Kayakity Quacks

Hoist to Transfer Athletes from Wheelchair into a Kayak

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Statement of Disclaimer

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1 - Introduction

Disabled Sports Eastern Sierra (DSES), based in Mammoth Lakes, California, provides resources and opportunities for athletes with disabilities so they can fully participate in a variety of outdoors activities. The goal is to minimize the effects of the disabilities and give the participants as much independence and freedom as possible. Tandem kayaking is one of the events that takes place every spring and summer and one of the challenges that DSES faces is transferring the athletes from their wheelchairs to the kayaks. Currently, several able-bodied volunteers manually lift the athletes and place them in the kayaks, but this method is not ideal for several reasons. Not only does it place a lot of stress on the people lifting, but more importantly this method also takes away independence from the athletes. With funding from a National Science Foundation grant, a new hoist has been designed to safely and easily transfer the athletes from their wheelchair to a kayak with minimal assistance required. Our team, the Kayakity Quacks, consists of California Polytechnic State University mechanical engineering seniors Jennifer Batryn, Javier Mendez, and Kyle Mooney, with advisors Professor Sarah Harding and Dr. Brian Self overseeing the project. DSES representatives E.L. Smoogen and Maggie Palchak also served as a link to the end users of this project and aided in communicating the needs and requirements of the organization. Team Kayakity Quacks has researched the need, produced a design, and built a prototype which meets the criteria specified. A complete report from the beginning designs to the manufacturing and testing of the prototype hoist is being presented. The prototype has received very positive feedback from athletes and volunteers alike. The prototype hoist will be put to use by the DSES athletes at upcoming kayaking events for years to come.

2 - Background Research

2.1 Kayak Design

Kayaks are split into several main categories, based on their design and intended use.

2.1.1 Recreational

Recreational kayaks are relatively wide and fairly stable. They have a large cockpit for sit-inside designs making them easier to get into and out of but are not the best for open water [1].

Figure 2-1. Recreational Kayak
http://www.neckykayaks.com/kayaks/recreation_kayaks/

2.1.2 Touring

Touring kayaks are generally longer and more slender than recreational kayaks. The cockpits are also smaller but they are better for open water and paddling for longer durations. Touring kayaks are also more expensive [1].

Figure 2-2. Touring Kayak
http://www.neckykayaks.com/kayaks/touring/

2.1.3 Sit-on-Top

Sit-on-top kayaks allow the easiest transfer in and out due to the open design and lack of cockpit. They are generally wider, more stable and the person sits higher from the water [1].

Figure 2-3. Sit on Top Kayak - Single
http://www.neckykayaks.com/kayaks/vector_series/

Ocean sit-on-top kayaks are chosen by Disabled Sports Eastern Sierra for their annual kayaking events. Sit-on-top kayaks are preferred primarily due to their increased stability and ease of getting in and out compared to other kayak designs. In addition, tandem kayaks are always used so that the athletes ride in front with an instructor from DSES in back. Since DSES does not own their own kayaks and instead rents them from a local outfitter each season, there is no guarantee that the brand and models of kayaks used will be the same from year to year. However, there is a good chance that they will at least be similar. Last year, Malibu Pro 2 Tandem kayaks were used and their basic dimensions and specifications are shown below. In addition, the Malibu Pro 2 Tandem kayak weighs 62 lbs. and has a weight capacity of 550 lbs. [2].

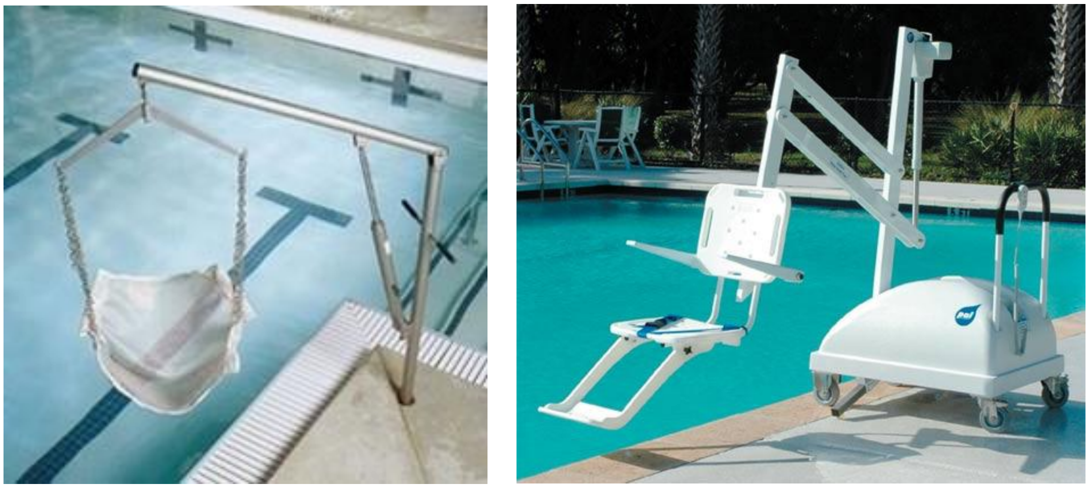
Figure 2-4. Sit on Top Kayak - Tandem
http://www.cruisefishdive.com/pro-2-tandem-kayak.php

2.2 Existing Lifts

While there are no existing products on the market that specifically meet our need of transferring disabled athletes from a wheelchair to a kayak on uneven terrain, there are many similar products that transfer people with disabilities to and from wheelchairs. The two categories that we investigated the most were pool lifts and hospital lifts.

2.2.1 Pool lifts

Most of the pool lifts we investigated were semi-permanent devices that utilized a constant position alongside a pool deck to provide an anchor and stabilizing force (Figure 2-5 a) [3]. Other designs advertised as portable had wheels and could be rolled on the pool deck (Figure 2-5 b). However, in order to support and counterbalance the weight of the person being lifted, they all utilized large counterweights on the order of 800lbs, making it not very practical or portable for our application [4].



http://www.mobilitytoys.com/images/catalog/category93.jpg
http://swimmingpoolhandicaplifts.com/wp-content/uploads/2011/11/pal-20-0000-lift-500.jpg

(a) (b)

Figure 2-5. Typical pool lift designs (a) semi-permanent design that anchors into pool deck (b) Portable lift with counterweight

There were several main methods used to power the pool lifts [5].

- Manual/hydraulic

  The manual powered lifts mainly utilized hydraulic pumps that an assistant would pump in order to lift the person out of their wheel chair. To get them into the pool, the overhead rod suspending them would rotate and bring them over the pool, at which point the assistant could lower them by again manually pumping. Most manual lifts used a sling and included portable as well as permanent models.

- Battery powered

  Battery powered lifts were separated into models where the battery controlled the lifting and rotation or just the lifting. The models where only the lifting was battery operated required the assistance of someone else to rotate the structure, whereas the other models could be completely controlled by the user. Many of these models also had waterproof remotes for easy and safe operation around the water and utilized rigid seats.

- Water powered

  These devices used water pressure from a source such as a regular garden hose or supply pipe. Water power is seen as a safe, cost effective and environmentally friendly alternative to battery power. These devices are generally permanently installed and most of them used rigid seats.

2.2.2 Hospital lifts

The hospital lifts we investigated all had the same basic design with variations in their lifting capacity and power method. They are all designed to transport patients from one resting surface to another (bed, chair, commode, etc.) and are not meant as a transport device. In addition, all of the hospital lifts researched operated on the assumption that the patient being lifted does not necessarily have physical control over their bodies and thus does not aid at all in the operation of the lift. Therefore, all lifts required the help of least one other person to operate, with some recommending the assistance of two others. Lifting capacity varies based on specific models, but standard lifts have a typical capacity ranging from 300-450lbs. Other models are specially designed to transfer larger patients up to 850lbs. Most lifts utilize slings (canvas, polyester, or nylon) to interface with the patient and hold them when suspended in transit. The main methods of powering the lifts included manual/hydraulics (Figure 2-6) and battery powered [6].

Figure 2-6. Basic manually powered (hydraulic pump) hospital lift design

http://www.1800wheelchair.com/siteimages/large/C-HLA-1.jpg

2.3 Existing Seats and Slings

Many of the pool lifts researched utilized rigid seats to transport and interface with the person being lifted. However, a larger number of devices used fabric slings, which are generally cheaper and more adaptable to different people's needs. There are three main types of slings available on the market.

2.3.1 U-sling

One of the most commonly used sling designs is the U-sling. These come in a variety of sizes and levels of support ranging from full back and neck support to just a support across the mid back. They are fairly easy to get into and out of while in a sitting position.

Figure 2-7. The U-Sling Design
http://www.rehabmart.com/imagesfromrd/DRV-13220S_head.jpg

http://www.alphamodalities.com/Products/Slings/Reusable/Universal_Sling_Series/AM-U_SeatSling/gallery/album/large/AM-U-SeatSling_ClipS.jpg

2.3.2 Hygiene sling

These are a subset of u-slings and are mainly used for toileting and sanitary needs. They do not provide as much support as some u-slings but make it easy to get clothes on and off. Hygiene slings are also very easy to get a person into and out of in a sitting position.

Figure 2-8. The Hygiene Sling
http://www.rehabmart.com/imagesfromrd/IN-R121_ToiletingSlingwBelt.jpg
http://www.rehabmart.com/imagesfromrd/ROM-43504003.jpg

2.3.3 Fully body sling

Full body slings provide the most support and are often used for amputees and others that need the extra support. They are much more cumbersome to get into and out of though since part of the sling actually goes under the person's bottom, meaning that they have to be either lifted or repositioned just to get the sling in place.

Figure 2-9. The Full Body Sling
http://www.rehabmart.com/imagesfromrd/IN-R110_FullBodySling_Mesh.jpg
http://www.united-rehab.net/monkeewrench//files/products/images/Full_Body_Sling_Plus.jpg

3 - Objectives

Team Kayakity Quacks will produce a hoist that will safely transfer the athletes from their wheelchair to the kayak and vice-versa. There is currently no mechanism being used by Disabled Sports Eastern Sierra to transfer the athletes between their wheelchairs and kayaks except human power. After speaking with our sponsors, DSES representative Ms. Maggie Palchak, E.L. Smoogen, and Dr. Brian Self, a set of requirements were agreed upon, which were the basis for our design process.

- The hoist will be transportable by one person and will have a minimal storage footprint.
- The athlete will be able to be transferred with the help of only one other person.
- No external power source will be used.
- The hoist will be made to function along the shore, be it sand, rocks, or launch ramp. It cannot be used to take off from a dock.
- It will be made to at the least be partially waterproof.
- The hoist will safely and comfortably lift a person of up to 250 pounds.
- The cost to prototype will be less than the NSF grant given.

All requirements that were discussed were put into a Quality Function Deployment (QFD) and plausible specifications for the hoist were then created. The QFD's purpose is to identify and meet the needs and desires of the customer. The QFD ultimately resulted in our engineering specifications in Table 3-1.

Table 3-1. Kayak Hoist Engineering Specifications

Spec #	Parameter	Target	Tolerance	Risk	Compliance
1	Weight	80 lb	Max	H	A, I
2	Length (stored)	7 ft	Max	H	A, I
3	Operator Force	30 lb	+10/ -0 lbs	M	I, T, S
4	Range	36 in	Min	M	A, S
5	Time (operation)	5 minutes	Max	M	T, A, I
6	Time (assembly)	20 minutes	+ 10 / -0	M	T, A, I
7	Weight Capacity	250 lbs	Min	L	A, I
8	Cost	1500 $	Max	L	A

The targets of each parameter are plausible values for meeting the requirements desired by the customer. A compliance section lists how each parameter will be met. The methods are Analysis (A), Testing (T), Similarity to Existing Products (S), Inspection (I). There is a risk assessment which labels how difficult it will be to reach the aforementioned target of the parameter. These levels of risk are High (H), Medium (M), and Low (L).

As shown in Table 3-1, our highest risk parameters are keeping the stored size small and weight low. These targets will be difficult to meet, as similar lifts do not possess values anywhere close in these parameters. Ms. Palchak expressed that the small storage footprint is of grave importance. Therefore the team has decided that the time needed for assembly may be sacrificed in order to maintain the dimensions of the stowed product at a minimum. The capabilities of the athlete will determine how much assistance is needed. We will make sure that at most only one assistant will be needed to move the athlete and launch them onto the lake. A force of 30 lbs. by the operator is a plausible quantity, but if needed an absolute maximum of 40 lbs. The time to operate will be considered from the time that the athlete is strapped in to the time they are sitting on the kayak and vice-versa. The range is the distance that the hoist will be able to move the athlete vertically. The target is to be able to manufacture a working model with a total cost less than $1500.

