Lerner Exoskeleton Actuator

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Content:

- Project Description
- Customer needs & Engineering Requirements
- Final Product
- Design Solution
- Manufacturing
- Testing
- Result
- Future Improvement
- Conclusion
- Acknowledgements

What is Cerebral palsy ?

- Cerebral palsy is a type of disorder that affects a person to have a difficulty in maintain balance and posture.
- Cerebral means having to do with the brain.
- Palsy the weakness or problems with the muscles

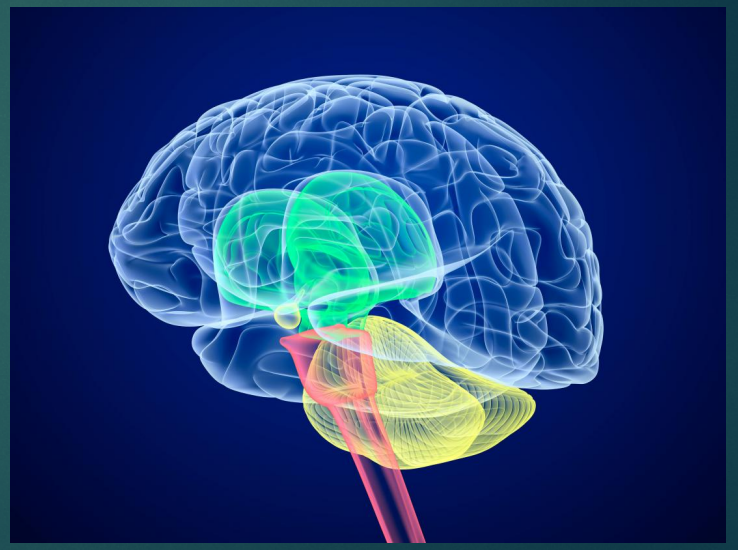


Figure 1: Brain

What is Clinical Gate ?

- Clinical Gate is the eight phases walk from the point of view in Medical field that represent the human movement.

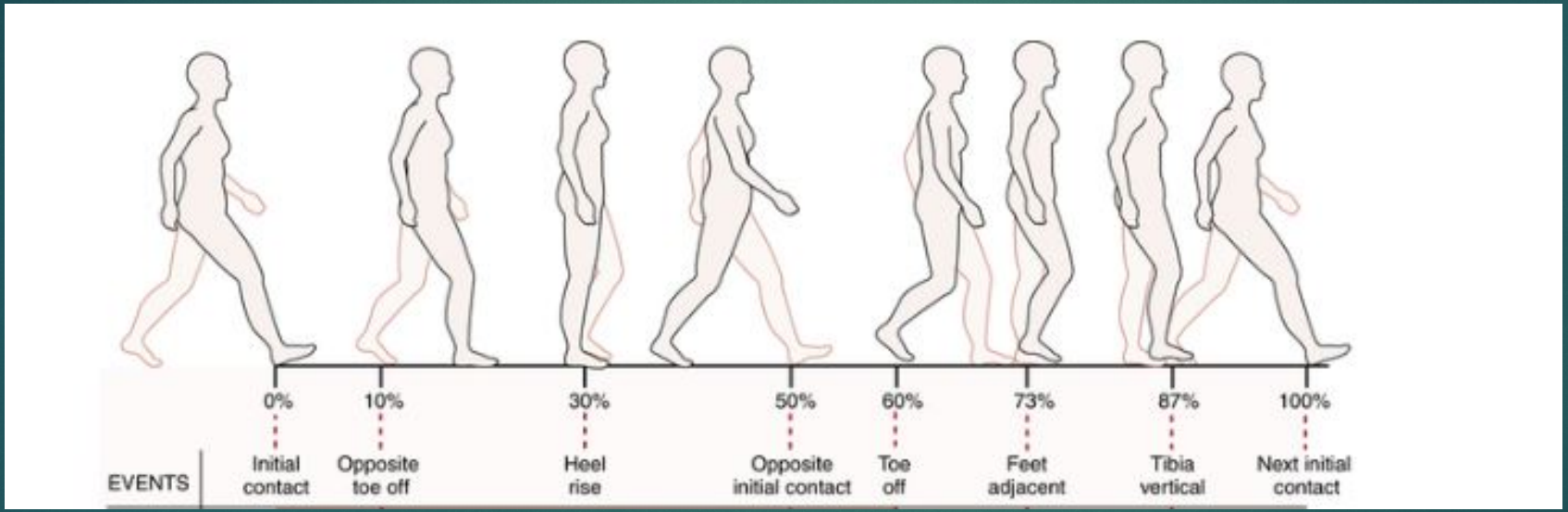


Figure2:Clinical Gate

Project Description

- Design a series elastic actuation system for a robotic lower-extremity exoskeleton
- Our device should:
  - Help people with disability
  - Provide clinical gait .

