BME 400

DEPARTMENT OF

Biomedical Engineering

UNIVERSITY OF WISCONSIN–MADISON

Continuing Project: Adaptive Rowing Machine

Preliminary Presentation October 7th, 2022

Client: Ms. Staci Quam

Advisor: Dr. TJ Puccinelli, Lab Section 307

Team Members





BSAC:	**Communicator:**	**BWIG:**	**Team Leader:**	**BPAG:**
Samuel Skirpan	Josh Andreatta	Tim Tran	Annabel Frake	Roxi Reuter

Overview of Presentation

- Client Introduction
- Problem Statement
- Background Knowledge
- Competing Designs
- PDS
- Past Design Work
- Design Improvements
- Future Work

Client Introduction

- Ms. Staci Quam
- Mechanical Engineer and Biomech Lab Lead at Johnson Health Tech

[1][2]

Problem Statement

- Individuals in wheelchairs have trouble utilizing exercise equipment
- Rowing machines are not accessible to wheelchair users
- A standard Matrix rowing machine [3] will be adapted
- User safety must be ensured during interactions

[3]

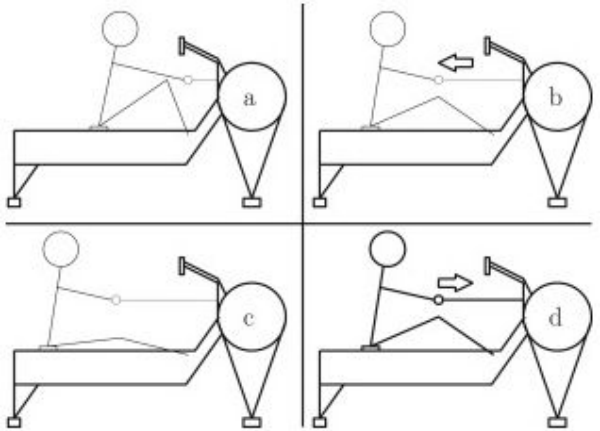
Motivation

- 5.5 million wheelchair users in the U.S. [4]
- Exercise machines at fitness centers lack adaptive equipment [5]
- Upper body pain is common problem amongst wheelchair users [6]
- Existing devices permanently change functionality of rower [7]

[5]

Physiological Research

- Consistent exercise is essential to prevent pain [6]
- A rowing exercise activates numerous muscle groups [8]
- 4 phases of the exercise [9]:
  - Catch (a)
  - Drive (b)
  - Finish (c)
  - Recovery (d)



[9]

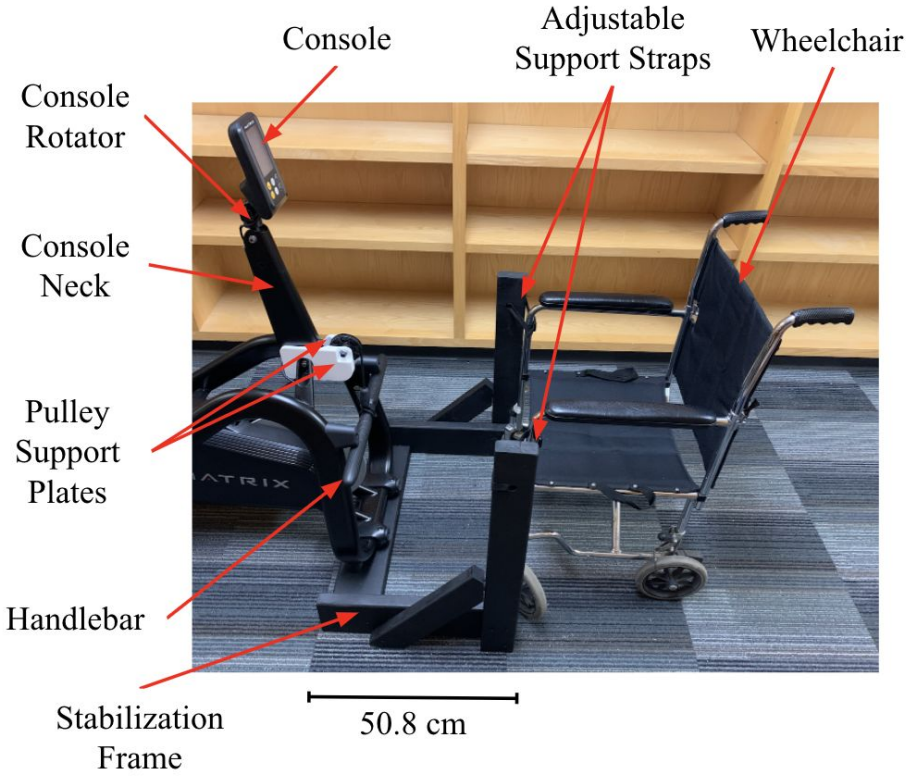
Competing Designs: Adaptive Rowing Machine (AROW)

