1. Zeroth (0th) Law of Thermodynamics
   1. [History](https://en.wikipedia.org/wiki/Zeroth_law_of_thermodynamics#History)

Of the four existing laws of thermodynamics, this *Zeroth Law* was actually the third to be discovered. In Laughin’s course notes, he states that, “Joseph Black was the founder of this Law. It was he who emphasized that there is a difference between Temperature and Heat content” (Laughlin, 2018). Joseph Black was also referred to as the father of calorimetry and was the first to measure latent heats. However, Wikipedia states differently as, “According to Arnold Sommerfeld, Ralph H. Fowler invented the title 'the zeroth law of thermodynamics' when he was discussing the 1935 text of Saha and Srivastava” (Zeroth Law of Thermodynamics, n.d.). In this article Ralph Fowler presumes that temperature is a physical quantity and that, “If a body A is in temperature equilibrium with two bodies B and C, then B and C themselves will be in temperature equilibrium with each other” (Fowler, 1935). This statement does not use the phrase zeroth law and it was only later when Fowler co-authored a paper with Edward A. Guggenheim did they write the zeroth law to be as follows, **“If two assemblies are each in thermal equilibrium with a third assembly, they are in thermal equilibrium with each other”** (Fowler & Guggenheim, n.d.).

* 1. [Summary](https://en.wikipedia.org/wiki/Zeroth_law_of_thermodynamics)

The *zeroth law of thermodynamics* states that if, **“two thermodynamic systems each are in thermal equilibrium with a third, then they are in thermal equilibrium with each other”** (Zeroth Law of Thermodynamics, n.d.). This provides a *transitive relation* (i.e. a=b & b=c, thus c=a) between the systems that are in thermal equilibrium.

Thermal Equilibrium

Thermodynamic

System B

Thermodynamic

System A

Thermal Equilibrium

Thermal Equilibrium

Thermodynamic

System C

Figure 3: Diagram depicting the transitive relation of the zeroth law between equilibrium thermodynamic systems

The diagram above shows the relationship that relationship between system A and system B are in thermal equilibrium. It also shows system A and system C are also in thermal equilibrium and with the transitive relationship of the zeroth law, system B and system C must also be in thermal equilibrium. The resulting relationship from this law provides the foundation for showing the existence of an intensive property known as temperature.

* 1. [Foundation of Temperature](https://en.wikipedia.org/wiki/Zeroth_law_of_thermodynamics#Foundation_of_temperature)

The zeroth law establishes that thermal equilibrium is an equivalence relationship where a set of all systems with each own’s state of internal equilibrium is divided into a collection of distinct subsets. With the case of the zeroth law, the subsets consist of systems which are in mutual equilibrium and justifies the use of thermodynamic systems for labeling. Thus temperature is, “the new term to understanding the physics of matter” (Laughlin, 2018). This allows us to determine whether or not a system is thermal equilibrium where if the *spatial gradient* (T) ≠ 0, then the system is not in thermal equilibrium. This is useful as this gradient will give rise to the transfer of energy down the gradient until the gradient in T become equal to 0.

T2

T1

Figure 4: Diagram depicting steady state for heat flow, not equilibrium

1. Relevant Examples