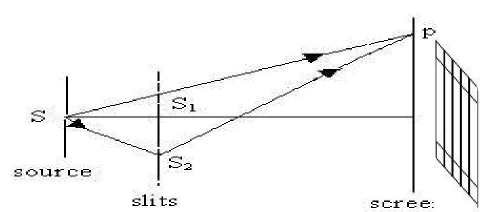
PHYSICAL OPTICS

SYNOPSIS

- **WAVE FRONT:**
  - A continuous locus of all the points which are in the same phase or state of vibration.
  A Point source of light produces a spherical wave front.
  A linear source of light produces a cylindrical wave front
  - Any wave front from a distant source is a plane wave front
- Huygens enunciated a principle to explain how a wave front advances in a medium.
- **HUYGENS' PRINCIPLE:** Every point on the wave front becomes a source of secondary disturbance and generates wavelets which spread out in the medium with the same velocity as that of light in the forward direction only.
  - The envelope of these secondary waves at any instant of time gives the position of the new wave front at that instant.
  - The wave front in medium is always perpendicular to the direction of wave propagation.
- **SUPERPOSITION PRINCIPLE:** When two or more waves travelling in the same region of space superpose one on the other, the total displacement at any point is equal to the vector sum of their individual displacements.
  $Y = y_1 + y_2 + \ ---$
- **INTERFERENCE:**
  When two light waves of same frequency travelling in the same direction superpose with each other, the modification in the distribution of intensity of light in the region of superposition is called Interference.
  - Interference of light is a wave phenomenon when light added to light under suitable conditions may either produce no light or more light depending on the phase difference between the interfering beams. For a steady interference Coherent Sources are required.
  - The source of light emitting wave of same frequency and travelling with either same phase or constant phase difference are called Coherent Sources.
  - Two virtual sources derived from a single source can be used as identical Coherent Sources.
  - The source producing the light wave travelling with rapid and random phase changes are called Incoherent Sources.
  Ex: 1. Light emitted by two candles
  2. Light emitted by two lamps.
- **PATH DIFFERENCE:** The difference in the paths traversed by two light waves emitted by two coherent sources is called path difference.
  - If the path difference is zero or $n\lambda$, where n is an integer, they produce constructive interference.
  If the path difference is $(2n+1)\frac{\lambda}{2}$, where n is an integer, they produce destructive inteference.
- **PHASE DIFFERENCE:** The difference in angles expressed in radians between the waves at the time of arrival at a point is called phase difference.
  - For constructive interference, the phase difference must be $2n\pi$ (where n is an integer)
  - For destructive interference, the phase difference must be $n\pi$ [where n is a non zero integer]
  phase difference = $\frac{2\pi}{\lambda}$ (path difference).
  - The phase difference between any two points on a wave front is always zero.
- **CONDITIONS FOR STEADY INTERFERENCE:**
  - The two sources must be coherent.
  - Two sources must be narrow.
  - Two sources must be close together.
  NOTE: The two sources must be mono chromatic, otherwise the fringes of different colours overlap and hence cannot be observed.
- **YOUNG'S DOUBLE SLIT EXPERIMENT:**
  - Young with his experiment measured the most important characteristic of the light wave i.e wavelength (λ)
  - Young's experiment conclusively established the wave nature of light.



When source illuminates the two slits, the pattern observed on the screen consists of large number of equally spaced bright and dark bands called **"interference fringes"**
- Two light waves of same amplitude a, same angular frequency ω and differing in phase by 'δ' have the displacements
$Y_1 = a \sin \omega t$; $y_2 = a \sin(\omega t + \delta)$
- When two such light waves superpose with each other the resultant amplitude of two waves is
$R = 2a \cos \frac{\delta}{2}$

The resultant intensity of two waves is

$$I = R^2 = 4a^2 \cos^2 \frac{\delta}{2}$$

● When phase difference $\delta = 0, 2\pi, 4\pi, 6\pi, \ldots 2n\pi$ and path difference $x = 0, \lambda, 2\lambda, 3\lambda \ldots n\lambda$ the resultant intensity $I = 4a^2$ which is maximum produces bright point. It is the condition for constructive interference.

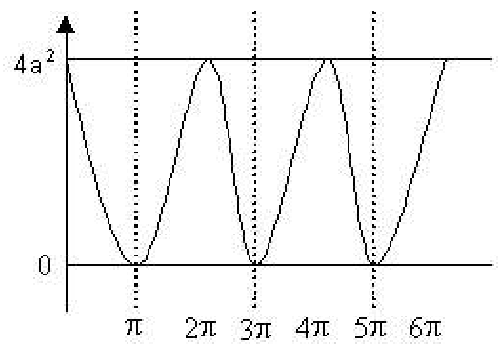
● When phase difference $\delta = \pi, 3\pi, 5\pi, \ldots (2n+1)\pi$ and path difference

$$x = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2} \ldots (2n+1)\frac{\lambda}{2}$$

are observed between the waves the resultant intensity I = 0 which is minimum produces dark point. It is the condition for destructive interference.

● The resultant intensity is $4a^2$ at bright points and minimum at dark points.

● Energy is transferred from the points of minimum intensity to the points of maximum intensity.



- **INTERFERENCE DUE TO UNEQUAL AMPLITUDES:** If two light waves of amplitudes A_1 and A_2 with intensities I_1 and I_2 superpose with each other.

Maximum intensity $I_{max} \alpha \ (\sqrt{I_1} + \sqrt{I_2})^2$

(or) $I_{max} \ \alpha \ (A_1 + A_2)^2$

Minimum intensity $I_{min} \ \alpha \ (\sqrt{I_1} - \sqrt{I_2})^2$

(or) $I_{min} \ \alpha \ (A_1 - A_2)^2$

- **APPLICATIONS OF INTERFERENCE:**

● It is used to determine the wave length of light (λ) precisely.

● To find the thickness or refractive index of transparent sheets.

● To test the flatness and parallelism of plane surfaces.

● In "Holography" to produce three dimensional images.

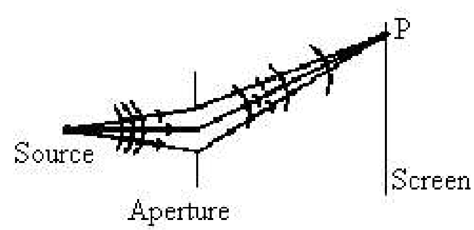
● In calibrating standard meter in terms of wave length of light.

