

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

An-Najah National University
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Hardware Graduation Project



Colors Mixer Machine

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Dedication

Dedication to the captive Zohdi Qwareeq, our loving parents, family, friends and for everyone who believed and loved us.

Acknowledgment

We extend our deepest gratitude and appreciation to the individuals who have played a significant role in our graduation project. Their guidance, support, and unwavering belief in our abilities have been invaluable throughout this journey.

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Disclaimer

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Abstract

Colors Mixer machine that enables craftsmen to choose the appropriate color that he needs through mobile application, so the machine makes the appropriate mixture in the appropriate quantities to produce the required color.

This machine contains four tubes of different colors: Black, Cyan, Magenta and Yellow, which are **CMYK** model for producing any color. It contains the tube in which the final paint will be placed. And a tube of thinner to clean the tube of paint after each operation.



Chapter 1: Introduction



- **Statement of the problem**

The nature of our work revolves around addressing the challenge faced by craftsmen when it comes to selecting and producing the appropriate color for their projects. The design problem we aim to tackle is the lack of a streamlined and efficient process for to mix and create custom colors accurately and conveniently.

Traditionally, craftsmen have relied on manual color mixing techniques, which can be time-consuming, imprecise, and result in inconsistencies. This not only hampers their productivity but also hinders their ability to deliver high-quality work that meets their clients' expectations.

Therefore, our goal is to develop a solution that empowers craftsmen with a mobile application and a corresponding machine, the Colors Mixer. This system allows craftsmen to easily select the desired color through the mobile application, and the machine automatically mixes the appropriate quantities of pigments to produce the exact color required. By utilizing the CMYK model and incorporating tubes of different colors (Black, Cyan, Magenta, and Yellow), the Colors Mixer offers a comprehensive color mixing solution.

The specific design problem we address is the need for craftsmen to have a reliable and efficient method to achieve accurate color mixing consistently. By providing a user-friendly mobile application and a machine that automates the mixing process, craftsmen can significantly improve their workflow, save time, and ensure consistent color outcomes for their projects.

- **Objective**

The purpose of our work is to address the limitations and challenges craftsmen face in

the process of color mixing, and to provide them with a comprehensive solution through the Colors Mixer system. The objectives of our work are as follow:

- **Develop a user-friendly mobile application:** Our first objective is to create a mobile application that is intuitive and easy to use. The application will allow craftsmen to select the desired color for their projects, providing them with a convenient interface to specify their color requirements.
- **Automate the color mixing process:** We aim to design and implement a machine that automates the color mixing process. By incorporating the CMYK model and utilizing tubes of different colors (Black, Cyan, Magenta, and Yellow), the machine will accurately and precisely mix the required quantities of pigments to achieve the desired color. This automation eliminates the need for manual mixing, reducing errors and inconsistencies.
- **Enhance efficiency and productivity:** Our objective is to streamline the color mixing process, saving craftsmen valuable time and effort. With the Colors Mixer system, craftsmen can quickly and easily produce custom colors on-demand, allowing them to focus on their craft without delays or interruptions.
- **Ensure color consistency:** Consistency in color output is crucial for craftsmen, as it directly affects the quality of their work. Our aim is to provide a reliable system that consistently produces the same color every time it is requested. This ensures that craftsmen can meet their clients' expectations and maintain a high standard of craftsmanship.
- **Improve overall quality and customer satisfaction:** By offering a reliable and efficient color mixing solution, our work seeks to enhance the overall quality of craftsmanship. The Colors Mixer system empowers craftsmen to produce accurate and consistent colors, leading to greater customer satisfaction and improved business outcomes.

▪ **Scope of the work**

- **Mobile Application using React Native:** Develop a mobile application using React Native that allows users to connect to the color mixing machine via the HC_06 Bluetooth module. The application should provide a user-friendly

interface for selecting colors and sending the color data to the mixing machine.

