Mechatronics Design Project

Liam Gilbert

S00312701 8/30/22 LIC: Matthew Christie

Abstract:

The model I intend to create is a dispensary type product that outputs multiple lollies at once. It will utilise a power switch to initiate the circuit, then an ultrasonic sensor to detect the user and objects, and then finally commence with the dispensing of lollies. It will also use LED lights as indicators of the device being active and on, and responding to the Arduino once commands are triggered. The primary mechanism will be the servo motor, which will dispense the lollies.

Table of Contents

Identification and exploration of the need:

The function that will be demonstrated within this model is dispensing. The primary need being explored is the possibility of exploring automation for trick-or-treaters during the Halloween season. Rather than manually distributing lollies, or not distributing lollies at all if you are absent from home, this device will dispense between 3-6 different lollies once a bag/hand is detected. Although trick-or-treat lolly dispensers exist, they are limited to only jellybeans due to the shape, or they are not commercially available. I intend my device to be a cost-affordable dispenser that suits a wide range of commonly available lollies such as Cadbury squares, lollipops, and sherbets.

Inputs of the device:

- An ultrasonic sensor will be used to detect any motion. Preferably, it will detect a hand or small bag, so that lollies are able to be dispensed. Once an object has been detected, the servo motor will rotate so that the lollies can drop. 3 second cool-down time for reloading.
- A breaker switch will be put in place, so that the device can initialise and turn on and off.

Outputs of the device:

- The device will output lollies as the primary dispensed object via the ultrasonic sensor input.
- The device will also output one LED light, that will indicate the device is on, and another LED light to show operation of the device, and a final LED light to show that power is active.

Pseudocode/ Flowchart of how the design is intended to operate:

Device initialises from breaker switch

When breaker switch is turned on, electricity from 9V battery activates

Red LED light turns on when the breaker switch activates.

Green and Yellow LED lights are flashing together to represent idle mode.

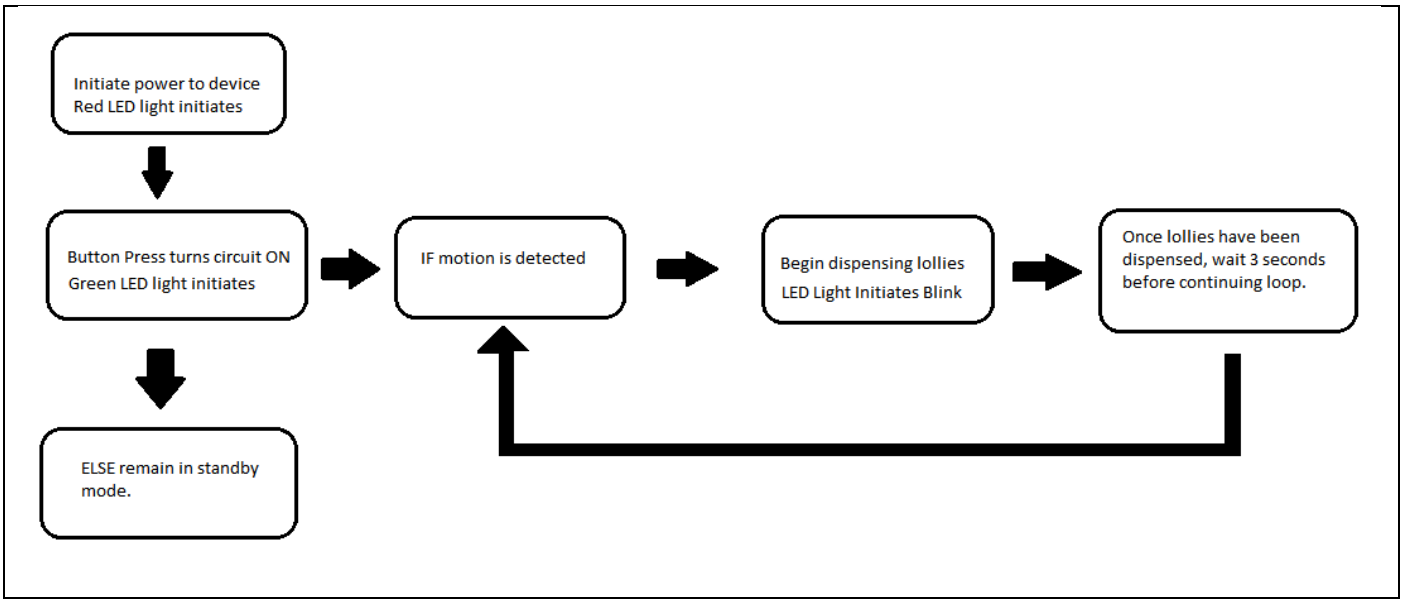
IF motion is detected within 10cm distance, servo motor activates.

