SCIENTIFIC LAWS VIA ART

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Introduction

The major objective of this article is to demonstrate three scientific laws by artworks. From the long experience of the author who developed this approach, it makes the laws clearer, easier to perception and most important to implement them in practice. The experience of the author can be summarized as follows: for the last 10 years he edited a one page column on art and science in the Scientific American Journal published in Israel and so far wrote 59 articles. For the last 6 years he edited such a column in the Quimica and Industria magazine published in Spain and so far wrote 25 articles where during 2000-2005 he acted as associate editor of art and science in the Canadian Journal of Chemical Engineering published in Canada in which he wrote 29 articles. In addition he established 40 exhibitions on Art and Science where in Ben-Gurion University of the Negev he established the museum of Art and Science.

Now what is the definition of a scientific law? In the internet many definitions can be found part of which are summarized in the following: 1) Scientific laws are statements that describe, predict, and perhaps explain why a range of phenomena behave as they appear to in nature. 2) A scientific law is a statement based on repeated experimental observations that describes some aspect of the world. 3) A scientific law is an empirical statement of great generality of something, which seems to always be true. 4) A scientific law or scientific principle is a concise verbal or mathematical statement of a relation that expresses a fundamental principle of science. 5) A law in science is a generalized rule to explain a body of observations in the form of a verbal or mathematical statement. The major properties of scientific laws are: 1) They can be formulated mathematically as one or several statement or equation, or at least stated in a single sentence, that it can be used to predict the outcome of an experiment, given the initial, boundary, and other physical conditions of the processes which take place, 2) They are strongly supported by empirical evidence. 3) They summarize a large collection of facts determined by experiment into a single statement.

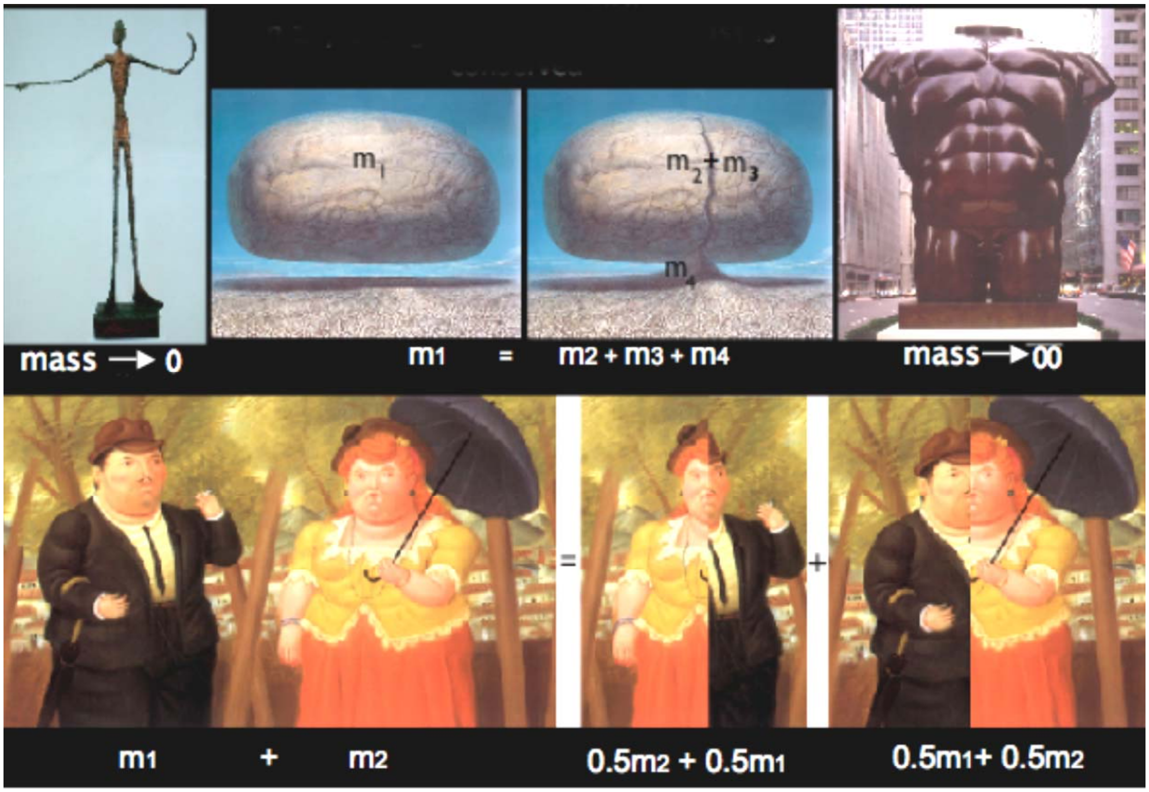
In the following the author decided to describe artistically the following three laws: 1) Newton's 2^{nd} Law. 2) Mass Conservation Law. 3) Law of Conservation of Energy.

