C2.2 Project Deliverable C:

Detailed Design and Bill of Materials

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C.1 - Detailed Design

1 - Introduction:

The purpose of this project deliverable C is to provide a detailed design of the chosen concept from project deliverable B. Additionally, it aims to give a more detailed design of all the chosen subsystems and a logical approach as to how the concept and its subsystems can be easily recreated by an individual with less experience. This deliverable will also serve as an assessment of our team's collective skills and experience in addition to our time management. Any critical product assumptions that may affect our team's ability to create this product will be defined as well. Finally, a bill of materials will also be created that will outline all the materials needed and their respective costs.

2 - Client feedback:

Following the second client meeting, we received a substantial amount of information and insightful feedback that has now allowed us as group to move forward with a variety of our ideas and concepts.

Concept Feedback:

When it came to the locomotion of our robotic arm, it was clear to us that tracks were the best fit for our client's needs. As understood, tracks will work best as they are simple to move/use and mobile enough to move freely around their home with ease. Through further suggestions and impressions, it was also noted that our clients liked the ideas of our dual gear claw hand along with our app interface / controller design.

Reminders / Additional Information:

Through questionnaire, the client also re-informed us the importance of being able to pick-up and hold certain items. These included her plastic bottle/cup and plastic Tupperware (referred to as cookie jar). See below measurements made after the client meeting:

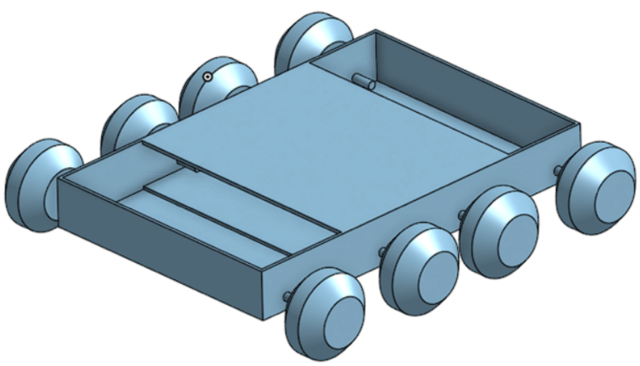
	Plastic Tupperware	Plastic Water Cup / Bottle
Weight	Tupperware without cover ≈44g Tupperware with cover ≈ 77g	Filled with water ≈ 566g Without Water ≈ 66g

Measurements	Width ≈ 6” Length ≈ 8” Height ≈ 2”	Top Diameter (Cap) ≈ 4” Bottom diameter ≈ 2” Height ≈ 5 ½”

3 - Detailed design of the concept:

3.1 Physical prototypes

3.1.1 Method of Locomotion



Note: Motors and batteries are not fitted in this concept drawing, wheels depicted are not representative of the actual sprockets.

The main platform that the arm will sit on will be constructed of a stainless-steel or an Aluminum sheet using a punch press or a laser cutter to cut the sheet to size and create any of the holes on the platform sides. Then it will be transformed into a box using a press brake, bending it on all four sides at a 90-degree angle. The top cover of the platform will wrap around the platform (Being bent using a press brake) and be secured by using 4 screws with two on each side.

Two motors will be mounted in the rear of the box (It will be screwed to the rest of the platform through holes made by the punch), where it will power the rear sprocket wheels. Both the sprocket and idler wheels will be made of plastic.

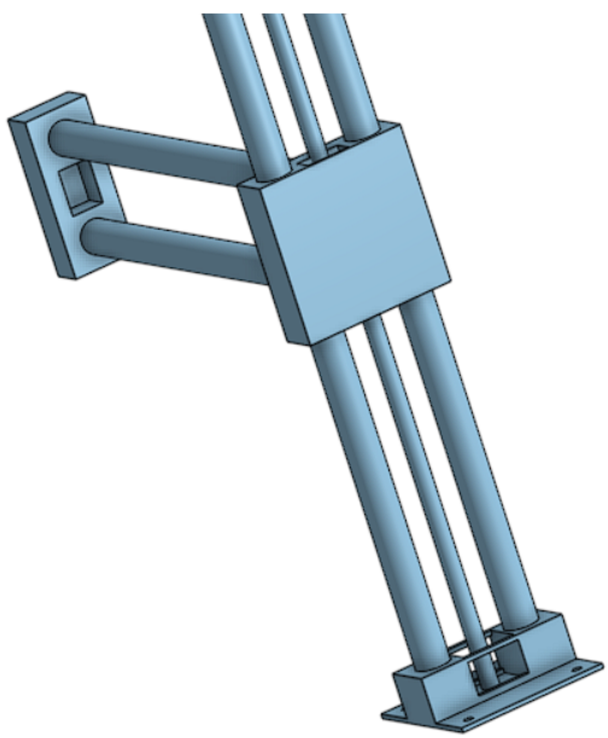
Initially, this platform will only use four total wheels. The two sprockets in the rear connected to the motors, and the two idler wheels in the front. As mentioned before, mounting holes on the motor will allow it to be mounted to the platform itself. The sprocket wheels will then be fastened to the motor by a center-lock hex bolt. The front mounted idler wheels will be mounted in a similar fashion to the sprocket wheels by using a hex bolt and two hex nuts. The Sprocket and Idler wheels can be made of sheet metal, where two plates can be secured together using hex nuts and a threaded rod.

