Handicapped Car Lifting Seat

by

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Submitted to the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degree of

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ABSTRACT

Currently there is a lack of assistance in automobile usage for the older people of our society. In an attempt to combat this problem, this thesis designs and builds a working conceptual model of a handicapped car lifting seat. An initial cost analysis is performed, an apparatus is designed, all necessary materials are gathered, an apparatus is constructed, and the device is tested. The result was the successful completion of a device that successfully assists in the lifting of up to a 300lbs person out of their car. With some further development, this handicapped car lifting seat could hopefully be used in real life.

Thesis Supervisor: Ernesto Blanco

Title: Adjunct Professor of Mechanical Engineering

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1 Introduction

Currently there are no devices made for automobiles that will assist handicapped or elderly people from exiting their car. Elderly people, typically characterized as being 65 years of age or older, are currently approximately 12% of the U.S. population and are expected to comprise up to 20% of the population by 2020. As stated in a conference by the Age Lab of the Massachusetts Institute of Technology, "Current automobiles are not designed for smaller, more fragile adults."[1] With elderly people numbering such a large portion of the population, there is a need to address the problem of this lack of assistance in automobile usage for the older people of our society.

In an attempt to combat this problem, this thesis aims to design and build a working conceptual model of a handicapped car lifting seat. A design will be proposed and examined with force diagram calculations, the appropriate materials will then be gathered, and the working model will be constructed and built accordingly. The working model will result in a device that with the press of a button will help hoist a person from their front seat, up and out of the car.

2 Apparatus

The initial concept for the handicapped car lifting seat came from Professor Ernesto Blanco. His idea is shown in the sketch in Figure 1. Before the device could be further designed for implementation, the apparatus or environment of the device had to be decided upon. Since the device is used in a car, a decision had to be made of whether to purchase a car or build a car-like structure to house the device. Since the overall goal was to construct a working model of this device by the cheapest means possible, research was done on to see which apparatus would potentially cost the least.

The option of buying a real car was researched first. This option was foreseen to be more expensive but would also be the preferred choice since implementation of the lifting device would be better understood viewed in its true environment. Several junk yard companies around the Boston/Cambridge area were contacted and probed for the price of their cheapest junk cars. Most of these companies gave their cheapest price as $500 for a working junk car.

[1] Excerpt from online article, "Catching the 'Age Wave'"
http://www.cwcog.org/aprnl02.pdf

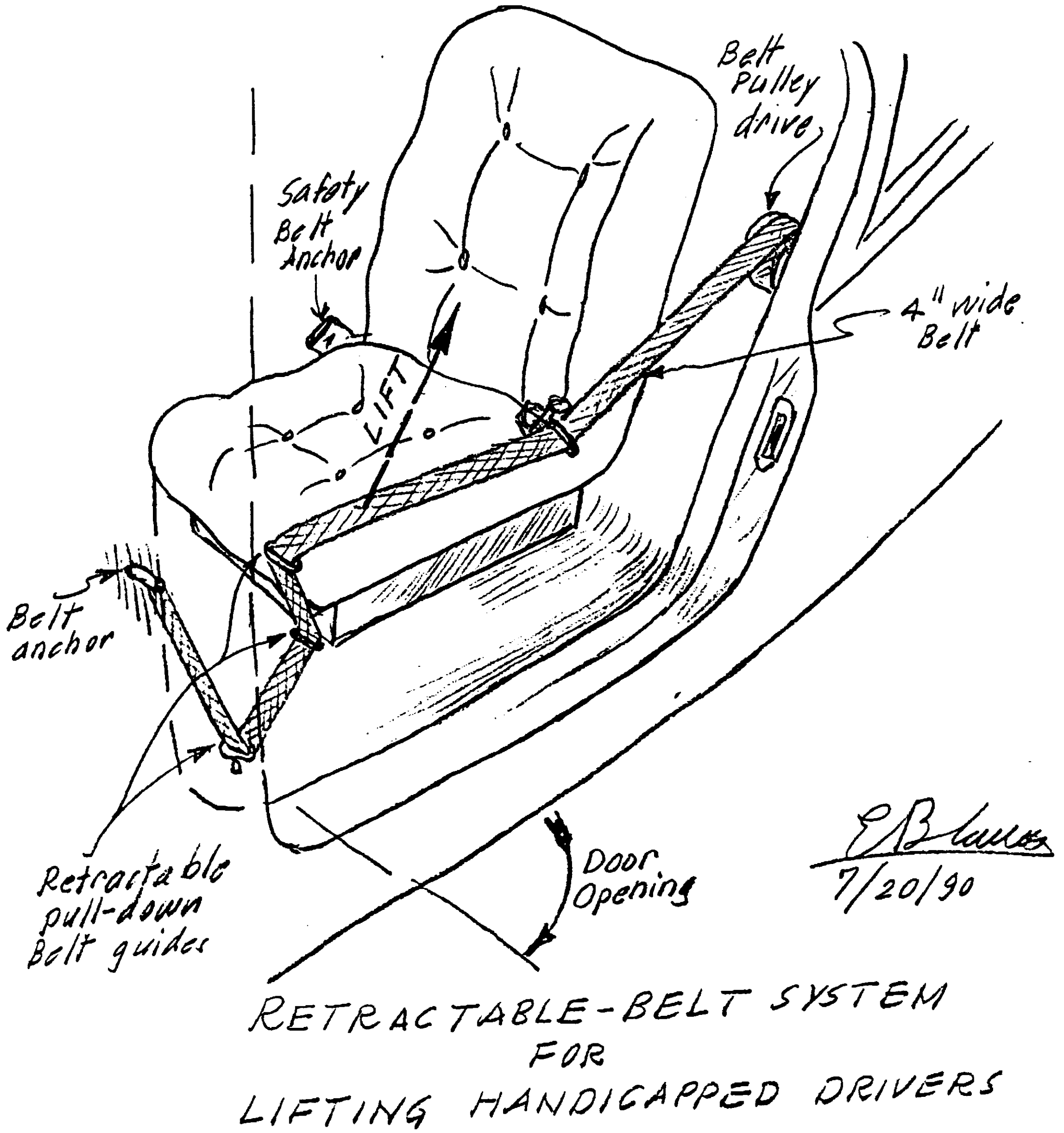

***Figure 1**: Conceptual sketch of handicapped car lifting seat.*

Further research was done using Craig's List, a local classified website used to sell a vast array of merchandise. Automobiles were searched for and a number of junk cars being sold by their owners were offered at much lower prices than those offered by the junk yard companies. An example of one of these cars and its description is shown in Figure 2. As shown, the cheapest cars for sale were priced at $200. In addition to these cars that were being sold for a set price, there were other cars that were advertised as being sold for the "best offer." One such car is shown in Figure 3. While a car such as this has the potential for being sold at a cheaper price than $200, it was considered a very unlikely occurrence. Generally, the cars sold for the "best offer" were of better quality than those sold with a fixed price, so it was expected that these cars would realistically not sell for less than those cars of worse quality priced at $200. Also, the hassle of having the right timing in order to make an acceptable offer to the owner was not seen as a good risk. Given that the "best offer" cars were a lot more variable and unpredictable, the lowest concrete price for the option of buying a real car for the apparatus of the device was taken to be on the order of $200.

1990 VW Fox - $200

Reply to: ultralightspecial@yahoo.com
Date: 2005-02-14, 3:40PM EST

1990 Volkswagon Fox
4 speed, 4cyl, Black exterior, Grey and Black interior
Clutch is in good shape
Exterior has no rust nor does the underneath, just a small dent on doors, barely noticable
Inteior is in great condition, no rips, or burnmarks, very clean
New front tires, rears have 75 % tread left. Good handleing in snow
Gas engine, 30 on highway, 26 city

Car needs:
Blower motor
Speedometer cable...miles read 135,246...actual miles around 137,000
Emergancy break cables..emergancy break does not work

Car runs and drives...drive it away, call 603-668-2747 or email if interested

***Figure 2**: Description of junk car at fixed price for sale by owner on Craig's List.*

UNBELEIVABLE DEAL CAR OF YOUR DREAMS!!! Mitsubishi Eclipse RS!! - $1

Reply to: anon-59727335@craigslist.org
Date: 2005-02-14, 3:15PM EST

UNBELEIVABLE DEAL CAR OF YOUR DREAMS!!! Mitsubishi Eclipse RS!!