4 - Idea Generation

Once the requirements and specifications were set and after our extensive background research, we were ready to start brainstorming ideas. The first thing we did was break the hoist down into the different components that would be necessary. Under each of these components, we listed ideas for possible solutions. The components were broken down as such:

- Power System
- Lifting Mechanism
- Frame
- Portability
- Stability
- Harness Configuration

After having a grasp on what would be needed, each team member created a separate sketch of a possible hoist. Although these ideas were good plausible solutions, we knew we were still not at an optimal design yet. Cal Poly has its own adaptive kayaking program and we were able to take part in one of their events held at Morro Bay. It was very helpful to be involved in this way and witness the transportation of the athletes first hand. We were also able to talk with some of the athletes, their caretakers, and the volunteers at the event and get their input regarding possible ideas and suggestions for improvement based on their experiences. We took into account that this event was using a boat launch ramp, whereas DSES primarily does their launches from a lake shore, but it was still a great experience and very helpful.

Our sponsor Maggie Palchak emphasized the importance of the storage size being small; therefore we decided that the frame was the most important aspect of the project. We would choose a frame design that meets the requirements, and design all other components based on this frame. We also conferred with Dr. Self about our designs. In this meeting, he left it open to our interpretation; however, he suggested a completely manually powered system. With no battery or power source other than manual, it should consistently work for years with little to no maintenance. The following are our top seven designs.

5 – Design Ideation

5.1 The Over Head Crank

The design shown in Figure 5-1 is based off of the lifts commonly seen in hospitals. The athlete would wheel their chair next to the kayak and a pulley or hydraulic system will lift them out of the wheelchair. Hospital lifts are able to have supports go under the bed to which the patient is being transferred which provides the stabilization when moving the center of mass away from the central frame; however our product will not be able to do this due to the kayak resting on the ground. The supports in this design will instead go over the kayak in order to prevent the entire structure from tipping over during the transfer of the athlete.

Pros

- Would allow the athlete to perform most duties in the transfer

Cons

- Bulky and difficult to move.
- Kayak and athlete move to hoist instead of hoist moving to athlete and kayak.
- The supports would interfere with the launching of the kayak.

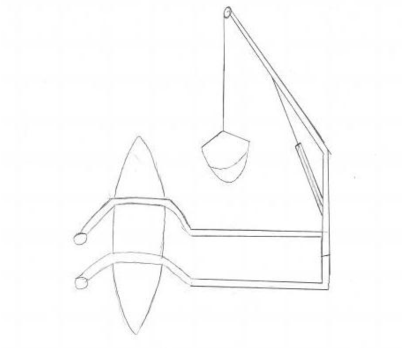


Figure 5-1. OverHead Crank

5.2 The Chair

The concept of the chair (seen below in Figure 5-2) came from the need of helping the athletes get through the terrain to the water. The athlete would sit in this new wheelchair that would make it easier on the athlete as well as the volunteers to move the athletes across the beach. The Chair will be wide enough to roll over the kayak and a special release mechanism would allow the athlete to lower themselves into the front seat of the kayak.

Pros

- Make it easier to move across the beach and transfer to the kayak independently

Cons

- The Chairs increased width (to fit around the kayak) might make it hard to wheel.
- Would still need a way to transfer from own wheelchair to the Chair.

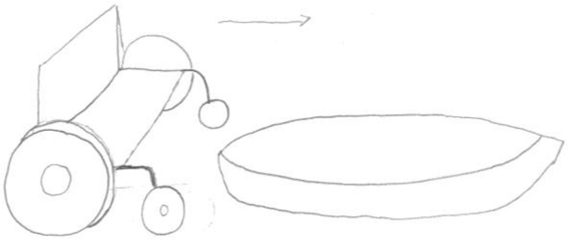


Figure 5-2. The Chair

5.3 The DockSlide

The DockSlide idea, seen in Figure 5-3, came from the thought of the athlete literally going down a slide to their seat in the kayak. Obviously this is not a plausible solution but we went from there. In this design the athlete would wheel up a ramp, move into a sling and then mechanically be lowered to their seat. Key features to this would be that the kayak could have a possible docking station and go under the ramp making the distance traveled by the athlete lower.

Pros

- The ramp allows for closer access to the water while keeping the structure small.

Cons

- To follow ADA guidelines, the ramp would have to be over 12 feet long, making the storage footprint very large.

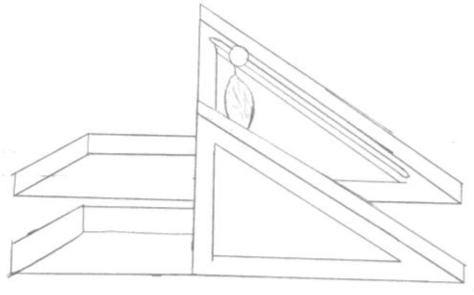


Figure 5-3. The DockSlide

5.4 The SideDock

The SideDock is an A-frame structure as shown in Figure 5-4 and would be large enough to accommodate both the wheelchair and kayak side by side. The athlete would wheel their chair alongside the kayak and strap themselves into the sling attached to the track overhead. A pulley mechanism attached to the sling would allow the athlete to raise themselves up out of their chair, where they could then traverse sideways on a track built into the structure, before finally lowering themselves into to the kayak.

Pros

- Simple structure and easy to use.
- Athlete could perform most duties themselves

Cons

- Large structure needed to get around both the wheelchair and kayak.
- To prevent the wheelchair from getting wet this would have to take place on dry land which means another person has to push them off to launch.

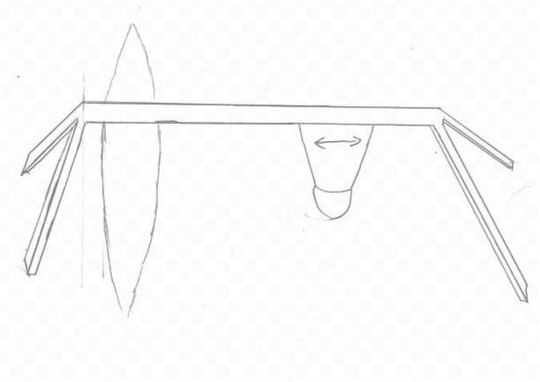


Figure 5-4. The SideDock

5.5 The Mover

In this concept the four legged structure surrounds the athlete. From an overhanging sling and pulley system, the athlete is lifted out of the chair. Another person from behind the structure must push the structure to the water and over the kayak. The athlete can then lower themselves down and launch on to the lake.

Pros

- Will be portable and lightweight
- Allows for access close or even in the water

Cons

- Another person is required to transport the structure while the person is suspended in the air

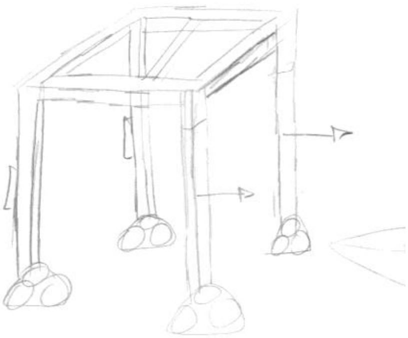


Figure 5-5. The Mover

5.6 The TrailLifter

The TrailLifter would allow ease of transport for the athlete as well as the kayak. The kayak will be loaded onto a trailer in the parking lot or a loading zone. The athlete will then be hoisted into the kayak from a lift that is attached to the trailer. Once in the kayak, another volunteer will push the trailer into the water and launch the kayak onto the lake.

Pros

- Easy transfer of athlete and kayak across the terrain to the water

Cons

- The organization would prefer to not have to take the kayak out of the water every time they switch athletes.

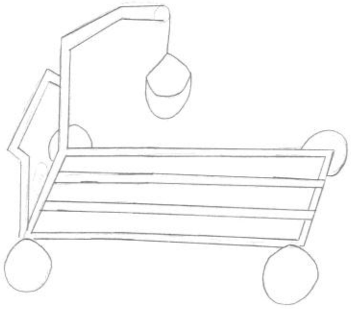


Figure 5-6. The TrailLifter

5.7 The Swiveler

In this design the athlete will be lifted in the air from an overhead hanger. A crank will be placed on the main base allowing the athlete to operate it themselves. The crank will cause the entire structure to turn on a pivot point, and after rotating 180 degrees the athlete will be directly above the kayak and capable of lowering themselves down.

Pros

- Allows for independent use by the athlete and close water access.

Cons

- To make it around the back edge the structure will have to be very large. Also, it would be difficult to turn through rough terrain.

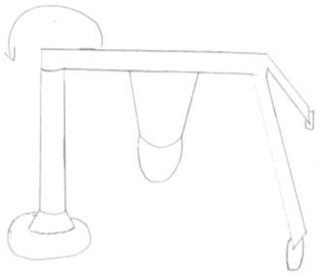


Figure 5-7. The Swiveler

6 - Final Concept

6.1 Frame

A decision matrix was created of the three best and most plausible ideas. These three were The Mover, The TrailLifter, and the SideDock. In this decision matrix we assigned a point value to each parameter based on their importance. The results are found in the following table.

Table 6-1. Decision Matrix for Frame Design

	Weight	The Mover		The TrailLifter		The SideDock	
Portability	3	-	-3	-	-3	-	-3
Safety	5	+	5	+	5	++	10
Lightweight	3	-	-3	--	-6	-	-3
Easy to Assemble	2	-	-2	-	-2	-	-2
Easy to Operate	4	+	4	+	4	+	4
Cost	2	-	-2	-	-2	-	-2
Manufacturability	1	-	-1	-	-1	-	-1
Operate in Rough Terrain	4	+	4	+	4	+	4
Level of Independence	4	+	4	+	4	++	8
Strain on Operator	5	++	10	+	5	+	5
	Total		16		8		20

According to our study we found that the Mover and the SideDock were the best options. Ms. Palchak informed us that the TrailLifter did not meet the needs of DSES and was therefore not a design to pursue further. Deciding between the other two was a difficult decision. The team originally thought that the Mover was the best option and we selected it for our original concept review. It would allow for a very minimal amount of strain by the volunteer and would break down and store nicely. The SideDock on the other hand would have to be much larger to accommodate both the wheelchair and kayak under its structure. In addition, the kayak would not be ready to launch as it would have to be mostly up on shore. The SideDock allows the athlete to perform most of the transfer duties themselves if they have the upper body strength, giving it a high level of independence for the athletes. After consulting with E.L. Smoogen at the beginning of winter quarter, it was agreed that the process of being transported while suspended from the Mover may be scary for some of the athletes. There is also a possibility of tipping over on the rough terrain, so the SideDock, which remains stationary and minimizes the in-air transfer distance, was ultimately chosen as the best design.

Figure 6-1. Final design of the SideDock frame

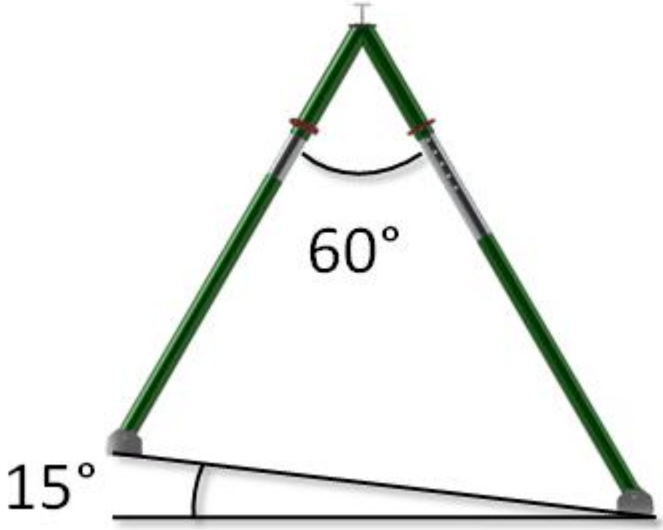


Figure 6-2. Side view of the SideDock showing adjustable leg heights for uneven terrain

6.2 Sling

Hospital lifts come with a full body sling, which is very secure; however the athlete would need to be completely lifted in order to get the sling under his/her buttocks. Our team tried to create mock-up designs of different types of slings that would safely secure the athlete but prevent having to lift them in the first place. We created a rigid body frame with L-shaped bars that would have two main pieces of fabric. The first would go behind the back of the athlete with the rigid bars on both sides. The athlete would then take the second strip of fabric and slide it under his/hers legs and attach it to the rigid frame. Then, cables to lift the athlete would be attached to the rigid bars and would lift the athlete like they are sitting in a chair. This design worked and was easier than the full body sling but had added unnecessary weight and complexity. Also it may not have worked for athletes with above knee amputations. We also created a U-sling. This sling slides down the back then wraps under the thighs of the athlete. This type of sling is widely used and is the best solution for the kayak hoist.

