

[CPMT 1971]

(a) One dot

(b) Two stationary dots

(c) Two rotating dots

(d) One dot rotating about the other

17. A light has amplitude *A* and angle between analyser and polariser is 60°. Light is reflected by analyser has amplitude

[UPSEAT 2001]

(a) $A\sqrt{2}$ (b) $A/\sqrt{2}$

(c) $\sqrt{3}A/2$ (d) $A/2$

18. When light is incident on a doubly refracting crystal, two refracted rays-ordinary ray (*O*-ray) and extra ordinary ray (*E*-ray) are produced. Then [KCET 2001]

(a) Both *O*-ray and *E*-ray are polarised perpendicular to the plane of incidence

(b) Both *O*-ray and *E*-ray are polarised in the plane of incidence

(c) *E*-ray is polarised perpendicular to the plane of incidence and *O*-ray in the plane of incidence

(d) *E*-ray is polarised in the plane of incidence and *O*-ray perpendicular to the plane of incidence

19. Light passes successively through two polarimeters tubes each of length 0.29*m*. The first tube contains dextro rotatory solution of concentration 60*kgm*· and specific rotation 0.01*rad m kg*·. The second tube contains laevo rotatory solution of concentration 30*kg/m* and specific rotation 0.02 *radm kg*·. The net rotation produced is[KCET 2002]

(a) 15° (b) 0°

(c) 20° (d) 10°

20. V_o and V_E represent the velocities, μ_o and μ_E the refractive indices of ordinary and extraordinary rays for a doubly refracting crystal. Then [KCET 2002]

(a) $V_o \geq V_E,\ \mu_o \leq \mu_E$ if the crystal is calcite

(b) $V_o \leq V_E,\ \mu_o \leq \mu_E$ if the crystal is quartz

(c) $V_o \leq V_E,\ \mu_o \geq \mu_E$ if the crystal is calcite

(d) $V_o \geq V_E,\ \mu_o \geq \mu_E$ if the crystal is quartz

21. Polarising angle for water is 53°4'. If light is incident at this angle on the surface of water and reflected, the angle of refraction is

(a) 53°4' (b) 126°56'

(c) 36°56' (d) 30°4'

22. When a plane polarised light is passed through an analyser and analyser is rotated through 90°, the intensity of the emerging light

(a) Varies between a maximum and minimum

(b) Becomes zero

(c) Does not vary [CPMT 1978]

(d) Varies between a maximum and zero

23. Consider the following statements *A* to *B* and identify the correct answer

A. Polarised light can be used to study the helical surface of nucleic acids.

B. Optics axis is a direction and not any particular line in the crystal [EAMCET (Med.) 2003]

(a) A and B are correct

(b) A and B are wrong

(c) A is correct but B is wrong

(d) A is wrong but B is correct

24. Two Nicols are oriented with their principal planes making an angle of 60°. The percentage of incident unpolarized light which passes through the system is

(a) 50% (b) 100%

(c) 12.5% (d) 37.5%

25. Unpolarized light falls on two polarizing sheets placed one on top of the other. What must be the angle between the characteristic directions of the sheets if the intensity of the final transmitted light is one-third the maximum intensity of the first transmitted beam

(a) 75° (b) 55°
(c) 35° (d) 15°

26. Unpolarized light of intensity $32\,Wm^{-2}$ passes through three polarizers such that transmission axes of the first and second polarizer makes and angle 30° with each other and the transmission axis of the last polarizer is crossed with that of the first. The intensity of final emerging light will be

(a) $32\ Wm^{-2}$ (b) $3\ Wm^{-2}$
(c) $8\ Wm^{-2}$ (d) $4\ Wm^{-2}$

27. In the visible region of the spectrum the rotation of the place of polarization is given by $\theta = a + \frac{b}{\lambda^2}$. The optical rotation produced by a particular material is found to be 30° *per mm* at $\lambda = 5000\,Å$ and 50° *per mm* at $\lambda = 4000\,Å$. The value of constant *a* will be

(a) $+\frac{50°}{9}$ *per mm* (b) $-\frac{50°}{9}$ *per mm*
(c) $+\frac{9°}{50}$ *per mm* (d) $-\frac{9°}{50}$ *per mm*

28. When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of the light which does not get transmitted is **[AIEEE 2005]**

(a) Zero (b) I_0
(c) $\frac{1}{2}I_0$ (c) $\frac{1}{4}I_0$

29. Refractive index of material is equal to tangent of polarising angle. It is called **[AFMC 2005]**

(a) Brewster's law (b) Lambert's law
(c) Malus's law (d) Bragg's law

30. In case of linearly polarized light, the magnitude of the electric field vector: **[AIIMS 2005]**

(a) Does not change with time
(b) Varies periodically with time
(c) Increases and decreases linearly with time
(d) Is parallel to the direction of propagation

31. When unpolarised light beam is incident from air onto glass (*n* = 1.5) at the polarising angle **[KCET 2005]**

(a) Reflected beam is polarised 100 percent
(b) Reflected and refracted beams are partially polarised
(c) The reason for (a) is that almost all the light is reflected
(d) All of the above

32. An optically active compound **[DCE 2005]**

(a) Rotates the plane polarised light
(b) Changing the direction of polarised light
(c) Do not allow plane polarised light to pass through
(d) None of the above

33. When the angle of incidence on a material is 60°, the reflected light is completely polarized. The velocity of the refracted ray inside the material is (in ms^{-1}) **[Kerala PMT 2005]**

(a) 3×10^8 (b) $\left(\frac{3}{\sqrt{2}}\right) \times 10^8$
(c) $\sqrt{3} \times 10^8$ (d) 0.5×10^8

34. Two polaroids are placed in the path of unpolarized beam of intensity I_0 such that no light is emitted from the second polaroid. If a third polaroid whose polarization axis makes an angle θ with the polarization axis of first polaroid, is placed between these polaroids then the intensity of light emerging from the last polaroid will be **[UPSEAT 2005]**

(a) $\left(\frac{I_0}{8}\right)\sin^2 2\theta$ (b) $\left(\frac{I_0}{4}\right)\sin^2 2\theta$
(c) $\left(\frac{I_0}{2}\right)\cos^4 \theta$ (d) $I_0 \cos^4 \theta$

35. For the study of the helical structure of nucleic acids, the property of electromagnetic radiation generally used is **[EAMCET 2005]**

(a) Reflection (b) Interference
(c) Diffraction (d) Polarization

EM Waves

1. Which of the following statement is wrong **[NCERT 1976]**

(a) Infrared photon has more energy than the photon of visible light
(b) Photographic plates are sensitive to ultraviolet rays
(c) Photographic plates can be made sensitive to infrared rays
(d) Infrared rays are invisible but can cast shadows like visible light rays

2. Pick out the longest wavelength from the following types of radiations **[CBSE PMT 1990]**

(a) Blue light (b) γ-rays
(c) *X*-rays (d) Red light

3. Wave which cannot travel in vacuum is **[MP PMT 1994]**

(a) *X*-rays (b) Infrasonic
(c) Ultraviolet (d) Radiowaves

4. Light is an electromagnetic wave. Its speed in vacuum is given by the expression **[CBSE PMT 1993; MP PMT 1994; RPMT 1999; MP PET 2001; Kerala PET 2001; AIIMS 2002]**

(a) $\sqrt{\mu_o \varepsilon_o}$ (b) $\sqrt{\frac{\mu_o}{\varepsilon_o}}$
(c) $\sqrt{\frac{\varepsilon_o}{\mu_o}}$ (d) $\frac{1}{\sqrt{\mu_o \varepsilon_o}}$

5. The range of wavelength of the visible light is **[MP PMT 2000; MP PET 2002]**

(a) 10 Å to 100 Å (b) 4,000 Å to 8,000 Å
(c) 8,000 Å to 10,000 Å (d) 10,000 Å to 15,000 Å

6. Which radiation in sunlight, causes heating effect **[AFMC 2001]**

(a) Ultraviolet (b) Infrared
(c) Visible light (d) All of these

7. Which of the following represents an infrared wavelength

[CPMT 1975; MP PET/PMT 1988]

(a) 10^{-4} *cm* (b) 10^{-5} *cm*

(c) 10^{-6} *cm* (d) 10^{-7} *cm*

8. The wavelength of light visible to eye is of the order of [CPMT 1982, 84]

(a) 10^{-2} *m* (b) 10^{-10} *m*

(c) 1 *m* (d) 6×10^{-7} *m*

9. The speed of electromagnetic wave in vacuum depends upon the source of radiation [Kerala PMT 2004]

(a) Increases as we move from γ-rays to radio waves

(b) Decreases as we move from γ-rays to radio waves

(c) Is same for all of them

(d) None of these

10. Which of the following radiations has the least wavelength [AIEEE 2003]

(a) γ -rays (b) β-rays

(c) α-rays (d) X-rays

11. The maximum distance upto which TV transmission from a TV tower of height h can be received is proportional to [AIIMS 2003]

(a) $h^{1/2}$ (b) h

(c) h (d) h^2

12. Which of the following are not electromagnetic waves [AIEEE 2002; CBSE PMT 2003]

(a) Cosmic rays (b) Gamma rays

(c) β-rays (d) X-rays

13. Ozone is found in [DPMT 2002]

(a) Stratosphere (b) Ionosphere

(c) Mesosphere (d) Troposphere

14. The electromagnetic waves travel with a velocity [J & K CET 2002]

(a) Equal to velocity of sound

(b) Equal to velocity of light

(c) Less than velocity of light

(d) None of these

15. The ozone layer absorbs [Kerala PET 2002]

(a) Infrared radiations (b) Ultraviolet radiations

(c) X-rays (d) γ-rays

16. Electromagnetic radiation of highest frequency is [Kerala PMT 2002]

(a) Infrared radiations (b) Visible radiation

(c) Radio waves (d) γ-rays

17. Which of the following shows green house effect [CBSE PMT 2002]

(a) Ultraviolet rays (b) Infrared rays

(c) X-rays (d) None of these

18. Which of the following waves have the maximum wavelength [AFMC 2002]

(a) X-rays (b) I.R. rays

(c) UV rays (d) Radio waves

19. Electromagnetic waves are transverse in nature is evident by [AIEEE 2002]

(a) Polarization (b) Interference

(c) Reflection (d) Diffraction

20. If $\vec{E}$ and $\vec{B}$ are the electric and magnetic field vectors of E.M. waves then the direction of propagation of E.M. wave is along the direction of [CBSE PMT 1992, 2002; DCE 2002, 05]

(a) $\vec{E}$ (b) $\vec{B}$

(c) $\vec{E} \times \vec{B}$ (d) None of these

21. Biological importance of Ozone layer is [CBSE PMT 2001]

(a) It stops ultraviolet rays

(b) Ozone rays reduce green house effect

(c) Ozone layer reflects radio waves

(d) Ozone layer controls O_2 / H_2 radio in atmosphere

22. What is ozone hole [AFMC 2001]

(a) Hole in the ozone layer

(b) Formation of ozone layer

(c) Thinning of ozone layer in troposphere

(d) Reduction in ozone thickness in stratosphere

23. Which rays are not the portion of electromagnetic spectrum [Haryana CEET 2000]

(a) X-rays (b) Microwaves

(c) α-rays (d) Radio waves

24. Radio wave diffract around building although light waves do not. The reason is that radio waves [AMU 2000]

(a) Travel with speed larger than c

(b) Have much larger wavelength than light

(c) Carry news

(d) Are not electromagnetic waves

25. The frequencies of X-rays, γ-rays and ultraviolet rays are respectively a, b and c. Then [CBSE PMT 2000]

(a) $a < b, b > c$ (b) $a > b, b > c$

(c) $a > b, b < c$ (d) $a < b, b < c$

26. Radio waves and visible light in vacuum have [KCET 2000]

(a) Same velocity but different wavelength

(b) Continuous emission spectrum

(c) Band absorption spectrum

(d) Line emission spectrum

27. Energy stored in electromagnetic oscillations is in the form of [Haryana CEET 2000; AFMC 1994]

(a) Electrical energy (b) Magnetic energy

(c) Both (a) and (b) (d) None of these

28. Heat radiations propagate with the speed of [AMU 2000]

(a) α-rays (b) β-rays

(c) Light waves (d) Sound waves

29. If a source is transmitting electromagnetic wave of frequency 8.2×10^6 *Hz*, then wavelength of the electromagnetic waves transmitted from the source will be [DPMT 1999]

(a) 36.6 *m* (b) 40.5 *m*

(c) 42.3 *m* (d) 50.9 *m*

30. In an apparatus, the electric field was found to oscillate with an amplitude of 18 *V/m*. The magnitude of the oscillating magnetic field will be [Pb. PMT 1999]

(a) $4 \times 10^{-6}\ T$ (b) $6 \times 10^{-8}\ T$

(c) $9 \times 10^{-9}\ T$ (d) $11 \times 10^{-11}\ T$

31. According to Maxwell's hypothesis, a changing electric field gives rise to [AIIMS 1998]

(a) An e.m.f. (b) Electric current

(c) Magnetic field (d) Pressure radiant

32. In an electromagnetic wave, the electric and magnetising fields are $100\ V m^{-1}$ and $0.265\ A m^{-1}$. The maximum energy flow is

(a) $26.5\ W/m^2$ (b) $36.5\ W/m^2$

(c) $46.7\ W/m^2$ (d) $765\ W/m^2$

33. The 21 *cm* radio wave emitted by hydrogen in interstellar space is due to the interaction called the hyperfine interaction is atomic hydrogen. the energy of the emitted wave is nearly

(a) 10^{-17} *Joule* (b) 1 *Joule*

(c) 7×10^{-8} *Joule* (d) 10^{-24} *Joule*

34. TV waves have a wavelength range of 1-10 *meter*. Their frequency range in *MHz* is [KCET 1998]

(a) 30-300 (b) 3-30

(c) 300-3000 (d) 3-3000

35. Maxwell's equations describe the fundamental laws of [CPMT 1996]

(a) Electricity only (b) Magnetism only

(c) Mechanics only (d) Both (a) and (b)

36. The oscillating electric and magnetic vectors of an electromagnetic wave are oriented along [CBSE PMT 1994]

(a) The same direction but differ in phase by 90°

(b) The same direction and are in phase

(c) Mutually perpendicular directions and are in phase

(d) Mutually perpendicular directions and differ in phase by 90°

37. In which one of the following regions of the electromagnetic spectrum will the vibrational motion of molecules give rise to absorption [SCRA 1994]

(a) Ultraviolet (b) Microwaves

(c) Infrared (d) Radio waves

38. An electromagnetic wave travels along *z*-axis. Which of the following pairs of space and time varying fields would generate such a wave

(a) E_x, B_y (b) E_y, B_x

(c) E_z, B_x (d) E_y, B_z

39. Which of the following rays has the maximum frequency [CBSE PMT 1994]

(a) Gamma rays (b) Blue light

(c) Infrared rays (d) Ultraviolet rays

40. A signal emitted by an antenna from a certain point can be received at another point of the surface in the form of [CPMT 1993]

(a) Sky wave (b) Ground wave

(c) Sea wave (d) Both (a) and (b)

41. Approximate height of ozone layer above the ground is [CBSE PMT 1991]

(a) 60 to 70 *km* (b) 59 *km* to 80 *km*

(c) 70 *km* to 100 *km* (d) 100 *km* to 200 *km*

42. The electromagnetic waves do not transport [Pb. PET 1991]

(a) Energy (b) Charge

(c) Momentum [Pb. PMT 1997, 98] (d) Information

43. A plane electromagnetic wave is incident on a material surface. If the wave delivers momentum *p* and energy *E*, then

(a) $p = 0, E = 0$ (b) $p \neq 0, E \neq 0$

(c) $p \neq 0, E = 0$ (d) $p = 0, E \neq 0$

44. An electromagnetic wave, going through vacuum is described by $E = E_0 \sin(kx - \omega t)$. Which of the following is independent of wavelength [CBSE PMT 1998]

(a) k (b) ω

(c) k/ω (d) $k\omega$

45. An electromagnetic wave going through vacuum is described by $E = E_0 \sin(kx - \omega t)$; $B = B_0 \sin(kx - \omega t)$. Which of the following equation is true

(a) $E_0 k = B_0 \omega$ (b) $E_0 \omega = B_0 k$

(c) $E_0 B_0 = \omega k$ (d) None of these

46. An *LC* resonant circuit contains a 400 *pF* capacitor and a 100 μH inductor. It is set into oscillation coupled to an antenna. The wavelength of the radiated electromagnetic waves is

(a) 377 *mm* (b) 377 *metre*

(c) 377 *cm* (d) 3.77 *cm*

47. A radio receiver antenna that is 2 *m* long is oriented along the direction of the electromagnetic wave and receives a signal of intensity $5 \times 10^{-16}\ W/m^2$. The maximum instantaneous potential difference across the two ends of the antenna is

(a) 1.23 μV (b) 1.23 *mV*

(c) 1.23 *V* (d) 12.3 *mV*

48. Television signals broadcast from the moon can be received on the earth while the TV broadcast from Delhi cannot be received at places about 100 *km* distant from Delhi. This is because [CBSE PMT 1994]

(a) There is no atmosphere around the moon

(b) Of strong gravity effect on TV signals

(c) TV signals travel straight and cannot follow the curvature of the earth

(d) There is atmosphere around the earth

49. A TV tower has a height of 100 *m*. The average population density around the tower is 1000 per *km*. The radius of the earth is 6.4×10^{6} *m*. the population covered by the tower is

(a) 2×10^{6} (b) 3×10^{6}

(c) 4×10^{6} (d) 6×10^{6}

50. The wavelength 21 *cm* emitted by atomic hydrogen in interstellar space belongs to

(a) Radio waves (b) Infrared waves

(c) Microwaves (d) γ-rays

51. Which scientist experimentally proved the existence of electromagnetic waves [AFMC 2004]

(a) Sir J.C. Bose (b) Maxwell

(c) Marconi (d) Hertz

52. An electromagnetic wave of frequency $\nu = 3.0\,MHz$ passes from vacuum into a dielectric medium with permitivity $\varepsilon = 4.0$. Then

(a) Wavelength is doubled and the frequency remains unchanged

(b) Wavelength is doubled and frequency becomes half

(c) Wavelength is halved and frequency remains unchanged

(d) Wavelength and frequency both remain unchanged

53. Frequency of a wave is $6\times10^{15}\,Hz$. The wave is [Orissa PMT 2004]

(a) Radiowave (b) Microwave

(c) X-ray (d) None of these

54. The region of the atmosphere above troposphere is known as

(a) Lithosphere (b) Uppersphere

(c) Ionosphere (d) Stratosphere

55. Which of the following electromagnetic waves have minimum frequency [Pb PET 2000]

(a) Microwaves (b) Audible waves

(c) Ultrasonic waves (d) Radiowaves

56. Which one of the following have minimum wavelength [Pb PET 2001]

(a) Ultraviolet rays (b) Cosmic rays

(c) *X*-rays (d) γ – rays

57. Radiations of intensity $0.5\ W/m^{2}$ are striking a metal plate. The pressure on the plate is [DCE 2004]

(a) $0.166\times10^{-8}\ N/m^{2}$ (b) $0.332\times10^{-8}\ N/m^{2}$

(c) $0.111\times10^{-8}\ N/m^{2}$ (d) $0.083\times10^{-8}\ N/m^{2}$

58. Electromagnetic waves travel in a medium which has relative permeability 1.3 and relative permittivity 2.14. Then the speed of the electromagnetic wave in the medium will be

(a) $13.6\times10^{6}\ m/s$ (b) $1.8\times10^{2}\ m/s$

(c) $3.6\times10^{8}\ m/s$ (d) $1.8\times10^{8}\ m/s$

59. The intensity of gamma radiation from a given source is *I*. On passing through 36 *mm* of lead, it is reduced to $\frac{I}{8}$. The thickness of lead which will reduce the intensity to $\frac{I}{2}$ will be [AIEEE 2005]

(a) 18 *mm* (b) 12 *mm*

(c) 6 *mm* (d) 9 *mm*

60. If λ_v, λ_r and λ_m represent the wavelength of visible light *x*-rays and microwaves respectively, then [CBSE PMT 2005]

(a) $\lambda_m > \lambda_x > \lambda_v$ (b) $\lambda_v > \lambda_m > \lambda_y$

(c) $\lambda_m > \lambda_v > \lambda_v$ (d) $\lambda_v > \lambda_x > \lambda_m$

61. For skywave propagation of a 10 *MHz* signal, what should be the minimum electron density in ionosphere [AFMC 2005]

(a) $\sim 1.2\times10^{12}\,m^{-3}$ (b) $\sim 10^{6}\,m^{-3}$

(c) $\sim 10^{14}\,m^{-3}$ (d) $\sim 10^{22}\,m^{-3}$

62. The pressure exerted by an electromagnetic wave of intensity *I* (*watts/m*) on a nonreflecting surface is [*c* is the velocity of light]

