# A STUDY OF NEWTONS LAW OF COOLING AND ITS APPLICATION

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## ABSTRACT:

Hopefully, this generalization of Newton’s law of cooling will allow both gaining a better insight into heat convection processes through fractal media and developing a wide variety of new applications.

## KEYWORDS:

Newtons Law of Colling , Temperature , Body Cooling , Heat

## INTRODUCTION:

Newtons law of cooling is invoked in a wide range of contexts in applied science. A recent example, and one that has caused considerable interest, is the reported observation of nuclear fusion at room temperature, but the law is also applied in other areas, for example, in materials science, high temperature superconductivity, and atmospheric physics. Newtons law can be invoked in a wide Variety of contexts including in the measurement of the heat capacity of calorimetric systems, in determining heat losses of the surroundings during experimental runs, etc. Because of the widespread use of this law of cooling and, in particular, because of the importance of the cold fusion results, if confirmed, it would seem appropriate to carry out a critical study of the regime of applicability of the basics assumptions involved in applying the law in these contexts.

The law of governing the cooling of hot bodies by convection first appeared in a paper read by Newton at Royal Society on 28 May 1701 and published anonymously in Philosophical Transactions for March and April 1701. The law states that the rate of heat loss per unit area from a body is directly proportional to the temperature difference between the body and the surrounding fluid medium in contact with the body with the body. It was realized from as early as 1740 at least that Newtons model was not applicable to all situations and the question seems to have been a matter of much debate throughout the 18$^{th}$ and19th centuries. Clearly, other heat loss mechanisms, in particular radiation, must be considered. Furthermore, a distinction must be made between cooling by convention currents arising from the heating of the surrounding medium directly by the cooling body (“natural convention”), on the one hand, and by convection currents resulting from external influences (“forced cooling”), on the other.

## LITERATURE SURVEY :

Textbooks on heat transfer generally refer to Newton's law of cooling but they give no details of Newton's experiment. The purpose of the first part of this paper is to give details of Newton's work. His explanation of why he thought the law was correct, and the experiment that he did to confirm it, are still of interest. It is worth stressing that he did not write his law down in the form of an equation nor did he define or use the heat transfer coefficient. He was however the first to postulate that the rate of loss of temperature of a hot object, with air blowing past, is proportional to the temperature itself. The second part of the paper is an attempt to reconstruct Newton's transient cooling experiment using modern knowledge of heat transfer. It is necessary to allow for varying heat transfer coefficients and specific heats and hence a numerical approach has to be used on a computer. The output of the process is data for temperature versus time for the test section. The next step is to take this simulated cooling time data and analyse it using the same method Newton used, to produce the same type of estimated temperatures that he obtained. By modern standards his estimates of the melting point of various metals were too low. It has been suggested that this was because the metals were impure but a purely heat transfer explanation is shown to be more plausible. A simple extension of his explanation of why the law works is used to derive a result close to accepted modern equations for heat transfer coefficient.

## OBJECTIVE:

To study the relationship between the temperature of a hot body and its time of cooling using Liquid Nitrogen by plotting a cooling curve.

## METHODOLOGY:

This Law of Cooling is named after the famous English Physicist Sir Isaac Newton, who conducted the first experiments on the nature of cooling.

Liquid Nitrogen: Liquid Nitrogen has great value for demonstrating scientific principles ; although it is very cold and requires careful handling , LN2 is inexpensive ,nontoxic and chemically inert. Because it is cold around minus 196 Celsius , it can help you demonstrate phenomena in a way which is unattainable at normal room temperatures.

### Statement of the Law :

According to Newton's Law of Cooling, the rate of cooling of a body is directly proportional to the difference in temperatures of the body (T) and the surrounding ($T_0$), provided difference in temperature should not exceed by $30^0$C.

From the above statement,

$$\frac{dQ}{dt}\alpha(T - T_0)$$

For a body of mass m, specific heat s, and temperature T kept in surrounding of temperature $T_0$;

$$Q = msT$$

Now, the rate of cooling,

$$\frac{dQ}{dt} = ms\frac{dT}{dt}$$

Hence ,

$$ms\frac{dT}{dt}\alpha\,(T - T_0)$$

Since the mass and the specific heat of the body are taken as constants, the rate of change of temperature with time can be written as,

$$\frac{dT}{dt}\alpha\,(T - T_0)$$

The above equation explains that, as the time increases, the difference in temperatures of the body and surroundings decreases and hence, the rate of fall of temperature also decreases.

It can be graphically represented as,

### Learning Outcomes

- Students understand the different modes of transfer of heat.
- Students identify the variables which affect the cooling rate of a substance.
- Students verify Newton's Law of Cooling.
- Students understand the relationship between temperature and time of cooling of objects.

