GNG 1103 – Engineering Design

Project Deliverable E

Project Plan and Cost Estimate

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1.0 Introduction

As the project nears the end of its first ideation phase it is important to start purchasing components and preparing prototypes. This allows the project to be better understood with visual and physical examples. Physical prototypes demonstrated to the client allow the team to receive early feedback which can be used for troubleshooting the design to ensure the next iteration will have solved the issues.

The idea for our prototype is having two different modules, one containing the Arduino attached to the side of the drone and connected to the main computer. The temperature sensors are in another module close to the cardboard container which is connected by wires passing through the locking mechanism and the 10mm hole.

In this document the bill of materials is presented with explanations, prices, and sources for each. In addition, a detailed task list is shown that outlines all the project tasks and deadlines for the rest of the semester.

2.0 Design: Project Task Plan

2.1 Detailed Design

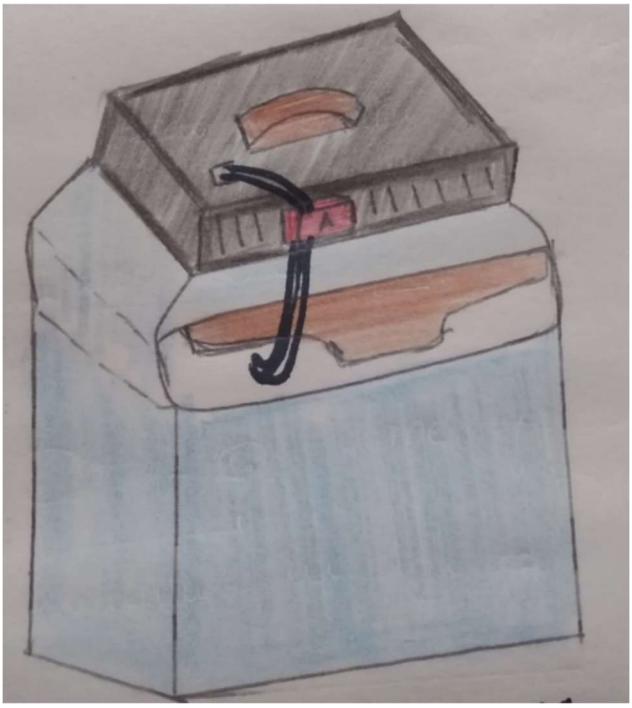


Figure 1 Side View of Arduino Module Clipped to the Side of the Drone

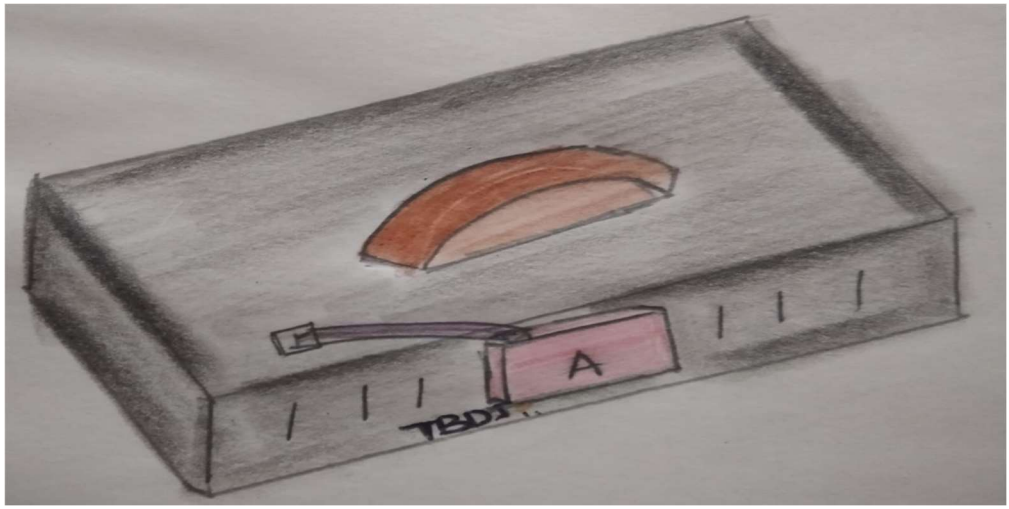


Figure 2 Zoomed-in view of the main module of the Climate Sensor, with its power, and serial connections.

