Design of a non-invasive Hip Exoskeleton

- Team Members:
- 1.Lahdan Alfihan
- 2.Meshal Alghammas
- 3.Abdullah Almarri
- 4.Mohammed Janshah

Project Description

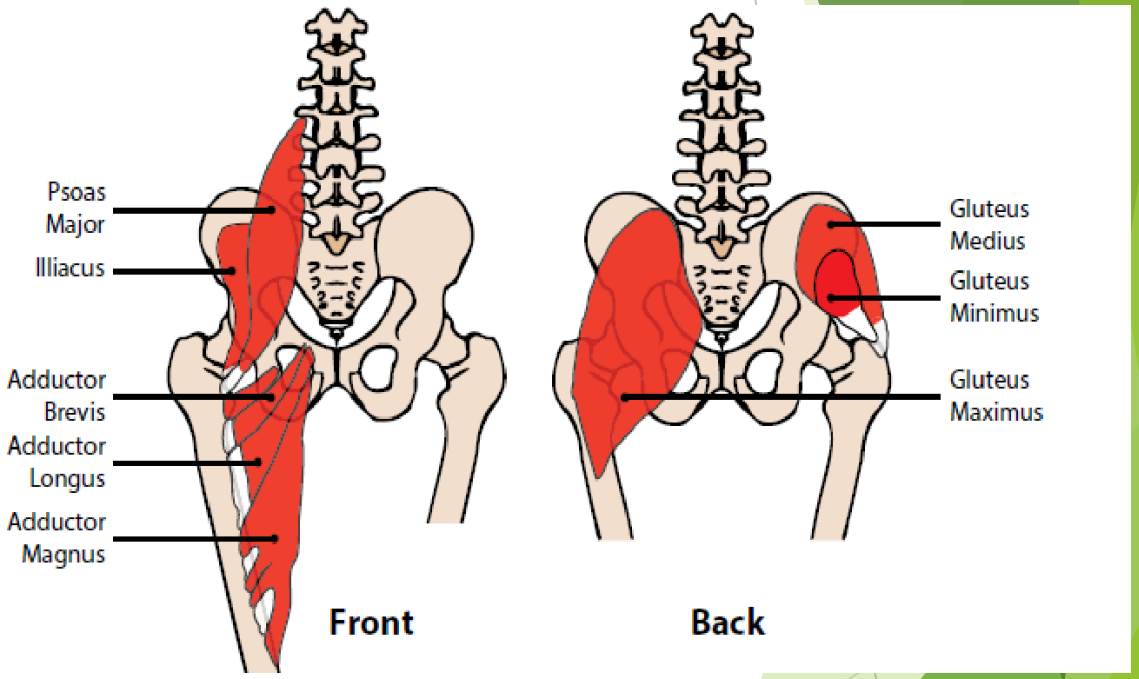
- The purpose of the project
- Existing exoskeletons
- The aspect of stability
- Budget
- Sponsors/Client

[1]

Lahdan Alfihan
10/07/2019
Hip exoskeleton

Background Information

- Large number of aged population requires exoskeletons for movements [2].
- Injured athletes requires them for support during the recovery period.
- Most of the existing designs of hip exoskeleton have minimal focus on the aspect of stability [3].
- Weight of the exoskeleton has been reduced extensively in the new designs.



[4]

Concept Generation

- Team members brainstormed the concepts to achieve the desired functionality.

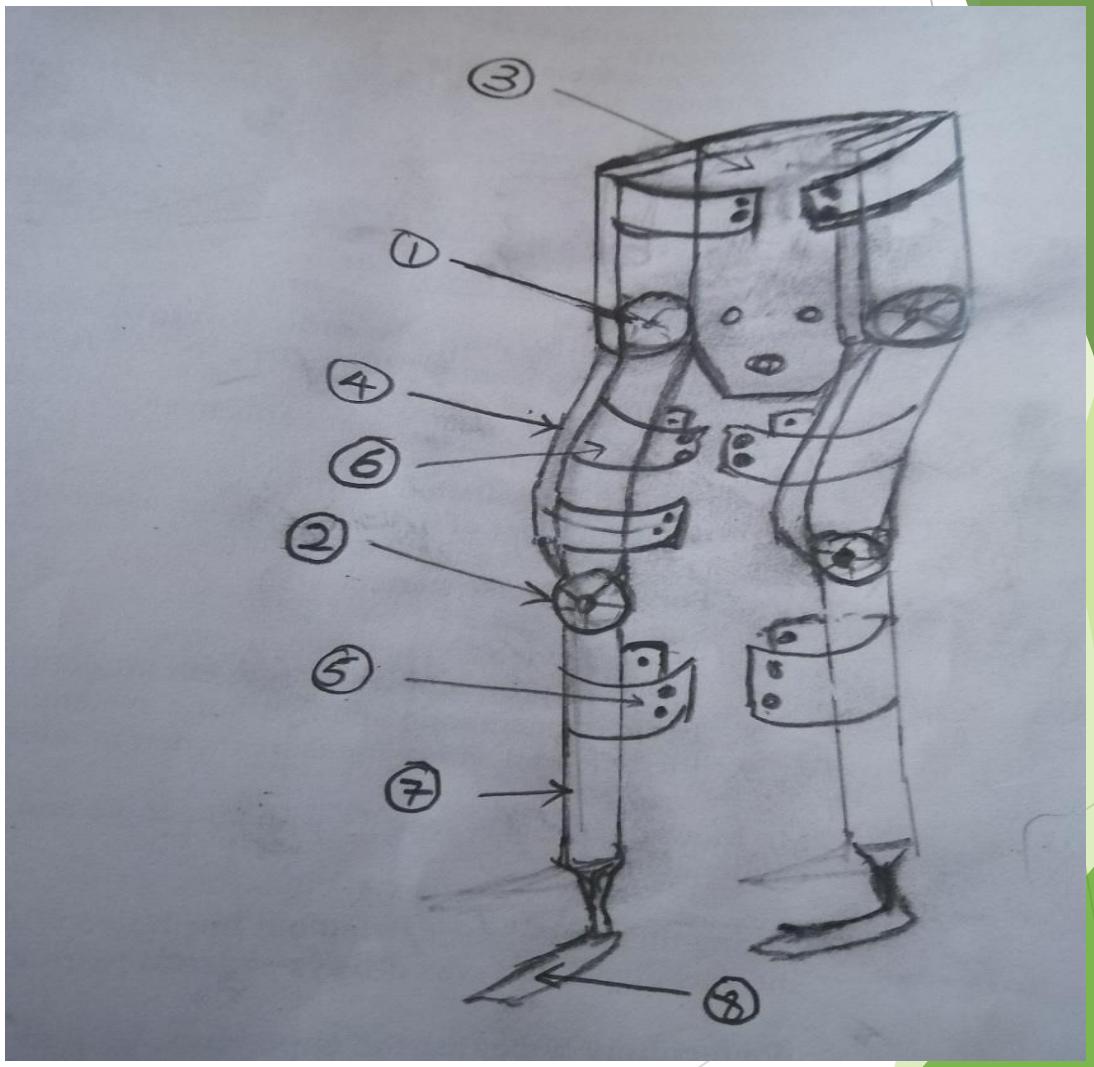
- Ten design. (see appendix A)