(a) Ic (b) Ic^{2}

(c) I/c (d) I/c^{2}

63. Infrared radiation was discovered in 1800 by [AIEEE 2004] [KCET 2005]

(a) William Wollaston (b) William Herschel

(c) Wilhelm Roentgen (d) Thomas Young

64. Which of the following is electromagnetic wave [BCECE 2005]

(a) *X*-rays and light waves

(b) Cosmic rays and sound waves

(c) Beta rays and sound waves

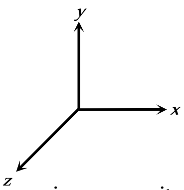
(d) Alpha rays and sound waves

65. Which one of the following is not electromagnetic in nature [Kerala PMT 2005] [BCECE 2004]

(a) *X*-rays (b) Gamma rays

(c) Cathode rays (d) Infrared rays

66. Light wave is travelling along y-direction. If the corresponding $\vec{E}$ vector at any time is along the x-axis, the direction of $\vec{B}$ vector at that time is along [UPSEAT 2005]



(a) *y*-axis

(b) *x*-axis

(c) + *z*-axis

(d) – *z* axis

67. If *c* is the speed of electromagnetic waves in vacuum, its speed in a medium of dielectric constant *K* and relative permeability μ_r is

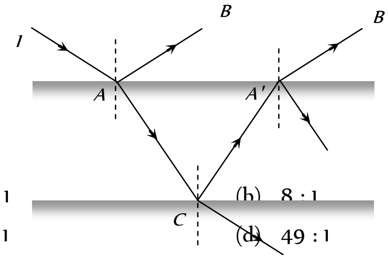
(a) $v = \frac{1}{\sqrt{\mu_r K}}$ (b) $v = c\sqrt{\mu_r K}$

(c) $v = \frac{c}{\sqrt{\mu_r K}}$ [MH CET 2003] (d) $v = \frac{K}{\sqrt{\mu_r C}}$

Critical Thinking

Objective Questions

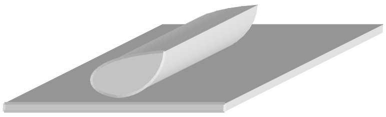
1. A ray of light of intensity I is incident on a parallel glass-slab at a point A as shown in fig. It undergoes partial reflection and refraction. At each reflection 25% of incident energy is reflected. The rays AB and $A'B'$ undergo interference. The ratio I_{max} / I_{min} is



(a) 4 : 1 (b) 8 : 1

(c) 7 : 1 (d) 49 : 1

2. A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat glass plate as shown. The observed interference fringes from this combination shall be



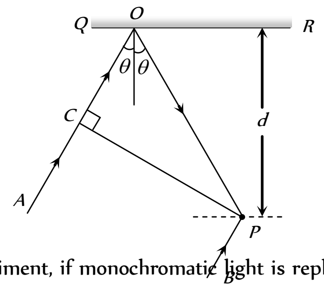
(a) Straight

(b) Circular

(c) Equally spaced

(d) Having fringe spacing which increases as we go outwards

3. In the adjacent diagram, CP represents a wavefront and AO & BP, the corresponding two rays. Find the condition on θ for constructive interference at P between the ray BP and reflected ray OP



(a) $\cos\theta = 3\lambda/2d$

(b) $\cos\theta = \lambda/4d$

(c) $\sec\theta - \cos\theta = \lambda/d$

(d) $\sec\theta - \cos\theta = 4\lambda/d$

4. In Young's double slit experiment, if monochromatic light is replaced by white light

[AIIMS 2001; Kerala PET 2000; KCET 2004]

(a) All bright fringes become white

(b) All bright fringes have colours between violet and red

(c) Only the central fringe is white, all other fringes are coloured

(d) No fringes are observed

5. In Young's double slit experiment, if the two slits are illuminated with separate sources, no interference pattern is observed because

(a) There will be no constant phase difference between the two waves

(b) The wavelengths are not equal

(c) The amplitudes are not equal

(d) None of the above

6. In Young's double slit experiment, white light is used. The separation between the slits is b. The screen is at a distance d ($d >> b$) from the slits. Some wavelengths are missing exactly in front of one slit. These wavelengths are

[IIT 1984; AIIMS 1995]

(a) $\lambda = \dfrac{b^2}{d}$ (b) $\lambda = \dfrac{2b^2}{d}$

(c) $\lambda = \dfrac{b^2}{3d}$ (d) $\lambda = \dfrac{2b^2}{3d}$

7. In a Young's double slit experiment the source S and the two slits A and B are vertical with slit A above slit B. The fringes are observed on a vertical screen K. The optical path length from S to B is increased very slightly (by introducing a transparent material of higher refractive index) and the optical path length from S to A is not changed, as a result the fringe system on K moves

[IIT 1990]

(a) Vertically downwards slightly

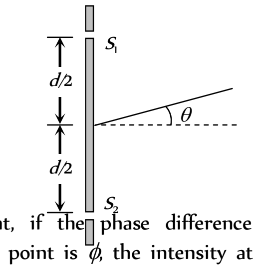
(b) Vertically upwards slightly

(c) Horizontally, slightly to the left

(d) Horizontally, slightly to the right

8. In an interference arrangement similar to Young's double slit experiment, the slits S_1 and S_2 are illuminated with coherent microwave sources each of frequency 10^6 Hz. The sources are synchronized to have zero phase difference. The slits are separated by distance d = 150 m. The intensity $I(\theta)$ is measured as a function of θ, where θ is defined as shown. If I_0 is maximum intensity, then $I(\theta)$ for $0 \le \theta \le 90^o$ is given by

[IIT-JEE (Screening)1999]



(a) $I(\theta) = I_0$ for $\theta = 0^o$

(b) $I(\theta) = I_0 / 2$ for $\theta = 30^o$

(c) $I(\theta) = I_0 / 4$ for $\theta = 90^o$

(d) $I(\theta)$ is constant for all values of θ

[IIT-JEE (Screening) 2003]

9. In the Young's double slit experiment, if the phase difference between the two waves interfering at a point is ϕ, the intensity at that point can be expressed by the expression

[MP PET 1998; MP PMT 2003]

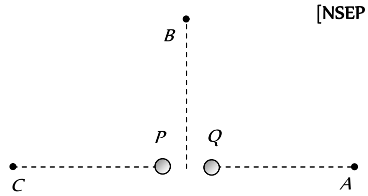
(a) $I = \sqrt{A^2 + B^2 \cos^2 \phi}$ (b) $I = \dfrac{A}{B}\cos\phi$

(c) $I = A + B\cos\dfrac{\phi}{2}$ (d) $I = A + B\cos\phi$

Where A and B depend upon the amplitudes of the two waves.

10. Figure here shows P and Q as two equally intense coherent sources emitting radiations of wavelength 20 m. The separation PQ is 5.0 m and phase of P is ahead of the phase of Q by 90°. A, B and C are three distant points of observation equidistant from the mid-point of PQ. The intensity of radiations at A, B, C will bear the ratio

[NSEP 1994]



(a) 0 : 1 : 4

(b) 4 : 1 : 0

(c) 0 : 1 : 2

(d) 2 : 1 : 0

11. In Young's double slit experiment, the intensity on the screen at a point where path difference is λ is K. What will be the intensity at the point where path difference is $\lambda / 4$

[RPET 1996]

(a) $\dfrac{K}{4}$ (b) $\dfrac{K}{2}$

(c) K (d) Zero

12. When one of the slits of Young's experiment is covered with a transparent sheet of thickness 4.8 *mm*, the central fringe shifts to a position originally occupied by the 30th bright fringe. What should be the thickness of the sheet if the central fringe has to shift to the position occupied by 20th bright fringe

(a) 3.8 *mm* (b) 1.6 *mm*

(c) 7.6 *mm* (d) 3.2 *mm*

13. In the ideal double-slit experiment, when a glass-plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wavelength λ), the intensity at the position where the central maximum occurred previously remains unchanged. The minimum thickness of the glass-plate is [IIT-JEE (Screening) 2002]

(a) 2λ (b) $\frac{2\lambda}{3}$

(c) $\frac{\lambda}{3}$ (d) λ

14. The time period of rotation of the sun is 25 days and its radius is $7\times10^{8}m$. The Doppler shift for the light of wavelength 6000 Å emitted from the surface of the sun will be [MP PMT 1994]

(a) 0.04 Å (b) 0.40 Å

(c) 4.00 Å (d) 40.0 Å

15. In hydrogen spectrum the wavelength of H_α line is 656 *nm* whereas in the spectrum of a distant galaxy, H_α line wavelength is 706 *nm*. Estimated speed of the galaxy with respect to earth is [IIT-JEE 1999; UPSEAT 2003]

(a) $2\times10^{8}m/s$ (b) $2\times10^{7}m/s$

(c) $2\times10^{6}m/s$ (d) $2\times10^{5}m/s$

16. A rocket is going towards moon with a speed *v*. The astronaut in the rocket sends signals of frequency ν towards the moon and receives them back on reflection from the moon. What will be the frequency of the signal received by the astronaut (Take *v*<<*c*) [RPMT 1996; DPMT 2000]

(a) $\frac{c}{c-v}\nu$ (b) $\frac{c}{c-2v}\nu$

(c) $\frac{2v}{c}\nu$ (d) $\frac{2c}{v}\nu$

17. The periodic time of rotation of a certain star is 22 days and its radius is 7 × 10⁸ *metres*. If the wavelength of light emitted by its surface be 4320 Å, the Doppler shift will be (1 day = 86400 *sec*) [MP PET 2001]

(a) 0.033 Å (b) 0.33 Å

(c) 3.3 Å (d) 33 Å

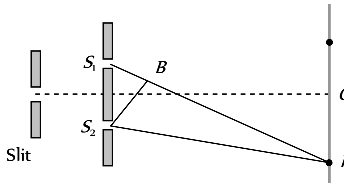
18. In a two slit experiment with monochromatic light fringes are obtained on a screen placed at some distance from the sits. If the screen is moved by $5\times10^{-2}m$ towards the slits, the change in fringe width is $3\times10^{-5}m$. If separation between the slits is $10^{-3}m$, the wavelength of light used is

[Roorkee 1992]

(a) 6000 *Å* (b) 5000 *Å*

(c) 3000 *Å* (d) 4500 *Å*

19. In the figure is shown Young's double slit experiment. Q is the position of the first bright fringe on the right side of O. P is the 11th fringe on the other side, as measured from Q. If the wavelength of the light used is $6000\times10^{-10}m$, then S_1B will be equal to [KCET 2002]



(a) $6\times10^{-6}m$

(b) $6.6\times10^{-6}m$

(c) $3.138\times10^{-7}m$

(d) $3.144\times10^{-7}m$

20. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude A and wavelength λ. In another experiment with the same set up the two slits are of equal amplitude A and wavelength λ but are incoherent. The ratio of the intensity of light at the mid-point of the screen in the first case to that in the second case is

[IIT-JEE 1986; RPMT 2002]

(a) 1 : 2 (b) 2 : 1

(c) 4 : 1 (d) 1 : 1

21. Four light waves are represented by

(i) $y=a_1\sin\omega t$ (ii) $y=a_2\sin(\omega t+\phi)$

(iii) $y=a_1\sin2\omega t$ (iv) $y=a_2\sin2(\omega t+\phi)$

Interference fringes may be observed due to superposition of

(a) (i) and (ii) (b) (i) and (iii)

(c) (ii) and (iv) (d) (iii) and (iv)

22. In Young's double slit experiment the *y*-coordinates of central maxima and 10th maxima are 2 *cm* and 5 *cm* respectively. When the YDSE apparatus is immersed in a liquid of refractive index 1.5 the corresponding *y*-coordinates will be

(a) 2 *cm*, 7.5 *cm*

(b) 3 *cm*, 6 *cm*

(c) 2 *cm*, 4 *cm*

(d) 4/3 *cm*, 10/3 *cm*

23. The maximum intensity in Young's double slit experiment is I_0. Distance between the slits is d = 5 λ, where λ is the wavelength of monochromatic light used in the experiment. What will be the intensity of light in front of one of the slits on a screen at a distance $D=10\,d$

(a) $\frac{I_0}{2}$ (b) $\frac{3}{4}I_0$

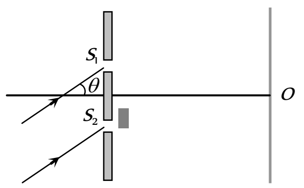
(c) I_0 (d) $\frac{I_0}{4}$

24. A monochromatic beam of light falls on YDSE apparatus at some angle (say θ) as shown in figure. A thin sheet of glass is inserted in front of the lower slit S_2. The central bright fringe (path difference = 0) will be obtained

(a) At O

(b) Above O

(c) Below O



(d) Anywhere depending on angle θ, thickness of plate t and refractive index of glass μ

25. In Young's double slit experiment how many maximas can be obtained on a screen (including the central maximum) on both sides of the central fringe if $\lambda = 2000\,Å$ and $d = 7000\,Å$

(a) 12 (b) 7

(c) 18 (d) 4

26. In a Young's double slit experiment, the slits are 2 *mm* apart and are illuminated with a mixture of two wavelength $\lambda_0 = 750nm$ and $\lambda = 900nm$. The minimum distance from the common central bright fringe on a screen $2m$ from the slits where a bright fringe from one interference pattern coincides with a bright fringe from the other is

(a) 1.5 *mm* (b) 3 *mm*

(c) 4.5 *mm* (d) 6 *mm*

27. A flake of glass (refractive index 1.5) is placed over one of the openings of a double slit apparatus. The interference pattern displaces itself through seven successive maxima towards the side where the flake is placed. if wavelength of the diffracted light is $\lambda = 600nm$, then the thickness of the flake is

(a) 2100 *nm* (b) 4200 *nm*

(c) 8400 *nm* (d) None of these

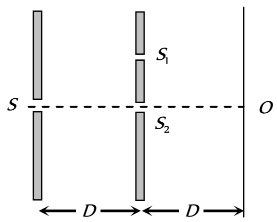
28. Two ideal slits S_1 and S_2 are at a distance d apart, and illuminated by light of wavelength λ passing through an ideal source slit S placed on the line through S_1 as shown. The distance between the planes of slits and the source slit is D. A screen is held at a distance D from the plane of the slits. The minimum value of d for which there is darkness at O is

(a) $\sqrt{\frac{3\lambda D}{2}}$

(b) $\sqrt{\lambda D}$

(c) $\sqrt{\frac{\lambda D}{2}}$

(d) $\sqrt{3\lambda D}$



29. In a double slit arrangement fringes are produced using light of wavelength 4800 $Å$. One slit is covered by a thin plate of glass of refractive index 1.4 and the other with another glass plate of same thickness but of refractive index 1.7. By doing so the central bright shifts to original fifth bright fringe from centre. Thickness of glass plate is

(a) 8 μm (b) 6 μm

(c) 4 μm (d) 10 μm

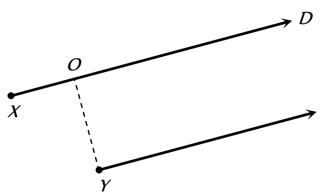
30. Two point sources X and Y emit waves of same frequency and speed but Y lags in phase behind X by $2\pi l$ radian. If there is a maximum in direction D the distance XO using n as an integer is given by

(a) $\frac{\lambda}{2}(n-l)$

(b) $\lambda(n+l)$

(c) $\frac{\lambda}{2}(n+l)$

(d) $\lambda(n-l)$



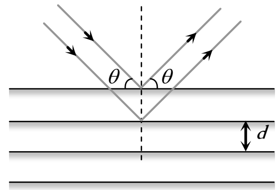
31. A beam with wavelength λ falls on a stack of partially reflecting planes with separation d. The angle θ that the beam should make with the planes so that the beams reflected from successive planes may interfere constructively is (where n =1, 2, ...)

(a) $\sin^{-1}\left(\frac{n\lambda}{d}\right)$

(b) $\tan^{-1}\left(\frac{n\lambda}{d}\right)$

(c) $\sin^{-1}\left(\frac{n\lambda}{2d}\right)$

(d) $\cos^{-1}\left(\frac{n\lambda}{2d}\right)$



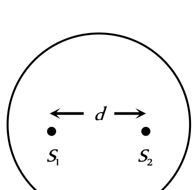
32. Two coherent sources separated by distance d are radiating in phase having wavelength λ. A detector moves in a big circle around the two sources in the plane of the two sources. The angular position of n = 4 interference maxima is given as

(a) $\sin^{-1}\frac{n\lambda}{d}$

(b) $\cos^{-1}\frac{4\lambda}{d}$

(c) $\tan^{-1}\frac{d}{4\lambda}$

(d) $\cos^{-1}\frac{\lambda}{4d}$



33. Two coherent sources S_1 and S_2 are separated by a distance four times the wavelength λ of the source. The sources lie along y axis whereas a detector moves along + x axis. Leaving the origin and far off points the number of points where maxima are observed is

(a) 2 (b) 3

(c) 4 (d) 5

34. A circular disc is placed in front of a narrow source. When the point of observation is at a distance of 1 *meter* from the disc, then the disc covers first HPZ. The intensity at this point is I_0. The intensity at a point distance 25 *cm* from the disc will be

(a) $I_1 = 0.531I_0$ (b) $I_1 = 0.053I_0$

(c) $I_1 = 53I_0$ (d) $I_1 = 5.03I_0$

35. A wavefront presents one, two and three HPZ at points A, B and C respectively. If the ratio of consecutive amplitudes of HPZ is 4 : 3, then the ratio of resultant intensities at these point will be

(a) 169 : 16 : 256 (b) 256 : 16 : 169

(c) 256 : 16 : 196 (d) 256 : 196 : 16

36. A circular disc is placed in front of a narrow source. When the point of observation is 2 *m* from the disc, then it covers first HPZ. The intensity at this point is I. When the point of observation is 25 *cm* from the disc then intensity will be

(a) $\left(\frac{R_6}{R_2}\right)^2 I$ (b) $\left(\frac{R_7}{R_2}\right)^2 I$

(c) $\left(\frac{R_8}{R_2}\right)^2 I$ (d) $\left(\frac{R_9}{R_2}\right)^2 I$

37. In a single slit diffraction of light of wavelength λ by a slit of width *e*, the size of the central maximum on a screen at a distance *b* is

(a) $2b\lambda + e$ (b) $\frac{2b\lambda}{e}$

(c) $\frac{2b\lambda}{e} + e$ (d) $\frac{2b\lambda}{e} - e$

38. Angular width of central maxima in the Fraunhoffer diffraction pattern of a slit is measured. The slit is illuminated by light of wavelength 6000 Å. When the slit is illuminated by light of another wavelength, the angular width decreases by 30%. The wavelength of this light will be

(a) 6000 Å (b) 4200 Å

(c) 3000 Å (d) 1800 Å

39. In a single slit diffraction experiment first minimum for red light (660 *nm*) coincides with first maximum of some other wavelength λ'. The value of λ' is

(a) 4400 Å (b) 6600 Å

(c) 2000 Å (d) 3500 Å

40. The ratio of intensities of consecutive maxima in the diffraction pattern due to a single slit is

(a) 1 : 4 : 9 (b) 1 : 2 : 3

(c) $1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2}$ (d) $1 : \frac{1}{\pi^2} : \frac{9}{\pi^2}$

41. Light is incident normally on a diffraction grating through which the first order diffraction is seen at 32°. The second order diffraction will be seen at

(a) 48°

(b) 64°

(c) 80°

(d) There is no second order diffraction in this case

42. White light may be considered to be a mixture of waves with λ ranging between 3900 Å and 7800 Å. An oil film of thickness 10,000 Å is examined normally by reflected light. If μ = 1.4, then the film appears bright for

(a) 4308 Å, 5091 Å, 6222 Å

(b) 4000 Å, 5091 Å, 5600 Å

(c) 4667 Å, 6222 Å, 7000 Å

(d) 4000 Å, 4667 Å, 5600 Å, 7000Å

43. Among the two interfering monochromatic sources *A* and *B*; *A* is ahead of *B* in phase by 66°. If the observation be taken from point *P*, such that *PB* – *PA* = $\lambda/4$. Then the phase difference between the waves from *A* and *B* reaching *P* is

(a) 156° (b) 140°

(c) 136° (d) 126°

44. The ratio of the intensity at the centre of a bright fringe to the intensity at a point one-quarter of the distance between two fringe from the centre is

(a) 2 (b) 1/2

(c) 4 (d) 16

45. A parallel plate capacitor of plate separation 2 *mm* is connected in an electric circuit having source voltage 400 *V*. if the plate area is 60 *cm*, then the value of displacement current for 10^{-6} sec will be

(a) 1.062 *amp* (b) 1.062×10^{-2} *amp*

(c) 1.062×10^{-3} *amp* (d) 1.062×10^{-4} *amp*

46. A long straight wire of resistance *R*, radius *a* and length *l* carries a constant current *I*. The Poynting vector for the wire will be

(a) $\frac{IR}{2\pi al}$ (b) $\frac{IR^2}{al}$

(c) $\frac{I^2R}{al}$ (d) $\frac{I^2R}{2\pi al}$

47. In an electromagnetic wave, the amplitude of electric field is 1 *V/m*. the frequency of wave is $5 \times 10^{14}\ Hz$. The wave is propagating along *z*-axis. The average energy density of electric field, in *Joule/m*, will be

(a) 1.1×10^{-11} (b) 2.2×10^{-12}

(c) 3.3×10^{-13} (d) 4.4×10^{-14}

48. A laser beam can be focussed on an area equal to the square of its wavelength *A He-Ne* laser radiates energy at the rate of 1*mW* and its wavelength is 632.8 *nm*. The intensity of focussed beam will be

