Rehabilitation Device for the Lower Extremities for Developing Countries

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Abstract

A team of five, female biomedical engineering students are focused on the design and fabrication of a device that will be used to rehabilitate the lower extremities. This project will be carried out at the University of Wisconsin-Madison and the product will be transported to La Cieba, Honduras where it will be used at the CRILA rehabilitation clinic. The device will be used by physical therapists to provide patients with a gradual physical therapy treatment plan that may be customized to each patient's specific needs. The device will serve as a platform for women in the community to develop skills in science and engineering. The team intends to teach these women how to replicate multiple versions of this device. This would in turn improve the quality and access to medical care for a larger percentage of the population.

Problem Statement

CRILA is a rehabilitation clinic in Honduras that serves people with a variety of disabilities. Specifically, many young adults to elderly patients suffer from ailments in the lower extremities resulting in the need for unique treatment and rehabilitation programs. In order to strengthen the lower extremities resulting of the patients, we will design a device that allows the patient to lie on their back with their knees at a ninety-degree angle and feet pressed against a solid plate. The device will also include elastic cords of increasing strength with simple hook ends to aid in strengthening of the lower extremities. Our client Karen Patterson requests that the device be cost effective, locally manufactured, and easily assembled and replicated in Honduras. Additionally, it must be able to withstand a high frequency of use, require low maintenance, and be portable for ease of transport.

Keywords:

Lower Extremity Device
Rehabilitation
Closed Kinetic Chain
CRILA Clinic
La Ceiba, Honduras
Women Empowerment

Acknowledgements

We would like the give a special thanks to Dr. Amit Nimunkar and the UW Madison Biomedical Engineering Department for guidance and input throughout the entire design process. Additionally, Mary Doherty, Jeff Patterson, and the Hackettt Hemwall Foundation for inviting us to join them on their travels to Honduras to implement the device. A thanks to the Karen Patterson and the UW physical therapy department for contributing their knowledge in the physiological effects of our design. Finally, we would like to thank Chet Hermansen and Kendra Zimmerman for their assistance in fabrication.

I: Introduction

Physiological Need for Device in Honduras

The United Nations reports that Honduras has the highest rate of homicide on the planet. It is estimated that there is violent death every 74 minutes in Honduras (BBC, 2012). As a result of the high level of corruption, which often leads to attacks such as gunfire, those afflicted end up with various disabilities. Consequently, there is a high demand for physical therapy in the area. In addition, several viruses and degenerative diseases are also prevalent in Honduras, such as Polio, leaving many citizens in need of muscle rehabilitation in their lower extremities.

CRILA (Centro de Rahbilitation Integral del Litoral Alantico) is a rehabilitation clinic in La Ceiba, Honduras that serves people with a variety of disabilities. Specifically, many young adults to elderly patients suffer from ailments in the lower extremities resulting in the need for unique treatment and rehabilitation programs. Currently, the organization lacks the necessary resources to provide essential care to its population, as it services about 50 patients a day. It has access to open kinetic chain exercises, such as free weights and elastic bands. However, these types of exercises aren't as efficient for gradual recovery as closed kinetic chain exercises. This is because closed kinetic chain exercises much more closely mimic the average person's muscle movement. Since our device will be a closed kinetic chain device, it will be a great resource for those needing muscle rehabilitation.

Our Solution

In order to strengthen the lower extremities of the patients, we will design a device that allows the patient to lie on their back with the knees at a ninety-degree angle and feet pressed against a solid plate. The device will also include elastic cords of increasing strength with simple hook ends to aid in strengthening of the lower extremities. Our client Karen Patterson requests that the device be cost effective, locally manufactured, and easily assembled and replicated. Additionally, it must be able to withstand high frequency of use, require low maintenance, and be portable for the ease of transport.

II. Background Research

Patents and Commercial Products

To begin our project, we read numerous research papers and patents. A lot of our research was put into closed kinetic chain devices and resistance bands. From the beginning, we knew that one of the most challenging parts of our device would be the resistance aspect. We were unsure of how to minimize costs, while finding resistance bands that would execute properly. During our research, we looked into how to fabricate elastic resistance bands ourselves, as well as prices and types of various bands that could possibly work in our device. Another important aspect of our research was looking into commercial products. We found many products on the market and created a list of pros and cons for each one.

Figure 1: Reformer with simplistic design and ease of fabrication

We liked the "Reformer" for its simplicity (Figure 1). The device's frame is made of wood, which is accessible, easy to fabricate with, and inexpensive. We also liked that the device was raised off the ground because this makes it more user friendly.

a)

b)

Figure 2: a) Shuttle Recovery found in the rehabilitation center at UW-Madison b) Elastic bands connection to the Shuttle MVP.

We found quite a few "Shuttle Systems" that were useful in helping with our design as well such as the MVP, Recovery, and 2000-1 (Figure 3A). Although more complicated than others we looked at, we liked the ease of use of the Shuttle products. They feature movable backrests which creates individual comfort. The footplate for these products was quite large which made it simple for each person to put their knees at a ninety degree angle. The footplate was also lifted off the base of the machine, so that the device could also be used for other exercises such as calf raises.

Luckily, our physical therapy department here at UW Madison has the Shuttle MVP, so we were able to get a close up view of the product. This was very helpful in our design process and allowed us to get a better look at how each aspect of the device worked in conjunction with the next. We spent a lot of time looking at the resistance aspect of the product, as well as the track that the carriage slid on while in use. The product had two different size bands of differing resistance, and they incorporated "pull straps" attached to the bands. The pull straps made it easier for the user to change the resistance. When resistance was added, the user pulls the pull straps back and simply hooks a stopper into an open U shaped hook. We found this design simple and effective. The track on this device was very interesting. There were vertical wheels as well as horizontal wheels. The vertical wheels were used for the sliding up and down the machine, and the horizontal wheels prevented the carriage from moving side to side while being used.