- **Bluetooth Connectivity:** Implement the Bluetooth communication between the mobile application and the color mixing machine using the HC06 Bluetooth module. Establish a reliable connection to facilitate data transmission between the mobile application and the mixing machine.
- **Determining Appropriate Colors and Tubes:** Develop an algorithm or mapping system within the mobile application to determine the appropriate colors and corresponding tubes required to produce the desired color. This process should use the captured RGB values from the color sensor.
- **Mixing Color using peristaltic pump:** Set up and configure a peristaltic pump within the color mixing system. Implement control mechanisms that allow the pump to accurately dispense the required amounts of each color into a mixing chamber or container.
- **Cleaning the Machine with Thinner:** Integrate a thinner tube and pump mechanism into the system to clean the machine after each mixing operation. Develop a control mechanism that allows the system to pump an appropriate amount of thinner to flush out any remaining color residues and prepare the machine for the next mixing operation.
- **System Integration and Testing:** Integrate all the components and functionalities of the system, including the mobile application, Bluetooth connectivity, color sensor, peristaltic pump, tube system, and cleaning mechanism. Conduct thorough testing to ensure the system operates reliably and accurately.

▪ **Importance of the work**

The Colors Mixer system holds significant importance for craftsmen and their work. Here are the key reasons why this work is essential:

- **Accuracy and Precision:** The Colors Mixer machine ensures accurate color mixing by automating the process and utilizing the CMYK model. This level of precision allows craftsmen to achieve the exact color they desire, eliminating inconsistencies and guesswork. The ability to produce consistent and accurate colors enhances the overall quality of their work.
- **Time and Effort Savings:** Traditional manual color mixing methods can be time-consuming and labor-intensive. The Colors Mixer system significantly reduces the time and effort required for color mixing. Craftsmen can quickly select the desired color through the mobile application, and the machine will handle the mixing process. This efficiency allows craftsmen to focus more on their craft, complete projects faster, and increase their productivity.
- **Streamlined Workflow:** By providing craftsmen with a dedicated system for color mixing, the Colors Mixer simplifies their workflow. Craftsmen no longer need to rely on trial and error or manual mixing techniques. The system offers a straightforward and streamlined process, allowing them to create custom colors efficiently and consistently. This streamlined workflow enhances their overall efficiency and helps them meet project deadlines more effectively.
- **Improved Customer Satisfaction:** The Colors Mixer system enables craftsmen to consistently deliver high-quality work that meets their clients' color expectations. The ability to produce accurate and consistent colors enhances customer satisfaction and establishes a reputation for craftsmanship. Satisfied customers are more likely to recommend the craftsmen's services and contribute to their success.
- **Professionalism and Competitiveness:** By adopting the Colors Mixer system, craftsmen demonstrate a commitment to professionalism and innovation in their field. The system offers a competitive edge by providing a modern and efficient solution for color mixing. Craftsmen who utilize this advanced technology position themselves as industry leaders and attract clients who value high-quality work and attention to detail.

▪ **Organization of the report**

The report is structured in a logical and systematic manner to effectively present the information related to the project. The organization of the report is as follows:

- **Introduction:** This section provides an overview of the project, highlighting the problem statement, objectives, and the importance of the work. It sets the context for the rest of the report.
- **Constraints, Standards/Codes, and Earlier Course Work:** In Chapter 2, a detailed discussion is provided on the constraints, standards, and codes that were considered during the project. Additionally, any relevant earlier coursework that informed the project's methodology or approach is discussed.
- **Literature Review:** Chapter 3 focuses on the literature review. It presents a comprehensive review of existing research, studies, and relevant literature related to color mixing, automation techniques, and similar projects. This section helps establish the project's context and highlights any gaps in the existing knowledge.
- **Methodology:** Chapter 4 explains the materials and methods used throughout the project. It provides a detailed description of the experimental setup, the mobile application development process, and the design and implementation of the Colors Mixer machine. The chapter outlines the steps taken to achieve the project objectives.
- **Results and Analysis:** Chapter 5 presents the results obtained from the project. It includes the outcomes of the color mixing process using the Colors Mixer system, as well as any relevant data or measurements. The results are analyzed and interpreted to draw meaningful conclusions.
- **Discussion:** Chapter 6 focuses on the discussion of the results. It provides a comprehensive analysis of the findings, highlighting the features, benefits, and limitations of the Colors Mixer system. The chapter also addresses any challenges faced during the project and offers recommendations for future improvements.
- **Conclusion:** The report concludes by summarizing the key findings, reiterating the significance of the work, and highlighting its potential impact. It may also include a reflection on the overall project experience and suggestions for further research.
- **References:** A list of all the references cited throughout the report is provided in the References section, following the conclusion.

