12-5-2017

Boat-Lift Design and Analysis

Nathan Schick
Western Michigan University, nathanschick9@hotmail.com

Follow this and additional works at: http://scholarworks.wmich.edu/honors_theses
Part of the Applied Mechanics Commons, and the Other Mechanical Engineering Commons

Recommended Citation
http://scholarworks.wmich.edu/honors_theses/2915
Boat-Lift Design and Analysis

ME 4800 - Senior Design
December 2017
Dr. Shrestha, Depart of Mechanical Engineering, WMU

Group # 12-17-02:
Nathan Schick
Jacob Tussey

Faculty Mentor:
Dr. Javier Montefort, Department of Mechanical Engineering, WMU

Industry Mentor:
Jim Tussey, BSME, Business Owner

Western Michigan University
Department of Mechanical and Aerospace Engineering
Acknowledgements

Javier Montefort – A critical member of the design team that gave us his experience, input, and time.

Dave Sturtevant – Worked with the team as a customer and manufacturer.

Jim Tussey – Provided helpful design ideas, insight, and guidance.
Disclaimer

This project was accomplished by students in partial fulfillment of a Mechanical Engineering Degree at Western Michigan University. The University nor the design team make any claims as to the accuracy of the information nor any responsibility for those choosing to use the information contained within. Western Michigan University and the members of this team are not responsible for any damages or injuries that may occur.
Abstract

A current in production 6000 lb. rated boat-lift is being sold at “Great Lake Lifts”. The lift was tested experimentally and proved to hold at least 8000 lb. The design team successfully modeled the current lift on Ansys to help the customer understand where the weakest points in the design were. Following the creation of the initial lift design, the design team proposed and tested modifications that could be made in order to make the lift more structurally sound. The initial lift had a maximum deflection of 0.43846 inches, a maximum stress of 15880 psi, and a safety factor of 2.5216. The final recommendations from the design team decreased the maximum deflection to 0.24904 inches, a maximum stress of 5490.2 psi, and a safety factor of 7.2912. The recommendations were all built using SOLIDWORKS and tested using Ansys with a few recommendations showing that relatively small modifications can result in significant changes.
# Table of Contents

