

Design of a noninvasive 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

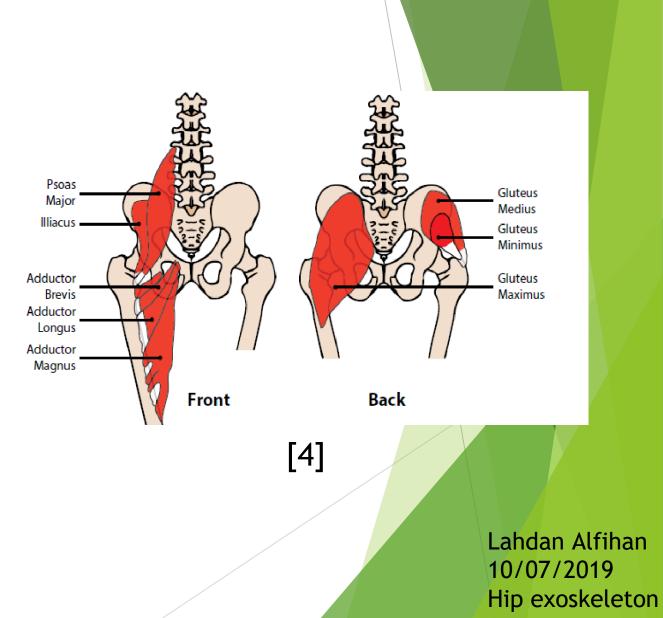


[1]

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.



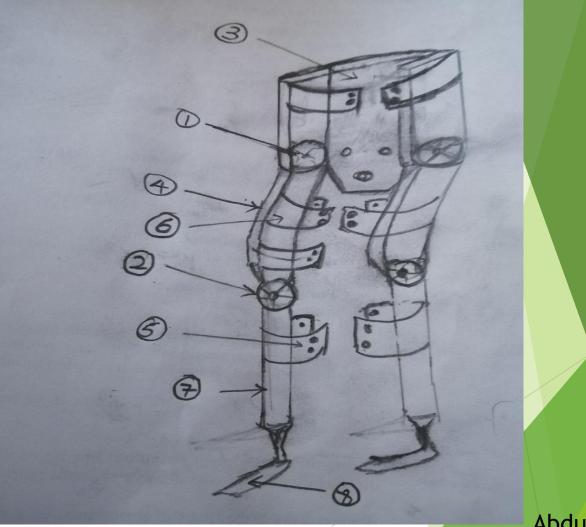
Concept Generation

- Team members brainstormed the concepts to achieve the desired functionality.
- ► Ten design. (see appendix A)
- Best three designs:
- Pelvic Support and Leg Support
 Lower body Support Suit
- 3. Robotic Exoskeleton

Meshal Alghammas 10/07/2019 Hip exoskeleton

Design 1: (Pelvic Support and Leg Support)

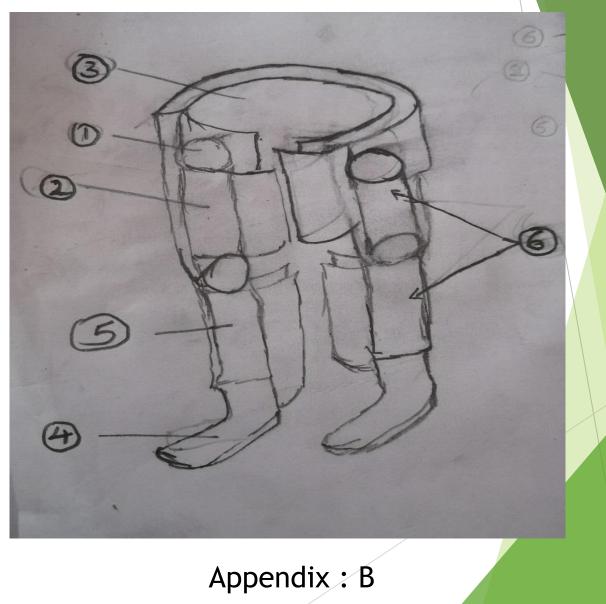
- The design has three subsystems
 - The pelvic subsystem design
 - The thigh sub-system design
 - Leg support subsystem



