

EDD 104

Section 62

Project 1: Toaster Oven for the Blind

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Executive Summary

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Introduction

Design Statement: Design a toaster oven that will provide ease of use and safety for the blind.

Design Focus:

System Level Requirements:

TFTB 1.1: The appliance shall be operational by the blind

TFTB 1.2: The appliance shall be safe for the primary users

TFTB 1.3: The appliance shall provide accessible controls to the users

TFTB 1.4: The appliance shall abide by all applicable standards.

Evaluation Matrix

Criteria	Weighting Factor (W)
Cost	.3
Safety	.3
Simplicity	.15
Maintainability	.05
Durability	.1
Reliability	.1
Total	1.0

Justifications for Evaluation Criteria

Cost: Cost is one of the most important factors in our toaster oven which is why it has one of the highest weighting factors of 0.3. We must ensure that the bulk of our very specific demographic can afford to buy our toaster oven. If the price isn't considered, we could scare away a lot of our potential customers. Furthermore, unaffordable products are often unmarketable since consumers do not want to buy overly expensive products. Our group should also strive to make our product as cheap as possible to produce for practical purposes such as revenue return from sales as well as to give our team the best chance of winning the EDD 112 project "competition".

Safety: Safety should have a higher weight factor because the problem statement specifically includes “safety for the blind”. If the toaster oven is unsafe for the blind, the main task will not have been completed. An unsafe product is not marketable since consumers do not wish to buy a product that has a probability of causing injury. Furthermore, if our toaster oven’s safety was not prioritized, lawsuits due to injury could become a problem.

Simplicity: Simplicity of a toaster oven has a high weighting factor falling third behind safety and cost because it is stated in the requirements that the toaster oven “shall provide accessible controls to the users”. Since our specific population, blind people, struggles with daily tasks, making this appliance simple to operate is important to fulfill this requirement. Our toaster oven design must be ready to accommodate the additional needs of blind people.

Maintainability: While the maintainability of a toaster is important because it includes cleaning the toaster oven to keep the toaster functioning, other factors like safety and cost are imperative and must be considered more heavily. The group assigned maintainability a .05 weight because maintainability should still be factored while designing a toaster, but should not be factored as much as the other criteria because it poses less of a threat to the safety of the user. However, it is still important because making a toaster maintainable protects it against internal debris and crumb build-up that can lead to internal fires.

Durability: The durability of our toaster oven is important because durability equates to a longer life span. Since many consumers value the life span of a product when purchasing one, it is important to prioritize the durability of our device in order to increase the life span of our toaster oven. While our group did not believe the durability was important as factors such as safety, cost, and simplicity; the group decided it was still an essential criterion of our device so it was assigned a 0.1 weighting factor.

Reliability: Product reliability is an important weighting criterion because it promises that the product will perform as expected or advertised. Consumers value products that perform as they are expected and sales of our toaster will increase when the reliability is prioritized. Furthermore, the reliability of our product is directly related to the reputation of the product and the company as a whole. Because reputation is not only important to sales but the future of a company as well, we assigned reliability a 0.1 weighting factor.

Design Description

Feature 1: Auto-Shutoff (Brandon Bruetsch)

Additionally, another feature that satisfies two of our most heavily weighted evaluation criteria, simplicity and safety, is an auto-shutoff feature. According to a website dedicated to helping the elderly find appropriate appliances for their home, an important thing to look for in a toaster is an auto-shutoff feature (W, A., 2009). Having an auto-shutoff feature removes the possibility that the toaster oven will be left on by accident. Since the majority of people using this product will be blind, it is important to incorporate this feature because they will not be able to see whether the toaster is on or off. Including an auto-shutoff feature in our design allows us to fulfill project requirement TFTB 1.1 that says that toasters must be operational by the blind as well as UI 2.1 that states that the toaster oven shall shut off after use. These two requirements, TFTB 1.1 and UI 2.1, can be found in Appendix A and the full verification of these requirements can be found in Appendix B. Our toaster oven will feature an auto-shutoff feature that powers down the device if cooking has finished and no additional settings have been activated. Furthermore, our design will also automatically shut off when the temperature exceeds 500°F in order to account for the safety of the user. The auto-shutoff feature of our device will use a coded Arduino Mega 2560 rev3 microprocessor to function. An example of the code flowchart to be used in the programming of this microprocessor can be found in Appendix C and the cost analysis of this feature can be located in Appendix D. By using an auto-shutoff feature, our design is becoming simpler and easier for the blind to use and is saving energy as well.

