FPL Lower Body Exoskeleton

Group 1

Thomas Kipping – Computer Engineering

Ford Perry – Electrical Engineering

Moose Atiya – Electrical Engineering

Kaden Poulter – Electrical Engineering

Christopher Oliveira – Electrical Engineering

Sponsored by Florida Power & Light

Project Description - Kaden

To create an exoskeleton that will help linemen be able to climb poles more efficiently and for it to be less strenuous on the body. It will consist of multiple motors to help linemen ascend and descend high-powered electrical poles. It needs to be cheaper than the other exoskeletons on the market.

Goals

Basic

Design a system of four motors that will power the knee joints and hip joints

Design a control system that will allow the microcontroller to control the exoskeleton motors

Provide suitable power to motors and other electrical components

Advanced

Design a control system that connects the user’s body input to the exoskeleton motors through the use of sensors

Design a fail safe system that senses if the user falls and will shut off the exoskeleton when the need arises

Test a sub assembly of the exoskeleton to extract raw date before assembling the exoskeleton

Stretch

Create a UI to show the battery usage, battery life, and to input the users height and weight

Build a working exoskeleton prototype

Objectives

To build an exoskeleton to help linemen be able to climb poles faster and more efficiently.

Project Function

Reference input of customer, marketing analysis of competing product, projects used to identify project features (no “numbers”, conceptual, specific, descriptions such as “light weight, portable, low cost, easy to use, high power, accurate, etc.” when identifying project goals.)

Table 1. Requirements and Specifications - Thomas

Designation	Requirement	Unit
DR 2	The system shall have a locking mechanism that can lock and unlock.	≥ 54 Nm ≥ FOS of 2
DR 3	The system shall withstand all necessary environments, ESD, heat, cold, water, and fire, for one hour.	≥ 0 Fahrenheit ≤ 109 Fahrenheit ≥ 30 seconds in water
DR 4	System shall have a safety system that will keep the user safe in case of failure or emergency.	≤ .5 second reaction ≥ 50000 N impact ≥ 36.6 meters
DR 5	The system shall be a comfortable, adjustable, and practical tool to assist in the climbing power line poles.	≤ 100° F ≥ 96° F ≤ 120° of motion
DR 8	The system shall be designed to minimize the number of parts while using safe and cost effective materials that are replaceable where possible.	≤ $4500 ≤ 50 parts total ≥ 4 replaceable parts
DR 9	The system shall be able to ascend and descend a utility pole disregarding any obstacles on the pole.	5.5 inch wide obstacles 360 movement
DR 12	The system shall provide a hybrid active and passive solution to generate torque at the knees and hips to reduce the user's workload and strain.	> 10 Nm active

Standards
Microcontroller (Ardiuno, MSP430, RasberryPi) Libraries
Voltage ratings (120V outlet)
Current ratings
Battery Pack (LiPo) connectors and chargers
Metal finishing
3D printing

Table 1 describes the 7 system requirements and specifications that are most relevant to the electrical design of the system. There are 14 total requirements that are sourced from the customer, Florida Power and Light. Three requirements are highlighted to designate that these could be demonstrated.

Fig 1. Hardware/Software Block Diagram - Moosa and Ford

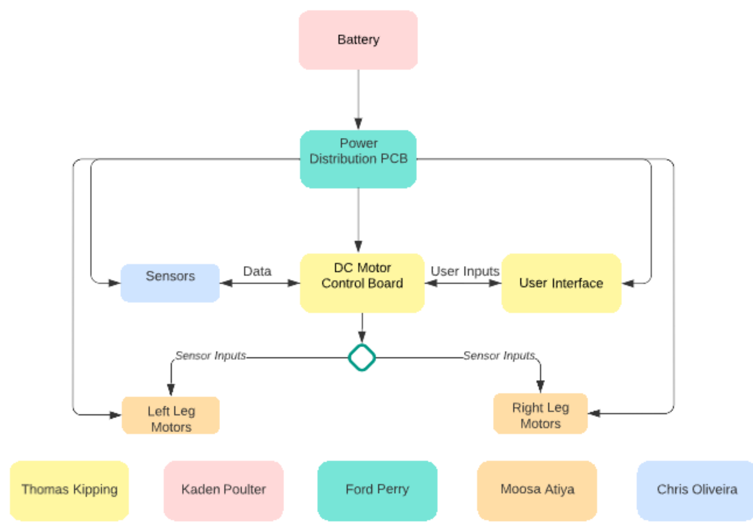

Fig 1: Thomas Kipping will be in charge of the DC motor and the control board, as well as the user interface. His Major being computer engineering, he has a strong background in coding.

Kaden Poulter will be in charge of choosing the proper battery and integrating it with the exoskeleton. Constant active discussion with the other members to find the battery most suitable for this build.