Appendix : A

Design 2: Lower body Support Suit

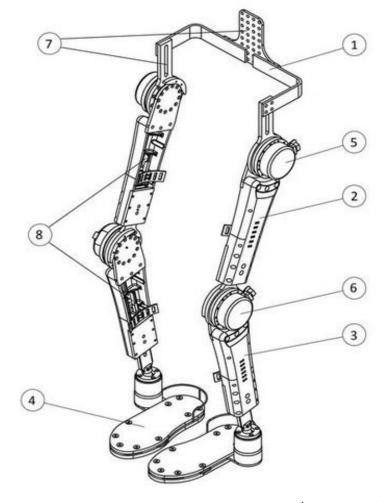
- Contains a full suit for lower body
- uses small motors for actuations
- Inbuilt Sensors



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

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.

Pugh Chart (top three designs)

Pugh Concept Selection Process	y Chart									
PROJECT	DESIGN OF AN HIP EXOSKELETON									
	DATU	Pelvic and	Robotic	Lower body						
	Μ	leg support	Exoskeleton	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	an	d Leg	Low	er H	Body	Robotic			
		Sp	po	rt	Supp	port	Suit	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

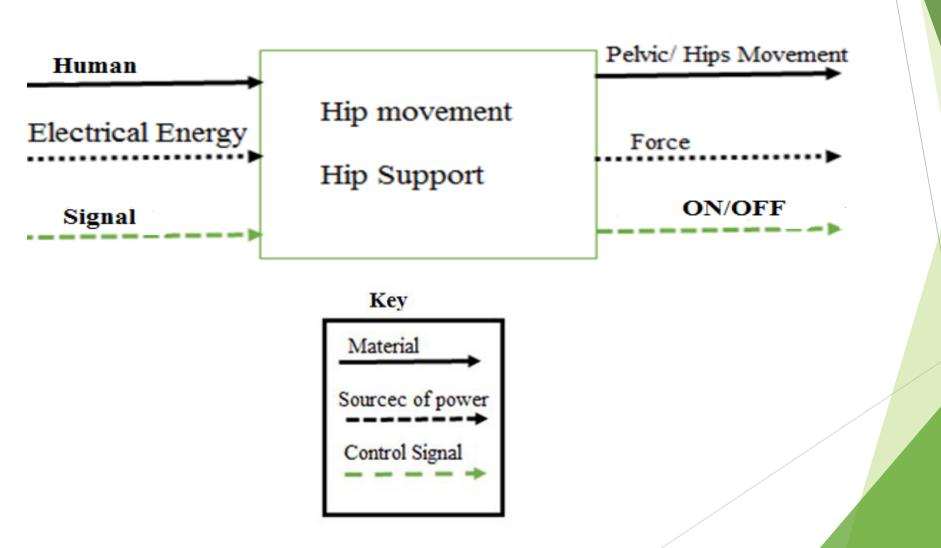
Summary of the Design

- > 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.