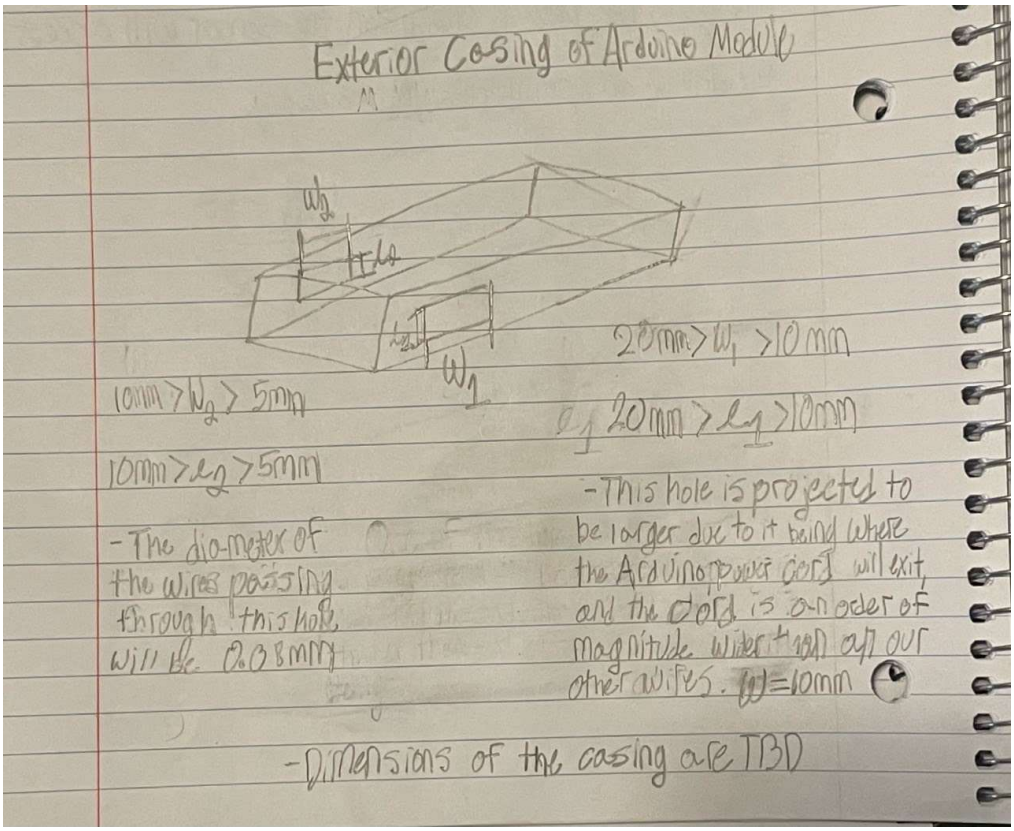


Figure 3 Description of the casing of the main module, and description of the holes for the wires to leave.

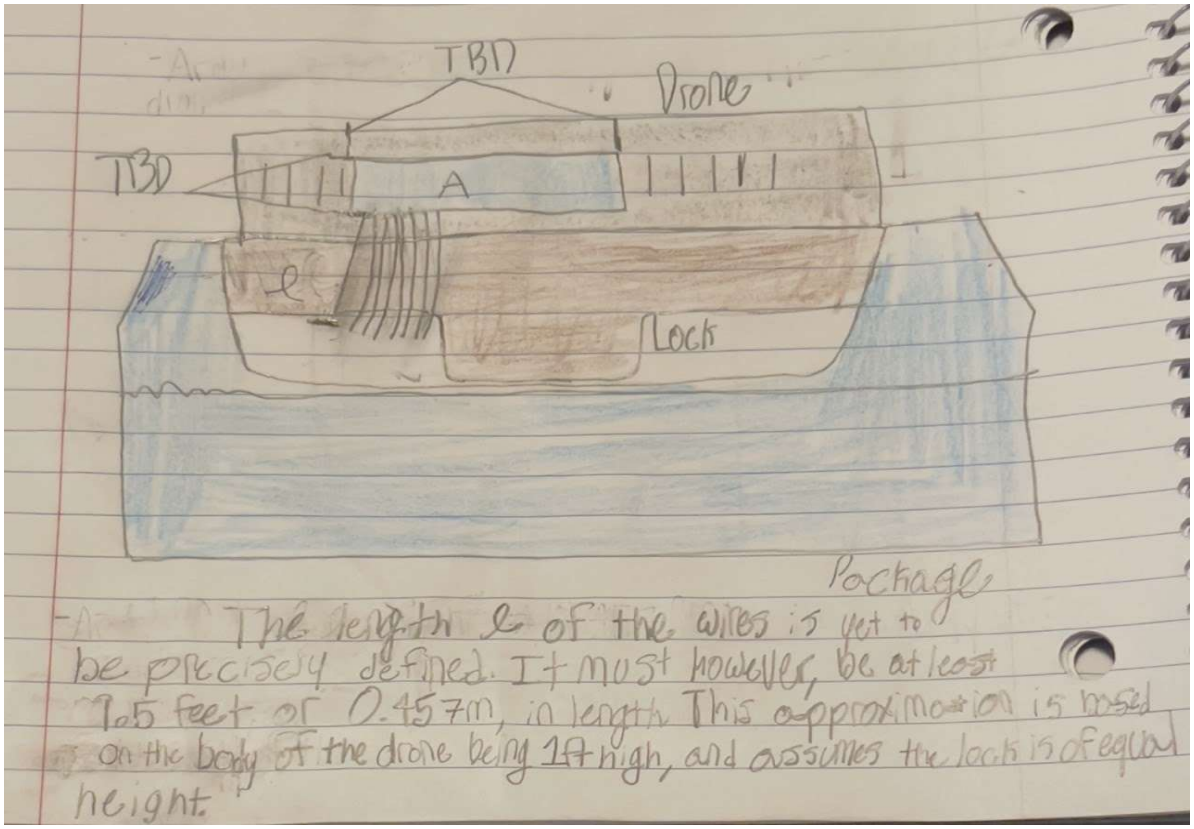


Figure 4 2D side view of the module attached to the drone.