(a) $1.5 \times 10^{13}\ W/m^2$ (b) $2.5 \times 10^{9}\ W/m^2$

(c) $3.5 \times 10^{17}\ W/m^2$ (d) None of these

49. A lamp emits monochromatic green light uniformly in all directions. The lamp is 3% efficient in converting electrical power to electromagnetic waves and consumes 100 *W* of power. The amplitude of the electric field associated with the electromagnetic radiation at a distance of 10*m* from the lamp will be

(a) 1.34 *V/m* (b) 2.68 *V/m*

(c) 5.36 *V/m* (d) 9.37 *V/m*

50. A point source of electromagnetic radiation has an average power output of 800 *W*. The maximum value of electric field at a distance 4.0 *m* from the source is

(a) 64.7 *V/m* (b) 57.8 *V/m*

(c) 56.72 *V/m* (d) 54.77 *V/m*

51. A wave is propagating in a medium of electric dielectric constant 2 and relative magnetic permeability 50. The wave impedance of such a medium is

(a) 5 Ω (b) 376.6 Ω

(c) 1883 Ω (d) 3776 Ω

52. A plane electromagnetic wave of wave intensity 6 *W/m* strikes a small mirror area 40 *cm*, held perpendicular to the approaching wave. The momentum transferred by the wave to the mirror each second will be

(a) $6.4 \times 10^{-7}\ kg - m/s^2$ (b) $4.8 \times 10^{-8}\ kg - m/s^2$

(c) $3.2 \times 10^{-9}\ kg - m/s^2$ (d) $1.6 \times 10^{-10}\ kg - m/s^2$

53. Specific rotation of sugar solution is 0.01 SI units. 200 kgm^{-3} of impure sugar solution is taken in a polarimeter tube of length 0.25*m* and an optical rotation of 0.4*rad* is observed. The percentage of purity of sugar is the sample is

[KCET 2004]

(a) 80% (b) 89%

(c) 11% (d) 20%

54. A 20 *cm* length of a certain solution causes right-handed rotation of 38°. A 30*cm* length of another solution causes left-handed rotation of 24°. The optical rotation caused by 30*cm* length of a mixture of the above solutions in the volume ratio 1 : 2 is

(a) Left handed rotation of 14°

(b) Right handed rotation of 14°

(c) Left handed rotation of 3°

(d) Right handed rotation of 3°

55. A beam of natural light falls on a system of 6 polaroids, which are arranged in succession such that each polaroid is turned through 30° with respect to the preceding one. The percentage of incident intensity that passes through the system will be

(a) 100% (b) 50%

(c) 30% (d) 12%

56. A beam of plane polarized light falls normally on a polarizer of cross sectional area $3 \times 10^{-4} m^2$. Flux of energy of incident ray in 10^{-3} *W*. The polarizer rotates with an angular frequency of 31.4 *rad/sec*. The energy of light passing through the polarizer per revolution will be

(a) 10^{-4} *Joule* (b) 10^{-3} *Joule*

(c) 10^{-2} *Joule* (d) 10^{-1} *Joule*

57. In a YDSE bi-chromatic light of wavelengths 400 *nm* and 560 *nm* are used. The distance between the slits is 0.1 *mm* and the distance between the plane of the slits and the screen is 1*m*. The minimum distance between two successive regions of complete darkness is

[IIT JEE (Screening) 2004]

(a) 4 *mm* (b) 5.6 *mm*

(c) 14 *mm* (d) 28 *mm*

58. The maximum number of possible interference maxima for slit-separation equal to twice the wavelength in Young's double-slit experiment is **[AIEEE 2004]**

(a) Infinite (b) Five

(c) Three (d) Zero

59. The *k* line of singly ionised calcium has a wavelength of 393.3 *nm* as measured on earth. In the spectrum of one of the observed galaxies, this spectral line is located at 401.8 *nm*. The speed with which the galaxy is moving away from us, will be

(a) 6480 *km/s* (b) 3240 *km/s*

(c) 4240 *km/sec* (d) None of these

60. A Young's double slit experiment uses a monochromatic source. The shape of the interference fringes formed on a screen is

(a) Straight line (b) Parabola

(c) Hyperbola (d) Circle

61. If I_0 is the intensity of the principal maximum in the single slit diffraction pattern, then what will be its intensity when the slit width is doubled **[AIEEE 2005]**

(a) I_0 (b) $\frac{I_0}{2}$

(c) $2I_0$ (d) $4\,I_0$

62. In Young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is

[IIT-JEE (Screening) 2005]

(a) $\sin^{-1}(\lambda/d)$ (b) $\sin^{-1}(\lambda/2d)$

(c) $\sin^{-1}(\lambda/3d)$ (d) $\sin^{-1}(\lambda/4d)$

63. A beam of electron is used in an *YDSE* experiment. The slit width is d. When the velocity of electron is increased, then

[IIT-JEE (Screening) 2005]

(a) No interference is observed

(b) Fringe width increases **[KCET 2001]**

(c) Fringe width decreases

(d) Fringe width remains same

[Pb. PET 2003]

[AIEEE 2005]

Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below:

(a) *If both assertion and reason are true and the reason is the correct explanation of the assertion.*
(b) *If both assertion and reason are true but reason is not the correct explanation of the assertion.*
(c) *If assertion is true but reason is false.*
(d) *If the assertion and reason both are false.*
(e) *If assertion is false but reason is true.*

1. Assertion : When a light wave travels from a rarer to a denser medium, it loses speed. The reduction in speed imply a reduction in energy carried by the light wave.

Reason : The energy of a wave is proportional to velocity of wave.

2. Assertion : A narrow pulse of light is sent through a medium. The pulse will retain its shape as it travels through the medium.

Reason : A narrow pulse is made of harmonic waves with a large range of wavelengths.

3. Assertion : No interference pattern is detected when two coherent sources are infinitely close to each other.

Reason : The fringe width is inversely proportional to the distance between the two slits.

4. Assertion : Newton's rings are formed in the reflected system. When the space between the lens and the glass plate is filled with a liquid of refractive index greater than that of glass, the central spot of the pattern is dark.

Reason : The reflection is Newton's ring cases will be from a denser to a rarer medium and the two interfering rays are reflected under similar conditions. **[AIIMS 1998]**

5. Assertion : The film which appears bright in reflected system will appear dark in the transmitted light and vice-versa.

Reason : The conditions for film to appear bright or dark in reflected light are just reverse to those in the transmitted light.

6. Assertion : For best contrast between maxima and minima in the interference pattern of Young's double slit experiment, the intensity of light emerging out of the two slits should be equal.

Reason : The intensity of interference pattern is proportional to square of amplitude.

7. Assertion : In Young's double slit experiment, the fringes become indistinct if one of the slits is covered with cellophane paper.

Reason : The cellophane paper decrease the wavelength of light.

8. Assertion : The unpolarised light and polarised light can be distinguished from each other by using polaroid.

Reason : A polaroid is capable of producing plane polarised beams of light.

9. Assertion : Nicol prism is used to produce and analyse plane polarised light.

Reason : Nicol prism reduces the intensity of light to zero.

10. Assertion : In everyday life the Doppler's effect is observed readily for sound waves than light waves.

Reason : Velocity of light is greater than that of sound.

[AIIMS 1995]

11. Assertion : In Young's experiment, the fringe width for dark fringes is different from that for white fringes.

Reason : In Young's double slit experiment the fringes are performed with a source of white light, then only black and bright fringes are observed. [AIIMS 2001]

12. Assertion : Coloured spectrum is seen when we look through a muslin cloth.

Reason : It is due to the diffraction of white light on passing through fine slits. [AIIMS 2002]

13. Assertion : When a tiny circular obstacle is placed in the path of light from some distance, a bright spot is seen at the centre of shadow of the obstacle.

Reason : Destructive interference occurs at the centre of the shadow. [AIIMS 2002]

14. Assertion : Thin films such as soap bubble or a thin layer of oil on water show beautiful colours when illuminated by white light.

Reason : It happens due to the interference of light reflected from the upper surface of the thin film. [AIIMS 2002]

15. Assertion : Microwave communication is preferred over optical communication.

Reason : Microwaves provide large number of channels and band width compared to optical signals. [AIIMS 2003]

16. Assertion : Corpuscular theory fails in explaining the velocities of light in air and water.

Reason : According to corpuscular theory, light should travel faster in denser medium than, in rarer medium. [AIIMS 1998]

17. Assertion : Interference pattern is made by using blue light instead of red light, the fringes becomes narrower.

Reason : In Young's double slit experiment, fringe width is given by relation $B=\frac{\lambda D}{d}$.

[AIIMS 1999]

18. Assertion : The cloud in sky generally appear to be whitish.

Reason : Diffraction due to clouds is efficient in equal measure at all wavelengths. [AIIMS 2005]

19. Assertion : Television signals are received through sky-wave propagation.

Reason : The ionosphere reflects electromagnetic waves of frequencies greater than a certain critical frequency. [AIIMS 2005]

20. Assertion : It is necessary to use satellites for long distance T.V. transmission.

Reason : The television signals are low frequency signals.

21. Assertion : The electrical conductivity of earth's atmosphere decrease with altitude.

Reason : The high energy particles (*i.e.* γ-rays and cosmic rays) coming from outer space and entering our earth's atmosphere causes ionisation of the atoms of the gases present there and the pressure of gases decreases with increase in altitude.

22. Assertion : Only microwaves are used in radar.

Reason : Because microwaves have very small wavelength.

23. Assertion : In Hertz experiment, the electric vector of radiation produced by the source gap is parallel to the gap.

Reason : Production of sparks between the detector gap is maximum when it is placed perpendicular to the source gap.

24. Assertion : For cooking in a microwave oven, food is always kept in metal containers.

Reason : The energy of microwave is easily transferred to the food in metal container.

25. Assertion : X-ray astronomy is possible only from satellites orbiting the earth.

Reason : Efficiency of X-rays telescope is large as compared to any other telescope.

26. Assertion : Short wave bands are used for transmission of ratio waves to a large distance

Reason : Short waves are reflected by ionosphere

[AIIMS 1994]

27. Assertion : Ultraviolet radiation are of higher frequency waves are dangerous to human being.

Reason : Ultraviolet radiation are absorbed by the atmosphere [AIIMS 1995]

28. Assertion : Environmental damage has increased the amount of ozone in the atmosphere.

Reason : Increase of ozone increases the amount of ultraviolet radiation on earth. [AIIMS 1996]

29. Assertion : Radio waves can be polarised.

Reason : Sound waves in air are longitudinal in nature.

[AIIMS 1998]

30. Assertion : The earth without atmosphere would be inhospitably cold.

Reason : All heat would escape in the absence of atmosphere. [AIIMS 2002]

Answers

Wave Nature and Interference of Light

1	a	2	c	3	b	4	c	5	d
6	c	7	d	8	c	9	c	10	b
11	a	12	d	13	c	14	a	15	d
16	a	17	c	18	b	19	c	20	b
21	c	22	c	23	a	24	c	25	a
26	a	27	b	28	b	29	c	30	a
31	b	32	d	33	d	34	a	35	a
36	c	37	b	38	c	39	b	40	c
41	d	42	b	43	b	44	c	45	d
46	c	47	d	48	b	49	c	50	a
51	d	52	c	53	d	54	c	55	b
56	a	57	c	58	d	59	d	60	b
61	b	62	a	63	c	64	d	65	d
66	c	67	a	68	a	69	a	70	c
71	b	72	d						

Young's Double Slit Experiment

1	a	2	c	3	c	4	c	5	a
6	c	7	a	8	c	9	a	10	d
11	d	12	c	13	bd	14	b	15	c
16	c	17	a	18	a	19	a	20	b
21	a	22	c	23	d	24	c	25	d
26	a	27	b	28	c	29	d	30	d
31	d	32	a	33	b	34	b	35	a
36	b	37	b	38	d	39	b	40	a
41	b	42	d	43	d	44	a	45	b
46	d	47	d	48	b	49	b	50	a
51	bc	52	b	53	d	54	a	55	a

56	b	57	c	58	c	59	c	60	b
61	b	62	c	63	b	64	d	65	b
66	a	67	c	68	b	69	a	70	b
71	d	72	b	73	b	74	b	75	c
76	d	77	a	78	c	79	b	80	a
81	b	82	b	83	d	84	a	85	a
86	b	87	b	88	d	89	b	90	a
91	a	92	c	93	a	94	a	95	b
96	b	97	d						

Doppler's Effect of Light

1	d	2	a	3	b	4	b	5	b
6	b	7	b	8	d	9	c	10	c
11	a	12	c	13	b	14	a	15	a
16	d	17	b	18	c	19	b	20	d
21	b	22	b	23	c	24	c	25	b
26	b	27	c	28	b	29	a	30	d
31	c	32	a	33	a				

Diffraction of Light

1	c	2	a	3	b	4	c	5	c
6	a	7	a	8	a	9	c	10	b
11	a	12	b	13	a	14	d	15	a
16	b	17	a	18	a	19	a	20	d
21	a	22	a	23	c	24	b	25	d
26	a	27	d	28	d	29	b	30	d
31	d	32	d	33	b	34	a	35	c
36	c	37	a	38	c	39	a	40	b
41	c								

Polarisation of Light

1	b	2	a	3	c	4	d	5	d
6	d	7	b	8	d	9	a	10	c
11	a	12	d	13	a	14	a	15	c
16	d	17	d	18	d	19	b	20	c
21	c	22	d	23	a	24	c	25	b
26	b	27	b	28	c	29	a	30	b
31	a	32	a	33	c	34	a	35	d

EM Waves

1	a	2	d	3	b	4	d	5	b
6	b	7	a	8	d	9	c	10	a
11	a	12	c	13	a	14	b	15	b
16	d	17	b	18	d	19	a	20	c
21	a	22	d	23	c	24	b	25	a
26	a	27	c	28	c	29	a	30	b
31	c	32	a	33	d	34	a	35	d
36	c	37	b	38	a	39	a	40	d
41	a	42	b	43	b	44	c	45	a
46	b	47	a	48	c	49	c	50	a
51	c	52	c	53	d	54	d	55	b
56	b	57	a	58	d	59	b	60	c
61	a	62	c	63	b	64	a	65	c
66	d	67	c						

Critical Thinking Questions

1	d	2	a	3	b	4	c	5	a
6	ac	7	a	8	ab	9	d	10	d
11	b	12	d	13	a	14	a	15	b
16	b	17	a	18	a	19	a	20	b
21	ad	22	c	23	a	24	d	25	b
26	c	27	c	28	c	29	a	30	b
31	c	32	b	33	b	34	a	35	b
36	d	37	c	38	b	39	a	40	c
41	d	42	a	43	a	44	a	45	b
46	d	47	b	48	b	49	a	50	d
51	c	52	d	53	a	54	d	55	d
56	a	57	d	58	b	59	a	60	c
61	d	62	c	63	b				

Assertion and Reason

1	d	2	e	3	b	4	a	5	a
6	b	7	c	8	a	9	c	10	b
11	d	12	a	13	c	14	c	15	a
16	a	17	a	18	c	19	d	20	c
21	e	22	a	23	c	24	d	25	c
26	b	27	b	28	d	29	b	30	a

Answers and Solutions

Wave Nature and Interference of Light

1. (a) Corpuscular theory explains refraction of light.

2. (c) According to Corpuscular theory different colour of light are due to different size of Corpuscules.

3. (b)

4. (c) According to Plank's hypothesis, black bodies emits radiations in the form of photons.

5. (d) The coherent source cannot be obtained from two different light sources.

6. (c) Huygen's wave theory fails to explain the particle nature of light (*i.e.* photoelectric effect)

7. (d) Interference is shown by transverse as well as mechanical waves.

8. (c) $I_{max}=(\sqrt{I_1}+\sqrt{I_2})^2=(\sqrt{I}+\sqrt{4I})^2=9I$

$I_{min}=(\sqrt{I_1}-\sqrt{I_2})^2=(\sqrt{I}-\sqrt{4I})^2=I$

9. (c)

10. (b) The idea of secondary wavelets is given by Huygen.

11. (c) Monochromatic wave means of single wavelength not the single colour.

12. (d) Sound wave and light waves both shows interference.

13. (c) $\frac{I_{max}}{I_{min}}=\left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2=\left(\frac{\sqrt{\frac{9}{1}}+1}{\sqrt{\frac{9}{1}}-1}\right)=\frac{4}{1}$

14. (a) A wave can transmit energy from one place to another.

15. (d) $\frac{I_1}{I_2}=\frac{1}{25}$; $\therefore \frac{a_1^2}{a_2^2}=\frac{1}{25}\Rightarrow\frac{a_1}{a_2}=\frac{1}{5}$

16. (a) For interference phase difference must be constant.

17. (c) Interference is explained by wave nature of light.

18. (b) Coherent time $=\frac{\text{Coherence length}}{\text{Velocity of light}}=\frac{L}{c}$

19. (c) $\frac{a_1}{a_2}=\frac{3}{5}$

$\therefore\frac{I_{max}}{I_{min}}=\frac{(a_1+a_2)^2}{(a_1-a_2)^2}=\frac{(3+5)^2}{(3-5)^2}=\frac{16}{1}$

20. (b) Colour's of thin film are due to interference of light.

21. (c) For constructive interference path difference is even multiple of $\frac{\lambda}{2}$.

22. (c) Two coherent source must have a constant phase difference otherwise they can not produce interference.

23. (a) Phenomenon of interference of light takes place.

24. (c) Transverse waves can be polarised.

25. (a) $\frac{I_{max}}{I_{min}}=\left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2=\left(\frac{\sqrt{\frac{4}{1}}+1}{\sqrt{\frac{4}{1}}-1}\right)^2=\frac{9}{1}$

26. (a) Reflection phenomenon is shown by both particle and wave nature of light.

27. (b) When two sources are obtained from a single source, the wavefront is divided into two parts. These two wavefronts acts as if they emanated from two sources having a fixed phase relationship.

28. (b) $\lambda=\frac{c}{\nu}=\frac{3\times10^8}{100}=3\times10^6 m$

29. (c) $\frac{I_{max}}{I_{min}}=\left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2=\left(\frac{\sqrt{\frac{25}{4}}+1}{\sqrt{\frac{25}{4}}-1}\right)^2=\frac{49}{9}$

30. (a) Wavefront is the locus of all the particles which vibrates in the same phase.

31. (b) Direction of wave is perpendicular to the wavefront.

32. (d) Origin of spectra is not explained by Huygen's theory.

33. (d) The refractive index of air is slightly more than 1. When chamber is evacuated, refractive index decreases and hence the wavelength increases and fringe width also increases.

34. (a) $I\propto a^2\Rightarrow\frac{a_1}{a_2}=\left(\frac{4}{1}\right)^{1/2}=\frac{2}{1}$

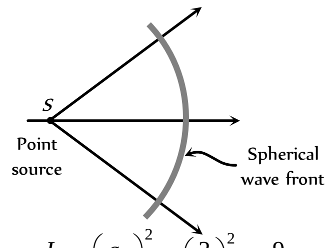
35. (a) The essential condition for sustained interference is constancy of phase difference.

36. (c) $\frac{I_{max}}{I_{min}}=\left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2=\left(\frac{\frac{4}{3}+1}{\frac{4}{3}-1}\right)^2=\frac{49}{1}$

37. (b) Energy is conserved in the interference of light.

38. (c) $I\propto a^2$

39. (b)



40. (c) $I\propto a^2\Rightarrow\frac{I_1}{I_2}=\left(\frac{a_1}{a_2}\right)^2=\left(\frac{3}{4}\right)^2=\frac{9}{16}$

41. (d) $\frac{I_1}{I_2}=\frac{100}{1}$

Now $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{\sqrt{100}+1}{\sqrt{100}-1}\right)^2 = \frac{121}{81} \approx \frac{3}{2}$

42. (b) $\phi = \pi/3, a_1 = 4, a_2 = 3$

So, $A = \sqrt{a_1^2 + a_2^2 + 2a_1.a_2 \cos\phi} \Rightarrow A \approx 6$

43. (b) $y_1 = a\sin\omega t$, and $y_2 = b\cos\omega t = b\sin\left(\omega t + \frac{\pi}{2}\right)$

So phase difference $\phi = \pi/2$

44. (c) For 2π phase difference $\rightarrow$ Path difference is λ

$\therefore$ For ϕ phase difference $\rightarrow$ Path difference is $\frac{\lambda}{2\pi} \times \phi$

45. (d) Resultant intensity $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

For maximum I_R, $\phi = 0^o$

$\Rightarrow I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

46. (c) Newton first law of motion states that every particle travels in a straight line with a constant velocity unless disturbed by an external force. So the corpuscles travels in straight lines.

47. (d) Diffraction shows the wave nature of light and photoelectric effect shows particle nature of light.

48. (b) At point *A*, resultant intensity

$I_A = I_1 + I_2 = 5I$; and at point *B*

$I_B = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\pi = 5I + 4I$

$I_B = 9I$ so $I_B - I_A = 4I$.

49. (c)

50. (a) Photoelectric effect varifies particle nature of light. Reflection and refraction varifies both particle nature and wave nature of light.

