EML4501 Spring 2020 – Group 12
Christian Brame, Ryan Brouillette, Anthony Marquez,
Lucas Mir, Sean Stelzer, Jack Reinke, James Wheeler

B.R.A.M.E. Frame

UF | Department of Mechanical & Aerospace Engineering
UNIVERSITY of FLORIDA

Product Functionality

A **B**alancing and **R**eactionary **A**utomatic **M**oveable **E**levator frame has been developed to lift patients who have lost the use of their legs and provide body weight support during elliptical training. The system is composed of two symmetric motor assemblies that lift the patient out of their wheelchair and provide balancing during elliptical operation via a closed-loop control system. Trainers will manually move the patient forward to the elliptical using a guided rail system, locking the structure in position. Using the same motor assemblies for both the primary and secondary lifting systems allows for easier design and fabrication. The final system considered is a user interface for the controls operations of patient movement. This is fulfilled by an iPad which provides not only a smoother workflow for the technician operating the machine but also a simple yet adaptive control panel.

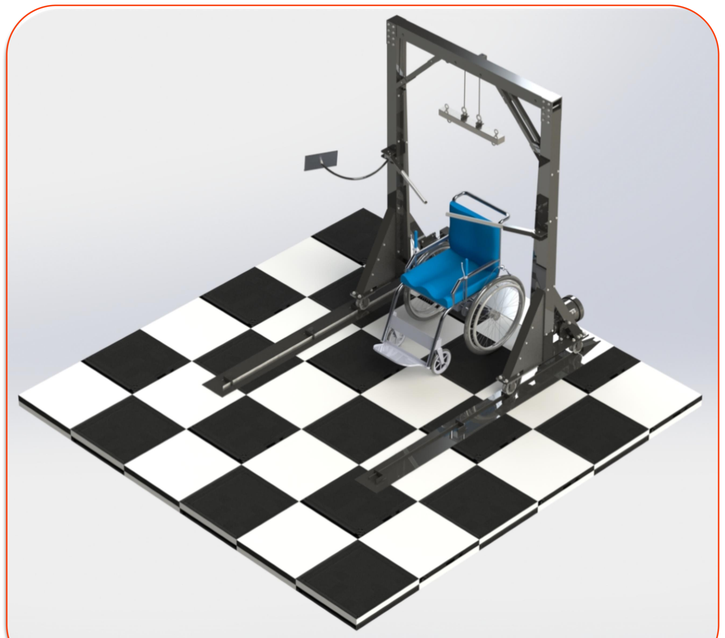

Figure 1. Isometric view of full frame assembly.

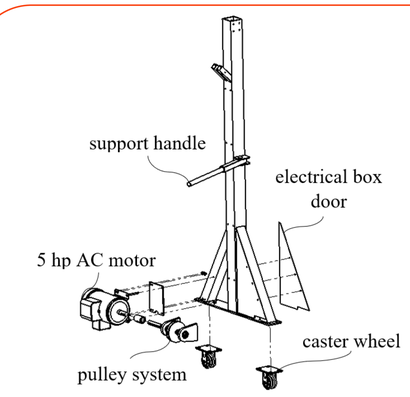

Figure 2. Exploded view of right structure.

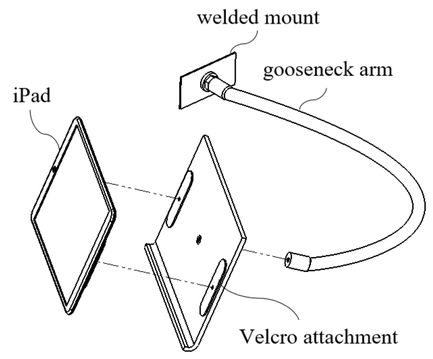

Figure 3. Exploded view of UI assembly.

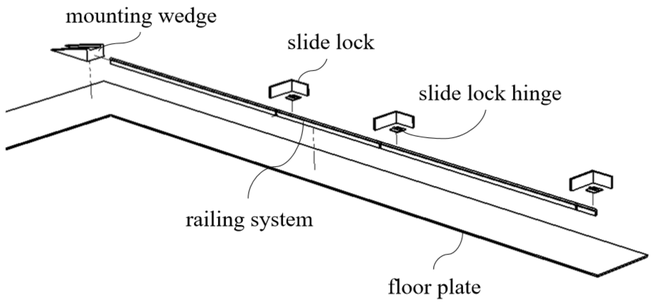

Figure 4. Exploded view of right half of floor assembly.