Figure 6-3. U-sling

Table 6-2. Decision Matrix for Sling

	Weight	U sling	Weighted Score	Rigid frame sling	Weighted score	Full body sling	Weighted score
Comfort	3	+	3	+	3	+	3
Safety	5	+	5	+	5	+	5
Ease of use	1	+	1	+	1		0
Cost	2	-	-2	--	-4	-	-2
Withstand outdoor environment	3		0	-	-3		0
Level of independence	4	++	8	++	8	+	4
Strain on operator	4	+	4	+	4	+	4
Total			19		14		14

6.3 Hoist Mechanism

The Hoyer lift uses a hydraulic system which pumps the hoist up and down. This option was considered however it makes it harder to allow the athlete to operate themselves and was not as easy to incorporate into our frame design. Still wanting everything to be manually powered, we looked into using a pulley system. A multi-pulley system would need numerous pulleys to have a reasonable force-to-lift ratio. We then discovered a differential pulley or a chain hoist system. These systems offer an excellent mechanical advantage with only two pulleys. The mechanism is also self-locking which is

Figure 6-4.Chain hoist

a necessary safety feature. The only downside is that to get the mechanical advantage, a very long chain pull is required to lift but it does come at a very low application force. Retail prices on existing chain hoists start at around $80, making them very affordable for our project budget.

Table 6-3. Decision Matrix for Hoist Mechanism

	Weight	Chain hoist	Weighted score	Pulley system	Weighted score	Hydraulics	Weighted score
Safety	5	+	5	+	5	+	5
Durability	3		0	-	-3		0
Cost	1	--	-2	-	-1	--	-2
Withstand outdoor environment	2	-	-2	-	-1		0
Level of independence	4	++	8	+	4	+	4
Strain on operator	4	++	8	+	4	+	4
Operation time	1	-	-1		0	+	1
			16		8		12

6.4 Legs

The legs will be in the shape of an upside down "V". This will give the entire structure stability with each leg angled at 30° from the vertical. The legs are connected to the beam by custom made pieces that will be designed to fit each leg. These connections will permit each leg to be adjustable allowing the height to change up to an angle of 15 degrees. This will ensure that the structure can be level on any surface. The bottom of each leg will feature a small foot. This foot will be covered in rubber and will give traction to the structure in the case that it is put on cement or gravel surface.

6.5 Overhead Beam and Trolley

An Aluminum I-beam works well for our design. The I-beam is lightweight; however, has a large moment of inertia. This will allow us to put a high force and moment on this beam. I-beams are not good for torsion but we do not need to worry about that with our current design. Many existing trolley systems run along an I-beam.

Figure 6-5. I-beam trolley

This allowed us to buy a trolley that is specified to carry and move the load needed. To easily move from side to side along the I-beam, the team has decided to purchase a trolley with chain and gear mechanism. This additional chain will allow the athlete to move themselves in the horizontal direction.

6.6 Overall Design

Fig 6-6: SideDock design with major components

6.7 Features

Some major design features of the SideDock include:

- Lock washers and wing nuts on the connection for quick assembly without the need for tools
- Pin connections on legs with six holes in each leg for individual height adjustment. Can account for up to 15° angled surface or uneven terrain.
- Feet swivel to adjust for inclined surfaces
- Rubberized bottoms on feet for increased traction
- Geared trolley with chain for easy and independent lateral movement
- Chain hoist for easy and independent vertical movement (less than 10 pounds of pulling force necessary to lift 250 pound person)

- U-sling allows for easy transfer into and out of the sling. Provides full support without having to move athlete from sitting position

6.8 How to Operate

The entire structure will be placed near the water with the kayak inside the legs and against one of the sides. There will be enough room for the athlete to then wheel up alongside the kayak. The sling will be connected to a hanger, or support bar, which in turn is attached to the hoist mechanism. After securing themselves in the sling, the athlete will be able to lift themselves out of their chair using the chain hoist. Once securely lifted in the sling, an assistant will pull the wheelchair away. The trolley is geared and has an additional chain that the athlete can use to move themselves laterally across the overhead beam. Once above the kayak, the athlete will lower themselves to the seat, again using the chain hoist. The athlete then unhooks from the sling and they are ready to launch.

6.9 Maintenance & Warnings

The hoist was designed and manufactured to safely move an athlete of up to 400 lbs. However, some maintenance and safety precautions must still be exercised to ensure the safety of the athletes. The following table lists all the maintenance the hoist must receive in order to prevent any failures.

Table 6-4. Kayak Hoist Maintenance List

Maintenance	Description	Frequency
Check chain links and ensure there are no knots	Unwind any chain knots that might have resulted from transportation or set-up.	Before Each Use
Check Feet Connections	Ensure the bolts are tightly fastened. If not, use a wrench to tighten.	Before Each Set-Up
Clean sand residue	Wipe down the whole structure and get rid of any sand residue.	After Taking it Apart

Aside from maintenance, there are several safety precautions that must be met to ensure safety. The following table lists warnings and safety precautions when using the hoist.

Table 6-5. Kayak Hoist Warning List

Safety Precaution	Description	Frequency
Check Sling and Hanger	Ensure the sling is safely secured to the Hanger, and the Hanger safely secured to the chain hoist.	Before Each Use
Ensure Hoist is leveled	Place level on top of the I-beam. Adjust legs as necessary to ensure Level is centered while it's parallel and perpendicular to I-beam.	Before Each Set-Up
Check Leg Connection	Ensure the connections are tightly fastened. If not hand tighten the wing nuts.	Before Each Set-Up
Do Not use Hoist as Swing	The kayak hoist was not designed to act as a swing.	Never use as Swing

7 - Engineering Analysis

The goal is to make the product as small, portable, and lightweight as possible. However we cannot risk safety in order to achieve these goals. Assumptions were made in order to calculate the necessary beam widths.

1. Assume the force is at the center point of the top frame. Therefore producing an even distribution between the two legs.
2. The force is the weight of the maximum person with a specified factor of safety.
3. In Buckling assume a pin to pin joint for maximum safety.

With these assumptions we can calculate the necessary beam thickness and width to safely support and transfer the maximum load with a specified material.

7.1 Material Selection

In order to make the appropriate engineering analysis, a material had to be selected for the structure. The main criteria we were searching for are as follows:

- Lightweight
- Strong
- Corrosion Resistant
- Low Cost

We found that Aluminum Alloy 6061would be an appropriate material selection. It is strong with a yield strength of 40ksi and ultimate strength of 45ksi. It is relatively lightweight with a density of .0975 lb/in^3. Aluminum is corrosion resistant and will not rust therefore it can go in and out of the water. Aluminum Alloy 6061 is often used in construction of yachts and SCUBA tanks.

7.2 Testing Critical Points

The critical points are where the greatest forces and moments occur within the structure. We had to size each component of our frame to safely endure these stresses. Hand calculations were done to find the minimum width of the legs and the overhead beam and can be found in Appendix C.

7.2.1 Overhead beam

The critical point of the overhead beam is the center point. We know this point will have the greatest deflection as well as the largest bending moment. We selected an I-beam and size and then did the testing calculations. To solve for the maximum deflection, superposition was used. The maximum moment that is created must be less than the yield strength of the material of the beam. The beam sized 3” x 2.5” x .15” is sufficient to hold the load.

7.2.2 Legs

The legs must withstand the moment that will be created by the person hanging, as well as not buckling from the force. In this exercise the goal was to find the minimum diameter that could support these loads. We wanted to stay very conservative because it is crucial that the legs never fail. The structure does not really act as a pin to pin column; however, this was chosen in order to have a larger effective length factor (K). With this criteria the minimum diameter needed to prevent buckling, with a thickness of .125 in, is 1.5 inches. The load in which one leg will feel is exaggerated in each case. The maximum moment that we applied to the leg is 14400in-lb. The minimum diameter to withstand this, with the same thickness, is 1.98in. A leg diameter of 2.5 in. was chosen to safely satisfy this requirement. These calculations can be found in Appendix C. Finite element analysis was also performed to ensure that the hand calculations were accurate results.

7.3 Finite Element Analysis (FEA)

Finite Element Models were used to investigate the stresses observed by the top beam of our design. Since we were only considering the top beam, the rest of the structure was not modeled. Instead, the joint between the top beam and legs was modeled as a pin-fixed connection. Lastly, all models were validated with hand calculations to verify the accuracy of the FEA model.

7.3.1 I-Beam

I-beams are typically used in factory settings along with trolley systems. To determine whether it would be a good option for our design, a finite element model was created. A load of 500 pounds was placed in the middle of the beam to simulate the critical loading. The beam was modeled with a 2-D beam element. Symmetry was used to reduce computation time, and increase accuracy. Section properties given were those of 6061 T6 Aluminum 3”x2.5”x0.15” I-beam.

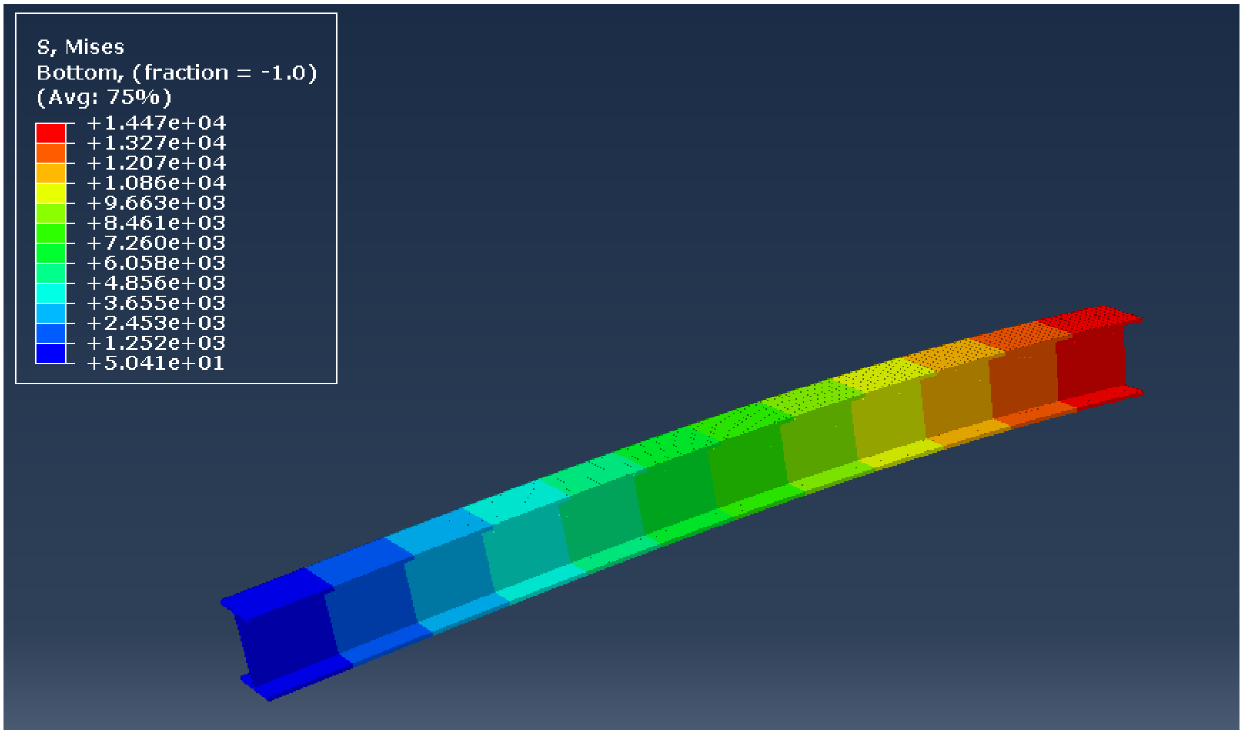


Figure 7-1. Von mises stress on I-beam at its critical point. Image shows half of the beam since a symmetrical constraint was used. Max stress is approximately 14.5 Ksi.

Results of the analysis showed that the maximum stress would be 14.5 Ksi. This value is far below the yield strength of aluminum, which is 40 ksi. This gives a final safety factor of 2.7. These results prove that the I-beam is a good and safe design.