Definition of Exoskeleton:
The Exoskeleton is device used to help and improve the human life.

Where can we use it?
We can use the Exoskeleton on the outer human body.

- Our Goal:
  modify the current Exoskeleton to have a clinical movement for the ankle (using the engineering requirements)

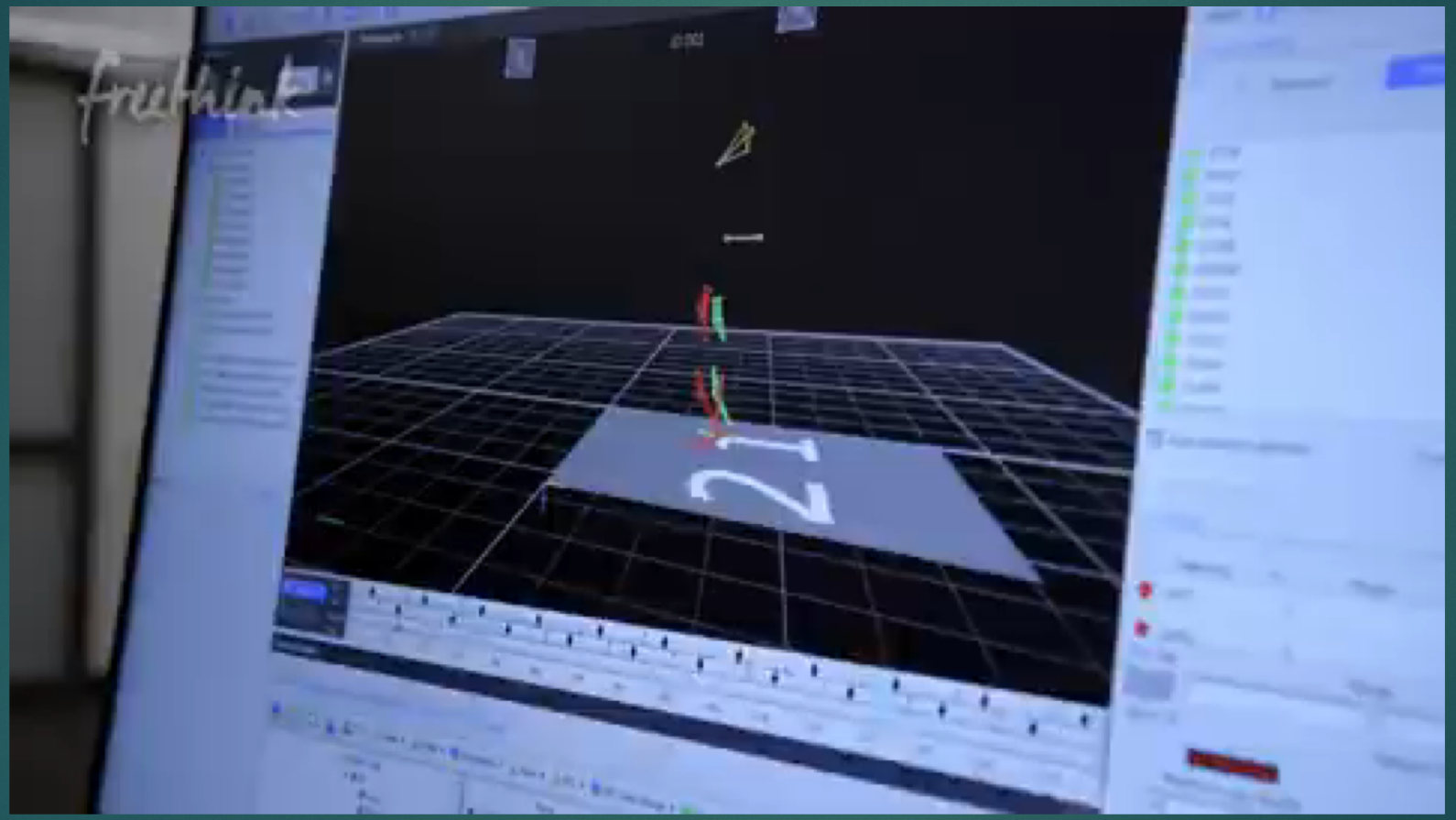
Client

- Zach Lerner, Ph.D.
- Director of NAU's Biomechatronics Lab
- Our Stakeholders are people with disability



- Why is it important?
- To help people with disability needs

Exoskeleton video



Customer needs & Engineering Requirements

Table [1]

Customer Requirements	Description
Measure torque	0-7 Nm out of the motor 0-21 Nm out of the pulley
Weight	Patient 50 lbs-150lbs
Spring location	design selection for the spring
Non-invasive	Dose not contact the ankle
simple	Not complicated design

