RAY OPTICS AND OPTICAL INSTRUMENTS

FACT/DEFINITION TYPE QUESTIONS

1. Electromagnetic radiation belonging to _____ region of spectrum is called light.
   (a) 100 nm to 400 nm   (b) 400 nm to 750 nm
   (c) 750 nm to 10 nm   (d) 1000 nm to 1400 nm

2. The turning back of light into the same medium after incident on a boundary separating two media is called
   (a) reflection of light   (b) refraction of light
   (c) dispersion of light   (d) interference of light

3. A point source of light is placed in front of a plane mirror. Then
   (a) all the reflected rays meet at a point when produced backward
   (b) only the reflected rays close to the normal meet at a point when produced backward.
   (c) only the reflected rays making a small angle with the mirror, meet at a point when produced backward.
   (d) light of different colours make different images.

4. The field of view is maximum for
   (a) plane mirror   (b) concave mirror
   (c) convex mirror   (d) cylindrical mirror

5. A virtual image larger than the object can be obtained by
   (a) concave mirror   (b) convex mirror
   (c) plane mirror   (d) concave lens

6. An object is placed 40 cm from a concave mirror of focal length 20 cm. The image formed is
   (a) real, inverted and same in size
   (b) real, inverted and smaller
   (c) virtual, erect and larger
   (d) virtual, erect and smaller

7. All of the following statements are correct except
   (a) the magnification produced by a convex mirror is always less than one
   (b) a virtual, erect, same-sized image can be obtained using a plane mirror
   (c) a virtual, erect, magnifield image can be formed using a concave mirror
   (d) a real, inverted, same-sized image can be formed using a convex mirror.

8. A person is six feet tall. How tall must a plane mirror be if he is able to see his entire length?
   (a) 3 ft   (b) 4.5 ft   (c) 7.5 ft   (d) 6 ft

9. The image formed by a concave mirror is
   (a) always real
   (b) always virtual
   (c) certainly real if the object is virtual
   (d) certainly virtual if the object is real

10. In image formation from spherical mirrors, only paraxial rays are considered because they
    (a) are easy to handle geometrically
    (b) contain most of the intensity of the incident light
    (c) form nearly a point image of a point source
    (d) show minimum dispersion effect

11. For reflection through spherical surfaces, the normal at the point of incidence is
    (a) perpendicular to the principle axis and passes through the centre of curvature
    (b) perpendicular to the focal plane and passes through the pole.
    (c) perpendicular to the tangent plane at pole and passes through the focus.
    (d) perpendicular to the tangent plane at the point of incidence and passes through the centre of curvature.

12. The equation $\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$ holds true for
    (a) only concave mirror
    (b) only convex mirror
    (c) both concave and convex mirror
    (d) any type of reflecting surface

13. Which of the following (referred to a spherical mirror) depends on whether the rays are paraxial or not?
    (a) Pole   (b) Focus
    (c) Radius of curvature   (d) Principal axis

14. Which of the following is correct for the beam which enters the medium?
    (a) Travel as a cylindrical beam
    (b) Diverge
    (c) Converge
    (d) Diverge near the axis and converge near the periphery

15. When light is refracted into a medium,
    (a) its wavelength and frequency both increase
    (b) its wavelength increases but frequency remains unchanged
    (c) its wavelength decreases but frequency remains unchanged
    (d) its wavelength and frequency both decrease

16. When light is refracted, which of the following does not change ?
    (a) Wavelength   (b) Frequency
    (c) Velocity   (d) Amplitude

17. If the light moving in a straight line bends by a small but fixed angle, it may be a case of
    (a) reflection   (b) refraction
    (c) diffraction   (d) both (a) & (b)

18. Total internal reflection can take place only if
    (a) light goes from optically rarer medium (smaller refractive index) to optically denser medium
    (b) light goes from optically denser medium to rarer medium
    (c) the refractive indices of the two media are close to different
    (d) the refractive indices of the two media are widely different

19. The difference between reflection and total internal reflection is that
    (a) the laws of reflection hold true for reflection but not for total internal reflection.
    (b) total internal reflection can take place only when light travels from a rarer medium to a denser medium while reflection can take place vice-versa also.
    (c) reflection can take place when light travels from a rarer medium to denser medium and vice-versa but total internal reflection can take place only when it travels from an optically denser to an optically rarer medium.
    (d) reflection is a natural phenomena while total internal reflection is man-made.

20. When the angle of incidence of a light ray is greater than the critical angle it gets
    (a) critically refracted
    (b) totally reflected
    (c) total internally reflected
    (d) totally refracted

21. Which of the following phenomena is used in optical fibres ?
    (a) Total internal reflection
    (b) Scattering
    (c) Diffraction
    (d) Refraction

22. Critical angle of light passing from glass to water is minimum for
    (a) red colour   (b) green colour
    (c) yellow colour   (d) violet colour

23. Which of the following is not due to total internal reflection?
    (a) Working of optical fibre
    (b) Difference between apparent and real depth of pond
    (c) Mirage on hot summer days
    (d) Brilliance of diamond

24. Identify the wrong sign convention
    (a) The magnification for virtual image formed by a convex lens is positive
    (b) The magnification for real image formed by a convex lens is negative

    (c) The height measured normal to the principal axis upwards is positive
    (d) The magnification for virtual image formed by a concave lens is negative

25. The apparent flattening of the sun at sunset and sunrise is due to
    (a) refraction
    (b) diffraction
    (c) total internal reflection
    (d) interference

26. The speed of light in an isotropic medium depends on
    (a) the nature of the source
    (b) its wavelength
    (c) its direction of propagation
    (d) its intensity

27. A parallel beam of light is incident on a converging lens parallel to its principal axis. As one moves away from the lens on the other side on its principal axis, the intensity of light
    (a) remains constant
    (b) continuously increases
    (c) continuously decreases
    (d) first increases then decreases

28. The rays of different colours fail to converge at a point after going through a converging lens. This defect is called
    (a) spherical aberration   (b) distortion
    (c) coma   (d) chromatic aberration

29. What causes chromatic aberration?
    (a) Marginal rays
    (b) Central rays
    (c) Difference in radii of curvature of its surfaces
    (d) Variation of focal length of lens with colour

30. The focal length of a converging lens are f_V and f_R for violet and red light respectively. Then
    (a) $f_V > f_R$
    (b) $f_V = f_R$
    (c) $f_V < f_R$
    (d) any of the three is possible depending on the value of the average refractive index m

31. A narrow beam of white light goes through a slab having parallel faces
    (a) the light never splits in different colours
    (b) the emergent beam is white
    (c) the light inside the slab is split into different colours
    (d) the light inside the slab is white

32. Chromatic aberration in a lens is caused by
    (a) reflection   (b) interference
    (c) diffraction   (d) dispersion

33. Which of the following is Lens maker's formula?
    (a) $\dfrac{\mu_2}{v} = \dfrac{\mu_1}{u} = \left(\dfrac{\mu_2 - \mu_1}{R}\right)$ (b) $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{R}$
    (c) $\dfrac{1}{f} = \dfrac{1}{v} + \dfrac{1}{u}$ (d) $\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

34. The angular dispersion produced by a prism
    (a) increases if the average refractive index increases
    (b) increases if the average refractive index decreases
    (c) remains constant whether the average refractive index increases or decreases
    (d) has no relation with average refractive index.

35. If a glass prism is dipped in water, its dispersive power
    (a) increases
    (b) decreases
    (c) does not change
    (d) may increase or decrease depending on whether the angle of the prism is less than or greater than 60°

36. If D is the deviation of a normally falling light beam on a thin prism of angle A and δ is the dispersive power of the same prism then
    (a) D is independent of A.
    (b) D is independent of refractive Index.
    (c) δ is independent of refractive index.
    (d) δ is independent of A.

37. When white light enters a prism, it gets split into its constituent colours. This is due to
    (a) high density of prism material
    (b) because μ is different for different wavelength
    (c) diffraction of light
    (d) velocity changes for different frequency

38. Yellow light is refracted through a prism producing minimum deviation. If i_1 and i_2 denote the angle of incidence and emergence for this prism, then
    (a) $i_1 = i_2$ (b) $i_1 > i_2$
    (c) $i_1 < i_2$ (d) $i_1 + i_2 = 90°$

39. By properly combining two prisms made of different materials, it is not possible to have
    (a) dispersion without average deviation
    (b) deviation without dispersion
    (c) both dispersion and average deviation
    (d) neither dispersion nor average deviation

40. When the incidence angle is equal to the angle of emergence of light from the prism the refracted ray inside the prism
    (a) becomes parallel to the right face of prism
    (b) becomes perpendicular to the base of prism
    (c) becomes parallel to the base of prism
    (d) becomes perpendicular to the left face of prism

41. The dispersive power of a prism depends on its
    (a) shape
    (b) size
    (c) angle of prism
    (d) refractive index of the monitorial of the prism

42. The angle of prism is 60° and angle of deviation is 30°. In the position of minimum deviation, the values of angle of incidence and angle of emergence are:
    (a) $i = 45°$; $e = 50°$ (b) $i = 30°$; $e = 45°$
    (c) $i = 45°$; $e = 45°$ (d) $i = 30°$; $e = 30°$

43. In primary rainbow what is the order of colours observed from earth ?
    (a) Violet innermost, red outermost.
    (b) Red innermost, violet outermost.
    (c) Random.
    (d) White and dark alternatively

44. Which light rays undergoes two internal reflection inside a raindrop, which of the rainbow is formed?
    (a) Primary rainbow   (b) Secondary rainbow
    (c) Both (a) and (b)   (d) Can't say

45. In secondary rainbow what is the order of colours observed from earth?
    (a) Violet innermost, red outermost.
    (b) Red innermost, violet outer most.
    (c) Random.
    (d) White and dark alternatively.

