QB365

Important Questions - Wave Optics

12th Standard CBSE

Physics

Reg.No. : | | | | | |

Time : 01:00:00 Hrs

Total Marks : 50

Section-A

1) A source of light lies on the angle bisector of two plane mirror included at angle θ. The value of θ so that the light reflected from one mirror does not reach the other mirror does not reach each other mirror will be **1**

(a) $\theta \geq$ (b) 120° $\theta \geq$ (c) 90° $\theta \geq$ (d) 90° None of the above

2) The ratio of the speed of an object to the speed of its real image of magnification m in the case of a convex mirror is **1**

(a) $-\frac{1}{m^2}$ (b) m^2 (c) -*m (d) $\frac{1}{m}$

3) The correct mirror equation is **1**

(a) $\frac{1}{f}$ (b) $\frac{1}{v}\frac{1}{f}$ + (c) $\frac{1}{u}\frac{1}{v}\frac{1}{f}$ (d) $\frac{1}{u}\frac{1}{u}$ none $\frac{1}{v}$ of these

4) For any position of an object, image formed in a convex mirror is **1**

(a) virtual (b) erect (c) smaller in size (d) as far behind the mirror as the object is in front

5) Image of an object in a concave mirror is **1**

(a) always real (b) always virtual (c) always erect (d) real or virtual depending on position of object

6) The linear magnification of a convex mirror is **1**

(a) always positive (b) always negative (c) sometimes positive and sometimes negative (d) cannot predict

Section-B

7) How can we see a virtual image when it cannot be obtained on a screen? **2**

8) Where does a myopic eye focus the parallel rays falling on it? **2**

9) A myopic person prefers to remove his spectacles while reading a book.Why? **2**

10) Can a microscope function as atelecope by inverting it.Can a telescope function as a microscope? **2**

11) How does the magnification of a magnifying glass differ from its magnifying power? **2**

12) What is the difference between the virtual images produced by (i) plane mirror (ii) concave mirror and (iii) convex mirror? **2**

