NORTHERN ARIZONA UNIVERSITY

Department of Mechanical Engineering

Team 7, AFO
ME 486C, Section 2

To: Dr. David Willy

From: Team 7, AFO

Date: September 9th, 2022

Re: Project Management

Reflection

The goals set by the capstone class were completed in addition to some other testing and manufacturing. These technical challenges were all important milestones in our Gantt chart, and it shows that we are on track with our project goals. The most successful and promising results/milestones that were achieved are listed below:

- The neutral angle adjustment prototype was tested for 10,000 walking and running steps with no failures.
- An angle sensor was developed to interface with the current prototype of the AFO.
- Spring stiffness data was collected to characterize the applied torque to the pulley as a function of ankle angle.
- A full CAD model of the device was developed, and all critical components of the powertrain passed a stress analysis using the expected forces during walking/running.

There are improvements that need to be made in communication between the team. Some of these include:

- More consistent progress updates
    - Use PowerPoint presentations or a template to organize content with discussion topics and updates on progress
- Smaller aspects of the project direction need to be determined before we move forward
    - Changes desired by client in torque sensing method and desired accuracy
    - Talk to client to get recommendations for manufacturing and ordering
- Stay on top of deadlines
    - Make small but consistent progress on large goals like big machining projects specifically for the pulley and neutral angle
- Break large projects into smaller more manageable goals
    - Have smaller deadlines that can track the progress of bigger manufacturing projects

There are a few design details that need to be completed before manufacturing of parts can begin:

- Plan to integrate the electrical systems to be compatible with our current GUI
- Package microcontroller electronics and finish writing the firmware
- Determine tolerancing for parts that need to be machined

Gantt Chart

Table 1: Fall 2022 Gantt Chart

Lerner Lab Project Schedule

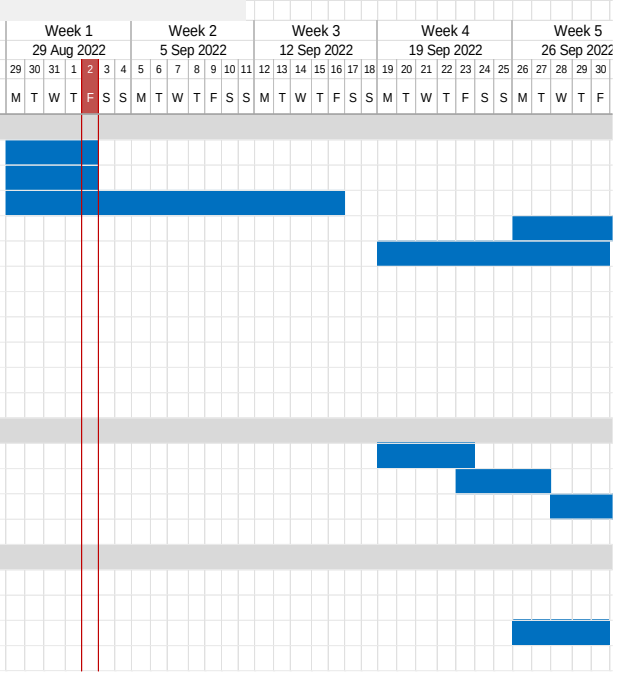
ME486C Fall 2022

Gantt Chart Template © 2006-2018 by Vertex42.com.