Looking into commercial products was very helpful in our brainstorming and design process. Not only was it helpful to have the overall product knowledge, but also it was helpful to look into minute details such as the size of the footplate and carriage, the connection of resistance bands, and the handles for stability. Many of the aspects we liked from current products, we were able to incorporate into our own device. We decided to use the large static footplate, the handles on the sides of the carriage, and the comfortable seat. We also used many of the dimensions we found from commercial products.

Our next step in the design process was to decide on our design specifications. From our client, we knew that our design must be cost effective, portable, and easily replicable in Honduras with local materials. Our device will be used as a rehabilitation for the lower extremities, so it will be necessary for our device to strengthen the lower extremities. Because patients will be using this machine, our device must be very safe and should accurately fit all patients from young adults to elderly. It will not be designed for children. Since many people will be using the device each day, our device must be able to withstand high frequency of use, and the elastic bands should provide the same amount of resistance with each use. Due to the humid environment, it is necessary to make our device out of materials that can withstand these conditions. Our device should last for approximately ten years and the bands should last for three to five years. We hope to make the device for under $500.

III. Design Considerations/Decision Matrix

The design requirements provided by our client, greatly affected the materials that we chose for this device. Because of the fact that it is going to be used in the humid, and occasionally termite infested, environment of Honduras we chose to build with treated lumber for the major structural components of the device. Major structural components in this context refer to the base of the device as well as the most of the carriage. We made this decision based on the fact that treated lumber is significantly more durable in these types of conditions. Another material decision that we made right away was the use of steel for components under a lot of shearing stress such as the footplate and its respective supports that extend to the ground. Other components of the device such as the design of the track and the attachment of the bands required further brainstorming and evaluation. For these categories we used a decision matrix broken up in the following design criteria: feasibility, functionality, accuracy/precision, cost and safety. Out of these criteria we listed feasibility and functionality as the most important criteria. We chose these two criteria to hold the most weight because having the device function is essential and we also want the women on La Cieba to be fabricate additional versions of the device as necessary.

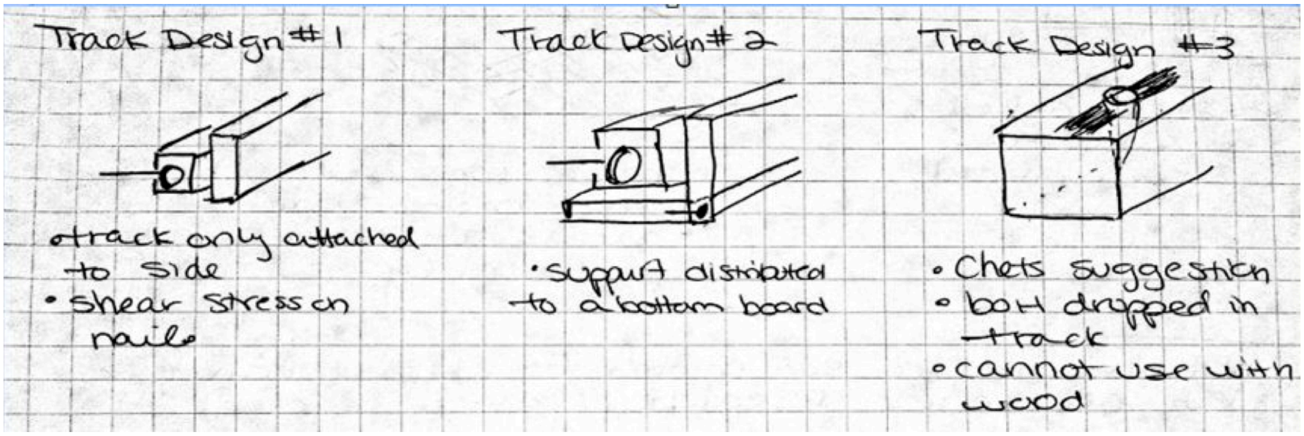


Figure 3: Original Track Designs. Track design #1 is the “Side Track”, track design #2 is the “Base Track” and track design #3 is the “Bolt Track”.

Criteria	Side Track	Base Track	Bolt Track
Feasibility (15)	13	11	5
Functionality (15)	11	14	7
Accuracy/Precision (10)	8	9	8
Cost (10)	10	9	6
Safety (15)	4	5	5
Total (55)	46	48	31

Figure 4: Decision matrix for the track designs. Based on the decision matrix, wedecided that the base track would be the best choice out of these options because it would provide additional support for the load-bearing track.

Our initial track ideas came down to three main designs. Design number one we referred to as the “Side Track” because the track would be secured directly to the sideboard of the frame. This design was appealing because it kept things simple and was similar to the reformer and Shuttle MVP Pro however, we ruled it out due to functionality, accuracy, and safety. Using basic analysis we determined that the shearing strain felt by the frame would be excessive and could potentially lead to failure. The second track design that we had was the “Base Track”. This design was similar to the first design however it had an additional reinforcing board underneath the track. This design gave us two options for attachment of the track, either on the side or on the bottom. This design scored the most points on our decision matrix as you can see from the table. The third design that we had was the “Bolt Track”. In this design a bolt would slide within a lubricated block. This design received the fewest number of points due to limitations with feasibility and functionality. After numerous discussions with you fabrication assistant, Chet, we determined that none of these original ideas would be sufficient. Instead, we took the advice of Chet and are using a plastic track and plastic slats that are attached to the bottom of the carrage. Each of the plastic pieces will be coated with a silicon lubricant in order to reduce friction forces and ensure smooth movement.