Feature 2: Heat Resistant Handle (Brandon Bruetsch)

To account for the safety of the primary user, our team has introduced a heat resistant handle to the sliding glass door of our toaster oven. The material of the handle will be heat resistant polypropylene. The low conductivity of this material fulfills requirement STR 2.1 which states that the user should not come in to contact with conductive materials (See Appendix A and B). Furthermore, since the low conductivity of the polypropylene protects the user from any injury or burns due to heat, this feature also fulfills requirement TFTB 1.2 dealing with the safety of the primary user and satisfies the safety evaluation criterion. Requirement TFTB 1.2, as well as the verification of this requirement, can be found in Appendix A and B.

Feature 3-Crumb Tray (Connor Lounsbery):

Another feature we will add to our toaster oven design is a crumb tray. This is shown on our functional schematic. A crumb tray is a tray located at the bottom of a toaster oven that collects crumbs from food. The tray can be taken out and then the crumbs can be disposed of. The function of this feature is to assist the user while cleaning the toaster. This feature will help achieve the requirement [UI 2.4] The toaster oven shall feature a crumb removal facility identifiable by both sight and touch. (Appendix A). According to IEC standards, “it should be possible to remove and correctly replace the crumb tray for people of all abilities” when using a toaster oven. Additionally, “Removal and replacement should be simple and should be possible to do with only one hand, preferably either hand. Incorrect replacement of the crumb tray should not be possible” (IEC, 2015). A crumb tray is a worthy feature to add to our toaster oven since it helps clean the oven. A review of the toaster oven BLACK+DECKER Natural Convection

Toaster Oven, Stainless Steel, TO1755SB with a crumb tray feature stated, “the removable crumb tray is super convenient” (Walmart,2020). Another said, “The crumb tray helps cut down on some of the mess when using the toaster oven.” Reviews like these prove that the crumb tray feature is a valuable addition to our toaster oven design. The crumb tray feature addresses the evaluation criteria maintainability since it makes the toaster oven easier to clean and maintain. This feature addresses one requirement and one evaluation criteria making it an important feature to our design. The cost of this feature will approximately add about \$5.00 to our toaster oven design according to our cost analysis.

Feature 4- Stainless Steel Toaster Oven (Connor Lounsbery)

One feature we want to add to our toaster oven design is to make the material primarily stainless steel. Stainless steel is a common material for toaster ovens and makes durable long-lasting ovens. One article suggests stainless steel by saying “Due to its excellent mechanical and corrosion properties, stainless steel is chosen for countless applications across various industries because it ensures low maintenance costs, a long life and high recapture rates once that life is over.” (Patel, 2018). This article also says that this material may save cost on production. “If the correct type or grade of stainless steel is chosen for an application, it can last till the project lasts. In its lifetime, it saves maintenance costs, inspection costs and production downtime costs” (Patel,2019). This stainless-steel material will help meet two requirements. First it will help meet the requirement [STR 2.2] The toaster oven shall be operational for at least five years. {TFTB 1.4} (Appendix A). This will also help achieve the requirement [STR 2.1] User shall be isolated from internal heating components during cooking. {TFTB 1.4} (Appendix A). This is because the stainless steel will separate the user from the interior part of the toaster oven. This feature helps address three evaluation criteria. First, this address durability since it makes the toaster stronger and long lasting. Second, it addresses reliability since the toaster is less likely to break due to its material. Third, it addresses safety since if a toaster oven were to break it could cause harm to the user. This toaster oven is less likely to break making it safer. This is a helpful feature to include in our toaster oven. It will make our toaster more durable and long lasting. According to our cost analysis adding stainless steel as the material of our toaster oven will add approximately \$4.00 to our toaster oven design.

