# Final exam equation sheet

**Dispersion** $V \equiv \frac{n_D - 1}{n_F - n_C}$ $\frac{\theta_F - \theta_C}{\theta_D} = \frac{1}{V}$ $\frac{\Phi_F - \Phi_C}{\Phi_D} = \frac{1}{V}$

$$\frac{1}{t'_F} - \frac{1}{t'_C} = \Phi_F - \Phi_C = \frac{\Phi_D}{V}$$

**Doublets** $\Phi_{D1} = -\frac{V_1}{V_2}\Phi_{D2} = \frac{V_1}{V_1 - V_2}\Phi_{D,Doublet}$

$$\Phi_{F,Doublet} - \Phi_{C,Doublet} = \frac{\Phi_{D,1}}{V_1} + \frac{\Phi_{D,2}}{V_2}$$

**Aberration free imaging** $\frac{n \sin\alpha}{n' \sin\alpha'} = M$ $\frac{\tan\bar{\alpha}'}{\tan\bar{\alpha}} = M\frac{t}{t'}$

**Ray aberration polynomial** $\delta y = -\frac{R}{n'}\frac{\partial W(x_p, y_p)}{\partial y_p}$ $\partial z = -R\frac{\partial y}{y_p}$

| | | |
|---|---|---|
| $x = A_1 \sin\theta$ | $y = A_1 \cos\theta + A_2 h$ | Defocus & magnification |
| $+B_1 r^3 \sin\theta$ | $+B_1 r^3 \cos\theta$ | Spherical |
| $+B_2 r^2 h \sin 2\theta$ | $+B_2 r^2 h\,(2 + \cos 2\theta)$ | Coma |
| $+(B_3 + B_4)\, r\, h^2 \sin\theta$ | $+(3B_3 + B_4)\, r\, h^2 \cos\theta$ | Astigmatism & Petzval |
| | $+B_5 h^3$ | Distortion |

**GRIN lenses** $n(\rho) = n_0\left[1 - \Delta\left(\frac{\rho}{a}\right)^2\right]$ $z_l = \frac{2\pi}{\kappa}P$ $\kappa = \frac{\sqrt{\Delta}}{a}$

$\rho(z) = \rho_0 \cos(\kappa z) + \frac{\rho'_0}{\kappa}\sin(\kappa z)$ $f = \frac{1}{n_0 \kappa \sin\kappa z_l}$ $NA = \sqrt{n_0^2 - n^2(a)} \approx n_0\sqrt{2\,\Delta}$

**Grating equation** $\sin\theta_m = \sin\theta_{inc} + m\frac{\lambda}{\Lambda}$ $R \equiv \frac{\lambda_0}{\delta\lambda} = m\frac{L}{\Lambda}$

**Fresnel lenses** $\Delta r = \frac{f\, m\, \lambda_0}{r\, M}$ $f' = f\,\frac{m\,\lambda}{m'\,\lambda'}$