Final Product

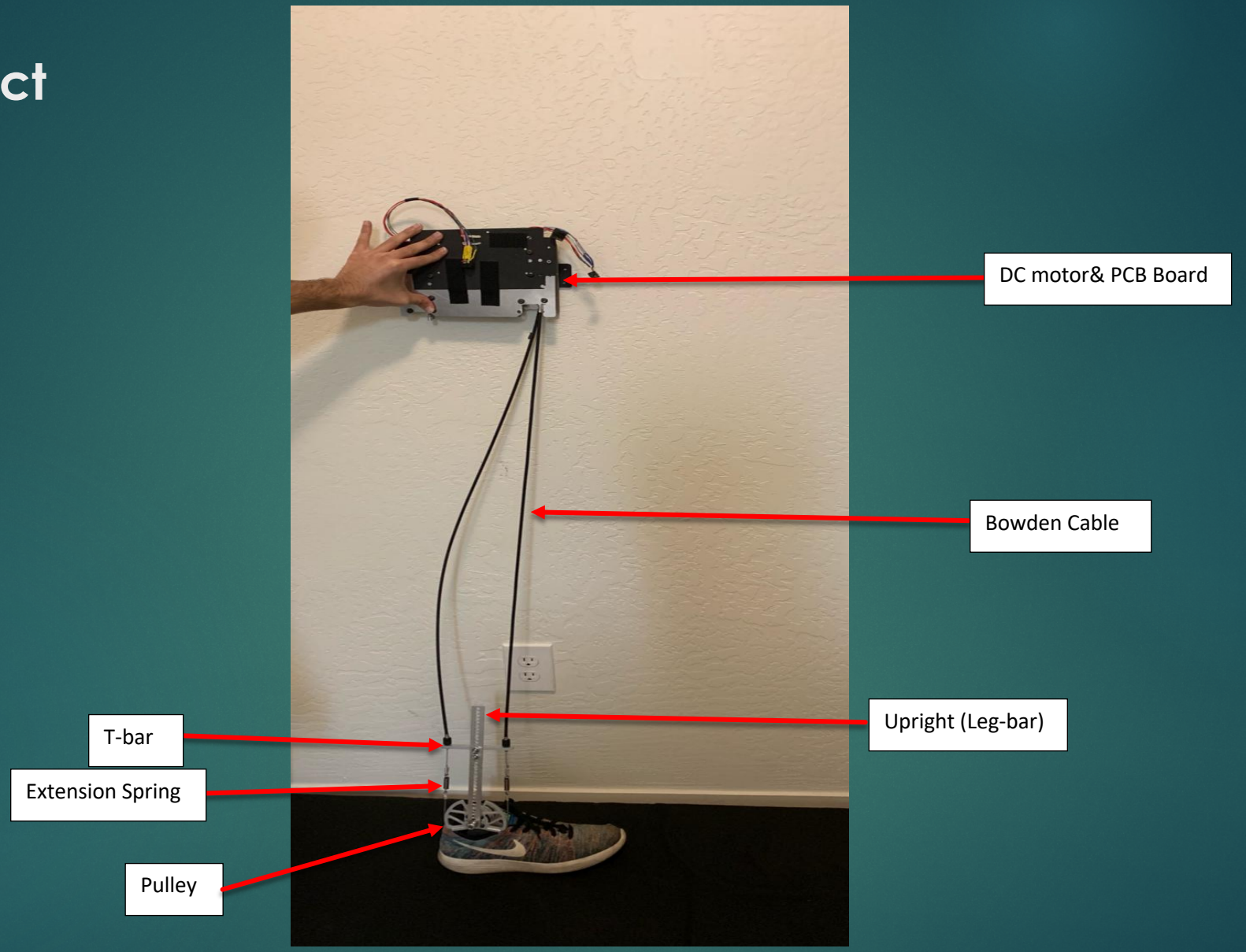


Figure 3: Final product with Subsystem labels

Final Product (upper part)

