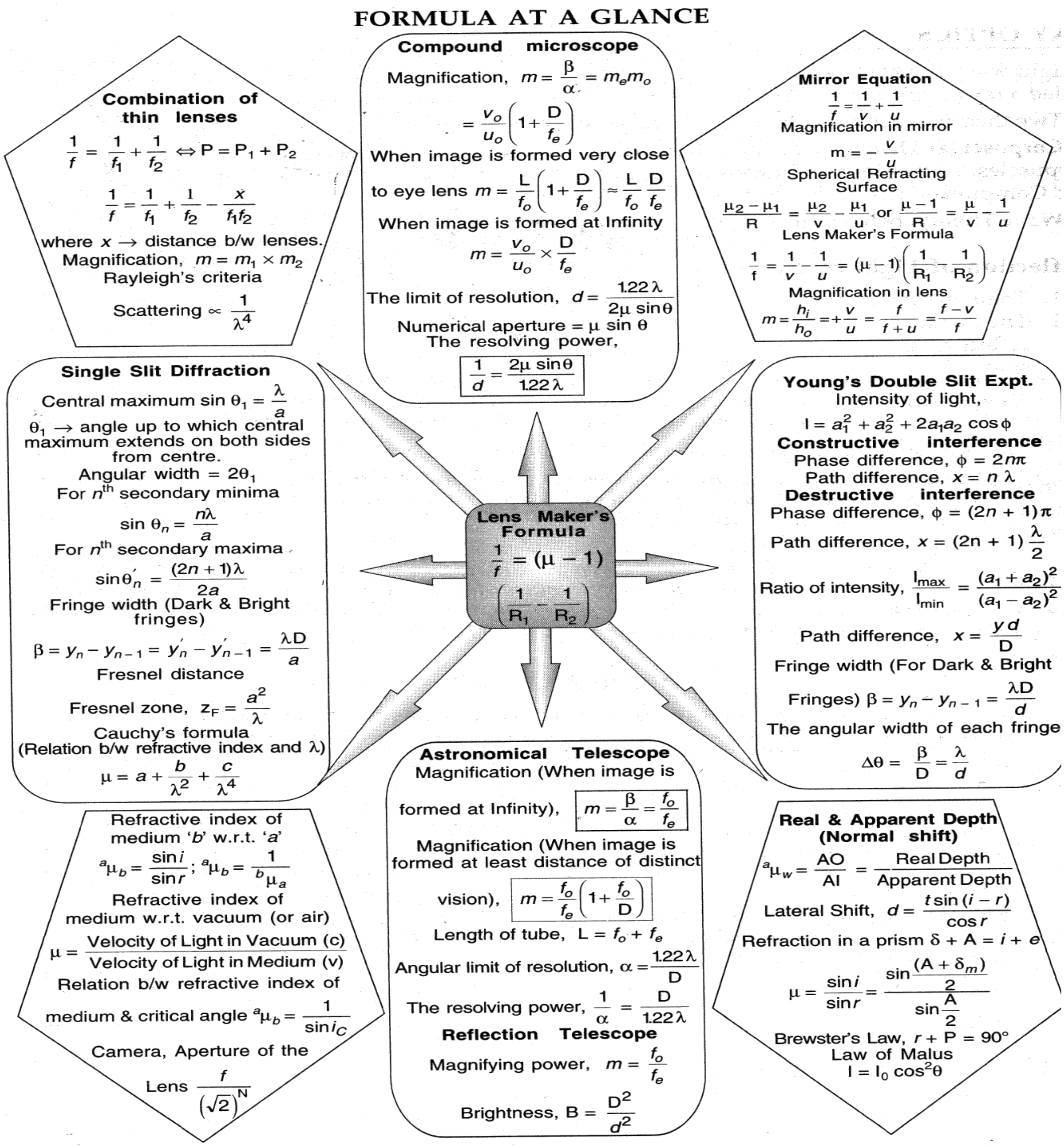
UNIT-6 OPTICS



FORMULA AT A GLANCE

Combination of thin lenses

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \Leftrightarrow P = P_1 + P_2$

$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$

where $x \rightarrow$ distance b/w lenses.

Magnification, $m = m_1 \times m_2$

Rayleigh's criteria

Scattering $\propto \frac{1}{\lambda^4}$

Compound microscope

Magnification, $m = \frac{\beta}{\alpha} = m_e m_o$

$= \frac{v_o}{u_o}\left(1 + \frac{D}{f_e}\right)$

When image is formed very close to eye lens $m = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right) \approx \frac{L}{f_o}\frac{D}{f_e}$

When image is formed at Infinity

$m = \frac{v_o}{u_o} \times \frac{D}{f_e}$

The limit of resolution, $d = \frac{1.22\lambda}{2\mu \sin\theta}$

Numerical aperture $= \mu \sin\theta$

The resolving power,

$\boxed{\frac{1}{d} = \frac{2\mu \sin\theta}{1.22\lambda}}$

Mirror Equation

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

Magnification in mirror

$m = -\frac{v}{u}$

Spherical Refracting Surface

$\frac{\mu_2 - \mu_1}{R} = \frac{\mu_2}{v} - \frac{\mu_1}{u}$, or $\frac{\mu - 1}{R} = \frac{\mu}{v} - \frac{1}{u}$

Lens Maker's Formula

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

Magnification in lens

$m = \frac{h_i}{h_o} = +\frac{v}{u} = \frac{f}{f+u} = \frac{f-v}{f}$

Lens Maker's Formula

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

Single Slit Diffraction

Central maximum $\sin\theta_1 = \frac{\lambda}{a}$

$\theta_1 \rightarrow$ angle up to which central maximum extends on both sides from centre.