ELIF motion is detected, Yellow LED remains constant, and green LED temporarily shuts off.

Task repeats until there is no motion within the ultrasonic sensor being detected.

ELSE: No motion detected, yellow and green light continues flashing, servo motor remains on standby.

Device turns off from breaker switch toggle.



Areas of investigation:

The primary sensor that will trigger responses will be the ultrasonic sensor, as it will detect objects allowing for the automation of the dispenser to function. The potential to use IR sensors, physical buttons, ultrasonic sensors, and the servo motor will be investigated to determine whether these are suitable options for the design. The primary actuator will be the servo motor, as it can operate a back and forth, allowing for rotational motion to dispense the lollies, however, further investigation into a stepper motor will also be conducted to determine whether it can suitably be used as well.

What problems/ aspects of the design need to be considered?

For this design, the intended primary means of dispensing will occur through the use of a rotating servo motor. Since the design uses rotational movements opposed to linear movement, setting the angle for the servo motor will be important when calculating the amount of tolerance needed for dispensing and reloading the lollies. If the tolerance is not large enough, then lollies have the potential of jamming the servo motor while dispending, whereas is the tolerance is too large, lollies also have the potential of falling through and getting caught thus jamming the servo motor during reloading.

Another aspect of the design that needs to be considered is how and where the electrical components of the design will be placed. Since the design must only occupy a maximum space of 30x30x30cm, it is imperative that there is enough room for a hand to fit within the device, for lollies to be stored, and for the electrical components to be accessed and modified if needs be.

Durability of the design is also another factor that needs to be considered, as electrical components and fixtures need to be held down to prevent any damages internally. Especially for a dispenser aimed towards trick-or-treaters, the construction of the parts and what holds the product together is important, as accidental bumping from hands entering over the device is a possibility that may cause potential damage.

The aesthetic appeal of the design needs to be considered, as I intend for the design to be a marketable product that will entice trick-or-treaters, while also being able to functionally operate as a dispenser.

What inputs/ outputs/ actuators need to be considered?

For this dispensary type design, I need to consider the best possible sensors, motors, and actuators that will be most effective from a functional, cost, and manufacturability perspective. In the following table, there is a PMI list of the possible accessories that I will be using, to help guide the design of my project. The servo motor in particular is the primary mechanism I intend to use for the design, as the rotational motion will theoretically allow for the lollies to be pushed out for dispensing. I am also investigating the stepper motor to explore alternative devices, as a possibility if the servo motor isn't powerful or fast enough. In terms of cost affordability, I will investigate the commercial cost of the finalised items to determine how viable this design would be economically, and whether it would be sustainable for mass production. Finally, components that are directly related to the Arduino such as 3-D printed object parts to store the lollies, or a holster for the Arduino, will need to be considered, as they contribute a reasonable size to the physical appearance of the design, and must be 3-D printed to ensure clear accuracy within the project.

How will the design be manufactured and produced?

As an initial product, this design will be manufactured primarily using 3-D printing components for the mechanism, shell, and operation of the device. By creating the parts by 3-D printing PLA (Polylactic acid), I am able to actualise my fusion360 sketches and renders, in order to produce working product. Once the individual items have been 3-D printed, I will sand the individual pieces up to a grit of 2000, before adding a primer to the components, and then spray painting it with a metallic paint. The primary way I intend to join the components at this stage will be done through the use of super glue. There is opportunity for future iterations of this design to incorporate locking mechanisms and joints, however, as an early design concept, it is still being developed.

In an industrial setting, the most optimal way of producing this design would best occur through the use of injection moulding and laser cutting. By mass producing the shell components through multiple moulds, and laser cutting the structure of the design, while also limiting the 3-D printing for only small pieces, it is better economically, and is greatly more efficient. Injection moulding would also remove the need to constantly sand the 3-D printed parts and would result in a smoother finish for the design.

What makes the project unique?

The aspects of this design that makes the project unique, is the way it operates, appears, and engages with the user. In terms of operation, I intend to dispense multiple lollies at once, opposed to the conventional one lolly at a time in previous pre-existing designs. I also intend to integrate a cool down period time to allow for reloading, and LED relevant lights that reflect the status of the machine. From an appearance perspective, I will be taking inspiration from pre-