The sprockets and idler wheels will be made of sheet metal and 4 bolts and nuts. It will involve two plates fastened together to create the wheel.

Inside the box will be a battery and the Arduino that will be mounted in the front of the vehicle. It will have wires that will connect to the motors to power and control them.

3.1.2 Method of Arm Motion

Linear Actuator:



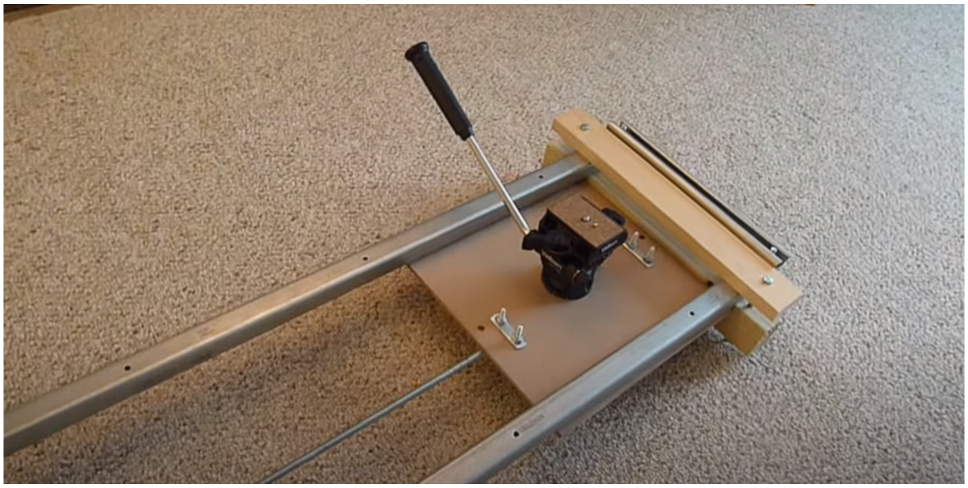


Image obtained from: [Camera Dolly from RigWheels with motorized threaded rod system]

This represents a similar concept to what our team plans to implement regarding the movement of both axes for the arm.

Method of moving the arm up and down:

Based upon feedback received during the design review, our team has decided to change the approach from using the belt/gear system to a motorized 3/8 in diameter 16 TPI threaded rod system. This will simplify the production and procurement process while still being an effective method of movement for the arm.

On both axes between the support beams, there will be a threaded rod. A motor will be placed at the base of the arm and will turn the threaded rod, which in turn will move the nut up or down. To cut costs, our team will attempt to obtain them by looking around to see if we may have any existing examples, rather than purchasing them outright. There will also be two PVC pipes where the threaded rod will be located in between them.

Method of moving the arm forwards and backwards:

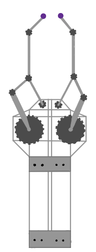
The method of moving the arm forwards and backwards will work in the exact method as described as above. A hex nut on a threaded rod and two PVC pipes will be attached to a 3D printed base plate and the threaded rod will move the actual claw (mounted to the base plate) through the motor that will turn the threaded rod.

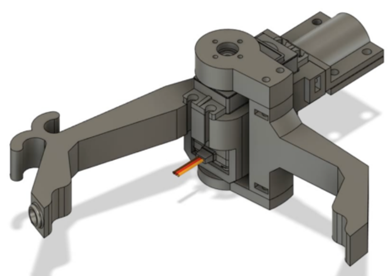
Propulsion:

The propulsion system that we plan on utilising will consist of two stepper motors. Where one will be used to turn the threaded rod in the up and down direction, and one used in the forward and backward direction. The stepper motor will be bolted to the base of the arm where it will be out of the way of the payload of the arm. The second motor will be mounted to the axis of the forward/backward direction, allowing it to move up and down with the rest of the arm.