- Best three designs:

1. Pelvic Support and Leg Support
2. Lower body Support Suit
3. Robotic Exoskeleton

Design 1: (Pelvic Support and Leg Support)

- The design has three subsystems
  - The pelvic subsystem design
  - The thigh sub-system design
  - Leg support subsystem

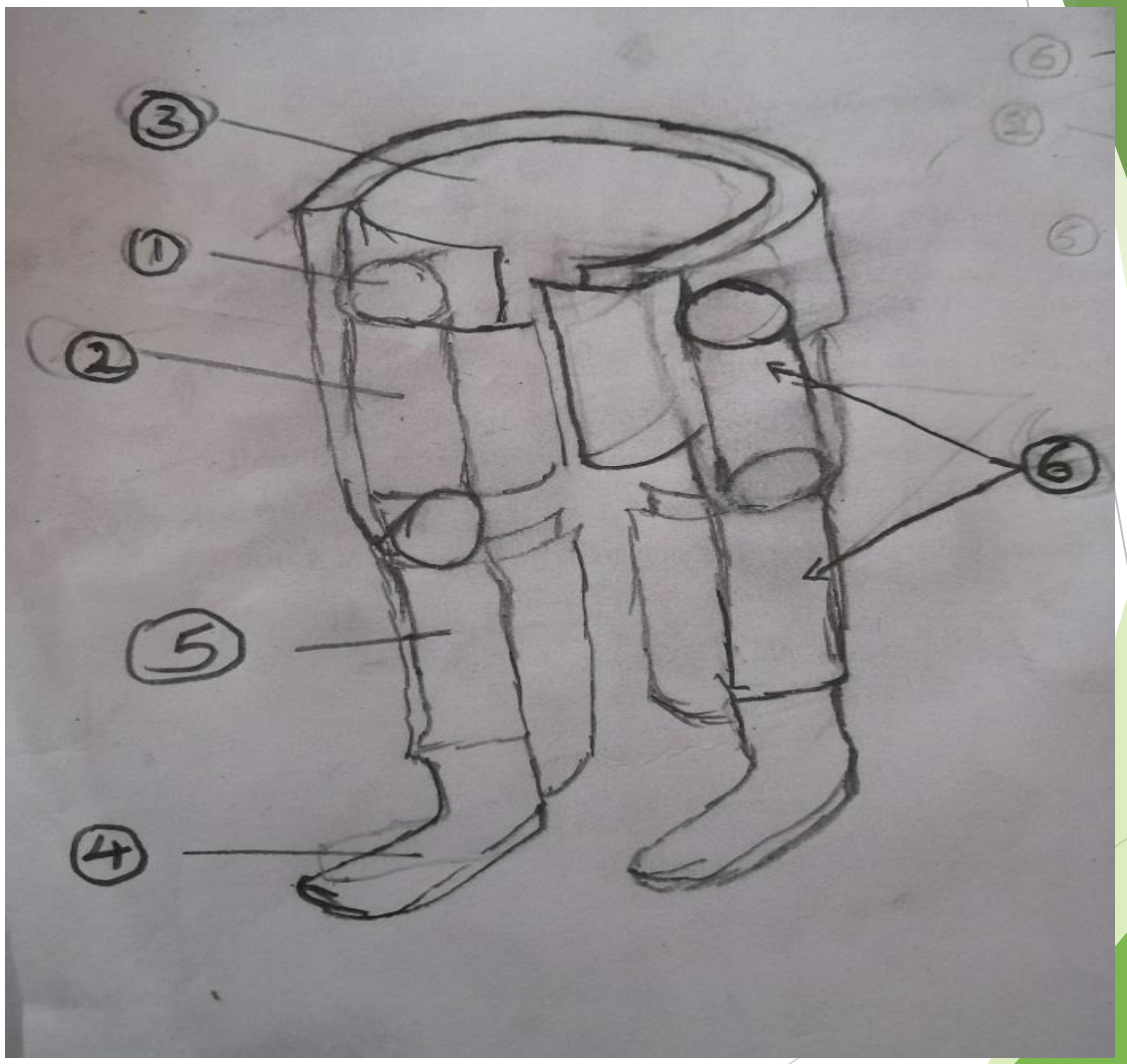


Appendix : A

Abdullah Almarri
10/07/2019
Hip exoskeleton

Design 2: Lower body Support Suit

- Contains a full suit for lower body
- uses small motors for actuations
- Inbuilt Sensors

