Design of a non-invasive Hip Exoskeleton

Lahdan Alfihan
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Mohammed Janshah

Introduction

- Project description and background.
- Target are children from 6 to 14 years old.

Figure 1: Design Prototype.

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Project Description

- The purpose of this project
- The goal of the project
- Who can use it.
- It comprises of three subsystems.
- Sponsor.
- Client.

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Project Description

- Subsystems Functions:
  - Pelvic subsystem

    - Hold the device.

  - Thigh subsystem

    - Hold actuators and attached to the thigh.

  - Actuators subsystem

    - Support movement.

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CAD Model

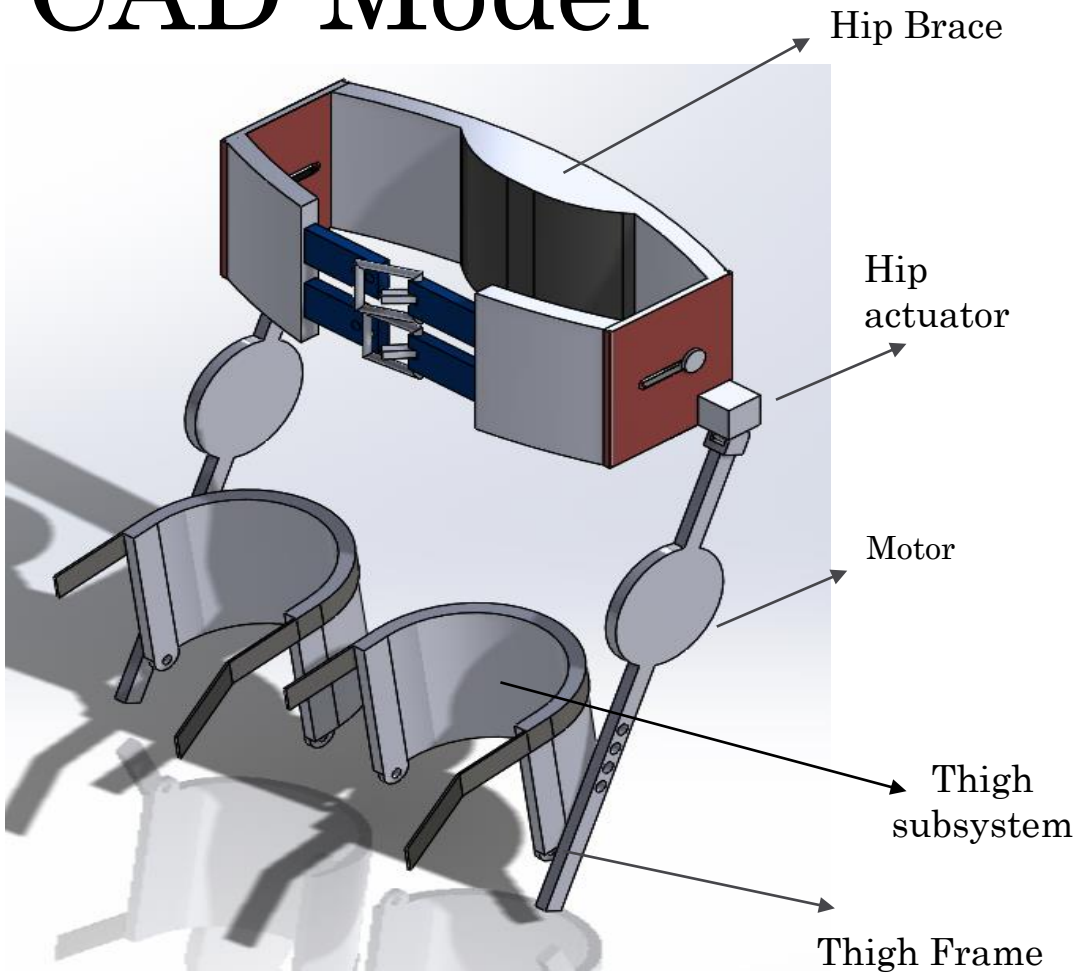

Figure 2: isometric view of CAD design

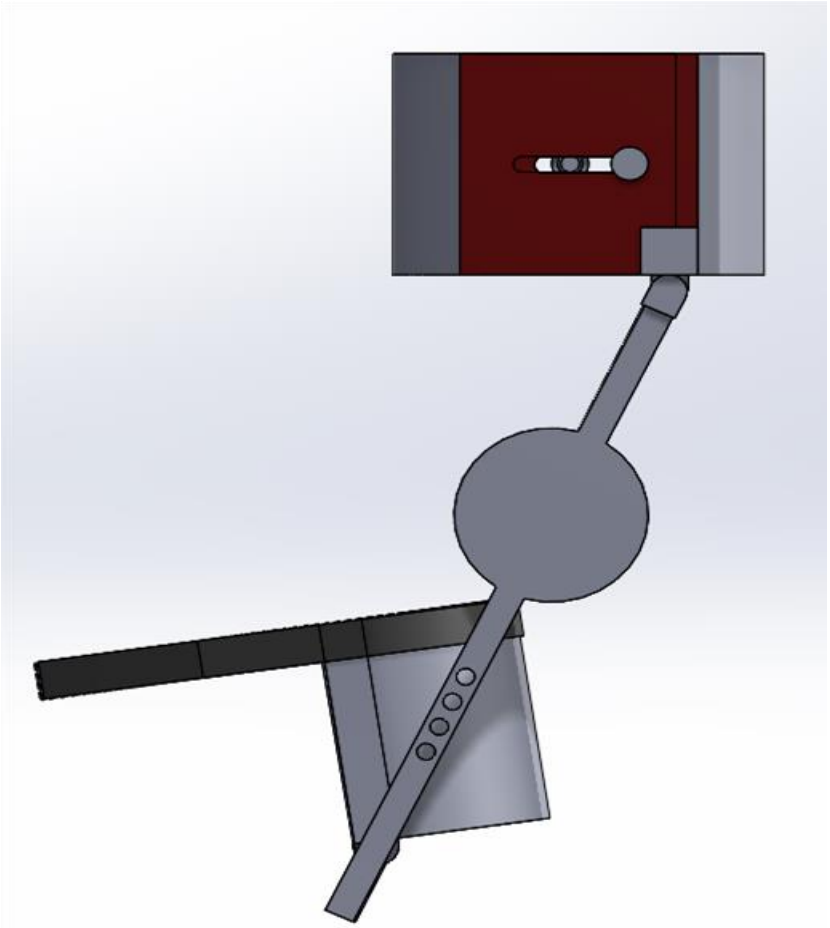

Figure 3: Side view of CAD design

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Design Description

- Design of the pelvic:
- Fabric lining.
- Strap.

- Design of the thigh:
- Fabric lining.
- Strap.

- Motor actuators.
- Hip actuators.
- Less energy to initiate movement.