● To minimize the reflective losses in lenses and solar cells by coating them with thin film of MgF_2 and SiO respectively.

● In Michelson Morley experiment to disprove the existence of ether medium.

DIFFRACTION:

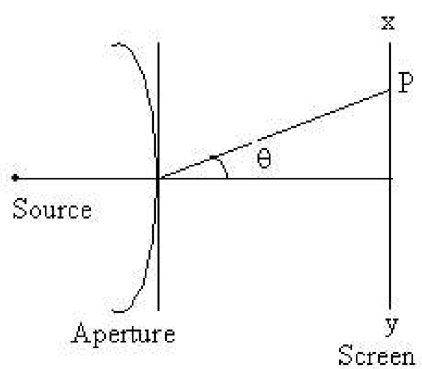
- Bending of wave around obstacles is called diffraction
- Diffraction is a characteristic wave property.
- Diffraction is an effect exhibited by all electromagnetic waves, water waves and sound waves
- Dittraction takes place with very small moving particles such as atoms, neutrons and electrons which show wavelike properties.
- An obstacle kept in between a point source of light and screen produces a dark shadow on screen. The observations of the shadow reveals that
  a. the shadow is not completely dark
  b. edges of shadow are not perfectly black
  c. some light encroaches into the dark zone.
  d. dark fringes are observed in the illuminated zone of the shadow.
- When light passes through a narrow aperture some light is found to be encroached into shadow regions.
- When slit width is larger the encroachment of light is small and negligible.
- When slit width is comparable to wavelength of light the encroachment of light is more
- If the size of obstacle or aperture is comparable with the wave length of light, light deviates from rectilinear propagation near edges of obstacle or aperture and encroaches into geometrical shadow.
- The bending of light around edges of an obstacle on the encroachment of light within geometrical shadow is known as "diffraction of light"
- Diffraction phenomenon is classified into two types
  a)Fresnel diffraction
  b) Fraunhoffer diffraction
- **FRESNEL DIFFRACTION:** The source or screen or both are at finite distances from diffracting device (obstacle or aperture)



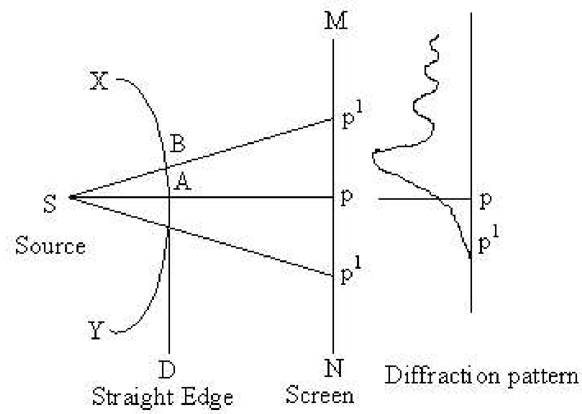
- In Fresnel diffraction, the effect at any point on the screen is due to exposed wave front which may be spherical or cylindrical in shape.
- Fresnel diffraction does not require any lens to modify the beam.

- Fresnel diffraction can be explained in terms of "half period zones or strips"

- **FRAUNHOFER DIFFRACTION:**
The source and the screen are at infinite distance from diffracting device (aperture or obstacle).
  - In Fraunhofer diffraction the wave front meeting the obstacle is plane wave front.
  - Fraunhofer diffraction requires lenses to modify the beam.
- The phenomenon of diffraction was explained by Fresnel combining Huygens' principle and interference of light.
- **FRESNEL'S DIFFRACTION AT A SMALL APERTURE:**
  - Fresnel's diffraction occurs when spherical or cylindrical wave fronts pass through a small aperture
  - The intensity at a point on the screen in front of the aperture depends on
    1. Number of Fresnel's half period zones to which the point is exposed
    2. The distance between point and aperture and
    3. Obliquity factor
  - The obliquity factor α (1+cos θ) where "θ" is the angle between the normal drawn to the screen passing through pole of wave front and the line joining the pole of wave front and the point of interest on the screen



- When θ=0, obliquity factor α 2. Hence intensity becomes maximum.
- When θ = 180^0, obliquity factor = 0. Hence intensity is maximum in forward direction and zero in backward direction.
  - The concept of obliquity factor clearly indicates that secondary wave intensity is maximum in forward direction and zero in backward direction
  - Fresnel's explanation of diffraction strengthens Huygens' principle which states that THERE IS NO BACK WAVE IN PROPAGATION OF LIGHT.
  - According to Fresnel wave front is made up of number of zones(strips or elements) divided in such a way that the path difference between secondary waves coming from corresponding points in adjacent zones is half of the wave length "$\frac{\lambda}{2}$". Hence these zones are called half period zones or half period strips or half period elements.
  - The area of Fresnel's strips on cylindrical wave front decreases with increasing order of strip
- **DIFFRACTION AT A STRAIGHT EDGE:**



- Fresnel diffraction occurs when a cylindrical wave front strikes the straight edge and diffraction pattern forms on the screen in front of it.
- The intensity at any point on the screen will be maximum when odd number of Fresnel zones are present between straight edge and pole of wave front and minimum when even number of zones are present.
- If light exhibits rectilinear propogation the region on the screen below the point "p" i.e. , geometrical shadow region must be completely dark. But this region is illuminated with decreasing intensity as the distance from the point "p" increases.
- The intensity of illumination in the geometrical shadow decreases gradually as more and more half period zones are cut off with increasing distance from the point p^1
- The encroachment of light in geometrical shadow shows that light undergoes diffraction and rectilinear propagation of light is only approximately true.
- **APPLICATIONS OF DIFFRACTION:**

i. diffraction gratings are used to measure wavelength of light.
ii. to measure X- ray wavelength
iii. crystal structure is determined by X- ray diffraction
iv. Velocity of sound in liquids can be determined by ultra sound diffraction.
v. Ultra sound scans make use of diffration to estimate the size & shape of tumors, ulcers etc.,

- **EXAMPLES OF DIFFRACTION:**

  i. A mountain profile just before the sun rise appears to have a silver lining.