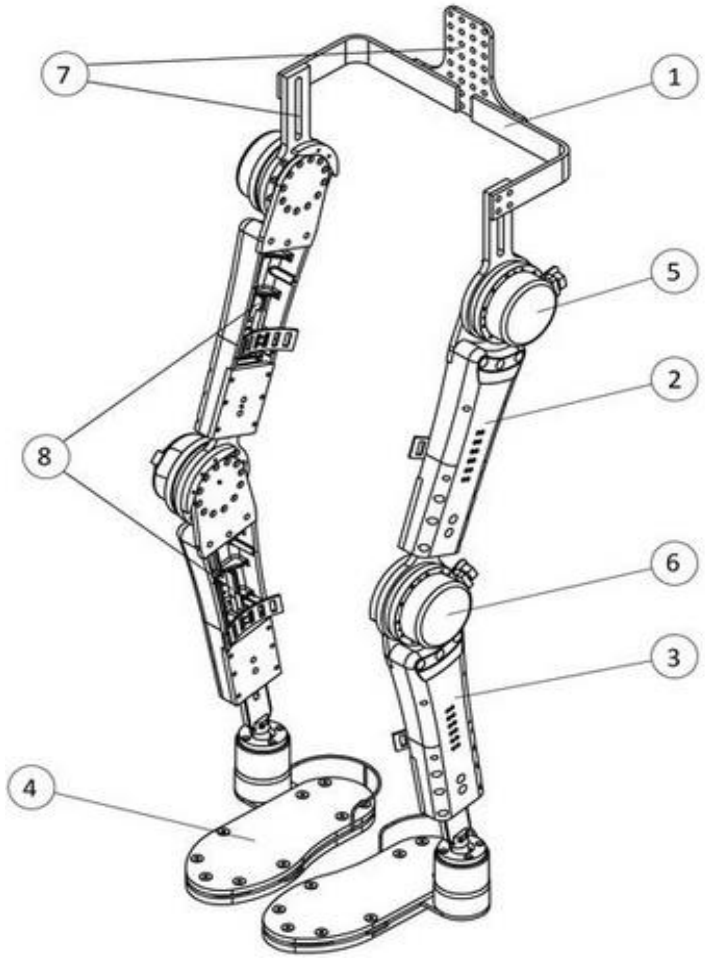


Appendix : B

Abdullah Almarri
10/07/2019
Hip exoskeleton

Design 3: Robotic Exoskeleton

- Minimizes the pressure on the hips
- Transfers human weight to the ground.
- Fully automated



1. Waist
2. Upper Leg
3. Lower Leg
4. Foot
5. Hip Actuator
6. Knee Actuator
7. Waist Adjustment Mechanisms
8. Leg Adjustment Mechanisms

Appendix : A

Abdullah Almarri
10/07/2019
Hip exoskeleton

Concept Evaluation

- Ten concept designs.
- Comparing the designs.
- The methods used for concept evaluation.

Meshal Alghammas
10/07/2019
Hip exoskeleton

Design Selection Criteria

- Eliminate 9 of the thigh designs
- Criteria
  - Cost
  - Durability
  - Comfortability
  - Weight
  - Flexibility
  - Ease of design implementation
  - Designs meet customer requirements
- Selected Design for decision matrix analysis is the Pelvic and leg support.

Abdullah Almarri
10/07/2019
Hip exoskeleton

Pugh Chart (top three designs)

Pugh Concept Selection Process Summary Chart				
PROJECT	**DESIGN OF AN HIP EXOSKELETON**			
	DATUM	Pelvic and leg support	Robotic Exoskeleton	Lower body Support Suit
Cost	0	1	-1	1
Durability	0	1	-1	0
Comfortability	0	0	1	0
Weight	0	1	-1	1
Flexibility	0	0	1	0
Ease of design implementation	0	-1	0	0
Designs meet customer requirem	0	1	1	1
Number better: S+	+0	+4	+3	+3
Number worse: S-	0	-1	-3	0
Number same: S0	7	2	1	4

