List of formulae for Phys 2P51

- Optical path length $$S = Ln = L\frac{c}{v}$$
- Snell's Law $$n \sin I = n' \sin I'$$
- Prism Equation $$\frac{n_p}{n_0} = \frac{\sin(\frac{D_0+A}{2})}{\sin(\frac{A}{2})}$$
- Abbe's number $$V_a = \frac{n_e - 1}{n_{F'} - n_{c'}}$$
- Vergence $$V = \frac{n}{R}$$
- Power $$P = \frac{n}{f}$$
- Surface Power Equation $$P = \frac{n' - n}{R}$$
- Gauss' formula $$\frac{n'}{s'} = \frac{n}{s} + \frac{(n' - n)}{R}$$
- $$V' = V + P$$
- Lens-Makers Formula $$P_{lens} = (n_{lens} - n_0)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$
- Thin-lens equation $$\frac{1}{s} + \frac{1}{f} = \frac{1}{s'}$$
- Transverse magnification $$M_T = \frac{y'}{y} = \frac{ns'}{n's} = \frac{V}{V'}$$
- Axial magnification $$M_x = M_t^2$$
- Angular magnification $$M_\theta = \frac{\theta'}{\theta}$$
- Equivalent Focal Length $$f_{eq} = \frac{f_1 f_2}{f_1 + f_2 - d}$$
- Change-of- Vergence / Power -equations $$V_{eff} = \frac{V_0}{1 - \frac{d}{n_0}V_0}; \qquad P_{eff} = \frac{P_0}{1 - \frac{d}{n_0}P_0}$$
- Front / Back Vertex Power $$P_{FV} = P_1 + \frac{P_2}{1 - \frac{d}{n_0}P_0}, \qquad P_{BV} = \frac{P_1}{1 - \frac{d}{n_0}P_1} + P_2$$

- Input-Output matrices $$\begin{bmatrix} nu \\ h \end{bmatrix}, \begin{bmatrix} n'u' \\ h' \end{bmatrix}$$
- Refraction matrix $$R = \begin{bmatrix} 1 & P \\ 0 & 1 \end{bmatrix}$$
- Translation matrix $$T = \begin{bmatrix} 1 & 0 \\ \frac{-d}{n'} & 1 \end{bmatrix}$$
- System matrix $$S = \begin{bmatrix} b & a \\ d & c \end{bmatrix}$$
- $$f_{eq_1} = \frac{-n_0}{a}$$
- $$f_{FV} = -\frac{bn_0}{a}$$
- $$f_{eq_2} = \frac{n_f}{a}$$
- $$f_{BV} = \frac{c\ n_f}{a}$$
- Focal Length of a Spherical Mirror $$f = \frac{-R}{2}$$
- Chromatic Aberration $$\frac{P_A}{P_B} = \frac{-V_A}{V_B}$$ $$d = \frac{1}{2}(f_A + f_B)$$
- f-stop number $$f/\# = f/D$$
- Refractive Gradients $$\delta \simeq \frac{1}{n}\frac{\partial n}{\partial y}L$$ $$R \simeq \frac{n}{(\frac{\partial n}{\partial y})}$$
- Step-index fiber $$n_0 \sin I = \sqrt{n_1^2 - n_2^2}$$
- Relationship between phase- and path-difference $$\frac{\delta}{2\pi} = \frac{\Gamma}{\lambda}$$

- For $\begin{matrix} 0 \\ \pi \end{matrix}$ -phase difference, $\begin{matrix} \text{maxima} \\ \text{minima} \end{matrix}$ occur for $\Gamma = m\lambda$, and $\begin{matrix} \text{minima} \\ \text{maxima} \end{matrix}$ occur for $\Gamma = (m - \frac{1}{2})\lambda$.

- Two-slit experiment $$\Gamma = d \sin\theta$$
- Michelson Interferometer $$\Gamma = 2d\cos\theta$$
- Thin-film Interference $$\Gamma = 2nd\cos\theta_t$$
- Newton's Rings $$R = \frac{nr^2}{\Gamma}$$
- Fabry-Perot Interferometer $$\frac{\lambda}{\Delta\lambda} = \frac{m\theta}{2\Delta\theta}, \quad \delta\lambda = \frac{\lambda_{avg}^2}{2d}$$
- Reflectance $$R = \left(\frac{n_2 - n_1}{n_2 + n_1}\right)^2$$
- Anti-reflection coatings $$n_{coating}d = \frac{\lambda}{4}; \quad n_1 = \sqrt{n_G}; \quad \frac{n_1^2 n_3}{n_2^2} = n_0$$

- Spatial coherence width $$d_{max} = \frac{r\lambda}{2s};\ \ d_{max} = \frac{r\lambda}{s};\ \ d_{max} \approx \frac{1.22\lambda}{\theta}$$
- Coherence length $$\Delta s = N\lambda$$
- Coherence time $$\Delta t = \frac{\Delta s}{c}$$
- Natural linewidth $$\Delta\lambda \approx \frac{\lambda^2}{\Delta s}$$
- Degree of coherence $$C = \frac{I_{max} - I_{min}}{I_{max} + I_{min}} \times 100\%$$
- Fraunhofer diffraction $$\underline{\text{Single slit}} : I = I_o \text{sinc}^2\beta \text{ where } \beta = \frac{1}{2}kb\sin\theta$$

$$\underline{\text{Multiple slits}} : I_{\theta_{int}} = \frac{I_o \sin^2(N\alpha)}{\sin^2\alpha} \text{ where } \alpha = \frac{\pi}{\lambda}d\sin\theta$$

$$\underline{\text{Circular aperature}} : I = I_{\theta=0}\left[\frac{2J_1(\gamma)}{\gamma}\right]^2 \text{ where } \gamma = \frac{1}{2}kD\sin\theta$$

$$J_1(\gamma) \text{ is the first} - \text{order Bessel function of the first kind}$$

$$\text{diffraction maxima/minima occur at } \gamma = 0, 3.8317, 5.1365, 7.0156, 8.4163...$$

- Diffraction grating $$d\sin\theta = m\lambda;\ \ \frac{\lambda}{\Delta\lambda} = Nm$$
- Fresnel diffraction $$\underline{\text{Linear obstacle or slit}} : I = I_o\Big[X^2(v) + Y^2(v)\Big]$$

$$\text{where } X(v_o) = \int_0^{v_o} \cos\left(\frac{\pi}{2}v^2\right)dv,\ \ Y(v_o) = \int_0^{v_o} \sin\left(\frac{\pi}{2}v^2\right)dv,$$

$$\text{and } v = z\sqrt{\frac{2}{L\lambda}};\ \ \frac{1}{L} = \frac{1}{p} + \frac{1}{q}$$

$$\underline{\text{Circular aperature}} : R_N = R_1\sqrt{N} = \sqrt{N\lambda b}$$

$$f_M = \frac{R_1^2}{(2M-1)\lambda},\ \ d_{min} = \frac{1.22R_N}{2N(2M-1)},\ \ M = 1, 2, 3...$$

- Brewster's law $$\theta_B = \tan^{-1}\left(\frac{n_1}{n_o}\right)$$
- Birefringence $$\Gamma = L(n_\perp - n_\parallel)$$