Space-Time Dimensions and Natural Unit Values of Physical Quantities

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Abstract

This paper presents the derivation of the space-time dimensions and the natural unit values of physical quantities in the Reciprocal System. The factors include space, s, and time, t, only (with auxiliary units of cycles, revolutions, radians, and steradians). The appropriate time-space region (macroscopic) value and/or time region (microscopic) value of space is used for the various mechanical, electrical, magnetic, thermal, and photonic units. The dimensional system of the Reciprocal System is unique: no previous system compares.

keywords: space, time, dimensional systems, natural physical units, mechanical units, electrical units, magnetic units, thermal units, photonic units

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Introduction and Literature Survey

Many dimensional systems exist; Ref. [3], pp. 146-166 and pp. 386-418, provides the most detailed treatment of these. Included are the dynamical system, the gravitational system, the astrophysical system, the electrophysical system, the electrotechnical system, the "definitive" system, the "practical" system, the energetical system, the electrostatic system, the electromagnetic system, the thermophysical system, the thermotechnical system, the Gaussian or cgs system, and the MKS or SI system. None of these systems is "natural" in the sense of being based on the *fundamental* properties of space and time.

Dewey B. Larson, the originator of the Reciprocal System of theory, was the first theoretician to ground a dimensional system on the *true physical realities* of *space and time*. He presented his new dimensional system in Ref. [1], first ed., pp.25-27, pp. 73-83, pp. 210-211; Ref. [1], second ed., pp. 157-171; and Ref. [2], pp. 102-111, pp. 183-186, pp. 219-229.

This paper extends the work to the calculation of the space-time units, the cgs units, and the SI units of all mechanical, electrical, magnetic, thermal, and photonic physical quantities for the time-space region and/or the time region, as appropriate. A convenient table summarizing the results is presented at the end.

Ref. [4], [5], [6], and [7] provide conversion factors for going to and from the cgs and SI systems. Most of the factors provided are given to three decimal places only. For more precise work, one would have to use the conversion factors in Ref. [5], pp. 1-23 to 1-32, which are expressed to five or six decimal places.

James Clerk Maxwell, in Ref. [8], Vol. 2, p. 267, gives a table of electric and magnetic dimensions which are quite bizarre--yet this physicist is considered to be the greatest of the 19th century. Nonetheless he did provide one very useful suggestion in Vol. 1, p. 5: "If we adopt the units of length and time derived from the vibrations of light, then the unit of velocity is the velocity of light." Unfortunately, Maxwell didn't follow up on his own suggestion, but Larson did!

The space-time dimensions given in this paper apply to our half of the universe, the *material sector*. The space-time dimensions for the other half of the universe, the *cosmic sector*, are just the *inverse, with space and time interchanged.*

Nomenclature for Natural Units--see Table at end of paper for values in space-time, cgs, and SI units

A_u = area (time-space region)

A_u = magnetic vector potential

A_{t_u} = area (time region)

Av = Avogadro's number

a_u = linear acceleration (time-space region)

a_u = thermal diffusivity

a_{t_u} = linear acceleration (time region)

B_{e_u} = photonic energy brightness (per steradian)

B_{φ_u} = photonic brightness in given direction ϕ

B_u = magnetic flux density (time-space region)

B_{t_u} = magnetic flux density (time region)

C_u = capacitance

c_{p_u} = specific heat at constant pressure (molar)

c_{v_u} = specific heat at constant volume (molar)

c_u = speed of light

D_u, d_u = space (atomic diameter)

D_u = electric flux density (time-space region)

D_{t_u} = electric flux density (time region)

D_u = electric displacement (time_space region)

D_{t_u} = electric displacement (time region)

E_{a_u} = photonic irradiance (absorbed)

E_u = energy, work, heat (time-space region); includes electric energy

E_u = electric field intensity (time-space region)

E_u = photonic illuminance (intensity of illumination over Ω)

E_{u_photon} = energy of unit frequency photon

E_{t_u} = energy, work, heat (time region)

E_{t_u} = electric field intensity (time region)

F_{M_u} = magnetomotive force (time-space region)

$F_{M\_t\_u}$ = magnetomotive force (time region)

F_u = force (time-space region)

F_{t_u} = force (time region)

f_{rot} = rotational vibration frequency (subscript rev = revolutions/sec, subscript rad = radians/sec)

G_u = electric conductance

H_{a_u} = luminous exposure solid angle

H_{e_u} = radiant energy exposure

H_u = magnetic field intensity (time-space region)

H_{t_u} = magnetic field intensity (time region)

h_{u_G} = specific molar enthalpy of gas

h_{u_SL} = specific molar enthalpy of solid/liquid

h_{u_V} = specific molar enthalpy of vapor

I_{a_u} = illuminance (intensity of illumination over solid angle Ω)

I_{e_u} = radiant intensity (per steradian)

I_R = inter-regional ratio

I_{u_G} = specific molar internal energy of gas

I_{u_SL} = specific molar internal energy of solid/liquid

I_{u_V} = specific molar internal energy of vapor

I_u = moment of inertia (time-space region)

I_{t_u} = moment of inertia (time region)

i_u = electric current

j_u = electric current density (time-space region)

j_{t_u} = electric current density (time region)

L_u = rotational momentum

L_u = magnetic inductance

M_{e_u} = luminosity (radiance, emitted)

M_u = linear momentum

M_u = magnetic charge or flux

M_{M_u} = magnetization (time-space region)

$M_{M\_t\_u}$ = magnetization (time region)

m_u = mass

P_{G_u}, P_u = pressure (gas)

P_{L_u} = pressure (liquid)

P_{M_u} = magnetic polarization (time-space region)

$P_{M\_t\_u}$ = magnetic polarization (time region)

P_{S_u} = pressure (solid)

P_{V_u}, P_u = pressure (vapor)

P_u = electric polarization (time-space region)

P_{t_u} = electric polarization (time region)

p_u = power (time-space region); includes electric power

p_u = electric dipole moment

p_{t_u} = power (time region)

p_{t_u} = electric dipole moment (time region)

Q_u = electric charge or flux

Q_u = luminous energy (for solid angle Ω)

q_u = electric quantity

R = linear vibration frequency

R_{e_u} = luminance (radiance, emitted over solid angle Ω)

R_{M_u} = magnetic reluctance

R_u = electric resistance

R_u = luminance (radiance, emitted over Ω)

R_{Θ_u} = thermal resistance

S_u = molar specific entropy

S_{Θ_u} = thermal conductance

s_u = space (time-space region)

s_{t_u} = space (time region)

T_{G_u} = temperature (gas)

T_{SL_u} = temperature (solid, liquid)

T_{V_u} = temperature (vapor)

T_u = torque (time-space region)

T_{t_u} = torque (time region)

t_u = time

V_u = volume (time-space region)

V_u = specific volume (time-space region)

V_u = electric voltage or potential

V_{t_u} = volume (time region)

V_{t_u} = specific volume (time region)

$v_{rot,}$ ω_u = rotational velocity

v_u = linear velocity (time-space region)

v_{t_u}= linear velocity (time region)

α_u = angular acceleration (subscript rev = rev/sec^2, subscript rad = rad/sec^2)

α_u = thermal diffusivity (gas)

α_{t_u} = thermal diffusivity (solid, liquid)

γ_{L_u} = surface tension (liquid)

Φ_{e_u} = radiant flux

Φ_{v_u} = luminous flux (for solid angle Ω)

ε_0 = electric permittivity (free space)

η_u = dynamic viscosity

κ_u = thermal conductivity

μ_0 = magnetic permeability (free space)

μ_{c_u} = magnetic moment from curret (time-space region)

$\mu_{c\_t\_u}$ = magnetic moment from curret (time region)

μ_L = Larson magneton (atomic magnetic moment)

μ_u = magnetic dipole moment (time-space region)

μ_{t_u} = magnetic dipole moment (time region

ν_u = kinematic viscosity

ν_u = linear vibration frequency

ρ_u, d_u = density (time-space region)

ρ_u = electric charge volume density (time-space region)

ρ_{t_u} = electric charge volume density (time region)

ρ_{t_u} = electric resistivity

ρ_u = electric resistivity

ρ_{t_u}, d_{t_u} = density (time region--atoms)

ρ_{θ_u} = thermal resistivity

σ_{t_u} = electric conductivity

χ_{μ_u} = magnetic susceptibility (free space)

χ_{ε_u} = electric susceptibility (free space)

Note 1: A black square in the upper right of an equation means that the equation is disabled from running in *Mathcad*. This is done because not all variables in the equation have, as yet, been given numerical values at that point in the program.

Note 2: We have attempted to use the same symbols here as in other papers and books on the Reciprocal System, but given the large number of symbols necessary, there will be some differences. Please consult the nomenclature of each individual paper for the symbols used in that paper. Also, in a few cases, duplicate symbols for different properties have been used, but no ambiguity should result; always consider the context.

Note 3: In the following equations, the subscript "u" in the variables will apply to the natural space-time units (stated in cm, sec, and auxiliary units, if any); for cgs values, the subscript cgs will be used; and for SI values, the subscript SI will be used. If only cm and sec and auxiliary units are used, the cgs subscript will usually be left off. The subscript t means the time region value.

Note 4: The calculated values of the natural units are given to six decimal places. Because there is some uncertainty in the speed of light and the Rydberg frequency of H^1 there is uncertainty in the 5th and 6th decimal place. For most scientific and engineering work, four decimal places should suffice; the slight differences in the values given in the various books and papers of the Reciprocal System are *de minimis*.

1. Mechanical Units

a. space, time, translational speed

In pure natural units, the Reciprocal System time-space region equation for velocity is, of course,

$$\text{natural\_unit\_speed} := \frac{\text{natural\_unit\_space}}{\text{natural\_unit\_time}} \qquad (1a)$$

$$1 := \frac{1}{1} \qquad (1b)$$

All *natural* physical units in the Reciprocal System are 1, of course! To get anything useful out of the theory we must identify the *corresponding* physical quantities expressed in *conventional* units, such as in cgs or SI. Obviously, the speed of light is the natural unit speed of the universe, and so we have:

$$c := \frac{1}{1} \qquad (1c)$$

In many Reciprocal System books and papers we use this cgs value for c:

$$c_u := 2.997925 \cdot 10^{10} \quad \text{cm/sec} \qquad (1d)$$

The physics/chemistry establishment (Ref. [5], p. 1-1) has recently "fixed" the value at

$$c_u := 2.99792458 \cdot 10^{10} \quad \text{cm/sec} \tag{1e}$$

In Ref. [1], 2nd ed., p. 160, Larson used this value:

$$c_u := 2.997930 \cdot 10^{10} \quad \text{cm/sec} \tag{1f}$$

Depending on which particular value one chooses, the values of the resultant natural unit of space and natural unit of time *expressed in conventional units* will be *slightly* different.

In order to get the natural unit of time, we use the Rydberg frequency of H^1--this is the *natural unit frequency*. In most Reciprocal System books and papers, we use this value for R (with the auxiliary unit *cycles*):

$$R := 3.288057 \cdot 10^{15} \quad \text{cycles/sec} \qquad \nu_u := R \tag{2}$$

Unfortunately, the physics/chemistry establishment has switched to the "infinite mass" definition for this constant, rather than that based on the unit mass of H^1. We think this is an error, and so we will continue to use the above value.

In the unit linear vibration of a Rydberg photon, there are two units of space and two units of time, one of each for up and one of each for down. The natural unit value of time can therefore be calculated by taking 1/2 the inverse of R:

$$t_u := \frac{1}{2 \cdot R} \qquad t_u = 1.520655 \times 10^{-16} \quad \text{sec} \tag{3}$$

With c_u and t_u known, s_u can be found:

$$s_u := c_u \cdot t_u \qquad s_u = 4.558809 \times 10^{-6} \ \text{cm} \tag{4a}$$

But this value is bit lower than what we have commonly used in the Reciprocal System:

$$s_u := 4.558816 \cdot 10^{-6} \ \text{cm} \tag{4b}$$

This implies that the "true" speed of light is

$$c_u := \frac{s_u}{t_u} \qquad c_u = 2.997929 \times 10^{10} \ \text{cm/sec} \qquad v_u := c_u \tag{1g}$$

As you can see, there is some uncertainty in the last two digits. For our purposes here, and to stay consistent with previous work, we will stick with using the value of s_u from Eq. (4b) and the value of c_u from Eq. (1g). All of the values of c round to the value given by Larson, regardless. (In the Table below, the value from Eq. (1d) will be put below the value from Eq. (1g), as an alternate.)

The SI values are

$$s_{u\_SI} := 4.558816 \cdot 10^{-8} \ \text{m} \tag{4c}$$

$$c_{u\_SI} := 2.997929 \cdot 10^{8} \ \text{m/sec} \qquad v_{u\_SI} := c_{u\_SI} \tag{1h}$$

The above values are all for the *macroscopic* time-space region. For the *microscopic* time region values, we must divide by the inter-regional ratio (see Ref. [1], 2nd ed., p. 154, p. 162):

$$I_R := 156.4444 \qquad (5)$$

$$s_{t\_u} := \frac{s_u}{I_R} \qquad s_{t\_u} = 2.914017 \times 10^{-8} \quad \text{cm} \qquad (6a)$$

$$s_{t\_u\_SI} := 2.914017 \cdot 10^{-10} \quad \text{m} \qquad (6b)$$

A specialized length unit is used for atomic diameter. In the Reciprocal System, the atom is the same size as the supposed "nucleus" of the conventional atomic theory. Using the Reciprocal System alpha-particle scattering theory and a reflection angle of 156^o, the standard angle used, the natural unit value of atomic diameter can be shown to be

$$D_u := 3.359 \cdot 10^{-13} \quad \text{cm} \qquad (7a)$$

$$D_{u\_SI} := 3.359 \cdot 10^{-15} \quad \text{m} \qquad (7b)$$

(See Appendix 1 for a derivation.)

