UNIVERSITI TEKNOLOGI MARA

JIIICaS 2024
JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

PROCEEDINGS OF JOHOR INTERNATIONAL INNOVATION INVENTION COMPETITION AND SYMPOSIUM 2024 (JIIICaS 2024)

"Flourish and Nurturing Sustainable Innovation for a Prosperous Nation"

JIICOS 2024
JOHOR INTERNATIONAL INNOVATION, INVENTION COMPETITION AND SYMPOSIUM

Editorial Board

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Preface

In the name of Allah, the Almighty who gives us the enlightenment, the truth, the knowledge and with regards to Prophet Muhammad (peace be upon him) for guiding us to the straight path. We thank to Allah for giving us guidance and strength to write this e-book.

This e-book compiles the extended abstracts that submitted to Johor International Innovation Invention Competition and Symposium 2024 (JIIICaS2024), where JIIICaS2024 is a virtual platform for all creative minds to share and present their invention and innovation. Each abstract gives a brief background on the innovation or project.

We hope that this e-book will help the readers to get to know the innovation done by the students and get some ideas to develop future innovation products.

Foreword Rector

Assalamualaikum warahmatullahi Wabarakatuh, Salam Sejahtera, Salam Malaysia MADANI and Salam UiTM Dihatiku.

In the name of Allah, the Most Gracious, the Most Merciful.

It is a great honor to welcome you to the Johor International Innovation, Invention, Competition, and Symposium 2024 (JIIICaS 2024). This event connects various disciplines, focusing on education and engaging educators, students, researchers, and innovators from all walks of life.

Innovation is not just about ideas; it demands perseverance, creativity, and determination to turn those ideas into reality. The remarkable projects showcased today highlight the dedication and spirit of all participants. Initiatives like this not only explore new technologies but also cultivate skills and leadership among our youth. At Universiti Teknologi MARA (UiTM) Johor Branch, we are fully committed to fostering a dynamic culture of innovation, promoting the commercialization of new products, and encouraging meaningful collaborations with industry and society.

As we celebrate this event, I would like to extend my heartfelt gratitude to all sponsors, judges, the College of Computing, Informatics and Mathematics, UiTM Pasir Gudang Campus as the event organizer, as well as to the researchers and participants for their hard work in making this event a success. Let us continue striving for innovation and excellence. May the ideas presented today inspire us and lay the groundwork for future achievements.

Thank you.

Associate Professor Dr. Saunah Zainon
Rector
Universiti Teknologi MARA (UiTM)
Johor Branch

(A-PP026) APPLICATION NEWTON'S LAW OF COOLING USING FIRST-ORDER DIFFERENTIAL EQUATIONS

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ABSTRACT

Newton's Law of Cooling describes how the temperature of an object changes over time when it is exposed to a surrounding medium with a different temperature. The rate at which the temperature of the object decreases is proportional to the difference between its temperature and the constant temperature of its surroundings. By applying first-order differential equations, we can calculate how much an object's temperature decreases over time relative to the surrounding environment. This study aims to analyze the principles governing the rate of temperature change, solve the differential equation using mathematical methods, and validate the theoretical model to predict future temperature changes. The findings provide a quantitative foundation for understanding temperature variations in objects exposed to different thermal conditions, offering accurate predictions and practical solutions to real-world cooling problems.

Keywords: Newton's Law of Cooling, differential equations, temperature

1.0 INTRODUCTION

Understanding the thermal behavior of objects in various environments is crucial for applications ranging from industrial processes to everyday situations like food preservation. Newton's Law of Cooling offers a framework for analyzing how the temperature of an object evolves when it is not in thermal equilibrium with its surroundings. This law states that the rate of change in temperature is directly proportional to the difference between the object's temperature and the ambient temperature. The mathematical formulation of this law, a first-order differential equation, allows for the precise prediction of temperature over time, making it a valuable tool for scientists and engineers.