existing designs and ideas which will be conducted through research, as the theme for my design is for Halloween trick-or-treaters.			
Sensor/ Actuator/ Tool	**Plus**	**Minus**	**Notes**
Servo Motor (Robu, 2017)	- It can operate at fast and slow speeds. - If heavy object is placed on top, the driver will increase current to the motor to help keep the rotations constant with the speed. - Micro server motors are relatively affordable and can fit in a variety of tight spaces.	- There is a minor lag between the motor and commands, as it utilises command pulses of current. - Maximum of a 180-degree angle whilst rotating. - Position needs to be reset if the motor is bumped, damaged or moved from the rotating shaft.	A servo motor is a rotary actuator which allows rotations to occur up to 180 degrees. It utilises drive gears, a motor, integrated circuit, and a potentiometer.
Stepper Motor (Robu, 2020)	- High torque at low speeds, meaning that it can move a good amount of weight. - Relatively cheap too, and widely available. - Since it is a low-speed device, this means that it has a lot higher precision, and less erratic vibration.	- At high speeds, it has significantly less torque. - Potential for feedback within the motor to skip steps, as an increased load will also make the motor increase quickly. - Less efficient, as the stepper motor requires more amperes, making it less energy efficient.	The stepper motor is a DC motor that concerts electrical pulses into mechanical of the shaft. Once the stator of the motor has energy flowing into it, the motor begins to function and rotate in discrete steps.
Physical Button (Topshall (Dongguan) Electronics & Technology Co.,Ltd, 2019)	- Simple, easy to use, and responds to the input of code easily. - Cost effective, widely available. - Appearance is relatively discreet and	- Constant pushing of the button can potentially cause the metal shrapnel to lose its elasticity, and thus disable the push on the switch.	The physical push button is an electronic switch, which is often used to activate actuators, LEDs, or the main power supply. Unlike toggle switches that have an on and off mode, physical pushbuttons only

	isn't an eyesore if externally displayed.	- The push button requires input from a PCB board with instructions, or else it will not be able to function.	have the singular option to push down.
Ultrasonic Sensor (Electrical terminology, 2021)	- Small form factor, which makes them easily available and accessible to use in small systems. - Low cost - High sensitivity, which means that it can detect objects quite easily, including solids or liquids. - Long life span, does not need regular maintenance. - Good for short distance areas.	- The angle of measurement is low, as it ascends from upwards of 10 degrees from the sensor. - Acoustic measurement is slower than light measurement, due to the lower speed of acoustic signals. - Cannot detect sound-absorbing materials such as foam, soft clothing or sponge.	Ultrasonic sensors produce ultrasonic echoes which reflects off surfaces to gauge the area it occupies, and to determine whether anything protrudes the ultrasonic field.
IR Sensor (Rf-Wireless World, 2012)	- Uses point to point mode of communication, meaning that it is secure and less likely to be disturbed. - Physically small and does not require much maintenance at all. - Response rate is fast since it utilises light. - Works in both daytime and night-time conditions.	- Cannot pass through physical objects. - WHS concerns as infrared light waves at a high power can damage eyesight. - Best for short range use, as it degrades in long rang distances. - For the sensor to activate, the object must emit heat, and must be within the	An IR sensor is a device that utilises infrared waves to sense object in its surroundings. Infrared sensors measure heat emitted by and object such as a person and can also detect motion of the object by tracing the heat.

		vicinity of the sensor beam.	
LED lights (Brennan Electric, 2020)	- LED lights have a very long-life span, with them lasting for up to 50,000 hours for the majority of commercial bulbs. - 80% of energy passed through to the LED is used for emitting light, while 20% is used for heat transfer, meaning that LED lights are very efficient. - LED lights can emit different colours such as Red, Green, and Blue clearly. - Efficient in cold environments.	- The cost	LEDs (Light Emitting Diode) are semiconductors that turn power into light through the LED bulb. LED lights come in small variants of large ones, and emit a strong light in a single course contrast.

Criteria to Evaluate Success:

Item/ Process	**What it needs to achieve**	**How it will be achieved**
Dispensing multiple objects	My design needs to be able to dispense multiple lollies once motion is detected. It needs to ensure that once the lollies are dispensed, that it can be reloaded, and that adequate time is given to reload.	The primary way of achieving this can be done through the use of constructing a decline chute within the device, where a servo motor will be able to control a gate that opens and shuts the lollies from falling. The idea is still in the design phase, however, it is meant to utilise gravity to dispense the lollies, as the lollies will be stored on a declined angle.
LED relevant lights	For this design, I need to incorporate 3 different LED lights	To achieve the first LED light recognising that power is active, I will connect it