1997 Mitsubishi Eclipse RS

Price: $Best Offer
Mileage: 95,000 miles
Body Style: 3 DR Hatchback
Exterior: Black
Transmission: Automatic
Engine: 2.0 L 4 CYL.
Doors: 2

***Figure 3**: Description and picture of junk car sold by owner on Craig's List for "best price" offer.*

In order to estimate the cost of the alternative option, a constructed apparatus, the essential components of this option were considered and priced. The main objects needed for constructing a car-like apparatus would be a front bucket seat from a car and the wood and fasteners with which to build the structure around it. Since the bucket seat is a little bit harder to acquire, it was priced first. Again, many junk yard companies were called and asked for the price of their cheapest bucket seat. Most of the companies gave their cheapest price for a bucket seat as $50. However, one company, J P Carroll's, gave their cheapest price as $25. Since wood is not very expensive, the price of the wood and fasteners were over-estimated to be near a maximum of $100. In conclusion, it was estimated that for this alternative option, the price of constructing an apparatus for the device would cost roughly $125.

These two options were compared to each other and the construction of the apparatus seemed to be the better option. Simply from a price analysis, the construction of the apparatus would cost at least roughly $75 less than the buying of a real car. In addition, while having a real car to put the device in would be better for its application purposes, the construction of the apparatus would allow for greater flexibility as a working model and would still be able to convey the concept of the device. With this reasoning, it was decided that the apparatus for the device would be constructed, not directly purchased.

3 Design

Designing the constructed apparatus began with the inspection of the structure of a real car. Figure 4 shows a view of a car when looking at the front driver side seat. The point of the constructed apparatus was to give the structure the feel and similar appearance of a car. Therefore, the design of the constructed apparatus was created piece by piece from the known necessary components of a car. The initial sketch of the structure that will be compared with the real car in Figure 4 is shown in Figure 5.

The sketch began with the base. It was obvious that the structure would have to have a base to represent the floor of the car, so boards 1-4 were the first ones sketched. The appearance of the door frame was also necessary for the structure, so the square configuration consisting of boards 5, 6, and 7 was included next. In order to support the door frame from forces in the x-direction, boards 8 and 9 were inserted into the sketch and connected to the base. Since boards 8 and 9 would provide minimal support to the door frame for forces in the y-direction, board 10 was inserted and connected to the base as well. Boards 11-14 were added next simply as the rest of the ground supports for the base. Boards 1-14 made up the basic structure of the constructed car-like apparatus.

Getting deeper into the full design of the structure, a couple of the last components for the device were taken into account and designed for. It was known that a winch of some sorts was going to be needed as referenced by the "belt pulley drive" in Figure 1, so a little research on winches was done in order to get a feel for the size and possible placement of the winch. In general, it looked as though winches were rather large and would probably not be mounted in the air, so boards 15 and 16 were added to the structure. Board 15 was inserted as a mounting board for the winch to the main door frame. Board 16 then became necessary as part of a pulley support for the seat belt that would be coming up from the winch. A pulley would be inserted between boards 6 and 16 so that the seat belt could have a smooth path from the winch, across the seat, to the resulting anchor that would be located at the front end of the structure or dashboard part of the car. A primitive sketch of the pulley is shown in the lower right corner of Figure 5. The last thing added to the design sketch was board 17, which actually consists of two identical blocks of wood. Board 17 would be the anchor that the seat belt for the device would attach to. Basically the seat belt would be inserted between the two identical blocks as to create friction from the force holding the two blocks together. With the anchor set, the designing of the wood portion of the structure was all but done.

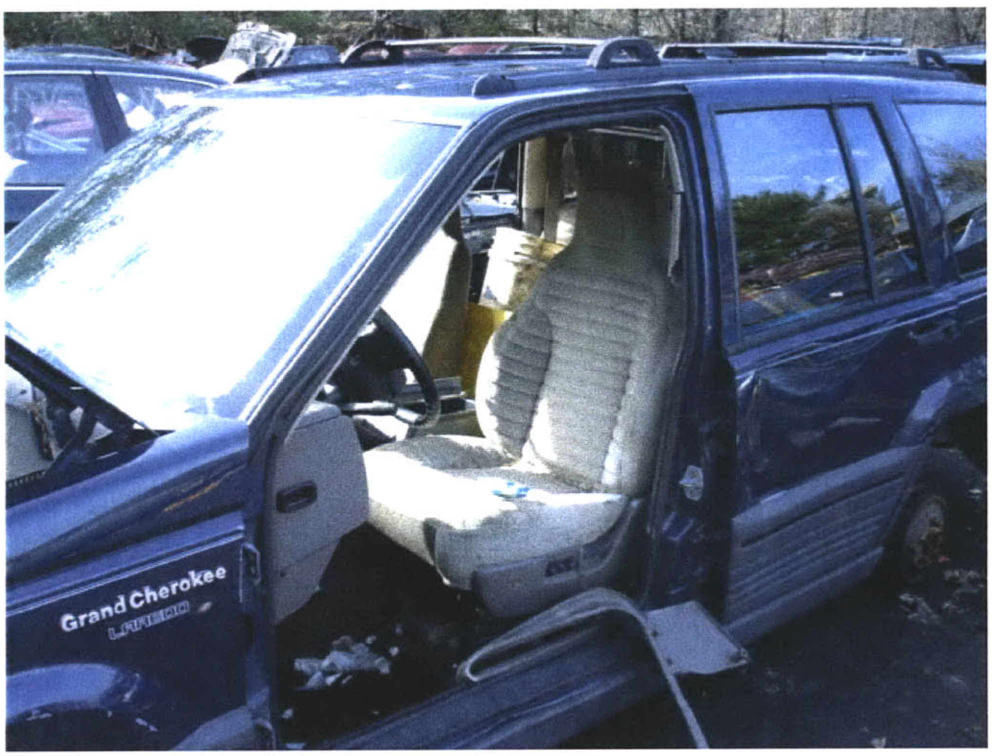

Figure 4: *View of front bucket seat in a real automobile from which to model the constructed apparatus.*