1.1 PROBLEM STATEMENT

Accurately predicting the rate of temperature change in an object exposed to different thermal environments is essential for various scientific and industrial applications. Despite the simplicity of Newton's Law of Cooling, real-world conditions often present challenges that can complicate the application of the law, such as varying surrounding temperatures and heat exchange rates. This study seeks to address these challenges

by applying the method of separation of variables to solve the first-order differential equation associated with Newton's Law of Cooling.

2.0 OBJECTIVE

The main objectives of this studies are:

d) To employ the method of separation of variables to solve the first-order differential equation derived from Newton's Law of Cooling.
e) To validate the theoretical model and predict future temperature changes.

3.0 METHODOLOGY

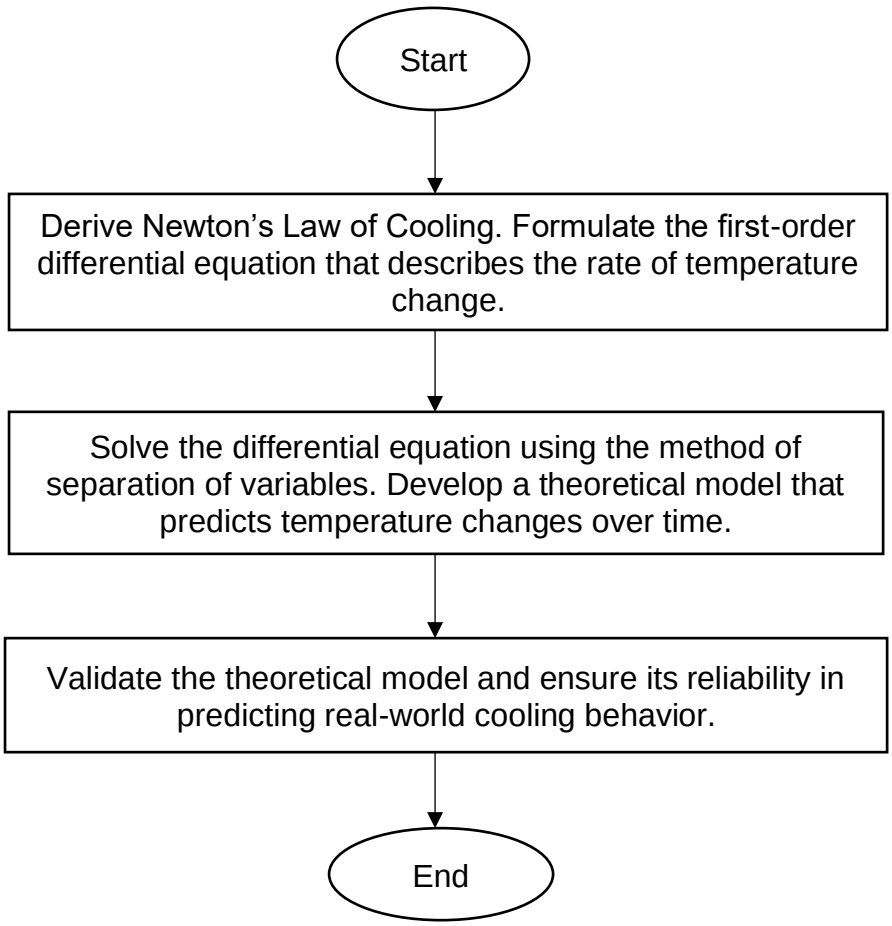

Figure 1: The methodology framework of study.

Figure 1 shows this study involves a combination of theoretical analysis, experimental design, data collection, and model validation. Initially, Newton's Law of Cooling is reviewed and the corresponding first-order differential equation is derived to establish the mathematical framework. An experiment is then set up in a controlled environment where the temperature of selected objects is measured at regular intervals using precise instruments, ensuring that the ambient temperature remains constant. The collected data is used to solve the differential equation using the method of separation of variables, allowing for the development of a theoretical model that predicts temperature changes over time. This model is validated by comparing its predictions with the experimental data, and statistical methods are employed to assess its accuracy. The analysis includes an evaluation of any discrepancies between the

theoretical and experimental results, followed by a discussion of the model's limitations and implications for real-world applications.