- Students understand working with Liquid Nitrogen

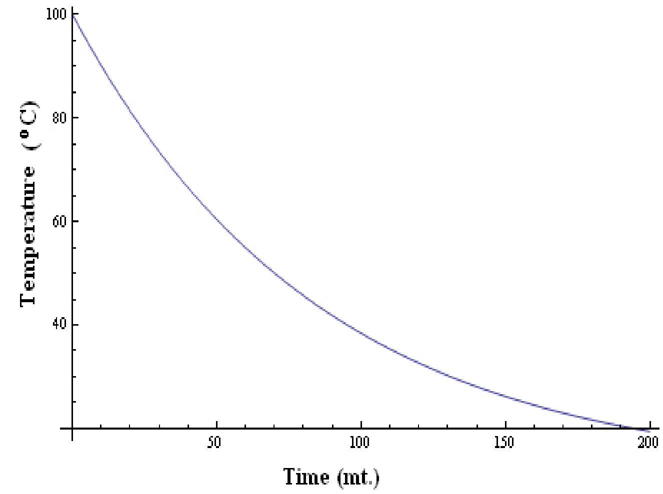


**Fig.1:Graph of time vs tempertaure**

Materials

- Water
- LN2
- Beaker, 250 mL
- Thermometer
- Hot Plate
- Scientific Calculator
- Graph Paper or Computer with Spreadsheet Software

**Observation Table 1** : Temperature change with time

| **Temperature (°C)** | **Temperature (°C)** | **Time (minutes)** |
|---|---|---|
| $T_a$ | $T_a$ | |
| T(0) | T(0) | 0 |
| T(10) | T(10) | 10 |
| T(20) | T(20) | 20 |
| T(30) | T(30) | 30 |
| T(40) | T(40) | 40 |
| T(50) | T(50) | 50 |
| T(60) | T(60) | 60 |

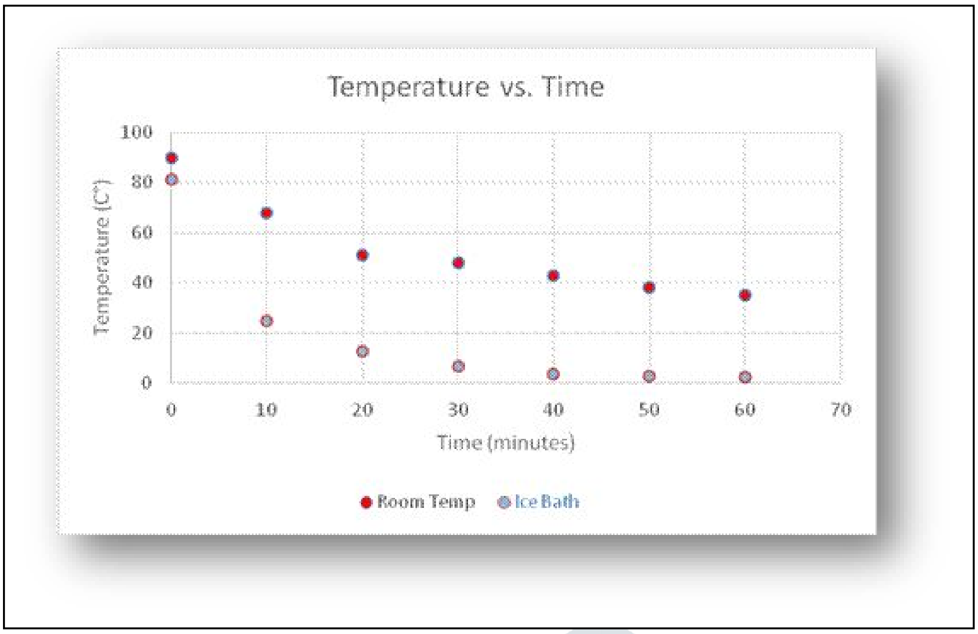


**Fig:- Graph of temperature vs time**

## OBSERVATION:

This law of cooling leads to classical equation of exponential decline over time, which can be applied to many phenomena in science and engineering, such as determining the time it takes a capacitor to discharge and in radioactive decay. Hurley (1974), Boyce and Diprima (1992), Jaffe (1989) and Smith (1978) used the Newton's law of cooling to determine the time of death in the investigation of a homicide or accidental death.

## CONCLUSION:

Discussion in standard textbooks of theories describing cooling of warm bodies has been unnecessarily empirical and reticent about the regime of applicability of such theories. The experiment described in this article indicate that a model based on combined conductive-convective (Newtonian) and radiative (Stefan) cooling can be applied with confidence over the range of conditions usually found in laboratory calorimetric experiments provided care is taken to ensure that the temperature of all nearby radiation sources is the same as that of the fluid surrounding the systems. This condition can be achieved most easily by shielding the system from any sources likely to present problems in this regard.

The techniques described here also provide reasonably simple and pedagogically satisfactory method estimating the value of Stefan's constant without the need for high temperatures or creating a vacuum around the system.

## REFERENCES:


[1] History of Newton's cooling law Archived 2015-06-14 at the Wayback Machine

[2] L. Loreanz, "Ueber das Leitungsvermogen der Metalle fur Warme und Electricitat,"Ann. Phys. 13, 582-606 (1881)

[3] *Whewell, William (1866). History of the Inductive Sciences from the Earliest to the Present Times.*

[4] Louis C. Burmeister, (1993) "Convective Heat Transfer", 2nd ed. Publisher Wiley-Interscience, p 107 ISBN 0-471-57709-X, 9780471577096

[5] Huber O, Thermodynamics,Fluid Flow and Heat Transmission(McGraw-Hill,New York,(1938) Chap.IX.

[6] *Frank Incropera; Theodore L. Bergman; David DeWitt; Adrienne S. Lavine (2007). Fundamentals of Heat and Mass Transfer (6th ed.). John Wiley & Sons. pp. 260–261. ISBN 978-0-471-45728-2.*

[7]John Stewart Turner , Buoyancy Effects in Fluids ( Cambridge U.p. ,Cambridge, 1973),pp. 207-244.

[8]John Tyndall , Fragments Of Science (Longmans, Greens, London,1872), Chap. VIII.

[9]BMDP Statistical Software, edited by W.J. Dixon ( University Of California Press, Berkeley, 1981), pp.305-314.