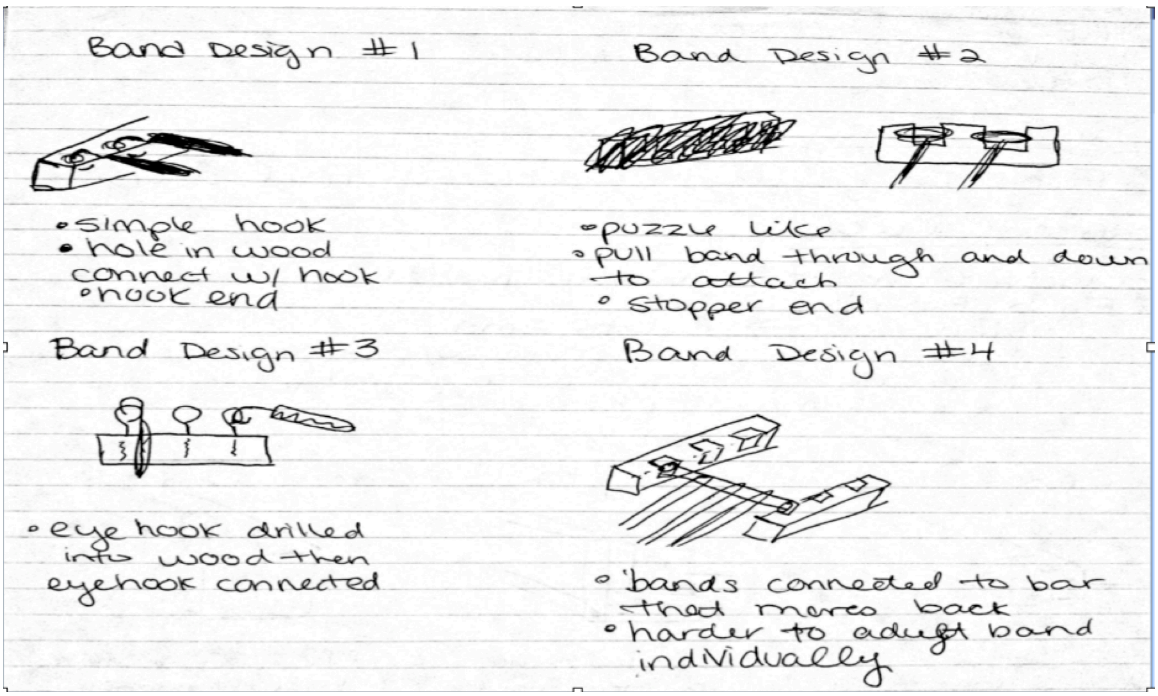


Figure 5: Band attachment designs. Band attachment design #1 is the "Simple Hook", band attachment design #2 is the "Puzzle/Knot Attachment", band attachment #3 is the "Eye Hook" Attachment, and band attachment design #4 is the "Simple Hook with Adjustable Bar". Based on the decision matrix shown below we have decided to go with the "Simple Hook" design however this may change upon further testing.

Criteria	Simple Hook	Puzzle knot	Eye Hook	Adjustable Bar
Feasibility (15)	14	14	15	8
Functionality (15)	9	9	6	8
Accuracy/Precision (10)	15	15	13	7
Cost (10)	8	8	9	4
Safety (15)	5	4	3	2
Total (55)	51	50	46	29

Figure 6: Decision matrix for band attachment designs. Thus far, we have decided to go with the simple hook design however this may change with further testing and analysis.

The way in which we attach the band was another design component that we felt would be best decided using a decision matrix. Our first design idea was the simple hook which consisted of a thin metal plate with holes that each back will hook into (Figure 5). The ends of the chords will consist of hooks just like a bungee cord. This design scored high in our decision matrix for a variety of reasons; however, we really like it because it is a material that is available in La Cieba which means that it could be easily replaced if necessary. This first design is the one that we are currently planning on using. The second band attachment design that we had was the puzzle or knot attachment. This design is similar to the first however instead of attaching with a hook the end of the cord would attach into a fitted slot like a puzzle piece. This design was similar to the designs on the Shuttle MVP and reformer however we ruled it out for safety reasons. The third band attachment design that we had was referred to as the eye hook attachment. In this design a hook on the end of the cord would hook into an eye hook located at the front of the frame. Although this idea would have been simple to fabricate, we decided against it because we did not feel that eye hooks would be sufficient to withstand the approximately 34 lbs of force that would be exerted on each one. The fourth and final band attachment design was the simple hook with adjustable bar. This design would have an adjustable bar that could be moved backward or forwards in order to increase or decrease the resistance based upon the patients needs. One benefit of this design is that the resistance could be adjusted without having to unhook a single band. As you can see from the decision matrix (Figure 6) we decided against this design because we could not verify that the bar would remain in place therefore making it potentially unsafe for the patient to use the device.

Overall Design and SolidWorks 3D Modeling

While considering the availability of local materials, feasibility of replication, ease of use, and cost effectiveness, we made our final design selections. Whereas many of the commericial products that we reseach cost up to $1500, we have proposed a design that can be built for under $500.

The majority of the device is to be constructed out of treated wood. This enables it to last longer and withstand the humid temperatures of Honduras and other developing countries. The frame will stand two feet allowing the clinic therapists to assist patients in the rehabilitation and use of the device. At the end of the frame will be a solid plate cut from a sheet of diamond steel plating. As patients press against the plate, the lower steel supports will be an area of high stress. To reduce bending at this location, the steel supports will extend down through the wood to a steel base support in contact with the lower end of the frame. Additionally, the steel supports will be welded and bolted to the front ridge of the frame.

