Project Deliverable E
Prototype 2 and Project Constraints

GNG2101 [D]
Introduction to Product Development and Management for Engineers and Computer Scientists

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Introduction

In this report, our team will outline our current prototype, how we tested them and what we learnt. We will also outline the feedback received from our client during our third client meeting where we demonstrated our prototype to the client, outlined the various design constraints we faced during the development of this project, and updated our project plan for the following weeks.

Client Feedback

On February 28th, 2023, our team had our third client meeting of the semester. During this meeting, we showed the client our current progress on our prototypes outlined below in Prototype 2. After demonstrating our prototype to the client, we discussed ways to improve and move forward with our designs. This involved a practical discussion/consultation with Alex from the Brunsfield Center. One of the notable pieces of feedback received involved the rigidity of the spring and its corresponding spring coefficient. Due to the industrial nature of the spring purchased, the amount of force required to ensure full compression is not plausible to be produced from a simple push-up. Feedback was given to investigate the process of creating our own custom-designed spring, but it was quickly understood that that would not be possible within our budget and time constraint. Some feedback was received on the durability of the 3D-printed pipe fittings; due to their thin base, they could be prone to snapping. Our client suggested creating custom pipe fittings using Delrin and a lathe to machine it. This can be further addressed in the design of our next prototype, along with the fact that our product is potentially prone to tipping. Lastly, our client recommended some modifications to the handle design due to the specific range of motion in his wrist. To fix this, a better angle for the handle design will be drafted and it will include soft materials to ensure comfort for the client.

Design Constraints

Design for Manufacturing and Cost

During the design of the aerobic workout device, cost and manufacturing were one of the leading factors in decisions and conversations. The budget at the time of design was 100$ (Was changed to 400$ in week 6, 2 weeks after the design was complete), and with this 100$, we needed numerous parts and numerous different connection methods to ensure the parts work in unison. To minimize cost, we decided to try and simplify manufacturing. When it came to the bolts to connect all our parts together, we decided to ditch all the different sizes of threading in the original design and implement the constraint that all our bolts need to be ¼”-20 threaded nuts and bolts to save on the cost by buying 1 bag of nuts at a bulk price. In addition to saving on connection methods, we also decided to save some money by implying the constraint that the pipe joints had to be 3D printed. Pipe fittings were not cheap and 2 pipe fittings alone ate through more than 50% of the budget. To fit the monetary constraint, we had to manufacture the pipe fittings with 3D printers.

Design for the load which the system can support

When we were coming up with concepts and deciding the best concept we didn't think too deeply about the load that the system could support. We also didn't think that what kind of spring we should be using so that the client won't have any problem using the device. The week that we had the class design review we presented our design concept and after presenting to one of the TAs we got feedback about our spring. TM told us that we should carefully consider what kind of spring we will be using since not getting the right spring could cause the whole device to not work. After thinking about what could be the right spring for our system, we first had to take into consideration the weight of our client which is 195lb and we also realized that having more than one spring for our system wouldn't be ideal since it would take up so much space. We did some simple calculations using the distance the client needs to get down which is about 5 inches and his weight. After doing that calculation we decided that our spring should be 10 inches in length, 2.906 inches wide, and have a 0.281 inches wire diameter.

Prototype 2

Outlined below are the various different prototypes we constructed to test some assumptions made during the design phase of this project and the test plan for the prototypes. For this deliverable, our team prototyped the handle system and the platform.

Test Plan

Table 1: Test Plan

Test ID	Test Objective	Prototype	Results Recorded	Duration
1	Determine if the handle can support the weight	Handle system	1. Weight applied 2. Any deflection in the handle 3. Any fracture	This test will last for 100 pushups
2	Determine if the handle can handle the moment created	Handle system	1. Weight applied 2. Device stability	This test will last for 100 pushups
3	Determine if the platform system can handle the weight applied	Platform system	1. Weight applied 2. Any fracture	This test will last for 5 minutes of applied weight

Handle System

To construct the handle system prototype, we needed our 6" pipe, our 4" bolt, and our ¼"-20 threaded nut, along scrap pieces of 2x4 wood for the future modification of the handle. To begin, we drilled a ¼" hole in the side of the pipe. The hole is located 6.5" off the base of the pipe. We then installed the nut and bolt through these holes to stick out the side of the pipe. The assumption we wanted to test during this phase was that the handle could support the

weight and that the moment created by forces on the handle was able to be controlled and wouldn't tip the device. To test these assumptions, we completed 100 push-ups on the device over multiple days and noted down any results discovered. Throughout the testing, we realized the single use of a bolt would not suffice as a handle. This led us to think of a new handle design. We will be using scrap pieces of 2x4 wood to help design a more reliable handle. We will be drilling a second hole into the pipe where it is just slightly higher than the base. A second 4" bolt will be installed in that hole, which will be lined up with the current positioning of the bolt as seen in figure 1. We then drilled ¼" holes into the 2x4 wood pieces to connect to the bolts and glued them for extra support. The shape of the handle will simulate a tea cup shape, thus ensuring stronger reinforcement for the moment/tipping balance.