Project Start Date: 8/29/2022 (Monday) | Display Week: 1

Project Lead: Adrian Tran

WBS	TASK	LEAD	PREDECESSOR	START	END	DAYS	% DONE	WORK DAYS
1	**Team Deliverables**				-			-
1.1	Project Management	Sam		Mon 8/29/22	Fri 9/02/22	5	0%	5
1.2	Finalized testing plan	Adrian		Mon 8/29/22	Fri 9/02/22	5	0%	5
1.3	Self Learning	Individual		Mon 8/29/22	Fri 9/16/22	19	0%	15
1.4	Creating testing plan	Jacob		Mon 9/26/22	Fri 10/14/22	19	0%	15
1.5	Hardware Check 1	Sam		Mon 9/19/22	Fri 9/30/22	12	0%	10
1.6	Hardware Check 2	Adrian		Mon 10/03/22	Fri 10/21/22	19	0%	15
1.7	Hardware Check 3	Jacob		Mon 10/24/22	Fri 11/04/22	12	0%	10
1.8	Initial Testing Plan	Sam		Mon 10/17/22	Fri 10/28/22	12	0%	10
1.9	Product Demo and Testing Results	Jacob		Mon 11/21/22	Fri 12/09/22	19		15
1.11	Operation/Assembly Manual	Adrian		Mon 10/31/22	Fri 11/25/22	26	0%	20
1.12	Final CAD Package	Jacob		Mon 10/31/22	Fri 11/25/22	26		20
2	**Individual Deliverables**				-			-
2.2	Desired date to receive materials (Maybe order over break)	Adrian		Mon 9/19/22	Fri 9/23/22	5	0%	5
2.2.1	First Assembly	All		Fri 9/23/22	Tue 9/27/22	5	0%	3
2.2.2	First Tryout of Assembly	All		Wed 9/28/22	Sun 10/02/22	5	0%	3
2.3	Client Meetings Outreaches	Sam		Periodically			0%	-
3	**Media (Website/Poster)**				-			-
3.1	Poster Draft	Jacob		Mon 10/03/22	Sun 10/16/22	14	0%	10
3.2	Final Poster	Jacob		Mon 10/17/22	Fri 10/21/22	5	0%	5
4.3	Website Check 1	Jacob		Mon 9/26/22	Fri 9/30/22	5	0%	5
4.4	Website Check 2	Jacob		Mon 11/28/22	Fri 12/09/22	12	0%	10



The team did well last semester doing research and designing the product and plan on continuing this work this semester. The major milestones this semester include the 3 hardware checks, the poster and website checks, and the testing plan. The team plans to order all the parts within the first 2 weeks of the course to allow for proper delivery time to have most parts ready for the first hardware check. Once all the parts come in the team will start assembling within the week and will test the product within a week after that. Testing is being aimed to start on the 28th of September and finishing up by October 2nd. The team will hold meetings with the client, Dr. Lerner biweekly throughout the semester to provide updates and obtain approval on purchases and decisions.

Everyone also has a self-learning project due which each member will focus on learning something that will help progress the state of the project, especially in the manufacturing and assembly stages. As of the time of writing this memo, the team has not decided what we will be focusing on but will decide in the coming weeks.

Purchasing Plan

For our project, a soft budget was given to the team. Any purchased parts are going to be ordered through the Biomechanics Lab and the budget is not defined. The team will be given budget as the client deems necessary. Below in table 2 is the current bill of materials.

Table 2: Current Bill of Materials

Item No.	Item	Count	Make/Buy	Cost	Primary Vendor	Manufacturer	Lead Time	Part Status
1	Neutral Angle Adapter Footplate	1	-	Donated	Biomechatronics Lab	Biomechatronics Lab	None	In inventory
2	Neutral Angle Tube	1	Make	Donated	Biomechatronics Lab	Team 7	1 week	To be manufactured
3	Neutral Angle Pulley	1	Buy	$277.96	Protolabs	Protolabs	2 weeks	To be ordered by Sept. 8th
4	Tube Cap	2	Make	< $1.00	3d Printed	Team 7	2 days	To be manufactured
5	Spring	2	-	Donated	Biomechatronics Lab	Biomechatronics Lab	None	In inventory
6	Leaf Mount	1	Make	< $5.00	3d Printed	3D Printed	2 days	To be manufactured
7	Neutral Angle Slider	1	Make	< $1.00	3D Printed	Team 7	2 days	To be manufactured
8	Calf Cuff	1	-	Donated	Biomechatronics Lab	Biomechatronics Lab	None	In inventory
9	8017T2_D-Profile Shaft	1	Buy	$18.62	McMaster	-	1 week	To be ordered by Sept. 15th
10	6383K227_Bearings	2	Buy	$7.75	McMaster	-	1 week	To be ordered by Sept. 15th
11	Friction Pad	1	Make	Donated	Biomechatronics Lab	Team 7	1 week	To be manufactured
12	Neutral Angle Plate	1	Make	$6.23	McMaster	Team 7	1 week	To be manufactured
13	9687T441_D-Profile Collar	1	Buy	$24.57	McMaster	-	1 week	To be ordered by Sept. 15th
14	Steel wire	1	-	Donated	Biomechatronics Lab	-	None	In inventory
15	97763A431_M5 Screws	2	-	Donated	Biomechatronics Lab	-	None	In inventory
16	92095A113_M2.5 Screws	4	-	Donated	Biomechatronics Lab	-	None	In inventory