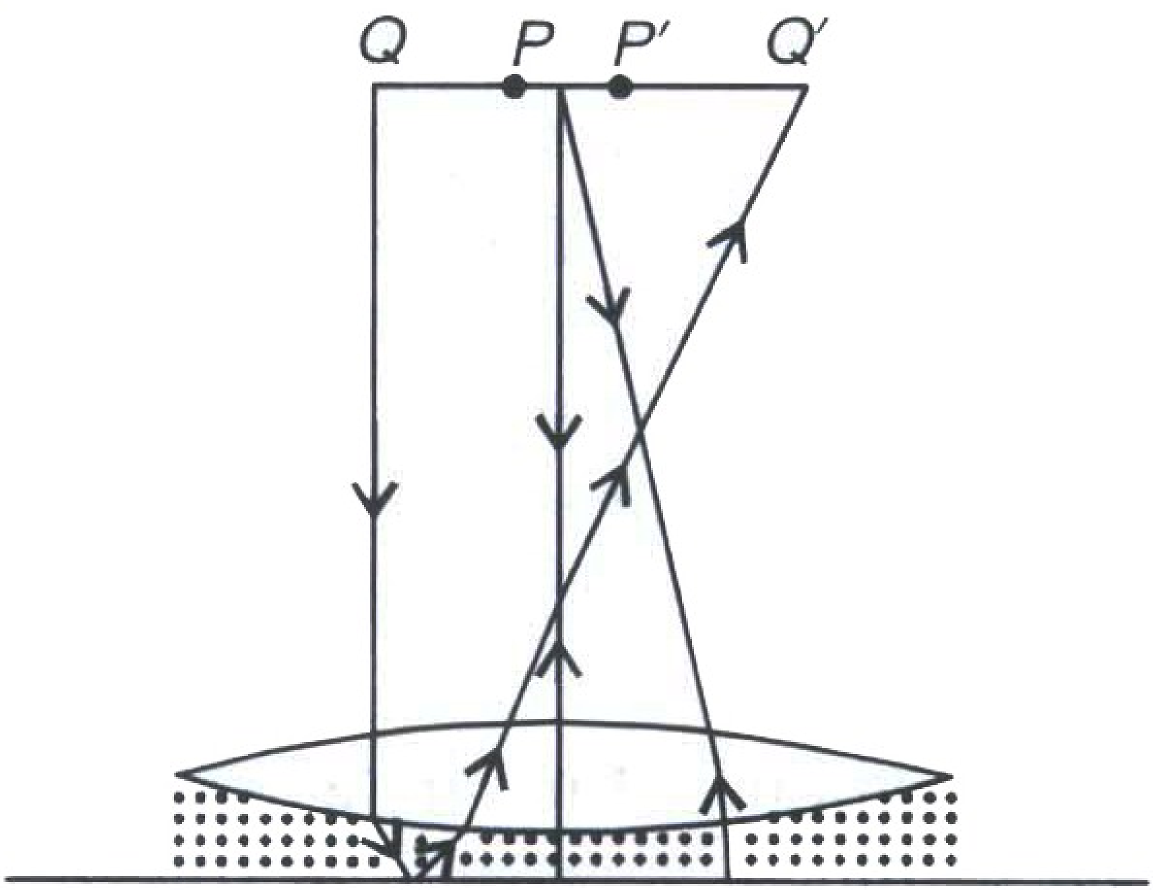
Section-C

13) What are coherent sources of light? In Young's double slit experiment, two slits are separated by 3 mm distance and illuminated by light of wavelength 480 nm, The screen is at 2 m from the plane of the slits. Calculate the separation between the 8 bth bright fringe and the 3 rd dark fringe observed with respect to the central bright fringe. **3**

14) A double convex lens made of glass of refractive index 1.5 has both radii of curvature of magnitude 20 cm. An object 2 cm high is placed at 10 cm from the lems. Find the position, nature and size of the image. **3**

15) The bottom of a container is a 4.0 cm thick glass (n=1.5) slab. The container contain two immiscible liquids A and B of depths 6.0 cm and 8.0 cm, respectively. what is the apparent position of a scratch on the outer surface of the bottom of the glass slab when viewed through the container? Refractive indices of A and B are 1.4 and 1.3 respectively. **3**

16) Figure shows an equiconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle with its tip on the principal axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be 45.0 cm The liquid is removed and the experiment is repeated. The new distance is measured to be 30.0 cm. What is the refractive index of the liquid ? **3**



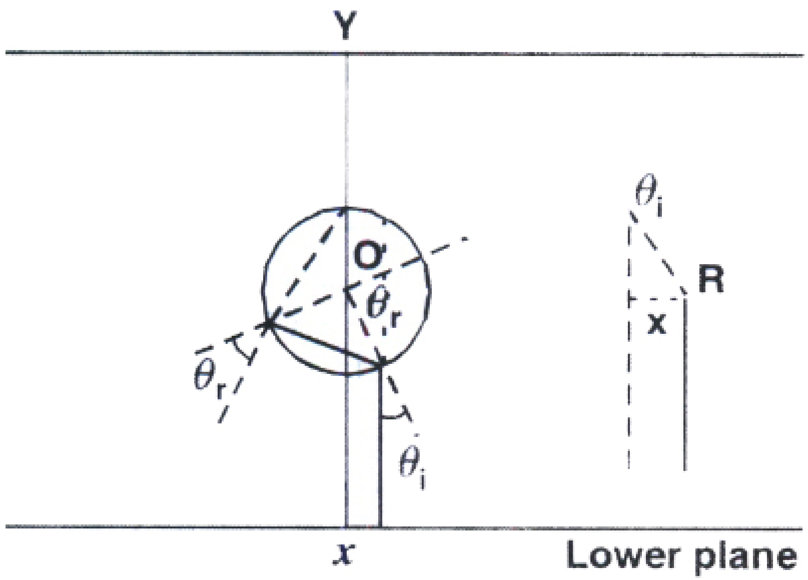
Section-D

17) Show that at polarising angle, the reflected and refracted beams of light are at 90° to each other. **5**

18) The mixture a pure liquid and a solution in a long vertical column (i.e., horizontal dimensions << vertical dimensions) produces diffusion of solute particles and hence a refractive index gradient along the vertical dimension. A ray of light entering the column at right angles to the vertical deviates from its original path. find the deviation in travelling a horizontal distance d<<h, the height of the column. **5**

19) If light passes near a massive object, the gravitational interaction causes a bending of the ray. This can be thought of as happening due to a change in the effective refractive index of the medium given by $n(r) = 1 + \frac{2GM}{rc^2}$ where r is the distance of the point of consideration from the centre of the mass of the massive body. G is the universal gravitational constant, M the mass of the body and c the speed of light in vacuum. considering a spherical object find the deviation of the ray from the original path as it grazes the object **5**