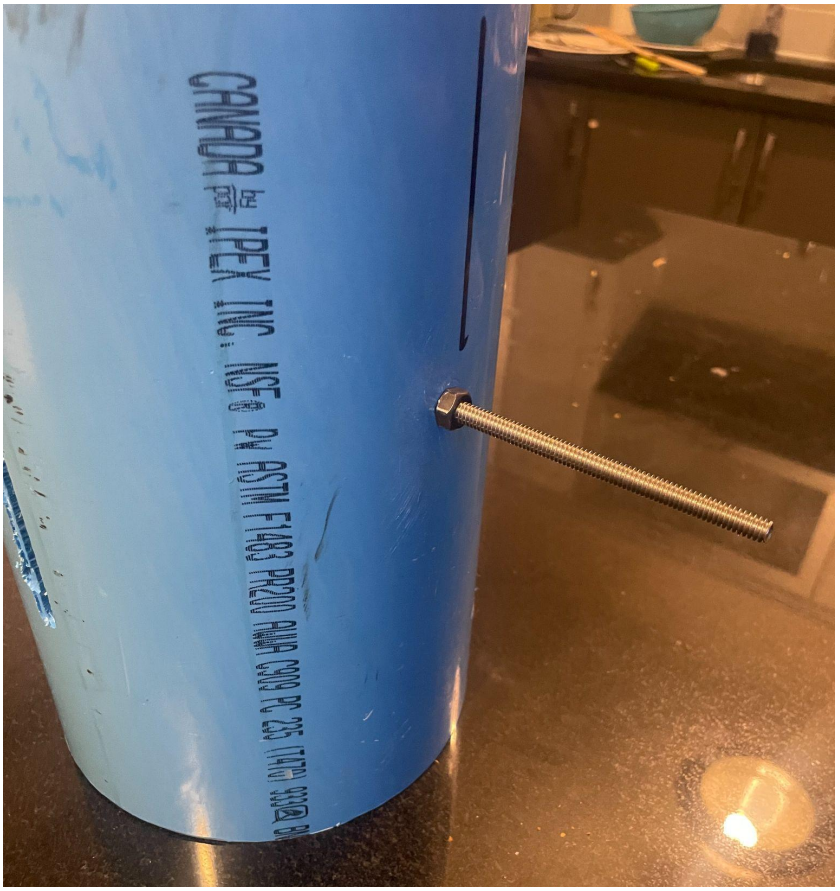

Figure 1: Handle System Prototype

Platform System

To construct the platform system, we needed our 7" x 9" platform, 4 separate ¼" diameter, 1" long bolts, 2 separate ¼" diameter, 3" long diameter bolts, 2 of our custom pipe fittings, 6 separate ¼"-20 threaded bolts and a 10" long, 2" in diameter pipe. To construct this prototype, we drilled 4 ¼" holes through the flange of the custom pipe fitting and 4 ¼" holes through the platform and bolted them together. We drilled 2 ¼" holes through the fitting cylinder and 2 ¼" holes through the 2" pipe and bolt them together and we repeated this on the other end of the pipe and on the other pipe fitting and bolted that together. The assumption being tested in this prototype is that the platform system can support the weight

that will be applied during the use of the device. To test these assumptions, we applied 100 pounds to the platform for 30 minutes. After our results, the platform successfully withstood the weight with no visible cracks or damage.

Figure 2: Platform System Prototype

Project Plan

In this deliverable, our team updated our project plan for the following weeks by adding updated tasks and deadlines. The following link will take you to a snapshot of our current schedule.

Wrike Gantt Chart Link:
https://www.wrike.com/frontend/ganttchart/index.html?snapshotId=IDP8sBFdeEn8mYryJHNuuNDfqPs0T0jk%7CIE2DSNZVHA2DELSTGIYA

Conclusion

In conclusion, due to the prototypes developed during this deliverable, we were able to validate our assumptions during the design phase and confirmed our parts are usable in the final prototype. Since these parts are able to be used, our team's remaining work on the final prototype is to mill the slots for the guide bolt in the 6” pipe and to laser cut the disk to connect the platform system to the spring.