Project Deliverable G: **Prototype II and Customer Feedback**
GNG 1103 – Engineering Design
Faculty of Engineering – University of Ottawa
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Group A6:

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Why are we doing this test?

Our ideation process was a long and changing phase in the lifetime of the project. To create a system that applies force on the wheels in a way that creates enough friction to stop and slow down the robot, many diverse ideas came up. Most of them involved mechanical parts with different convoluted systems. That process was recorded and can be seen in the image below.

The above ideas had many problems that were associated with them. Most of those problems were related to the placement on the robot, and the feasibility of the proposed systems. With those dilemmas in mind, a brand new design was formulated. Instead of using a mechanical system, based on a motor to activate the brake, a purely electrical system controlled by arduino was created. This system involves a solenoid that would be used to oscillate or apply a constant force on the wheel to slow down or stop Bowie. This system will be more reliable, and be much easier to equip to Bowie due to the smaller size of the solenoid in comparison to most mechanical systems ideated. However, there are a few potential problems with this solution that could only be verified through thorough testing. The amount of force that can be applied through a given amount of voltage is an important aspect to observe. Since there are only 5 available volts for the entire system, it is important to verify that the given voltage will be sufficient to brake Bowie's wheels in the required time. Moreover, the complexity of programming required to attain our desired objective might arise some problems which could force us to change the plan of our system. Similarity, the structural integrity of the system under a perpendicular force also has to be analyzed. The general objective of the second prototype is to build off of the flaws we encountered in prototype I and to give more insight into those potential problems by testing a revised system with the same general properties as the solenoid system planned.

Higher speeds can also be tested to give some space for error, and make the system usable for possible future variations of Bowie. Additionally, the prototype can be use to get more required feedback from Erin, to find the best way, if any, to place the system on Bowie.

Test Objectives Description

What are the specific test objectives?

-ability to stop wheels, if possible with our programing skills to implement a gradient breaking system.
-Develop a program using Arduino to control the speed of a motor
-Develop a program using Arduino to implement different types of braking levels with the solenoid

What exactly is being learned or communicated with the prototype?

-Ability to stop a replica of Bowie's wheel
-To develop our programming skills and knowledge
-improvements to be made to the design
-mechanism
- developing an arduino program

What are the possible types of result?

If our prototype goes as planned hopefully our program will rotate the replica wheel, efficiently stop the wheel and potentially implement gradient breaking. Another outcome is failure, our prototype could easily malfunction or our knowledge on programming with arduino might not be enough to achieve our objectives. We know from last prototype that our solenoids will produce enough force to stop the prototype wheel, although the replica wheel of Bowie has treds which may require redesign our original solution.

How will these results be used to make decisions or select concepts?

With these results in mind we will be more cautious with our materials, use the most efficient method, and we will prepare for the worst. Our concept may still change, we will use our scientific and mathematical knowledge to make our decisions and select any new concepts required.

What are the criteria for test success or failure?

The main criteria for the test of success or failure is if our programming skills are efficient enough to accomplish our desired goals. Another factor is if our new rubber brush system will suitable to stop the replica wheel.

What is going on and how is it being done?

Describe the prototype type (e.g. focused or comprehensive) and the reason for the selection of this type of prototype.

This prototype was based off prototype I and the feedback we received from our client. We gathered all the flaws and successes in prototype I and recreated a more reliable and efficient way to stop Bowie the robots wheel. For prototype II we came up with the solution of using Bowie's exact design of his wheel, which we 3D printed from the design our client sent us. Furthermore, with the addition of treds on the wheel we came to conclusion that our original idea of a rubber pad lowering onto the wheel. Instead we decided to use a rubber brush which would lower onto the wheel, by using a similar solenoid that produces more force than the initial one in prototype I. Essentially this idea was the most reasonable and efficient. After researching which type of material would be most capable to stop the wheel we determined to use a rubber brush. To make this prototype as realistic as possible we created an identical wheel to Bowie's and improved braking system which are both controlled with an arduino that we've programmed. In conclusion, we wanted to implement gradient breaking into our idea. To involve this plan our group proposed that the

solenoid should pulsate going up and down relative to how much we would want to decrease the speed of the robot. This is definitely an ideal situation entirely dependant on our programming skills.

Describe the testing process in enough detail to allow someone else to build and test the prototype instead of you.

Our improved prototype was thought of by adjusting the flaws of prototype I and using some remaining ideas which were thought of in our initial design thinking process.