The time-region unit velocity is obviously

$$v_{t\_u} := \frac{s_{t\_u}}{t_u} \qquad v_{t\_u} = 1.916291 \times 10^{8} \quad \text{cm/sec} \qquad (8a)$$

$$v_{t\_u\_SI} := 1.916291 \cdot 10^{6} \quad \text{m/sec} \qquad (8b)$$

b. area and volume

$A_u := s_u^2$ $\quad A_u = 2.078280 \times 10^{-11}$ cm^2 (9a)

$A_{u\_SI} := 10^{-4} \cdot A_u$ $\quad A_{u\_SI} = 2.078280 \times 10^{-15}$ m^2 (9b)

$A_{t\_u} := s_{t\_u}^2$ $\quad A_{t\_u} = 8.491494 \times 10^{-16}$ cm^2 (10a)

$A_{t\_u\_SI} := 10^{-4} \cdot A_{t\_u}$ $\quad A_{t\_u\_SI} = 8.491494 \times 10^{-20}$ m^2 (10b)

$V_u := s_u^3$ $\quad V_u = 9.474498 \times 10^{-17}$ cm^3 (11a)

$V_{u\_SI} := 10^{-6} \cdot V_u$ $\quad V_{u\_SI} = 9.474498 \times 10^{-23}$ m^3 (11b)

$V_{t\_u} := s_{t\_u}^3$ $\quad V_{t\_u} = 2.474435 \times 10^{-23}$ cm^3 (12a)

$V_{t\_u\_SI} := 10^{-6} \cdot V_{t\_u}$ $\quad V_{t\_u\_SI} = 2.474435 \times 10^{-29}$ m^3 (12b)

c. rotational speed and frequency

The unit rotational speeds are the same as the unit translational speeds. But the natural unit rotational vibration frequency is different from the natural unit linear vibration frequency. By inspection,

$$f_{rot\_rev} := \frac{2 \cdot R}{\pi} \quad \text{or} \quad f_{rot\_rev} := \frac{1}{\pi \cdot t_u} \qquad f_{rot\_rev} = 2.093242 \times 10^{15} \quad \text{rev/sec} \qquad (13a)$$

In terms of radians:

$$f_{rot\_rad} := \frac{2}{t_u} \qquad f_{rot\_rad} = 1.315223 \times 10^{16} \quad \text{rad/sec} \qquad (13b)$$

d. acceleration

The various acceleration values follow, by definition:

$a_u := \frac{s_u}{t_u^2}$ $a_u = 1.971473 \times 10^{26}$ cm/sec^2 (14a)

$a_{u\_SI} := 10^{-2} \cdot a_u$ $a_{u\_SI} = 1.971473 \times 10^{24}$ m/sec^2 (14b)

$a_{t\_u} := \frac{s_{t\_u}}{t_u^2}$ $a_{t\_u} = 1.260175 \times 10^{24}$ cm/sec^2 (15a)

$a_{t\_u\_SI} := 10^{-2} \cdot a_{t\_u}$ $a_{t\_u\_SI} = 1.260175 \times 10^{22}$ m/sec^2 (15b)

$\alpha_{u\_rev} := \frac{1}{\pi \cdot t_u^2}$ $\alpha_{u\_rev} = 1.376540 \times 10^{31}$ rev/sec^2 (16a)

In terms of radians,

$\alpha_{u\_rad} := \frac{2}{t_u^2}$ $\alpha_{u\_rad} = 8.649055 \times 10^{31}$ rad/sec^2 (16b)

e. mass

Mass in the Reciprocal System is

$$m_u := \frac{t_u^{\,3}}{s_u^{\,3}} \qquad m_u = 3.711383 \times 10^{-32} \quad \text{sec}^3/\text{cm}^3 \qquad (17a)$$

There is no time region value! Unit atomic mass, 1 amu (not u), can be identified as the conventional equivalent. Therefore

$$m_{u\_cgs} := 1.659790 \cdot 10^{-24} \quad \text{g} \qquad (17b)$$

$$m_{u\_SI} := 1.659790 \cdot 10^{-27} \quad \text{kg} \qquad (17c)$$

f. density

The density values then follow, by inspection:

$\rho_u := \frac{t_u^{3}}{s_u^{6}}$ $\rho_u = 3.917235 \times 10^{-16}$ sec³/cm⁶ (18a)

$\rho_{u\_cgs} := \frac{m_{u\_cgs}}{s_u^{3}}$ $\rho_{u\_cgs} = 1.751850 \times 10^{-8}$ g/cm³ (18b)

$\rho_{u\_SI} := \frac{m_{u\_SI}}{s_{u\_SI}^{3}}$ $\rho_{u\_SI} = 1.751850 \times 10^{-5}$ kg/m³ (18c)

$\rho_{t\_u} := \frac{\left(\frac{t_u^{3}}{s_u^{3}}\right)}{s_{t\_u}^{3}}$ $\rho_{t\_u} = 1.499891 \times 10^{-9}$ sec³/cm⁶ (19a)

$\rho_{t\_u\_cgs} := \frac{m_{u\_cgs}}{s_{t\_u}^{3}}$ $\rho_{t\_u\_cgs} = 6.707752 \times 10^{-2}$ g/cm³ (19b)

$\rho_{t\_u\_SI} := 10^{3} \cdot \rho_{t\_u\_cgs}$ $\rho_{t\_u\_SI} = 6.707752 \times 10^{1}$ kg/m³ (19c)

g. specific volume

Specific volume is the inverse of density.

$$V_u := \frac{s_u^3}{\left(\frac{t_u^3}{s_u^3}\right)} \qquad V_u = 2.552821\times 10^{15} \qquad cm^6/sec^3 \qquad (20a)$$

$$V_{u\_cgs} := \frac{s_u^3}{m_{u\_cgs}} \qquad V_{u\_cgs} = 5.708251\times 10^{7} \qquad cm^3/g \qquad (20b)$$

$$V_{u\_SI} := \frac{s_{u\_SI}^3}{m_{u\_SI}} \qquad V_{u\_SI} = 5.708251\times 10^{4} \qquad m^3/kg \qquad (20c)$$

$$V_{t\_u} := \frac{s_{t\_u}^3}{\frac{t_u^3}{s_u^3}} \qquad V_{t\_u} = 6.667151\times 10^{8} \qquad cm^6/sec^3 \qquad (21a)$$

$$V_{t\_u\_cgs} := \frac{s_{t\_u}^3}{m_{u\_cgs}} \qquad V_{t\_u\_cgs} = 1.490812\times 10^{1} \qquad cm^3/g \qquad (21b)$$

$$V_{t\_u\_SI} := 10^{-3}\cdot V_{t\_u\_cgs} \qquad V_{t\_u\_SI} = 1.490812\times 10^{-2} \qquad m^3/kg \qquad (21c)$$

h. linear momentum

Linear momentum is simply mass times velocity.

$M_u := \frac{t_u^2}{s_u^2}$ $M_u = 1.112646 \times 10^{-21}$ sec²/cm² (22a)

$M_{u\_cgs} := m_{u\_cgs} \cdot v_u$ $M_{u\_cgs} = 4.975933 \times 10^{-14}$ g cm/sec (22b)

$M_{u\_SI} := m_{u\_SI} \cdot v_{u\_SI}$ $M_{u\_SI} = 4.975933 \times 10^{-19}$ kg m/sec (22c)

$M_{t\_u} := \left(\frac{t_u^3}{s_u^3}\right) \cdot \frac{s_{t\_u}}{t_u}$ $M_{t\_u} = 7.112089 \times 10^{-24}$ sec²/cm² (23a)

$M_{t\_u\_cgs} := m_{u\_cgs} \cdot v_{t\_u}$ $M_{t\_u\_cgs} = 3.180640 \times 10^{-16}$ g cm/sec (23b)

$M_{t\_u\_SI} := 10^{-5} \cdot M_{t\_u\_cgs}$ $M_{t\_u\_SI} = 3.180640 \times 10^{-21}$ kg m/sec (23c)

i. rotational momentum

By definition:

$L_u := \frac{t_u^{\,2}}{s_u}$ $L_u = 5.072351 \times 10^{-27}$ sec^2/cm (24a)

$L_{u\_cgs} := m_{u\_cgs} \cdot v_u \cdot s_u$ $L_{u\_cgs} = 2.268436 \times 10^{-19}$ g cm^2/sec (24b)

$L_{u\_SI} := m_{u\_SI} \cdot v_{u\_SI} \cdot s_{u\_SI}$ $L_{u\_SI} = 2.268436 \times 10^{-26}$ kg m^2/sec (24c)

$L_{t\_u} := \left(\frac{t_u^{\,3}}{s_u^{\,3}}\right) \cdot \frac{s_{t\_u}^{\,2}}{t_u}$ $L_{t\_u} = 2.072475 \times 10^{-31}$ sec^2/cm (25a)

$L_{t\_u\_cgs} := m_{u\_cgs} \cdot v_{t\_u} \cdot s_{t\_u}$ $L_{t\_u\_cgs} = 9.268438 \times 10^{-24}$ g cm^2/sec (25b)

$L_{t\_u\_SI} := 10^{-7} \cdot L_{t\_u\_cgs}$ $L_{t\_u\_SI} = 9.268438 \times 10^{-31}$ kg m^2/sec (25c)

j. force

Force is mass times acceleration.

$F_u := \frac{t_u}{{s_u}^2}$	$F_u = 7.316890 \times 10^{-6}$	sec/cm^2	(26a)
$F_{u\_cgs} := m_{u\_cgs} \cdot a_u$	$F_{u\_cgs} = 3.272230 \times 10^{2}$	dynes	(26b)
$F_{u\_SI} := 10^{-5} \cdot F_{u\_cgs}$	$F_{u\_SI} = 3.272230 \times 10^{-3}$	N	(26c)
$F_{t\_u} := m_u \cdot a_{t\_u}$	$F_{t\_u} = 4.676991 \times 10^{-8}$	sec/cm^2	(27a)
$F_{t\_u\_cgs} := m_{u\_cgs} \cdot a_{t\_u}$	$F_{t\_u\_cgs} = 2.091625$	dynes	(27b)
$F_{t\_u\_SI} := 10^{-5} \cdot F_{t\_u\_cgs}$	$F_{t\_u\_SI} = 2.091625 \times 10^{-5}$	N	(27c)

The mechanical time region values are appropriate to use for nanotechnology machines. But whereas gravitational force may usually be neglected for time-space calculations, the reverse gravitational and progression forces must usually be considered when doing time region calculations. See Appendix 2.

k. pressure

Pressure is force divided by area.

$$P_u := \frac{t_u}{{s_u}^4} \qquad P_u = 3.520646 \times 10^5 \quad \text{sec/cm}^4 \qquad (28a)$$

$$P_{u\_cgs} := \frac{F_{u\_cgs}}{{s_u}^2} \qquad P_{u\_cgs} = 1.574489 \times 10^{13} \quad \text{dynes/cm}^2 \qquad P_{G\_u} := P_{u\_cgs} \qquad (28b)$$

$$P_{u\_SI} := 10^{-1} \cdot P_{u\_cgs} \qquad P_{u\_SI} = 1.574489 \times 10^{12} \quad \text{N/m}^2 \qquad (28c)$$

This is the natural unit of pressure for ideal gases. Because of inter-atomic attraction in solids, liquids, and vapors (and real gases) the pressure is different for these states of matter.

For solids, we use the *time region expression for force but keep the time-space region expression for area* (because pressure is a *macroscopic* property).

$$P_{S\_u\_cgs} := \frac{F_{t\_u\_cgs}}{{s_u}^2} \qquad P_{S\_u\_cgs} = 1.006421 \times 10^{11} \quad \text{dynes/cm}^2 \qquad (29a)$$

$$P_{S\_u\_SI} := 10^{-1} \cdot P_{S\_u\_cgs} \qquad P_{S\_u\_SI} = 1.006421 \times 10^{10} \quad \text{N/m}^2 \qquad (29b)$$

For liquids, which have 2/3 of the cohesion of solids, we must multiply the solid value by 2/3 and divide by another I_R.

$$P_{L\_u} := \frac{2}{3} \cdot \frac{t_u}{s_u^{\,4}} \cdot \frac{1}{l_R^{\,2}} \qquad P_{L\_u} = 9.589834 \qquad \text{sec/cm}^4 \qquad (30a)$$

$$P_{L\_u\_cgs} := \frac{\frac{2}{3} \cdot P_{S\_u\_cgs}}{l_R} \qquad P_{L\_u\_cgs} = 4.288727 \times 10^{8} \qquad \text{dynes/cm}^2 \qquad (30b)$$

$$P_{L\_u\_SI} := 10^{-1} \cdot P_{L\_u\_cgs} \qquad P_{L\_u\_SI} = 4.288727 \times 10^{7} \qquad \text{N/m}^2 \qquad (30c)$$

For vapors, which have 1/3 of the cohesion of solids, we must multiply the solid value by 1/3 and divide by still another l_R.

$$P_{V\_u} := \frac{1}{3} \cdot \frac{t_u}{s_u^{\,4}} \cdot \frac{1}{l_R^{\,3}} \qquad P_{V\_u} = 3.064934 \times 10^{-2} \qquad \text{sec/cm}^4 \qquad (31a)$$

$$P_{V\_u\_cgs} := \frac{1}{3} \cdot \frac{P_{S\_u\_cgs}}{l_R^{\,2}} \qquad P_{V\_u\_cgs} = 1.370687 \times 10^{6} \qquad \text{dynes/cm}^2 \qquad (31b)$$

$$P_{V\_u\_SI} := 10^{-1} \cdot P_{V\_u\_cgs} \qquad P_{V\_u\_SI} = 1.370687 \times 10^{5} \qquad \text{N/m}^2 \qquad (31c)$$

I. torque

Torque is simply force times distance.

$T_u := \frac{t_u}{s_u}$ $T_u = 3.335636 \times 10^{-11}$ sec/cm (32a)

$T_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $T_{u\_cgs} = 1.491750 \times 10^{-3}$ dynes cm (32b)

$T_{u\_SI} := 10^{-7} \cdot T_{u\_cgs}$ $T_{u\_SI} = 1.491750 \times 10^{-10}$ N m (32c)

$T_{t\_u} := m_u \cdot a_{t\_u} \cdot s_{t\_u}$ $T_{t\_u} = 1.362883 \times 10^{-15}$ sec/cm (33a)

$T_{t\_u\_cgs} := F_{t\_u\_cgs} \cdot s_{t\_u}$ $T_{t\_u\_cgs} = 6.095031 \times 10^{-8}$ dynes cm (33b)

$T_{t\_u\_SI} := 10^{-7} \cdot T_{t\_u\_cgs}$ $T_{t\_u\_SI} = 6.095031 \times 10^{-15}$ N m (33c)

m. moment of inertia

The moment of inertia is defined as mass times distance squared.

$I_u := \frac{t_u^3}{s_u^3} \cdot s_u^2$ $I_u = 7.713295 \times 10^{-43}$ sec^3/cm (34a)

$I_{u\_cgs} := m_{u\_cgs} \cdot s_u^2$ $I_{u\_cgs} = 3.449509 \times 10^{-35}$ g cm^2 (34b)

$I_{u\_SI} := m_{u\_SI} \cdot s_{u\_SI}^2$ $I_{u\_SI} = 3.449509 \times 10^{-42}$ kg m^2 (34c)

$I_{t\_u} := \frac{t_u^3}{s_u^3} \cdot s_{t\_u}^2$ $I_{t\_u} = 3.151519 \times 10^{-47}$ sec^3/cm (35a)

$I_{t\_u\_cgs} := m_{u\_cgs} \cdot s_{t\_u}^2$ $I_{t\_u\_cgs} = 1.409410 \times 10^{-39}$ g cm^2 (35b)

$I_{t\_u\_SI} := m_{u\_SI} \cdot s_{t\_u}^2$ $I_{t\_u\_SI} = 1.409410 \times 10^{-42}$ kg m^2 (35c)

n. dynamic and kinematic viscosity

Dynamic viscosity and kinematic viscosity are macroscopic properties of liquids and so only time-space region values apply.

$\eta_u := \frac{t_u^{\,2}}{s_u^{\,4}}$ $\eta_u = 5.353688 \times 10^{-11}$ sec^2/cm^4 (36a)

$\eta_{u\_cgs} := \frac{M_{u\_cgs}}{s_u^{\,2}}$ $\eta_{u\_cgs} = 2.394255 \times 10^{-3}$ poise (36b)

$\eta_{u\_SI} := \frac{M_{u\_SI}}{s_{u\_SI}^{\,2}}$ $\eta_{u\_SI} = 2.394255 \times 10^{-4}$ N sec/m^2 (36c)

We commonly use centipoise, instead of poise.

$\eta_{u\_cgs} := 2.394255 \cdot 10^{-1}$ centipose (36d)

Kinematic viscosity is dynamic viscosity divided by density.

$\nu_u := \frac{s_u^{\,2}}{t_u}$ $\nu_u = 1.366701 \times 10^{5}$ cm^2/sec (37a)

$\nu_{u\_cgs} := 1.366701 \cdot 10^{7}$ centistokes (37b)

$\nu_{u\_SI} := 1.366701 \cdot 10^{5}$ stokes (37c)

o. surface tension

Surface tension is 1/3 the natural unit of pressure times the natural unit of distance divided by the cube of the inter-regional ratio. It is a macroscopic one-dimensional property only.

$\gamma_u := \frac{1}{3} \cdot \frac{P_u \cdot s_u}{I_R^{\,3}}$ $\gamma_u = 1.397247 \times 10^{-7}$ sec/cm^3 (38a)

$\gamma_{u\_cgs} := \frac{1}{3} \frac{P_{u\_cgs} \cdot s_u}{I_R^{\,3}}$ $\gamma_{u\_cgs} = 6.248712$ dynes/cm (38b)

$\gamma_{u\_SI} := 10^{-3} \cdot \gamma_{u\_cgs}$ $\gamma_{u\_SI} = 6.248712 \times 10^{-3}$ N/m (38c)

p. energy

Energy is the inverse of velocity, or force times distance.