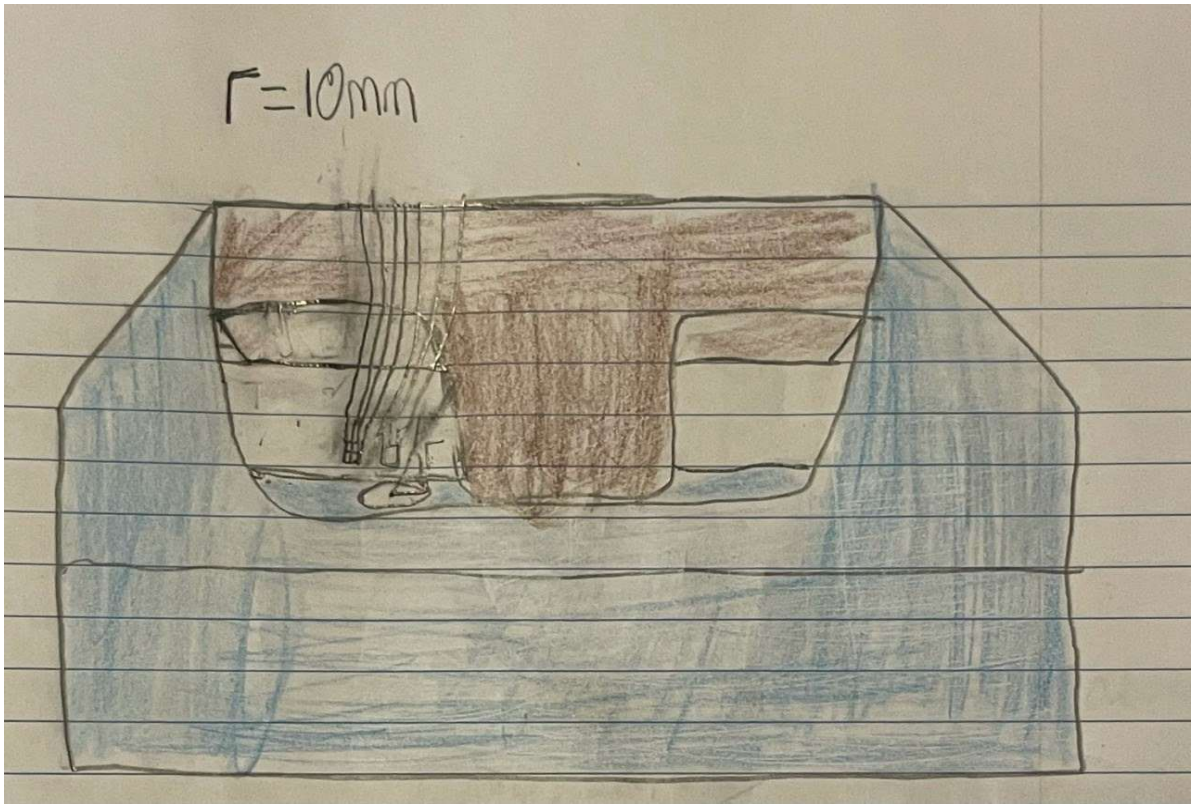


Figure 5 View under the locking mechanism of the main two component thermometers, ready to pass through the 10mm wide hole to measure temperature in the package.

2.2 Concept Design Description

The concept is split into two main functional sub-systems—the Arduino module and the sensor module. The Arduino module is a 3D-printed case that contains the Arduino connected to the power supply, the raspberry Pi via serial communication and the breadboard. The breadboard contains the circuit wires and resistors for the sensor components. The output wires are fed through an output hole that acts as through wire to the second module. The second module, another 3D-printed case, houses both temperature sensors secured to the case, with holes for both the input wires and for the sensors to have unimpeded access to the surroundings in the box. In essence the group's chosen concept design combines proximity to the Raspberry Pi and proximity to the package of food. In figure 2, the main body of the module, containing the Arduino Uno board, is tied to the side of the drone using zip-ties, keeping it close to the Pi for serial communication. The temperature sensors are situated just above a 10mm hole in the package, as shown in figure 5, allowing for an accurate measurement of the climate inside the package. This allows the module to be close to the body of the drone, where the power and serial communication are connected, and at the same time be close to the package that the climate sensor is tracking, as the wholesale view in figure 1 demonstrates.

