C2.2 Project Deliverable D:

Prototype 1, Project Progress Presentation, Peer Feedback and Team Dynamics

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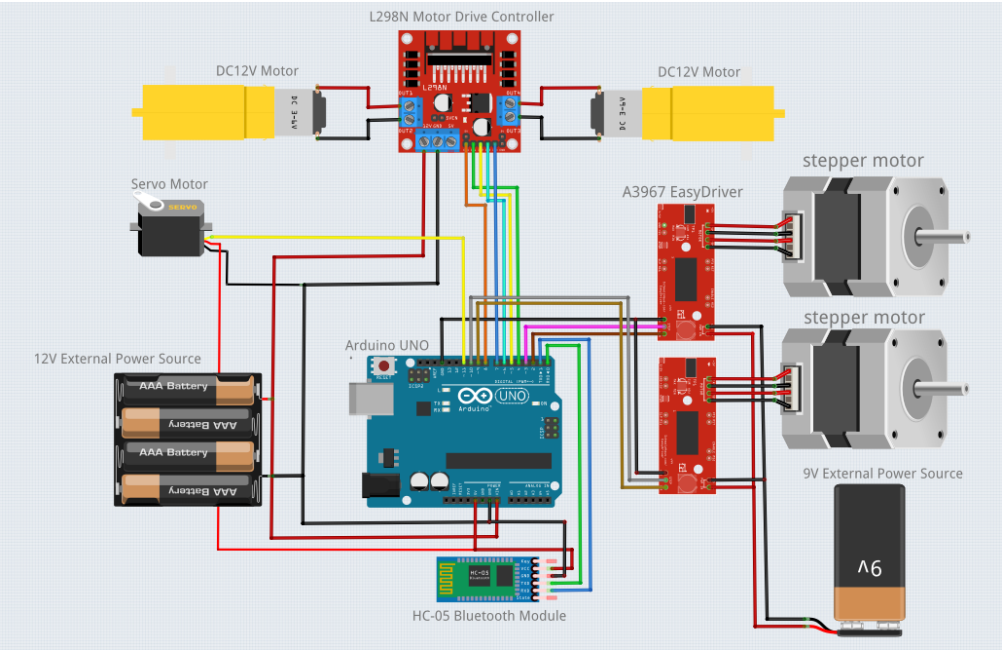
D.1- Prototype 1

Introduction:

The purpose of this project deliverable D is to provide an update on the prototype development. This deliverable contains two prototypes that will be used in order to gain further insight into technical requirements with respect to some of the target specs. Additionally, it aims to reflect on the feedback our team received from the clients and present the plan for improving our prototypes moving.

1 – Prototype 1:

Electrical Circuit Prototype:



This part of the prototype demonstrates the basic logic of the electrical circuit of our project. The purpose is to test the pin connections and list the components required. Since the software that used to create the circuit does not allow simulations, the testing process is done by calculations with the data from the manual or datasheet. Basically, calculating the voltage requirement for each motor, checking the usage of the pins, and verifying the overall power consumption.

From the circuit diagram, the Arduino UNO board provides enough pins (12 signal pins) for all the control signals of the motors as well as the Bluetooth module. Based on the data collected from datasheets (listed in the table below), the total power consumption is 16.338 W from the calculations. From the voltage requirements data, motors require external power to drive them separately. As a result, the 12 V and 9V external power supply is added in the circuit. Furthermore, some other information is collected from researching. For example, regular AAA battery will have a battery of 50 hours and the Bluetooth module support 10m range of connection.

Components	Drive Voltage	Power Consumption
A3967 EasyDriver (for stepper motors)	6-30 V	7.3 W *2 = 14.6 W
NEMA17 Stepper Motor	7.3 V	
L298N Motor Drive Controller	5-35 V	1.92 W
Servo Motor	4.8–6V	
HC-05 Bluetooth Module	5 V	
12 V Gear Box DC motor	12 V	0.78 W * 2 = 1.56 W
		Total Power Consumption = 18.08 W

The table below demonstrates all the target specifications that are tested with this part of the prototype. All metrics satisfied and the testing results are showed.