- Designed by researchers at British Columbia Institute of Technology
- Specifically for Concept 2
- Design and fabrication instructions are free

[5]

BME 301 Rower Accomplishments

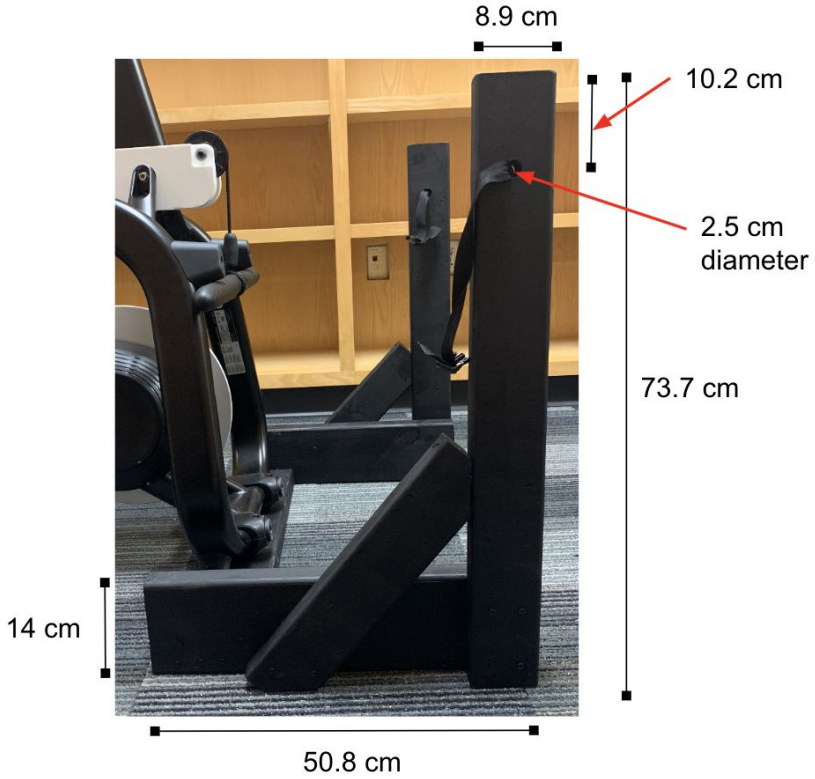
- Slit cut in rower neck to transition rope
- Pulley plates to support 2nd pulley
- Console swivel bracket to turn display
- Wooden stabilization frame