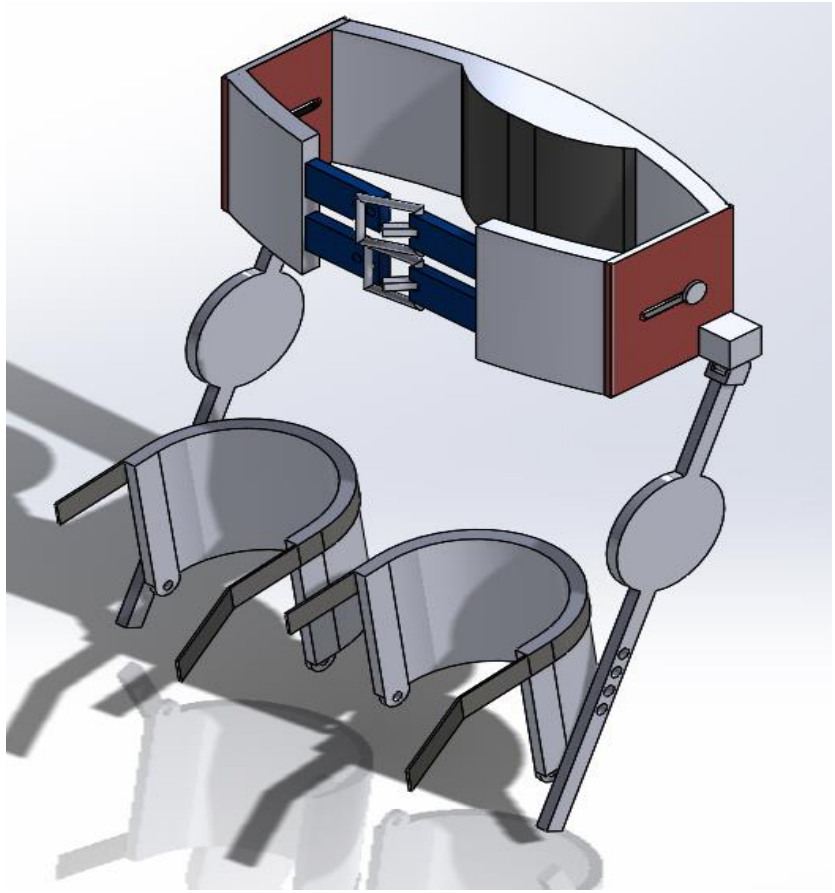

Figure 2: isometric view of CAD design

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Design Requirements

Customer Needs:

1. Lightweight Design
2. durability
3. Flexible for all sizes.
4. Comfort
5. Simple system

How the Device Meets The Customer Needs:

1. Lightweight material.
2. Durable and strong materials.
3. Adjustment.
4. No contact between the metal bars and the body.
5. Uses actuators on the hips to facilitate functionality.

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Design Requirements

1. Torque : 30% of actual human hip torque.
2. The hip and thigh braces.
3. The thigh frame.
4. Materials
5. Cost.

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Design Requirements

Customers needs:

CN.	Weight
Light weight	7
Low mobility	3
Adjustable size	9
Comfortability	8
Reliability	9
Durability	9
Ease of wearing	4
Range of motion	9

Engineering Requirements:

ER.	RTI (%)
Weight	14
Flexibility	16
Ease to put on/off	8
Yield strength	13
Cost	15
Non-invisible	12
Young modulus	11
Torque	11

(See Appendix A: HoQ)

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Design Validation

Critical Potential Failures:

- Dust or particles in the motor housing.
- Presence of cracks on support frames.
- Lose hip and thigh braces.
- Failure of the sensors.

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Design Validation

How the design mitigated the potential failures.

- Examination of the motor housing.
- Physical examination of the frames to identify any cracks.
- Precise measurements of the length and diameters of the braces.
- Calibration of the sensors.

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Testing Procedures

Weight limit:

- 50 lbs to 120 lbs.
- Test the device on different weights.
- Analyze the results.

Adjustability:

- Test the device on children of different sizes.

(See Appendix B: Design Validation)

Mohammed Janshah

Budget

Project budget: $2250

Prototype: $350

Materials: $710 (See Appendix C: Bill of Materials.)

Carbon fiber (~$300)

- Two thigh frame

Motors (~$360)

- Two small motors

Arrestors (~$30)

- Three arrestors

Sensors (~20)

- Two sensors.

Contingency budget: $400

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Improvement needed

- Passive movement.
- Connection point between hip and thigh subsystems.