Angular width $= 2\theta_1$

For n^{th} secondary minima

$\sin\theta_n = \frac{n\lambda}{a}$

For n^{th} secondary maxima

$\sin\theta_n' = \frac{(2n+1)\lambda}{2a}$

Fringe width (Dark & Bright fringes)

$\beta = y_n - y_{n-1} = y_n' - y_{n-1}' = \frac{\lambda D}{a}$

Fresnel distance

Fresnel zone, $z_F = \frac{a^2}{\lambda}$

Cauchy's formula

(Relation b/w refractive index and λ)

$\mu = a + \frac{b}{\lambda^2} + \frac{c}{\lambda^4}$

Young's Double Slit Expt.

Intensity of light,

$I = a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi$

Constructive interference

Phase difference, $\phi = 2n\pi$

Path difference, $x = n\lambda$

Destructive interference

Phase difference, $\phi = (2n+1)\pi$

Path difference, $x = (2n+1)\frac{\lambda}{2}$

Ratio of intensity, $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$

Path difference, $x = \frac{yd}{D}$

Fringe width (For Dark & Bright Fringes) $\beta = y_n - y_{n-1} = \frac{\lambda D}{d}$

The angular width of each fringe

$\Delta\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

Refractive index of medium 'b' w.r.t. 'a'

${}^a\mu_b = \frac{\sin i}{\sin r}$; ${}^a\mu_b = \frac{1}{{}^b\mu_a}$

Refractive index of medium w.r.t. vacuum (or air)

$\mu = \frac{\text{Velocity of Light in Vacuum (c)}}{\text{Velocity of Light in Medium (v)}}$

Relation b/w refractive index of medium & critical angle ${}^a\mu_b = \frac{1}{\sin i_C}$

Camera, Aperture of the Lens $\frac{f}{(\sqrt{2})^N}$

Astronomical Telescope

Magnification (When image is formed at Infinity), $\boxed{m = \frac{\beta}{\alpha} = \frac{f_o}{f_e}}$

Magnification (When image is formed at least distance of distinct vision), $\boxed{m = \frac{f_o}{f_e}\left(1 + \frac{f_o}{D}\right)}$

Length of tube, $L = f_o + f_e$

Angular limit of resolution, $\alpha = \frac{1.22\lambda}{D}$

The resolving power, $\frac{1}{\alpha} = \frac{D}{1.22\lambda}$

Reflection Telescope

Magnifying power, $m = \frac{f_o}{f_e}$

Brightness, $B = \frac{D^2}{d^2}$

Real & Apparent Depth (Normal shift)

${}^a\mu_w = \frac{AO}{AI} = \frac{\text{Real Depth}}{\text{Apparent Depth}}$

Lateral Shift, $d = \frac{t \sin(i - r)}{\cos r}$

Refraction in a prism $\delta + A = i + e$

$\mu = \frac{\sin i}{\sin r} = \frac{\sin\frac{(A + \delta_m)}{2}}{\sin\frac{A}{2}}$

Brewster's Law, $r + P = 90°$

Law of Malus

$I = I_0 \cos^2\theta$

SYNOPSIS

Refraction of light It is the phenomenon of bending of the ray of light from its path when it goes from one medium to another. Refraction of light is due to the fact that speed of light is different in different media.

Laws of refraction (I) refractive index of the medium, n= **Error! Reference source not found.** , where i is an angle of incident and r is angle of refraction.

(II) Incident ray, refracted ray and normal lie in the same plane.

Refractive index. When the ray of light goes from medium 1 to medium 2, **Error! Reference source not found.**= Error! Reference source not found.

During refraction of light velocity and wave length of light changes and but frequency remains unchanged.

Refraction through a glass slab: A ray of light incident obliquely on the parallel sided glass slab emerges out parallel to the incident ray but , the incident ray is laterally displaced.

Lateral shift or displacement, **Error! Reference source not found.** where ' t 'is the thickness of glass slab, i and r_1 are the angles of incidence and refraction respectively.

Normal shift in the position of the object lying in the denser medium due to refraction of light, x = R.D. – A.D.= t- A.D.= t(1-1/n) where, t is the real depth.

Total internal reflection takes place when light travels from denser to rare medium and angle of incidence is greater than the critical angle.

Brilliance of a diamond, mirage and optical fibers are due to total internal reflection.

Critical angle Is the angle of incidence of the ray of light incident on denser – rarer medium interface corresponding to which angle of refraction becomes 90^0.