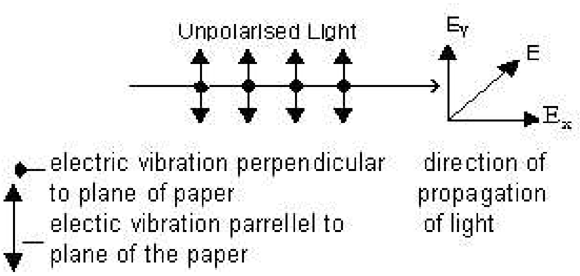
  ii. Light streaks observed when we look at a strong source through half closed eyelids.

  NOTE-1: Interference is due to interaction between two separate wave fronts originating from the two coherent sources while diffraction is due to interaction between the secondary wavelets originating from different points of same wave front.

  NOTE-2: The fringe width in interference may or may not be equal while in diffraction fringe width is never equal.

  NOTE-3: In an interference pattern all the maxima are of same intensity but in a diffraction pattern they are of varying intensity.

- **POLARISATION:**
  - The properties of light, like interference and diffraction demonstrate the wave nature of light.
  - Both longitudinal and transverse waves can exhibit interference and diffraction effects.
  - The properties like polarization can be exhibited only by transverse waves.
  - The peculiar feature of polarized light is that human eye cannot distinguish between polarised and unpolarised light.
  - As light is an electromagnetic wave, among its electric and magnetic vectors only electric vector is mainly responsible for optical effects.
  - The electric vector of wave can be identified as a “light vector”
  - Ordinary light is unpolarised light in which electric vector is oriented randomly in all directions perpendicular to the direction of propagation of light.
    The average amplitude is same in all directions perpendicular to the direction of propagation. Hence the ordinary light is “symmetrical about the direction of propagation.”
  - The electric vector is resolved into two components vibrations E_x and E_y such that the component E_y vibrates perpendicular to the plane of paper.

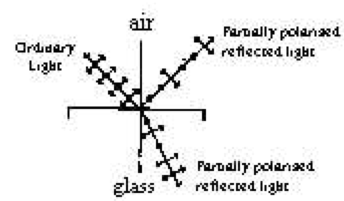


  - The phenomena of confining the vibrations of electric vector to a particular direction perpendicular to the direction of propagation of light is called “Polarisation”. Such polarised light is called linearly polarised or plane polarised light.
  - The plane in which vibrations are present is called the “plane of vibration.”
  - The plane in which vibrations are absent is called “plane of polarisation.”
  - The vibrations of electric vector occur at right angles to the plane of polarisation.
  - Both planes of vibration and polarisation are at right angles to each other.
  - The combination of two plane polarised lights which are at right angles to each other can be considered as “ordinary light”.
  - Plane polarised light can be produced by different methods like

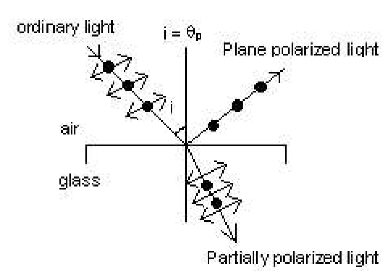
    i. reflection ii. refraction

    iii. double refraction iv. Polaroids.

- **POLARISATION BY REFLECTION:**
  - Malus discovered the polarisation of light by reflection.
  - The ordinary light beam is incident on transparent surface like glass or water. Both reflected and refracted beams get partially polarised.

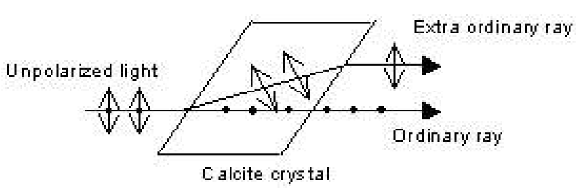


  - The degree of polarisation changes with angle of incidence.
  - At a particular angle of incidence called “polarising angle” the reflected beam gets completely plane polarised. The reflected beam has vibrations of electric vector perpendicular to the plane of paper.
  - The polarising angle depends on the nature of reflecting surface.
  - Law of Malus was later modified by Brewster.
  - According to Brewster when angle of incidence is equal to “polarising angle” the reflected and refracted rays will be perpendicular to each other.
  - Brewster’s law states that “ The refractive index of a medium is equal to the tangent of polarising angle θ_p ”.



- The refractive index of the medium changes with wave length of incident light and so polarising angle will be different for different wave lengths.
- The complete polarisation is possible when incident light is monochromatic.
- From Brewster's law μ = Tan i.
  - If i=θ_p, the reflected light is completely polarised and the refracted light is partially polarised.
  - If i=θ_p, both the reflected and refracted light rays are perpendicular to each other.
  - If i<θ_p or i>θ_p, both reflected and refracted rays get partially polarised.
  - For glass $\theta_p = \tan^{-1}(1.5) \approx 57^0$

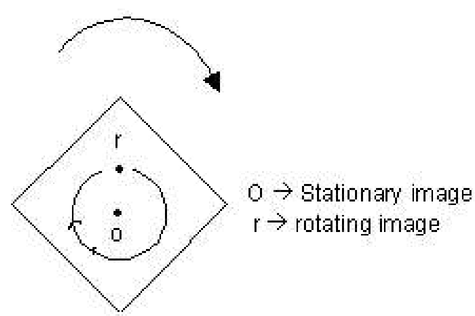
    For water $\theta_p = \tan^{-1}(1.33) \approx 53^0$
- **POLARISATION BY REFRACTION:**
  - The unpolarised light when incident on a glass plate at an angle of incidence equal to the polarising angle, the reflected light is completely plane polarised, but the refracted light is partially polarised.
  - The refracted light gets completely plane polarised if incident light is allowed to pass through number of thin glass plates arranged parallel to each other. Such an arrangement of glass plates is called "pile of plates".
  - The refracted light emerging from the pile of plates will have vibrations in the plane of paper.
  - A pile of plates consists of about 15 – 20 thin glass plates arranged in a tube such that each plate is at angle of 32.5^0 to the axis of the tube.
- **POLARISATION BY DOUBLE REFRACTION:**
  - Bartholinus discovered that when light is incident on a calcite crystal two refracted rays are produced. It is called "double refraction" or "birefringence"
  - When a light ray is incident on the face of a calcite crystal (Iceland spar) the refracted light splits into two refracted rays within the crystal.
    1. ordinary ray 2. extra ordinary ray



  - Calcite crystal is a colourless transparent crystal. It is also known as Iceland spar. It belongs to the rhombohedral class of hexagonal system.
  - A plane which contains the optic axis and is perpendicular to the two opposite faces is called the principal section of crystal
  - The ordinary ray emerging from the calcite crystal obey the laws of refraction and vibrations are perpendicular to the principal section of the crystal.
  - The image due to ordinary ray is called ordinary image.
  - The refractive index of calcite crystal with respect to ordinary ray remains constant.

