Thermodynamic Functions via Art

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Thermodynamics is the science engaged with the transformation of heat into mechanical work under the restrictions of four laws. By law is meant a generalization that describes recurring facts or events in nature. The 1st Law tells us that energy is always conserved, but it can be converted from one form to the other. According to the 2nd Law "there is no free lunch", namely, heat flows spontaneously from a high temperature to a lower one, however, the opposite can only be achieved by investing work. The impossible attainability of the absolute zero is the 3rd Law, while according to the Zeroth Law, if two temperatures are equal to a third one, they are also equal to each other. A quantitative presentation of the laws requires the definition of basic functions such as volume, enthalpy, entropy, etc. A combination of these functions makes it possible to define additional ones. The major aim of this article is to illustrate these functions by means of the artworks on the back cover making them more perceptible.

We begin with *Pressure* P, the force per unit area in a fluid acting normally on a surface. It is demonstrated by the artwork of Hanoch Piven, cartoonist, who was born in Uruguay. It is interesting to note that the concept of pressure appeared for the first time in Genesis 19:9: " They kept bringing Pressure on Lot …"

Volume V, the space occupied by a body, is demonstrated by "Campbell's Soup I" (1968) of Andy Warhol (1928-1987), an American pop artist.

Absolute temperature T means temperature measured on a scale, Kelvin and Rankine, with absolute zero as 0. The latter is the lowest temperature which could occur naturally, while there is no limit to how hot an object can become. It is astounding how the artwork "Homo Vitruvius" (c.1490) by Leonardo da Vinci (1459-1519) demonstrates this function T. The artwork is also a study of the proportions with the human figure inscribed in a circle and square.

Heat Q, is the energy transferred from one body or system to another as result of a temperature difference. It is demonstrated by "Eruption" (1990) of the Polish artist Jacek Yerka (1952). It was Benjamin Thompson, also known as Count Rumford of the Holy Roman Empire (1753-1814), who discovered the true nature of heat as a form of energy while operating a factory for boring cannon. In the process of boring the hole in the barrel the metal got hot. Rumford was able to show that the only explanation for this phenomenon was that the work being put into turning the drill bit was being converted into heat.

Work W, the force times the distance through which it acts, is established for two cases. Like heat, work is energy in transfer formed or invested during when a process takes place between two states. $W = 0$ is demonstrated by "Noon Rest" (1890) of Vincent van Gogh (1853-1890) a Dutch Expressionist, while "The Gleaners" (1857) by Jean-Francois Millet (1814-1875), a French realist painter, illustrates $W > 0$. The work function is very ancient. Already in Genesis 2:2 it is emphasized that by the seventh day God had finished the *work* he had been doing; so on the seventh day he rested from all his *work*.

Internal Energy U, is that energy that a substance possesses because of the motion and configuration of its atoms, molecules, and subatomic particles. In other words, it is the energy related to the inside of a body, thus, U of a system is the sum of all the microscopic forms of energy. The internal energy of a system can be changed by a flow of work, heat or both, and when these are added to a thermodynamic system, they are stored as an internal energy. The "Girl With Gloves" (1929) by Tamara de Lempicka, Polish (1898-1980) illustrates this function noting that the inside of the body is convincingly emphasized.

