**Chapter – 10 Wave Optics**

1. **Newton's corpuscular theory of light:**

(i) A luminous source of light emits a stream of extremely small, very light weighed material particles in quick succession in all directions. These particles are called as **corpuscles.**

(ii) The corpuscles travel with velocity of light

(iii) When these corpuscles fall on produce sensation of vision.

(iv) Corpuscles of colours possess different sizes.

(v) Corpuscular theory successfully explains the phenomena like reflection, refraction, rectilinear propagation of light, etc., but fails to explain the phenomena of interference, diffraction and polarisation of light.

(vi) This theory failed due to the following reasons:

(a) The corpuscular theory predict higher velocity of light in denser medium like water as compared to that in a rarer medium as vacuum.

(b) According to this theory, velocity of corpuscles and hence velocity of light increases with rise in temperature. But in practice, velocity of light is independent of temperature.

(c) With the emission of corpuscles, the mass of the source of light should decrease but in practice no such change in mass is detected.

**2. Wavefront:**

(i) The locus of all particles vibrating in the same phase is called a **wavefront**.

(ii) For a point source of light, the wavefront is spherical in shape with source lying at its centre. When the

source of light is linear, then the wavefront takes the cylindrical shape.

(iii) If a point or linear source is placed at infinity then the portion of spherical or cylindrical wavefront in limited or small region, is simply a plane and is called a **plane wavefront**.

**3. Huygens' wave theory:**

(i) Every point on the luminous source of light is a centre of disturbance and gives out waves in all directions. These waves set ether particles into vibrations. The continuous locus of all ether particles vibrating in the same phase is called a wavefront.

(ii) Huygens' principle provides a geometrical method of finding the successive positions of the wavefront as follows:

(a) Every point on the wavefront is a centre of new disturbance giving out secondary wavelets. These secondary wavelets travel out in all directions with the same speed as that of light.

(b) The envelope of these wavelets in the forward direction gives the position of the new wavefront at any subsequent time.

(c) A ray of light is the direction along which light energy travels. It is impossible to separate a ray of light on account of diffraction of light. Though it is usual to represent a ray by a straight line but the ray has a finite width although a straight line has no width.

**4.Maxwell's electromagnetic theory:**

(i) According to Maxwell's e.m. theory, the light waves travel through oscillating electric and magnetic fields whose directions are at right angles to each other. Hence, e.m. waves can travel through vacuum as well as a non-conducting medium.

(ii) In an e.m. wave, the electric vector **E**, magnetic field vector **B** and velocity vector **C** are all mutually perpendicular. **Thus, e.m. waves are transverse in nature**.

(iii) Electromagnetic waves travel through vacuum with a velocity c given by: c = 1/√(μo∈o)

for any other medium v = 1/√(μ∈) ;

**5.Planck's quantum theory:** According to Planck's quantum theory, the light moves in the form of small bundles or packets called **photon**s. The energy of each photon is h*v*, where *v* is the frequency of light and h is Planck’s constant.

**6.Modern theory: dual nature of Light:**

(i) According to modern theory, light consists of both particle and wave properties, i.e., a dual nature.

(ii) The wave properties are manifested in the phenomenon of interference, diffraction and polarisation where light interacts with light.

(iii) The particle nature is more prominent in the phenomenon where light interacts with matter as in phenomena of photoelectric effect, Compton effect, Raman effect, etc.

(iv) **The wave properties of light predominate at low frequencies while corpuscular properties predominate at higher frequencies**.

(v) According to de Broglie, the wavelength of light λ, associated with a moving particle of mass m and velocity v is given by λ, = (h/mv),where h is Planck's constant. The waves associated with material particles are called **matter waves**.

**7. Interference of light:**

(i) When two light waves of same frequency with zero initial phase difference or constant phase difference superimpose over each other, then the resultant amplitude (or intensity) in the region of superimposition is different from the amplitude (or intensity) of individual waves. **This modification in intensity in the region of superposition is called interference.**

(ii) (a) When the resultant intensity is greater than the sum of two individual wave intensities [I > (I1 + I2)],then the interference is said to be **constructive**.

(b) When the resultant intensity is less than the sum of two individual wave intensities [I < (I1 + I2)],then the interference is said to be destructive.

(iii) There is no violation of the law of conservation of energy in interference. Here, the energy from the points of minimum energy is shifted to the points of maximum energy.

(iv) To obtain the stationary interference pattern, **the following conditions** must be fulfilled

(a) The two sources should be **coherent**, i.e., they should vibrate in the same phase or there should be a constant phase difference between them.

(b) The two sources must emit continuously waves of same wavelength and frequency.

(c) The separation between two coherent sources should be small.

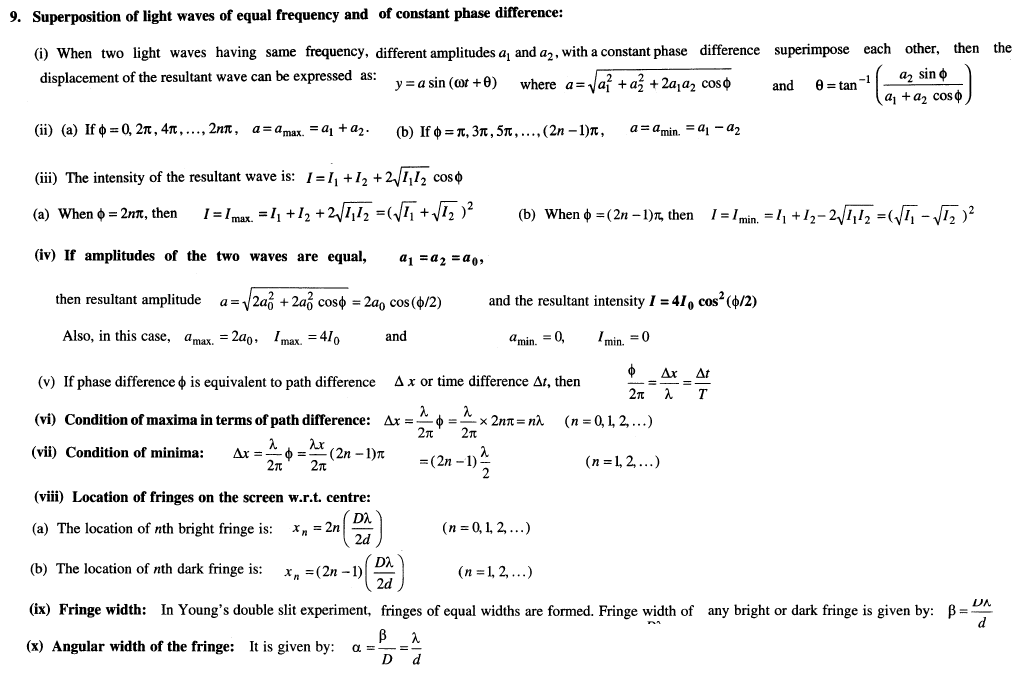
(d) The distance of the screen from the two sources should be large.