Refractive index, n = 1/Sin i_c

Refraction at spherical refracting surface. For refraction at spherical surface when object lies in a rare medium, we get

$$-\frac{n_1}{u}+\frac{n_2}{v}=\frac{n_2-n_1}{R}$$

Where u is distance of object, v is the distance of image R is radius of spherical surface, n_1 is refractive index of rarer medium and n_2 is refractive index of denser medium.

For refraction at spherical surface when object lies in denser medium, we have

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Lens Makers Formula: The relation among the focal length (f) of the lens, radii of curvature of its surface ($R_1$and R_2) and refractive index of (n) of the material of the lens is called lens maker's formula.

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$-\frac{1}{u}+\frac{1}{v}=\frac{1}{f}$**Lens formula:** the relation between object distance u image distance v and focal length f of the lens is called lens formula.

Linear magnification: Produced by a lens for an object of height O and image of height h is given by $m=\frac{1}{O}=\frac{v}{u}=\frac{f}{u+f}=\frac{f-v}{f}$

Equivalent lens: Two lenses in contact behaving as a single lens are known as equivalent lens. The focal length of an equivalent lens made by two lenses of focal lengths $f_1$and f_2 in contact is given by $\frac{1}{F}=\frac{1}{f_1}+\frac{1}{f_2}$

- Power of an equivalent lens is given by $P = P_1 + P_2$
- The focal length of a equivalent lens made by two lenses of focal length f_1 and f_2, separated by a small distance x is given by,

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{x}{f_1 f_2}$$ And $P = P_1 + P_2 - xP_1P_2$

Simple microscope is a convex lens of small focal length. E.g. magnifying glass.
Magnifying power of simple microscope when the image is formed at infinity (Normal adjustment of microscope) is given by M.P. = D/u = D/f. where D is the distance of distinct vision, u is the distance of the object and f is focal length.
Magnifying power of simple microscope when image is formed at least distance of distinct vision is given by M.P. = (1 + D/f)

Compound microscope consists of two lenses. The focal length and aperture of the objective is small compared to the eyepiece.
Magnifying power of compound microscope, M.P. = m_0 x m_e where m_0 is magnification of objective, m_e is magnification of eye piece.

Magnifying power of astronomical telescope when final image is formed at infinity (Normal adjustment of telescope) is given by M.P. = f_0/f_e where $f_0$is focal length of the objective and f_e is focal length of the eye piece.

HUYGENS PRINCIPLE:

(i) Each source of light is a centre of disturbance from which waves spread in all directions. All particle vibrating in same phase lie on a surface called wave front.(wave front is the locus of all the particles of medium vibrating in the same phase at a given instant. There can be spherical wave fronts, cylindrical wave fronts and plane wave fronts)

(ii) Every point on a wave front is source of secondary wave front. Envelope of secondary wavelet gives new wave front.
A line perpendicular to wave front gives the direction of propagation of a wave and is called ray of light.

COHERENT SOURCES . Two sources of light are coherent if they emit waves of same frequency having constant initial phase difference otherwise the sources are incoherent.

INTERFERENCE. Redistribution of energy due to superposition of light waves from two coherent sources resulting in maxima and minima.
Resultant intensity due to interference of two waves is given by $I_R = I_a+I_b$ +2 **Error! Reference source not found.** where I_a is intensity of one wave ,I_b is intensity of second wave and φ is angle between them.
For **constructive interference**, path difference , $\Delta x = m\lambda$, m = 0,1,2,3…..
For **destructive interference**, path difference ,
$\Delta x = \left(m + \frac{1}{2}\right)\lambda$ Where m = 0,1,2,3…..

Fringe width of interference pattern in **young's experiment** $\beta = \frac{\lambda D}{d}$

Width of central maximum = 2λD/d where D is distance of screen from the plane of the slit and d is distance between the slit

Resolving power of optical instruments is the ability of an optical instrument to form clear separate images of two nearly objects.

- **Resolving power of telescope = D/ 1.22λ** where D is diameter of objective lens and λ is wavelength of light.
- **Resolution of microscope** = 2nsinΘ/ 1.22λ where n sinΘ is numerical aperture of the objective lens.

Validity of ray optics: Ray optics is valid for distance less than Fresnel distance, $Z_f = a^2/\lambda$

DIFFRACTION is the phenomenon of bending of light round the sharp corners of an obstacle and spreading into the regions of the geometrical shadow is called diffraction.

POLARISATION of light is the phenomenon due to which the vibrations of light are restricted in a particular plane is called the polarization of light.

Brewster's Law states that when light is incident at polarizing angle at the interface of a refracting medium, the refractive index of the medium is equal to the tangent of the polarizing angle. $\boxed{\mu = \tan p}$

Law of Malus states that when a completely plane polarised light beam is incident on an analyser, the intensity of the emergent light varies as the square of the cosine of the angle between the plane of transmission of the analyser and the polariser.