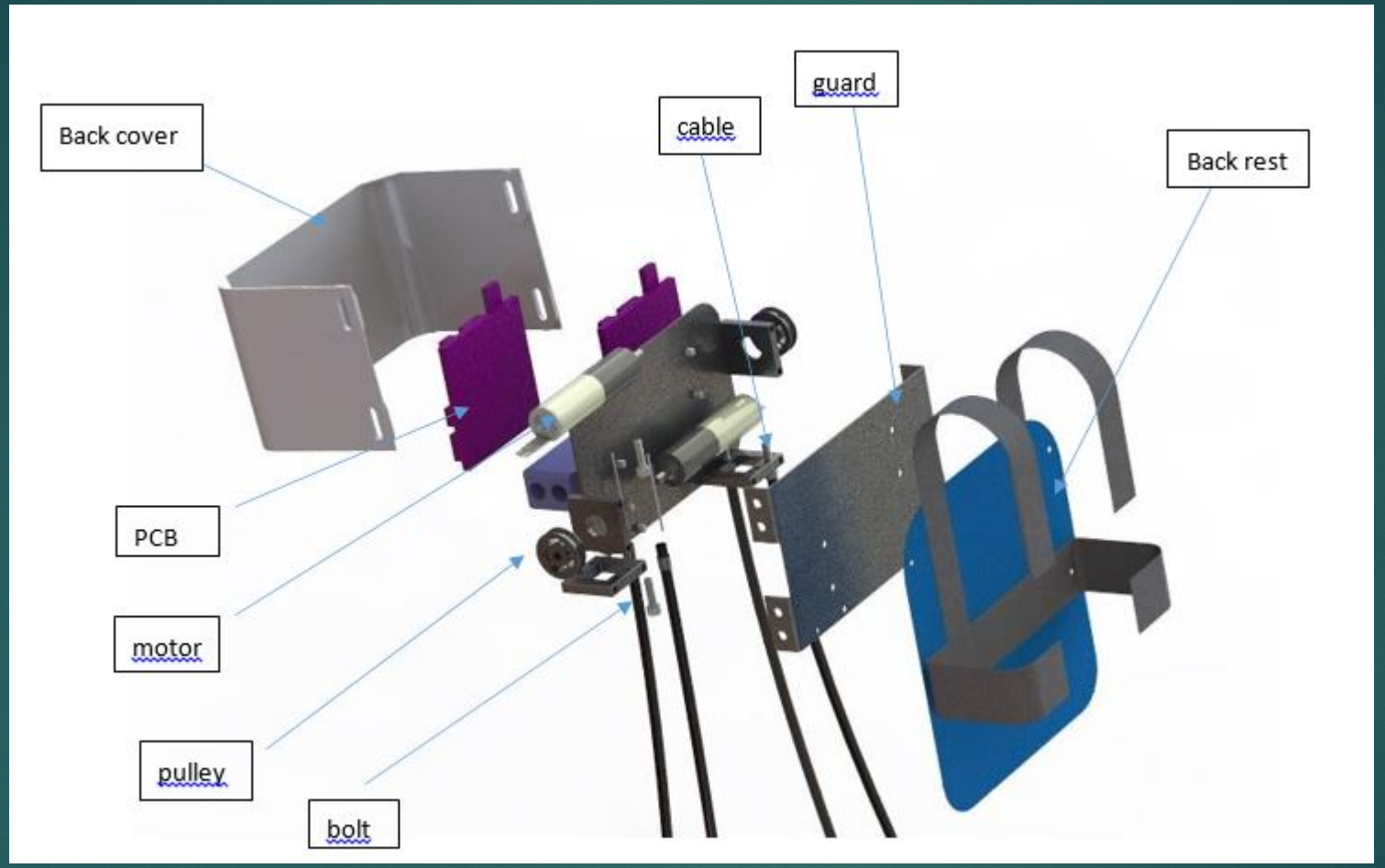


Figure 4: Upper part with subsystem labels

Bowden Cable (Mid part)