$E_u := \frac{t_u}{s_u}$ $E_u = 3.335636 \times 10^{-11}$ sec/cm (39a)

$E_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $E_{u\_cgs} = 1.491750 \times 10^{-3}$ ergs (39b)

$E_{u\_SI} := F_{u\_SI} \cdot s_{u\_SI}$ $E_{u\_SI} = 1.491750 \times 10^{-10}$ J (39c)

$E_{t\_u} := F_{t\_u} \cdot s_{t\_u}$ $E_{t\_u} = 1.362883 \times 10^{-15}$ sec/cm (40a)

$E_{t\_u\_cgs} := F_{t\_u\_cgs} \cdot s_{t\_u}$ $E_{t\_u\_cgs} = 6.095031 \times 10^{-8}$ ergs (40b)

$E_{t\_u\_SI} := F_{t\_u\_SI} \cdot s_{t\_u\_SI}$ $E_{t\_u\_SI} = 6.095031 \times 10^{-15}$ J (40c)

For Einstein's famous equation:

$E_u = 3.335636 \times 10^{-11}$ sec/cm $m_u \cdot c_u^2 = 3.335636 \times 10^{-11}$ sec/cm [checks]

q. power

Power is energy per unit time.

$$P_u := \frac{1}{s_u} \qquad P_u = 2.193552 \times 10^{5} \quad cm^{-1} \qquad (41a)$$

$$P_{u\_cgs} := \frac{E_{u\_cgs}}{t_u} \qquad P_{u\_cgs} = 9.809916 \times 10^{12} \quad \text{ergs/sec} \qquad (41b)$$

$$P_{u\_SI} := \frac{E_{u\_SI}}{t_u} \qquad P_{u\_SI} = 9.809916 \times 10^{5} \quad \text{J/sec} \qquad (41c)$$

$$P_{t\_u} := \frac{1}{s_{t\_u}} \qquad P_{t\_u} = 3.431689 \times 10^{7} \quad cm^{-1} \qquad (42a)$$

$$P_{t\_u\_cgs} := \frac{E_{t\_u\_cgs}}{t_u} \qquad P_{t\_u\_cgs} = 4.008162 \times 10^{8} \quad \text{ergs/sec} \qquad (42b)$$

$$P_{t\_u\_SI} := \frac{E_{t\_u\_SI}}{t_u} \qquad P_{t\_u\_SI} = 4.008162 \times 10^{1} \quad \text{J/sec} \qquad (42c)$$

2. Electrical Units

We will give both the time-space region and time region values here as appropriate.

a. electric quantity

Electric quantity is simply one natural unit of space *whether using the time-space region value* or *the time region value.* From Larson, Ref. [2], p. 111: "...the unit of space in the region inside unit distance, the time region, as we are calling it, is inherently just as large as the unit of space in the region outside unit distance, but as measured it is reduced by the inter-regional ratio, 156.4444, for reasons previously explained. We cannot legitimately regard this quantity as something less than a full unit, since, as we saw in Volume I [Ref. [1]], it has the same status in the time region that the full-sized natural unit of space has in the region outside unit distance. The logical way of handling this situation appears to be to take the stand there are two different natural units of distance (one-dimensional space), a simple unit and a compound unit, that apply under different circumstances." *Time-space values will apply to quantities which are not per distance or per area or per volume; those which are per distance or per area or per volume can have either time-space or time region values.*

$q_u := s_u \qquad q_u = 4.558816 \times 10^{-6}$ cm (43a)

$q_{u\_cgs} := 4.802870 \cdot 10^{-10}$ $esu_{quantity}$ (43b)

$q_{u\_SI} := 1.602062 \cdot 10^{-19}$ $coulombs_{quantity}$ (43c)

Unlike conventional theory, the Reciprocal System distinguishes between electric quantity and electric charge; they have different dimensions, hence the subscript.

b. electric current

Ordinary electric current is the flow of massless, chargeless electrons.

$i_u := \frac{s_u}{t_u}$ $i_u = 2.997929 \times 10^{10}$ cm/sec (44a)

$i_{u\_cgs} := \frac{q_{u\_cgs}}{t_u}$ $i_{u\_cgs} = 3.158422 \times 10^{6}$ $esu_{quantity}$/sec (44b)

$i_{u\_SI} := \frac{q_{u\_SI}}{t_u}$ $i_{u\_SI} = 1.053534 \times 10^{-3}$ amps (44c)

c. electric current density

Electric current density is electric current per unit area.

$$j_u := \frac{i_u}{s_u^2} \qquad j_u = 1.442505 \times 10^{21} \qquad \mathrm{cm^{-1}sec^{-1}} \qquad (45a)$$

$$j_{u\_cgs} := \frac{i_{u\_cgs}}{s_u^2} \qquad j_{u\_cgs} = 1.519729 \times 10^{17} \qquad (\mathrm{esu_{quantity}/sec})/\mathrm{cm^2} \qquad (45b)$$

$$j_{u\_SI} := \frac{i_{u\_SI}}{s_{u\_SI}^2} \qquad j_{u\_SI} = 5.069260 \times 10^{11} \qquad \mathrm{amps/m^2} \qquad (45c)$$

$$j_{t\_u} := \frac{i_u}{s_{t\_u}^2} \qquad j_{t\_u} = 3.530509 \times 10^{25} \qquad \mathrm{cm^{-1}sec^{-1}} \qquad (46a)$$

$$j_{t\_u\_cgs} := \frac{i_{u\_cgs}}{s_{t\_u}^2} \qquad j_{t\_u\_cgs} = 3.719513 \times 10^{21} \qquad (\mathrm{esu_{quantity}/sec})/\mathrm{cm^2} \qquad (46b)$$

$$j_{t\_u\_SI} := \frac{i_{u\_SI}}{s_{t\_u\_SI}^2} \qquad j_{t\_u\_SI} = 1.240693 \times 10^{16} \qquad \mathrm{amps/m^2} \qquad (46c)$$

d. electric charge or flux

Electric charge or flux is the unit charge of the electron. Notice that the *dimensions* of charge are *different* from those of quantity.

$Q_u := \frac{t_u}{s_u}$ $Q_u = 3.335636 \times 10^{-11}$ sec/cm (47a)

$Q_{u\_cgs} := 4.802870 \cdot 10^{-10}$ esu_{charge} (47b)

$Q_{u\_SI} := 1.602062 \cdot 10^{-19}$ $coulombs_{charge}$ (47c)

e. electric dipole moment

Electric dipole moment is electric charge times distance.

$p_u := Q_u \cdot s_u$	$p_u = 1.520655 \times 10^{-16}$	sec	(48a)
$p_{u\_cgs} := Q_{u\_cgs} \cdot s_u$	$p_{u\_cgs} = 2.189540 \times 10^{-15}$	$esu_{charge}\ cm$	(48b)
$p_{u\_SI} := Q_{u\_SI} \cdot s_{u\_SI}$	$p_{u\_SI} = 7.303506 \times 10^{-27}$	$coulombs_{charge}\ m$	(48c)
$p_{t\_u} := Q_u \cdot s_{t\_u}$	$p_{t\_u} = 9.720098 \times 10^{-19}$	sec	(49a)
$p_{t\_u\_cgs} := Q_{u\_cgs} \cdot s_{t\_u}$	$p_{t\_u\_cgs} = 1.399564 \times 10^{-17}$	$esu_{charge}\ cm$	(49b)
$p_{t\_u\_SI} := Q_{u\_SI} \cdot s_{t\_u\_SI}$	$p_{t\_u\_SI} = 4.668436 \times 10^{-29}$	$coulombs_{charge}\ m$	(49c)

f. electric charge volume density

Electric charge volume density is charge per unit volume.

$$\rho_u := \frac{Q_u}{s_u^3} \qquad \rho_u = 3.520646 \times 10^5 \qquad \text{sec/cm}^4 \qquad (50a)$$

$$\rho_{u\_cgs} := \frac{Q_{u\_cgs}}{s_u^3} \qquad \rho_{u\_cgs} = 5.069261 \times 10^6 \qquad \text{esu}_{\text{charge}}\text{/cm}^3 \qquad (50b)$$

$$\rho_{u\_SI} := \frac{Q_{u\_SI}}{s_{u\_SI}^3} \qquad \rho_{u\_SI} = 1.690920 \times 10^3 \qquad \text{coulombs}_{\text{charge}}\text{/m}^3 \qquad (50c)$$

$$\rho_{t\_u} := \frac{Q_u}{s_{t\_u}^3} \qquad \rho_{t\_u} = 1.348039 \times 10^{12} \qquad \text{sec/cm}^4 \qquad (51a)$$

$$\rho_{t\_u\_cgs} := \frac{Q_{u\_cgs}}{s_{t\_u}^3} \qquad \rho_{t\_u\_cgs} = 1.940996 \times 10^{13} \qquad \text{esu}_{\text{charge}}\text{/cm}^3 \qquad (51b)$$

$$\rho_{t\_u\_SI} := \frac{Q_{u\_SI}}{s_{t\_u\_SI}^3} \qquad \rho_{t\_u\_SI} = 6.474453 \times 10^9 \qquad \text{coulombs}_{\text{charge}}\text{/m}^3 \qquad (51c)$$

g. electric energy

The natural unit of electric energy is the same as the natural unit of mechanical energy.

$E_u := \frac{t_u}{s_u}$ $E_u = 3.335636 \times 10^{-11}$ sec/cm (52a)

$E_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $E_{u\_cgs} = 1.491750 \times 10^{-3}$ ergs (52b)

$E_{u\_SI} := F_{u\_SI} \cdot s_{u\_SI}$ $E_{u\_SI} = 1.491750 \times 10^{-10}$ J (52c)

h. electric power

The natural unit of electric power is the same as the natural unit mechanical power.

$P_u := \frac{1}{s_u}$ $P_u = 2.193552 \times 10^5$ cm^{-1} (53a)

$P_{u\_cgs} := \frac{E_{u\_cgs}}{t_u}$ $P_{u\_cgs} = 9.809916 \times 10^{12}$ ergs/sec (53b)

$P_{u\_SI} := \frac{E_{u\_SI}}{t_u}$ $P_{u\_SI} = 9.809916 \times 10^5$ J/sec (53c)

i. electric voltage

Electric voltage is simply electric force. It is unit power divided by unit current.

$$V_u := \frac{t_u}{{s_u}^2} \qquad V_u = 7.316890 \times 10^{-6} \quad \text{sec/cm}^2 \qquad (54a)$$

$$V_{u\_cgs} := \frac{P_{u\_cgs}}{i_{u\_cgs}} \qquad V_{u\_cgs} = 3.105955 \times 10^{6} \quad \text{statvolts} \qquad (54b)$$

$$V_{u\_SI} := \frac{P_{u\_SI}}{i_{u\_SI}} \qquad V_{u\_SI} = 9.311435 \times 10^{8} \quad \text{volts} \qquad (54c)$$

j. electric field intensity

Electric field intensity is electric voltage per unit distance.

$E_u := \frac{t_u}{{s_u}^3}$	$E_u = 1.604998$	sec/cm^3	(55a)
$E_{u\_cgs} := \frac{V_{u\_cgs}}{s_u}$	$E_{u\_cgs} = 6.813073 \times 10^{11}$	statvolts/cm	(55b)
$E_{u\_SI} := \frac{V_{u\_SI}}{s_{u\_SI}}$	$E_{u\_SI} = 2.042512 \times 10^{16}$	volts/m	(55c)
$E_{t\_u} := \frac{t_u}{{s_u}^2 \cdot s_{t\_u}}$	$E_{t\_u} = 2.510929 \times 10^{2}$	sec/cm^3	(56a)
$E_{t\_u\_cgs} := \frac{V_{u\_cgs}}{s_{t\_u}}$	$E_{t\_u\_cgs} = 1.065867 \times 10^{14}$	statvolt/cm	(56b)
$E_{t\_u\_SI} := \frac{V_{u\_SI}}{s_{t\_u\_SI}}$	$E_{t\_u\_SI} = 3.195395 \times 10^{18}$	volts/m	(56c)

k. electric flux density

Electric flux density is electric charge per unit area.

$$D_u := \frac{\left(\frac{t_u}{s_u}\right)}{s_u^{\,2}} \qquad D_u = 1.604998 \qquad \text{sec/cm}^3 \qquad (57a)$$

$$D_{u\_cgs} := \frac{Q_{u\_cgs}}{s_u^{\,2}} \qquad D_{u\_cgs} = 2.310983 \times 10^{1} \qquad \text{esu}_{\text{charge}}/\text{cm}^2 \qquad (57b)$$

$$D_{u\_SI} := \frac{Q_{u\_SI}}{s_{u\_SI}^{\,2}} \qquad D_{u\_SI} = 7.708594 \times 10^{-5} \qquad \text{coulombs}_{\text{charge}}/\text{m}^2 \qquad (57c)$$

$$D_{t\_u} := \frac{\left(\frac{t_u}{s_u}\right)}{s_{t\_u}^{\,2}} \qquad D_{t\_u} = 3.928208 \times 10^{4} \qquad \text{sec/cm}^3 \qquad (58a)$$

$$D_{t\_u\_cgs} := \frac{Q_{u\_cgs}}{s_{t\_u}^{\,2}} \qquad D_{t\_u\_cgs} = 5.656096 \times 10^{5} \qquad \text{esu}_{\text{charge}}/\text{cm}^2 \qquad (58b)$$

$$D_{t\_u\_SI} := \frac{Q_{u\_SI}}{s_{t\_u\_SI}^{\,2}} \qquad D_{t\_u\_SI} = 1.886667 \qquad \text{coulombs}_{\text{charge}}/\text{m}^2 \qquad (59c)$$

I. electric resistance

Electric resistance is electric voltage divided by electric current. It's also equal to mass per unit time.

$$R_u := \frac{\frac{t_u^3}{s_u^3}}{t_u} \qquad R_u = 2.440648 \times 10^{-16} \quad \text{sec}^2/\text{cm}^3 \qquad (60a)$$

$$R_{u\_cgs} := \frac{V_{u\_cgs}}{i_{u\_cgs}} \qquad R_{u\_cgs} = 9.833881 \times 10^{-1} \quad \text{statohms} \qquad (60b)$$

$$R_{u\_SI} := \frac{V_{u\_SI}}{i_{u\_SI}} \qquad R_{u\_SI} = 8.838284 \times 10^{11} \quad \text{ohms} \qquad (60c)$$

$$E_u := \frac{t_u}{s_u} \qquad E_u = 3.335636 \times 10^{-11} \quad \text{sec/cm} \qquad i_u^2 \cdot R_u \cdot t_u = 3.335636 \times 10^{-11} \quad \text{sec/cm} \qquad \text{[checks]}$$

m. electric conductance

Electric conductance is the inverse of electric resistance.

$$G_u := \frac{t_u}{\frac{t_u^3}{s_u^3}}$$ $G_u = 4.097273 \times 10^{15}$ cm^3/sec^2 (61a)

$$G_{u\_cgs} := \frac{i_{u\_cgs}}{V_{u\_cgs}}$$ $G_{u\_cgs} = 1.016893$ statmhos (61b)

$$G_{u\_SI} := \frac{i_{u\_SI}}{V_{u\_SI}}$$ $G_{u\_SI} = 1.131441 \times 10^{-12}$ mhos (61c)

n. electric resistivity

Electric resistivity is resistance times distance. Crystal unit cell parameters determine this value, and so the time region unit of space must be used.

$\rho_{t\_u} := R_u \cdot s_{t\_u}$ $\quad\rho_{t\_u} = 7.112089 \times 10^{-24}$ $\quad sec^2/cm^2$ (62a)

$\rho_{t\_u\_cgs} := R_{u\_cgs} \cdot s_{t\_u}$ $\quad\rho_{t\_u\_cgs} = 2.865609 \times 10^{-8}$ $\quad$ statohms cm (62b)

$\rho_{t\_u\_SI} := R_{u\_SI} \cdot s_{t\_u\_SI}$ $\quad\rho_{t\_u\_SI} = 2.575491 \times 10^{2}$ $\quad$ ohms m (62c)

o. electric conductivity

Electric conductivity is the inverse of electric resistivity.