RAY OPTICS

IMAGE FORMED BY A CONVEX LENS

(i) **When object lies at infinity.** Then **Error! Reference source not found.**

From by the lens equation we have - **Error! Reference source not found.** or **Error! Reference source not found.**

As focal length of the convex lens is positive, v is also positive. Therefore real image will be formed at focus on the other side of the lens. Now magnification **Error! Reference source not found.** (point in size)

Therefore when object lies **at infinity** image will be formed **at F** and it will be real, inverted and **point in size.**

(ii) **When object lies beyond 2F** u is negative and |u| > 2f

now - **Error! Reference source not found.** **Error! Reference source not found.**

Since |u| > 2f, It follows that v will be positive and will have a value between f and 2f (image between F and 2F on the other side of the lens)

Since **Error! Reference source not found.**, the value of m will be negative and |m| < 1 (real image and smaller in size)

Therefore when object lies **beyond 2F** the image will be formed between F and 2F and will be **real inverted and smaller in size.**

(iii) **When object lies at 2F**. in such case **Error! Reference source not found.**From the lens equation we have

$$v = \frac{uf}{u+f}$$

Error! Reference source not found. we obtain **Error! Reference source not found.**

Since **Error! Reference source not found.**,

The value of *m* will be equal to -1 (real image and equation in size).

Therefore when object lies at 2F the image will be **at 2F** and will be **real inverted and equal in size.**

(iv) **When object lies between F and 2F**. when object lies between F and 2F

f **<** |u| < 2f. from the equation we have **Error! Reference source not found.**

Since f < |u| < 2f,

v will be positive and have a value greater than 2f (image beyond 2F on the other side of the lens).

Since **Error! Reference source not found.** *m* will be negative and (real image and larger in size)

Therefore when object lies between **F and 2F,** the image will be formed **beyond 2F** and will be **real inverted and larger size.**

(v)**When object lies at F.** When object lies at F, **Error! Reference source not found.** From the lens equation

we have **Error! Reference source not found.** or **Error! Reference source not found.** or **Error! Reference source not found.** (image at infinity)

Now, **Error! Reference source not found.** (real image and highly magnified)

Therefore when object lies **at F** the image will be formed **at infinity** and will be **real inverted and highly magnified**

(vi) **When object lies between F and C**. For object lying between F and C

|u| < f . From the lens equation we have **Error! Reference source not found.**

Since |u| < f, v will be negative and |v| > f.

From **Error! Reference source not found.**, It follows that *m* will be positive and greater than 1 (virtual and magnified image).

Therefore, when object lies **between F and C,** image will be formed **beyond F** on the same side of the lens. Further the image will be **virtual erect and magnified**.

IMAGE FORMED BY CONCAVE LENS

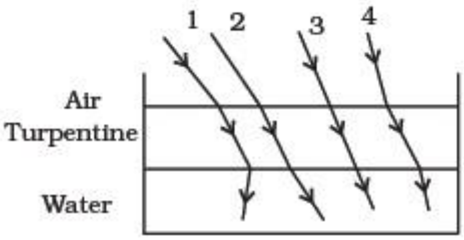
For a concave lens both u and f are negative. From the lens equation

we have **Error! Reference source not found.**

Since both u and f are negative, it follows that v will be negative and |v| < |f| (image on same side of the lens and between F and C).

From **Error! Reference source not found.** , it follows that m will be positive and less than 1 (virtual image and smaller in size).

It may be pointed out that irrespective of the position of the object, a concave lens always produces a **virtual** and **erect image on the side of the lens**, which is **smaller in size.**

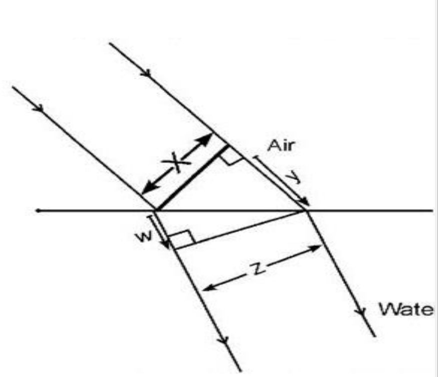
Sl.No.	Question Details	Marks
	MULTIPLE CHOICE QUESTIONS	
1.	A ray of light incident at an angle θ on a refracting face of a prism emerges from the other face normally. If the angle of the prism is 5° and the prism is made of a material of refractive index 1.5, the angle of incidence is (a) 7.5° (b) 5°. (c) 15°. (d) 2.5°.	**1**
2.	A passenger in an aeroplane shall (a) never see a rainbow. (b) may see a primary and a secondary rainbow as concentric circles. (c) may see a primary and a secondary rainbow as concentric arcs. (d) shall never see a secondary rainbow	**1**
3.	The optical density of turpentine is higher than that of water while its mass density is lower. Fig 9.2. shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in Fig 9.2, the path shown is correct? (a) 1 (b) 2 (c) 3 (d) 4  Fig. 9.2	**1**
4.	A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen. (a) half the image will disappear.	**1**

