Newton's law of cooling

Science background

Newton's law of cooling

When a body loses or gains heat from its surroundings, the rate of heat transfer (ΔQ/Δt) depends upon the difference in temperature between the body and its surroundings:

$$\frac{\Delta Q}{\Delta t} = -a \cdot (T - T_s)$$

where T and T_s are the temperatures of the body and surroundings respectively and K is a constant of proportionality.

$$\text{Since } \Delta Q = mc(T - T_s)$$

$$\text{then the equation can be written as } \frac{\Delta T}{\Delta t} = -k(T - T_s) \text{ where } k = \frac{a}{mc}.$$

This equation says that the rate of cooling is proportional to the temperature difference between an object and its surroundings. This is a differential equation and its solution is:

$$T = T_S + (T_0 - T_s)e^{-kt}$$

where T_0 is the initial temperature of an object at the time t=0.

This equation represents Newton's law of cooling. This is the classic equation of exponential decline over time that also applies to many phenomena in science and engineering, such as the discharge of a capacitor and the decay in radioactivity.

The graph drawn between the temperature of the body T and time is known as cooling curve. The slope of the tangent to the curve at any point gives the rate of change of temperature.