ACCMT ENGINEERING LTD.

Helping Hand Walker

Final Report

Prepared for:

Dr. Emeka Oguejiofor, FEC, P. Eng

Mr. Paul Doiron, P. Eng

Prepared by:

Group 7

Amelia LeBlanc, 201801218

Cameron de Winter, 201701799

Connor Lobb-Macdonald, 201604637

Michael MacGillivray, 201804432

Tristan French, 201802197

Department of Engineering

St. Francis Xavier University

Design and Communications II

April 17, 2020

5009 Chapel Square
PSC, Rm 3034
St.FX University, Antigonish, NS
B2G 2W5

ACCMT ENGINEERING LTD.

April 17th, 2020

Mr. Paul Doiron, P. Eng,

275 Main Street Suite 100

Antigonish, NS

B2G 2C3

Dear Mr. Doiron,

I am writing to you on behave of ACCMT Engineering LTD. with the following enclosed, a final report requested for April 17th, 2020 correlated towards the design titled 'Helping Hand Walker.' This project has been a collective effort towards helping individuals with mobility issues, such as the elderly, in achieving more mobility and independence in their everyday life. ACCMT Engineering has worked with professionals in the field of strengths of materials, electronics, elderly care, and Healthcare. The following is being submitted as the final PDF copy of the report. Please let us know if you have any concerns.

Regards,

Amelia LeBlanc

Amelia LeBlanc

For ACCMT Engineering LTD

5009 Chapel Square
PSC, Rm 3034
St.FX University, Antigonish, NS
B2G 2W5

ACCMT ENGINEERING LTD.

April 17th, 2020

Dr. Emeka Oguejiofor, FEC, P. Eng,

5009 Chapel Square

PSC, Rm 3044

St.FX University, Antigonish, NS

B2G 2W5

Dear Dr. Oguejiofor,

I am writing to you on behave of ACCMT Engineering LTD. with the following enclosed, a final report requested for April 17th, 2020 correlated towards the design titled 'Helping Hand Walker.' This project has been a collective effort towards helping individuals with mobility issues, such as the elderly, in achieving more mobility and independence in their everyday life. ACCMT Engineering has worked with professionals in the field of strengths of materials, electronics, elderly care, and Healthcare. The following is being submitted as the final PDF copy of the report. Please let us know if you have any concerns.

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For ACCMT Engineering LTD

Abstract

The Helping Hand Walker is a design project by ACCMT Engineering, aimed to help elderly individuals who use a walker to get from the sitting to standing position. A walker is a type of mobility aid used for individuals who can walk on their own but need extra support while standing to rest and maintain their balance. It was made clear that individuals who struggle when doing a simple task like getting from the sitting position to the standing position, have identified that there is a lack of equipment on the market which would alleviate these issues. Independence was lost, and individuals resulted in injuring themselves as asking for help to stand was defying their pride.

Building this walker safety was the biggest concern. The research was required to figure out a way for someone who uses a walking device to safely and independently stand them self. The main problem that was identified was that walkers are usually unstable and with some user unsafe. It was recommended to us that an acceptable solution to this problem was to design a walker system that would aid elderly individuals in the standing position so they are stable to available to go about their day with no concern of injuring themselves or a healthcare provider.

The approach from the beginning was to design a walker system that conclusively meets all design goals to build a safe, lightweight, stable, and mobile walker system that gives users back their independence. ACCMT Engineering conducted research and recognized that current lifting aids, seats, and walkers on the market have a variety of problems with them, which makes it more difficult for its users. These problems include, unstable walkers, lift aids that injury the resident, seat lifts that do not fit all walkers' types, and the list goes on. Although these products may work for some, there was no product on the market that provide users with a safe way to lift themselves. Taking all these problems into account, ACCMT Engineering has designed a walker that is: user-friendly, stable, cost-efficient, and can easily be integrated into a household or nursing home.

Enclosed in this report, will be a further detailed analysis of the design project which includes: the design process, calculations, structural analysis, circuits analysis, and cost analysis, all being done using the concepts of mathematics, engineering, economics, and ethics.

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Abbreviations and Units

St.FX – St Francis Xavier University

kg – Kilogram

m – Meter

M- mass

N – Newton

CAD – Computer Aided Design

T – Torque

F – Force

d – diameter

W – Watt

AH – Amp Hour

V – Volt

E – Youngs Modules of Elasticity (Values found in Hibblier, 2015)

P_{Cr} – Critical Force

Q – Moment if Area

τ – Shear Stress

M- Bending Moment

I – Area Moment of Inertia

σ – Normal Stress

k – Spring constant

k (structural analysis) – Effective length factor

Acknowledgments

ACCMT Engineering would like to thank the following people for their assistance in this project:

Dr. Emeka Oguejiofor, for his feedback, insight and time he has given ACCMT Engineering on this project.

Mr. Paul Dorion, for his time and feedback and insight on this project.

Rochelle Heighton, for her time meeting with ACCMT Engineering team to discuss the design.

Lori Young, for her time meeting with ACCMT Engineering team to discuss the design.

Craig Seaboyer, for his time, assistance, and feedback in designing the Helping Hand Walker also for the allowing the use of his workspace when it was planned to make a prototype.

Steve MacDonald, for his time, assistance, and feedback in designing the Helping Hand Walker.

Professor Mohammad Azad, for his time, assistance, and feedback in calculations to ensuring all calculations were valid in designing the Helping Hand Walker.

Introduction

The objective for this course was to be able to solve a problem using the knowledge and skills of engineering principles acquired through previously taken courses such as Statics, Dynamics, Electric Circuits etc. Deciding on a project idea involved brainstorming problems many people are affected by that can be solved from an engineering perspective. ACMMT Engineering decided to investigate how the modern-day walker can be improved to assist people. Walkers are used to increase the stability of the user and help them walk independently while reducing the chance of a fall. There are a lot of people with the ability to walk around and enjoy their day but are confined to their couch because they must wait for someone to help them get up each time. To solve this problem, ACCMT Engineering has proposed a new walker with a built-in mechanical lifting system. The walker would help the user to their feet so they can walk around independently and not wait for a family member or healthcare provider to help them up. The Helping Hand walker is an affordable mixture between everyday walkers and heavy-duty lifting aids.

Need for an Engineering Solution

For senior citizens or people with low mobility issues, walkers are a safe, flexible, cost effective way to still maintain an active lifestyle. They offer a support system that allows the user to lean on the walker for balance and to help guide them as they walk. 11.6 percent of elderly people in America use walkers to reduce their chance of falling (Times). This shows a large group of people use a walker which creates the need for improvement where seen applicable.

However, the problem with standard walkers is that they only assist the person whilst standing up. Going from the sitting position to the standing position, for some, can be challenging or even impossible without the help of another individual. The Helping Hand Walker is envisaged to provide support that gradually raises the person from the sitting position without putting a strain on the lower back and minimizes the chances of falling over due to instability.

Safety is always a significant concern for engineers when designing new products but for the design of the Helping Hand Walker especially. Research was conducted to figure out a way for someone who uses a walking device to safely and independently stand by themselves. The proper techniques to getting up are for the user to move themselves to the edge of their chair, place both hands on the armrest of the chair, lean forward and to use their arms to push off the chair. Once the user starts pushing off the armrests of the chair, they can start to gradually straighten their legs. These are aspects to help understand the movement of a seemingly healthy body and what is required to lift a person from the sitting position to the standing position. For an elderly person who may also have other common issues such as arthritis, knee and hip problems, etc. Getting from the sitting to standing position may not be as easy.

"Injuries and medical conditions aside, the normal aging process causes the body to lose muscle mass (sarcopenia). Because of this, it is easy to lose strength in the hip muscles and knee extensors, the muscles that help straighten the legs. The human body relies on these muscles to walk, climb stairs, and rise" (Inverarity). With this information, The Helping Hand Walker aims to relieve the stress that is put on an elderly person's body who may suffer from preexisting injuries while standing up

Similar Products

There is a wide range of walking and lifting aids on the market. These products range from a simple stability tool, all the way to heavy-duty lift and transportation aids. Two main categories summarize walking/lifting aids. The first being basic walking aids such as walkers and rollators, and the second being heavy-duty lifting/transportation aids. While these two categories cover many of the problems people with mobility issues face, there is still a large gap in the market. Heavy-duty lifting aids are great at helping people with less strength get to their feet, but they are very expensive. On the other hand, basic walking aids offer great support for people with stability issues while walking, but most of the time offer no support when standing up from a sitting position.

There are three basic walker types on the market right now: the standard walker, the front wheeled walker, and the 4 wheeled rollators. The standard walker is the most basic for the three having handles on either side of the user and a non-slip rubber tip on each of the four legs. This type of walker is used by people with little lower body support and a decent amount of upper body support. The four rubber-tipped legs give great support when moving about but provide less maneuverability than other models. The front wheeled walker has a similar concept but with more mobility. The front wheels allow the user to push the walker forward with more ease than the regular walker. With more ease comes more responsibility as the walker loses the sturdy support that the standard walker offers. The third basic walker model is a four-wheeled bariatric walker. This model offers the most mobility and maneuverability to the user, where the front wheels pivot the back wheels glide giving the most directional control to the user. This model is more for people with a moderate amount of strength altogether, but need a bit of stabilizing support every so often

In more extreme cases, patients may not be able to stand or even walk on their own. There are a few products on the market such as the Get-U-up sit-to-stand lift aid. These products allow for patients that have difficulty getting up, the ability to do so with ease. These products also offer complete walking support, but this is unnecessary information as the goal of this project is to design a personal walker that needs no additional help. That’s why these are great for people that need help when standing up from a sitting position but lack the basic stability aspect that most people would prefer when finally standing. Some products are in the middle ground between basic support walkers and heavy-duty lifting/walking aids. Even though there are a few models that give support when standing up, no design has any good answer to complete sit-to-stand support.

Meeting with Occupational Therapists

On Monday, March 9th, 2020, ACCMT Engineering met with staff from St. Martha’s Regional Hospital to get feedback on the design of The Helping Hand Walker. Rochelle Heighton, an occupational therapist and Lori Young, a department therapist gave feedback regarding questions ACCMT Engineering had towards developing The Helping Hand Walker. They were able to provide valuable insight as they have firsthand experience with elderly people who have low mobility issues. They were also able to discuss common injuries and some of the equipment they use for different patients and their different needs.

The main concerns for the Helping Hand Walker are safety and functionality so Lori was able to discuss how elderly patients that have low mobility issues and use a walker, are most commonly injured/suffer from pain. If support workers or family members tend to hurt the patient, it’s from improper lifting techniques which can cause harm to the elderly person. A common mistake Lori states is that family members commonly try to lift from underneath the elderly person's arms and yank therefore causing pain to the shoulders and their back. Many elderly people suffer from arthritis, joint pains, and loss of muscle mass as that's the natural aging process.

Rochelle explained that the most challenging thing from getting from sitting to a standing position is leaning forward. Many elderly people have had previous injuries and/or falls so there is a big fear factor when pushing off a chair to stand up. Rochelle was able to demonstrate some of the exercises used for elderly people, so they are more comfortable getting up but claim that it is more of a psychological fear rather than the person not being able to get up themselves. If there were to be an issue with the patient getting up it would be from the patient having one good knee or hip and therefore trying to pull them self-up to avoid having to push off from both legs. This can lead to damage in the upper body such as the shoulders as Lori stated to be the most common injury type.

Some of the equipment that Lori and Rochelle discussed during the meeting that is used in the hospital and in transportation methods are the Hoer lift and the Uplift. The Hoyer lift (Figure 1), is not ideal to incorporate into the Helping Hand Walkers design as it's not for people who maintain an independent lifestyle and must be strapped into to use. Lori had suggested an idea of trying to incorporate the Uplift (Figure 2), to alleviate some of the counterweights on the walker as to still have the walker light enough for the user to lift. After further discussion, it became clear that this idea wouldn't be very probable for the Helping Hand Walker as the Helping Hand Walker does not have a chair on it for the Uplift to be used.

Figure 1"Hoyer Lift"

Figure 2"Up Lift"

System Design

The group has been faced with many challenges which were met with solutions. The project goal was to design a walker with a built-in lifting system that is lightweight and affordable. The product was designed with a user in mind that had reasonable mobility but struggled to get to their feet from the sitting position. When the system is activated, the user will be pulled up and forward by two DC motors. Using the lower hand supports on the walker to support their weight, the system will bring the user to a position where their nose is past their toes. From this position, they will be able to use their upper and lower body strength to stand up fully.

The harness being used is a simple sling that will slide under the user's buttock and slightly up the back. It will boost the user forward causing the motion mentioned above. The sling is shown in figure 4.

Figure 3 "Lifting Sling"

To resist rotation of the system when the lift is in process, the group designed stability stands that extend past the back legs of the walker seen in figure 4. The stability stands have a wider area on the floor, so the stress is distributed better, leading to minimal damage to the system and the floor.

A new addition to the design is floor clips (figure 4) that will hold the front end of the walker still when the lift is in process. The floor clip consists of a metal bar that can be pushed down by the wheel then clip inside the rim of the wheel. Once the lift is completed, there will be a foot pedal that unlocks the clip allowing it to rotate upwards and release the wheel. The bar inside of the mechanism will be made from Structural Steel Alloy A-36. The reason for this material is because it has a large modulus of elasticity, therefore it has a large tolerance to deform under stress. (Hibbler,2015)

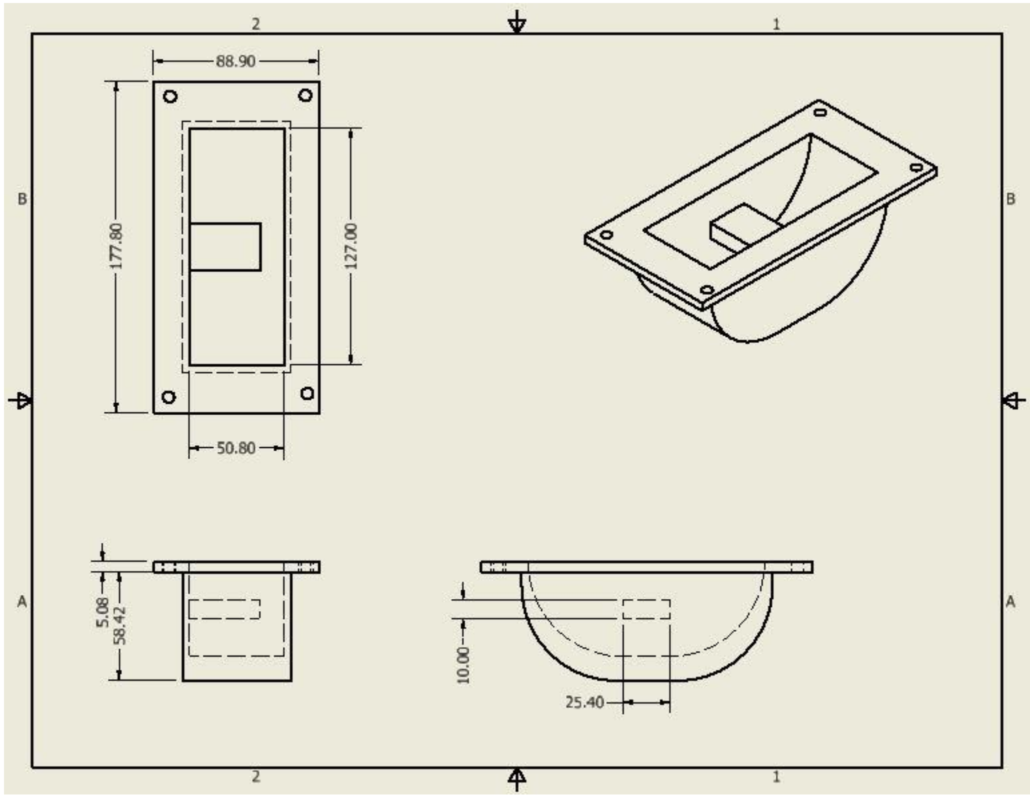


Figure 4 "Floor Clip"

To reduce the chance of a fall occurring, another feature added is a spring loaded "catch" system in the front legs of the walker. This allows the front legs to meet the ground if a strong downwards force is applied. Calculations were completed to show what strength of spring is needed.

In figure 5, the full system is shown. There is also a chair shown to indicate where the user is being pulled from. This drawing was created in Inventor. This is an extremely useful program that allowed the group to successfully detail the design ideas.

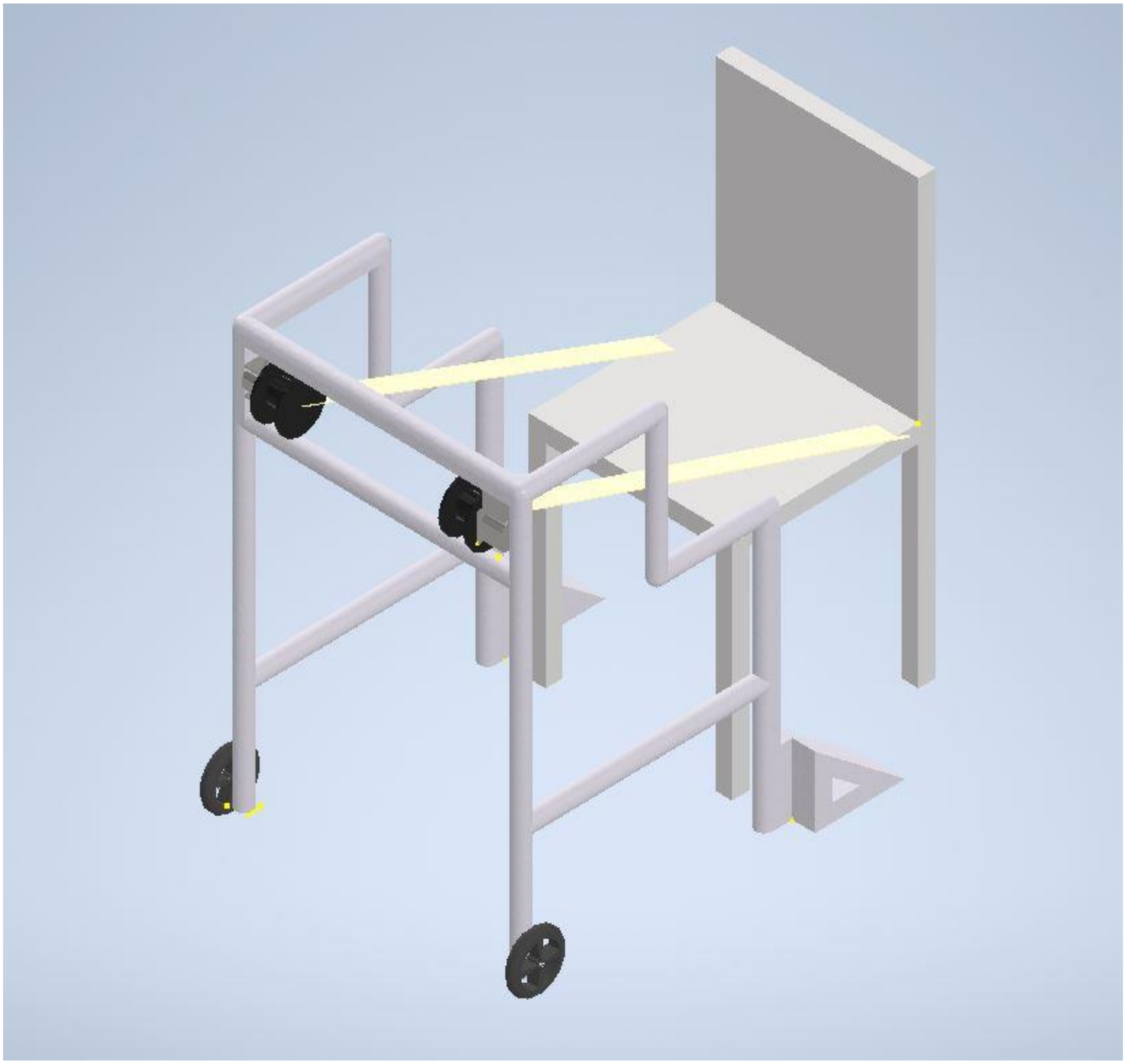


Figure 5 ”Final Inventor Drawing”

Materials Information and Analysis

Physical Materials:

Aluminum Frame

The aluminum frame chosen for our walker is primarily made from aluminum tubing that has a 0.0381m outer diameter with a hollow 0.03302m inner diameter, shown in figure 5. Following the diagram in appendix 1a, the lengths of each of the members have been displayed in the table below. The material properties if the tubing is 73.1 MPa, and the density of 2.72 Mg/m^3. The material is very strong while also being light weight.

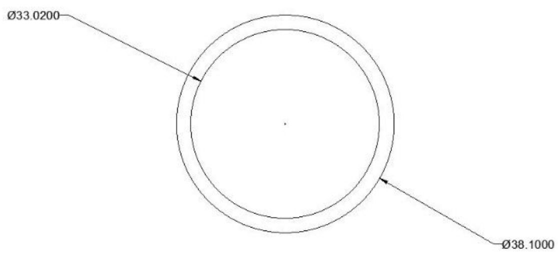


Figure 6 "Diameter of Pipe"

Length of Member (these members are all doubled as the walker is symmetrical)
0.528642m x2
0.6604m x2
0.92019m x2
0.28369m x2
0.6365m x2
0.3232433m x2
0.2794003m x2

The addition of all these members gives the total length of aluminum pipe required to build one walker. The length of pipe needed is 7.2641m. This is a slight over approximation as the parts will be cut down and less material will be needed but it is good to know the maximum amount of material needed. Since the cross-sectional area of each pipe will be the same the choice of aluminum tube was solely based on price and quality of goods. After researching the costs and quality of different manufacturers an aluminum pipe manufacturer was found with the ability to create an aluminum pipe suited to the walker's specifications. It was found that aluminum pipe of the exact diameter was found and sold at lengths of up to 7.3152m. The cost of one of these pipes is $98.88 American which transfers to $138.76 Canadian. This means that the cost of the entire frame of the walker will cost $138.76. There was some research into buying the product in mass quantities, but the price only drops a negligible amount. Which means the scaling of a product like this would have to be done by manufacturing an aluminum frame which is not feasible at this point.

Sling

Originally for the sling, the idea was to use a workman's harness as it is very secure and trusted to lift people at heights. After further analysis it was found that this harness was safe yet did not allow for an easy access when tasked with putting on and taking off. Less mobile patients would not be able to complete this task independently. This brought the conclusion that a "Bestcare Stand Assist Buttock Strap" was much more suitable and comfortable to our users. This strap is assured to be secure for lifting patients of up to 600lb bariatric size and 400lb standard size. This means that this sling will be well suited for all weight ranges of patients. This sling will cost $64.95 per Helping Hand Walker.

Harness Ropes

The harness ropes will be used as a tensile force between the walker and the weight of the patient. The ropes need to be small in diameter as well as have tensile strength to ensure the patients safety. The Hardness Rope chosen called "Arborist climbing ropes" from a company called Grainger Industrial Supply. This rope best suited The Helping Hand Walker as it has a tensile strength of 3.1kN. It was determined that the rope can be bought in bulk resulting in saving some money. The rope would be purchased at 182.88m length costing $706. While each walker only needs about 1.82 of rope (0.91m for each side), this means that 100 walkers can be supplied with ample rope with one purchase of 182.8m. When the cost of the entire spool of rope is divided over the potential yield of 100, at 182.88 meters, this allows for the cost to be brought down to $7.06 of rope per helping hand walker.

Wheels

The wheels that were needed for this project were 0.1524m basic walker wheels. Without variation in price or quality of wheels it was settled that we would use a pair of "Stander 0.1524m walker replacement wheels". These wheels are a great price and do not lack in quality. A pair of these wheels would cost $28.60 per helping hand walker.

Handle Grips

The hand grips for the walker need to be high density to be able to take years of pressure. They also need to provide ample grip to allow good handling of the helping hand walker. The choice was made easy when a fitness company was found that sold the proper size grips for the helping hand walker. The company sells 1.8288m long open-ended handle grips that can be cut down to the size needed. Since the handles that are needed for the walker are only 0.127m long, one 1.8288m handle grip can be cut down to make 14 grips. with the cost of the entire 1.8288m grip being $28.90, this cost can be divided into 14 parts making it only $2.06 per grip. The helping hand walker needs 4 grips (two for the upper supports and two for the lower supports), so the total cost of grips for one walker is $8.25.

Rear Non-Slip Pads

On the rear legs of the walker there is an extra triangular based support. This support allows for the lifting assistance without the chance of the walker being pulled back and falling on the user. These pads are aided with non-slip rubber grips that are screwed into plates underneath the triangular supports. This non-slip rubber material, that is 0.4064m x 0.08255m, and can be bought online with amazon for $46.25. When cut into 0.08128m by 0.247m this allows a yield of 20 individual non-slip pads per sheet of material. Dividing the total cost into 20 pieces means that each piece will cost $2.31. Since each walker needs two of these the price per helping hand walker is $4.62.

Electrical materials

Battery

The battery the choice of a was the most important choices for the electrical components. Proper power rating as well as a durable long-lasting battery is needed to ensure a durable and safe product. A "TalentCell 24V Lithium ion Rechargeable Battery, 22400mAh 82.88Wh Li-ion Batteries Pack with DC 24V/12V and 5V USB Output" was chosen as the battery for the motors. This battery has more than enough power needed as well as a long battery life between charges. This battery will end up costing $86.95 per helping hand walker.

DC Motors

The motor that was chosen was a "DMKE variable DC 12-24v brushless geared motor" with an output power capability of 150W. Since there is the need for two of these motors and each motor costs $80.00, these motors will cost $160 per helping hand walker.

DC Speed Controller

When choosing a motor, the speed of the motors needed to be adjustable. As some patients need less assistance, resulting in higher speed and less force, whereas others need the extra assistance with much less speed. An affordable DC motor speed controller was found with a reputable distributer. The controller has a power rating of 12-40v, meaning that it can handle as much as 40 volts or as little as 12 volts. (cite) The Helping Hand Walker only required a 24v battery, so this product was perfect, and has the output capacity of 0.01-400W which is well over the wattage required to power both motors. This product can be purchased on "Banggood" website under "DC 12V-40V 10A 13Khz Motor Speed Controller Pump PWM Stepless Speed Change Speed Control Switch Large Torque 50V 1000uF Large Capacitor IRF3205 Power Tube with Over-Voltage Protection Function". This controller will add $6.42 per cost of the Helping Hand Walker expenses.

3 Position Switch

The three-position switch allows for the motors to be run in clockwise as well as counterclockwise. This is done through specific wiring of the 3position switch from the speed controller, as shown in the circuit diagram above. This will cost only $2.27 per helping hand walker. (Banggood.com)

Cost Analysis for an Individual Walker

Item Description	Item Price ($CAD)
Aluminum	138.76
Sling	64.95
Rope	7.06
Wheels	25.60
Handles	8.25
Non-Slip Pads	4.62
Battery	86.95
Motors	160
Speed Controller	6.42
3 Position Switch	2.27
Compression Springs	30.06
Total	**534.94**

All pricing can be found in the work cited page. The Pricing in this table is a rough estimate given different tax laws per region as well as different shipping prices.

Dynamics Calculations

To figure what size motor was needed for this system torque calculations needed to be completed. Torque is rotational equivalent to a linear force and is computed by multiplying the magnitude of the applied linear force by the perpendicular distance of the line of action of force from the axis of rotation. This is expressed by the equation $T = F \cdot r$. To compute the force that the motor needs to produce, a conservation of momentum analysis was completed. For the calculation a few assumptions need to be made.

1. The initial and final speed of the user during the lift. The initial is zero, but the final speed is an unknown value. After group discussions, a value of 0.2 m/s was chosen.
2. The time it will take for the process to occur. The group expected the change in displacement of the user to be around 0.5 m. With the already chosen velocity value of 0.2m/s, a time of 3s was chosen.
3. It was assumed that the user would be able to lift 50% of their bodyweight.

Once the group decided these values it was a straightforward solution, using the law of impulse and momentum the force applied for the user was found to be 8N.

Solution

M= 100 kg * 0.5 = 50 kg

$\Delta t = 2.5s$

V initial = 0

V final = 0.2 m/s

Using the principle of impulse and momentum to calculate F pull

$MV_1 + (F-W (\sin (30))\Delta t = MV_2$

$V_1 = 0$ therefore the equation is,

$(F-W\sin(30))\Delta t = MV_2$

Re arrange to solve for F

$F = (MV_2 / \Delta t) + W\sin(30) = ((50\ kg)\ (0.2m/s) / 2.5s) + (50kg)(9.81\ m/s^2)(\sin 30) = 249.25N$

The system consists of two motors so each will need to produce a lifting force of 125 N.

Finally, torque is calculated my multiplying this number by the radius of the pully in figure 5. The radius is 0.0254m.

$T = F \cdot r = (125\ N)\ (0.0254m) = 3.175\ N \cdot m$

After obtaining this information, a motor was selected.

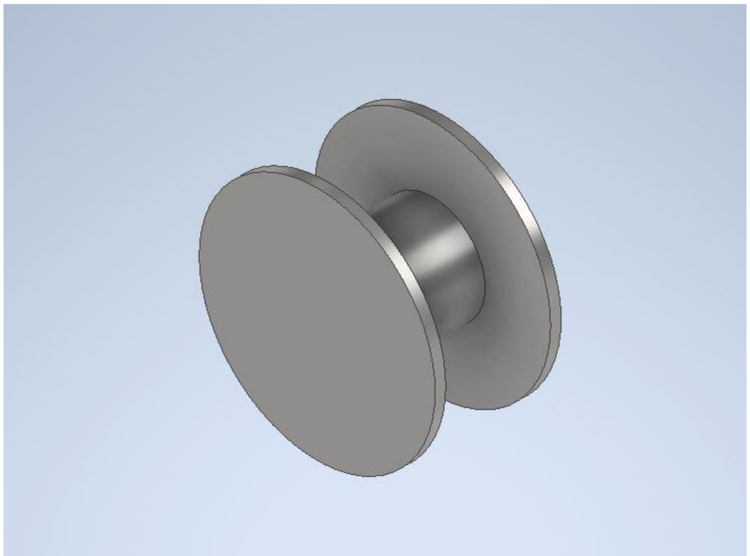


Figure 7"Pulley"

Spring Force Calculations

It has been brought to the groups attention that the wheels could become more of a danger than an advantage. But with the implementation of the floor clips, the wheels integral to that design. A solution to this is implementing a "catch" that would allow the front legs of the walker to touch the ground when a large enough force is applied. This system will consist of a spring that will compress when the force is applied to it. To choose a spring, some knowledge from Physics 121 needs to be applied.

$$F = k\Delta x$$

For the front to reach the ground they must move downwards 0.0254 m. The force will need to be strong enough, so the legs aren't always on the ground.

For our theory user of 100 kg, an applied downwards force of 250N would be reasonable. (tested by applying pressure to a scale while falling forward.

$k = F/\Delta x = 9.84$ N/mm

Spring rated at 9.8 N/mm were found and have a net cost of $15.03/spring. Giving a total of $30.06. The spring have an outer diameter of 0.02794 m, so they will fit inside the legs.

Structural Analysis

As the lift is in process, the structure needs to resist forces and rotation at each joint. Because of this, many force reactions need to be calculated to find the stresses in the system. The system was broken up into two sets if four key members that are connected rigidly. These four members are the two legs, the lower handles and the upper handles. On the system, there are two applied forces. One is the pull forces applied by the motor when the lift id in process and the other is the force applied to lower handles by the user. This force was calculated experimentally. The force that is applied by the hands of the user was calculated by using a scale. The weight force was approximately 20% of the user's body weight. For the calculations, this force was doubled to endure the handles wouldn't break during the process.

When completing the calculations, it was found that the system of forces was indeterminant. After lots of trial and error, a method for solving the problem was selected. Using the method of integration for deflection, an unknown, redundant moment reaction was obtained, and the internal force calculations were completed. With these internal forces, the normal stresses were computed for each member. Look at the calculations, two main things stood out. First, it shows that the front legs were going to lift off the ground during the lifting process. And second, the back legs had high compressive stress. In the design process, the group came up with solutions for this problem.

First, to keep the front of the walker on the floor, the group implemented a floor clip device. The device holds the front wheel steady when the lift is in process. For this portion, a full stress analysis was complete showing the maximum bending moment and shear steer force, and the normal and shear stresses in the bar.

<u>Stress calculations for the floor clip</u>:

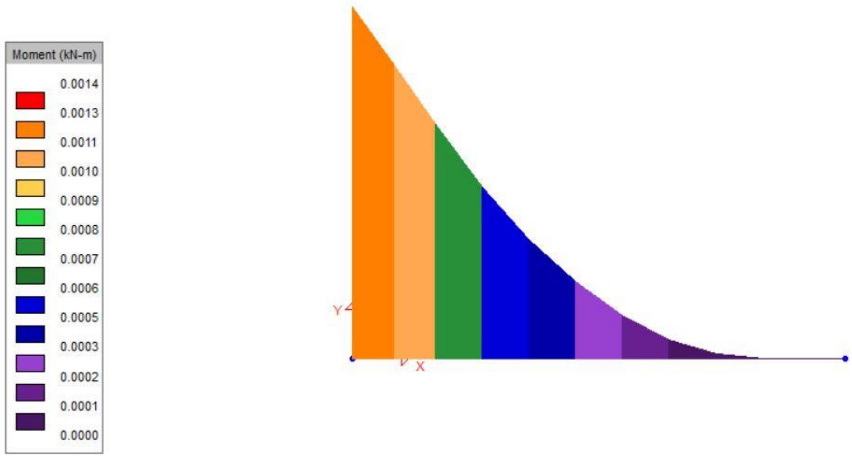


Figure 8"Bending Moment Diagram"

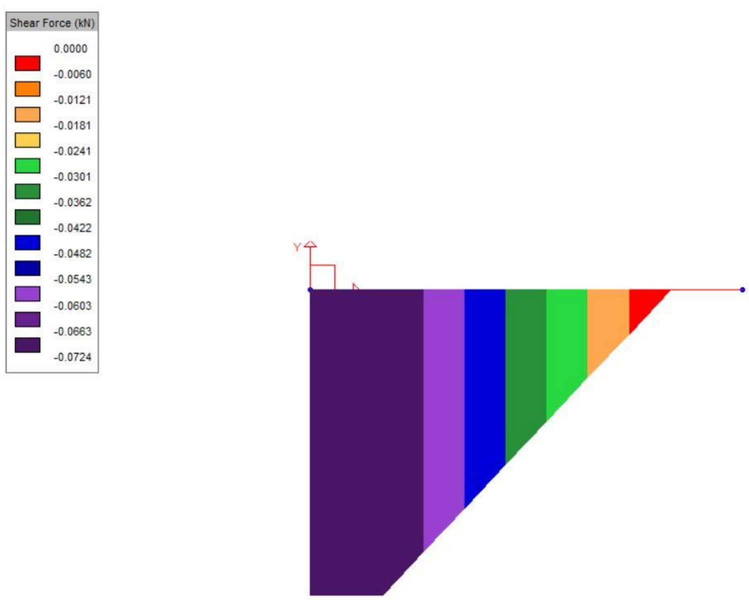


Figure 9 "Shear Force Diagram"

Shown in the bending moment and shear force diagrams in figures 8 and 9, respectively, the maximum bending moment is 1.3 Nm and the maximum shear force is 72.33N. Using techniques used in strengths of Materials, the maximum normal and shear stress can be calculated.

<u>Maximum Normal Stress</u>

σ = M*c/I

I = (base)(height)^3/12

I = 2.116 x 10^{-9}

C = b/2 = 0.05 m

This data gives us, $\sigma = 4.235\ MPa$

Maximum Shear Stress

τ = VQ/It

V = 72.35N

Q = 2.38 x 10^{-7}

I = 2.116 x 10^{-9}

t = 0.0254

This data gives us τ=0.320 MPa

From, (Hibbler, 2015), The yield stress of stainless steel is 250 MPa, therefore the metal clip is still in the elastic region, so no permanent deformation will occur.

Stress analysis for back leg:

For the back legs, a stability stand was implemented that will reduce the tendency for the walker to tip over on itself and to distribute the force on the back leg. Reducing the stress, the front floor will face. It will also take a share of the stress the back-leg faces. Reducing the chance of damage to the walker itself and increase the total life span of the system. to make sure the back legs wouldn't buckle under the compressive force a buckling calculation was completed to endure the critical pressure was larger than the pressure obtained from the force calculation equation.

The compressive force in the back legs is 311.05 N. The normal stress in the member is calculated using the formula,

$$\sigma = F/A$$

The normal stress in the back leg is 1.1 MPa (compressive).

To calculate the critical pressure in the leg we use the equation,

$$P_{Cr} = \pi^2 EI/(k*L)$$

Our member is made from Aluminum 2014-T6.

E = 73.1 GPa

I= $\pi/64(d_{out}^4 – d_{in}^4) = 4.51x10^{-8}\ m^4$

K = 0.7

L = 0.636 m

P_{Cr} = 164.166 kN

Therefore, the critical pressure is P_{Cr} / area which equals 578.5 MPa. The critical pressure is much larger than the actual pressure. So, the member will not buckle. Also, to ensure this, a cross member was attached between the front and back legs to strengthen the members. Which is seen in the engineering drawings. These calculations were completed without the stability stands attached. With the stands attached, the stresses in the legs would be lower than the calculated values. But because these calculated values don't show signs of damages, we can conclude the same with the supports.

Maximum Bending moment is system is 13.27 MPa. This is in member CD (see force calculation in appendix 2). With A yield strength of aluminum of 440 MPa (Hibbler, 2015). There is no permanent deformation in the member.

Further calculations were completed on paper and can be found in appendix II.

Electrical Analysis

Motor Selection

To complete the electrical analysis, the motor had to be selected to satisfy the torque found in the Dynamics Calculations.

Each motor requires 3.125 N · m.

By adding an acceptable safety factor of 1.5, the new torque of each motor is

(3.125 N · m) x 1.5 = **4.70 N · m**

The motor selected to satisfy the new torque is a gear motor that has a starting torque of 5 N · m. (See Motors in cost analysis Page 20)

Battery Selection

To determine what battery is required, the following assumptions had to be made.

1. The individual uses the walker upwards of 15 times per day.
2. The battery life will last 15 days without recharge.

The total time that the motors are running is calculated below.

2.5s x 15 x 15 = 562.5s or 0.156h

Knowing the max current running through the motor is 15.63A, the calculation for capacity is

C = time x current

C = 0.156h x (15.63A x 2) = **4.9AH**

Voltage grade of the motor is 12V**,** therefore, **24V** total

Since batteries don't come in this distinct size, a **24V 22.4AH Battery** was selected (See Battery in cost analysis Page 20).

The run time of the theoretical battery was 0.9375h. With the actual battery having a grade of 10AH the new run time is shown below.

Capacity/Current = time

22.4AH/31.26A = 0.717h or 2580s

DC Switch/Motor Control

To turn the motor on and off, a user-friendly DC Large Torque Control Switch has been integrated into the circuit for convenience (See Speed Controller in cost analysis Page 20). This can change the speed of the two different motors while simultaneously turning them on and off.

Circuit Diagram

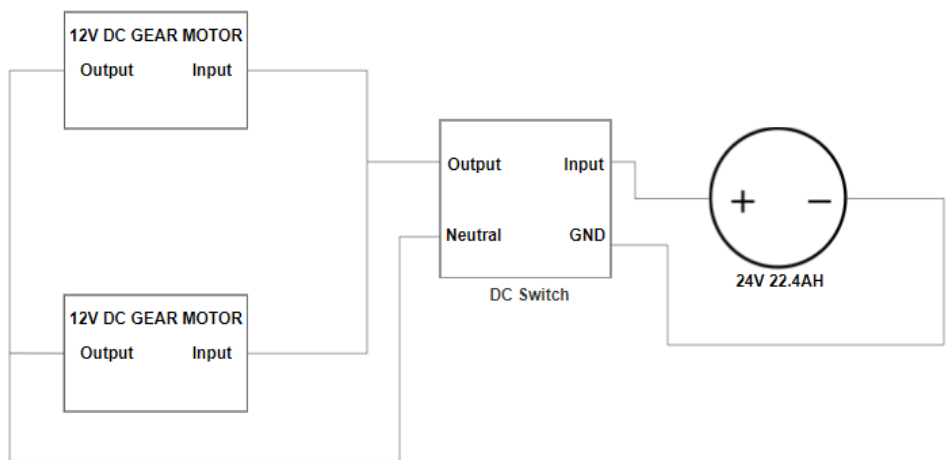


Figure 10 "Circuit Diagram"

DC Switch Diagram

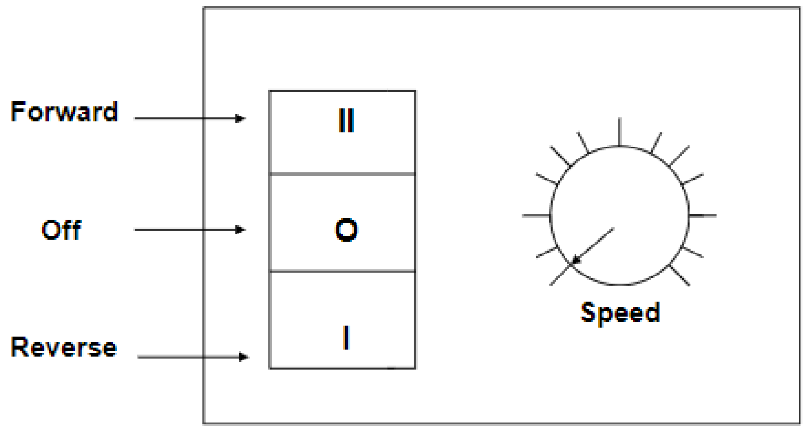


Figure 11 " DC switch Diagram"

Challenges Encountered

For the design project, group 7 had some challenges coming up with a problem to focus on. Initially deciding to look at the problem of water usage in irrigation systems and how fresh water can be better utilized. There are many places worldwide that have water shortages/droughts that need ways to minimize their water waste. So, with this being a large issue with fresh water sources decreasing, the problem was coming up with a way to cut down on water waste for crops to also help crop growth and consistency. After 3 weeks of brainstorming and further research, it was decided that this problem didn't suit the group very well. With no one having a farming background, it would have been more of a research paper than a design project.

After a group discussion, there was a switch in project ideas to improve on the current walker for the elderly and disabled. Walkers are great for seniors who are struggling with reduced mobility to still have an active lifestyle but there are still many risks associated with using a walker. According to a National Center for Injury Prevention, up to 47,300 people each year over the age of 65 go to the ER due to a fall with a walking aid (Bartoletti). There is a need for a product to help solve this issue.

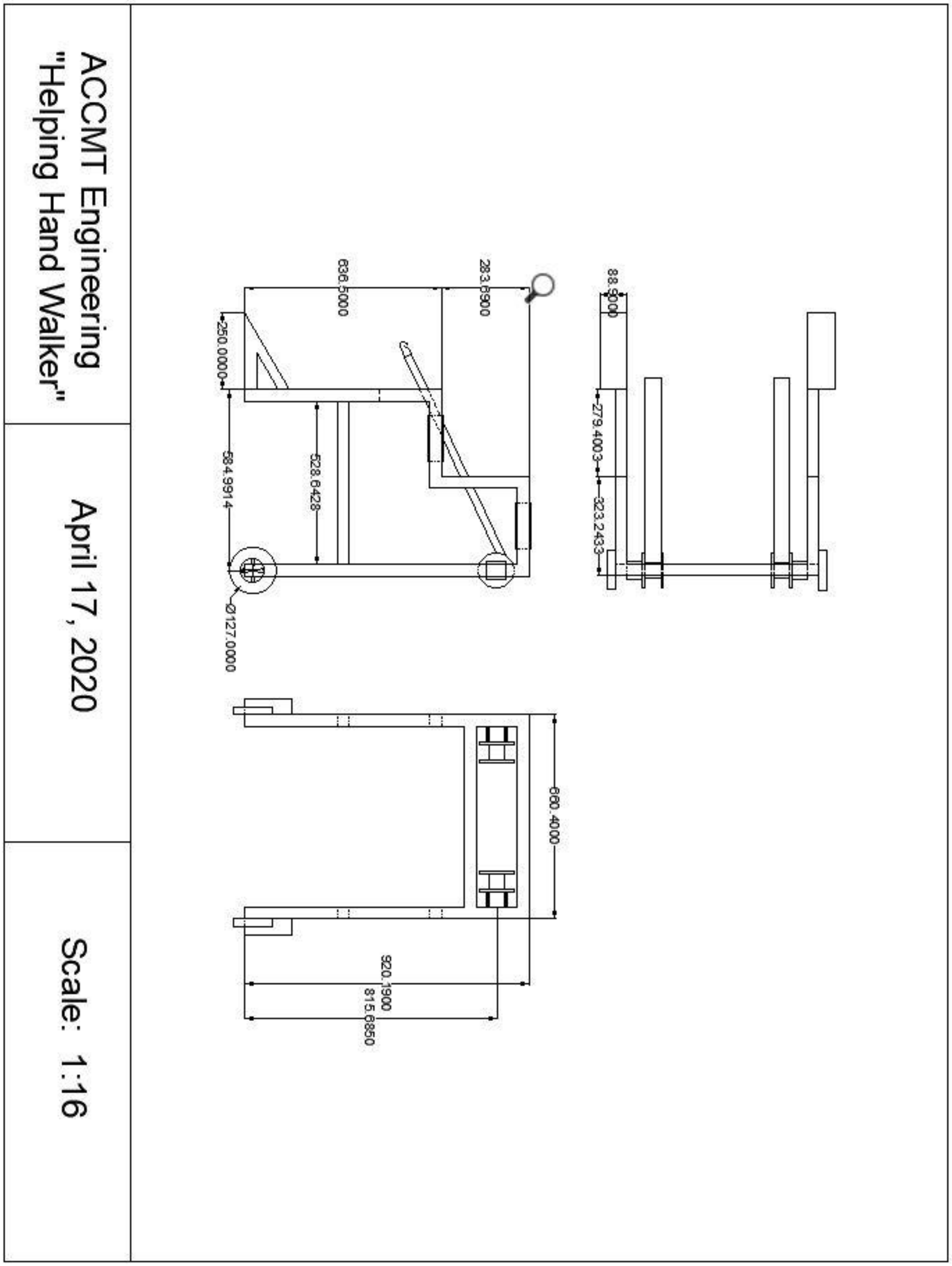
Also, with the spread of Covid-19, some of the group's goals couldn't be achieved. First, a trip to a senior's home was planned so the group could interview residence and get their input on the problem. Second, because of the transfer to online courses, the group had to adapt and finish the project. Using Zoom and other online services, the group was able to communicate efficiently and complete the project. Finally, the plan of creating a scaled down prototype wasn't possible. This would have fully explained the design.

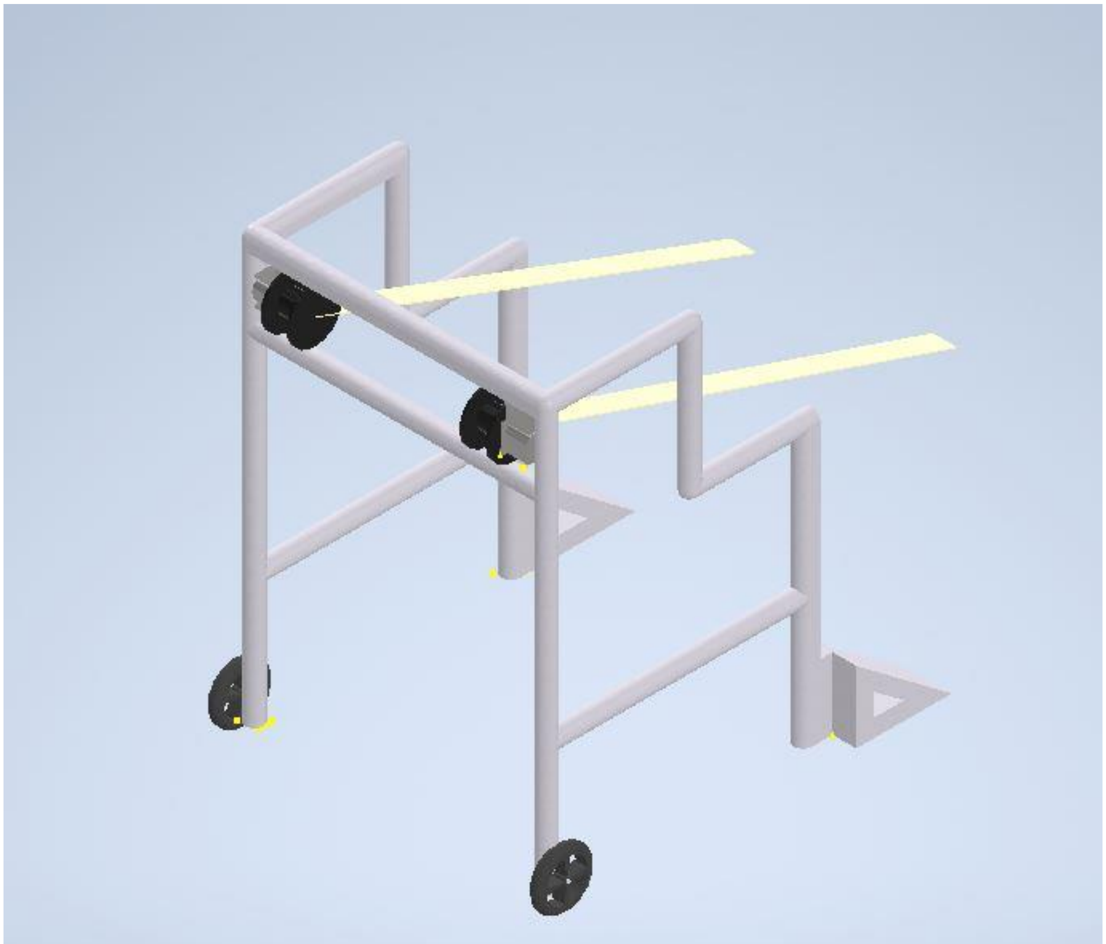
Conclusion

In conclusion, a stable safe Helping Hand Walker was designed and analyzed for its real-life applications. Though the prototype design was unable to be showcased to the class due to the pandemic of COVID- 19. The research, design, and calculations show for themselves. The design plans conclusively show a Helping Hand Walker that meets all design goals set at the beginning of the project, safe, lightweight, stable, mobile. Each goal resulted in calculations, consultation, and engineering analysis to be completed.

Further recommendations for groups in the future would be to start by making a timeline for the project and to have weekly deadlines to achieve to stay on track. This involves staying consistent throughout the project with group meetings and being able to communicate effectively. Having scheduled meetings ahead of time would help the group stay organized and to communicate effectively with members in the group so everyone's opinions are discussed. Another recommendation would be to take advantage of the resources that are given for the project such as both the mechanical and electrical workshops St.FX has to offer and utilizing the help and knowledge that Professors at St.FX have to offer.

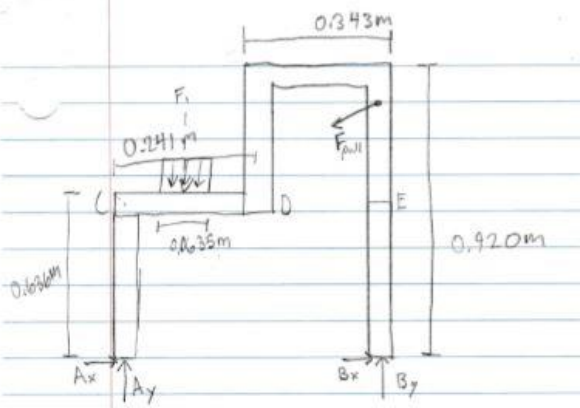
Appendix I – CAD Drawings





Appendix II

Stress calculations A



$F_{pull} = 125N$

$F_1 = 196.2N$

$\Sigma F_x = 0;$

$A_x + B_x = 125\cos 30°$

$\Sigma M_B = 0;$

$-A_y(0.584m) + F_1(0.4635m) + F_{pull}\cos 30°(0.838m) = 0$

$A_y = 311.05N$

$\Sigma F_y = 0;$

$A_y + B_y - F_1 - F_{pull}(\sin 30°) = 0$

$B_y = -72.35N$

Cant solve Forces in the x dir right now.

Break up the system into components to solve.

Member AC

$C_y = A_y = 311.05\ N$

$\circlearrowleft + \sum M_c = 0;$

$+M_c + A_x(0.636m) = 0$

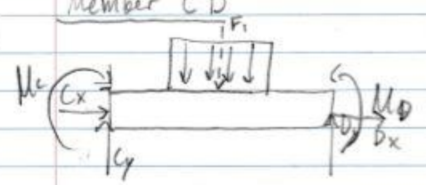
$M_c = -0.636 A_x$ — (1)

$-\frac{(-19.89)}{0.636} = A_x$

$\boxed{A_x = 31.28\ N}$

$C_x = A_x = 31.28N$

Member CD



$C_y = 311.06\ N$

$\sum F_y = 0;$

$D_y = F_1 - C_y$

$= -114.85N$

$\circlearrowleft + \sum M_D = 0;$

$+M_D - M_c - C_y(0.241m) + F_1\left(\frac{0.241}{2}\right) = 0$

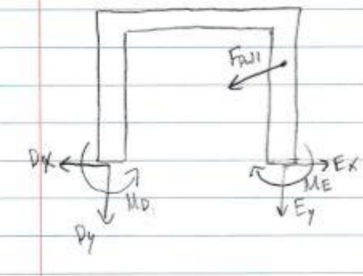
$M_D - M_c = 51.32\ N.m$

$M_D = 51.32 + (-19.89 N\cdot m)$

$= 31.43 N\cdot m$

$D_x = -C_x = -31.28N$

Member DE



$\Sigma F_x = 0;$

$-D_x + E_x - F_{pull}\cos 30° = 0$

$E_x = 76.97\ N$

$\Sigma F_y = 0;$

$E_y = -D_y - F_{pull}\sin 30°$

$= -(-114.85) - (125\sin 30°)$

$= 52.35\ N$

$\circlearrowleft + \Sigma M_E = 0;$

$M_D - M_E + F_{pull}\cos 30°(0.202m)$

$+ D_y(0.343m) = 0$

$M_D - M_E = 17.526\ N\ m$

Member BE

$\Sigma F_y = 0;$

$B_y + E_y = 0$

$B_y = -F.$

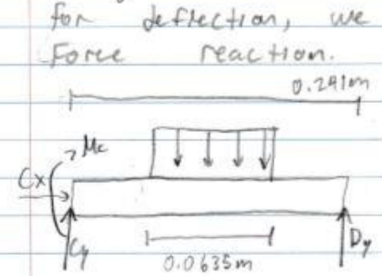
$E_y = 72.35\ N$ ✓

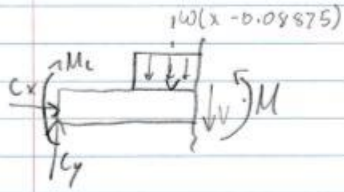
$\circlearrowleft + \Sigma M_E = 0;$

$M_E + B_x(0.636) = 0$

$B_x = -E_x =$ 76.97 N [redacted]

looking at member CD, Using the method of Integration for deflection, we can solve an indeterminate Force reaction.





$$M = EIV'' = C_y x + M_c - w(x-0.08875)\left(\frac{x-0.08875}{2}\right)$$

$$= C_y x + M_c - \frac{w}{2}\left(x^2 - 0.1775x + 0.007876\right)$$

$$EIV' = \frac{C_y x^2}{2} + M_c x - \frac{w}{2}\left(\frac{x^3}{3} - \frac{0.1775x^2}{2} + 0.008x\right) + C_1$$

$$EIV = \frac{C_y x^3}{6} + \frac{M_c x^2}{2} - \frac{w}{2}\left(\frac{x^4}{12} - \frac{0.1775x^3}{6} + \frac{0.008x^2}{2}\right)$$

$$+ C_1 x + C_2$$

We have to Find our boundary conditions.

@ $x=0$; $V'=0 \Rightarrow C_1 = 0$

@ $x=0$; $V=0 \Rightarrow C_2 = 0$

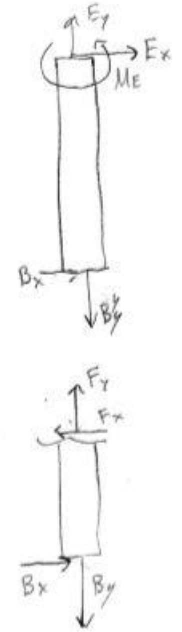
@ $x=L$; $V=0$

$$0 = \frac{C_y L^3}{6} + \frac{M_c L^2}{2} - \frac{w}{2}\left(\frac{L^4}{12} - \frac{0.1775L^3}{6} + \frac{0.008L^2}{2}\right)$$

$M_c = -19.84$ N·m

Stress Calculations

Member BE



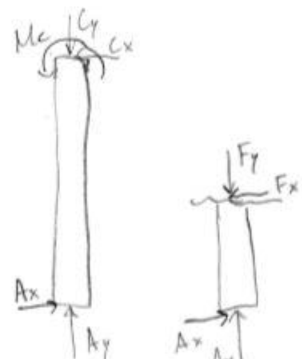
$$\sigma_{BE} = \frac{F_y}{A} = \frac{72.35\,N}{\frac{\pi}{4}(0.0381^2 - 0.03302^2)}$$

$$= 271.48\ kPa\ (T)$$

$$\tau_{BE} = \frac{F_x}{A} = \frac{76.97\ N \cdot m}{}$$

$$= 271.25\ kPa$$

Member AC



$$\sigma_{AC} = \frac{F_y}{A} = \frac{-311.05\,N}{\frac{\pi}{4}(0.0381^2 - 0.03302^2)}$$

$$= -1096.19\ kPa$$

$$= 1.1\ MPa\ (C)$$

$$\tau_{AC} = \frac{F_x}{A} = 110.23\ kPa$$

Buckling For member AC

Because this member is in compression, we need to check it will not buckle under this Force.

We have a Fixed support at the top, and a bottom support that gives force rxn's in the x and y direction.

$\therefore K = 0.7$

$$P_{cr} = \frac{\pi^2 E I}{(KL)^2}$$

$$= \frac{(\pi^2)(73.1\times10^9 Pa)(4.51\times10^{-8} m^4)}{((0.7)(0.636m))^2}$$

$$\approx 164.166 kN$$

- E for aluminum 2014-T6 is 73.1 GPa

$$I = \frac{\pi}{64}(d_{out}^4 - d_{in}^4)$$

$$\approx 4.51\times10^{-8} m^4$$

$d_{out} = 0.0381 m$

$d_{in} = 0.03302 m$

$L = 0.636 m$

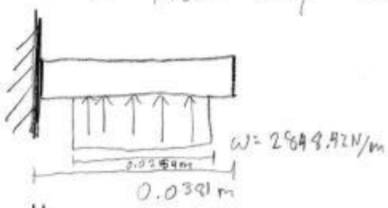
Force acting on the member is 311.05 N

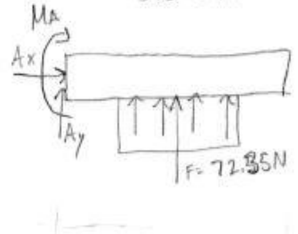
$P_{cr} >>> 311.05 N$

$\therefore$ There is no worry of buckling during the lifting Process.

$\sigma_{cr} = \frac{P_{cr}}{A} \approx 578.5 MPa >> \sigma_{AC}$ ✓

\- Floor Clip Rod



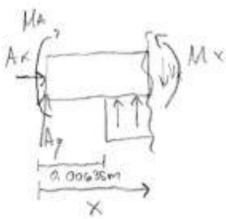


$\Sigma F_x = 0;$
$A_x = 0;$

$\Sigma F_y = 0;$
$A_y + 72.35 = 0$
$A_y = -72.35N$

$\circlearrowleft + \Sigma M_A = 0;$
$M_A = (72.35)(0.01905)$
$= 1.378 \text{ N.m}$

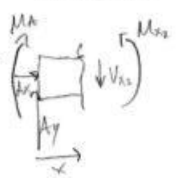
$0 \le x_1 \le 0.03175$



$V_x = -72.35 + w(x-0.00635)$

$M_x = M_A + A_y x + \frac{w}{2}(x-0.00635)(x-0.00635)$
$= 1.378 - 72.35x + \frac{w}{2}(x^2 - 0.0127x + 4.03\times10^{-5})$
$= 1424.21x^2 - 90.437x + 1.435$

$0 \le x_2 \le 0.00635m$



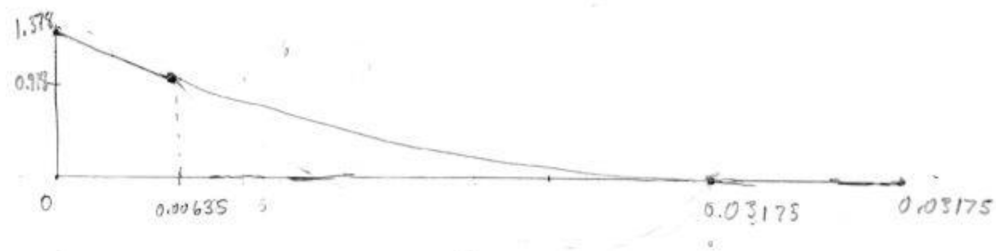
$V_x = A_y = -72.35N$

$M_x = M_x + A_y x$
$= 1.378 - 72.35x$

$0 < x_3 < 0.00635$

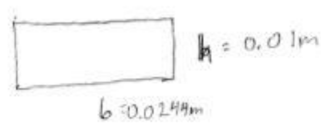
$V_{x_3} = 0$
$M_{x_3} = 0$

Bending Moment Diagram



$M = 0$ @ $x = 0.02245\,m$

-1.667



$I = \frac{1}{12} b h^3$

$= 2.116 \times 10^{-9}\, m^4$

$$\sigma = \frac{M}{I} c = \frac{1.378\ N \cdot m}{2.116 \times 10^{-4}\ m^4} (0.05m)$$

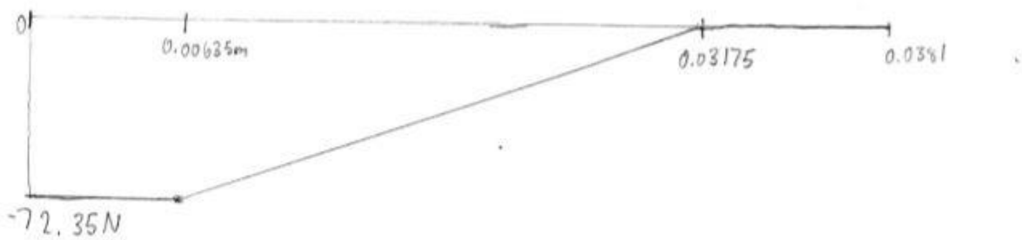
$$= 4235\ kPa$$

$$\approx 4.235\ MPa$$

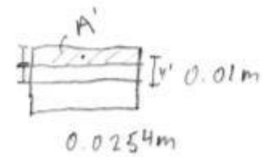
Applying a Factor of safty of 1.5 we need the support clip to support

<u>6.35 MPa</u>

Shear Force Diagram



Maximum Shear Force = 72.35 N



$$\tau = \frac{VQ}{It} = \frac{(-72.35N)(2.38 \times 10^{-7} m^3)}{(2.116 \times 10^{-9} m^4)(0.0254m)}$$

$$= -0.320 MPa$$

$Q = \bar{y}' A'$

$y' = 0.00375m$

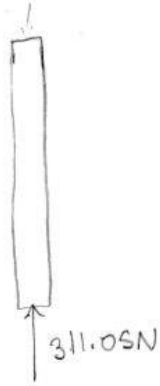
$A' = (0.0025)(0.0254)$
$= 6.35 \times 10^{-5} m^2$

$Q = 2.38125 \times 10^{-7} m^3$

$I = 2.116 \times 10^{-9} m^4$

$t = 0.0254 m$

Deformation in Member AC



$$\delta = \frac{PL}{EA} = \frac{-311.05N(0.636m)}{(73.1\times10^{9}Pa)\left(\frac{\pi}{4}(0.0381^2-0.03302^2)\right)}$$

$$= -9.537\times10^{-6}\,m$$

$$\approx -9.5\times10^{-3}\,mm$$

This is such a small change it can be neglected.

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