2.3 Planning

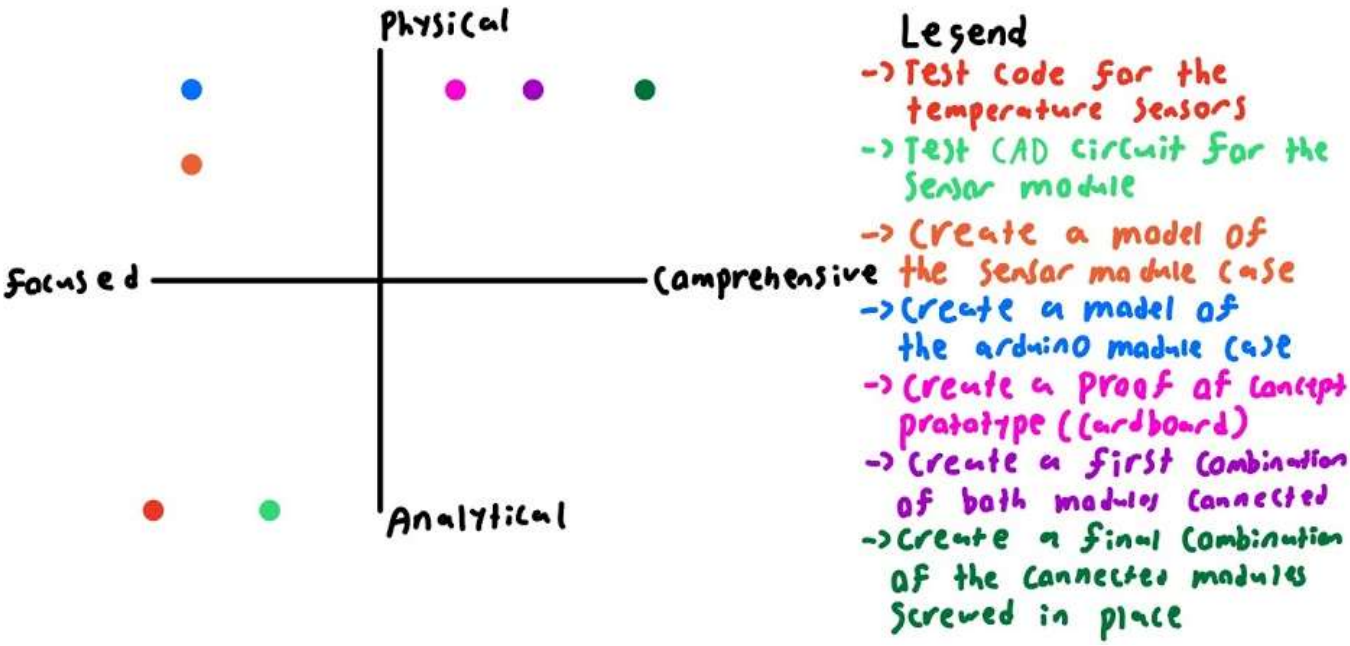


Figure 6 Relative classifications of different prototyping phases

Table 1: Prototyping task plan

Test ID + Member Responsible	**Test Objective**	**Description of Prototype and Testing Method**	**Description of Recorded Results and How They Will be Used**	**Estimated task Duration, Dependencies, and Planned Start Date**
1 Noah	Ensure the code used with the DHT22 is compatible with the library i.e., the code compiles. Also test that the data received can be formatted and sent as an average to the central computer.	Using the Arduino ide, and the external GitHub library, we will test if the code compiles using the DHT22. (requires data from the DHT22).	The results will be recorded using the DHT22 and the completed initial circuit prototype. They will be used to make sure we can even collect the data in the first place and compile it into an average list to be sent to the central computer.	Start date: March 1, 2021. Duration: 4 days Dependency: Stands alone; however, it should be done in parallel with the code for the TMP36, and must be done by March 4th, 2021, so it can be formatted into the deliverable.
2 Rakshita	Test code for the TMP36. The goal of this test is to make certain the code will compile with a CAD circuit using readings taken from a simplified CAD version of our sensor module.	The code is written out of the Arduino IDE using the default Arduino compatible functions. The code will be tested through a circuit made on Tinker CAD as a proof-of-concept code.	The recorded results, provided they work, will ensure the logic used in our code is suitable for the temperature and humidity readings needed. This code can be used for the TMP36 in future prototypes but is mostly done to ensure the logic is sound and functional.	Start date: March 1, 2021. Duration: 4 days Dependency: Done in parallel with the DSHT22 code and must be done by March 4th, 2021, so it can be tested.
3 Riley	Make sure the circuit framework for the TMP36 is functional. The amount of	The circuit will be done as a CAD model using Tinker CAD. It will use two TMP36 modules, one for	The results provided the code runs in tandem with the circuit will then be implemented as a	Start date: March 1, 2021. Duration: 4 days Dependency: Must be done in parallel with the

	resistance and power being sent in must be tested and regulated to ensure the components do not get fried.	the sensor itself and the other as a substitute for the DHT22. They take the same power and require the same resistance, so the circuit test is to ensure it is wired correctly and that the components are functional and safe.	proof-of-concept prototype in future prototypes. Knowing the code runs with the circuit means as long we have a contingency plan and a base if the placement of the wires do not work out i.e. there is too much tension from being too compact.	TMP36 code and finished by March 4th, 2021, so it can be tested.
4 Lucas	Make sure the case design fits the Arduino, breadboard, and wires. This test is simply to ensure the case design will fit the electronic components along with holes suitable for the power supply, the serial connection, and the through wires connecting the sensor module.	The prototype will be done in On Shape with a high care for the dimensions meeting the required dimensions of the Arduino and the combined height of the Arduino, breadboard, and space taken up by the wires. This can be tested by including a scaled model of the Arduino dimensions, the breadboard, and the wires in On Shape. This can be tested in tandem with the cardboard prototype.	The results of relative measurements obtained from the cardboard prototype can be used as a base criteria for the CAD model of the case. The CAD model must be able to match with the dimensions proven to be functional. This CAD model will be used as a base model for the future design including the dimensions necessary for the screw points of attachment.	Start date: March 1, 2021. Duration: 4 days Dependency: Must be done in parallel with the sensor case CAD design. Must be completed by March 4th, 2021, so it can be formatted into the deliverable.
5 Riley	Ensure the dimensions of the case covering fit all	This prototype is simply a cardboard cut-out of our case design and wire	The results of this test are simply that of finding base dimensions	Start date: March 1, 2021. Duration: 2 day

	the necessary components- Arduino, breadboard, and wires. Ensure the idea of the through wire is feasible and the components can be connected.	connection design concept. The test method will be to take an Arduino or Arduino sized object and wires or wires shaped objects and see if the case covering fits the electronics.	of the Arduino case, and to see if the idea of the connection wires is feasible. The results of this test will be used in the CAD models and future physical prototypes of our case designs as base dimensions needed for the design.	Dependency: Predecessor to the CAD models. (Milestone)
6 Timi	Ensure the sensors are supported and have sufficient exposure to the inside of the box. The goal of this prototype is to ensure the case supports the sensors and has holes large enough for input wires and adequate exposure to the atmosphere of the box	This prototype will be another CAD model using On Shape and will be made as a case design that will be able to the dimensions of the sensors and have enough room for screws to be screwed into the body of the drone box.	The results from this test are the based dimensions of a first case design that will fit the sensors, including that of the body and the hole required for the head of the sensors. The results will be used as a baseline that we know will work and can then be adjusted as fit to meet the crew dimension requirements on the drone.	Start date: March 1, 2021. Duration: 4 days Dependency: Successor to the Carboard prototype. This will be done in parallel with the Arduino module CAD design.
7 Lucas	Ensure the through wire is long enough to connect the two modules together and is stable enough. This test also aims to make certain the data	This will be a physical prototype that will use the CAD models created previously along with the necessary sensors and wires. The test will be conducted by fitting the	The results for this test will be a series of Booleans. Does power reach both modules? Does the data taken from the sensor reach the Arduino? Is the	Start date: March 8, 2021. Estimated Duration: 6 days Dependency: Successor to all CAD models completed, TMP36 code completed, and