46. Identify the mismatch in the following
    (a) Myopia   -   Concave lens
    (b) For rear view   -   Concave mirror
    (c) Hypermetropia   -   Convex lens
    (d) Astigmatism   -   Cylindrical lens

47. Astigmatism is corrected using
    (a) cylindrical lens   (b) plano-convex lens
    (c) plano-concave lens   (d) convex lens

48. The focal length of a normal eye-lens is about
    (a) 1 mm   (b) 2 cm
    (c) 25 cm   (d) 1 m

49. A normal eye is not able to see objects closer than 25 cm because
    (a) the focal length of the eye is 25 cm
    (b) the distance of the retina from the eye-lens is 25 cm
    (c) the eye is not able to decrease the distance between the eye-lens and the retina beyond a limit
    (d) the eye is not able to decrease the focal length beyond a limit

50. The image formed by an objective of a compound microscope is
    (a) real and diminished   (b) real and enlarged
    (c) virtual and enlarged   (d) virtual and diminished

51. An astronomical telescope has a large aperture to
    (a) reduce spherical aberration
    (b) have high resolution
    (c) increases span of observation
    (d) have low dispersion

52. To increase the angular magnification of a simple microscope, one should increase
    (a) the focal length of the lens
    (b) the power of the lens
    (c) the aperture of the lens
    (d) the object size

53. In which of the following the final image is erect ?
    (a) Simple microscope
    (b) Compound microscope
    (c) Astronomical telescope
    (d) None of these

54. Resolving power of a telescope increases with
    (a) increase in focal length of eye-piece
    (b) increase in focal length of objective
    (c) increase in aperture of eye piece
    (d) increase in apeture of objective

55. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by
(a) a vernier scale provided on the microscope
(b) a standard laboratory scale
(c) a meter scale provided on the microscope
(d) a screw gauge provided on the microscope

56. If the focal length of objective lens is increased then magnifying power of :
(a) microscope will increase but that of telescope decrease.
(b) microscope and telescope both will increase.
(c) microscope and telescope both will decrease.
(d) microscope will decrease but that of telescope increase.

57. The light gathering power of an astronomical telescope depends upon
(a) length of tube   (b) focal length of objective
(c) area of eye-piece   (d) area of objective

58. The objective of a telescope must be of large diameter in order to
(a) remove chromatic aberration
(b) remove spherical aberration and high magnification
(c) gather more light and for high resolution
(d) increase its range of observation

STATEMENT TYPE QUESTIONS

59. Which of the following statements about laws of reflection is/are correct?
I. The incident ray, the reflected ray and the normal all lie in the same plane.
II. Angle of incidence is equal to the angle of reflection.
III. After reflection, velocity, wavelength and frequency of light remains same but intensity decreases.
(a) I only   (b) II only
(c) I and II   (d) I, II and III

60. A convex mirror is used to form the image of an object. Then which of the following statements is/are true?
I. The image lies between the pole and the focus
II. The image is diminished in size
III. The image is real
(a) I only   (b) II only
(c) I and III   (d) I and II

61. In case of reflection over spherical surface, which of these are correct ?
I. Normal is taken as perpendicular of tangent at point of incidence.
II. Perpendicular to incident ray which is perpendicular to plane of incident ray.
III. Line joining centre of curvature of mirror with point of incidence.
IV. Line joining centre of curvature and pole of curved surface.
(a) I and II   (b) I and III
(c) II and III   (d) II and IV

62. If i = angle of incidence and r = angle of refraction, then the ratio $\dfrac{\sin i}{\sin r}$
I. is a constant for a pair of media.
II. is called refractive index of medium 2 with respect to medium 1.
III. is called absolute refractive index of medium 2.
IV. varies with temperature.
(a) I, II and III   (b) II, III and IV
(c) I, II and IV   (d) I, III and IV

63. Which of the following is/are correct relations?
I. $n_{21} = \dfrac{1}{n_{12}}$ II. $n_{32} = n_{31} \times n_{12}$
III. $n_{21} = \dfrac{n_{1a}}{n_{2a}}$ IV. $n_{21} = \dfrac{n_{2a}}{n_{1a}}$
(a) I, II and IV   (b) I, III and IV
(c) II, III and IV   (d) I, II, III and IV

64. Which of the following statements is/are correct about a convex lens?
I. Convex lens is converging for light for all wavelengths.
II. For virtual object, the image is also virtual.
III. For real object, the image is always real.
(a) I and II   (b) II and III   (c) I and III   (d) Only I

65. Sunlight reaches to us in composite form and not in its constituent colours because
I. vacuum is non–dispersive.
II. speed of all colours is same in vacuum.
III. light behaves like a particle in vacuum.
IV. light travels in a straght line in vacuum.
(a) I and II   (b) II and III   (c) III and IV   (d) I and IV

66. Which of the following statements is/are incorrect?
I. At sunset or sunrise, the sun's rays have to pass through a small distance in the atmosphere.
II. At sunset or sunrise, the sun's rays have to pass through a larger distance in the atmosphere.
III. Rayleigh scattering which is proportional to $(1/\lambda)^2$.
(a) I and II   (b) I and III
(b) II and III   (d) I, II and III

MATCHING TYPE QUESTIONS

67. Match the Column-I and Column-II

Column – I	Column – II
(A) An object is placed at focus before a convex mirror	(1) Magnification is $-\infty$
(B) An object is placed at centre of curvature before a concave mirror	(2) Magnification is 0.5
(C) An object is placed at focus before a concave mirror	(3) Magnification is +1
(D) An object is placed at centre of curvature before a convex mirror	(4) Magnification is –1
	(5) Magnification is 0.33

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (5)
(b) (A) → (5); (B) → (4); (C) → (3); (D) → (1)
(c) (A) → (2); (B) → (4); (C) → (1); (D) → (5)
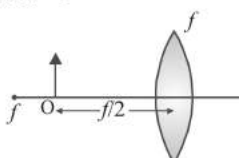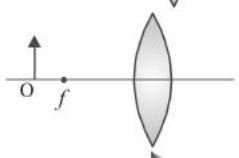(d) (A) → (3); (B) → (5); (C) → (2); (D) → (4)

68. Match the columns I and II
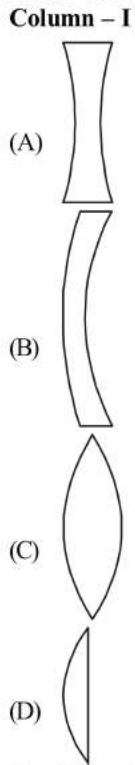
Column – I		Column – II
(A)		(1) Planoconvex
(B)		(2) Biconcave
(C)		(3) Convexoconcave
(D)		(4) Biconvex

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(c) (A) → (2); (B) → (4); (C) → (3); (D) → (1)
(d) (A) → (3); (B) → (2); (C) → (1); (D) → (4)

69. Match the columns I and II

Column I	Column II
(A) Mirage	(1) Refraction of light by
(B) Apparent depth of object is lesser than the actual depth in water	(2) Scattering of sunlight
(C) Blue colour of sky	(3) Total internal reflection
(D) The formation of rainbow	(4) Dispersion of sunlight

(a) (A) → (2); (B) → (3); (C) → (4); (D) → (1)
(b) (A) → (3); (B) → (4); (C) → (1); (D) → (2)
(c) (A) → (4); (B) → (1); (C) → (2); (D) → (3)
(d) (A) → (3); (B) → (1); (C) → (2); (D) → (4)

70.
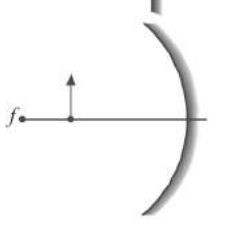
Column I	Column II
(A) Lens of power + 2.0 D	(1) Convex lens of focal length 200 cm.
(B) Lenses of combination of power +0.25 D and +0.25 D	(2) Concave lens of focal length 40 cm
(C) Lens of power –2.0 D	(3) Convex lens of focal length 50 cm
(D) Lenses combination of power –60 D and +3.5 D	(4) Concave lens of focal length 50 cm

(a) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(b) (A) → (3); (B) → (1); (C) → (4); (D) → (2)
(c) (A) → (4); (B) → (3); (C) → (1); (D) → (2)
(d) (A) → (3); (B) → (4); (C) → (2); (D) → (1)

71. For an object placed in front of a mirror, magnification (m) is given in Column I, Column II gives the possible nature of the mirror or that of image. Match appropriately.
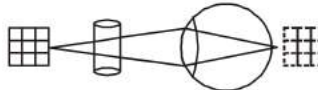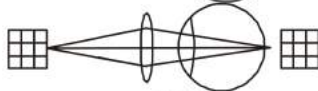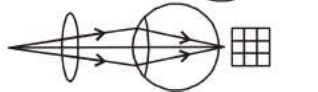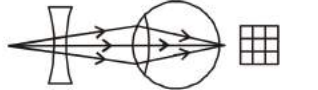
Column – I	Column – II
(A) $m = \dfrac{1}{4}$	(1) Concave mirror
(B) $m = -1$	(2) Convex mirror
(C) $m = 2$	(3) Plane mirror
(D) $m = 1$	(4) Real

(a) (A) → (2); (B) → (1); (C) → (1); (D) → (3)
(b) (A) → (1); (B) → (2); (C) → (4); (D) → (2)
(c) (A) → (2); (B) → (4); (C) → (1); (D) → (3)
(d) (A) → (1); (B) → (4); (C) → (3); (D) → (2)

72. Match the following Column II gives nature of image formed in various cases given in Column I

Column – I		Column – II
(A)		(1) Real
(B)		(2) Inverted
(C)		(3) Virtual
(D)		(4) Upright
		(5) Magnified

(a) (A) → (1, 2, 3); (B) → (4, 5); (C) → (2); (D) → (1, 5)
(b) (A) → (3, 4, 5); (B) → (1, 2, 5); (C) → (3, 4); (D) → (3, 4, 5)
(c) (A) → (1); (B) → (2, 3); (C) → (4, 5); (D) → (1)
(d) (A) → (4); (B) → (3, 4); (C) → (2, 3); (D) → (1)

73.

Column I	Column II
(A) Hypermetropia	(1)
(B) Myopia	(2)
(C) Astigmatism	(3)
(D) Presbyopia	(4)

(a) (A) → (3); (B) → (1); (C) → (2); (D) → (4)
(b) (A) → (4); (B) → (3); (C) → (2); (D) → (1)
(c) (A) → (1); (B) → (2); (C) → (3); (D) → (4)
(d) (A) → (3); (B) → (4); (C) → (1); (D) → (2)

74. Match the columns I and II

Column I	Column II
(i) Terrestrial telescope	(1) Final image is inverted w.r.t. the object.
(ii) Galileo's telescope	(2) No chromatic aberration
(iii) Reflecting telescope	(3) Final image is erected.
(iv) Astronomical telescope	(4) Uses concave lens for the eyepiece to obtain an erected image.