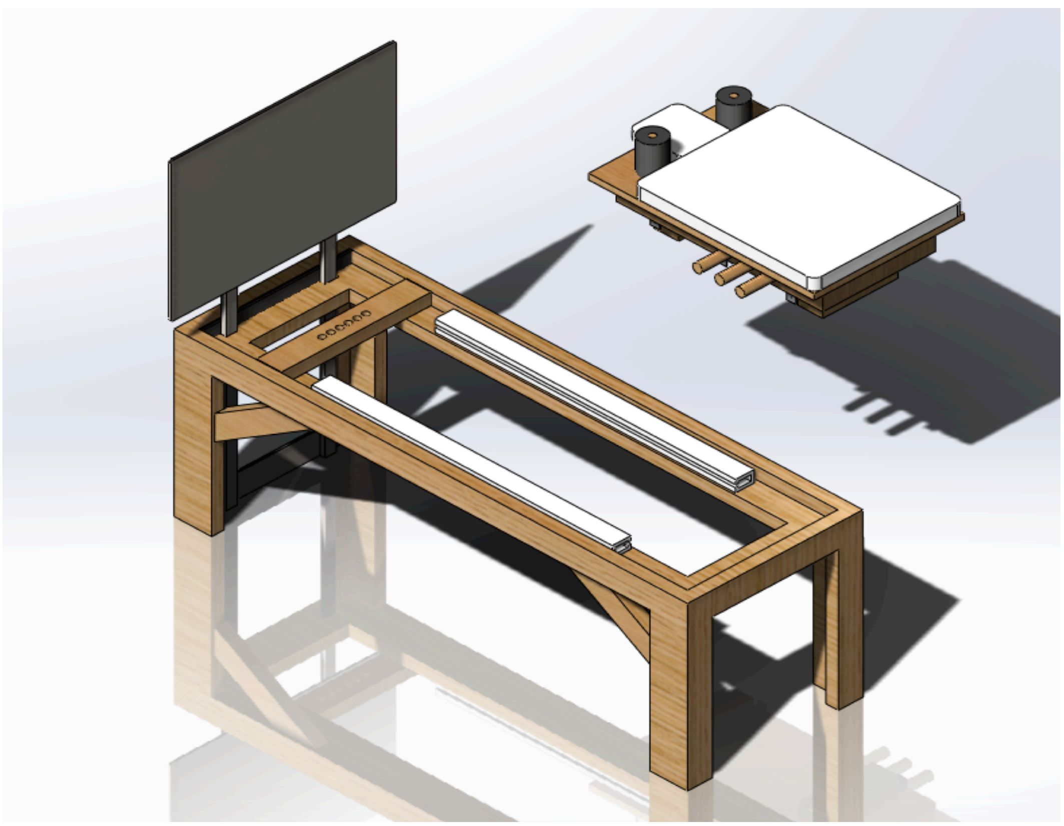


Figure 7: The base composed of a rectangular frame, steel plate with steel supports extending to the bottom of the base, band attachment bar, and plastic track.

Each side of the frame will be constructed from a 4-by-4 with a 2-by-2 extrution along which the track and band connection bar will lay. The end of each side will be cut at a forty-five degree angle and fit together.

After multiple designs ideas and matrices, we have taken the advice of Chet to use a mortise tenon joint to connect the legs of the device to the frame. A mortise is a recess cut into a piece of wood that accepts a tenon and a tenon is the cheek at the end of a board that fits into a mortise. Using a mortise tenon joint provides not only simplicity to the design but strength. The legs will be the tenon and the frame of the device the mortise. The use of tenon and mortise joint not only adds simplicity to the design but also support.

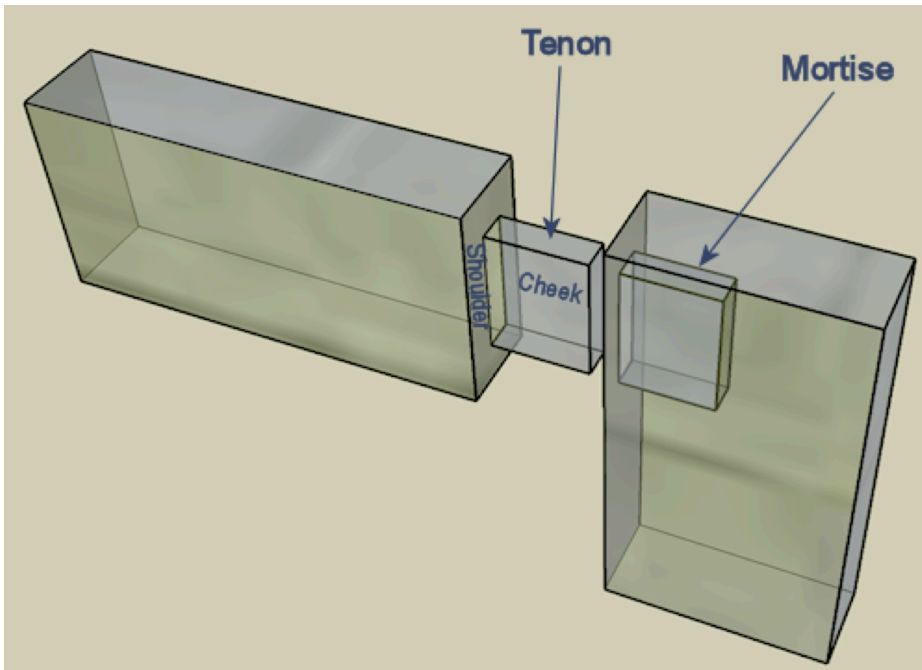


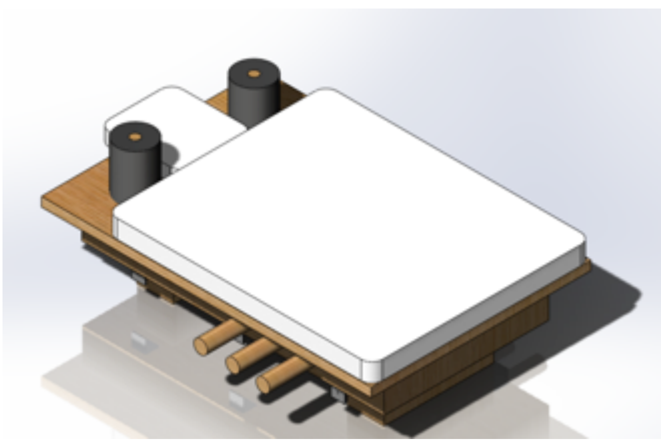
Figure 8: Tenon and mortise joint used for connecting the legs to frame of device.

They will be further reenforced by support beams running parallelt to the frame (note that the SolidWorks Model includes gussets, but this aspect has been changed). These beams will prevent the legs from shifting outwards when a patient lays on the device.