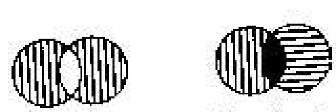
$$\mu_0 = \frac{Sini}{Sinr_0}$$

  - The extra ordinary ray does not obey the laws of refraction and the vibrations are in the plane of principal section of crystal.
  - The image due to extra ordinary ray is called extra ordinary image.
  - The refractive index of calcite crystal with respect to extraordinary ray is not constant for a given pair of media and for a given colour of light. The refractive index of crystal for extra ordinary ray when it travels perpendicular to optic axis is known as μ_e.
  - In the case of calcite crystal $\mu_0 > \mu_e$ because $r_0 < r_e$.
  - Both ordinary and extraordinary rays are plane polarised.
  - An ink dot made on the paper when viewed through calcite crystal two images are seen due to double refraction. On rotating the crystal one image remains stationary and the other image rotates around the stationary image.
  - The rotating image revolves round the stationary image in circular path.
  - The stationary image is formed due to ordinary ray and revolving image is formed by extraordinary ray.
  - The distance between the two images depend on thickness of crystal.



- μ_0 for the calcite crystal is same for all the angles of incidence. Hence ordinary ray travels with same speed in all directions.
- μ_e for the calcite crystal changes with changing angle of incidence. Hence the extra-ordinary ray has different speeds in different directions.

- **POLAROID :**
  - Polaroid is an optical device used to produce plane polarised light making use of the phenomenon of "selective absorption".
  - Certain crystals and minerals which can produce double refraction for incident light have a peculiar property of absorbing one of the double refracting beams. This property of selective absorption is known as "Dichorism".
  - More recent type of polaroids are H-polaroids.
  - H-polaroids are prepared by stretching a film of polyvinyl alcohol three to eight times to original length.
  - When the planes of transmission of two polaroids are parallel the light transmitted by first can also be transmitted by the second and emergent beam is plane polarized.
  - When two polaroids are crossed the transmission of light is not possible. i.e., light gets extinguished.



Parallel polaroids   Crossed polaroids

- **USES OF POLAROIDS:**
  They are used to produce and analyse plane polarised light.
  - They are used as polarisers and analysers
  - They are used in sun glasses to protect the eyes from glare.
  - The window panes of trains and aeroplanes are made of polaroids in order to control the light entering through windows.
  - They are used as filters in photography.
  - The pictures taken by a stereoscopic camera, when seen through Polaroid produces 3-D effect.
  - They are used to prove the colour contrast in old paintings.
- **APPLICATIONS OF POLARISATION:**
  - It is used to test and measure the optical activity of crystals like quartz.
  - To measure the optical activity of organic substances like glucose.
  - It is used to study the helical structure of nucleic acids.
  - Light scattering studies estimate depolarisation of transversely scattered light and help to study size and shape of molecules.

NOTE-1: The property of rotating the plane of vibration of plane polarized light about its direction of travel by some crystals is known as optical activity. This phenomenon is known as optical rotation.

NOTE-2: The substances which show the phenomenon of optical rotation are said to be optically active.

CONCEPTUAL QUESTIONS

WAVE FRONT

1. Which of the following statements are true for light waves but not for sound waves?
(I) The speed of waves is greater in vacuum than in a medium
(II) Waves of different frequencies travel with different speeds in a medium
(III) Waves travel with different speeds in different media.
Choose your answer according to the code given below.
1. (I) and (II)   2. (I) and (III)
3. (II) and (III)   4. (I), (II) and (III)

2. A plane wave front falls on a convex lens. The emergent wave front is
1. Plane   2. Cylindrical
3. Spherical diverging   4. Spherical converging

3. When two light waves meet at a place
1. their displacements add up
2. their intensities add up
3. both will add up
4. Energy becomes zero

4. Which one of the following phenomena is not explained by Huygens' construction of wave front
1.refraction   2.reflection
3.diffraction   4.origin of spectra

INTERFERENCE

5. When interference of light takes place
1. Energy is created in the region of maximum intensity
2. Energy is destroyed in the region of maximum intensity
3. Conservation of energy holds good and energy is redistributed
4. Conservation of energy doesn't hold good

6. For constructive interference to take place between two monochromatic light waves of wavelength λ, the path difference should be
1. $(2n-1)\frac{\lambda}{4}$ 2. $(2n-1)\frac{\lambda}{2}$
3. n/   4. $(2n+1)\frac{\lambda}{3}$

7. For constructive interference between two waves of equal wavelength, the phase angle δ should be such that

1. $\cos^2\frac{\delta}{2}=-1$ 2. $\cos^2\frac{\delta}{2}=0$

3. $\cos^2\frac{\delta}{2}=1$ 4. $\cos^2\frac{\delta}{2}=$ infinite

8. Which of the following can give sustained interference?
1. Two independent laser sources
2. Two independent light bulbs
3. Two sources must be of larger width
4. Two sources must be far away from one other

9. In young's double slit experiment if one of the slits is covered with a thin transparent sheet.
1. at maximum, intensity increases ; at minimum, intensity increases
2. at maximum, intensity decreases ; at minimum, intensity decreases
3. at maximum intensity increases; at minimum, intensity decreases
4. at maximum intensity decreases; at minimum intensity increases

10. When viewed in white light, soap bubble show colours because of
1. Interference 2. Scattering
3. Diffraction 4. Dispersion

11. When petrol drops from a vehicle fall over rain water on road surface colours are seen because of
1. Dispersion of light 2. Interference of light
3. Scattering of light 4. Absorption of light

12. Two coherent waves each of amplitude 'a' traveling with a phase difference δ when superpose with each other the resultant intensity at a given point on the screen is

1. $a^2(1+\cos\delta)$ 2. $4a^2(1+\cos\delta)$

3. $2a^2(1+\cos\delta)$ 4. $(1+\cos\delta)$

13. Michelson's interferometer is used to
1. Find density of a liquid
2. Find energy of a photon
3. Find velocity of light
4. Find critical angle of medium

14. Interference is produced with two coherent sources of same intensity. If one of the sources is covered with a thin film so as to reduce the intensity of light coming out of it to half, then
1. Bright fringes will be less bright and dark fringes will be less dark
2. Bright fringes will be more bright and the dark fringes will be more dark
3. Brightness of both types of the fringes will remain the same
4. Dark region will spread completely

15. 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
1. no interference
2. interference with central bright band
3. interference with central dark band
4. interference in which breadth of the fringe will be slightly increased.