Metric #	**Metric**	**Unit**	**Marginal value**	**Ideal value**	**Testing value**
8	Uses battery	Boolean	False	True	True
9	Battery life	Min	300	600	3000
10	Power Consumption	W	<25	<20	18.08
11	Can move freely around house	Boolean	False	True	True

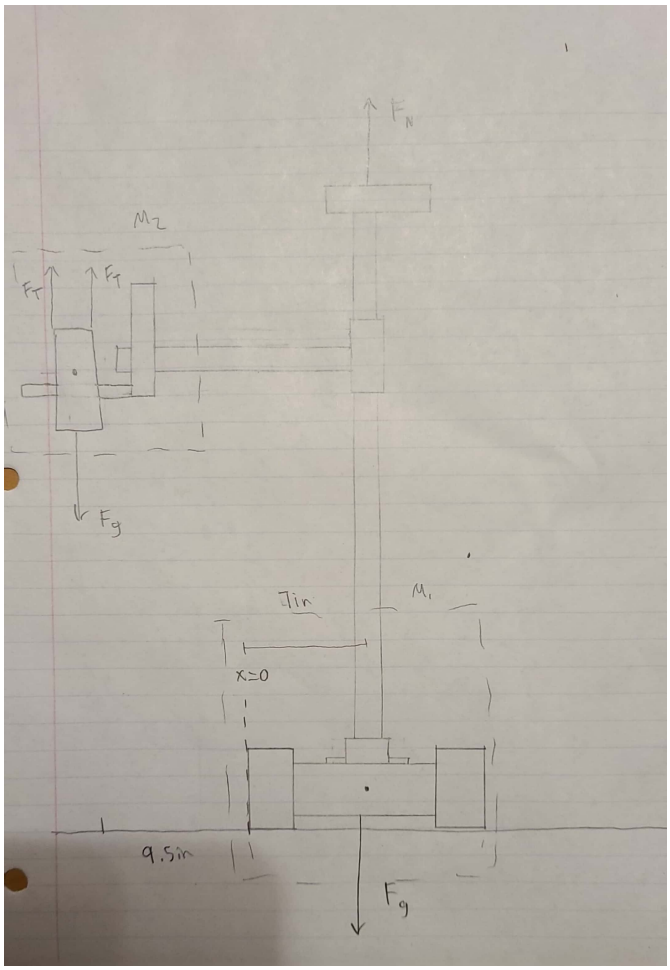
2 – Prototype 1:

Stability analysis of the entire system at rest:

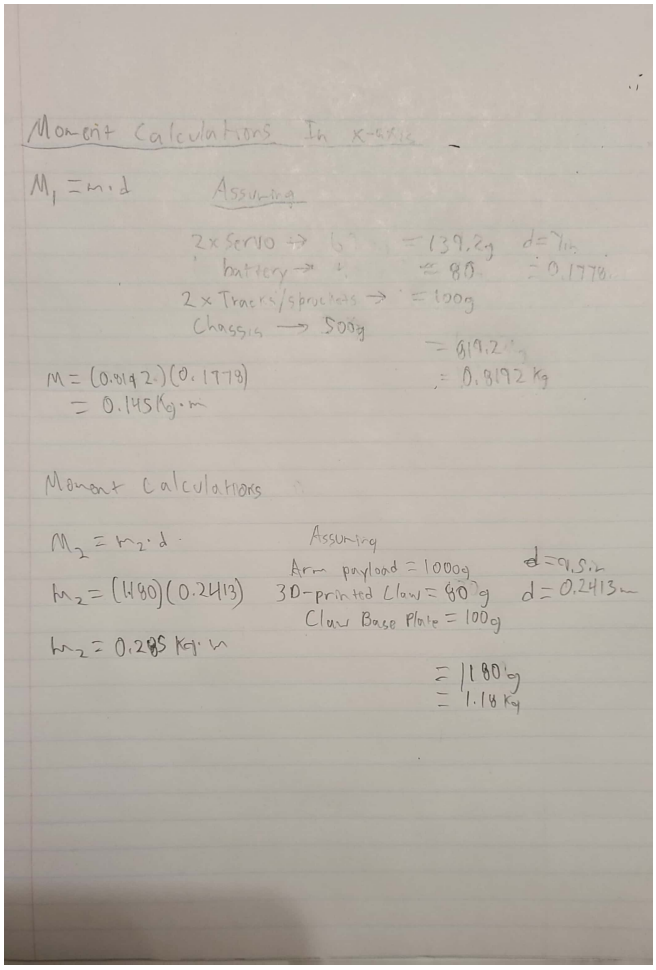
Using data from the critical product assumptions, our team identified a potential issue regarding the arm's static stability when carrying heavier loads. Therefore, it was decided that further investigation was necessary in order to determine the extent of this issue with respect to the target specification of arm payload that our team has developed. **Regarding the target specifications, we used the ideal value of 1000g or 1 kg for our analysis.**

To begin this analysis, we drew a free-body diagram to get an idea of the different types of forces and how they will impact the stability of the arm at rest with a payload. Forces such as gravity, the normal force and the tension force (the force of the gripper acting on the payload) were included in the analysis.

Below is a free-body diagram of the system:



The succeeding step was to then use the concepts of moments within statics in order to determine more precisely the arm's tendency to tip over under load. Below details the exact calculations that determined the two different moment values:



Firstly, the formula for moments was the mass of the component multiplied by the distance of the component to a set reference point. On the free-body diagram, this was determined to be x = 0 at on the left side of the tracks. Then, it was determined that two moment calculations were needed for comparison (1 component being the base of the arm and the other being the gripper assembly).

Then the mass of both components was obtained by adding up the contents of each component. Additionally, the distance from the components was determined using assumptions based on rough dimensions of the arm. Then, the calculations for both components were performed.

The results indicated that when the arm is carrying a 1kg payload (Ideal value for target spec.), it may have a tendency to tip over. This is due to the moment values being larger than the base of the arm for the gripper assembly component, meaning that this payload may overwhelm the stability. To resolve this issue, we can either adjust the amount of weight in the base of the arm (adding or removing mass) or we may adjust how far the arm should extend out based upon the dimensions of the table and the counter.

It is worth noting that when this calculation was conducted with a payload of 566g (The client's personal water cup). The arm did not have a tendency to tip over, as the moment value for the gripper assembly was less than that of arm base. Additionally, we will conduct a stability analysis into the dynamics portion of this product. As it is intended to move, which requires analysis into how the moving platform may affect the stability of the arm.

Outline of Next Client Meeting:

For the next client meeting, we will present the slides and some potential physical prototypes for a better visual demonstration. The presentation will be more focus on the prototypes comparing the progress report. The feedback received from the client in terms of user experience will be important to our team. The information that we would like to gather at the next client meeting are listed below:

1. Anything detail that requires to be changed or improved in the first prototype design.
2. Anything missing from the current design, or not reaching the target specifications.
3. Further feedback on the physical prototypes that we will develop in the future, which will be taken into consideration alongside improving the prototypes.

Project Plan Update (Wrike):

The project plan will be submitted independently of this document.

Conclusion:

In deliverable D, we have demonstrated the progress on our project and introduced the two parts of our prototype and create the plan for improving your prototypes moving. These prototypes incorporated mathematical and scientific analysis and in addition to some of the target specs., we were able to gain further insight into our technical requirements and any

changes that we should make. Furthermore, we generate the schedule for the next client meeting and the information we would like to obtain from them for the sake of development.