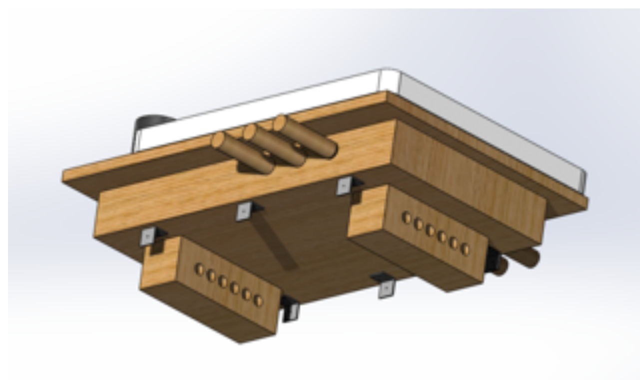
When performing the exercise, the patient will lie on his or her back with their feet pressed against the steel plate at a 90 degree angle. As they extend their legs, the carraige will slide along the track resisted by elastic bands. A series of five elastic bands will be located allow the bottom of the carraige. When one desires to increase resistance of their exercise, they may simpy hook another band to the connection bar at the front of the frame.

The carraige component will be composed of a cushioned back and headrest and padded shoulder supports. A set of handles along the side assist in patient stabilization. The carraige will have a set of plastic sliders located on the bottom, which extend outwards and insert into a plastic track. It may then slide along the track which will be sprayed with a silicon lubricant to reduce friciton. This silicon layer should last up to ten years, but may be reapplied if needed.

Plastic type may be determined by considering the amount of strain the plastic sliders will experience due to patient loading. The maximum bending moment will be located at the center of the plastic planks, and thus this is the location of maximum strain. By knowing the maximum strain values for elastic deformation of our plastic material (ε_{max}, a material constant), along with the dimenstions of the plastic, we can determine the maximum weight of a patient that they may support. This is done using the equation $\varepsilon_{max} = (M_{max}\ C) / IE$ where the moment (M) is affected by the length of the sliders and the weight of the patient, C is a factor of plastic thickness, the moment of inertia (I) is also a factor of width and thickness, and E represents the modulus of elasticity. Thus we can make an intelligent decision when selecting the type and dimensions of our plastic in relation to the amount of loading the sliders will experience.



(a)



(b)

Figure 9: The carriage component. a) Top view shows cushioned back and headrest, shoulder supports, and set of handles. b) bottom view should band connection extended along the underside of the carraige. Not shown: a set plastic rectangular sliders protuding from the sides to be placed in the track.

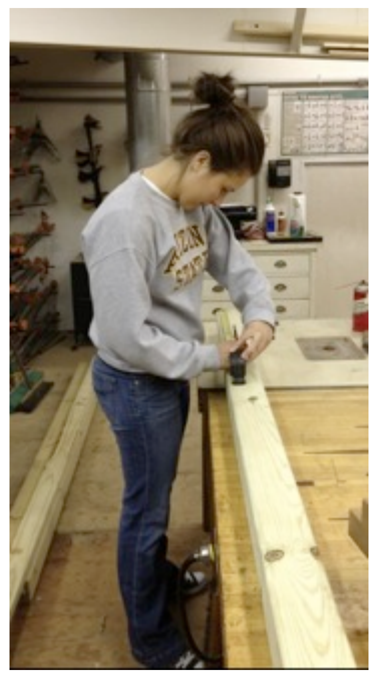
IV. Fabrication in Progress

After constructing our design matrices, creating the SolidWorks model, and making final design alternations, we were able to begin fabrication. Andrea went with Chet to Menards to buy the treated wood for the frame, carriage, and legs component of the device and on October 7th, 2012 Andrea, Amy, and Hannah went to Chet's workshop to begin fabrication process.

The first step of our fabrication process was to enhance the strength of the wood. We used a table saw to cut the pieces of wood that we were using for the frame of the base in half (Figure 10A). We then sanded each of these pieces by putting the boards through a sander and hand sanding them to ensure a smooth surface (Figure 10B). Next, one of the boards were roated 180° so that the grains of the boards were in opposite directions (Figure 10C). Reverseing the grain orientation of each piece of wood helps elimnate the effects of natural weakness found in the boards.

After, the boards' orientations had been reversed, glue was evenly applied, and the boards were clamped back together (See Figure 10D and 10E) and allowed to dry over a twenty-four hour period.

a)



b)

c)

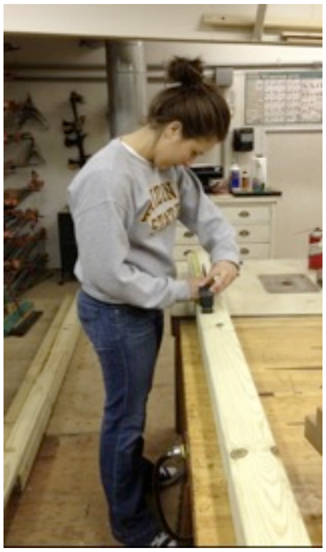
d)

e)

Figure 10: The fabrication process of strengthening the wood for the frame and carriage. A) cutting the wood in half on table saw b) Boards run through sander and hand sanded for smooth surface c) boards grain orienation reversed d) glue evenly applied to boards e) boards clamped back together

Fabrication on the legs and tenon joint were also completed during our first day of fabrication. First, the wood was measured to the PDS determined two feet and then cut using a drop saw (Figure 11A-11B). Multiple passes on the table saw were made to create the tenon end (Figure 11C). With each pass the blade was adjusted ¼". The board was flipped after each pass to create a tenon with shoulders (Figure 11D). Next time during fabrication we hope to create the mortise joint and frame.

As mentioned previously we aim to have the finished device implemented in CRILA in March. We hope to finish fabrication within five-to-six weeks, which will be roughly between late November and early December. This allows us to perform our mechanical testing and ensure the safety and performance of our device before our plan to travel in March.



a)

b)

c)

d)

Figure 11: Fabrication process of creating the legs with the tenon joint end. A) boards of leg measured to two feet b) drop saw used for cutting c) passes made on table saw d) legs with tenon joint ends

V. Safety Concerns

The device should not put the patient at risk of injury from the treatment, and the device itself should not cause the patient harm. The height of the device should not exceed two feet to prevent injury from falling. Additionally, it should be free from sharp edges and protruding parts.