	obtained from the sensors will be transmitted properly to the Arduino module.	electronics and wires in the Arduino module, filtering the connecting wires down to the sensor module fit in its case and finally running the code made specifically for the TMP36 and seeing if the data reaches the Arduino.	through wire supported enough to keep both modules connected? The answers to these questions will allow for more engineering analysis to be conducted on the structural integrity of the connection of modules. It will also allow for a rework of the code if needed or case design.	most if not, all parts arrived from the mail. (Milestone)
8 Timi	Ensure the points of attachment to the drone are functional with a modified sensor case design. The screw holes must be inline with the size of screws outlined by the hardware list, and to the case dimensions must reflect where it can be attached.	This model will build upon or reinvent the earlier On Shape CAD model. The testing method will be to print out the model with the new outer dimensions and test it upon a replica of the drone bottom with the screw hole placements.	The results of this test will allow us to know if the dimensions of the case are perfectly fit for the design. If the dimensions are fit for the design, it can then be brought into the final model prototype.	Start date: March 8, 2021. Duration: 4 days Dependency: Successor to Prototype 1 of the CAD sensor module.
9 Lucas	Ensure the connection of the two cases is perfectly supported, all dimensions are optimal, the material for the	This model is the final prototype. It will be made using all the sensors connected to the circuit model, the case designs created, connected,	This is the final product created through the combination of previous prototypes. The results of this	Start date: March 15, 2021. Duration: 8 days Dependency: Successor to all 2nd phase CAD models completed, all

	case modules is functional, the wires are supported, and everything is fixed and plugged into the drone.	and fixed to the drone, the wires bundled and fixed through the indicated drone hole, and the Arduino module connected to the power supply with a converter and to the raspberry Pi using Rx and Tx pins.	prototype should be market ready.	2nd phase code is functional and optimized, and the 2nd phase physical prototype had been completed. (Milestone)

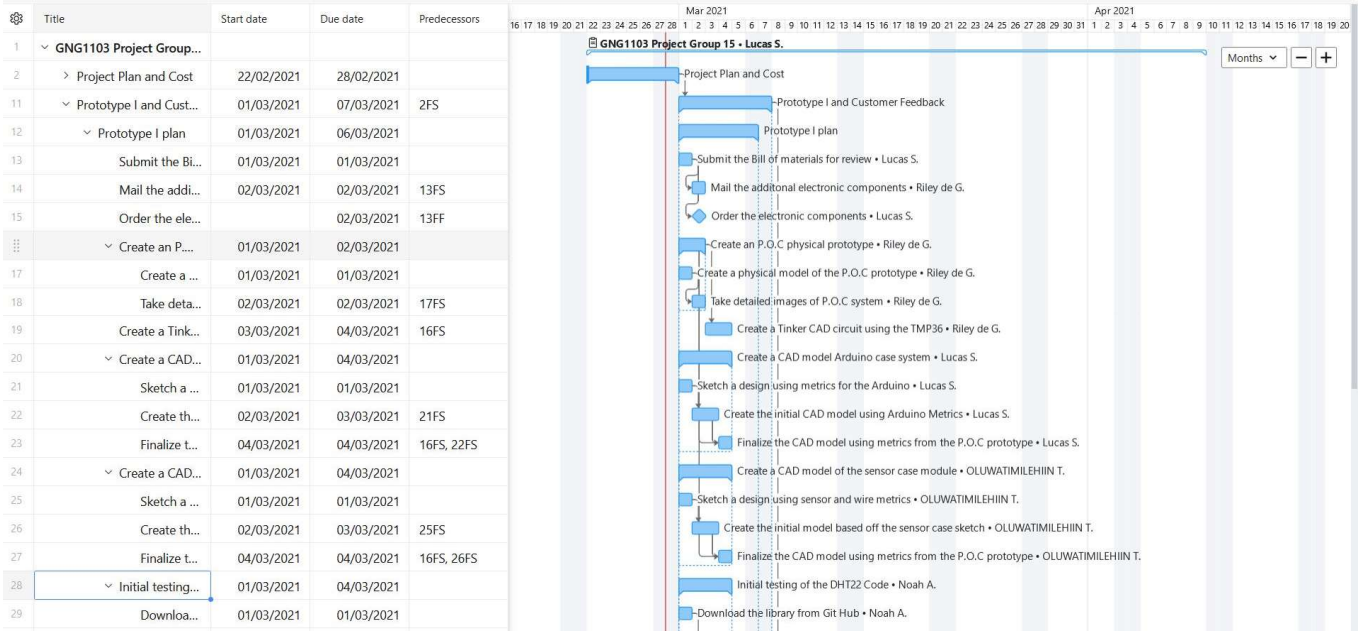
Table 2: Additional Tasks for the prototyping task Plan:

Task List	**Member Responsible**	**Description**	**Estimated Task duration**	**Dependencies**	**Uncertainties**
Order/the circuit components	Lucas	Order the TMP36, the converter, the power jack, and the cables.	Date of order: March 2nd, 2021 Estimated shipping times: 1-2 weeks.	Bill of materials must be completed and submitted for review before any parts are ordered.	Shipping times can fluctuate and could be longer due to COVID-19
3D - Print the case prototypes	Lucas	Print the CAD models into physical prototypes of the case designs.	Start date: March 10th, 2021. (Milestone)	These models can only be printed once both initial CAD models have been completed.	If Lucas cannot make it down to the makerspace to print the materials. This responsibility shifts to Noah as a backup.
Mail the additional circuit components	Riley	Mail the breadboard, the wires and the DHT22 to Lucas or Noah	Start date: March 3rd , 2021. Estimated shipping time 1-2 weeks	This depends on the availability of stock, as well as the bill of materials completed and submitted.	Barrie is going into the grey zone of lockdown, so it remains uncertain whether Riley can locally pick

					up the components. If not, then the components will have to be bought from another retailer or shipped from Simcoe.

3.0 Project Planning and Initial Task Assignment

[Wrike Snapshot taken February 28, 2021]



	Title	Start date	Due date	Predecessors
1	GNG1103 Project Group...			
2	Project Plan and Cost	22/02/2021	28/02/2021	
11	Prototype I and Cust...	01/03/2021	07/03/2021	2FS
12	Prototype I plan	01/03/2021	06/03/2021	
13	Submit the Bi...	01/03/2021	01/03/2021	
14	Mail the addi...	02/03/2021	02/03/2021	13FS
15	Order the ele...		02/03/2021	13FF
	Create an P....	01/03/2021	02/03/2021	
17	Create a ...	01/03/2021	01/03/2021	
18	Take deta...	02/03/2021	02/03/2021	17FS
19	Create a Tink...	03/03/2021	04/03/2021	16FS
20	Create a CAD...	01/03/2021	04/03/2021	
21	Sketch a ...	01/03/2021	01/03/2021	
22	Create th...	02/03/2021	03/03/2021	21FS
23	Finalize t...	04/03/2021	04/03/2021	16FS, 22FS
24	Create a CAD...	01/03/2021	04/03/2021	
25	Sketch a ...	01/03/2021	01/03/2021	
26	Create th...	02/03/2021	03/03/2021	25FS
27	Finalize t...	04/03/2021	04/03/2021	16FS, 26FS
28	Initial testing...	01/03/2021	04/03/2021	
29	Downloa...	01/03/2021	01/03/2021	

Figure 7 Gantt chart for prototyping 1 phase with most tasks, and dependent subtasks.

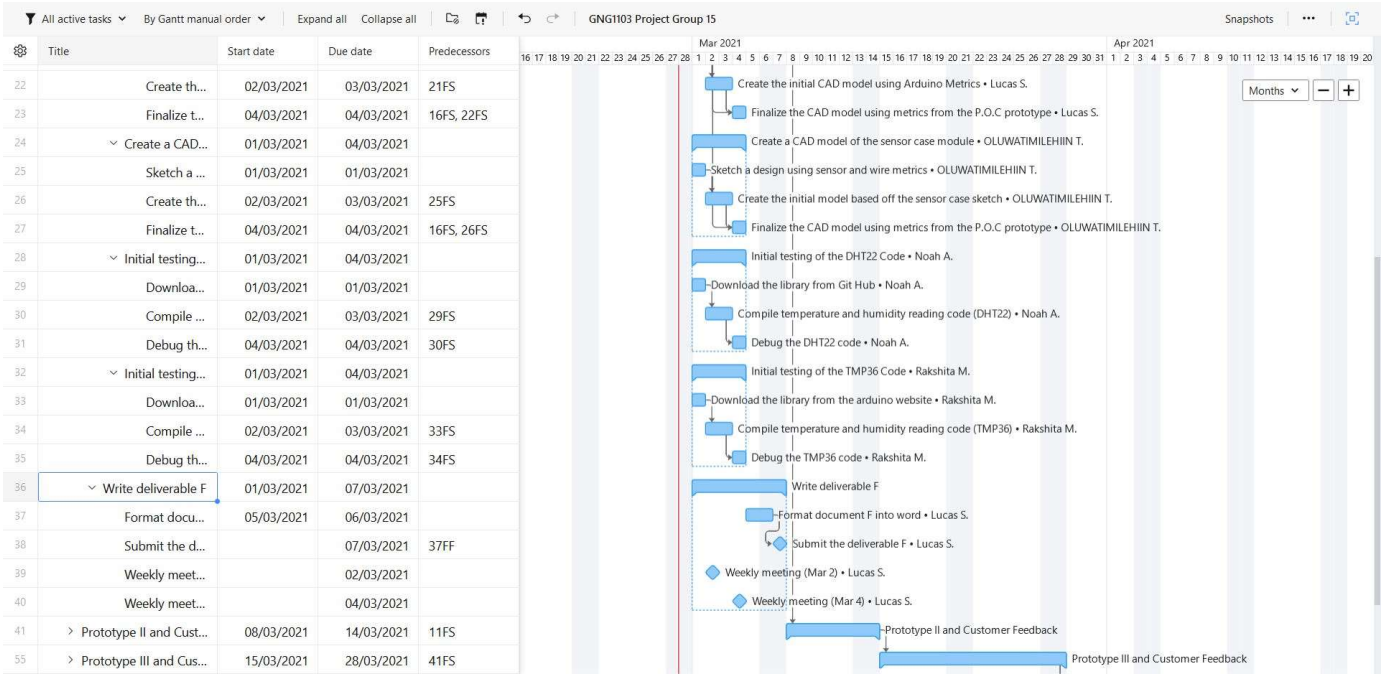


Figure 8 Continued Gantt chart for prototyping 1 phase.

