Useful Constants and Formulae from Astro 120

Physical Constants

Quantity	Symbol	Value
Speed of light in a vacuum	c	2.997925×10^{8}m/s 2.997925×10^{10}cm/s
Planck's Constant	h	6.6261×10^{-34}J s 6.6261×10^{-27}erg s
Boltzmann's Constant	k	1.3807×10^{-23}J/K 1.3807×10^{-16}erg/K
Gravitational Constant	G	6.67×10^{-11}m^3/(kg s^2) 6.67×10^{-8} cm^3/(g s^2)
Proton rest mass	m_p	1.6726×10^{-27} kg 1.6726×10^{-24}g
Neutron rest mass	m_n	1.6748×10^{-27} kg 1.6748×10^{-24}g
Electron rest mass	m_e	9.1091×10^{-31} kg 9.1091×10^{-28}g
Stefan-Boltzmann Constant	σ	5.6693×10^{-5} erg/(cm^2 s K^4) 5.6693×10^{-1} erg/(m^2 s K^4) 5.6693×10^{-8} J/(m^2 s K^4)
Wien's Law Constant	$\lambda_{max}T$	0.290 cm K

Astronomical Constants

Quantity	Symbol	Value
Solar mass	$M_\odot$	1.989×10^{30} kg 1.989×10^{33} g
Solar radius	$R_\odot$	6.96×10^{8} m 6.96×10^{10} cm
Solar luminosity	$L_\odot$	3.90×10^{26} Watts 3.90×10^{33} erg/sec
Solar temperature	$T_\odot$	5785 K
Earth mass	$M_\oplus$	5.974×10^{24} kg 5.974×10^{27} g
Lunar mass	M_{moon}	7.348×10^{22} kg 7.348×10^{25} g
Earth's orbital radius (actually semi-major axis)	A.U.	1.496×10^{11} m 1.496×10^{13} cm 1 Astronomical Unit

Angular Size (small angle approximation):

$$\theta = d/D$$

The angle θ should be expressed in radians. In this equation d stands for diameter and D for distance.

Newton's Second Law:

$$F = ma$$

Where F is the force, m is the mass and a is the acceleration.

Newton's Gravitation Law:

$$F = \frac{GMm}{R^2},$$

where F is the gravitational force, G is the universal constant of gravitation, M and m are the masses of the two objects under consideration and R is the distance between these two objects.

Kepler's Third Law (very good approximation):

$$(M + m)P^2 = R^3,$$

where the masses are expressed in solar masses, the period in years, and the distance in astronomical units. In other units some constant factors will have to be inserted.

Kepler's Third Law (exact expression):

$$0.999997(M + m) \times P^2 = R^3,$$

again, the masses should be expressed in solar masses, the period in years, and the distance in astronomical units.

Relation between wavelength and frequency:

$$\lambda = c/\nu,$$

where λ is the wavelength, c is the speed of light and ν is the frequency.

Relation between energy and frequency:

$$E = h\nu$$

where h is Plank's constant.

Wien's Law:

$$\lambda_{max}T = 0.29\text{cm K},$$

where λ_{max} is the wavelength at which the maximum in the black body spectrum appears and T is the temperature that characterizes that black body.

Stefan-Boltzmann Law:

$$F = \sigma T^4$$

where F is the flux, T is the temperature, and σ is the Stefan-Boltzman constant.

Luminosity:

$$L = F \times A$$

where L is the luminosity, F is the flux, and A is the area.

Luminosity of a spherical blackbody:

$$L = 4\pi R^2 \sigma T^4$$

Lifetime of a star:

$$t = \text{(energy available)/(rate of energy consumption)} = E/L$$

Parallax:

$$d = 1/p$$

where p is the parallax angle in arc-seconds and d is the distance in pc.

Inverse Square Law:

$$B = \frac{L}{4\pi d^2},$$

where B is the brightness observed, L is the intrinsic luminosity of the object, and d is the object's distance.

Doppler shift:

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c},$$

where $\Delta\lambda$ is the wavelength shift, λ_0 is the rest wavelength, v is the velocity measured along the line of sight, and c is the speed of light.

Rotational velocity:

$$v_{rot}^2 = MG/r$$

where M is the mass inside a radius r.

Escape velocity:

$$v_{esc}^2 = 2GM/r$$

Density:

$$\text{Density} = \text{Mass/Volume} = M/V$$

Volume of a sphere:

$$V = 4/3\pi r^3$$

Schwarzschild radius:

$$R_{Sch} = 2GM/c^2$$

or,

$$R_{Sch} \approx 3M$$

where M is in solar masses and R_{Sch} in km.

Hubble's Law:

$$v = H_0 r$$

Redshift (z):

$$z = v/c$$

Age of the Universe (t_0):

$$t_0 = f/H_0$$

where $f = 0$ if $\Omega \to \infty$; $f = 2/3$ if $\Omega = 1$; $f = 1$ if $\Omega \to 0$.

Density parameter (Ω):

$$\Omega = \frac{\rho_0}{\rho_{crit}}$$

Critical density (ρ_{crit}):

$$\rho_{crit} = \frac{3H_0^2}{8\pi G}$$

Cosmological time:

$$1 + z = (t_0/t_e)^{2/3}$$

where t_e is the age of the universe when light was emitted.