# SMART GLOVE: Designing of hand motion translator

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**INSTITUTE OF BIOMEDICAL ENGINEERING & TECHNOLOGY**
**LIAQUAT UNIVERSITY OF MEDICAL AND HEALTH SCIENCE,**
**JAMSHORO**

# Certification

This is to certify that QAMAR-UN-NISA**(20BME028),** TOOBA ALI **(20BME034),** SHUJA MEMON**(20BME033)** and, SANIYA ZEHRA**(20BME029)** have successfully completed the final project **SMART GLOVE** at the **LIAQUAT UNIVERSITY OF MEDICAL AND HEALTH SCIENCE**, to fulfill the partial requirement of the degree **BIOMEDICAL ENGINEERING**

**External Examiner**

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Department of [Name of Department], [Name of University]

# Project Title (SMART GLOVE: Designing of hand motion translator for deaf and dumb person)

Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

| SDG No | Description of SDG | SDG No | Description of SDG |
|---|---|---|---|
| SDG 1 | No Poverty | SDG 9 | Industry, Innovation, and Infrastructure |
| SDG 2 | Zero Hunger | SDG 10 | Reduced Inequalities |
| SDG 3 | Good Health and Well Being | SDG 11 | Sustainable Cities and Communities |
| SDG 4 | Quality Education | SDG 12 | Responsible Consumption and Production |
| SDG 5 | Gender Equality | SDG 13 | Climate Change |
| SDG 6 | Clean Water and Sanitation | SDG 14 | Life Below Water |
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| SDG 8 | Decent Work and Economic Growth | SDG 16 | Peace, Justice and Strong Institutions |
| | | SDG 17 | Partnerships for the Goals |


| **Range of Complex Problem Solving** | | | |
|---|---|---|---|
| | **Attribute** | **Complex Problem** | |
| 1 | Range of conflicting requirements | Involve wide-ranging or conflicting technical, engineering and other issues. | |
| 2 | Depth of analysis required | Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models. | |
| 3 | Depth of knowledge required | Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach. | |
| 4 | Familiarity of issues | Involve infrequently encountered issues | |
| 5 | Extent of applicable codes | Are outside problems encompassed by standards and codes of practice for professional engineering. | |
| 6 | Extent of stakeholder involvement and level of conflicting requirements | Involve diverse groups of stakeholders with widely varying needs. | |
| 7 | Consequences | Have significant consequences in a range of contexts. | |
| 8 | Interdependence | Are high level problems including many component parts or sub-problems | |
| **Range of Complex Problem Activities** | | | |
| | **Attribute** | **Complex Activities** | |

| | | | |
|---|---|---|---|
| 1 | Range of resources | Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies). | |
| 2 | Level of interaction | Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues. | |
| 3 | Innovation | Involve creative use of engineering principles and research-based knowledge in novel ways. | |
| 4 | Consequences to society and the environment | Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation. | |
| 5 | Familiarity | Can extend beyond previous experiences by applying principles-based approaches. | |

# Abstract

A hand gesture serves as a non-verbal mode of communication, involves finger's bending to convey information. Therefore; to lessen the barrier and to boost the confidence of such individuals, there have been developed a few technologies to bridge the gap between normal and disable person. In this project, our aim is to create a cost-effective electronic hand for gesture recognition using flex sensors and an ESP32 microcontroller. The working principle of Flex sensors is detecting changes in internal resistance, capturing the angle formed by the user's finger. Various finger movements combine to create unique gestures, which can be translated into signals and displayed as text on a screen and audio through speaker. This system assists in recognizing human sign language, enabling machines to execute tasks or identify words based on hand gestures and respond accordingly.

**Keywords**: method; thesis; computer

# Undertaking

I certify that the project **SMART GLOVE** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. Where material has been used from other sources it has been properly acknowledged/ referred.

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# Acknowledgement

We truly acknowledge the cooperation and help make by [**Name of Acknowledger], Designation** of **[Address of Organization].** He has been a constant source of guidance throughout the course of this project. We would also like to thank [**Name of Acknowledger**] from [**Designation]**, [**Address of Organization]** for his help and guidance throughout this project.

