

**Class: 12**  
**Subject: Physics**  
**Topic: Wave Optics**  
**No. of Questions: 30**

- Two convex lenses of same focal length but of aperture  $A_1$  and  $A_2$  ( $A_2 < A_1$ ) are used as the objective lenses in two astronomical telescopes having identical eye pieces. What is the ratio of their resolving power? Which telescope will you prefer and why? Give reason.
- What is the shape of the wavefront in each of following cases?
  - Light diverging from point source.
  - Light emerging out of a convex lens when a point source is placed at its focus.
  - The portion of the wavefront of light from a distant star intercepted by earth.
- Answer the following questions:
  - 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?
- In what way is diffraction from each slit related to interference pattern in a double slit experiment?
- 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?
- Two students are separated by a 7 m partition wall in a room 10 m high. If both light and sound waves can bend round corners, how is it that the students are unable to see each other even though they can converse easily?
- Ray optics is based on the assumption that light travels in a straight line. Diffraction effects 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?
- Answer the following questions:

When a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our TV screen. Suggest a possible explanation.
- As you have learnt in the text, the principle of linear superposition of wave displacement is basic to understanding intensity distributions in diffraction and interference patterns. What is the justification of this principle?
- When a sheet of transparent plastic is placed between two crossed polarizers, no light is transmitted. When the sheet is stretched in one direction, some light passes through the crossed polarizers. What is happening?

11. In Young's double slit experiment, if the distance between the slits and the screen is doubled and the separation between the slits is reduced to half, the fringe width
- A. is doubled
  - B. becomes four times
  - C. is halved
  - D. remains unchanged
12. In Young's double slit experiment, sodium light composed of two wavelengths  $\lambda_1$  and  $\lambda_2$  close to each other (with  $\lambda_2$  greater than  $\lambda_1$ ) is used. The order  $n$  up to which the fringes can be seen on the screen is given by
- A.  $n = \frac{\lambda_2}{\lambda_2 - \lambda_1}$
  - B.  $n = \frac{\lambda_1}{\lambda_2 - \lambda_1}$
  - C.  $n = \frac{\lambda_2}{2(\lambda_2 - \lambda_1)}$
  - D.  $n = \frac{\lambda_1}{2(\lambda_2 - \lambda_1)}$
13. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude  $A$  and of wavelength  $\lambda$ . In another experiment with the same set up, the two slits are sources of equal amplitude  $A$  and wavelength  $\lambda$ , but are incoherent. The ratio of the intensity of light at the midpoint of the screen in the first case to that in the second case is
- A. 1 : 1
  - B. 1 : 2
  - C. 2 : 1
  - D.  $\sqrt{2} : 1$
14. How is the interference pattern affected if the Young's experiment was performed in still water than in air?
- A. Fewer fringes will be visible.
  - B. Fringes will be broader.
  - C. Fringes will be narrower.
  - D. No fringes will be observed.

15. What is the effect on the interference fringes in Young's double slit experiment if the widths of the two slits are increased?
- A. The fringe width decreases.
  - B. The fringe width increases.
  - C. The bright fringes are equally bright and equally spaced.
  - D. The bright fringes are no longer equally bright and equally spaced.
16. The fact that light can be polarized establishes that light
- A. travels in the form of particles
  - B. is an electromagnetic wave
  - C. is a transverse wave
  - D. is a longitudinal wave
17. In a single slit diffraction experiment, the width of the slit is made double its original width. Then the central maximum of the diffraction pattern will become
- A. narrower and fainter
  - B. narrower and brighter
  - C. broader and fainter
  - D. broader and brighter
18. The dispersion of light in a medium implies that
- A. lights of different wavelengths travel with different speeds in the medium
  - B. lights of different frequencies travel with different speeds in the medium
  - C. the refractive index of the medium is different for different wavelengths of light
  - D. all of the above
19. Which one of the following statements is correct?
- A. The refractive index of a given piece of glass is less for violet than for red light.
  - B. The refractive index of a given piece of glass is more for blue than for green light.
  - C. The refractive index of a given piece of glass is less for green than for yellow light.
  - D. The refractive index of a given piece of glass is the same for all colours of light.
20. Choose the only WRONG statement. The speed of light in a given glass plate is
- A. greater for violet than for red light
  - B. less for green than for yellow light
  - C. less for blue than for green light
  - D. the same for all colours of light

21. In Young's double slit experiment using two identical slits, the intensity of the maximum at the centre of the screen is  $I$ . What will be the intensity at the centre of the screen if one of the slits is closed?

