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1. Discussion (Individual)

1.1. What went well:

A working prototype was created, and the task was completed in line with a Product Design Specification. All the high priority requirements were met and most of the lower priority requirements were also met. The creation and use of a PDS ensured sight of what was needed when building the prototype was never lost. The divide and conquer technique was successfully used to split the prototype into different sub-problems including the main structure, vertical movement, horizontal movement, electrical wiring and control box. Each of these sub-problems were completed by smaller groups and then were brought together for the final prototype. This drastically improved efficiency as the manpower was distributed rather than everyone working on the same thing. Pugh matrices were used among other methods to analyse the best concept designs. Our initial overall designs were a gantry crane, a slide, a conveyor belt and a normal crane. These designs are shown in Figure 3, Figure 4, Figure 8.

Some of these designs were eliminated due to limitations in our PDS. For example, our 4th performance criteria states that the “Mass must not damage the ground when it lands” which eliminated the slide concept as that was the most likely to cause damage. There were also a lot of minor issues that were resolved quickly through ingenuity and quick thinking. For example, the pulley string kept slipping off of the spool. To solve this problem a pair of laser-cut disks were made to go on either side to prevent slipping. The disks are shown in Figure 23.

1.2. What went badly:

On the second day, a roadblock was hit. There was an issue with the function of the cart in the horizontal direction. Bevel gears were used to transmit the power from the DC motor to the wheels and hence move the cart. However, these gears kept on slipping which meant power wasn’t being transferred. Instead of moving away from this concept and using a different type of gear, i.e. a worm gear, multiple hours were spent attempting to solve the issue as the solution felt near. In the end, to solve this issue a worm gear was used which however resulted in another problem arising. The motor was not secure enough within the cart so when functioning it would keep moving until it slipped. The system was essentially “breaking itself” when functioning. To solve this secondary issue a laser-cut acrylic “box” was manufactured to secure the motor in place as this box was fully attached to the main cart assembly ensuring security.

Another issue that arose was with the system controlling the vertical movement of the cart. Although this was able to work as intended, the use of bevel gears in this part of the prototype also complicated things as they kept slipping which required bushes to secure them. Also, the gear train was incorrectly configured. Our intended gears ratio was 3:10 however the second and third gear were placed on the same axle rather than connecting them which meant that the ratio that the gear train produced was only 3:4. Although the vertical system was able to work its efficiency was very low at 4.3% and a lot of demand was placed on the motor. The motor was drawing an average current of 0.4 A which is much higher than what is rated for this motor potentially damaging it.

1.3. Improvements

To improve, a different manufacturing process other than 3D printing could be used due to the long wait times and high cost associated with it. If this prototype were to be upscaled, using additive manufacturing processes may not be feasible so finding another solution such as a CNC machined part to connect the motor to the axle would be beneficial.

Also, if more time had been spent on the concept generation stage it could've prevented the selection of an overly complicated concept. The further into the design process you are the harder it is to make fundamental changes. Although the task was completed, after analysing other designs it was noted that far less complex and overall, more cost-effective designs could have solved the same problem. The production of this prototype has made it easier to know which components (e.g. bevel gears) should only be used if necessary. Taking more care and frequently referring to designs created during the prototyping phase will prevent issues such as incorrectly configuring the gearbox from arising. The incorrect gearbox had negative environmental impacts especially if the prototype was upscaled as the electrical power provided to the motor was relatively high at around 4W. An improved gear train and pulley system will improve efficiency. A reduction in the weight of the cart could also have significant effects.

2. Conclusion (Individual)

The main outcome of this task was a completed prototype machine that will lift a mass over an obstacle as described in our PDS which then can be upscaled. This prototype was to be made in line with a Product Design Specification. The PDS ensured the team stayed on track and no time was wasted. The design process that was used began with concept generation where fundamental designs were conjured and Pugh matrices among others were used to decide which design will move forward to the next stage. Also, during this stage, it was decided which group members will be assigned to specific sub-problems to divide the overall problem. The concept that was decided upon was a gantry crane with an external control box. This concept was in line with our PDS which had been made prior to generating concepts. The next stage was embodiment and prototyping. CAD software and other techniques were used by the specific sub-groups to design their respective section in more detail. Small scale tests also took place. For example, testing whether the motor to Lego axle adaptor worked as designed. Finally, the final prototyping stage where all physical designs were brought together to create the final prototype. During this stage, full tests of the entire prototype were conducted to ensure it completed the initial task that was given. The gantry crane prototype in the end was able to complete this task while also passing the most important criteria in the PDS as shown in the Production Solution Specification. This prototype is shown in Figure 24.