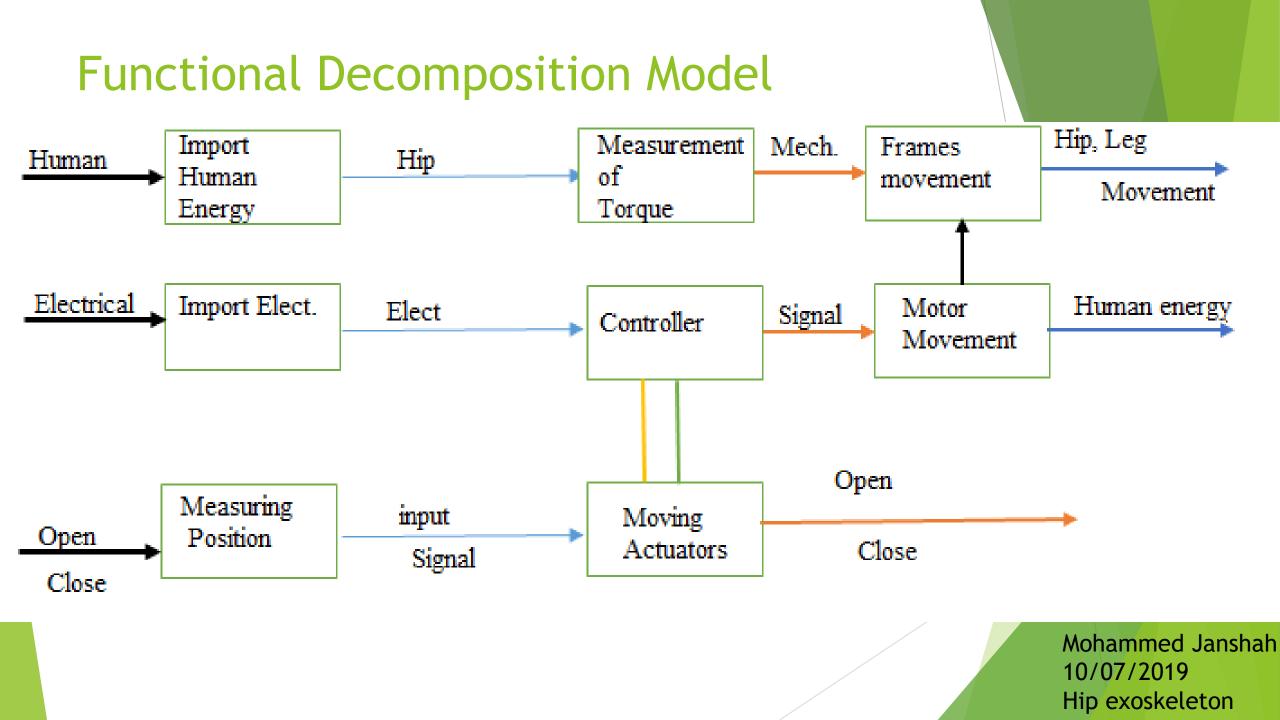


Meshal Alghammas 10/07/2019 Hip exoskeleton

Black Box Model



Mohammed Janshah 10/07/2019 Hip exoskeleton



Bill of Materials



movement signal <u>egory/sensor?etcc_cu=onsite&etcc_med_on</u> <u>lc=Overview-Page-</u>		Bill of Materials													
1 Frame 2 Contains holes at different parts for holding other upper body and the legs 4 ft (each) \$150 https://www.composites.world.com/bloc/posites.org/bloc/posites.in-exoskele.org 1 Frame 2-for the thighs 1- Supporting the thights and hips support PVC 2 ft https://www.made-in-china.com/cs/hot-chiproducts/Pvc_Sheet.html?gclid=Cj0KCQjwoe BRCHARISAC3JPOKUNNKYmuqF1070eydGnHet DAad qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_w 2 Arrestors 3 For hip and knee joints Joint actuation Signal https://www.maxongroup.com/maxon/view/egor/sensor?etcc_cu=onsite&etcc_med_on 3 Small Motors 4 Carbon 19mm \$180 Sensors 2 Placed on the hip isignal Detecting the movement signal 19mm \$180															
1 Frame 2 Contains holes at different parts for holding other parts support the upper body and the legs 4 ft (each) \$150 https://www.composites.world.com/bloc/posionposites.in-exoskele.ong 1 Frame 2-for the thighs 1- Supporting the thights and hips support PVC 2 ft https://www.made-in-china.com/cs/hot-chip products/Pvc_Sheet.html?gclid=Cj0KCQjwoe BRCHARISAC3JPOKUNNKYmuqF1070eydGnHet DAda qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_w 2 Arrestors 3 For hip and knee joints Joint actuation https://www.maxongroup.com/maxon/view/egor/sensor?etcc_cu=onsite=Encoders&etcc 3 Small Motors 4 Carbon 19mm \$180 Sensors 2 Placed on the hip movement Detecting the movement signal 19mm \$180			_		-										
1 Frame 2 different parts for holding other upper body and the legs Fibre \$150 https://www.compositescondit.com/blog/positescondit.	Part #	Part Name	Qty		Functions			Cost	Link to Cost estimate						
1 Frame upper body and the legs upper body and the legs upper body and the legs 1 Frame 2-for the thighs 1-Pelvic area Supporting the thights and hips during movement PVC 2 ft https://www.made-in-china.com/cs/hot-ching.com/cs/hot-chi							4 ft (each)								
1 Frame parts upper body and parts omposites-in-exosikele units 1 Frame parts the legs https://www.made-in-china.com/cs/hot-chinproducts/Pvc_Sheet.html?gclid=Cj0KCQjwoe BRCHARIsAC3JP0KUNNKYmUqF1070eydGnnHo during 2 Arrestors 3 For hip and knee joints Joint actuation point actuation https://www.maxongroup.com/maxon/view/ egory/sensor?etc_cu=onsite&etc_med_on e=Product&etc_cu=onsite&etc_med_on e=Product&etc_cu=-onsite&etc_med_on egory/sensor?etc_u=mosite&etc_med_on e=Product&etc_u=%5bcom%5d%23en%23_ Sensors 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip isgnal Detecting the movement Detecting the movement Imm \$180 ⌖=filter&filterCategory=encoder			2			Fibre		\$150							
