3.1: Zeroth Law of Thermodynamics

Perhaps the simplest concept of temperature is to regard it as a potential function whose gradient determines the direction and rate of flow of heat. If heat flows from one body to another, the first is at a higher temperature than the second. If there is no net flow of heat from one body to another, the two bodies are in thermal equilibrium, and their temperatures are equal.

We can go further and assert that

> *If two bodies are separately in thermal equilibrium with a third body, then they are also in thermal equilibrium with each other.*

According to taste, you may regard this as a truism of the utmost triviality or as a fundamental law of the most profound significance. Those who see it as the latter will refer to it as the *Zeroth Law of Thermodynamics* (although the "*zeroth*" does sound a little like an admission that it was added as an afterthought to the other "real" laws of thermodynamics).

We might imagine that the third body is a thermometer of some sort. In fact it need not even be an accurately calibrated thermometer. We insert the thermometer into one of our two bodies (we are not thinking particularly of human bodies here), and it indicates some temperature. Then we insert it into the second body. If it indicates the same temperature as indicated for the first body, then the Zeroth Law asserts that, if we now place our two bodies into contact with each other, there will be no net flow of heat from one to the other. There exists some measure which all three bodies have in common and which dictates that there is no net flow of heat from any one to any other, and the three bodies are in thermal equilibrium. That measure is what we call their **temperature**.

To some, this will sound like saying :"if A and C are at the same temperature, and if B and C are at the same temperature, then A and B are at the same temperature". Others, of philosophical bent, may want to pursue the concept to greater rigor. In any case, at whatever level of rigor is used, what the Zeroth Law establishes is the existence of some quantity called temperature, but it doesn't really tell us how to define a temperature scale quantitatively. It is as if we have established the existence of something called "length" or "mass", but we haven't really specified yet how to measure it or what units to express it in. We could, for example, discuss the concepts of "length" or of "mass" by describing a test to show whether two lengths, or two masses, were *equal*, but without developing any units for expressing such concepts qualitatively. That, I think, is where the Zeroth Law leaves us.