*see Appendix D for full Pough chart

Decision Matrix

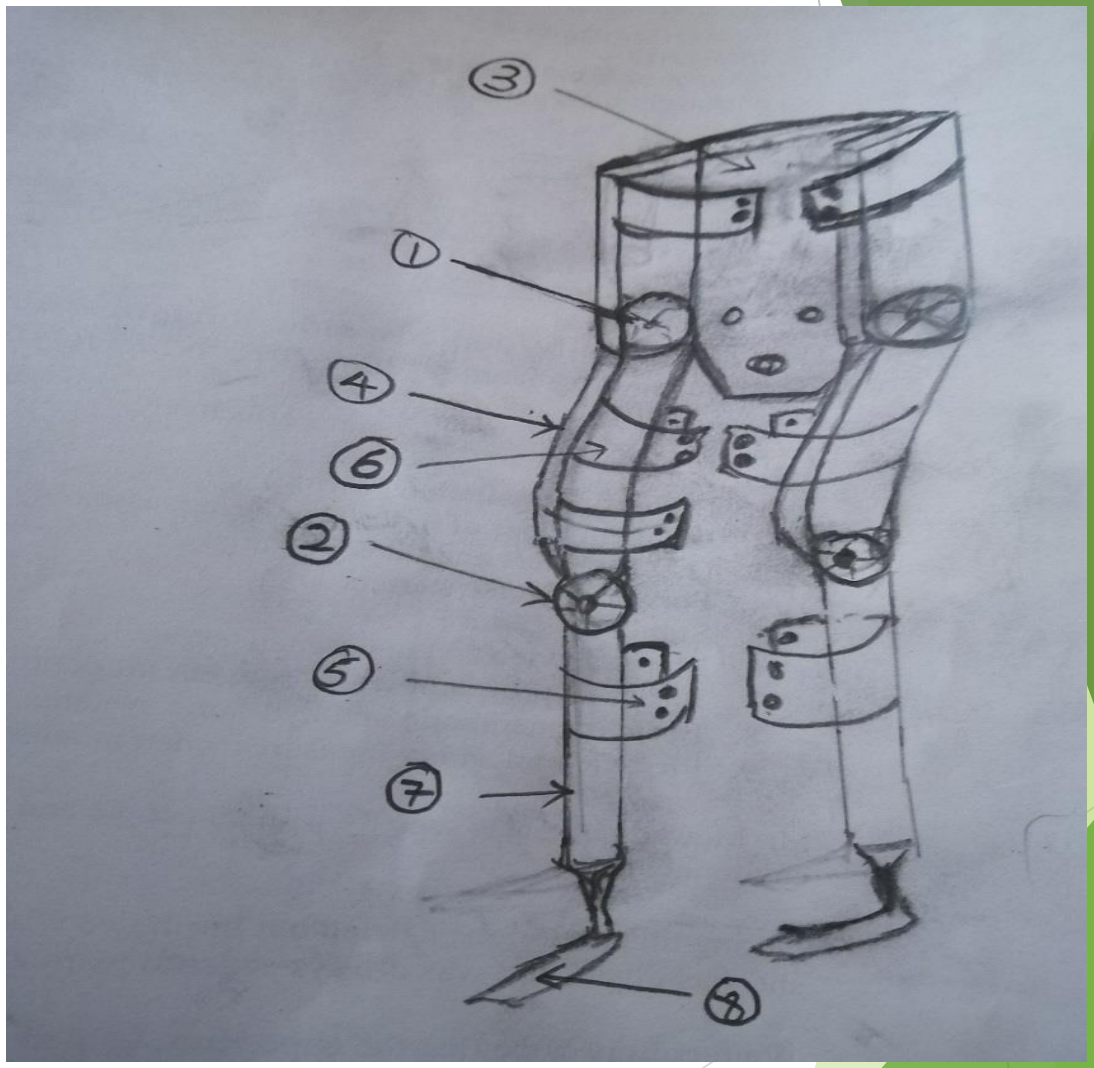
		Pelvic and Leg Spport			Lower Body Support Suit			Robotic Exoskeleton		
Criteria	**Weighting**	**Rating**		**Total**	**Rating**		**Total**	**Rating**		**Total**
Cost of Materials	0.11	100		11	85		9.35	0		0
Implementation time	0.07	95		6.65	90		6.3	70		4.9
Reliability	0.12	100		12	60		7.2	95		11.4
Necessary Modifications	0.03	100		3	100		3	0		0
Flexibilty	0.15	90		13.5	75		11.25	100		15
Weight	0.14	100		14	80		11.2	65		9.1
Durabilty	0.12	100		12	100		12	80		9.6
Comfortability	0.14	100		14	70		9.8	100		14
Assembly	0.12	80		9.6	90		10.8	50		6
Totals	**1**			**95.75**			**80.90**			**70.00**
Relative Rank				**1**			**2**			**3**