8 - Management Plan

The following is a breakdown of roles delegated to each member of our team. Although only a limited amount of roles overlap between team members, it is everyone’s responsibility to uphold their engineering ethics with their own roles and other team member’s roles. That includes completing their assigned tasks to the best of their ability before each deadline, and occasionally reviewing other member’s tasks.

Team Member	Roles
Jennifer Batryn	Information Gathering, Engineering Analysis, Prototype Fabrication, Testing Plans
Javier Mendez	Information Gathering, Engineering Analysis, Documentation of Project Progress, Prototype Testing
Kyle Mooney	Information Gathering, Engineering Analysis , Manufacturing Considerations, Prototype Testing

9 - Manufacturing Plan

The Side Dock consists of components which will be outsourced and a few that will be self-manufactured. Having our main components outsourced, such as the trolley and chain hoist, will reduce our manufacturing time. In addition, outsourcing our main components from a reputable source will add credibility to our product since these products have already undergone extensive engineering analysis from their respective vendor. At the same time, we still have to manufacture some components giving us hands-on experience and staying true to Cal Poly's "Learn by Doing" motto.

9.1 Manufacturing Process

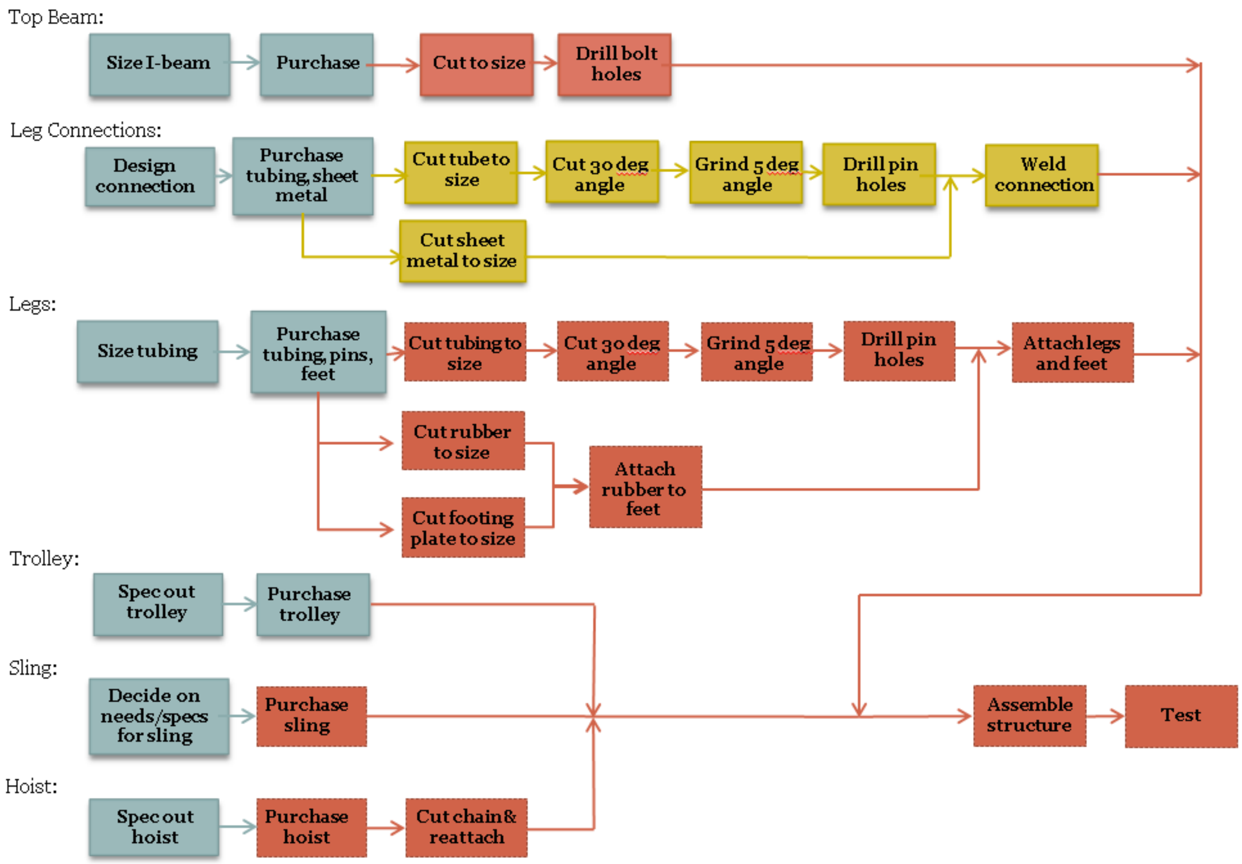


Figure 9-1. Manufacturing flow diagram showing simultaneous fabrication.

9.2 Outsourced and Purchased Components

The major components that will be outsourced are the trolley system, chain hoist, and the sling. Trolley system and chain host applications are common in industrial settings where heavy loads are transported. Mostly all products have a load capacity of 1 ton; however since we are dealing with much lower loads we will buy a product with a load capacity of ½ ton. Selecting this product will reduce the weight of the trolley while keeping a very reasonable safety factor in our product. The sling is often found in hospitals today. They come in different sizes based on the size of the person. We have chosen a size that is rated to fit the maximum weight of 250 lbs. The smaller people will still be able to fit in this because it is adjustable on the hanger.

10 - Building of Hoist

The manufacturing was broken into segments. Many of the sections could be built simultaneously, therefore giving us options on what and when to work. The following will show and describe each component and its fabrication.

10.1 Legs

The pipes purchased for the legs had a 2 ½ inch outer diameter. They were designed to telescope in the connection pipes, which had a 2 ½ inch inner diameter. However, due to the tolerances for each pipe dimension, there was some interference initially. In order to obtain a proper fit, it was decided that the legs should be machined down. Due to the 8 foot length, the legs were too big to fit on the lathes in the mechanical engineering shop, so they were taken to the bio resource and agricultural engineering shop. The pipes were not perfectly true or straight due to standard manufacturing of them and several passes were made on the lathe to make them more true and get the diameter down to a more acceptable level for telescoping.

Fig 10-1: The legs in the lathe

Once the legs were machined to easily slide in and out of the connections pieces, they were taken to a mill to drill a series of holes for the pin connections. The mill helped ensure that the holes were all aligned with respect to one another and went through the center of the pipe. After the pin holes were made, a hole for the feet was also made.

Fig 10-2: Legs in the mill

10.2 Connections

The connection pieces were the most intricate part of the manufacturing process. The tubes needed to be cut to create a 60 degree angle, but because it needed to be welded along a flat plate another angle cut was needed to make the tube flat. To add stability to our hoist we needed to splay the connections outward at a minimum of 5 degrees. This small angle was accomplished by using a compound miter saw. Holes on the uncut end were drilled to fit the pins in order to secure the leg's height.

Fig 10-3: Compound Miter Saw

For the top part of the connection, a ¼” flat plate was cut to fit on the I-beam, as well as have enough room for the welder to weld the tubes to the plate. Holes were drilled in these plates to fit a bolt through for a spot to attach to the I-beam. The strength of the welds is a critical part of our design and TIG welding aluminum is hard to do well without a lot of experience, so we hired a student shop tech to do the welding for the connections.

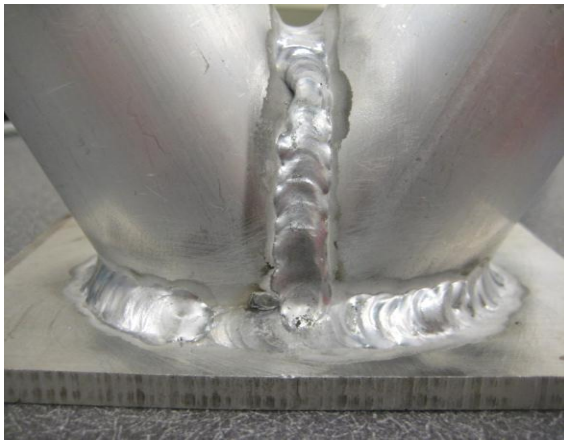


Fig 10-4: Welding of Connection Pieces

10.3 I-Beam

The I-beam was cut down to fit the maximum storage length of 7 ft. This length still left plenty of room for the wheelchair and kayak to fit underneath the device. Holes were then drilled to attach the connections to the I-beam. The ¼” bolts can be attached without any tools. This is accomplished with lock washers and wing nuts.

Fig 10-5: Drilling Holes into the overhead beam

10.4 Feet

The feet were designed similar to those of an extension ladder. They were designed to allow one degree of freedom and a full range of motion along one axis. This ensures that the feet remain flat on any angle of surface. A ¼" aluminum sheet metal was used to create these. The trapezoidal shape was done to prevent sharp corners and to be aesthetically pleasing. A rig with the same size legs was created to create an easy environment for our welder. The rig ensured that the trapezoidal wall of the feet were perpendicular with the bottom plate of the feet and parallel with the legs.

Fig 10-6: Feet Being Cut and Welded

10.5 Purchased Components

The components that were outsourced worked perfectly. We did however notice opportunity to optimize some of these components to better fit our application. The chains on the geared trolley were much too long. Knowing that the person would only be moving side to side after they are at their highest point, we decided to resize the chain to a height that was not bumping into the person, but still long enough to easily be reached. There are two chains on the chain hoist. The black chain lifts the person up and down, whiles the silver chain loops through the hoist and is what the person pulls. The range of the black chain was for 10 ft. As the maximum height of our hoist is not this tall, we cut the chain shorter. The silver chain was also cut; however, because the entire hoist is adjustable we realized that this chain still needed to have a very large range. The excess chain was always in the lap of the athlete and this could cause some discomfort. To prevent this, a cover for the hanger was created. This cover comes attached with a bag which will hold the excess chain as the athlete pulls themselves up and down.

Fig 10-7: Hanger with Cover and Bag

11 - Cost Analysis

The team was given $1,500 from a grant by the National Science Foundation (NSF) to buy all components needed to manufacture a working hoist. Table 11-1 shows the following price of all materials which were purchased as well as any outside labor costs. Pieces that are labeled as no cost were graciously donated to our team.

Table 11-1: Cost Analysis

Part	Item	Part #	Quantity	Price ($)
Overhead Beam	I-beam	100	1	98.04
	Level	101	1	6.67
Connection	Tubes	200	4	106.04
	Bolts	201	8	6.57
	Lock Washers	202	8	
	Wing Nuts	203	8	
Legs	Poles	300	4	243.80
	Pins	301	4	19.61
Feet	Bolts	400	4	10.07
	Washers	401	8	
	Nuts	402	4	
	Rubber	403	1	0.00
	Sheet Metal	404	1	0.00
Chain Hoist	Hoist	500	1	94.51
	Chain Links	501	2	3.77
Trolley	Geared Trolley	600	1	151.19
Sling Attachment	Hanger	700	1	25.57
	Cover	701	1	25.00
Sling	Sling	800	1	82.99
Labor and Misc.	Welding		4 hr.	64.00
	Powder Coating		1	120.00
	Duffle Bag		1	21.59
			Total	$1079.42

12 – Testing

12.1 Failure Modes and Effects Analysis

To verify that we are satisfying all the specifications we made a failure modes and effects analysis (FMEA) The FMEA is used as a way to identify all the ways in which the hoist may fail. The FMEA lists each component and the different functions that could fail. Then each component is looked at how specifically it could fail. Each potential failure is ranked on a severity scale of 1-10 (with 10 causing death or serious injury to the athlete). The FMEA can be found in Appendix E.

12.2 Hardware Review

Two types of tests were conducted with our built product. The type was a review on the hardware of the final prototype. These are hard values which were measured or tested.

Table 12-1: Testing of Hardware

Spec. #	Parameter	Target	Tolerance	Test	Result
1	Weight	80 lbs.	Max	73 lbs.	Pass
2	Length	7 ft.	Max	7 ft.	Pass
3	Operator Force	30 lbs.	Max	<10 lbs.	Pass
4	Vertical Range	36 in.	Min.	54 in.	Pass
5	Operation Time	5 minutes	Max	3 minutes	Pass
6	Assembly Time	20 minutes	-0/+10	8 minutes	Pass
7	Weight Capacity	250 lbs.	Min	400 lbs.	Pass
8	Cost	$1500	Max		Pass

In regards to the time to assemble, a fellow student was shown how to set up the entire hoist by a member of the Kayakity Quacks team. She was then timed in putting it back together. This was also the time to build with the connection pieces unattached to the overhead beam. In most cases we recommend keeping these attached. It will also cut off a few minutes from the assembly time. In regards to the time to operate, we timed a student from the moment that the sling was under their body and connected to the hanger. Time was then taken from the moment the athlete started to pull them up, until they moved themselves over and touched down on the kayak. The hoist was also taken to different locations to show that it could be stable on different terrains.

