PHY392
USEFUL CONSTANTS AND FORMULAS

Constants

Gravitational constant	G	6.67 x 10^{-11} N m^2 kg^{-2}
Universal gas constant	R^*	8.3143 J K^{-1} $mole^{-1}$
Speed of light in vacuum	c	2.998 x 10^8 m s^{-1}
Planck's constant	h	6.626 x 10^{-34} J s
Boltzmann's constant	k	1.381 x 10^{-23} J K^{-1}
Avogadro's number	N_A	6.02 x 10^{23} particles/mole
Stefan-Boltzmann constant	σ	5.67 x 10^{-8} W m^{-2} K^{-4}
First radiation constant	c_1	1.191×10^{-16} W m^2 sr^{-1}
Second radiation constant	c_2	1.439×10^{-2} m K

Planetary and Sun

Mean surface pressure on Earth	p_s	1.013×10^5 Pa = 1013 mbar
Mean surface temperature on Earth	T_s	288 K
Earth's emission temperature	T_e	255 K
Mean surface density on Earth	ρ_s	1.235 kg m^{-3}
Earth's rotation rate	Ω	7.27 x 10^{-5} s^{-1}
Earth's mean radius	a	6.38 x 10^6 m
Mean Earth-Sun distance	d_{Earth}	1.5 x 10^{11} m
Solar constant	L_0	1367 W m^{-2}
Mean Earth albedo	A_p	0.30

Properties of Dry Air

Standard pressure	p_o	1013.25 hPa
Standard temperature	T_o	273.15 K
Specific heat at constant pressure	c_p	1005 J kg^{-1} K^{-1}
Specific heat at constant volume	c_v	718 J kg^{-1} K^{-1}
Air density at 273 K, 1013 hPa	ρ_0	1.293 kg m^{-3}
Gas constant for dry air	R or R_d	287 J kg^{-1} K^{-1}
Gas constant for water vapour	R_v	461.39 J kg^{-1} K^{-1}
Mean molecular weight of dry air	M_a	28.97 g/mole

PHY392
POSSIBLY USEFUL EQUATIONS

$p = \rho RT = n_0 kT$ $\quad$ $pV = NkT$ $\quad$ $R = \dfrac{R^*}{M_a}$

volumetric mixing ratio $(VMR_i) = \dfrac{N_i}{\sum_i N_i} = \dfrac{n_i}{\sum_i n_i} = \dfrac{p_i}{\sum_i p_i}$

mass mixing ratio $(MMR_i) = \dfrac{m_i}{\sum_i m_i} = \dfrac{\rho_i}{\sum_i \rho_i} = \left(\dfrac{M_i}{\bar{M}}\right) VMR_i$

Relative humidity for gas A $= \dfrac{p_A}{p_{sat,A}} \times 100\%$ $\quad$ $H = \dfrac{R^* T}{M_a g} = \dfrac{RT}{g}$

For water $p_{sat}(T) = Ae^{\beta T}$ where $A = 6.11$ hPa and $\beta = 0.067°\text{C}^{-1}$

$\dfrac{dP}{dz} = -\rho g$ $\quad$ $p(z) = p_0\ e^{-\frac{z}{H}}$ $\quad$ $\rho(z) = \rho_0\ e^{-\frac{z}{H}}$

$\theta = T\left(\dfrac{p_o}{p}\right)^{R/c_p}$ $\quad$ $c_p = c_v + R$ $\quad$ $\Gamma_d = \dfrac{g}{c_p}$

$\dfrac{d\ln T}{d\ln P} = \dfrac{R}{c_p}$ $\quad$ $dS = c_p d\ln\theta$ $\quad$ $T(p) = \dfrac{T_0}{1 - \frac{RT_0}{L}\ln\left(\frac{p}{p_{sat}(T_0)}\right)}$

$d\Omega = d\left(\dfrac{A}{r^2}\right) = \sin\theta\ d\theta\ d\varphi$ $\quad$ $\lambda_{\max} = \dfrac{2897.9}{\text{T}}$ $\quad$ $F_\lambda = \pi B_\lambda$

$B_\lambda(T) = \dfrac{2hc^2\lambda^{-5}}{\exp\left(\dfrac{hc}{\lambda kT}\right) - 1} = \dfrac{c_1\lambda^{-5}}{\exp\left(\dfrac{c_2}{\lambda T}\right) - 1}$ $\quad$ $B_\nu(T) = \dfrac{2h\nu^3 c^{-2}}{\exp\left(\dfrac{h\nu}{kT}\right) - 1}$

$T_s = (N+1)^{1/4} T_e$ $\quad$ $T_s = \left(\dfrac{2}{2-\varepsilon}\right)^{1/4} T_e$ $\quad$ $T_a = \left(\dfrac{1}{2-\varepsilon}\right)^{1/4} T_e$

$T_e = \left[\dfrac{L_0(1-A_p)}{4\sigma}\right]^{1/4}$ $\quad$ $\Delta T_s = \lambda \Delta F$ $\quad$ $F = \sigma T^4$

$\dfrac{1}{\alpha_\nu}\dfrac{dI_\nu}{ds} = -I_\nu + B_\nu(T)$ $\quad$ $\alpha_\nu = \rho k_\nu$ $\quad$ $\tau_\nu(s_2, s_1) = \int_{s_1}^{s_2} \rho k_\nu\, ds$

$T_\nu(s_2, s_1) = \exp\left(-\int_{s_1}^{s_2} \rho k_\nu\, ds\right)$ $\quad$ $ds = \dfrac{dz}{\cos\theta}$ $\quad$ $W_\nu(z) = \dfrac{dT_\nu(z)}{dz}$

$I_\nu(s) = I_\nu(0)e^{-\tau_\nu(s,0)} + \int_0^s B(T)e^{-\tau(s,s')}\, ds'$ $\quad$ $\tau_\nu(z) = \int_z^\infty \rho k_\nu\, dz'$

$I_\nu(s) = I_\nu(0)e^{-\tau_\nu(s,0)} = I_\nu(0)\exp\left(-\int_0^s \rho k_\nu\, ds'\right) = I_\nu(0)T_\nu(s,0)$