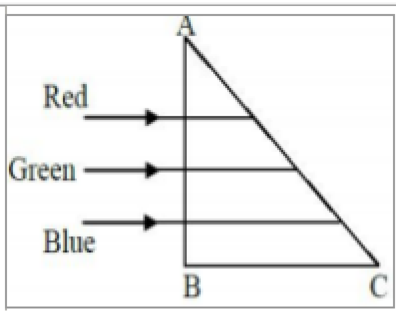
	(b) incomplete image will be formed. (c) intensity of image will decrease but complete image is formed. (d) intensity of image will increase but image is not distinct.	
5.	In optical fibres, the refractive index of the core is (a) greater than that of the cladding. (b) equal to that of the cladding. (c) smaller than that of the cladding. (d) independent of that of cladding.	**1**
6.	An astronomical refractive telescope has an objective of focal length 20m and an eyepiece of focal length 2cm. (a) The length of the telescope tube is 20.20m. (b) The magnification is 100. (c) The image formed is inverted. (d) An objective of a larger aperture will increase the brightness and reduce chromatic aberration of the image.	**1**
7.	A magnifying glass is used, as the object to be viewed can be brought closer to the eye than the normal near point. This results in (a) a larger angle to be subtended by the object at the eye and hence viewed in greater detail. (b) the formation of a virtual inverted image. (c) increase in the field of view. (d) infinite magnification at the near point.	**1**
8.	Tom' lenses of focal lengths ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be (a) + 15 cm (b) + 150 cm (c) – 150 cm (d) – 15 cm	**1**
9.	In Young's double slit experiment is the slit widths are in the ratio 1 : 9, the ratio of the intensity at minima to that at maxima will be a) 1 b) 1/3 c) 1/9 d) 1/4	**1**
10.	We shift young's double slit experiment from air to water. Assuming that water is still and clear, it can be predicted that the fringe pattern will a) Remain unchanged b) Disappear c) Shrink	**1**

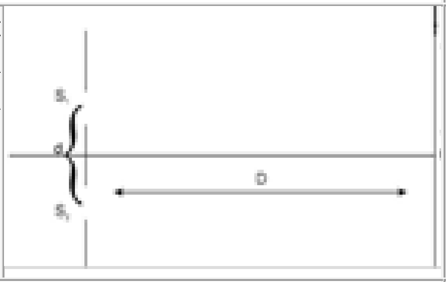
	d) Be enlarged	
11.	Two slits separated by a distance of 1 mm are illuminated with red light of wavelength 6.5x 10 ^7 m. The interference fringes are observed on a screen placed 1 m from the slits. The distance between third dark fringe and the fifth bright fringe is equal to a) 0.65 mm b) 3.25 mm c) 1.63 mm d) 4.88 mm	**1**
12.	In young's double slit interference experiment, the distance between two sources is 0.1 mm. The distance of the screen from the sources is 20 cm. Wavelength of light used is 5460 Angstrom Then the angular position of the first dark fringe is a) 0.08 degree b) 0.16 degree c) 0.2 degree d) 0.32 degree	**1**
13.	In the Young's double slit experiment, the two equality bright slits are coherent, but of phase difference is pi/3. If the maximum intensity on the screen is I0, the intensity at the point on the screen equidistant from the slits is a) I0 b) I0/2 c) I0/4 d) 3I0/4	**1**
14.	If two sources have a randomly varying phase difference $\Phi(t)$, the resultant intensity will be given by a) $I_0\sqrt{2}$ b) $I_0/2$ c) $2I_0$ d) $I_0/\sqrt{2}$	**1**
15.	What happens, if the monochromatic light used in Young's double slit experiment is replaced by white light? (a) No fringes are observed. (b) All bright fringes become while. (c) All bright fringes have colour between violet and red. (d) Only the central fringe is white and all other fringes are coloured.	**1**
	FILL IN THE BLANKS	
1.	Optical density of a medium is measured in terms of ------------------------------------	**1**
2.	Optical fibre works on the principle of ---	**1**
3.	An astronomical telescope has a large aperture to -----------------------------------	**1**
4.	Blue colour of the sky is due to the phenomenon of -----------------------------of light	**1**
5.	A convex lens is dipped in a liquid whose refractive index is equal to the refractive index of the lens. Then its focal length will be ----------	**1**

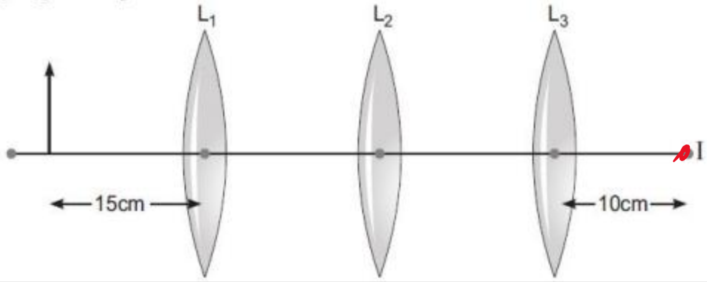
6.	The phenomenon of restricting the oscillations of a wave to just one direction in the transverse plane is ---	**1**
7.	Width of dark and bright fringes in interference is -------------------------	**1**
8.	For constructive interference to occur between two monochromatic light waves of wavelength λ, the path difference should be ------------------	**1**
9.	The condition for the second secondary maxima in diffraction pattern is ------------------	**1**
	VERY SHORT ANSWER QUESTIONS	
1.	Draw the shape of the reflected wave front when a plane wave front is incident on a concave mirror.	**1**
2.	When light travels from a rarer medium to denser medium, the speed of light decreases. Does the reduction in speed imply a reduction in the energy ?	**1**
3.	You are given following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope?	**1**