- A.  $I$   
 B.  $\frac{I}{2}$   
 C.  $\frac{I}{4}$   
 D. None of these

Right Answer Explanation:

Let  $I_0$  be the intensity at the centre of the screen due to each slit. Then, for the central maximum, the intensity is

$$I = I_0 + I_0 + 2\sqrt{I_0 I_0} = 4I_0$$

or 
$$I_0 = \frac{I}{4}.$$

22. Two waves of intensities  $I$  and  $4I$  superpose, then the maximum and minimum intensities are

- A.  $5I, 3I$   
 B.  $9I, I$   
 C.  $9I, 3I$   
 D.  $5I, I$

Right Answer Explanation:

Given  $I_1 = I$  and  $I_2 = 4I$ . Now

$$\begin{aligned} I_{\max} &= I_1 + I_2 + 2\sqrt{I_1 I_2} \\ &= I + 4I + 2\sqrt{4I^2} = 9I \end{aligned}$$

and 
$$I_{\min} = I_1 + I_2 - 2\sqrt{I_1 I_2} = 5I - 4I = I$$

Hence the correct choice is (2).

23. When one of the slits in Young's experiment is covered with a transparent sheet of thickness  $3.6 \times 10^{-3}$  cm, the central fringe shifts to a position originally occupied by the 30<sup>th</sup> bright fringe. If

$\lambda = 6000 \text{ \AA}$ , then the refractive index of the sheet is

- A. 1.50
- B. 1.60
- C. 1.55
- D. 1.65

Right Answer Explanation:

The position of the 30th bright fringe is given by

$$y_{30} = 30 \frac{\lambda D}{d}$$

Hence the shift of the central fringe is

$$y_0 = 30 \frac{\lambda D}{d}$$

But  $y_0 = \frac{D}{d} (\mu - 1)t$

$$\therefore 30 \frac{\lambda D}{d} = \frac{D}{d} (\mu - 1)t$$

$$\text{or } (\mu - 1) = \frac{30\lambda}{t} = \frac{30 \times (6000 \times 10^{-10})}{(3.6 \times 10^{-5})} = 0.5$$

$$\therefore \mu = 1.5$$

24. In an interference experiment, 20<sup>th</sup> order maximum is observed at a point on the screen when light of wavelength 480 nm is used. If this light is replaced by light of wavelength 600 nm, the order of the maximum at the same point will be

- A. 16
- B. 14
- C. 12
- D. 10

Right Answer Explanation:

The position of the  $n$ th order maximum is given by

$$y_n = \frac{n\lambda D}{d}$$

For a given point  $y_n$  is fixed. Since  $D$  and  $d$  are also fixed,  $n\lambda = \text{constant}$ , i.e.  $n_1 \lambda_1 = n_2 \lambda_2$ . Hence

$$n_2 = n_1 \frac{\lambda_1}{\lambda_2} = \frac{20 \times 480}{600} = 16, \text{ which is choice (1).}$$

25. In Young's double slit experiment, the fringe width with light of wavelength 6000 Å is found to be 4.0 mm. What will be the fringe width if light of wavelength 4800 Å is used?

- A. 2.8 mm
- B. 3.2 mm
- C. 4.0 mm
- D. 4.8 mm

Right Answer Explanation:

Given  $\beta = 4.0$  mm and  $\lambda = 6000$  Å.

We know that the fringe width is given by

$$\beta = \frac{\lambda D}{d} \quad (i)$$

for  $\lambda' = 4800$  Å, the fringe width will be

$$\beta' = \frac{\lambda' D}{d} \quad (ii)$$

From (i) and (ii) we have

$$\beta' = \beta \frac{\lambda'}{\lambda} = \frac{4.0 \text{ mm} \times 4800 \text{ Å}}{6000 \text{ Å}} = 3.2 \text{ mm}$$

26. In Young's double slit experiment, the fringe width with light of wavelength  $6000 \text{ Å}$  is found to be  $4.0$  mm, what will be the fringe width using light of wavelength  $6000 \text{ Å}$  if the entire apparatus is immersed in a transparent liquid of refractive index  $4/3$ ?
- A. 2.0 mm
  - B. 3.0 mm
  - C. 4.0 mm
  - D. 5.0 mm

Right Answer Explanation:

Wavelength in air is  $\lambda_a = 6000 \text{ \AA}$ . Let its speed in air be  $v_a$ . When the apparatus is immersed in a liquid the frequency of the wave remains unchanged but its wavelength and speed both will change. Let  $\lambda_l$  be the wavelength and  $v_l$  be the speed in the liquid. Since  $v = \nu\lambda$ , we have

$$\nu = \frac{v_a}{\lambda_a} = \frac{v_l}{\lambda_l}$$

or 
$$\lambda_l = \frac{\lambda_a v_l}{v_a} = \lambda_a \frac{v_l}{c} \frac{c}{v_a}$$

( $c$  is the speed of light in vacuum). Now the refractive index of a medium is  $n = c/v$ . Hence

$$\lambda_l = \lambda_a \frac{n_a}{n_l} = \frac{\lambda_a}{n_l} \quad (\because n_a = 1)$$

Given  $\lambda_a = 6000 \text{ \AA}$  and  $n_l = 4/3$ . Therefore

$$\lambda_l = \frac{6000 \text{ \AA}}{4/3} = 4500 \text{ \AA}$$

Hence the fringe width in liquid will be

$$\beta_l = \frac{\beta_a \lambda_l}{\lambda_a} = \frac{4.0 \text{ mm} \times 4500 \text{ \AA}}{6000 \text{ \AA}} = 3.0 \text{ mm}$$

27. What is the effect on the interference fringes in Young's double slit experiment if the width of the source slit is increased?
- The fringe width increases.
  - The fringe width decreases.
  - The fringes become more distinct.
  - The fringes become less distinct.

**Right Answer Explanation:**

Let  $x$  be the width of the source slit and  $X$  the distance between the source slit and the plane of the two slits. For interference fringes to be distinctly visible, the condition  $x/X < \lambda/d$  should be satisfied. If  $x$  is too large (i.e. the source slit is too wide) or if  $X$  is too small ( $X$  is the distance between the source slit and the two slits) the requirement  $x/X < \lambda/d$  may be violated and fringes will no longer be distinct. The reason is that the interference patterns due to various parts of the source slit overlap. Consequently, the minima will not be totally dark and fringe pattern becomes indistinct. However, as long as the fringe pattern remains visible, a change in  $x$  or  $X$  has no effect on the fringe width  $\beta$ .

28. Monochromatic light rays are refracted from air into glass of refractive index  $\mu$ . The ratio of the wavelengths of the incident and refracted rays is

- A. 1 : 1
- B. 1 :  $\mu$
- C.  $\mu$  : 1
- D.  $\mu^2$  : 1

Right Answer Explanation:

Since the frequency  $n$  of the light does not change as light travels from air into glass, we have

$$v_a = n \lambda_a \text{ and } v_g = n \lambda_g$$

Therefore 
$$\frac{\lambda_a}{\lambda_g} = \frac{v_a}{v_g} = \mu$$

29. The wavelength of sodium light is 589 nm in air. What will be the wavelength of sodium light if it travels in glass of refractive index 1.5?

- A. 589 nm
- B.  $589 \times 1.5$  nm
- C.  $\frac{589}{1.5}$  nm
- D. None of these

Right Answer Explanation:

The frequency of a wave does not change when it goes from one medium into another. Thus

$$v = \frac{v_a}{\lambda_a} = \frac{v_g}{\lambda_g}$$

$$\therefore \frac{\lambda_g}{\lambda_a} = \frac{v_g}{v_a} = \frac{v_g}{c} \times \frac{c}{v_a} = \frac{\mu_a}{\mu_g}$$

$$\therefore \lambda_g = \frac{\mu_a \lambda_a}{\mu_g} = \frac{1}{1.5} \times 589 = \frac{589}{1.5} \text{ nm}$$

30. In Young's double slit experiment, the 10<sup>th</sup> maximum of wavelength  $\lambda_1$  is at a distance  $y_1$  from its central maximum and the 5<sup>th</sup> maximum of wavelength  $\lambda_2$  is at a distance  $y_2$  from its central maximum. The ratio  $y_1/y_2$  will be

- A.  $\frac{2\lambda_1}{\lambda_2}$



- B.  $\frac{2\lambda_2}{\lambda_1}$
- C.  $\frac{\lambda_1}{2\lambda_2}$
- D.  $\frac{\lambda_2}{2\lambda_1}$

Right Answer Explanation:

We know that  $y_m = \frac{m\lambda D}{d}$ . Therefore, for wavelength  $\lambda_1$ ,

$$y_1 = \frac{10\lambda_1 D}{d}$$

and for wavelength  $\lambda_2$ ,

$$y_2 = \frac{5\lambda_2 D}{d}$$

$$\therefore \frac{y_1}{y_2} = \frac{2\lambda_1}{\lambda_2}$$

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