Acknowledgements ............................................................................................................. 2
Disclaimer .............................................................................................................................. 3
Abstract ................................................................................................................................. 4
Table of Contents .................................................................................................................. 5
Table of Figures ..................................................................................................................... 7
List of Tables ......................................................................................................................... 10
Introduction .......................................................................................................................... 11  
  Background ......................................................................................................................... 11  
  Problem ............................................................................................................................... 12  
  Set-up ................................................................................................................................. 12  
  Limitations ......................................................................................................................... 12
Objective ............................................................................................................................... 14
Procedure ............................................................................................................................ 15
Initial Design ........................................................................................................................ 17  
  Initial Design Results ....................................................................................................... 21
Initial Modification Proposals ........................................................................................... 22  
  Proposal 1 ......................................................................................................................... 22  
  Proposal 2 ......................................................................................................................... 23  
  Proposal 3 ......................................................................................................................... 24  
  Proposal 4 ......................................................................................................................... 25  
  Proposal 5 ......................................................................................................................... 26  
  Proposal 6 ......................................................................................................................... 27  
  Proposal 7 ......................................................................................................................... 28  
  Proposal 8 ......................................................................................................................... 29  
  Proposal 9 ......................................................................................................................... 30  
  Proposal 10 ....................................................................................................................... 31  
  Proposal 11 ....................................................................................................................... 32  
  Proposal 12 ....................................................................................................................... 33  
  Proposal 13 ....................................................................................................................... 34
Proposal 14..............................................................................................................35
Decision Matrix........................................................................................................36
Proposal 14................................................................................................................37
Testing.........................................................................................................................37
Proposal 14 Results .....................................................................................................40
Proposal 13..................................................................................................................41
Testing.........................................................................................................................41
Proposal 13 Results .....................................................................................................42
Proposal 12..................................................................................................................43
Testing.........................................................................................................................43
Proposal 12 Results .....................................................................................................44
Proposals 7 and 8.......................................................................................................45
Test...............................................................................................................................45
Proposals 7 and 8 Results ...........................................................................................47
Proposal 7....................................................................................................................48
Test...............................................................................................................................48
Proposal 7 Results ......................................................................................................53
Proposal 10..................................................................................................................54
Test...............................................................................................................................54
Proposal 10 Results .....................................................................................................61
Final Modification Proposals .....................................................................................62
Conclusion/Recommendations .....................................................................................63
References ..................................................................................................................64
Appendix A – Cap .......................................................................................................65
Appendix B – Plate .......................................................................................................66
Appendix C – Exterior Truss Schematic ......................................................................67
Appendix D – More Material at Vertical Support .......................................................70
Appendix E – Presentation ..........................................................................................72
Appendix F – ABET Forms .........................................................................................90
Appendix G - Résumés ...............................................................................................98
## Table of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Original Boat-Lift Being Made</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Initial Design</td>
<td>17</td>
</tr>
<tr>
<td>3</td>
<td>Initial Design Deflection Analysis</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Initial Design Deflection Analysis</td>
<td>18</td>
</tr>
<tr>
<td>5</td>
<td>Initial Design Deflection Analysis</td>
<td>19</td>
</tr>
<tr>
<td>6</td>
<td>Initial Design Stress Analysis</td>
<td>19</td>
</tr>
<tr>
<td>7</td>
<td>Initial Design Stress Analysis</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>Initial Design Safety Factor Analysis</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td>Initial Design Safety Factor Analysis</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td>Proposal 1</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td>Proposal 2</td>
<td>23</td>
</tr>
<tr>
<td>12</td>
<td>Proposal 3</td>
<td>24</td>
</tr>
<tr>
<td>13</td>
<td>Proposal 4</td>
<td>25</td>
</tr>
<tr>
<td>14</td>
<td>Proposal 5</td>
<td>26</td>
</tr>
<tr>
<td>15</td>
<td>Proposal 6</td>
<td>27</td>
</tr>
<tr>
<td>16</td>
<td>Proposal 7</td>
<td>28</td>
</tr>
<tr>
<td>17</td>
<td>Proposal 8</td>
<td>29</td>
</tr>
<tr>
<td>18</td>
<td>Proposal 9</td>
<td>30</td>
</tr>
<tr>
<td>19</td>
<td>Proposal 10</td>
<td>31</td>
</tr>
<tr>
<td>20</td>
<td>Proposal 11</td>
<td>32</td>
</tr>
<tr>
<td>21</td>
<td>Proposal 12</td>
<td>33</td>
</tr>
<tr>
<td>22</td>
<td>Proposal 13</td>
<td>34</td>
</tr>
<tr>
<td>23</td>
<td>Current Design (Left) and Proposal 14 (Right)</td>
<td>35</td>
</tr>
<tr>
<td>24</td>
<td>Before Suppression of Security Bars</td>
<td>37</td>
</tr>
<tr>
<td>25</td>
<td>After Suppression of Security Bars</td>
<td>37</td>
</tr>
<tr>
<td>26</td>
<td>Before Suppression of Security Bars Stress Analysis</td>
<td>38</td>
</tr>
<tr>
<td>27</td>
<td>After Suppression of Security Bars Stress Analysis</td>
<td>38</td>
</tr>
<tr>
<td>28</td>
<td>Before Suppression of Security Bars Deflection Analysis</td>
<td>39</td>
</tr>
<tr>
<td>29</td>
<td>After Suppression of Security Bars Deflection Analysis</td>
<td>39</td>
</tr>
</tbody>
</table>
Figure 30: Before (Left) and After (Right) Suppression Stress Analysis ......................................... 41
Figure 31: Before (Left) and After (Right) Suppression Stress Analysis ......................................... 42
Figure 32: Before (Left) and After (Right) Suppression Stress Analysis ......................................... 43
Figure 33: Before (Left) and After (Right) Suppression Stress Analysis ......................................... 44
Figure 34: Before (Left) and After (Right) Extension Deflection Analysis ...................................... 45
Figure 35: Before (Left) and After (Right) Extension Stress Analysis ............................................. 46
Figure 36: Before (Left) and After (Right) Extension Stress Analysis ............................................. 47
Figure 37: Before Addition of Exterior Truss .................................................................................. 48
Figure 38: After Addition of Exterior Truss .................................................................................... 48
Figure 39: Before Addition of Exterior Truss Deflection Analysis .................................................. 49
Figure 40: After Addition of Exterior Truss Deflection Analysis ..................................................... 49
Figure 41: Before Addition of Exterior Truss Stress Analysis .......................................................... 50
Figure 42: After Addition of Exterior Truss Stress Analysis ............................................................ 50
Figure 43: Before (Left) and After (Right) Addition of Exterior Truss Stress Analysis ................. 51
Figure 44: Before (Left) and After (Right) Addition of Exterior Truss Stress Analysis ................. 51
Figure 45: Before Addition of Exterior Truss Safety Factor Analysis .............................................. 52
Figure 46: After Addition of Exterior Truss Safety Factor Analysis ................................................. 52
Figure 47: Before (Left) and After (Right) Addition of Exterior Truss Safety Factor Analysis ... 53
Figure 48: Before Addition of Material .......................................................................................... 54
Figure 49: After Addition of Material (Green) .............................................................................. 54
Figure 50: Before Addition of Material Deflection Analysis ............................................................ 55
Figure 51: After Addition of Material Deflection Analysis ............................................................... 55
Figure 52: Before Addition of Material Stress Analysis ................................................................... 56
Figure 53: After Addition of Material Stress Analysis ...................................................................... 56
Figure 54: Before Addition of Material Stress Analysis .................................................................. 56
Figure 55: After Addition of Material Stress Analysis ..................................................................... 56
Figure 56: Before (Left) and After (Right) Addition of Material Stress Analysis ..................... 58
Figure 57: Before (Left) and After (Right) Addition of Material Stress Analysis ..................... 58
Figure 58: After Addition of Material Important Stress Areas ....................................................... 59
Figure 59: Before Addition of Material Safety Factor Analysis ...................................................... 60
Figure 60: After Addition of Material Safety Factor Analysis ......................................................... 60
Figure 61: Before (Left) and After (Right) Addition of Material Safety Factor Analysis ...........61
Figure 62: Cap Top View (inches) ..................................................................................65
Figure 63: Cap Side View (inches) ..................................................................................65
Figure 64: Plate Side View (inches) ..................................................................................66
Figure 65: Plate Front View (inches) ..................................................................................66
Figure 66: Truss Support Side View (inches) .....................................................................67
Figure 67: Truss Support Side View (inches) .....................................................................67
Figure 68: Truss Support Front View (inches) .....................................................................68
Figure 69: Horizontal Truss Support Side View (inches) ......................................................69
Figure 70: Horizontal Truss Support Front View (inches) .....................................................69
Figure 71: More Material Side View (inches) .......................................................................70
Figure 72: More Material Front View (inches) ....................................................................70
Figure 73: More Material Top View (inches) ......................................................................71
List of Tables