Lens	Power(P)	Aperture (A)
L_1	30	8cm
L_2	60	1cm
L_3	100	1cm

4.	A plane wave front, of width X, is incident on an air-water interface and the corresponding refracted wave front has a width Z as shown. Express the refractive index of air with respect to water, in terms of the dimension shown. [${}^{a}_{w}\mu = \frac{\sin r}{\sin i} = \frac{w}{y}$] 	**1**
5.	If the angle between the planes of polarizer and the analyzer is 45^0, write the ratio of the intensity of original incident light to the transmitted light after passing through the analyzer?	**1**
6.	What is ratio of the fringe width for bright and dark fringes in Young's double slit experiment?	**1**
7.	the same angle of incidence, the angle of refraction in three different media A, B and C are 15^o, 25^o and 35^o. In which medium, will the velocity light be minimum?	**1**
8.	The interference fringe pattern according to the theory is hyperbola. What is the condition for seeing nearly straight fringes?	**1**
9.	Under what condition does the angle of deviation attain the minimum value when a ray	

	of light passes through a prism?	
10.	The focal length of an equiconvex lens is equal to the radius of curvature of either face. What is the refractive index of the material of the lens ?	
	2 MARKER QUESTIONS	
11.	A concave mirror and a concave lens are held in water. What changes, if any, do you expect in their respective focal lengths as compared to their values in air? Justify?	**2**
12.	A concave lens has the same radii of curvature for both sides and has refractive index 1.6 in air. In the second case, it is immersed in a liquid of refractive index 1.4. Calculate the ratio of the focal length of the lens in the two cases.	**2**
13.	Violet light is incident on a converging lens of focal length f. State with reason, how focal length of the lens will change, if violet is replaced by red light.	**2**
14.	In the figure given below, light rays of blue, green, red wavelengths are incident on an isosceles right angled prism. Explain with reason, which ray of light will be transmitted through the face AC. The refractive index of the prism for red, green, blue light is 1.39, 1.424, and 1.476 respectively. 	**2**

15.	Laser light of wavelength 630 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 8.1mm. A second light produces an interference pattern in which the fringes are separated by 7.2 mm. Calculate the wavelength of the second light.	**2**
16.	The aperture of the objective lens of an astronomical telescope is doubled. How does it affect (i) the resolving power of the telescope and (ii) the intensity of the image?	**2**
17.	A concave lens has the same radii of curvature for both sides and has refractive index 1.6 in air. In the second case, it is immersed in a liquid of refractive index 1.4. Calculate the ratio of the focal length of the lens in the two cases.	
18.	Two coherent sources have intensities in the ratio 25:16. Find the ratio of the intensities of maxima to minimum, after interference of light occurs.	**2**
19.	The intensity, at the central maxima (0) in a Young's double slit set up is I_o. If the distance OP equals one third of the fringe width of the pattern, show that the intensity, at point P., would equal $I_o/4$. 	**2**
20.	Violet light is incident on a converging lens of focal length f. State with reason, how focal length of the lens will change, if violet is replaced by red light.	**2**
21.	The magnifying power of the two astronomical telescopes is same, but aperture of their objective lenses is in the ratio 2:3.State with reason, which telescope has (1) larger resolving power and (2) which one produces image of greater intensity.	**2**
22.	Light of wavelength 600nm is incident on an aperture of size 2mm.Calculate the distance up to which the ray of light can travel such that its spread is less than the size of the aperture.	**2**
23.	Consider interference between two sources of intensities I and 4I. Obtain intensity at a point where the phase difference is $\pi/2$.	**2**
24.	The ratio of intensity of maxima and minima in an interference pattern is 100:64. Calculate the ratio of intensities of the coherent sources producing this pattern.	**2**
25.	Find the intensity at a point on a screen in Young's double slit experiment where the interfering waves of equal intensity have a path difference of (i) $\lambda/4$, (ii) $\lambda/3$	**2**
	3 MARKER QUESTIONS	
26.	A convex lens made up of glass of refractive index 1.5 is dipped in turn, (i) in a medium A of μ = 1.65 and (ii) in a medium B of μ = 1.33. Explain giving reasons whether it will behave as a converging lens or a diverging lens in each of these two media?	**3**
27.	An object is placed 40 cm from a convex lens of focal length 30 cm. If a concave lens of	**3**

	focal length 50 cm is introduced between the convex lens and the image formed such that it is 20 cm from the convex lens, find the change in the position of the image.	
28.	You are given three lenses L_1, L_2 and L_3 each of focal length 10 cm. An object is kept at 15 cm in front of L_1, as shown. The final real image is formed at the focus 'I' of L_3. Find the separations between L_1, L_2 and L_3. 	**3**