16. For the sustained interference of light, the necessary condition is that the two sources should
1. have constant phase difference
2. be narrow
3. be close to each other
4. of same amplitude with constant phase difference

17. Laser light is considered to be coherent because it consists of
1. many wavelengths
2. uncoordinated wavelengths
3. coordinated waves of exactly the same wavelength
4. divergent beams

18. In Young's double slit experiment, the intensity at the center of screen is
1. equal to the intensity of each source
2. equal to twice the intensity of each source
3. half the intensity of each source
4. four times the intensity of each source

19. Interference fringes in Young's double slit experiment are
1. always equispaced
2. always unequally spaced
3. both equally and unequally spaced
4. formed by a portion of the wave front.

20. In young's experiment with white light central fringe is white. If now a transparent film is introduced in the upper beam coming from the top slit, the white fringe
1. moves down ward 2. moves upward
3. remains at the same place
4. totally disappears

21. In Young's double slit experiment
1. only interference occurs
2. only diffraction occurs
3. both interference and diffraction occurs
4. polarisation occurs

22. Thickness of very thin films can be found by the technique
1.Dispersion 2.Interference
3.polarization 4.Diffraction

23. Two coherent waves are represented by $y_1=a_1\cos\omega t$ and $y_2=a_2\sin\omega t$. The resultant intensity due to interference will be

1. $\left(a_1^2-a_2^2\right)$ 2. $\left(a_1^2+a_2^2\right)$

3. (a_1-a_2) 4. (a_1+a_2)

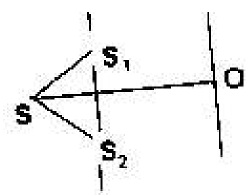
24. The amplitude of two interfering waves are 'a' and '2a' respectively. The resultant amplitude in constructive interference will be
1.5a 2.a 3.3a 4.2a

25. In an interference pattern produced by two identical slits, the intensity at the site of the central maximum is I. The intensity at the same spot when either of the two slits is closed is I_0. We must have
1. $I = I_0$ 2. $I = 2I_0$
3. $I = 4I_0$ 4. I & I_0 are not related

26. Four different independent waves are represented by
1. $Y_1=a_1 \sin \omega_1 t$ 2. $y_2=a_2 \sin \omega_2 t$
3. $y_3=a_3 \sin \omega_3 t$ 4. $y_4=a_4 \sin (\omega t + \pi/3)$
The interference is possible due to
1. 1&3 2. 1&4
3. 3&4 4. not possible with any combination

27. In young's double slit experiment the slits are of different length and widths. The amplitude of the light waves is directly proportional to the
1. length of the slit 2. distance between the slits 3. area of the slits 4. width of slits

28. In the set up shown, the two slits ***S_1 and S_2 are*** not equidistant from the slit S.



The central fringe at O is then
1. always bright 2. always dark
3. either dark or bright depending on the position of S.
4. neither dark nor bright

29. The phase difference between two waves from successive half period zones or strips is
1. $\pi/4$ 2. $\pi/2$ 3. π 4. zero.

DIFFRACTION

30. Diffraction of light was discovered by
1. Young 2. Hertz 3. Girmaldi 4. Malus

31. The bending of light about corners of an obstacle is called
1. Dispersion 2. Refraction
3. Deviation 4. Diffraction

32. The diffraction of light by an aperture can become more pronounced
1. If the wavelength of light is either increased or decreased
2. If the aperture is made narrower
3. If the aperture is made wider
4. All the above

33. The class of diffraction in which the incident and diffracted wave fronts are spherical is called
1. Fraunhofer diffraction 2. Fresnel diffraction
3. Huygen's diffraction 4. Newton's diffraction

34. To observe diffraction, the size of an obstacle
1. Should be of the same order as wave length
2. Should be much larger than the wave length
3. Has no relation to wave length
4. May be greater or smaller than the wave length

35 The class of diffraction in which incident and diffracted wave fronts are planar is called
1. Fresnel diffraction 2. Fraunhofer diffraction
3. Huygen's diffraction 4. Newton's diffraction

36. In diffraction pattern
1. The fringe widths are equal
2. The fringe widths are not equal
3. The fringes can not be produced
4. The fringe width may or may not be equal

37. According to Fresnel's assumptions in diffraction pattern,
1. Light propagates in the form of transverse waves
2. Light propagates in the form of stationary waves
3. Rectilinear propagation of light is approximately true
4. Rectilinear propagation of light is absolutely true

38. Neutron diffraction pattern is used to determine
1. Density of solids
2. Atomic number of elements
3. Crystal structure of solid
4. Refractive index of liquid

39. Sun light filtering through a tree leaves often makes circular patches on the ground because
1. The sun is round
2. The space through which light penetrates is round
3. Light is transverse in nature
4. Of diffraction effects

40. The amplitude modulated (AM) radio wave bends appreciably round the corners of a 1m x 1m board but the frequency modulated (FM) wave only negligibly bends. If the average wavelengths of AM and FM waves are λ_a and λ_f then,
1. $\lambda_a = \lambda_f$ 2. $\lambda_a < \lambda_f$ 3. $\lambda_a > \lambda_f$
4. Sufficient information is not available to decide about the relation of $\lambda_a > \lambda_f$

41. In studying diffraction pattern of different obstacles, the effect of
1. full wave front is studied
2. portion of a wave front is studied
3. waves from two coherent sources is studied
4. waves from one of the coherent source is studied.