For this prototype it we took a more circuit and programing approach. We drew up a basic sketch of our ideal circuit so we had something to work from. Then we gathered our materials and started working on the function of the wheel. Our plan was to rotate the wheel on command from an arduino. We connected our arduino to a motor by using connecting wires and a breadboard. Next, we attached the arduino to a computer and began writing a basic code to choose when we wanted to rotate the wheel and for how long.

Once we got a fully functioning circuit we could add a wheel to the motor. To attach the wheel to the motor we cut out a piece of cardboard and taped it in the center of the wheel then cut a tiny hole in it. The reason for this was so we could place the motor drive shaft right in the center to rotate smoothly. We wanted our prototype to be more realistic than the last so we decided to 3D print an exact replica of Bowie The Robots wheel. After we placed the wheel onto the motor we hot glued them together assuring that when the motor spinned the wheel also spinned.

With the part of the wheel out of the way, it allowed us to start working on the actual braking system. To start we got a solenoid similar to the one we used last time. We attached the solenoid to the same breadboard as the wheel and began securing all connecting wires. For the action of the solenoid we decided to have it activate in both a oscillating

motion, to gradually slow it down, and a emergency break which would activate then hold its position. Moreover, we learned enough programming language to follow through with this plan as hoped. By using the arduino we could activate the solenoid whenever and however we wanted. Furthermore, we found a pre-made 3D printed box and placed the breadboard and arduino inside. We cleaned up our circuit and made sure everything was functional from the computer. We didn't focus too much on the actual braking system since our plan was to further develop it in prototype 3. We wanted a solid circuit which we could implement in the next prototype.

What information is being measured?

During our testing of prototype II we measured the speed of the motor attached to the wheel, the time required to stop the wheel using the Solenoid with a rubber brush, and the rate of which the solenoid would pulsate to decrease the speed of the wheel.

What is being observed and how is it being recorded?

Our progress throughout the development of prototype II is being observed with pictures and notes. We had to modify specific parts of the prototype by problem solving the obstacles we encountered in prototype I. Such as, writing the most efficient code which would include our ideas and making the prototype as clean and reliable as possible.

What materials are required and what is the approximate estimated cost?

1st Prototype

Materials	**Cost ($)**
Rubber Tape	4.32 + tax = 4.88
Cardboard boxes	Free (From CBY)
Solenoid (12V 5N)	Free (From CBY)
Breadboard	4.00
Electrical Wires	Free (From CBY)
4 AA batteries	Free (From CBY)
Battery holder	Free (From CBY)
Button	Free (From CBY)
Switch	Free (From CBY)
Fan	Free (From CBY)
3D printed wheel and cylinder	Free (From CBY)

2nd Prototype

Materials	**Cost ($)**
4 Relay Module	Free (From CBY)
Arduino Uno board	Pre-owned
Breadboard	Pre-owned
Wires	Pre-owned & Free (From CBY)
3D printed casing	Free (From CBY)
Tactile buttons x 3	Pre-owned

Solenoid (4.5V)	6.08 + tax = 6.87
Diode	Free (From CBY)

What work (e.g. test software or construction or modeling work or research) needs to be done?

We had to continue to research the best type of solenoid which would produce enough force to stop the wheel of Bowie The Robot. After the inconvenience of our original solenoids not producing enough force we reconsidered the required force to stop or slow down the rotation of the wheel. Plus a suitable rubber brush which would provide enough friction to stop the wheel. We had to model a CAD tray container for the breadboard, Arduino board and Relay module board. After we had the systems working for prototype II we could construct the containers to hold the created circuit which powered the required subsystems.

When is it happening?

How long will the test take and what are the dependencies (i.e. what needs to happen before the testing can occur)?

We set the time frame to complete prototype II for our lab section on March 7th. Before the testing can occur the we must gather all the materials and improve the outline of our plan. We depend on an efficient and effective team in order to finish our prototype in the desired timeframe. After contacting our client and receiving sufficient feedback on prototype I we can include her desired adjustments plus the modifications we seek and add them to prototype II. Another dependency is our ability to learn a suitable amount of coding to be able to control and adjust both the motor and the braking system.

A separate test planning Gantt chart can be created to help making sure that the testing fits with the overall project schedule or it can be defined as part of that schedule (i.e. as a sub-task).

Since we created a fairly reasonable Gantt chart to follow it has made it easy to stay on schedule so far. Therefore, to this point the testing fits with the overall project schedule.