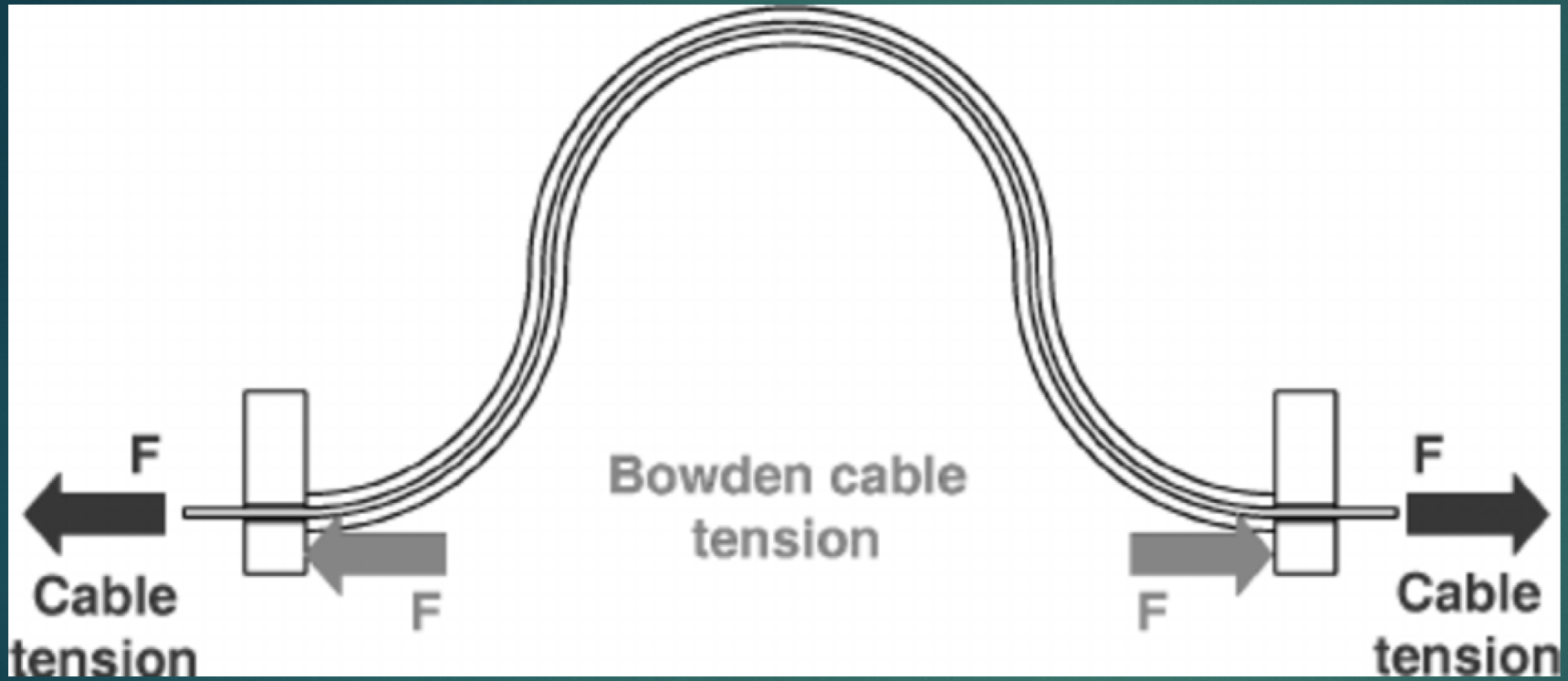


Figure 5: Bowden Cable

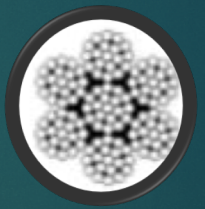


Figure 6: Bowden Cable Detailed view

Final Product (Lower part)