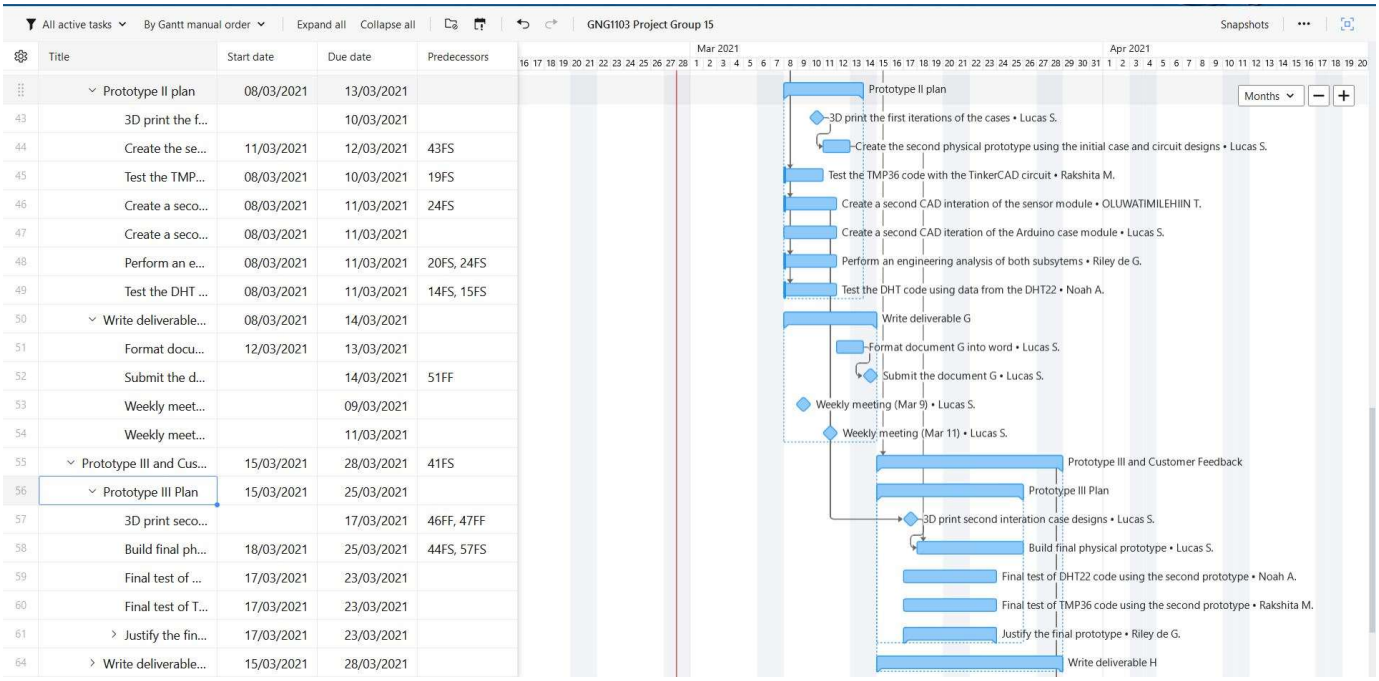


Figure 9 Gantt chart of main tasks for prototyping phases 2 & 3. Note the dates are longer for prototyping phase 3 in order to remain realistic with exam studying.

4.0 Economics: Project Costs and Component/Tool Selection

Table 3: Bill of Materials for all Parts Required for Overall Design

Component	Price ($CAD)	Source	Reasoning	Product already owned	Links
DHT22	5.94	Simcoe DIY (Free shipping / Riley can pick up in store)	Benchmarked against other sensors, DHT22 is cheapest, most accurate and measures temperature and humidity	✗	Link
DHT22 Software	0	Arduino IDE	Needed to run sensor	✓	Link
TMP36	2.18	Digi Key	Additional high accuracy, inexpensive temperature sensor for averaging values	✗	Link
TMP36 Software	0	Isaacr100	Needed to run sensor	✓	Link
Voltage Converter	8.00	Digi Key	Needed to convert power supply from 44.4V to 5V	✗	Link
Wires	3.78	Simcoe DIY (Free shipping / Riley can pick up in store)	Needed for through wire, cheapest option	✗	Link
M3 Bolts x10	2.33	Robot shop	Needed for fixing, size specified by JAMZ, cheap and reliable source	✗	Link
Breadboard	2.23	Simcoe DIY (Free shipping / Riley can pick up in store)	Small enough to fit in case and inexpensive, has enough pins	✓	Link
Arduino Uno	8.67	Simcoe DIY (Free shipping / Riley can pick up in store)	Cheapest available and from same source as other parts to save shipping	✓	Link