3.1.3 Hand Mechanism

The main idea of our hand design was to originally use a dual gear concept (see on left) however after recent presentations and deliberation between the team we found a similar, simplified option (see on right).





GNG2101-C3p2-Power Grabber-EH
https://makerepo.com/ZitaiPeng/1140.gng2101c3p2power-grabbereh

The idea of our newer hand design follows closely a team's work from last semester (see reference below). Instead of having forceps that would both open and close in unison; only one finger will open and close. Hence because of this we will only use a single servo motor which will easily move one finger whilst the other stays in a stagnant position.

The servo motor and its wiring will be connected to the Arduino (see below in 3.2 for further explanation).

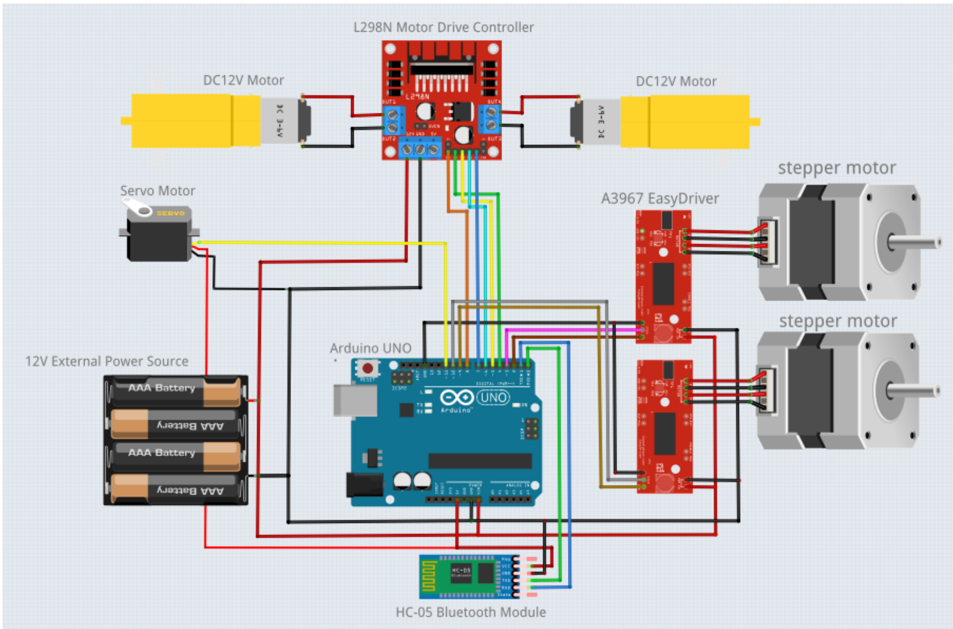
The hand itself will be slotted and bolted onto a plate which will be connected securely into the arm mechanism which can be seen above. It is also important to note that we may need to add a additional extension pole to the hand as it may prevent items from hitting / banging into the

We plan to reach out to the team members regarding their full CAD design as well as the physical design to see what we can both extract and possibly add into our own version of the hand. On top of this we plan to 3D print any remaining parts or additions we feel will benefit our design of the robotic arm.

3.2 Software prototypes

3.2.1 Controller

Microcontroller (Basic concept of Arduino) for robotic arm motion



The Initial Arduino Circuit Design Using "Fritzing"

Microcontrollers are used by servo motors to control the precision and angular position. An Arduino, a single- board microcontroller that can be tailored to the needs of the application, is one example. It is made for an Atmel AVR CPU and has USB power connectors and on-board Io structures.

The Arduino UNO is chosen for the project, because it is easy to use from the coding aspect, and it have many examples as well as library online which can support our tasks. Since many motors are needed for the design, multiple external power supplies are required. The Arduino only output the control signal and support the servo motor and Bluetooth module. The Bluetooth module will be used to build the connection between the phone application and the controller board.

3.2.2 App Interface

Initial Web-App release

The initial release of the app interface will be uploaded through *GitHub* as a live page. It will be built using html, for the main structure of the app and for the general layout. As well as CSS, to improve the visual appearance of the project. The utilization of CSS allows for a high degree of customisation and flexibility in terms of presentation, making it the ideal choice for enhancing the overall aesthetic. We will be utilizing JavaScript for the main functionality of the buttons, to ensure that the robot performs as intended.

App development

The main app that will be built using **ReactJS** because of its efficiency and flexibility in app development. React is one of the greatest front-end development technologies, which will allow for an appealing and user-friendly product.