(a) (A) → (3); (B) → (2); (C) → (4); (D) → (1)
(b) (A) → (1); (B) → (4); (C) → (3); (D) → (2)
(c) (A) → (3); (B) → (4); (C) → (2); (D) → (1)
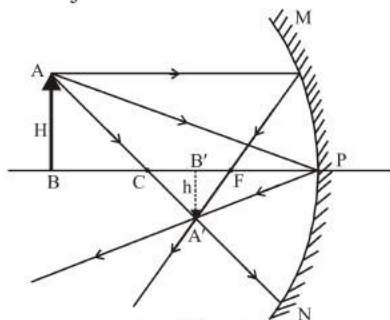(d) (A) → (2); (B) → (1); (C) → (2); (D) → (3)

DIAGRAM TYPE QUESTIONS

75. Figure shows two rays A and B being reflected by a mirror and going as A' and B'. The mirror
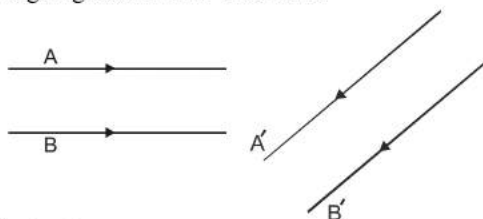
(a) is plane
(b) is convex
(c) is concave
(d) may be any spherical mirror

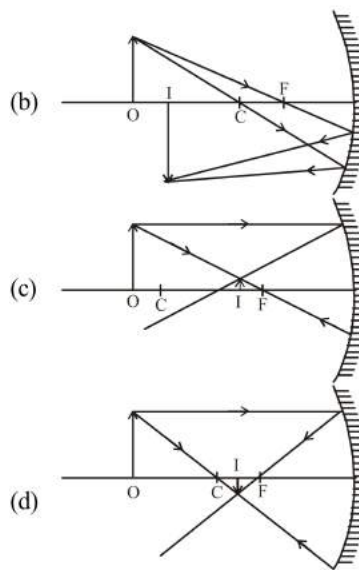76. The correct sign convention for the following figure where the object is at 'c' will be

(a) $u = -ve$; $v = +ve$; $H = +ve$; $h = -ve$
(b) $u = +ve$; $v = -ve$; $H = -ve$; $h = +ve$
(c) $u = -ve$; $v = -ve$; $H = +ve$; $h = -ve$
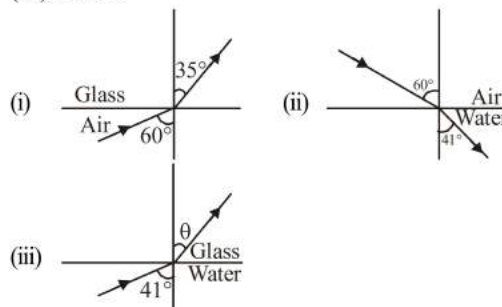(d) $u = +ve$; $v = +ve$; $H = -ve$; $h = +ve$

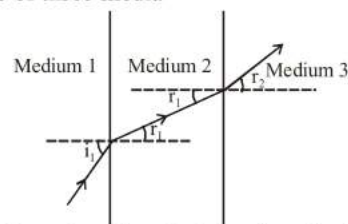77. The correct image formation by a concave mirror is depicted in

(b)

(c)

(d)
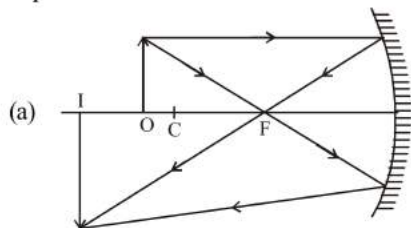
78. Refraction of light from air to glass and from air to water are shown in figure (i) and figure (ii) below. The value of the angle θ in the case of refraction as shown in figure (iii) will be


(a) 30°   (b) 35°   (c) 60°   (d) 41°

79. The following figure shows refraction of light at the interface of three media

Correct the order of optical density (d) of the media is
(a) $d_1 > d_2 > d_3$
(b) $d_2 > d_1 > d_3$
(c) $d_3 > d_3 > d_2$
(d) $d_2 > d_3 > d_1$

80. A rays of light is incident on a thick slab of glass of thickness t as shown in the figure. The emergent ray is parallel to the incident ray but distance d. If the angles are small then d is
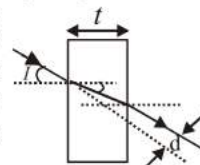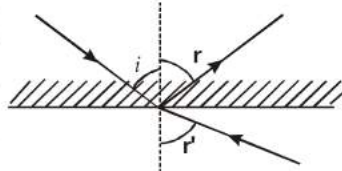

(a) $t\left(1 - \dfrac{i}{r}\right)$
(b) $rt\left(1 - \dfrac{i}{r}\right)$
(c) $it\left(1 - \dfrac{r}{i}\right)$
(d) $t\left(1 - \dfrac{r}{i}\right)$

81. A ray of light passes through four transparent media with refractive indices μ_1, μ_2, μ_3 and μ_4 as shown in the figure. The surfaces of all media are parallel. If the emergent ray CD is parallel to the incident ray AB, we must have
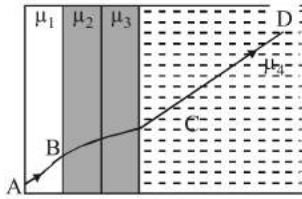
   (a) $\mu_1 = \mu_2$ (b) $\mu_2 = \mu_3$ (c) $\mu_3 = \mu_4$ (d) $\mu_4 = \mu_1$

82. A ray of light from a denser medium strike a rarer medium at an angle of incidence i (see Fig). The reflected and refracted rays make an angle of 90° with each other. The angles of reflection and refraction are r and r'. The critical angle is
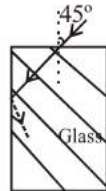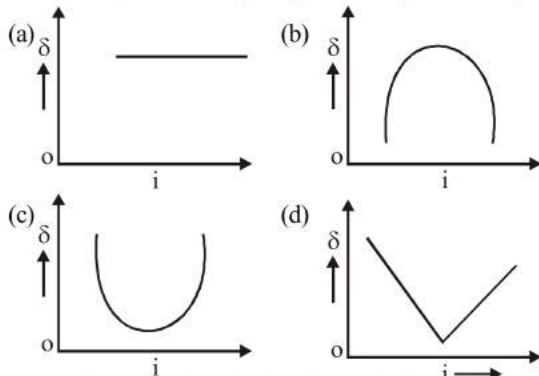

   (a) $\sin^{-1}(\tan r)$ (b) $\sin^{-1}(\tan i)$
   (c) $\sin^{-1}(\tan r)$ (d) $\tan^{-1}(\tan i)$

83. A light ray falls on a rectangular glass slab as shown. The index of refraction of the glass, if total internal reflection is to occur at the vertical face, is

   (a) $\sqrt{3/2}$ (b) $\dfrac{(\sqrt{3}+1)}{2}$
   (c) $\dfrac{(\sqrt{2}+1)}{2}$ (d) $\sqrt{5}/2$

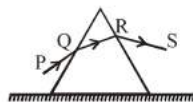84. The graph between angle of deviation (δ) and angle of incidence (i) for a triangular prism is represented by



85. An equilateral prism is placed on a horizontal surface. A ray PQ is incident onto it. For minimum deviation

   (a) PQ is horizontal
   (b) QR is horizontal
   (c) RS is horizontal
   (d) Any one will be horizontal

86. A light ray is incident perpendicularly to one face of a 90° prism and is totally internally reflected at the glass-air interface. If the angle of reflection is 45°, we conclude that the refractive index
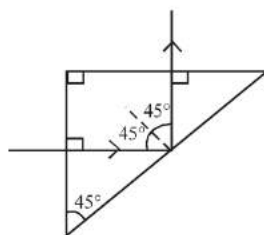
   (a) $n > \dfrac{1}{\sqrt{2}}$ (b) $n > \sqrt{2}$
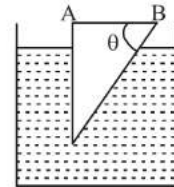   (c) $n < \dfrac{1}{\sqrt{2}}$ (d) $n < \sqrt{2}$

87. A glass prism of refractive index 1.5 is immersed in water (refractive index 4/3). A light beam incident normally on the face AB is totally reflected to reach on the face BC if

   (a) $\sin\theta \geq \dfrac{8}{9}$
   (b) $\dfrac{2}{3} < \sin\theta < \dfrac{8}{9}$
   (c) $\sin\theta \leq \dfrac{2}{3}$
   (d) None of these

ASSERTION - REASON TYPE QUESTIONS

Directions : Each of these questions contains two statements, Assertion and Reason. Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes (a), (b), (c) and (d) given below.
(a) Assertion is correct, reason is correct; reason is a correct explanation for assertion.
(b) Assertion is correct, reason is correct; reason is not a correct explanation for assertion
(c) Assertion is correct, reason is incorrect
(d) Assertion is incorrect, reason is correct.

88. **Assertion :** Plane mirror may form real image.
   Reason : Plane mirror forms virtual image, if object is real.

89. **Assertion :** The focal length of the convex mirror will increase, if the mirror is placed in water.
   Reason : The focal length of a convex mirror of radius R is equal to, $f = R/2$.

90. **Assertion :** The image formed by a concave mirror is certainly real if the object is virtual.
   Reason : The image formed by a concave mirror is certainly virtual if the object is real.

91. **Assertion :** The image of an extended object placed perpendicular to the principal axis of a mirror, will be erect if the object is real but the image is virtual.
   Reason : The image of an extended object, placed perpendicular to the principal axis of a mirror, will be erect if the object is virtual but the image is real.

92. **Assertion :** An object is placed at a distance of f from a convex mirror of focal length f its image will form at infinity.
   Reason : The distance of image in convex mirror can never be infinity.

93. **Assertion :** Critical angle is minimum for violet colour.
   Reason : Because critical angle $\theta_c = \sin^{-1}\left(\dfrac{1}{\mu}\right)$ and $\mu \propto \dfrac{1}{\lambda}$.

94. **Assertion :** Two convex lenses joined together cannot produce an achromatic combination.
   Reason : The condition for achromatism is $\dfrac{\omega_1}{f_1} + \dfrac{\omega_2}{f_2} = 0$ where symbols have their usual meaning.

95. **Assertion :** The image of a point object situated at the centre of hemispherical lens is also at the centre.
Reason : For hemisphere Snell's law is not valid.

96. **Assertion :** When a convex lens ($\mu_g = 3/2$) of focal length f is dipped in water, its focal length becomes $\frac{4}{3}f$.
Reason : The focal length of convex lens in water becomes $4f$.

97. **Assertion:** The focal length of an equiconvex lens of radius of curvature R made of material of refractive index $\mu = 1.5$, is R.
Reason : The focal length of the lens will be R/2.