Mohammed Janshah
10/07/2019
Hip exoskeleton

Summary of the Design

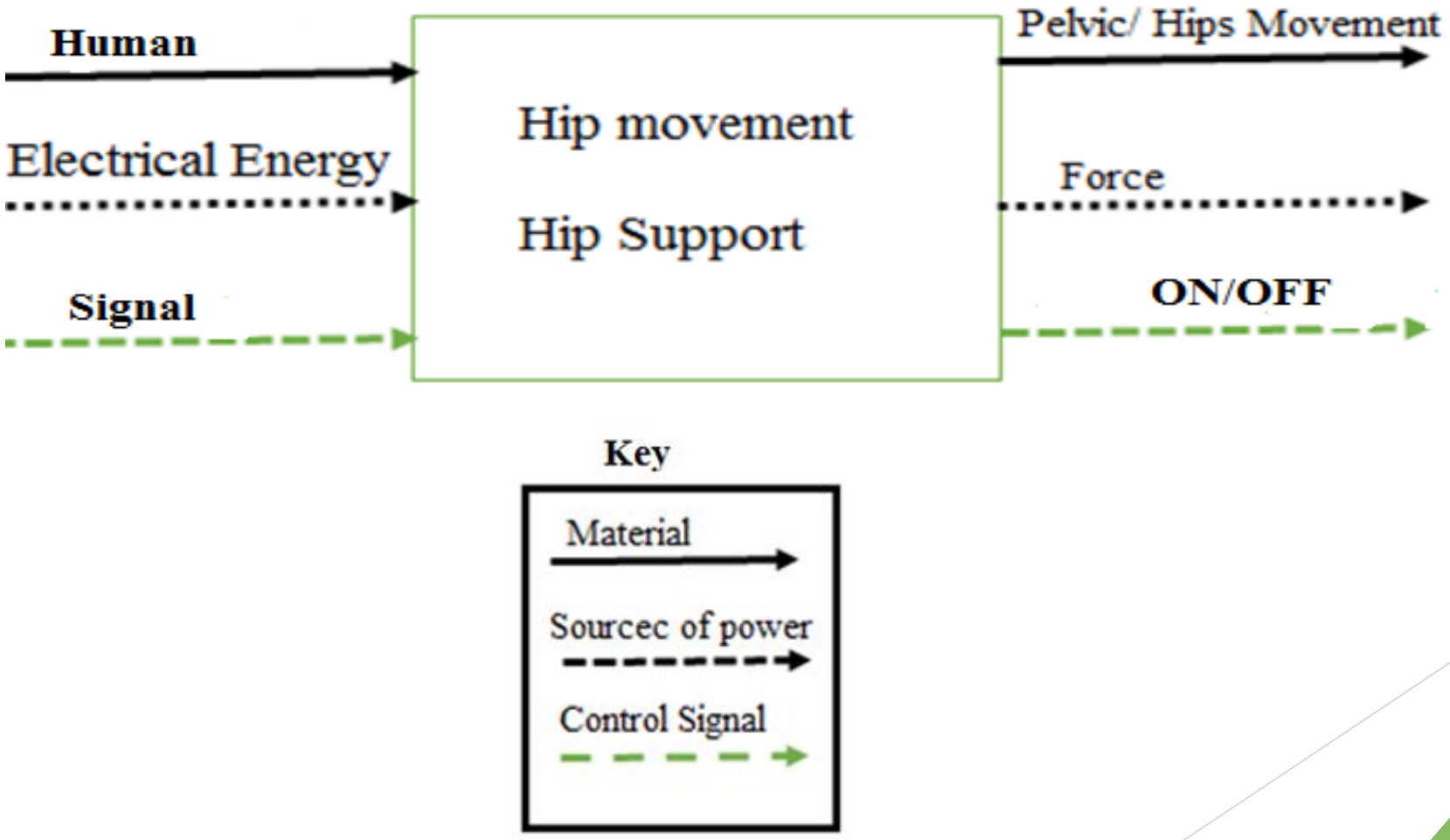
- The design has two subsystem

- The joint movement contains a all and 2 degrees of freedom.
- Thigh Support
- Small motors with bearings
- Below Knee Support
- Hip support frame
- Small motors on each side of the hip for hip movement
- Battery.
- Pelvic part Support.