2-for the thighs 1- Supporting the thights and hips during movement PVC 2 ft https://www.made-in-china.com/cs/hot-chi products/Pvc_Sheet.html?gclid=Cj0KCQjwoe BRCHARtsAC3JP0KUNNKYmUqF1070eydGnHt 2 Arrestors 3 For hip and knee joints Joint actuation joints \$10 https://www.maxongroup.com/maxon/view/egory/sensor?etcc_cu=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcd is com/cs/https://www.maxongroup.com/maxon/view/egory/sensor?etcc_var=%5bcom%5d%23en%23_Sensors 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip ignal Detecting the movement signal Imm \$180 https://www.maxongroup.com/maxon/view/egory/sensor?etcc_u=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcd is coverview-Page-Sensors&etcc_var=%5bcom%5d%23en%23_en%23_en%24_egory/sensor?etcc_u=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcd is coverview-Page-Sensors%etcc_var=%5bcom%5d%23en%23_en%23_en%24_egory/sensor?etcc_u=onsite&etcc_med_on e=Product&etcc_u=onsite%etcc_med_on e=Product&etcc_u=onsite%etcc_med				_					<u>omposites-in-exos keletons</u>						
Pelvic area thights and hips products/Pvc_Sheet.html?gclid=Cj0KCQjwoe Support aving products/Pvc_Sheet.html?gclid=Cj0KCQjwoe BRCHARIsAC3JP0KUNNKYmJqF1070eydGnHd DAad Q Arrestors 3 For hip and knee Joint actuation joints Joint actuation joints Joint actuation Small Motors 4 Sensors 2 Placed on the hip Detecting the movement carbon signal Signal	1	Frame													
support during movement support during movement support BRCHARIsAC3JP0KUNNkYmUqF1070eydGnHd DAad qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_w 2 Arrestors 3 For hip and knee joints Joint actuation https://www.maxongroup.com/maxon/view/ egory/sensor?etcc_cu=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcc lc=Overview-Page- Sensors&etcc_var=%5bcom%5d%23en%23_ 8target=filter&filterCategory=encoder 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip movement signal Detecting the movement signal https://www.maxongroup.com/maxon/view/ egory/sensor?etcc_u=onsite&etcc_mp_onsite=Encoders&etcc_ lc=Overview-Page-				_	–		2 ft								
2 Arrestors 3 2 Arrestors 3 For hip and knee joints Joint actuation joints 3 Small Motors 4 2 Sensors 2 Placed on the hip isignal Detecting the movement signal Carbon 19mm \$10 DAad qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_w Arrestors 3 For hip and knee joints Joint actuation Joint actuation Arrestors For hip and knee joints Joint actuation https://www.maxongroup.com/maxon/view/ egory/sensor?etcc_u=onsite&etc_med_on e=Product&etcc_trare%5bcom%5d%23en%23_ Sensors&cc_vare%5bcom%5d%23en%23_ Sensors@etcleategory=encoder Arrestors 2 Placed on the hip Detecting the movement signal Bensors 2 Placed on the hip Detecting the movement signal															