(e) For good contrast between maxima and minima, the amplitudes of the two interfering waves Should be as nearly equal as possible and the background should be dark.

(f) For a large number of fringes in the field of view, the sources should be narrow and monochromatic.

**8. Methods of producing coherent sources:**

**(i) Division of wavefront** In this method, the wavefront is divided into two or more parts with the help of mirrors, lenses and prisms. The common methods are Young's double slit arrangement, Fresnel's biprism method, Lloyd's mirror method, etc.

**(ii) Division of amplitude**: In this method, the amplitude of the incoming beam is divided into two or more parts by partial reflection or refraction. These divided parts travel different paths and finally brought together to produce interference. Newton's rings, Michelson's interferometer, etc., are the examples of division of amplitude.

**10. Some other important points concerning Young's interference experiment :**

(i) Although the intensity at maximum is **4Io (**i.e., double of that expected on the basis of average value 2Io) and the intensity at minimum is zero, but **(Imax +Imin)/2 = Iaverage = 2Io**. **This shows that energy is simply redistributed in interference**. Some energy is transferred from the destructive interference region to the constructive interference region.

(ii) If the entire arrangement of Young's double slit experiment is immersed in water, then fringe width decreases.



(iii) (a) It a **monochromatic light source is replaced by a white light** source in Young's interference experiment, then the central fringe is white and some coloured fringes are formed around the central white fringe.

(b) Because λred > λviolet we expect βred >βviolet

(c) At the central position, as path difference is zero, all colours reach at this position in same phase. Their superposition, therefore, gives white fringe at the centre. Since, βred >βviolet etc., the bright fringe of violet (or blue) colour forms first and that of red forms later.

(d) Inner edge of the dark fringe is red, while the outer edge is violet (or blue). Similarly, the inner edge of the bright fringe is violet (or blue) and the outer edge is red.

(iv) **If a filter allowing only wavelength of red colour is placed infront of slit S1 and a filter allowing only the wavelength of blue colour infront of slit S2, then there does not occur any interference.**

(v) If a thin glass plate or mica sheet is placed infront of one of the slits, then the central fringe shifts towards the slit infront of which the glass plate is placed. If t is the thickness of glass or mica sheet and μ is the refractive index of the material of sheet, then **extra path difference introduced by the sheet is (μ - 1)t.**

If the central fringe now appears at the location of previously formed nth bright fringe, then **(μ - 1)t = nλ.**

If the central fringe appears at the position of previously formed nth dark fringe, then **(μ - 1)t = (2n-1)λ/2**

(vi) The fringe visibility is defined by the relation V = (Imax – Imin) / ((Imax + Imin)

The fringe visibility is maximum when I1 =I2 or Imin = 0 , i.e., when both slits are of equal width,the fringe visibility is best, equal to 1.

**(vii) Colours of thin films:**

(a) The colours of thin films, soap bubbles and oil slicks can be explained on the basis of phenomenon of interference.

(b) In all these phenomena, the formation of interference pattern is by the division of amplitude.

(c) For light of wavelength λ, for reflected light, the constructive interference takes place when

**2μt cosr = (2n-1)λ/2**

and the destructive interference takes place when **2μt cosr = (2n)λ/2**

(d) For interference due to **transmitted light**, the conditions of constructive and destructive interference are reversed, i.e.,

**2μt cosr = (2n)λ/2 [ Constructive ]**

**2μt cosr = (2n-1)λ/2 [ Destructive ]**

**11. Diffraction of light:**

(i) When light waves fall on a small aperture or a small sized obstacle whose linear dimension e is comparable to the wavelength λ, of the wave, then there is a departure from straight line propagation and wave energy flares out into the region of geometrical shadow of the obstacle or aperture. **The spreading of wave energy beyond the limits prescribed by the straight line propagation of the rays is called diffraction**. Diffraction effects become more prominent when (λ/e) increases.

(ii) As λsound > λlight, diffraction is more easily observed in sound as compared to light.

(iii) Diffraction was discovered by Grimaldi.

(iv) Interference takes place when there is superposition of two separate wavefronts originating from two separate coherent sources. **Diffraction takes place due to superposition of secondary wavelets starting from different points of the same wavefront.**

(v) **Fraunhofer diffraction due to a single slit**: When monochromatic light of wavelength λ is used to illuminate a single slit of width e, the minima are given by e sinθ = nλ where n= ±1,±2,±3 …. but n ≠0

**For first minimum esinθ = λ or sinθ = λ/e**

(vi**) Diffraction at a plane grating**: When polychromatic or monochromatic light of wavelength λ is incident normally on a plane transmission grating, the principal maxima are given by:

**(e+d) sinθ=nλ**

where n: order of maximum, θ = angle of diffraction and (e + d) : grating element.

(vii)

(a) **Fraunhofer diffraction at a circular aperture**: When monochromatic light of wavelength λ is used to illuminate a circular aperture of diameter d, then the angular radius of the first dark ring is given by:

d sin θ =1.22λ or sin θ =1.22λ/d and θ also represents the radius of the central bright disc.

