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Art and Science: Thermodynamic Functions via Art

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Abstract

The basis of thermodynamics is four laws that form an axiomatic basis. The laws are quantitatively defined on the basis of "Thermodynamic Functions" such as temperature, heat, work, entropy etc. that are derived from the thermodynamic definition of the specific function and demonstrated in this article by artworks.

Keywords: Thermodynamic functions; Heat; Work; Entropy; Temperature; Pressure; Internal energy; Free energy; Enthalpy; Entropy; Potential energy; Kinetic energy; Dead state

Thermodynamics, in general, is concerned with those physical and chemical phenomena that involve heat, work and other functions elaborated in the following. From the practical definition, thermodynamics is the theory of converting heat to work and understanding the role of energy and other properties of matter in this conversion process. The four laws are: The zero law that is the definition of thermodynamic equilibrium; the 1st law is the law of energy conservation; the 2nd law with its popular statement that there is no free lunch and the 3rd law stating that all processes cease as temperature approaches zero. Among the "thermodynamic functions" are "state functions" that are properties whose values do not depend on the path taken to reach that specific value but depend on the state of the system. For example, internal energy, enthalpy and entropy are *state quantities* because they describe quantitatively an equilibrium state of a thermodynamic system, irrespective of how the system arrived in that state. In contrast, mechanical work and heat are process quantities because their values depend on the specific transition (or path) between two equilibrium states. Figures 1-7 demonstrate the "state functions". Figure 1 demonstrates the "absolute temperature" T where Leonardo Da Vinci painted the original artwork entitled "The Vitruvian Man". Figure 2 demonstrates the "pressure" P. On the left is the artwork of Hanoch Piven, an Israel Illustrator and Caricature Artist that demonstrates a relatively high pressure. On the right is a demonstration of an atmospheric pressure. Figure 3 demonstrates by an artwork of Rene Magritte, Belgium Surrealist, the function "volume" V. Figure 4 demonstrates the "internal energy" U. The left artwork was painted by the English illustrator Walter Hodges demonstrating man's brain. It is well known that the internal energy consumption of the brain is very high although its mass constitutes only 2% of the entire body weight. On the right is an artwork by an unknown artist demonstrating the inside of human's body that is the storage of our internal energy. Figure 5 demonstrates the "Helmholz free energy" G in a system. Figure 6 is a combination of artworks that demonstrate the function "enthalpy" H that is the sum of the internal energy of the system plus the product of its volume multiplied by the pressure exerted on it by its surroundings. Figure 7 demonstrates the "entropy" state function S defined as the quantitative measure of disorder in a system. Left bottom is the artwork of the French artist Ives Klein that demonstrates minimal entropy. Top left and right are paintings of the Dutch artist Piet Mondrian where on right bottom are a painting of the Italian artist Gino Severini that demonstrates a highest disorder, namely maximal entropy. And now we discuss Figures 8-12 that present "non-state functions" because their values depend on the specific path between two equilibrium states. Figure 8 demonstrates the "gravitational potential energy" P.E. On the left is an artwork of the German artist Quint Buchholz where on the right is an artwork of Magritte. Figure 9 demonstrates the "kinetic energy" K.E. On the left K.E=0 where on the right, by Magritte, K.E>0. Figure 10 demonstrates the "heat" Q. The two paintings on the left for Q>0 and Q=0 were painted by De Es Schwertberger an Austrian artist. On the right is a surrealistic painting by Magritte. Figure 11 by Magritte demonstrates the "work" function W. On the right is the original painting by Magritte for which W>0 where on the left W=0. And finally the function "dead state" that is the state when a system has zero availability is demonstrated in Figure 12 painted by the Italian painter Enzo Cucchi. To conclude the article the authors believe that the artistic demonstrations of the thermodynamic functions make them clearer and more understandable. And finally it should be emphasized that all information in the article as well as artworks is based on Google as source reference.