Newton's 2nd Law via Art

First of all who was Newton? Sir Isaac Newton (1643-1727), born in UK, was a mathematician and physicist, one of the foremost scientific intellects of all time. He was a premature infant not expected to live who showed no particular promise in his early years. Surprisingly, Newton was highly productive only for eighteen years, 1669-1687, while a breakdown at an age of 51 ended his scientific work. He then became a highly paid government official in London with little further interest in mathematical research. Newton never married, but was at his happiest in the role of patron to younger scientists while from 1703 he served as a tyrannical president of the Royal Society. He was knighted in 1705. Newton's 2nd Law demonstrated below is given by F = ma where F is the force, m is mass where a is the acceleration. *Force* F, a push or pull exerted on an object, is demonstrated by "Sisyphus" pushing a heavy boulder. It was painted by Franz von Stuck (1863-1928), born in Lower Bavaria. *Mass* m, a measure of how much material is in an object, is demonstrated by Rafi Carasso in his sculpture "Lady with Basket." Carasso is a doctor of medicine, a practicing psychologist and sculptor born in Israel in 1945. Although the upper part of the lady looks normal, it is hers lower part which gives the observer a strong sensation of a high mass. The standing lady demonstrates also Newton's third law where the force exerted by the lady on the floor is balanced by an identical force exerted on the sole of her foot by the floor. And finally, the *gravity acceleration* g is demonstrated by Fernando Botero in his painting "Woman Falling from a Balcony". Botero, a painter and sculptor, was born in 1932 in Medellin, Columbia. Botero, one of today's preeminent artists, is marked by unique qualities and a distinct figurative style which includes a wide repertoire of themes such as self-portraits, nudes, lovers, bullfights, nuns, prostitutes and saints. A closer examination of his picture brings to the conclusion that it represents Newton's 2nd law for free fall under force of gravity, i.e. a = g.

Mass Conservation Law

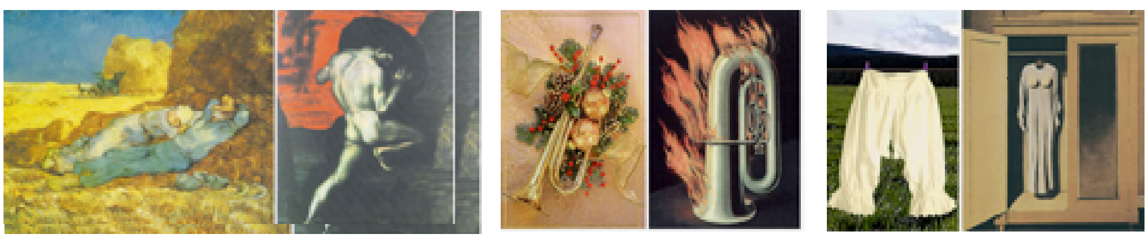
“Mass” is a basic property of a physical body that describes the amount of matter in it, and in contrast to weight it does not depend in the location of a body in space. The concept of mass is demonstrated in the article by two artworks trying to realize two“extremes” of this concept. Mass approaching to zero is demonstrated by the artwork of the Swiss surrealist Giacometti (1901-1966), and in comparison, mass approaching to infinity is demonstrated by the impressive sculptor of the Colombian Botero (b.1932) located in one of the streets of New York. In the following we discuss the Law of Conservation of Mass attributed to Lavoisier (1743-1794), a French chemist which formulated it in 1789 as follows:” in a chemical reaction the total mass of the products is always equal to the total mass of the reactants”. It should be noted also that the Russian Lomonosov suggested a similar statement already in 1784 so that the law is also named Lomonosov-Lavoisier Law. An alternative more general statement to the law that is demonstrated here by art reads: ”in any change of state the total mass is conserved”. Let us consider the surrealist artwork of the Austrian Schwertberger (b.1942) in which we see a split rock into three parts the mass of which is the mass of its three parts. The author of the article changed the “state” of the split rock into a single unit floating in the air so that the combination of the two pictures fulfills the law in its above statement. The original artwork of Botero, down on the left, describes a couple the total mass of which is the sum of the masses of the man and woman. The author changed again the “state” of the couple and created two new “states” in which every image is composed of two different halves of the man and woman. According to the law the change of state does not change the total mass.