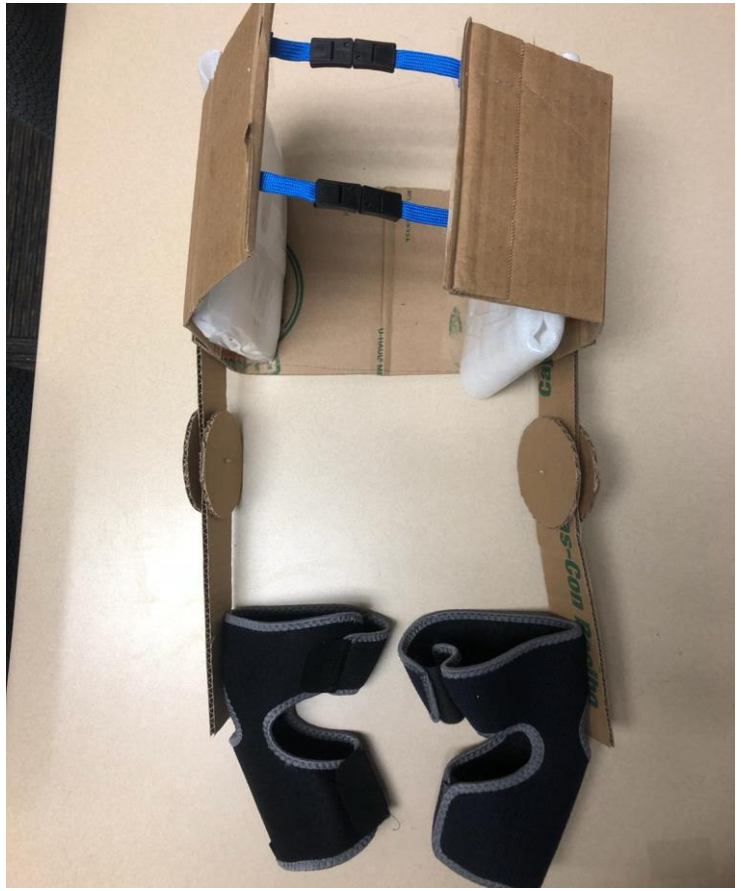
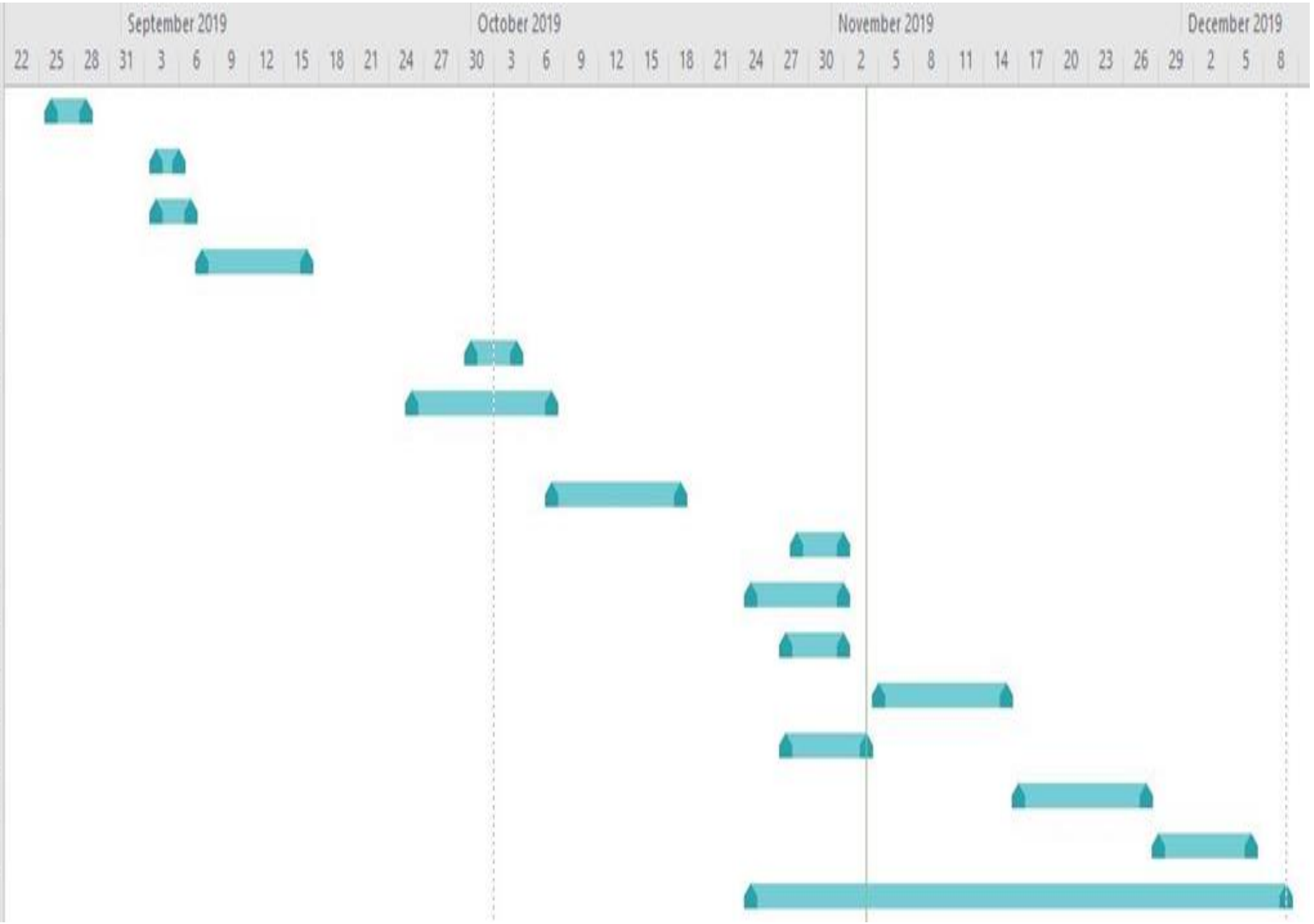


