A simpler system of dimensions and units. Publication #1

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Besides being one of the world intellectual leaders in the field of the theory and practise of representative sampling, the Theory of Sampling (TOS), Francis F. Pitard is also a prolific writer on several other subjects, a.o. having published two novels: *Heirs of a Lost Race* and its sequel: *Rapa Nui Settlers*, as well as a scientitic tour-de-force arguing for a radically alternative view of the world, developed from his decade long collaboration with Charles O. Ingamells, entitled: "The Possibilities of Our Sub-Quantic Identity — The Theory of Vacuoles and a Simpler System of Dimensions and Units", which has caused a stir in physical, history of science and philosophical circles. From this work, *TOS forum* has asked Francis to edit the last topic into a series of papers for this audience. You may perhaps wonder what such a topic has to do with sampling, with representative sampling? Please read, and be enlightened...—Editor.

Many publications show beyond any possible doubt that our current system of dimensions and units, metric or not, is not an appropriate tool for advanced Nuclear Physics and Astronomy; it is unnecessarily complex with foundations that are more emotional than scientific. The system is acceptable for our day-to-day lives, when we cook for the family or build a car, totally unacceptable when we explore what the Universe is. A much better and simpler system is suggested. Let us prove beyond any possible doubt that time, mass, permeability and permittivity do not need units of their own. In the suggested new system, all values for the "fundamental" physical constants are absolute, with the exception of the time–thickness constant. This alone eliminates unnecessary ambiguity and greatly simplifies our research for the ultimate truth about our place in this Universe.

There are flaws in standard models. All standard models have flaws. Flaws are not easy to find, otherwise they would not exist. Flaws in the current model are from a faulty dimensional system and an irrational system of units, metric or not, that do not seem appropriate for advanced Physics. A series of short publications is suggested, so the reader can slowly eliminate one of the greatest paradigms of our time that may be responsible for slow progress in Science. So, this is publication #1, and others will follow. The suggested publications are a series of adapted topics for the purpose of making progressive reviews of weaknesses in the ways we think today. Publications will start exposing simple concepts, and then getting increasingly more complex to the point where fundamental changes in the ways we understand matter will be suggested and speculated on. This work is inspired from a textbook published in 2012 by the author and his late friend Charles O. Ingamells (ISBN: 978–0-9850631–0-8).

Units—a history

On 10 December 1799, the French Legislative Assembly voted to define a standard of length, the "metre" as the E^{-7} part of the earth's quadrant. For those who may not know, Napoleon Bonaparte was in charge, and you did not argue with the First Consul, a short time before he self-promoted to the title of Emperor. On the same day, the mass of a cubic decimetre of water at its maximum density was chosen as the standard of mass and was named the kilogram. The third fundamental unit, time, was determined by astronomers as 1/86,400 of a solar day. Thermal and electrical units are both vaguely related to this *MLT* system. The National Bureau of Standards defined the calorie as 4.184 joules. One joule is E^{7} cgs units of energy. The electrostatic unit of quantity of electricity is the quantity which when concentrated at a point 1 cm from an equal and similarly concentrated quantity is repelled by a force of 1 dyne. The quantity transferred by one ampere in one second is the coulomb. The *MKS/Giorgi* system of units required four fundamentals: metre, kilogram, second and ohm. The ohm is the resistance of a column of mercury of uniform cross-section having a length of 106.380 cm and a mass of 14.4521 g and a temperature of 0°C. A centigrade degree is 1/100 of the temperature rise of water on being heated from its freezing to its boiling point under a pressure of one atmosphere, i.e. the pressure exerted by 760 mm of mercury at the surface of the earth. The ohm has also been defined as the electric resistance between two points in a conductor when a constant potential difference of one volt, when applied between these two points, produces in this conductor a current of one ampere. An ampere is 1.0363 E^{-5} faraday/second or 2.9979 electrostatic cgs units. And so on and on… this is what we do science with!

The plethora of units and their definitions and the inconsistencies therein has led to innumerable congresses, bureaus, publications and passionate discussion, leading to the *SI* system today which as we will see is far from being the panacea. Long ago, Eddington proposed that the number of physical constants may eventually be reduced from five or more to only one: "I believe that the whole system of fundamental hypotheses can be replaced with epistemological principles... all the fundamental laws and constants of Physics can be deduced unambiguously from *a priori* considerations, and are therefore subjective."

Currently accepted definitions of the various "fundamentals" appear in the International System of Units (*SI*) as follows: the metre is the length of the path travelled by light in vacuum during a time interval of 1/299792458 of a second. The kilogram is the mass of the International prototype of the kilogram. The second is the duration of 9,192,631,770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of ^{133}Cs atom. The ampere is that constant current which, if maintained in two straight parallel conductors would produce between these conductors a force equal to 2×10^{-7} newton per metre of length. The Kelvin, unit of thermodynamic temperature, is the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. The mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of ^{12}C. It is very hard to resist noting the "King-Henry's Thumb" principle here, over which we did not make much improvement.

An attempt for a simpler system of units

As mortals, we live by the clock, with life flowing through us as length [*L*], mass [*M*] and time [*T*]. The commonly accepted dimensions of physical quantities are [*L*], [*M*] and [*T*]. Most ordinary things and phenomena are described in terms of these dimensions; it is our today paradigm and it is extremely difficult to think any other way; it is the way we were told to think.

If you spill mercury on a smooth floor, the liquid metal will bead into droplets of various sizes. The same happens if water is spilled on a well-waxed car roof. The small droplets are very nearly spheres. The large droplets are flattened or nearly ellipsoidal. The larger ones are flat puddles of uniform height or thickness. Using the "method of dimensions" we may calculate the depth, height or thickness of these drops from three known parameters. The height, h, depends on ρ, the density of the liquid, its surface tension, γ and g, the force (acceleration) due to gravity, which flattens the droplets of water or mercury. The height of the puddles is a function of these three parameters. Writing this sentence in abbreviated form gives $h=f(\rho,\gamma,g)$. We can state the dimensions of density, surface tension and the acceleration due to gravity on the earth's surface in terms of length, mass and time. Density, ρ, is mass per unit volume. Volume is length times length times length, or $[V]=[L\cdot L\cdot L]=[L^3]$. If a brick is 0.05 m by 0.08 m by 0.20 m, its volume is $0.05\times0.08\times0.20=0.0008\,m^3$. If the brick weighs 2 kg on this earth (it would weigh much less on the moon), its mass is 2 kg and its density is 2 kg per 0.0008 m^3, or $\rho=2/0.0008=2500\,kg\,m^{-3}$. This is one of the silly systems by which we live and it would not be a very good idea for anyone to challenge it.

Surface tension, γ, has dimensions $[M/T^2]$, and the force of gravity is due to an acceleration, g, with dimensions $[L/T^2]$. These statements require explanations. Acceleration is easiest to describe because everyone knows what it is! It is the rate of speed increase when you step on the car gas pedal. In a car, you may measure it in km per hour per second. In one second, you may go from 50 km/h to 60 km/h. Your acceleration, a, is 10 km per hour per second, with dimensions km (length) per hour (time) per second (time): acceleration = $[L/T^2]$. Acceleration due to gravity, g, is the acceleration of an object that free-falls from a height onto the earth. It determines the downward force, F, that any standing object exerts on its floor.

If we put our $0.05\times0.08\times0.20\,m^3$ brick on a scale, the scale registers 2 kg. The brick is exerting a 2-kg force on the scale. If we were on the moon with the same brick and the same scale, the brick would weigh much less than 2 kg, but it still has the same mass!

If W is the weight of an object, M the mass of this object, and g the acceleration due to gravity of the object in free fall, we have the relationship:

$$W=M\cdot g \qquad (1)$$

Therefore, if g at the surface of the earth is a reference taken as 1, then the weight and the mass appear to be the same thing; they most certainly are not.

Too often, deeply set axioms and beliefs, in exquisitely subtle ways, foiled attempts at the expansion of human understanding.

So, back to the thickness or height, h, of fluid drops: if we hold our 2-kg brick above the floor, it exerts a downward force on the hand that holds it. This force is its weight, 2 kg of force. While we hold it, its downward speed, with respect to the earth, is zero. If we drop it, its downward speed increases from zero until it hits the floor. It accelerates as it drops. The acceleration, g, is the acceleration due to gravitational attraction of the earth or, better, the mutual attraction of brick and earth: the earth, being much bigger, does not fall very far toward the brick! If bricks don't inspire you, use Newton's apple! It falls with the same acceleration as a brick.

The downward force, F, on the brick is the product of its mass, M, and the acceleration, g, due to gravitational attraction. $F=M\cdot g=W$ is the weight of the brick on earth. Similarly, the downward force on a puddle of water or mercury is the weight of the puddle, or its mass, M, times the acceleration, g, due to gravitational attraction between the puddle and earth. We now have established that the dimensions of force F, are:

$$[mass]\cdot[acceleration]=[F]=\left[\frac{M\cdot L}{T^2}\right] \qquad (2)$$

Acceleration g has dimensions $[L/T^2]$; distance (km) per hour per second. Surface tension γ has dimensions $[M/T^2]$—mass per hour per second?

Surface tension γ is best described as the energy that keeps the droplet of mercury or water from collapsing. This energy accomplishes this by forming a sort of "skin" on the surface of the droplet, or puddle. It is "energy per unit surface". We shall, therefore, have to investigate the dimensions of energy. Energy, as everyone who works for a living knows, is the ability to do work! It is the energy to do something. Our 2-kg brick, held in hand, has energy! If you drop it on your toe it will do work! The energy E in the brick in hand, available for doing work on your toe, is the product of its weight (the force F it exerts on your hand) and the distance d it falls before it hits your toe. The dimensions of energy are force time distance.

We have found that force F is mass M times acceleration and acceleration g is distance per time per time. Thus, the dimensions of energy are:

$$[E]=[F\cdot d]=[M\cdot g\cdot d]=\left[M\cdot\frac{L}{T^2}\cdot L\right]=\left[\frac{M\cdot L^2}{T^2}\right] \qquad (3)$$

In passing, we may remark that the dimensions of velocity, v, are $[L/T]$, distance per unit time. Thus

$$[E]=[M\cdot v^2] \qquad (4)$$

This fits nicely with Einstein's deduction that $E=M\cdot c^2$, therefore we must be on the right track.

We may now discover the dimensions of surface tension, γ:

$$[\gamma]=\left[\frac{energy}{area}\right]=\left[\frac{E}{L^2}\right]=\left[\frac{M\cdot v^2}{L^2}\right]=\left[\frac{\frac{M\cdot L^2}{T^2}}{L^2}\right]=\left[\frac{M}{T^2}\right] \qquad (5)$$

Finally, we may find the height, h, of the drops and puddles. What sort of function shall this be? Shall it be an exponential function?

$$h = f(\rho, \gamma, g) = c \cdot d^x \cdot \gamma^y \cdot g^z \quad (6)$$

where c is a number to be determined.

Dimensionally,

$$[L] = \left[\frac{M}{L^3}\right]^x \cdot \left[\frac{M}{T^2}\right]^y \cdot \left[\frac{L}{T^2}\right]^z = \left[M^0 \cdot L^1 \cdot T^0\right] \quad (7)$$

Since we are after [*L*] it has an exponent 1 and [*M*] and [*T*] have exponents zero.

Dimensions on both sides of the equal sign must be the same, so

$$x+y=0$$
$$-3x+z=1$$
$$-2y-2z=0$$

then

$$x=-y$$
$$3x=z-1$$
$$z=-y$$

then

$$x=z$$
$$3x=x-1$$
$$z=x$$

then

$$x=-1/2;\ y=1/2;\ z=-1/2$$

and

$$h = c \times \rho^{-1/2} \times \gamma^{1/2} \times g^{-1/2} \quad (8)$$

or

$$h = c\sqrt{\frac{\gamma}{\rho \cdot g}} \quad (9)$$

Let us now find if this formula actually works!

Look up the values for ρ, γ and g in a handbook and we find the characteristics shown in Table 1.

We also find acceleration due to gravity, $g=9.80$ m per second per second.

Since the numbers we looked up are all in the metres, kilogram and second system (*L* in m, *M* in kilograms, *T* in seconds), the answers we calculate will appear in metres.

For mercury, $h = c\sqrt{\frac{0.48548}{(13500)(9.80)}} = 0.00192c$

For water, $h = c\sqrt{\frac{0.07423}{(1000)(9.80)}} = 0.00275c$

We did not determine the dimensionless constant c, but if you watch the water beads on your newly waxed car, I feel sure you can decide that c is very close to 1. In other dimensional exercises, even very complicated ones, we find that *Nature* likes her constants to be simple, like 1, 2, π, $3\pi/4$ etc.

Table 1. Density and surface tension for mercury and water.

Physical quantity	Mercury	Water	Units
Density, ρ	13,500	1000	kg m^{-3}
Surface tension, γ (25°C)	0.48548	0.07423	N/m (N/m) = kg·s^{-2}

Eliminating the necessity of time and mass units of their own

Currently, the International Standard system of dimensions and units (SI) is summarised as follows in the 2011–2012 *CRC Handbook of Chemistry and Physics*: "The core of the *SI* is the seven base units for the physical quantities length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity". You may already know all this, but I feel its statement is needed, because it contains at least one important false implication! It also implies that there is something fundamental about the seven base units. You may reply, "So what? We all know that the metre is a fraction of the earth's circumference, the second 1/86400 of a solar day, the kilogram the weight of a litre of water, etc. …"

We now have better ways of measuring the metre, kilogram and second! We also measure mass in electron volts, length in terms of reproducible wave lengths, time using vibrating crystals, and so on.

Before proceeding, may I repeat the dimensional analysis that discovers the height, *h*, of beads of liquid on a smooth surface, using a slightly different approach.

We found the dimensions of density:

$$[\rho] = \left[\frac{M}{L^3}\right] \quad (10)$$

This gives mass the dimensions:

$$M = \left[\rho \cdot L^3\right] \quad (11)$$

We found the dimensions of force:

$$[F] = \left[\frac{M \cdot L}{T^2}\right] \quad (12)$$

Pressure, *P*, is force per unit area:

$$[P] = \left[\frac{\frac{M \cdot L}{T^2}}{L^2}\right] = \left[\frac{M}{L \cdot T^2}\right] \quad (13)$$

If we put (11) in (13):

$$[P] = \left[\frac{\rho \cdot L^3}{L \cdot T^2}\right] = \left[\frac{\rho \cdot L^2}{T^2}\right] \quad (14)$$

From this, dimensions of time are given by:

$$\left[T^2\right] = \left[\frac{\rho \cdot L^2}{P}\right] \quad (15)$$

We have now invented a new dimensional system, $LP\rho$, replacing the conventional *LMT* (i.e., length, mass, time) part of the *SI* system, in which there is no need for separate dimensions for *[M]* and *[T]*.

Returning to the problem of the height of beads of liquids:

$$h = f(\rho, \gamma, g) = c \cdot \rho^x \cdot \gamma^y \cdot g^z \quad (16)$$

Dimension of density:

$$\left[\frac{M}{L^3}\right] = [\rho] \quad (17)$$

Dimension of surface tension:

$$\left[\frac{M}{T^2}\right] = \left[\frac{\rho \cdot L^3 \cdot P}{\rho \cdot L^2}\right] = [P \cdot L] \quad (18)$$

Dimension of acceleration:

$$\left[\frac{L}{T^2}\right] = \left[\frac{L \cdot P}{\rho \cdot L^2}\right] = \left[\frac{P}{\rho \cdot L}\right] \quad (19)$$

Dimensionally:

$$[L]^1 = [\rho]^x \cdot [P \cdot L]^y \cdot \left[\frac{P}{\rho \cdot L}\right]^z \quad (20)$$

For dimensional homogeneity:

$$x-z=0$$
$$y+z=0$$
$$y-z=1 \quad (21)$$

As before:

$$x = -\frac{1}{2} \quad y = \frac{1}{2} \quad z = -\frac{1}{2} \quad (22)$$

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and

$$h = c\sqrt{\frac{\gamma}{\rho \cdot g}} \qquad (23)$$

At this point, this only shows the obvious, that the *LP*ρ and *SI* systems are equally useful in resolving this small problem. It also shows that there is nothing sacrosanct about length, mass and time as primary dimensions.

The importance of this lesson, a simplistic appetiser, does not fully appear until the other "dimensionally independent base quantities", the thermal and more especially the electromagnetic quantities are taken into consideration, which have huge implications; but this will be addressed in subsequent publications.

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Charles Oliver Ingamells (1917–1994)
A simpler system of dimensions and units
"The International System of Units adapted "seven dimensionally independent quantities" that are measured with their respective units. These quantities are not independent and some of them do not deserve their own units. Therefore, it becomes conceivable that our ways of thinking today in Physics and Astronomy are flawed, or at least unnecessarily complicated".