98. **Assertion :** If the rays are diverging after emerging from a lens; the lens must be concave.
Reason : The convex lens can give diverging rays.

99. **Assertion :** A lens, whose radii of curvature are different, is forming the image of an object placed on its axis. If the lens is reversed, the position of the image will not change.
Reason : The focal length of a lens is given by $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$, and so focal length in both the cases is same.

100. **Assertion :** The resolving power of a telescope is more if the diameter of the objective lens is more.
Reason : Objective lens of large diameter collects more light.

101. **Assertion :** The optical instruments are used to increase the size of the image of the object.
Reason : The optical instruments are used to increase the visual angle.

CRITICAL THINKING TYPE QUESTIONS

102. A rod of length 10 cm lies along the principal axis of a concave mirror of focal length 10 cm in such a way that its end closer to the pole is 20 cm away from the mirror. The length of the image is
(a) 10 cm (b) 15 cm (c) 2.5 cm (d) 5 cm

103. A ray of light travelling in the direction $\frac{1}{2}(\hat{i} + \sqrt{3}\hat{j})$ is incident on a plane mirror. After reflection, it travels along the direction $\frac{1}{2}(\hat{i} - \sqrt{3}\hat{j})$. The angle of incidence is
(a) 30° (b) 45° (c) 60° (d) 75°

104. A vessel of depth x is half filled with oil of refractive index μ_1 and the other half is filled with water of refractive index μ_2. The apparent depth of the vessel when viewed from above is
(a) $\dfrac{x(\mu_1 + \mu_2)}{2\mu_1\mu_2}$ (b) $\dfrac{x\mu_1\mu_2}{2(\mu_1 + \mu_2)}$
(c) $\dfrac{x\mu_1\mu_2}{(\mu_1 + \mu_2)}$ (d) $\dfrac{2x(\mu_1 + \mu_2)}{\mu_1\mu_2}$

105. A ray of light travelling inside a rectangular glass block of refractive index $\sqrt{2}$ is incident on the glass-air surface at an angle of incidence of 45º. The refractive index of air is one. Under these conditions the ray will
(a) emerge into the air without any deviation
(b) be reflected back into the glass
(c) be absorbed
(d) emerge into the air with an angle of refraction equal to 90º

106. A glass slab of thickness 4 cm contains the same number of waves as 5 cm of water when both are traversed by the same monochromatic light. If the refractive index of water is 4/3, what is that of glass?
(a) 5/3 (b) 5/4 (c) 16/15 (d) 1.5

107. The index of refraction of diamond is 2.0. The velocity of light in diamond is approximately
(a) 1.5×10^{10} cm/sec (b) 2×10^{10} cm/sec
(c) 3.0×10^{10} cm/sec (d) 6×10^{10} cm/sec

108. Light travels through a glass plate of thickness t and refractive index μ. If c is the speed of light in vacuum, the time taken by light to travel this thickness of glass is
(a) mtc (b) $\dfrac{tc}{\mu}$ (c) $\dfrac{t}{\mu c}$ (d) $\dfrac{\mu t}{c}$

109. One face of a rectangular glass plate 6 cm thick is silvered. An object held 8 cm in front of the first face, forms an image 12 cm behind the silvered face. The refractive index of the glass is
(a) 0.4 (b) 0.8 (c) 1.2 (d) 1.6

110. A beam of monochromatic blue light of wavelength 420 nm in air travels in water ($\mu = 4/3$). Its wavelength in water will be
(a) 280 nm (b) 560 nm (c) 315 nm (d) 400 nm

111. The frequency of a light wave in a material is 2×10^{14} Hz and wavelength is 5000 Å. The refractive index of material will be
(a) 1.50 (b) 3.00 (c) 1.33 (d) 1.40

112. A ray of light travelling in a transparent medium of refractive index μ, falls on a surface separating the medium from air at an angle of incidence of 45°. For which of the following value of μ the ray can undergo total internal reflection?
(a) m = 1.33 (b) m = 1.40 (c) m = 1.50 (d) m = 1.25

113. Light travels in two media A and B with speeds 1.8×10^8 m s^{-1} and 2.4×10^8 m s^{-1} respectively. Then the critical angle between them is
(a) $\sin^{-1}\left(\dfrac{2}{3}\right)$ (b) $\tan^{-1}\left(\dfrac{3}{4}\right)$
(c) $\tan^{-1}\left(\dfrac{2}{3}\right)$ (d) $\sin^{-1}\left(\dfrac{3}{4}\right)$

114. The critical angle for light going from medium X into medium Y is θ. The speed of light in medium X is v, then speed of light in medium Y is
(a) v(1 – cos θ) (b) v/sin θ
(c) v/cos θ (d) v cos θ

115. A ray of light travelling in a transparent medium of refractive index μ, falls on a surface separating the medium from air at an angle of incidence of 45°. For which of the following value of μ the ray can undergo total internal reflection?
(a) $\mu = 1.33$ (b) $\mu = 1.40$ (c) $\mu = 1.50$ (d) $\mu = 1.25$

116. A luminous object is placed at a distance of 30 cm from the convex lens of focal length 20 cm. On the other side of the lens, at what distance from the lens a convex mirror of radius of curvature 10 cm be placed in order to have an upright image of the object coincident with it?
(a) 12 cm (b) 30 cm (c) 50 cm (d) 60 cm

117. A thin glass (refractive index 1.5) lens has optical power of $-5\,D$ in air. Its optical power in a liquid medium with refractive index 1.6 will be
(a) $-1D$ (b) $1\,D$ (c) $-25\,D$ (d) $25\,D$

118. A plano-convex lens is made of material of refractive index 1.6. The radius of curvature of the curved surface is 60 cm. The focal length of the lens is
(a) 50 cm   (b) 100 cm   (c) 200 cm   (d) 400 cm

119. The radius of curvature of a thin plano-convex lens is 10 cm (of curved surface) and the refractive index is 1.5. If the plane surface is silvered, then it behaves like a concave mirror of focal length

120. Two identical thin plano-convex glass lenses (refractive index 1.5) each having radius of curvature of 20 cm are placed with their convex surfaces in contact at the centre. The intervening space is filled with oil of refractive index 1.7. The focal length of the combination is
(a) –25 cm   (b) –50 cm   (c) 50 cm   (d) –20 cm

121. A thin convex lens made from crown glass $\left(\mu = \dfrac{3}{2}\right)$ has focal length f. When it is measured in two different liquids having refractive indices $\dfrac{4}{3}$ and $\dfrac{5}{3}$, it has the focal lengths f_1 and f_2 respectively. The correct relation between the focal lengths is:
(a) $f_1 = f_2 < f$
(b) $f_1 > f$ and f_2 becomes negative
(c) $f_2 > f$ and f_1 becomes negative
(d) f_1 and f_2 both become negative

122. A green light is incident from the water to the air - water interface at the critical angle (θ). Select the correct statement.
(a) The entire spectrum of visible light will come out of the water at an angle of 90° to the normal.
(b) The spectrum of visible light whose frequency is less than that of green light will come out to the air medium.
(c) The spectrum of visible light whose frequency is more than that of green light will come out to the air medium.
(d) The entire spectrum of visible light will come out of the water at various angles to the normal.

123. A plano convex lens of refractive index 1.5 and radius of curvature 30 cm. Is silvered at the curved surface. Now this lens has been used to form the image of an object. At what distance from this lens an object be placed in order to have a real image of size of the object
(a) 60 cm   (b) 30 cm   (c) 20 cm   (d) 80 cm

124. A double convex lens of focal length 6 cm is made of glass of refractive index 1.5. The radius of curvature of one surface is double that of other surface. The value of small radius of curvature is
(a) 6 cm   (b) 4.5 cm   (c) 9 cm   (d) 4 cm

125. An achromatic convergent doublet of two lenses in contact has a power of + 2D. The convex lens has power + 5D. What is the ratio of dispersive powers of convergent and divergent lenses ?
(a) 2 : 5   (b) 3 : 5   (c) 5 : 2   (d) 5 : 3

126. The dispersive power of material of a lens of focal length 20 cm is 0.08. What is the longitudinal chromatic aberration of the lens ?
(a) 0.08 cm   (b) 0.08/20 cm   (c) 1.6 cm   (d) 0.16 cm

127. A planoconvex lens of focal length 16 cm, is to be made of glass of refractive index 1.5. The radius of curvature of the curved surface should be
(a) 8 cm   (b) 12 cm   (c) 16 cm   (d) 24 cm

128. A man's near point is 0.5 m and far point is 3 m. Power of spectacle lenses required for (i) reading purposes, (ii) seeing distant objects, respectively, are
(a) $-2\,D$ and $+3\,D$ (b) $+2\,D$ and $-3\,D$
(c) $+2\,D$ and $-0.33\,D$ (d) $-2\,D$ and $+0.33\,D$

129. Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, then the power of the other lens will be
(a) 1.66 D   (b) 4.00 D   (c) $-100\,D$ (d) $-3.75\,D$

130. A thin convergent glass lens ($\mu_g = 1.5$) has a power of $+5.0\,D$. When this lens is immersed in a liquid of refractive index μ, it acts as a divergent lens of focal length 100 cm. The value of μ must be
(a) 4/3   (b) 5/3   (c) 5/4   (d) 6/5

131. For the angle of minimum deviation of a prism to be equal to its refracting angle, the prism must be made of a material whose refractive index
(a) lies between $\sqrt{2}$ and 1
(b) lies between 2 and $\sqrt{2}$
(c) is less than 1
(d) is greater than 2

132. The refractive index of a glass is 1.520 for red light and 1.525 for blue light. Let D_1 and D_2 be angles of minimum deviation for red and blue light respectively in a prism of this glass. Then,
(a) $D_1 < D_2$
(b) $D_1 = D_2$
(c) D_1 can be less than or greater than D_2 depending upon the angle of prism
(d) $D_1 > D_2$

133. A right prism is made by selecting a proper material and the angle A and B ($B <<$ A) as shown in *fig.* It is desired that a ray of light incident on the face AB emerges parallel to the incident direction after two internal reflections.