Fig 12-1: Hoist on Boat Ramp

Fig 12-2: Hoist on Beach

12.3 Subjective Testing

Subjective testing was accomplished through the help of a participant and a volunteer of the Cal Poly Adaptive Kayaking program. These tests are based on their judgment and compared to the previous method as well as other existing similar products.

Table 12-2: Subjective Testing

Parameter	Test
Comfort	Approved
Ease of Use (Athlete)	Approved
Ease of Use (Volunteer)	Approved
Level of Independence	Approved

Fig 12-3: Testing with Adapted Kayaking participant John Lee

13 - Conclusion

The goal of this project was to produce a hoist that will safely transfer athletes from their wheelchair to the kayak and vice-versa. With this goal in our mind we designed and manufactured a light weight, easy to operate, and collapsible hoist for Disabled Sports Eastern Sierra to use for their kayaking activities. This report clearly lists our design process, engineering analysis, manufacturing, and testing that we completed this year.

Working on this project was a wonderful experience. We'd like to thank the efforts of Dr. Kevin Taylor, Dr. Brian Self, and Professor Sarah Harding of the Kinesiology and Mechanical Engineering Departments at Cal Poly San Luis Obispo for making this project a success. Assistive devices like these prove that people with disabilities can get past any limitations. In addition, it is devices like these that make Team Kayakity Quacks proud to be engineers and proud to have such a huge impact on society. We hope that Disabled Sports Eastern Sierra takes full advantage of our device and help improve the quality of life for many athletes.

Fig 13-1: Kayakity Quacks at Expo

Works Cited

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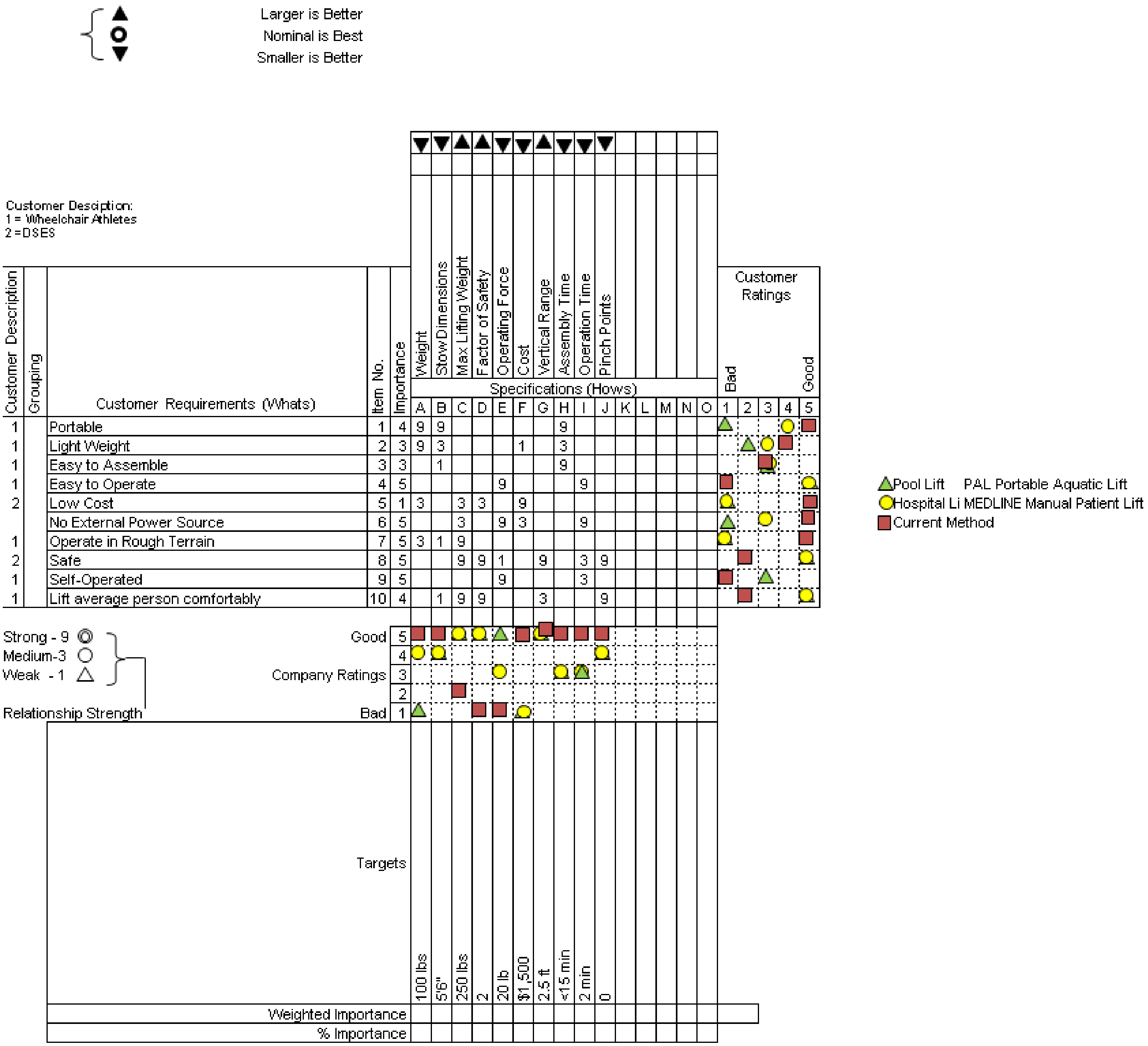
Appendices

A. Quality Function Deployment (QFD)
B. Project Timeline
C. Engineering Analysis (Hand Calculations)
D. Engineering Drawings
E. FMEA
F. Hardware and Set-up Guide

Appendix A: Quality Function Deployment (QFD)



▲ Larger is Better
○ Nominal is Best
▼ Smaller is Better

Customer Desciption:
1 = Wheelchair Athletes
2 = DSES

					A	B	C	D	E	F	G	H	I	J	K	L	M	N	O					
					▼	▼	▲	▲	▼	▼	▲	▼	▼	▼						Customer Ratings				
Customer Description	Grouping	Customer Requirements (Whats)	Item No.	Importance	Weight	Stow Dimensions	Max Lifting Weight	Factor of Safety	Operating Force	Cost	Vertical Range	Assembly Time	Operation Time	Pinch Points						1 Bad	2	3	4	5 Good
1		Portable	1	4	9	9						9								▲			●	■
1		Light Weight	2	3	9	3				1		3									▲	●	■	
1		Easy to Assemble	3	3		1						9										■●▲		
1		Easy to Operate	4	5					9				9							■				●
2		Low Cost	5	1	3		3	3		9										●				■
		No External Power Source	6	5			3		9	3			9							▲		●		■
1		Operate in Rough Terrain	7	5	3	1	9													●				■
2		Safe	8	5			9	9	1		9		3	9							■			●
1		Self-Operated	9	5					9				3							■		▲		
1		Lift average person comfortably	10	4		1	9	9			3			9							■			●

Specifications (Hows)

Strong - 9 ◎
Medium-3 ○
Weak - 1 △
Relationship Strength

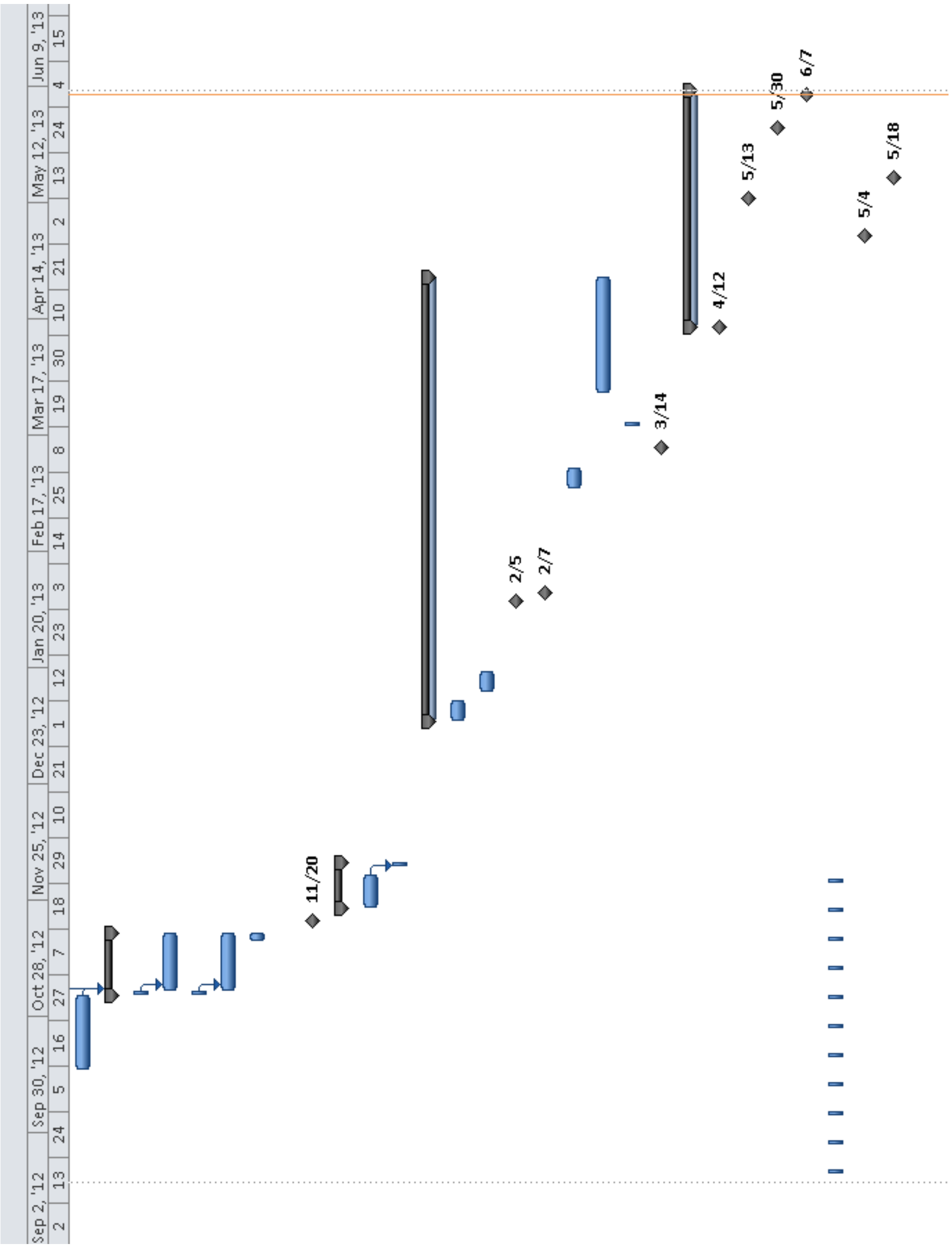
Company Ratings		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Good	5	■	■	●	●	▲	■	●■	■	■	■					
	4	●	●								●					
	3					●			●	▲						
	2			■												
Bad	1	▲			■	■	●									
Targets		100 lbs	5'6"	250 lbs	2	20 lb	$1,500	2.5 ft	<15 min	2 min	0					
Weighted Importance																
% Importance																

▲ Pool Lift PAL Portable Aquatic Lift
● Hospital Li MEDLINE Manual Patient Lift
■ Current Method

