Chapter-9: Ray Optics

Reflection of Light Through a Spherical Mirror

1. Relation between radius of Curvature and focal length

$$\boxed{R = 2f}$$

2. Relation between object distance, image distance and focal length

Mirror Formula

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

Magnification (Linear or transverse or lateral}

$$\boxed{m = \frac{h_I}{h_o} = -\frac{v}{u}}$$

Refraction of Light through a Spherical Lens

4. Relation between object distance, image distance and focal length

Lens Formula

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

Magnification Formula

$$\boxed{m = \frac{h_I}{h_0} = \frac{v}{u}}$$

Refraction of Light Through One Plane Surface

5. Snell's law

$$\boxed{\mu_1 \sin\theta_1 = \mu_2 \sin\theta_2}$$

6. Absolute Refractive Index

$$\boxed{\mu = \frac{speed\ of\ light\ in\ vacuum}{speed\ of\ light\ in\ medium} = \frac{c}{v}}$$

7. Relative Refractive Indices

$$\boxed{\mu_{21} = \frac{\mu_2}{\mu_1}, \mu_{12} = \frac{\mu_1}{\mu_2}}$$

Or

$$\boxed{Refractive\ index\ of\ medium - 2\ with\ respect\ to\ medium - 1 = \frac{\mu_2}{\mu_1} = \mu_{21}}$$

And

$$Refractive\ index\ of\ medium-1\ with\ respect\ to\ medium-2=\frac{\mu_1}{\mu_2}=\mu_{12}$$

8. Relation between refractive index (μ) and speed of light (v)

$$\mu v = constant$$

Or

$$\mu_1 v_1 = \mu_2 v_2$$

9. Relation between refractive index and wavelength of light

$$\mu\lambda = constant$$

Or

$$\mu_1\lambda_1 = \mu_2\lambda_2$$

10. Relation between refractive index, real depth and apparent depth

$$Apparent\ depth = \frac{Real\ depth}{\mu}$$

Or

$$Apparent\ depth = \frac{Real\ depth}{\frac{\mu}{\mu_0}}$$

11. Lateral Displacement

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

Or

$$d = t\sin i\left[1-\frac{\cos i}{(\mu^2-sin^2 i)^{\frac{1}{2}}}\right]$$

12. Critical Angle

$$\sin i_C = \frac{\mu_R}{\mu_D}$$

Where,

μ_R = Refractive index of rarer medium and

μ_D = Refractive index of denser medium

Refraction of Light through Curved Spherical Lenses

13. When light travels from rarer medium to denser medium

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

14. When light travels from rarer medium to denser medium

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

Lens Maker Formula

15. When same medium μ_1 around a lens of refractive index (μ_2)

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

16. When air $(\mu_1 = 1)$ around a lens

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

17. One medium refractive index (μ_1) to face surface-1 of radius of curvature R_1, lens refractive index μ_2 and towards second face surface-2, refractive index μ_3, that is, light is travelling from rarer medium (μ_1) to denser medium $(lens\ \mu_2)$ and then to rarer medium (μ_3)
Then

$$\frac{\mu_3}{f} = \left(\frac{\mu_2 - \mu_1}{R_1}\right) + \left(\frac{\mu_3 - \mu_2}{R_2}\right)$$

18. Power of a lens

$$P = \frac{1}{f}$$

Combined Focal Length of Two or More Thin Lenses in Contact

19. Combined focal length of two thin lenses in contact

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

20. Combined focal length of more than two thin lenses in contact

$$\frac{1}{f} = \sum_{i=1}^{n} \frac{1}{f_i}$$

Or

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + --------$$

21. Combined Power of two thin lenses in contact

$$P = P_1 + P_2$$

22. Combined Magnification

$$\boxed{m = m_1 \times m_2}$$

Refraction of Light through a Equilateral Triangular Prism

23. Deviation angle in equilateral

$$\boxed{\delta = i + e - A}$$

24. Minimum deviation angle

$$\boxed{\delta_{min} = 2i - A = 2e - A}$$

25. Refractive index at minimum deviation angle

$$\boxed{\mu = \frac{\sin\left(\frac{A + \delta_{min}}{2}\right)}{sin\left(\frac{A}{2}\right)}}$$

Optical Instruments

Simple Microscope

26. Magnifying Power when final image is formed at least distance of distinct Vision (D)

$$\boxed{M_D = 1 + \frac{D}{f_e}}$$

27. Magnifying Power when final image is formed infinity (normal adjustment)

$$\boxed{M_\infty = \frac{D}{f_e}}$$

Compound Microscope

28. Magnifying Power when final image is formed at least distance of distinct Vision (D)

$$\boxed{M_D = -\frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)}$$

29. Tube length (distance between two lenses) in case of final image at D

$$\boxed{L_D = v_0 + |u_e|}$$

30. Magnifying Power when final image is formed infinity (normal adjustment)

$$\boxed{M_\infty = -\frac{v_0}{u_0} \times \frac{D}{f_e}}$$

31. Tube length (distance between two lenses) in case of final image at infinity

$$L_{\infty} = v_0 + f_e$$

32. Magnifying Power when final image formed at near point

$$M_{near\ point} = -\frac{L}{f_0}\left(1 + \frac{D}{f_e}\right)$$

Astronomical Refractive Telescope

33. Magnifying Power when final image formed at least distance of distinct vision

$$M_D = -\frac{f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$$

34. Magnifying Power when final image is formed at infinity

$$M_{\infty} = -\frac{f_0}{f_e}$$

35. Tube length when final image formed at least distance of distinct vision

$$L_D = f_0 + |u_e|$$

36. Tube length when final image formed at infinity

$$L_{\infty} = f_0 + f_e$$