What should be the minimum refractive index μ for this to be possible ?
(a) $\sqrt{3}$ (b) 1.5   (c) $\sqrt{2}$ (d) 1.8

134. The refractive index of the material of a prism is $\sqrt{2}$ and its refracting angle is 30°. One of the refracting surfaces of the prism is made a mirror inwards. A beam of monochromatic light enters the prism from the mirrored surface if its angle of incidence of the prism is
(a) 30°   (b) 45°   (c) 60°   (d) 0°
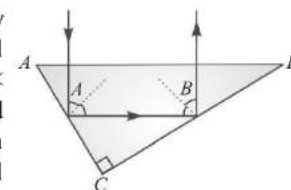
135. The angle of a prism is 'A'. One of its refracting surfaces is silvered. Light rays falling at an angle of incidence 2A on the first surface returns back through the same path after suffering reflection at the silvered surface. The refractive index μ, of the prism is :

(a) $2 \sin A$ (b) $2 \cos A$

(c) $\dfrac{1}{2} \cos A$ (d) $\tan A$

136. The refracting angle of a prism is 'A', and refractive index of the material of the prism is $\cot(A/2)$. The angle of minimum deviation is :

(a) $180° - 2A$ (b) $90° - A$
(c) $180° + 2A$ (d) $180° - 3A$

137. A ray of light is incident normally on one refracting surface of an equilateral prism. If the refractive index of the material of the prism is 1.5, then

(a) the emergent ray is deviated by $30°$
(b) the emergent ray is deviated by $60°$
(c) the emergent ray just graces the second reflecting surface
(d) the ray undergoes total internal reflection at second refracting surface
(e) the ray emerges normally from the second refracting surface

138. A thin prism of angle $15°$ made of glass of refractive index $\mu_1 = 1.5$ is combined with another prism of glass of refractive index $\mu_2 = 1.75$. The combination of the prism produces dispersion without deviation. The angle of the second prism should be

(a) $7°$ (b) $10°$ (c) $12°$ (d) $5°$

139. A prism has a refracting angle of $60°$. When placed in the position of minimum deviation, it produces a deviation of $30°$. The angle of incidence is

(a) $30°$ (b) $45°$ (c) $15°$ (d) $60°$

140. A ray of light passes through an equilateral prism such that the angle of incidence is equal to the angle of emergence and the latter is equal to 3/4th of the angle of prism. The angle of deviation is

(a) $45°$ (b) $39°$ (c) $20°$ (d) $30°$

141. A telescope has an objective lens of 10 cm diameter and is situated at a distance of one kilometer from two objects. The minimum distance between these two objects, which can be resolved by the telescope, when the mean wavelength of light is 5000 Å, is of the order of

(a) 5 cm (b) 0.5 m (c) 5 m (d) 5 mm

142. Wavelength of light used in an optical instrument are

$\lambda_1 = 4000$ Å and $\lambda_2 = 5000$ Å, then ratio of their respective resolving powers (corresponding to λ_1 and λ_2) is

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

143. The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye piece is found to be 20 cm. The focal length of lenses are

(a) 18 cm, 2 cm (b) 11 cm, 9 cm
(c) 10 cm, 10 cm (d) 15 cm, 5 cm

144. The focal length of the objective of a telescope is 60 cm. To obtain a magnification of 20, the focal length of the eye piece should be

(a) 2 cm (b) 3 cm (c) 4 cm (d) 5 cm

145. The focal lengths of objective and eye lens of an astronomical telescope are respectively 2 meter and 5 cm. Final image is formed at (i) least distance of distinct vision (ii) infinity Magnifying power in two cases will be

(a) $-48, -40$ (b) $-40, -48$
(c) $-40, +48$ (d) $-48, +40$

146. A simple telescope, consisting of an objective of focal length 60 cm and a single eye lens of focal length 5 cm is focussed on a distant object in such a way that parallel rays emerge from the eye lens. If the object subtends an angle of $2°$ at the objective, the angular width of the image is

(a) $10°$ (b) $24°$ (c) $50°$ (d) $(1/6)°$

HINTS AND SOLUTIONS

FACT/DEFINITION TYPE QUESTIONS

1. (b) 2. (a) 3. (a) 4. (c)
5. (a) Virtual image formed is larger in size in case of concave mirror.
6. (a) Real, inverted and same in size because object is at the centre of curvature of the mirror.
7. (d) Convex mirror always forms, virtual, erect and smaller image.
8. (a) To see his full image in a plane mirror a person requires a mirror of at least half of his height.
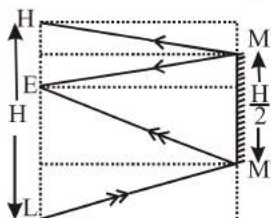
9. (c)
10. (c) Because they form nearly point image of point source.
11. (d)
12. (c) Relation $\dfrac{n_2}{v} - \dfrac{n_1}{u} = \dfrac{n_2 - n_1}{R}$ true for both concave and convex mirror.
13. (b)
14. (c) Since the refractive index is less at beam boundary, the ray at the edges of the beam move faster compared to the axis of beam. Hence the beam converges.
15. (b) According to Snell's law $\dfrac{\sin i}{\sin r} = \dfrac{v_1}{v_2} = \dfrac{\mu_2}{\mu_1}$

From fig. we see that
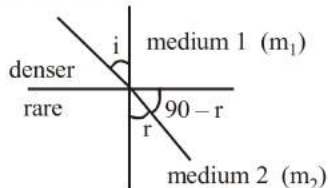
$r > i \Rightarrow v_2 > v_1$ from Snell's Law
So $v_2 = n\lambda_2 > v_1 = n\lambda_1 \Rightarrow \lambda_2 > \lambda_1$
(Frequency of wave does not change on refraction)
16. (b) Frequency does not change on refraction.
17. (d) It occurs in both reflection & refraction & the angle of bending rays is constant.
18. (b) According to Snell's Law, $\dfrac{\sin i}{\sin r} = \dfrac{\mu_2}{\mu_1}$

where $r = 90°$ for particular incidence angle called critical angle. When the incidence angle is equal to or greater than i_c, then total internal reflection occurs. It takes place when ray of light travels from optically denser medium ($\mu_1 > \mu_2$) to optically rarer medium.
19. (c) For total internal reflection light ray must travel from optically denser to an optically rarer medium.
20. (c) As $i > i_c$
At $i = i_c$ angle of refraction
'r' = 90°
$\therefore \dfrac{\sin i_c}{\sin 90°} = \mu = 1$
21. (a) The basic principle of communication in fibre optics is based on the phenomenon of total internal reflection.
22. (d)
23. (b) Difference between apparent and real depth of a pond is due to the refraction of light, not due to the total internal reflection. Other three phenomena are due to the total internal reflection.
24. (d) The magnification for vertual image formed by concave lens is positive.
25. (a) The apparent flattening (oval shape) of the sun at sunset and sunrise is due to refraction.
26. (b) In an isotropic medium, speed of light depends on its wavelength.
27. (a)
28. (d) Since refractive index for different wave length of light is different. Hence the different colours of light forms images at different position. This phenomenon is called chromatic aberration.
29. (d) The cause of chromatic aberration is that lens focusses different colours at different points.
30. (c) Since $l_R > l_V \qquad m_R < m_V$
$\left(\because \mu \propto \dfrac{1}{\lambda} \right) \Rightarrow f_V < f_R \left(\because \dfrac{1}{f} \propto (\mu - 1) \right)$
31. (b,c) If faces of prism on which light is incident & from which it emerge are parallel, then angle of prism will be zero & so deviation will also be zero i.e., the prism will act as a transparent prism.
32. (d) 33. (d)
34. (a) The angular dispersion θ i.e., the angle between the extreme rays of light,
$\theta = (\delta_V - \delta_R)$ where $\delta_V = (\mu_V - 1)A$, $\delta_R = (\mu_V - 1)A$ & A is angle of prism.
So if refractive index increases, then δ increases & hence θ increases.
35. (b) Dispersive power of a prism $\omega = \dfrac{\mu_V - \mu_R}{\mu_y - 1} = \dfrac{d\mu}{\mu - 1}$,
where $\mu = \mu_y = \dfrac{\mu_V + \mu_R}{2}$
36. (d)

37. **(b)** Refractive index of medium is given by

$$\mu = A + \frac{B}{\lambda^2} \quad \left(\text{where A and B are constant}\right.$$

Light has seven different colour, so its each colour has different wavelength and so different refractive index.

Due to difference in refractive index different refractive angle $\left(\mu = \frac{\sin i}{\sin r}\right)$.

So this is due to dependence on wavelength of refractive index.

38. **(a)** In the position of minimum deviation, $i_1 = i_2$.

39. **(d)** We can combine two prisms in such a way
   (i) deviation is zero but dispersion not
   (ii) dispersion is zero but deviation is not.
   But in any situation both deviation & dispersion can not be zero simultaneously.

40. **(c)** At the minimum deviation, $f = D_m$ angle of incidence $\angle i$ = angle of emergence $\angle e$ and inside the prism refracted ray parallel to the base of the prism
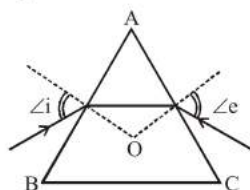
41. **(d)**

42. **(c)** In the position of minimum deviation

$$i = e = \frac{A + \delta m}{2} = \frac{60 + 30}{2} = 45°$$

43. **(a)**

44. **(b)** Secondary rainbow is formed by rays undergoing interanal reflection twice inside the drop.

45. **(b)**

46. **(b)** For rear view, Convex mirror is used in vehicle

47. **(a)** Cylindrical lens is used to rectify eye defect astigmatism

48. **(b)**

49. **(d)** Because, the focal length of eye lens can not decrease beyond a certain limit.

50. **(b)** The image formed by objective lens of compound microscope is real and enlarged, while final image formed by compound microscope is inverted, virtual, enlarged and at a distance D to infinite or from an eye, on same side of eye piece.

51. **(b)** The aperture of objective lens of Astronomical telescope is large to get better resolution. Since resolution of telescope power is $R = \frac{D}{1.22\lambda}$, where D is the diameter of the objective lens of Telescope.

52. **(b)** One should increase the power of lens i.e., decrease the focal length of a lens.

53. **(a)** In simple microscope the final image is erect.

54. **(d)** Resolving power $= \frac{\lambda}{d\lambda}$ plane transmission grating

Resolving power for telescope

$$= \frac{1}{\text{limit of resolution}} = \frac{d}{1.22\lambda} = \frac{d_0}{d_1}$$

by increasing the aperture of objective resolving power can be increased.

55. **(a)** To find the refractive index of glass using a travelling microscope, a vernier scale is provided on the microscope.

56. **(d)** Magnifying power of microscope

$$= \frac{LD}{f_0 f_e} \propto \frac{1}{f_0}$$

Hence with increase f_0 magnifyig power of microscope decreases.