20) An infinitely long cylinder of radius R is made of an unusual exotic material with refractive index -1. The cylinder is placed between two planes whose normals are along the y direction. The centre of the cylinder O lies along the y-axis. A narrow laser beam is directed along the y direction from the lower plate. The laser source is at a horizontal distance x from the diameter in the y direction. find the range of x such that light emitted from the lower plane does not reach the upper plane **5**



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Section-A

1) (a) $\theta \geq 120^\circ$ **1**

2) (a) $-\frac{1}{m^2}$ **1**

3) (a) $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$ **1**

4) (d) as far behind the mirror as the object is in front **1**

5) (d) real or virtual depending on position of object **1**

6) (b) always negative **1**

Section-B

7) **2**

True, a virtual image cannot be taken on screen.But our eye lens forms a real image of(virtual image acting as virtual object) on the retina of our eyes.

8) These rays are focussed in front of the retina. **2**

9) 2

A myopic person has to use spectacles with concave lens.He may have normal near point (≈25cm).To read with specs, he has o hold the book at a distance greater than 25cm.As angular size of object at a distance >25cm is less than angular size of object at 25 cm, therefore, the person prefers to remove his spectacles while reading.

10) 2

No, in a telescope, objective lens has much larger focal length than the eye lens.In a microscope, both lenses have short focal lengths.

11) Magnification, $m = \frac{size\ of\ image}{size\ of\ object} = \frac{v}{u}$; 2

Magnifying power,

$m' = \frac{angle\ subtended\ at\ eye\ by\ image}{angle\ subtended\ at\ eye\ by\ objet}$,

When both the object and image are located at the least distance of distinct vision (d) from the eye.

$m' = \frac{d}{u}$

Clearly, $m \neq m'$, unless v=d

12) 2

In a plane mirror, virtual image is of same size as the object. In a concave mirror, the virtual image is magnified and in a convex mirror, virtual image is always diminished in size.

Section-C

13) 1.76×10^{-3} m 3

14) u = -20 cm, I = 4 cm 3

15) 4.9 cm 3

16) 1.33 3

Section-D

17) 5

Let μ be refractive index of the transparent surface. If i_p is polarising angle r is the angle of refraction as shown in Fig. then from Snell law, we have

$$\mu = \frac{\sin i_p}{\sin r} \quad \ldots.(1)$$

i.e. the reflected

$$From \quad Breester' \quad law, \quad we \quad have$$

$$\mu = \tan i_p = \frac{\sin i_p}{\sin i_p} \quad \ldots.(2)$$

$$From \quad Eqs. \quad (1)\&(2), \quad we \quad have$$

$$\frac{\sin i_p}{\sin r} = \frac{\sin i_p}{\cos i_p}$$

$$or \quad \sin r = \cos i_p$$

$$or \quad \sin r = \sin(90^\circ - i_p)$$

$$or \quad r = 90^\circ - i_p$$

$$or \quad i_p + r = 90^\circ$$

and refracted beams of light at polarising angle are perpendicular to each other.

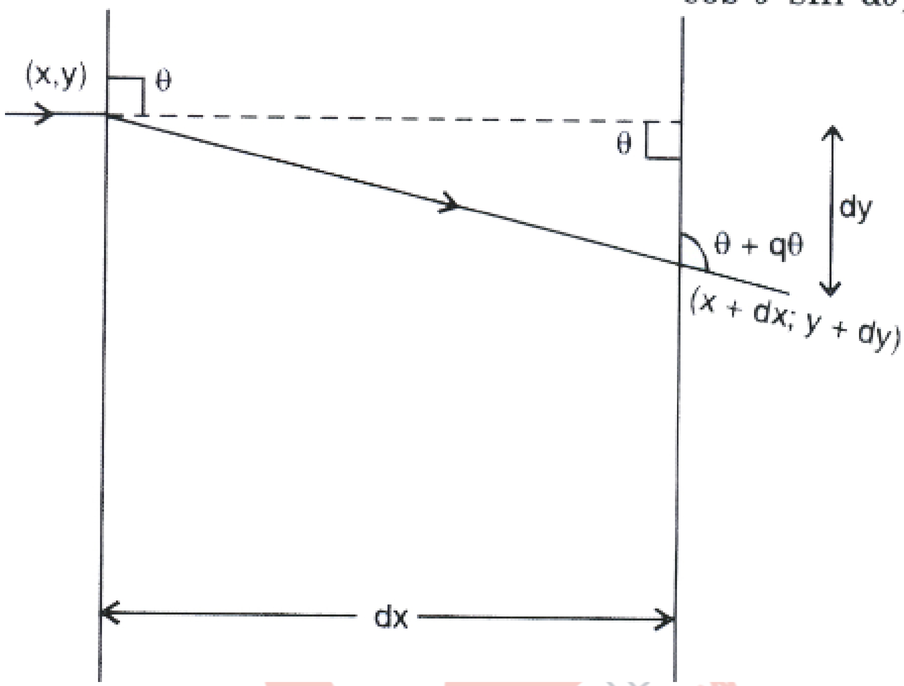
18)