2 Arrestors 3 and better the second sec				••	-										
2 Arrestors 3					movement			\$10							
Bensors 2 Placed on the hip movement signal Detecting the movement signal									qTy7EUK72KDkQPQGk5bv9atsaApaWEALw_wcB						
Bensors 2 Placed on the hip movement signal Detecting the movement signal															
joints joints egory/sensor?etcc_cu=onsite&etcc_med_on 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip Detecting the movement signal https://www.maxongroup.com/maxon/view/regory/sensor?etcc_cu=onsite&etcc_med_on	2,	Arrestors	3												
3 Small Motors 4 Carbon 19mm \$180 \$e=Product&etcc_cmp_onsite=Encoders&etcoder 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip Detecting the movement signal https://www.maxongroup.com/mexon/view/regory/sensor?etcc_cu=onsite&etcoders&etcoder				•	Joint actuation										
3 Small Motors 4 Carbon 19mm \$180 \$c=Overview-Page-Sensors&etcc_var=%5bcom%5d%23en%23_Sensors&etcc_var=%5bcom%5d%23en%23_Sensors 3 Small Motors 4 Carbon 19mm \$180 \$target=filter&filterCategory=encoder Sensors 2 Placed on the hip movement signal Detecting the movement signal https://www.maxongroup.com/maxon/view/egory/sensor?etcc_cu=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcc_med_on				joints											
3 Small Motors 4 Carbon 19mm \$180 Sensors&etc c_var=%5bc om%5d%23en%23_ 3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip Detecting the movement signal https://www.maxongroup.com/maxon/view/egory/sensor?etcc_cu=onsite&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcc_med_on e=Product&etcc_cmp_onsite=Encoders&etcc_med_on															
3 Small Motors 4 Carbon 19mm \$180 ⌖=filter&filterCategory=encoder Sensors 2 Placed on the hip Detecting the movement signal https://www.maxongroup.com/maxon/view/egory/sensor?etcc_cu=onsite&etcc_med_on_e=Product&etcc_cmp_onsite=Encoders&etcc_															
Sensors 2 Placed on the hip Detecting the movement signal between the signal between the signal between the between the signal between the															
movement signal <u>egory/sensor?etcc_cu=onsite&etcc_med_on</u> <u>lc=Overview-Page-</u>			4			Carbon	19mm	\$180							
signal <u>e=Product&etcc_cmp_onsite=Encoders&etcc</u> <u>lc=Overview-Page-</u>		Sensors	2	Placed on the hip	Detecting the				https://www.maxongroup.com/maxon/view/cat						
<u>lc=Overview-Page-</u>					movement				egory/sensor?etcc cu=onsite&etcc med onsit						
					signal				e=Product&etcc cmp onsite=Encoders&etcc p						
<u>Sensors&etcc_var=%5bcom%5d%23en%23_</u>									Sensors&etcc_var=%5bcom%5d%23en%23_d_						
4 5mm \$10 <u>⌖=filter&filterCategory=encoder</u>	4						5mm	\$10	⌖=filter&filterCategory=encoder						