Product Design Specifications

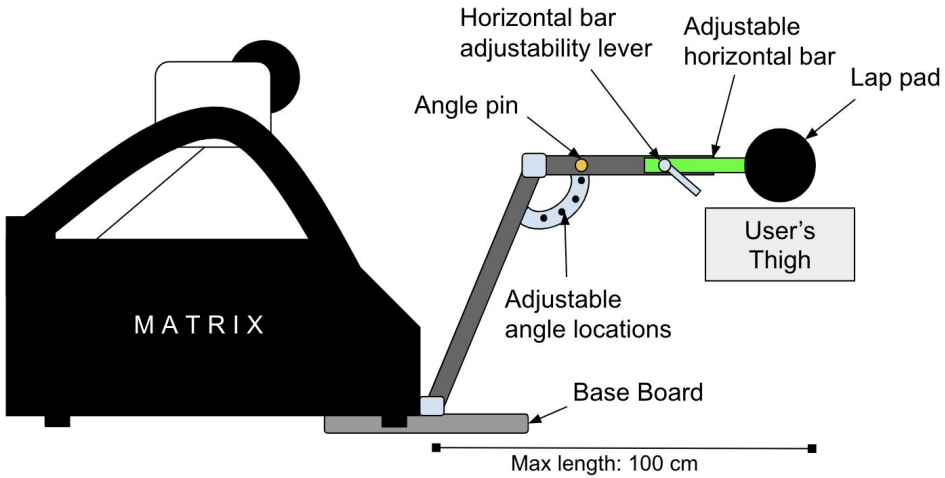
- Zero outside assistance required
- Materials made out of metal and professionally fabricated
- Withstands at least 10 years of usage or 8 million meters [11]
- Users will need to reach a max of 0.55 m to grab the handle [12]
- Normal rowing motion is preserved - 4 rowing phases
- Pulley Plates withstand 1050 N load (safety factor = 2) [13]
- Adjustable design to accommodate varying sized wheelchairs [14]
  - Width of Frame: 0.6 - 0.7 m
  - Height of Seat: 0.45 - 0.5 m
  - Length: 0.9 - 1.25 m

Current Stabilization Design



- Made out of 2x4s and 2x6s
- Utilizes strap mechanism to secure wheelchair
- Prevents tipping from occurring
- Room for improvement:
  - Not adjustable
    - Max width of 66 cm
  - User is not prevented from falling out of wheelchair

Design Improvement: Pad Support

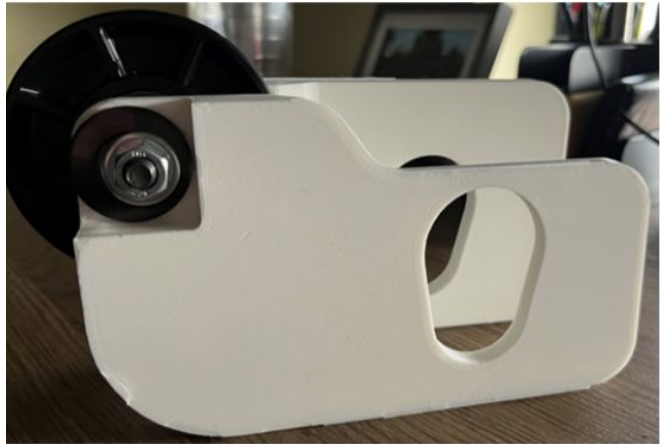


*Note: Drawings not to scale

- Frame will be built out of durable metal
- Utilizes both pin-angle and lever adjustability
- Lap pad supports user and prevents tipping
- Connects to rower via baseboard

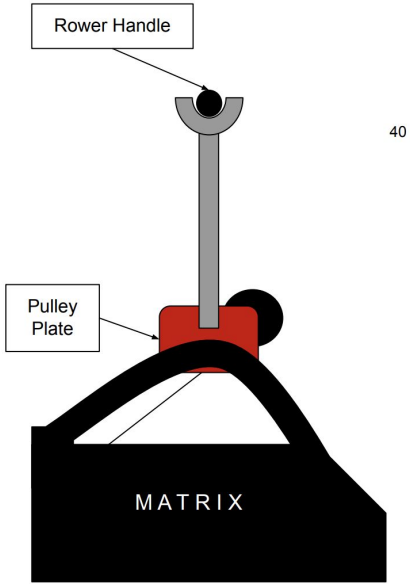
Current Design: Pulley Plate

- 2nd pulley held in place by pulley plates (tough PLA)
- Slit in the rower neck for rope transition
- Room for improvement:
  - Rower welds inhibit plate fit
  - Must remove rope tension to transition handlebar