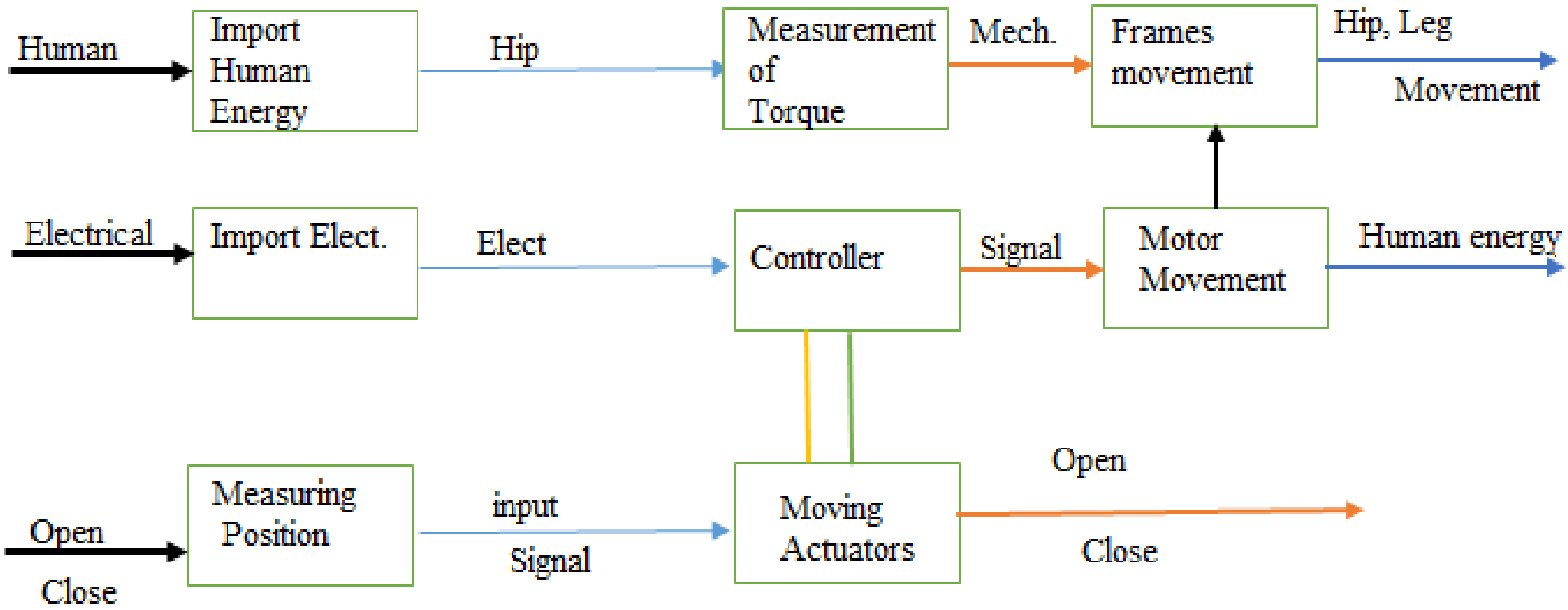


Meshal Alghammas
10/07/2019
Hip exoskeleton

Black Box Model



Functional Decomposition Model



Bill of Materials

Bill of Materials

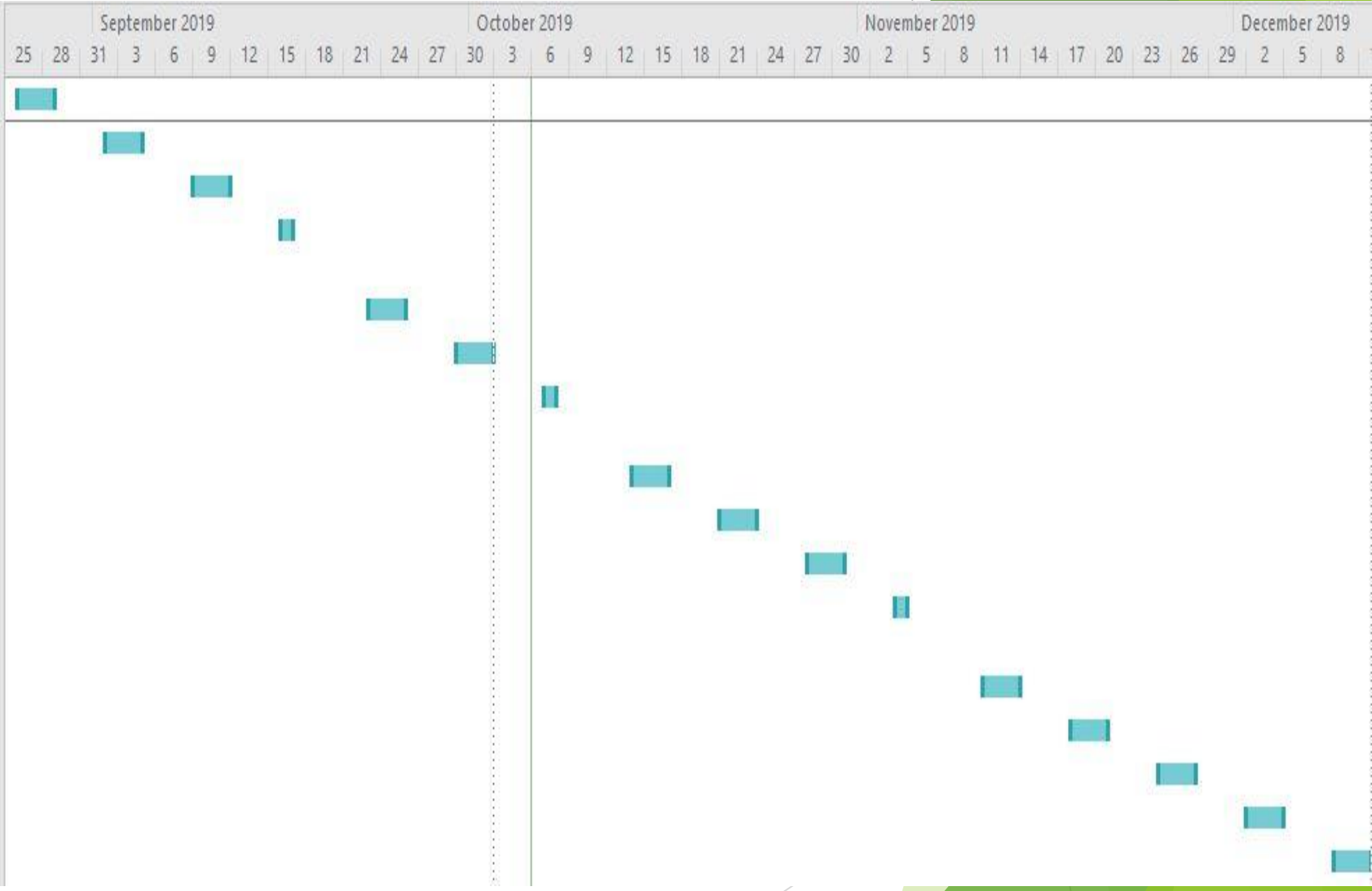
Part #	Part Name	Qty	Description	Functions	Material	Dimensions	Cost	Link to Cost estimate
1	Frame	2	Contains holes at different parts for holding other parts	support the upper body and the legs	Carbon Fibre	4 ft (each)	$150	https://www.compositesworld.com/blog/post/composites-in-exoskeletons
2	Arrestors	3	2-for the thighs 1-Pelvic area support	Supporting the thights and hips during movement	PVC	2 ft	$10	https://www.made-in-china.com/cs/hot-china-products/Pvc_Sheet.html?gclid=Cj0KCQjwoebsBRCHARIsAC3JP0KUNNkYmUqF1O70eydGnnHo6DAad--qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_wcB
3	Small Motors	4	For hip and knee joints	Joint actuation	Carbon	19mm	$180	https://www.maxongroup.com/maxon/view/category/sensor?etcc_cu=onsite&etcc_med_onsite=Product&etcc_cmp_onsite=Encoders&etcc_plc=Overview-Page-Sensors&etcc_var=%5bcom%5d%23en%23_d_&target=filter&filterCategory=encoder
4	Sensors	2	Placed on the hip	Detecting the movement signal		5mm	$10	https://www.maxongroup.com/maxon/view/category/sensor?etcc_cu=onsite&etcc_med_onsite=Product&etcc_cmp_onsite=Encoders&etcc_plc=Overview-Page-Sensors&etcc_var=%5bcom%5d%23en%23_d_&target=filter&filterCategory=encoder

Total project materials: $1070
Prototype: $200

Lahdan Alfihan
10/07/2019
Hip exoskeleton

Gantt Chart

	Task Mode	Task Name	Start	Finish
1		Project signup	Mon 8/26/19	Wed 8/28/19
2		Staff/Team meetings	Mon 9/2/19	Wed 9/4/19
3		Staff/Team meetings	Mon 9/9/19	Wed 9/11/19
4		Presentation 1: CNs/Ers and Background	Mon 9/16/19	Mon 9/16/19
5		Staff/Team meetings	Mon 9/23/19	Wed 9/25/19
6		Staff/Team meetings	Mon 9/30/19	Wed 10/2/19
7		Presentation 2: Concept Gen and Eval	Mon 10/7/19	Mon 10/7/19
8		Staff/Team meetings	Mon 10/14/19	Wed 10/16/19
9		Staff/Team meetings	Mon 10/21/19	Wed 10/23/19
10		Staff/Team meetings	Mon 10/28/19	Wed 10/30/19
11		Presentation 3: Final presentation	Mon 11/4/19	Mon 11/4/19
12		Staff/Team meetings	Mon 11/11/19	Wed 11/13/19
13		Staff/Team meetings	Mon 11/18/19	Wed 11/20/19
14		Staff/Team meetings	Mon 11/25/19	Wed 11/27/19
15		Prototype demo	Mon 12/2/19	Wed 12/4/19
16		Finals	Mon 12/9/19	Wed 12/11/19



Lahdan Alfihan
10/07/2019
Hip exoskeleton

Conclusion

- Pelvic design
- Budget
- Deliver a design that meets all customer requirements

Mohammed Janshah
10/07/2019
Hip exoskeleton

Any Question?