$\sigma_{t\_u} := \frac{1}{\rho_{t\_u}}$ $\quad\sigma_{t\_u} = 1.406057 \times 10^{23}$ $\quad cm^2/sec^2$ (63a)

$\sigma_{t\_u\_cgs} := \frac{1}{\rho_{t\_u\_cgs}}$ $\quad\sigma_{t\_u\_cgs} = 3.489659 \times 10^{7}$ $\quad$ statmhos/cm (63b)

$\sigma_{t\_u\_SI} := \frac{1}{\rho_{t\_u\_SI}}$ $\quad\sigma_{t\_u\_SI} = 3.882755 \times 10^{-3}$ $\quad$ mhos/m (63c)

p. electric permittivity (free space)

$\varepsilon_0 := \frac{s_u^2}{t_u}$ $\varepsilon_0 = 1.366701 \times 10^5$ cm²/sec (64a)

$\varepsilon_{0\_cgs} := 1$ (by definition in cgs) (64b)

$\varepsilon_{0\_SI} := 8.854188 \cdot 10^{-12}$ farad/m (by definition in SI) (64c)

q. electric susceptibility (free space)

By definition,

$\varepsilon_{0\_r} := 1$ (relative permittivity of free space) (65a)

$\chi_{\varepsilon\_u} := 1 - \varepsilon_{0\_r}$ $\chi_{\varepsilon\_u} = 0.000000$ $\chi_{\varepsilon\_u\_cgs} := 0$ $\chi_{\varepsilon\_u\_SI} := 0$ (65b)

The cgs and SI units are also the same: 0.

r. electric capacitance

Only the time-space region value applies, because unit capacitance is equal to the unit of time divided by the unit of resistance.

$$C_u := \frac{{s_u}^3}{t_u} \qquad C_u = 6.230538 \times 10^{-1} \quad \text{cm}^3\text{/sec} \qquad (66a)$$

To get the corresponding cgs and SI units, we note that the time constant, RC, of an RC DC circuit, must be equal to unit time.

$$C_{u\_cgs} := \frac{t_u}{R_{u\_cgs}} \qquad C_{u\_cgs} = 1.546343 \times 10^{-16} \quad \text{statfarads} \qquad (66b)$$

$$C_{u\_SI} := \frac{t_u}{R_{u\_SI}} \qquad C_{u\_SI} = 1.720532 \times 10^{-28} \quad \text{farads} \qquad (66c)$$

Note that

$$C_{u\_SI} \cdot V_{u\_SI} = 1.602062 \times 10^{-19} \quad \text{coulombs\_q} \quad \text{as it should}$$

Also:

$$E_u := \frac{t_u}{s_u} \qquad E_u = 3.335636 \times 10^{-11} \quad \text{sec/cm} \qquad C_u \cdot {V_u}^2 = 3.335636 \times 10^{-11} \quad \text{sec/cm} \qquad \text{[checks]}$$

s. electric displacement

By definition, electric displacement is electric quantity per unit area:

$D_u := \frac{s_u}{s_u^2}$ $D_u = 2.193552 \times 10^5$ cm^{-1} (67a)

$D_{u\_cgs} := \frac{q_{u\_cgs}}{s_u^2}$ $D_{u\_cgs} = 2.310983 \times 10^1$ $esu_{quantity}/cm^2$ (67b)

$D_{u\_SI} := \frac{q_{u\_SI}}{s_{u\_SI}^2}$ $D_{u\_SI} = 7.708594 \times 10^{-5}$ $coulombs_{quantity}/m^2$ (67c)

$D_{t\_u} := \frac{s_u}{s_{t\_u}^2}$ $D_{t\_u} = 5.368686 \times 10^9$ cm^{-1} (68a)

$D_{t\_u\_cgs} := \frac{q_{u\_cgs}}{s_{t\_u}^2}$ $D_{t\_u\_cgs} = 5.656096 \times 10^5$ $esu_{quantity}/cm^2$ (68b)

$D_{t\_u\_SI} := \frac{q_{u\_SI}}{s_{t\_u\_SI}^2}$ $D_{t\_u\_SI} = 1.886667$ $coulombs_{quantity}/m^2$ (68c)

t. electric polarization

By definition, electric polarization is electric displacement minus the permittivity of free space times the electric field intensity. Therefore the natural units are the same as those for electric displacement.

$P_u := \frac{s_u}{s_u^2}$ $P_u = 2.193552 \times 10^5$ cm^{-1} (69a)

$P_{u\_cgs} := \frac{q_{u\_cgs}}{s_u^2}$ $P_{u\_cgs} = 2.310983 \times 10^1$ $esu_{quantity}/cm^2$ (69b)

$P_{u\_SI} := \frac{q_{u\_SI}}{s_{u\_SI}^2}$ $P_{u\_SI} = 7.708594 \times 10^{-5}$ $coulombs_{quantity}/m^2$ (69c)

$P_{t\_u} := \frac{s_u}{s_{t\_u}^2}$ $P_{t\_u} = 5.368686 \times 10^9$ cm^{-1} (70a)

$P_{t\_u\_cgs} := \frac{q_{u\_cgs}}{s_{t\_u}^2}$ $P_{t\_u\_cgs} = 5.656096 \times 10^5$ $esu_{quantity}/cm^2$ (70b)

$P_{t\_u\_SI} := \frac{q_{u\_SI}}{s_{t\_u\_SI}^2}$ $P_{t\_u\_SI} = 4.008162 \times 10^1$ $coulombs_{quantity}/m^2$ (70c)

Note that, unlike conventional theory, the esu and coulombs here are electric quantities, not electric charges: ordinary capacitors store massless, chargeless electrons, not charged electrons.

3. Magnetic Units

Magnetic quantities which are analogous to electric quantities have the dimensions of the corresponding electric quantities multiplied by t/s.

a. magnetic charge or flux

Real magnetic charges exist in the Reciprocal System, unlike in Quantum Mechanics.

$M_u := \frac{t_u^2}{s_u^2}$ $M_u = 1.112646 \times 10^{-21}$ sec^2/cm^2 (70a)

$M_{u\_cgs} := \frac{Q_{u\_cgs}}{c_u}$ $M_{u\_cgs} = 1.602062 \times 10^{-20}$ emu (70b)

$M_{u\_SI} := M_{u\_cgs} \cdot 299.7925$ $M_{u\_SI} = 4.802863 \times 10^{-18}$ weber (70c)

b. Larson magneton

This is to the Reciprocal System what the Bohr magneton is to Quantum Mechanics.

$D_u := 3.359 \cdot 10^{-13}$ cm

$D_{u\_SI} := 3.359 \cdot 10^{-15}$ m

$\mu_{L\_u} := \frac{t_u^{\,2}}{s_u^{\,2}} \cdot D_u$ $\qquad \mu_{L\_u} = 3.737380 \times 10^{-34}$ sec²/cm (71a)

$\mu_{L\_cgs} := \frac{M_{u\_cgs} \cdot D_u}{\sqrt{\frac{c_u}{1}}}$ $\qquad \mu_{L\_cgs} = 3.107984 \times 10^{-38}$ emu cm (71b)

$\mu_{L\_SI} := \frac{M_{u\_SI} \cdot D_{u\_SI}}{\sqrt{\frac{c_{u\_SI}}{1}}}$ $\qquad \mu_{L\_SI} = 9.317503 \times 10^{-37}$ weber m (71c)

c. magnetic dipole moment

Magnetic dipole moment is magnetic charge times distance.

$\mu_u := \frac{t_u^2}{s_u}$	$\mu_u = 5.072351 \times 10^{-27}$	sec²/cm	(72a)
$\mu_{u\_cgs} := M_{u\_cgs} \cdot s_u$	$\mu_{u\_cgs} = 7.303508 \times 10^{-26}$	emu cm	(72b)
$\mu_{u\_SI} := M_{u\_SI} \cdot s_{u\_SI}$	$\mu_{u\_SI} = 0.000000$	weber m	(72c)
$\mu_{t\_u} := \frac{t_u^2}{s_u^2} \cdot s_{t\_u}$	$\mu_{t\_u} = 3.242271 \times 10^{-29}$	sec²/cm	(73a)
$\mu_{t\_u\_cgs} := M_{u\_cgs} \cdot s_{t\_u}$	$\mu_{t\_u\_cgs} = 4.668437 \times 10^{-28}$	emu cm	(73b)
$\mu_{t\_u\_SI} := M_{u\_SI} \cdot s_{t\_u\_SI}$	$\mu_{t\_u\_SI} = 1.399562 \times 10^{-27}$	weber m	(73c)

d. magnetic moment from current

$\mu_{c\_u} := \frac{s_u}{t_u} \cdot s_u^{2}$ $\mu_{c\_u} = 6.230538 \times 10^{-1}$ cm³/sec (74a)

$\mu_{c\_u\_cgs} := i_{u\_cgs} \cdot s_u^{2}$ $\mu_{c\_u\_cgs} = 6.564086 \times 10^{-5}$ $(esu_{quantity}/sec)\ cm^2$ (74b)

$\mu_{c\_u\_SI} := i_{u\_SI} \cdot s_{u\_SI}^{2}$ $\mu_{c\_u\_SI} = 2.189539 \times 10^{-18}$ amps m^2 (74c)

$\mu_{c\_t\_u} := \frac{s_u}{t_u} \cdot s_{t\_u}^{2}$ $\mu_{c\_t\_u} = 2.545690 \times 10^{-5}$ cm^3/sec (75a)

$\mu_{c\_t\_u\_cgs} := i_{u\_cgs} \cdot s_{t\_u}^{2}$ $\mu_{c\_t\_u\_cgs} = 2.681972 \times 10^{-9}$ $(esu_{quantity}/sec)\ cm^2$ (75b)

$\mu_{c\_t\_u\_SI} := i_{u\_SI} \cdot s_{t\_u\_SI}^{2}$ $\mu_{c\_t\_u\_SI} = 8.946081 \times 10^{-23}$ amps m^2 (75c)

e. magnetic flux density

Magnetic flux density is magnetic charge per unit area.

$B_u := \frac{t_u^2}{s_u^4}$ $B_u = 5.353688 \times 10^{-11}$ sec²/cm⁴ (76a)

$B_{u\_cgs} := \frac{M_{u\_cgs}}{s_u^2}$ $B_{u\_cgs} = 7.708596 \times 10^{-10}$ emu/cm² (76b)

$B_{u\_SI} := \frac{M_{u\_SI}}{s_{u\_SI}^2}$ $B_{u\_SI} = 2.310979 \times 10^{-3}$ weber/m² (76c)

$B_{t\_u} := \frac{t_u^2}{s_u^2 \cdot s_{t\_u}^2}$ $B_{t\_u} = 1.310307 \times 10^{-6}$ sec²/cm⁴ (77a)

$B_{t\_u\_cgs} := \frac{M_{u\_cgs}}{s_{t\_u}^2}$ $B_{t\_u\_cgs} = 1.886667 \times 10^{-5}$ emu/cm² (77b)

$B_{t\_u\_SI} := \frac{M_{u\_SI}}{s_{t\_u\_SI}^2}$ $B_{t\_u\_SI} = 5.656086 \times 10^{1}$ weber/m² (77c)

Incidentally, 1 weber/m² = 1 tesla = 10000 gauss.

f. magnetic permeability (free space)

$\mu_0 := \dfrac{t_u^{\,3}}{s_u^{\,4}}$ $\mu_0 = 8.141112 \times 10^{-27}$ sec^3/cm^4 (78a)

$\mu_{0\_cgs} := 1$ $\mu_{0\_cgs} = 1.000000$ (dimensionless) (78b)

$\mu_{0\_SI} := 4\cdot\pi\cdot 10^{-7}$ $\mu_{0\_SI} = 1.256637 \times 10^{-6}$ henries/m (78c)

g. magnetic susceptibility (free space)

By definition,

$\mu_{0\_r} := 1$ (relativity permeability of free space) (79a)

$\chi_{\mu\_u} := 1 - \mu_{0\_r}$ $\chi_{\mu\_u} = 0.000000$ $\chi_{\mu\_u\_cgs} := 0$ $\chi_{\mu\_u\_SI} := 0$ (79b)

The cgs and SI units are also the same: 0. Remember that

$$\chi_{\mu\_cgs} := \frac{\chi_{\mu\_SI}}{4\cdot\pi}$$

h. magnetic field intensity

Magnetic field intensity is defined as magnetic flux density divided by magnetic permeability. We generally prefer to use external magnetic flux density (divided by μ_0) rather than this.

$H_u := \frac{B_u}{\mu_0}$ $H_u = 6.576114 \times 10^{15}$ sec^{-1} (80a)

$H_{u\_cgs} := \frac{B_{u\_cgs}}{\mu_{0\_cgs}}$ $H_{u\_cgs} = 7.708596 \times 10^{-10}$ emu/cm^2 (80b)

$H_{u\_SI} := \frac{B_{u\_SI}}{\mu_{0\_SI}}$ $H_{u\_SI} = 1.839019 \times 10^{3}$ (weber/m)/(henry) (80c)

$H_{t\_u} := \frac{B_{t\_u}}{\mu_0}$ $H_{t\_u} = 1.609494 \times 10^{20}$ sec^{-1} (81a)

$H_{t\_u\_cgs} := \frac{B_{t\_u\_cgs}}{\mu_{0\_cgs}}$ $H_{t\_u\_cgs} = 1.886667 \times 10^{-5}$ emu/cm^2 (81b)

$H_{t\_u\_SI} := \frac{B_{t\_u\_SI}}{\mu_{0\_SI}}$ $H_{t\_u\_SI} = 4.500971 \times 10^{7}$ (weber/m)/(henry) (81c)

i. magnetomotive force and magnetic vector potential

Magnetomotive force and magnetic vector potential are the same: electric force times t/s.

$$F_{M\_u} := \frac{t_u^{\ 2}}{s_u^{\ 3}} \qquad F_{M\_u} = 2.440648 \times 10^{-16} \qquad sec^2/cm^3 \qquad (82a)$$

The conventional units for magnetomotive force are mistakenly defined thusly:

$$F_{M\_u\_cgs} := i_{u\_cgs} \cdot \mu_{0\_cgs} \qquad F_{M\_u\_cgs} = 3.158422 \times 10^{6} \qquad \text{"(esu}_{quantity}\text{/sec) turns"}$$

$$F_{M\_u\_SI} := i_{u\_SI} \cdot \mu_{0\_SI} \qquad F_{M\_u\_SI} = 1.323910 \times 10^{-9} \qquad \text{"amp turns"}$$

But magnetic force cannot have the dimensions given. The correct values are

$$F_{M\_u\_cgs} := \frac{M_{u\_cgs}}{s_u} \qquad F_{M\_u\_cgs} = 3.514207 \times 10^{-15} \qquad emu/cm \qquad (82b)$$

$$F_{M\_u\_SI} := \frac{M_{u\_SI}}{s_{u\_SI}} \qquad F_{M\_u\_SI} = 1.053533 \times 10^{-10} \qquad weber/m \qquad (82c)$$

Note: If using magnetic vector potential instead of magnetomotive force, subsitute A_u for F_{M_u} in the above equations.

For the time region:

$$F_{M\_t\_u} := \frac{t_u^{\,2}}{s_u^{\,2} \cdot s_{t\_u}} \qquad F_{M\_t\_u} = 3.818257 \times 10^{-14} \quad \text{sec}^2/\text{cm}^3 \qquad (83a)$$

$$F_{M\_t\_u\_cgs} := \frac{M_{u\_cgs}}{s_{t\_u}} \qquad F_{M\_t\_u\_cgs} = 5.497780 \times 10^{-13} \quad \text{emu/cm} \qquad (83b)$$

$$F_{M\_t\_u\_SI} := \frac{M_{u\_SI}}{s_{t\_u\_SI}} \qquad F_{M\_t\_u\_SI} = 1.648193 \times 10^{-8} \quad \text{weber/m} \qquad (83c)$$

Note: If using magnetic vector potential instead of magnetormotive force, substitue A_{t_u} for $F_{M\_t\_u}$ in the above equations.

j. magnetic polarization

Magnetic polarization has the same dimensions as magnetic flux density.

