Alternative Power Source for Dental Hygiene Device

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1. Introduction

1.1 Problem Statement

The NAU Department of Dental Hygiene provides humanitarian services in some remote areas of the world. Sometimes, these areas have limited access to electricity. A dental device, Wig-L-Bug, is used to mix cavity filling material. The Wig-L-Bug requires electricity to run. Since there is no electricity supply available, the team needs to design an alternative power source for the dental device. Moreover, the power source has to provide sufficient energy to run the Wig-L-Bug for ten hours continuously. The power source also needs to be portable in both size and weight.

1.2 Design Concepts

The team came up with two designs. The first one is a battery design, which was proved to work successfully last semester. The second is a Mechanical Wig-L-Bug. The team is working on the Mechanical Wig-L-Bug design this semester. A mechanical Wig-L-Bug requires no electricity. It works with manual power input using a hand crank. A gearbox is used to increase the angular velocity from 75 RPM to 5000 RPM. The mechanical Wig-L-Bug is portable in both weight and size. Unlike the battery design, there is no worry about running out of electrical energy. The biggest advantage of the mechanical Wig-L-Bug design is that it works perfectly even there is no access to electricity.

2. Wig-L-Bug Motion Analysis

The dental hygiene department uses a Wig-L-Bug to shake the liquid in small bottles with a high frequency. A mechanical Wig-L-Bug is the final design of our team. In Figure.1, a motion converter taken off from an abandoned Wig-L-Bug will be used in this project. It is used to convert rotation into pendulum motion. A claw is used to handle the bottles. The cylinder part will be connected to the output shaft of the gearbox and it will rotate when the shaft rotates. A holder is used to fix this converter on the box and prevent the claw to rotate while the cylinder rotates. A small shaft is used to connect the cylinder and claw. There is a 3° angle between the cylinder and the small shaft. An uneven ring is attached to the shaft. While the cylinder and small shaft rotate, the ring will push the claw to go forward and backward.

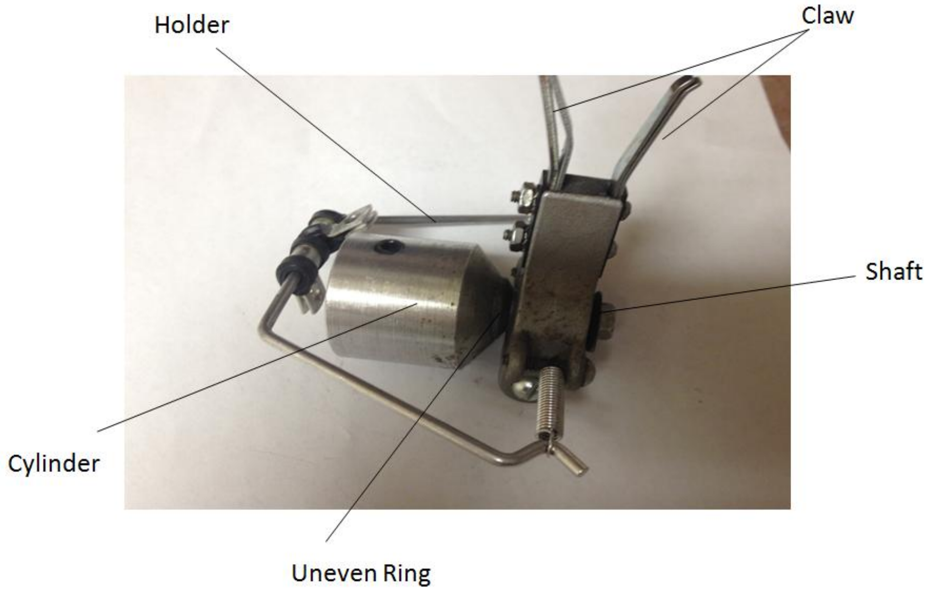


Figure 1. Motion Converter

The motion track of the claw is a cosine curve, which is shown in Figure 2. The amplitude of this motion is about 4 millimeter and the period is 0.4 microseconds. The calculated force that the small shaft exerts on the claw in the process of rotation is about 76 N and the stress on the claw is 0.34 MPa, which is much lower than the tolerance of the material.