	that represent varying aspects of the design. One LED light needs to show that the circuit has power flowing into it so that the user can distinguish that it is in standby mode. Another LED light needs to respond to a button pressed that indicates the circuit is active for use and is no longer in standby mode. Finally, the last LED light needs to indicate that the device is operating, and dispensing is occurring.	physically to a positive connection, as it will always remain constant when power is flowing. No code is required for this LED. The second LED will be linked to an Arduino UNO board and button, which will remain off if the button has not been pressed and will then light up once the button has been pressed. For this, a code is required to input into the Arduino. The final LED light will be connected to the ultrasonic sensor and Arduino, as once motion is detected, the LED light will turn on to recognise that there is an object present, followed by dispensing of the lollies.
Size of the design	Although there is a 30X30X30cm limitation on the physical size of this design, I intend for the size of the design to only have a maximum of 30X20X20cm for the dimensions. The primary reason for this, is so that it looks less off-putting like a cube and appears more vending machine-like from an aesthetic perspective. Since the premise of this design is for Halloween, enticing trick-or-treaters is the intention in terms of aesthetics. From a production point of view, I don't want to waste materials on an unnecessary size, and would prefer the design to be compact,	To create the size of the design, I will first establish a fixed variable, in which case is the Arduino circuitry. Since the Arduino circuitry is a requirement for the functionality of the product, the physical dimensions of the product cannot be smaller than it. Then through the use of pre-existing designs, I will gather data on how those designs have been setup and organised, to determine what would possibly work, and what may interfere with the operation of the dispenser. Finally, I will experiment on fusion360 using the physical dimension of the Arduino, pushing mechanism, and lollies to determine if my design is viable, before I begin 3-D printing the parts.

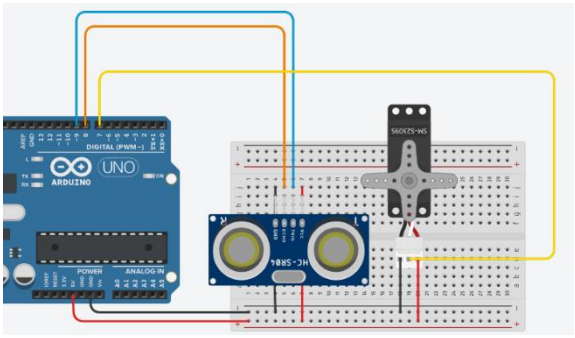
	yet ergonomic so that people are able to retrieve dispensed lollies with ease.	
Operating from a 9V Battery	The circuit needs to be powered from a 9-volt power supply or a 9-volt battery.	To ensure that I am still in the range of using a 9-volt battery, I will not use any overly excessive actuators or motors such as full-sized stepper motors or servo motors.
Utilising a toggle switch to initiate power	The toggle switch needs to be able to give power to the circuit, and also cut power entirely.	To achieve this I will be connecting the wires from a 9volt socket into a toggle on/off switch, so that I am able to allow current to flow when connected, and no current when turned off.

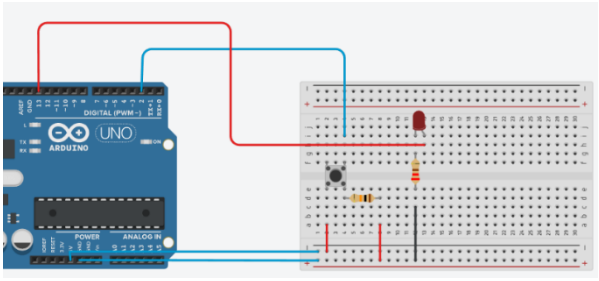
Intended Time Action Plan (For the entire project):

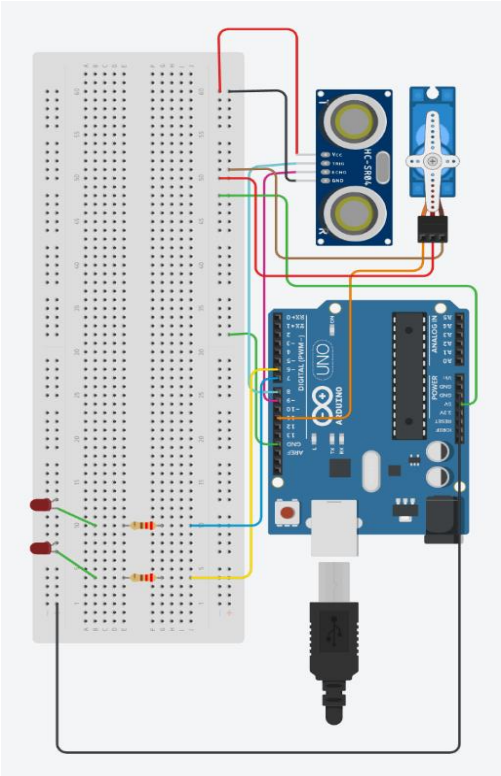
ACTION	**TIME [INTENDED TIME] [ACTUAL TIME]**						
	Week 1	**Week 2**	**Week 3**	**Week 4**	**Week 5**	**Week 6**	**Week 7**
Understanding/ analysing parameters of the project.							
Investigating pre-existing Arduino mechatronic designs to gather ideas, and inspiration.							
Using pre-existing ideas, establish a genuine need for the design product.							
Map out a flowchart and pseudocode of how the design will function, and what is required to achieve the functions.							
Using the pseudocode, create sketches on tinker cad to determine whether the circuitry can be made.							