$P_{M\_u} := \frac{t_u^2}{s_u^4}$ $P_{M\_u} = 5.353688 \times 10^{-11}$ sec²/cm⁴ (84a)

$P_{M\_u\_cgs} := \frac{M_{u\_cgs}}{s_u^2}$ $P_{M\_u\_cgs} = 7.708596 \times 10^{-10}$ emu/cm² (84b)

$P_{M\_u\_SI} := \frac{M_{u\_SI}}{s_{u\_SI}^2}$ $P_{M\_u\_SI} = 2.310979 \times 10^{-3}$ webers/m² (84c)

$P_{M\_t\_u} := \frac{t_u^2}{s_u^2 \cdot s_{t\_u}^2}$ $P_{M\_t\_u} = 1.310307 \times 10^{-6}$ sec²/cm⁴ (85a)

$P_{M\_t\_u\_cgs} := \frac{M_{u\_cgs}}{s_{t\_u}^2}$ $P_{M\_t\_u\_cgs} = 1.886667 \times 10^{-5}$ emu/cm² (85b)

$P_{M\_t\_u\_SI} := \frac{M_{u\_SI}}{s_{t\_u\_SI}^2}$ $P_{M\_t\_u\_SI} = 5.656086 \times 10^{1}$ webers/m² (85c)

k. magnetic inductance

By reason of consistency with the resistance units, only the time-space value applies.

$L_u := \frac{t_u^3}{s_u^3}$ $L_u = 3.711383 \times 10^{-32}$ sec^3/cm^3 (86a)

$L_{u\_cgs} := R_{u\_cgs} \cdot t_u$ $L_{u\_cgs} = 1.495394 \times 10^{-16}$ stathenries (86b)

$L_{u\_SI} := R_{u\_SI} \cdot t_u$ $L_{u\_SI} = 1.343998 \times 10^{-4}$ henries (86c)

$E_u := \frac{t_u}{s_u}$ $E_u = 3.335636 \times 10^{-11}$ sec/cm $L_u \cdot i_u^2 = 3.335636 \times 10^{-11}$ sec/cm [checks]

I. magnetization

Magnetization has the same dimensions and natural units as magnetic field intensity.

$M_{M\_u} := H_u$	$M_{M\_u} = 6.576114 \times 10^{15}$	sec^{-1}	(87a)
$M_{M\_u\_cgs} := H_{u\_cgs}$	$M_{M\_u\_cgs} = 7.708596 \times 10^{-10}$	emu/cm^2	(87b)
$M_{M\_u\_SI} := H_{u\_SI}$	$M_{M\_u\_SI} = 1.839019 \times 10^{3}$	(weber/m)/(henry)	(87c)
$M_{M\_t\_u} := H_{t\_u}$	$M_{M\_t\_u} = 1.609494 \times 10^{20}$	sec^{-1}	(88a)
$M_{M\_t\_u\_cgs} := H_{t\_u\_cgs}$	$M_{M\_t\_u\_cgs} = 1.886667 \times 10^{-5}$	emu/cm^2	(88b)
$M_{M\_t\_u\_SI} := H_{t\_u\_SI}$	$M_{M\_t\_u\_SI} = 4.500971 \times 10^{7}$	(weber/m)/(henry)	(88c)

m. magnetic reluctance

Reluctance is the inverse of inductance.

$R_{M\_u} := \frac{s_u^3}{t_u^3}$ $R_{M\_u} = 2.694413 \times 10^{31}$ cm³/sec³ (89a)

$R_{M\_u\_cgs} := \frac{1}{L_{u\_cgs}}$ $R_{M\_u\_cgs} = 6.687201 \times 10^{15}$ stathenries^{-1} (89b)

$R_{M\_u\_SI} := \frac{1}{L_{u\_SI}}$ $R_{M\_u\_SI} = 7.440487 \times 10^{3}$ henries^{-1} (89c)

Supplement: The Maxwell Relations

cgs: $c_u = 2.997929 \times 10^{10}$ cm/sec $\dfrac{1}{\sqrt{\varepsilon_{0\_r} \cdot \mu_{0\_r}}} = 1.000000$ (relative to c)

SI: $c_{u\_SI} = 2.997929 \times 10^{8}$ m/sec $\dfrac{1}{\sqrt{\varepsilon_{0\_SI} \cdot \mu_{0\_SI}}} = 2.997925 \times 10^{8}$ m/sec

$c_u = 2.997929 \times 10^{10}$ cm/sec $\dfrac{1}{\sqrt{\varepsilon_{0} \cdot \mu_{0}}} = 2.997929 \times 10^{10}$ cm/sec

For cgs we have to use the relative permittivity and relative permeability of free space. Otherwise, the calculations come out to the speed of light, as required.

Incidentally, here is a comparison of the natural unit ratios and the conventional ratios:

$\dfrac{\varepsilon_0}{\mu_0} = 1.678764 \times 10^{31}$ $\dfrac{\varepsilon_{0\_SI}}{\mu_{0\_SI}} = 7.045939 \times 10^{-6}$ (The SI values are arbitrarily selected.)

4. Thermal Units

a. temperature

Gas constant (given): $R_{cgs} := 1.9869$ cal/mol K

$conv_{caltoJ} := 4.1868$ $R_{SI} := conv_{caltoJ} \cdot R_{cgs}$ $R_{SI} = 8.318753$ J/mol K

$conv_{caltoergs} := 4.1868 \cdot 10^{7}$ $R_{erg} := R_{cgs} \cdot conv_{caltoergs}$ $R_{erg} = 8.318753 \times 10^{7}$ erg/mol K

Avogadro's number (given): $Av := 6.02486 \cdot 10^{23}$ (atoms or molecules)/gram-mole

Boltzmann's constant (calculated): $k_B := \dfrac{R_{erg}}{Av}$ $k_B = 1.380738 \times 10^{-16}$ ergs/K per atom or molecule

Natural unit of energy (from above): $E_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $E_{u\_cgs} = 1.491750 \times 10^{-3}$ ergs

Natural unit of gas temperature: $T_{G\_u} := \dfrac{E_{u\_cgs}}{\frac{3}{2} \cdot k_B}$ $T_{G\_u} = 7.202668 \times 10^{12}$ K (90)

Larson's calculated value in Ref. [2], p. 59 is 7.20423 x 10^{12}. $\frac{7.20423 \cdot 10^{12}}{7.202668 \cdot 10^{12}} = 1.000217$ a minor difference

(Both values will be displayed in the Table below.)

The thermal energy of radiation is proportional to the fourth power of temperature--this is known as the Stefan-Boltzmann law. When the thermal motion reaches the time region boundary, the thermal energy becomes proportional to the third power of temperature. Therefore, for the vapor state:

$$T_{V\_u} := T_{G\_u}^{\frac{3}{4}} \qquad T_{V\_u} = 4.396631 \times 10^{9} \quad K \tag{91a}$$

Larson, Ref. [2], p. 59, points out that "...the thermal motion is a motion of matter and involves the 2/9 vibrational addition to the rotationally distributed linear motion of the atoms. This reduces the effective temperature by the factor 1 + 2/9."

Natural unit of vapor temperature: $$T_{V\_u} := \frac{T_{G\_u}^{\frac{3}{4}}}{1 + \frac{2}{9}} \qquad T_{V\_u} = 3.597244 \times 10^{9} \quad K \tag{91b}$$

Larson's calculates 3.5978 x 10^{9} K. Given the uncertainty in k_B we can continue to use the values given in Ref. [2]. Both values will be given in the Table.

For the condensed states of matter, solids and liquids, we reduce the above three-dimensional unit to the one-dimensional basis and multiply by 1/3.

Natural unit of liquid and solid temperature:

$$T_{SL\_u} := \frac{1}{3} \cdot T_{V\_u}^{\frac{1}{3}} \qquad T_{SL\_u} = 510.742549 \quad K \qquad (92)$$

Larson calculates 510.8 K for this, and we can continue to use this value--it's close enough given the uncertainties, and will also be displayed in the Table below.

b. specific heat (molar)

Gas constant (given): $R_{cgs} := 1.9869$ cal/mol K

$R_{SI} = 8.318753$ J/mol K

$R_{erg} = 8.318753 \times 10^{7}$ erg/mol K

Convert erg to natural energy units: $R_n := \dfrac{R_{erg}}{F_{u\_cgs} \cdot s_u}$ $R_n = 5.576507 \times 10^{10}$ natural_energy_units/mol K

Convert natural energy units to sec/cm: $R_u := R_n \cdot \dfrac{t_u}{s_u}$ $R_u = 1.860120$ (sec/cm)/mol K

Specific heat at constant volume (ideal gas):

$c_{v\_u} := \dfrac{3}{2} \cdot R_u$ $c_{v\_u} = 2.790180$ (sec/cm)/mol K (93a)

$c_{v\_u\_cgs} := \dfrac{3}{2} \cdot R_{cgs}$ $c_{v\_u\_cgs} = 2.980350$ cal/mol K (93b)

$c_{v\_u\_SI} := \dfrac{3}{2} \cdot R_{SI}$ $c_{v\_u\_SI} = 12.478129$ J/mol K (93c)

Note: the specific heat at constant pressure has the *same* natural unit as the specific heat at constant volume. For an ideal gas, it is equal to R + the specific heat at constant volume.

Specific heat at constant pressure (ideal gas):

$$c_{p\_u} := \frac{5}{2} \cdot R_u \qquad c_{p\_u} = 4.650299 \quad \text{(sec/cm)/mol K} \qquad (94a)$$

$$c_{p\_u\_cgs} := \frac{5}{2} \cdot R_{cgs} \qquad c_{p\_u\_cgs} = 4.967250 \quad \text{cal/mol K} \qquad (94b)$$

$$c_{p\_u\_SI} := \frac{5}{2} \cdot R_{SI} \qquad c_{p\_u\_SI} = 20.796882 \quad \text{J/mol K} \qquad (94c)$$

The maximum thermal specific heat for solids is 3R (= 2 natural units) and this is also the basis for the specific heat calculation of liquids; see Ref. [2] and Ref. [10]. Note that for solids and liquids the specific heat at constant pressure is really more fundamental than that at constant volume.

c. specific enthalpy (molar)

Gas

$h_{u\_G} := c_{p\_u} \cdot T_{G\_u}$ $h_{u\_G} = 3.349456 \times 10^{13}$ (sec/cm)/mol (95a)

$h_{u\_G\_cgs} := c_{p\_u\_cgs} \cdot T_{G\_u}$ $h_{u\_G\_cgs} = 3.577745 \times 10^{13}$ cal/mol (95b)

$h_{u\_G\_SI} := c_{p\_u\_SI} \cdot T_{G\_u}$ $h_{u\_G\_SI} = 1.497930 \times 10^{14}$ J/mol (95c)

Vapor

$h_{u\_V} := c_{p\_u} \cdot T_{V\_u}$ $h_{u\_V} = 1.672826 \times 10^{10}$ (sec/cm)/mol (96a)

$h_{u\_V\_cgs} := c_{p\_u\_cgs} \cdot T_{V\_u}$ $h_{u\_V\_cgs} = 1.786841 \times 10^{10}$ cal/mol (96b)

$h_{u\_V\_SI} := c_{p\_u\_SI} \cdot T_{V\_u}$ $h_{u\_V\_SI} = 7.481146 \times 10^{10}$ J/mol (96c)

Solid/Liquid

$c_{p\_u} := c_{v\_u}$ $c_{p\_u\_cgs} := c_{v\_u\_cgs}$ $c_{p\_u\_SI} := c_{v\_u\_SI}$

$h_{u\_SL} := c_{p\_u} \cdot T_{SL\_u}$ $h_{u\_SL} = 1.425063 \times 10^{3}$ (sec/cm)/mol (97a)

$h_{u\_SL\_cgs} := c_{p\_u\_cgs} \cdot T_{SL\_u}$ $h_{u\_SL\_cgs} = 1.522192 \times 10^{3}$ cal/mol (97b)

$h_{u\_SL\_SI} := c_{p\_u\_SI} \cdot T_{SL\_u}$ $h_{u\_SL\_SI} = 6.373112 \times 10^{3}$ J/mol (97c)

Note that for solids and liquids, there is very little difference in specific heat at constant pressure and at constant volume; the specific heat at constant pressure is just a little higher.

c. specific internal energy (molar)

Gas

$c_{v\_u} := \frac{3}{2} \cdot R_u \quad c_{v\_u\_cgs} := \frac{3}{2} \cdot R_{cgs} \quad c_{v\_u\_SI} := \frac{3}{2} \cdot R_{SI}$

$i_{u\_G} := c_{v\_u} \cdot T_{G\_u}$ $\quad i_{u\_G} = 2.009674 \times 10^{13}$ (sec/cm)/mol (98a)

$i_{u\_G\_cgs} := c_{v\_u\_cgs} \cdot T_{G\_u}$ $\quad i_{u\_G\_cgs} = 2.146647 \times 10^{13}$ cal/mol (98b)

$i_{u\_G\_SI} := c_{v\_u\_SI} \cdot T_{G\_u}$ $\quad i_{u\_G\_SI} = 8.987583 \times 10^{13}$ J/mol (98c)

Vapor

$i_{u\_V} := c_{v\_u} \cdot T_{V\_u}$ $\quad i_{u\_V} = 1.003696 \times 10^{10}$ (sec/cm)/mol (99a)

$i_{u\_V\_cgs} := c_{v\_u\_cgs} \cdot T_{V\_u}$ $\quad i_{u\_V\_cgs} = 1.072105 \times 10^{10}$ cal/mol (99b)

$i_{u\_V\_SI} := c_{v\_u\_SI} \cdot T_{V\_u}$ $\quad h_{u\_V\_SI} = 7.481146 \times 10^{10}$ J/mol (99c)

Solid/Liquid

$i_{u\_SL} := c_{v\_u} \cdot T_{SL\_u}$ $\quad i_{u\_SL} = 1.425063 \times 10^{3}$ (sec/cm)/mol (100a)

$i_{u\_SL\_cgs} := c_{v\_u\_cgs} \cdot T_{SL\_u}$ $\quad i_{u\_SL\_cgs} = 1.522192 \times 10^{3}$ cal/mol (100b)

$i_{u\_SL\_SI} := c_{v\_u\_SI} \cdot T_{SL\_u}$ $\quad i_{u\_SL\_SI} = 6.373112 \times 10^{3}$ J/mol (100c)

For solids and liquids, actual internal energy is just a little less than the enthalpy.

d. specific entropy (molar)

The natural unit of specific entropy is the same as the natural unit of specific heat.