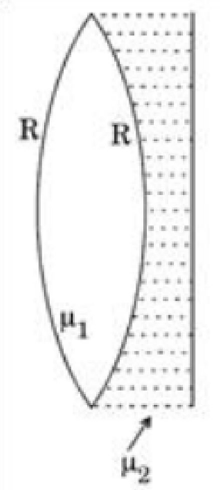
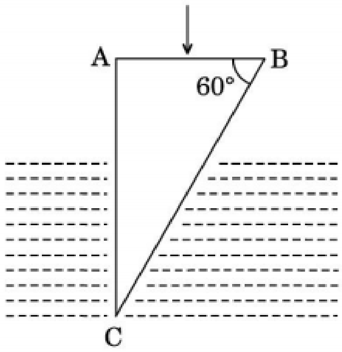
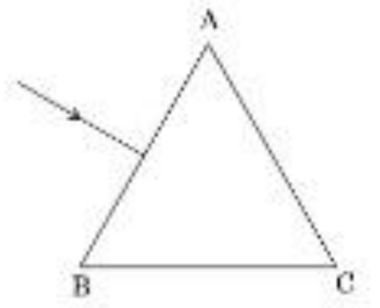
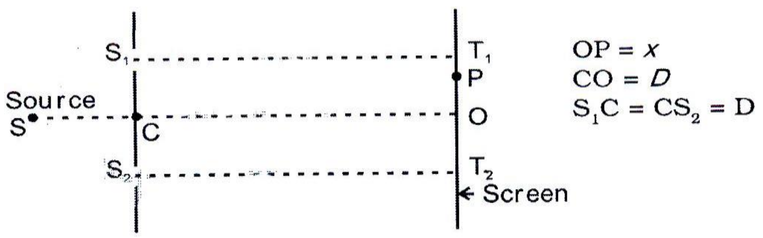
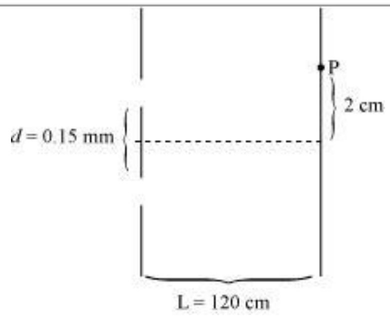
29.	A biconvex lens with its two faces of equal radius of curvature R is made of a transparent medium of refractive index μ1. It is kept in contact with a medium of refractive index μ2 as shown in the figure. (a) Find the equivalent focal length of the combination. (b) Obtain the condition when this combination acts as a diverging lens. (c) Draw the ray diagram for the case μ1 > (μ2 + 1) / 2, when the object is kept far away from the lens. Point out the nature of the image formed by the system 	**3**
30.	In the diffraction in a single slit experiment, how would the width and the intensity of central maximum change if(i) slit width is halved and (ii) visible light of longer wavelength is used ? Give reason?	**3**
31.	A ray of light is incident normally on the face AB of a right-angled glass prism of refractive index aμg = 1·5. The prism is partly immersed in a liquid of unknown refractive index. Find the value of refractive index of the liquid so that the ray grazes along the face BC after refraction through the prism. Trace the path of the rays if it were incident normally on the face AC 	**3**
32.	(a) In Young's double slit experiment, two slits are 1 mm apart and the screen is placed 1m away from the slits. Calculate the fringe width when light of wavelength 500nm is used. (b) What should be the width of each slit in order to obtain 10 maxima of the double slits pattern within the central maximum of the single slit pattern?	**3**
33.	The following data was recorded for values of object distance and the corresponding values of image distance in the experiment on study of real image formation by a convex lens of power +5D. One of these observations is incorrect. Indentify this observation and give reason for your choice:	**3**
34.	In a double slit experiment, the distance between the slits is 3 mm and the slits are 2 m away from the screen. Two interference patterns can be seen on the screen one due to light with wavelength 480 nm, and the other due to light with wavelength 600 nm. What is the separation on the screen between the fifth order bright fringes of the two interference patterns?	**3**

Table for Q33:

S.No.	1	2	3	4	5	6
Object distance (cm)	25	30	35	45	50	55
Image distance (cm)	97	61	37	35	32	30

35.	(a)Show using a proper diagram how unpolarised light can be linearly polarised by reflection from a transparent glass surface. (b) The figure shows a ray of light falling normally on the face AB of an equilateral glass prism having refractive index 3/2 , placed in water of refractive index 4/3 . Will this ray suffer total internal reflection on striking the face AC ? Justify your answer  	**3**
36.	Describe an experiment to show that light waves are transverse in nature.	**3**
37.	a) Draw a schematic diagram of the reflecting telescope. b) State the advantages of reflecting telescope over refracting telescope.	**3**
38.	a) Draw a schematic ray diagram of a compound microscope when image is formed at distance of distinct vision b) Write the expression for resolving power of a compound microscope. How can the resolving power of a microscope be increased ?	**3**
39.	a) Two nearby narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen b) One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? c) Write two differnces between the patterns obtained in the two cases.	**3**
40.	Consider a two slit interference arrangements (Fig.) such C that the distance of the screen from the slits is half the distance between the slits. Obtain the value of D in terms of λ such that the first minima on the screen falls at a distance D from the centre O.  	**3**
41.	What is meant by diffraction of light? Draw a graph to show the relative intensity distribution for a single slit diffraction pattern. Obtain expression for the first minimum of diffraction.	**3**
42.	Write the expression for the resultant intensity at a point due to the superposition of two monochromatic waves y1 = a cos ωt, y2 = a cos (ωt + φ) where φ is the phase difference between the two waves and a and ωdenote the amplitude and angular frequency.	**3**
43.	A monochromatic light of wavelength λ is incident normally on a narrow slit of width 'a' to produce a diffraction pattern on the screen placed at a distance D from the slit. With the help of a relevant diagram, deduce the conditions for obtaining maxima and minima on the screen.	**3**