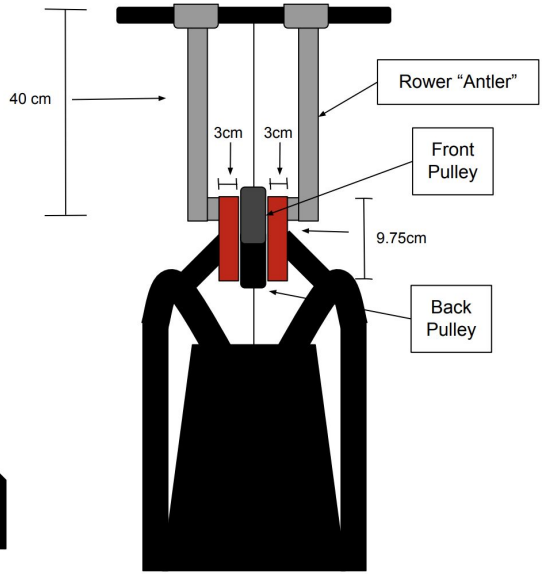


Design Improvement: Antler Design

- Removal of rower neck
- Addition of 2 antlers to relocate the rower handle
- Attached to pulley plates
- Solves tension-removal issue for handle bar transition



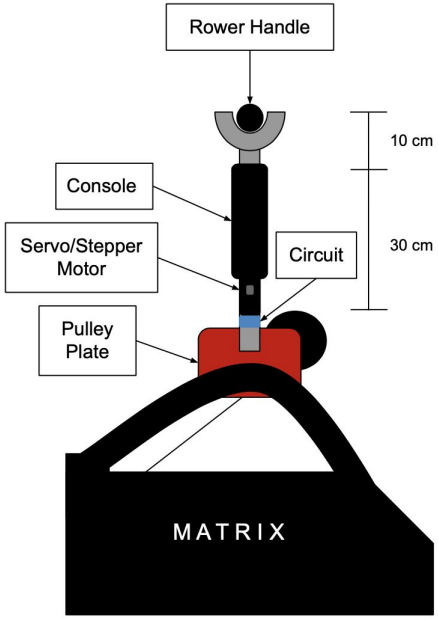
Side View
(Left of adapted side)



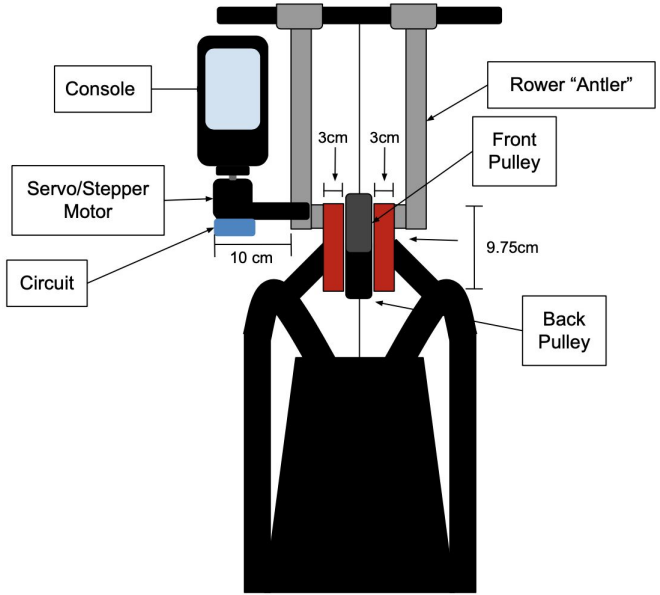
Front View
(Adapted Side)

*Note: Drawings not to scale

Console Design



Side View
(Left of adapted side)