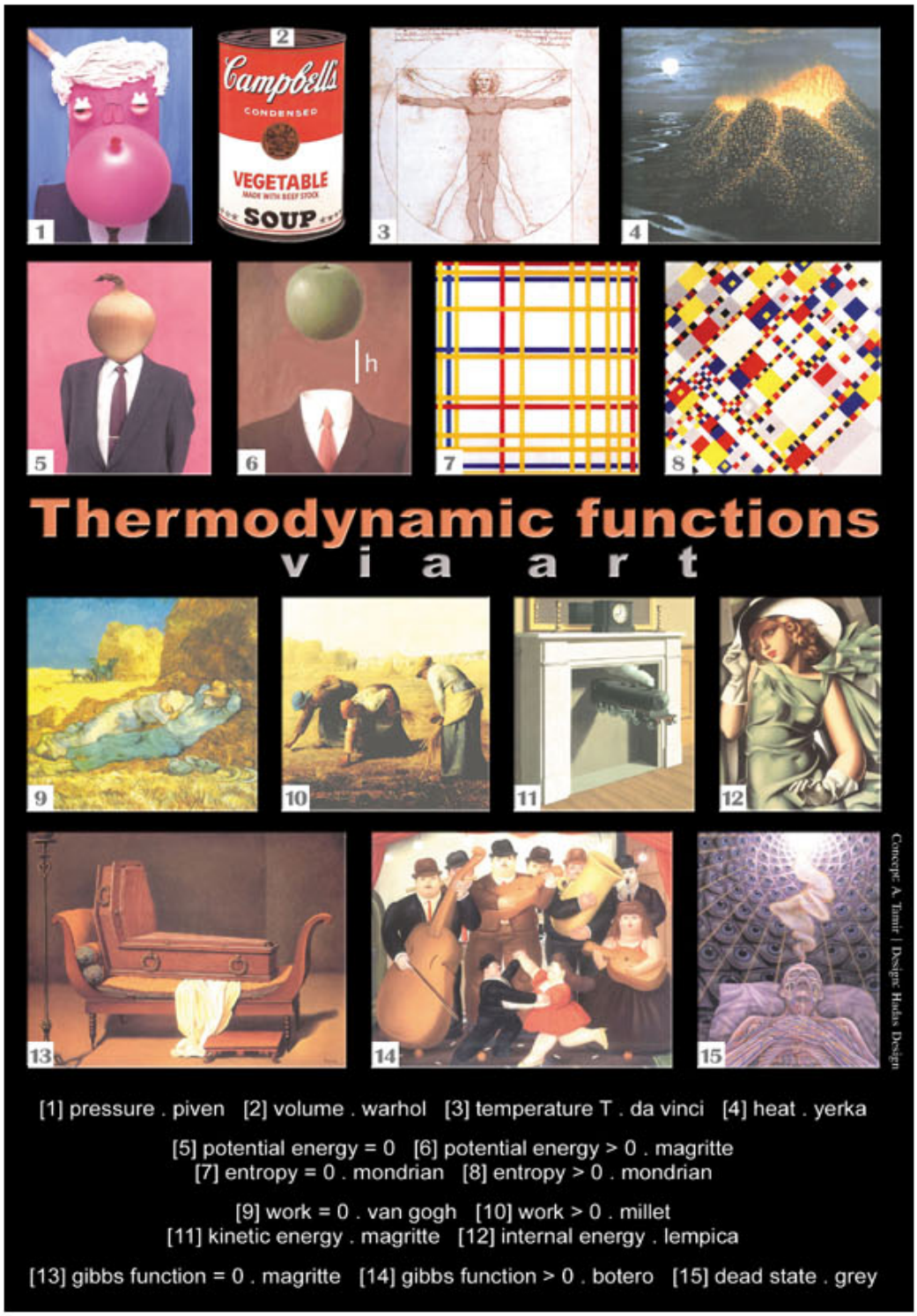
Potential Energy mgh, the energy that a body possesses by virtue of its position, is demonstrated by two artworks. $mgh = 0$ was advertised by Wm. Wrigley Jr. Company (1999) where that for $mgh > 0$, "The Idea" (1966) was painted by Rene Magritte (1898-1978) a Belgium Surrealist.

Kinetic Energy $mv^2/2$, the energy that a body possesses by virtue of its motion, is demonstrated by Magritte's artwork "Time Transfixed" (1938). The surrealistic presentation of a tiny locomotive emerging incongruously from the vent, where its smoke is nearly disappearing up the chimney, enhances the impression of speed, i.e. kinetic energy.

Entropy S of a system is a measure of its degree of disorder or randomness on the molecular scale. This quantity was introduced in the first place to facilitate the calculations, and to give clear expression to the results. From this point of view, the first and second laws of thermodynamics help to set up the foundation or entropy. Thermodynamic systems tend to react in ways that increase their entropy, namely, the amount of energy that is no longer available for doing mechanical work. If the universe is considered as an isolated system, entropy increases as matter and energy in it degrade to an ultimate state of inert uniformity. Human's life is related to the amount of entropy in our body. Once the entropy increases to a certain level, we are no longer able to complete our required functions. We constantly increase our entropy from the day we are born. However, to maintain a (healthy) low entropy, a state of order until old age, we should take into account the kind of food that we eat and other activities we perform. The artworks, by Piet Mondrian (1872-1944), Dutch Geometric constructivist are illustrations of this function. "New York City I" (1942) represents $S = 0$ and "Victory Boogie-Woogie" (1943/44) $S > 0$.

The *Gibbs function* G is the energy available to do useful work. It is also called Gibbs free energy and given the symbol *G* in honor of Josiah Willard Gibbs (1893-1903) who almost single-handedly developed both the concept and the quantitative equations that describe it. The artwork by Magritte," Perspective: Madame Recamier de David" (1951) demonstrates the situation of $G = 0$ and that of Fernando Botero (1932), Colombian, "Ball in Colombia" (1980) illustrates $G > 0$.

The last function demonstrated is " Dead State", which is a state where the system has lost its capacity of delivering available energy. It is demonstrated by the artwork "Dying" (1990) of Alex Grey (1953) an American artist of anatomy of the body. In conclusion it is believed that the presentation of thermodynamic functions via art makes them clearer and more perceptible.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SOUP
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Thermodynamic functions
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Concept: A. Tamir | Design: Hadas Design
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[5] potential energy = 0 [6] potential energy > 0 . magritte
[7] entropy = 0 . mondrian [8] entropy > 0 . mondrian
[9] work = 0 . van gogh [10] work > 0 . millet
[11] kinetic energy . magritte [12] internal energy . lempica
[13] gibbs function = 0 . magritte [14] gibbs function > 0 . botero [15] dead state . grey