



An-Najah National University
Faculty of Engineering & Information Technology
Department of Computer Engineering

Hardware Graduation Project

ChocoCup

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Dedication

We want you to know that with this work we also want to express our love and gratitude to our families, who were our safe places and the biggest supporters of us throughout. Your love, care, and presence gave us so much strength that we were able to go on even if the situation was not good.

To our parents – we really can't find words to thank you enough for trusting us when even we ourselves were not sure. For your patience, your night time cheering up, and for being there always, no matter what.

To our friends and those who stayed with us – your kindness, motivation, and good energy were the lightest load on this journey and also made it more meaningful.

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We thank him for his patience and desire to help us in all moments, even in difficult moments. His dedication made a huge difference in our journey. Because of his help we stayed motivated and overcame the challenges.

Disclaimer

Tamara Abu Aisheh and Raya Break, students of the Computer Engineering Department, Faculty of Engineering, An-Najah National University, have written this report. Except for editorial changes that were introduced through the assessment process, it has not been altered in any way and may still contain language and content errors.

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Abstract

ChocoCup, which we designed, is a production line for making chocolate-covered biscuits with the toppings the customer wants. We have automated the process for better consistency and speed, and to include what each person prefers in their dessert.

The production process begins with the automated delivery of a cup, which serves as the base of the desert. Then, we placed a very fragile biscuit base and pressed it gently to create a stable and even layer. The best quality chocolate, warmed in a water bath system designed specifically for this purpose, was used to give the chocolate a smooth and uniform texture. When the chocolate is completely liquid, we put it on the biscuit, thus making a cover that is not only very shiny but also evenly distributed.

Pistachios, chocolate chips, and colorful sprinkles. We have included a simple-to-use keypad, through which customers may select one or more of these primary options. This interactive aspect plays a role in making each of our ChocoCup products a little more personal.

The ChocoCup machine performs this step one at a time. First, it doles out cups. The biscuit base is then placed inside. Subsequently, the chocolate is melted and poured in. Finally, it is topped off. At each stage of production, we pay attention to quality, which guarantees that the dessert is fit for home use or for sale in stores. Our machine is a consistent performer that also provides customers with a choice of what they prefer. Thus, ChocoCup is a smart and modern solution for creating great-tasting desserts.

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List of Abbreviations

Full Form	Abbreviation
Liquid Crystal Display	LCD
Light Dependent Resistor	LDR
Direct Current	DC
Input/Output	I/O
Inter-Integrated Circuit	I2C
Integrated Development Environment	IDE
Advanced Technology eXtended	ATX
Serial Data Line	SDA
Serial Clock Line	SCL
Dual Motor Driver	H-Bridge
Digital Temperature Sensor	DS18B20
Universal Serial Bus	USB

Chapter 1

Introduction

1.1 Statement of the problem

Today, people love their special, particularly chocolate desserts. But for the most part, choices are limited in dessert shops. People only get to buy premade cakes, which at times do not correspond to what he or she really wants. For example, if someone wants a tiny chocolate cake with chocolate chips and pistachios only, it is often ordered in advance and waited for time to have it made hard to enjoy dessert at the moment.

Cakes are also made by hand in many places. This brings challenges such as variations in cake quality, ingredient waste, and slower service.

Although a lot of industries have moved to smart, automatic machines, dessert making is a little behind from that. This is why we saw a need for a machine to prepare chocolate cake cups quickly with the toppings each person chooses. This will save time and reduce effort and still provide a fun, fresh dessert experience for the customers in minutes.

1.2 Objectives of the work

Therefore, it is planned to develop and construct a ChocoCup – machine for automatic and simple preparation of small chocolate cakes in cups. In this way, the machine ensures that people have easy access to a fresh and delicious dessert at the time they require it and they can choose their favorite toppings. Everything will be done by machine: first make the base of the biscuit, then melt chocolate and pour onto the biscuit, and lastly add the topping. Options like chocolate chips, pistachios, and colorful sprinkles are selected by pressing buttons on the keypad.

The ChocoCup machine saves time and is consistently productive. Apart from that, it proves to be a source of amusement for consumers occurring in cafes, dessert shops, or even at home and at parties. At the finish of the project, ChocoCup will be a wise solution to homemade personal chocolate desserts in an easy modern way.

1.3 Scope of the work

This project covers several main phases toward the development of a complete system for making chocolate cake cups. The needs and features that suit our purpose were identified through research; essentially, an automated, dessert machine that can be customized.

Then we took a look at how to implement each component both in hardware and software, for example, the mechanical cup holder and topping dispenser, as well as motors and sensors as electronic parts. After we constructed and tested every stage, we began to integrate everything into one system. Finally, we provided the control system through a keypad with an LCD display as a way for the users to conveniently choose from.

1.4 Significance of our work

Modern and inventive consumption of personalized chocolate cake cups is brought by the ChocoCup machine. Ideal for a café, dessert booth, or special event where individuals on the go want quick and fresh treats. It empowers users to select their preferred toppings and witness the whole ‘cooking’ process which turns out to be a funny experience while creating a dessert.

It adds an interactive and custom appeal that’s loved by many customers. Moreover, since the machine makes one cup per order, it reduces leftovers, which supports a better way of being eco-friendly towards dessert production. Apart from this, the machine also improves hygiene since it reduces human contact with the preparation technique, always maintains the same level of quality through accurate portion control, and is highly scalable – serving immense quantities without affecting quality or appearance.

1.5 Organization of the report

This report spans many chapters. Firstly, the introductory chapter states the problem, our objectives and the significance of the project. The second chapter also covers the design constraints, the equipment used, and the software, in addition to the skills and knowledge obtained from university courses. Next, the following chapter narrates background on the related works and the initial ideas that inspired us during our system development. The fourth chapter is the method section where both software and hardware parts are described in detail. The fifth chapter contains the interpretation of the results and the gained knowledge from the experiments and the construction of the system. In the end, the last chapter gives an overview of the research and our take on the limitations as well as the possible continuation of the work.