Here ray of light at (x, y) enters at 90°. consider a portion of the ray between x and x+dx inside the liquid. the ray deviates at an angle $d\theta$ between x and x+dx. emerging at (x+dx, y+dy) at an angle $\theta + d\theta$ while entering at θ, at height ay and y + dy. from snell's law

$$\mu(y) \quad sin \quad \theta \quad = \quad \mu(y+dy) \quad sin \quad (\theta + d\theta)$$

or $$\mu(y) \quad sin \quad \theta \quad = \quad \left(\mu(y) + \frac{d\mu}{dy}dy\right)(sin \quad \theta \quad cos \quad d\theta + cos \quad \theta \quad sin \quad d\theta)$$

$\cos\,\theta\,\sin\,d\theta)$ As is small, cos = 1



$d\theta$ $d\theta$

and sin $d\theta$ = $d\theta$

$\therefore \quad \mu(y) \quad sin \quad \theta \quad = \quad \mu(y) \quad sin \quad \theta + \quad \mu(y) \quad cos \quad \theta \quad d\theta + \frac{d\mu}{dy}dy \quad sin \quad \theta$ (the fourth term is negligibly small hence neglected)

or $\mu(y) \quad cos \quad \theta \quad d\theta \quad = -\frac{d\mu}{dy}dy \quad sin \quad \theta$ but from the figure, we find

or $$d\theta \quad = -\frac{1}{\mu}\frac{d\mu}{dy}dy \quad tan \quad \theta$$

$tan \quad \theta = \frac{dx}{dy} \quad \Rightarrow \quad dy \quad tan \quad \theta = dx$ This is the deviation in

so $$d\theta = -\frac{1}{\mu}\frac{d\mu}{dy}dx$$

or $$\theta = -\frac{1}{\mu}\frac{d\mu}{dy}\int_0^d dx = -\frac{1}{\mu}\frac{d\mu}{dy}(d)$$

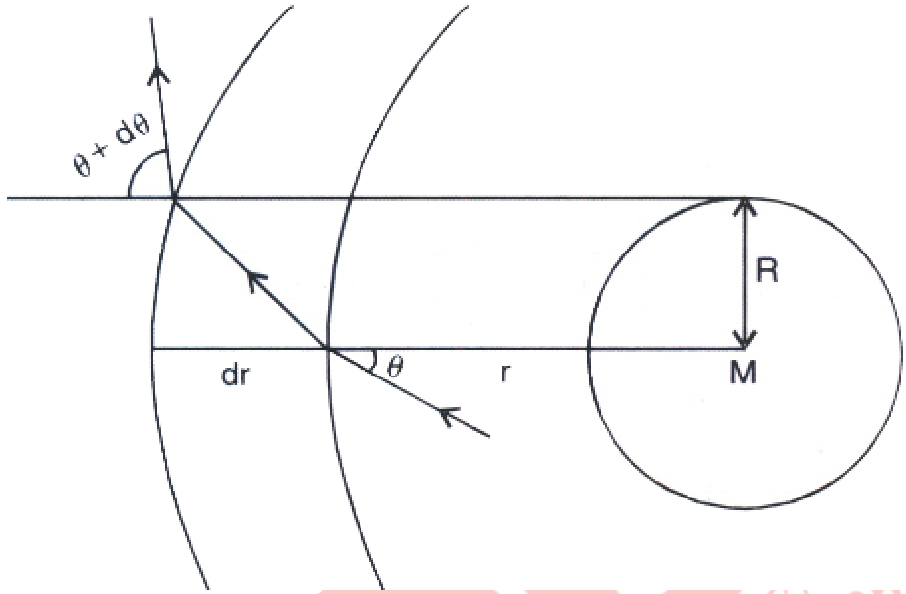
travelling a horizontal distance d.