Chapter 2: Constraints, Standards and earlier course work



▪ Constraints and design limitations

- **Effects of High Viscosity of paint:** difficulties in achieving accurate and consistent color mixing, increased pressure requirements for dispensing, potential clogging and blockages in the tubes or mixing components, we solve it using special type of pump called **peristaltic pump** and **thinning steps**.
- **The liquid nature of the paint:** as it has the potential to infiltrate the machine or hardware components. This infiltration can lead to various issues, including damage to electrical circuits, clogging of tubes or valves, and potential system malfunction. The compatibility of the materials used in the system with the liquid paint and the need for appropriate seals or coatings to prevent infiltration are crucial considerations. Addressing this constraint is essential to ensure the longevity, reliability, and proper functioning, one effective solution to address the constraint of infiltration caused by the liquid nature of the paint is to employ a **specially designed tube fabricated through 3D printing technology** . Additionally, incorporating **Teflon plumber's tape** as an additional protective measure ensures proper sealing and minimizes the risk of leakage and **using silicone**.
- The choice to utilize the HC-06 Bluetooth module initially seemed promising for our project. However, upon further investigation, we discovered that the module does not support Bluetooth Low Energy (BLE), which introduced a significant constraint. This constraint arises from the incompatibility of the HC-06 module with certain devices that rely on BLE technology.

▪ **Standards**

- **The RGB model:** is a standard used in electronic displays, such as computer monitors, televisions, and digital devices. It represents colors by combining different intensities of red, green, and blue light. This additive color model is extensively employed in digital imaging, web design, and other visual applications.
- **The CMYK model:** on the other hand, serves as a standard in print and graphic design. It represents colors by combining different amounts of cyan, magenta, yellow, and black inks. This subtractive color model is utilized in printing processes to achieve a wide range of colors accurately.
- **Bluetooth technology for communication:** employed as the standard protocol for communication between the mobile application using “sereal-bluetooth-next” in react native and the machine.

▪ **Earlier course work**

Our project development heavily relied on the knowledge and skills obtained from previous coursework, specifically in the areas of PIC microcontrollers, the C programming language, and relevant digital and electronic courses.

The coursework on PIC microcontrollers provided us with a comprehensive understanding of microcontroller architecture, programming concepts, and interfacing techniques. We gained proficiency in writing code for the microcontrollers, implementing various functionalities, and effectively controlling hardware components.