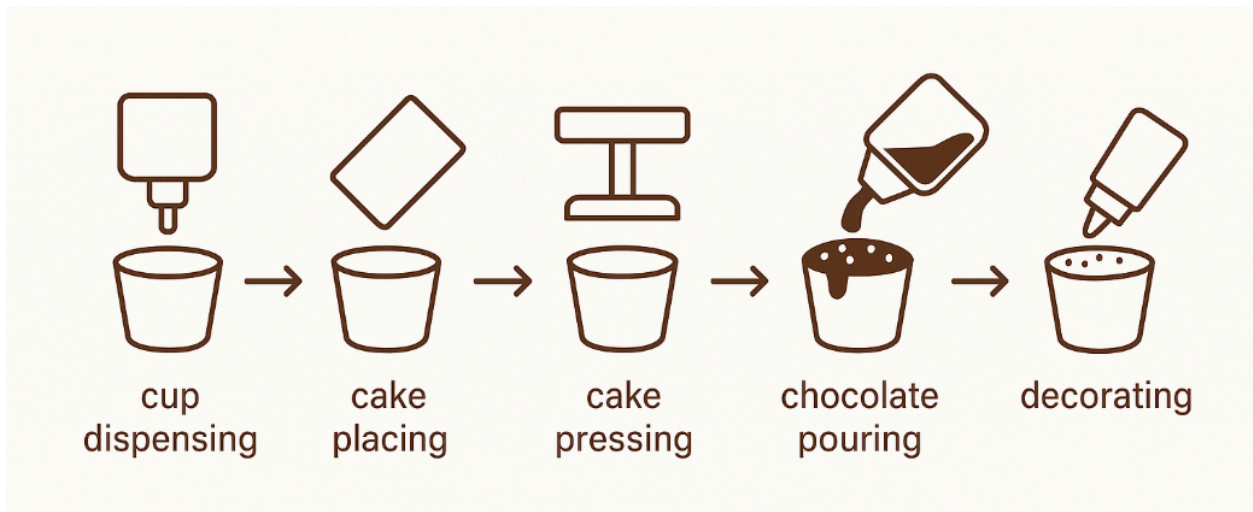


Figure 1.1: ChocoCup Production Line

Chapter 2

Constraints, Standards/Codes and Earlier Coursework

2.1 Constraints and Limitations

The limitations encountered during the designing of the ChocoCup production line have had a great influence on our technical decisions.

- **Heating Delay:** The most important obstacle was the time lag in the heating operation. The chocolate melting system is a water bath, which, however, takes about four minutes for the temperature to be ideal. This consequently changes the overall speed of the machine and therefore, when planning our automation flow, we have to take into consideration this time lag.
- **Temperature Sensitive:** The procedure is most efficient at a comfortable room temperature. If the atmosphere is too cold or too hot, it may influence the characteristics of the chocolate and also the cooling system which in turn may be the cause of re-texturing and the loss of quality. Indeed, this experience taught us that, from the very beginning of testing, we should be taking into account the environmental factors.
- **Hardware Dependencies:** Specific parts like air valves are the ones that need an air compressor from outside in order to operate. Hence, if such a facility is not available, then the automation will be incomplete and moreover, it will probably not work very well. This has made us aware of how the availability of the supporting equipment can influence the functionality of the system.

Despite the limitations we faced, recognizing them from the outset enabled us to remain grounded and steer clear of problems during the execution of our project.

2.2 Standards and Codes

Though there were certain limitations, recognizing them at the very beginning clearly made it possible for us to avoid surprises during the implementation phase, keep our project realistic, and still achieve our goals.

The programming part of ChocoCup was created using the Arduino IDE in C++. We used various libraries that were specifically designed for our system's requirements:

- “Keypad.h” for user interaction.
- “DallasTemperature.h” and “OneWire.h” for monitoring chocolate temperature.
- “Wire.h” and “LiquidCrystal_I2C.h” for the LCD display interface.
- “Stepper.h” to control the stepper motor movement.

2.3 Earlier Coursework

Our project would never have been successful without the knowledge gained in our earlier coursework. The electrical engineering courses such as Electronics 1, Electronics 2, Electrical Circuits, and Signal Analysis have given us a very persuasive grounding in the field of electricity. It enabled us to accurately calculate current, readily calculate voltage, and connect hardware together properly. The PIC microcontroller lab is undoubtedly the major factor which has made us comprehend the working of the Arduino Mega2560. Moreover, microcontroller and PIC are the courses that have taught us the basics of programming of microcontrollers.

Anyway, the Critical Thinking course is the one which gives us the opportunity to learn and practice skills such as planning, analysis, and making logical decisions that equip us to think through problems more effectively and efficiently.

Chapter 3

Theoretical Background and Previous Work

“SweetCup Zone” was a graduation project developed in 2024 by students of An-Najah National University. The students showcased an automated system that used Arduino, sensors, motors, and a mobile app for preparing customized cheesecake in a cup.

That project gave us a good basis and enabled us to know how different hardware phases could be connected into one working system. Since our purpose and the dessert type were different, we made several significant changes to both the design and the result to be improved.

Our project, ChocoCup, was about chocolate cake cups that definitely needed a different preparation method. One of the first key upgrades that we put in was applying a water bath system to melt the chocolate softly. This source of heat protects the chocolate from the burn and the smoothness is retained. We also introduced the stage of pressing to flatten the biscuits before the addition of chocolate, so that the final product is not only visually stable, but also of a more professional appearance. In addition, we have created our own decoration mechanism to order the addition of the toppings, so the process will be more exact and visually clean.

All these changes gave us the opportunity to produce a more customized and dependable dessert-making machine that satisfies the product’s requirements and improves the user experience.

Chapter 4

Methodology

4.1 Hardware Components

4.1.1 Microcontrollers

- **Arduino MEGA 2560**

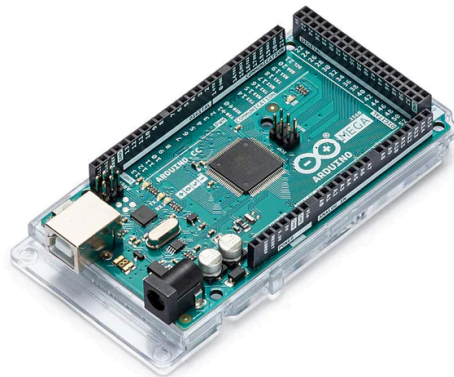


Figure 4.1: Arduino Mega 2650

Our project team selected the Arduino Mega 2560 as the main control unit because of its excellent features and high performance. It not only has 54 digital input/output pins but also 16 analog inputs which enable it to control a variety of sensors, motors, and other devices. Besides, its 256 KB of flash memory allows for big and complicated programs that fit perfectly for running the whole automation logic of ChocoCup.

The Arduino Mega also has the advantage of being reliable and compatible with many external modules, so the Mega can undertake all the main functions smoothly — such as getting the sensor values, deciding the user input, and driving the motors and relays. Its usability and the ease of plugging in various gadgets make it the best platform for creating a dessert-making system that is both responsive and stable.

4.1.2 Motors and drivers

- **Nema17 Stepper Motor**

The Nema17 stepper motor may be small, but it provides good movement and good accuracy. The motor moves 1.8 degrees at a time so it is great for doing small delicate actions. In our project, we employed the Nema17 at two locations. First, we used it to lower the cup at the start of the process. It lowers the cup gently and puts it in the exact location. Secondly, we used it to drop the biscuit into the cup.

The motor just opens the container for a short time to let the biscuit fall and then closes it again. Although not particularly strong, the Nema17 was great for these small tasks. The motor integrated with the Arduino and achieved smooth motion and accurate placement every time.

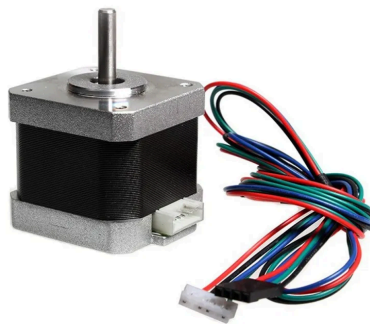


Figure 4.2: Nema17 Stepper Motor

- **H Bridge L298N**

A motor driver called the L298N is used to control the speed and direction of both DC and stepper motors. In our project, we used it to drive some Nema17 motors. It delivers solid power at 12V, should the heatsink stay cool. It was no trouble to use for stable and reliable control over our motors.

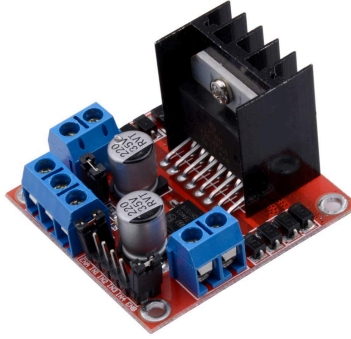


Figure 4.3: H Bridge L298N

- **Servo Motors**

We utilized four servo motors in all. Three of them were used in the topping stage to control the actuator for the opening and closing of the topping containers. Each servo was connected to a sliding gate beneath the dispenser. When a user wants a topping, for example chocolate chips, pistachios, sprinkles, etc., the servo will open the gate a small amount, allowing the topping to fall, before closing it again. This happens very quickly, so it allows us to move to the next topping and mitigate spills; we are in control of the amount that comes out of each of the containers.

The fourth motor was used in the chocolate stage, which was attached to an actuator on the valve that released melted chocolate. The valve only opens when the melted chocolate is completely ready to pour. Once the chocolate is poured, the valve closes immediately, allowing us to keep the actuation accurate and clean.

Using servo motors made it easier to perform precise decoration and chocolate pours, and additionally provided a simple way of controlling the motors via the Arduino program.



Figure 4.4: Servo Motors

- **Car Window Motor**

In the project we worked on, we utilized a car window DC motor to move the belt. This type of motor because it is powerful and designed to be continuously moving, was ideal to move the cup through each action stage. The belt is moving the cup through each step, with the cup dispenser first, then the biscuits, chocolate and finally the topping. The motor must turn in one direction to advance the belt and can also stop when the cup reaches the target position. This motor has given us high torque and smooth motion which allowed us to have a stable and reliable flow from beginning to end!

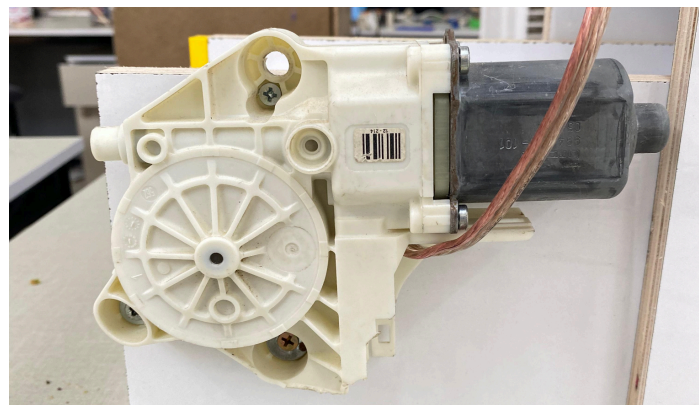


Figure 4.5: Car Window Motor

4.1.3 Sensors

- **Ultrasonic**

The ultrasonic sensor measures the distance from the sensor to an object by emitting sound waves and measuring the duration of the echo as it returns. In this case, in our project we used it to assess how much ingredients remained in the containers. We placed the sensor in the lid, so it could say whether the container was full, half or near empty. This will help us keep the machine running without surprises, and it makes it more reliable as a system.



Figure 4.6: UltraSonic

- **Laser and LDR Module**

In our project we used four different Laser Modules and four different LDR (Light Dependent Resistor) sensors to detect the position of the cup at different stages. Each laser was located facing a receptor LDR. When the cup passed between the two devices, the laser beam was interrupted and the change was detected by the LDR.

The first laser-LDR pair was used to stop the cup dispenser at the appropriate position before it dropped the cup. The second laser-LDR pair stopped the cup roughly under the biscuits dispenser to make sure that the cake was falling in the center of the cup.

The third laser-LDR pair was provided before the piston in order to ensure that we pressed the biscuits correctly into the cup during the process. The fourth and last laser-LDR pair was placed at the topping stage to ensure that we stop the cup directly under the decorations. The system allowed us to control the movements and the timing very accurately at each stage, which improved the reliability of the process, and made it smoother and more accurate.

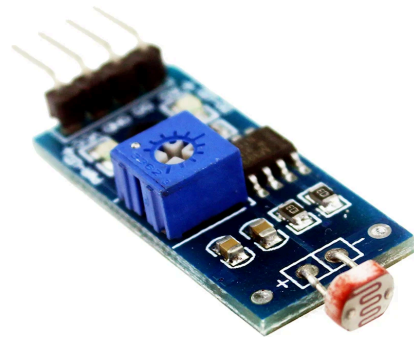


Figure 4.7: LDR Module



Figure 4.8: Laser

- **Temperature Sensor DS18B20**

We used a DS18B20 heat sensor to check what the water in the kettle was in temperature. We submerged the heat sensor in the kettle with the water and it monitored the temperature accurately.

When we turned the kettle on, the kettle began to heat the water, and the sensor was independently measuring the temperature, and sending the data to the Arduino, which performed the task of telling the chocolate what dispositions of state to melt. The addition of the sensor gave a lot of accuracy and safety to the heating.



Figure 4.9: Temperature Sensor DS18B20

- **Hall Effect Sensor**

In our project, we utilized the Hall Effect Sensor in the cup dispensing stage. Its purpose was to bring the dispenser back to the home point when the system is activated. This is required because when we turn the machine on we want the dispenser to know where to return. We added a little magnet to the rim of the cup dispenser. The magnet is detected by the Hall sensor when the dispenser rotates into its path. The Hall sensor tells the Arduino, "I'm at the beginning". This configuration allows the dispenser to rotate only one time, so every time the dispenser operates it only drops one cup - no more and no less. This made everything else about the process more efficient and organized.

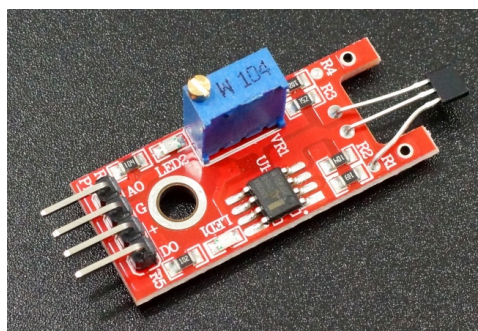


Figure 4.10: Hall Effect Sensor

4.1.4 Input/Output Devices

- **LCD & I2C**

In our project we utilized an LCD screen to display messages visible to the user. For example "Choose Your Topping", and "Ready to Pick Up" made the experience more interactive, immersive, and user-friendly.

An I2C module is wired into the display, so instead of four data pins, only two pins are attached to the monolithic Arduino: SDA (data pin) and SCL (clock pin). This reduces wiring clutter in general, but also frees up some pins for other components (sensors, motors).

Additionally, the I2C interface allowed simple commands in the Arduino code that would easily send commands to the display, and was a quick way to update the display. The I2C LCD was essential in contributing towards usability as well as providing feedback to the user.

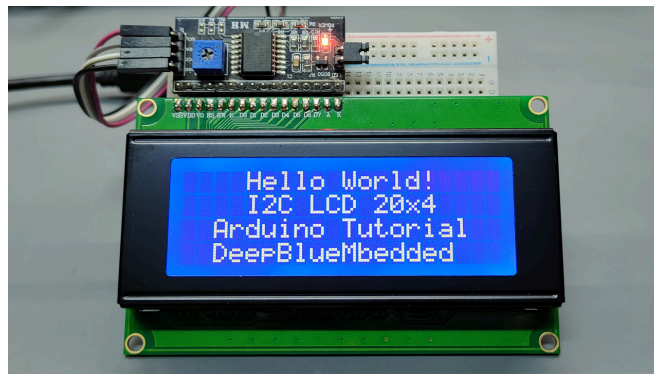


Figure 4.11: LCD & I2C

- **Keypad**

In our project we implemented an input device that we could use as a 4×4 keypad. This allowed a user to interact with the project by pressing buttons to make selections. For example a user would select which toppings they want or confirm they are ready to start.

The keypad had 16 buttons (numbers and letters), and it could easily connect to the Arduino.

When any button is pressed, a signal is sent, which the program reads when it needs to understand the user selection. This functionality improved the interactivity of the system, and put the user fully in control of the desert experience. Using the keypad was simple and helped make the experience personal and fluid.



Figure 4.12: 4×4 Keypad

4.1.5 Power Devices

- **Power Supply**

We used a computer power supply (ATX) to provide stable, repeatable power to all the parts for our machine. It was attached to the motors, sensors, and all control boards, in order to make sure they all worked safely and without power drops. The power supply was a good choice for our needs, because it provides multiple voltage outputs (5V, 12V...) as needed for the components we used. It also allowed us the flexibility to operate multiple devices simultaneously and did not require us to have many separate adapters. The high quality of this power supply helped to create a reliable and organized system.

4.1.6 Input/Output Devices

- **3D printings**

Through our project, we used 3D printing to create a large number of valuable components of the system. We created a unique assembly for the cup dispenser, a unique assembly for the biscuits dispenser, and a unique assembly for the topping stage component and each supplied much needed custom items that could fit our specific use, and enable the designed machine to properly function.

One of the more critical and properly printed items is the cup holder unit. This was designed to pin-point and ensure the cup is placed correctly, stable, and ultimately will not drop or shift from intentional location upon the conveyor.

The integration of this assembly allowed us to accurately keep alignment of parts further reducing potential for any errors while processing. 3D printing allowed us to create aligned parts accurately, light and well-fitting that improved assembly design and resistance to tipping.

3D-Printed Cup Dispenser

In this project, we designed a simple cup dispenser that rotates only a full rotation to dispense a cup then needs to go back to the original start point. We needed the starting point to be indicated, which we accomplished using a Hall effect sensor and a small magnet.

Once the rotating part has the correct position, the hall effect sensor can read the position of the magnet and send a signal to stop the motor. As a result, this utilizes a feedback loop to ensure that our dispenser has the correct orientation with respect to the cup holder.

In other words, whenever we drop a cup, it will always fall in the same place without any discrepancies or shifting. Using this type of mechanism for the cup drop, allows for a dispenser that is much more precise, organized, and reliable.



Figure 4.16: 3D-Printed Cup Dispenser

3D-Printed Cup Holder

The cup holder made from 3D printing attaches directly to the belt and serves to hold the cup in place. This cup holder ensures that when the cup is dropped from the dispenser, it lands perfectly without falling or moving inside.

Its custom design matches the shape perfectly so the cup doesn't slip or lean to one side during the next phases of the process. This was helpful in maintaining the smoothness of the process without any errors that could occur with positioning the cup prior to putting on the biscuits or the chocolate.

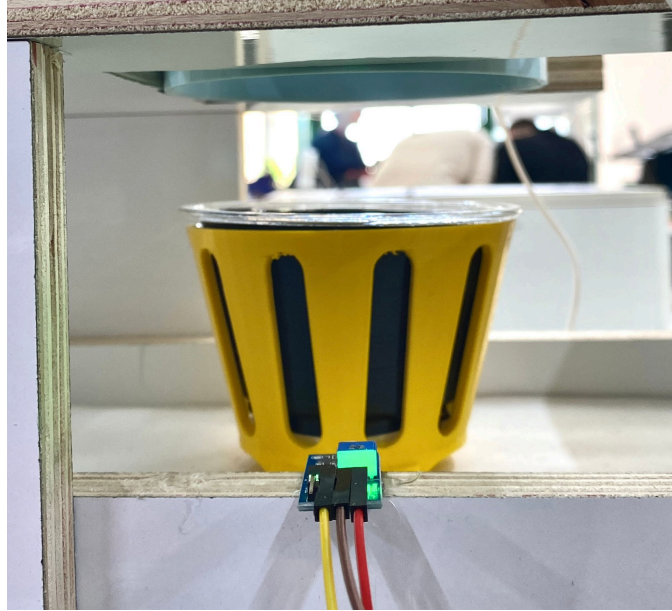


Figure 4.17: 3D-Printed Cup Holder

Custom 3D-Printed Topping Dispensers

We created custom 3D printed topping dispensers for the inclusion of any additional ingredients such as chocolate chips, pistachios and sprinkles. The dispensers each have unique open/close sliding mechanisms that we created with a servo motor to allow the toppings to fall into the cup at the desired time.

Initially, we used custom designs for the dispensers but we found many of the toppings would jar and get stuck in the dispenser, mostly larger items such as pistachios or chocolate chips. That is when we created our own mechanism to open just enough to let the right amount out, but the mechanism moves back into the closed position immediately.

This allows for a more accurate and more reliable decoration step of our process, and also helps alleviate the clogging or drooping string from various elevations.



Figure 4.18: Custom 3D-Printed Topping Dispensers

3D-Printed Biscuits Dispenser

The biscuits dispenser was created to dispense whatever amount we want. It turns based on steps, and the number of steps we set will determine how much biscuits drop into the cup. By simply adjusting the motor steps, we can increase or decrease the amount.

This will ensure that we have the correct amount of biscuits, and maintain a clean and precise method.



Figure 4.19: 3D-Printed Biscuits Dispenser

4.1.7 Other Devices

- **Pneumatic Piston**

In our project we used a pneumatic piston to compress the cake layer into the cup. This step was important so that the cake formed a leveled supported surface for the chocolate to smoothly pour on top of it.

The piston we selected works on 20 volts and provides linear motion using pneumatic pressure. When using the piston, it applies downward force, and then the piston moves down and back up to compress and therefore hold its integrity. The outcome is a dessert that looks nice and organized with clean even layers.

The piston created more tasks that were more precise packaging for each cup that we were provided with similar outputs of results.

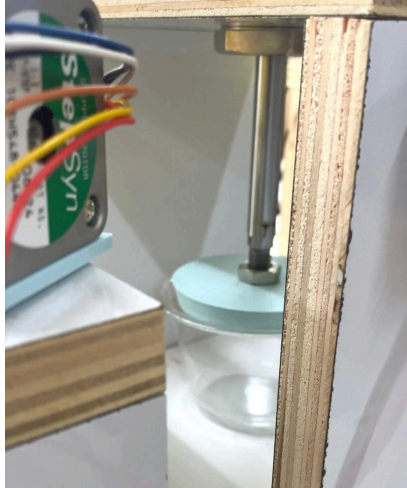


Figure 4.20: Pneumatic Piston

- **Air Solenoid Valve**

In the piston stage, we have demonstrated how we would use an air solenoid to route air flow. This valve was very critical because it allowed us to determine when we did not need to push or pull on the piston. The timing of the smooth movement of the piston and only moving the piston when needed was a key component.

The solenoid was connected to the relay and the Arduino was controlling this relay. This allows the class to manage air pressure and a controlled piston to push down the layer of biscuits each time.

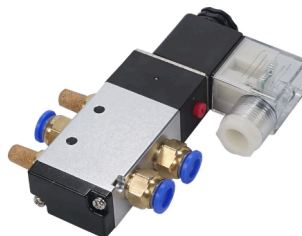


Figure 4.21: Air Solenoid Valve

- **Kettle**

In this project, we used a kettle to heat the dark chocolate until it was melted to the correct melting temperature. The kettle was a 220V kettle connected to a separate single channel relay so that we only have one kettle on a relay.

The kettle works as a water bath system: that is, the kettle heats the water which surrounds the chocolate container so that it is not possible to burn the chocolate while melting it and melting the chocolate smoothly and evenly. When the dark chocolate had melted completely, we opened the valve that was located under the kettle and poured the melted chocolate over the biscuit layer in the cup. The kettle allowed us to control both the dispensing and heating it in a precision and safety controlled manner.



Figure 4.22: Kettle

- **Valve for Melted Chocolate Dispensing**

The kettle with a valve will allow us to control the flow of melted chocolate into the cup. The valve was similar to a little faucet or tap flowing melted chocolate and we could open the valve when we wanted to; as our kettle with the water heated and melted the chocolate the valve opened and melted chocolate flowed freely out of the cup.

Once we decided on the amount of chocolate we wanted in the cup the valve would now close completely, and then chocolate stopped flowing. This allowed us to have complete control, it also gave us the convenience of not screwing everything up and wasting chocolate in the process. The operation of the valve was provided by a servo motor which gave us nice consistent and smooth operation opening and then closing the valve.



Figure 4.23: Valve for Melted Chocolate Dispensing

- **Arduino USB Cable**

Plugging in the USB cable to the Arduino Mega 2560 allowed it to connect to the laptop. That enabled uploading code from the Arduino IDE, powered the board during development, and monitored the system before an external power supply would be used.



Figure 4.24: Arduino USB Cable

4.2 Software Implementation

When the user makes their selection, the kettle heats up until the water melts the chocolate chips. As this occurs, the cup dispenser is returned home using the Hall effect and a magnet for proper alignment. Next, the dispenser rotates, dropping the cup into a holder. To assure the cup has landed in the correct position, a laser and the LDR stop the belt directly below the cup dispenser. Next, the belt (conveyor) moves forward, and the cup holder stops below the cake dispenser, utilizing the laser and LDR to ensure precise stopping.

Then the cup moves forward to the piston stage, where it must also stop exactly aligned. Once again, the piston presses the biscuits to create a flat layer, so accurate stopping is important in this step.

After this, the cup moves into the kettle area, where the chocolate will be poured, and again the laser and LDR ensure the cup holder is stopped exactly below the chocolate valve. Next, the cup moves to the topping stage. Here again, the laser and LDR confirm that the cup is stopping exactly below the correct topping dispenser to allow the ingredients to fall cleanly.

At the end of the process, the user can pick up their ready cup from the system.

4.3 Hardware Implementation

4.3.1 Input/Output Unit

Within our project work, the user interface through the LCD screen provided clarity in interaction through a friendly approach. Upon start-up of the system the first message displayed to the user was, "Welcome to ChocoCup!" to give a positive introduction. Next the user was prompted to select their topping from the three choices (Sprinkles, Pistachios, or Chocolate Chips).

Once they selected their topping - the system could then begin to prepare the dessert. The final message would read "Pick your Cup!" indicating to the user that they may now collect their customized ChocoCup.



Figure 4.25: Greeting Message



Figure 4.26: Topping Selection

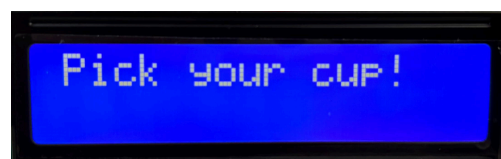


Figure 4.27: Final Step

4.3.2 Cup Dispensing

When the system is powered on, the cup dispenser first uses a Hall Effect sensor with a small magnet attached to the cup dispenser's edge to first return back to its home position. Also to ensure accurate alignment before proceeding with the operation. Then the cup dispenser performs a full rotation to only drop one cup. Below it, the cup holder is already in place to catch the cup correctly, and secure it on the conveyor belt, allowing the remaining process to complete successfully.

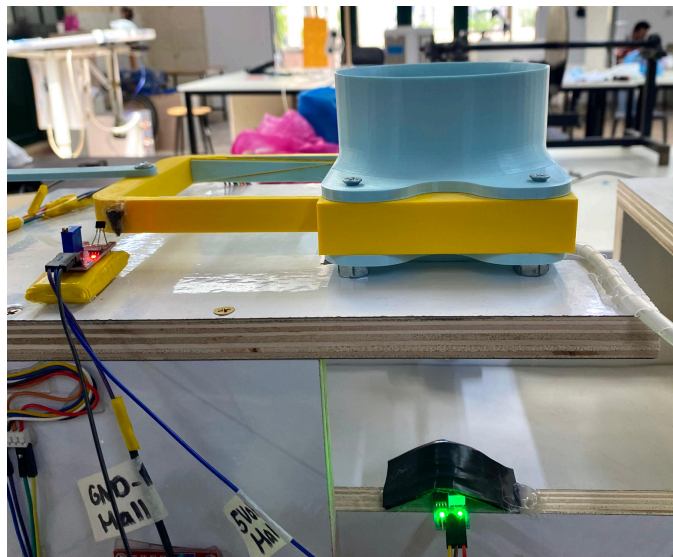


Figure 4.28: Cup Dispenser Stage

4.3.3 Biscuits Dispensing

The base layer is contained in one container. The one container contains biscuit powder. The container is affixed with a stepper motor that rotates a number of steps to dispense the biscuit into the cup. As the cup is travelling to the correct position on the belt, the biscuit is released into the cup. A stepper motor can be controllable with a very high level of precision which allows us to dispense the same amount of biscuit every time.



Figure 4.29: Biscuits Dispensing Stage

4.3.4 Piston Stage

In the piston step, we used a 20V pneumatic piston to press down on the biscuit layer that was inside the cup. This step ensures that a flat, stable layer registers in the biscuits before adding chocolate. The piston goes down when the cup fits under the piston, then it comes back up after it has pressed.



Figure 4.30: Pneumatic Piston Stage

4.3.5 Melted Chocolate Stage

While we melted the chocolate, we used a water bath system so we could melt the chocolate, which is a way of getting the chocolate to the right temperature to keep it fully melted and flowing without burning it. Once we melted our chocolate and were ready to finish the chocolate, it flowed right out of the valve and poured over the biscuit layer on top of the cup - covered it in a solid full wide layer of chocolate over the biscuit layer.

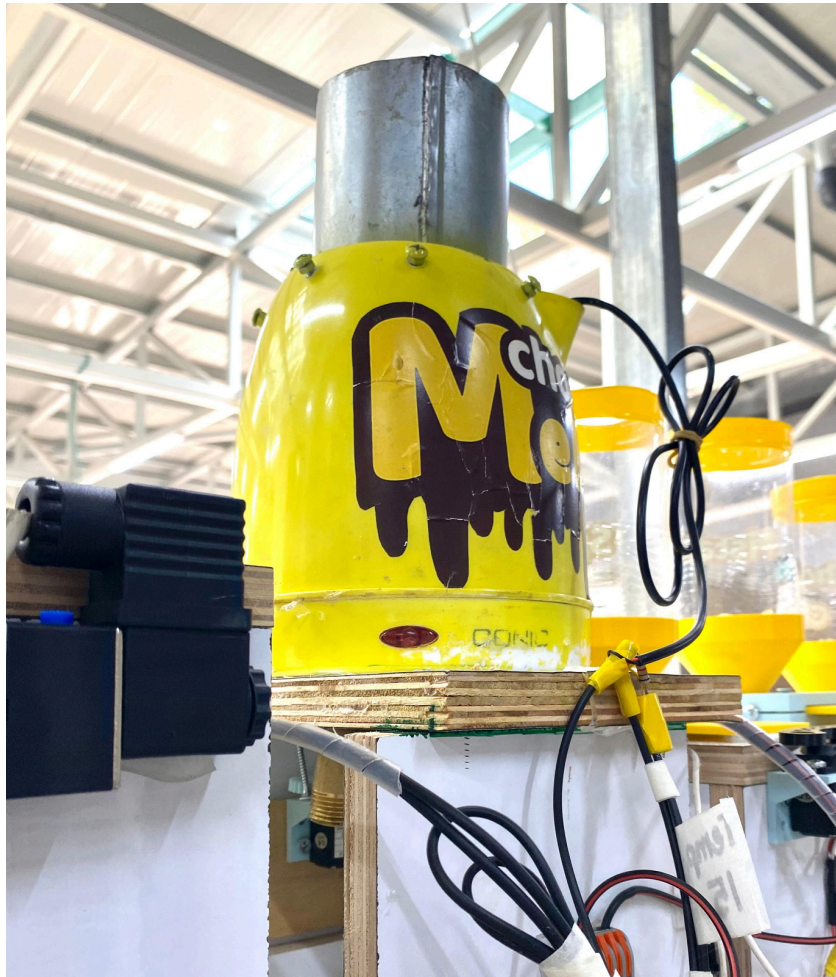


Figure 4.31: Melted Chocolate Stage

4.3.6 Topping Stage

During the toppings phase, you have the cup beneath the toppings area, and you need to select one and only one topping from three choices, pistachio, chocolate chips, or sprinkles. Each topping is kept in its own dispenser and has its own dedicated servo.

The product is dispensed into the cup based on the user's first and only selection of the topping to place on their dessert.



Figure 4.32: Topping Stage

4.4 Website

The site we produced has only two major pages to facilitate user experience. The first page is simply a welcoming screen that illustrates the ChocoCup logo within an introduction message about the concept. The other page is the actual product page that has clear buttons to allow the user to select any topping such as sprinkles, pistachios, or chocolate chips. We wanted to keep the design simple, colorful, and navigable while keeping with the playful conception of the project.

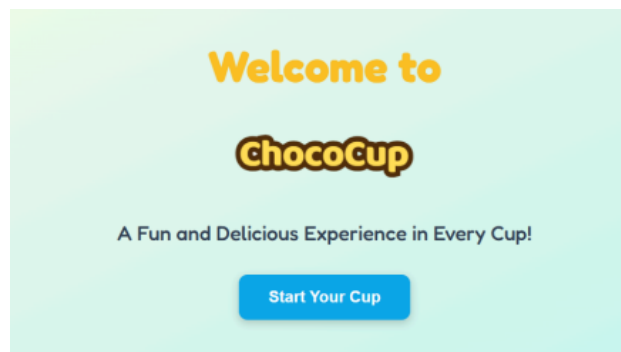


Figure 4.33: Opening Page

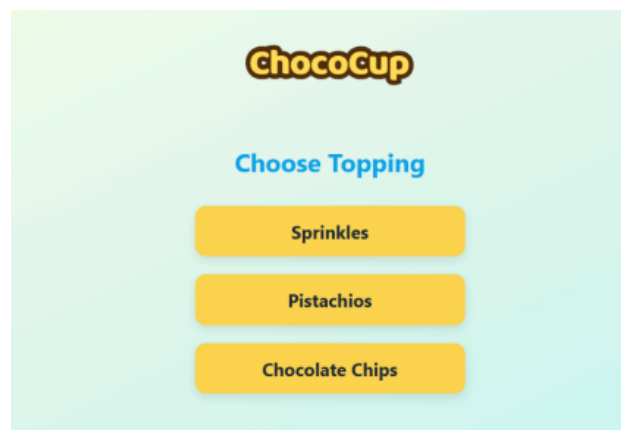


Figure 4.34: Ordering Page

Chapter 5

Result and Discussion

This project set out to design and build an automated system called ChocoCup, which prepares individualized chocolate cake cups. The thought behind this was to have users select how they wanted this dessert, whether it was beginning with the biscuits base and ending their choice with toppings like chocolate chips, and/or pistachios and/or sprinkles. We aimed to make this process more efficient (including faster, more fun, fully automatic), and while it was not our main focus, cleaner/accurate.

This was accomplished by developing a system with several stages linked. The stages consisted of cup dispensing, biscuits dispensing, a pressing function that would smoothly create a layer of biscuits, heating and pouring of melted chocolate (water bath system), and lastly, the decorating phase with toppings based on user selection. Each stage of the process is fully automated, and is performed based on the feedback from the sensor systems so the cup stops in the correct place and added toppings are added correctly.