Electrical Tape	1.24	Amazon.ca	Needed to cover soldered connections for water proofing and to prevent short circuiting		Link
Flux and Solder Wire	N/A	Maker Space	Needed for soldering connections between sensors and through wires		N/A
3D Printed Case	N/A	Maker Space	Needed for housing Arduino and breadboard		N/A
USB Type A/B Arduino Cable	1.48	Prime Cables	Needed for uploading code to Arduino		Link
Soldering Iron	N/A	Maker Space	Needed for soldering connections		N/A
Multimeter	N/A	Maker Space	Needed for testing circuits		N/A
Drill and Bits	N/A	Maker Space	Needed for drilling holes and attaching screws		N/A
Alternative to Voltage Converter					
DC Power Jack to 9V	3.12	Simcoe DIY	Attaches 9V battery to Arduino		Link
9V Battery	2.78	Amazon.ca	Alternate power supply if voltage converter fails		Link
Total	$28.13	-	-	-	-

5.0 Conclusion

After discussing as a group each other's interests, abilities and experience, an equal weight of specific tasks were assigned to each member. These tasks included dependencies and deadlines to guarantee that all milestones were met on time. If this task plan is followed correctly the group should be able to present 6 analytical prototypes and 3 physical prototypes, of which one is the final product, to the JAMZ before the end of the semester.

Using the decisions for components made in previous deliverables with a selection matrix and design criteria, a bill of materials was created. Items were chosen based on shipping time, reliability of vendor and price, with price being the main concern with a budget as small as $50.

The next step in the design process for the group will be to start doing hands-on work with modeling, circuits, and code for prototype design. It is important to create a product that not only fulfills the customer's needs but goes above and beyond. If many prototypes are constructed and receive feedback from the customer, it can be made certain that they are happy with the product. Prototyping also helps highlight real-world issues that may not have been clear during the conceptual design phase and these can be solved before the construction of the final product.

6.0 References

2 Pcs Male DC Power Jack to 9V Battery Clip. (n.d.). Simcoe Diy Elect. Retrieved February 26, 2021, from https://www.simcoe-diy.ca/product-page/2-pcs-male-dc-power-jack-to-9v-battery-clip

3M Temflex General Use Vinyl Electrical Tape, 7 mil, 3/4" x 60', 1 Roll per Pack—TEMFLEX-3/4X60: Amazon.ca: Industrial & Scientific. (n.d.). Retrieved February 26, 2021, from https://www.amazon.ca/3M-Temflex-General-Vinyl-Electrical/dp/B003DXV9HY/ref=sr_1_5?dchild=1&keywords=electrical+tape&qid=1614287940&sr=8-5

10 Meters/roll 30AWG Flexible Silicone Rubber Wire with Tinned Copper line. (n.d.). Simcoe Diy Elect. Retrieved February 26, 2021, from https://www.simcoe-diy.ca/product-page/10-meters-roll-30awg-flexible-silicone-rubber-wire-with-tinned-copper-line

170 Tie-point Prototype Solderless PCB Breadboard. (n.d.). Simcoe Diy Elect. Retrieved February 26, 2021, from https://www.simcoe-diy.ca/product-page/170-tie-point-prototype-solderless-pcb-breadboard

Arduino Uno R3 Board. (n.d.). Simcoe Diy Elect. Retrieved February 26, 2021, from https://www.simcoe-diy.ca/product-page/arduino-uno

BlueDot Trading Heavy Duty 9 Volt Battery, Single battery: Amazon.ca: Health & Personal Care. (n.d.). Retrieved February 26, 2021, from https://www.amazon.ca/BlueDot-Trading-Battery-Single-battery/dp/B00MGLBWZI/ref=sr_1_8?dchild=1&keywords=9v+battery&qid=1614289897&sr=8-8

DHT sensor library—Arduino Reference. (n.d.). Retrieved February 26, 2021, from https://www.arduino.cc/reference/en/libraries/dht-sensor-library/

DHT22 AM2302 Digital Temperature and Humidity Sensor. (n.d.). Simcoe Diy Elect. Retrieved February 26, 2021, from https://www.simcoe-diy.ca/product-page/dht22-am2302-digital-temperature-and-humidity-sensor

High Quality USB 2.0 A Male to B Male 28/24AWG Cable—PrimeCables®. (n.d.). Retrieved February 26, 2021, from https://www.primecables.ca/p-315372-at-usb2-ambm-all-high-quality-usb-20-a-male-to-b-male-2824awg-cable-primecables?from_pla=google&sku=315372&gclid=Cj0KCQiAst2BBhDJARIsAGo2ldVxiUtgmcdgPyyGwYrFR4KSFpPylbmeJhQuAbU5uf8v4heL8FmNdacaAnyMEALw_wcB#sku315372

Industries, A. (n.d.). *TMP36—Analog Temperature sensor*. Retrieved February 26, 2021, from https://www.adafruit.com/product/165

Isaac. (2021). *Isaacr100/TMP36* [C++]. https://github.com/Isaacr100/TMP36 (Original work published 2017)

LM2594HVN-5.0/NOPB Texas Instruments | Integrated Circuits (ICs) | DigiKey. (n.d.). Retrieved February 26, 2021, from https://www.digikey.ca/en/products/detail/texas-instruments/LM2594HVN-5.0%2FNOPB/363688?utm_adgroup=Texas%20Instruments&utm_source=google&utm_medium=cpc&utm_campaign=Smart%20Shopping_Supplier_Texas%20Instruments&utm_term=&productid=363688&gclid=Cj0KCQiAst2BBhDJARIsAGo2ldVbFiDBVnq3GjMnGFIeCyQuCPKyzuivtYi3r9p9n0PwwNlpsGT51eIaAiW8EALw_wcB

Lynxmotion Steel Phillips Countersunk Screws—M3 x 8mm (10pk). (n.d.). Retrieved February 26, 2021, from https://www.robotshop.com/ca/en/lynxmotion-steel-phillips-countersunk-screws---m3-x-8mm-10pk.html