51. (d) $y_1 = a\sin\omega t, y_2 = a\cos\omega t = a\sin\left(\omega t + \frac{\pi}{2}\right)$

52. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \frac{25}{1}$

53. (d) Laser beams are perfectly parallel. So that they are very narrow and can travel a long distance without spreading. This is the feature of laser while they are monochromatic and coherent these are characteristics only.

54. (c) $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 \Rightarrow \frac{I_1}{I_2} = \frac{9}{4}$

55. (b) $\nu = \frac{c}{\lambda} = \frac{3\times 10^8}{3000\times 10^{-10}} = 10^{15}$ *cycles/sec*

56. (a) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \left(\frac{\frac{1}{9}+1}{\frac{1}{9}-1}\right)^2 = \left(\frac{5}{4}\right)^2 = \frac{25}{16}$.

57. (c)

58. (d) For destructive interference path difference is odd multiple of $\frac{\lambda}{2}$.

59. (d) $\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 \Rightarrow \frac{a_1+a_2}{a_1-a_2} = 6$

$\frac{a_2}{a_1} = 7:5$

60. (b) $I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2}$

So, $I_{max} = I + 4I + 2\sqrt{I.4I} = 9I$

61. (b) In interference energy is redistribution.

62. (a) For interference frequency must be same and phase difference must be constant.

63. (c) When a beam of light is used to determine the position of an object, the maximum accuracy is achieved if the light is of shorter wavelength, because

$\text{Accuracy} \propto \frac{1}{\text{Wavelength}}$

64. (d) Intensity $\propto \frac{1}{(\text{Distance})^2}$

65. (d) Huygen's theory explains propagation of wavefront.

66. (c) Wave theory of light is given by Huygen.

67. (a) When light reflect from denser surface phase change of π occurs.

68. (a) Photoelectric effect explain the quantum nature of light while interference, diffraction and polarization explain the wave nature of light.

69. (a) Light is electromagnetic in nature it does not require any material medium for its propagation.

70. (c) For viewing interference in oil films or soap bubble, thickness of film is of the order of wavelength of light.

71. (b)

72. (d) For maximum intensity $\phi = 0°$

$\therefore I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi = I + I + 2\sqrt{I I}\cos 0° = 4I$

Young's Double Slit Experiment

1. (a)

2. (c) In interference of light the energy is transferred from the region of destructive interference to the region of constructive interference. The average energy being always equal to the sum of the energies of the interfering waves. Thus the phenomenon of interference is in complete agreement with the law of conservation of energy.

3. (c) $\beta = \frac{\lambda D}{d} = \frac{5\times 10^{-7}\times 2}{10^{-3}} m = 10^{-3} m = 1.0\ mm$.

4. (c) Slit width ratio = 1 : 9

Since slit width ratio is the ratio of intensity and intensity ∝ (amplitude)

$\therefore I_1 : I_2 = 1 : 9$

$\Rightarrow a_1^2 : a_2^2 = 1 : 9 \Rightarrow a_1 : a_2 = 1 : 3$

$I_{\max} = (a_1 + a_2)^2,\ I_{\min} = (a_1 - a_2)^2 \Rightarrow \frac{I_{\min}}{I_{\max}} = \frac{1}{4}$

5. (a) $\beta \propto \frac{1}{d} \Rightarrow$ If d becomes thrice, then β become becomes $\frac{1}{3}$ times.

6. (c) $\frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$ or $\frac{1.0}{\beta_2} = \frac{5000}{6000}$ or $\beta_2 = \frac{6000}{5000} = 1.2\ mm$.

7. (a) $\beta = \frac{6000\times 10^{-10}\times 25\times 10^{-2}}{10^{-3}}$

$= 150000\times 10^{-9} = 0.15\times 10^{-3} m = 0.015\ cm$.

8. (c) For brightness, path difference $= n\lambda = 2\lambda$

So second is bright.

9. (a) If one of slit is closed then interference fringes are not formed on the screen but a fringe pattern is observed due to diffraction from slit.

10. (d)

11. (d) $\beta = \frac{\lambda D}{d} \Rightarrow$ If D becomes twice and d becomes half so β becomes four times.

12. (c) Suppose slit width's are equal, so they produces waves of equal intensity say I'. Resultant intensity at any point $I_R = 4 I' \cos^2 \phi$ where ϕ is the phase difference between the waves at the point of observation.

For maximum intensity $\phi = 0^o \Rightarrow I_{\max} = 4I' = I$ ...(i)

If one of slit is closed, Resultant intensity at the same point will be I' only *i.e.* $I' = I_O$ ...(ii)

Comparing equation (i) and (ii) we get

$I = 4 I_O$

13. (b, d) $\frac{I_{\max}}{I_{\min}} = 9 \Rightarrow \left(\frac{a_1 + a_2}{a_1 - a_2}\right)^2 = 9 \Rightarrow \frac{a_1 + a_2}{a_1 - a_2} = 3$

$\Rightarrow \frac{a_1}{a_2} = \frac{3+1}{3-1} \Rightarrow \frac{a_1}{a_2} = 2$. Therefore $I_1 : I_2 = 4 : 1$

14. (b)

15. (c) Distance of n bright fringe $y_n = \frac{n\lambda D}{d}$ *i.e.* $y_n \propto \lambda$

$\therefore \frac{x_{n_1}}{x_{n_2}} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{x(\text{Blue})}{x(\text{Green})} = \frac{4360}{5460}$

$\therefore$ *x* (Green) > *x* (Blue).

16. (c) $\beta = \frac{\lambda D}{d} = \frac{5000\times 10^{-10}\times 1}{0.1\times 10^{-3}} m = 5\times 10^{-3} m = 0.5\ cm$.

17. (a) We know that fringe width $\beta = \frac{D\lambda}{d}$

$\therefore x = \frac{L\lambda}{d} \Rightarrow \lambda = \frac{xd}{L}$

18. (a) In the normal adjustment of young's, double slit experiment, path difference between the waves at central location is always zero, so maxima is obtained at central position.

19. (a) $\beta = \frac{\lambda D}{d};\ \therefore B \propto \lambda$

$\frac{\lambda'}{\lambda} = \frac{0.4}{4/3} \Rightarrow \lambda' = 0.3\ mm$.

20. (b) $\beta \propto \lambda,\ \therefore \lambda \propto \frac{1}{\mu}$

21. (a) $\beta \propto \lambda,\ \therefore \lambda_v =$ minimum.

22. (c) $\beta_{\text{medium}} = \frac{\beta_{\text{air}}}{\mu} = \frac{0.6}{1.5} = 0.4\ mm$.

23. (d) $\because n = 3,\ \therefore 2n\pi = 2\times 3\pi = 6\pi$

24. (c) Slit width ratio $= 4 : 9$; hence $I_1 : I_2 = 4 : 9$

$\therefore \frac{a_1^2}{a_2^2} = \frac{4}{9} \Rightarrow \frac{a_1}{a_2} = \frac{2}{3}$

$\therefore \frac{I_{\max}}{I_{\min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{1}$

25. (d) $\beta = \frac{\lambda D}{d} \Rightarrow d = \frac{\lambda D}{\beta} = \frac{6000\times 10^{-10}\times (40\times 10^{-2})}{0.012\times 10^{-2}} = 0.2\ cm.$

26. (a) As $\beta = \frac{D\lambda}{d} \Rightarrow \frac{\beta_1}{\beta_2} = \left(\frac{D_1}{D_2}\right)\left(\frac{\lambda_1}{\lambda_2}\right)\left(\frac{d_2}{d_1}\right)$

$\Rightarrow 1 = \left(\frac{D_1}{D_2}\right)\times\left(\frac{1}{2}\right)\times\left(\frac{1}{2}\right) \Rightarrow \frac{D_1}{D_2} = \frac{4}{1}$

27. (b)

28. (c) Fringe width $(\beta) = \frac{D\lambda}{d} \Rightarrow \beta \propto \lambda$

As $\lambda_{\text{red}} > \lambda_{\text{yellow}}$, hence fringe width will increase.

29. (d) $\beta = \frac{\lambda D}{d} \Rightarrow \frac{\beta_2}{\beta_1} = \frac{\lambda_2 D_2 d_1}{\lambda_1 D_1 d_2} \Rightarrow \beta_2 = 2.5\times 10^{-4} m$.

30. (d) For interference, λ of both the waves must be same.

31. (d) $\beta \propto D$

32. (a) $\theta = \frac{\lambda}{d}$; θ can be increased by increasing λ, so here λ has to be increased by 10%

i.e., % Increase $= \frac{10}{100}\times 5890 = 589 Å$

33. (b) $d = \frac{D\lambda}{\beta} = \frac{1\times 5\times 10^{-7}}{5\times 10^{-3}} = 10^{-4} m = 0.1\ mm$.

34. (b) If intensity of each wave is *I*, then initially at central position $I_o = 4I$. when one of the slit is covered then intensity at central position will be *I* only *i.e.*, $\frac{I_o}{4}$.

35. (a) Shift $= \frac{\beta}{\lambda}(\mu - 1)\,t = \frac{\beta}{(5000\times 10^{-10})}(1.5)\times 2\times 10^{-6} = 2\beta$

i.e., 2 fringes upwards.

36. (b) $\beta = \frac{\lambda D}{d}$

37. (b) Separation n^{th} bright fringe and central maxima is $x_n = \frac{n\lambda D}{d}$

So, $x_3 = \frac{3\times 6000\times 10^{-10}\times 1}{0.5\times 10^{-3}} = 3.5\,mm.$

38. (d) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow 62\times 5893 = n_2\times 4358 \Rightarrow n_2 = 84.$

39. (b) Angular fringe width $\theta = \frac{\lambda}{d} \Rightarrow \theta \propto \lambda$

$\lambda_w = \frac{\lambda_a}{\mu_w}$

So $\theta_w = \frac{\theta_{\text{air}}}{\mu_w} = \frac{0.20}{\frac{4}{3}} = 0.15°$

40. (a) By using $x_n = \frac{n\lambda D}{d}$

$\Rightarrow (5\times 10^{-3}) = \frac{10\times\lambda\times 1}{(1\times 10^{-3})} \Rightarrow \lambda = 5\times 10^{-7}m = 5000\,Å$

41. (b) Distance of third maxima from central maxima is $x = \frac{3\lambda D}{d} = \frac{3\times 5000\times 10^{-10}\times(200\times 10^{-2})}{0.2\times 10^{-3}} = 1.5\,cm.$

42. (d) Distance of n^{th} dark fringe from central fringe

$x_n = \frac{(2n-1)\lambda D}{2d}$

$\therefore x_2 = \frac{(2\times 2-1)\lambda D}{2d} = \frac{3\lambda D}{2d}$

$\Rightarrow 1\times 10^{-3} = \frac{3\times\lambda\times 1}{2\times 0.9\times 10^{-3}} \Rightarrow \lambda = 6\times 10^{-5}\,cm$

43. (d) $\beta = \frac{\lambda D}{d} \Rightarrow (4\times 10^{-3}) = \frac{4\times 10^{-7}\times D}{0.1\times 10^{-3}} \Rightarrow D = 1\,m$

44. (a) $\beta = \frac{\lambda D}{d} \Rightarrow (0.06\times 10^{-2}) = \frac{\lambda\times 1}{1\times 10^{-3}} \Rightarrow \lambda = 6000\,Å$

45. (b)

46. (d) $(n_1\lambda_1 = n_2\lambda_2)\ \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} \Rightarrow \frac{n_1}{92} = \frac{5898}{5461} \Rightarrow n_1 = 99$

47. (d) If we use torch light in place of monochromatic light then overlapping of fringe pattern take place. Hence no fringe will appear.

48. (b)

49. (b) Position of 3rd bright fringe $x_3 = \frac{3D\lambda}{d}$

$\Rightarrow \lambda = \frac{x_3 d}{3D} = \frac{(0.9\times 10^{-2})\times(0.28\times 10^{-3})}{3\times 1.4} = 6000Å$

50. (a) Distance between two consecutive

Dark fringes $= \frac{\lambda D}{d} = \frac{6000\times 10^{-10}\times 1}{0.6\times 10^{-3}}$

$= 1\times 10^{-3}m = 1\,mm.$

51. (b, c) For maxima, path difference $\Delta = n\lambda$

So for $n = 1$, $\Delta = \lambda = 6320Å$

52. (b) Shift in the fringe pattern $x = \frac{(\mu-1)t.D}{d}$

$= \frac{(1.5-1)\times 2.5\times 10^{-5}\times 100\times 10^{-2}}{0.5\times 10^{-3}} = 2.5\,cm.$

53. (d) In the presence of thin glass plate, the fringe pattern shifts, but no change in fringe width.

54. (a) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$

55. (a) In interference between waves of equal amplitudes *a*, the minimum intensity is zero and the maximum intensity is proportional to $4a$. For waves of unequal amplitudes *a* and *A*(*A* > *a*), the minimum intensity is non zero and the maximum intensity is proportional to $(a + A)^2$, which is greater than $4a$.

56. (b) $\beta = \frac{\lambda D}{d} = \frac{6000\times 10^{-10}\times 2}{4\times 10^{-3}} = 3\times 10^4 m = 0.3\,mm$

57. (c) $\beta \propto \lambda$

58. (c) $\beta = \frac{\lambda D}{d}$

59. (c) Distance between consecutive bright fringes or dark fringes $= \beta$

$\beta = \frac{\lambda D}{d} = \frac{550\times 10^{-9}\times 1}{1.1\times 10^{-3}} = 500\times 60^{-6} = 0.5\,mm$

60. (b) $\frac{I_{\max}}{I_{\min}} = \frac{\left(\frac{a_1}{a_2}+1\right)^2}{\left(\frac{a_1}{a_2}-1\right)^2} = \frac{4}{1} \Rightarrow \frac{a_1}{a_2} = \frac{3}{1}$

61. (b) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda$

62. (c)

63. (b) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow n_2 = n_1\times\frac{\lambda_1}{\lambda_2} = 12\times\frac{600}{400} = 18$

64. (d) Using relation, $d\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{d}$

For $n = 3$, $\sin\theta = \frac{3\lambda}{d} = \frac{3\times 589\times 10^{-9}}{0.589}$

$= 3\times 10^{-6}$ or $\theta = \sin^{-1}(3\times 10^{-6})$

65. (b) $\beta \propto \frac{1}{d}$

66. (a) When white light is used, central fringe will be white with red edges, and on either side of it, we shall get few coloured bands and then uniform illumination.

67. (c) $\beta \propto \frac{\lambda}{d}$

68. (b) $\beta \propto \lambda$

69. (a) $\frac{I_{\max}}{I_{\min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}}+1}{\sqrt{\frac{I_1}{I_2}}-1}\right)^2 = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 \approx 34;$ (given $I_1 = 2I_2$)

70. (b) $B \propto \lambda$

71. (d) $\beta \propto \frac{\lambda}{d}$

72. (b)

73. (b) For dark fringe at P

$S_1P - S_2P = \Delta = (2n-1)\lambda/2$

Here n =3 and λ = 6000

So, $\Delta = \frac{5\lambda}{2} = 5 \times \frac{6000}{2} = 15000 Å = 1.5\ micron$

74. (b) Distance of n minima from central bright fringe

$x_n = \frac{(2n-1)\lambda D}{2d}$

For n=3 *i.e.* 3rd minima

$x_3 = \frac{(2\times 3-1)\times 500\times 10^{-9}\times 1}{2\times 1\times 10^{-3}}$

$= \frac{5\times 500\times 10^{-6}}{2} = 1.25\times 10^{-3} m = 1.25\ mm.$

75. (c) $\beta = \frac{\lambda D}{d}$ and $\lambda \propto \frac{1}{\mu}$

76. (d) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow 3\times 700 = 5\times \lambda_2 \Rightarrow \lambda_2 = 420\ nm$

77. (a) $\beta \propto \frac{\lambda}{d}$ as $d \to \frac{d}{3}$ so $\beta \to 3\beta \therefore n = 3$

78. (c) If shift is equal to n fringes width, then

$n = \frac{(\mu-1)t}{\lambda} = \frac{(1.5-1)\times 2\times 10^{-6}}{500\times 10^{-9}} = \frac{1}{500}\times 10^3 = 2$

Since a thin film is introduced in upper beam. So shift will be upward.

79. (b) Distance between n^{th} Bright fringe and m^{th} dark fringe $(n > m)$

$\Delta x = \left(n - m + \frac{1}{2}\right)\beta = \left(5 - 3 + \frac{1}{2}\right)\times \frac{6.5\times 10^{-7}\times 1}{1\times 10^{-3}}$

= $1.63\ mm$

80. (a) $\beta = \frac{\lambda D}{d}$; If λ and d both increase by 10%, there will be no change in fringe width (β).

81. (b) $\frac{I_1}{I_2} = \frac{1}{4} \Rightarrow I_1 = k$ and $I_2 = 4k$

$\therefore$ Fringe visibility $V = \frac{2\sqrt{I_1 I_2}}{(I_1 + I_2)} = \frac{2\sqrt{k\times 4k}}{(k+4k)} = 0.8$

82. (b) $\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)^2 = \left(\frac{3a+a}{3a-a}\right)^2 = \frac{4}{1}$

83. (d) Angular position of first dark fringe

$\theta = \frac{\lambda}{d} = \frac{5460\times 10^{-10}}{0.1\times 10^{-3}}\times \frac{180}{\pi}$ (in degree)

= 0.313°

84. (a) Distance between two consecutive dark fringes $\beta = \frac{\lambda D}{d}$

$= \frac{5000\times 10^{-10}\times 1}{0.2\times 10^{-2}} = 0.25\ mm.$

85. (a) If thin film appears dark

$2\mu t \cos r = n\lambda$ for normal incidence $r = 0^o$

$\Rightarrow 2\ \mu\, t = n\lambda \Rightarrow t = \frac{n\lambda}{2\mu}$

$\Rightarrow t_{min} = \frac{\lambda}{2\mu} = \frac{5890\times 10^{-10}}{2\times 1} = 2.945\times 10^{-7} m$.

86. (b) In case of destructive interference (minima) phase difference is odd multiple of π .

87. (b) $\beta = \frac{(a+b)\lambda}{2a(\mu-1)\alpha}$

where a = distance between source and biprism = 0.3 m

b = distance between biprism and screen = 0.7 m.

α = Angle of prism = 1°, μ = 1.5, λ = 6000 × 10–10 m

Hence, $\beta = \frac{(0.3+0.7)\times 6\times 10^{-7}}{2\times 0.3(1.5-1)\times(1^o\times \frac{\pi}{180})}$

= 1.14 × 10–4 m = 0.0114 cm.

88. (d) For minima, path difference $\Delta = (2n-1)\frac{\lambda}{2}$

For third minima $n = 3 \Rightarrow \Delta = (2\times 3-1)\frac{\lambda}{2} = \frac{5\lambda}{2}$

89. (b) Fringe width $(\beta) \propto \frac{1}{\text{prism Angle}(\alpha)}$

90. (a) By using $\beta = \frac{(a+b)\lambda}{2a(\mu-1)\alpha} = \frac{(0.3+0.7)\times 180\pi\times 10^{-9}}{2\times 0.3(1.54-1)\times\left(1\times\frac{\pi}{180}\right)}$

= $10^{-4} m$

91. (a) $\because\ \beta \propto \lambda \Rightarrow \lambda_w < \lambda_a$ so $\beta_w < \beta_a$

92. (c) With white light, the rays reaching the centre has zero path difference. So we get white fringe at the centre and coloured near the central fringe.

93. (a) $\beta_{water} = \frac{\beta_{air}}{\mu_w}$

94. (a) $\beta = \frac{\lambda D}{d}$

95. (b) Lateral displacement of fringes = $\frac{\beta}{\lambda}(\mu-1)t$

$= \frac{1\times 10^{-3}}{600\times 10^{-9}}(1.5-1)\times 0.06\times 10^{-3} = \frac{1}{20} m = 5\ cm.$

96. (b)

97. (d) Distance of the n bright fringe from the centre $x_n = \frac{n\lambda D}{d}$

$\Rightarrow x_3 = \frac{3\times 6000\times 10^{-10}\times 2.5}{0.5\times 10^{-3}} = 9\times 10^{-3} m = 9\ mm.$

Doppler's Effect of Light

1. (d) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$, Now $\Delta\lambda = \frac{0.5}{100}\lambda \Rightarrow \frac{\Delta\lambda}{\lambda} = \frac{0.5}{100}$

$\therefore v = \frac{0.5}{100}\times c = \frac{0.5}{100}\times 3\times 10^8 = 1.5\times 10^6 m/s$

Increase in λ indicates that the star is receding.

2. (a) Doppler's shift is given by

$$\Delta\lambda = \frac{v\lambda}{c} = \frac{5000\times 6000}{3\times 10^8} = 0.1\mathring{A}$$

3. (b) Shifting towards ultraviolet region shows that Apparent wavelength decreased. Therefore the source is moving towards the earth.

4. (b) Due to expansion of universe, the star will go away from the earth thereby increasing the observed wavelength. Therefore the spectrum will shift to the infrared region.

5. (b) With reference to this theory the velocity of the observer is neglected *w.r.t.* the light velocity.