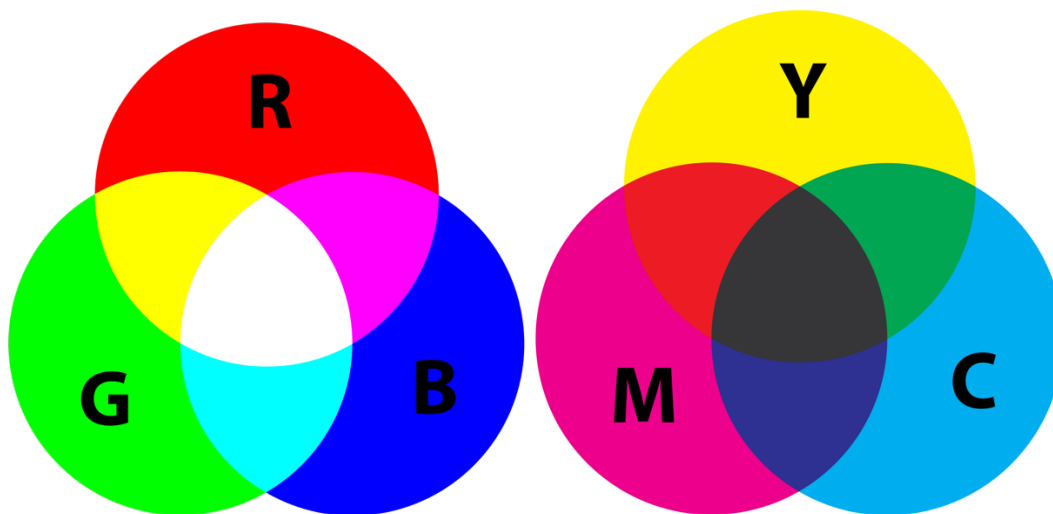
Chapter 4: Methodology

- **How It Works?**

The **RGB color model** is an additive color model used in electronic systems such as televisions and computers. It involves the combination of red, green, and blue light in varying intensities to create a wide range of colors. The RGB model is primarily used for sensing, representation, and display of images in digital media.

On the other hand, the **CMYK color model**, also known as the process color or four-color model, is a subtractive color model commonly used in color printing. It utilizes four inks: cyan, magenta, yellow, and key (black). The CMYK model works by subtracting or masking colors on a lighter background, such as white paper, to produce the desired colors. This model is used in the printing industry to reproduce colors accurately on paper.

a color selection process using the RGB color model within the React Native mobile application. Users are able to choose their desired color by adjusting the red, green, and blue values using mobile app, Once the RGB color is selected, we perform a conversion to the CMYK color model.



▪ The Mechanism

The RGB values and the final quantity will be sent via Bluetooth. Then these RGB values will be converted into CMYK percentage by using the conversion formula here an pseudocode explain that :

```
double r, g, b, vol, c, m, y, k;
// Get user input with validation for r,g,b,vol

double r0 = r / 255;
double g0 = g / 255;
double b0 = b / 255;

k = 1 - fmax(fmax(r0, g0), b0);
c = (1 - r0 - k) / (1 - k);
m = (1 - g0 - k) / (1 - k);
y = (1 - b0 - k) / (1 - k);

int c_255 = c * 255;
int m_255 = m * 255;
int y_255 = y * 255;
int k_255 = k * 255;

int total = c_255 + m_255 + y_255 + k_255;

double c_part = c_255 /total;
double m_part = m_255 /total;
double y_part = y_255 /total;
double k_part = k_255 /total;
```

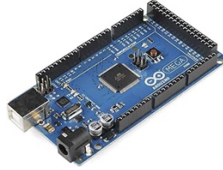




Then these C, M, Y, and K volumes will be multiplied by the Steps per Revolution of the respective Motor.







Steps required to pump Color = Color(mL) * Steps/Rev of respective motor .

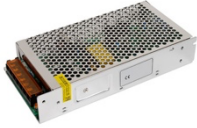

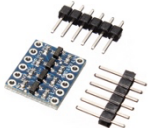


After conducting a series of trial and error experiments, we determined that the optimal Steps/Rev value for our peristaltic pump is 153. This value was obtained by programming the pump to dispense various color volumes and measuring the actual volume pumped using a calibrated measuring device. Through this iterative process, we adjusted the Steps/Rev value until we achieved the desired accuracy . The final value of 153 proved to be the most effective in achieving precise and reliable color volumes.

▪ **What We Need?**

• **Hardware component**

Hardware Component	Image	Number of times Used	Purpose
Arduino Mega		1	Main controller board for overall system functionality.
HC-06 Bluetooth Module		1	Used for wireless communication between the Color Mixer machine and the mobile application.
RGB Color Sensor CJMCU-29125 ISL29125		1	Used to accurately detect and measure the RGB color.
Peristaltic pump		4	Controls the precise flow of color components during mixing.
A4988 Stepper Motor Driver Carrier		4	Drives the stepper motor responsible for precise movement in the system