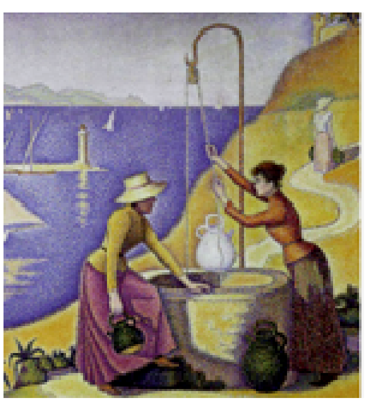
Law of Conservation of Energy

One of the basic concepts in thermodynamics is the concept of energy. Its activation makes it possible to do work and to perform a variety of processes. The artworks below in the first line demonstrate different energies the values of which are equal to or greater than zero. Two artworks demonstrate the energy of work, W: the two images of Van Gogh (1853-1890) on the left demonstrate zero work in contrast to Sisyphus seen pushing a stone up the hill in the artwork of the German artist Von Stuck (1863-1928). After the stone reached the top of the hill it rolled down, and Sisyphus had to push it again to the top and again and again. From here comes the concept sysyfical work, namely, non-useful work. The two trumpets demonstrate the heat energy, Q: the burning trumpet of the Belgium surrealist Rene Magritte (1898-1967) that emits heat to the surroundings due to temperature gradient, is an exact demonstration of the heat energy definition. On the other hand the temperature gradient between the "flowered" trumpet and the surroundings is equal to zero, which demonstrate a situation of no heat transfer. The internal energy, U, is related in thermodynamics to the internal properties of matter and is demonstrated by two artworks on top right. In the right artwork by Magritte, the internal content of the dress is reflected which might demonstrate the case where $U > 0$, while the empty dress on the left demonstrates the situation where $U = 0$. The 1st Law of Thermodynamics, which was stated at about 1850, is based on the Law of

Conservation of Matter stating that in a closed system the total amount of energy remains unchanged. In other words, energy can be transformed from one form to the other but cannot be formed from nothing, or disappear. The above is demonstrated by the artworks on the second row. The artwork on the bottom-right is a combination of a sowing farmer by Van Gogh and a woman's picture of the Polish artist Tamara de Lempica (1898-1980). The radiating sun relates between the two pictures: on the right picture there is an impression that the sun's energy is transformed to work energy of the farmer, where without any intention Van Gogh brings to the attention of the reader a technological process which due to space shortage will not be explained here. On the left-hand sun energy is transformed into internal energy of the woman, thus her body is warming. An additional example of the law is shown on the left down in the artwork of the French artist Signac (1863-1935). The woman invests work energy and increases the potential energy of the jar, namely the energy stored in it due to its position. Simultaneously she raises also the kinetic energy of the jar due to its motion. And finally, an interesting question is whether Signac who painted his artwork in 1892, namely, about 40 years after the law was stated, indeed meant to demonstrate it by his artwork? To Signac the answers.



W = 0 W>0 Q=0 Q>0 U=0 U>0



work is transformed to potential and kinetic energy

sun energy is transformed to work of the farmer and to heat and internal energy of the body