Magnifying power of telescope $= \frac{f_0}{f_e} \propto f_0$

Hence with increase f_0 magnifying power of telescope increases.

57. **(d)** Because of large objective area more light is gathered.

As magnification $m = \frac{\beta}{\alpha}$

β = angle subtended at the eye by the final image
α = angle subtended by the object at the lens or eye

58. **(c)** With large diameters of objective, the ability to observe two objects distinctly, increases as more light is gathered.

STATEMENT TYPE QUESTIONS

59. **(d)**

60. **(d)** The image formed by a convex mirror is always virtual.

61. **(b)** Normal is perpendicular to the tangent to surface at the point of incidence i.e., the normal is along the radius, the line joining the centre of curvature of the mirror to the point of incidence.
   So, geometric centre of a spherical mirror is called its pole while that of a spherical lens is called its optical centre. The line joining the pole and the centre of curvature of the spherical mirror is known as the principal axis. In the case of spherical lenses, the pricipal axis is the line joining the optical centre with its principal focus.

62. **(c)** The ratio of the sine of the angle of incidence to the sine of angle of refraction is constant. Remember that the angles of incidence (i) and refraction (r) are the angles that the incident and its refracted ray make with the normal, respectively. We have,

$$\frac{\sin i}{\sin r} = n_{21} \qquad \qquad \text{...(i)}$$

where, n_{21} is a constant, called the refractive index of the medium 2 w.r.t. the medium 1. Eq. (i) is the well known Snell's law of refraction. We note that n_{21} is a characteristic of the pair of media (and also depends on the wavelength of light) but is independent of the angle of incidence

63. (a) If n_{21} is the refractive index of medium 2 with respect to medium 1 and n_{12} the refractive index of medium 1 with respect to medium 2, then it should be clear that

$$n_{12} = \frac{1}{n_{21}}$$

It also follows that if n_{32} is the refractive index of medium 3 with respect to medium 2, then $n_{32} = n_{31} \times n_{12}$, where n_{31} is the refractive index of medium III with respect to medium I.
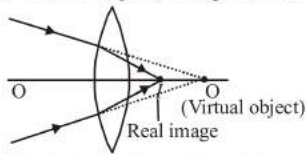
64. (a) Convex lens is a converging lens provided refractive index of the material of the lens is greater than the surrounding medium in which the lens is kept.
From lens maker's formula,

$$\frac{1}{f} = (\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

Refracting index of lens varies inversely with the wavelength of light used.
II. For virtual object, image is real for convex lens.

(Virtual object)
Real image

65. (a) The variation of refractive index with wavelength may be more pronounced in some media than the other. In vacuum, of course, the speed of light is independent of wavelength. Thus, vacuum (or air approximately) is a non-dispersive medium in which all colours travel with the same speed.
This also follows from the fact that sunlight reaches us in the form of white light and not as its components. On the other hand, glass is a dispersive medium.

66. (b) At sunset or sunrise the sun's rays have to pass through a larger distance in the atmosphere and most of the blue or other shorter wavelengths are removed by scattering.

MATCHING TYPE QUESTIONS

67. (c) A-2 : For $u = -f$,

$$\frac{1}{v} + \frac{1}{-f} = \frac{1}{f}$$

$$\therefore \ v = \frac{f}{2}$$

and $M = -\dfrac{v}{u} = -\dfrac{f/2}{(-f)} = 0.5$.

B-4 : $u = -2f$, so $v = -2f$

$$M = -\frac{v}{u} = -\left(\frac{-2f}{-2f}\right) = -1$$

C-1 : In concave mirror, $u = -2f$, $\ v = -\infty$

$$\therefore \ M = -\frac{v}{u} = -\infty.$$

D-5 : In convex mirror $\quad u = -2f$

so $\dfrac{1}{v} + \dfrac{1}{-2f} = \dfrac{1}{f} \Rightarrow v = \dfrac{2f}{3}$.

Now $M = -\dfrac{v}{u} = \dfrac{1}{3}$.

68. (b)   69. (d)

70. (b) (i) $P = +2.0 \Rightarrow f = \dfrac{1}{+2.0} \times 100\,\text{cm} = +50\,\text{cm}$

(Positive power convex lens)

(ii) $P = P_1 + P_2 = (+0.25) + (+0.25) = +0.50\,\text{D}$

$f = \dfrac{1}{P} = \dfrac{1}{+0.5} \times 100\,\text{cm} = 200\,\text{cm}$

(iii) $P = -2.0 \Rightarrow f = \dfrac{1}{-2.0} \times 100\,\text{cm} = -50\,\text{cm}$

(–ve power concave lens)

(iv) $P = P_1 + P_2 = (-6.0) + (+3.5) = -2.5\,\text{Da}$

$f = \dfrac{1}{p} = \dfrac{1}{-2.5} \times 100\,\text{cm} = -40\,\text{cm}$

71. (a) A-(2) : $M = \dfrac{1}{4}$ is for erect or virtrual image and so it is possible for convex mirror.

B-(1) : $m = -1$, negative magnification is possible in concave mirror.

C-(1) : $m = 2$, is possible for concave mirror when object is put between focal point and pole of the mirror.

D-(3) : $m = 1$ is possible for plane mirror.

72. (b)

73. (d)   74. (c)

DIAGRAM TYPE QUESTIONS

75. (a)

76. (c) According to sign-convention, distance left or below pole is – (ve) and right or above pole is +(ve).

77. (d) The ray parallel to principle axis after reflection through mirror passes through the focus and the ray passing through the centre of curvature set retr its path.

78. (b) $^a\mu_g = \dfrac{\sin 60°}{\sin 35°}$ ... (i)

$^a\mu_w = \dfrac{\sin 60°}{\sin 41°}$ ... (ii)

$^w\mu_g = \dfrac{\sin 41°}{\sin \theta}$ ... (iii)

$^a\mu_w \times {}^w\mu_g = {}^a\mu_g$

$\dfrac{\sin 60°}{\sin 41°} \times \dfrac{\sin 41°}{\sin \theta} = \dfrac{\sin 60°}{\sin 35°}$ (Using (i), (ii) and (iii))

$= \sin \theta = \sin 35° \quad \theta = 35°$

79. (d) As $r_1 < i_1$ i.e., the incident ray bends towards the normal $\Rightarrow$ medium 2 is denser than medium 1.
Or $r_2 < i_1 \Rightarrow$ medium 3 is denser than medium 1.
Also, $r_2 > r_1 \Rightarrow$ medium 2 is denser than medium 3.

80. (c)

From figure, in right angled ΔCDB

$\angle CBD = (i - r)$

$\therefore \sin(i-r) = \dfrac{CD}{BC} = \dfrac{d}{BC}$

or $d = BC \sin(i-r)$ .... (i)

Also, in right angled $\triangle CNB$

$\cos r = \dfrac{BN}{BC} = \dfrac{t}{BC}$

or $BC = \dfrac{t}{\cos r}$ .... (ii)

Substitute equation (ii) in equation (i), we get

$d = \dfrac{t}{\cos r} \sin(i-r)$

For small angles $\sin(i-r) \approx \sin i - r \cos r \approx 1$

$d = t(i-r)$, $d = it\left[1-\dfrac{r}{i}\right]$

81. (d)

82. (a) $_2\mu = \dfrac{\sin 90°}{\sin C} = \dfrac{1}{\sin C}$ [For critical angle]

$\therefore C = \sin^{-1}\left(\dfrac{1}{\frac{1}{2}\mu}\right)$ ...(i)

Applying Snell's law at P, we get

$_2^1\mu = \dfrac{\sin r'}{\sin i} = \dfrac{\sin(90-r)}{\sin r}$ [$\because i = r ; r'+r = 90°$]

$\dfrac{1}{2}\mu = \dfrac{\cos r}{\sin r}$ ...(ii)

From (i) and (ii)

$C = \sin^{-1}(\tan r)$

83. (a) For point A, $_a\mu_g = \dfrac{\sin 45°}{\sin r} \Rightarrow \sin r = \dfrac{1}{\sqrt{2}\,_a\mu_g}$

for point B, $\sin(90-r) = {_g\mu_a}$

$(90-r)$ is critical angle.

$\therefore \cos r = {_g\mu_a} = \dfrac{1}{_a\mu_g}$

$\Rightarrow {_a\mu_g} = \dfrac{1}{\cos r}$

$= \dfrac{1}{\sqrt{1-\sin^2 r}} = \dfrac{1}{\sqrt{1-\dfrac{1}{2\,_a\mu_g^2}}}$

$\Rightarrow {_a\mu_g^2} = \dfrac{1}{1-\dfrac{1}{2\,_a\mu_g^2}} = \dfrac{2\,_a\mu_g^2}{2\,_a\mu_g^2 - 1}$

$\Rightarrow 2\,_a\mu_g^2 - 1 = 2 \Rightarrow {_a\mu_g} = \sqrt{\dfrac{3}{2}}$

84. (c) For the prism as the angle of incidence (i) increases, the angle of deviation (δ) first decreases goes to minimum value and then increases.

85. (b) For minimum deviation, incident angle is equal to emerging angle.

$\therefore$ QR is horizontal.

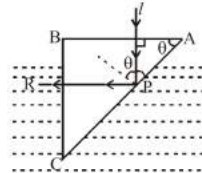**86. (b)** The incident angle is 45° incident angle > critical angle, $i > i_c$

$\therefore \sin i > \sin i_c$ or $\sin 45 > \sin i_c$

$\sin i_c = \dfrac{1}{n}$ $\therefore \sin 45° > \dfrac{1}{n}$ or $\dfrac{1}{\sqrt{2}} > \dfrac{1}{n} \Rightarrow n > \sqrt{2}$

87. (a) The phenomenon of total internal reflection takes place during reflection at P.

$\sin \theta = \dfrac{1}{_g^\omega\mu}$ ...(i)

When θ is the angle of incidence at P

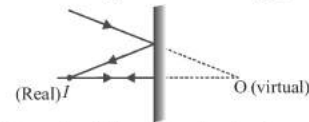Now, $_g^\omega\mu = \dfrac{_g^a\mu}{_g^\omega\mu} = \dfrac{1.5}{4/3} = 1.125$

Putting in (i), $\sin \theta = \dfrac{1}{1.125} = \dfrac{8}{9}$

$\therefore \sin \theta$ should be greater than or equal to $\dfrac{8}{9}$.

ASSERTION - REASON TYPE QUESTIONS

88. (b) Plane mirror may form real image, if object is virtual.

89. (d) Focal length of the spherical mirror does not depend on the medium in which it placed.