6. (b) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} = \frac{6\times 10^7}{3\times 10^8} = 0.2$

$$\Delta\lambda = \lambda' - \lambda = 0.2\lambda \Rightarrow \lambda' = 1.2\lambda = 1.2\times 4600 = 5520\mathring{A}$$

7. (b) $\Delta\lambda = 5200 - 5000 = 200\mathring{A}$

Now $\frac{\Delta\lambda}{\lambda'} = \frac{v}{c} \Rightarrow v = \frac{c\Delta\lambda}{\lambda'} = \frac{3\times 10^8\times 200}{5000}$

$$= 1.2\times 10^7\, m/\sec \approx 1.15\times 10^7\, m/\sec$$

8. (d) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = \frac{c}{\lambda}\Delta\lambda = \frac{c}{\lambda}(\lambda' - \lambda) = c\times\frac{0.01}{100}$

$$= 3\times 10^4\, m/s = 30\ km/\sec$$

9. (c) Blue radiations have the wavelength around 4600 $\overset{o}{A}$. It shows that apparent wavelength is smaller than the real wavelength. It means that the star is proceeding towards earth.

10. (c)

11. (a)

12. (c)

13. (b) $\Delta\lambda = \lambda\frac{v}{c} = 5700\times\frac{100\times 10^3}{3\times 10^8} = 1.90\mathring{A}$

14. (a) According to Doppler's effect, wherever there is a relative motion between source and observer, the frequency observed is different from that given out by source.

15. (a) $\Delta\lambda = \lambda.\frac{v}{c} = \frac{1.5\times 10^6}{3\times 10^8}\times 5000 = 25\mathring{A}$

16. (d) $\Delta\lambda = \frac{v}{c}\lambda = \frac{3600\times 10^3}{3\times 10^8}\times 5896 = 70.75\mathring{A}$

So the increased wavelength of light is observed.

17. (b) Observed frequency $\nu' = \nu\left(1 - \frac{v}{c}\right)$

$$\Rightarrow \nu' = 6\times 10^{14}\left(1 - \frac{0.8\,c}{c}\right) = 1.2\times 10^{14}\,Hz$$

18. (c) According to Doppler's principle $\lambda' = \lambda\sqrt{\frac{1 - v/c}{1 + v/c}}$ for $v = c$

$$\lambda' = 5500\sqrt{\frac{(1-0.8)}{1+0.8}} = 1833.3$$

$\therefore$ Shift = 5500 – 1833.3 = 3167 Å

19. (b) $\Delta\lambda = \lambda\frac{v}{c}$

$$\Rightarrow (3737 - 3700) = 3700\times\frac{v}{3\times 10^8} \Rightarrow v = 3\times 10^6\, m/s$$

20. (d) $\Delta\lambda = \frac{v_s}{c}\lambda \Rightarrow v_s = \frac{\Delta\lambda . c}{\lambda} = \frac{47\times 3\times 10^8}{4700}$

$= 3\times 10^6\, m/s$ away from earth

21. (b) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \frac{0.05}{100} = \frac{v}{3\times 10^8} \Rightarrow v = 1.5\times 10^5\ m/s$

(Since wavelength is decreasing, so star coming closer)

22. (b)

23. (c) $\lambda' = \lambda\left(1 - \frac{v}{c}\right) = 5890\left(1 - \frac{4.5\times 10^6}{3\times 10^8}\right) \approx 5802$Å

24. (c) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \therefore v = \frac{\Delta\lambda}{\lambda}c = \frac{0.1}{6000}\times 3\times 10^5\, km/s = 5\ km/s$

25. (b) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \Delta\lambda = \frac{5700\times 10^6}{3\times 10^3} = 19\mathring{A}$

26. (b) $\nu' = \nu\left(1 - \frac{v}{c}\right) = 4\times 10^7\left(1 - \frac{0.2c}{c}\right) = 3.2\times 10^7\,Hz$

27. (c) When the source and observer approach each other, apparent frequency increases and hence wavelength decreases.

28. (b)

29. (a) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow 1 = \frac{v}{c} \Rightarrow v = c$

30. (d) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = \frac{\Delta\lambda}{\lambda}.c = \frac{5}{6563}\times(3\times 10^8) = 2.29\times 10^5$ *m/sec*

31. (c)

32. (a) Using $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = \frac{\Delta\lambda}{\lambda}c$

$\Rightarrow v = 0.004\times 3\times 10^8 = 1.2\times 10^6$ *m/sec*

33. (a)

Diffraction of Light

1. (c) For first minima $\theta = \frac{\lambda}{a}$ or $a = \frac{\lambda}{\theta}$

$\therefore a = \frac{6500\times 10^{-8}\times 6}{\pi}$ (As $30^\circ = \frac{\pi}{6}$ radian)

$= 1.24\times 10^{-4}\,cm = 1.24$ microns

2. (a) The angular half width of the central maxima is given by

$\sin\theta = \frac{\lambda}{a} \Rightarrow \theta = \frac{6328\times 10^{-10}}{0.2\times 10^{-3}}$ *rad*

$= \frac{6328\times 10^{-10}\times 80}{0.2\times 10^{-3}\times\pi}$ *degree* = 0.18°

Total width of central maxima $= 2\theta = 0.36^o$

3. (b)

4. (c) It is caused due to turning of light around corners.

5. (c) Width of central maxima $= \frac{2\lambda D}{d}$

$$= \frac{2\times 2.1\times 5\times 10^{-7}}{0.15\times 10^{-2}} = 1.4\times 10^{-3}\,m = 1.4\ mm$$

6. (a) Band width $\propto \lambda$,

$\because \lambda_{Blue} < \lambda_{Red}$, hence for blue light the diffraction bands becomes narrower and crowded together.

7. (a) Using $d\sin\theta = n\lambda$, for n =1

$$\sin\theta = \frac{\lambda}{d} = \frac{550\times10^{-9}}{0.55\times10^{-3}} = 10^{-3} = 0.001\,rad$$

8. (a) For single slit diffraction pattern $d\sin\theta = \lambda$ (d = slit width)

Angular width = $2\theta = 2\sin^{-1}\left(\frac{\lambda}{d}\right)$

It is independent of D *i.e.* distance between screen and slit

9. (c) Width of central bright fringe.

$$= \frac{2\lambda D}{d} = \frac{2\times500\times10^{-9}\times80\times10^{-2}}{0.20\times10^{-3}} = 4\times10^{-3}m = 4mm.$$

10. (b) Diffraction is obtained when the slit width is of the order of wavelength of EM waves (or light). Here wavelength of X-rays (1-100 Å) is very-very lesser than slit width (0.6 *mm*). Therefore no diffraction pattern will be observed.

11. (a) Multiple focii of zone plate given by $f_p = \frac{r_n^2}{(2p-1)\lambda}$, where $p = 1, 2, 3......$

12. (b) $A = n\pi d\lambda \;\; \Rightarrow nd = \frac{A}{\pi\lambda}$ = constant $\Rightarrow n \propto \frac{1}{d}$ (n = number of blocked HPZ) on decreasing d, n increases, hence intensity decreases.

13. (a) For secondary maxima $d\sin\theta = \frac{5\lambda}{2}$

$$\Rightarrow d\theta = d.\frac{x}{D(\approx f)} = \frac{5\lambda}{2}$$

$$\Rightarrow 2x = \frac{5\lambda f}{d} = \frac{5\times0.8\times10^{-7}}{4\times10^{-4}} = 6\times10^{-3}m = 6mm$$

14. (d) By using $f_p = \frac{r^2}{(2p-1)\lambda}$

For first HPZ $r = \sqrt{f_p\lambda} = \sqrt{0.6\times6000\times10^{-10}}$

$= 6\times10^{-4}m.$

15. (a) $f_1 = \frac{r^2}{\lambda} = \frac{(2.3\times10^{-3})^2}{5893\times10^{-10}} = 9\,m.$

16. (b) $\lambda_{Blue} < \lambda_{Red}$. Therefore fringe pattern will contract because fringe width $\propto \lambda$

17. (a)

18. (a) For diffraction size of the obstacle must be of the order of wavelength of wave *i.e.* $a \approx \lambda$

19. (a) Angular width of central maxima

$$= \frac{2\lambda}{d} = \frac{2\times589.3\times10^{-9}}{0.1\times10^{-3}}rad = 0.0117\times\frac{180}{\pi} = 0.68°$$

20. (d)

21. (a) $r_n = \sqrt{nd\lambda} \Rightarrow r_n \propto \sqrt{n}$

22. (a) $\beta = \frac{\lambda.D}{d}$ w here D = distance of screen from wire, d = diameter of wire

23. (c) Angular width $= \frac{2\lambda}{d} = \frac{2\times6000\times10^{-10}}{12\times10^{-5}\times10^{-2}} = 1\,rad.$

24. (b)

25. (d)

26. (a) $2\theta = \frac{2\lambda}{d}$ (where d = slit width)

As d decreases, θ increases.

27. (d)

28. (d) Distance between the first dark fringes on either side of central maxima = width of central maxima = $\frac{2\lambda D}{d}$ = $\frac{2\times600\times10^{-9}\times2}{1\times10^{-3}}$ = 2.4 *mm*.

29. (b) Thickness of the film must be of the order of wavelength of light falling on film (*i.e.* visible light)

30. (d)

31. (d) For n secondary maxima path difference

$$d\sin\theta = (2n+1)\frac{\lambda}{2} \;\Rightarrow a\sin\theta = \frac{3\lambda}{2}$$

32. (d) The phase difference (ϕ) between the wavelets from the top edge and the bottom edge of the slit is $\phi = \frac{2\pi}{\lambda}(d\sin\theta)$ where d is the slit width. The first minima of the diffraction pattern occurs at $\sin\theta = \frac{\lambda}{d}$ so $\phi = \frac{2\pi}{\lambda}\left(d\times\frac{\lambda}{d}\right) = 2\pi$

33. (b)

34. (a) For second dark fringe $d\sin\theta = 2\lambda$

$$\Rightarrow 24\times10^{-5}\times10^{-2}\times\sin30 = 2\lambda$$

$$\Rightarrow \lambda = 6\times10^{-7}m = 6000\,Å$$

35. (c) For the first minima $d\sin\theta = \lambda$

$$\Rightarrow \sin\theta = \frac{\lambda}{d} \;\Rightarrow \theta = \sin^{-1}\left(\frac{5000\times10^{-10}}{0.001\times10^{-3}}\right) = 30^o$$

36. (c)

37. (a)

38. (c) Position of first minima = position of third maxima *i.e.*, $\frac{1\times\lambda_1 D}{d} = \frac{(2\times3+1)}{2}\frac{\lambda_2 D}{d} \Rightarrow \lambda_1 = 3.5\lambda_2$

39. (a) Position of n^th^ minima $x_n = \frac{n\lambda D}{d}$

$$\Rightarrow 5\times10^{-3} = \frac{1\times5000\times10^{-10}\times1}{d}$$

$$\Rightarrow d = 10^{-4}\;m = 0.1\;mm.$$

40. (b) Width of n HPZ $B_n = r_n - r_{n-1}$

$r_n = \sqrt{nb\lambda}$, $r_{n-1} = \sqrt{(n-1)b\lambda}$

$$B_n = \sqrt{nb\lambda} - \sqrt{(n-1)b\lambda} = \sqrt{b\lambda}\,[\sqrt{n} - \sqrt{(n-1)}]$$

41. (c) In single slit experiment,

Width of central maxima (y) = $2\lambda D/d$

$$\Rightarrow \frac{y'}{y} = \frac{\lambda'}{d'}\times\frac{d}{\lambda} = \frac{600}{d/2}\times\frac{d}{400} \;\Rightarrow\; y' = 3y.$$

Polarisation of Light

1. (b) Polariser produced prolarised light.

2. (a) Only transverse waves can be polarised.

3. (c) Polarisation is not shown by sound waves.

4. (d) By using $\mu = \tan\theta_p \Rightarrow \mu = \tan 60 = \sqrt{3}$,

also $C = \sin^{-1}\left(\frac{1}{\mu}\right) \Rightarrow C = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$

5. (d) $\mu = \tan\theta_p \Rightarrow \theta_p = \tan^{-1} n$

6. (d) Ultrasonic waves are longitudinal waves.

7. (b) $I = I_0\cos^2\theta = I_0\cos^2 45 = \frac{I_0}{2}$

8. (d)

9. (a) It magnitude of light vector varies periodically during it's rotation, the tip of vector traces an ellipse and light is said to be elliptically polarised. This is not in nicol prism.

10. (c) At polarizing angle, the reflected and refracted rays are mutually perpendicular to each other.

11. (a) When unpolarised light is made incident at polarising angle, the reflected light is plane polarised in a direction perpendicular to the plane of incidence.

Therefore $\vec{E}$ in reflected light will vibrate in vertical plane with respect to plane of incidence.

12. (d) In the arrangement shown, the unpolarised light is incident at polarising angle of 90° – 33° = 57°. The reflected light is thus plane polarised light. When plane polarised light is passed through Nicol prism (a polariser or analyser), the intensity gradually reduces to zero and finally increases.

13. (a)

14. (a) A plane which contains $\vec{E}$ and the propagation direction is called the plane of polarization.

15. (c)

16. (d) Light suffers double refraction through calcite.

17. (d) The amplitude will be $A\cos 60^o = A/2$

18. (d)

19. (b) Rotation produced $\theta = Slc$

Net rotation produced $\theta_r = \theta_1 - \theta_2 = l(S_1c_1 - S_2c_2)$

$= 0.29 \times [0.01 \times 60 - 0.02 \times 30] = 0$

20. (c) In double refraction light rays always splits into two rays (*O*-ray & *E*-ray). *O*-ray has same velocity in all direction but *E*-ray has different velocity in different direction.

For calcite $\mu_e < \mu_0 \Rightarrow v_e > v_0$

For quartz $\mu_e > \mu_0 \Rightarrow v_0 > v_e$

21. (c) $\theta_P + r = 90^\circ$ or $r = 90^\circ - \theta_p = 90^\circ - 53^\circ4' = 36^\circ56'$.

22. (d)

23. (a)

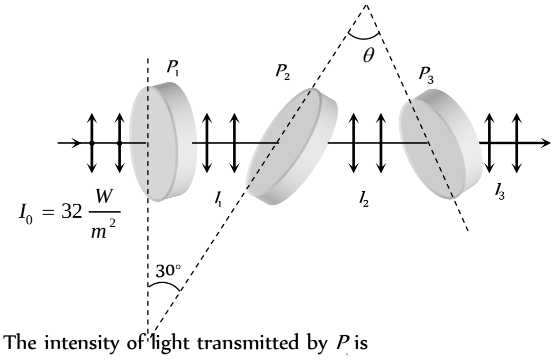
24. (c) Intensity of polarized light from first polarizer $= \frac{100}{2} = 50$

$I = 50\cos^2 60^\circ = \frac{50}{4} = 12.5$

25. (b) $I' = \frac{I}{2}\cos^2\theta = \frac{I}{6}$ or $\cos\theta = \frac{1}{\sqrt{3}}$ $\therefore \theta = 55^o$

26. (b) Angle between P_1 and P_2 = 30° (given)

Angle between P_2 and P_3 = θ = 90° – 30° = 60°



The intensity of light transmitted by P_1 is

$I_1 = \frac{I_0}{2} = \frac{32}{2} = 16\,\frac{W}{m^2}$

According to Malus law the intensity of light transmitted by P_2

is $I_2 = I_1\cos^2 30^\circ = 16\left(\frac{\sqrt{3}}{2}\right)^2 = 12\,\frac{W}{m^2}$

Similarly intensity of light transmitted by P_3 is

$I_3 = I_2\cos^2\theta = 12\cos^2 60^\circ = 12\left(\frac{1}{2}\right)^2 = 3\,\frac{W}{m^2}$

27. (b) $\theta = a + \frac{b}{\lambda^2}$

$30 = a + \frac{b}{(5000)^2}$ and $50 = a + \frac{b}{(4000)^2}$

Solving for a, we get $a = -\frac{50^\circ}{9}$ *per mm*

28. (c) If an unpolarised light is converted into plane polarised light by passing through a polaroid, it's intensity becomes half.

29. (a)

30. (b) The magnitude of electric field vector varies periodically with time because it is the form of electromagnetic wave.

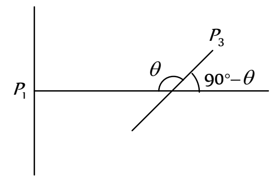
31. (a) According to Brewster's law, when a beam of ordinary light (i.e. unpolarised) is reflected from a transparent medium (like glass), the reflected light is completely plane polarised at certain angle of incidence called the angle of polarisation.

32. (a) When the plane-polarised light passes through certain substance, the plane of polarisation of the light is rotated about the direction of propagation of light through a certain angle.

33. (c) From Brewster's law $\mu = \tan i_p \Rightarrow \frac{c}{v} = \tan 60^\circ = \sqrt{3}$

$\Rightarrow v = \frac{c}{\sqrt{3}} = \frac{3\times 10^8}{\sqrt{3}} = \sqrt{3}\times 10^8$ *m/sec.*

34. (a) No light is emitted from the second polaroid, so P_1 and P_2 are perpendicular to each other



Let the initial intensity of light is I_0. So Intensity of light after transmission from first polaroid = $\frac{I_0}{2}$.

Intensity of light emitted from P_3 $I_1 = \frac{I_0}{2}\cos^2\theta$

Intensity of light transmitted from last polaroid *i.e.* from $P_2 = I_1\cos^2(90^o - \theta) = \frac{I_0}{2}\cos^2\theta.\sin^2\theta$

$= \frac{I_0}{8}(2\sin\theta\cos\theta)^2 = \frac{I_0}{8}\sin^2 2\theta$.

35. (d)

EM Waves

1. (a)

2. (d) $\lambda_{Red} > \lambda_{Blue} > \lambda_{X-ray} > \lambda_\gamma$

3. (b) Infrasonic waves are mechanical waves.

4. (d) $\mu_0 = 4\pi\times10^{-7}, \varepsilon_0 = 8.85\times10^{-12}\frac{N\text{-}m^2}{C^2}$

so $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = 3\times10^8\frac{meter}{sec}$.

5. (b) Wavelength of visible spectrum is 3900 Å – 7800 Å.

6. (b) Infrared causes heating effect.

7. (a)

8. (d)

9. (c) Speed of EM waves in vacuum = $\frac{1}{\sqrt{\mu_0\epsilon_0}}$ =constant

10. (a) $\lambda_{\gamma-rays} < \lambda_{x-rays} < \lambda_{\alpha-rays} < \lambda_{\beta-rays}$.

11. (a) Distance covered by T.V. signals = $\sqrt{2hR}$

$\Rightarrow$ maximum distance $\propto h$

12. (c) β-rays are beams of fast electrons.

13. (a)

14. (b) Velocity of EM waves = $\frac{1}{\sqrt{\mu_0\epsilon_0}}$ $3\times10^8 m/s$ =velocity of light

15. (b) Ozone layer absorbs most of the *UV* rays emitted by sun.

16. (d) $\nu_{\gamma-rays} > \nu_{\text{visible radiation}} > \nu_{\text{Infrared}} > \nu_{\text{Radio waves}}$

17. (b) Infrared radiations reflected by low lying clouds and keeps the earth warm.

18. (d) $\lambda_{Radiowaves} > \lambda_{UV\ rays} > \lambda_{J\ Rays} > \lambda_{X-rays}$

19. (a) Polarization is shown by only transverse waves.

20. (c) EM waves travels with perpendicular to *E* and *B*. Which are also perpendicular to each other $\vec{v} = \vec{E}\times\vec{B}$

21. (a)

22. (d) Ozone hole is depletion of ozone layer in stratosphere because of gases like CFC'S etc.

23. (c)

24. (b)

25. (a) $\nu_{\gamma-rays} > \nu_{X-rays} > \nu_{UV-rays}$

26. (a) In vacuum velocity of all EM waves are same but their wavelengths are different.

27. (c)

28. (c)

29. (a) $\lambda = \frac{c}{\nu} = \frac{3\times10^8}{8.2\times10^6} = 36.5\ m$

30. (b) $c = \frac{E}{B} \Rightarrow B = \frac{E}{c} = \frac{18}{3\times10^8} = 6\times10^{-8}T$.

31. (c) According to the Maxwell's EM theory, the EM waves propagation contains electric and magnetic field vibration in mutually perpendicular direction. Thus the changing of electric field give rise to magnetic field.

32. (a) Here $E_0 = 100\ V/m,\ B_0 = 0.265\ A/m$.

$\therefore$ Maximum rate of energy flow $S = E_0\times B_0$

$= 100\times.265 = 26.5\frac{W}{m^2}$

33. (d) $E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^8}{21\times10^{-2}} = 0.94\times10^{-24} \approx 10^{-24}J$

34. (a) $v = \frac{C}{\lambda} \Rightarrow v_1 = \frac{3\times10^8}{1} = 3\times10^8 Hz = 300\ MHz$

and $v_2 = \frac{3\times10^8}{10} = 3\times10^7 Hz = 30MHz$

35. (d)

36. (c) $\vec{E}$ and $\vec{B}$ are mutually perpendicular to each other and are in phase i.e. they become zero and minimum at the same place and at the same time.

37. (b) Molecular spectra due to vibrational motion lie in the microwave region of EM-spectrum. Due to Kirchhoff's law in spectroscopy the same will be absorbed.