19)

Let the light be incident at the angle θ at the plane at r and leave r+dr at an angle $\theta + d\theta$ From snell's law $n(r) sin \quad \theta \quad = \quad n(r+dr) \quad sin(\theta + d\theta)$

$$= \left[n(r) + \frac{dn}{dr} dr\right] \quad [sin\theta \quad cos \quad d\theta + cos\theta \quad sind\theta]$$

$\left[\sin\theta\cos d\theta + \cos\theta\sin d\theta\right]$ As is small, so



$d\theta$

$cos \quad d\theta = \quad 1$ and $sind\theta = d\theta$ and neglecting the product of differentiates, we get

$$n(r) sin \quad \theta \quad = \quad n(r) \quad sin\theta + n(r) \quad cos \quad d\theta + \frac{dn}{dr} dr \quad sin\theta$$

$$or \qquad -\frac{dn}{dr} dr \quad sin\theta \quad = \quad n(r) cos\theta \quad d\theta$$

$$or \qquad -\frac{dn}{dr} dr \quad tan\theta \quad = \quad n(r) \frac{d\theta}{dr}$$

$As \qquad n(r) \quad = \quad 1 + \frac{2GM}{rc^2}$ Putting in eq, we get

$$\therefore \qquad \frac{dn}{dr} \quad = \quad \frac{-2GM}{r^2c^2}$$

$\frac{-2GM}{r^2c^2} tan\theta \quad = \quad \left(1 + \frac{2GM}{rc^2}\right) \frac{d\theta}{dr} = \frac{d\theta}{dr}$ Integrating both sides, we get

$$or \qquad d\theta \quad = \quad \frac{2GM}{c^2} \frac{tan\theta}{r^2} dr$$

$$\int_0^{\theta_0} d\theta \quad = \quad \frac{2GM}{c^2} \int_{-\infty}^{\infty} \frac{tan\theta \quad dr}{r^2}$$

$$= \quad \frac{2GM}{c^2} \int_{-\infty}^{\infty} \frac{tan\theta \quad dr}{r^3} . r$$

$$As \quad r^2 = x^2 + R^2 \quad and \quad tan\theta = \frac{R}{X}, \quad we \quad get$$

$$2r \quad dr = 2xdx$$

$$\therefore \qquad \int_0^{\theta_0} d\theta = \frac{2GM}{c^2} \int_{-\infty}^{\infty} \frac{R}{x} \frac{x \quad dx}{(X^2+R^2)^{3/2}}$$

$$let \qquad x = R \quad tan \quad \phi$$

$$\therefore \qquad dx = R \quad sec^2\phi \quad d\phi$$

$$\therefore \qquad \theta_0 = \frac{2GMR}{c^2} \int_{-\pi/2}^{\pi/2} \frac{Rsec^2\phi \quad d\phi}{R^3 sec^3\phi}$$

$$= \frac{2GMR}{c^2} \int_{-\pi/2}^{\pi/2} cos\phi \quad d\phi = \frac{4GM}{Rc^2}$$

20)

As the material is of refractive index-1. θ_2 is negative and θ'_2 is positive Now $|\theta_i| = |\theta_r| = |\theta'_r|$ The total deviation of the out coming ray from the incoming ray is $4\theta_i$ The ray shall not reach the receiving plate if $\frac{\pi}{2} \leq 4\theta_i \leq \frac{3\pi}{2}$ (Angles measured clockwise from the y-axis) or $\frac{\pi}{8} \leq \theta_i \leq \frac{3\pi}{8}$ From the figure $sin\theta_i = \frac{\pi}{R}$ Thus for $\frac{R\pi}{8} \leq x \leq \frac{3R\pi}{8}$ light emitted from the source shall not

$\therefore \quad \frac{\pi}{8} \leq sin^{-1}\frac{\pi}{R} \leq \frac{3\pi}{8}$

$or \quad \frac{\pi}{8} \leq \frac{\pi}{R} \leq \frac{3\pi}{8}$

reach the receiving plate