Total project materials: \$1070 Prototype: \$200 Lahdan Alfihan 10/07/2019 Hip exoskeleton

Gantt Chart

6	Task				Septe	mber 2019			Octobe	er 2019					Novemb	oer 2019				[ecember	2019
0	Mode	👻 Task Name 👻	Start 👻	Finish 👻	25 28 31 3	6 9	12 15 1	8 21 24 2	27 30 3	6 9	9 12	15 1	8 21 24	4 27 3	2	5 8	11 1	4 17	20 23	26 29	2 5	8
1	*	Project signup	Mon 8/26/19	Wed 8/28/19																		
2	*	Staff/Team meetings	Mon 9/2/19	Wed 9/4/19		l.																
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						Ш												
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															1			
14	*	Staff/Team meetings	Mon 11/25/19	Wed 11/27/19																		
15	*	Prototype demo	Mon 12/2/19	Wed 12/4/19																1		
16	*	Finals	Mon 12/9/19	Wed 12/11/19																		
										-							10)/07	7/20	lfiha 19 celet		

Conclusion

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

Mohammed Janshah 10/07/2019 Hip exoskeleton

Any Question?

References

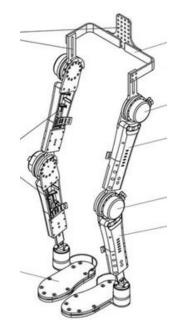
- [1]https://www.sciencedirect.com/topics/nursing-and-health-professions/hip-kneeankle-foot-orthosis [Accessed 29 Sep. 2019].
- [2] https://kushaldoshi.portfoliobox.net/hipexoskeleton [Accessed 2 Oct. 2019].
- [3] https://www.popsci.com/indego-exoskeleton-gets-fda-approval [Accessed 3 Oct. 2019].
- [4] 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].



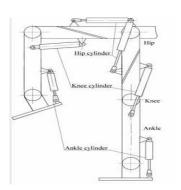
Hip Suite Design



Robotic Design



Hydraulic Design



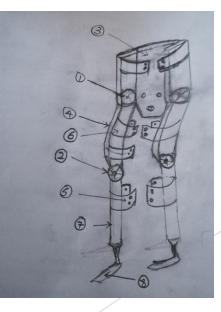
Assist Mode Design



Electrical Powered Design



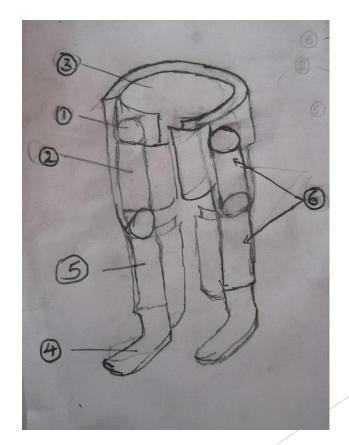
Hip and Leg Support Design





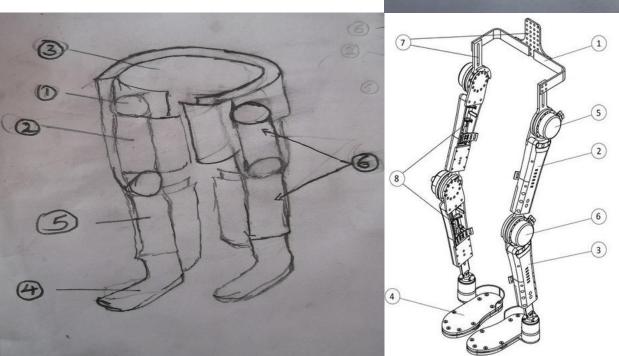
Pelvic, Thigh and Arms support Design

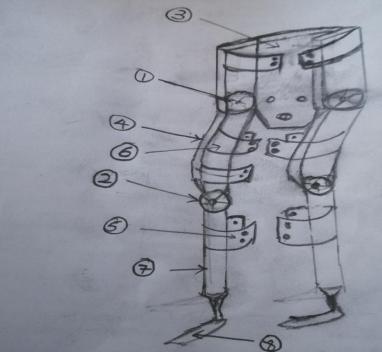
Lower Body Support Suit



Appendix C: Best Three Designs

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





Lower Leg
 Foot
 Hip Actuator

1. Waist

2. Upper Leg

- -----
- 6. Knee Actuator
- 7. Waist Adjustment Mechanisms
- 8. Leg Adjustment Mechanisms

Appendix D: Full Pough chart

Pugh Concept Selection Process														
PROJECT			DESIGN OF AN HIP EXOSKELETON											
	DATU	Thigh	Pelvic	Hip	Hydraulic Hip	Electrical	Robotic	Assist mode	Pelvic and	Pelvic, Thigh and	Lower body			
	Μ	Design	Design	Suite	exoskeleton design	Powered	Exoskeleton	Design	leg support	Arms support	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			