Ford Perry will be in charge of the Power Distribution and PCB board. With his strong background, he will be able to lead the design for the PCB board and to best distribute the power for the exoskeleton.

Moosa Atiya will be in charge of the motors. The motors are one of the most important aspects of the build and with his strong experiences using motors in the past, he is well equipped on choosing the correct motors and power outputs.

Chris Oliveira will be in charge of the sensors. With the constant movement and for the motors needing to know when to kick on and off, it is important to have someone be able to properly choose the correct sensors and have to integrate it with the rest of the body.

Fig 2. Project Illustration - Moosa and Ford

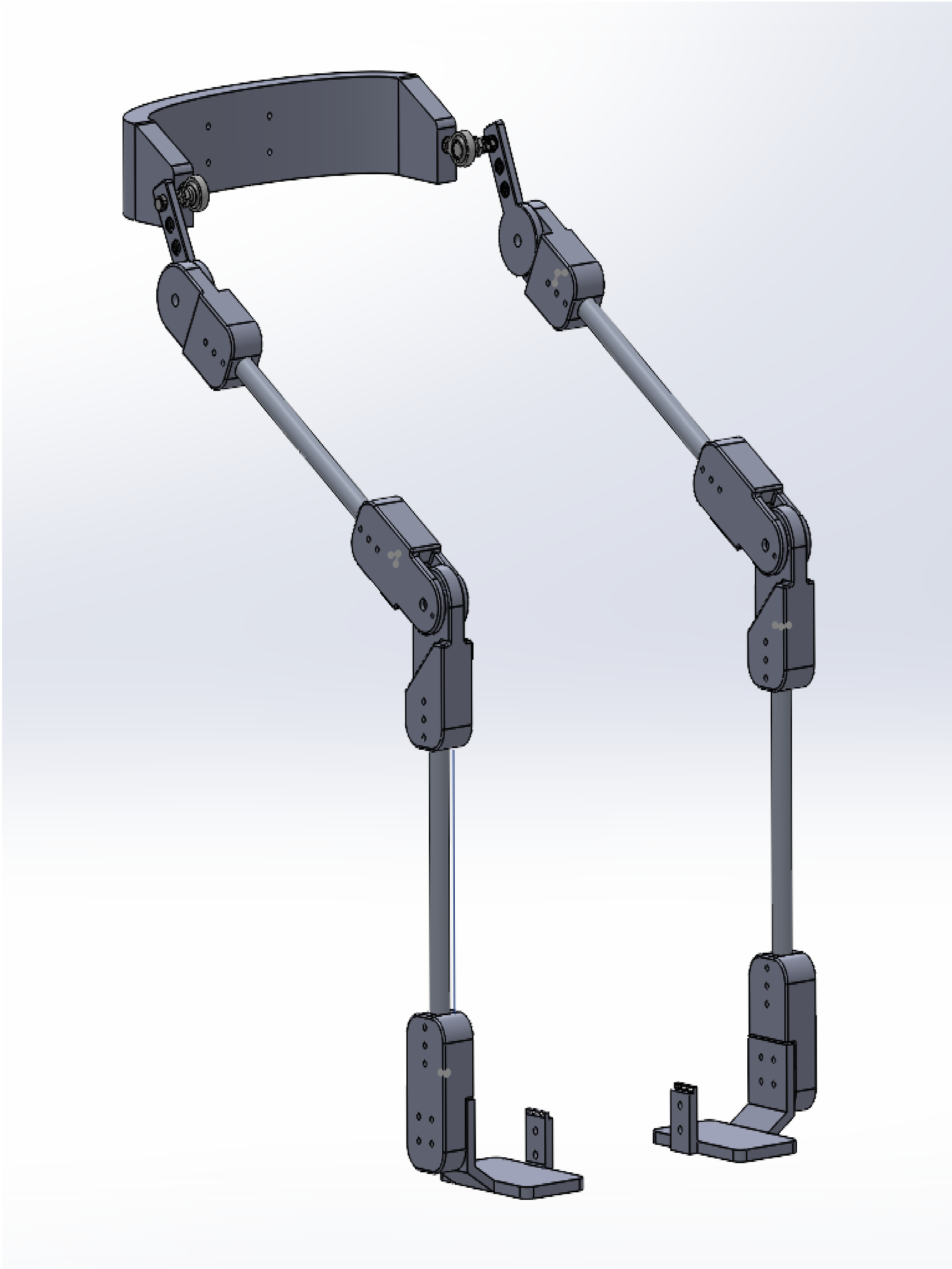

Fig 2: Rough model of our lower body exoskeleton design. With fully functional and motorized hip and knee joints, and a battery pack with User Interface located on the back panel.