Figure 4: Design Prototype.

Gantt Chart

	Task Name	Start	Finish	Task Owner
1	Project signup	Mon 8/26/19	Wed 8/28/19	Dr, Sarah
2	Team charter	Wed 9/4/19	Thu 9/5/19	Mohammed
3	Solid work	Wed 9/4/19	Fri 9/6/19	Individual
4	Presentation 1: CNs/Ers and Background	Sun 9/8/19	Mon 9/16/19	Meshal
5	Self-Learning	Tue 10/1/19	Fri 10/4/19	Individual
6	Presentation 2: Concept Gen and Eval	Wed 9/25/19	Mon 10/7/19	Abdullah
7	Preliminary Report	Tue 10/8/19	Fri 10/18/19	Lahdan
8	Analyses Team Memo	Tue 10/29/19	Fri 11/1/19	Meshal
9	Website Check 1	Fri 10/25/19	Fri 11/1/19	Mohammed
10	Presentation 3: Final presentation	Mon 10/28/19	Fri 11/1/19	Abdullah
11	Final Report	Tue 11/5/19	Fri 11/15/19	Mohammed
12	Final BOM/CAD Package	Mon 10/28/19	Sun 11/3/19	Lahdan
13	Analytical Report	Sun 11/17/19	Wed 11/27/1	Abdullah
14	Prototype demo	Fri 11/29/19	Fri 12/6/19	Lahdan
15	Website Check 2	Fri 10/25/19	Mon 12/9/19	Mohammed



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Any Question?

References:

[1] Disabled World, “Average Height to Weight Chart - Babies to Teenagers,” *Disabled World*, 22-Aug-2019. [Online]. Available: https://www.disabled-world.com/calculators-charts/height-weight-teens.php. [Accessed: 01-Nov-2019].

[2] Agarwal, Priyanshu and Deshpande, Ashish. Exoskeletons: State-of-the-Art, Design Challenges, and Future Directions. 2019; p.234-259.

[3] Gorgey, Ashraf S. "Robotic exoskeletons: The current pros and cons." *World journal of orthopedics* 9.9 (2018): 112.