Feature 5-Audio Alerts (Benjamin Nacht)

Audio alerts assist the user by making a sound when the cooking of food in the toaster oven is completed. There are also audio alerts when a specific setting is turned on via the remote such as preheating, bake, broil, toast, cookie, and on/off features. Whenever a button on the remote is selected an audio alert that is specific to that button will be played. These audio alerts let the user know what settings they have just selected. When the cooking time of food has been completed the audio alert played is a loud sound that will draw the user's attention immediately. As a result of the user of the device being alerted when the food is completed cooking, there is a small chance that a blind user may mistakenly open the toaster oven thinking their food has finished and come into contact with dangerously high temperatures. This will help fulfill requirement [UI 2.3]: The toaster shall alert the user when cooking is done. {TFTB 1.1} (Appendix A). This feature also helps fulfill requirement [UI 2.2]: The user shall understand the controls without sight.

{TFTB 1.1} (Appendix A) and requirement, TFTB 1.3: The appliance shall provide accessible controls to the users. Audio alerts will allow the toaster oven to become more accessible to blind users since they will no longer have to rely on sight to operate the toaster. Audio alerts that notify the user when food is finished cooking provides a greater simplicity to the toaster oven as well.

Feature 6-Rubber Feet (Benjamin Nacht)

To protect the user the toaster oven shouldn't be able to move unless it is picked up by the user to be moved to a different location. The rubber studs in the design of the toaster create a large force of friction with a countertop and therefore the toaster can't be moved by forces such as being knocked into or an object falling on it. The rubber feet help ensure the safety of the user and help fulfil requirement, TFTB 1.2: The appliance shall be safe for the primary users, because the rubber feet prevent unexpected drops. This feature protects the safety of the user by preventing accidents like the toaster oven falling. This helps ensure the toaster oven "poses little to no risk to the people handling it" (Patel, 2018). This feature also helps fulfill the requirement, [STR 2.2.] The toaster oven shall be operational for at least five years. {TFTB 1.4} Because the rubber studs enforce the sturdiness of the toaster oven on the countertop and increase the longevity of the appliance.

Discussion

Conclusion

Appendix A:

System Requirements

- TFTB 1.1: The appliance shall be operational by the blind
- TFTB 1.2: The appliance shall be safe for the primary users
- TFTB 1.3: The appliance shall provide accessible controls to the users
- TFTB 1.4: The appliance shall abide by all applicable standards.

Subsystem Requirements

[STR 2.1] The user shall be isolated from internal heating components during cooking. {TFTB 1.4}

- To protect the user during use, the toaster should be built so that no user ever comes in contact with the heating components of the toaster oven accidentally in order to prevent burns and other serious injuries.

[STR 2.2] The toaster oven shall be operational for at least five years. {TFTB 1.4}

- A toaster oven's average lifespan is five years, and the product should last that span for reliability. This information was found in a report by ENERGY STAR, a program run by the U.S. Environmental Protection Agency and the U.S. Department of Energy (ENERGY STAR, 2011).

[STR 2.3] The toaster oven shall feature assistive technology. {TFTB 1.3}

- Because of the difficulty blind people face finding controls, assistive technology must be included in order for the toaster oven to be operational by the blind. Controls should be made so that user does not depend on sight.

[STR 2.4] The toaster oven shall fit under a cabinet that is 15" deep. {TFTB 1.1}

- The toaster oven shall be a portable size and sit safely on kitchen counters to avoid falling, this is the average size of a wall cabinet.

[STR 2.5] The toaster oven shall fit under a cabinet 20" above the countertop. {TFTB 1.1}

- The toaster oven shall be to fit in the average distance between the countertop and the cabinet.

[FUN 2.1] The toaster oven shall preheat to 450 °F in 6 minutes. {TFTB 1.4}

- It is important that our toaster oven is able to cook food in a reasonable amount of time that is acceptable by all users. The average toaster oven preheats to 450 °F in 5-6 minutes, so our toaster should be able to do the same (Williams, 2020)

[FUN 2.2] The toaster oven shall not exceed 500 °F. {TFTB 1.4}

- Most toaster ovens cook between 200 °F to 500 °F ("How Baking"). There are almost no situations where a toaster oven is needed to exceed 500 °F in order to cook food. Exceeding temperatures of 500 °F would only cause safety concerns.