We are also thankful to our friends and families whose silent support led us to complete our project.

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# Chapter 1

## 1.1 Introduction

## 1.2 Statement of the problem

This project aims to overcome the cost barriers associated with existing hand gesture recognition solutions by developing an affordable system utilizing flex sensors and an ESP32 board. Key challenges include achieving precision in custom flex sensors, creating a robust algorithm for accurate gesture translation and display, seamlessly integrating the ESP32 board, and enhancing human-machine interaction by enabling the recognition of sign language and specific gestures. The ultimate goal is to deliver a cost-effective and reliable electronic hand gesture recognition system that facilitates improved communication between users and machines.

## 1.3 Goals/Aims & Objectives

*Efficient design and construction of a smart wearable device for hand gesture recognition.
*Integration of sensor and Gesture Recognition technologies, data processing, and advanced algorithms for precise gesture detection.
*Implementation of wireless connectivity and user interface for seamless interaction.
*Integration with software for comprehensive functionality.
*Inclusion of a text-to-speech module for audible output, facilitating easy communication.
*Real-time translation capability to improve communication effectiveness.
*Compact and portable system design for convenience and practicality.

## 1.4 Motivation

This transformative project is propelled by a profound understanding of the crucial role hand gestures play in non-verbal communication. Beyond being integral to sign language for those with hearing or speech challenges, hand gestures serve as a universal language extending to the control and interaction with digital devices.

The core motivation is to seamlessly connect our tangible world with the expanding digital realm by tapping into the innate human ability to communicate through intuitive gestures. The vision is to establish a symbiotic relationship where advanced algorithms interpret and respond to the nuances of hand movements, empowering individuals to effortlessly engage with technology.

A driving force is the commitment to delivering an advanced yet cost-effective electronic solution for hand gesture recognition. Integrating flex sensors and an ESP32 board, the aim is to utilize changes in internal resistance to precisely discern finger angles, transforming diverse finger flexes into identifiable gestures that seamlessly translate into signals or text displays on a screen.

At the heart of this initiative is the development of a smart glove, housing meticulously crafted custom-made flex sensors. These sensors, working in collaboration with the ESP32 board, efficiently capture and enhance detected gestures. The resulting synergy grants the system a unique capability to recognize human sign language, enabling users to execute tasks and discern words with precision.

Beyond its technological prowess, the project is motivated by a deeper commitment to enhancing accessibility and communication for individuals with hearing or speech challenges. The envisioned smart glove, embodying a blend of affordability, precision, and responsiveness, signifies a forward-thinking approach to human-machine interaction. The ultimate aspiration is to actively contribute to a more inclusive and user-friendly digital environment by seamlessly integrating technology into the subtleties of hand movements. This project arises from the belief that technology, when infused with empathy and innovation, becomes a potent tool for fostering a more connected and accessible world for everyone.

## 1.5 Assumption and Dependencies

**ASSUMPTIONS:**

- The internal battery source is assumed by the system to provide a steady and dependable power supply. Power outages or variations may have an impact on the device functionality.
- The gestures that the flex sensors recognise are assumed to be consistently understood and executed by users. Individual differences in their gestures or signing styles may have an impact on the system's accuracy.
- The system assumes stable performance of sensors and other hardware components.Reliability issues with hardware or variations in sensor performance could affect gesture recognition.

### Dependencies:

- The system is dependent on the performance of ESP-32 Microcontroller for processing and decoding gestures. Any limits placed on the microcontroller's capabilities could affect how responsive the system is.
- Device performance may be impacted by disruptions to the reliable wireless connections that are necessary.
- The successful output of spoken words or displayed text relies on the compatibility and proper functioning of the output device such as an LCD screen or a speech synthesis module.

## 1.6 Methods

Arduino IDE is an open-source platform which is used to sketch the whole code for the discussed prototype. The goal to develop a program is an easy communication of devices through the ESP32 to the server and vice versa. To receive and transmit the data from peripheral devices different libraries have been installed which were not built-in in the IDE.

The sketch is design by initializing the libraries and pin numbers of the components communicating with the server. It is a looped program based of **IF/ELSE** commands. ***20?*** movements are being and ***20?*** conditions are given with set range for every movement and to generate the output commands accordingly.