Table 1: Benchmark .................................................................................................................. 21
Table 2: Decision Matrix........................................................................................................... 36
Table 3: Proposal 14 Results .................................................................................................... 40
Table 4: Proposal 13 Results .................................................................................................... 42
Table 5: Proposal 7 Results .................................................................................................... 53
Table 6: Proposal 10 Results .................................................................................................... 61
Table 7: Results Summary and Recommendations ................................................................. 62
Introduction

Background

Michigan is surrounded by large bodies of water with most of the population of Michigan being within miles from the nearest lake. With the large amounts of water, there are a large amount of boats, which means there is a need to store the boats during the boating season. There are a number of ways to store a boat during the boating season without having to remove the boat completely from the lake. Many people use a marina to store their boats during the year and they simply tie the boat to the dock and get out. However, it is almost impossible to clean, customize or repair the bottom half of the boat using a dock because it is underwater. There is also a benefit in longevity to keeping the boat above water. Therefore, some people decide on using boat-lifts.

A boat-lift is a structure that is placed permanently in shallow water. To use the boat-lift the driver simply drives into the space that the lift occupies, activates the lift, then the lift raises the boat out of the water. The lift offers the benefit of allowing the owner to clean, customize, and make repairs on the whole boat without spending the time it takes to get the boat out of the water using a truck and bringing it to a place to get the cleaning, customization or repairs.

The customer owns a small business, “Great Lake Lifts” in Caro, Michigan. “Great Lake Lifts” specializes in building boat-lifts and docks. The boat-lifts can hold a wide variety of boat sizes. The lifts are made to be placed permanently in the lakes, so the boat operator can simply drive into the lift and park. Boat-lifts must be able to hold a boat of a certain size and weight for months at a time. At the moment, the largest boat lift being made is designed to hold a 6000 lb. boat.
Problem

The lifts produced at Great Lakes Lifts have never been structurally, therefore the lifts could have too much or even not enough material in over designed or high stress areas. The lifts may have locations where more material could greatly extend the life or strength of the lift, and locations where it would be possible to reduce material to save on cost. The designer was only able to use experimental testing, resulting in possible inefficiencies and overdesign.

