# Below the Knee Exoskeleton

Team: Ryan Oppel (Budget Lead), Alexandra Schell (Team Lead), Nicolas Watkins (Website and CAD Lead)

NAU NORTHERN ARIZONA UNIVERSITY

## **Design Efforts**

Our team has fully designed the Ankle Exo skeleton. Our parts and contributions consist of:

- Carbon fiber 3-D printed calf cuff bracket
- ECX Maxon Motor
- E-flite 22.2V Battery
- PCB sealed cover, battery protector, and switch housing unit with O-rings(IP rating of 54)
- Metal brackets for the motor mount
- Cardon fiber 3-D printed ankle joint wire gear
- Manufacturing of gears and mounts on the motor
- Sprocket cover





## **Design Efforts**

### What is the plan with the motors?

As stated in the last presentation, Our client wants to test the new motor further, so we have to see if it is an improvement in the design. We have created covers for this motor, but our client would like to further test this motor to see if we stick with it.

This new motor has a larger power output, but it comes with a large amount of weight which might be too much for our application.



## **Design Efforts**



## **Purchasing Plan**

- We had an original budget of \$4000, and we have purchased \$2084.56 worth of parts so far.
- Total Assembly had 59 parts/pieces.
- 12 parts have been purchased
- 36 parts have been donated
- 11 have been manufactured or are in the process of being manufactured
- 97% of the purchase is on hand (this will not set back our testing schedule)

Purchased Items:	Price
800cc Onyx Filament Spool	254.97
150cc Carbon Fiber CFF Spool	518.5
E-Flite 22.2v 910mAh li-po battery	53.29
ECXFL32L motor with a 1:35 Gear Ratio X2	599.51
Fluorine Rubber O-Rings, 42mm OD 38mm ID 2mm Width (pack of 10)	16.9
10 PCS O Rings Nitrile Rubber Round O-Rings Seal Grommets 185mm OD 181mm ID 2mm	
Width	16.91
SUNLU PLA 3D Printer Filament PLA Filament 1.75mm	27.27
Creality PLA Carbon Fiber Filament 1.75mm	39.28
Aluminum Brackets	75.00
Aluminum Mount	90.00
Aluminum Rachet and Picket	65.00
Aluminum Spacer	249.99
Total:	\$2084.56

## **Purchasing Plan**

- 100% of parts have Bean Purchased
- 100% of the quintessential Design has been complete
- 72.7% of parts have been manufactured
- We have spent approximately 4 days (96 hours) on printing parts, and we expect to spend 15 hours in future 3-D printing, 2 hours in manufacturing, and 8 more hours in assembly.
- By our calculations we have completed 79.33% of our manufacturing time.

Parts:	Part#:						
Roller Chain sprocket	Manufactured						
Big Gear modified							
Koge	Manufactured						
Foot plate	Manufactured						
Pully Quick connect	Manufactured						
Bridge pulley	Manufactured						
PCB sensor case	Manufactured						
Calf Cuff adjuster Cable Cover	Manufactured Manufactured						
Motor Bearing Case	Manufactured						
Battery Box Cover	Manufactured						
C.F. Upright	Manufactured						

Parts:	Column1
Bondable Flex Circuit	Donated
Cable Chain Linker	Donated
Carbon Fiber square tubing	Donated
Quick Connect torque sensor	Donated
Calibration Magnet	Donated
Sensor cable	Donated
Strain Gage	Donated
Torque Sensor Wires	Donated

Parts:	Part #	Price
6mm ball bearing	49DD43	Donated
35 mm button head screw	38DA12	Donated
flanged ball bearing	49 DD 88	Donated
M8 Steel locknut	38DH71	Donated
M8 steel button head bolt	811X86	Donated
socket head screw	5GUD5	Donated
Hex Head drive screw	5KY28	Donated
M8 bracket bolt	808A65	Donated
Cable Crimp	16X825	Donated
6M Cuff Locknut	38DH70	Donated
FSR	FSR01CE	Donated
small linkage chain.	B1293497	Donated
M3 Nut	4EFZ9	Donated
M3 hex flat screw	811YK3	Donated
Clearance Cable	2TAA1	Donated
Pogo Pin Connector	3RWL9	Donated
M2 flat head screw	6HB56	Donated
M2 nut	6CA66	Donated
M3 sealing socket head screw	6CE47	Donated
M5 button head screw	811X87	Donated
M5 lock washer	826K20	Donated
6mm M5 shoulder screw	38CZ28	Donated
Thermal Pads	1MVP8	Donated
M3 25mm flathead screw	38 DE 7 2	Donated
M5 12mm torque screw	26LG26	Donated
M8 bolt	808A65	Donated
6mm Washer	38CV95	Donated
Total:		Donated

## Manufacturing Plan

#### Current Plan:

 Switch out motor bracket for Aluminum ones.

#### Then test product

Part:	Cost:	Materials:	Manufacturing:	Manufacturer:	Part #:
Motor Cover	Undetermined	7075 Aluminum Alloy	Machined	NAU CNC	N/A
PCB Housing	518.5	PLA Carbon Fiber Filament	3D Printed	Biomechatronics 3D Printer	F-FG-0005
Motor - Mount Upright	Undetermined	7075 Aluminum Alloy	Machined	Ordered	N/A
Motor Mount - leaf	Undetermined	7075 Aluminum Alloy	Machined	Ordered	N/A
Upright	173.99	Carbon Fiber	Milled	Rock West Composites	25502
Front Cover 518.5 PLA Carbon Fiber Filament		3D Printed	Biomechatronics 3D Printer	F-FG-0005	











Arduino thermocouple DAQ assembled for testing motor housing thermals



Lerner's Ankle Exo-Skeleton:

Here is a view of an Ankle Exoskeleton we will be working with. Our team will be building off this exoskeleton and be modifying some parts and changing the design. As per Lerner's instruction this Exoskeleton will stay with him in his lab.



## **Gantt Chart**

3	Major Deadlines 2nd Semester																					
WBS Number	Task Title	Task Owner	Start Date	End Date	Duration	% Done	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
3.1	Engineering Model	Team	1/13/25	1/23/25	10	100%																
3.2	Test 2nd Prototype	Alex S	12/13/24	1/20/25	37	100%																
3.3	Analysis of 2nd Prototype	Alex S	1/13/25	2/1/25	18	90%																
3.4	Hardware Status Check 1	Team	1/13/25	2/13/25	30	100%																
3.5	Order all parts	Ryan O	1/13/25	2/13/25	30	98%																
3.6	Website check	Nick W	1/13/25	2/27/25	44	100%																
3.7	Testing Plan	Ryan O	3/1/25	3/27/25	26	90%																
3.8	Hardware Status Check 2	Team	2/13/25	3/6/25	23	100%																
3.9	Final CAD	Ryan O	3/6/25	4/3/25	27	100%																
4	Final Hardware Status and Prototype	Team	3/6/25	4/3/25	27	98%																
4.1	Website check	Nick W	2/28/25	4/17/25	47	80%																
4.2	Test and Analyze Protype	Alex S	4/3/25	4/17/25	14	20%																
4.3	Final Report	Team	4/1/25	4/17/25	16	0%																

## **Overall Percents**

Task	Percent Complete	Percent on Hand
Design Efforts	100%	
Purchasing Plan	100%	97%
Manufacturing Plan	99% time	
Demonstration	97% of parts	

# **Thank You!**