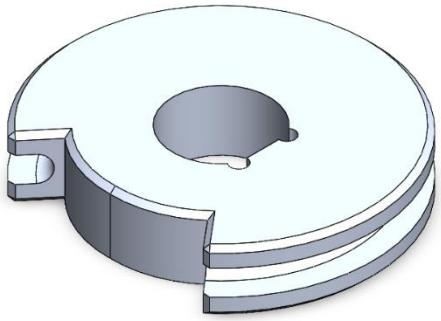
The purchasing plan will be following the current BOM. The purchased items are shown below in table 3 and in figures 1-4. Each purchased item is presented with a list of action items.

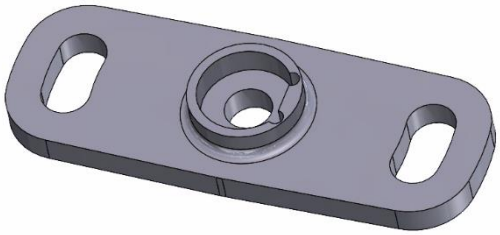
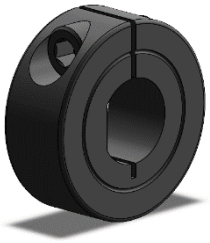
Table 3: Purchasing Plan for current BOM.

Item No.	Item	Count	Make/Buy	Cost	Primary Vendor	Manufacturer	Lead Time	Part Status
3	**Neutral Angle Pulley**	**1**	**Buy**	**$277.96**	**Protolabs**	**Protolabs**	**2 weeks**	**To be ordered by Sept. 8th**
9	**8017T2_D-Profile Shaft**	**1**	**Buy**	**$18.62**	**McMaster**	**-**	**1 week**	**To be ordered by Sept. 15th**
10	**6383K227_Bearings**	**2**	**Buy**	**$7.75**	**McMaster**	**-**	**1 week**	**To be ordered by Sept. 15th**
12	**Neutral Angle Plate**	**1**	**Buy**	**TBD**	**Protolabs**	**Protolabs**	**2 weeks**	**To be ordered by Oct. 1st**
13	**9687T441_D-Profile Collar**	**1**	**Buy**	**$24.57**	**McMaster**	**-**	**1 week**	**To be ordered by Sept. 15th**

The neutral angle pulley is the highest priority item on the team's list right now, it is expected to have the longest lead time. The pulley is responsible for transferring the force from the leaf springs to the footplate.

Table 4: **Action Items** for Purchased Items

Action Items, Pulley	
1. Preform GD&T analysis for shaft fitment and update model geometry 2. Preform FEA analysis on updated geometry and select material 3. Get a quote from Protolabs for new model 4. Meet with client to get an order approval **5.** Order from Protolabs by **Sept. 8th.**	 Figure 1: Neutral Angle Pulley
Action Items, D-Shaft	

1. Preform FEA analysis using given torque and confirm factor of safety >2 2. Order from McMaster-Carr **by Sept. 15th.**	 Figure 2: D-Profile Shaft
Action Items, Ball Bearings 1. Order from McMaster-Carr by **Sept. 15th.**	 Figure 3: Ball Bearing
Action Items, Neutral Angle Plate 1. 3d print item for fitment test with machined parts 2. Order from Protolabs by **Oct. 1st**	 Figure 4: Neutral Angle Plate
Action Items, D-Profile Collar 1. Look into other solutions for retaining the shaft assembly, snap ring, endcap, etc. 2. Order from McMaster-Carr by **Sept. 15th.**	 Figure 5: D-Profile Collar