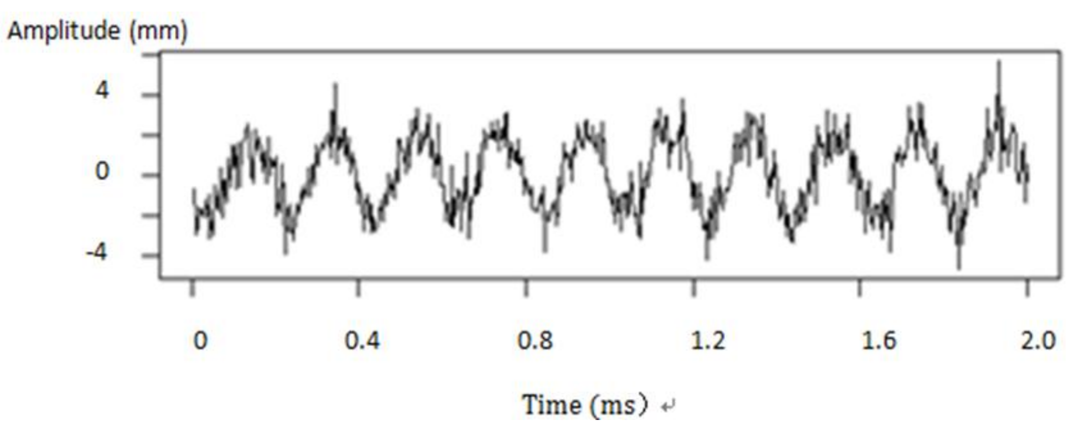


Figure 2. Claw Motion Graph

3. Design Details

3.1 Gearbox Calculations

The gearbox was designed to reach a 1:72 gear ratio in three steps. Using a safety factor of 3, the following gear loads and sizes were calculated.

Table 1. Gear Calculation

	RPM	z	Torque (Nm)	Tooth Load (N)	Pitch Line Velocity (FPM)
P1	72	72	19.81		
G1	217	24	6.60	433	69
P2	217	72	6.60		
G2	1042	15	1.38	144	208
P3	1042	72	1.38		
G3	5000	15	0.29	30	997

The modified Lewis form factor equation with the Barth Velocity factor was used to calculate the required material and minimum face-width for each gear. Cost and availability was also considered for the gear selection. The team decided to go with high carbon steel, 20 pitch, 20° and pressure angle spur gears with plain bores. Plastic gears were considered, but rejected due to not meeting the strength requirements.

3.2 Gear Shaft

The gears will be pinned to shafts made of low carbon steel. The gear shafts have a minimum safety factor of 4. They have been machined to a rough finish. See Appendix A for dimensions.

3.3 Bearings

The gear shafts will ride on double sealed ball bearings intended for skateboarding applications. The bearings have a self-contained lubricant, and will last for the life of the mechanical Wig-L-Bug.

3.4 Housing

The housing for the gearbox will be constructed from .25” polycarbonate sheet. Polycarbonate was chosen for its strength, cost, and ease of machining. The sides will be glued together using 2 part epoxy glue. The case will be completely sealed, and contain a suitable gear oil to lubricate the gear train.

3.5 Crank Handle

The structure of the crank handle is presented in Figure 3. The material of the crank handle is nylon since it is light and strong. The arm length of the handle is chosen to be about 8 inches because it feels comfortable for a person to crank at 75 RPM. The team plans to thread the end of the shaft and then screw the handle on. This makes the connection more stable. The specification of the handle is shown in Table 2.

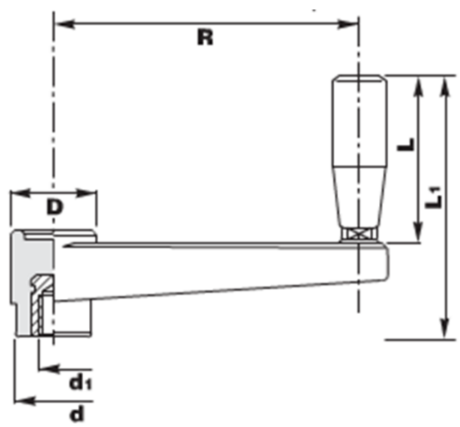


Figure 3. Structure of Crank Handle

Table 2. Specifications of Crank Handle

Bore Diameter, d (in)	1.58
Arm Length, R (in)	7.29
Hub Diameter, D (in)	1.85
Handle Length, L (in)	3.39
Overall Height, L1 (in)	5.28
Bore Diameter, d1 (in)	0.375
Material	PA6Nylon with 30% Reinforced Fiber

