Some Useful Formulas

Basic Data

1 km = 10^3 m 1 mm = 10^{-3} m 1 nm = 10^{-9} m 1 AU = 1.5×10^{11} m 1 ly = 9.5×10^{15} m 1 pc = 3.26 ly

Earth's radius = 6.4×10^3 km Moon's radius = 1.7×10^3 km Sun's radius = 7.0×10^5 km

Geometry

- circumference of circle = $2\,\pi\,r$
- area of circle = πr^2
- surface area of sphere = $4\pi r^2$
- volume of sphere = $\frac{4}{3}\,\pi\,r^3$

Distance Relationships

- distance—velocity—time: $d = V \times t$
- linear size—angular size: $L = d \times A / 57.3°$
- distance from parallax: *d(in parsecs) = 1 / p(in arcsec)*
- Hubble law: $V = H_0 \times d$

Gravity

- Kepler's 3rd Law—orbits around Sun with semi-major axis a (in AU) and period P (in years): $P^2 = a^3$
- gravitational force between masses M and m: $F_G = G\dfrac{M \times m}{d^2}$
- Newton's modified form of Kepler's 3rd Law for the total mass of two orbiting bodies: $M = \dfrac{4\pi^2}{G} \times \dfrac{d^3}{P^2}$
- mass of object producing orbital speed V at distance d: $M = \dfrac{d \times V^2}{G}$
- escape velocity from a mass M at radius R: $V_{esc} = \sqrt{\dfrac{2GM}{R}}$

Light

- speed of light: $c \approx 300{,}000$ km/sec
- frequency (ν) - wavelength (λ) relation: $\lambda \times \nu = c$
- energy of a photon: $E = h \times \nu = \dfrac{h \times c}{\lambda}$
- Stefan-Boltzmann Law—luminosity L of thermal source at temperature T: $L = \sigma\, T^4 \times$ (surface area)
- Wien's Law—temperature of thermal source from wavelength of maximum emission: $T = \dfrac{2.9 \times 10^6\ \text{nm} \cdot \text{K}}{\lambda_{\max}}$
- brightness B − luminosity L relation: $B = \dfrac{L}{4\pi d^2}$
- Doppler Effect: radial velocity = $V_R = c \times \dfrac{\Delta\lambda}{\lambda}$

Other Physical Relationships

- density = $\dfrac{\text{mass}}{\text{volume}}$
- Newton's 2nd Law—acceleration a produced by force F on mass m: $a = F / m$
- kinetic energy = ½ $m\,V^2$
- conservation of angular momentum: (mass) × (circular velocity) × (radius) = constant
- Lorentz factor for special relativistic contraction at speed V: $\gamma = \dfrac{1}{\sqrt{1 - V^2 / c^2}}$
- light variability size limit: (size) < $c \times \Delta t$