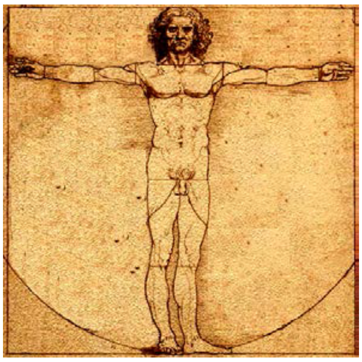

Figure 1: Absolute temperature.

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Figure 2: Pressure.

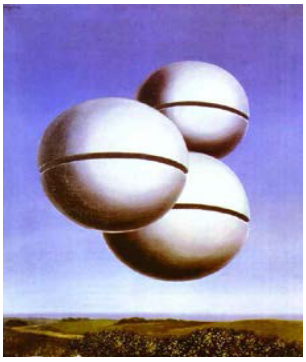

Figure 3: Artwork of Rene Magritte.

Figure 4: Internal energy.

Figure 5: Helmholz free energy.

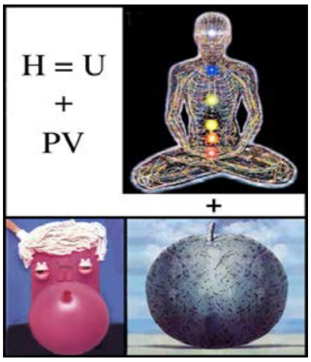

Figure 6: Enthalpy.

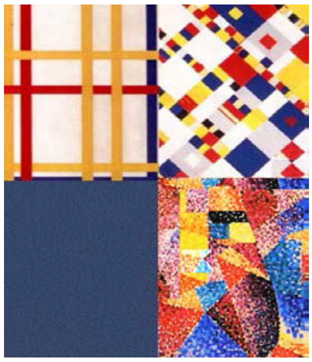

Figure 7: Entropy.

Figure 8: Gravitational potential energy.

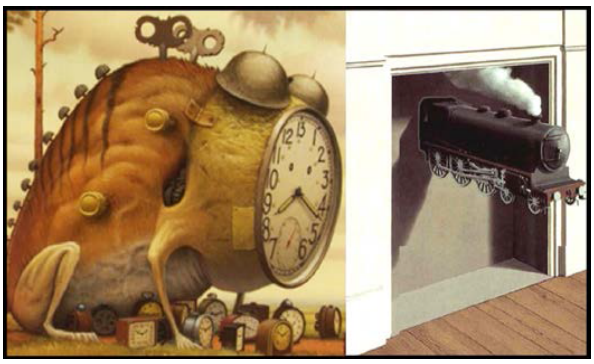

Figure 9: Kinetic energy.

Figure 10: Heat.

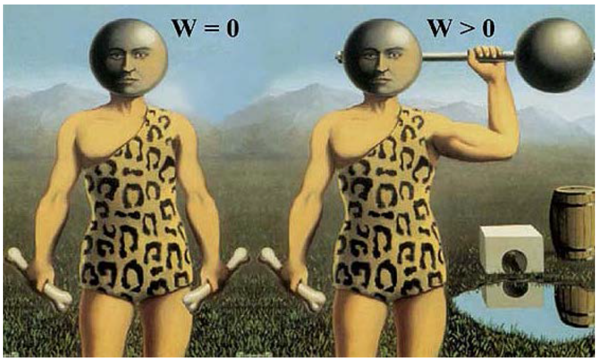

Figure 11: Work function.

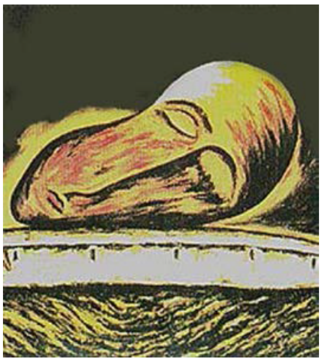

Figure 12: Zero availability.