4 - Skills and Resources:

In general, our team provides a wide range of various skills and experience that involve the major topics of this project. We believe that we are proficient in the mechanical, electrical and software aspects of this project.

- Ashan, Kyle, and Shark have experience in the mechanical side of things, which will prove useful in the design and production of the locomotive and arm elements of the project.
- Jiadong is in the Electrical Engineering program so he can deal with electronic parts and connections with knowledge learned in class. It could be helpful in the design and construction of controller parts for the project.
- Since Michael is in the Software Engineering program, he has some experience with programming languages, which will facilitate the process of creating an interactive app.

5 - Time Assessment:

Our group will manage our time effectively and efficiently. We conduct a variety of activities such as discussing the project & giving each other feedback frequently in our discord project group. For instance, talking about how we can build a prototype which will satisfy our client and introducing innovative designs & specifications.

Listed below are a few specific time assessments for the project and its various aspects:

- Building the electronic connection and coding the Arduino board will take about 2 weeks, including the self-study period.

- Constructing the locomotive portion of the arm will take a week and will begin during reading week. This entails will include the chassis and all mounting holes for the wheels, motors, and batteries.
- Constructing the arm and claw mechanism will also take place within same week of the locomotive portion. However, the arm and claw mechanism will continue its development through the following week.
- The coding portion of the project in already in active development and will continue to be developed and tested alongside the other systems.
- Initially we have targeted to finish building our physical prototype before the second in –class presentation. If not, we are optimistic about finishing our whole physical before the design day.

6 - Critical Product Assumptions:

Our team has recognized some factors which can affect our ability to make this product. They are:

Torque limitations of the motor:

Real- world applications place a variety of limitations on our stepper motor that might have a negative effect on ultimate performance in terms of power-to-weight ratio and torque density (torque- carrying capability of mechanical component). We are concerned that our stepper motor might fail since it may not have enough torque to be able to effectively lift the arm and its payload.

Concern about the flexibility of the robotic arm:

The robotic arm movement will be affected by different loads. Which may result in changing the robotic arm's centre of mass and the moment of inertia. The change in moment of inertia can cause change in angular momentum which may change the product's centre of mass. Frequent changes in inertia and centre of mass can lead the robotic arm to potentially tip over and damage itself and its payload.

<u>Programming difficulties:</u>

Programming a robot requires an understanding of the physical limits and capabilities of the robot. The code must go together with the robot's design and function. As we are mostly second year students, we might find difficulty in coding for a complex project such as this robotic arm.

<u>Power insufficiency for motors and controllers:</u>

Powering up several motors is a challenge which requires multiple external power sources. Especially, the stepper motors will likely require higher voltage, so that they can support the heavy function of lifting and stretching. The total voltage requirement needs to be calculated accurately and verified with simple connection tests.

7 - Bill of Materials:

Extensive list of products and cost:

Item Name	Description	Unit of Measure	Quantity	Unit Cost (CAD)
Arduino	The microcontroller used for controlling the arm.	N/A	1	$0.00 - Using one we already have
12V DC Motor From Amazon	Used for moving the tracks.	Volts	2	$16.98
½" 10ft PVC Pipe	Used as the sliding mechanism for the arm axis.	ft	1	$0.00 - Already have
L298N Motor Drive Controller - Amazon	Drive DC motors.	N/A	1	$11.99
HC-05 Bluetooth Module - Amazon	Connect the board to the mobile phone.	N/A	1	$10.91
A3967 EasyDriver - Amazon	Drive the stepper motors.	N/A	2	$3.90
Stepper motor	Used to drive the axis of the arm.	Kg*Cm (Torque)	2	$18.99
Sprocket	Drive wheel for the tracks.	Cm (Diameter)	2	Can make them

Idler Wheel	Transmits the rotational movement.	Cm (Diameter)	2	Can make them
Tracks – From Amazon	Used to move the arm forwards, backwards and neutral steer.	Inch (Length/Width)	1	$24.94
Threaded Rod	Used to move the arm up and down.	Inch (Height)	2	$0.00 - Already have/Can make
Screws, Bolts, Washers	Used to fasten the different pieces together.	TPI, inch	30-40	$0.00 - Already have + can purchase at Home Depot for around $1.00 per
ReactJS	JavaScript framework used for user interface.	N/A	1	$0.00 – Can be installed for free
Integrated Development Environment (Visual Studio Code)	Software application with developer tools used to facilitate the programming process.	N/A	1	$0.00 - The IDE we will be using is free to install