(b) Angular radius of central maximum is given by: sin θ =1.22λ/d ; when θ is small sin θ =θ =1.22λ/d

**12. Polarisation of light:**

(i) The ordinary light also called as unpolarised light consists of a very large number of vibrations in all planes with equal probability at right angles to the direction of propagation, i.e., **unpolarised light is symmetrical about the direction of propagation.**

(ii) The light which has acquired the property of **one-sideness is called polarised light or lack of symmetry of vibration** **around the direction of wave propagation is called polarisation.**

(iii) Polarisation of light waves shows that they are **transverse** waves.

(iv)When the vibrations are confined only to a single direction in a plane perpendicular to the direction of propagation, it is called a **plane polarised light.**

(v) A plane passing through the direction of propagation and perpendicular to the plane of vibration is called as **plane of polarisation**.

(vi) Plane polarised light can be produced by the following methods:

(a) **By reflection**: Brewster's Law -;μ-tan p, where p is the angle of polarisation (Brewster's angle) and μ is the refractive index of the reflecting medium.

(b) By **refraction** (pile of plates)

(c) By **dichroism**

(d) By **double refraction** (Nicol's prism)

(e) By **scattering**.

**(vii) Polaroids**: These are artificially prepared polarising materials in the form of sheets or plates capable of producing strong beam of plane polarised light.

**Home Assignment- Wave Optics**

1. Define Wavefront and coherent source of light?
2. Write Huygen’s principle?
3. Explain the phenomenon of reflection and refraction on the basis of wave theory?
4. What do you mean by coherent sources ? Write 3 conditions for coherence?
5. What do you mean by interference ? Mathematically derive condition for constructive and destructive interference in YDSE?
6. What do you mean by fringe width ? Write an expression for it ?
7. What are different conditions for sustained interference ?
8. Derive an expression for fringe shift?
9. What is diffraction ? What are it’s different types?
10. Derive an expression mathematically for condition of destructive interference from single slit?
11. What is the difference between interference and diffraction ?
12. What do you mean by fresnel distance?
13. What do you mean by resolving power ?
14. What is Rayleigh’s criterion for just resolving two images ?
15. Derive an expression for resolving power of a microscope ?
16. Derive an expression for resolving power of a telescope ?
17. Write expressions for Doppler effect in light ?
18. Write some of the applications of Doppler effect in light?
19. What do you mean by polarization?
20. What do you mean by linearly polarized light beam ?
21. What do you mean by Malus’s Law ?
22. What do you mean by polarizing angle or Brewster’s angle?
23. State Brewster’s law?
24. What do you mean by polaroids ? Also write some of their applications?

**NCERT (Solved)**

1. What speed should a galaxy move with respect to us so that the sodium line at 589.0 nm is observed

at 589.6 nm?

* 1. When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why?
  2. When light travels from a rarer to a denser medium, the speed decreases. Does the reduction in speed imply a reduction in the energy carried by the light wave?
  3. In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity of light in the photon picture of light.

1. Two slits are made one millimetre apart and the screen is placed one metre away. What is the fringe separation when bluegreen light of wavelength 500 nm is used?
2. Assume that light of wavelength 6000Å is coming from a star. What is the limit of resolution of a telescope whose objective has a diameter of 100 inch?
3. Discuss the intensity of transmitted light when a polaroid sheet is rotated between two crossed polaroids?
4. Unpolarised light is incident on a plane glass surface.What should be the angle of incidence so that the reflected and refracted rays are perpendicular to each other?

**NCERT (Unsolved)**

1. Monochromatic light of wavelength 589 nm is incident from air on a water surface. What are the wavelength, frequency and speed of (a) reflected, and (b) refracted light? Refractive index of water is 1.33.
2. What is the shape of the wavefront in each of the following cases:
   1. Light diverging from a point source.
   2. Light emerging out of a convex lens when a point source is placed at its focus.
   3. The portion of the wavefront of light from a distant star intercepted by the Earth.
3. The refractive index of glass is 1.5. What is the speed of light in glass? (Speed of light in vacuum is 3.0 × 108 m s–1)
4. Is the speed of light in glass independent of the colour of light? If not, which of the two colours red and violet travels slower in a glass prism?
5. In Young’s double-slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is *K* units. What is the intensity of light at a point where path difference is λ/3?
6. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young’s double-slit experiment.
   1. Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm.
   2. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?
7. What is the Brewster angle for air to glass transition? (Refractive index of glass = 1.5.)
8. Light of wavelength 5000 Å falls on a plane reflecting surface. What are the wavelength and frequency of the reflected light? For what angle of incidence is the reflected ray normal to the incident ray?
9. Estimate the distance for which ray optics is good approximation for an aperture of 4 mm and wavelength 400 nm.
10. Let us list some of the factors, which could possibly influence the speed of wave propagation:

(i) nature of the source. (ii) direction of propagation.

(iii) motion of the source and/or observer.

(iv) wavelength. (v) intensity of the wave.

1. On which of these factors, if any, does

(a) the speed of light in vacuum,

(b) the speed of light in a medium (say, glass or water),depend?

1. For sound waves, the Doppler formula for frequency shift differs slightly between the two situations: (i) source at rest; observer moving, and (ii) source moving; observer at rest. The exact Doppler formulas for the case of light waves in vacuum are, however, strictly identical for these situations. Explain why this should be so. Would you expect the formulas to be strictly identical for the two situations in case of light travelling in a medium?
2. Answer the following questions:
   1. In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band?
   2. In what way is diffraction from each slit related to the interference pattern in a double-slit experiment?
   3. When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot is seen at the centre of the shadow of the obstacle. Explain why?
   4. Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend around obstacles, how is it that the students are unable to see each other even though they can converse easily.
   5. Ray optics is based on the assumption that light travels in a straight line. Diffraction effects (observed when light propagates through small apertures/slits or around small obstacles) disprove this assumption. Yet the ray optics assumption is so commonly used in understanding location and several other properties of images in optical instruments. What is the justification?
3. Answer the following questions:
   1. When a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our TV screen. Suggest a possible explanation.
   2. As you have learnt in the text, the principle of linear superposition of wave displacement is basic to understandingintensity distributions in diffraction and interference patterns. What is the justification of this principle?

