Mind Map-9

RAY OPTICS AND OPTICAL INSTRUMENTS

Ray optics
Optics - branch of study of light (EM waves wavelength 400 nm to 750 nm). The path of light (always travel in straight line) is ray of light

Laws of refraction

Snell's law $\mu = \frac{\sin i}{\sin r}$

For two media $_1\mu_2 = \frac{\mu_2}{\mu_1} = \frac{\sin i}{\sin r}$

The incident ray, the normal and the refracted ray all lie in the same plane

Refractive index, $\mu = \frac{c}{v} = \frac{\text{real depth}}{\text{apparent depth}}$

Refraction of light Bending of light ray while passing from one medium to another medium
- A ray of light bends towards the normal, while going from rarer to denser medium
- And bends away from the normal while going from denser to rarer medium
- Refraction of light takes place because the speed of light is different in the two media

Total internal Reflection Ray totally reflected back to denser medium

Phenomena based on TIR
- Mirage - optical illusion in deserts
- Looming - optical illusion in cold countries
- optical fibre
- Brilliance of diamond

Necessary conditions for TIR
(i) ray of light must travel from denser to rarer medium
(ii) $\angle i > \angle c$ for two media

Critical angle (c) Angle *i* in denser medium for which angle of refraction in rarer medium is 90° $\mu = \frac{1}{\sin C}$

Reflection of light Turning back of light in the same medium after striking the reflecting surface or mirror
- After reflection, velocity, frequency and wavelength of light remains same but intensity decreases
- If reflection takes place from denser medium then phase change 'π'

Laws of reflection
- The incident ray the normal and the reflected ray all lie in the same plane
- The angle of incidence (I)is always equal to angle of reflection (r) i.e., $\angle i = \angle r$

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

When two plane mirrors are held at an angle θ with their reflecting surfaces facing each other and an object is placed between them, images are formed by successive reflections.

$f_{concave}$ = negative
f_{convex} = positive
and $f_{plane} = \infty$

Relation between focal length (f) and radius of curvature, R
$f = \frac{R}{2}$

Magnification
$m = \frac{v}{u} = \frac{\text{height of image}}{\text{height of object}}$
$m = \frac{f}{f-u} = \frac{f-v}{f}$

Refraction at a single spherical surface $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$

(A) In case, the object (real or virtual) is situated in rarer medium so that the incident ray travels in denser medium, then the relation between *u*, *v*, R, μ_1 and μ_2 is

$$-\frac{\mu_1}{u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

(B) In case, the object (real or virtual) is situated in denser medium, so that the incident ray travels in denser medium and refracted ray travels in rarer medium then the relation between *u*, *v*, R, μ_1 and μ_2 is

$$-\frac{\mu_2}{u} + \frac{\mu_1}{v} = \frac{\mu_1 - \mu_2}{R}$$

(C) The factor $\frac{\mu_2 - \mu_1}{R}$ is called power of the spherical refracting urface. It gives the measure of the degree to which the refracting surface can converge or diverge the rays of light passing through it.

Optical Instruments

Microscope Forms large image of tiny objects

Magnification produced by simple microscope

Image formed at near point $M = 1 + \frac{D}{f}$ D = 25 cm

Image formed at infinity $M = \frac{D}{f}$

Magnification by compound microscope

When final image is formed at infinity
$M = -\frac{v_0}{u_0}\frac{D}{f_e}$
Length of the microscope
$L = |v_0| + f_e$

When final image is formed at near point
$M = -\frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$
Length of the microscope
$L = |v_0| + |u_e|$

Telescope provide angular magnification of distant objects magnification by telescope

When final image is formed at near point
$M = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$
Length of the telescope,
$L = f_0 + |u_e|$

When final image is formed at infinity
$M = -\frac{f_0}{f_e}$
Length of the telescope,
$L = f_0 + f_e$

Dispersion Without Deviation (Direct Vision Spectroscope)
- To produce dispersion without mean deviation we use a combination of two prisms of different materials such that
$A' = -\left(\frac{\mu - 1}{\mu' - 1}\right)A$ or $\frac{A'}{A} = \frac{(\mu - 1)}{(\mu' - 1)}$
- Net dispersion caused
$= (\mu_v - \mu_R)A + (\mu'_v - \mu'_R)A'$
$= (\mu - 1)A(\omega - \omega') = \delta(\omega - \omega')$

Deviation Without Dispersion (Achromatic Prism)
- To produce deviation without dispersion we use a combination of two prisms of different materials such that $A' = \left[\frac{\mu_V - \mu_R}{\mu_V - \mu_R}\right]A$

Refraction by lens

Power of a lens
$P = \frac{1}{f(\text{in metre})}$
Unit of power of lens is diopter (D)
$P_{convex} \rightarrow$ Positve
$P_{concave} \rightarrow$ Negative
and $P_{plane} \rightarrow$ Zero

Lens formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
$f_{concave}$ = negative
f_{convex} = positive
and $f_{plane} = \infty$

Focal length of lens-**Lens maker's formula**
$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

When one face of a lens is silvered, it behaves as a concave mirror. If f_e is the effective focal length of the lens, then $\frac{1}{f_e} = \frac{2}{f_\ell} + \frac{1}{f_m}$ is the focal length of the mirror

(i) Plano-convex lens silvered at plane surface, then
$f_e = \frac{R}{2(\mu - 1)}$

(ii) Plano-convex lens silvered at plane surface, then
$f_e = \frac{R}{2\mu}$

Refraction through Prism

Prism Formula
$\mu = \frac{\sin\left(\frac{A + \delta m}{2}\right)}{\sin A/2}$

Angle of deviation $\delta = A(\mu - 1)$
- When prism is thin, then value of A will be small (≤ 10°) $\delta_m = (n - 1)A$
- Condition for maximum deviation i_1 or $i_2 = 90°$.

Dispersive power
$\omega = \left(\frac{\mu_v - \mu_r}{\mu_y - 1}\right)$