Input test samples of code into tinker cad to try and operate the circuit.							
Using a breadboard, Arduino UNO board, and USB cable, assemble tinker cad sketches, and test the code to see if it works.							
Using the measurements of the Arduino and the associated parts, create models in fusion360, and construct a generic housing for the components and mechanism							
After you have a general shape for the components, sketch hand drawings to improve the shape and aesthetic of the design.							
Transfer the intended look for the design into the generic structure for your product on fusion360. Set the parts into an exploded view before exporting them as individual files for 3-D printing.							
In a 3-D printer, upload the individual components, and print them.							
Once printed, sand the components, prime them, and spray paint them in a metallic spray paint.							
Fix the Arduino to the 3-D printed components, then use super glue to assemble everything together.							

Ideation:

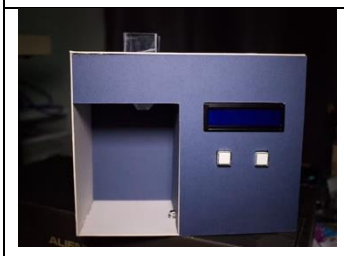
Concept Idea	What is happening?	What could be improved on?
	In this sketch, I took a pre-existing drawing of a servo motor, and added an ultrasonic sensor to it. The idea was to test the ultrasonic sensor working in sequence with the servo motor. I also modified and combined a servo motor and ultrasonic sensor motor to produce this sketch as an operation.	I know that within this sketch, there needs to be more happening, such as LED lights operating, button switches turning the circuit on, and also factoring in that the design will need a power toggle switch.


`const int buttonPin = 2;`
`const int ledPin = 13;`
`int buttonState = 0;`
`void setup() {`
`pinMode(ledPin, OUTPUT);`
`pinMode(buttonPin, INPUT);`
`}`
`void loop() {`
`buttonState = digitalRead(buttonPin);`
`if (buttonState == HIGH) {`
`digitalWrite(ledPin, HIGH);`
`} else {`
`digitalWrite(ledPin, LOW);`
`}`
`}`
	For this Arduino sketch, I didn't want to overcomplicate the prior one, so I investigated buttons, and how I can incorporate it into my design. For this, I used a pre-existing button design, however, I modified the code, so that when pressed, it would turn on. After testing the code, I inputted it into my original Arduino sketch.	For this design, I could have improved the code, where the LED light would behave differently when pressed. I could have also tried running multiple LED lights, and having different functions applied to them, however, this was just a test to see if my idea in general would be valid.

	In this tinker cad sketch, I attempted to combine LED lights, with the ultrasonic sensor, and servo motor. The intention was for one of the lights to remain active and on always, while the other light would only activate once an object was detected by the ultrasonic sensor. The sketch ended up working and was tested on a proper Arduino board.	Unfortunately, one of the biggest issues I found with this sketch, was the wires were messy, and that I didn't need the GND going onto the LEDs directly. The code operated fine, however; the circuitry of the board needs a bit of fine tuning to ensure that all the coloured wires are recognisable. I also did not attach the button to this sketch, as I was uncertain about how I would connect all the pieces together, including the code too.

Exploration of pre-existing ideas:

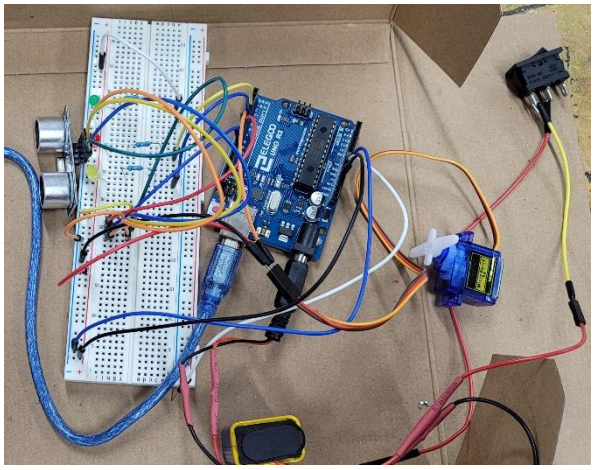
Design	Plus	Minus	Interesting
	**(Instructables, 2021)** This design uses a simple ultrasonic sensor, stepper motor, and 9v battery for power, and is able to dispense multiple types of lollies at once. It is also very minimalistic in design, less than 30X30X30cm in size, and uses simple rotating mechanisms to dispense.	The design uses 9mm plywood, which gives the rotating mechanism strength to push the lollies, however, it is also heavier and consumes more energy. If the dispenser is activated too many times and lollies are not collected, then the dispenser has the	I find it very interesting that the creator of this design was able to dispense more than one object at a time without it conventionally jamming. It's also interesting that the design is run off a stepper motor as the primary mechanism for turning, which gives it strong torque and