Appendix B: Project Timeline

Task Name	Duration	Start	Finish
Define Project	1 day	Mon 9/24/12	Mon 9/24/12
Form Team	1 day	Mon 9/24/12	Mon 9/24/12
Speak With Sponsor	1 day	Mon 10/1/12	Mon 10/1/12
Proposal	**13 days**	**Tue 10/2/12**	**Thu 10/18/12**
Research	**13 days**	**Tue 10/2/12**	**Thu 10/18/12**
Existing Technology	13 days	Tue 10/2/12	Thu 10/18/12
Patents	13 days	Tue 10/2/12	Thu 10/18/12
Develop Specs	8 days	Tue 10/2/12	Thu 10/11/12
Complete QFD	5 days	Fri 10/12/12	Thu 10/18/12
Kayak Event	1 day	Sun 11/4/12	Sun 11/4/12
Idea Generation	**27 days**	**Mon 10/15/12**	**Fri 11/16/12**
Brainstorm	14 days	Mon 10/15/12	Thu 11/1/12
Sketching	14 days	Mon 10/15/12	Thu 11/1/12
Modeling	**13 days**	**Fri 11/2/12**	**Fri 11/16/12**
Procure PVC Pipes	1 day	Fri 11/2/12	Fri 11/2/12
Build Different Frames	12 days	Sat 11/3/12	Fri 11/16/12
Buy Harness Material	1 day	Fri 11/2/12	Fri 11/2/12
Create different Harnesses	12 days	Sat 11/3/12	Fri 11/16/12
Initial Engineering Frame Analysis	2 days	Thu 11/15/12	Fri 11/16/12
Concept Review Presentation	0 days	Tue 11/20/12	Tue 11/20/12
Concept Design Report	**7 days**	**Fri 11/23/12**	**Mon 12/3/12**
Written Report	6 days	Fri 11/23/12	Fri 11/30/12
Design Review Feedback	1 day	Mon 12/3/12	Mon 12/3/12
Build	**96 days**	**Mon 1/7/13**	**Fri 5/17/13**
Assembly Drawings	5 days	Mon 1/7/13	Fri 1/11/13
BOM Development	5 days	Mon 1/14/13	Fri 1/18/13
Design Report	0 days	Tue 2/5/13	Tue 2/5/13
Critical Design Review	0 days	Thu 2/7/13	Thu 2/7/13
Raw Material Orders	5 days	Mon 3/4/13	Fri 3/8/13
Labor (welding, milling)	20 days	Wed 3/27/13	Tue 4/23/13
Manufacturing and Test Review	1 day	Tue 3/19/13	Tue 3/19/13
End Of Quarter Report	0 days	Thu 3/14/13	Thu 3/14/13
Test	**43 days**	**Fri 4/12/13**	**Fri 6/7/13**
Project Memo to Sponsor	0 days	Fri 4/12/13	Fri 4/12/13
Hoist Demo	0 days	Mon 5/13/13	Mon 5/13/13
Design Expo	0 days	Thu 5/30/13	Thu 5/30/13
Final Report	0 days	Fri 6/7/13	Fri 6/7/13

Advisor Meeting	**53 days**	**Thu 9/20/12**	**Thu 11/29/12**
Adaptive Kayak Training Day	0 days	Sat 5/4/13	Sat 5/4/13
Event at Morro Bay	0 days	Sat 5/18/13	Sat 5/18/13



Appendix C: Engineering Analysis (Hand Calculations)

Overhead beam

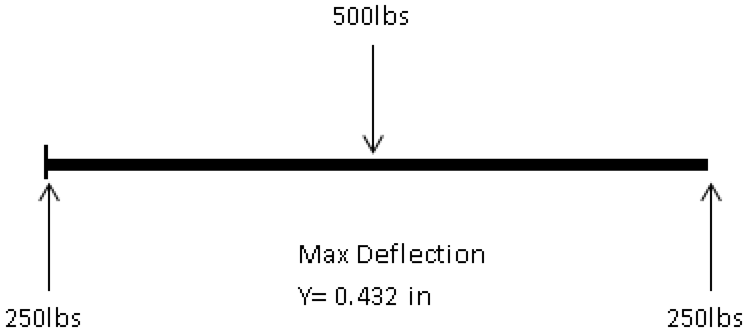


Figure C-1. Free body diagram of overhead beam

Beam Deflection

Width of beam (w) = 2.5in

Modulus of elasticity (E) = 10x10^6 lbs/in^2

Moment of inertia (I) = 1.77in^4

Length of beam (L) = 7ft

$$y_{max} = \frac{5wL^4}{384EI}$$

$$y_{max} = \frac{5(2.5in)(7ft * 12in/ft)^4}{384(10x10^6 lb/in^2)(1.77in^4)}$$

$$y_{max} = .4231in$$

Yielding

Force applied (F) = 500lb

Yield Strength (σ_Y) = 40,000psi

Distance from Neutral Axis (c) = 1.5in

$$M = F * d$$

$$M = 500lb(3.5ft * 12in/ft) = 18000in\ lb$$

$$\sigma_Y = \frac{M * c}{I}$$

$$40{,}000psi = \frac{18000in\ lb(1.5in)}{1.77in^4}$$

Factor of Safety = 2.6

APPENDIX C CONTINUED

Legs

Buckling

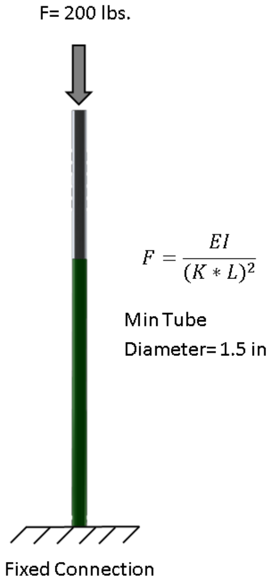


Figure C-2. Diagram of buckling

Force (F) = 200lb

Modulus of Elasticity (E) = $10x10^6$lb/in^2

Length (L) = 80in

Effective Length Factor (K) = 1.0

Thickness (t) = 0.125in

Outside diameter (d)

$$F = \frac{EI}{(K*L)^2}$$

$$I = \frac{\pi}{64}(d_o^4 - (d_o - 2t)^4)$$

$$200lb = \frac{10x10^6 lb/in^2(\frac{\pi}{64}(d_o^4 - (d_o - 2(0.125in))^4))}{(1.0*80in)^2}$$

$$d_o = 1.5in$$

APPENDIX C CONTINUED

Bending Stress

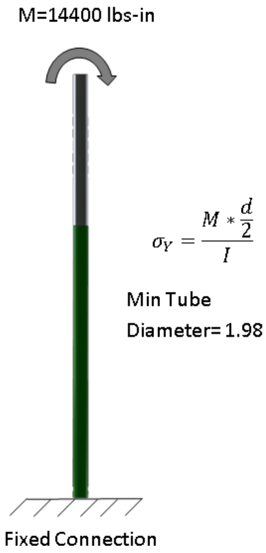


Figure C-3. Moment on single leg

Moment Applied (M) = 14400in-lb

Yield Strength (σ_Y) = 40,000psi

Distance from Neutral Axis (c) = d/2

$$\sigma_Y = \frac{M * \frac{d}{2}}{I}$$

$$I = \frac{\pi}{64}(d_o^4 - (d_o - 2t)^4)$$

$$40{,}000psi = \frac{14400in\ lb(\frac{d}{2})}{(\frac{\pi}{64}(d_o^4 - (d_o - 2(0.125in))^4))}$$

$$d = 1.98in$$

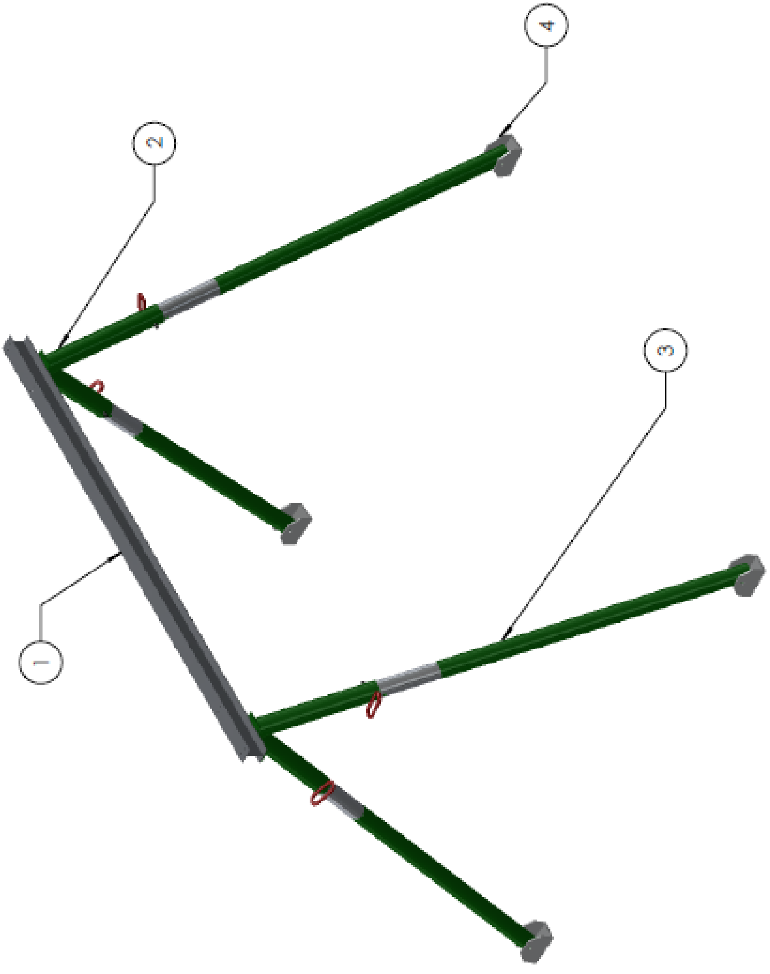
Pins

$$\tau = \frac{F}{A}$$

$$\tau = \frac{250lb}{\frac{\pi}{4}(0.125in)^2} = 5092psi$$

Appendix D: Drawings

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	100	Aluminum I-Beam	1
2	200	Connection	2
3	300	Legs	4
4	400	Feet	4