Additionally, a push button is equipped and programmed for the mere purpose to ON/OFF the prototype.

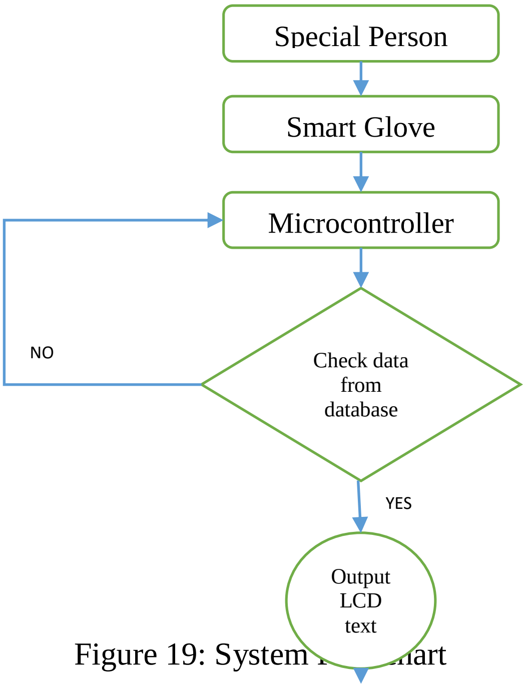


Figure 19: System Flowchart

Once the sketching and wiring is done the algorithm is fed to the ESP32 by connecting it to the laptop and also to give power to the board via microUSB. The algorithm used in this system is programmed to detect specific ranges of these movements and generate an appropriate output based on the movement's pattern. The ranges of hand movement are monitored on the serial monitor and noted down for further processing.

The first step after uploading the sketch is to read raw values of the acquired movements from the flex sensors with the help of the glove worn on the hand of the subject and compare to the set value ranges that is initialized in the code until the matched value for the given movement is reached.

After the calibration is done, the given hand movement value goes through every **If** condition to match the desired value of the given movement. Once the acquired range is detected and interpreted correctly, the specific command or text message given to that condition will be displayed on the 16x2 LCD in real time along with the RGD LED indicator lighting the set color assigned to it. Additionally, an MP3 player is interfaced with the ESP32, allowing voice-based output to be played through a speaker or headphones for the better understanding.

For instance, the subject makes a specific gesture, the signal generated because of potential difference will be acquired by the flex sensors attached to the glove. It is then fed to the ESP32 to interpret the analog data and match it with the given ranges. Once it is matched the text message assigned to the movement such that ***command*** will be displayed on the LCD with the RGB indicating “Red” hue and the displayed command will then be voiced out at the same time to complete the process. However, if it doesn’t find any match then the no display or indication will initiate until the next movement will be given or acquired.

The system flowchart for the prototype is given in Fig. 19.

## 1.7 Report Overview

The smart glove will serve as a communication aid, enabling users to express themselves through a combination of sign language and gesture recognition The goal encompasses translating the wearer's gestures into both visual and auditory outputs to empower deaf and mute individuals to communicate effectively with the broader community, fostering inclusivity and breaking down communication barriers through a cutting-edge smart glove solution.

# Chapter 2

## 2.1 Proposed Solution

The experimental setup contains a wearable data glove on which the flex sensors are placed. An internal battery source powers this glove. The new techniques for using small-sized hardware with hardware components create a new way for recognition. As a result, compared to a few other approaches, a smart glove equipped with flex sensors has been employed to improve communication efficiency and accuracy. This gadget is also lightweight and portable. Every flex sensor is linked to the ESP-32 after being attached to the breadboard. In order to increase stability and compactness, connections can be established into a Vero Board (VB) and ESP-32, which together will eventually result in a lightweight glove module. Simple conditional statements can be used to configure ESP-32 and Flex sensors. A set of values is established when the flex sensors' resistance varies due to bending. The ESP-32 receives the resistance measurements. Consequently, the required output will be produced by the control statements that gesture is given. The ESP-32 receives signals from the sensors when the user makes a gesture. The gesture will be decoded by the microcontroller, which will then compare it with the database. The LCD receives the decoded instruction.After then, the text message can either be spoken or displayed on the output device. The sensor detects hand movements when the gadget turns on and transmits data to the ESP-32. If the board successfully recognizes the, then the receiving side will get voice output or displaying a text. The ESP-32 will restart from the beginning if it is unable to detect the sign .