Set-up

The design team theoretically analyzed the lift that holds 6000 lb. boats. Using software SOLIDWORKS and Ansys, the team recreated the current lift, then analyzed applying the same 8000 lb. testing weight used by the customer. Following the testing of the initial design, the team analyzed the points in the current design that could be improved. The team made modifications according to the results of the analysis until it was believed that a sufficient design was completed.

Currently the lift has a hydraulic system in place to lift the boats out of the water. This lift has proven to be acceptable in real world situations. The structure that the boat rests on has also proven to be reliable and relatively no changes could be made, so it would be considered acceptable. The lifts are generally stationary, therefore it was decided to only do the analysis in the static position, i.e. when the lift was holding a boat. The dynamic forces of the lift were ignored for this testing.

Limitations

Due to the size and time needed to properly make the lift, along with the time of year the design team’s analysis was completed, it was not possible to get an experimental test done for the final design that was decided on. In order to account for the fact that there was no
experimental testing completed and the design team had no experience with designing boat-lifts, the team was constantly in contact with industry and faculty mentors to understand if proposed ideas were possible/beneficial to the end goal. While the design team made the changes, there was constant contact to make sure everything was going in the direction the mentors believed were important.
Objective

The objective of the team was to analyze the current lift being made and make modifications to improve the design. The team used material that the current manufacturer had at its disposal because it was proven to be effective. The modifications were approved by the mentors before testing began. The design team was only making recommendations for modifications that would improve the structural soundness of the lift. At the very least, the customer would be able to understand where the weak points in the current design were, even if none of the recommendations were used. At most, the customer would be able to make changes that could greatly improve important characteristics of the lift. All of the data collected was presented to the customer so an informed decision could be made.
Procedure

To begin, the design team met with the customer to ensure that there was a clear understanding of the end goal. Once an agreed upon goal was met, the team began taking measurements of the current lift being made. While taking the dimensions and creating schematics of the lift, the team asked vital questions to help gain a further understanding of key elements that are needed when creating boat-lifts. Also, the team looked at some other designs that the customer makes so that they could identify important features needed.

Following the collection of the dimensions of the current lift design, the team began modeling in SOLIDWORKS. Using the design created, it was exported into a testing software, Ansys, to begin theoretically testing the lifts similarly to the experimental testing. The customer tested the lifts by placing a cylinder filled with water to a weight of 8000 lbs. then placed the cylinder in the same location the boat would be to mimic the real world conditions of the boat's weight.

The initial theoretical testing allowed the team to see where the lifts’ highest stress and deflection areas were, along with the lowest safety factor. The team then modified the current lift design to make it more structurally sound and/or reduce material in areas where the lift was overdesigned. The team suggested a number of modifications that could be made to the customer and mentors. If approved, the design team continued with that possible modification, if rejected, the design team immediately stopped the process of including that possible modification. The design team then used a decision matrix to determine which modifications should be further pursued.

The design team tested the modifications that the decision matrix showed could improve the design of the lift. The design team compared the before and after results of the modifications
to show whether or not they helped. After completion of the testing of the final modifications, the team summarized how each change helped the lifts overall design.

Figure 1: Original Boat-Lift Being Made
Initial Design

The initial design was very important as the benchmark of what the current design standards were. Using Ansys, a simulation of the initial design was tested to understand where the highest amounts of stress and deflection, while also finding where the lowest safety factor occurred.

Figure 2: Initial Design
Figure 3: Initial Design Deflection Analysis

Figure 4: Initial Design Deflection Analysis
Figure 5: Initial Design Deflection Analysis

Figure 6: Initial Design Stress Analysis
Figure 7: Initial Design Stress Analysis

Figure 8: Initial Design Safety Factor Analysis
Initial Design Results

The initial design allowed the design team to get a benchmark of the characteristics that would need to be improved and where to improve them. Table 1 shows the benchmarking data used.