38. (a) E_x and B_y would generate a plane EM wave travelling in *z*-direction. $\vec{E}$, $\vec{B}$ and $\vec{k}$ form a right handed system $\vec{k}$ is along z-axis. As $\hat{i}\times\hat{j} = \hat{k}$

$\Rightarrow E_x\hat{i}\times B_y\hat{j} = C\hat{k}$ *i.e. E* is along *x*-axis and *B* is along *y-axis.*

39. (a) $\nu_{\gamma-rays} > \nu_{UV\text{-rays}} > \nu_{\text{Blue light}} > \nu_{\text{Infrared rays}}$

40. (d) Ground wave and sky wave both are amplitude modulated wave and the amplitude modulated signal is transmitted by a transmitting antenna and received by the receiving antenna at a distance place.

41. (a)

42. (b) EM waves transport energy, momentum and information but not charge. EM waves are uncharged

43. (b) EM waves carry momentum and hence can exert pressure on surfaces. They also transfer energy to the surface so $p \neq 0$ and $E \neq 0$.

44. (c) The angular wave number $k = \frac{2\pi}{\lambda}$; where λ is the wave length. The angular frequency is $w = 2\pi\nu$.

The ratio $\frac{k}{\omega} = \frac{2\pi/\lambda}{2\pi\nu} = \frac{1}{\nu\pi} = \frac{1}{c}$ = constant

45. (a) $\frac{E_0}{B_0} = C$. also $k = \frac{2\pi}{\lambda}$ and $\omega = 2\pi\nu$

These relation gives $E_0K = B_0\omega$

46. (b) $\nu = \frac{1}{2\pi\sqrt{LC}}$ and $\lambda = \frac{C}{\nu}$

47. (a) $I = \frac{1}{2}\varepsilon_0 C E_0^2$

$\Rightarrow E_0 = \sqrt{\frac{2I}{\varepsilon_0 C}} = \sqrt{\frac{2\times 5\times 10^{-16}}{8.85}} = 0.61\times 10^{-6}\frac{V}{m}$

Also $E_0 = \frac{V_0}{d} \Rightarrow V_0 = E_0 d = 0.61\times 10^{-6}\times 2 = 1.23\mu V$

48. (c)

49. (c) Population covered = $2\pi hR\times$ Population density

$= 2\pi \times 100 \times 6.4 \times 10^{6} \times \frac{1000}{(10^3)^2} = 4 \times 10^{6}$

50. (a)

51. (c)

52. (c) Refractive index $= \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}}$

Here μ is not specified so we can consider $\mu = \mu_0$

then refractive index $= \sqrt{\frac{\varepsilon}{\varepsilon_0}} = 2$

$\therefore$ Speed and wavelength of wave becomes half and frequency remain unchanged.

53. (d)

54. (d)

55. (b)

56. (b)

57. (a) Intensity or power per unit area of the radiations $P = fv \Rightarrow$

$f = \frac{P}{v} = \frac{0.5}{3\times 10^8} = 0.166\times 10^{-8}\ N/m^2$

58. (d) $v = \frac{c}{\sqrt{\mu_r\varepsilon_r}} = \frac{3\times 10^8}{\sqrt{1.3\times 2.14}} = 1.8\times 10^8 m/sec$

59. (b) $I' = Ie^{-\mu x} \Rightarrow x = \frac{1}{\mu}\log_e\frac{I}{I'}$ (where I = original intensity, I' = changed intensity)

$36 = \frac{1}{\mu}\log_e\frac{I}{I/8} = \frac{3}{\mu}\log_e 2$ ....(i)

$x = \frac{1}{\mu}\log_e\frac{I}{I/2} = \frac{1}{\mu}\log_e 2$ .....(ii)

From equation (i) and (ii), $x = 12\ mm$.

60. (c) $\lambda_m > \lambda_v > \lambda_x$

61. (a) If maximum electron density of the ionosphere is N_{max} per m^3 then the critical frequency f_c is given by $f_c = 9(N_{max})^{1/2}$.

$\Rightarrow 1\times 10^6 = 9(N)^{1/2} \Rightarrow N = 1.2 \times 10^{12}\ m^{-3}$

62. (c)

63. (b)

64. (a)

65. (c)

66. (d) Direction of wave propagation is given by $\vec{E}\times\vec{B}$.

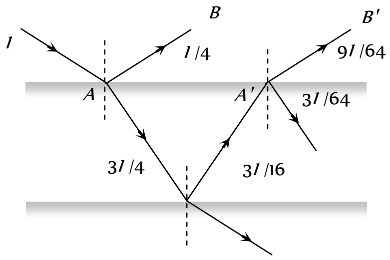
67. (c) Speed of light of vacuum $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$ and in another medium

$v = \frac{1}{\sqrt{\mu\varepsilon}}$

$\therefore \frac{c}{v} = \sqrt{\frac{\mu\varepsilon}{\mu_0\varepsilon_0}} = \sqrt{\mu_r K} \Rightarrow v = \frac{c}{\sqrt{\mu_r K}}$

Critical Thinking Questions

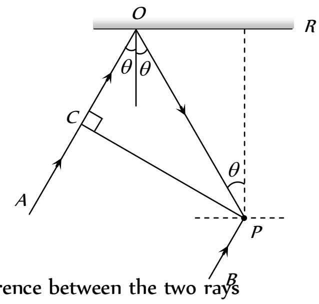
1. (d) From figure $I_1 = \dfrac{I}{4}$ and $I_2 = \dfrac{9I}{64}$ $\Rightarrow \dfrac{I_2}{I_1} = \dfrac{9}{16}$



By using $\dfrac{I_{max}}{I_{min}} = \left(\dfrac{\sqrt{\dfrac{I_2}{I_1}}+1}{\sqrt{\dfrac{I_2}{I_1}}-1}\right) = \left(\dfrac{\sqrt{\dfrac{9}{16}}+1}{\sqrt{\dfrac{9}{16}}-1}\right) = \dfrac{49}{1}$

2. (a) The cylindrical surface touches the glass plate along a line parallel to axis of cylinder. The thickness of wedge shaped film increases on both sides of this line. Locus of equal path difference are the lines running parallel to the axis of the cylinder. Hence straight fringes are obtained.

3. (b) $\because PR = d \Rightarrow PO = d\sec\theta$ and $CO = PO\cos 2\theta = d\sec\theta\cos 2\theta$ is



Path difference between the two rays

$\Delta = CO + PO = (d\sec\theta + d\sec\theta\cos 2\theta)$

Phase difference between the two rays is

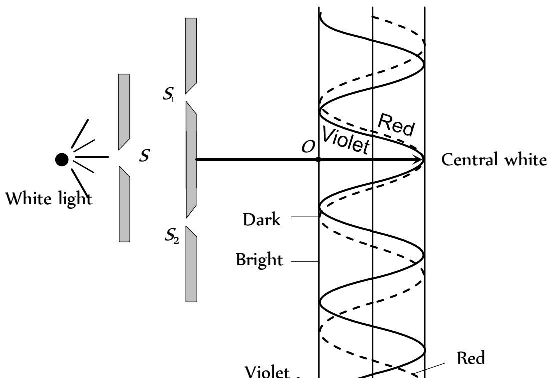
$\phi = \pi$ (One is reflected, while another is direct)

Therefore condition for constructive interference should be $\Delta = \dfrac{\lambda}{2}, \dfrac{3\lambda}{2}$ ......

or $d\sec\theta(1+\cos 2\theta) = \dfrac{\lambda}{2}$

or $\dfrac{d}{\cos\theta}(2\cos^2\theta) = \dfrac{\lambda}{2} \Rightarrow \cos\theta = \dfrac{\lambda}{4d}$

4. (c) In young's double slit experiment, if white light is used in place of monochromatic light, then the central fringe is white and some coloured fringes around the central fringe are formed.

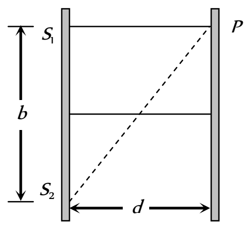


Since $\beta_{red} > \beta_{violet}$ etc., the bright fringe of violet colour forms first and that of the red forms later.

It may be noted that, the inner edge of the dark fringe is red, while the outer edge is violet. Similarly, the inner edge of the bright fringe is violet and the outer edge is red.

5. (a) In conventional light source, light comes from a large number of independent atoms, each atom emitting light for about 10^{-} *sec i.e.* light emitted by an atom is essentially a pulse lasting for only 10^{-} *sec*. Light coming out from two slits will have a fixed phase relationship only for 10^{-} *sec*. Hence any interference pattern formed on the screen would last only for 10^{-} *sec*, and then the pattern will change. The human eye can notice intensity changes which last at least for a tenth of a second and hence we will not be able to see any interference pattern. In stead due to rapid changes in the pattern, we will only observe a uniform intensity over the screen.

6. (a,c) Path difference between the rays reaching infront of slit S_1 is.



$S_1P - S_2P = (b^2+d^2)^{1/2} - d$

For distructive interference at P

$S_1P - S_2P = \dfrac{(2n-1)\lambda}{2}$

i.e., $(b^2+d^2)^{1/2} - d = \dfrac{(2n-1)\lambda}{2}$

$\Rightarrow d\left(1+\dfrac{b^2}{d^2}\right)^{1/2} - d = \dfrac{(2n-1)\lambda}{2}$

$\Rightarrow d\left(1+\dfrac{b^2}{2d^2}+......\right) - d = \dfrac{(2n-1)\lambda}{2}$

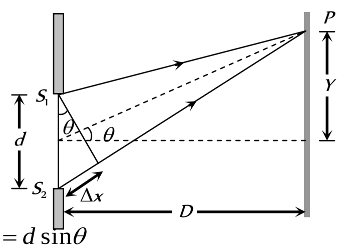
(Binomial Expansion)

$\Rightarrow \dfrac{b}{2d} = \dfrac{(2n-1)\lambda}{2} \Rightarrow \lambda = \dfrac{b^2}{(2n-1)d}$

For $n = 1, 2$......... .., $\lambda = \dfrac{b^2}{d}, \dfrac{b^2}{3d}$

7. (a)

8. (a,b) For microwave $\lambda = \dfrac{c}{f} = \dfrac{3\times 10^8}{10^6} = 300\ m$



As $\Delta x = d\sin\theta$

Phase difference $\phi = \frac{2\pi}{\lambda}$ (Path difference)

$$= \frac{2\pi}{\lambda}(d\sin\theta) = \frac{2\pi}{300}(150\sin\theta) = \pi\sin\theta$$

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Here $I_1 = I_2$ and $\phi = \pi\sin\theta$

$$\therefore I_R = 2I_1[1 + \cos(\pi\sin\theta)] = 4I_1\cos^2\left(\frac{\pi\sin\theta}{2}\right)$$

I will be maximum when $\cos^2\left(\frac{\pi\sin\theta}{2}\right) = 1$

$$\therefore (I_R)_{\max} = 4I_1 = I_o$$

Hence $I = I_o\cos^2\left(\frac{\pi\sin\theta}{2}\right)$

If $\theta = 0$, then $I = I_o\cos\theta = I_o$

If $\theta = 30°$, then $I = I_o\cos^2(\pi/4) = I_o/2$

If $\theta = 90^o$, then $I = I_o\cos^2(\pi/2) = 0$

9. (d) $I = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$

Put $a_1^2 + a_2^2 = A$ and $a_1a_2 = B$; $\therefore I = A + B\cos\phi$

10. (d) Since P is ahead of Q by 90° and path difference between P and Q is $\lambda/4$. Therefore at A, phase difference is zero, so intensity is $4I$. At C it is zero and at B, the phase difference is 90°, so intensity is $2I$.

11. (b) By using phase difference $\phi = \frac{2\pi}{\lambda}(\Delta)$

For path difference λ, phase difference $\phi_1 = 2\pi$ and for path difference $\lambda/4$, phase difference $\phi_2 = \pi/2$.

Also by using $I = 4I_0\cos^2\frac{\phi}{2} \Rightarrow \frac{I_1}{I_2} = \frac{\cos^2(\phi_1/2)}{\cos^2(\phi_2/2)}$

$$\Rightarrow \frac{K}{I_2} = \frac{\cos^2(2\pi/2)}{\cos^2\left(\frac{\pi/2}{2}\right)} = \frac{1}{1/2} \Rightarrow I_2 = \frac{K}{2}.$$

12. (d) If shift is equivalent to n fringes then

$$n = \frac{(\mu-1)t}{\lambda} \Rightarrow n \propto t \Rightarrow \frac{t_2}{t_1} = \frac{n_2}{n_1} \Rightarrow t_2 = \frac{n_2}{n_1}\times t$$

$$t_2 = \frac{20}{30}\times 4.8 = 3.2\ mm.$$

13. (a) According to given condition

$(\mu-1)t = n\lambda$ for minimum t, $n = 1$

So, $(\mu-1)t_{\min} = \lambda$

$$t_{\min} = \frac{\lambda}{\mu-1} = \frac{\lambda}{1.5-1} = 2\lambda$$

14. (a) $\Delta\lambda = \lambda\frac{v}{c}$ and $v = r\omega$

$$v = 7\times10^8\times\frac{2\pi}{25\times24\times3600},\ c = 3\times10^8\ m/s$$

$$\therefore \Delta\lambda = 0.04\text{Å}$$

15. (b) $v = \frac{c\Delta\lambda}{\lambda} = \frac{3\times10^8\times(706-656)}{656} = \frac{1500}{656}\times10^7$

$$= 2\times10^7\ m/s$$

16. (b) In this case, we can assume as if both the source and the observer are moving towards each other with speed v. Hence $v' = \frac{c-u_o}{c-u_s}v = \frac{c-(-v)}{c-v}v = \frac{c+v}{c-v}v$

$$= \frac{(c+v)(c-v)}{(c-v)^2}v = \frac{c^2-v^2}{c^2+v^2-2vc}v$$

Since $v \ll c$, therefore $v' = \frac{c^2}{c^2-2vc} = \frac{c}{c-2v}v$

17. (a) $\Delta\lambda = \lambda.\frac{v}{c}$ where $v = r\omega = r\times\left(\frac{2\pi}{T}\right)$

$$\therefore \Delta\lambda = \frac{4320\times7\times10^8\times2\times3.14}{3\times10^8\times22\times86400} = 0.033\text{Å}$$

18. (a) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto D$

$$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{D_1}{D_2} \Rightarrow \frac{\beta_1-\beta_2}{\beta_2} = \frac{D_1-D_2}{D_2} \Rightarrow \frac{\Delta\beta}{\Delta D} = \frac{\beta_2}{D_2} = \frac{\lambda_2}{d_2}$$

$$= \lambda_2 = \frac{3\times10^{-5}}{5\times10^{-2}}\times10^{-3} = 6\times10^{-7}m = 6000\text{Å}$$

19. (a) P is the position of 11th bright fringe from Q. From central position O, P will be the position of 10th bright fringe.

Path difference between the waves reaching at $P = S_1B = 10\ \lambda = 10 \times 6000 \times 10^{-10} = 6 \times 10^{-6} m$.

20. (b) Resultant intensity $I = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

At central position with coherent source (and $I_1 = I_2 = I_0$

$I_{con} = 4I_0$ ... (i)

In case of incoherent at a given point, ϕ varies randomly with time so $(\cos\phi)_{av} = 0$

$\therefore\ I_{Incoh} = I_1 + I_2 = 2I_0$ ... (ii)

Hence $\frac{I_{coh}}{I_{Incoh}} = \frac{2}{1}$.

21. (a, d) These waves are of same frequencies and they are coherent

22. (c) Fringe width $\beta \propto \lambda$. Therefore, λ and hence β decreases 1.5 times when immersed in liquid. The distance between central maxima and 10th maxima is 3 cm in vacuum. When immersed in liquid it will reduce to 2 cm. Position of central maxima will not change while 10th maxima will be obtained at $y = 4cm$.

23. (a) Suppose P is a point infront of one slit at which intensity is to be calculated from figure it is clear that $x = \frac{d}{2}$. Path difference between the waves reaching at P

$$\Delta = \frac{xd}{D} = \frac{\left(\frac{d}{2}\right)d}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$

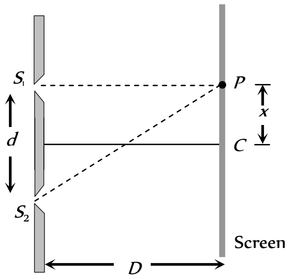
Hence corresponding phase difference

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$$

Resultant intensity at P

$$I = I_{max} \cos^2 \frac{\phi}{2}$$

$$= I_0 \cos^2\left(\frac{\pi}{4}\right) = \frac{I_0}{2}$$



24. (d) If $d\sin\theta = (\mu - 1)t$, central fringe is obtained at O

If $d\sin\theta > (\mu - 1)t$, central fringe is obtained above O and

If $d\sin\theta < (\mu - 1)t$, central fringe is obtained below O.

25. (b) For maximum intensity on the screen

$$d\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{d} = \frac{n(2000)}{7000} = \frac{n}{3.5}$$

Since maximum value of $\sin\theta$ is 1

So $n = 0, 1, 2, 3,$ only. Thus only seven maximas can be obtained on both sides of the screen.

26. (c) From the given data, note that the fringe width (β) for $\lambda_1 = 900\,nm$ is greater than fringe width (β) for $\lambda_2 = 750\,nm$. This means that at though the central maxima of the two coincide, but first maximum for $\lambda_1 = 900\,nm$ will be further away from the first maxima for $\lambda_2 = 750\,nm$, and so on. A stage may come when this mismatch equals β, then again maxima of $\lambda_1 = 900\,nm$, will coincide with a maxima of $\lambda_2 = 750\,nm$, let this correspond to n order fringe for λ. Then it will correspond to $(n+1)^{th}$ order fringe for λ.

Therefore $\frac{n\lambda_1 D}{d} = \frac{(n+1)\lambda_2 D}{d}$

$$\Rightarrow n \times 900 \times 10^{-9} = (n+1)750 \times 10^{-9} \Rightarrow n = 5$$

Minimum distance from

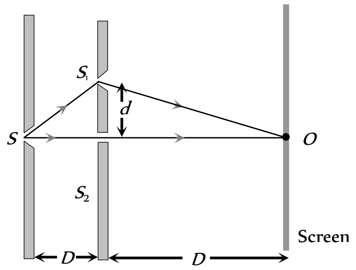
Central maxima $= \frac{n\lambda_1 D}{d} = \frac{5 \times 900 \times 10^{-9} \times 2}{2 \times 10^{-3}}$

$$= 45 \times 10^{-4} m = 4.5\,mm$$

27. (c) Shift $= \frac{\beta}{\lambda}(\mu - 1)t$

$$\Rightarrow 7\beta = \frac{\beta}{\lambda}(\mu - 1)t \Rightarrow t = \frac{7\lambda}{(\mu - 1)} = \frac{7 \times 600}{(1.5 - 1)} = 8400\,nm.$$

28. (c) Path difference between the waves reaching at P, $\Delta = \Delta_1 + \Delta_2$



where $\Delta_1 =$ Initial path difference

$\Delta_2 =$ Path difference between the waves after emerging from slits.

$$\Delta_1 = SS_1 - SS_2 = \sqrt{D^2 + d^2} - D$$

and $\Delta_2 = S_1O - S_2O = \sqrt{D^2 + d^2} - D$

$$\therefore \Delta = 2\left\{(D^2 + d^2)^{\frac{1}{2}} - D\right\} = 2\left\{(D^2 + \frac{d^2}{2D}) - D\right\}$$

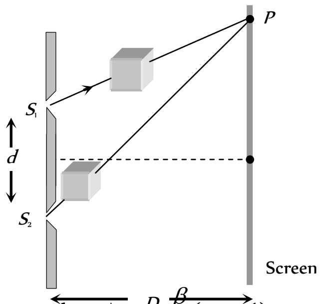
$$= \frac{d^2}{D} \quad \text{(From Binomial expansion)}$$

For obtaining dark at O, Δ must be equals to $(2n-1)\frac{\lambda}{2}$ *i.e.*

$$\frac{d^2}{D} = (2n-1)\frac{\lambda}{2} \Rightarrow d\sqrt{\frac{(2n-1)\lambda D}{2}}$$

For minimum distance $n = 1$ so $d = \sqrt{\frac{\lambda D}{2}}$

29. (a) Shift $\Delta x = \frac{\beta}{\lambda}(\mu - 1)t$



Shift due to one plate $\Delta x_1 = \frac{\beta}{\lambda}(\mu_1 - 1)$

Shift due to another path $\Delta x_2 = \frac{\beta}{\lambda}(\mu_2 - 1)t$

Net shift $\Delta x = \Delta x_2 - \Delta x_1 = \frac{\beta}{\lambda}(\mu_2 - \mu_1)t$ .....(i)

Also it is given that $\Delta x = 5\beta$ .....(ii)

Hence $5\beta = \frac{\beta}{\lambda}(\mu_1 - \mu_2)t$

$$\Rightarrow t = \frac{5\lambda}{(\mu_2 - \mu_1)} = \frac{5 \times 4800 \times 10^{-10}}{(1.7 - 1.4)} = 8 \times 10^{-6} m = 8\mu m.$$

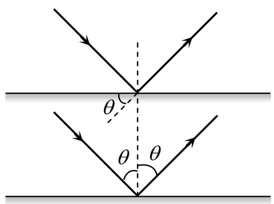
30. (b) For maxima $2\pi n = \frac{2\pi}{\lambda}(XO) - 2\pi l$

or $\frac{2\pi}{\lambda}(XO) = 2\pi(n + l)$ or $(XO) = \lambda(n + l)$

31. (c) Path difference $= 2d\sin\theta$

$\therefore$ For constructive interference

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



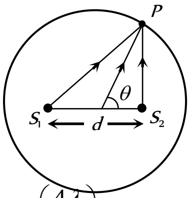
$\Rightarrow \theta = \sin^{-1}\left(\frac{n\lambda}{2d}\right)$

32. (b) Here path difference at a point P on the circle is given by

$\Delta x = d\cos\theta$ ..... (i)

For maxima at P

$\Delta x = n\lambda$ ..... (ii)



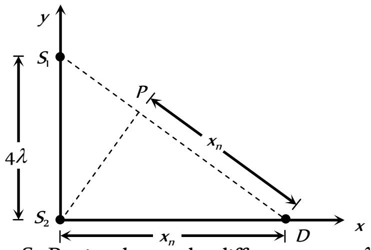
From equation (i) and (ii)

$n\lambda = d\cos\theta \Rightarrow \theta\cos^{-1}\left(\frac{n\lambda}{d}\right) = \cos^{-1}\left(\frac{4\lambda}{d}\right)$

33. (b) From ΔS_1S_2D,

$(S_1D)^2 = (S_1S_2)^2 + (S_2D)^2$

$(S_1P + PD)^2 = (S_1S_2)^2 + (S_2D)^2$



Here S_1P is the path difference $= n\lambda$ for maximum intensity.