**Exemplar Problems**

1. Is Huygen’s principle valid for longitudinal sound waves?
2. What is the shape of the wavefront on earth for sunlight?
3. Why is the diffraction of sound waves more evident in daily experience than that of light wave?
4. A polariod (I) is placed in front of a monochromatic source. Another polariod (II) is placed in front of this polaroid (I) and rotated till no light passes. A third polaroid (III) is now placed in between (I) and (II). In this case, will light emerge from (II). Explain.
5. Can reflection result in plane polarised light if the light is incident on the interface from the side with higher refractive index?
6. Consider a point at the focal point of a convergent lens. Another convergent lens of short focal length is placed on the other side. What is the nature of the wavefronts emerging from the final image?

**Objective Questions**

1. Two independent monochromatic sources are said to be incoherent, because the detector of light intensity requires time to detect intensity at a given position, that is:

(a) much greater than l0-8 sec (b) nearly equal to 10-8 sec

(c) much less than 10-8 sec (d) none of the above

2. In the Young's double slit experiment, if monochromatic light is replaced by white light, then

(a) no fringes are observed (b) all bright fringes become white

(c) all bright fringes have colours between violet and red

(d) only central fringe is white and all other fringes are coloured

3. Two coherent monochromatic light beams of intensities I and 4I are superposed; the maximum and minimum possible intensities in the resulting beam are:

(a) 5I and I (b) 5I and 3I (c) 9I and I (c) 9I and 3I

4. If two waves, each of intensity Io, having the same frequency but differing by a constant phase angle of 600, superpose at a certain point in space, then the intensity of resultant wave is:

(a) 2Io (b) √3 Io (c) 3Io (c) 4Io

5. The necessary condition for an interference by two sources of light is that:

(a) two light sources must have the same wavelength

(b) two point sources should have the same amplitude and same wavelength

(c) two sources should have the same wavelength, nearly the same amplitude and have a constant phase angle difference

(d) the two point sources should have a randomly varying phase difference

6. Yellow light emitted by sodium lamp in Young's double slit experiment is replaced by monochromatic blue light of the same intensity, then: (a) fringe width will decrease (b) fringe width will increase

(c) fringe width will remain unchanged (d) fringes will become less intense

7. In Young's double slit experiment the angular width of a fringe formed on a distant screen is 10. The wavelength of light used is 6000 A0. The spacing between the slits is approximately:

(a) 1 mm (b) 0.05 mm (c) 0.03 mm (d) 0.01 mm

8. The light waves from two independent monochromatic light sources are given by:

y1 = 2sinwt & y2 = 3coswt , then the correct statement is:

(a) both the waves are coherent (b) both the waves are incoherent

(c) both the waves have different time periods (d) none of the above

9. In a Young's double slit experiment, fringe width equal to 1mm is observed. Then the distance of the nearest bright fringe from the central fringe will be:

(a) 1 mm (b) 0.5 mm (c) 2 mm (d) insufficient data, cannot be determined

10. In Young's double slit experiment carried out with light of wavelength λ= 5000 A0, the distance between the slits is 0.2 mm and the screen is at 200 cm from the plane of slits. The central maximum is at x = 0. The third maximum will be at x equal to: (a) 1.67cm (b) 1.5 cm (c) 0.5cm (d) 5 cm

11. In Young's experiment when sodium light of wavelength 5893 A0 is used, then 62 fringes are seen in the field of view. Instead, if violet light of wavelength 4358 A0 is used then the number of fringes that will be seen in the field of view will be nearly: (a) 54 (b) 64 (c) 74 (d) 84

12. Interference was observed in an interference chamber, when air was present. Now, the chamber is evacuated and if the same light is used, a careful observation will show:

(a) no interference (b) interference with bright bands (c) interference with dark bands

(d) interference in which breadth of the fringe will be slightly increased

13.In a two slit experiment with white light, a white fringe is observed on a screen kept behind the slits. When the screen is moved away by 0.05 m, this white fringe:

(a) does not move at all (b) gets displaced from its earlier position

(c) becomes coloured (d) disappears

14. In the Young's double slit experiment, separation between the two slits is 0.9 mm 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, then wavelength of the monochromatic source of light used is:

(a) 400 nm (b) 450 nm (c) 500 nm (d) 600 nm

15. In a biprism experiment, by using light of wavelength 5000 A0, 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

16. Find the thickness of a plate which will produce a change in optical path equal to half the wavelength λ, of the light passing through it normally. The refractive index of the plate is μ.

(a) λ/4(μ-1) (b) 2λ/4(μ-1) (c) λ/(μ-1) (d) λ/2(μ-1)

17. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude *a* and of wavelength λ. In another experiment with the same set-up, the two slits are sources 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: (a) 2: I (b) 1:2 (c) 3 :4 (d) 4: 3

18. In Young's double slit experiment, the 7th maximum with wavelength λ1 is at a distance d1 and that with wavelength λ2 is at a distance d2 Then (d1/d2) is:

(a) λ1/λ2 (b) λ2/λ1 (c) λ12/λ22 (d) λ22/λ12

19. Waves from two different sources overlap at a particular point. The amplitude and frequency of the two waves are same. The ratio of the intensity when the two waves arrive in phase to that when they arrive 900 out of phase is: (a)1:l (b)√2:1 (c)2:I (d)4:1

20. A source emits electromagnetic waves of wavelength 3 m. One beam reaches the observer directly and other after reflection from a water surface, travelling 1.5 m extra distance and with intensity reduced to (¼) as compared to intensity due to direct beam alone. The resultant intensity will be:

(a) (1/4) fold (b) (3/4) fold (c) (5/4) fold (d) (9/4) fold

21. In Young's experiment the wavelength of red light is 7.8 x 10-5 cm and that of blue light 5.2 x10-5 cm. The value of n for which (n+ l)th blue bright band coincides with nth red band is:

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

22. White light is used to illuminate the two slits in a Young's double slit experiment. The separation between the slits is *b* and the screen is at a distance *d* (>> b) from the slits. At a point on the screen directly infront of one of the slits, certain wavelengths are missing. Some of these missing wavelengths are:

(a) λ =3b2/d (b) λ = 2b2/d (c) λ = b2/3d (d) λ = 2b2/3d

23.Light of wavelength 5.0 x 10-7 m falls on a pair of narrow slits separated by a distance *2d*.The interference pattern on a screen placed 2.0 m away shows that there is darkness at the positions exactly opposite to each slit. The separation between the slits is: (a) 0.5 mm (b) 1.0 mm (c) 2.0 mm (d) 5 x 10-7 mm

24. In Young's experiment with sodium light, the slits are 0.589 m apart. What is the angular width of the fourth maximum? (Given that λ = 589 nm)

(a) sin-1 (3 x 10-6) (b) sin-1 (3 x 10-8) (c) sin-1 (0.33 x 10-6) (d) sin-1 (0.33 x 10-8)

25. A slit 5.0 cm wide is irradiated normally with microwaves of wavelength 1.0 cm. Then the angular spread of the central maximum on either side of the incident light is nearly:

(a) (l/5) radian (b) 4 radian (c) 5 radian (d) 6 radian

26. White light may be considered to be a mixture of waves with λ ranging between 3000 A0 and 7800 A0. An oil film of thickness 10,000 A0 is examined normally by the reflected light. If μ = 1.4, then the film appears bright for: (a) 4308 A0, 5091 A0 , 6222 A0 (b) 4000 A0, 5091 A0, 5600 A0

(c) 4667 A0 , 6222 A0, 7000 A0 (d) 4000 A0, 4667 A0, 5600 A0, 7000 A0

27. Two light rays having the same wavelength λ, in vacuum are in phase initially. Then the first ray travels a path L1 through a medium of refractive index n1 while the second ray travels a path of length L2 through a medium of refractive index n2. The two waves are then combined to observe interference. The phase difference between the two waves is



28. In the 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 (λ/4)? (a) K/4 (b) K/2 (c) K (d) Zero

29. In a Fresnel biprism experiment, the two positions of lens give separation between the slits as 16 cm and 9 cm respectively. What is the actual distance of separation? (a) 12.5 cm (b) 12.0 cm (c) 13 cm (d) 14 cm

30. In an experiment similar to Young's experiment, interference is observed using waves associated with electrons. The electrons are being produced in an electron gun. In order to increase the fringe width:

(a) electron gun voltage be increased (b) electron gun voltage be decreased

(c) the slits be moved away (d) the screen be moved closer to interfering slits

31. Microwaves from a transmitter are directed normally towards a plane reflector. A detector moves along the normal to the reflector. Between positions of 14 successive maxima the detector travels a distance of 0.14 m. The frequency of transmitter is: (c=3 x 108 m/s)

(a) 1.5 x 1010 Hz (b) 1010 Hz (c) 3 x 1010 Hz (d) 6 x 1010 Hz

32. Interference fringes were produced in Young's double slit experiment using light of wavelength 5000 A0. When a film of material 2.5 x10-3 cm thick was placed over one of the slits, the fringe pattern shifted by a distance equal to 20 fringe widths. The refractive index of the material of the film is:

(a) 1.25 (b) 1.33 (c) 1.4 (d) 1.5

33. What is the minimum thickness of a soap bubble needed for constructive interference in reflected light if the light incident on the film has wavelength 900 nm? Assume the refractive index for the film is μ =1.5.

(a) 100 nm (b) 150 nm (c) 200 nm (d) 250 nm

34. Young's double slit experiment is made in a liquid. The 10th bright fringe in the liquid lies where the 6th dark fringe lies in vacuum. The refractive index of the liquid is approximately:

(a) 1.8 (b) 1.54 (c) 1.67 (d) 1.2

35. In Young's double slit experiment, the type of diffraction is:

(a) Fresnel (b) Fraunhofer (c) both (a) and (b) (d) none of these

36. The first diffraction minimum due to a single slit diffraction is at θ =300 for a light of wavelength 5000 A0. The width of the slit is (a)5 x 10-5 cm (b) 10-4 cm (c) 2.5 x 10-5 cm (d) 1.25 x 10-5 cm

37. A slit of width *a* is illuminated by white light. The first minimum for red light (λ = 6500 A0) will fall at θ =300, when *a* will be (a) 3250 A0 (b) 6.5 x 10-4 cm (c) 1.3 micron (d) 2.6 x 10-4 cm

38. Light of wavelength λ is incident on a slit of width *d*. The resulting diffraction pattern is observed on a screen at a distance D. The linear width of the principal maximum is then equal to the width of the slit if D equals: (a) *d/λ* (b) 2*λ/d* (c) *d2/2λ* (d) 2*λ2/d*

39. Light of wavelength 6328 A0 is incident normally on a slit having a width of 0.2 mm. The width of the central maximum measured from minimum to minimum of diffraction pattern on a screen 9.0 metres away will be about: (a) *0.360* (b) *0.180* (c) *0.720* (d) *0.090*

40. In Young's double slit experiment, the 10th maximum of wavelength λ1 is at a distance of y1 from the central maximum. When the wavelength of the source is changed to λ2 ,5th maximum is at a distance of y2 from its central maximum. The ratio (y1/y2) is : (a) *2λ1/λ2* (b) *2λ2/λ1* (c) *λ1/2λ2* (d) *λ2/2λ1*

41. In case of diffraction at single slit if the wavelength of light becomes equal to the aperture of slit, on the screen we shall observe: (a) image of slit (b) diffraction band

(c) uniform illumination (d) non-uniform illumination

42. In a double slit experiment, the screen is placed at e distance 1.25 m from the slits. When the apparatus is immersed in water (μw= 4/3), the angular width of a fringe is found to be 0.20. When the experiment is performed in air with same set-up, the angular width of the fringe is

(a) *0.40* (b) *0.270* (c) *0.350* (d) *0.150* (e) *0.220*

43. Light of wavelength 6000 A0 falls on a single slit of width 0.1mm.The second minimum will be formed for the angle of diffraction of (in radian): (a)0.08 (b) 0.06 (c) 0.12 (d) 0.15 (e)0.012

44. H-polaroid is prepared by: (a) using thin tourmaline crystals

(b) orienting herapathite crystal in the direction of nitrocellulose

(c) Stretching polyvinyl alcohol and then impregnating with iodine.