In regards to sanitation, the cushioned components of the carriage should be covered with material that may be cleaned by disinfectant spray and wiped down thus preventing spread of diseases.

VI. Standards and Regulations

The regulations regarding medical devices in Honduras are virtually nonexistent and decisions regarding the approval of a specific medical device for use in Honduras are directed through the ASTM and ISO. We have found no specific standards or regulations but because the device does not have direct contact with the patient it can be viewed similar to a wheelchair or hospital bed.

VII. Future Work/Considerations

Band Testing

Primarily, we plan to perform tensile testing on different bands in order to select the optimal choice in withstanding high frequency of use and high force. While considering the local temperature and humidity of Honduras, the bands will be tested on increasing tensile force to determine the maximum force (F) and length (Δx) they may undergo before breaking. Thus, we can determine the spring coefficient (K) which expresses the bands stiffness through the equation of spring force, $F = K(\Delta x)$.

With the spring coefficient, we may then determine the maximum velocity that the band may undergo by finding the potential energy of a spring ($\frac{1}{2} k \Delta x^2$) and setting this equal to maximum kinetic energy ($\frac{1}{2} m v_{max}^2$). When solving for the maximum velocity, we result in $v_{max} = x_{maz} \sqrt{(k/m)}$.

Prototype Testing

Once the protype is fabricated we plan on testing the durability, stability, and performance quality the device as a whole. We will do this testing on members of our group under the supervision of the Physical Therapy Department to ensure that the device is functioning adequately and mimicing the natural muscle movements of the lower extremities.

Costs and Fundraising

Thus far, we have been awarded $3644 from the Kemper K. Knapp Bequest Committee of UW Madison for the research and development of our device. Roughly only $500 of this grant is issued to us for the fabrication of the device, while the rest is for the travel funds of the PT Department. It has been estimated by Chet and others who have gone to Honduras in the past through the Hackett Hemwall Foundation that the cost per person is roughly $1500-$2000. With five engineering students that puts us at a goal of $10,000 (Figure 12).

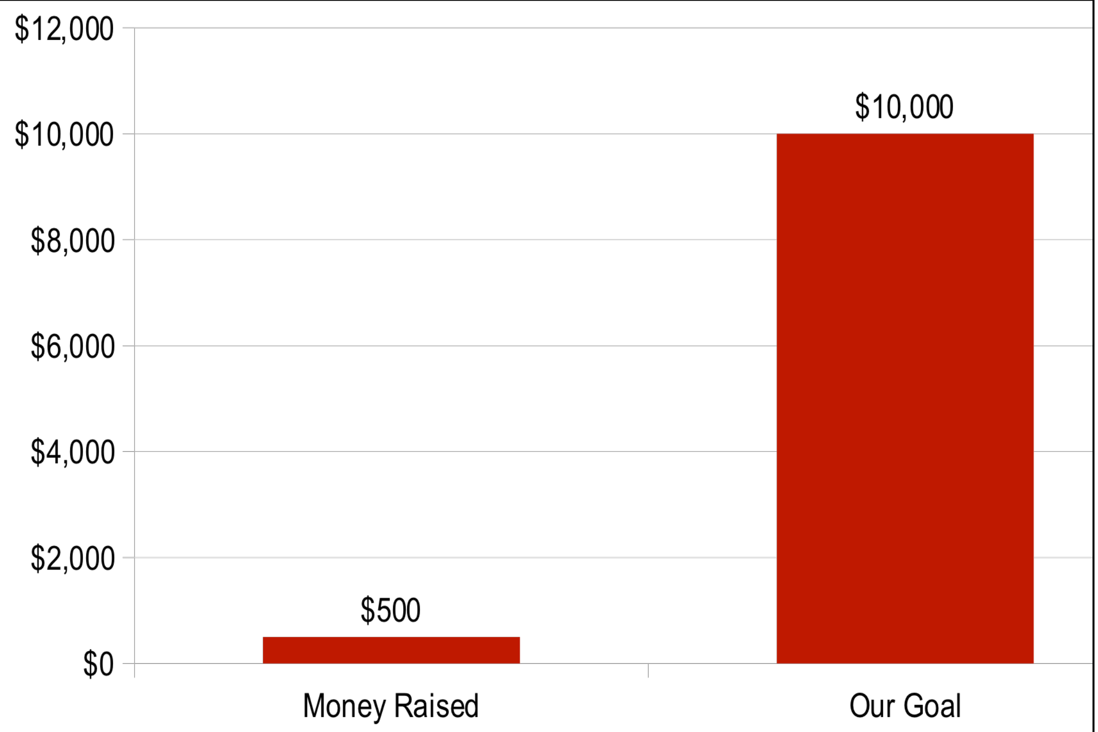


Figure 12: Bar graph of money raised and our goal for fundraising.

With our timeline for traveling to Honduras quickly approaching we have been fundraising over the past few months to hopefully gain the funds for traveling to Honduras ourselves. Beginning in August we began researching and applying to additional grants we found through the Alumni Association and UW-Madison programs. On October 10th, 2012 we sent out a fundraising letter to over 150 engineering corporations and companies in the Madison area (see Appendix). We have also spoken on October 18th, 2012 at the Hackett Hemwall Conference for over a hundred doctors and physicians, after which we handed out our fundraising letter and a gift donation sheet. Additionally, throughout the process of our design we have been filming our progression through the design process and fabrication. Not only do we hope to use this as a media video for influencing and empowering women in science and engineering, but we also will create an instructional video for the fabrication and assembly of our device. We hope that through all of our efforts we will be able to reach our goal of $10,000 and travel with the PT students, Karen Patterson, and the Hackett Hemwall Foundation to Honduras.

Traveling to Honduras and hosting a workshop in Le Ceiba to teach women engineering and physical therapy skills is essential. This workshop would include training the women in developing additional models of the device, which will correspond to improving the healthcare of the community. Through this process we hope provide the women of Honduras with knowledge, skills, and opportunities for economic and social advancements.

In conclusion, this is not simply a BME300/200 design project for us; we have an overarching intention to influence and empower women to pursue careers and opportunities in engineering and science.