When are the results required (i.e. what depends on the results of this test in the project plan)?

For prototype II our results are required to be completed by March 11th according to our project plan. In order to meet this requirement we scheduled to find all the compulsory materials to create a visual representation of our enhanced idea. Furthermore, we had to make an outline of prototype II so we had a general plan we could follow, from there we used the time given to use during our lab to create the second prototype of our braking system.

Pictures of Prototype 2

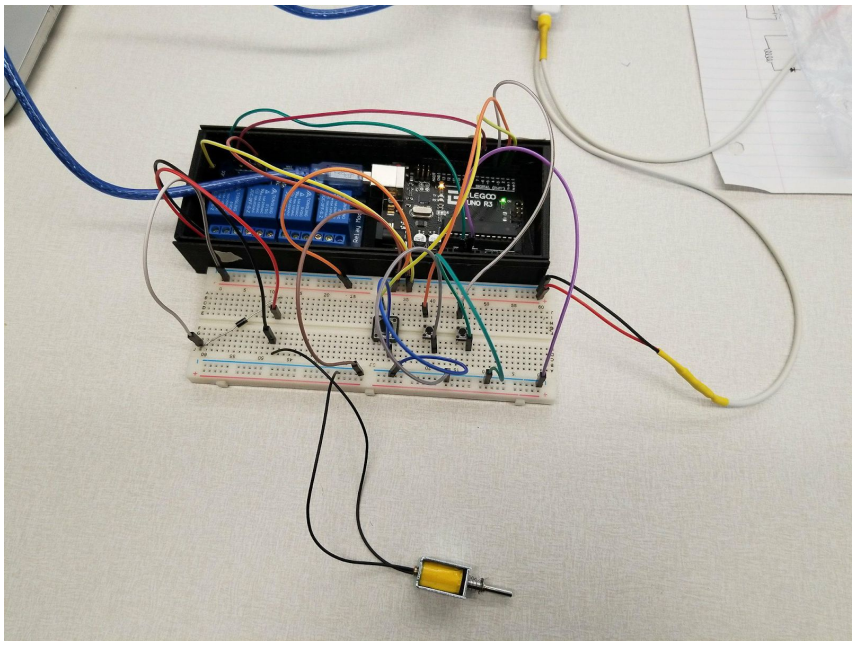

Figure 1 - Solenoid attached to the circuit and Arduino

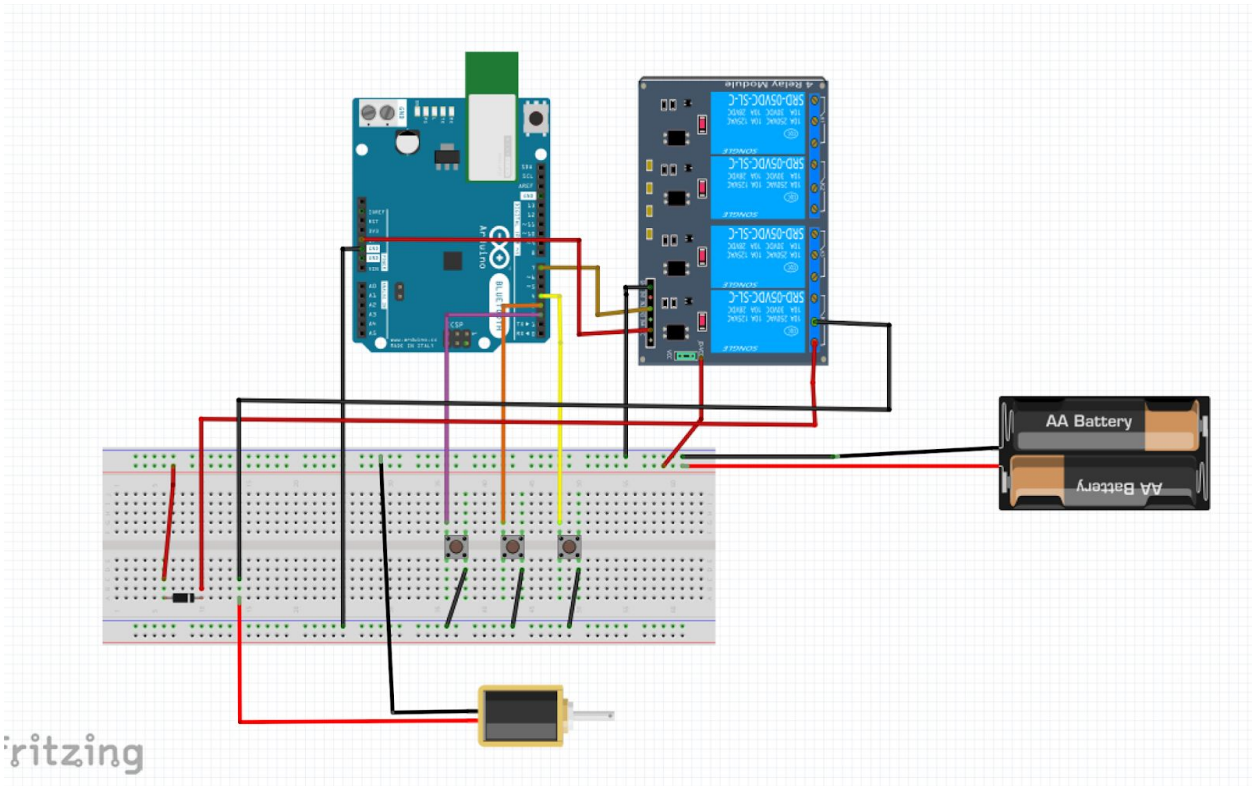

Figure 2 - Wiring diagram of prototype

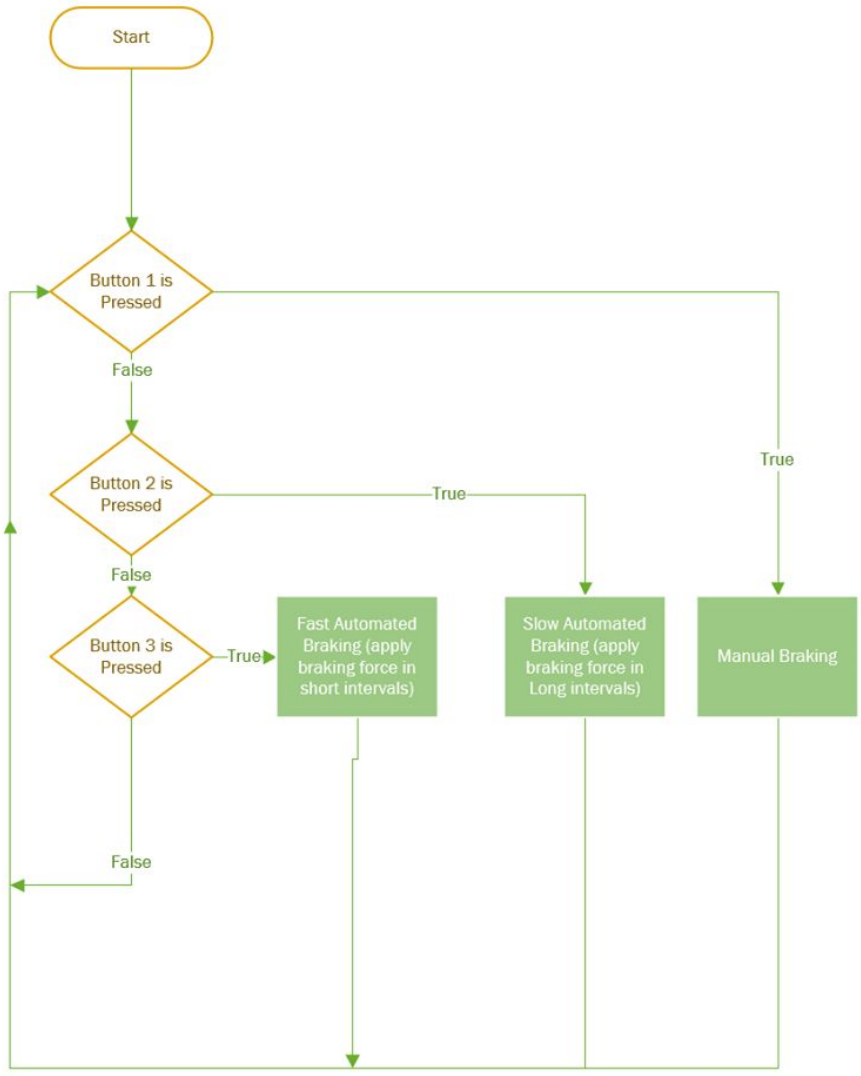

Figure 3 - Programming flowchart