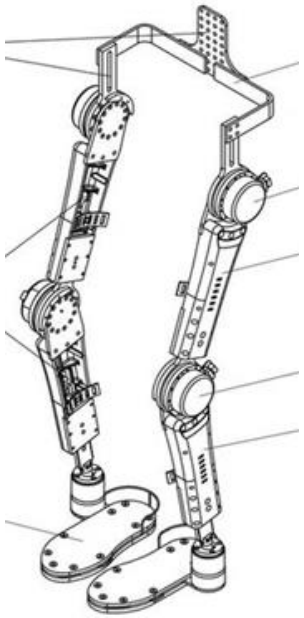
References

- [1]https://www.sciencedirect.com/topics/nursing-and-health-professions/hip-knee-ankle-foot-orthosis [Accessed 29 Sep. 2019].
- [2] https://kushaldoshi.portfoliobox.net/hipexoskeleton [Accessed 2 Oct. 2019].
- [3] https://www.popsci.com/indego-exoskeleton-gets-fda-approval [Accessed 3 Oct. 2019].
- [4] https://keldysh.ru/papers/2004/prep79/prep2004_79.html [Accessed 5 Oct. 2019].
- [5]https://exoskeletonreport.com/2015/04/12-commercial-exoskeletons-in-2015 [Accessed 5 Oct. 2019].

