MAIN ASTRO 103 EQUATIONS TO DATE

Equations of Motion:

Kepler's Third Law states that the period P of orbit and semi-major axis a follow this equation:

$$\frac{P^2}{a^3} = Constant \tag{1}$$

Where $\frac{p^2}{a^3}$ is equal to the same number for all of the planets going around the same star, or for all of the satellites going around the same planet, etc.

Newton then showed how Kepler's Third Law Works:

$$\frac{a^3}{p^2} = \frac{Gm}{4\pi^2} \tag{2}$$

Simplifying Newton's Take on Kepler's Third Law:

$$\frac{a^3}{p^2} \propto Mass\,of\,Central\,Object \tag{3}$$

Finally, Newton's Second Law:

$$F = m \times a \tag{4}$$

Where force F is equal to the mass of an object times its acceleration.

Light:

The speed of light ($c = 3 \times 10^8 ms^{-1}$) is equal to the frequency f and wavelength λ by:

$$c = \lambda \times f \tag{5}$$

The longer the wavelength, the smaller the frequency. The shorter the wavelength, the higher the frequency.

Light can be thought of as particles, or photons; where the smallest amount of energy E each photon carries is:

$$E = h \times f \tag{6}$$

Where f is the frequency, and h is Planck's Constant.

Telescopes:

The theoretical best possible angle you can see with a telescope Θ is related to the wavelength of light and the diameter D of the primary mirror of the telescope by:

$$\Theta = 60^\circ \times \frac{\lambda}{D} \tag{7}$$

Stars:

Luminosity L of a star is related to its apparent brightness (or flux) f and distance d by:

$$L = 4\pi \times d^2 \times f \tag{8}$$

Blackbodies emit a peak wavelength λ_{max} that is directly related to their temperatures (measured in Kelvin's), called Wien's Law:

$$\lambda_{max} = \frac{3mm}{T} \tag{9}$$

The Stefan-Boltzmann Law gives the light per meter squared F that a blackbody radiates, at its surface, which is directly related to its temperature (measured in Kelvin's).

$$F = 6 \times 10^{-8} \times T^4 \, light/m^2 \tag{10}$$

AKA: The hotter you are, the more light you give off per meter squared.

From the Stefan-Boltzmann Law, you can relate the luminosity of a star to its radius R:

$$L = 4\pi \times R^2 \times F \tag{11}$$

By substituting $F = 6 \times 10^{-8} \times T^4 \, light/m^2$ into this equation, you get a relation between the star's luminosity, radius and temperature:

$$L = 4\pi R^2 \times (6 \times 10^{-8} \times T^4) \tag{12}$$

Or, simplified:

$$L = Const. \times R^2 \times T^4 \tag{13}$$

A useful way to use this equation, is to relate another star to our sun:

$$\frac{L_{star}}{L_{sun}} = \left(\frac{R_{star}}{R_{sun}}\right)^2 \left(\frac{T_{star}}{T_{sun}}\right)^4 \tag{14}$$

Distance D and parallax P are inversely related:

$$D\,(pc) = \frac{1}{P\,(arcsec)} \tag{15}$$

The lifetime LT of a star is related to its mass M by:

$$LT \propto \frac{1}{M^3} \tag{16}$$

Where the luminosity L of a star is also related to its mass M:

$$L \propto M^4 \tag{17}$$

Binary Systems:

The masses of the two objects in a binary system can be calculated using Kepler's Law. The simplified version below specifies that the mass has to be in solar masses, the period in years, and the distance in AU to work properly:

$$\frac{p(years)^2}{a(AU)^3} = \frac{1}{M_1 + M_2\,M_{sun}} \tag{18}$$

Doppler Shift:

When a source is in motion with respect to your point of view, the light that you receive can be red shifted or blue shifted, depending on if the source is moving away from you, or towards you, respectively. The velocity of that source is directly related to the shifted wavelength of light, given by the Doppler Formula:

$$\frac{v}{c} = \frac{\Delta\lambda}{\lambda_o} \tag{19}$$

Where v is the velocity of the object toward or away from you, c is the speed of light, λ_o is the original wavelength of the source, and $\Delta\lambda = \lambda_{shifted} - \lambda_o$.