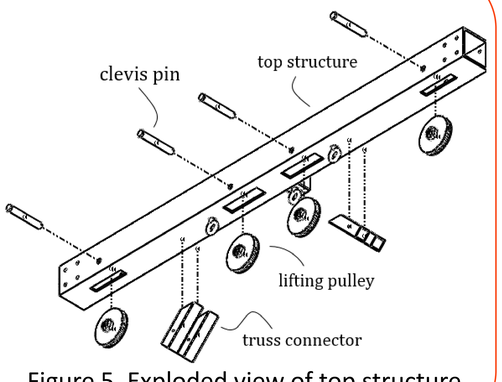

Figure 5. Exploded view of top structure assembly.

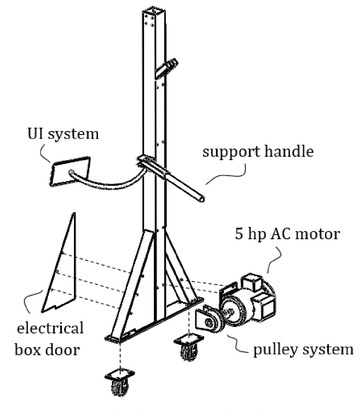

Figure 6. Exploded view of left structure.

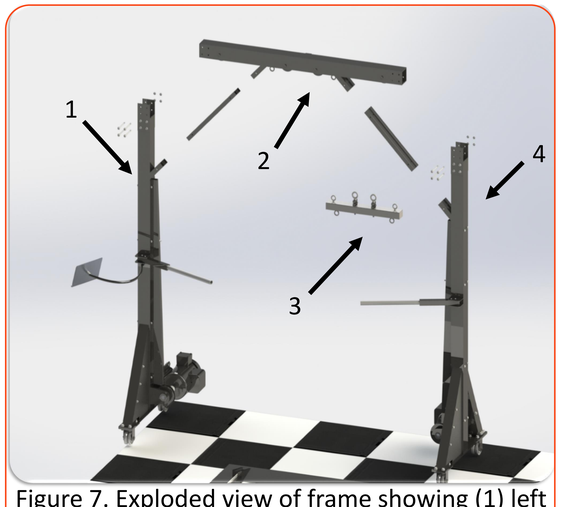

Figure 7. Exploded view of frame showing (1) left structure, (2) top structure, (3) lifting block, (4) right structure.

Floor Mounted Rail System

The rail system is welded to a 3/16" plate which has an adhesive backed rubber mat attached to the bottom. The rails are V-Groove caster wheel rails with custom slits. These slits line up with several foot operated locks to maintain the assembly position. The ramp at the rear will guide the assembly onto the rails and act as a passive stopper during operation. To move the assembly to a new location, all rail locks can be disengaged, allowing the assembly to move forward off of the rails. From here, the floor plate can be moved, and the assembly can be guided onto the track again using the ramps.

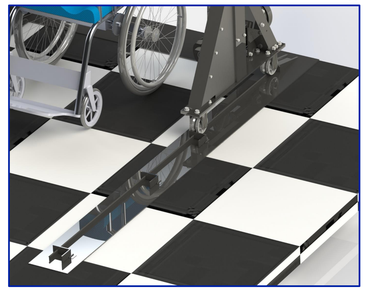

Figure 8. Floor mounted rail system.

Adjustable Handlebars

The BRAME frame also features adjustable handlebars to assist patient stability during operation. The arms can be placed forward during patient loading to not interfere with the loading space. When the BRAME frame is stored, the handlebars can be folded parallel to the top structure whilst the entire structure is locked into position above the elliptical, allowing for minimal space usage when not in operation.

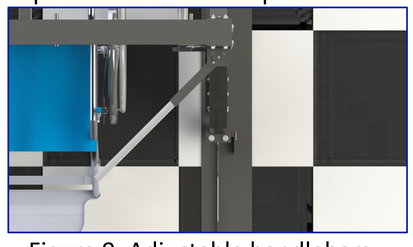

Figure 9. Adjustable handlebars.

Internal Pulleys

Shown to the right is the internal cross section of the BRAME frame. The top structure houses several internal sheaves which redirect the ultra-flexible 6x37 IWRC wire rope down to the load cells and lift block. The internal pulleys allow for space and cost savings over another lifting mechanism. The wire rope has a guard on either side stretching from the motor to the truss-extensions to prevent patient interference with the wire rope during operation.