$S_u := c_{v\_u}$	$S_u = 2.790180$	(sec/cm)/mol K	(101a)
$S_{u\_cgs} := c_{v\_u\_cgs}$	$S_{u\_cgs} = 2.980350$	cal/mol K	(101b)
$S_{u\_SI} := c_{v\_u\_SI}$	$S_{u\_SI} = 12.478129$	J/mol K	(101c)

e. thermal resistance

Natural unit of energy:

$E_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $\qquad E_{u\_cgs} = 1.491750 \times 10^{-3}$ ergs

$E_{u\_SI} := F_{u\_SI} \cdot s_{u\_SI}$ $\qquad E_{u\_SI} = 1.491750 \times 10^{-10}$ J

Natural unit of power:

$P_u := \frac{1}{s_u}$ $\qquad P_u = 2.193552 \times 10^{5}$ cm^{-1}

$P_{u\_cgs} := \frac{E_{u\_cgs}}{t_u}$ $\qquad P_{u\_cgs} = 9.809916 \times 10^{12}$ ergs/sec

$P_{u\_SI} := \frac{E_{u\_SI}}{t_u}$ $\qquad P_{u\_SI} = 9.809916 \times 10^{5}$ J/sec (watts)

Natural unit of thermal resistance:

$R_{\theta\_u} := \frac{T_{G\_u}}{P_u}$ $\qquad R_{\theta\_u} = 3.283564 \times 10^{7}$ K cm (102a)

$R_{\theta\_u\_cgs} := \frac{T_{G\_u}}{P_{u\_cgs}}$ $\qquad R_{\theta\_u\_cgs} = 7.342233 \times 10^{-1}$ K/(ergs/sec) (102b)

$R_{\theta\_u\_SI} := \frac{T_{G\_u}}{P_{u\_SI}}$ $\qquad R_{\theta\_u\_SI} = 7.342233 \times 10^{6}$ K/watt (102c)

Like electrical resistance, there is no distinction here between the time-space region and time region. The massless, chargeless electrons in a solid are like a gas.

f. thermal conductance

Thermal conductance is the inverse of thermal resistance.

$$S_{\theta\_u} := \frac{1}{R_{\theta\_u}} \qquad S_{\theta\_u} = 3.045471 \times 10^{-8} \qquad \text{1/(K cm)} \qquad (103a)$$

$$S_{\theta\_u\_cgs} := \frac{1}{R_{\theta\_u\_cgs}} \qquad S_{\theta\_u\_cgs} = 1.361984 \qquad \text{(erg/sec)/K} \qquad (103b)$$

$$S_{\theta\_u\_SI} := \frac{1}{R_{\theta\_u\_SI}} \qquad S_{\theta\_u\_SI} = 1.361984 \times 10^{-7} \qquad \text{watt/K} \qquad (103c)$$

g. thermal resistivity

Thermal resistivity is thermal resistance times distance. As with electrical resistivity, here we have to use the time region value of space.

$\rho_{\theta\_u} := R_{\theta\_u} \cdot s_{t\_u}$ $\rho_{\theta\_u} = 9.568360 \times 10^{-1}$ cm sec (104a)

$\rho_{\theta\_u\_cgs} := R_{\theta\_u\_cgs} \cdot s_{t\_u}$ $\rho_{\theta\_u\_cgs} = 2.139539 \times 10^{-8}$ K cm sec/erg (104b)

$\rho_{\theta\_u\_SI} := R_{\theta\_u\_SI} \cdot s_{t\_u\_SI}$ $\rho_{\theta\_u\_SI} = 2.139539 \times 10^{-3}$ K m / watt (104c)

A common unit used in practice is K cm / watt, giving a natural unit of .2139539.

h. thermal conductivity

Thermal conductivity is the inverse of thermal resistivity.

$$\kappa_{\theta\_u} := \frac{1}{\rho_{\theta\_u}} \qquad \kappa_{\theta\_u} = 1.045111 \qquad cm^{-1}\ sec^{-1} \qquad (105a)$$

$$\kappa_{\theta\_u\_cgs} := \frac{1}{\rho_{\theta\_u\_cgs}} \qquad \kappa_{\theta\_u\_cgs} = 4.673904 \times 10^{7} \qquad \text{(erg/sec)/(K cm)} \qquad (105b)$$

$$\kappa_{\theta\_u\_SI} := \frac{1}{\rho_{\theta\_u\_SI}} \qquad \kappa_{\theta\_u\_SI} = 4.673904 \times 10^{2} \qquad \text{watt/(K m)} \qquad (105c)$$

A common unit used in practice is watt/(K cm), giving a natural unit of 4.673904.

i. thermal diffusivity

By definition:

Gases (time-space region)

$$\alpha_u := \frac{{s_u}^2}{t_u} \qquad \alpha_u = 1.366701 \times 10^5 \quad \text{cm}^2\text{/sec} \qquad (106a)$$

$$\alpha_{u\_cgs} := \alpha_u \qquad \alpha_{u\_cgs} = 1.366701 \times 10^5 \quad \text{cm}^2\text{/sec} \qquad (106b)$$

$$\alpha_{u\_SI} := \frac{{s_{u\_SI}}^2}{t_u} \qquad \alpha_{u\_SI} = 1.366701 \times 10^1 \quad \text{m}^2\text{/sec} \qquad (106c)$$

Solids and Liquids (time region)

$$\alpha_{t\_u} := \frac{{s_{t\_u}}^2}{t_u} \qquad \alpha_{t\_u} = 5.584103 \quad \text{cm}^2\text{/sec} \qquad (107a)$$

$$\alpha_{t\_u\_cgs} := \alpha_{t\_u} \qquad \alpha_{t\_u\_cgs} = 5.584103 \quad \text{cm}^2\text{/sec} \qquad (107b)$$

$$\alpha_{t\_u\_SI} := \frac{{s_{t\_u\_SI}}^2}{t_u} \qquad \alpha_{t\_u\_SI} = 5.584104 \times 10^{-4} \quad \text{m}^2\text{/sec} \qquad (107c)$$

5. Photonic Units

See Ref. [6], pp. 12-14, for a good review of these units. These are defined for large numbers of photons, and so only the time-space region values apply.

a. energy of unit frequency photon

$E_u := \frac{t_u}{s_u}$ $E_u = 3.335636 \times 10^{-11}$ sec/cm

$E_{u\_cgs} := F_{u\_cgs} \cdot s_u$ $E_{u\_cgs} = 1.491750 \times 10^{-3}$ ergs

$h := 4.14 \cdot 10^{-15}$ eV sec (Planck's constant)

$conv_{eVtoergs} := 1.602 \cdot 10^{-12}$ $conv_{eVtoJ} := 1.602 \cdot 10^{-19}$

$E_{u\_photon} := h \cdot R$ $E_{u\_photon} = 13.612556$ eV (108a)

$E_{u\_photon\_cgs} := h \cdot R \cdot conv_{eVtoergs}$ $E_{u\_photon\_cgs} = 2.180731 \times 10^{-11}$ ergs (108b)

$E_{u\_photon\_SI} := h \cdot R \cdot conv_{eVtoJ}$ $E_{u\_photon\_SI} = 2.180731 \times 10^{-18}$ J (108c)

In terms of sec/cm: $E_{u\_photon\_cgs} \cdot \frac{E_u}{E_{u\_cgs}} = 4.876238 \times 10^{-19}$ sec/cm (108d)

b. radiant energy exposure

Radiant energy exposure is defined as the ratio of energy of radiation falling on a surface to the area of the surface.

$H_{e\_u} := \dfrac{E_u}{{s_u}^2}$ $\quad H_{e\_u} = 1.604998$ $\quad$ sec/cm^3 $\quad$ (109a)

$H_{e\_u\_cgs} := \dfrac{E_{u\_cgs}}{{s_u}^2}$ $\quad H_{e\_u\_cgs} = 7.177808 \times 10^7$ $\quad$ ergs/cm^2 $\quad$ (109b)

$H_{e\_u\_SI} := \dfrac{E_{u\_SI}}{{s_{u\_SI}}^2}$ $\quad H_{e\_u\_SI} = 7.177808 \times 10^4$ $\quad$ J/m^2 $\quad$ (109c)

The subscript "e" used here can be mean either "exposure" or "emitted"--the context determines which. The subscript "a" will be used for "absorbed" or "impinged."

c. radiant flux

Radiant flux is defined as the ratio of radiation energy to the time interval of the radiation transfer (which significantly exceeds the period of oscillations).

$$\Phi_{e\_u} := \frac{E_u}{t_u} \qquad \Phi_{e\_u} = 2.193552 \times 10^{5} \quad cm^{-1} \qquad (110a)$$

$$\Phi_{e\_u\_cgs} := \frac{E_{u\_cgs}}{t_u} \qquad \Phi_{e\_u\_cgs} = 9.809916 \times 10^{12} \quad ergs/sec \qquad (110b)$$

$$\Phi_{e\_u\_SI} := \frac{E_{u\_SI}}{t_u} \qquad \Phi_{e\_u\_SI} = 9.809916 \times 10^{5} \quad J/sec \quad (watts) \qquad (110c)$$

d. luminosity (radiance, emitted)

Luminosity is defined as the ratio of the radiant flux to the surface area from which this radiation is emitted.

$$M_{e\_u} := \frac{E_u}{t_u \cdot s_u^2} \qquad M_{e\_u} = 1.055465 \times 10^{16} \quad cm^{-3} \qquad (111a)$$

$$M_{e\_u\_cgs} := \frac{E_{u\_cgs}}{t_u \cdot s_u^2} \qquad M_{e\_u\_cgs} = 4.720208 \times 10^{23} \quad (ergs/sec)/cm^2 \qquad (111b)$$

$$M_{e\_u\_SI} := \frac{E_{u\_SI}}{t_u \cdot s_{u\_SI}^2} \qquad M_{e\_u\_SI} = 4.720208 \times 10^{20} \quad (J/sec)/m^2 \qquad (111c)$$

e. irradiance (absorbed)

Irradiance is the ratio of radiant flux to the area by which this radiance is absorbed. This has the same natural units as luminosity.

$$E_{a\_u} := \frac{E_u}{t_u \cdot s_u^{2}} \qquad E_{a\_u} = 1.055465 \times 10^{16} \quad cm^{-3} \qquad (112a)$$

$$E_{a\_u\_cgs} := \frac{E_{u\_cgs}}{t_u \cdot s_u^{2}} \qquad E_{a\_u\_cgs} = 4.720208 \times 10^{23} \quad (ergs/sec)/cm^{2} \qquad (112b)$$

$$E_{a\_u\_SI} := \frac{E_{u\_SI}}{t_u \cdot s_{u\_SI}^{2}} \qquad E_{a\_u\_SI} = 4.720208 \times 10^{20} \quad (J/sec)/m^{2} \qquad (112c)$$

f. radiant intensity per steradian

Radiant intensity per steradian is defined as the ratio of the radiant flux of a source to a solid angle Ω (= 1 steradian) within which this radiation is propagated.

$$I_{e\_u} := \frac{E_u}{t_u} \qquad I_{e\_u} = 2.193552 \times 10^{5} \quad \text{cm}^{-1}\ \text{sterad}^{-1} \qquad (113a)$$

$$I_{e\_u\_cgs} := \frac{E_{u\_cgs}}{t_u} \qquad I_{e\_u\_cgs} = 9.809916 \times 10^{12} \quad \text{(ergs/sec)/sterad} \qquad (113b)$$

$$I_{e\_u\_SI} := \frac{E_{u\_SI}}{t_u} \qquad I_{e\_u\_SI} = 9.809916 \times 10^{5} \quad \text{(J/sec)/sterad} \qquad (113c)$$

Incidentally, a "candela" is equal to 1/683 (J/sec) per steradian. Therefore the natural unit in candelas is

$$683 \cdot I_{e\_u\_SI} = 6.700172 \times 10^{8} \quad \text{candelas}$$

A common candle emits one candela.

g. energy brightness per steradian

Energy brightness per steradian is defined as the ratio of radiant intensity of a surface element to the area of the projection of this element on a plane perpendicular to the observed direction.

$B_{e\_u} := \frac{I_{e\_u}}{{s_u}^2}$ $B_{e\_u} = 1.055465 \times 10^{16}$ $sterad^{-1}\ cm^{-3}$ (114a)

$B_{e\_u\_cgs} := \frac{I_{e\_u\_cgs}}{{s_u}^2}$ $B_{e\_u\_cgs} = 4.720208 \times 10^{23}$ (ergs/sec)/(cm^2 sterad) (114b)

$B_{e\_u\_SI} := \frac{I_{e\_u\_SI}}{{s_{u\_SI}}^2}$ $B_{e\_u\_SI} = 4.720208 \times 10^{20}$ (J/sec)/(m^2 sterad) (114c)

h. luminous flux for a solid angle of 1 steradian

Luminous flux for a solid angle of 1 steradian is defined as the product of the light intensity and this solid angle.

$\Phi_{v\_u} := I_{e\_u}$ $\Phi_{v\_u} = 2.193552 \times 10^{5}$ steradian/cm (115a)

$\Phi_{v\_u\_cgs} := I_{e\_u\_cgs}$ $\Phi_{v\_u\_cgs} = 9.809916 \times 10^{12}$ (ergs/sec) steradian (115b)

$\Phi_{v\_u\_SI} := I_{e\_u\_SI}$ $\Phi_{v\_u\_SI} = 9.809916 \times 10^{5}$ (J/sec) steradian (115c)

Incidentally, a lumen is equal to 1 candela times 1 steradian.

i. luminous energy

Luminous energy is equal to the the luminous flux produced over time t during which luminous flux is emitted or received.

$Q_u := \Phi_{v\_u} \cdot t_u$ $Q_u = 3.335636 \times 10^{-11}$ steradian sec/cm (116a)

$Q_{u\_cgs} := \Phi_{v\_u\_cgs} \cdot t_u$ $Q_{u\_cgs} = 1.491750 \times 10^{-3}$ steradian ergs (116b)

$Q_{u\_SI} := \Phi_{v\_u\_SI} \cdot t_u$ $Q_{u\_SI} = 1.491750 \times 10^{-10}$ steradian J (116c)

j. brightness in given direction ϕ

Brightness of a luminous surface in a given direction ϕ is define as the ratio of luminous intensity in this direction in relation to the area of the projection of the luminous surface on a plane perpendicular to that direction. We assume that ϕ = 1 radian.

$$B_{\phi\_u} := \frac{I_{e\_u}}{{s_u}^2 \cdot \cos(1)} \qquad B_{\phi\_u} = 1.953471 \times 10^{16} \quad \text{cm}^{-3} \qquad (117a)$$

$$B_{\phi\_u\_cgs} := \frac{I_{e\_u\_cgs}}{{s_u}^2 \cdot \cos(1)} \qquad B_{\phi\_u\_cgs} = 8.736235 \times 10^{23} \quad \text{(ergs/sec)/cm}^2 \qquad (117b)$$

$$B_{\phi\_u\_SI} := \frac{I_{e\_u\_SI}}{{s_{u\_SI}}^2 \cdot \cos(1)} \qquad B_{\phi\_u\_SI} = 8.736235 \times 10^{20} \quad \text{(J/sec)/m}^2 \qquad (117c)$$

k. luminance (radiance, emitted over 1 steradian)

Luminance (radiance) is defined as the ratio of luminous flux emitted by a luminous surface in relation to its area.

$R_{e\_u} := \frac{\Phi_{v\_u}}{s_u^{\,2}}$ $R_{e\_u} = 1.055465 \times 10^{16}$ steradian/cm^3 (118a)

$R_{e\_u\_cgs} := \frac{\Phi_{v\_u\_cgs}}{s_u^{\,2}}$ $R_{e\_u\_cgs} = 4.720208 \times 10^{23}$ (ergs/sec) steradian/cm^2 (118b)

$R_{e\_u\_SI} := \frac{\Phi_{v\_u\_SI}}{s_{u\_SI}^{\,2}}$ $R_{e\_u\_SI} = 4.720208 \times 10^{20}$ (J/sec) steradian/m^2 (118c)

I. illuminance (intensity of illumination over 1 steradian)

Illuminance is defined as the ratio of luminous flux falling on a surface element, in relation to the area of this element.

$$I_{a\_u} := \frac{\Phi_{v\_u}}{{s_u}^2} \qquad I_{a\_u} = 1.055465 \times 10^{16} \quad \text{steradian/cm}^3 \qquad (119a)$$

$$I_{a\_u\_cgs} := \frac{\Phi_{v\_u\_cgs}}{{s_u}^2} \qquad I_{a\_u\_cgs} = 4.720208 \times 10^{23} \quad \text{steradian (ergs/sec)/cm}^2 \qquad (119b)$$

$$I_{a\_u\_SI} := \frac{\Phi_{v\_u\_SI}}{{s_{u\_SI}}^2} \qquad I_{a\_u\_SI} = 4.720208 \times 10^{20} \quad \text{steradian (J/sec)/m}^2 \qquad (119c)$$

Incidentally, a lux = 1 lumen per meter^2.

m. luminous exposure over 1 steradian

Luminous exposure is defined as the illuminance produced over time t during which the radiation occurs.

$H_{a\_u} := I_{a\_u} \cdot t_u$ $H_{a\_u} = 1.604998$ steradian sec/cm^3 (120a)

$H_{a\_u\_cgs} := I_{a\_u\_cgs} \cdot t_u$ $H_{a\_u\_cgs} = 7.177808 \times 10^7$ steradian (ergs/cm^2) (120b)

$H_{a\_u\_SI} := I_{a\_u\_SI} \cdot t_u$ $H_{a\_u\_SI} = 7.177808 \times 10^4$ steradian (J/m^2) (120c)

6. Interconversion of Units

Given that all physical quantities may be expressed in space-time units, it is possible to convert units in one group of units to units of another group. We'll give just two examples.

a. mass and inductance

By inspection:

$L_u := \frac{t_u^{\,3}}{s_u^{\,3}}$ $L_u = 3.711383 \times 10^{-32}$ sec^3/cm^3

$R_{u\_SI} := \frac{V_{u\_SI}}{i_{u\_SI}}$ $R_{u\_SI} = 8.838284 \times 10^{11}$ ohms

$L_{u\_SI} := R_{u\_SI} \cdot t_u$ $L_{u\_SI} = 1.343998 \times 10^{-4}$ henries

$m_u := \frac{t_u^{\,3}}{s_u^{\,3}}$ $m_u = 3.711383 \times 10^{-32}$ sec^3/cm^3

$m_{u\_SI} := 1.659790 \cdot 10^{-27}$ kg

$\frac{m_{u\_SI}}{L_{u\_SI}} = 1.234965 \times 10^{-23}$ kg/henry

b. mechanical force and voltage

$V_u := \frac{t_u}{{s_u}^2}$ $V_u = 7.316890 \times 10^{-6}$ sec/cm^2

$V_{u\_SI} := \frac{P_{u\_SI}}{i_{u\_SI}}$ $V_{u\_SI} = 9.311435 \times 10^{8}$ volts

$F_u := \frac{t_u}{{s_u}^2}$ $F_u = 7.316890 \times 10^{-6}$ sec/cm^2

$F_{u\_SI} := 10^{-5} \cdot F_{u\_cgs}$ $F_{u\_SI} = 3.272230 \times 10^{-3}$ N

$\frac{F_{u\_SI}}{V_{u\_SI}} = 3.514206 \times 10^{-12}$ N/volts

The Table summarizing all of the results follows.

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
space (time-space region)	s_u	s_u	4.558816e-06 cm	4.558816e-06 cm	4.558816e-08 m
space (time region)	s_{t_u}	s_u/I_R	2.914017e-08 cm	2.914017e-08 cm	2.914017e-10 m
space (atomic diameter)	D_u,d_u	$k_1 s_u$	3.359e-13 cm	3.359e-13 cm	3.359e-15 m
area (time-space region) area (time region)	A_u A_{t_u}	s_u^2 $s_{t\_u}^2$	2.078280e-11 cm^2 8.491494e-16 cm^2	2.078280e-11 cm^2 8.491494e-16 cm^2	2.078280e-15 m^2 8.491494e-20 m^2
volume (time-space region)	V_u	s_u^3	9.474498e-17 cm^3	9.474498e-17 cm^3	9.474498e-23 m^3
volume (time region--atoms)	V_{t_u}	$s_{t\_u}^3$	2.474435e-23 cm^3	2.474435e-23 cm^3	2.474435e-29 m^3
time	t_u	t_u	1.520655e-16 sec	1.520655e-16 sec	1.520655e-16 sec
linear velocity (time-space region) linear velocity (time region--atoms)	v_u v_{t_u}	s_u/t_u s_{t_u}/t_u	2.997929e+ 10 cm/sec 2.997925e+ 10 cm/sec 1.916291e+ 08 cm/sec	2.997929e+ 10 cm/sec 1.916291e+ 08 cm/sec	2.997929e+ 08 m/sec 1.916291e+ 06 m/sec
linear vibration frequency	R, ν_u	$1/(2 \times t_u)$	3.288057e+ 15 cycles/sec	3.288057e+ 15 cycles/sec	3.288057e+ 15 cycles/sec
rotational frequency in rev/sec	f_{rot_rev}	$1/(\pi \times t_u)$	2.093242e+ 15 rev/sec	2.093242e+ 15 rev/sec	2.093242e+ 15 rev/sec
rotational frequency in rad/sec	f_{rot_rad}	$2/t_u$	1.315223e+ 16 rad/sec	1.315223e+ 16 rad/sec	1.315223e+ 16 rad/sec
linear acceleration (time-space region)	a_u	s_u/t_u^2	1.971473e+ 26 cm/sec^2	1.971473e+ 26 cm/sec^2	1.971472e+ 24 m/sec^2
linear acceleration (time region) angular acceleration in rev/sec^2	a_{t_u} α_{u_rev}	s_{t_u}/t_u^2 $1/(\pi \times t_u^2)$	1.260175e+ 24 cm/sec^2 1.376540e+ 31 rev/sec^2	1.260175e+ 24 cm/sec^2 1.376540e+ 31 rev/sec^2	1.260175e+ 22 m/sec^2 1.376540e+ 31 rev/sec^2
angular acceleration in rad/sec^2	α_{u_rad}	$2/t_u^2$	8.649055e+ 31 rad/sec^2	8.649055e+ 31 rad/sec^2	8.649055e+ 31 rad/sec^2

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
mass	m_u	t_u^3/s_u^3	3.711383e-32 sec^3/cm^3	1.659790e-24 g (= 1 amu = .9996822 u)	1.659790e-27 kg (= 1 amu= .9996822u
density (time-space region)	ρ_u, d_u	t_u^3/s_u^6	3.917235e-16 sec^3/cm^6	1.751850e-08 g/cm^3	1.751850e-05 kg/m^3
density (time region--atoms)	ρ_{t_u}, d_{t_u}	$(t_u^3/s_u^3)/s_{t\_u}^3$	1.499891e-09 sec^3/cm^6	6.707752e-02 g/cm^3	6.707752e+ 01 kg/m^3
specific volume (time-space region)	V_u	$s_u^3/(t_u^3/s_u^3)$	2.552821e+ 15 cm^6/sec^3	5.708251e+ 07 cm^3/g	5.708251e+ 04 m^3/kg
specific volume (time region--atoms)	V_{t_u}	$s_{t\_u}^3/(t_u^3/s_u^3)$	6.667151e+ 08 cm^6/sec^3	1.490812e+ 01 cm^3/g (not including close packing factor .7071)	1.490812e-02 m^3/kg
linear momentum (time-space region)	M_u	t_u^2/s_u^2	1.112646e-21 sec^2/cm^2	4.975933e-14 g cm/sec	4.975933e-19 kg m/sec
linear momentum (time regon)	M_{t_u}	$(t_u^3/s_u^3)(s_{t\_u}/t_u)$	7.112089e-24 sec^2/cm^2	3.180640e-16 g cm/sec	3.180640e-21 kg m/sec
rotational momentum (time-space region)	L_u	t_u^2/s_u	5.072351e-27 sec^2/cm	2.268436e-19 g cm^2/sec	2.268436e-26 kg m^2/sec
rotational momentum (time region)	L_{t_u}	$t_u^3/s_u^3)(s_{t\_u}^2/t_u)$	2.072475e-31 sec^2/cm	9.268438e-24 g cm^2/sec	9.268438e-31 g cm^2/sec
force (time-space region)	F_u	t_u/s_u^2	7.316891e-06 sec/cm^2	3.272230e+ 02 dynes	3.272230e-03 N
force (time region--atoms)	F_{t_u}	$(t_u^3/s_u^3)s_{t\_u}/t_u^2$	1.025922e-02 sec/cm^2	2.091625 dynes	2.091625e-05 N
pressure (gas)	P_{G_u}, P_u	(t_u/s_u^4)	3.520647e+ 05 sec/cm^4	1.574489e+ 13 $dynes/cm^2$	1.574489e+ 12 N/m^2
pressure (solid)	P_{S_u}	$(t_u^3/s_u^5)s_{t\_u}/t_u^2$	2.250414e+ 03 sec/cm^4	1.006421e+ 11 $dynes/cm^2$	1.006421e+ 10 N/m^2
pressure (liquid)	P_{L_u}	(2/3) $(t_u^3/s_u^5 I_R)s_{t\_u}/t_u^2$	9.589834 sec/cm^4	4.288727e+ 08 $dynes/cm^2$	4.288727e+ 07 N/m^2
pressure (vapor)	P_{V_u}	(1/3) $(t_u^3/s_u^5 I_R^2)s_{t\_u}/t_u^2$	3.064934e-2 sec/cm^4	1.370687e+ 06 $dynes/cm^2$	1.370687e+ 05 N/m^2

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
torque (time-space region)	T_u	t_u/s_u	3.335636e-11 sec/cm	1.491750e-03 dynes cm	1.491750e-10 N m
torque (time region)	T_{t_u}	$(t_u^3/s_u^3)s_{t\_u}^2/t_u$	1.362883e-15 sec/cm	6.095031e-08 dynes cm	6.095031e-15 N m
moment of inertia (time-space region)	I_u	t_u^3/s_u	7.713295e-43 sec^3/cm	3.449509e-35 g cm^2	3.449509e-42 kg m^2
moment of inertia (time region)	I_{t_u}	$(t_u^3/s_u^3)(s_{t\_u}^2)$	3.151519e-47 sec^3/cm	1.409410e-39 g cm^2	1.409410e-42 kg m^2
dynamic viscosity	η_u	t_u^2/s_u^4	5.353688e-11 sec^2/cm^4	2.394255e-01 centipoise	2.394255e-03 poise
kinematic viscosity	ν_u	s_u^2/t_u	1.366701e+ 05 cm^2/sec	1.366701e+ 07 centistoke	1.366701e+ 05 stokes
surface tension	γ_{L_u}	$(1/3)t_u/(s_u^3 I_R^3)$	1.397247e-07 sec/cm^3	6.248712 dynes/cm	6.248712e-03 N/m
energy, work, and heat (time-space region)	E_u	t_u/s_u	3.335636e-11 sec/cm	1.491750e-03 ergs	1.491750e-10 J
energy, work, and heat (time-region–atoms)	E_{t_u}	$(t_u^3/s_u^3)(s_{t\_u}^2/t_u^2)$	1.362883e-15 sec/cm	6.095031e-08 ergs	6.095031e-15 J
power (time-space region)	p_u	$1/s_u$	2.193552e+ 05 cm^{-1}	9.809916e+ 12 ergs/sec	9.809916e+ 05 J/sec
power (time region--atoms)	p_{t_u}	$(t_u^3/s_u^3)(s_{t\_u}^2/t_u^2)/t_u$	8.962474 cm^{-1}	4.008162e+ 08 ergs/sec	4.008162e+ 01 J/sec
electric quantity	q_u	s_u	4.558816e-06 cm	4.802870e-10 $esu_{quantity}$	1.602062e-19 $coulombs_{quantity}$
electric current	i_u	s_u/t_u	2.997929e+ 10 cm/sec	3.158422e+ 06 $esu_{quantity}/sec$	1.053534e-03 amps
electric current density (time-space region	j_u	$1/(s_u t_u)$	1.442505e+ 21 $cm^{-1}sec^{-1}$	1.519729e+ 17 $(esu_{quantity}/sec)/cm^2$	5.069250e+ 11 amps/m^2
electric current density (time region)	j_{t_u}	$(s_u/t_u)/s_{t\_u}^2$	3.530509e+ 25 $cm^{-1}sec^{-1}$	3.719513e+ 21 $(esu_{quantity}/sec)/cm^2$	1.240693e+ 16 amps/m^2
electric charge or flux	Q_u	t_u/s_u	3.335636e-11 sec/cm	4.802870e-10 esu_{charge}	1.602062e-19 $coulombs_{charge}$

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
electric dipole moment (time-space region)	p_u	t_u	1.520655e-16 sec	2.189540e-15 esu_{charge} cm	7.303506e-27 $coulombs_{charge}$ m
electric dipole moment (time region)	p_{t_u}	$(t_u/s_u)s_{t\_u}$	9.720098e-19 sec	1.399564e-17 esu_{charge} cm	4.668436e-29 $coulombs_{charge}$ m
electric charge volume density (time-space region)	ρ_u	$t_u/s_{t\_u}^4$	3.520646e+ 05 sec/cm^4	5.069261e+ 06 esu_{charge} $/cm^3$	1.690920e+ 03 $coulombs_{charge}/cm^3$
electric charge volume density (time region)	ρ_{t_u}	$(t_u/s_u)/s_{t\_u}^3$	1.348039e+ 12 sec/	1.940996e+ 13 esu_{charge} $/cm^3$	6.474453e+ 09 $coulombs_{charge}/cm^3$
electric energy	E_u	t_u/s_u	3.335636e+ 11 sec/cm	1.491750e-03 ergs	1.491750e-10 J
electric pow er	P_u	$1/s_u$	2.193552e+ 05 cm^{-1}	9.809916e+ 12 ergs/ec	9.809916e+ 05 J/sec
electric voltage or potential	V_u	t_u/s_u^2	7.316890e-06 sec/cm^2	3.105955e+ 06 statvolts	9.311435e+ 08 volts
electric field intensity (time-space region)	E_u	t_u/s_u^3	1.604998 sec/cm^3	6.813073e+ 11 statvolts/cm	2.042512e+ 16 volts/m
electric field intensity (time region)	E_{t_u}	$t_u/(s_u^2 s_{t\_u})$	2.510929e+ 2 sec/cm^3	1.065867e+ 14 statvolts/cm	3.195395e+ 18 volts/m
electric flux density (time-space region)	D_u	$(t_u/s_u)/s_u^2$	1.604998 sec/cm^3	2.310983e+ 01 esu_{charge}/cm^2	7.708594e-05 $coulombs_{charge}/m^2$
electric flux density (time region)	D_{t_u}	$(t_u/s_u)/s_{t\_u}^2$	3.928208e+ 04 sec/cm^3	5.656096e+ 05 esu_{charge}/cm^2	1.886667 $coulombs_{charge}/m^2$
electric resistance	R_u	t_u^2/s_u^3	2.440648e-16 sec^2/cm^3	9.833881e-01 statohms	8.838284e+ 11 ohms
electric conductance	G_u	s_u^3/t_u^2	4.097273e+ 15 cm^3/sec^2	1.016893 statmhos	1.131441e-12 mhos
electric resistivity	ρ_{t_u}	$(t_u^2/s_u^3)s_{t\_u}$	7.112089e-24 sec^2/cm^2	2.865609e-08 statohms cm	2.575491e+ 02 ohms m
electric conductivity	σ_{t_u}	$s_u^3/(t_u^2 s_{t\_u})$	1.406057e+ 23 cm^2/sec^2	3.489659e+ 07 statmhos/cm	3.882755e-03 mhos/cm
electric permittivity (free space)	ε_0	s_u^2/t_u	1.366701e+ 05 cm^2/sec	1 (dimensionless)	8.854188e-12 farad/m

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
electric susceptibility (free space)	χ_{E_u}	0	0	0	0
capacitance	C_u	s_u^3/t_u	6.230538e-01 cm^3/sec	1.546343e-16 statfarads	1.720532e-28 F
electric displacement (time-space region)	D_u	$1/s_u$	2.193552e+ 05 cm^{-1}	2.310983e+ 01 $esu_{quantity}/cm^2$	7.708594e-05 $coulombs_{quantity}/m^2$
electric displacement (time region)	D_{t_u}	$s_u/s_{t\_u}^2$	5.368686e+ 09 cm^{-1}	5.656096e+ 05 $esu_{quantity}/cm^2$	1.886667 $coulombs_{quantity}/m^2$
electric polarization (time-space region)	P_u	$1/s_u$	2.193552e+ 05 cm^{-1}	2.310983e+ 01 $esu_{quantity}/cm^2$	7.708594e-05 $coulombs_{quantity}/m^2$
electric polarization (time region)	P_{t_u}	$s_u/s_{t\_u}^2$	5.368686e+ 09 cm^{-1}	5.656096e+ 05 $esu_{quantity}/cm^2$	1.886667 $coulombs_{quantity}/m^2$
magnetic charge or flux	M_u	t_u^2/s_u^2	1.112646e-21 sec^2/cm^2	1.602062e-20 emu	4.8028631e-18 weber
Larson magneton (magnetic moment)	μ_{L_u}	$(t_u^2/s_u^2)D_u$	3.737380e-34 sec^2/cm	3.107984e-38 emu cm	9.317503e-37 weber m
magnetic dipole moment (time-space region)	μ_u	t_u^2/s_u	5.072351e-27 sec^2/cm	7.303508e-26 emu cm	2.189537e-25 weber m
magnetic dipole moment (time region)	μ_{u_t}	$(t_u^2/s_u^2)s_{t\_u}$	3.242271e-29 sec^2/cm	4.668437e-28 emu cm	1.399562e-27 weber m
magnetic moment from current (time-space region)	μ_{c_u}	s_u^3/t_u	6.230538e-01 cm^3/sec	6.564086e-05 $(esu_{quantity}/sec)\ cm^2$	2.189539e-18 amps m^2
magnetic moment from current (time region)	$\mu_{c\_t\_u}$	$(s_u/t_u)s_{t\_u}^2$	2.545690e-05 cm^3/sec	2.681972e-09	8.946081e-23 amps m^2
magnetic flux density (time-space region)	B_u	$t_u^2/s_{t\_u}^4$	5.353688e-11 sec^2/cm^4	7.708596e-10 emu/cm^2	2.310979e-03 $weber/m^2$
magnetic flux density (time region)	B_{t_u}	$(t_u^2/s_u^2)/s_{t\_u}^2$	1.310307e-06 sec^2/cm^4	1.886667e-05 emu/cm^2	5.656086e+ 01 $weber/m^2$
magnetic permeability	μ_0	t_u^3/s_u^4	8.141112e-27 sec^3/cm^4	1 [dimensionless in cgs]	1.256637e-06 henries/m
magnetic susceptibility	χ_{μ_u}	0	0	0	0

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
magnetic field intensity (time-space region)	H_u	$1/t_u$	6.576114e+ 15 sec^{-1}	7.708596e-10 emu/cm^2	1.839019e+ 03 (weber/m)/henry
magnetic field intensity (time region)	H_{t_u}	$(s_u^2/t_u)/s_{t\_u}^2$	1.609494e+ 20 sec^{-1}	1.886667e-05 emu/cm^2	4.500971e+ 07 (weber/m)/henry
magnetomotive force (time-space region)	F_{M_u}	t_u^2/s_u^3	2.440648e-16 sec^2/cm^3	3.154207e-15 emu/cm	1.053533e-10 weber/m
magnetomotive force (time region)	$F_{M\_t\_u}$	$(t_u^2/s_u^2)/s_{t\_u}$	3.818257e-14 sec^2/cm^3	5.497780e-13 emu/cm	1.648193e-08 weber/m
magnetic polarization (time-space region)	P_{M_u}	$t_u^2/s_{t\_u}^4$	5.353688e-11 sec^2/cm^4	7.708596e-10 emu/cm^2	2.310979e-03 $weber/m^2$
magnetic polarization (time region)	$P_{M\_t\_u}$	$(t_u^2/s_u^2)/s_{t\_u}^2$	1.310307e-06 sec^2/cm^4	1.886667e-05 emu/cm^2	5.656086e+ 01 $weber/m^2$
magnetic inductance	L_u	t_u^3/s_u^3	3.711383e-32 sec^3/cm^3	1.495394e-16 stathenries	1.343998e-04 henries
magnetization (time-space region)	M_{M_u}	$1/t_u$	6.576114e+ 15 sec^{-1}	7.708596e-10 emu/cm^2	1.839019e+ 03 (weber/m)/henry
magnetization (time region)	$M_{M\_t\_u}$	$(s_u^2/t_u)/s_{t\_u}^2$	1.609494e+ 20 sec^{-1}	1.886667e-05 emu/cm^2	4.500971e+ 07 (weber/m)/henry
reluctance	R_{M_u}	s_u^3/t_u^3	2.694413e+ 31 cm^3/sec^3	6.687201e+ 15 $stathenries^{-1}$	7.440487e+ 03 $henries^{-1}$
temperature (gas)	T_{G_u}	$(t_u/s_u)/((3/2)k_B)$	3.335636e-11 $(sec/cm)/((3/2)k_B)$	7.202668e+ 12 K, 7.204230e+ 12 K	7.202668e+ 12 K, 7.204230e+ 12 K
temperature (vapor)	T_{V_u}	$T_{G\_u}^{3/4}$ / (1+ 2/9)	$[3.335636e-11 (sec/cm)/((3/2)k_B)]^{3/4}/(1+ 2/9)$	3.597244e+ 09 K, 3.597800e+ 09 K	3.597244e+ 09 K,3.597800e+ 09 K
temperature (solid, liquid)	T_{SL_u}	$(1/3)T_{V\_u}^{1/3}$	$1/3\ [[3.335636e-11 (sec/cm)/((3/2)k_B)]^{3/4}/(1+ 2/9)]^{1/3}$	510.742549 K, 510.8 K	510.742549 K, 510.8 K
specific heat (molar)	c_{V_u}, c_{p_u}	$(3/2)R_u$ (Gas Constant)	2.790180 (sec/cm)/mol K	2.980350 cal/mol K	12.478129 J/mol K
specific molar enthalpy (gas)	h_{u_G}	$c_{p\_u}T_{G\_u}$	3.349456e+ 13 (sec/cm)/mol	3.577745e+ 13 cal/mol	1.497930e+ 14 J/mol

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
specific molar enthalpy (vapor)	h_{u_V}	$c_{p\_u}T_{V\_u}$	1.672826e+ 10 (sec/cm)/mol	1.786841e+ 10 cal/mol	7.481146e+ 10 J/mol
specific molar enthalpy (solid, liquid)	h_{u_SL}	$c_{p\_u}T_{SL\_u}$	1.425063e+ 03 (sec/cm)/mol	1.522192e+ 03 cal/mol	6.373112e+ 03 J/mol
specific molar internal energy(gas)	i_{u_G}	$c_{v\_u}T_{G\_u}$	2.009674e+ 13 (sec/cm)/mol	2.146647e+ 13 cal/mol	8.987583e+ 13 cal/mol
specific molar internal energy (vapor)	i_{u_V}	$c_{v\_u}T_{V\_u}$	1.003696e+ 10 (sec/cm)/mol	1.072105e+ 10 cal/mol	7.481146e+ 10 J/mol
specific molar internal energy (solid, liquid)	i_{u_SL}	$c_{v\_u}T_{SL\_u}$	1.425063e+ 03 (sec/cm)/mol	1.522192e+ 03 cal/mol	6.373112e+ 03 J/mol
specific molar entropy	S_u	$(3/2)R_u$ (Gas Constant)	2.790180 (sec/cm)/mol K	2.980350 cal/mol K	12.478129 J/mol K
thermal resistance	R_{θ_u}	T_{G_u}/P_u	3.283564e+ 07 K cm	7.342233e-01 K/(ergs/sec)	7.342233e+ 06 K/watt
thermal conductance	S_{θ_u}	P_u/T_{G_u}	3.045471e-08 $(K\ cm)^{-1}$	1.361984 (erg/sec)/K	1.361984e-07 watt/K
thermal resistivity	ρ_{θ_u}	$R_{\theta\_u}s_{t\_u}$	9.568360e-01 cm sec	2.139539e-08 K cm sec/erg	2.139539e-03 K m /watt
thermal conductivity	κ_u	$1/(R_{\theta\_u}s_{t\_u})$	1.045111 $cm^{-1}\ sec^{-1}$	4.673904e+ 07 (erg/sec)/(K cm)	4.673904e+ 02 watt/(K m)
thermal diffusivity (gas)	α_u	s_u^2/t_u	1.366701e+ 05 cm^2/sec	1.366701e+ 05 cm^2/sec	1.366701e+ 01 m^2/sec
thermal diffusivity (solid, liquid)	α_{t_u}	$s_{t\_u}^2/t_u$	5.584103 cm^2/sec	5.584103 cm^2/sec	5.584104e-04 m^2/sec
energy of unit frequency photon	E_{u_photon}	hR	4.876238e-19 sec/cm	2.180731e-11 ergs	2.180731e-18 J
radiant energy exposure	H_{e_u}	t_u/s_u^3	1.604998 sec/cm^3	7.177808e+ 07 $ergs/cm^2$	7.177808e+ 04 J/m^2
radiant flux	Φ_{e_u}	$1/s_u$	2.193552e+ 05 cm^{-1}	9.809916e+ 12 ergs/sec	9.809916e+ 05 J/sec
luminosity (radiance, emitted)	M_{e_u}	$1/s_u^3$	1.055465e+ 16 cm^{-3}	4.720208e+ 23 $(ergs/sec)/cm^2$	4.720208e+ 20 $(J/sec)/m^2$

Physical Quantity	Symbol	Space-Time Dimensions	Reciprocal System Natural Unit Value Stated in terms of cm and sec	Reciprocal System Natural Unit Value Stated in normal cgs units	Reciprocal System Natural Unit Value Stated in normal SI units
irradiance (absorbed)	E_{a_u}	$1/s_u^3$	1.055465e+ 16 cm^{-3}	4.720208e+ 23 $(ergs/sec)/cm^2$	4.720208e+ 20 $(J/sec)/m^2$
radiant intensity (per steradian)	I_{e_u}	$1/s_u$ $sterad^{-1}$	2.193552e+ 05 Ω^{-1} $sterad^{-1}$ cm^{-1} (Ω = 1)	9.809916e+ 12 ergs/sec per sterad	9.809916e+ 05 J/sec per sterad
energy brightness (per steradian)	B_{e_u}	$1/s_u^3$ $sterad^{-1}$	1.055465e+ 16 Ω^{-1} $sterad^{-1}$ cm^{-3} (Ω = 1)	4.720208e+ 23 $(ergs/sec)/cm^2$ per sterad	4.720208e+ 20 $(J/sec)/m^2$ per sterad
luminous flux (for solid angle Ω)	Φ_{v_u}	Ω/s_u	2.193552e+ 05 cm^{-1} Ω sterad (Ω = 1)	9.809916e+ 12 sterad ergs/sec	9.809916e+ 05 sterad J/sec
luminous energy (for solid angle Ω)	Q_u	$\Omega t_u/s_u$	3.335636e-11 Ω sterad cm^{-1} (Ω = 1) sec/cm	1.491750e-03 sterad ergs	1.491750e-10 sterad J
brightness in given direction φ	B_{ϕ_u}	$1/s_u^3$	1.953471e+ 16 cm^{-3} [ϕ = 1 rad]	8.736235e+ 23 $(ergs/sec)/cm^2$	8.736235e+ 20 $(J/sec)/m^2$
luminance (radiance, emitted over Ω)	R_{e_u}	Ω/s_u^3	1.055465e+ 16 Ω sterad cm^{-3} (Ω = 1)	4.720208e+ 23 sterad $(ergs/sec)/cm^2$	4.720208e+ 20 sterad $(J/sec)/m^2$
illuminance (intensity of illumination over Ω)	I_{a_u}	Ω/s_u^3	1.055465e+ 16 Ω sterad cm^{-3} (Ω = 1)	4.720208e+ 23 sterad $(ergs/sec)/cm^2$	4.720208e+ 20 sterad $(J/sec)/m^2$
luminous exposure over Ω	H_{a_u}	$\Omega t_u/ s_u^3$	1.604998 Ω sterad sec/cm^3 (Ω = 1)	7.177808e+ 07 sterad $ergs/cm^2$	7.177808e+ 04 sterad J/m^2

Table 1. Space-Time Dimensions and Natural Unit Values of Physical Quantities

Table Notes:

1. Values are given to six decimal places, but there is uncertainty in the fifth and sixth places. This is so because there is uncertainty in the true value of the speed of light, the Rydberg hydrogen frequency, Avogadro's number, Boltzmann's number, etc., which have been used in converting from the natural units to conventional units.

2. Values may be *slightly* different from those in other Reciprocal System papers and books. The differences are *de minimis*.

3. In some cells, alternate values are given; again, the differences are *de minimis*.

4. Some physical quantities have only time-space region values; others have only only time region values; and still others have both.

5. Given the large number of symbols, there are some duplications; context determines which is appropriate.

Conclusion

The Reciprocal System supercedes all other physical theories and dimensional systems. Unlike other systems, in the Reciprocal System a*ll* physical quantities are expressed in terms of space, s, and time, t, *only*. Mass and charge, therefore, are *derived* quantities, as is everything else. This paper adds to existing Reciprocal System literature in providing the natural unit values in cgs and SI of not only the mechanical and electrical quantities, but also the magnetic and thermal and photonic quantities. A convenient table is included, summarizing the results.

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last updated 02/11/2013--fixed another typo and added natural unit form of Einstein's famous equation
updated 01/20/2013 and 01/22/2013--fixed various typos

Appendix 1. Determination of Reciprocal System Natural Unit Value for Atomic Diameter

See Ref. [11] for the derivation of the Reciprocal System alpha particle scattering equations. The impact parameter, which is the effective radius of the target atom, is

$$b := \frac{K_G}{2 \cdot s_{u\_SI}^{\ 2} \cdot E_k} \cdot \cot\left(\frac{\Theta \cdot deg}{2}\right) \qquad \text{(A1)}$$

where K_G is the repulsion coefficient, E_k is the kinetic energy of the alpha particle, and Θ is the resultant scattering angle. The repulsion coefficient is expressed as

$$K_G := \frac{F_{u\_SI} \cdot s_{u\_SI}^{\ 4}}{l_R^{\ 4}} \cdot LntM^4 \qquad \text{(A2)}$$

The factor LntM depends on the rotational characteristics of the target atom and is not of importance here. What we're looking for is the coefficient for Eq. (A1). The usual alpha particle energy is

$$E_k := 7.03 \cdot 10^{-13} \quad J \qquad \text{(A3)}$$

(or 4.39 MeV). The value of Θ is usually set to 156.5 degrees to determine the *effective* size of the target atom. Then

$$\Theta := 156.5 \quad \text{degrees} \qquad \text{(A4)}$$

$$b := \frac{F_{u\_SI} \cdot s_{u\_SI}^{4}}{l_R^{4} \cdot 2 \cdot s_{u\_SI}^{2} \cdot E_k} \cdot \cot\left(\frac{\Theta \cdot deg}{2}\right) \cdot LntM^4 \qquad \text{(A5)}$$

Then

$$D_{u\_SI} := \frac{2 \cdot F_{u\_SI} \cdot s_{u\_SI}^{4}}{l_R^{4} \cdot 2 \cdot s_{u\_SI}^{2} \cdot E_k} \cdot \cot\left(\frac{\Theta \cdot deg}{2}\right) \qquad \text{(A6)}$$

$$D_{u\_SI} = 3.359 \times 10^{-15} \quad m$$

which is the value used in the paper proper. Use of this value, together with the calculation of LntM gives values for atomic diameters which are very close to those calculated by $2r_0A^{1/3}$ for the "nucleus" of conventional theory (r_0 is the "Fermi radius" and A is the mass number here).

Appendix 2. Special Dimensions for Interatomic Distance Calculation in the Time Region

Larson explains this clearly in Ref. [2], pp. 6-7:

"As explained in introducing the concept of the time region in Chapter 8 of Vol. I, equivalent space 1/t replaces space in the time region, and velocity is therefore $1/t^2$. Energy, the one-dimensional equivalent of mass, which takes the place of mass in the time region expression of the force equation, because the three rotations of the atom act separately, rather than jointly, in this region, is the reciprocal of this expression, or t^2. Acceleration is velocity divided by time: $1/t^3$. The time region equivalent of the equation F = ma [for the purpose of interatomic distance calculation] is therefore $F = Ea = t^2 \times 1/t^3 = 1/t$ in each distance." The reader can follow the remainder of the discussion in Ref. [2].

A nanotechnology force could be applied to individual atoms in the time region and the appropriate natural unit would be $F_{t\_u\_cgs}$ or $F_{t\_u\_SI}$ as given in the paper proper but this force must be added to the interatomic force given by Larson's modified expression above.