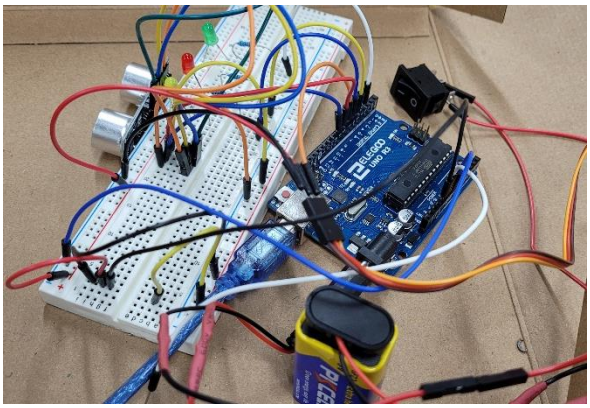
	The decline chute/ ramp allows for lollies to dispense very easily.	potential to clog up and not work. Does not hold a large amount of lollies.	accuracy, despite less speed.
	**(Hackster, 2017)** This design uses a servo motor, IR sensor, and LCD screen to dispense lollies, while also showing the quantity being dispensed on the screen. It is also power off a 9v battery, and has a toggle switch button placed into the power that turns the circuit on and off. Once a button is pressed, the circuit begins functioning, and the IR sensor is able to detect heat from an object, and continue with the dispensing into a cup or hand.	The physical materials of the design is weak, as it is primarily made out of thin card that was CNC cut. The only 3-D printed parts are related to the actual mechanism of the servo motor which allows dispending. Can only dispense one item at a time through the chute.	I find it interesting that this design incorporates an LED screen into the design while dispensing. Due to this, users are able to interact with the product more clearly and easily. I also find it interesting that this design has a toggle power on/off switch, and then has two options to dispense one lolly, or multiple lollies in repetition.
	**(Arduino Project Hub, 2018)** Uses a drive shaft, conveyor belt, hopper, and stepper motor to push the lollies.	The design needs two Arduino boards to function. The design also uses more industrial materials such as copper and wood, which is harder to	I find it very interesting that this dispensary object uses a conveyor belt to dispense lollies opposed to a gate or chute. It's also very interesting that other components

	Multiple lollies are able to be held, and then dispensed easily. The design uses ball bearings to help reduce the friction on the conveyor belt once the lollies are added onto it.	economically produce for an affordable price. The design also has issues with creating too much friction on the conveyor belt causing it to warp.	such as a hopper, drive shaft, and ball bearings are used to allow the lollies to move more easily, while also holding a lot more weight compared to the other designs.
	**(How To Mechatronics, 2022)** This design incorporates the use of multiple servo motors, an LCD screen, multiple buttons, an IR sensor, and a 12v power supply. Utilises a pulley type system to allow for the user to select different outputs from the input. This design uses the servo motor to rotate a spring shaped object that holds lollies and chips to push them out as a traditional vending machine would. This design holds the item within the spring shaped vessel, and pushes it along the surface, until there is no surface in which it falls	Needs 12 volts to operate. The materials of MDF and Perspex were CNC cut, while the internal pulley system utilises aluminium and steel bolts which will be hard to produce in an industrial setting for a low cost. Very large, and exceeds the 30X30X30cm design constraint.	This design is a vending machine design, where it is dispensing items through the use of a servo motor rotating a spring. I like how this design uses vending machine springs to dispense the objects, as larger lollies and foods are able to be stored more easily in there. It is also interesting how this design allows for the input to choose a various selection of outputs, compared to the other designs that randomly dispense lollies.

	down and can be collected. The buttons allow for the input to choose which candy the user wants, and then dispenses it, while the IR sensor detects that the object has been collected.		

Prototyping and experimentation:

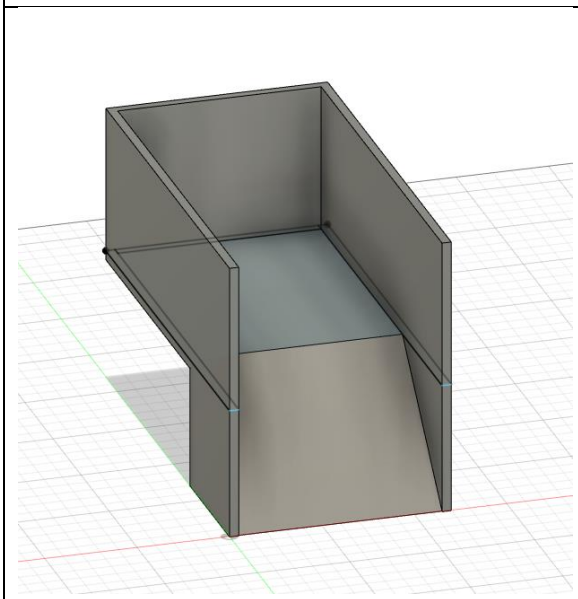
Experiment/ Prototype	**What is occurring or meant to be occurring?**	**What could be improved on?**
	In this prototype setup, I physically tested the tinker cad sketches I had made up, and modified them so that the circuit would incorporate a toggle power on/off switch. Within this circuit, I am testing the 9volt battery, to see if the circuit operates. I am also testing how the code I inputted in the design responds to the physical components, such as the servo motors relationship to the ultrasonic. What I found from this experiment, was that I had the battery wired incorrectly, which is why the battery itself was heating up, and drained after 30 minutes of use. I also found that	To improve on this design, I believe that I could revisit the code to ensure that the LED lights are responding to different functions, such as the Green LED showing standby, Red LED showing the circuit is active, and yellow LED showing the dispensing process. The management of the cables could also be improved, as I was constantly pulling on the incorrect cables.