[FUN 2.3] The toaster oven shall be able to cook a wide variety of foods. {TFTB 1.4}

- To satisfy the user, the toaster oven must be able to cook a wide range of foods without any issues.

[FUN 2.4] The toaster oven shall contain a variety of settings. {TFTB 1.4}

- Consumers want to be able to cook their food in different ways, having a variety of settings such as bake or broil satisfies the user.

[UI 2.1] The toaster oven shall turn off after use automatically. {TFTB 1.3}

- Removing the need to power off the toaster after use makes the toaster more convenient for the blind.

[UI 2.2] - The user shall understand the controls without sight. {TFTB 1.1}

- If the user can't see, they must be able to understand the controls. They can not operate the toaster properly if they don't understand what buttons they are pressing.

[UI 2.3]- The toaster shall alert the user when cooking is done. {TFTB 1.1}

- It is important for the toaster to include a setting where a sound is made when toasting is completed. This way, those who cannot see will know when their food is done.

[UI 2.4] The toaster oven shall feature a crumb tray. {TFTB 1.4}

- According to IEC standards, "it should be possible to remove and correctly replace the crumb tray for people of all abilities" when using a toaster oven. Additionally, "Removal and replacement should be simple and should be possible to do with only one hand, preferably either hand. Incorrect replacement of the crumb tray should not be possible" (IEC).

Appendix B:

Requirement: (Brandon Bruetsch)

[TFTB 1.2]: The appliance shall be safe for the primary users

Verification:

In order to ensure the safety of any toaster oven, all users of the oven should be protected from the internal heating components of the device and the toaster must be made reliable and resistant to internal fires, damage from falls, and any other accidental damages that could cause injury to the user. In order to ensure that our device is safe to use, our team designed a toaster oven that

adheres to common safety procedures taken in many other toaster oven designs and prevents against many common injuries associated with them. The first and most obvious safety concern in any toaster oven involves the internal heating components and the user's interaction with them. In order to remove any possibility of the user interacting with the dangerous heating coils of the device, especially those who are blind, our team has increased the dimensions of our toaster oven to allow for more space when inserting and removing food items. As soon in our functional schematic seen in figure 1 of Appendix C, the dimensions of our toaster oven will be 15" in width and length and 18" in height (Seen Appendix C). These dimensions, along with the fact that our toaster oven is a single rack design, ensure that the user has no contact with the heating components that could cause burns and other serious injuries. Furthermore, to add additional precaution to our device, we have designed a mechanism in our toaster that allows the rack food items placed inside the toaster oven to slide out when the sliding door of the oven is opened. This feature further decreases the user's chance of coming in contact with the heating components of the toaster as the user will no longer have to stick their hand as far in the toaster to insert food items. Furthermore, the material used in our toaster oven will also prevent the user from obtaining burns or injury of any sort from the heating components of our device or the high temperature emitted by them. The tempered glass door of the toaster made from the same glass seen in large ovens in kitchens ensures that no heat will escape the cooking chamber. Furthermore, heat resistant polypropylene used in the handle ensures that heat conduction will not reach the user. To address safety concerns dealing with reliability in our device, our team has added a few features that are sure to make our device completely safe for the primary users. A crumb removal tray that attaches and detaches within the toaster and is placed under the racks ensures the safe and easy maintainability of the toaster. Therefore, as long as the toaster oven is maintained responsibly, there will be no accidental internal fires from crumb and debris build-up within the device. Furthermore, rubber feet placed under the toaster on the four corners ensure that the device will be resistant to sliding, and will, therefore, be of no danger to sliding off the counter and harming the user. The friction between the rubber feet and the counter will be high enough so that an accidental interaction between the user and the counter will have no chance of moving the toaster off of the counter. Finally, our team has also added two features within the coding of the microprocessor of the device to protect the user against heat damage. Our automatic shutoff feature will shut down the device without any user interaction if the temperature of the oven reaches above 500°F. Because 500°F is not only the maximum temperature allowed in our device but most ovens manufactured today; implementing a feature that ensures that this temperature is never exceeded ensures that no internal problems arise from an increasingly dangerous temperature. Additionally, our device also features an audio alert system that alerts the user when food is done cooking. The goal of this system is to not only provide ease of use to the user but safety as well. Because the primary user of the device is alerted audibly of completed cooking, there is little chance that a blind user may mistakenly open the toaster oven thinking their food has finished and come into contact with dangerously high

temperatures. The abundance of safety features included in our device, as well as an added precaution, fulfill requirement TFTB 1.1 which states that the appliance shall be safe for the primary users (See Appendix A). In Figure 1, a highlighted schematic shows off all visible safety features of our device (See Appendix C).