$\therefore (n\lambda + x_n)^2 = (4\lambda)^2 + (x_n)^2$

or $x_n = \frac{16\lambda^2 - n^2\lambda^2}{2n\lambda}$

Then $x_1 = \frac{16\lambda^2 - \lambda^2}{2\lambda} = 7.5\,\lambda$

$x_2 = \frac{16\lambda^2 - 4\lambda^2}{4\lambda} = 3\lambda$

$x_3 = \frac{16\lambda^2 - 9\lambda^2}{6\lambda} = \frac{7}{6}\lambda$

$x_4 = 0$.

$\therefore$ Number of points for maxima becomes 3.

34. (a) $I_0 = R^2 = \frac{R_2^2}{4}$

Number of *HPZ* covered by the disc at $b = 25\,cm$

$n_1b_1 = n_2b_2$

$n_2 = \frac{n_1b_1}{b_2} + \frac{1\times 1}{0.25} = 4$

Hence the intensity at this point is

$I = R'^2 = \left(\frac{R_5}{2}\right)^2 = \left(\frac{R_5}{R_4}\times\frac{R_4}{R_3}\times\frac{R_3}{R_2}\right)^2 \times \left(\frac{R_2}{2}\right)^2$

or $1 = [0.9]^6$

$I_1 = 0.531\, I_0$

Hence the correct answer will be (a).

35. (b) $I_A = R_1^2$

$I_B = (R_1 - R_2)^2 = R_1^2\left(1 - \frac{R_2}{R_1}\right)^2 = R_1^2\left(1 - \frac{3}{4}\right)^2 = \frac{R_1^2}{16}$

$I_C = (R_1 - R_2 + R_3)^2 = R_1^2\left(1 - \frac{R_2}{R_1} + \frac{R_3}{R_1}\right)^2$

$= R_1^2\left(1 - \frac{R_2}{R_1} + \frac{R_3}{R_2}\times\frac{R_2}{R_1}\right)^2$

$= R_1^2\left(1 - \frac{3}{4} + \frac{3}{4}\times\frac{3}{4}\right)^2 = \left(\frac{13}{16}\right)^2 R_1^2 = \frac{169}{256}R_1^2$

$\therefore I_A : I_B : I_C = R_1^2 : \frac{R_1^2}{16} : \frac{169}{256}R_1^2 = 256:16:169$

36. (d) $I = \frac{R_2^2}{4}$ given $n_1b_1 = n_2b_2 \Rightarrow 1\times 200 = n_2\times 25$

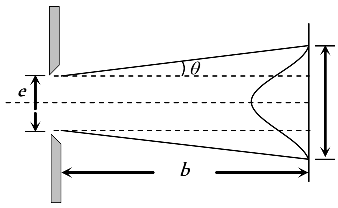
$\therefore n_2 = 8\ HPZ$

$\therefore I = \left(\frac{R_9}{2}\right)^2$

$= \left(\frac{R_9}{R_8}\times\frac{R_8}{R_7}\times\frac{R_7}{R_6}\times\frac{R_6}{R_5}\times\frac{R_5}{R_4}\times\frac{R_4}{R_3}\times\frac{R_3}{R_2}\times\frac{R_2}{R_2}\right)^2$

$= \left(\frac{R_9}{R_2}\right)^2 I$

37. (c) The direction in which the first minima occurs is θ (say). Then $e\sin\theta = \lambda$ or $e\theta = \lambda$ or, $\theta = \frac{\lambda}{e}$ ($\because \theta = \sin\theta$ when θ small)



Width of the central maximum $= 2b\theta + e = 2b.\frac{\lambda}{e} + e$

38. (b) Angular width $\beta = \frac{2\lambda}{d} \Rightarrow \beta \propto \lambda$

$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2} \Rightarrow \frac{\beta}{\frac{70}{100}\beta} = \frac{6000}{\lambda_2} \Rightarrow \lambda_2 = 4200\,Å$

39. (a) In a single slit diffraction experiment, position of minima is given by $d\sin\theta = n\lambda$

So for first minima of red $\sin\theta = 1\times\left(\frac{\lambda_R}{d}\right)$

and as first maxima is midway between first and second minima, for wavelength λ', its position will be

$$d\sin\theta' = \frac{\lambda' + 2\lambda'}{2} \Rightarrow \sin\theta' = \frac{3\lambda'}{2d}$$

According to given condition $\sin\theta = \sin\theta'$

$$\Rightarrow \lambda' = \frac{2}{3}\lambda_R \text{ so } \lambda' = \frac{2}{3}\times 6600 = 440\,nm = 4400\,Å$$

40. (c) $I = I_0\left[\frac{\sin\alpha}{\alpha}\right]^2$, where $\alpha = \frac{\phi}{2}$

For n^{th} secondary maxima $d\sin\theta = \left(\frac{2n+1}{2}\right)\lambda$

$$\Rightarrow \alpha = \frac{\phi}{2} = \frac{\pi}{\lambda}[d\sin\theta] = \left(\frac{2n+1}{2}\right)\pi$$

$$\therefore\ I = I_0\left[\frac{\sin\left(\frac{2n+1}{2}\right)\pi}{\left(\frac{2n+1}{2}\right)\pi}\right]^2 = \frac{I_0}{\left\{\frac{(2n+1)}{2}\pi\right\}^2}$$

So $I_0 : I_1 : I_2 = I_0 : \frac{4}{9\pi^2}I_0 : \frac{4}{25\pi^2}I_0$

$$= 1 : \frac{4}{9\pi^2} : \frac{4}{25\pi^2}$$

41. (d) For a grating $(e+d)\sin\theta_n = n\lambda$

where $(e+d) =$ grating element

$$\sin\theta_n = \frac{n\lambda}{(e+d)}$$

For $n = 1$, $\sin\theta_1 = \frac{\lambda}{(e+d)} = \sin 32°$

This is more than 0.5. Now $\sin\theta_2$ will be more than 2×0.5, which is not possible.

42. (a) The film appears bright when the path difference

$(2\mu t\cos r)$ is equal to odd multiple of $\frac{\lambda}{2}$

i.e. $2\mu t\cos r = (2n-1)\lambda/2$ where $n = 1, 2, 3$ .....

$$\therefore\ \lambda = \frac{4\mu t\cos r}{(2n-1)}$$

$$= \frac{4\times 1.4\times 10{,}000\times 10^{-10}\times\cos 0}{(2n-1)} = \frac{56000}{(2n-1)}\,Å$$

$\therefore\ \lambda = 56000\,Å$ $18666\,Å$, $8000\,Å$, $6222\,Å$, $5091\,Å$, $4308\,Å$, $3733\,Å$.

The wavelength which are not within specified range are to be refracted.

43. (a) Total phase difference

= Initial phase difference + Phase difference due to path

$$= 66° + \frac{360°}{\lambda}\times\Delta x = 66° + \frac{360°}{\lambda}\times\frac{\lambda}{4} = 66° + 90 = 156°$$

44. (a) $I = 4I_0\cos^2\frac{\phi}{2}$

At central position $I_1 = 4I_0$ ......(i)

Since the phase difference between two successive fringes is 2π, the phase difference between two points separated by a distance equal to one quarter of the distance between the two, successive fringes is equal to $\delta = (2\pi)\left(\frac{1}{4}\right) = \frac{\pi}{2}$ radian

$$\Rightarrow I_2 = 4I_0\cos^2\left(\frac{\frac{\pi}{2}}{2}\right) = 2I_0 \quad ......(ii)$$

Using (i) and (ii), $\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = 2$

45. (b) $I_D = \varepsilon_0\frac{d\phi_E}{dt} = \varepsilon_0\frac{EA}{t} = \varepsilon_0\left(\frac{V}{d}\right).\frac{A}{t}$.

$$= \frac{8.85\times 10^{-12}\times 400\times 60\times 10^{-4}}{10^{-3}\times 10^{-6}} = 1.602\times 10^{-2}\,amp$$

46. (d) Electric field $E = \frac{V}{l} = \frac{iR}{l}$ (R = Resistance of wire)

Magnetic field at the surface of wire $B = \frac{\mu_0 i}{2\pi a}$ (a = radius of wire)

Hence poynting vector, directed radially inward is given by

$$S = \frac{EB}{\mu_0} = \frac{iR}{\mu_0 l}.\frac{\mu_0 i}{2\pi a} = \frac{i^2R}{2\pi a l}$$

47. (b) Average energy density of electric field is given by

$$u_e = \frac{1}{2}\varepsilon_0 E^2 = \frac{1}{2}\varepsilon_0\left(\frac{E_0}{\sqrt{2}}\right)^2 = \frac{1}{4}\varepsilon_0 E_0^2$$

$$= \frac{1}{4}\times 8.85\times 10^{-12}(1)^2 = 2.2\times 10^{-12}\,J/m^3.$$

48. (b) Area through which the energy of beam passes

$$= (6.328\times 10^{-7}) = 4\times 10^{-13}\,m^2$$

$$\therefore\ I = \frac{P}{A} = \frac{10^{-3}}{4\times 10^{-13}} = 2.5\times 10^9\,W/m^2$$

49. (a) $S_{av} = \frac{1}{2}\varepsilon_0 cE_0^2 = \frac{P}{4\pi R^2}$

$$\Rightarrow E_0 = \sqrt{\frac{P}{2\pi R^2\varepsilon_0 C}}$$

$$= \sqrt{\frac{3}{2\times 3.14\times 100\times 8.85\times 10^{-12}\times 3\times 10^8}}$$

= 1.34 *V/m*

50. (d) Intensity of EM wave is given by

$$I = \frac{P}{4\pi R^2} = v_{av}.c = \frac{1}{2}\varepsilon_0 E_0^2\times c$$

$\Rightarrow E_0 = \sqrt{\dfrac{P}{2\pi R^2 \varepsilon_0 c}}$

$= \sqrt{\dfrac{800}{2\times 3.14\times (4)^2\times 8.85\times 10^{-12}\times 3\times 10^8}}$

$= 54.77\ \dfrac{V}{m}$

51. (c) Wave impedance $Z = \sqrt{\dfrac{\mu_r}{\varepsilon_r}}\times\sqrt{\dfrac{\mu_0}{\varepsilon_0}}$

$= \sqrt{\dfrac{50}{2}}\times 376.6 = 1883\,\Omega$

52. (d) Momentum transferred in one second

$p = \dfrac{2U}{c} = \dfrac{2S_{av}A}{c} = \dfrac{2\times 6\times 40\times 10^{-4}}{3\times 10^8}$

$= 1.6\times 10^{-10}$ *kg-m/s*.

53. (a) Specific rotation

$(\alpha) = \dfrac{\theta}{l\,c} \Rightarrow c = \dfrac{\theta}{\alpha l} = \dfrac{0.4}{0.01\times 0.25} = 160\ kg/m^3$

Now percentage purity of sugar solution

$= \dfrac{160}{200}\times 100 = 80\%$

54. (d) As $\theta \propto l$

Volume ratio 1 : 2 in a tube of length 30 *cm* means 10 *cm* length of first solution and 20 *cm* length of second solution .

Rotation produced by 10 *cm* length of first solution

$\theta_1 = \dfrac{38°}{20}\times 10 = 19°$

Rotation produced by 20*cm* length of second solution

$\theta_2 = -\dfrac{24°}{30}\times 20 = -16°$

$\therefore$ Total rotation produced = 19° – 16° = 3°

55. (d) If I is the final intensity and I_0 is the initial intensity then

$I = \dfrac{I_0}{2}(\cos^2 30°)^5$ or $\dfrac{I}{I_0} = \dfrac{1}{2}\times\left(\dfrac{\sqrt{3}}{2}\right)^{10} = 0.12$

56. (a) Using Matus law, $I = I_0\cos^2\theta$

As here polariser is rotating *i.e.* all the values of θ are possible.

$I_{av} = \dfrac{1}{2\pi}\int_0^{2\pi} I\,d\theta = \dfrac{1}{2\pi}\int_0^{2\pi} I_0\cos^2\theta\,d\theta$

On integration we get $I_{av} = \dfrac{I_0}{2}$

where $I_0 = \dfrac{\text{Energy}}{\text{Area}\times\text{Time}} = \dfrac{p}{A} = \dfrac{10^{-3}}{3\times 10^{-4}} = \dfrac{10}{3}\dfrac{Watt}{m^2}$

$\therefore I_{av} = \dfrac{1}{2}\times\dfrac{10}{3} = \dfrac{5}{3} Watt$

and Time period $T = \dfrac{2\pi}{\omega} = \dfrac{2\times 3.14}{31.4} = \dfrac{1}{5} sec$

$\therefore$ Energy of light passing through the polariser per revolution

$= I_{av}\times\text{Area}\times T = \dfrac{5}{3}\times 3\times 10^{-4}\times\dfrac{1}{5} = 10^{-4}\ J.$

57. (d) Let *n*th minima of 400 *nm* coincides with *m*th minima of 560 *nm* then

$(2n-1)400 = (2m-1)560 \Rightarrow \dfrac{2n-1}{2m-1} = \dfrac{7}{5} = \dfrac{14}{10} = \dfrac{21}{15}$

i.e. 4th minima of 400 *nm* coincides with 3rd minima of 560 *nm*.

The location of this minima is

$= \dfrac{7(1000)(400\times 10^{-6})}{2\times 0.1} = 14\,mm$

Next, 11th minima of 400 *nm* will coincide with 8th minima of 560 *nm*

Location of this minima is

$= \dfrac{21(1000)(400\times 10^{-6})}{2\times 0.1} = 42\,mm$

$\therefore$ Required distance = 28 *mm*

58. (b) For maxima $\Delta = d\sin\theta = n\lambda$

$\Rightarrow 2\lambda\sin\theta = n\lambda \Rightarrow \sin\theta = \dfrac{n}{2}$

since value of sin θ can not be greater 1.

$\therefore$ n = 0, 1, 2

Therefore only five maximas can be obtained on both side of the screen.

59. (a) $\dfrac{\Delta\lambda}{\lambda} = \dfrac{v}{c} \Rightarrow \dfrac{(401.8-393.3)}{393.3} = \dfrac{v}{3\times 10^8}$

$\Rightarrow v = 6.48\times 10^6$ *m/s* = 6480 *km/sec.*

60. (c) The interference fringes for two slits are hyperbolic.

61. (d) If you divide the original slit into N strips and represents the light from each strip, when it reaches the screen, by a phasor, then at the central maximum in the diffraction pattern you add N phasors, all in the same direction and each with the same amplitude. The intensity is therefore N. If you double the slit width, you need $2N$ phasors, if they are each to have the amplitude of the each to have the amplitude of the phasors you used for the narrow slit. The intensity at the central maximum is proportional to $(2N)^2$ and is, therefore, four times the intensity for the narrow slit.

62. (c) $I = 4I_0\cos^2(\phi/2) \Rightarrow \phi = 2\pi/3$

$\Rightarrow \Delta x\times(2\pi/\lambda) = 2\pi/3 = \lambda/3$

sin $\theta = \Delta x/d \Rightarrow$ sin $\theta = \lambda/3d$

63. (b) Momentum of the electron will increase. So the wavelength ($\lambda = h/p$)of electrons will decrease and fringe width decreases as $\beta \propto \lambda$.

Assertion and Reason

1. (d) When a light wave travel from a rarer to a denser medium it loses speed, but energy carried by the wave does not depend on its speed. Instead, it depends on the amplitude of wave.

2. (e) A narrow pulse is made of harmonic waves with a large range of wavelength. As speed of propagation is different for different wavelengths, the pulse cannot retain its shape while travelling through the medium.

3. (b) When d is negligibly small, fringe width β which is proportional to $1/d$ may become too large. Even a single fringe may occupy the whole screen. Hence the pattern cannot be detected.

4. (a) The central spot of Newton's rings is dark when the medium between plano convex lens and plane glass is rarer than the medium of lens and glass. The central spot is dark because the phase change of π is introduced between the rays reflected from surfaces of denser to rarer and rarer to denser media.

5. (a) For reflected system of the film, the maxima or constructive interference is $2\mu t\cos r = \frac{(2n-1)\lambda}{2}$ while the maxima for transmitted system of film is given by equation $2\mu t\cos r = n\lambda$

where t is thickness of the film and r is angle of reflection.

From these two equations we can see that condition for maxima in reflected system and transmitted system are just opposite.

6. (b) When intensity of light emerging from two slits is equal, the intensity at minima,

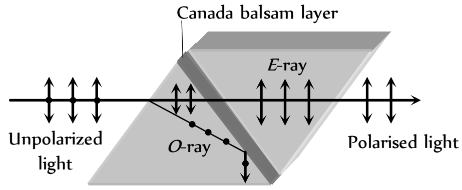
$$I_{\min} = \left(\sqrt{I_a} - \sqrt{I_b}\right)^2 = 0, \text{ or absolute dark.}$$

It provides a better contrast.

7. (c) When one of slits is covered with cellophane paper, the intensity of light emerging from the slit is decreased (because this medium is translucent). Now the two interfering beam have different intensities or amplitudes. Hence intensity at minima will not be zero and fringes will become indistinct.

8. (a) When a polaroid is rotated in the path of unpolarised light, the intensity of light transmitted from polaroid remains undiminished (because unpolarised light contains waves vibrating in all possible planes with equal probability). However, when the polaroid is rotated in path of plane polarised light, its intensity will vary from maximum (when the vibrations of the plane polarised light are parallel to the axis of the polaroid) to minimum (when the direction of the vibrations becomes perpendicular to the axis of the crystal). Thus using polaroid we can easily verify that whether the light is polarised or not.

9. (c) The nicol prism is made of calcite crystal. When light is passed through calcite crystal, it breaks up into two rays (i) the ordinary ray which has its electric vector perpendicular to the principal section of the crystal and (ii) the extra ordinary ray which has its electric vector parallel to the principal section. The nicol prism is made in such a way that it eliminates one of the two rays by total internal reflection, thus produces plane polarised light. It is generally found that the ordinary ray is eliminated and only the extra ordinary ray is transmitted through the prism. The nicol prism consists of two calcite crystal cut at – 68° with its principal axis joined by a glue called Canada balsam.



10. (b) Doppler's effect is observed readily in sound wave due to larger wavelengths. The same is not the case with light due to shorter wavelength in every day life.

11. (d) In Young's experiments fringe width for dark and white fringes are same while in Young's double slit experiment when a white light as a source is used, the central fringe is white around which few coloured fringes are observed on either side.

12. (a) It is quite clear that the coloured spectrum is seen due to diffraction of white light on passing through fine slits made by fine threads in the muslin cloth.

13. (c) As the waves diffracted from the edges of circular obstacle, placed in the path of light interfere constructively at the centre of the shadow resulting in the formation of a bright spot.

14. (c) The beautiful colours are seen on account of interference of light reflected from the upper and the lower surfaces of the thin films.

15. (a) Microwave communication is preferred over optical communication because microwaves provide large number of channels and wider band width compared to optical signals as information carrying capacity is directly proportional to band width. So, wider the band width, greater the information carrying capacity.

16. (a)

17. (a) $\beta = \frac{\lambda D}{d}$

18. (c) The clouds consists of dust particles and water droplets. Their size is very large as compared to the wavelength of the incident light from the sun. So there is very little scattering of light. Hence the light which we receive through the clouds has all the colours of light. As a result of this, we receive almost white light. Therefore, the cloud are generally white.