	Use these conditions to show that angular width of central maximum is twice the angular width of secondary maximum.	
44.	a) State Huygen's principle. Show, with the help of a suitable diagram, how this principle is used to obtain the diffraction pattern by a single slit. b) Draw a plot of intensity distribution and explain clearly why the secondary maxima become weaker with increasing order (n) of the secondary maxima.	**3**
45.	Consider the double slit arrangement given below: a)A light of wavelength λ = 833 nm is made incident on the slits. **(i)** What is the path difference δ for the rays from the two slits arriving at point P? **(ii)** Express this path difference in terms of λ. **(iii)** Does point P correspond to a maximum, minimum, or intermediate situation?  	**3**
46.	Two narrow slits are illuminated by a single monochromatic source. Name the pattern obtained on the screen. One of the slits is now completely covered. What is the name of the pattern now obtained on the screen? Draw intensity pattern obtained in the two cases. Also write differences between the two patterns obtained above.	**3**
47.	What should be the width of each slit to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern, for green light of wavelength 500 nm, if the separation between two slits is 1 mm ?	**3**
48.	A double slit is illuminated by light of wavelength 6000 Å. The slits are 0.1cm apart and the screen is placed one metre away. Calculate (i) the angular position of the 10^{th} maxima in radian (ii) separation of the two adjacent minima	**3**
	5 MARKER QUESTIONS	
49.	Obtain an expression for fringe width in Youngs double slit experiment. What is the effect on the interference pattern in Youngs experiment when: (i) screen is moved closer to the plane of slits? (ii) Separation between the two slits is increased. Explain your answer in each case.	**5**
50.	In Young's double slit experiment, a monochromatic source of light S is kept equidistant from the slits S1 and S2 . Explain the formation of dark and bright fringes on the screen. (b) A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment. (i) Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm. (ii) What is the least distance from the central maximum where the bright fringes due to both the	**5**

	wavelengths coincide ? Given : the separation between the slits is 4 mm and the distance between the screen and plane of the slits is 1.2 m	
51.	State the essential condition for the diffraction of light to take place. A parallel beam of monochromatic light falls normally on a narrow slit and light coming out of the slit is obtained on the screen. Derive an expression for the angular width of the central bright maxima obtained on the screen.	**5**
52.	State Huygens principle. Using geometrical construction of secondary wavelets, explain the refraction of a plane wave front incident at a plane surface. Hence verify Snells law of refraction.	**5**
53.	.(a)There are two sets of apparatus of Young's double slit experiment. In set A, the phase difference between the two waves emanating from the slits does not change with time, 5 8 whereas in set B, the phase difference between the two waves from the slits changes rapidly with time. What difference will be observed in the pattern obtained on the screen in the two set ups? (c) Deduce the expression for the resultant intensity in both the above mentioned set ups (A and B), assuming that the waves emanating from the two slits have the same amplitude A and same wavelength λ.	**5**
65.	(a) Derive an expression for path differnce in Young's double slit experiment and obtain the conditions for constructive and destructive interference at a point on the screen. (b) The intensity at the central maxima in Young's double slit experiment is I_0. Find out the intensity at a point where the path difference is $\lambda/6$, $\lambda/4$ and $\lambda/3$.	**5**
66.	(a) Define a wavefront. Using Huygens' principle, verify the laws of reflection at a plane surface. (b) 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 ? Explain. (c) 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 obstacle. Explain why.	**5**
68.	With the help of a ray diagram, explain the formation of image in an astronomical telescope for a distant object. Define the term magnifying power of a telescope. Derive an expression for its magnifying power when the final image is formed at the least distant of distinct vision?	**5**
69.	(a) State the importance of coherent sources in the phenomenon of interference of light. (b) In Young's double slit experiment, obtain the conditions for constructive and destructive interfernce. Hence deduce the expression for the fringe width. (c) How do you explain the fact that fringes in double slit experiment are of the same intensity, whereas in a diffraction experiment, the intensity of the bands produced decreases with order n?	**5**

ANSWER KEY - MCQ

1	2	3	4	5	6
a	b	b	c	a	c
7	**8**	**9**	**10**	**11**	**12**
a	a	d	c	b	b
13	**14**	**15**			
d	c	d			

ANSWER KEY – FILL IN THE BLANKS

1	2	3	4	5
Refractive index	TIR	Objective	Scattering	Infinity
6	**7**	**8**	**9**	
Polarization	$\lambda D/d$	$n\lambda$	$(2n+1)\lambda/2a$	