Requirement: (Brandon Bruetsch)

[FUN 2.4]: The toaster oven shall contain a variety of settings.

Verification:

As seen in the functional flowchart of our toaster oven's code shown in Figure 2 of Appendix C, our device contains numerous single click settings as well as a temperature and time change control which features two up and down arrows for temperature change and two up and down arrows for the time change. The six single-click settings featured in our device include preheating, bake, broil, toast, cookie, and on/off features. As seen in the functional flowchart in Figure 2 of Appendix C, the preheat setting will preheat the toaster oven to 450°F in six minutes

once pressed. Furthermore, the bake button will prompt the user to input a desired temperature to cook at and a duration of cooking in order to start the bake. The broil button will utilize only the heating coils on the top of the toaster oven making it useful for foods you only want one side to be cooked such as nachos. Like the bake feature, the broil feature will prompt the user to input their desired temperature and time. The next feature is a toast feature which picks an ideal temperature of 450°F and toasts for exactly 2 minutes. This combination of temperature and time will produce the best quality toast for the user. Additionally, the cookie feature of our device will also use predetermined values of temperature and time, 375°F and 13 minutes respectfully, in order to bake the highest quality cookies in the simplest way. The toaster oven will also feature a manual shutoff button in addition to the auto-shutoff feature. If any of the above features do not satisfy the user or will not cook a certain food to their liking, the bake feature can be used to input custom values of temperature and time to assure that the user is satisfied. The abundance of features, as well as the inclusion of fundamental settings such as bake and an on/off button, fulfills requirement FUN 2.4 stating that our toaster shall contain a variety of settings (See Appendix A and C).

As seen on a functional schematic drawn of our remote in Figure 3, the remote will consist of the six settings previously mentioned: temperature, time, bake, broil, toast, and cookie. The temperature and time settings will be controlled by up and down arrows indicating an increase or decrease in both temperature in time according to the direction of the arrows. The words on the remote will feature a braille translation directly underneath in order for blind users to interpret which button is which (See Appendix C).

Requirement: (Brandon Bruetsch)

[UI 2.1]: The toaster oven shall turn off after use automatically.

Verification:

As seen in figure 4 of Appendix A, the microprocessor of our device asks the user for input of temperature and time. The microprocessor will then use an if statement to test the temperature of the toaster using an internal thermometer. If this temperature has exceeded 500°F, then the microprocessor will automatically power off the device. If the temperature has not exceeded 500°F, then the code will use another if statement to test if the toaster oven has finished cooking. If the toaster has not finished cooking, and the time the user set has not been completed, then the

loop will direct the code back to the first if statement where the microprocessor will continue to test both the temperature and status of completion until either the temperature exceeds 500°F or the toaster is done cooking. If the toaster is done cooking, the code then prompts the toaster oven to automatically shut off. This functional flowchart of code will be uploaded to an Arduino microprocessor that will perform these commands in our toaster oven. Therefore, the use of this code in the Arduino microprocessor fulfills requirement UI 2.1 which states that the toaster oven shall turn off after use (See Appendix A and C)

Appendix C:

Supporting Documents:

TFTB 1.1 Verification: (Brandon Bruetsch)