90. (c) The image of real object may be real in case of concave mirror.

91. (b)

92. (d) The distance of image in convex mirror is always $v \le f$.

93. (a) 94. (a)

95. (c) The rays from centre of hemisphere cut at the centre after refraction - Snell's law is valid in each case of refraction.

96. (d) $f_w = f\dfrac{_a\mu_g - 1}{\left(\dfrac{_a\mu_g}{_a\mu_w} - 1\right)} = f\dfrac{\left(\dfrac{3}{2}-1\right)}{\left(\dfrac{3/2}{4/3}-1\right)} = 4f$

97. (c) $\dfrac{1}{f} = (\mu-1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right) = (1.5-1)\left(\dfrac{1}{R} - \dfrac{1}{-R}\right)$

or $f = R$.

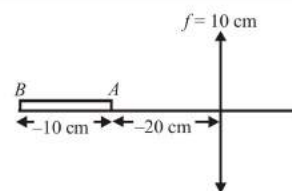**98. (d)** If the rays cross focal point of convex lens, they become diverging.

99. (a)

100. (a) RP $\propto$ diameter of objective.

101. (d)

CRITICAL THINKING TYPE QUESTIONS

102. (d)

The focal length of the mirror

$$-\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$$

For A end of the rod the image distance
When $u_1 = -20$ cm

$$\Rightarrow \frac{-1}{10} = \frac{1}{v_1} - \frac{1}{20}$$

$$\frac{1}{v_1} = \frac{-1}{10} + \frac{1}{20} = \frac{-2+1}{20}$$

$v_1 = -20$ cm
For when $u_2 = -30$ cm

$$\frac{1}{f} = \frac{1}{v_2} - \frac{1}{30}$$

$$\frac{1}{v_2} = \frac{-1}{10} + \frac{1}{30} = \frac{-30+10}{300} = \frac{-20}{300}$$
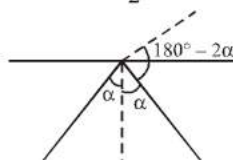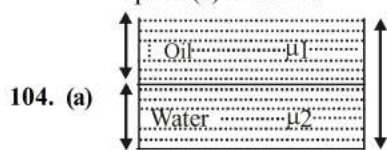
$v_2 = -15$ cm
$L = v_2 - v_1 = -15 - (-20)$
$L = 5$ cm

103. (a)
$$\cos(180° - 2\alpha) = \frac{\left(\frac{\hat{i}}{2} + \frac{\sqrt{3}}{2}\hat{j}\right)\cdot\left(\frac{\hat{i}}{2} - \frac{\sqrt{3}}{2}\hat{j}\right)}{\sqrt{\left(\frac{1}{2}\right)^2 + \left(\frac{\sqrt{3}}{2}\right)^2}\sqrt{\left(\frac{1}{2}\right)^2 + \left(-\frac{\sqrt{3}}{2}\right)^2}}$$

$$\therefore \cos(180° - 2\alpha) = -\frac{1}{2}$$

$\therefore 180° - 2\alpha = 120°$ $\therefore \alpha = 30°$
Option (a) is correct.

104. (a)

As refractive index, $\mu = \dfrac{\text{Real depth}}{\text{Apparent depth}}$

$\therefore$ Apparent depth of the vessel when viewed from above is

$$d_{apparent} = \frac{x}{2\mu_1} + \frac{x}{2\mu_2} = \frac{x}{2}\left(\frac{1}{\mu_1} + \frac{1}{\mu_2}\right)$$

$$= \frac{x}{2}\left(\frac{\mu_2 + \mu_1}{\mu_1\mu_2}\right) = \frac{x(\mu_1 + \mu_2)}{2\mu_1\mu_2}$$

105. (d) $\sin C = \dfrac{1}{\mu} = \dfrac{1}{\sqrt{2}}$ $\therefore C = \sin^{-1}\left(\dfrac{1}{\sqrt{2}}\right) = 45°$

Now $\dfrac{\sin C}{\sin r} = \dfrac{1}{\mu}$ or $\dfrac{\sin 45°}{\sin r} = \dfrac{1}{\sqrt{2}}$
$\sin r = 1$ or $r = 90°$

106. (a) Given that ${}_w\mu_g = \dfrac{5}{4}$ and ${}_a\mu_w = \dfrac{4}{3}$

$$\therefore {}_a\mu_g = {}_w\mu_g \times {}_a\mu_w = \frac{5}{4} \times \frac{4}{3} = \frac{5}{3}$$

107. (a)

108. (d) Total thickness $= t$; Refractive index $= \mu$

Speed of light in Glass plate $= \dfrac{c}{\mu}$

$$\left[\because v = \frac{\text{Speed of light in vacuum}}{\text{R.I. of Medium}}\right]$$

Time taken $= \dfrac{t}{\dfrac{c}{\mu}} = \dfrac{\mu t}{c}$

(where t = thickness of glass plate)

109. (c) Thickness of glass plate (t) = 6 cm;
Distance of the object (u) = 8 cm. and
distance of the image (v) = 12 cm.
Let x = Apparent position of the silvered surface in cm.
Since the image is formed due to reflection at the silvered
face and by the property of mirror image distance of object
from the mirror = Distance of image from the mirror
or $x + 8 = 12 + 6 - x$ or $x = 5$ cm.
Therefore refractive index of glass

$$= \frac{\text{Real depth}}{\text{Apparent depth}} = \frac{6}{5} = 1.2.$$

110. (c) $v = \dfrac{c}{\mu}$ or $\lambda_m = \dfrac{\lambda_0}{\mu}$ $\therefore \lambda_m = \dfrac{420}{(4/3)} = 315$ nm

111. (b) $\mu = \dfrac{\text{velocity of light in vacuum (c)}}{\text{velocity of light in medium (v)}}$

But $v = \upsilon\lambda = 2 \times 10^{14} \times 5000 \times 10^{-10}$
In the medium, $v = 10^8$ m/s.

$$\therefore \mu = \frac{v_{vac}}{v_{med}} = \frac{3 \times 10^8}{10^8} = 3.$$

112. (c) : For total internal reflection
$\sin i > \sin C$
where,
i = angle of incidence, C = critical angle

But, $\sin C = \dfrac{1}{\mu}$ $\therefore \sin i > \dfrac{1}{\mu}$ or $\mu > \dfrac{1}{\sin i}$

$\mu > \dfrac{1}{\sin 45°}$ $(i = 45°$ (Given))

$\mu > \sqrt{2}$
Hence, option (c) is correct.

113. (d) Here, $v_A = 1.8 \times 10^8$ m s^{-1}
$v_B = 2.4 \times 10^8$ m s^{-1}
Light travels slower in denser medium. Hence
medium A is a denser medium and medium B is a
rarer medium. Here, Light travels from medium A to
medium B. Let C be the critical angle between them.

$$\therefore \sin C = {}^A\mu_B = \frac{1}{{}^B\mu_A}$$

Refractive index of medium B w.r.t. to medium A is

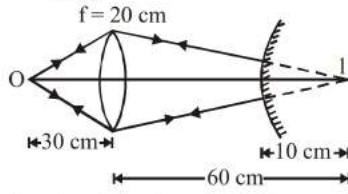$${}^A\mu_B = \frac{\text{Velocity of light in medium } A}{\text{Velocity of light in medium } B} = \frac{v_A}{v_B}$$

$\therefore \quad \sin C = \dfrac{v_A}{v_B} = \dfrac{1.8 \times 10^8}{2.4 \times 10^8} = \dfrac{3}{4}$ or $C = \sin^{-1}\left(\dfrac{3}{4}\right)$

114. (b)

115. (c) For total internal reflection,

$\mu \geq \dfrac{1}{\sin C} \geq \sqrt{2} \geq 1.414 \Rightarrow \mu = 1.50$

116. (c)

f = 20 cm

$\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$; $\dfrac{1}{v} - \dfrac{1}{-30} = \dfrac{1}{20} \Rightarrow v = 60$ cm

Coincidence is possible when the image is formed at the centre of curvature of the mirror. Only then the rays refracting through the lens will fall normally on the convex mirror and retrace their path to form the image at O. So the distance between lens and mirror = 60 − 10 = 50 cm.

117. (b) $\dfrac{1}{f_a} = \left(\dfrac{1.5}{1} - 1\right)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$ ...(i)

$\dfrac{1}{f_m} = \left(\dfrac{\mu_g}{\mu_m} - 1\right)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{f_m} = \left(\dfrac{1.5}{1.6} - 1\right)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$ ...(ii)

Dividing (i) by (ii), $\dfrac{f_m}{f_a} = \left(\dfrac{1.5-1}{\dfrac{1.5}{1.6}-1}\right) = -8$

$P_a = -5 = \dfrac{1}{f_a} \Rightarrow f_a = -\dfrac{1}{5}$

$\Rightarrow \quad f_m = -8 \times f_a = -8 \times -\dfrac{1}{5} = \dfrac{8}{5}$

$P_m = \dfrac{\mu}{f_m} = \dfrac{1.6}{8} \times 5 = 1\,D$

118. (b) $R_1 = 60$ cm, $R_2 = \infty$, $\mu = 1.6$

$\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{f} = (1.6 - 1)\left(\dfrac{1}{60}\right) \Rightarrow f = 100$ cm.

119. (c) The silvered plano convex lens behaves as a concave mirror; whose focal length is given by

$\dfrac{1}{F} = \dfrac{2}{f_1} + \dfrac{1}{f_m}$

If plane surface is silvered

$f_m = \dfrac{R_2}{2} = \dfrac{\infty}{2} = \infty$

$\therefore \dfrac{1}{f_1} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$= (\mu - 1)\left(\dfrac{1}{R} - \dfrac{1}{\infty}\right) = \dfrac{\mu - 1}{R}$

$\therefore \quad \dfrac{1}{F} = \dfrac{2(\mu-1)}{R} + \dfrac{1}{\infty} = \dfrac{2(\mu-1)}{R}$

$F = \dfrac{R}{2(\mu-1)}$

Here R = 20 cm, $\mu = 1.5$

$\therefore \quad F = \dfrac{20}{2(1.5-1)} = 20$ cm

120. (b) Using lens maker's formula,

$\dfrac{1}{f} = (\mu - 1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$\dfrac{1}{f_1} = \left(\dfrac{1.5}{1} - 1\right)\left(\dfrac{1}{\infty} - \dfrac{1}{-20}\right)$

$\Rightarrow f_1 = 40$ cm

$\dfrac{1}{f_2} = \left(\dfrac{1.7}{1} - 1\right)\left(\dfrac{1}{-20} - \dfrac{1}{+20}\right)$

$\Rightarrow f_2 = -\dfrac{100}{7}$ cm

and $\dfrac{1}{f_3} = \left(\dfrac{1.5}{1} - 1\right)\left(\dfrac{1}{\infty} - \dfrac{1}{-20}\right) \Rightarrow f_3 = 40$ cm

n = 1.5   n = 1.5
n = 1.7

$\dfrac{1}{f_{eq}} = \dfrac{1}{f_1} + \dfrac{1}{f_2} + \dfrac{1}{f_3} \Rightarrow \dfrac{1}{f_{eq}} = \dfrac{1}{40} + \dfrac{1}{-100/7} + \dfrac{1}{40}$

$\therefore \quad f_{eq} = -50$ cm

Therefore, the focal length of the combination is − 50 cm.