42. Among the Fresnel zones the operative zones contributing intensity are
1. last zones 2. first few zones
3. middle zones 4. all the zones

43. The average path difference between two waves coming from third and fifth fresnel zones of a wave front at the centre of the screen is
1. $\frac{\lambda}{2}$ 2. 2λ 3. λ 4. 4λ

44. Crystalline structure of solids can be studied by using the method of
1. Diffraction 2. Interference
3. polarization 4. Refraction

45. One of the following statements is correct. Pick out the one
1.Diffraction can not take place without interference
2.Interference will not take place with out diffraction.
3.Interference and diffraction are the result of polarization
4.The fringe width in Young's double slit experiment does not depends on the wave length.

POLARISATION

46. Waves that cannot be polarised are
1. Longitudinal 2. Transverse
3. Electromagnetic 4. Light

47. Human eye
1. Can detect polarised light
2. Can not detect polarisation of light
3. Can detect only circularly polarised light
4. Can detect only linearly polarised light

48. Polarisation of light was first successfully explained by
1. Corpuscular theory
2. Huygens' wave theory
3. Electromagnetic wave theory
4. Planck's theory

49. Plane of polarisation is
1. The plane in which vibrations of the electric vector takes place
2. A plane perpendicular to the plane in which vibrations of the electric vector takes place
3. Is perpendicular to the plane of vibration
4. 2 and 3

50. The Polaroid is
1. Celluloid film 2. Big crystal
3. Cluster of small crystal arranged in a regular way
4. Cluster of small crystals arranged in a haphazard way

51. In the propagation of polarised light waves, the angle between the plane of vibration and the plane of polarization is
1. 0^0 2. 90^0 3. 45^0 4. 180^0

52. Bartholinus discovered
1. Interference by splitting the wave front
2. Polarisation by reflection
3. Polarisation by refraction
4. Polarisation by double refraction

53. Pile of plates can be used to produce completely polarised light due to
1. Reflection 2. Refraction
3. Double refraction 4. 1 and 2

54. A pile of plates to produce polarised light by refraction contains the glass plates kept inclined to the axis of tube at an angle
1. 57.5^0 2. 67^0 3. 90^0 4. 32.5^0

55. 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 index of glass with respect to air the angle between the reflected and the refracted rays is
1. $(90+\phi)$ 2. 90^0
3. $\sin^{-1}(4\cos\phi)$ 4. $\sin^{-1}\left(\frac{\sin\phi}{4}\right)$

56. In double refraction, the stationary image can be produced by
1. O-ray 2. E-ray
3. Both O-ray and E-ray combined together
4. None

57. In double refraction
1. The velocity of the E-ray varies with direction
2. E-ray does not obey Snell's law
3. m of E-ray is constant 4. 1 and 2

58. When two Polaroid sheets are crossed perpendicular to each other
1. Light gets completely transmitted
2. Light gets completely extinguished
3. Light causes harm to the human eye
4. Alternate bright and dark bands can be seen

59. The helical structures of nucleic acids can be studied by using
1. Interference phenomenon
2. Diffraction pattern 3. Polarised light
4. Photoelectric effect

60. In the light emerging from calcite crystal
1. Both O-ray and E-ray are partially polarised
2. Both O-ray and E-ray are completely polarised
3. O-ray is partially polarised and E-ray is completely polarised.
4. O-ray is completely polarised and E-ray is partially polarised.

61. A calcite crystal is placed over a dot on a piece of paper and rotated, on seeing through the calcite, one will see
1. One dot 2. Two stationary dots
3. Two rotating dots
4. One dot rotating about the other

62. Polaroid glass is used in sun glasses because
1. It reduced the light intensity to half on account of polarisation
2. It is fashionable
3. It has good colour 4. It is cheaper

63. In Plane polarized light the orientation of electric field vector is,
1.symmetrical about the direction of propagation
2. asymmetric about the direction of propagation
3. Parallel to the direction of propagation
4. Unsteady

64. when unpolarised light passes through a Polaroid sheet the beam that emerges from it is plane polarized. This is due to selective
1.absorption of the O-Ray
2.absorption of the E-Ray
3.absorption of the E & O Rays
4.reflection of one of the rays

65. In propagation of electromagnetic waves the angle between the direction of propagation and plane of polarization is
1.)0^0 2. 45^0 3.90^0 4.180^0

66. When an unpolarised light is polarized, then the intensity of light of the polarized wave
1.remains same 2.doubled
3.halved 4.depends on the colour of the light.

67. The wavelength of light play no role in
1.interference 2.diffraction 3.polarization
4.resolving power

68. Choose the correct statement.
1.the Brewster's angle is independent of wavelength of light.
2.the Brewster's angle is independent of the nature of reflecting surface
3.the Brewster's angle is different for different wavelengths
4.Brewster's angle depends on wavelength but not on the nature of reflecting surface.

69. Unpolarising light falls on two polarizing sheets so oriented that no light is transmitted. If a third polarizing sheet is placed between them; not parallel to either of two sheets in question
1.no light is transmitted.
2.some light is transmitted
3.light may or may not be transmitted
4.certainly 50% light is transmitted.

70. Plane polarized light is passed through a Polaroid. Now the Polaroid is given one complete rotation about the direction of light propagation. When viewed through the Polaroid, one of the following is observed.
1.The intensity of light gradually decreases to zero and then remains as zero.
2.The intensity of light becomes maximum twice and zero twice
3.The intensity of light becomes maximum and stays maximum.
4.Intensity of light does not change.

71. O-beam and E-beam, if superpose
1. Can produce interference
2. Cannot produce interference
3. Diffraction fringes will result.
4. Partially polarized light will be produced

72. The polarising angle for glass is
1. same for different kinds of glass
2. different for different kinds of glass
3. same for lights of all colours
4. varies with time

KEY

1. 1	2. 4	3. 1	4. 4	5. 3
6. 3	7. 3	8. 1	9. 4	10. 1
11. 2	12. 3	13. 3	14. 1	15. 2
16. 4	17. 3	18. 4	19. 1	20. 2
21. 3	22. 2	23. 2	24. 3	25. 3
26. 4	27. 3	28. 3	29. 3	30. 3
31. 4	32. 2	33. 2	34. 1	35. 2
36. 2	37. 3	38. 3	39. 4	40. 3
41. 2	42. 4	43. 3	44. 1	45. 1
46. 1	47. 2	48. 3	49. 4	50. 3
51. 2	52. 4	53. 2	54. 4	55. 2
56. 1	57. 4	58. 2	59. 3	60. 2
61. 4	62. 1	63. 2	64. 1	65. 1
66. 3	67. 3	68. 3	69. 2	70. 2
71. 2	72. 2			

