Arithmetic

$\pi = \sqrt{10} \sim 3$; $\sqrt{2} \sim 1.4$; $1/\sqrt{2} \sim 0.7$
$\ln 2 \sim 0.7$; $\ln 10 \sim 2.3$; $\log_{10} 2 \sim 0.3$
1 radian = $180/\pi \sim 60$ degrees
$\delta f \equiv f(x + \delta x) - f(x) \sim (df/dx)\,\delta x$ if δx is small (Taylor expansion)
For $x << 1$: $(1+x)^n \sim 1 + nx$; $e^x \sim 1 + x$; $\sin x \sim x$; $\cos x \sim 1$; $\ln(1+x) \sim x$

Metric Prefixes

Prefix	Symbol	Exp	Prefix	Symbol	Exp
yotta	Y	10^{24}	deci	d	10^{-1}
zetta	Z	10^{21}	centi	c	10^{-2}
exa	E	10^{18}	milli	m	10^{-3}
peta	P	10^{15}	micro	μ	10^{-6}
tera	T	10^{12}	nano	n	10^{-9}
giga	G	10^{9}	pico	p	10^{-12}
mega	M	10^{6}	femto	f	10^{-15}
kilo	k	10^{3}	atto	a	10^{-18}
hecto	h	10^{2}	zepto	z	10^{-21}
deca	da	10^{1}	yocto	y	10^{-24}

Unit Conversions

Length:	1 cm ~ 0.4 in; 30 cm ~ 1 ft; 1 m ~ 1.1 yd ~ 3.3 ft ; 1 km = 10^3 m ~ 0.6 mile
Area:	1 ha = 1 hm^2= 10^{-2} km^2 ~ 2.5 acre
Volume:	1 liter = 1 dm^3 = 10^{-3} m^3 ~ 0.25 gallon
Mass:	1 kg ~ 2.2 lb ; 1 ton = 10^3 kg = 1 Mg ~ 2,200 lb
Temperature	$T_K = T_C + 273.15$; $T_F = (9/5)*T_C + 32 \sim 2T_C + 30$ (in human range)
Pressure:	1 Pa = 1 N/m^2
Energy:	1 cal = 4.18 J (Joule constant); 1 Cal = 10^3 cal
Speed:	60 mph = 88 ft/s ~ 27 m/s

Physical

Ideal gas

$P = nRT$; Gas constant (R) = 8.3 $m^3 \cdot Pa \cdot K^{-1} \cdot mol^{-1}$
1 mol = Avogadro's number = 6.02×10^{23}
Specific heat (C_v) = 12.5 J/mol-K; $C_p/C_v = 5/3$

Standard temperature and pressure (STP)

P = 10^2 kPa ~ 1 atm; T = 273.15 K; molar volume = 22.4 liter
Loschmidt's constant (L) = 2.7×10^{19} cm^{-3} = number density at STP

$$\left(\frac{P}{1\ atm}\right) = \left(\frac{n}{L}\right)\left(\frac{T}{273\ K}\right)$$

BB radiation

$\lambda T = 0.0029$ m-K ; "Shortwave" ~ 1 μm ; "Longwave" ~ 10 μm
Power/Area = $\varepsilon\sigma T^4$; $\varepsilon \sim 1$; $\sigma = 5.67 \times 10^{-8}$ $W/m^2\text{-}K^4$
~ 315 W/m^2 at 273 K

Sun

Radius = 7×10^5 km; Mass = 2×10^{30} kg
Spectral peak ~0.5 μm; Surface temperature = 5,778 K; Solar constant = 1.362 kW/m^2

Earth

Geometrical

Mass: $M_\oplus = 5.97 \times 10^{24}$ kg
Radius: $R_\oplus$ = 6,371 km (equator = 6,378 km; polar = 6,357 km)
Circumference = 40,074 km (at equator)
1° latitude = 111 km = 1° longitude (at equator)
Area = 5.10×10^8 km^2
Land fraction: 0.30 global; 0.39 in NH; 0.19 in SH
"Zonal" – along a parallel of latitude; "Meridional" – along a line of longitude