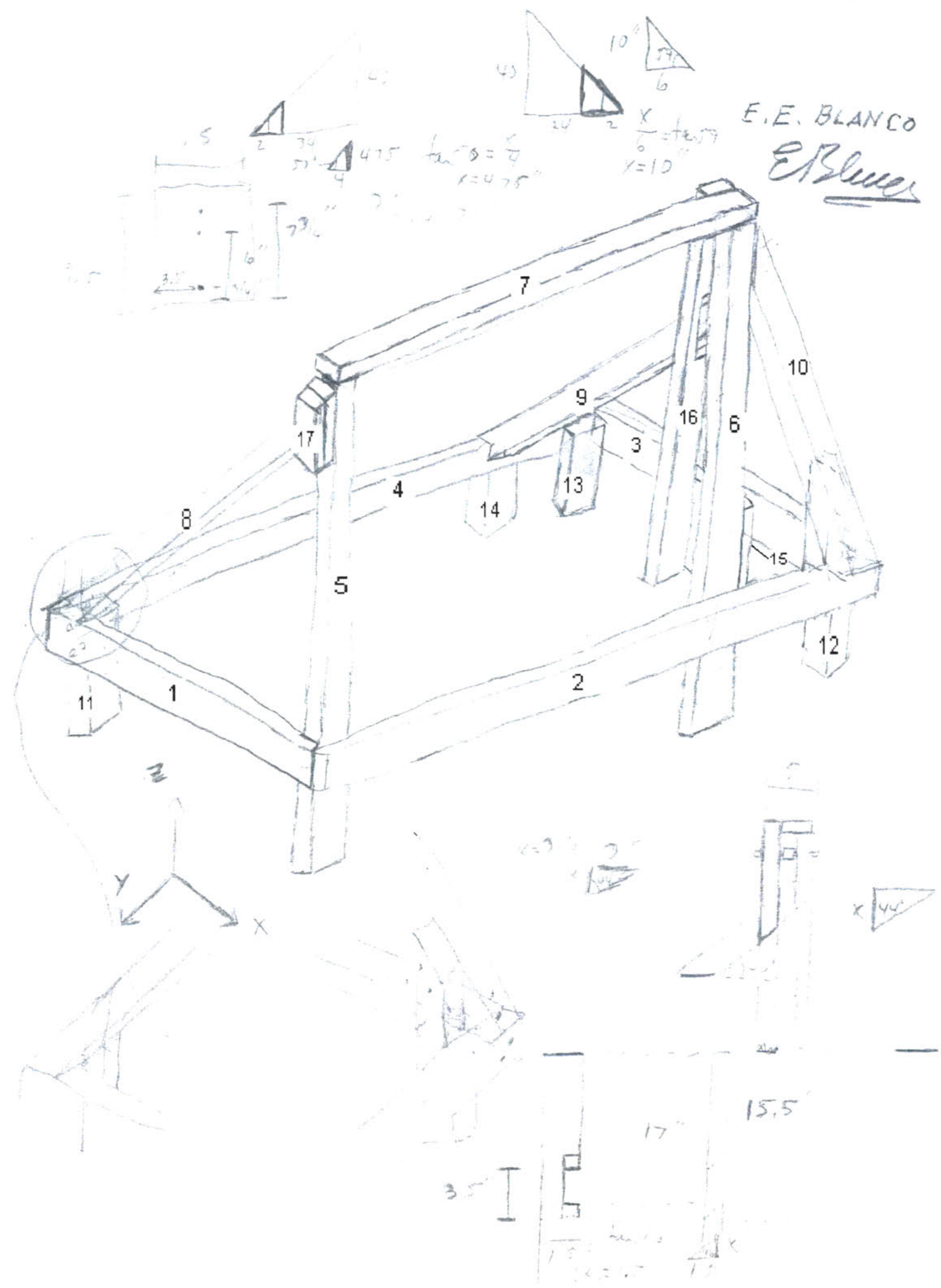

***Figure 5**: Initial design sketch for constructed apparatus.*

Before the initial design could be dimensioned and completed with specific wood cut angles, another crucial part of the apparatus had to be examined. The structure had to be strong enough to withstand the forces generated by picking a large portion of handicapped or elderly people. Therefore, the maximum force the device was estimated to have to withstand were the forces generated from a person weighing 300lbs. In order to examine this, a force diagram of the frame was made and is shown in Figures 6 and 7. The two figures give the forces in the vertical and horizontal supports of the door frame based on a 30° and 60° angle of the seatbelt with the side support. The angles of the seatbelt with the side supports were varied to simulate the range of forces that would occur as the seat belt became more taught and started lifting the person in the seat.

In Figure 6, the weight of the 300lb person would be equally distributed on the two vertical supports of the frame and therefore, the vertical weight on one of the side supports is shown to be 150lbs. The 150lbs compression force at a 30° angle to the side support would produce an 87lbs horizontal force into the top, horizontal support of the frame. The forces incurred on the left vertical support of the door frame would be a mirror image, equal in magnitude to those forces on the right vertical support. Therefore, the resulting compression force on the horizontal support of the door frame would be approximately 174lbs. Finally, the resulting tension in the seat belt at this angle is 173lbs. The tension in the belt reveals the pulling force that would be required of a pulling device in order for the belt to be held in place with a 300lbs person sitting on it. Assuming a winch would be mounted to the bottom of the right vertical support of the door frame, the winch would apply an additional 173lbs compression force to the right vertical support. This additional force provided from the winch would produce a total compression force of 323lbs on the right vertical support.

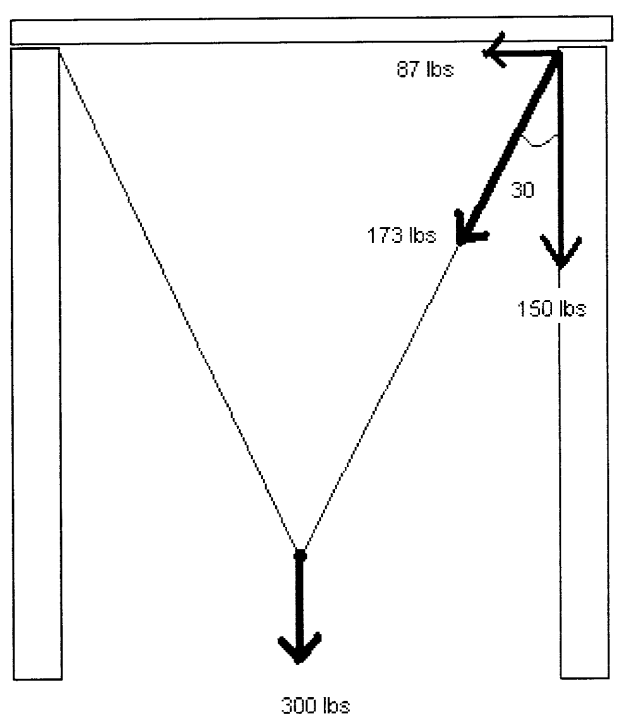

***Figure 6**: Force diagram of door frame with seatbelt at a 30° angle to the side support.*

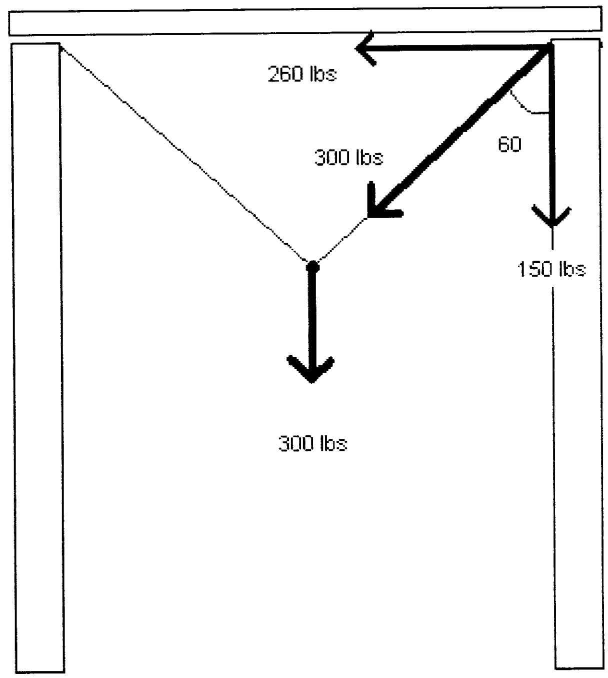

***Figure** 7: Force diagram of door frame with seatbelt at a 60° angle to the side support.*

Similar to Figure 6, in Figure 7 the weight of the 300 lbs person would be equally distributed on its two side supports, so again the vertical weight on one of the side supports would be 150lbs. This compression force at 60° would instead produce a much greater force of 260lbs on the top, horizontal support of the frame. Again, since the forces on the left support would be a mirror image, equal in magnitude to those on the right, the total compression force applied to the horizontal support of the door frame would be 520lbs. Finally, the resulting tension in the seatbelt at this 60° angle would be 300lbs. Using the same principles as in Figure 6, this would cause there to be a total compression force of 450lbs on the right vertical support.

The results of the force diagrams on the door frame of the apparatus showed that the forces during operation of the lifting device would probably range from anywhere between 150lbs to 520lbs of force on any given piece of wood at any given time. These large forces were additional reasons as to why boards 10 and 16 were added to the apparatus. These two boards gave addition support to combat those compression forces applied to boards 6 and 7 as described above.

The last thing done for design purposes was specifications for the boards. This included specific dimensions and angled cuts. Dimensions were done first. The approximate width and height of the door frame on the apparatus needed dimensions. These were obtained by measuring the width and height of the door frames of 3 different cars and taking their average. In addition the distance from the front of the bucket seat to the dashboard ahead was measured and averaged as well. The last dimension taken from real cars was the height of the bottom of the door frame from the ground below. The resulting dimensions for these four distances are shown in the final design sketch in Figure 8.

Other dimensions were added as well. Two additional dimensions were added in order to figure out the overall width and length of the apparatus. Based on the placement of the pulling device, an additional space was provided behind the seat in order to make room for the probable use of a relatively large winch. Also, the total width of the apparatus was given a distance to provide plenty of room for the bucket seat.

The pulley mechanism and the ply wood floor to the apparatus were also given complete dimensions. For the pulley, a steel rod and delrin piece were chosen to be used and given specified diameters while the length of the delrin piece was dimensioned based on the width of the seatbelt it would hold. The ply wood floor to the apparatus was given dimensioned based on all the ground and frame supports that would be protruding through it. All these dimensions are shown in the sketches in Figures 5 and 8.

With all the dimensions of the structure set, the different angles of board cuts were figured. Boards 8, 9, 10, 11, 12, 14, and 16 needed specific angled cuts in order to be properly constructed. Using trigonometry, the board lengths and angles were figured. The sketches for these boards can be seen in the lower right and upper left hand corners of Figures 5 and 8.

The last thing done in design was the preparation for the gathering for materials. With so many pieces of wood being cut to different lengths and angles, all the boards needed were laid out by their specified lengths. Foreseeing the fact that 96" long 2x4s were going to be used for the structure, the pieces were grouped together so that the total length needed for each group of boards would stay under 96". This way the 2x4s purchased could be used in the most efficient form and the exact amount of 2x4s needed would be known. The planning done for this can be seen at the bottom of Figure 8. With the designing completed, gathering the materials became the next step in the process.

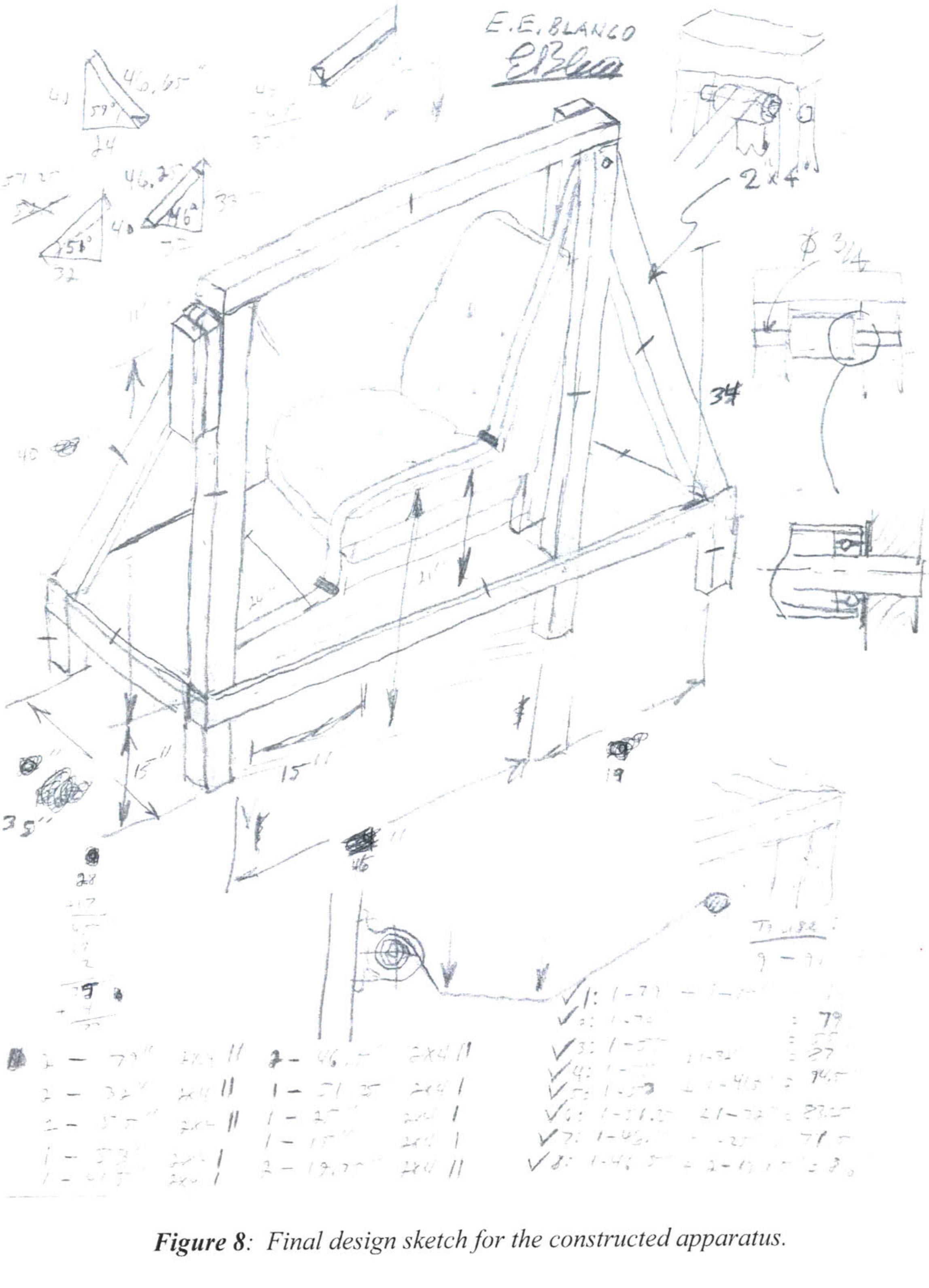

Figure 8: *Final design sketch for the constructed apparatus.*

4 Gathering Materials

The major materials needed for the project were the wood and fasteners for construction, a front bucket seat from a car, a seatbelt for the system, a pulling device such as a winch, and a battery with which to power the winch. The gathering of materials began with the substance of the apparatus, the wood.

A trip to Home Depot was made. 9 2x4s were purchased based on the figuring done in the design portion of the project. In addition to the 2x4s, a large sheet of ply wood was purchased to serve as the floor of the structure. Fasteners were also purchased since they would be needed to hold the wood together. 3" screws and 6" lag screws were selected since longer screws would be needed to attach together some of the pieces of wood with different cut angles. All the wood and fasteners were paid for and returned back to the Pappalardo Lab at MIT.

The bucket seat and seatbelts were acquired next. As mentioned previously, J P Carroll's junk yard had been called and gave their cheapest price of a bucket seat as $25. Since this was the cheapest, a trip was made to Carroll's in order to acquire a seat. Figures 9 and 10 give an idea of the environment of the junk yard. All the cars in the junk yard were searched for the best bucket seat available. The best bucket seat was eventually found in a 1992 Chrysler New Yorker 5th avenue. An example of one of these models is shown in Figure 11. The seat was then unbolted and removed from the car. A junk car with its front bucket seat removed is shown in Figure 12. In addition to removing its front bucket seat, two of the seatbelts from the Chrysler were cut and removed as well. The bucket seat and the seatbelts were paid for at the front office and also returned back to the Pappalardo lab at MIT. The seat and seatbelts removed from the car can be seen in Figure 13 sitting in the lab.

Figure 9: *J P Carroll's junk yard front office.*

Figure 10: *J P Carroll's junk yard.*

***Figure 11**: 1992 Chrysler New Yorker 5th avenue body and interior.*

***Figure 12**: Junk car with front bucket seat removed.*

***Figure 13**: Bucket seat and seatbelts from junk yard in the Pappalardo Lab at MIT.*

The next thing purchased for the project was the winch. Since the lifting device would be used in cars and cars use 12 Volt batteries, 12 Volt winches were researched on the internet. The cheapest winches were found on Ebay, an auction site for products. Figure 14 shows a sample advertisement for a winch on Ebay. The lowest price found for a winch on ebay had a starting bid of $22. A bid was made near the end of the bidding time period and a winch was purchased for just over $22. In a little over a week, the winch was shipped up to Boston and was taken to the MIT Pappalardo Lab.

A battery to power the winch was the last thing purchased for the project. Sears was used to look for 12 Volt car batteries and the cheapest one was priced at $36. As a result, Sears was visited and a car battery was purchased. It was brought back to the Pappalardo Lab at MIT and the gathering of materials for the project was completed.

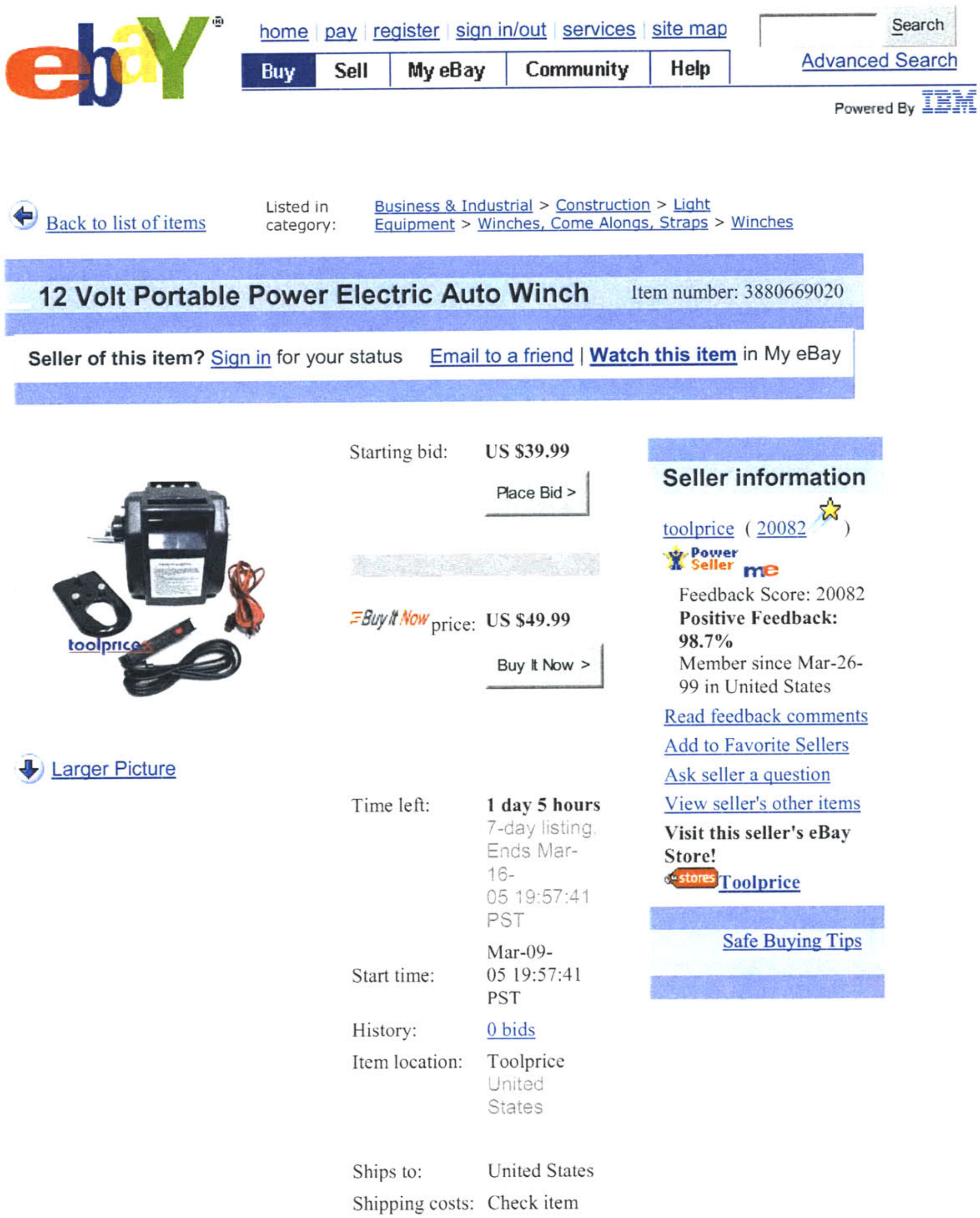

***Figure 14**: Sample Ebay auction page.*

5 Construction

The construction of the apparatus began with the cutting of all the needed boards. Since all the boards lengths had been figured and grouped together, each purchased 2x4 was cut one at a time into different length sections depending on how it had been planned during design. After the sections of one 2x4 had been cut, the end angles were then added to these sections using a special saw. Once the angles had been cut for the sections of one 2x4, they were marked as complete, labeled in pencil on each section, and then another 2x4 was started. Figure 15 shows all the 2x4s that had been purchased and gathered together to be cut. Figure 16 shows a demonstration as to how the boards were cut while Figure 17 shows how the angled cuts were made with the saw. Figure 18 shows all the boards once they had been cut and their end angles had been added.

***Figure 15**: Collection of purchased 2x4s from Home Depot, ready to be cut.*

***Figure 16**: Demonstration of wood sections being cut.*

***Figure 17**: View of angled saw and piece of wood with finished angled end.*

***Figure 18**: The finished boards once the specified lengths and end angles had been cut.*

With all the boards cut, the first thing to be constructed was the base of the apparatus. The outside frame of the floor of the structure was put together first. The side and end boards of the frame were placed together in the position they were going to be attached and then holes were drilled through both pieces of wood in the position where the screws were going to be inserted. These holes were drilled into the wood before screws were inserted so that the screws would perform more of a tightening action between the pieces of wood instead of serving as a widget-like object that would split the wood into two pieces. This is what can occur if too big of an object is inserted into a piece of wood. With the holes in place, screws were inserted into the ends of 2x4s in order to hold them together and the result was the rectangular frame shown in Figure 19.

Once the frame had been completed, the ground supports were the next logical boards to attach. Marks were made on the supports at 15" from each of their ends based on the design sketch shown in Figure 8. The marks were lined up with the top edge of the frame so that all the ground supports would make contact with the ground at the same height. One by one each ground support was lined up, holes were drilled, and the screws attached. Figure 20 shows a demonstration of the how the ground supports were attached and Figure 21 shows the standing apparatus with its base frame and ground supports attached.

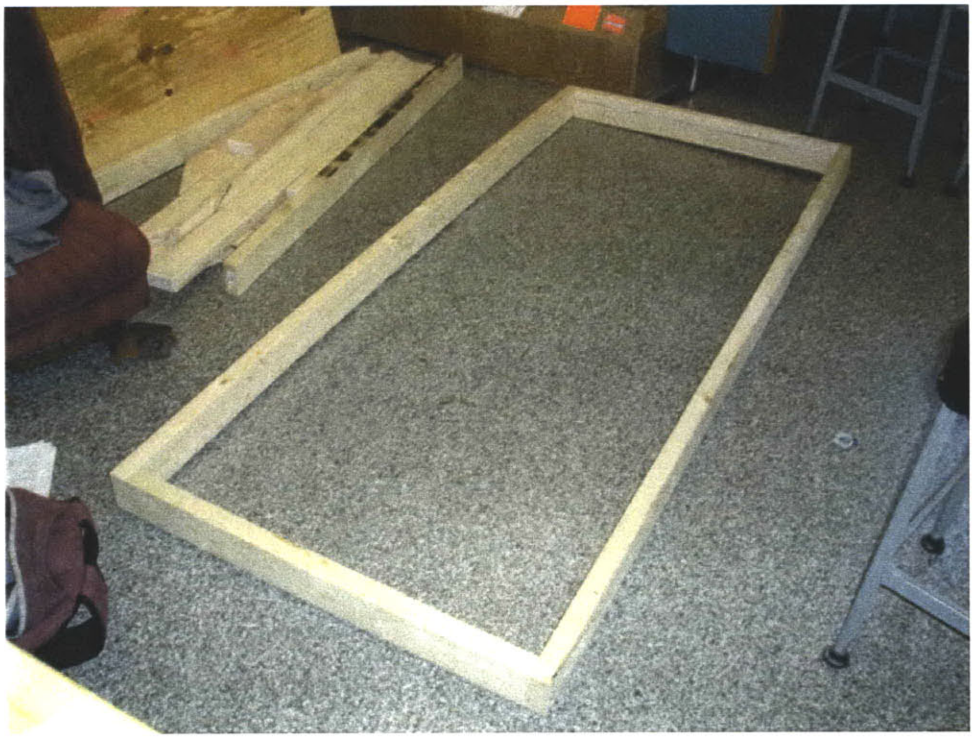

***Figure 19**: Base frame of apparatus.*

***Figure 20**: Demonstration of how ground supports were attached.*

***Figure 21**: Standing apparatus with base frame and supporting legs attached.*

The ply wood was attached to the apparatus next because the addition of the supports to the door frame would not allow enough space for the ply wood to fit and be placed onto the frame. From the dimensions figured during design, a jig saw was used and little sections of wood were cut out where the ground supports and door frame supports would protrude through the floor piece. Once these sections were cut out, the ply wood was placed on and attached to the frame with screws.

The door frame and its supports were the next things completed. The top, horizontal support board of the door frame was placed on top of the side supports and 2 holes were drilled into it and the support underneath on both sides. Screws were inserted and the door frame was complete. The 3 support boards to the frame were subsequently placed on the structure and attached as well. Two holes were drilled into the ends of each these boards and the longer lag screws were used as the fasteners. The lag screws were necessary since the angled cuts on the ends of the boards meant the screw had to span a distance that was longer than just the 3 ½" width of the 2x4 being attached. The standing structure with a completed floor, door frame, and supports is shown in Figure 22.

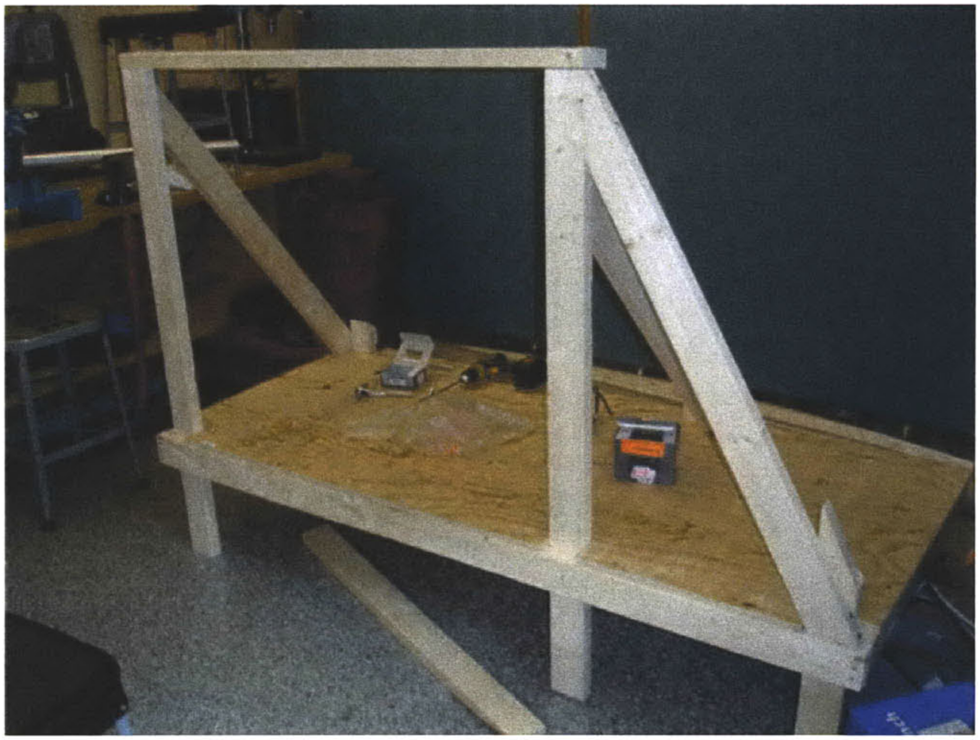

***Figure 22**: Structure with completed door frame, floor, and supports.*

The additional right vertical door frame support was added next so that the pulley mechanism could be added to the structure. The board with its correct angled cut was placed against the top of the frame and one of its side supports, holes were drilled, and screws fastened them together. The additional support was also attached at the bottom to the floor of the structure to make sure both ends were secure. The bottom was measured to be the same distance away from the door frame at the bottom as it was at the top, to make sure there were no induced forces put on the frame due to a tilt in the support. A picture of the attached additional support is shown in Figure 23.

For the pulley mechanism, a 3/4" steel rod was first cut to the correct length. The rod was then taken and chamfers were added onto the ends of the rod so that there would be less resistance when sliding the rod into the delrin piece and wood hole. Then a hole of the same diameter was drilled all the way through the two right supports on the door frame. This hole was drilled gradually with 3 different drill bits progressing in size to the 3/4" diameter hole. A piece of delrin with a 2" diameter was cut to the approximate size of the gap between the additional support and door frame (shown in Figure 23) minus 1/16" on both sides for space. Once the delrin piece was the correct length, a ¾" diameter hole was drilled into the center of the piece. This was also done gradually with 3 different drill bits. Once the center hole was drilled, it was bored out to a slightly larger diameter until the delrin piece could fit on the steel rod and rotate freely. The steel rod was taken and the center of the rod was sanded so that there would be less friction between it and the delrin piece. When this was done, the rod was tapped into the holes on the structure and the delrin piece was placed in the gap between the supports. The completed pulley mechanism can be see in Figure 24.

***Figure 23**: Additional support board attached to door frame, floor, and side support.*

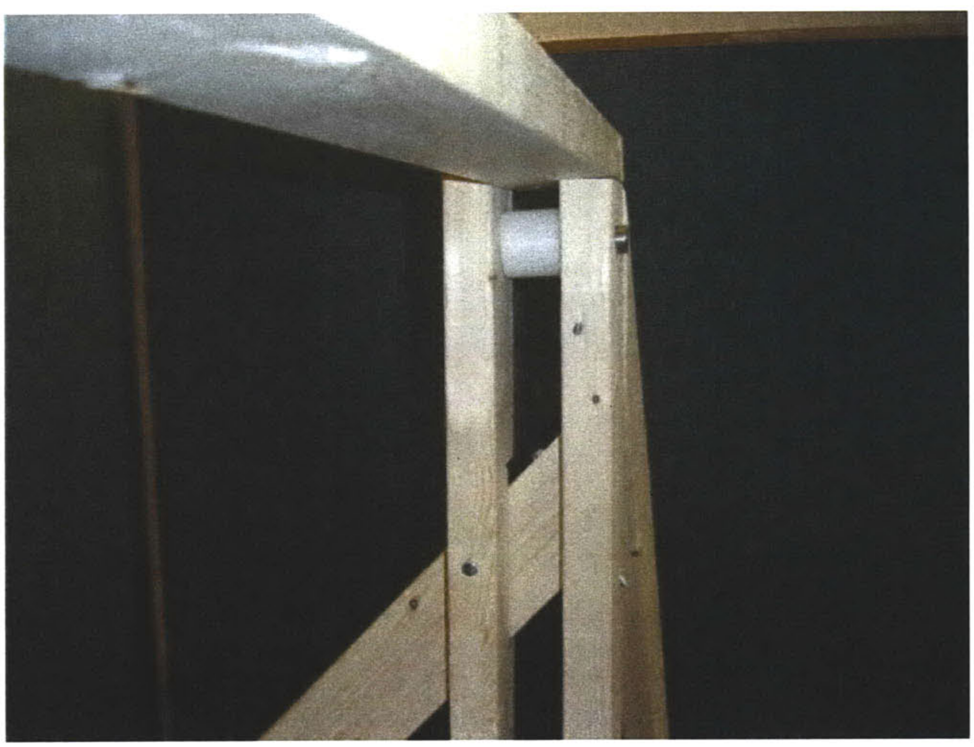

***Figure 24**: Completed pulley mechanism consisting of a delrin piece rotating on a steel rod.*

The next component attached to the structure was the winch. With the winch now in hand at the lab, the mounting holes on the winch were surveyed and dimensioned with respect to each other. The sketch for this mounting plate can be seen back in the design section in the upper left corner of Figure 5. Using a thin flat piece of wood as the mounting plate, holes were drilled through the wood with the same spacing as the mounting holes. The mounting plate was then screwed onto the bottom of the same two right side supports that were used for the pulley mechanism. Finally, the bolts were used to attach the winch to the mounting plate and thus, the winch was attached to the structure. Figure 25 shows how the winch was mounted to the structure and Figure 26 provides a complete view of the winch in its correct placement.

With the winch in place, the seatbelt, battery, and all other components of the winch were attached. The seat belts that were acquired from the junk yard were taken to a thread shop and were sewn together to create one continuous seat belt with twice the original length. A section of the winch cable, including the hook that comes attached to it, was then cut off using big wire cutters. One end of the seat belt was taken and manually wrapped around the bundle of cable until it had revolved a couple of times. This caused the seatbelt to wrap around itself creating enough friction that would keep it from unwinding from the bundle of cable and detaching. The car battery purchased from Sears was placed behind the winch and hooked on via the supplied battery cables. And finally, the control device for the winch was attached and placed behind the bucket seat. A photo of the winch with the seatbelt and all other attached components can be seen in Figure 27.

***Figure 25**: View showing bolts and mounting plate of the winch.*

***Figure 26**: View of winch attached to structure by the mounting plate.*

***Figure 27**: Winch with all components attached including seat belt, battery, and control.*

Nearing the end of construction, the dashboard mount was added next. Two boards were cut to equal length and attached to the door frame on the top of the left support boards. The first block was attached and then the opposite end of the seat belt was folded on top of itself and placed between the blocks of wood so that both ends of the seat belt were coming out at the top of the blocks. The second block was held in place while holes were drilled through the two blocks and then screws were used to fasten the blocks together. Multiple screws were used so that enough force and resulting friction was generated between the blocks on the seatbelt. The dashboard mount is shown in Figure 28.

The last things completed for the construction of the apparatus was bolting down the bucket seat and adding bungees to the seatbelt. The bucket seat was placed in its correct position and the spots for the bolt holes on the bottom of the seat were marked. The seat was removed and the holes were drilled in the ply wood floor. The seat was placed back on the ply wood and the bolts were added. The bungees were added in order to align the seatbelt and provide it with its proper shape. Bungee cord was acquired from the lab and it was cut into three pieces. The 3 pieces were strung through little springs that were roughly the width of the seatbelt and provided a much smoother surface for the seatbelt to pass under. Holes were drilled on both sides of the seatbelt where the bungees were needed, and the bungees and their springs were inserted through the holes and tied in a knot underneath the ply wood floor. This completed the constructed apparatus. The completed apparatus with all components attached is shown in Figure 29.

***Figure 28**: Dashboard mount for the seatbelt.*

***Figure 29**: Final constructed structure of the apparatus.*

6 Testing

Testing began with a test of basic successful operation of the device. Figure 30 shows the initial position of the seatbelt when the device is not being used. The control for the winch and device can also be seen behind the seat in an easily accessed position. The button on the winch control was pressed and the seatbelt was reeled in and made more taught by the winch. Figure 31 shows how the device works and looks when the winch, seatbelt and bungees are engaged. This test proved a general successful operation of the device as designed.

The next test performed was a weight test using a real person as a subject. The test was performed with a subject that weighed approximately 170lbs—about half the maximum weight desired for the device. The subject was placed in the seat as he would be positioned if ready to exit his car and then the device was used via the control to lift him up out of the seat. Figure 32 shows the subject in his initial position while Figure 33 shows the subject being lifted by the device. Figure 34 gives a better view to show that there is indeed space between the subject and the seat.

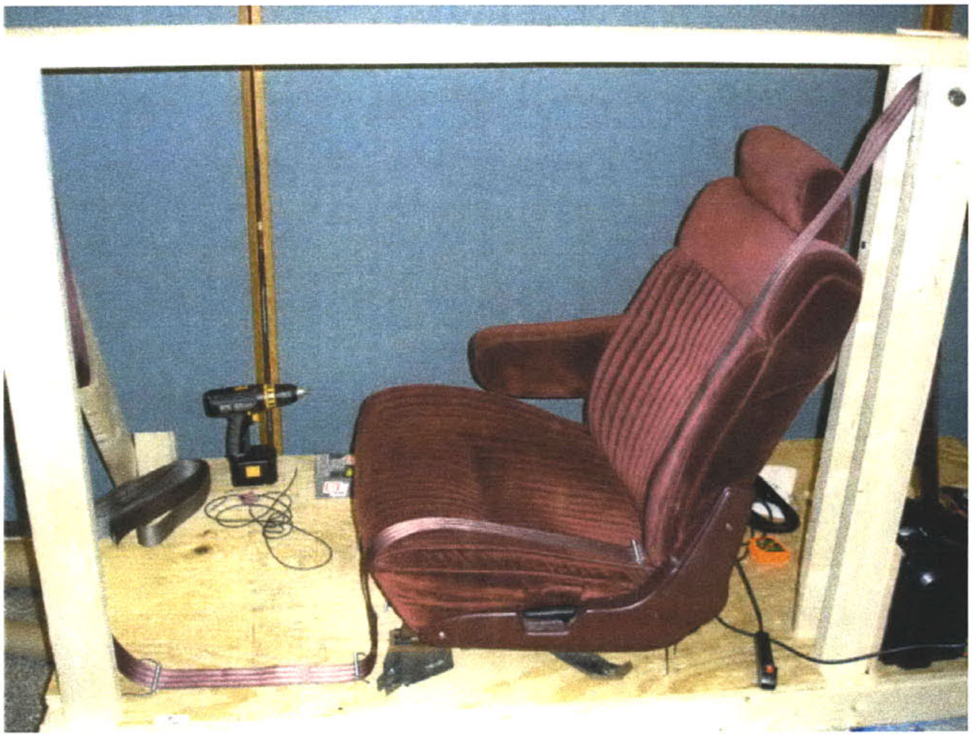

***Figure 30**: View of device with seatbelt in unused initial position.*

***Figure 31**: Device with winch, seatbelt, and bungees engaged.*

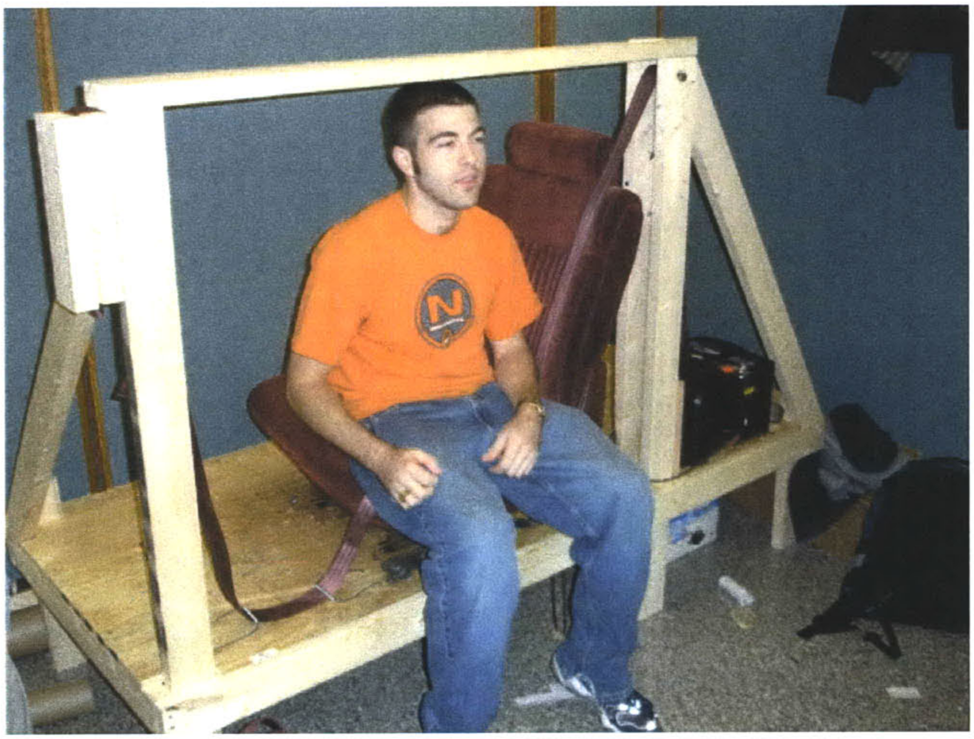

***Figure 32**: Subject in starting position for initial weight test.*

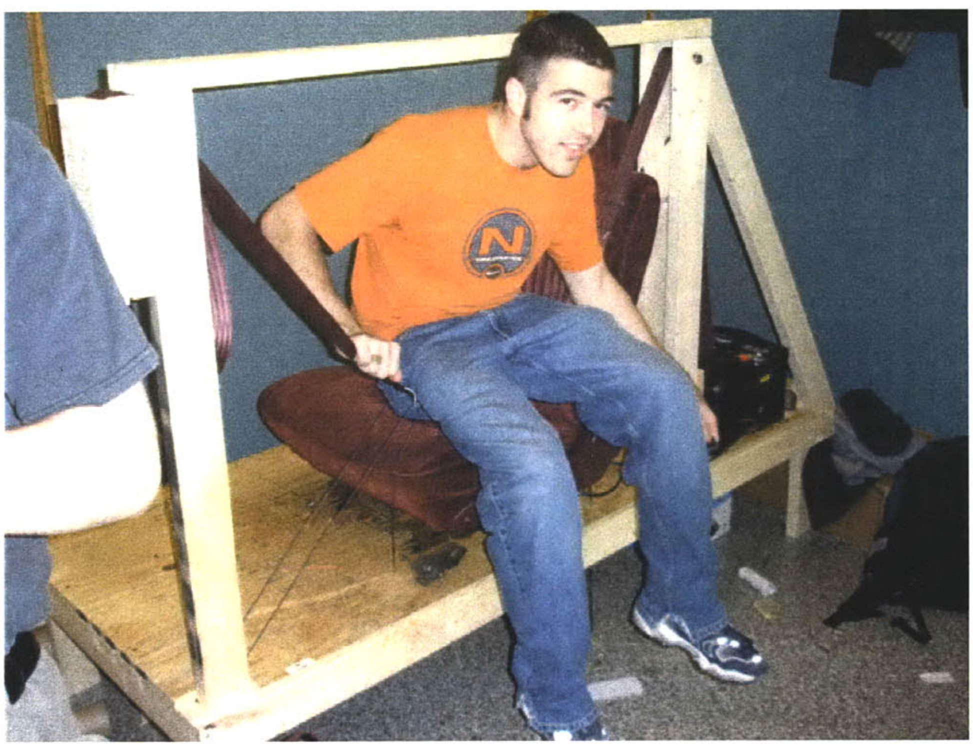

***Figure 33**: Subject lifting himself with device by use of control in his left hand.*

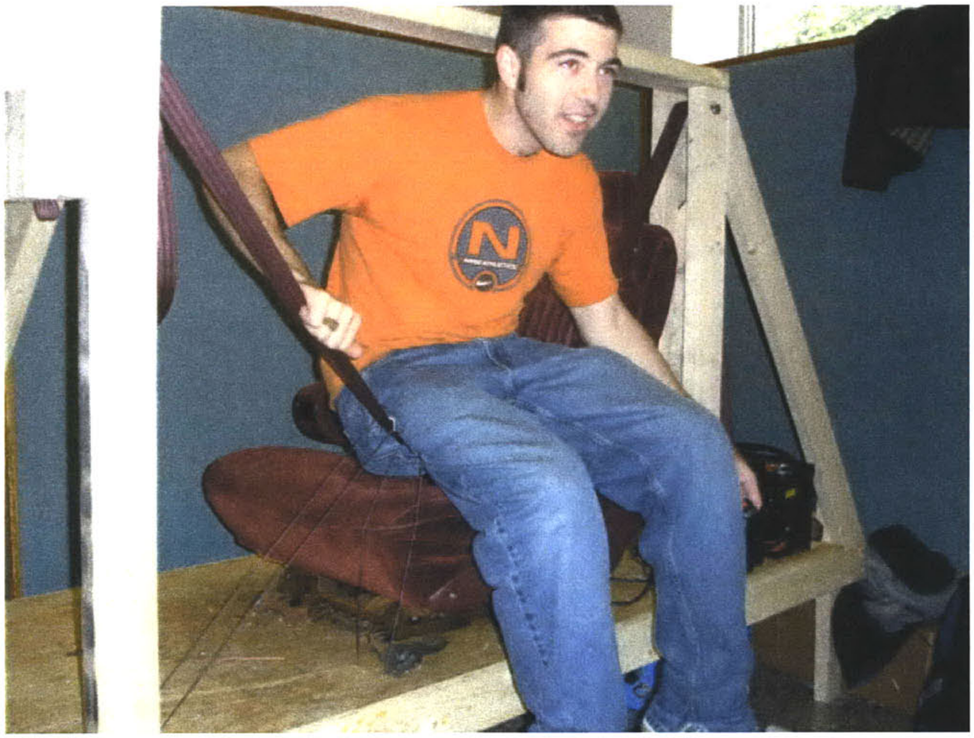

***Figure 34**: View showing space underneath subject when lifted.*

Before making a final test run in which the maximum weight of 300lbs would be tested on the structure, the angle between the seat belt and the right vertical support that resulted from the lifting of the subject was examined. The approximate compression forces being applied to the supports were inspected to compare the actual forces being applied to the forces that were designed for. The angle between the seat belt and support was taken to be a maximum of approximately 45°. A picture of the angle during use of the device is shown in Figure 35. With an angle of 45°, the maximum compression force that would be applied to the horizontal and vertical support would be 300lbs and 362lbs, respectively. Since these are well below those forces expected from design, the device would be expected to withstand the final test.

The final test was made by using the weight of two people on the device. The combined weight of the two subjects was roughly 300lbs. The two subjects sat on the seat to provide the appropriate weight and then the device was used to lift them. Figure 36 shows the two subjects being lifted and gives a better view of the space underneath them. The test proved the maximum desired weight of 300lbs could be withstood by the device.

***Figure 35**: View of angle of seatbelt with right vertical support board.*

***Figure 36**: View of space underneath the two subjects being lifted for 300lbs test.*

7 Conclusions and Recommendations

This thesis designed and developed a conceptual device that can successfully assist in the lifting of handicapped or elderly people out of their car. Initial cost analysis was performed, the apparatus was designed, all necessary materials were gathered, the apparatus was constructed, and the device was tested. While this is a small step in the quest to combat a lack of automobile devices for the handicapped and elderly people of our society, it is a practical one that can hopefully be further developed and used in real life.

While the device works successfully, it could be made better and therefore there are some recommendations for further development of this handicapped car lifting seat. Some sort of smooth cover could be placed on the seat where the seatbelt moves underneath the subject. During the reeling in of the seatbelt, the belt is sliding underneath the subject and a lot of friction is encountered if the subject is applying all of their weight on the edge of the seat. If a mobile thin cover was placed in this area to decrease the friction encountered, the subject would not have to worry about the belt sliding through.

The bungees used for the proper placement of the seatbelt could also be improved. Currently the bungees used all have the same stretching spring constants and therefore have to be tied with either more or less bungee cord available for stretching. This results in there being slack in the bungees while they are not in use. If they were tied in a manner that made them tight while unused, the bungees would probably stretch and break during use of the device at full stretch. If bungess with different stretching constants were used, they could be tied as tight as they needed to be in order for the seatbelt to be more securely fastened to the seat and floor of the car.

The final recommendation for the device would be the use of some other lifting device that doesn't require manual retracting. Currently, when a subject used the device and is lifted out of the seat, the seatbelt remains in its final position until the subject manually retracts the device and sets the seatbelt back into its initial position. This would be considered bothersome and some way of making this process automatic would be ideal.