NUMERICAL QUESTIONS

LEVEL-I

1. Two interfering waves have amplitudes in the ratio 5:1. The ratio of the maximum to the minimum intensity is
1. 25:1 2. 4:9 3. 6:4 4. 9:4

2. Ratio of intensities of two coherent waves are given by 4:1. The amplitudes of the two waves is
1. 2:1 2. 1:2 3. 4:1 4. 1:4

3. In Young's experiment, the ratio of maximum and minimum intensities in the fringe system is 9:1. The ratio of amplitudes of coherent sources is
1. 9:1 2. 3:1 3. 2:1 4. 1:1

4. At the polarising angle (θ_B), angle of refraction is given by
1. 90^0 2. $90+\theta_B$ 3. $90-\theta_B$ 4. $\frac{90}{\theta_B}$

5. If the critical angle of a medium is 30^0 , the polarizing angle for the medium is about
1. $\tan^{-1}(\sqrt{2})$ 2. $\tan^{-1}(2)$
3. $\tan^{-1}(\frac{1}{2})$ 4. $\sin^{-1}(\frac{1}{2})$

6. Sun light is reflected from a calm lake. The reflected light is 100% polarized at a certain instant. The angle between the sun light and the surface of lake is $\left(\tan^{-1}\left(\frac{4}{3}\right) = 53^0 4'\right)$
1. 90^0 2. $53^0 4'$ 3. $36^0 56'$ 4. 45^0

7. A light ray is incident on a transparent medium of μ = 1.732 at the polarising angle. The angle of refraction is
1. 60^0 2. 30^0 3. 45^0 4. 90^0

8. Young's double slit experiment is conducted with light of wavelength λ. The intensity of the bright fringe is I_0. The intensity at a point where path difference is $\lambda/4$ is given by
1. Zero 2. $I_0/8$ 3. $I_0/4$ 4. $I_0/2$

9. A ray of light in air is incident on a glass plate at polarising angle of incidence. It suffers a deviation of 22^0 on entering glass. The angle of polarization is
1. 90^0 2. 56^0 3. 68^0 4. Zero

10. In Young's double slit experiment with monochromatic source of light of wavelength 6000 A^0, if the path difference at a point on the screen is 6×10^{-6}m, the number of the bright band formed at that point is
1. 2 2. 4 3. 6 4. 10

11. In the above problem, if the path difference is 1.5×10^{-6}m, the point becomes
1. bright band 2. dark band
3. sometimes bright and sometimes dark
4. data insufficient.

12. Two light waves are represented by $y_1 = 3\sin\omega t$ and $y_2 = 4\sin\left(\omega t + \frac{\pi}{3}\right)$. The resultant amplitude due to interference will be
1. $\sqrt{21}$ 2. $\sqrt{26}$ 3. $\sqrt{37}$ 4. $\sqrt{41}$

13. Two light waves are represented by $y_1 = a\sin\omega t$ and $y_2 = a\sin(\omega t + \delta)$. The phase of the resultant wave is
1. 2δ 2. $\frac{\delta}{2}$ 3. $\frac{\delta}{3}$ 4. $\frac{\delta}{4}$

14. The amplitudes of two interfering waves are 4 cm and 3 cm respectively. If the resultant amplitude is 1 cm then the interference becomes
1. constructive 2. Destructive
3. Both constructive and destructive
4. given data is insufficient

15. The intensities of two light waves are 9 unit and 4 unit respectively. The ratio of maximum intensity to the minimum intensity is
1. 9:4 2. 4:9 3. 25:1 4. 1:25

KEY

1. 4	2. 1	3. 3	4. 3	5. 2
6. 3	7. 2	8. 4	9. 2	10. 4
11. 2	12. 3	13. 2	14. 2	15. 3

LEVEL - 4

NEW MODEL QUESTIONS

ASSERTION - REASON TYPE QUESTIONS:

Directions:

These questions consist of two statements as Aseertion (A), and Reason(R). While answering these questions you are required to choose any of the following four responses.

A) Both A and R are true and R is the correct explanation of A

B) Both A and R are true but R is not a correct explanation of A

C) A is true R is false

D) A is false and R is true

1. **A:** The phase difference between any two points on a wave front is zero
R: From the source light reaches every point on the wave front in the same time
1. A 2. B 3. C 4. D

2. **A:** In interference pattern intentensity of successive fringes is not same
R: In interference, only redistribution of energy takes place
1. B 2. C 3. D 4. A

3. **A:** In Young's double slit experiment white light is used and slits are covered with red and blue filters respectively. The phase difference at any point on the screen will continuously change and unifrom illumination is produced on the screen
R: Two independent sources of light would no longer act as coherent sources **[2004E]**
1. B 2. A 3. C 4. D

4. **A:** When a tiny circular obstacle is placed in the path of light coming from some distance, a bright spot is seen at the center of the shadow of the obstacle
R: Disrtuctive interference occurs at the center of the shadow **[AIIMS 2002]**
1. A 2. D 3. B 4. C

5. **A:**Coloured spectrum is seen when we look through a muslin cloth
R: Diffraction of light takes place when light is travelling through the pores of cloth
1. D 2. B 3. C 4. A

6. **A:** When unpolarized light is incident on a glass plate the reflected and refracted rays are perpendicular
R: The angle of incidence is equal to the polarizing angle
1. A 2. C 3. D 4. B

MORE THAN ONE ANSWER:

7. When two coherent waves interfere, the maximum and minimum intensities are in the ratio 16 : 25, then
a) the maximum and minimum amplitudes are in the rartio 5 : 4
b) the amplitues of individual waves are in the ratio 9 : 1
c)the intensities of individual waves are in the ratio 41: 9
d) the intensities of individual waves are in the ratio 81 : 1
1) a, b and c are true 2) a,b and d are true
3) a and b are true 4) b and c are true

8. A light of wavelength λ is incident on an object of size b. If a screen is at a distance D from the object. identify the correct condition for the observation of different phenomenon
a) if $b^2 = D\lambda$, Fresnel diffraction ios observed
b) if $b^2 >> D\lambda$, Fraunhoffer diffraction is observed
c) $b^2 << D\lambda$, Fraunhoffer diffraction is observed
d) $b^2 >> D\lambda$, the approximation of geometrical optics is applicable
1) a, b and d are true 2) a,c and d are true
3) a and c are true 4) a and d are true