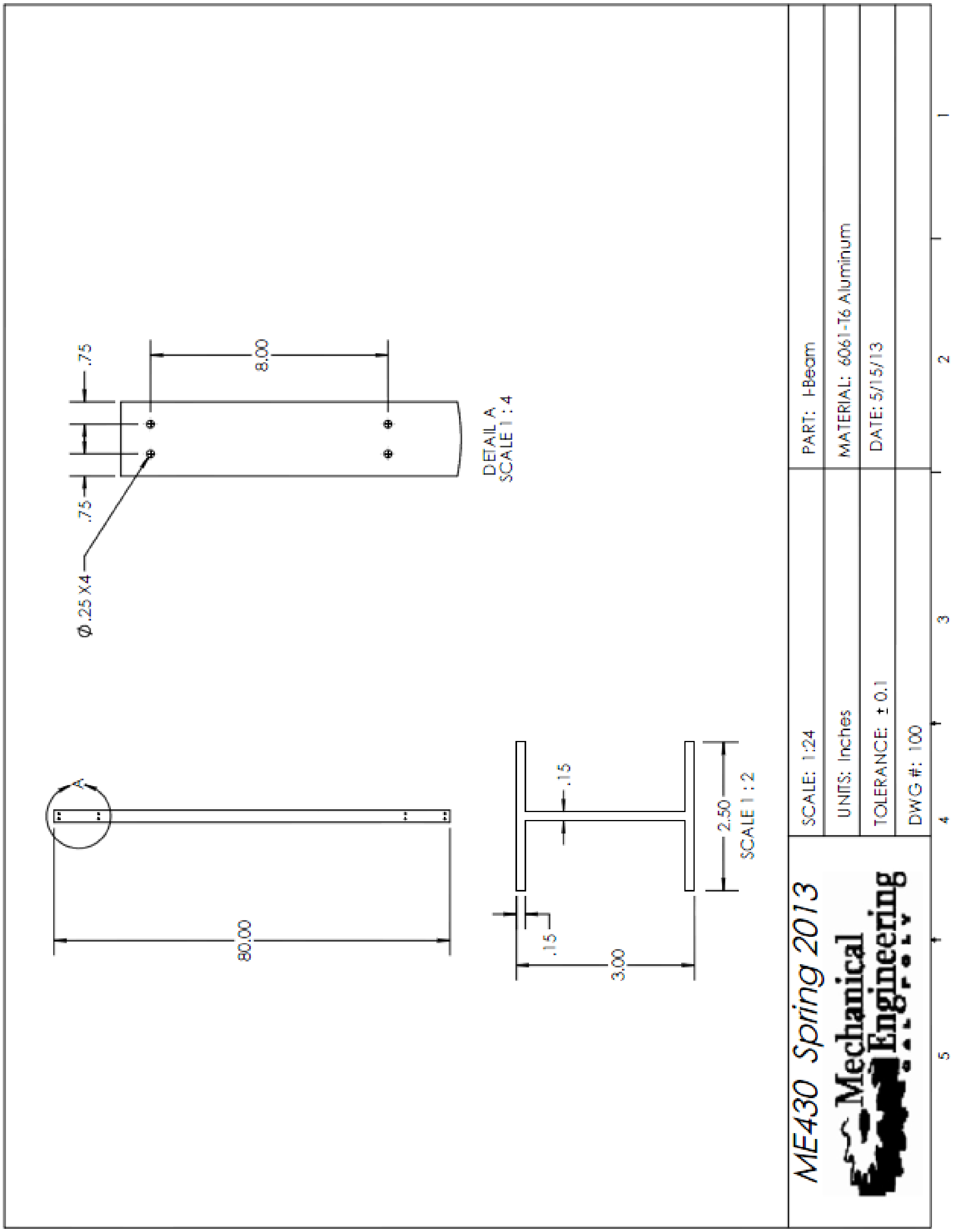


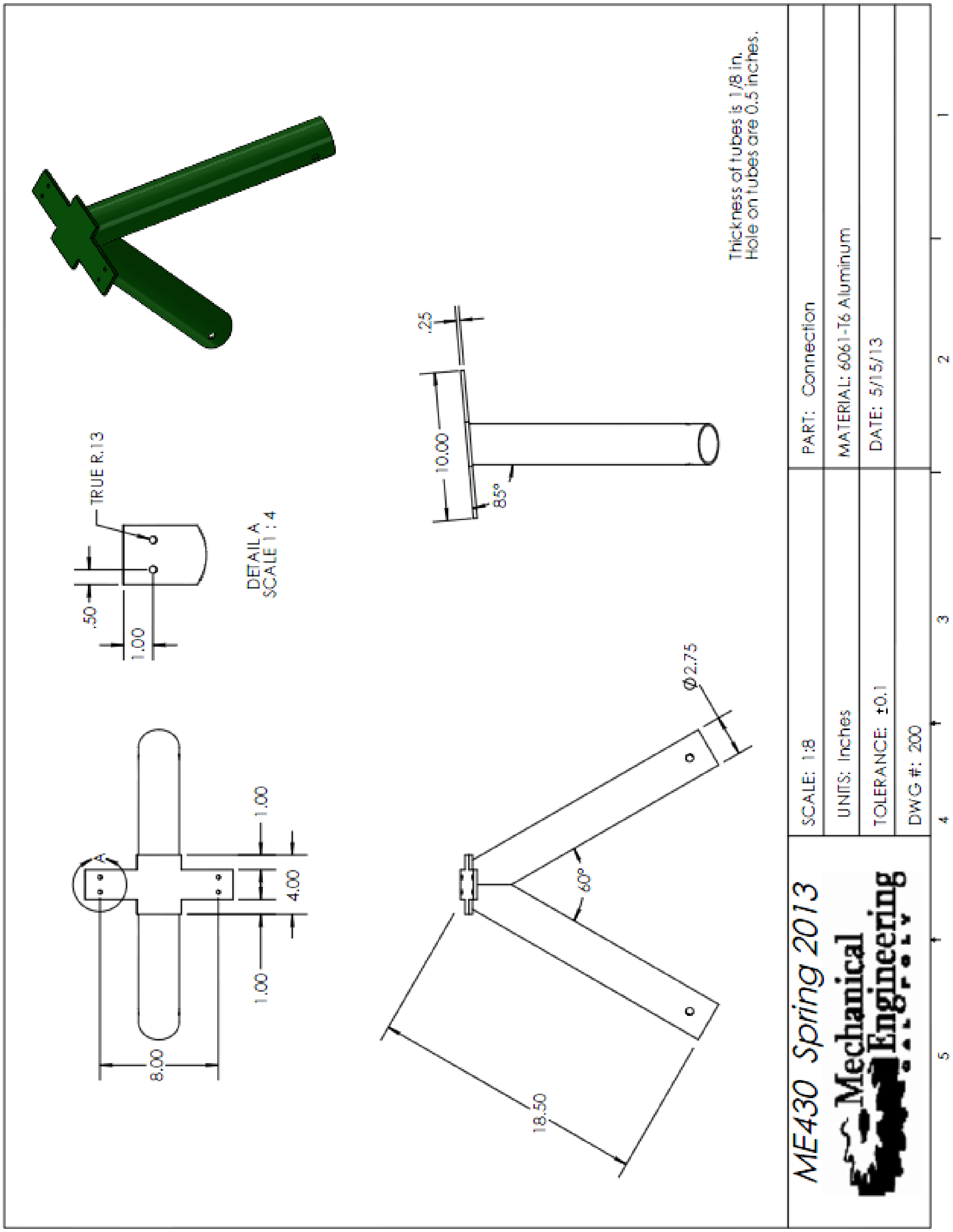
ME430 Spring 2013

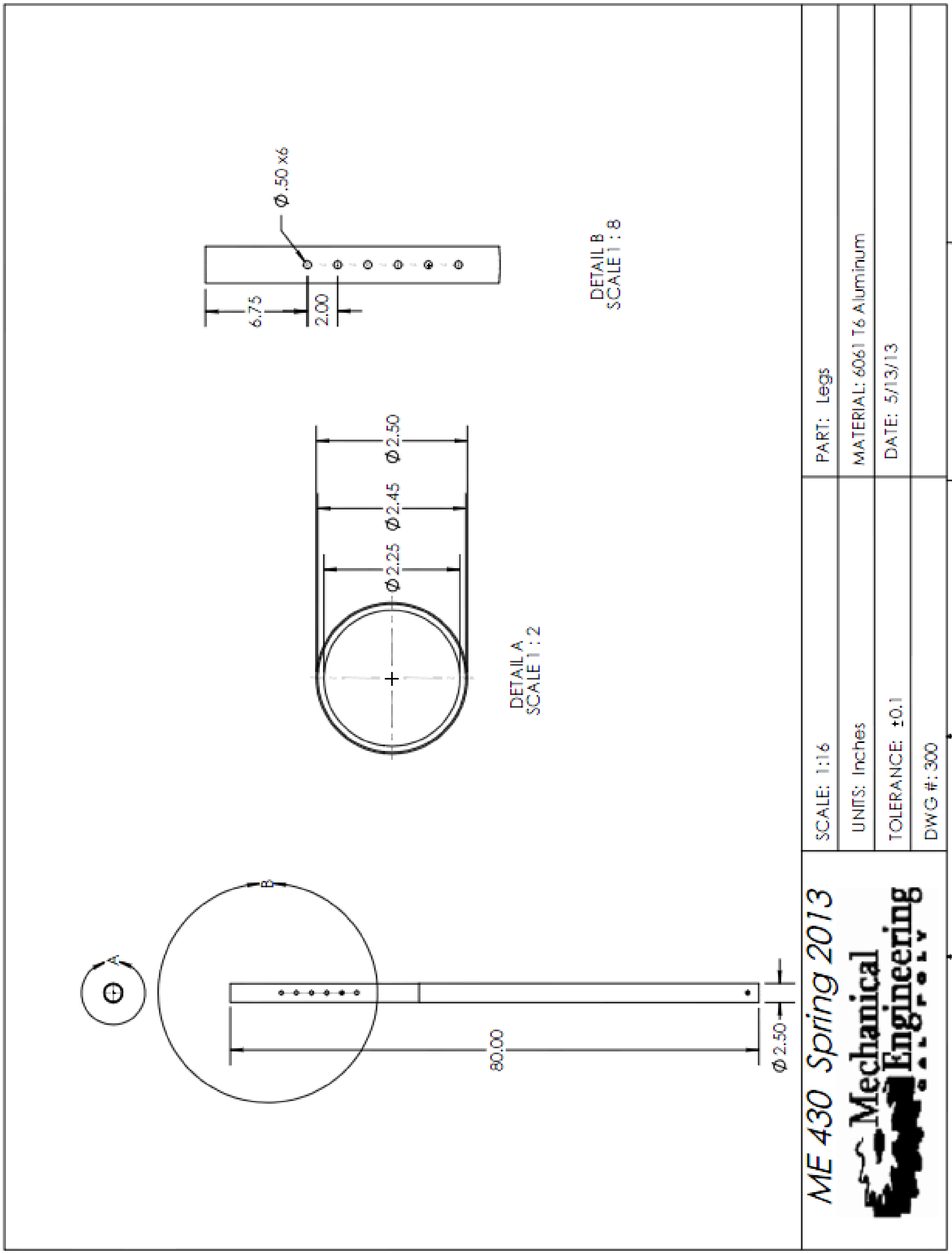
Mechanical Engineering
CAL POLY

SCALE: 1:20
UNITS:
TOLERANCE:
DWG #:

PART: Full Hoist Assembly
MATERIAL:
DATE: 5/20/13


.75
8.00
.75
Ø.25 X4
DETAIL A
SCALE 1 : 4
A
80.00
.15
2.50
SCALE 1 : 2
.15
3.00
PART: I-Beam
MATERIAL: 6061-T6 Aluminum
DATE: 5/15/13
SCALE: 1:24
UNITS: Inches
TOLERANCE: ± 0.1
DWG #: 100
ME430 Spring 2013
Mechanical Engineering
CAL POLY
1
2
3
4
5


Thickness of tubes is 1/8 in.
Hole on tubes are 0.5 inches.
TRUE R.13
.50
1.00
DETAIL A
SCALE 1 : 4
.25
10.00
85°
1.00
4.00
1.00
8.00
A
Ø2.75
60°
18.50
PART: Connection
MATERIAL: 6061-T6 Aluminum
DATE: 5/15/13
SCALE: 1:8
UNITS: Inches
TOLERANCE: ±0.1
DWG #: 200
ME430 Spring 2013
Mechanical Engineering
1
2
3
4
5


Ø .50 x6
6.75
2.00
DETAIL B
SCALE 1 : 8
Ø 2.25
Ø 2.45
Ø 2.50
DETAIL A
SCALE 1 : 2
A
B
80.00
Ø 2.50
ME 430 Spring 2013
Mechanical Engineering
SCALE: 1:16
UNITS: Inches
TOLERANCE: ±0.1
DWG #: 300
PART: Legs
MATERIAL: 6061 T6 Aluminum
DATE: 5/13/13
1
2
3
4
5

Part # 301: Connection Pins

Description

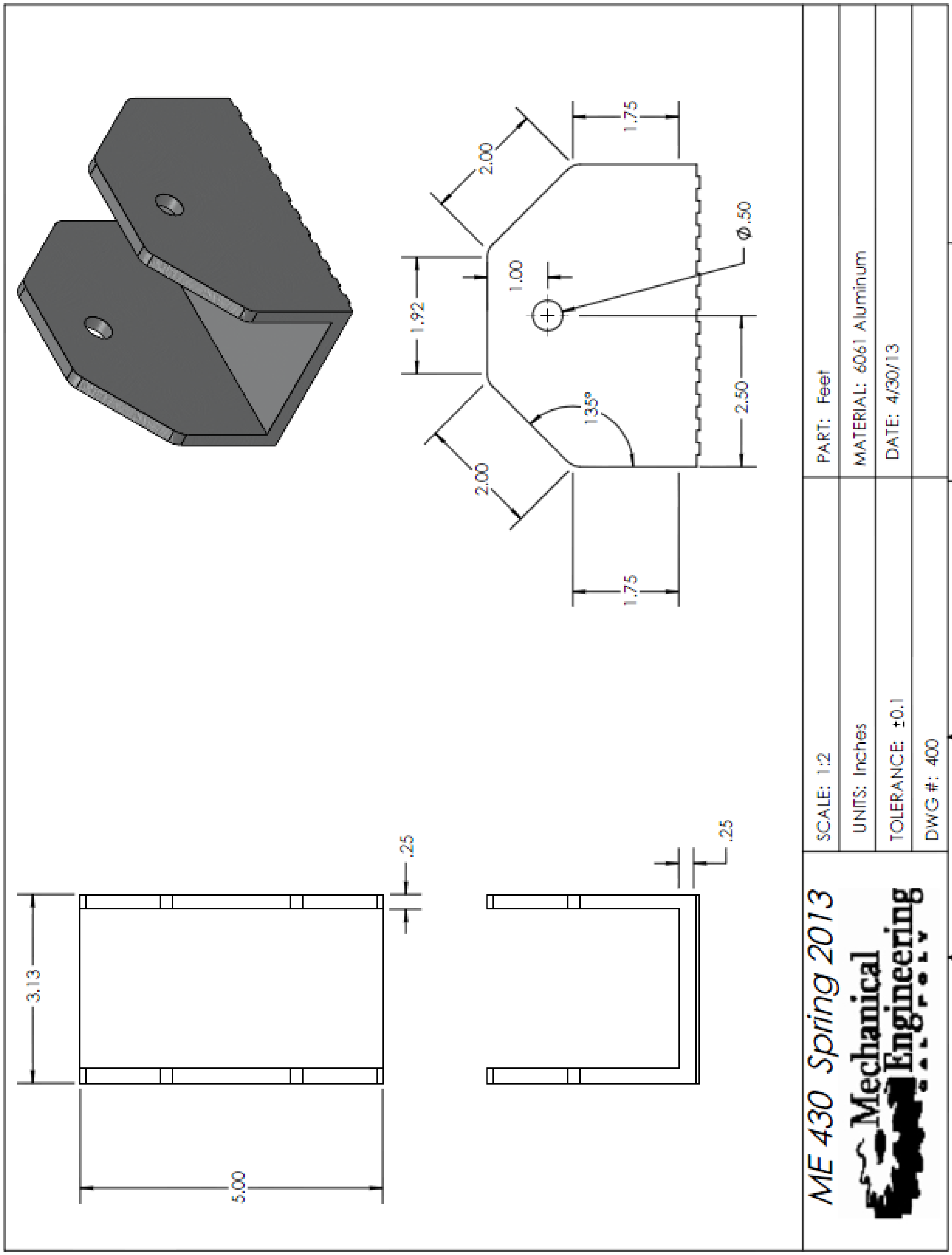
This hitch pin has a large cushion grip handle that stays cool to the touch even on hot days.

- Solid steel construction
- Weather-resistant powder-coat finish
- Cushion grip handle
- "Hairpin" style securing pin
- 1/2" diameter pin for standard hitches

Specifications

Name	1/2" Diameter Easy Grip Hitch Pin
SKU	60440
Brand	Haul-Master
Color	Red/Black
Diameter	1/2 in.
Finish	Powder Coated
Material	Steel
Number of pieces included	2
Rust resistant (y/n)	No
Universal fit	No
Pin length (in.)	4 in.
Product Height	1/2 in.
Product Length	7 in.
Product Weight	0.41 lbs.
Product Width	2-7/8 in.
Warranty	90 Day

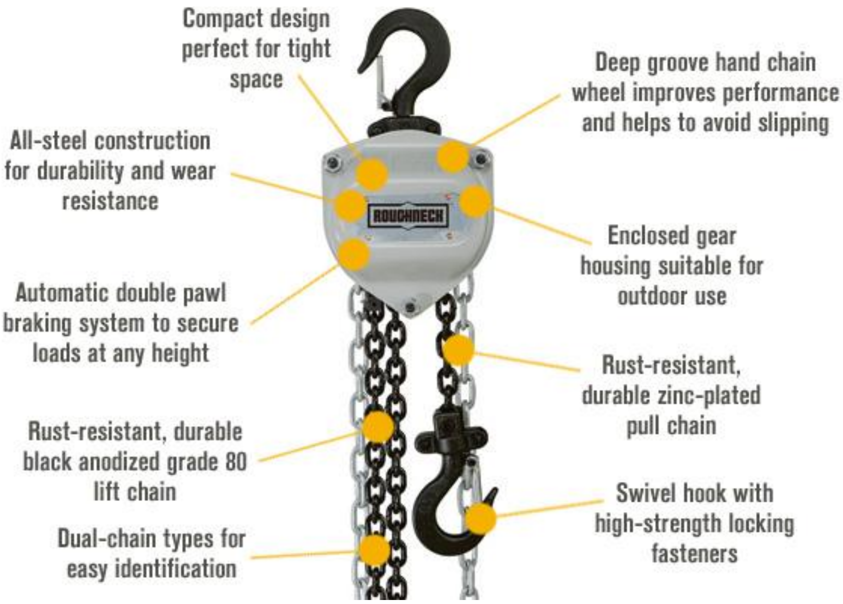
Reference:
http://www.amazon.com/dp/B005ZCT1OY/ref=pe_175190_21431760_3p_M3T1_ST1_dp_1


2.00
1.75
Ø.50
1.00
1.92
2.50
135°
2.00
1.75
3.13
.25
.25
5.00
PART: Feet
MATERIAL: 6061 Aluminum
DATE: 4/30/13
SCALE: 1:2
UNITS: Inches
TOLERANCE: ±0.1
DWG #: 400
ME 430 Spring 2013
Mechanical Engineering
CAL POLY
1
2
3
4
5

CHAIN HOIST – Part # 500

Product Details

Roughneck™ manual chain hoist features steel-casting housing, Grade 80 chain and a compact design that's perfect for tight spaces. Black finish lift chain is rust resistant and durable, while zinc-plated pull chain resists rust. 2-tone chain (black finish lift chain and zinc-plated pull chain) is easy to identify. All-steel construction for durability and wear resistance.



FEATURES + BENEFITS

- Deep groove hand chain wheel makes the chain work better
- Automatic double-pawl braking system
- Hook is assembled with high-strength locking fasteners
- Suitable for both inside and outside use
- Tested at 150% capacity

KEY SPECS

Item#	21284
Ship Weight	19.44 lbs
Lift Capacity (tons)	1/2
Lift Height (ft.)	10
Lift Chain Length (in.)	118
Pull Chain Length (in.)	118
Required Head Room (in.)	12 1/2
Lift Chain Diameter (in.)	3/16

Reference: http://www.northerntool.com/shop/tools/product_200485260_200485260

I-BEAM TROLLEY – Part # 600

Adjusts to fit width of beam. Self-aligning frame and ball bearing wheels. Usable on straight or curved track.

Beam flange width: 2-1/2" - 8"
Min. radius curve: 32"
Beam height: 4" - 19"
Alloy steel construction with double sealed ball bearings provides smooth and easy traversing
Smooth operation over curved or straight track. Easily installed or removed at any point along the beam
Easily fit various sizes of rail, flange and I-beam
Side plates formed to include bumpers and trolley guards ensure extra safety
Hardened axles and wheels for added durability
Complies with OSHA and ANSI/ASME B30.11 and B30.17 standards

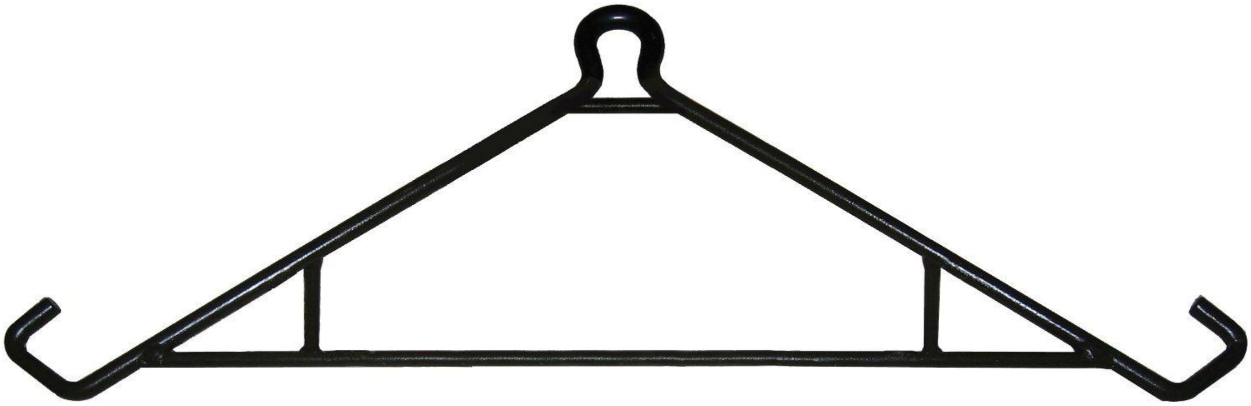
Reference: http://www.arizonatools.com/chain-hoists-147/detail/HIT16-GT05H/

SLING ATTACHMENT – Part # 700

Do-All Outdoors Bull Gambrel

Description

- Suspends up to 1500 pounds
- Tubular steel
- Powdercoated
- Anti-slip hook point
- 26" gambrel width



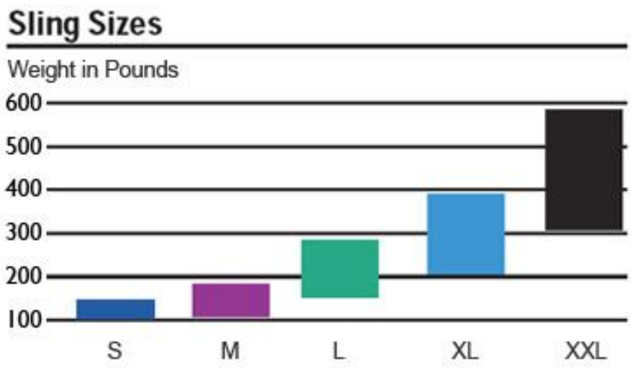
Reference:
http://www.amazon.com/dp/B004MXGNZM/ref=pe_175190_21431760_M3T1_ST1_dp_1

U-SLING – Part # 800

U-Sling for Hoyer Lift 4-point Large Polyester Padded Features:

- This is a more specialized sling
- It allows correct positioning to be made via the 4-pointcradle and uses the Securi3 sling connection system ensuring no inadvertent detachment of the sling from the cradle
- It incorporates a removable comfort pad for head support and snuggles the resident providing full protection for residents who go into extension or have involuntary movements or behavioral problems *

Size:	Small	Medium	Large	X-Large
Weight Capacity:	55 - 110 lbs.	99 - 210 lbs.	198 - 350 lbs.	270 - 600 lbs.
Overall Width:	29.5”	33”	38”	45.5”
Seat Width:	19”	22.5”	27”	30”
Overall Length:	46”	52”	59”	61”
Seat Depth:	14”	17”	18”	22”
Width Between Straps:	9.5”	14”	17”	21”



References: http://www.patientliftusa.com/hoyer-padded-u-sling.html?manufacturer=148
http://www.dmesupplygroup.com/70001.html

Appendix E: Failure Mode Effects Analysis (FMEA)

Item	Function	Potential Failure Mode	Potential Effects	Sev.	Potential Causes of Failure	Test Results
Legs	Hold entire frame upright	Collapse from bending	Structure falls and injury occurs	9	Tubing too thin	Pass
		Collapse from buckling	Structure falls and injury occurs	9	Tubing too thin	Pass
	Adjustable height	Pin holes shear	Not able to adjust height	4	Holes too large cause shear	Pass
Overhead beam	Support athlete	Collapse from bending	Injury	9	Not strong enough	Pass
	Track for trolley	Deflection too large for trolley	Trolley can't move	3	Force is too large creates large deflection	Pass
Hoist	Lifts athlete	Chain sticks	Unable to pull athlete up or down	4	Rust in chain causes kink and unable to move	Pass
		Chain does not lock	Athlete crashes to ground	7	Locking mechanism breaks	Pass
Trolley	Moves horizontally	Unable to move horizontally	Athlete is stuck	3	Bearings in wheels unable to support load	Pass
		Falls off track	Athlete crashes to ground	7	Stresses cause trolley to yield	Pass
Sling	Support athlete while in air	Rips	Athlete falls	6	Fabric is not strong enough to support weight	Pass
		Connection to hanger fails	Athlete falls	6	The clips yield to the weight	Pass
Connection	Connects overhead to the legs	Detaches from overhead beam	Structure falls	8	Poor welds	Pass
		Legs wiggle or fall out	Structure unstable	7	Tubing not a good fit	Pass
Pins	Adjusts height of legs	Shear from weight	Legs go to top	5	Pin not thick enough	Pass
		Stuck in certain pin hole	Unable to adjust height or take apart	5	Pin and hole not good fits	Pass

Appendix F: Hardware and Set-up Guide

Wheelchair to Kayak Hoist Set-up Guide

Overview of Hardware

Hardware checklist (quantity):

- ☐ I-beam (1)
- ☐ Trolley (1)
- ☐ Chain hoist (1)
- ☐ Legs (4)
- ☐ Feet (4)
- ☐ Leg connections (2)
- ☐ ½ inch bolt with nut and washers for feet connection (4)
- ☐ ¼ inch bolt with wing nut and lock washer for top connection (8)
- ☐ Pins for leg connection (4)
- ☐ Hanger (1)
- ☐ U-sling (1)
- ☐ Bubble level (1)

Wheelchair to Kayak Hoist Set-up Guide

Instructions for set up

1. Slide trolley onto I-beam. Ensure that bolt holes on I-beam are facing up (same direction as trolley hook)

2. Attach connections to I-beam using ¼ inch bolts, lock washers and wing nuts. Wing nuts can be tightened by hand.

3. Attach feet to legs using ½ inch bolts, washers and nuts. Once attached, feet can be left on legs for future use

4. Slide legs into connections

5. Secure legs at desired height with pins. There are six height adjustments for each leg to account for inclines and uneven terrain.

6. Once all 4 legs are attached, rotate structure so it is standing upright

7. Clip chain hoist to trolley connection and clip sling connection to chain hoist

8. Use included bubble level to ensure that hoist is level