<u>Calculus</u>

by William Gray

“Mathematics, the non-empirical science par excellence, the science of sciences, delivering the key to those laws of nature and the universe … concealed by appearances.”

- Hannah Arendt

Mathematics is a language of logic, a way to think that allows us to understand things, predict the future, or see what is concealed, and there is one branch of math that ties everything together. Calculus is the most powerful of the mathematical platforms because it includes all other mathematics from arithmetic on up and it is able to describe all physical reality.

Everything we see or do is possible because it all just builds upon itself, like particles becoming atoms, the world, the solar system and the universe or arithmetic becoming geometry, algebra, trigonometry, and so on. Calculus was invented simultaneously and independently by Leibniz and Newton because they were trying to describe how things change, and that’s what everything in the universe does. Now consider the following diagram:

$$e^x = \sum_{n=0}^{\infty} \frac{x^n}{n!} = \frac{x^0}{0!} + \frac{x^1}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} + \frac{x^6}{6!} \; ....$$

n = 0-D 1-D 2-D 3-D 4-D 5-D 6-D

This looks complex but it’s based on a very simple concept, “What happens when you change one thing?” If you start out with a point and you change it, the simplest change you can have is a line, like a thought becomes a line of reasoning. Both Newton and Leibniz were philosophers so their mathematics reflected the logic of their thoughts.

It’s easy to see a pattern here: point → line → area → volume → velocity → acceleration → acceleration of acceleration → and so on, as the figures at the bottom of the diagram show. Each figure simply adds a degree of freedom, as reflected in the line above which shows 0-dimensions (0-D) over a point because a point has no size, 1-dimension (1-D) over a line, and so on. Actually, in math things are represented in their simplest form (Occam’s Razor) so by Symmetry only a ½-dimension (½-D), or degree of freedom, is used to keep things simple.

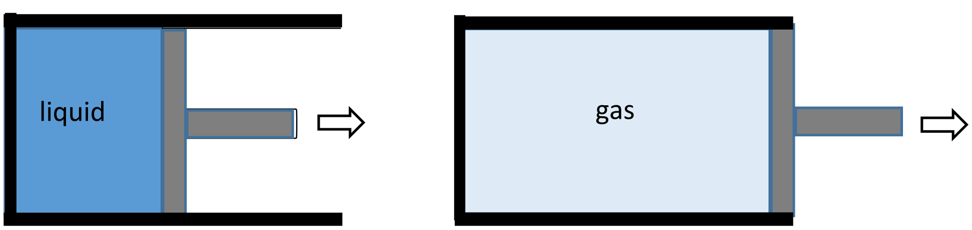
Now the equation part of the diagram looks a little more complex, but it's not. Equations are just symbols, like hieroglyphics, that represent a thought or picture. On the far left is a very simple e^x symbol, pronounced "e to the x power," that means everything to the right of it so there is an "=" equal sign that states that. Next is a $\sum_{n=0}^{\infty} \frac{x^n}{n!} =$ more complex looking calculus expression we will come back to because it symbolizes everything to the right of it.

The $\frac{x^0}{0!} + \frac{x^1}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} + \frac{x^6}{6!} \cdots$ series of math elements is called a progression because each element only changes by the same amount. The numerators' exponents in the progression start at 0 and increase by 1, matching the numbers shown in the 0-D, 1-D, 2-D, … dimensions. Each exponent is shorthand for how many times the number x is multiplied by itself: $x^0 = 1$ because any number to the zero power equals 1, $x^1 = x$, $x^2 = x{\cdot}x$, $x^3 = x{\cdot}x{\cdot}x$, $x^4 = x{\cdot}x{\cdot}x{\cdot}x$, and so on, and x is a variable that can represent any number.

Notice each element's denominator follows the same pattern, each incrementing by 1, but also truncated by an exclamation point "!." This is short hand for "times the numbers under it," where 0! = 1 by definition because it has the potential to become something. Thus if 0! = 1 then $1! = 1{\cdot}0! = 1$, $2! = 2{\cdot}1{\cdot}0! = 2$, $3! = 3{\cdot}2{\cdot}1{\cdot}0! = 6$, $4! = 4{\cdot}3{\cdot}2{\cdot}1{\cdot}0! = 24$, and so forth.

This incremental pattern in each element's numerator and denominator now takes on a special significance because it conceptually shows how things change when a degree of freedom is added. This is Calculus, the math of changing things by the addition or subtraction of a degree of freedom. These functions are respectively called "Integration" and "Differentiation, like integrating parts into a whole or differentiating a whole into its parts.

Conceptually, integration increments a numerator's exponent to add a degree of freedom so it has more information, but the denominator also increments so the content of the previous element becomes less dense because it is divided between more degrees of freedom. For instance, if a container is filled with water and one side is suddenly pulled outward like a piston the liquid will boil and vaporize to fill the void:



The same concept applies to everything, so integration increases the complexity of something while dividing its content between the new complexity. The busier we get the less time we have.

