UBC ASTR 102 Formula Sheet

Formulae

$D = \frac{ad}{206{,}265}$
d = distance, D = diameter, a = angular size (arcseconds)
$c = \lambda\nu$
λ = wavelegth, ν = frequency
$F = \sigma T^4$
F = energy flux (power per unit surface area),
T = temperature
λ_{max} (in nm) = (3.0×10^6 K nm) / T (in K)
$E = h\nu = \frac{hc}{\lambda}$
E = energy
$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{m^2}\right)$
n = final state, m = initial state
$\frac{\Delta\lambda}{\lambda_0} = \frac{\lambda - \lambda_0}{\lambda_0} = \frac{v_r}{c}$
λ_0 = original wavelength, v_r = radial velocity
negative v_r = source is approaching
$F = ma$
F = force (N), m = mass (kg), a = acceleration (ms^{-2})
$F = \frac{Gm_1m_2}{r^2}$
r = distance between m_1 and m_2
$E_k = \frac{1}{2}mv^2$
E_k = kinetic energy
$E_p = mgh$
E_p = potential energy
$U = -\frac{GMm}{r}$
U = gravitational potential energy for object in orbit
$v_{esc} = \sqrt{\frac{2GM}{r}}$
v_{esc} = escape velocity, M = larger mass
$L = 4\pi\sigma T^4 R^2$
L = Luminosity (Watts), R = radius
$E = mc^2$
d (parsecs) $= \frac{1}{p}$ (arcseconds)
d = distance, p = parallax angle
$v_t = 4.74\mu d$
v_t = transverse (tangential) velocity (kms^{-1}),
μ = proper motion (arcsec/year), d = distance (parsec)
$v = \sqrt{v_t^2 + v_r^2}$
$b = \frac{L}{4\pi d^2}$
b = apparent brightness (Wm^{-2})
$\frac{L_1}{L_2} = \left(\frac{d_1}{d_2}\right)^2 = \frac{b_1}{b_2}$
$\frac{b_1}{b_2}$ (ratio of brightness of stars) $= (2.512)^{\Delta m}$
Δm = difference in apparent magnitude of stars
$m_2 - m_1 = 2.5\log_{10}\left(\frac{b_1}{b_2}\right)$
m_1, m_2 = apparent magnitudes, b_1, b_2 = brightness
$m - M = 5\log d - 5$
m = apparent magnitude, M = absolute magnitude
d = distance in parsecs.
$\frac{b_V}{b_B}, \frac{b_B}{b_U}$ = color ratios (lower is hotter)
$M_1 + M_2 = \frac{a^3}{P^2}$ (Kepler's 3^{rd} law for binary stars)
a = orbital separation (in AU), P = orbital period (in years)
$\frac{M_1}{M_2} = \frac{a_2}{a_1}$
$\frac{L}{L_\odot} \simeq \left(\frac{M}{M_\odot}\right)^{3.5}$
$\tau_{MS} \simeq \left(\frac{M}{M_\odot}\right)\left(\frac{L_\odot}{L}\right)$ Gyr
τ_{MS} = main sequence lifetime, Gyr = Giga year
$E = fMc^2$
Energy derived from $H->He$ conversion
$f = 7 \times 10^{-4}$
$L = \frac{E}{t}$
L is Luminosity, t is time
$Lt = fMc^2$
$t = \frac{fMc^2}{L} \propto \frac{M}{L} \propto \frac{M}{M^{3.5}} \propto M^{-2.5}$

Constants

c (speed of light)	3×10^8 ms^{-1}
σ (Stefan-Boltzmann constant)	5.67×10^{-8} $\mathrm{Wm}^{-2}\mathrm{K}^{-4}$
h (Planck's constant)	6.626×10^{-34} Js
R (Rydberg constant)	1.097×10^7 m^{-1}
G (Newton's constant)	6.67×10^{-11} $\mathrm{Nm}^2\mathrm{kg}^{-2}$
g (gravity)	9.8 ms^{-2}

Conversions

`1 degree`	60 arcminutes
`1 arcminute`	60 arcseconds
`1 lightyear`	9.46×10^{12} km
`1 AU`	1.5×10^{11} m
`1 parsec`	3.26 lightyears
`1 m`	10^9 nm
`1 Gyr`	10^9 years

Chemical Processes

proton proton chain
triple alpha process

Diagrams

Blackbody spectrum
Cumulative Luminosity
Temperature and Density from the core
HR diagram

Miscellaneous 1

- absolute magnitude: apparent magnitude a star would have if it were located exactly 10 parsecs from Earth
- 10% of the mass of the star will be converted from H to He while it is on the main sequence.
- emission nebulae glow because UV knocking off electrons, which then recombine, and release photons in the visible spectrum.
- dark nebulae is caused due to dust, required for star formation, don't block infrared.
- reflection nebula contain fine grains of dust, they scatter short wavelength blue light efficiently, causing a reddening effect on stars.
- Protostars are initial stars formed in dark nebulae.
- Larger protostars take a shorter amount of time to reach the main sequence.
- planet $< 0.012M_\odot <$ brown dwarf $< 0.08M_\odot <$ main sequence stars $< 200M_\odot$
- high mass stars burn through their fuel first
- open clusters - held together by gravitational forces
- stellar association - fast moving cluster, mostly O, B stars (OB association)
- globular clusters - large, old clusters
- CO helps predict star formation
- A red dwarf is a main-sequence star with less than about 0.4 solar masses. Helium star.
- End of H fusion: core starts to cool, pressure in the core starts to decrease, the core compresses/shrinks, the temperature to increase again, and outer layers will expand.
- In red giants with a mass less than about 2 to 3 $M\odot$ but still more than 0.4 $M\odot$, helium fusion begins explosively and suddenly, in what is called the helium flash.
- If the core is contracting (no fusion): Core temperature goes up, Heat transfers to the outer layers, The outer layers expand, (Low mass: Luminosity increases)
- If the core is expanding (fusion): Core temperature goes down, Less heat to the outer layers, The outer layers shrink (Low mass: Luminosity decreases)

Miscellaneous 2

`violet light`	400 nm
`red light`	700 nm
`blue shift`	approaching (short λ)
`red shift`	receding (longer λ)
$L_\odot$	Luminosity of the sun
$M_\odot$	Mass of the sun
`layers of sun`	Thermonuclear $->$ radiative $->$ convection
$m - M$	Distance modulus (apparent - absolute)
OBAFGKM	current ordering of stars (hot to cold)
L, T, Y	brown dwarf spectral classes