(d) Stretching polyvinyl alcohol and then heating with dehydrating agent

45. The fringe width of bands in Young's double slit experiment can be increased by:

(a) decreasing the wavelength of light used (b) decreasing the distance between the two sources

(c) increasing the distance between the two sources (d) dipping the apparatus into water

46. When light is incident on a diffraction grating, the zero order principal maximum will be:

(a) white (b) absent (c) spectrum of the colours (d)one of the component colors

47. The angle of incidence at which reflected light is totally polarised for reflection from air to glass (refractive index n) is: (a) sin-1 (n) (b) sin-1 (1/n) (c) tan-1 (1/n) (d) tan-1 (n)

48. The maximum number of possible interference maxima for slit separation equal to twice the wavelength in Young's double slit experiment is: (a) infinite (b) five (c) three (d) zero

49. Light is incident normally on a diffraction grating through which the first order diffraction is seen at 320. The second order diffraction will be seen at:

(a) *480* (b) *640* (c) *800* (d) there is no second order diffraction in this case

50. White light is incident on a glass plate of thickness 5000 A0,and refractive index 1.5, the wavelength in the visible region (4000 A0 -7000 A0) that are strongly reflected by the plate in **A0** is:

(a) 4290 (b) 8000 (c) 4000 (d) 5000

51. If Io 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? (a) Io (b) Io/2 (c) 2 Io (d) 4 Io [AIEEE 2005]

52. When an unpolarised light of intensity Io is incident on a polarising sheet, the intensity of the light which does not get transmitted, is: (a) 0 (b) Io (c) Io/2 (d) Io/4 [AIEEE 2005]

53. In the Young's double slit experiment a point P on the central bright fringe is such that the intensity of the point P is ¼ times, the maximum intensity. Distance between the slits is d and wavelength is λ. Then angular separation of point P is: [IIT 2005]

(a) sin-1 (λ/d) (b) sin-1 (λ/2d) (c) sin-1 (λ/3d) (d) sin-1 (λ/2d)

54. When the speed of electron beam used in Young's double slit experiment is increased, then which among the following statements is correct ? (a) Interference pattern will not be observed in case of electrons.

(b) Distance between consecutive fringes increases. (c) Distance between consecutive fringes decreases.

(d) Distance between consecutive fringes remain same. [IIT 2005]

55. 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) y/3 (b) 3y (c) zero and the pattern vanishes (d) none of the above

56. When unpolarised light beam is incident from air onto glass (n -1.5) at the polarising angle, then

(a)reflected beam is polarised 100 per cent (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

57. When the angle of incidence on a material is 600, the reflected light is completely polarised. The velocity of the refracted ray inside the material is: (in ms-l)

(a) 3 x 108 (b) (3/√2) x 108 (c) √3x 108 (d) 0.5 x 108 (e) 0.75 x 108

58. Which one of the following statements is true?

(a) Both light and sound waves can travel in vacuum. (b) Both light and sound waves in air are transverse.

(c) The sound waves in air are longitudinal while the light waves are transverse.

(d) Both light and sound waves in air are longitudinal.

59. What does not change on polarization of light?

(a) Intensity (b) Phase (c) Frequency (d) Wavelength

60. In an interference experiment, third bright fringe is obtained 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?

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

61. The width of the diffraction band varies:

(a) inversely as the wavelength (b) directly as the width of the slit

(c) directly as the distance between the slit and the screen

(d) inversely as the size of the source from which the slit is illuminated

62. An unpolarised beam of intensity Io is incident on a pair of nicols making an angle of 600 with each other. The intensity of light emerging from the pair is: (a) Io (b) Io/2 (c) Io/4 (d) Io/8

63. A narrow slit of width 2 mm is illuminated by monochromatic light of wavelength 500 nm. The distance

between the first minima on either side on a screen at a distance of I m, is:

(a) 5 mm (b) 0.5 mm (c) 1 mm (d) 10 mm (e) 2.5 mm

64. An optically active compound:

(a) rotates the plane polarised light (b) changes the direction of polarised light

(c) do not allow plane polarised light to pass through (d) none of the above

65. The width of a single slit, if the first minimum is observed at an angle of 20 with a light of wavelength 6980 A0 (in mm) is: (a) 0.2 (b) 2 x 10-5 (c) 2 x 105 (d) 2 (e) 0.02

66. In Young's double slit experiment the wavelength of light λ=4 x 10-7 m and separation between the slit is d=0.1 mm. If the fringe width is 4 mm, then the separation between the slits and screen will be:

(a) 100 mm (b) 1 m (c) 106 cm (d) 10 A0

67. In a Fraunhofer diffraction at a single slit of width *d* with incident light of wavelength 5500 A0 , the first minimum is observed, at angle of 300. The first secondary maximum is observed at an angle θ equal to:

(a) sin-1 (1/√2) (b) sin-1 (¼) (c) sin-1 (¾) (d) sin-1 (√3/2) (e) sin-1 (⅜)

68. A plane electromagnetic wave of frequency 20 MHz is travelling in free space along X-direction. At a particular point in space and time, the magnitude of electric field is 6 V/m. The magnetic field at this point (in tesla) is: (a) 2 x 10-8 (b) 0.5 x 10-8 (c) 0.5 (d) 2

69.When the light is incident at the polarizing angle on the transparent medium, then the completely polarized light is: (a) refracted light (b) reflected light

(c) refracted and reflected light (d) neither reflected nor refracted light

70. In Young's double slit experiment, first slit has width four times the width of the second slit. The ratio of the maximum intensity to the minimum intensity in the interference fringe system is :

(a) 2:1 (b) 4:1 (c) 9:1 (d) 8:1

71. Select the right option in the following.

(a) Christian Huygens, a contemporary of Newton established the wave theory of light by assuming that Light waves were transverse.

(b) Maxwell provided the theoretical evidence that light is transverse wave.