Hardware Component	Image	Number of times Used	Purpose
Solenoid valve (½ inch)		8	Controls the flow of liquids in the system
Digital Flow Sensor		1	Monitors the flow of liquid to check if the thinner is being cleaned or not.
Pump		1	Pumps the cleaning solvent or thinner in the system to clean the components.
8-Channel 12V Relay Module High/Low		1	Controls the activation of the 8 solenoid valves for various system operations.
5V 1-Channel Relay Module Active High/Low		1	Controls the operation of the water pump, providing on/off control signals.
12V 16mm Metal Push Button Switch		1	Serves as an on/off switch for the entire system, allowing easy control of the system's power.

Hardware Component	Image	Number of times Used	Purpose
12V 12.5A Power Supply		1	Supplies the required power to the system, ensuring proper functioning of the components.
LM2596 Adjustable Step Down Buck Converter		2	<p>Provides a regulated 5V output to power several components in the system.</p> <p>Generates a stable 6.7V supply voltage to power the Arduino board and ensure its operation.</p>
4 Channel I2C Logic Level		1	Shifter Converter 5V To 3.3V
1M 12VDC White LED		1	To provide lighting in the system
Ultra-sonic		1	To check if there is a final tube present or not

- **Secondary Components**

encompasses a range of essential elements used in the design and construction of the system. These components include wires, tubes, pipes, Connector, transfer pipes, fitting and other. These components play a crucial role in assembling the system and ensuring its proper functioning. The inclusion of these auxiliary components is vital for the successful integration and overall construction of the hardware components within the system.



▪ Design

• Solenoid valves

In the design phase, our first task was to integrate 8 solenoid valves into the system. These solenoid valves were responsible for separating and directing the combined flow of color and thinner. To control the operation of these solenoid valves, we implemented a relay-based approach. The VCC signal of each solenoid valve was cut, and the control of the valves was managed through relays.

We connected the control pins of the relays to the Arduino Mega, specifically using pins 2 to 9 for this purpose. By utilizing the Arduino Mega digital output pins, we were able to send control signals to the relays, activating or deactivating the corresponding solenoid valves as required. This allowed us to precisely regulate the flow of color and thinner through the system.

The integration of relays and their connection to the Arduino Mega provided us with a reliable and flexible control mechanism. We could programmatically control the opening and closing of the solenoid valves, enabling us to manage the distribution of color and thinner accurately.



- **Body of machine**

We assembled the solenoids within the system, strategically connecting them to separate the flow of color and solvent. This configuration enabled precise and efficient control over the distribution of materials.

After mounting the pump inside the enclosure, the pump was connected to a relay module, and the control signal was connected to pin 12 of the Arduino Mega. This configuration allowed us to effectively manage the activation and deactivation of the tin pump, ensuring precise control of the thinner pumping process.

To monitor the liquid flow, we incorporated a flow sensor into the system. The flow sensor was powered by the VCC and GND outputs of the LM2596 DC converter. Its output signal was connected to pin 13 of the controller (Arduino Mega). By receiving the flow information from the sensor, the system could verify the presence of tinner before initiating the cleaning process.



- **HC_06 model connection**

In addition, we incorporated an HC-06 Bluetooth module into the system. The HC-06 module was connected to pins 10 and 11 of the Arduino Mega for transmitting (TX) and receiving (RX) data. We powered the module by connecting its VCC and ground pins to the logic converter, which, in turn, received 5 volts from the LM2596 DC-DC converter. This setup allowed us to establish a wireless communication link between the Arduino and a mobile device using the Bluetooth module. We utilized the Mobile Arduino Serial Bluetooth Terminal app to send and receive commands, enabling convenient control and monitoring of the system remotely, this pseudocode explain how its implemented in c :