# Chapter 3

## 3.1 Summary and Future work

In the domain of non-verbal communication, hand gestures emerge as a potent means of conveying information, serving not just in sign language for those with hearing or speech challenges but also as a means to command digital devices. The fundamental objective of gesture recognition technology is to effortlessly bridge the gap between our tangible world and the digital domain, enabling humans to engage with technology through instinctive gestures facilitated by sophisticated algorithms.

This groundbreaking project is committed to delivering an electronic solution for hand gesture recognition that emphasizes cost-effectiveness. The system ingeniously integrates flex sensors and an ESP32 board, with the flex sensors leveraging changes in internal resistance to discern the precise angles of the user's fingers. Through the combination of various finger flexes, an array of gestures is identified, translating into signals or text displays on a screen. At the core of this project is the development of a smart glove, meticulously equipped with custom-made flex sensors. These sensors adeptly capture gestures, and the ESP32 board serves as a critical component to interpret and enhance these detected gestures. The resultant synergy enables the recognition of human sign language, empowering the system to execute tasks or discern words based on the subtleties of hand gestures.

Beyond its technological finesse, the system's allure lies in its potential to enrich accessibility and communication for individuals facing hearing or speech challenges. The smart glove, with its amalgamation of affordability, precision, and responsiveness, epitomizes a forward-thinking approach to human-machine interaction. By seamlessly integrating technology into the nuances of hand movements, this project not only envisions but actively contributes to a more inclusive and user-friendly digital environment.

# Chapter 4

## 4.1 Conclusion & Recommendation

We efficiently designed and built an excellent and smart wearable device for hand gesture recognition. This device is based on sensor and Gesture Recognition, data processing and algorithms, wireless connectivity, user interface , integration with software, user feedback mechanism , design and Ergonomics. The combination of these technologies results in the effectiveness of the device, and the increasing precision of gesture detection is largely due to the progress made in artificial intelligence and machine learning.This device also contains text to speech module to have an audible output for easy communication. The developed system can be implemented in several areas. The main advantage of this system is it gives real time translation, deaf and mute individuals can achieve greater independence in their daily lives , also improves communication and increased independence can positively impact the mental well-being of individuals with hearing and speech impairments ,reducing feeling of isolation and frustration.The components that are used in this system are cost-effective and have a long life when compared to other devices, the projected arrangement is compact and portable. The hand gesture recognition system enables us to perform complex gestures and simulations with the usage of sensors attached to gloves in engineering applications. The system can be further enhanced by Accessibility features such ascompatibility with other assistive technologies to cater a broad range of users varying with needs.

# References

The articles from journals, books, and magazines are written as:

[3] “Deafness and hearing loss.” https://www.who.int/news-room/fact-sheets/detail/deafness-and-hearing-loss (accessed Sep. 14, 2023).

[7] M. A. Morris, S. K. Meier, J. M. Griffin, M. E. Branda, and S. M. Phelan, “Prevalence and etiologies of adult communication disabilities in the United States: Results from the 2012 National Health Interview Survey,” Disabil. Health J., vol. 9, no. 1, pp. 140–144, 2016, doi: 10.1016/J.DHJO.2015.07.004.

[9] Santosh Kumar J, Vamsi, Vinod, Madhusudhan and Tejas, “Design and Development of IoT Device that Recognizes Hand Gestures using Sensors,” Int. J. Mod. Trends Sci. Technol., vol. 7, no. 09, pp. 29–34, 2021, doi: 10.46501/ijmtst0709006.

[11] C. Oz and M. C. Leu, “Recognition of finger spelling of american sign language with artificial neural network using position/orientation sensors and data glove,” Lect. Notes Comput. Sci., vol. 3497, no. II, pp. 157–164, 2005, doi: 10.1007/11427445_25/COVER.