4.0 RESULTS

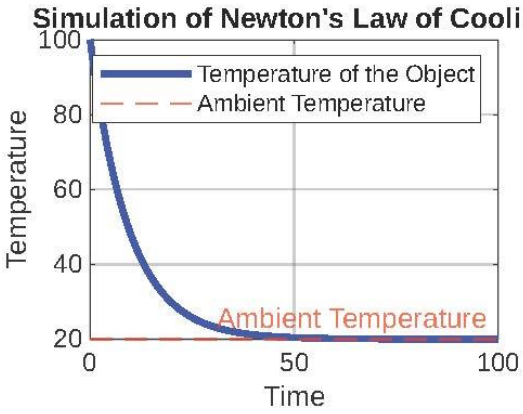

Figure 2: Graph of Simulation Newton's Law of Cooling Temperature vs Time

Figure 2 shows, demonstrate the cooling behavior of an object over time in accordance with Newton's Law of Cooling as shown in Figure 2. The temperature T(t) of the object at any time t is governed by the differential equation $\frac{dT}{dt} = -k(T - T_{ambient})$, where $T_{ambient}$ is the constant ambient temperature, and k is the cooling constant. The solution to this equation, obtained through the method of separation of variables, is $T(t) = T_{ambient} + (T_0 - T_{ambient})e^{-kt}$, where T_0 is the initial temperature of the object. The plot illustrates how the temperature T(t) decreases exponentially over time, approaching the ambient temperature asymptotically. The ambient temperature is marked as a horizontal dashed line on the graph, highlighting the convergence of the object's temperature to this value. The rate of cooling, dictated by the constant k, determines how quickly the object loses heat and reaches thermal equilibrium with its surroundings.

5.0 CONCLUSION

Newton's Law of Cooling, when solved as a first-order separable differential equation, shows that an object's temperature decreases exponentially towards the ambient temperature over time. The rate of cooling is influenced by the initial temperature difference and the material-specific constant k. This study illustrates the practical application of Newton's Law of Cooling in predicting temperature changes, providing valuable insights for various scientific and engineering fields.

6.0 BENEFIT OF STUDY

a) Improved Prediction: Provides accurate predictions of temperature changes over time, aiding in precise thermal management.
b) Practical Applications: Useful for industries requiring temperature control, such as electronics and food preservation.
c) Model Validation: Confirms the reliability of theoretical cooling models in real-world scenarios.

REFERENCES

Raju, C.M., Rao, N.S. & Rao, D.S.. (2018). Differential equations Application: Newton's Law of Cooling. *Suraj Punj Journal for Multidisciplinary Research*, *8*(12), 2394–2886. https://spjmr.com/gallery/spec-11.f.pdf

Gustavo, H.S. (2019). Application of Newton's law of cooling in production line. *Journal Industrial Organization*. https://doi.org/10.35429/JIO.2019.5.3.1.7

Da Silva, S. L. E. F. (2020). *Newton's cooling law in generalised statistical mechanics. Physica A: Statistical Mechanics and Its Applications, 125539.* https://doi.org/10.1016/j.physa.2020.125539

Vivas-Cortez, M.; Fleitas, A., Guzmán, P.M., Nápoles, J.E., Rosales, J.J. Newton's Law of Cooling with Generalized Conformable Derivatives. Symmetry 2021, 13, 1093. https://doi.org/10.3390/sym13061093

Rehan, Z. (2020) Application of First-Order Differential Equation to Heat Convection in Fluid. Journal of Applied Mathematics and Physics, 8, 1456-1462. https://doi.org/10.4236/jamp.2020.88111