121. (b) By Lens maker's formula for convex lens

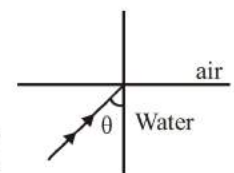$\dfrac{1}{f} = \left(\dfrac{\mu}{\mu_L} - 1\right)\left(\dfrac{2}{R}\right)$

for, $\mu_{L_1} = \dfrac{4}{3}, f_1 = 4R$

for $\mu_{L_2} = \dfrac{5}{3}, f_2 = -5R \Rightarrow f_2 = (-)$ ve
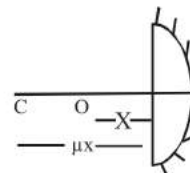
122. (b) For critical angle θ_c,

$\sin \theta_c = \dfrac{1}{\mu}$

air

Water

For greater wavelength or lesser frequency μ is less. So, critical angle would be more. So, they will not suffer reflection and come out at angles less then 90°.

123. (c)

C   O —X—

—— μx ——

For the image to be real and of same size as object, final image should be formed at the position of object itself.

Let x be the distance of object from plane surface.

Apparent distance from surface = μx

This should be centre of curve

$\therefore \mu x = 30 \Rightarrow 1.5x = 30 \Rightarrow x = 20$

124. (b) If $R_1 = R$, $R_2 = -2R$

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{1}{6} = (1.5 - 1)\left(\frac{1}{R} + \frac{1}{2R}\right) = \frac{0.5 \times 3}{2R}$$

$R = 4.5$ cm

125. (b) Here, $P_1 = 5$ D

$P_2 = P - P_1 = 2 - 5 = -3$ D

$$\frac{\omega_1}{\omega_2} = -\frac{f_1}{f_2} = \frac{-P_2}{P_1} = \frac{3}{5}$$

126. (c) Longitudinal chromatic aberration $= \omega f$

$= 0.08 \times 20 = 1.6$ cm

127. (a) $\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

$$\frac{1}{16} = (1.5 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$$

$$\Rightarrow \frac{1}{16} = 0.5 \times \frac{1}{R} \Rightarrow R = 8 \text{ cm}$$

128. (c) For reading purposes :

$u = -25$ cm, $v = -50$ cm, $f = ?$

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{50} + \frac{1}{25} = \frac{1}{50} \text{ ;}$$

$$P = \frac{100}{f} = +2 \text{ D}$$

For distant vision, $f' = $ distance of far point $= -3$ m

$$P = \frac{1}{f'} = -\frac{1}{3} D = -0.33 \text{ D}$$

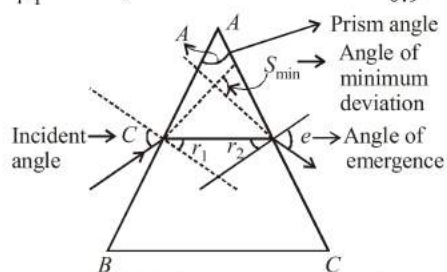**129. (d)** $P_2 = P - P_1 = \frac{100}{80} - \frac{100}{20} = -3.75$ D

130. (b) $\dfrac{P_a}{P_1} = \dfrac{\left(\dfrac{\mu_g}{\mu_a} - 1\right)}{\left(\dfrac{\mu_g}{\mu_1} - 1\right)} = \dfrac{+5}{-100/100} = -5$

$$-5\left(\frac{\mu_g}{\mu_1} - 1\right) = \frac{\mu_g}{\mu_a} - 1$$

$$\frac{1.5}{\mu_1} - 1 = \frac{-1}{5}(1.5 - 1) = -0.1 \text{ ; } \mu_1 = \frac{1.5}{0.9} = \frac{5}{3}$$

131. (b)

Prism angle, Angle of minimum deviation, Incident angle, Angle of emergence

The angle of minimum deviation is given as

$$\delta_{min} = i + e - A$$

for minimum deviation

$$\delta_{min} = A \text{ then}$$

$$2A = i + e$$

in case of δ_{min} $i = e$

$$2A = 2i \quad r_1 = r_2 = \frac{A}{2}$$

$$i = A = 90°$$

from smell's law

$$1 \sin i = n \sin r_1$$

$$\sin A = n \sin \frac{A}{2}$$

$$2 \sin \frac{A}{2} \cos \frac{A}{2} = n \sin \frac{A}{2}$$

$$2 \cos \frac{A}{2} = n$$

when $\quad A = 90° = i_{min}$

then $\quad n_{min} = \sqrt{2}$

$i = A = 0 \quad n_{max} = 2$

132. (a) For a thin prism, $D = (\mu - 1)A$

Since $\lambda_b < \lambda_r \Rightarrow \mu_r < \mu_b \Rightarrow D_1 < D_2$

133. (c) The ray is incident on face AC at an angle A, after reflection, it incident of face BC at an angle B. Thus
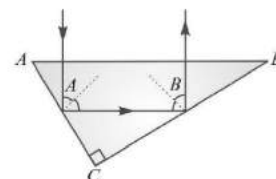
$$\angle A + \angle B = 90°.$$

As $B < A$, so the ray if totally reflected from face BC, it must be reflected from AC also. For this angle B should be greater than critical angle C. For minimum value of μ, B can be infinitesimally than C, so $B = C$ (critical angle). We know that

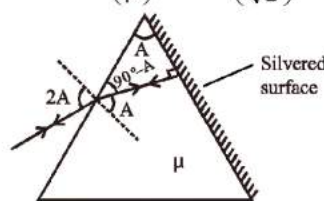$$\mu = \frac{1}{\sin C} = \frac{1}{\sin B}$$

For $A = B$, $\quad B = 45°$

$$\therefore \quad \mu_{min} = \frac{1}{\sin 45°} = \sqrt{2}$$

134. (b) The angle must be equal to the critical angle,

$$C = \sin^{-1}\left(\frac{1}{\mu}\right) = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45°$$

135. (b)

According to Snell's law $\mu = \dfrac{\sin i}{\sin r}$

$$\Rightarrow (1) \sin 2A = (\mu) \sin A \Rightarrow \mu = 2 \cos A$$

136. (a) As we know, the refractive index of the material of the prism

$$\mu = \frac{\sin\left(\dfrac{\delta_m + A}{2}\right)}{\sin(A/2)}$$

$$\cot A/2 = \frac{\sin\left(\dfrac{A + \delta_m}{2}\right)}{\sin A/2} = \frac{\cos(A/2)}{\sin(A/2)}$$

$$[\because \mu = \cot(A/2)]$$

$$\Rightarrow \sin\left(\frac{\delta_m + A}{2}\right) = \sin(90° + A/2)$$

$$\Rightarrow d_{min} = 180° - 2A$$

137. **(d)** As we know $\mu = \dfrac{1}{\sin C}$

$$\mu = \frac{1}{\sin 60°} = \frac{2}{\sqrt{3}}$$

For total internal reflection to take place

$$\sin C = \frac{1}{\mu} = \frac{2}{3}$$

$$C = \sin^{-1}\frac{2}{3} \cong 42°$$

$$\theta < 45°$$

Angle of incidence > critical angle, hence TIR takes place

138. **(b)** Deviation = zero

So, $\delta = \delta_1 + \delta_2 = 0$

$$\Rightarrow (\mu_1 - 1)A_1 + (\mu_2 - 1)A_2 = 0$$

$$\Rightarrow A_2(1.75 - 1) = -(1.5 - 1)15°$$

$$\Rightarrow A_2 = -\frac{0.5}{0.75} \times 15°$$

or $A_2 = -10°$.

Negative sign shows that the second prism is inverted with respect to the first.

139. **(b)** $i = \dfrac{A + \delta_m}{2} = \dfrac{60 + 30}{2} = 45°$

140. **(d)** $i_1 = i_2 = \dfrac{3}{4}A$

As $A + \delta = i_1 + i_2$

$$\therefore \delta = i_1 + i_2 - A = \frac{3}{4}A + \frac{3}{4}A - A = \frac{A}{2} = \frac{60°}{2} = 30°$$

141. **(d)** Here $\dfrac{x}{1000} = \dfrac{1.22\lambda}{D}$ or $x = \dfrac{1.22 \times 5 \times 10^3 \times 10^{-10} \times 10^3}{10 \times 10^{-2}}$

or $x = 1.22 \times 5 \times 10^{-3}$ m $= 6.1$ m

x is of the order of 5 mm.

142. **(d)** Resolving power $\alpha(1/\lambda)$.

Hence, $\dfrac{(R.P)_1}{(R.P)_2} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{5}{4}$

143. **(a)** $\dfrac{f_0}{f_e} = 9$, $\therefore f_0 = 9f_e$

Also $f_0 + f_e = 20$ ($\because$ final image is at infinity)

$9f_e + f_e = 20$, $f_e = 2$ cm, $\therefore f_0 = 18$ cm

144. **(b)** In normal adjustment,

$$M = \frac{f_0}{f_e} = 20, \quad f_e = \frac{f_0}{20} = \frac{60}{20} = 3 \text{ cm}$$

145. **(a)** (i) $M = -\dfrac{f_0}{f_e}\left(1 + \dfrac{f_e}{d}\right) = -\dfrac{200}{5}\left(1 + \dfrac{5}{25}\right) = -48$

(since least distance d = 25cm)

(ii) $M = -\dfrac{f_0}{f_e} = -\dfrac{200}{5} = -40$

146. **(b)** $M = \dfrac{\beta}{\alpha} = \dfrac{f_0}{f_e}$

$$\therefore \beta = \frac{f_0}{f_e}\alpha = \frac{60}{5} \times 2° = 24°$$