4. Conclusion

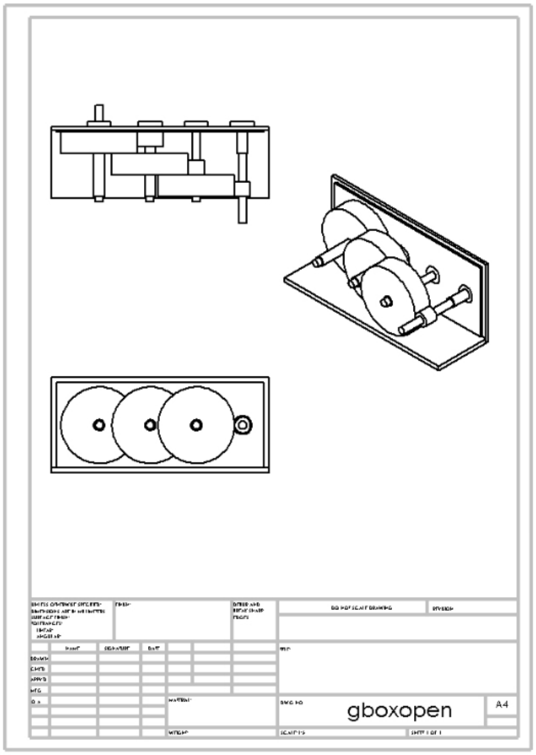
In this report, our team is mainly analyzing our final design, mechanical Wig-L-Bug. Mechanical Wig-L-Bug is quite different from our previous designs, and it doesn't need an electric motor to drive the Wig-L-Bug system. In this mechanical Wig-L-Bug system, there are mainly a manual crank handle and a gearbox which can replace the electric motor. In this report, our team analyze the motion of Wig-L-Bug. Besides, we list some specifications of our gearbox: gear shafts, housing, bearing, and the crank handle. The estimated cost of this mechanical Wig-L-Bug system is about $225, and the specifications of the cost is shown in Table 3 (Appendix A). In the future, our team will begin to build the prototype of the mechanical Wig-L-Bug.