- The design that was approved by the client
- The idea of this design met the engineering requirement according to our analytical overview
- The maximum amount of force on the spring can hold the required weight provided by our client
- Based on the Calculation it will provide the required Torque output
- Found The perfect location for the spring
- The design is simple based on the customer needs



Figure 7: Final product lower part

Design Solution

- Our task was to modify Dr. Lernner current Exoskeleton
- Improvement to old design:

1. Leg bar
2. T-bar
3. Spring

Upright-Leg Bar

- Increase the length of the leg bar:
- because we need the pulley to rotate more

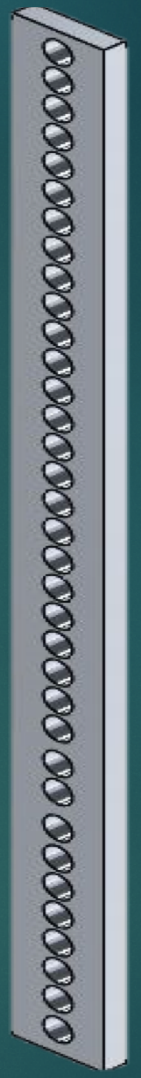


Figure 8: Upright-Leg Bar

T-bar

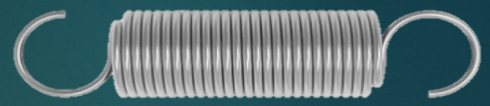
- Increasing the width of the T-bar:

So that the spring dose not contact the metal bar



Figure 9: T-bar

Spring



- First, Deflection of the Spring:

$\delta = \frac{8\ x\ Na\ x\ D^3 x\ F}{G\ d^4}$ = 10.5 mm

- Na = Length of the Spring/ Dia. Of wire= 25 Numbers of Turns.
- Spring Force Constant/ Stiffness of Spring:

$$K = \frac{F}{\delta} = 9.7\ N/mm$$

Spring Index :

$$C = \frac{D}{d} = 4.45$$

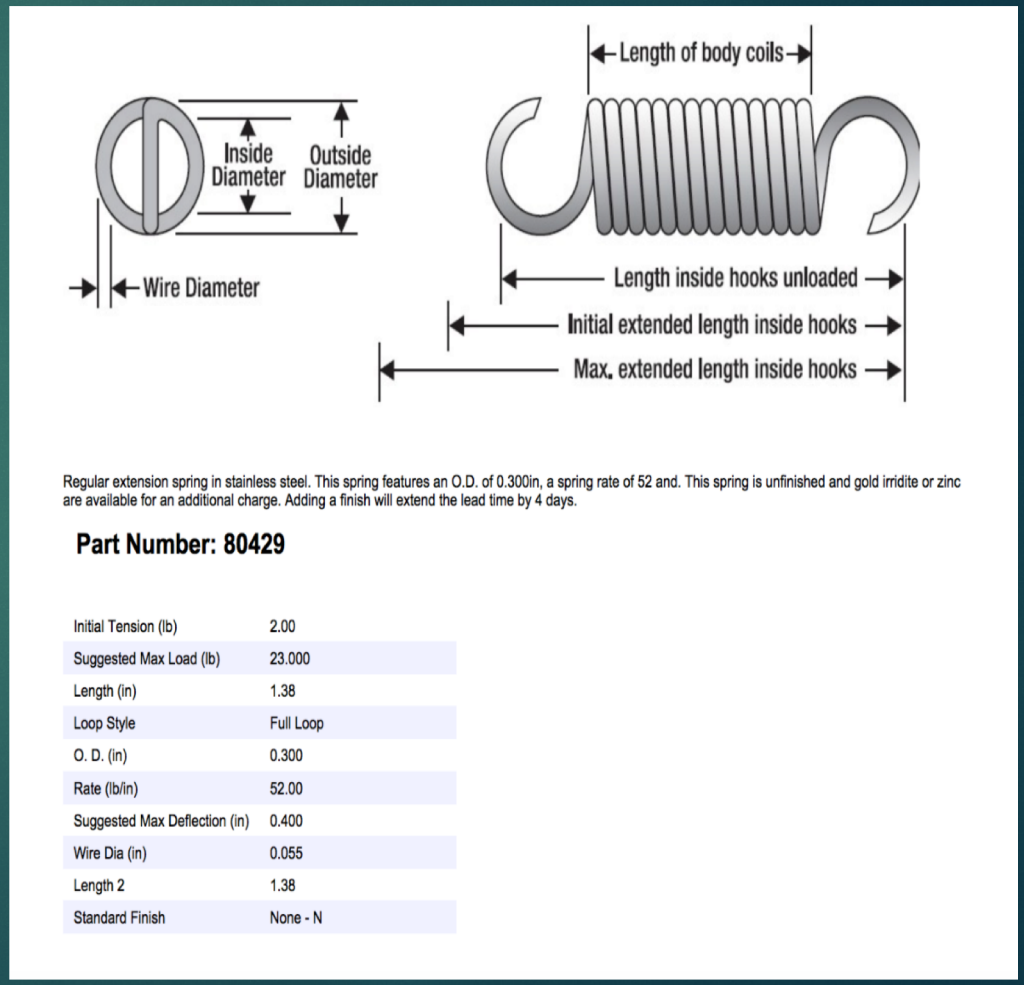
- Solid Stress:

$\tau_s = Max.Torsional\ Stress\ x\ F_S = 915.55\ Mpa$

Factor of Safety

$ns = \frac{S_{yt}}{\tau_s} = 1.04$

- Force of Spring(Load that Spring Can Withstand) = K* δ = 635.35 N
- Maximum Force of the Bowden Cable=588N
- Torque out of the pulley 20.40 Nm
- Torque out of the motor 6.97 Nm



Regular extension spring in stainless steel. This spring features an O.D. of 0.300in, a spring rate of 52 and. This spring is unfinished and gold irridite or zinc are available for an additional charge. Adding a finish will extend the lead time by 4 days.

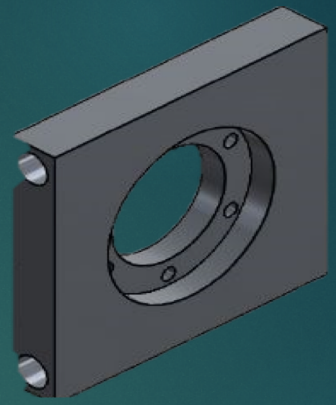
Part Number: 80429

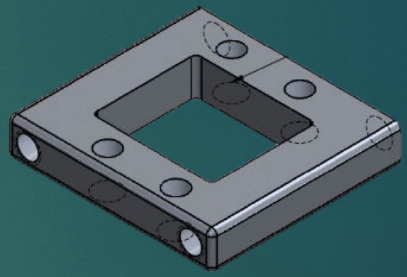
Initial Tension (lb)	2.00
Suggested Max Load (lb)	23.000
Length (in)	1.38
Loop Style	Full Loop
O. D. (in)	0.300
Rate (lb/in)	52.00
Suggested Max Deflection (in)	0.400
Wire Dia (in)	0.055
Length 2	1.38
Standard Finish	None - N

Manufacturing

- CNC (1)
  - Motor Support Bracket
  - Motor Block
  - T- bar
  - Threads for the T-bar
  - Leg Bar
- Sheet Metal
  - Foot Plate









Testing

- The testing of the project will have 2 phases:

1- By the team:

- Test to see if the mechanism is function

2- By the client:

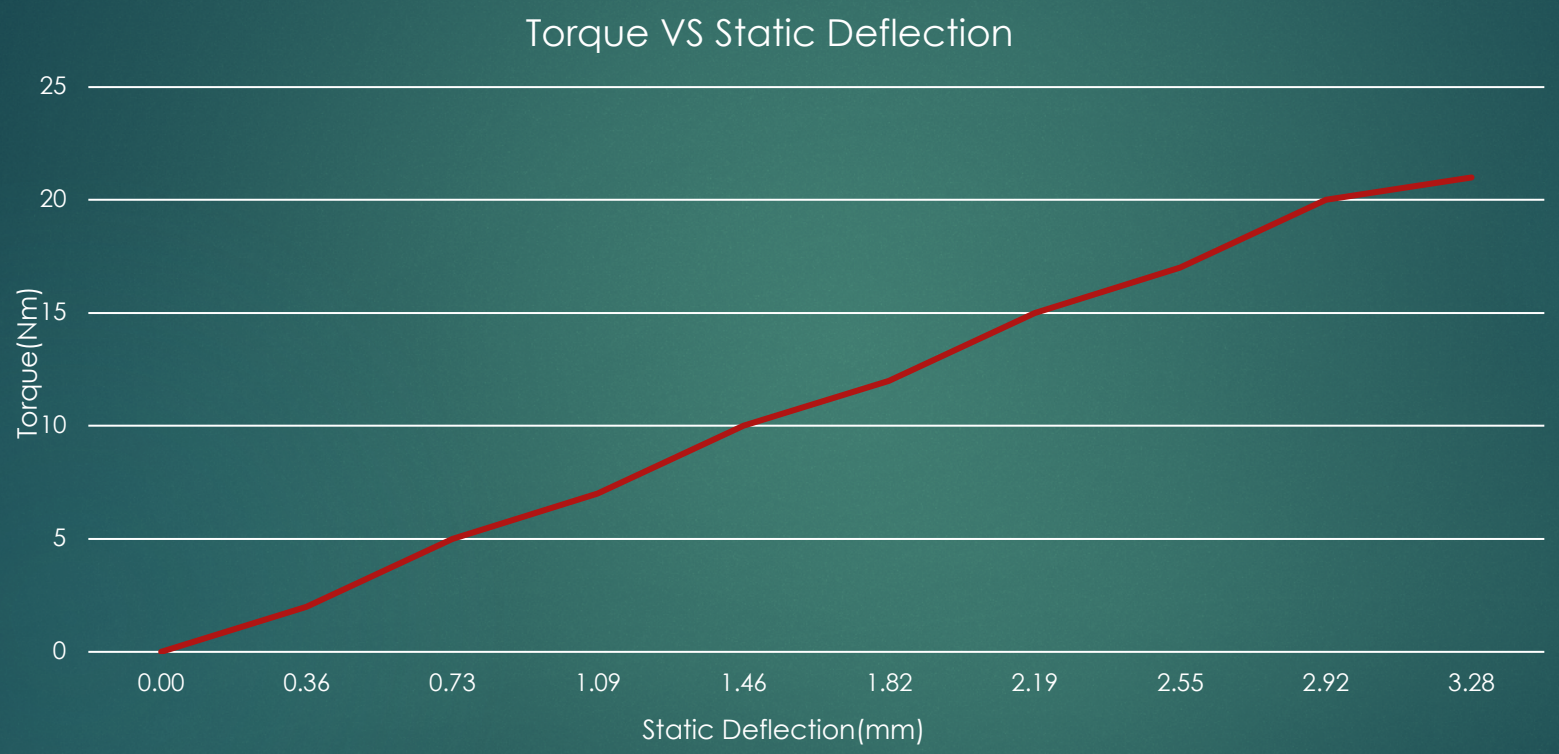
- The client will test the design to see if the device is meeting the requirement

Result

Table[2]

Engineering Requirement	Met or Not
0-7 Nm out of the motor 0-21 Nm out of the lower pulley	Met
Patient 50 lbs-150 lbs.	Met
Selection for the spring	Met
Does not contact the ankle	Met
Simple design	Met

Result



Graph 1: Torque VS Static Deflection Graph

Future Improvements

- Make the Foot plate and pulley from other materials like Carbon fiber
- Change the backpack to belt
- Decrease the size of the pulley

Conclusion

- Gained experience:
- Machining
- Transfer of Torque from one point to another
- Biomechanics
- Series elastic actuator system

Acknowledgements

- NAU Biomechatronics Lab & Dr. Lerner
- NAU



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Acronyms

- 1.CNC-(Computer Numerical Control)
- 2.PCB- (Printed Circuit Board)

References

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- [2] "Helping Kids Walk With Wearable Robots," *Freethink*, 12-Mar-2019. [Online]. Available: https://www.freethink.com/shows/superhuman/season-3/helping-kids-walk-with-robots. [Accessed: 12-Mar-2019].
- [3] Clinical Gate. (2019). *Gait*. [online] Available at: https://clinicalgate.com/gait-2/ [Accessed 26 Apr. 2019].

Any Questions ?