Project Budget - Chris

Financing breakdown:

Max budget: $5,000

Exoskeleton metal and assembly - $450

(4) Motor - $2,800

(4) Battery - $692.89

Control Board - $25

Motor speed controller - $10

Motor High Torque speed reduction - $14

High Power Motor Driver Module - $11

Miscellaneous - $350

Total: $4,352.89

Breakdown expanded:

(4) Battery - $173.22 (average price) * 4 (units) = $692.89

(4) Battery - $700.00 (Average price) * 4 (units) = $2,800

Project Milestones - Thomas

Fall Semester

1. Divide and Conquer
2. Choose Motor
3. Choose Battery
4. Divide and Conquer V2
5. Choose Microcontroller
6. Assignment on Standards
7. PCB Prototype
8. Finish Component Testing (Single battery and motor)
9. 60 Page draft
10. Finish Subsystem Testing (Single joint)
11. 100 Page draft
12. Frame 3D Print Prototype
13. Final Draft

Spring Semester

1. Develop software
2. Test PCB with subsystem
3. Full Assembly Built
4. Full Assembly Tested
5. Final presentation and demonstration

QFD: House of Quality C. Battles. (2011, May). QFD House of Quality Template. Schrodinger's Ghost.com [Online]. Available: http://www.schrodingersghost.com/?cat=54.

Project: FPL Exoskeleton
Revision: 2
Date: 10/07/2022

Correlations	
Positive	+
Negative	−
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

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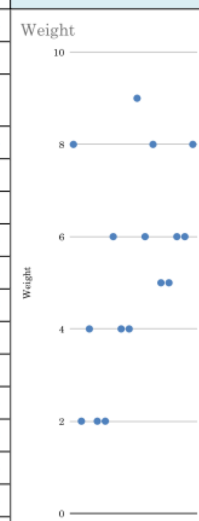
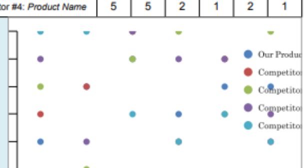
Category	Weight	Customer Requirements (Explicit and Implicit) / Engineering Requirements	1 Motors	2 Control System	3 Battery Pack	4 Bungey System	5 Power Distribution Board	6 User Interface	Our Product	Competitor #1: *SuitX LegX*	Competitor #2: *Lockheed Martin Fortis*	Competitor #3: *Rewalk Robotics Person*	Competitor #4: *Cyberdyne HAL*	Row #
		Direction of Improvement	▲	▼	◇	◇	◇	▲						
Safety	8	Locking Mechanism	●	●	○	▽	▽	▽	3	3	4	1	5	1
	2	Insulated materials	▽	○	●	▽	●	▽	5	4	1	2	4	2
	4	Withstand temperatures between 0 and 10	▽	○	○	○	●	○	1	2	4	0	2	3
	2	stand full submersion underwater for 30 sec	●	●	●	▽	●	●	6	4	0	4	5	4
	2	Fire Resistant rating	○	○	●	○	○	○	4	3	1	2	2	5
	6	User safety system	○	●	○	○	▽	○	2	6	5	6	1	6
	4	Withstand fall of 120 feet	○	○	○	●	○	●	4	5	9	8	6	7
	4	Withstand impact force of 50000N	○	○	○	●	○	○	9	7	1	4	8	8
	9	Safety Harness	▽	▽	▽	●	▽	▽	1	3	2	3	6	9
	6	Fall resistance mechanism	○	○	▽	●	▽	▽	2	1	3	2	4	10
	8	Manual override system	●	●	●	●	●	○	8	7	6	6	2	11
	5	Adjustable and comfortable	▽	▽	▽	○	▽	▽	6	8	4	8	3	12
	5	Transport system	▽	▽	▽	○	▽	▽	4	3	5	6	6	13
	6	Cheap and Replaceable parts	●	●	●	●	○	●	2	2	3	6	5	14
	6	Storage and tool compartments	▽	▽	▽	▽	▽	▽	6	7	1	5	6	15
	8	Hybrid passive and active	●	●	●	▽	▽	○	4	9	5	3	4	16
		Target	Target for Functional Requirement #1	Target for Functional Requirement #2	Target for Functional Requirement #3	Target for Functional Requirement #4	Target for Functional Requirement #5	Target for Functional Requirement #6						
		Max Relationship	9	9	9	9	9	9						

Customer Competitive Assesment: 0 1 2 3 4 5



Column #	1	2	3	4	5	6
Technical Importance Rating	66	76	74	74	56	52
Relative Weight	17%	19%	19%	19%	14%	13%
Weight Chart						
Our Product	1	3	4	2	3	3
Competitor #1: *Product Name*	2	3	5	1	4	1
Competitor #2: *Product Name*	3	0	4	5	2	5
Competitor #3: *Product Name*	4	1	5	4	4	2
Competitor #4: *Product Name*	5	5	2	1	2	1



Column # 1 2 3 4 5 6