Appendix A: HoQ

House of Quality (HoQ)										
Customer Requirement	**Weight**	**Engineering Requirement**	Weight	Flexibility	Ease of putting ON/OFF	Yield Strength	Cost	Non-invisible	Young Modulus	Torque
Light weight	7		9	5	9	9	5	8	5	9
Low Mobility	3		2	9	3	3	3	9	7	3
Adjustable size	9		5	3	1	3	6	6	1	1
Comfortable	8		7	4	1	7	8	3	5	2
Reliability	9		1	8	2	9	9	2	3	5
Durabiilty	9		3	3	1	1	1	5	9	8
Ease of Wearing	4		7	8	7	1	3	1	2	3
Range of Motions	9		6	9	3	2	1	3	1	1
Absolute Technical Importance (ATI)			**288**	**333**	**171**	**267**	**273**	**255**	**230**	**235**
Relative Technical Importance (RTI)			14%	16%	8%	13%	13%	12%	11%	11%
Target ER values			80N	18in	40 s	210Gpa	$2,500	-	215Gpa	7N.m

Appendix B: Design Validation

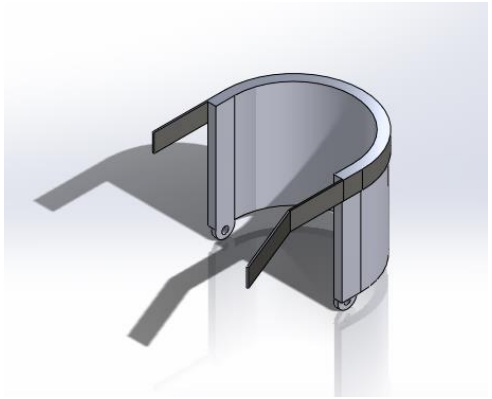
Part	*Potential Failure Modes*	*Potential Effect(s) of Failure*	Severity of the *Effect*	Potential Causes	Possibility of Occurrence	Current Design Controls	Ability to Detect a *Failure*	Risk-priority number (Severity * occurrence * detection)	Improvement Actions
Actuators/ Motors	Foreign materials	Flexibility/ and joint actuation.	9	Failure to clean the operations surface.	1	-Clean surface. -Motor casing	1	9	-casing the actuators to prevent dust. -Checking the motors before installation.
Support Frames	Cracked	Breakage/ user can fall	8	Wrong material/	1	-Testing of mechanical properties- Physical examination of the material.	1	8	-Physical examination for cracks.
Braces	loosened	Inadequate support and comfort.	6	Failure to fasten the braces adequately / Excess length	3	-Accurate length measurement -tightening of joints.	1	18	-accurate measurement to avoid excesses.
Sensors	Overlooked	Ineffective signal acquisition (hip movements)	9	Misplacement of the sensors in the pelvic area.	1	- Calibration	1	9	-calibration of the sensor. -Precision in installation of the sensors for increased efficiency.

