FORMULA SHEET

$$\tfrac{1}{2}\dot{r}^2 + \frac{h^2}{2r^2} - \frac{GM}{r} = E, \quad r_+ + r_- = 2a, \quad \frac{a^2 - b^2}{a^2} = e^2,$$

$$r_+ = a(1+e), \quad E = \frac{-GM}{2a}, \quad h^2 = GMa(1-e^2),$$

$$h = v_\theta r, \quad v_{circ} = \left(\frac{GM}{r}\right)^{1/2}, \quad v^2 = GM\left(\frac{2}{r} - \frac{1}{a}\right),$$

$$\frac{v_c^2}{r} = \frac{GM_{sun}}{r^2}, \quad \frac{1}{P} = \frac{1}{P_{Earth}} \pm \frac{1}{S}.$$

$$P^2 = \left(\frac{4\pi^2}{G(m_1 + m_2)}\right) a^3, \quad F_{tidal} = -2\left(\frac{GM_{moon}}{d^2}\right)\left(\frac{\Delta R}{d}\right)\cos(\phi).$$

$$F = \sigma T^4, \quad \lambda_{\max} = \frac{0.29\ cm\,K}{T}$$

$$B_\nu(T) = \frac{2h\nu^3}{c^2}\frac{1}{e^{h\nu/(kT)} - 1}, \quad \frac{L}{L_{sun}} = \frac{Area}{4\pi R_{sun}^2}\left(\frac{T}{T_{sun}}\right)^4$$

$$L_{in} = (1 - A_b)\frac{L_{sun}}{4\pi r^2}\pi R^2, \quad L_{out} = 4\pi R^2 \varepsilon\sigma T^4, \quad T_{eq} = \left(\frac{F_{sun}}{r_{AU}^2}\frac{(1 - A_b)}{4\varepsilon\sigma}\right)^{1/4}$$

Note: in the last formula F_{sun} is the solar constant 1360 W/m^2, and r_{AU} is the distance in AU.

$$H(z) = \frac{kT(z)}{g(z)\mu_a(z)m_{amu}} \quad \rho = \frac{M}{\frac{4\pi}{3}R^3} \quad \frac{dM(r)}{dr} = 4\pi r^2 \rho$$

$$g = \frac{GM(r)}{r^2} = \frac{-1}{\rho}\frac{\partial P}{\partial r}$$

$$\rho g h = P, \quad h = 6.2km\left(\frac{P}{3000atm}\right)\left(\frac{9.8m/s}{g}\right)\left(\frac{5.0g/cm^3}{\rho}\right) \quad P_{ram} = \rho v^2$$

$$v_{rms} = \sqrt{\frac{3kT}{m}}, \quad Y = \frac{GM}{kT_x R} \approx \frac{3v_{esc}^2}{2v_{rms}^2}, \quad \tau_{esc} = \frac{\sqrt{6\pi}}{3}\frac{v_{rms}}{g}\frac{e^Y}{Y}$$

$$\Delta\tau_\nu = n\sigma_\nu \Delta l, \quad \tau_\nu = \int_{path} n(x)\sigma_\nu dx, \quad \cos(\theta)\frac{dI_\nu}{d\tau_\nu} = I_\nu$$

$$I_\nu(\tau_\nu) = I_\nu^0 \exp\left(\frac{-\tau_\nu}{\cos(\theta)}\right)$$

$$R_{crit} = 13.7pc\left(\frac{T}{10K}\right)^{1/2}\left(\frac{n}{1cm^{-3}}\right)^{-1/2}\mu^{-1}, \qquad M_{crit} = 250M_{sun}\left(\frac{T}{10K}\right)^{3/2}\left(\frac{n}{1cm^{-3}}\right)^{-1/2}\mu^{-2}.$$