(c) Thomas Young experimentally proved the wave behaviour of light and Huygens assumption.

(d) All the statements given above, correctly answers the question "what is light".

72. For EM wave propagating along x-axis, Emax = 30 V/m. What is maximum value of magnetic field (in Tesla):(a) 10-7 (b) 10-8 (c) 10-9 (d) 10-6

73. In the phenomenon of diffraction of light, when blue light is used in the experiment instead of red light, then: (a) fringes will become narrower (b) fringes will become broader

(c) no change in fringe width (d) none of the above

74. A 20 cm length of a certain solution causes right handed rotation of 380. A 30 cm length of another solution causes left handed rotation of 240.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 140 (b) right handed rotation of 140

(c) left handed rotation of 30 (d) right handed rotation of 30

75. Two waves coming from two coherent sources, having different intensities interfere, their ratio of maximum intensity to the minimum intensity is 25.The intensities of the sources are in the ratio:

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

76. The relationship between phase difference ∆ϕ and the path difference ∆*x* between two interfering waves is given by(λ = wavelength)



77. In Young's double slit experiment, the interference pattern is found to have an intensity ratio between bright and dark fringes as 9. This implies that:

(a) the intensities at the screen due to two slits are 5 unit, and 4 unit, respectively

(b) the intensities at the screen due to the two slits are 4 unit and 1 unit, respectively

(c) the amplitude ratio is 7 (d) the amplitude ratio is 6

78. In a Young's double slit experiment the intensity at a point where the path difference is λ/6 is **I**. If **Io** denotes the maximum intensity ,then **I/Io** is equal to : (a)¾ (b)1/√2 (c)√3/2 (d)½

79. In a two-slit experiment, with monochromatic light, fringes are obtained on a screen placed at some distance from the slits.If the screen is moved by 5x l0-2 m towards the slits, the change in fringe width is 10-3 m. Then the wavelength of light used is: (given that distance between the slits is0.03 mm)

(a) 4000 A0 (b) 4500 A0 (c) 5000 A0 (d) 5500 A0 (e) 6000 A0

80. The electromagnetic theory of light failed to explain :

(a) photoelectric effect (b) polarisation (c) diffraction (d) interference

81. Light from two coherent sources of the same amplitude A and wavelength λ, illuminates the screen. The intensity of the central maximum is Io. If the sources were incoherent, the intensity at the same point will be:

(a) 4Io (b) 2Io (c) Io (d) Io/2

82. In Young's double slit experiment with sodium vapour lamp of wavelength 589 nm and the slits 0.589 mm apart, the half angular width of the central maximum is:

(a) sin-1 (0.01) (b) sin-1 (0.0001) (c) sin-1 (0.001) (d) sin-1 (0.1)

83. A single slit Fraunhofer diffraction pattern is formed with white light. For what wavelength of light the third secondary maximum in the diffraction pattern coincides with the second secondary maximum in the pattern for red light of wavelength 6500 A0? (a) 4400 A0 (b) 4100 A0 (c) 4642.8 A0 (d) 9100 A0

84. When the angle of incidence is 600 on the surface of a glass slab, it is found that the reflected ray is completely polarised. The velocity of light in glass is (in m/s):

(a) √2 x 108 (b) √3 x 108 (c) 2 x 108 (d) 3 x 108

85. Two beams of light of intensity I1 and I2 interfere to give an interference pattern. If the ratio of maximum intensity to that of minimum intensity is 25/9, then I1/I2 is:

(a) 5/3 (b) 4 (c) 81/625 (d) 16 (e)1/2

86. If the polarising angle of a piece of glass for green light is 54.740, then the angle of minimum deviation for an equilateral prism made of same glass is:(Given: tan 54.740 = 1.414)

(a) *450* (b) 54.740  (c) *600* (d) *900* (e) *300*

87. The dielectric constant of air is 1.006. The speed of electromagnetic wave travelling in air is *a* x 108 m/s,

where *a* is about :(a) 3 (b) 3.88 (c) 2.5 (d) 3.2 (e) 2.8

88. The value equal to the velocity of light in vacuum is:

89. The electric and magnetic field of an electromagnetic wave are

(a) in opposite phase and perpendicular to each other (b) in opposite phase and parallel to each other

(c) in phase and perpendicular to each other (d) in phase and parallel to each other

90. The ratio of maximum and minimum intensities of two sources is 4 : 1. The ratio of their amplitudes is:

(a)1:3 (b)3:1 (c)1:9 (d)1:16

91. The maximum number of possible interference maxima when slit separation is equal to 4 times the wavelength of light used in a double slit experiment is: (a)∞ (b)9 (c)8 (d)4

92. In Young's experiment, the third bright band for light of wavelength 6000 A0 coincides with the fourth bright band for another source of light in the same arrangement. Then the wavelength of second source is:

(a) 3600 A0 (b) 4000 A0 (c) 5000 A0 (d) 4500 A0 (e) 5500 A0

93.In Fraunhofer diffraction experiment, L is the distance between screen and the obstacle, *b* is the size of obstacle and λ, is wavelength of incident light. The general condition for the applicability of Fraunhofer diffraction is

94. Two periodic waves of intensities I1 and I2 pass through a region at the same time in the same direction. The sum of the maximum and minimum intensities is:

95. A ray of light travelling in water is incident on a glass plate immersed in it. When the angle of incidence is 510, the reflected ray is totally plane polarized, then find out the refractive index of glass.

(The refractive index of water is 1.3 and tan 510 = 1.235): (a) 1.33 (b) 1.805 (c) 1.605 (d) 1.305

96. At what angle of incidence, the light reflected from a glass slab will become completely polarised, if the angle of refraction at that incident angle is 33.60? (a) *900* (b) 00 (c) *56.40* (d) *46.40*

97.In Fraunhofer diffraction by a single slit, a position where first order minimum is formed by the wavelength of 9000 A0 , first order maximum is formed due to an unknown wavelength (λ). The unknown wavelength λ is : (a) 8000 A0 (b) 2000 A0 (c) 6000 A0 (d) 4000 A0

98. In Young's experiment, the distance between two slits is halved and the distance between the screen and slit is made three times. Then, width of the fringe:

(a) becomes half (b) remains the same (c) becomes 6 times (d) becomes 4 times

99. A parallel beam of fast moving electrons is incident normally on a narrow slit. A screen is placed at a large distance from the slit. If the speed of the electrons is increased, which of the following statement is correct? (a) Diffraction pattern is not observed on the screen in the case of electron.