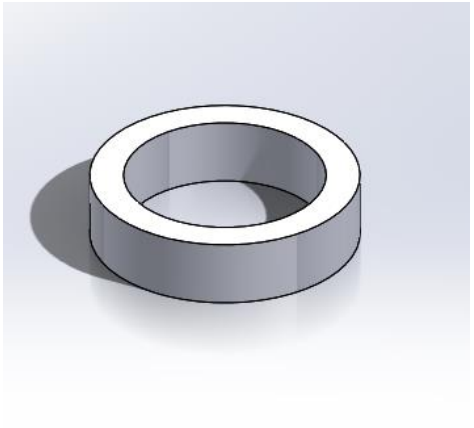
Appendix C: Bill Of Materials

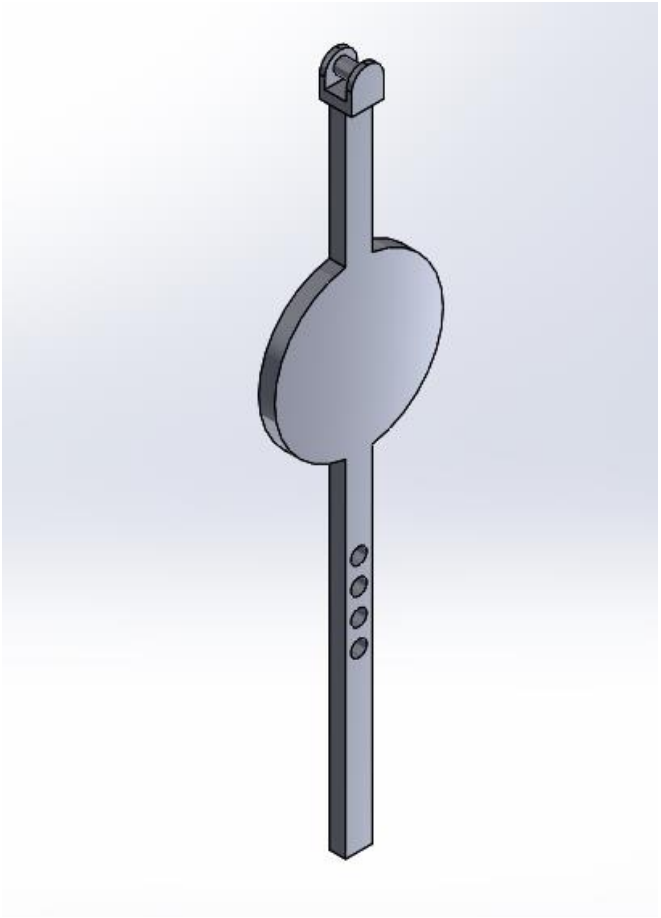
Bill of Materials

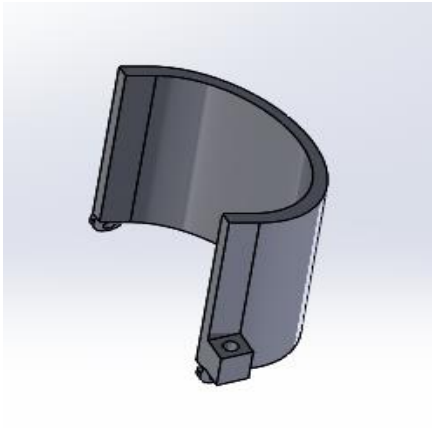
Part #	Part Name	Qty	Description	Functions	Material	Dimensions	Cost	Link
1	Frame	2	Contains holes at different parts for holding other parts	Hips and legs support	Carbon Fiber/ Aluminum	4 in each	$150	https://www.alibaba.com/trade/search?f0=y&IndexArea=product_en&CatId=&SearchText=carbon+fiber+tube&refine_attr_value=324-352311
2	Arrestors	3	2-for thighs and 1 for pelvic area support	Support to the thighs and hips	PVC	2 in each	$10	https://pvc-films.en.made-in-china.com/product/aqtQOTXKfNVy/China-PVC-Film-PVC-Sheet-PVC-Sheeting.html
3	Small Motors	2	Hip and knee joints actuation	Actuators	Carbon casing	19mm	$180	https://www.maxongroup.com/maxon/view/content/ec-flat-motors
4	Sensors	2	Placed on the pelvic component.	Signal detection on the hips.		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%23d &target=filter&filterCategory=encoder

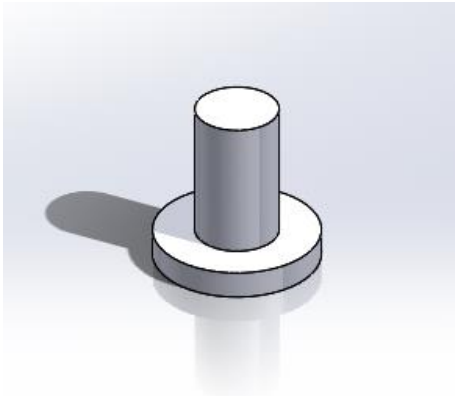
Appendix D: CAD Parts











Appendix E: CAD Parts