Bionic Prosthetic Arm

TEAM 20

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Customer Background

The client for this project consists primarily of Professor Condron, who has tasked the group with developing an improved bionic arm for Serena, the secondary client. Serena is an upper arm amputee, who currently utilized a bionic prosthetic that costs over $100,000. This arm, while functional, bears several critical issues, with the group being tasked to develop a new arm that solves those issues.

Problem Statement

While Serena is in need of a functional bionic arm that performs daily tasks, the prosthetic arm that Serena used bears several critical issues, including cost, ergonomic design, and weight balance.
Our final product for the capstone will be a fully-functional quick disconnect wrist for a prosthetic arm so they can quickly and efficiently detach the prosthetic at the wrist joint

Requirement Matrix

Description	Rational:
Product must be easily attachable / detachable with one hand.	Product must be easy to operate with a user with 1 hand
End product should be practical to the client.	Our end product should be helpful for our Client Serena
The product's battery must last at least for one working day.	Product must be capable of lasting a full day for the user
Product must have a grip such that 3 lbs of weight does not slip.	Product should be at least able to grip and support a pint of beer
Product must be capable of lifting at least a pint of real beer in weight	Product must be able to lift varying weights of objects
Product must be capable of performing within a specified range of motion. This range is specified by Professor James Condron.	Product must be capable of performing various ranges of motion

Concept Exploration

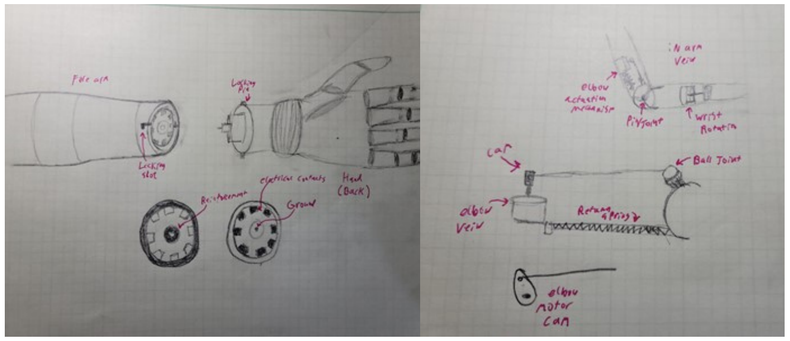


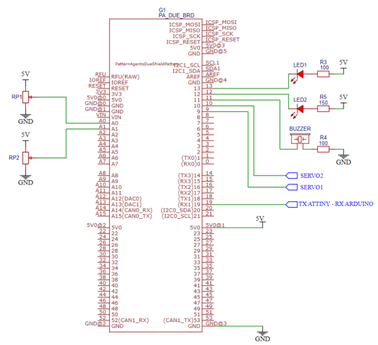
Figure 1: Modular Wrist Joint (Left) and Elbow Torque Design (Right)

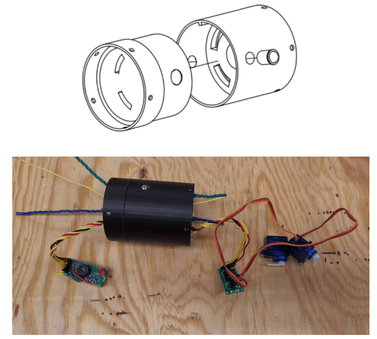
The first concept is a quick disconnect, modular attachment point is designed just behind the wrist. The system features two twist locking pins, a central core/ M-F reinforcement connection. The second concept is to solve the high torque caused by elbow joint by shifting up the arm for better weight distribution.

FMEA Analysis

Potential Effect(s) of Failure	Potential Causes of Failure	RPN	Recommended Actions (s)	Actions Taken	RPN	Improve %
Wrist attachment would not be held in solid state	Too much shear force for pin to hold, faulty spring from manufacturer	70	Analysis on forces acting upon pin joint and check pins to ensure spring action is proper	Performed analysis of forces of rotation on joint, compared with shear strength of plunger, strength of plunger is sufficient	28	60%
Wrist attachment would not be held in solid state, would freely revolve and may lead to detachment	Too much shear force for pin to hold, faulty spring from manufacturer	70	Analysis on forces acting upon pin joint and check pins to ensure spring action is proper	Performed analysis of forces of rotation on joint, compared with shear strength of plunger, strength of plunger is sufficient	28	60%
Break during manufacturing could scuff/scratch surface material, could also cause operator injury	User error of not using proper end mill for surface finish, user error of applying too much force to end mill causing breakage	36	Understand manufacturing process and forces delivered on end mills	Researched End mills and ordered end mills that are capable of performing machining in our project	9	60%

Final Design





Testing

Structural Capability

Simulated stress testing was performed inside Autodesk Inventor it was found that the shear force threshold of the joint is 50lB given the aluminum machined body of the final form. In preliminary prototyping testing it was found that the ABS plastic shrunk by 1.2%, this was expected and within the normal shrinkage range of ABS.

Usability

- The initial testing for the wrist joint itself focuses on the modular attachment and detachment using the spring-loadded pin. The testing results are rather ideal, as with the proper tolerances and ergonomics design, the wrist joint can be attached and detached with bare hands.
- In addition to initial testing of the modular, removable design of the two wrist joints, the direction key proved to be functional as it only allows the joint to fit in from one single direction.