(b) The angular width of the central maximum of the diffraction pattern will increase.

(c) The angular width of the central maximum will decrease.

(d) The angular width of the central maximum will remains the same.

100. Two beams of light will not give rise to an interference pattern, if:

(a) they are coherent (b) they have the same wavelength

(c) they are linearly polarized perpendicular to each other (d) they are not monochromatic

101. A slit of width *a* is illuminated with a monochromatic light of wavelength λ, from a distant source and the diffraction pattern is observed on a screen placed at a distance *D* from the slit. To increase the width of the central maximum one should:

(a) decrease D (b) decrease *a* (c) decrease λ (d) the width cannot be changed

102. A thin film of soap solution (μ=1.4) lies on the top of a glass plate (μ = 1.5). When visible light is incident almost normal to the plate, two adjacent reflection maxima are observed at two wavelength 400 and 630 nm. The minimum thickness of the soap solution is:(a) 420 nm (b) 450 nm (c) 630 nm (d) 1260 nm

103. Yellow light is used in a single slit diffraction experiment with slit width of 0.6 mm. If yellow light is replaced by X-rays, then the observed pattern will reveal:

(a) that the central maximum is narrower (b) more number of fringes

(c) less number of fringes (d) no diffraction pattern

104. On introducing a thin film in the path of one of the two interfering beam, the central fringe will shift by one fringe width. If μ=1.5, the thickness of the film is: (wavelength of monochromatic light is λ)

(a) 4λ (b) 3 λ (c) 2λ (d) λ

105.If white light is used in the Newton's rings experiment, the colour observed in the reflected light is complementary to that observed in the transmitted light through the same point. This is due to:

(a) 900 change of phase in one of the reflected waves (b) 1800 change of phase in one of the reflected waves

(c) 1450 change of phase in one of the reflected waves (d) 450' change of phase in one of the reflected waves

106. In Young's double slit interference pattern the fringe width:

(a) can be changed only by changing the wavelength of incident light

(b) can be changed only by changing the separation between the two slits

(c) can be changed either by changing the wavelength or by changing the separation between the two slits

(d) is a universal constant, hence cannot be changed

107. The angle of incidence of light is equal to Brewster's angle, then

(1) reflected ray is perpendicular to refracted ray (2) reflected ray is parallel to refracted ray

(3) reflected light is polarized having its electric vector in the plane of incidence

(4) refracted light is polarized

(a) (1) and (4) are true (b) (1) and (2) are true

(c) (1) and (3) are true (d) (2) and (4) are true

108. A mixture of light, consisting of wavelength 590 nm and an unknown wavelength, illuminates Young's double slit and gives rise to two overlapping interference patterns on the screen. The central maximum of both lights coincide. Further, it is observed that the third bright fringe of known light coincides with the 4th bright fringe of the unknown light. From this data, the wavelength of the unknown light is: (AIEEE 2009)

(a) 393.4 nm (b) 885.0 nm (c) 442.5 nm (d) 776.8 nm

109. 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 the incident beam. At the first minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of slit is:

(a) zero (b) π (c) π/2 (d) 2π

110. Young's double slit experiment gives interference fringes of width 0.3 mm. A thin glass plate made of material of refractive index 1.5 is kept in the path of light from one of the slits, then the fringe width becomes: (a) zero (b) 0.3 mm (c) 0.45 mm (d) 0.15 mm

111.In the Young's double slit experiment the intensities, at two points P1 and P2 on the screen, are respectively I1 and I2.If P1 is located at the centre of a bright fringe and P2 is located at a distance equal to a quarter of fringe width from P1, then I1/I2 is : (a) 2 : 1 (b) 1 : 2 (c)4 :1 (d) 16 : 1

112. lf the width of the slit in single slit diffraction experiment is doubled, then the central maximum of diffraction pattern becomes (a) broader and brighter (b) sharper and brighter

(c) sharper and fainter (d) broader and fainter

113. In Young's double slit experiment, the fringe width with light of wavelength 6000 A0 is 3 mm. The fringe width, when the wavelength of light is changed to 4000 A0 is:(a) 3 mm (b) 1 mm (c) 2 mm (d) 4 mm

**Answers Objective (Wave optics)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 1. A | 1. D | 1. C | 1. C | 1. C | 1. A |
| 1. C | 1. B | 1. A | 1. B | 1. D | 1. D |
| 1. A | 1. D | 1. B | 1. D | 1. A | 1. A |
| 1. C | 1. D | 1. C | 1. C | 1. B | 1. A |
| 1. A | 1. A | 1. B | 1. B | 1. B | 1. B |
| 1. A | 1. C | 1. B | 1. A | 1. A | 1. B |
| 1. C | 1. C | 1. A | 1. A | 1. D | 1. B |
| 1. E | 1. C | 1. B | 1. A | 1. D | 1. B |
| 1. D | 1. A | 1. A | 1. C | 1. C | 1. C |
| 1. B | 1. A | 1. C | 1. C | 1. C | 1. A |
| 1. C | 1. C | 1. B | 1. A | 1. E | 1. B |
| 1. C | 1. A | 1. B | 1. C | 1. B | 1. A |
| 1. A | 1. D | 1. C | 1. A | 1. B | 1. A |
| 1. E | 1. A | 1. D | 1. C | 1. C | 1. B |
| 1. D | 1. E | 1. A | 1. B | 1. C | 1. B |
| 1. D | 1. D | 1. C | 1. B | 1. C | 1. C |
| 1. C | 1. C | 1. C | 1. D | 1. B | 1. B |
| 1. D | 1. C | 1. B | 1. C | 1. A | 1. C |
| 1. D | 1. B | 1. D | 1. B | 1. C |  |

**Explanations Wave Optics**