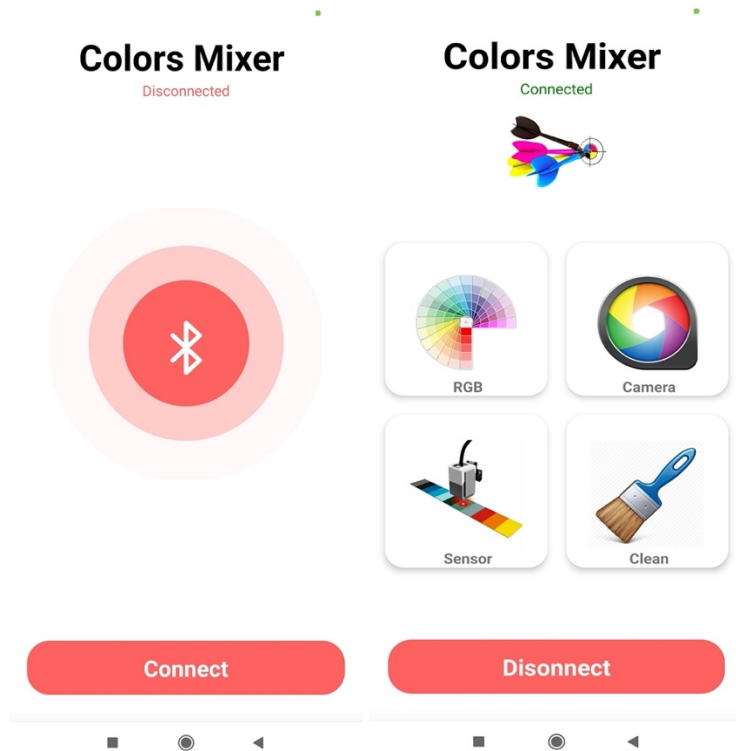
```
if (Serial.available()) {
    outgoing = Serial.readString();
    bluetooth.write(outgoing);
}

if (bluetooth.available()) {
    incoming = bluetooth.readString();
    Serial.print(incoming);
}

delay(100);
```

- **React native app**

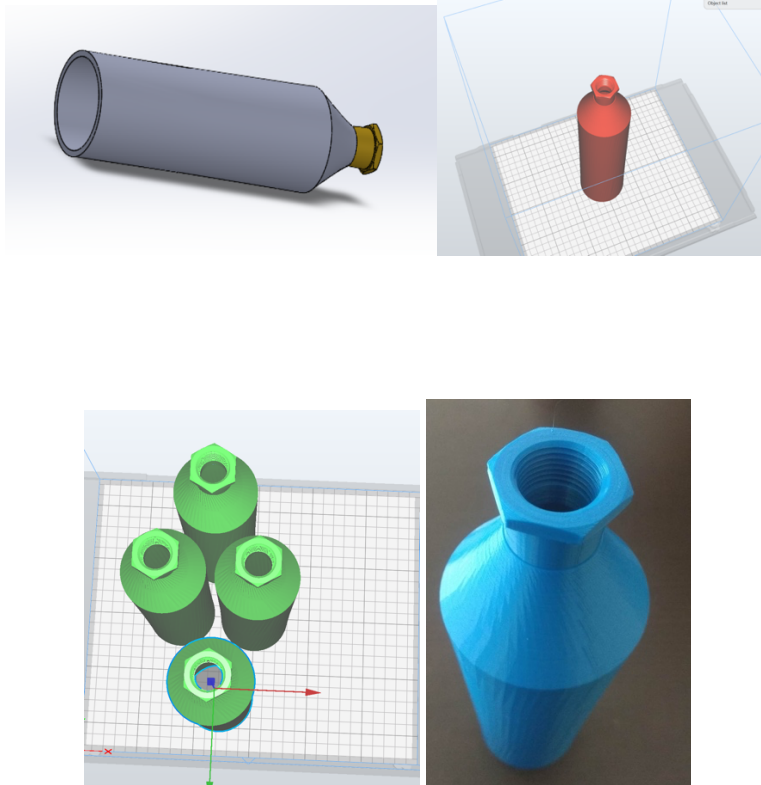
Furthermore, we developed a mobile application using React Native CLI with a user-friendly interface. This mobile app served as a control interface for the system, allowing users to conveniently interact with the various functionalities and settings. The React Native framework enabled us to create a cross-platform app compatible with Android .