19. (d) In sky wave propagation, the radio waves having frequency range 2 *MHz* to 30 *MHz* are reflected back by the ionosphere. Radio waves having frequency nearly greater than 30 *MHz* penetrates the inosphere and is not reflected back by the ionosphere. The TV signal having frequency greater than 30 *MHz* therefore cannot be propagated through sky wave propagation.

In case of sky wave propagation, critical frequency is defined as the highest frequency is returned to the earth by the considered layer of the ionosphere after having sent straight to it. Above this frequency, a wave will penetrate the inosphere and is not reflected by it.

20. (c) The television signals being of high frequency are not reflected by the ionosphere. So the T.V. signals are broadcasted by tall antenna to get large coverage, but for transmission over large distance satellites are needed. That is way, satellites are used for long distance T.V. transmission.

21. (e) We know, with increase in altitude, the atmospheric pressure decreases. The high energy particles (*i.e.* γ-rays and cosmic rays) coming from outer space and entering out earth's atmosphere cause ionisation of the atoms of the gases present there. The ionising power of these radiation decreases rapidly as they approach to earth, due to increase in number of collisions with the gas atoms. It is due to this reason the electrical conductivity of earth's atmosphere increase with altitude.

22. (a) In a radar, a beam signal is needed in particular direction which is possible if wavelength of wave is very small. Since the wavelength of microwaves is a few millimeter, hence they are used in radar.

23. (c) Hertz experimentally observed that the production of spark between the detector gap is maximum when it is placed parallel to source gap. This means that the electric vector of radiation produced by the source gap is parallel to the two gaps *i.e.,* in the direction perpendicular to the direction of propagation of the radiation.

24. (d) The atoms of the metallic container are set into forced vibrations by the microwaves. Hence, energy of the microwaves is not efficiently transferred to the metallic container. Hence food in metallic containers cannot be cooked in microwave oven. Normally in microwave oven the energy of waves is transferred to the kinetic energy of the molecules. This raises the temperature of any food.

25. (c) The earth's atmosphere is transparent to visible light and radio waves, but absorbs X-rays. Therefore X-rays telescope cannot be used on earth surface.

26. (b) Short wave (wavelength 30 *km* to 30 *cm*). These waves are used for radio transmission and for general communication purpose to a longer distance from ionosphere.

27. (b) The wavelength of these waves ranges between 4000 Å to 100 Å that is smaller wavelength and higher frequency. They are absorbed by atmosphere and convert oxygen into ozone. They cause skin diseases and they are harmful to eye and cause permanent blindness.

28. (d) Ozone layer in the stratosphere helps in protecting life of organism from ultraviolet radiation on earth. Ozone layer is depleted due to of several factors like use of chlorofluoro carbon (CFC) which is the cause of environmental damages.

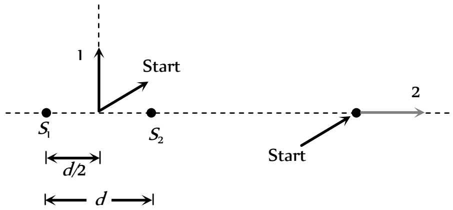
29. (b) Radio waves can be polarised becomes they are transverse in nature. Sound waves in air are longitudinal in nature.

30. (a) In the absence of atmosphere, all the heat will escape from earth's surface which will make earth in hospitably cold.

Wave Optics

SET Self Evaluation Test -30

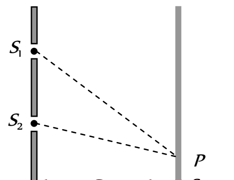
1. Following figure shows sources S_1 and S_2 that emits light of wavelength λ in all directions. The sources are exactly in phase and are separated by a distance equal to 1.5λ. If we start at the indicated start point and travel along path 1 and 2, the interference produce a maxima all along



(a) Path 1 (b) Path 2

(c) Any path (d) None of these

2. In a Young's double slit experimental arrangement shown here, if a mica sheet of thickness t and refractive index μ is placed in front of the slit S_1, then the path difference $(S_1P - S_2P)$



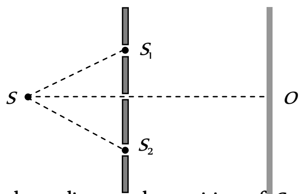
(a) Decreases by $(\mu - 1)t$

(b) Increases by $(\mu - 1)t$

(c) Does not change

(d) Increases by μt

3. In the set up shown in Fig the two slits, S_1 and S_2 are not equidistant from the slit S. The central fringe at O is then



(a) Always bright

(b) Always dark

(c) Either dark or bright depending on the position of S

(d) Neither dark nor bright.

4. The intensity ratio of two coherent sources of light is p. They are interfering in some region and produce interference pattern. Then the fringe visibility is

(a) $\frac{1+p}{2\sqrt{p}}$ (b) $\frac{2\sqrt{p}}{1+p}$

(c) $\frac{p}{1+p}$ (d) $\frac{2p}{1+p}$

5. Three waves of equal frequency having amplitudes $10\mu m$, $4\mu m$, $7\mu m$ arrive at a given point with successive phase difference of $\frac{\pi}{2}$, the amplitude of the resulting wave in μm is given by

(a) 4 (b) 5
(c) 6 (d) 7

6. Four different independent waves are represented by

(i) $y_1 = a_1 \sin\omega t$ (ii) $y_2 = a_2 \sin 2\omega t$

(iii) $y_3 = a_3 \cos\omega t$ (iv) $y_4 = a_4 \sin\left(\omega t + \frac{\pi}{3}\right)$

With which two waves interference is possible

(a) In (i) and (iii) (b) In (i) and (iv)

(c) In (iii) and (iv) (d) Insufficient data to predict.

7. A beam of light consisting of two wavelengths 650 *nm* and 520 *nm* is used to illuminate the slit of a Young's double slit experiment. Then the order of the bright fringe of the longer wavelength that coincide with a bright fringe of the shorter wavelength at the least distance from the central maximum is

(a) 1 (b) 2

(c) 3 (d) 4

8. Two identical radiators have a separation of $d = \lambda / 4$ where λ is the wavelength of the waves emitted by either source. The initial phase difference between the sources is $\pi / 4$. Then the intensity on the screen at a distant point situated at an angle $\theta = 30°$ from the radiators is (here I_o is intensity at that point due to one radiator alone)

(a) I_o (b) $2I_o$

(c) $3I_o$ (d) $4I_o$

9. In Young's double slit experiment, the $8th$ maximum with wavelength λ_1 is at a distance d_1 from the central maximum and the $6th$ maximum with a wavelength λ_2 is at a distance d_2. Then (d_1 / d_2) is equal to

(a) $\frac{4}{3}\left(\frac{\lambda_2}{\lambda_1}\right)$ (b) $\frac{4}{3}\left(\frac{\lambda_1}{\lambda_2}\right)$

(c) $\frac{3}{4}\left(\frac{\lambda_2}{\lambda_1}\right)$ (d) $\frac{3}{4}\left(\frac{\lambda_1}{\lambda_2}\right)$

10. Light of wavelength $500\,nm$ is used to form interference pattern in Young's double slit experiment. A uniform glass plate of refractive index 1.5 and thickness $0.1\,mm$ is introduced in the path of one of the interfering beams. The number of fringes which will shift the cross wire due to this is

(a) 100 (b) 200

(c) 300 (d) 400

11. The two coherent sources of equal intensity produce maximum intensity of 100 units at a point. If the intensity of one of the sources is reduced by 36% by reducing its width then the intensity of light at the same point will be

(a) 90 (b) 89

(c) 67 (d) 81

12. The path difference between two interfering waves of equal intensities at a point on the screen is $\frac{\lambda}{4}$. The ratio of intensity at this point and that at the central fringe will be

(a) 1 : 1 (b) 1 : 2

(c) 2 : 1 (d) 1 : 4

13. In a Young's double slit experiment, I_o is the intensity at the central maximum and β is the fringe width. The intensity at a point P distant x from the centre will be

(a) $I_o \cos\frac{\pi x}{\beta}$ (b) $4I_o \cos^2\frac{\pi x}{\beta}$

(c) $I_o \cos^2\frac{\pi x}{\beta}$ (d) $\frac{I_o}{4}\cos^2\frac{\pi x}{\beta}$

14. In a Fresnel's diffraction arrangement, the screen is at a distance of 2 meter from a circular aperture. It is found that for light of wavelengths λ_1 and λ_2, the radius of $4th$ zone for λ_1 coincides with the radius of 5th zone for λ_2. Then the ratio $\lambda_1 : \lambda_2$ is

(a) $\sqrt{4/5}$ (b) $\sqrt{5/4}$

(c) $5/4$ (d) $4/5$

15. If n represents the order of a half period zone, the area of this zone is approximately proportional to n^m where m is equal to

(a) Zero (b) Half

(c) One (d) Two

16. A screen is placed $50\,cm$ from a single slit, which is illuminated with $6000Å$ light. If distance between the first and third minima in the diffraction pattern is $3\,mm$, the width of the slit is

(a) $0.1\,mm$ (b) $0.2\,mm$

(c) $0.3\,mm$ (d) $0.4\,mm$

17. In Young's double slit experiment, the fringes are displaced by a distance x when a glass plate of one refractive index 1.5 is introduced in the path of one of the beams. When this plate in replaced by another plate of the same thickness, the shift of fringes is $(3/2)x$. The refractive index of the second plate is

(a) 1.75 (b) 1.50

(c) 1.25 (d) 1.00

18. Two waves of equal amplitude and frequency interfere each other. The ratio of intensity when the two waves arrive in phase to that when they arrive $90°$ out of phase is

(a) 1 : 1 (b) $\sqrt{2}$: 1

(c) 2 : 1 (d) 4 : 1

19. In Young's double slit experiment, we get 60 fringes in the field of view of monochromatic light of wavelength $4000Å$. If we use monochromatic light of wavelength $6000Å$, then the number of fringes obtained in the same field of view is

(a) 60 (b) 90

(c) 40 (d) 1.5

20. A parallel plate capacitor with plate are A and seperation between the plates d, is charged by a constant current i, consider a plane surface of area $A/2$ parallel to the plates and drawn symmetrically between the plates, the displacement current through this area, will be.

(a) i (b) $\frac{i}{2}$

(c) $\frac{i}{4}$ (d) None of these

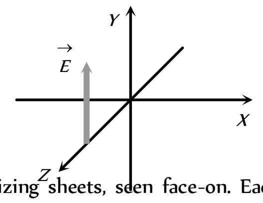
21. The figure here gives the electric field of an EM wave at a certain point and a certain instant. The wave is transporting energy in the negative z direction. What is the direction of the magnetic field of the wave at that point and instant

(a) Towards + X direction

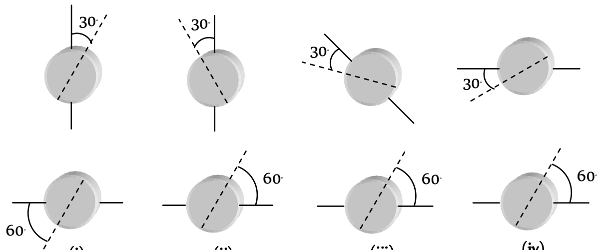
(b) Towards – X direction

(c) Towards + Z direction

(d) Towards – Z direction



22. The figure shows four pairs of polarizing sheets, seen face-on. Each pair is mounted in the path of initially unpolarized light. The polarizing direction of each sheet (indicated by the dashed line) is referenced to either a horizontal x-axis or a vertical y axis. Rank the pair according to the fraction of the initial intensity that they pass, greatest first



(a) (i) > (ii) > (iii) > (iv) (b) (i) > (iv) > (ii) > (iii)

(c) (i) > (iii) > (ii) > (iv) (d) (iv) > (iii) > (ii) > (i)

23. An astronaut floating freely in space decides to use his flash light as a rocket. He shines a 10 *watt* light beam in a fixed direction so that he acquires momentum in the opposite direction. If his mass is 80 *kg*, how long must he need to reach a velocity of 1 ms^{-1}

(a) 9 *sec* (b) 2.4×10^{3} *sec*

(c) 2.4×10^{6} *sec* (d) 2.4×10^{9} *sec*

Answers and Solutions

(SET -30)

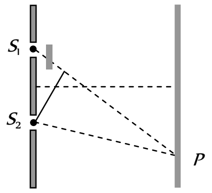
1. (a) At any point along the path 1, path difference between the waves is 0.

Hence maxima is obtained all along the path 1.

At any point along the path 2, path difference is 1.5 λ which is odd multiple of $\frac{\lambda}{2}$, so minima is obtained all along the path 2.

2. (b) Path difference at P $\Delta = (S_1P + (\mu - 1)t) - S_2P$

$=(S_1P - S_2P) + (\mu - 1)t$



3. (c) If path difference $\Delta = (SS_1 + S_1O) - (SS_2 + S_2O) = n\lambda$ n = 0, 1, 2, 3, ... the central fringe at O is a bright fringe and if the path difference $\Delta = \left(n - \frac{1}{2}\right)\lambda$, n = 1, 2, 3, ... the central bright fringe will be a dark fringe.

4. (b) $\text{Visibility } V = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{I_1 I_2}}{(I_1 + I_2)}$

$= \frac{2\sqrt{I_1 / I_2}}{\left(\frac{I_1}{I_2} + 1\right)} = \frac{2\sqrt{P}}{(P+1)}$

5. (b) The amplitudes of the waves are

a_1 = 10 μm, a_2 = 4 μm and a_3 = 7μm

and the phase difference between 1st and 2nd wave is $\frac{\pi}{2}$ and that between 2nd and 3rd wave is $\frac{\pi}{2}$. Therefore, phase difference between 1st and 3rd is π. Combining 1st with 3rd, their resultant amplitude is given by

$A_1^2 = a_1^2 + a_3^2 + 2a_1a_3\cos\phi$

or $A_1 = \sqrt{10^2 + 7^2 + 2\times 10\times 7\cos\pi} = \sqrt{100 + 49 - 140}$

$= \sqrt{9} = 3\mu m$ in the direction of first.

Now combining this with 2nd wave we have, the resultant amplitude

$A^2 = A_1^2 + a_2^2 + 2A_1a_2\cos\frac{\pi}{2}$

or $A = \sqrt{3^2 + 4^2 + 2\times 3\times 4\cos 90^o} = \sqrt{9+16} = 5\mu m$

6. (d) Since the sources are independent, interference will not occur unless they are coherent (such as laser beams *etc*). So, insufficient data to predict.

7. (d) $n\beta_1 = (n+1)\beta_2$

$\Rightarrow \frac{n\times 650\times 10^{-19} D}{d} = \frac{(n+1)\times 520\times 10^{-19}\times D}{d}$

$\Rightarrow n = 4$

8. (b) The intensity at a point on screen is given by

$I = 4I_0\cos^2(\phi/2)$

where ϕ is the phase difference. In this problem ϕ arises (i) due to initial phase difference of $\pi/4$ and (ii) due to path difference for the observation point situated at $\theta = 30^o$. Thus

$\phi = \frac{\pi}{4} + \frac{2\pi}{\lambda}(d\sin\theta) = \frac{\pi}{4} + \frac{2\pi}{\lambda}.\frac{\lambda}{4}(\sin 30°) = \frac{\pi}{4} + \frac{\pi}{4} = \frac{\pi}{2}$

Thus $\frac{\phi}{2} = \frac{\pi}{4}$ and $I = 4I_0\cos^2(\pi/4) = 2I_0$

9. (b) Position of n^{th} maxima from central maxima is given by $x_n = \frac{n\lambda D}{d}$

$\Rightarrow x_n \propto n\lambda \Rightarrow \frac{d_1}{d_2} = \frac{n_1\lambda_1}{n_2\lambda_2} = \frac{8\lambda_1}{6\lambda_2} = \frac{4}{3}\left(\frac{\lambda_1}{\lambda_2}\right)$

10. (a) The number of fringes shifting is decided by the extra path difference produced by introducing the glass plate. The extra path difference is $(\mu - 1)\,t = n\lambda$

or $(1.5 - 1)\times 0.1\times 10^{-3} = n\times 500\times 10^{-9}$

$\Rightarrow n = 100$

11. (d) Intensity of each source $= I_0 = \frac{100}{4} = 25\,unit$

If the intensity of one of the source is reduced by 36% then

$I_1 = 25\,unit$ and $I_2 = 25 - 25\times\frac{36}{100} = 16\,(unit)$

Hence resultant intensity at the same point will be

$I = I_1 + I_2 + 2\sqrt{I_1I_2} = 25 + 16 + 2\sqrt{25\times 16} = 81\,unit$

12. (b) By using $I = 4I_0\cos^2\left(\frac{\phi}{2}\right) = 4I_0\cos^2\left(\frac{\pi\Delta}{\lambda}\right)$

$\left\{\because \phi = \frac{2\pi}{\lambda}\Delta\right\}$

$\Rightarrow \frac{I_1}{I_2} = \frac{\cos^2\left(\frac{\pi\Delta_1}{\lambda}\right)}{\cos^2\left(\frac{\pi\Delta_2}{\lambda}\right)} = \frac{\cos^2\left(\frac{\pi.\frac{\lambda}{4}}{\lambda}\right)}{\cos^2(0)} = \frac{1}{2}$

13. (c) Path difference at point $P = \frac{xd}{D}$

Phase difference at point $P = \frac{2\pi}{\lambda}\frac{xd}{D} = \frac{2\pi x}{\beta}$

$I_0 = 4I_1$, intensity at point P

$I = I_1 + I_1 + 2I_1\cos\frac{2\pi x}{\beta} = 2I_1\left[1 + \cos\frac{2\pi x}{\beta}\right]$

$= I_0\cos^2\frac{\pi x}{\beta}$

14. (c) It is given that $r_4 = \sqrt{4b\lambda_1}$ and $r_5 = \sqrt{5b\lambda_2}$ are equal. Therefore $\sqrt{4b\lambda_1} = \sqrt{5b\lambda_2}$

or $4b\lambda_1 = 5b\lambda_2$

or $\frac{\lambda_1}{\lambda_2} = \frac{5}{4}$.

15. (a) Area of half period zone is independent of order of zone. Therefore, m is equal to zero in n.

16. (b) Position of n^{th} minima $y_n = \frac{n\lambda D}{d}$

$\Rightarrow (y_3 - y_1) = \frac{\lambda D}{d}(3-1) = \frac{2\lambda D}{d}$

$\Rightarrow 3\times10^{-3} = \frac{2\times6000\times10^{-10}\times0.5}{d}$

$\Rightarrow d = 0.2\times10^{-3} m = 0.2\, mm$

17. (b) Fringe shift is given by $x = \frac{(\mu-1)t\,\beta}{\lambda}$

For first plate, $x = \frac{(\mu_1 - 1)t\,\beta}{\lambda}$

For second plate $\frac{3}{2}x = \frac{(\mu_2-1)t\beta}{\lambda}$

$\Rightarrow \left(\frac{\mu_2-1}{\mu_1-1}\right) = \frac{3}{2} \Rightarrow \left(\frac{\mu_2-1}{1.5-1}\right) = \frac{3}{2}$

$\Rightarrow \mu_2 = 1.75$

18. (c) Resultant intensity $I = 4I_0\cos^2(\phi/2)$

$\Rightarrow \frac{I_1}{I_2} = \frac{\cos^2(\phi_1/2)}{\cos^2(\phi_2/2)} = \frac{\cos^2 0}{\cos^2(90/2)} = \frac{2}{1}$

19. (c) $n_1\lambda_1 = n_2\lambda_2 \Rightarrow 60\times4000 = n_2\times6000 \Rightarrow n_2 = 40$

20. (b) Suppose the charge on the capacitor at time t is Q, the electric field between the plates of the capacitor is $E = \frac{Q}{\varepsilon_0 A}$. The flux through the area considered is $\phi_E = \frac{Q}{\varepsilon_0 A}.\frac{A}{2} = \frac{Q}{2\varepsilon_0}$

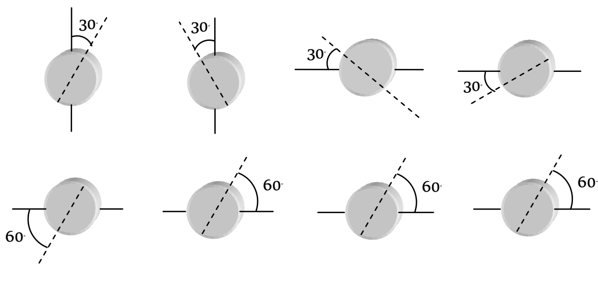
$\therefore$ The displacement current

$i_d = \varepsilon_0\frac{d\phi_E}{dt} = \varepsilon_0\left(\frac{1}{2\varepsilon_0}\right)\frac{dQ}{dt} = \frac{i}{2}.$

21. (a) The direction of EM wave is given by the direction of $\vec{E}\times\vec{B}$.

22. (b) Final intensity of light is given by Brewster's law $I = I_0\cos^2\theta$; where θ = Angle between transmission axes of polariser and analyser.

(i) (ii) (iii) (iv)



Hence decreasing order of intensity is (i) > (iv) > (ii) > (iii)

23. (d) Let it take t *sec* for astronaut to acquire a velocity of 1 ms^{-1}. Then energy of photons = 10 t

Momentum $= \frac{10t}{C} = 80\times1$

$t = \frac{80\times1\times3\times10^8}{10} = 2.4\times10^9\, sec$

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