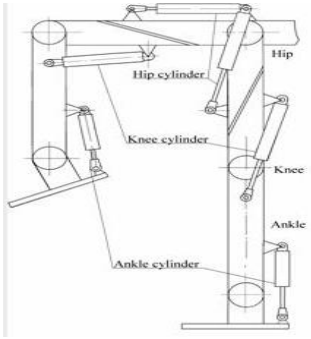
Appendix A

Hip Suite Design

Robotic Design



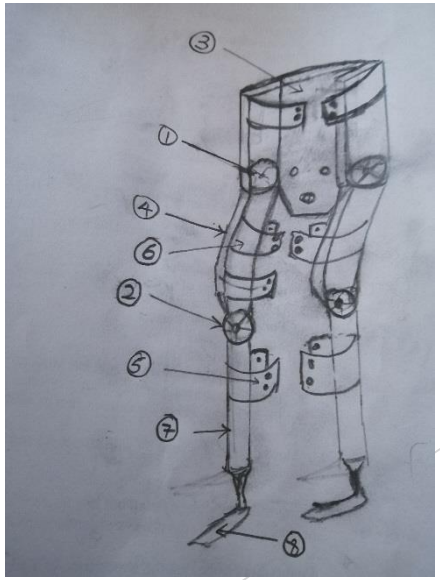
Hydraulic Design



Assist Mode Design

Electrical Powered Design

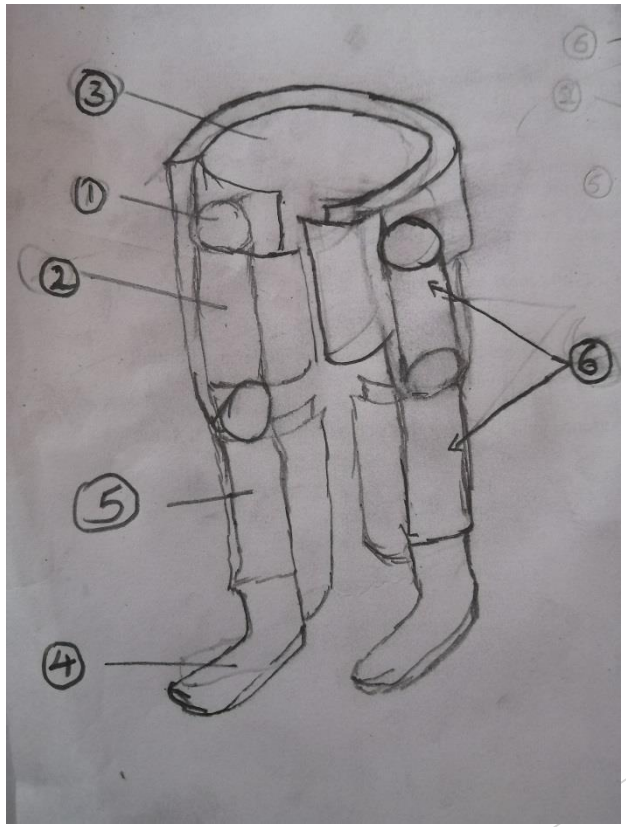
Hip and Leg Support Design



Appendix B

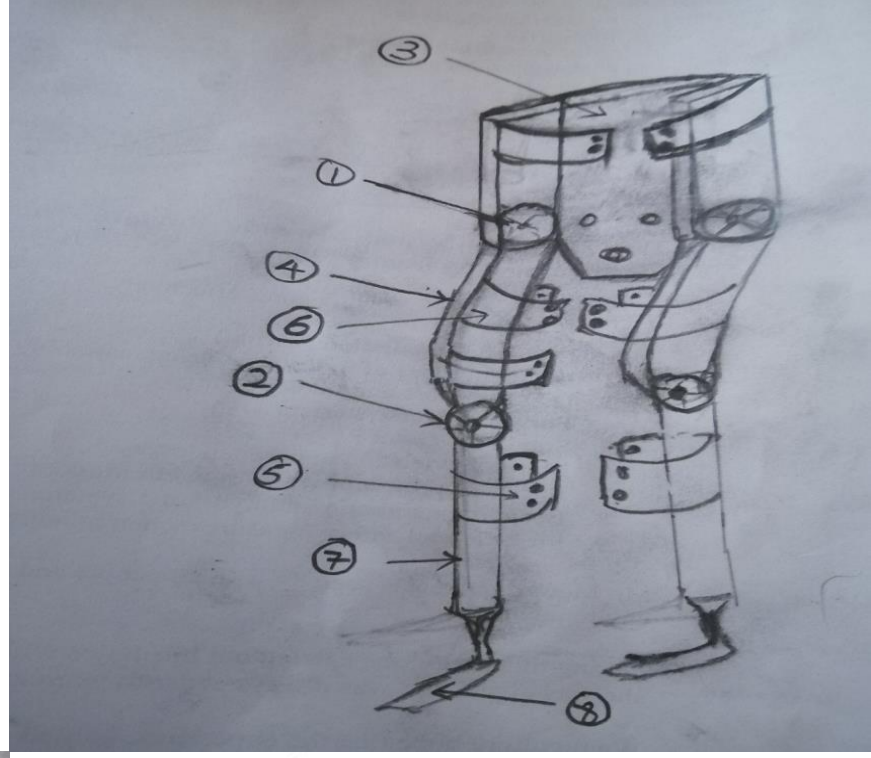
Pelvic, Thigh and Arms support Design

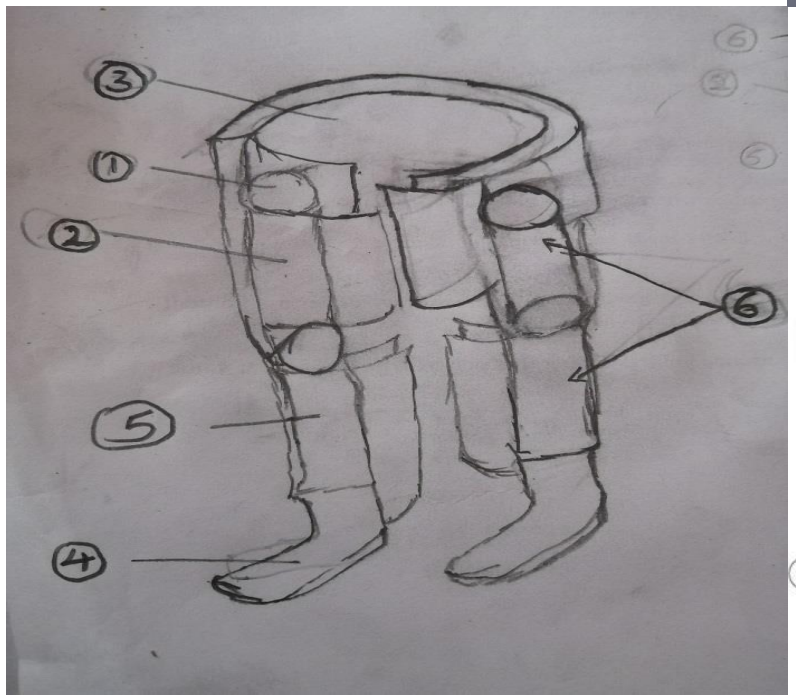
Lower Body Support Suit

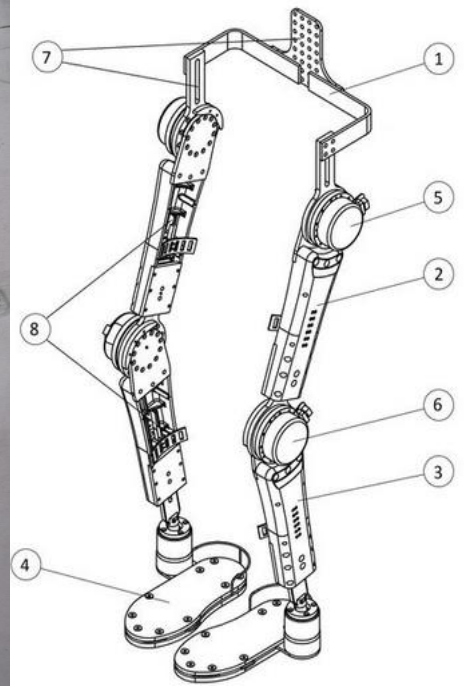


Appendix C: Best Three Designs

- Pelvic and leg support
- Lower body Support Suit
- Robotic Exoskeleton







1. Waist
2. Upper Leg
3. Lower Leg
4. Foot
5. Hip Actuator
6. Knee Actuator
7. Waist Adjustment Mechanisms
8. Leg Adjustment Mechanisms

Appendix D: Full Pough chart

Pugh Concept Selection Process Summary Chart											
PROJECT	DESIGN OF AN HIP EXOSKELETON										
	DATUM	Thigh Design	Pelvic Design	Hip Suite	Hydraulic Hip exoskeleton design	Electrical Powered	Robotic Exoskeleton	Assist mode Design	Pelvic and leg support	Pelvic, Thigh and Arms support	Lower body Support Suit
Cost	0	-1	0	-1	0	1	-1	-1	1	-1	1
Durability	0	0	-1	0	1	0	-1	1	1	1	0
Comfortability	0	1	1	1	1	1	1	1	0	1	0
Weight	0	1	-1	0	0	1	-1	0	1	-1	1
Flexibility	0	-1	1	1	0	-1	1	1	0	-1	0
Ease of design implementation	0	1	1	-1	-1	-1	0	-1	-1	0	0
Designs meet customer requirem	0	0	0	1	1	0	1	0	1	1	1
Number better: S+	+0	+3	+3	+3	+3	+3	+3	+3	+4	+3	+3
Number worse: S-	0	-2	-2	-2	-1	-2	-3	-2	-1	-3	0
Number same: S0	7	2	2	2	3	2	1	2	2	1	4