9. When light is incident on a glass block at polarizing angle
a) reflected ray is plane polarized
b) reflected and refracted rays are perpendicular
c) reflected and refracted rays are partiallly polarized
d) refracted ray is partially polarised
1) a, c and d are correct 2) a, b and d are correct
3) b, c and d are correct 4) a, b and c are correct

10. If μ_o and μ_e are the refractive indices of a double refracting crystal, then
a) $\mu_o < \mu_e$, for quartz crysatal
b) $\mu_o > \mu_e$, for calacite crystal
c) $\mu_o : \mu_e$ is maximum for quartz crystal, when the extrodinary ray moves perpendicular to the optic axis
d) $\mu_o : \mu_e$ is maximum for calacite crystal when the extrodinaryt ray moves perpendicular to the optic axis
1) a, b and c are true 2) a, b and d are true
3) a, c and d are true 4) b, c and d are true

TRUE OR FALSE TYPE QUESTIONS:

11. A: Primary waves can travel in all directions in eather
B: Secondary waves can travel only in backword in eather
1) A is true, B is false 2) Both A and B are true
3) A is false, B is true 4) Both A and B are false

12. A: Radio wave can diffract at the edges of buildings
B: X-rays can diffract at the interiors of a cryustal
1) A is true, B is false 2) Both A and B are true
3) A is false, B is true 4) Both A and B are false

13. A: Fresnel diffraction occurs when the source of light or the screen or both are at a finite distance from the diffracting device
B: Diffracted light can be used to estimate the helical structure of nuclic acids **[2004 E]**
1) A is true, B is false 2) Both A and B are true
3) A is false, B is true 4) Both A and B are false

14. A: In the phenomenon of double refraction ordinary ray obeys snell"s law where as extrodinary ray does not obey snell's law
B: Velocity of extrodinary ray in the negative crystal is greater than for ordinary ray in the same crystal
1) A is true, B is false 2) Both A and B are true
3) A is false, B is true 4) Both A and B are false

MATCH THE FOLLOWING TYPE

15. Match list A and list B accurately

LIST A	LIST B
a) spherical wave front	e) linear souce
b) plane wave front	f) point light source
c) cylindrical wave front	g) at infinite distane
d) electric bulb	h) at finite distance

1) (a, f); (b, g); (c, e); (d, h)
2) (a, f); (b, g); (c, e); (d, f)
3) (a, g); (b, f); (c, h); (d, e)
4) (a, h); (b, g); (c, f); (d, e)

KEY

1. 1	2. 4	3. 2	4. 4	5. 4
6. 1	7. 2	8. 2	9. 2	10. 1
11. 1	12. 2	13.1	14. 1	15. 1

PREVIOUS EAMCET QUESTIONS

1. In Young's double slit interference experiment the wavelength of light used is 6000A^0. If the path difference between Waves reaching a point P on the screen is (2002E)
1.5 micron, then at that point P
1. Second bright band occurs
2. Second dark band occurs
3. Third dark band occurs
4. Third bright band occurs

2. Consider the following statements A & B. Identify the correct choice in the given answers.
(A) The refractive Index of the extra-ordinary ray depends on the angle of incidence in double refraction.
(B) The vibrations of light waves acquire one sidedness for both ordinary and extraordinary rays in double refaraction. (2002E)
1. A & B are Wrong
2.A & B are correct
3. A is correct B is wrong
4. A is wrong B is correct.

3. When two coherent monochromatic light beams of intensities I and 4 I are superposed,the ratio between maximum and minimum intensities in the resultant beam is (2002 M)
1.9:1 2.1:9 3. 4:1 4.1:4

4. Consider the following statements A & B and identify correct choice in the given answers
(A) When light falls on two polaroid sheets having their axes mutually perpendicular, it is completely extinguished.
(B) When polyvinyl alchol is subjected to a large strain the molecules get oriented parallelto the direction of strain and material becomes double refractive. (2002 M)
1. A & B are correct 2. Both A& B are wrong
3. A correct B wrong 4. A wrong B correct

5. Light waves producing interference have their amplitudes in the ratio 3:2. The intensity ratio maximum and minimum of interference fringes is (2001E)
1. 36:1 2. 9:4 3. 25:1 4. 6:4

6. Two light sources are said to be coherent if they emit waves of the same ________1.______and constant __________2.______between them. Choose the appropriate words.
(1993, 96, 99E&M)
1. 1. intensity, 2.wave length
2. 1. wave length, 2. phase difference
3. 1. phase, 2. intensity
4. 1. intensity, 2. phase difference

7. If the critical angle of a crystal is 45^0, the polarising angle is (1988E)

1. $\tan^{-1}\sqrt{2}$ 2. $\tan^{-1}\left(\frac{1}{\sqrt{2}}\right)$ 3. 45^0 4. 37^0

8. In a Laser beam the photons emitted are all (1988E)
1. incoherent 2. coherent
3. of same velocity 4. of same wavelength

9. Two waves having the same wave length and amplitude but having a constant phase difference with time are known as (1987E & M)
1. identical waves 2. incoherent waves
3. coherent waves 4. collateral waves

10. Huygen's wave theory is used (1987E & M)
1. to determine the velocity of light
2. to find the position of the wave front
3. to determine the wavelength of light
4. to find the focal length of a lens.

OTHER ENTRANCE QUESTIONS

11. Light waves spreading from two sources produce interference only if they have (1987)
1. congruence 2. coherence
3. same intensity 4. same amplitude

12. In young's experiment of double slit the intensity of the central bright band is how many times the individual intensity of the interfering waves? (1987.
1. 2 2. 4 3. 6 4. 16

13. Light travels in a straight line because
1. it is not absorbed by atmosphere
2. its velocity is very high
3. diffraction effect is negligible
4. none (Raj PMT 1997)

14. Which of the following is conserved when light waves interfere (AIIMS 2000)
1. momentum 2. amplitude
3. energy 4. intensity

KEY

1. 3	2. 2	3. 1	4. 1	5. 3
6. 2	7. 1	8. 2	9. 3	10. 2
11. 2	12. 2	13.3	14.3	