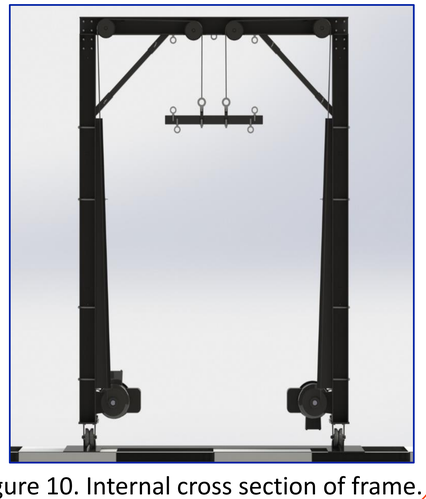

Figure 10. Internal cross section of frame.

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Cost

OTS Parts: $3181.20
Raw Materials: $2529.24
Manufacturing: $1201.85
Energy Consumption: $0.90
Assembly: $61.75

- Primary Lifting Sub-System
  - Speed
    - Runs on 120 VAC electricity with 15-amp breaker
    - Slowly transitions to preset offset weight
  - Maximum Capacity
    - Supports the full weight of the user
    - Lifts user from a seated position to fully suspended
    - Holds the user suspended
  - The motors are 208-230 V single phase, which can still work on 120V
  - The speed of the subsystem is 8 in/s
  - The subsystem can support a max of 358 pounds
- Secondary Lifting Sub-System
  - Maximum Capacity
    - Includes a fail-safe
    - Offset weight support feels continuous to the user despite the repeating periodic motion of their exercise
  - Hardware Response Time
    - Provides continuous user-defined offset weight support while user is exercising
  - The subsystem can support a max of 358 pounds
  - The response time of the subsystem is 2.48 seconds
  - The structural subsystem can support a max of 11,700 pounds
  - Entire structure weighs 240 pounds and has a width of 5 feet
  - The height of the entire structure is 7 feet which allows the user to comfortable operate the elliptical
- Structural Design Sub-System
  - Width
    - Must fit inside a medical or rehabilitation facility
  - Weight
  - Height
    - Allows the user to stand and exercise on a stand elliptical machine without interfering with the elliptical machine's operation
    - Allow user to translate unencumbered in the vertical direction
  - Installation
    - Can be mounted from structural members or can sit on the floor
  - Maximum Capacity
    - All design margins have an acceptable factor of safety
  - Points of Lifting
    - System prevents the suspended user from swinging
    - Prevents the user from losing balance in a sagittal and transverse fall
  - The assembly can be broken into 3 parts
- Harness Sub-System
  - Material Strength
    - Operational lifetime that exceeds by three times the operational lifetime
  - Harness Surface Area
    - Accommodates user body sizes ranging from 5% female to a 95% male
  - The harness subsystem is attached to the structural frame at 4 different points to prevent swinging
  - The subsystem's material strength is 7000 psi
  - The harness subsystem is attached to the structural frame at 4 different points to prevent traverse and sagittal fall
    he motors are 208-230 V single phase, which can still work on 120V
  - The harness subsystem has a surface area of 312 square inches and is adjustable
- Transition Sub-System
  - Speed
    - Lifted from wheelchair and can be placed on the elliptical trainer at safe and comfortable speeds
  - Maximum Capacity
    - Moves the fully suspended user from their original location over a standard elliptical trainer
  - Bounding Box
    - FES stimulation pad electrical connections must be accessible
    - Overall footprint of lift system cannot exceed 2.43 m X 3.05 m (8' X 10')
  - The speed to move the user from the lifting point to the elliptical is 3.8 in/s
  - The subsystem can support a max of 358 pounds
  - The total volume of the system is 85.67 feet cubed which allows enough space for FES stimulation connection
  - The total system footprint is 6.4' X 9'
- User Interface Sub-System
  - Increments
    - Allows user to select offset weight to any value between 0% and 100% of their body weight
  - Steps to Reprogram
    - Is programmable
  - Steps to Switch Function
    - Has an intuitive user interface
  - Emergency Button Size
    - Includes an emergency shut-off that can be actuated by the user or nearby trainer
  - Indicators
    - Includes an automatic force-based safety limit shutoff
    - Has visual indicator
  - The user can offset their weight down to an increment of 0.1 pounds for precise offset
  - It takes only 1 step to reprogram the iPad user interface system
  - It takes 2 steps to switch function with the iPad user interface system
  - The emergency button is 3 inches in diameter, so it is easily pushed by user or the trainer
  - The user interface indicates when the system senses the force-based limit is reached and shuts off
  - The user interface subsystem has 10 indicators
- Entire Assembly
  - Cost
    - Cost does not exceed $4,000
  - The total cost is over $4,000