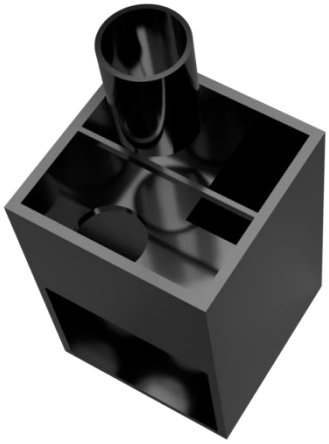
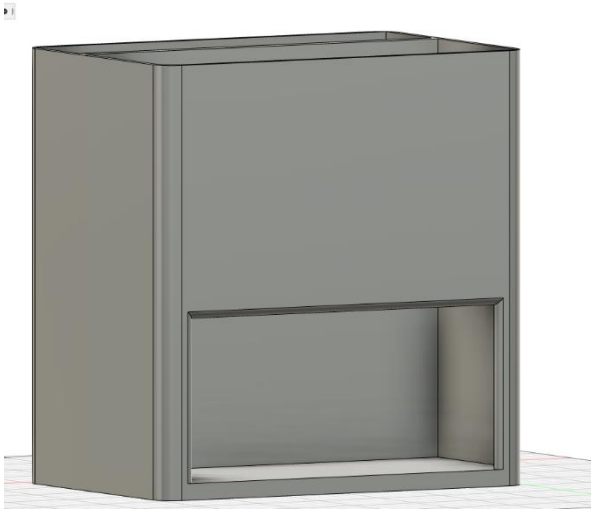
	the ultrasonic sensor needs to have a physical object reflecting the ultrasonic sound waves, or else it cannot gauge the distance to trigger the servo motor properly. Finally, this experiment also revealed that my LED lights were programmable, however, they were not operating as the code intended.	
	In this circuit, I edited the initial design, and amended some of the logical errors I had with the LED lights and the servo motor. The LED lights were able to respond to more thoroughly to the Arduino board, and turned on once the circuit was active, and turned off when there was no power. This experiment also allowed me to fine tune the ultrasonic sensor, where I found 10cm was the optimal range for detecting objects. I also experimented with the range of the servo motor too, in which rotating it at 180 degrees would allow for items to be potentially dispensed more easily.	For this design, I need to develop and improve on the third yellow LED light, as it was constantly blinking, even during the dispensing mode. I have a general foundation for this dispenser; however, I believe that I could be more ambitious and integrate an LCD screen or a sound device as additional output to increase the appeal of the design.

  	This is a cardboard model that I made based on some fusion sketches I did. This model was made so that I could physically visualise the intended dimensions of the project, as well as replicate a mechanism I had in mind. I also created a suitable sized slot for the Arduino and modelled the entire cardboard prototype based on how the Arduino would work if a servo motor were to push linear motion by converting rotational movements into forward-pushing action.	Since I used scrap cardboard materials, the aesthetic look of the design is off-putting, however, I strictly only wanted to see whether the size was suitable, in which it wasn't. I found the design to be too big unfortunately, however, it did have a lot of space for the Arduino. I also found that if I attach the servo motor, and create linear motion, I create a bit too much friction, whereby, the pushing mechanism gets stuck sometimes. I also found that since the prototype could hold up to 28 pieces of candy, the load was too heavy to push with the servo motor.
	In this cardboard prototype experiment, I tested the possibility of using a rotatory-type design that would be operated by a 360-degree stepper motor. The intention of this would be to reduce the load of lollies, however, it would allow for greater accuracy in	One of the main issues with this dispensing design is the spaced required for it to operate. It fits within the parameters, however, I believe the object would still be excessively large. The decreased load on this design would also mean

	dispensing the lollies, and would not jam. Using the decline ramp built into this design, the stepper motor could rotate this wheel that has eight slots, and once one of the slots pass by the gap left at the top of the ramp, the lollies will fall through. I used two-dollar coins to test this experiment, and it did successfully work out.	that the user would be required to refill it more often, unless I made the rotating wheel taller to hold more lollies. I need to do more research with the stepper motor to see if it is strong enough and viable for rotating heavy loads.