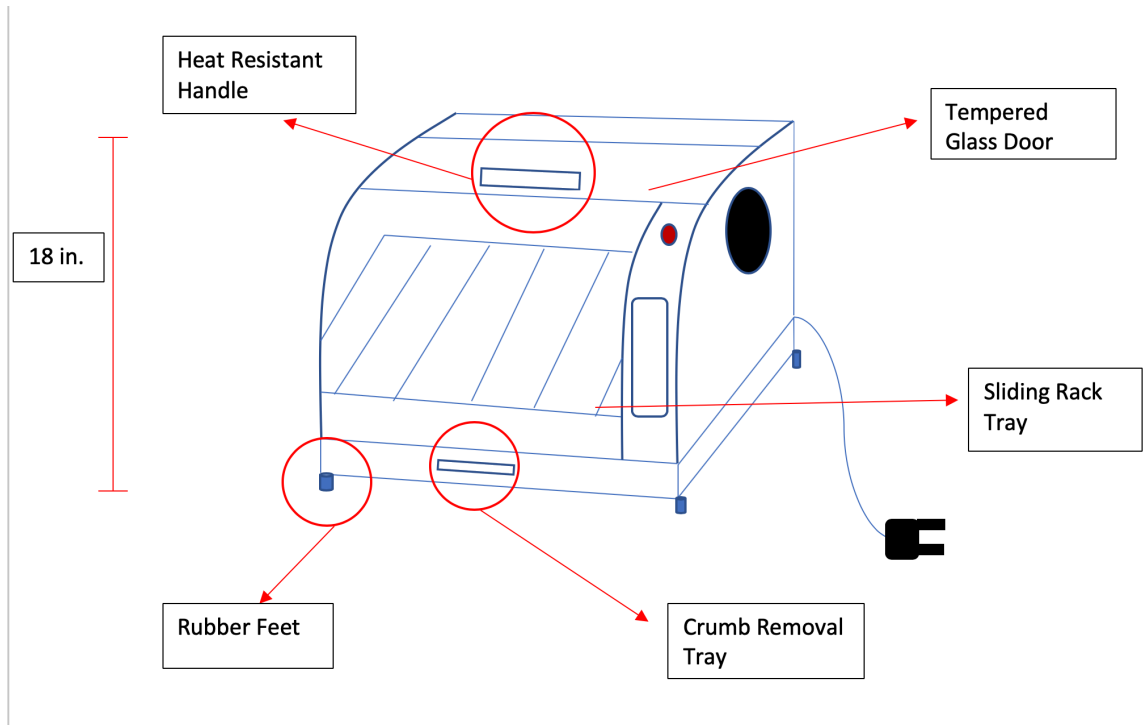


Figure 1: Highlighted Toaster Oven Safety Features

FUN 2.4 Verification: (Brandon Bruetsch)