[12] J. L. Hernandez-Rebollar, R. W. Lindeman, and N. Kyriakopoulos, “A multi-class pattern recognition system for practical finger spelling translation,” Proc. - 4th IEEE Int. Conf. Multimodal Interfaces, ICMI 2002, pp. 185–190, 2002, doi: 10.1109/ICMI.2002.1166990.

[13] R. H. Liang and M. Ouhyoung, “A real-time continuous gesture recognition system for sign language,” Proc. - 3rd IEEE Int. Conf. Autom. Face Gesture Recognition, FG 1998, pp. 558–567, 1998, doi: 10.1109/AFGR.1998.671007.

[14] C. S. Lee, Z. Bien, G. tae Park, W. Jang, J. S. Kim, and S. K. Kim, “Real-time recognition system of Korean sign language based on elementary components,” IEEE Int. Conf. Fuzzy Syst., vol. 3, pp. 1463–1468, 1997, doi: 10.1109/FUZZY.1997.619759.

[17] J. M. Allen, P. K. Asselin, and R. Foulds, “American sign language finger spelling recognition system,” Proc. IEEE Annu. Northeast Bioeng. Conf. NEBEC, pp. 285–286, 2003, doi: 10.1109/NEBC.2003.1216106.

[19] J. L. Hernandez-Rebollar, “Gesture-driven American sign language phraselator,” Proc.

Seventh Int. Conf. Multimodal Interfaces, ICMI'05, pp. 288–292, 2005, doi: 10.1145/1088463.1088512.

[20] L. Dipietro, A. M. Sabatini, S. Member, and P. Dario, "A Survey of Glove-Based Systems and Their Applications," Appl. Rev., vol. 38, no. 4, p. 461, 2008, doi: 10.1109/TSMCC.2008.923862.

[25] M. I. Sadek, M. N. Mikhael, and H. A. Mansour, "A new approach for designing a smart glove for Arabic Sign Language Recognition system based on the statistical analysis of the Sign Language," Natl. Radio Sci. Conf., pp. 380–388, Apr. 2017, doi: 10.1109/NRSC.2017.7893499.

[27] S. Ahmed, H. Shafiq, Y. Raheel, N. Chishti, and S. M. Asad, "Pakistan sign language to Urdu translator using Kinect," Comput. Sci. Inf. Technol., vol. 3, no. 3, pp. 186–193, Nov. 2022, doi: 10.11591/CSIT.V3I3.P186-193.

[28] K. Kanwal, S. Abdullah, Y. B. Ahmed, Y. Saher, and A. R. Jafri, "Assistive glove for Pakistani Sign Language translation," 17th IEEE Int. Multi Top. Conf. 2014, 2014, Accessed: Nov. 18, 2023. [Online]. Available: https://www.academia.edu/49595645/Assistive_glove_for_Pakistani_Sign_Language_translation

The books are written as:

[8] "Sign Language." https://education.nationalgeographic.org/resource/sign-language/ (accessed Sep. 14, 2023).

[15] K. N. Tarchanidis and J. N. Lygouras, "Data glove with a force sensor," IEEE Trans. Instrum. Meas., vol. 52, no. 3, pp. 984–989, Jun. 2003, doi: 10.1109/TIM.2003.809484.

[18] H. Wang, M. C. Leu, and C. Oz, "American Sign Language Recognition Using Multi-dimensional Hidden Markov Models *," J. Inf. Sci. Eng., vol. 22, pp. 1109–1123, 2006.

[21] "Glove-Talk II: 'A Neural Network Interface which Maps Gestures to Parallel Formant Speech Synthesizer Controls.'" https://www.cs.toronto.edu/~hinton/absps/glovetalkii.htm (accessed Sep. 20, 2023).

[22] "(PDF) Bend sensors modeling for fast signal recovering in human motion analysis."

https://www.researchgate.net/publication/285675723_Bend_sensors_modeling_for_fast_signal_recovering_in_human_motion_analysis (accessed Sep. 20, 2023).

