Thermodynamics Lecture Notes, Part 2

Concepts to Know

Symmetry

Broadly, the property of being the same when considered from various perspectives. The concept is illustrated clearly in geometry, where a circle has infinitely many symmetries of rotation (it is the same when looked at from any side), and an equilateral triangle has three axes of symmetry (each at 120 degrees from the other two).

Invariance

A generalization of the concept of symmetry to physical theories. An invariant quantity is one that does not change under certain transformations of the system. For a simple (if silly) example, your weight changes when you eat breakfast: but the total weight of

W = (You + what is left of your breakfast)

does not change even though the weight of each term changes as you eat. In a sense, this is a symmetry of the situation: the quantity W is the same when considered at various times.

Conservation Laws

A conservation law states that a measurable property of a system is invariant.

The First Law of Thermodynamics

One of the most famous scientific laws of all time, this states that the total quantity of energy in a closed, isolated system is a constant. Energy can be neither created nor destroyed.

The Second Law of Thermodynamics

This law states that the total useable energy in the universe decreases across time, even though the total quantity remains constant. Sometimes this is expressed by saying that water runs downhill; this is a special case of the second law. It is a consequence of the second law that perpetual motion machines are impossible. A crucial question about the second law is not whether it is true, but why.

People to Know

Daniel Bernoulli (1700-82)

Offered the first analysis of the pressure of a gas in an enclosed container that made explicit the statistical nature of that pressure - that the pressure could be understood as resulting from the averaging out of myriads of bombardments of the walls of the container by individual particles. This laid the groundwork for the development of the statistical approach to thermodynamics.

Antoine Lavoisier (1743-94)

French chemist and author of a major textbook on the subject. Lavoisier (pronounced "la Vwah zhee YAY") promoted the fluid theory of heat and included this fluid, which he called "caloric," in his list of the basic chemical elements.

Sadi Carnot (1796-1832)

Using the fluid theory of heat, Carnot (pronounced "car NO") was one of the first to glimpse the first and second laws of thermodynamics

James Prescott Joule (1818-89)

Joule, heir to a brewing fortune, made extremely precise instruments and with them performed delicate experiments attempting to determine how mechanical energy and heat could be interconverted. This gave a more precise formulation of the first law.

Rudolf Clausius (1822-88)

Building on the work of Carnot, Clausius developed in a clear and precise fashion the first two laws of thermodynamics. He is responsible for introducing the term "entropy" into scientific language and for making precise the concept that it denotes. Today this concept is indispensable in physics and in many other fields.