In our project, we utilized the **react-native-bluetooth-serial-next** library to establish Bluetooth communication in our React Native mobile application. This library provides a convenient interface for interacting with Bluetooth devices.

- **Container design**

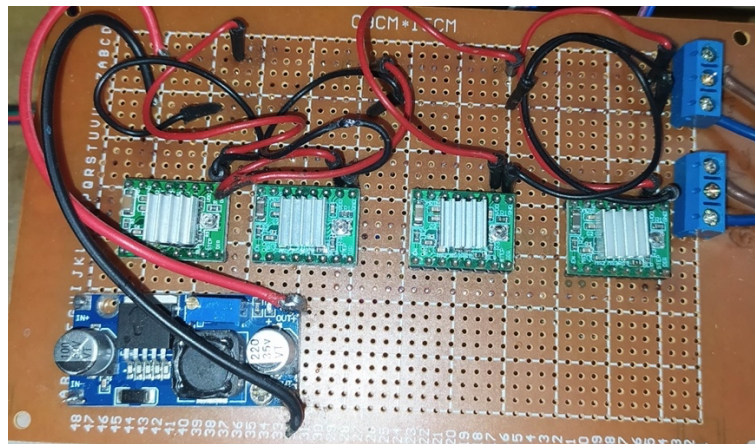
To ensure leak-proof and containment of the paints, we sought the assistance of a skilled 3D printing specialist to design a suitable container. The container was specifically designed with a 1/2 inch opening to seamlessly accommodate the solenoid valve and ensure compatibility with the system. This precise design enables efficient controlled to the paints without any leakage . The resulting design is as follows:



- **Control Peristaltic pump**

In our system, we employed four A4988 drivers to individually control four peristaltic pumps, each responsible for one color in the CMYK color model. These drivers were soldered onto a custom board, similar to a shield, along with a DC-to-DC buck converter. The buck converter efficiently converted the 12-volt input voltage to a stable 5-volt output, which powered both the drivers and other components in the system requiring 5 volts.

The circuit required six pins: four pins for enable signals linked to pins 22 to 25 in controller , one for the pulse signal, and one for the direction signal . These two pins were consistent across all four drivers connected to pins 26 and 27. The drivers were directly connected to the coil of each peristaltic pump, enabling precise control over the pumping action.



- **Peristaltic pump**

Each pump was programmed to operate for a specific duration, tailored to the requirements of each color. By assigning different time intervals to each pump, we could ensure that the colors were dispensed in the desired proportions and with precise timing, resulting in accurate color mixing and distribution within the system. This synchronized and coordinated operation of the pumps ensured consistent and reliable performance, enabling us to achieve the desired output quality and efficiency in our system.



- **Adding ultra-sonic**

We integrated an ultrasonic sensor into the system to check for the presence of a final tube. The ultrasonic sensor was connected to the controller, with the echo and trigger pins connected to pins 28 and 29 respectively. It was powered by a 5V supply from the LM2596 DC-DC converter.



- **Final design of machine**

The final design of the machine incorporates all the necessary hardware components and auxiliary elements to ensure its proper functionality.



Chapter 5: Result and Analysis



Furthermore, the Color Mixer machine demonstrated a reasonable level of accuracy in color mixing. Through testing and experiments, we observed that the machine produced color outputs that were generally close to the selected colors. While there were occasional variations and slight deviations, the overall accuracy of the Color Mixer met the requirements for most craftsmen's projects. It is important to note that achieving absolute color accuracy can be challenging due to various factors, including variations in paint batches and the subjective nature of color perception. However, the Color Mixer still provided craftsmen with a reliable tool to achieve satisfactory color mixtures, even if it may not reach the level of precision required for highly specialized .

Chapter 7: Conclusions and Recommendation



In summary, the Color Mixer demonstrated a satisfactory level of accuracy in color mixing, meeting the needs of most users. Overall, it provides craftsmen with a reliable solution for achieving desired color outcomes.

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