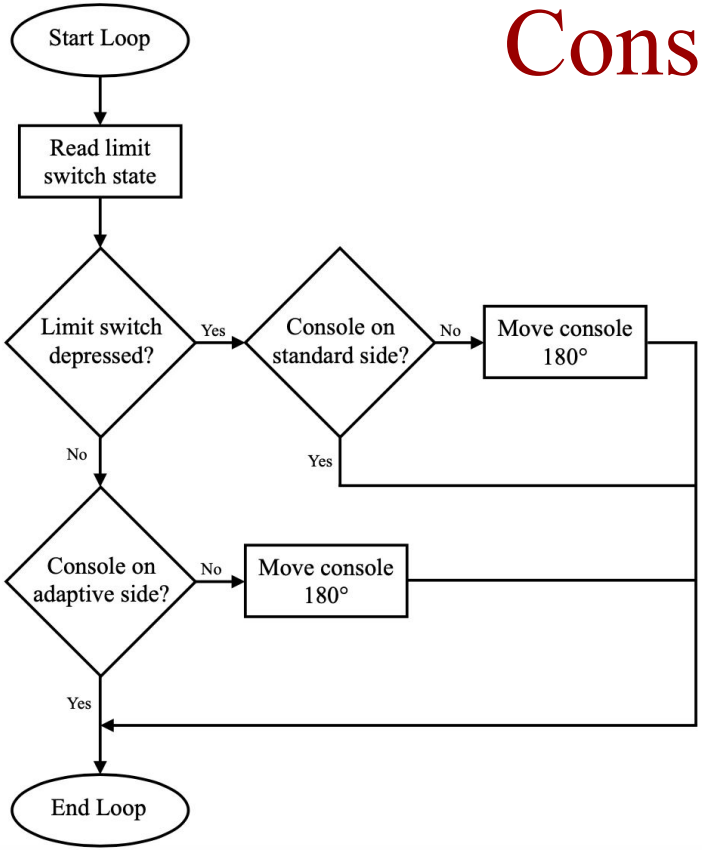


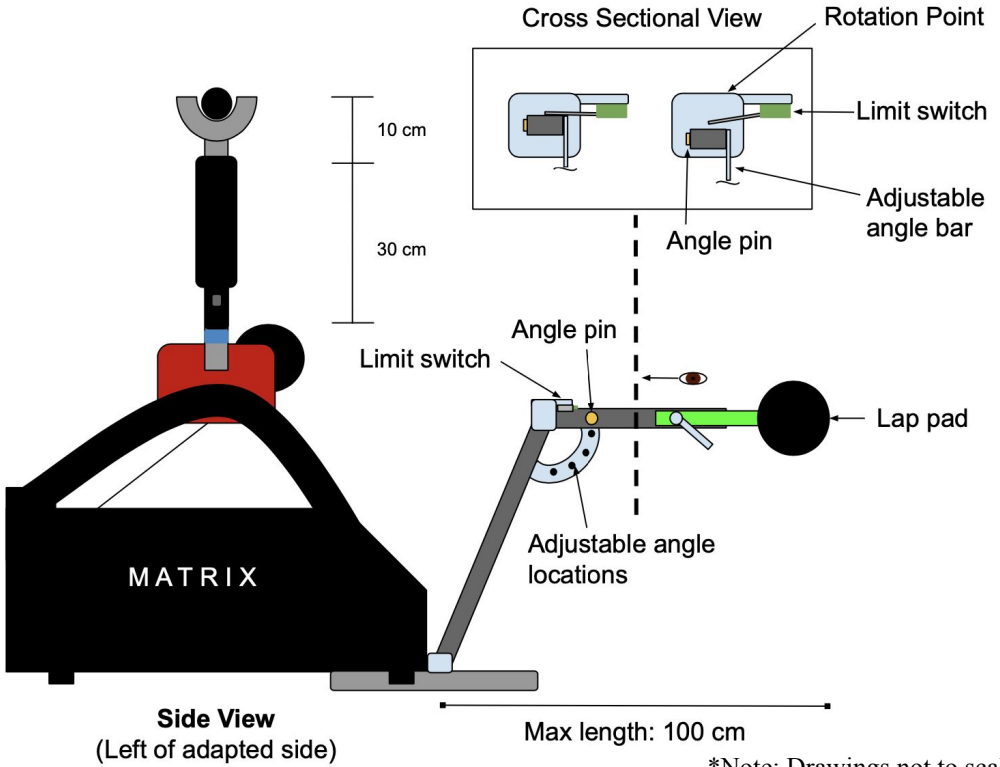
Front View
(Adapted Side)