Manufacturing Plan

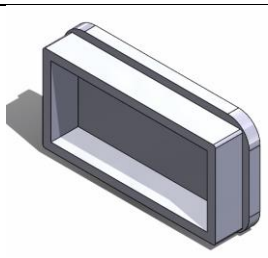
The biggest technical challenges in manufacturing this iteration are the steel neutral angle adjustment interface and steel pulley. Given the machinability of 303 stainless steel and the complex geometries of these parts we have concluded that it would be in the best interest of our time to have these projects outsourced. Machining the carbon fiber housing will be the next biggest challenge, however given the experience and available tools in the Biomechatronics Lab

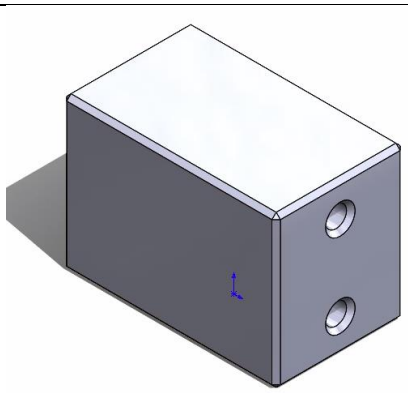
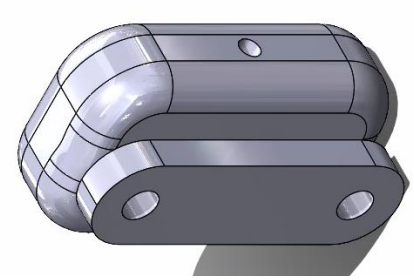
we believe this should be manageable for the team. The carbon fiber leaf spring components can be machined in a similar fashion on the Stepcraft CNC in the Biomechatronics Lab. The friction pad is made from friction clutch material available to buy in square sheets and is easily machinable, making it a project ideal for the Stepcraft CNC. Other parts will be 3D printed on a Markforged Mark 2 with composite reinforcement where necessary. This is available for use in the Biomechatronics Lab as well.

Table 5: Items to be Manufacture

Item No.	Item	Count	Make/Buy	Cost	Primary Vendor	Manufacturer	Lead Time	Part Status
2	Neutral Angle Tube	1	Make	Donated	Biomechatronics Lab	Team 7	1 week	To be manufactured
4	Tube Cap	2	Make	< $1.00	3d Printed	Team 7	2 days	To be manufactured
6	Leaf Mount	1	Make	< $5.00	3d Printed	3D Printed	2 days	To be manufactured
7	Neutral Angle Slider	1	Make	< $1.00	3D Printed	Team 7	2 days	To be manufactured
11	Friction Pad	1	Make	Donated	Biomechatronics Lab	Team 7	1 week	To be manufactured

Table 6: Action Items, Manufacturing Information for “Make” items

Action Items, Neutral Angle Tube Who: Jacob Due date: Sept. 19th. Material: Carbon Fiber Method: Stepcraft CNC Where: Biomechatronics Lab	
Action Items, Tube Cap Who: Samuel Due date: Sept. 21st. Material: Onyx Method: 3d printing Where: Biomechatronics Lab	

Action Items, Leaf Mount Who: Samuel Due date: Sept. 21st. Material: Onyx (Composite Reinforced) Method: 3d printing Where: Biomechatronics Lab	
Action Items, Neutral Angle Slider Who: Samuel Due date: Sept. 21st. Material: Onyx (Composite Reinforced) Method: 3d printing Where: Biomechatronics Lab	
Action Items, Friction Pad Who: Samuel Due date: Sept. 21st. Material: Friction material Method: Stepcraft CNC Where: Biomechatronics Lab