[23] S. K. M, “Indian Sign Languages using Flex Sensor Glove,” Int. J. Eng. Trends Technol., vol. 4, no. June, pp. 2478–2480, 2013, [Online]. Available: http://www.ijettjournal.org/volume-4/issue-6/IJETT-V4I6P149.pdf

[26] “(PDF) Boltay Haath - Pakistan Sign Language Recognition.” https://www.researchgate.net/publication/319182658_Boltay_Haath_-_Pakistan_Sign_Language_Recognition (accessed Nov. 18, 2023).

[31] “NodeMCU ESP32 | Joy-IT.” https://joy-it.net/en/products/SBC-NodeMCU-ESP32 (accessed May 06, 2023).

[32] “ESP32 Pinout Reference - Last Minute Engineers.” https://lastminuteengineers.com/esp32-pinout-reference/ (accessed May 06, 2023).

[33] “LCD 16X2 : Pin Configuration, Commands, Interfacing & Its Applications.” https://www.watelectronics.com/lcd-16x2/ (accessed May 05, 2023).

[34] “LCD 16x2: Pin Configuration, Features and Its Working.” https://www.elprocus.com/lcd-16x2-pin-configuration-and-its-working/ (accessed May 05, 2023).

[35] “Interfacing 16X2 LCD with ESP32 using I2C.” https://circuitdigest.com/microcontroller-projects/interfacing-16x2-lcd-with-esp32-using-i2c (accessed May 05, 2023).

[36] “I2C Serial Interface Adapter Module for LCD.” https://components101.com/modules/i2c-serial-interface-adapter-module (accessed May 05, 2023).

[37] “In-Depth: Interfacing an I2C LCD with Arduino.” https://lastminuteengineers.com/i2c-lcd-arduino-tutorial/ (accessed May 05, 2023).

[38] “MP3 player using Arduino and DFPlayer mini - Electronics-Lab.com.” https://www.electronics-lab.com/project/mp3-player-using-arduino-dfplayer-mini/ (accessed May 05, 2023).

[39] “Learn How To Interface DFPlayer Mini MP3 Module With Arduino .” https://electronicslovers.com/2018/01/interface-dfplayer-mini-mp3-module-with-

arduino.html (accessed May 05, 2023)

The Internet links shall be complete URLs to the final article.

[1] “Deaf and Dumb Definition.”

[2] “Deaf & Dumb – Able Manavata.”

[4] “World Report on Hearing - Executive Summary.”

[5] “Pakistan Population (2023) - Worldometer.”

[6] “Sign Language Accessibility for the Deaf in Pakistan - YES Programs.”

[16] D. J. S. Medialab and D. Zeltzer, “A Survey of Glove-based Input”.

[24] “SpeakJet.” https://www.canakit.com/speakjet-com-09578.html (accessed Sep. 20, 2023).

[40] “Flex Sensor 2.2" - SEN-10264 - SparkFun Electronics.”

[41] “MPU6050 Accelerometer and Gyroscope Sensor Guide with Arduino Pro...”

[42] “Arduino IDE - JavaTpoint.”

[43] “Arduino Integrated Development Environment (IDE) v1 | Arduino Documentation | Arduino Documentation

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**Fonts and Styles:**

Use a standard font such as Times New Roman, Arial, or Calibri

Font size should be 12 points for the main text.

Use consistent font sizes and styles (bold, italics) for headings, subheadings, and content.

**Footer:** Each page shall have a footnote "Page number, right align".

**Header**: Each page shall have a header "Project/Thesis Title".

**Chapter Startup:** Each chapter shall be numbered as Chapter 1, Chapter 2, etc.

**Paragraph Formatting:**

Single-spaced, Line entered paragraph, left align or justified.

**Line Spacing:**

**1.5** spacing is required for the text. Only footnotes, long quotations, bibliography entries (double space between entries), table captions, and similar special material may be single spaced.

Maintain consistent spacing between paragraphs

**Images, Figures, Hyperlink:**

Ensure that images, figures, and hyperlink are of high quality and are properly labeled.

**Tables and Equations:**

Format tables with clear column and row headings.

Provide captions for each Table.

Label equations and provide clear explanations.

**Citations and References:**

Follow a standardized citation style (e.g., APA, MLA, PEC etc.) for references.

Include a separate references section at the end of the document.

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Submitted files are named with a clear and concise title that reflects the content of the paper or thesis.