*Note: Drawings not to scale

- Console attached to one antler
- Servo/Stepper motor rotates console 180°
- Automatic adjustment of console with limit switch

Console Automation





*Note: Drawings not to scale

Future Work

- Create CAD files of design improvements
- Source materials
- Fabricate
- Generate test plans

Acknowledgements

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Thank you to past contributors - Dhruv Biswas, Cate Flynn, and Dr. John Puccinelli

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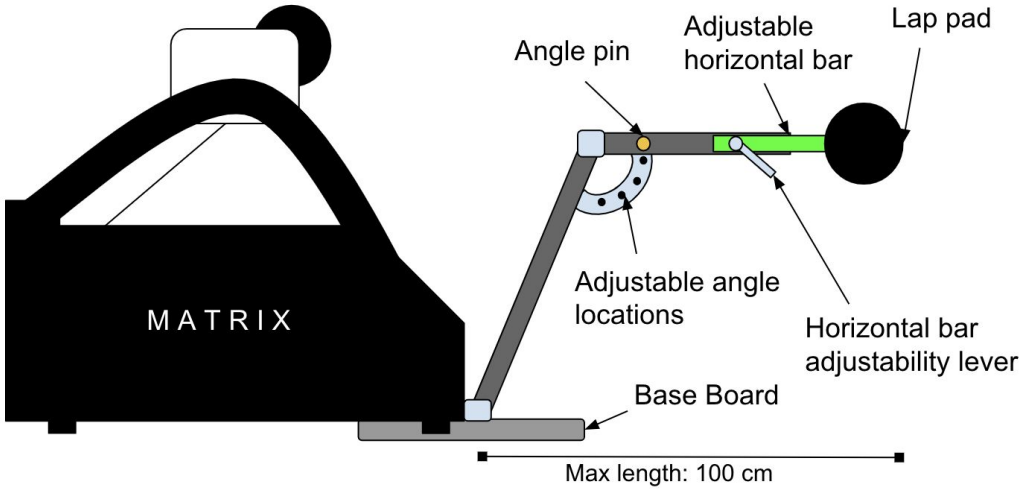
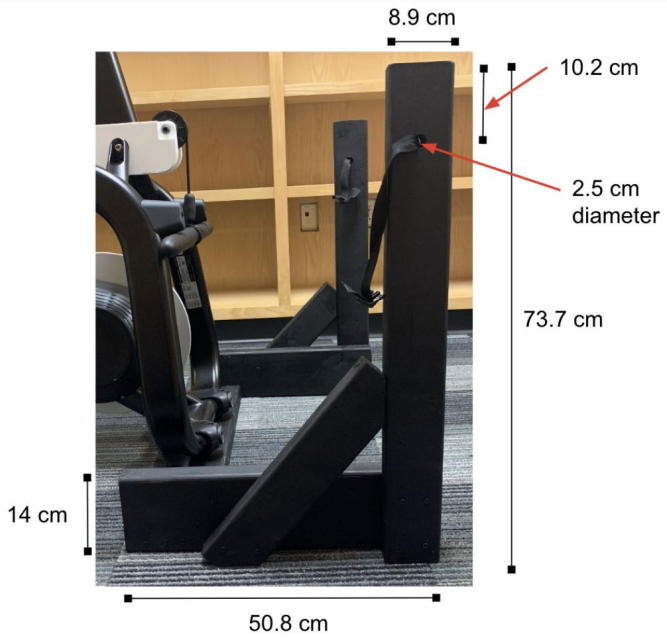
QUESTIONS