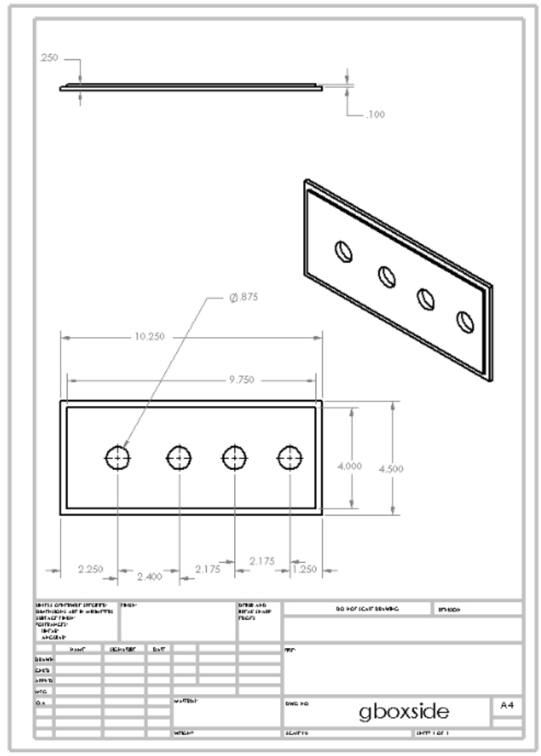
Appendix A: Bill of Material

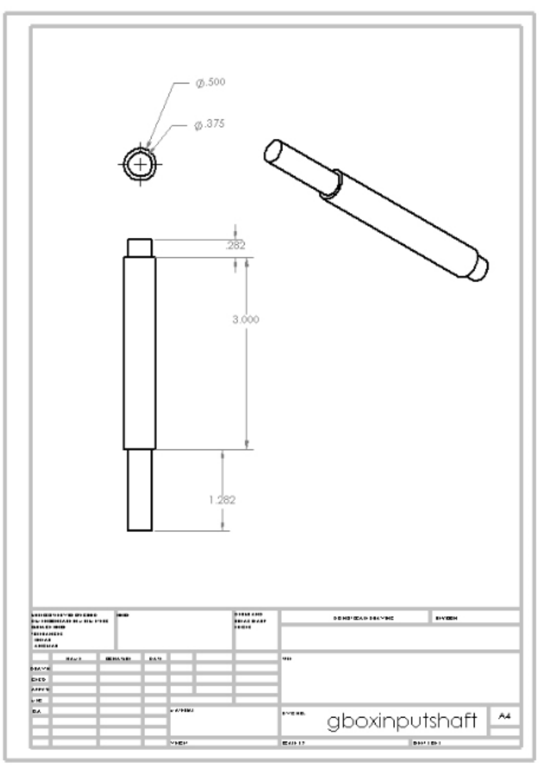
Table 3. Bill of Material

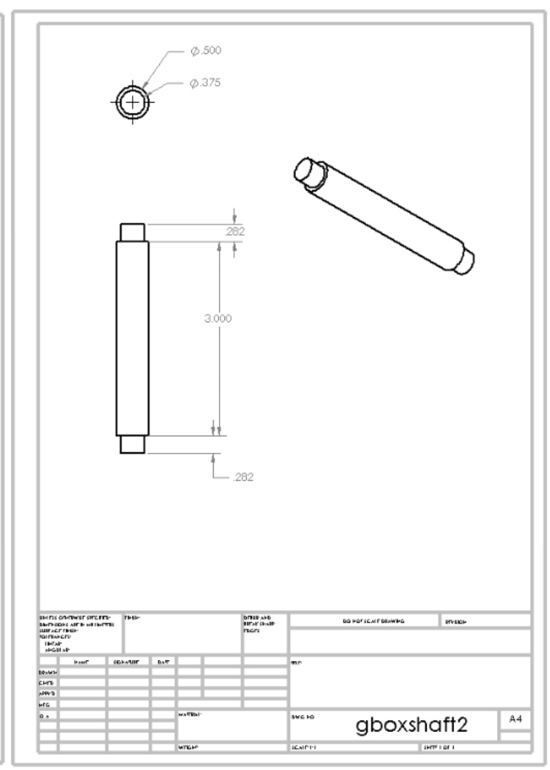
Amount	Item Description	Cost ($)
2	Spur gear, 15 teeth	13.02
1	Spur gear, 24 teeth	17.43
3	Spur gear, 70 teeth	42.29
2	Polycarbonate sheet, 12” x 12”	14.95
1	Low carbon steel rod, .5” x 36”	6.29
10	1604-2RS ball bearing	1.89
	Total	225.34

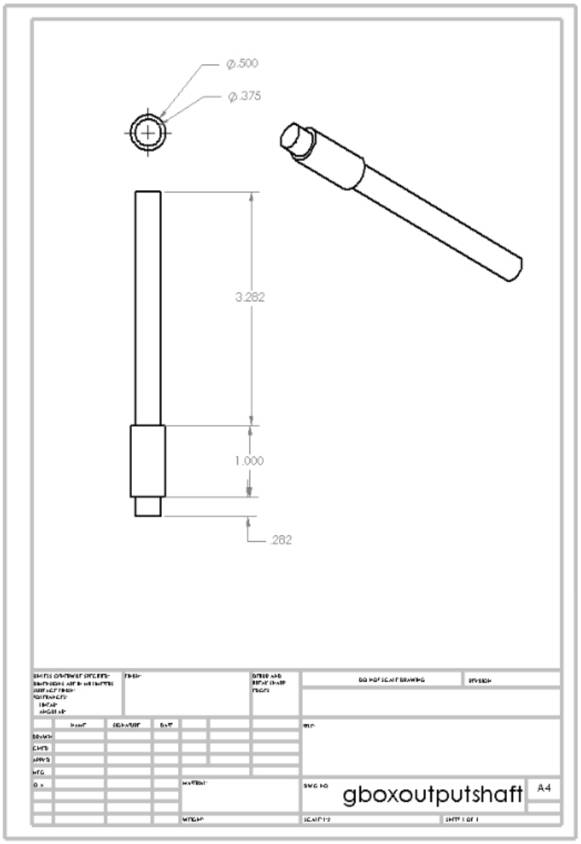
Appendix B: CAD Drawings







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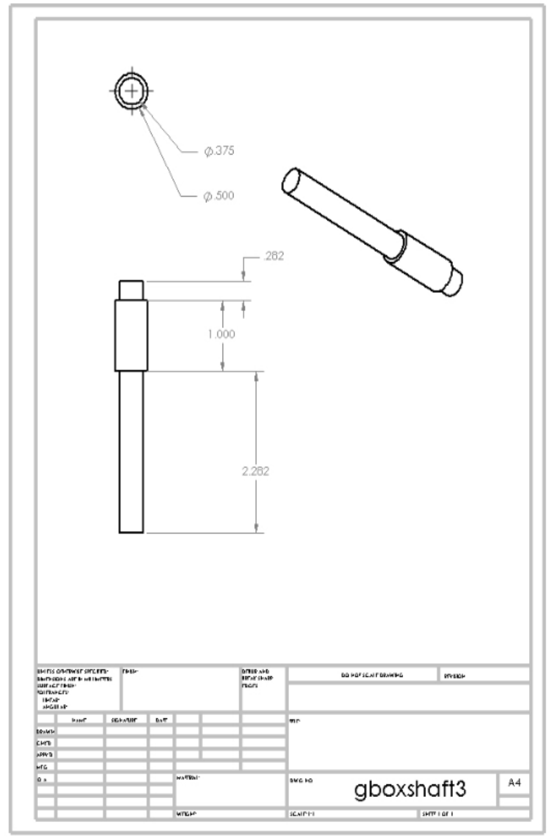
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Appendix C: Gantt Chart