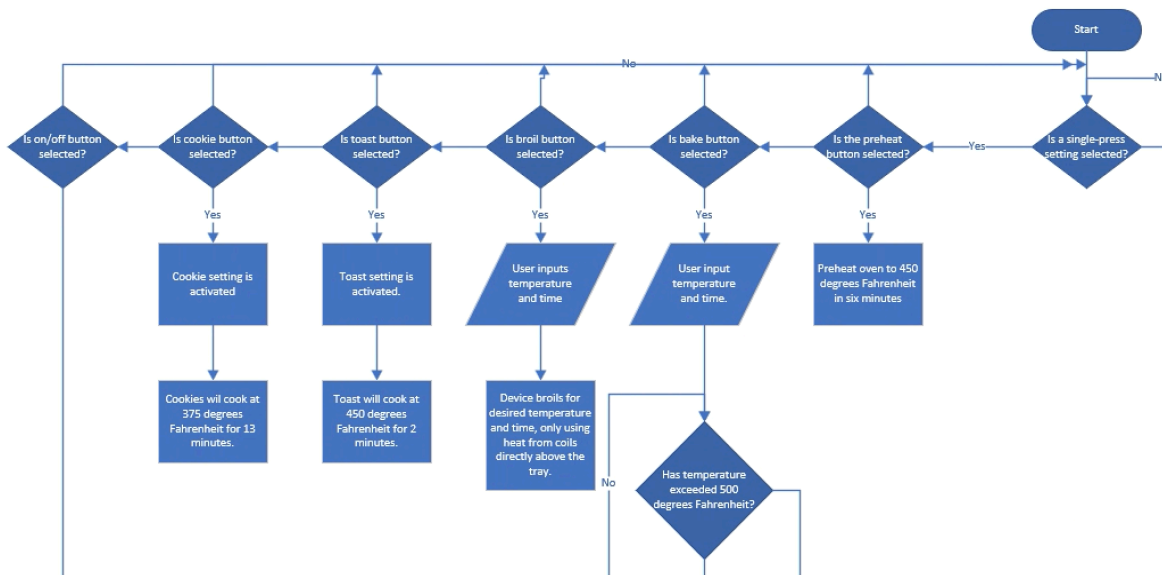


Figure 2: Functional Flowchart of Toaster Oven Code

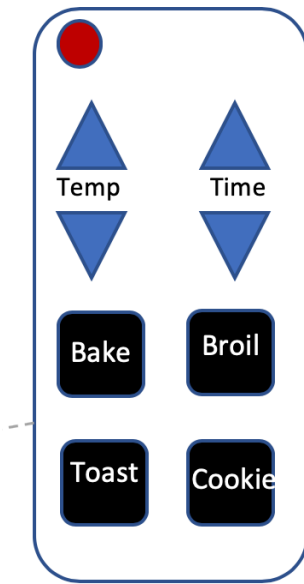


Figure 3: Toaster Oven Remote

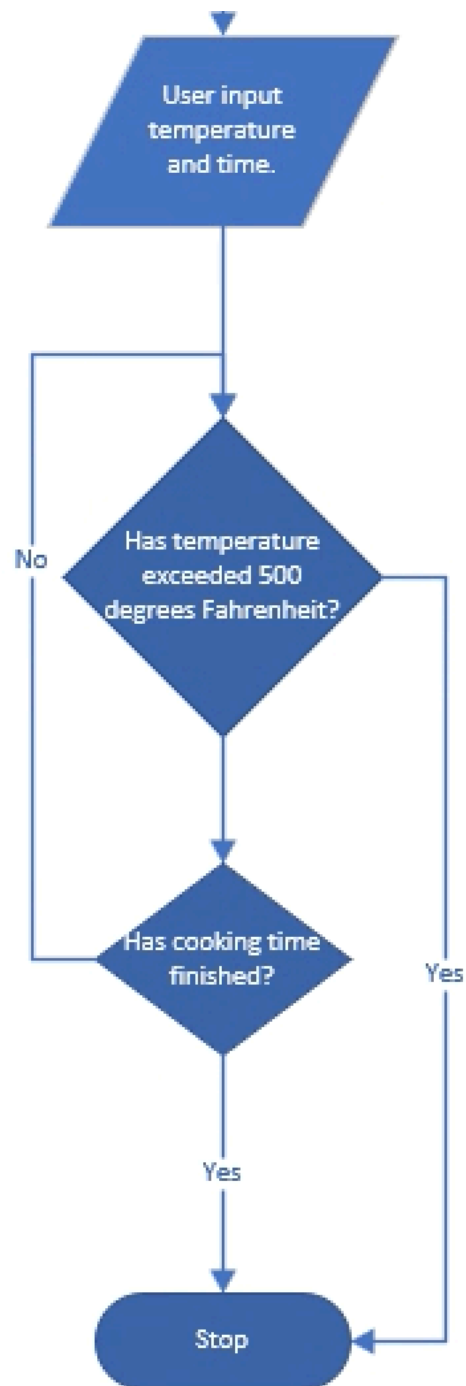


Figure 4: Section of Flowchart For Code of Auto-Shutoff Speech

Appendix D:

Cost Analysis:

Auto shutoff / Preheat to 450°F in six minutes features: (Brandon Bruetsch)

To incorporate an auto-shutoff feature into our design, a circuit board is needed in order to communicate with the toaster oven and tell it to shut down after thirty minutes. The circuit board that we will use in our design is an Arduino Mega 2560 rev3 microprocessor. This microprocessor costs \$40.30 on the Arduino website.

Heat Resistant Handle: (Brandon Bruetsch)

Polypropylene will be the heat resistant plastic used in our design as it is used in many consumer goods. The cost of polypropylene is \$5.55 per 1/16" x 12" x 48" sheet which comes out to approximately \$4.51 per pound after some density calculations ("1/16" x 12" x 48" Polypropylene Sheet", n.d). Since our handle will be approximately 4 cubic inches in volume, this equates to around 65 cubic centimeters. Using the density of the polypropylene (.92 g/cm³) and unit conversion, we can approximate the cost of our handle to be about \$0.60 per toaster oven.

Appendix E: