Optimal Design

Bed Railing Device (BRD) and Adapted Lawnmower

By:
Randy Corriveau
Eric Nastuk
Ian Wallis
Team #4

Client Contact 1:
Sean Stenglein, Brenda Stenglein
Phone: 860-429-1059
34 East Howey Road
Ashford, CT
brenda.stenglein@gmail.com

Client Contact 2:
Shane and Suzanne Davis
6 Sunrise Drive
Columbia, CT
(954) 850-5448 (Mobile)
davisrpt@aol.com
1.1 Introduction

1.1.1 Lawnmower

The adapted lawnmower for Shane is a project for Shane Davis, a 20 year old man with Cerebral Palsy (CP). Shane’s CP has limited his mobility, so he uses a motorized power chair on a daily basis to get around. His lower body is very inactive, but he has good upper body strength and can transfer himself in and out of chairs unassisted. Shane can best utilize his left hand for strength and fine motor control, which is why his joystick is mounted on that side of his power chair. Sitting upright in a chair is not a problem for Shane, provided he has armrests keeping him contained, and to lean on. Shane would like to be able to help his stepfather in mowing their two acre plot, and has had only limited success in the past in operating unmodified lawnmowers. Shane’s need for a modified lawnmower is easily justified, and a solid design has been selected to fit his needs and keep him safe and comfortable while he mows. This modified mower will give Shane greater freedom, and could potentially be lucrative if he decides to use his mower for his neighbor’s lawns for money.

In order to determine the optimal mower for Shane, three alternative designs were brainstormed, and a fourth optimal design was chosen based on the best characteristics from each of the alternatives. This design involves using a system of actuators and motors to incorporate a joystick for control of each mower function. The project will be constructed ruggedly to allow long term use, and to withstand strains Shane will put on the controls. Multiple safety measures will be implemented, including emergency shutoff switches and a custom seat with armrests to hold him upright and comfortably. A seat belt will also be added to keep him mounted when going across uneven terrain. Shane’s feet must stay together for comfort when he rides the machine, so the mower will have a step through design with the controls mounted by his hands rather than between the legs. After researching several different lawn tractors, it was determined that the optimal mower for the project would be an Ariens Lawn Tractor 42.

The Ariens Lawn Tractor 42 comes standard with a hydrostatic transmission, which eliminates the need to create additional clutch controls and interfacing between clutch and shifting. A joystick will be mounted on a set of custom arm rests on the left side, to utilize Shane’s strength in his left hand. The joystick will operate the left and right steering controls of the mower which will be controlled with a rack and pinion design, bypassing the original steering column. The joystick will also control an actuated lever attached to the hydrostatic drive lever, which will be able to change the mower’s direction from neutral to forward and reverse. The joystick will also have a trigger which must always be depressed in order to run the mower. The trigger acts as an emergency stop if Shane happens to lose grip on the handle, which will turn the mower off for safety. Along with the joystick, the left arm rest will also feature buttons which will control actuators attached to the cutter engagement drive, to turn the blades on and off. The armrest will also have buttons which will control actuators which change the height of the cutting blades. The throttle will also be wired to be closer to Shane’s reach for convenience and ease of operation. The parking break will also be modified such that it can be activated by hand. These modifications will provide Shane with a device that is comfortable, safe, and practical.

1.1.2 Sean’s Bed Railing Device (BRD)

The second project is to build a custom railing and stair system for Sean Stenglein, an intelligent and active 13 year old with severe CP. Sean currently uses a ten year old folding railing system, which has aged and seized up over time, making it difficult to operate. The railing is also very unstable, and he cannot use it to get himself out of bed, but rather an aid must struggle to collapse the railing, then reach over and pick him up every morning and evening. Sean’s need for this project is easily justifiable and an optimal design has been created to ensure that he can sleep safely and transfer to and from his bed with ease. This railing and
stair system would help him start his day with activity, and reduce strain on his family having to get him out of bed in the morning and into bed at night.

In order to determine the optimal bed rail device design for Sean, three alternative designs were brainstormed, and an optimal design was chosen based on the best characteristics from each of the alternative designs and other ideas that were brainstormed. The designed railing system would be made from the industrial erector set 80/20 out of 6105-T5 Aluminum. The two extrusion profiles the are used are 1010, a one inch by one inch profile, and 1020, which is a two inch by two inch extrusion profile. The BRD is mounted to the trusses to Sean’s bed to ensure a study design and a strong rail system. The rail will be padded with closed soft cell foam to prevent injury when he is in his bed because his movements are spastic while asleep. Vinyl will be used to cover the rail frame skeleton in order to prevent Sean from getting caught within the frame. The railing would be able to raise and lower with a button activated motor, and a set of stairs would also deploy and retract with the same button. These stairs would be custom built so that the height can be changed to an appropriate level as Sean ages and grows. Sean can now have a safe and secure bed rail instead of an aged railing system that is almost unserviceable. The family does not have another means of a bed railing besides the aged railing so this product will be a user friendly asset to the family.

1.2 Subunits

1.2.1.1 Lawnmower

The lawnmower chosen for the project is the Lawn Tractor 42 (serial number 936051) by Ariens, a Wisconsin based company that manufactures outdoor power equipment, namely snow removal and lawn care machines. The lawnmower selected for this project is best suited to the group’s needs, and to Shane’s eventual use.

Figure 1. Ariens Lawnmower that the group will purchase.
The Tractor 42 is powered by a 19 hp Kohler Courage Single engine, and has a cutting width of 42 inches which is ideal for 1-2 acre plots such as Shane’s. One of the main reasons the mower was chosen is due to the Hydrostatic Fender Shift Lever transmission, which eliminates the need for complicated shifting modifications. This way when Shane is riding, all he will need to do is push his joystick, and the microcontroller will yield the appropriate response for simplistic speed adjustment. The mower was also chosen because of its inexpensive list price, compared to customer feedback on the mower’s longevity, and need for maintenance. Ariens is an American company, which delivers a solidly constructed product and will grant Shane many years of use.

1.2.1.2 Joystick
The joystick we plan to use on this project has already been provided to by Shane. It is an old joystick that Shane used, and was unfortunately damaged and no longer in use. We will be fixing the broken joystick and modifying it to suit our needs for this project.

1.2.1.3 Microcontroller
Ideally, the circuitry for this project will all be controlled by the central processing unit (CPU) which is a Motorola MC68HC11. The board offers several capabilities which will be used to power the mower. Among these capabilities, the CPU has power-saving stop and wait modes, 256 bytes of on chip RAM, a 16 bit timer system, several input output ports, and other various utilities. In the event that budget is an issue, a cheaper board will be selected, or a customized circuit will be designed for basic controls.

1.2.1.4 Lawn Mower Actuators
In order to operate controls for the mower’s cutter height, direction (forward, reverse, neutral), and direction, each one of these controls will be operated by linear actuators connected to lever arms, which control the action of that particular mower operation. The actuators will supply the needed mechanical force to operate the levers. The actuators chosen will be from a variety of companies, including the Motion systems corp 9234C120-R10 linear actuator.

Figure 2. Discontinued Linear actuator
This actuator is no longer in production, but we have already obtained one actuator for free which we will use. We still need other actuators, so several other models will be chosen and ordered. Each actuator will be controlled by a bi-directional multi-way switch. In order to protect the linear actuators from the environment; they will be enclosed in a protective plastic case.

1.2.1.5 Transmission Actuator

The mower’s transmission can be put into three different positions. The transmission will have one gear for forwards, the other for reverse, and a neutral position for when not moving or cutting. Two directions of motion must occur in order for the mower to be put into either of these gears. From the neutral position, the lever that controls the mower’s gear must be pulled towards the operator, first, before going forwards or backwards for forward and reverse directions. This will be accomplished through the use of a single linear actuator. This actuator will be controlled with a bi-directional multi-way switch. The bi-directional multi-way switch will control the transmission lever’s direction of motion, from forward to reverse, or neutral. The linear actuator will move the transmission lever into the appropriate position, according to the input from the micro controller. The bi-directional multi-way switch will have two options, a forward and reverse, indicating which direction the linear actuator will travel when that switch direction is chosen.

1.2.1.6 Blade Actuator

The lawn mower blade will also be modified with a linear actuator controlled by a bi-direction multi-way switch. The switch directions will be labeled “engage” and “disengage” indicating which direction the linear actuator will travel. When the switch is thrown toward “engage” the actuator will move the blade engagement lever and the mower’s blade will be activated. When the switch is directed toward “disengage” the mower’s blade will be deactivated by the actuator returning to the “off” position.

1.2.2 Sean’s BRD

The team intends to build Sean an inexpensive bed rail device out of 6105-T5 Aluminum from the erector set company 80/20 Inc. Last year the team for the Joshua’s Jumper senior design project got 20 percent off from their order from 80/20 Inc so our team will see if this opportunity for a discount is also available to us. This inexpensive design would allow the team to use the majority of the budget on ways to ensure Sean’s safety and comfort.
1.2.2.1 Bed

The bed that the BRD will be used on is a full size bed and is Sean’s own bed from his house. Since Sean will have the same bed for the foreseeable future, the BRD can we designed to the bed’s dimension to ensure a safe and sturdy structure. Both the headboard and the footboard have a one and five-eighths inch width on both of the end posts so motors will be attached to each end. There will be enough space between the post and the frame to ensure that gears and other mechanical components do not become a safety hazard for Sean.

1.2.2.2 Railing

The horizontal and vertical supports of the railing frame skeleton will be made from part number 1020 from the erector set company 80/20 Inc. The frame is the red part of figure seen above in Figure 3. Part number 1020 is a one inch by two inch T-slotted profile made out of clear anodized 6105-T5 Aluminum. This allows for easy assembly and ensures a sturdy rail design for Sean's BRD. Also the T slotted profile increases its vibration dampening ability so when it is constructed as the frame it will not vibrate while being raised or lowered.
Figure 4. The clear anodized 6105-T5 Aluminum erector set that is used for the railing frame.

Figure 5. Specifications of the 1020 Aluminum profile.
The railing consists of six structural components: two horizontal supports that will run the length of the frame and four vertical supports that will support the frame and give it its structure. Horizontal supports will be 70 inches in length and be made out of 1020 aluminum.

![Figure 6. Horizontal support for the BRD frame.](image)

Hinges will be attached to the bottom horizontal railing support and connected to the rail support system to ensure 180 degree folding when the frame is raised and lowered. Hinges will also be purchased from 80/20 Inc as part 2086 to ensure proper compatibility with the 1020 horizontal supports and T-slotted extrusions. The hinges are made out of 6105-T5 clear anodized aluminum so they have excellent corrosion resistance which will allow for the BRD frame to maintain its functionality as it ages with Sean. Weight capacity for the hinge is 40 pounds so three hinges will be able to support the BRD frame for its lifetime of use. A bolt kit is needed for every hinge, and each kit consists of 4 assemblies of 80/20 part number 3386. The assemblies consists of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is three eights of an inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket and the five hole joining plate.
Figure 7. The slide-in economy T nut and the FBHSCS used for the bolt assemblies.

Flanged Button Head Socket Cap Screw (FBHSCS)

Figure 8. Technical drawing of the 2086 hinge.
Figure 9. Technical drawing of 1020 pieces joined by the aluminum hinge.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2086.06</td>
<td>2.000</td>
<td>2.000</td>
<td>1.000</td>
<td>1.063</td>
<td>0.257 (2)</td>
<td>0.257 (2)</td>
<td>1.000</td>
<td>1.000</td>
<td>0.078</td>
<td>0.063</td>
<td>40 Lbs.</td>
<td>0.065</td>
</tr>
</tbody>
</table>

Table 1. Corresponding measurements in inches for A through K in figures 8 and 9.
Four vertical supports will be placed in between the two horizontal rails to properly support the frame. Two supports will be on the end of the horizontal pieces and two will be evenly spaced out within the frame. All supports will be 15 inches long and have the profile of the 1020 aluminum.

![Image of vertical support for the BRD Frame.](image)

In order to connect the two end vertical supports with the horizontal supports the team will use part 4114 from 80/20 to ensure that the frame does not experience torsion and is structurally sound. Part number is 4114 is a eight hole corner inside corner bracket that allows bolt kits to firmly place the bracket in the T-slots of the 1020 profiled supports. Approximately four inside corner brackets will be used to support the BRD.
In order to mount the inside corners to the frame the team will use 32 bolt assemblies, with eight assemblies for each frame. The bolt assemblies from 80/20 Inc are denoted by part number 3393 and consists of a Button Head Socket Cap Screw (BHSCS) and a slide-in economy T nut. The BHSCS has a black zinc finish, is one half inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog, has a centered ¼-20 thread count and also has a black zinc finish. The synchronized thread count ensures the bolt assemblies will work and be successful in mounting the inside corner brackets to the frame.
Figure 12. The slide-in economy T nut and the BHSCS used for the bolt assemblies.

Figure 13. Example of corner bracket mounted to both supports by the bolt assembly.

The two inside vertical supports will be connected to the horizontal supports by a 5 hole tee joining plate on both sides of the horizontal rail. The part number for the 5 hole tee joining plate is 4140 in the 80/20 catalog. Joining plates width and height are three inches (denoted by A in the drawing) and the ends that go over the one inch horizontal profile view of the 1020 supports are one inch in width (denoted by B in the drawing). Eight joining plates will be used in the Assembly of the BRD.
In order to mount the joining plates to connect the supports the team will use 40 bolt assemblies, with five assemblies for each plate and eight plates on the frame. The bolt assemblies from 80/20 Inc are denoted by part number 3321 and consist of a Flanged Button Head Socket Cap Screw (FBHSCS) and a slide-in economy T nut. The FBHSCS has a black zinc finish, is one half inch in length and has a thread count of ¼-20 (one quarter inch in length with 20 threads). The slide-in economy T nut is part number 3785 in the 80/20 catalog and was used in the bolt assemblies for the inside corner bracket. It is important to note that although Figure 15 is used on 1010 erector set profile, the same assembly can be applied to the BRD’s 1020 erector set profile.
In order to protect the ends of the BRD frame the team will use part number 2025 from 80/20 Inc. Part number 2025 is a one inch by two inch end cap that is one-eighth of an inch thick and can fit the extruded profile of the 1020 frame. The team will order four of these end caps to ensure that the frame’s rough edges are not exposed, thus preventing Sean from any potential harm. All end caps come with the necessary fasteners to ensure a clean fit with the 1020 profile.
Another key component for the BRD railing is foam padding. Foam padding will be used as a safety measure to ensure that if Sean rolls into the frame when he is sleeping or bumps into while transferring from the bed that he will not be hurt by the frame. The team will purchase soft closed cell tubular foam from McMaster-Carr to cover the BRD’s aluminum frame. All foam padding will be cylindrical with a two and one-eighth inch inside diameter, a half-inch wall thickness and a three and one-inch outside diameter. The foam tube has an adhesive slit that will allow for the foam to be spread apart, placed over the horizontal and vertical supports, and then secured by the adhesive foam to ensure a tight fit on the frame. Since the foam comes in six foot tubular lengths, two tubes would be used for the horizontal rails and one tube would be used for the four 15 inch vertical supports. All tubes will be cut to their specified length for the support that they will be covering.

Once the rail frame has been covered in foam a vinyl coating will be applied to the BRD frame. A roll of vinyl will be purchased from US Cutter and will be used to cover the BRD frame. The team is going to use a 15 inch by 10 yard roll of ORACAL 751 High Performance Cast Vinyl. will be used as a safety measure to ensure that if Sean rolls into the frame when he is sleeping or bumps into will transferring from bed that he will not be hurt by the frame. Another alternative is to find scrap vinyl or get it donated because although the US Cutter prices is reasonable the team does not need that much vinyl to properly cover the bed. Sean will be able to pick out the color the vinyl so he can choose whatever color he desires. All vinyl coverings will be cut to their specified length for the support that they will be covering.

1.2.2.3 BRD Railing support system

The railing support system will also be made of clear anodized 6105-T5 Aluminum and the upper support uses the same 1020 extruded profile as the BRD frame. The horizontal support piece will be the same length as the BRD frame (70 inches) and will have the same 2025 end caps. Hinges will also be mounted to the horizontal support piece and allow for 180 degrees of folding motion. All hinge bolt assemblies that were used in the frame is used in the BRD railing support system.
The three vertical supports have the dimensions of the 1020 extruded aluminum and all are approximately eight and one quarter inches tall. All vertical supports are connected to the horizontal support by an 8 Hole Tee Joining Plate, 80/20 part number 4155. Bolt assembly part number 3321 will again be used as the plate fastener and eight bolt assemblies are used for every plate.

<table>
<thead>
<tr>
<th>Part No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4155</td>
<td>4.000</td>
<td>3.000</td>
<td>2.000</td>
<td>1.000</td>
<td>.170</td>
</tr>
</tbody>
</table>

Table 2. Measurements for the 8 Hole Tee Joining Plate technical drawing.
The lower portion of the vertical support will be fit against the right bed railing of the bed frame and on top of the truss that runs the width of Seans bed. It will be connected to a 52 inch base mounting piece that is made out of the 1010 extruded profile. The 1010 extruded profile is an one inch by one inch profile that consists of clear anodized 6105-T5 Aluminum.
The vertical support is connected to the base mounting piece by a 6 Hole Center Inside Corner Bracket, part number 4111 in the 80/20 catalog. Six bolt assemblies, part number 3393, are used for every mounting corner piece, with three corner pieces needed to connect all the mounting pieces to the vertical rails. Mounting pieces are screwed into the bed trusses to ensure maximum stability of the BRD support system.

![6 Hole Center Inside Corner Bracket Technical Drawing](image)

**Table 3. Measurements for 6 Hole Center Inside Corner Bracket Technical Drawing.**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>Lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4111</td>
<td>1.875</td>
<td>2.000</td>
<td>2.000</td>
<td>1.000</td>
<td>.105</td>
</tr>
</tbody>
</table>

![Total assembly of the bracket, bolt assemblies and both support pieces](image)

**Figure 25. Total assembly of the bracket, bolt assemblies and both support pieces.**

1.2.2.4 Stairs
The stairs will be made out of an aluminum frame with slotted steps that can adjust as Sean ages. The platform can adjust using the slotted notch feature and so can the step. All pins will have a connector system to ensure that the stairs remained locked in place. Grip tape will be applied to the edges to ensure that Sean has a non-slip surface to transfer to and from bed.
1.2.2.5 BRD motor

The railing will attract and retract with the assistance of two 12V motors. The operator will have the control over the motor with three DPDT switches an off, a forward and a reverse. The direction of the motor is controlled by the DC motor control circuit housed in the switchbox. The BRD switches will be mounted on the bedpost. It will be necessary to place the control switches at a position on the bedpost in such a way that the switch are not accidently thrown by Sean in his sleep. To prevent an accidental deployment the control switch unit will be located six inches from the base of the rail; when the rail is in the upright position. When the rail has be retracted into the lower position the motor’s armature rotational direction will have to be changed in order to get the rail into the protective position. This is done by changing the polarity of the motor. The length of time that the motor is running will also have to be controlled through the use of a controlling circuit, which will indicate the motor to come to a complete stop before changing rotational directions. The timer controller used is a 555 IC integrated circuit chip, which will control the delayed needed to prevent the motor from changing direction while still rotating.
2. Realistic Constraints

2.1 Economic Constraints

2.1.1 The lawn mower project is by far the more expensive of the two projects we are constructing. The main difficulty with this project will be acquiring the mower. Purchasing the lawnmower will cost at least $1000 for a new mower, and on top of that we will need to buy actuators, microchips, circuitry, and several other safety factors to modify the lawnmower for Shane's use. If the lawnmower is unable to be bought, we will need to seek alternative means to come up with the funds for it. Potentially the mower could be donated if the company is persuaded to do so, or perhaps a private investor could grant us extra money for the project. Least favorably, we could search for a used mower that will suit our needs. Also, the mower we receive might not have a battery powerful enough to provide the energy needed to power our actuators and controls. If that is the case, money will need to be allotted for a new, bigger battery.

2.1.2 The BRD project also has economic constraints in that the budget allotted for the railing must be considered with regards to the lawnmower, a much more expensive project. The BRD has several features we plan to install, but some of them might be less necessary than others. In the event of a budget shortage, shortcuts might be needed in the means of padding the device. We have plans to make a railing which is sleek and fun looking, but might be forced to cut corners and stick with a device purely based on utility, not aesthetics.

2.2 Environmental Constraints

2.2.1 Several features of the lawn mower will need to be addressed because it will be operated outdoors. The circuit components of the mower controls will experience varying degrees of climate change. The mower will be in use from the spring until the fall, so it will encounter an approximate temperate range of 40-110 degrees Fahrenheit. The terrain in which the mower is operated on will also be subject to change. Varying degrees of steep terrain will subject the mower’s modifications to displace. Due to rough terrain the linear actuators, electrical circuits, and protective cases all need to be securely adhered to the mower. The circuits will also experience varying degrees of humidity during spring and summer month. Extra care is taken to enclose any electrical components in order to prevent them from being exposed to any moisture. A resin will be used to shield and protect each electrical circuit.

2.2.2 The BRD is operated in the confines of Sean’s bedroom. Even though the BRD is used indoors certain aspects of the design must be addressed to ensure the BRD will operate successfully. The motor is to be enclosed in a protective cases to prevent any bed sheet or piece of Sean’s clothing from being entangled in the motor. The circuits are susceptible to damage when exposed to moisture or other small particles. Their protective cases will be sealed with a resin to prevent any moisture or particles from damaging the circuit.
2.3. Sustainability

2.3.1
The mower modifications are susceptible to derogating wear as they are used. Shane inflicts immense amount of derogation on the joystick of his everyday wheelchair. As the mower increases in the number of times it has been used the accuracy of the joystick may degrade. A vast number of electrical components on the lawn mower allows for a greater chance of electrical failure. Failure of any electrical component will render the lawn mower inactive; due to the mower controls solely being operated through the electrical circuits. The linear actuators cannot subject the mower control levers to a force that will degrade the levers overtime. A minimal amount of force must be used to ensure that the lever remains intact.

2.3.2
The BRD is subject to failure as the length of time of its operation increases. Structurally the BRD will experience forces and strains in nearly all directions; set forth by Sean when he is sleeping. Random sleeping motions subject the BRD to derogation at welding joints, hinge joints, frame to netting connections, and frame to protective foam connections. Precision in connecting metal to metal and metal to non-metal and quality materials ensures that derogation of these aspects of the BRD happen as slowly as possible. Strains may also be put on the bed frame in which the BRD is attached to. When the BRD is removed from the bed, in order to change the sheets or the mattress, it must happen in such a way where the bed frame is undamaged.

2.4 Health and Safety

2.4.1
The lawn mower’s electrical components pose a risk to the operator. There could be an electric shock caused by the circuits, which could result in burns or neurological damage. When operating the lawn mower Shane is subject to forces that could render him dislodged from the mower or render one of his appendages in a uncomfortable position. The modifications made to the lawn mower may cause the mower to become more top heavy. If the actuators and protective casings create a top-heavy affect; as a result the mower may be subject to tipping over while maneuvering around a corner.

2.4.2
Several aspects of the BRD must be addressed before it can be implemented in Sean’s home. The BRD must not cause injury to Sean while he is using the device. The distance between Sean’s mattress and the BRD must be minimal to prevent Sean from pinching himself against the frame. The foam and protective netting must be made of a material that when tested does not cause irritation to the skin when Sean rubs against it during the night. The hinges of the BRD will be subject to high levels of stress while being operated. It will be important to accurately secure the hinges to the frame; if they are not correctly secured the welded connection area may become derogated.
3. Safety Issues

3.1 Safety Issues

3.1.1 Several safety issues arise when the lawn mower is in regular use. The chance of electric shock is always a possibility when electrical circuits are in use. Improper grounding of the circuits that control the actuators may put the operator in danger. Failure of a circuit may cause the operator to attempt to repair it. This could cause a great deal of harm due to the use of capacitors in the circuit, which can cause electric shock if not properly discharged.

Metals are used in electrical components and structural components, and are subject to wear when used and stored in an outdoor environment. Oxidation of the metals forms rust, which compromises the possible motion, durability and strength of the metal components. Failure of any metal structural piece can yield the mower unsafe for operation. The effects of corrosion are also experienced by the actuators and will subject them to failure overtime. Materials used for the seat, seat belt, and armrest must be biocompatible with Shane. These materials cannot cause irritation to Shane’s skin. The seat and armrest provide the operator with stability while maneuvering the lawn mower. These structural modifications are what allow Shane to safely operate the mower.

3.1.2 Safety is a major concern when designing a device that prevents harm to the individual who it is used by. Compatibility of the materials and Sean’s skin must be addressed. If the material used for the netting and foam padding causes irritation to his skin the design will fail.

The stability of the stairs must be addressed because they are not supported by any part of the bed frame or the BRD. The actual steps of the stairs must be able to withstand the derogation facing them after Sean uses the device twice a day for the rest of his life. When Sean puts his weight on each individual step; the adjustable connections controlling the height of the step cannot be subject to large wearing. If the connections are worn down the ability for the stairs to adjust is compromised. The non-stick surface of the stairs must be a material that will not damage Sean’s feet but at the same time prevent him from slipping down the stairs. Improper design of the support legs will cause the BRD to fail during operation. The point of connection between the support legs and the mattress is designed to apply enough force normal to the mattress in order to prevent the BRD from moving linearly.
4. Impact of Engineering Solutions

4.1.1

Success of the modified lawn mower has great effect on a variety of aspects of Shane’s life. Operating the lawn mower gives a higher level of personal satisfaction when Shane is able to solely maintain his lawn. Even though this device is not as crucial to his life, as his wheelchair is, the lawn mower provides Shane with an increased amount of responsibilities and an increase in physical activity. People with disabilities sometimes experience a limitation on certain activities that others may not realize. The completion of a modified mower will leave Shane with a desired experience, cutting the lawn, which many people take for granted on a weekly basis.

The mass production of the modified Ariens lawn mower, on a global scale, provides Shane’s experienced to other individuals who are unable to mower their lawn. Doing so improves on the life of the operator and operator’s family because there is an expansion of responsibilities and an increase in exercise, which is a fairly common goal for families with disabled persons.

Despite the modifications made to the mower; it remains environmentally safe and friendly. A lack of toxic fumes and a relatively low rate of carbon dioxide emission do not cause a large enough impact on the environment for them to be relevant.

4.1.2

Such a protective device as the BRD does not exist in an inexpensive non-hospital environment. The designed BRD is able to maintain a safe sleeping environment inexpensively and in within the home. Despite the immense importance of a protective sleeping device one does not exist that can be made affordable and marketed towards the general public.

Global implementation of the BRD gives a wider range of people with disabilities with a safe means of sleeping. Currently crude railing devices are in use in many homes, which places great risk of injury on the individuals being protected by the railing. Rails that can be found in many homes consist of a rail built to protect a young child and are not adequate to protect a fully grown adult.

Environmental concerns for the BRD are limited due to the fact that it is operated indoors and produces no emissions. The two electric motors do not affect any environmental variables because they use a small amount of electricity, which is insignificant in the amount of electricity consumed every day. Above all else the BRD allows Sean to be well rested and more alert during because he has expended less energy getting in and out of bed.
5. Life-Long Learning

Both design projects for Shane and Sean utilize various fields of engineering to effectively solve a problem. The two designs require strong abilities in electrical circuits, structural mechanics and computer programming to create successful devices. In order to control the various electric motors and actuators a great understanding of microcontrollers was needed to create a safe working device. Circuit schematics are designed and evaluated in Multisim. Multisim provided experience in circuit theory and also provided a fast and inexpensive means of testing and building electrical circuits.

Structural visualization of the design components was necessary to accurately design a working device. CAD software was the most useful tool in generating a visualization of the design projects. The particular CAD program used is Solidworks, which provided assembly of parts made out of various materials. Solidworks is also able to aid in the testing of the devices in order to get a better understanding of structural integrity and weakness.

Another valuable aspect of the design projects is the experiences gained from working together in a team. Developing effective communications skills and project management skills was a crucial stepping stone to having successful designs. Various work and learning styles emitted by each group member brought a wider range of ideas and theories to the team; expanding the capabilities of the design team.
6. References


80/20 Inc. 80/20 Inc Product Catalog. Web  
<download.8020.net/2011_Product_Catalog/Fractional_8020_Catalog_17.pdf>

80/20 Inc. 80/20 Inc Price Catalog. Web.  

http://www.mcmaster.com/#foam/=egr7st

http://www.uscutter.com/Vinyl-Cutting-10
<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
<th>Price for Each</th>
<th>Total Price</th>
<th>Shipping</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRD frame vertical Supports</td>
<td>4</td>
<td>We have them</td>
<td>Free</td>
<td></td>
</tr>
<tr>
<td>BRD frame horizontal Supports</td>
<td>2</td>
<td>27.3</td>
<td>54.6</td>
<td></td>
</tr>
<tr>
<td>Joining Plates</td>
<td>8</td>
<td>6.8</td>
<td>54.4</td>
<td></td>
</tr>
<tr>
<td>joining plate bolt assemblies</td>
<td>40</td>
<td>.5</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Corner Brackets</td>
<td>4</td>
<td>5.35</td>
<td>21.4</td>
<td></td>
</tr>
<tr>
<td>corner bracket bolt assemblies</td>
<td>32</td>
<td>.4</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>End Caps</td>
<td>4</td>
<td>1.35</td>
<td>5.4</td>
<td></td>
</tr>
<tr>
<td>Foam Padding</td>
<td>3</td>
<td>13.93</td>
<td>41.79</td>
<td></td>
</tr>
<tr>
<td>Vinyl</td>
<td></td>
<td>1 roll 15&quot; by 10 yards</td>
<td>27</td>
<td>27</td>
</tr>
<tr>
<td>Hinges</td>
<td>3</td>
<td>6.15</td>
<td>18.45</td>
<td></td>
</tr>
<tr>
<td>Vertical supports BRD Support system</td>
<td>3</td>
<td>3.32</td>
<td>9.96</td>
<td></td>
</tr>
<tr>
<td>8 hole joining plate</td>
<td>3</td>
<td>5.10</td>
<td>15.3</td>
<td></td>
</tr>
<tr>
<td>bolt assemblies</td>
<td>24</td>
<td>.5</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>1010 mounting base</td>
<td></td>
<td>we have them</td>
<td>free</td>
<td></td>
</tr>
<tr>
<td>inside bracket</td>
<td>3</td>
<td>6.9</td>
<td>20.7</td>
<td></td>
</tr>
<tr>
<td>bolt assemblies</td>
<td>18</td>
<td>.4</td>
<td>7.2</td>
<td></td>
</tr>
<tr>
<td>Wood for stairs</td>
<td></td>
<td></td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>motors</td>
<td>2</td>
<td>one is free</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>electronics</td>
<td></td>
<td></td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Total Cost</td>
<td></td>
<td></td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Price for Each</td>
<td>Total Price</td>
<td>Shipping</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>----------</td>
<td>----------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>Ariens Lawn tractor 42</td>
<td>1</td>
<td>$1,299</td>
<td>$1,299</td>
<td>0</td>
</tr>
<tr>
<td>Wesco Performance Seatbelt</td>
<td>1</td>
<td>$25</td>
<td>$25</td>
<td>$6</td>
</tr>
<tr>
<td>PA-14-10-50 Micro linear actuator</td>
<td>3</td>
<td>$103.54</td>
<td>$310.62</td>
<td>$26.51</td>
</tr>
<tr>
<td>MTJPRO11A-BOT Microcontroller</td>
<td>1</td>
<td>$89.99</td>
<td>$89.99</td>
<td>$5.25</td>
</tr>
<tr>
<td>Rack and Pinion</td>
<td>1</td>
<td>$93.95</td>
<td>$93.95</td>
<td>$15</td>
</tr>
<tr>
<td>Armrests (NEAT?)</td>
<td>1</td>
<td>$30</td>
<td>$30</td>
<td>$6.50</td>
</tr>
<tr>
<td>Joystick (NEAT?)</td>
<td>1</td>
<td>Unknown</td>
<td>Unknown</td>
<td>(NEAT)</td>
</tr>
<tr>
<td>Wires</td>
<td></td>
<td>$40</td>
<td>$40</td>
<td>$7</td>
</tr>
<tr>
<td>Misc. Housing</td>
<td></td>
<td>$50</td>
<td>$50</td>
<td>$6.50</td>
</tr>
<tr>
<td>Mower Gas (and can)</td>
<td>1</td>
<td>$8</td>
<td>$8</td>
<td>0</td>
</tr>
<tr>
<td>Assistive platform</td>
<td>1</td>
<td>$80</td>
<td>$80</td>
<td>$10</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td></td>
<td></td>
<td><strong>$2076.56</strong></td>
<td><strong>$82.76</strong></td>
</tr>
</tbody>
</table>