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Appendix

Product Design Specifications

Lower Extremity Rehabilitation Device for the Use in Developing Countries

Product Design Specification Report

Team Members
Hannah Meyer: Team Leader
Maria Maza: Bwig
Andrea Schuster: Bsac
Amy Slawson: Communicator
Alenna Beroza

6/28/12

5:30- 7:00 PM

Product Design Specifications

Function: The device will aid the patient in strengthening their lower extremities by allowing the patient to lie on their back with their knees at a ninety-degree angle and feet pressed against a static solid plate. The patient can then move by extending their knees. Six elastic bands will be used to attain increasing resistance, which will aid in strengthening of the lower extremities throughout a patient's treatment plan.

Client requirements:

CRILA's requirements for the design include that the device be cost effective, portable within the clinic, and easily replicable in Honduras with local materials. Additionally the design should be constructed in a multiple part assembly for ease of transportation and require low maintenance.

Design requirements:

1. Physical and Operational Characteristics

a. *Performance requirements*:

The device will be used as part of a treatment plan to strengthen the lower extremities of patients undergoing rehabilitation.

b. *Safety*:

The device should not put the patient at risk of injury from the treatment and the device itself should not cause the patient harm. The height of the device should not exceed two feet and should incorporate a safety belt to secure the patient while the device is in use.

c. *Accuracy and Reliability*:

The device must be able to withstand a high frequency of use by a variety of different patients. Each elastic band on the device should provide the same amount of resistance with each use.

d. *Life in Service*:

Under frequent use and humid conditions, the device itself should last for approximately ten years with the elastic bands lasting for three to five years.

e. *Shelf Life*:

The device must be portable within the clinic and easily replicable in Honduras. The device should be able to withstand a hot and humid environment.

f. *Operating Environment*:

The device will be used in a hot and humid environment and thus must be built of corrosive resistant materials. It must also be compact enough to fit in a small rehabilitation center. Due to high frequency of use by patients of different skill level, the device must be durable.

g. *Ergonomics*:

The device is intended for use by young adults to elderly. It is not intended for use by children, people with back problems, or pregnant women. The device should be solely used for the rehabilitation of lower extremities. For patient comfort the device will include a back cushion and shoulder pads. The device will allow the patient to lie flat with no incline angle, such that the hips and torso are at a 90 degree angle with respect to the knees. In order to accommodate a variety of patients the static plate must be vertically adjustable and include a space at the bottom to allow ankle and calve rehabilitation. For the ease and convenience of the staff working with the patient, the device will be raised to a height not exceeding two feet.

h. *Size*:

The length of the device must be long and wide enough for the average person to comfortably lie back. The dimensions of the device must be X by X feet. The device should be easily portable and assembled within the clinic by two people.

i. *Weight*:

The weight of the device should not exceed 200 pounds. Wheels may be incorporated for ease of transport.

j. *Materials*:

All the materials used to develop the device should be locally available and affordable in Honduras.

k. *Aesthetics*, *Appearance, and Finish*:

The device should be aesthetically pleasing and if possible include UW Badger reference.

2. Production Characteristics

a. *Quantity*:

One device should be constructed in Madison, WI while the others will be replicated in Honduras.

b*. Target Product Cost*:

The target cost of production needs to be less than $500.

3. Miscellaneous

a. *Standards and Specifications*:

Currently, there are no standards and regulations in place for the use of the device in Honduras.

b. *Customer*:

The device will be implemented at the CRILA rehabilitation center in Honduras. The customer requires that the device be low cost, portable, replicable, durable, and manufactured with local materials.

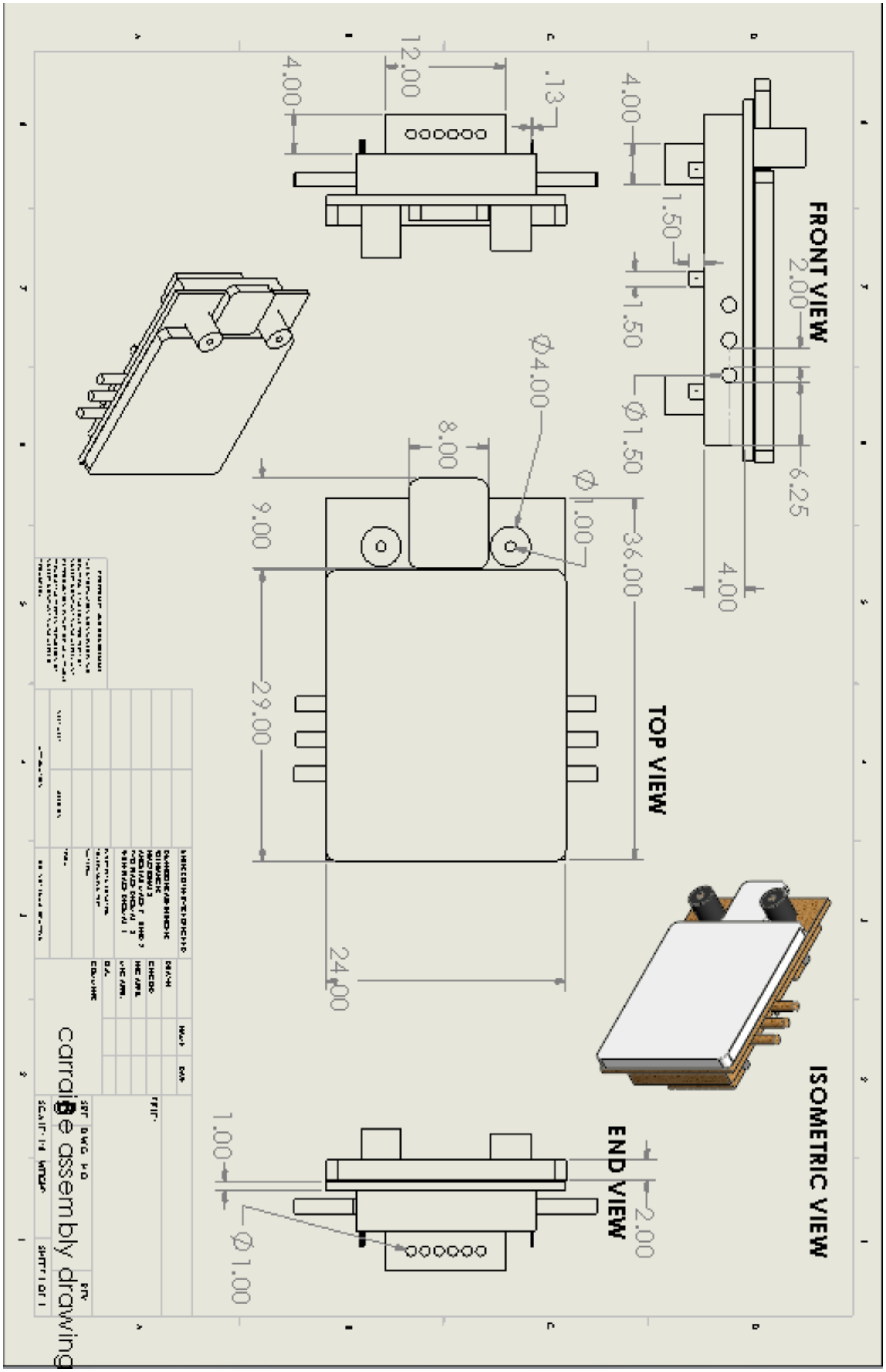
c. *Patient-related concerns*:

Due to the low staff to patient ratio, the device must be safely operated by the patient with minimal assistance.

d. *Competition*:

The following devices are currently used for strengthening lower extremities shuttle, leg press,

Schematics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TOP VIEW
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ISOMETRIC VIEW
carriage assembly drawing
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2.00
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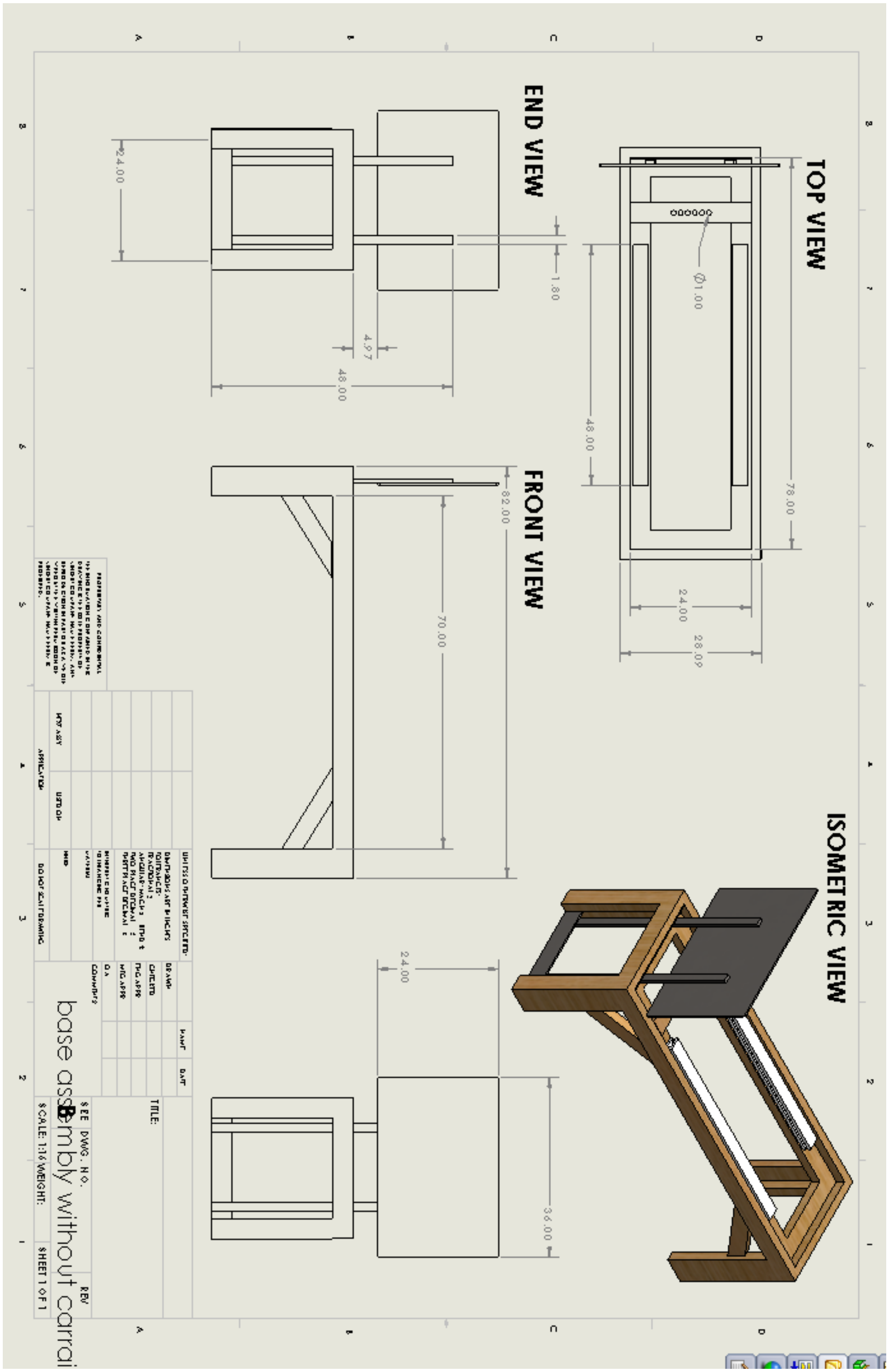
TOP VIEW
END VIEW
FRONT VIEW
ISOMETRIC VIEW
24.00
1.80
4.97
48.00
Ø1.00
48.00
78.00
24.00
28.09
82.00
70.00
24.00
36.00
TITLE:
base assembly without carri
SCALE: 1:16 WEIGHT:
SHEET 1 OF 1
DO NOT SCALE DRAWING
APPLICATION