Initial concept designs/ideas:

Experiment/ Prototype:	**What is occurring or meant to be occurring?**	**What could be improved on?**
	This is a rough model I had in mind for the lollies to be pushed and fall into the ramp. This was one of the earlier iterations I had in mind, and solely relies on the servo motor pushing the lollies gently down.	The design I felt was too simple, and was very difficult to visualise properly. I felt that I could use this as a foundation for how I would improve my dispensing method, in which I began to explore during the prototyping phase.

	This is a render of my project from one of the designs I came up with, whereby I created the shell for the components, and where the lollies would be stored. This design was built before the prototyping phase, as I intended to use the measurements of the Arduino, and pre-existing designs to construct a chimney/ furnace looking dispenser. The cylindrical object is meant to hold the lollies, and the servo motor is supposed to push the held lollies into the open hole so that it falls out.	I felt that I didn't understand how the dispensing would occur. I liked the theme of the design being a chimney/ furnace, however, I believe that I could have focused on the functionality more. The size of the design also felt very large and box-like, however, the individual components to assemble this dispenser design would be easy to 3-D print/ laser cut.
 	This design was made after I attempted some prototyping, as I tried to make my design look sleeker and more modern. For this design, I focused entirely on how the shell of the design would look, as I am still deciding which method of dispensing would be most suitable for this project. I found an Arduino fusion model that was to scale, and integrated it into the design to assist with the scaling of the shell. I found that the shell felt too big, as it was based off the physical cardboard prototype I made earlier. This iteration of the design is also easy to assembled via laser	The overall design feels boring and uninviting. I feel like the design still occupies an unnecessary amount of space, especially since the Arduino occupies a small portion of the shell. Despite only creating an idea for the shell, I should have considered how I will dispense the lollies more thoroughly, as I am still uncertain how the components will come together at this stage.

	cutting/ 3-D printing, as the shape is very geometric, and does not utilise complicated shapes.	

Applications of conclusions:

Throughout prototyping physical models, creating sketches on tinker cad, and designing potential housing units for the design, I believe that I have gathered a sufficient amount of information to improve my design. I understand that one of the main aspects of my design that I need to improve on, is knowing what the design will achieve, and how I can use more Arduino resources to enhance my current idea. For my final design, I intend to be more ambitious and incorporate an LCD screen, and sound device, so that it's more enticing, while also reducing the overall physical size of the design. I am also going to be following a "team fortress 2 dispenser" themed design, so that my design looks more intriguing and appealing to suit the Halloween themed brief. I will continue to experiment and test between the use of a stepper motor and servo motor, as I believe that these are the most suitable actuators for this design.

References:

Arduino Project Hub. (2018). *Candy Dispenser*. https://create.arduino.cc/projecthub/hadamiera/candy-dispenser-a61a60

Brennan Electric. (2020, July 11). *The Pros and Cons of LED Lights*. https://brennan-electric.com/the-pros-and-cons-of-led-lights/

Electrical terminology. (2021). *Advantages and disadvantages of ultrasonic sensors*. Electricalterminology. http://www.electricalterminology.com/advantages-and-disadvantages-of-ultrasonic-sensors/

Hackster. (2017). *Candy Dispenser with Google Assistant*. Hackster.io. https://www.hackster.io/gatoninja236/candy-dispenser-with-google-assistant-564724

How To Mechatronics. (2022, February 17). *DIY Vending Machine – Arduino based Mechatronics Project*. How to Mechatronics. https://howtomechatronics.com/projects/diy-vending-machine-arduino-based-mechatronics-project/

Instructables. (2021, November 23). *A Simple Arduino Touchless Candy Dispenser*. https://www.instructables.com/A-Simple-Touchless-Candy-Dispenser/

Rf-Wireless World. (2012). *Advantages and Disadvantages of Infrared sensor*. https://www.rfwireless-world.com/Terminology/Advantages-and-Disadvantages-of-Infrared-Sensor.html

Robu. (2017). *What is Servo Motor*. https://robu.in/what-is-servo-motor/

Robu. (2020). *What Is Stepper Motor*. https://robu.in/what-are-the-advantages-disadvantageous-of-the-stepper-motor/

Topshall (Dongguan) Electronics & Technology Co.,Ltd. (2019, February 16). *What Are The Advantages And Disadvantages Of Push On Switch? - News*. Retrieved September 13, 2022, from https://www.topshall-switch.com/news/what-are-the-advantages-and-disadvantages-of-p-21029126.html

Wheeler, T. (2019, October 24). *Automatic Halloween Candy Dispenser for Halloween*. Adafruit Industries - Makers, Hackers, Artists, Designers and Engineers! https://blog.adafruit.com/2019/10/26/automatic-halloween-candy-dispenser-for-halloween/