This brings us back to the $\Sigma_{n=0}^{\infty} \frac{x^n}{n!}$ expression which can now be easily explained. In math it's the Occam's Razor practice to express things in their simplest normalized or common denominator form: "The simplest explanation to accounts for all the facts is most likely correct." Since all the elements in the progression have x variable factors with exponents that correlate to their denominators they all have an $\frac{x^n}{n!}$ common denominator form. The symbol Σ sigma signifies a summation function, all the elements of the progression added together, and since the elements range from n = 0 to ∞ these limits are expressed as the sub- and super- scripts of the summation.

This is the basic syntax logic of calculus that explains what it means and how to express it but a few examples will show how it apples to everything we can think of, simply by changing the value of the variable x. If x = 1 then the progression is just a series of straight lined geometric changes, but anything can be substituted in for x. The universe also has curves, the fundamental form being a circle in which Circumference relates to Diameter by C = πD, where π = 3.14159…, or even more fundamentally, C = 2πr because a radius, being a line with only one degree of freedom, is less complex than a diameter with two degrees of freedom.

Now Calculus has one very important rule, one can integrate or differentiate something that changes, a variable like x, but they can't integrate or differentiate a constant like π or a fixed integer like 2 because they don't change, and Calculus is the math of change. To integrate the f(C) = 2πr function of a circle into an area we write it as: Area = $\int$ f(C) dr,

Substitute 2πr in for f(C) to get: Area = $\int$ 2πr dr,

Move the 2π constants outside $\int$ to get: Area = 2π $\int$ r dr,

And solve by looking at the progression to get: Area = 2π $\int$ r dr = 2π ½r^2 = πr^2

In the progression the $\frac{x^1}{1!}$ element simplifies to $\frac{x^1}{1}$, and when a degree of freedom is added it becomes the next element $\frac{x^2}{2!}$, which simplifies to $\frac{x^2}{2!}$ = ½x^2, so the $\int$ integration of the radius r with respect to dr changes in r becomes ½r^2, and when the 2π constants are incorporated it becomes Area = πr^2. The same process would apply to a circle area becoming a volume, or other shapes if a different shape function is used, so basically the integration of any shape into its area or volume becomes possible by simply substituting the relation in for x.

Now in physical reality there are three primary e^x behaviors behind all things:

(1) e^x decay or transform functions, like radioactive half-life decays;

(2) e^{-ix} stable matter construct states, like atoms; and

(3) $e^{S/k}$ statistical probabilities, like demographics or economics.

The most incredible thing about math is that a logical creation of our minds can predict physical reality. By substituting a linear dx/dt rate of change in for x in e^x we obtain a first order decay function like a radioactive half-life decay. The dx/dt expression is the basic Calculus differentiation function, taking the whole apart in terms of uniform functional pieces, and the opposite of putting the pieces together in an $\int f(x)\, dx$ integration function.

The dx term means "change," or "delta of x," the / division sign means "with respect to," and dt means change or delta in time, like a miles per hour or meters per second velocities:

(1) Because x and t are variables, differentials can define any linear rate of change like dx/dy latitude and longitude distances to indicate a direction;

(2) The dx/dt is a first order linear rate of change but differentials can describe d^2x/dt^2 second or higher order changes to indicate non-linearities like acceleration or sine and cosine functions;

(3) And they can become more complex, like $\partial x/\partial t$, $\partial y/\partial t$, $\partial z/\partial t$ partial differential functions where all the variables change with respect to each other at different rates.

So e^x can represent fundament decay, or growth, relations where energy transforms from one form to another, and since Calculus is a conceptual language it can also describe energy that transforms continuously between two equivalent forms in a resonance, like a pendulum, when ix is substituted for x to divide the e^x function between equal but different domains, imaginary i and real x. Or, it can describe statistical behaviors when S entropic degrees of freedom available to the fundamental system component energy k by substituting S/k for x in e^x.

Because the i means an "imaginary" dimension and ix splits the e^x function between the i imaginary and x real dimensions, e^{ix} describes the basis of stable matter, energy resonating at orthogonal (i.e. right angle) degrees of freedom by Euler's $e^{-ix} = \cos x - i \sin x$ Identity, which means a real cosine wave behavior in the x dimension and imaginary sine wave behavior in the i dimension, like a pendulum or electron $\psi(t)$ wave function behavior in an atom. For a pendulum ix is a positive energy state that is somewhat stable but decays over time and for an electron $\psi(t)$ wave function –ix is negative because energy must be added to destabilize it.

The $e^{S/k}$ term is Boltzmann's probability function and the basis statistics, like e^x being the basis of all Calculus relations, as shown in Laplace Transforms, because each element is a calculus of its adjacent elements. And a special form called Entropic Calculus can characterize any object by its behaviors within its entropic degrees of freedom by setting $e^{-ix} = e^{S/k} = e^{dx/dt}$ to define the component and system entropic degrees of freedom energies as $\psi(t)$ wave function harmonics of each other so there is no wasted energy and everything equates in a perfect ground state condition.