Our biggest challenge was melting the chocolate. At the start of the process, using a standard/heater was not melting the chocolate properly and at some points only burning it. We created a water bath system for more uniform melting. Later on, we improved the system by adding a 220V heater to make the melting of the chocolate quicker and safer.

We also had to consider the task of making the Cup stop at exactly the right position under each stage. To accomplish this, we made use of a series laser modules and LDR sensors. This set of sensors provided the best position detection for the cup, and allowed the belt to stop precisely every time. This was necessary in all the stages including the biscuits dispensing stage, piston pressing stage, chocolate drizzling stage, and lastly the topping/presentation stage. The other issue that came during the development was the topping dispensers. Some of the toppings are larger and don't drop easily, so we created a

custom 3D printed mechanism with servo motors that opens and closes smoothly and allows the toppings to fall cleanly, so they do not get stuck. This overall made the decoration part of the process more reliable, and clean.

In the piston pressing stage, we needed to level off the biscuits for the chocolate layer to look good. We achieved this level off by using a pneumatic piston. The piston needed to move down straight and push the biscuits flat enough. To ensure the piston pressed in the exact same place we used a Hall effect sensor and a magnet to detect the position in addition to resetting to the starting point.

Ultimately, we created a working machine that manufactures custom chocolate cake cups with little human involvement. We were pleased that the results were satisfying (and the machine worked flawlessly), this project showed us a real possibility for automation in food production, and we feel ChocoCup has taken a step in that direction.

Chapter 6

Conclusion and Recommendation

6.1 Summary

ChocoCup has designed an automated system with capabilities to bake individualized chocolate cake cups that can be topped with melted chocolate and toppings in various combinations. Our goal was to create a dessert itself that is simplified through automation, but to also fast track the process and provide a clean experience tailored to the user's desires.

By bringing together engineering design, smart sensors, and user control through a keypad, we successfully automated the entire process of dessert-making; this includes dispensing the cup and biscuits, pressing it with a piston, melting, and pouring the melted chocolate, and finally adding the toppings chosen by the user. The ChocoCup project opened the doors to see how automation could contribute to food preparation in a fun and illustrative manner. Our product has been shown to have a considerable opportunity to serve modern, fresh dessert in individual servings at home, in cafés, or at events.

6.2 Recommendations

Based on our experiences while constructing and testing the ChocoCup system, we have a number of suggestions to facilitate revisions for future efforts. While we do have an affinity for the Arduino system, we would suggest using a higher tier Arduino board or controller that offers more input/output ports and opportunities for memory handling, in case you decide to evolve it further. Second, we would suggest that you test the system with real ingredients right at the beginning; feature materials like melted chocolate or

sprinkles do not act quite the same as expected and do potentially require alterations in timing or mechanics.

In the context of wiring and connections, we recommend using a power collector or terminal blocks, to connect multiple wires in a neater way that does exactly that, without all the clutter and avoiding tangles. You'll appreciate your work a lot more. Also, be sure to label all wires and put insulation on the solder joints to avoid short circuits and ensure everything is safe. In the context of power distribution, we would suggest powering motors and heaters with external power supplies, rather than being powered through an Arduino.

On your last recommendation, if you're going to consistently use the machine, then we also suggest you 3D print the mechanical parts using good strong and heat-resistant material, to prevent repairs, and keep the system modular so that you can replace, repair or maintain a piece of it instead of the entire system having to be replaced.

6.3 What we have learned

Through the ChocoCup project, we benefited from an experience that was more than enriching from a technical skill perspective. The project taught us how to convert an idea into a functioning machine that involves real time coordination between hardware and software. We looked at how to work with servo motors, stepper motors, relays, sensors and heating and the final task to get everything to operate in one coherent process.

Also, we learned that when designing a food-grade system, timing and accuracy were essential with real food ingredients such as chocolate, pistachios and biscuits.

Each time we collected a sensor reading or moved a motor, we needed to verify and calibrate everything we had done which developed skills in problem solving and debugging.

This project also developed our teamwork and communications skills, as each different part of the system was designed and developed by a different team member and had to work as a whole system. We learned how to plan concerning complex systems and user-controlled systems, and what creative thinking meant when the not-standard solution did not work.

Ultimately, we gained resilience. Sometimes things just went wrong-there was chocolate that didn't melt; or a servo that didn't actuate at the right time. But we learned how to make a tough call, improvise, re-test, and come up with creative alternatives. This project gave us insight into what it is like to actually engineer something that works and can be used/enjoyed.

6.4 Future work

The ChocoCup project has opened up a lot of different avenues for potential ideas, and we see it as only the beginning. One possibility for the future is expanding the customization process from not only toppings, but even the biscuits flavor, the chocolate type, the decoration pattern, and so on. We envision a machine where the user would be able to choose as many parameters as they want from cake texture, chocolate consistency – making it a fully personalized dessert experience.

Another useful enhancement would be adding sensors in the machine to be able to measure ingredient levels so that the system can either request from the user or autonomously refill as it becomes depleted. This will add more complexity or autonomy to the system. Additionally we can add weight sensors to monitor the precise amount of each ingredient in real-time, which would guarantee accuracy and minimize waste in the process. It would also be useful to add sensors to monitor the weight of the final product,

especially in cases where the cup has a weight for sale or to check that what has been produced matches a specific predetermined target. We would like to also improve the chocolate dispensing valve.

With the right support, this project could be developed into a real commercial product, bringing fun, convenience, and creativity into the dessert-making world.

Chapter 7

References

Alsheikh, M., & Ahmad, A. (2021). *Development of a Smart Automated Dessert Machine Using Arduino and Embedded Control Systems*. International Journal of Modern Engineering Research (IJMER), 11(3), 45–52.

In this article, a similar method, Arduino-based control, to automate dessert preparation is present. The authors emphasized the improvement of user experience with integrated sensors, motor control, and real-time interaction with a user interface. When designing the modular stages of our system - especially the management of synchronous tasks and consistency - it was a useful reference.