Appendix A: Stabilization Designs

Bar-in-Bar Pad Support



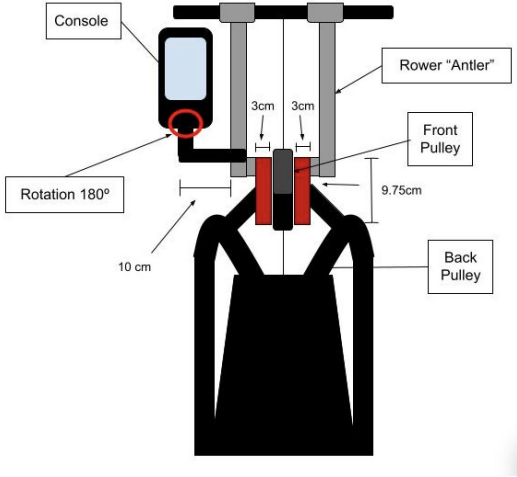
Base Stabilization Frame



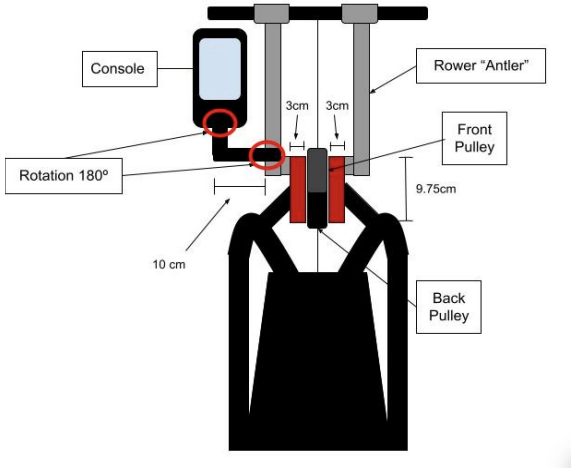
	Bar-in-Bar Pad Support		Base Stabilization Frame	
Safety / Security (30%)	5/5	30	3/5	18
Adjustability (25%)	5/5	25	1/5	5
Ease of Fabrication (15%)	2/5	6	4/5	12
Ease of Use (15 %)	4/5	12	5/5	15
Cost (10%)	3/5	6	4/5	8
Integration to Environment (5%)	5/5	5	3/5	3
Total for each design:	**84**		61	

Appendix B: Console Designs

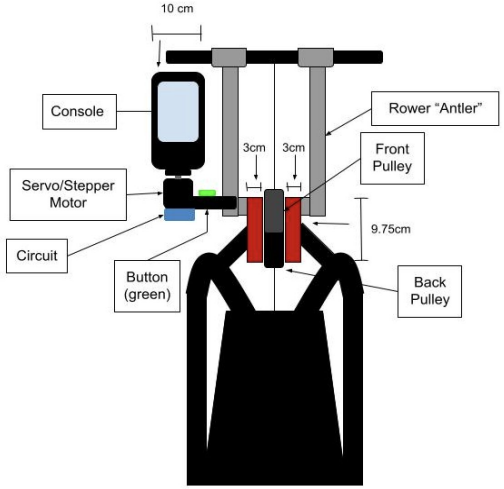
1 Pivot Point



2 Pivot Points



Motor



	1 Pivot Point		2 Pivot Points		Motor	
Ergonomics (30%)	4/5	24	5/5	30	4/5	24
Ease of Rotation (20%)	3/5	12	2/5	8	5/5	20
Ease of Fabrication (20%)	5/5	20	4/5	16	4/5	16
Durability (15%)	4/5	12	3/5	9	5/5	15
Safety (10%)	5/5	10	4/5	8	3/5	6
Cost (5%)	5/5	5	5/5	5	4/5	4
Total for each design:	83		76		**85**	