Orbital

Mean distance from sun: $D_0 = 1.496 \times 10^8$ km
Eccentricity (e) = 0.0167;
In January, $D = (1 - e)\, D_0$; In July, $D = (1 + e)\, D_0$
Orbital period = 1 year = 365.24 days ~ 3×10^7 s

Rotational

Inclination = 23.5 degrees
Rotational period = 1 day = 24 hrs = 86,400 s
Rotational speed at equator = 0.46 km/s

Physical

Surface gravity: $g = 9.8$ m/s^2
Short Wave Albedo ~ 0.3
BB temperature = 255 K

ATMOSPHERE

Composition (ppmv)

Nitrogen N_2	780,840	Neon Ne	18.18
Oxygen O_2	209,460	Helium He	5.24
Argon Ar	9,340	Methane CH_4	1.79
Carbon Dioxide CO_2	400	Water vapor H_2O	10–50,000

Physical

Mean molecular mass = 29.0; Total mass = 5.1×10^{18} kg
Surface mass density = 29 gm/22.4 l ~ 1.3 kg/m^3;
Surface density scale height = 7.6 km
Surface temperature ~ 288 K ;
Adiabatic lapse rate ~ 10 K/km (dry); ~5 K/km (moist)
Specific heat (C_P = 1 kJ/kg-K; C_P/C_V = 1.4)
Tropopause height = 17 km (equator); 9 km (poles)
Mean cloud cover ~ 0.6; Mean precipitable water = 22 mm;
Mean surface wind ~ 20 mph = 9 m/s
Jet stream: altitude ~12 km; width ~ 100 km; thickness ~ 5 km; speed ~ 100 km/hr

HYDROSPHERE

- Water density = 1.00 gm/cm^3 ; ice density = 0.92 gm/cm^3
- Water specific heat = 1 cal/gm-K = 4.2 J/gm-K
- Water heat of fusion = 79.72 cal/gm = 334 J/gm ; Water latent heat = 2.26 kJ/gm
- Ocean depth ~ 4 km; Mixed layer depth ~ 40 m
- Global water = 1.34×10^9 km^3 =1.34×10^{21} kg (fresh water = 3.4×10^{19} kg)
- Mean current speed ~ 1m/s
- GMSL rise ~ 3 mm/yr
- Global avg precipitation rate ~ 1,000 mm/yr

CRYOSPHERE

- Ice density = 0.92 g/cm^3
- Ice Masses (10^{18} kg): Antarctic = 26.5; Greenland = 2.9; Mountain glaciers = 0.16
- 368 Gt ice melt = 1 mm Sea Level Rise
- Sea ice extents (10^6 km^2): Global = 18-23; Arctic 5-15; Antarctic 3-18
- NH Snow cover = (2-50) $\times 10^6$ km^2

SOLID EARTH

- Mean crustal density = 2.8 gm/cm^3
- Mean crustal composition by weight: Oxygen (46.6%), Silicon (27.7), Aluminum (8.1), Iron (5.0), Calcium (3.6), Potassium (2.8), Sodium (2.6), and Magnesium (2.1)
- Tectonic velocity ~ 2 cm/yr
- Geothermal heat flux (average) = 8.7×10^{-2} W/m^2

Time scales

- Diurnal = daily
- Seasonal = DJF, MAM, JJA, SON
- Annual = yearly
- Interannual = year-to-year
- Pentadal = 5 years
- Decadal = 10 years
- Centennial = 100 years
- Millennial = 1,000 years

- Universe age = 13.9×10^9 yr; Earth age = 4.7×10^9 yr
- **Paleo times**
  - Quaternary =2.58 M years BP - present
  - Pleistocene ("Ice Age") = 2.58 M – 11,700 years BP
  - Last interglacial "Eemian" = 125,000 years BP
  - Last glacial maximum = 22,000 years BP
  - Younger Dryas = 12,900 – 11,700 years BP
  - Holocene (present interglacial) = 11,650 years BP
- **Recent climate events**
  - Mid-Holocene optimum = 9,000 – 5,000 years BP
  - Roman optimum 250 BC- 400 AD
  - Little Ice Age = 1500-1850 AD
  - Medieval optimum = 950 – 1250 AD