<table>
<thead>
<tr>
<th>Max Deflection (in.)</th>
<th>Max Stress (psi)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.43846</td>
<td>15880</td>
<td>2.5216</td>
</tr>
</tbody>
</table>

*Table 1: Benchmark*
Initial Modification Proposals

Proposal 1

After the initial testing and analysis of the data, it was concluded that the hydraulic side had a much lower maximum stress, less deflection, and a higher safety factor. The team decided it would make the non-hydraulic side match the hydraulic side, by adding the blue horizontal bar seen in Figure 10. However, after discussing the possible change with the customer, it was decided that this would not be a practical solution. The addition caused a problem for the user of the lift to get out of the boat and onto the deck. The hydraulic side needed the support bar because that is what supports the hydraulic lift.
Proposal 2

The initial design showed that the most deflection occurred at points 1 and 2, the points that hold the interior frame. Proposal 2 was created to help reduce deflection by raising the height at the point of contact between bars 3 and 4, and bars 6 and 7. The initial design showed that at the points of contact between bars 3 and 4, and bars 6 and 7, there was a small amount of deflection. However, the angle that was created between the bars caused it to make points 1 and 2 have a large deflection. Raising the bars helped to reduce the effect the angle had on the total deflection at points 1 and 2. Bar 5 was raised to help with the load at bars 4 and 6. However, the design would help the deflection at points 1 and 2, but greatly increased the maximum stress seen by the lift.

Figure 11: Proposal 2
Proposal 3 was intended to have the same effect as Proposal 2, which was to reduce the deflection seen at the top points. The non-vertical blue bars added reduced the effect at the top of the structure from the angle caused by the non-vertical blue bars. Proposal 3 also used a “Y” shape so that the 2 non-vertical bars will cancel out the horizontal forces of each other when doing the summation of forces at the intersection of the blue bars. Proposal 3 presented the same problems that Proposal 2 had while also adding a larger stress at the center of the horizontal black bar, which was a problem area when the customer was experimentally testing the original design.
Similar to Proposal 3, Proposal 4 used somewhat of a “Y” shape intended to decrease deflection at the top of the structure. Unlike Proposal 3, Proposal 4 would allow for the stress to be distributed along the horizontal black beam. Proposal 4 caused a greater stress at the top of the structure which was too high. Proposal 4 also would mean more manufacturing time and material cost when compared to Proposal 2, therefore there would be no benefit that Proposal 2 would not give.
Proposal 5

Proposal 5 included the added horizontal blue bar, reducing stress and deflection, much like Proposal 1. Unlike Proposal 1, Proposal 5 included two “Y” shaped support bars, these bars would help with the stress and deflection seen by the horizontal blue bar. However, like with Proposal 1, there can be no added horizontal bar because it makes it harder for the lift user to get out and onto the deck.

Figure 14: Proposal 5
Based on Proposal 2, Proposal 6 had the added benefit of reducing the stress seen by the horizontal black bar. Bars 5 and 7 took some of the stress given by bars 4 and 8 to the horizontal black bar and distributed it to bars 3 and 9. Bars 3 and 9 only had a small amount of stress, relative to how much it can hold, below the contacting points of bars 4 and 8 so it was more than capable of handling the extra stress. Unfortunately, like Proposal 2 there was still a very large stress seen by points 1 and 2. Proposal 6 also made it much more difficult for the lift user to get inside the boat lift if they would like to examine their boat while it was suspended in the air.
Proposal 7

Figure 16: Proposal 7

Proposal 7 used an exterior truss system to help reduce the deflection and stress seen at the top of the lift. Proposal 7 needed more material and manufacturing time to produce.
Proposal 8 was an addition to Proposal 7. Proposal 8 consisted of increasing the length of the vertical supports, allowing for the exterior additions to have a greater affect because of the increased moment arm. Proposal 8 needed more manufacturing time and material to produce.
Proposal 9

Figure 18: Proposal 9

Proposal 9 had the same concept of Proposal 7, allowing for a decrease in stress and deflection. However, with this design the exterior additions stuck out from the frame much further and the stress seen at the points where the blue bars contacted each other would be very high, causing possible problems.
Proposal 10 helped by increasing the area moment of inertia of the vertical supports. The vertical supports would have less stress, less deflection, and a larger factor of safety.
Proposal 11 was designed to help reduce the maximum stress seen by the black horizontal support bar. When experimentally tested, the initial design had a problem with bending and stress in the black horizontal support bar, adding the blue bars would have helped. The blue bars did not reduce the total load, instead it distributed the load evenly throughout the bar. However there was a problem with the ease of access to the inside of the lift because the blue bars cut off possible areas to enter.
Proposal 12 focused on the load-bearing lever; the lever that held the cable that held the interior frame. The dotted red triangle, currently in place on the lever, was a solid piece on the lift that helps support the load bearing lever and was on the inside of the lift. There was not a supporting triangular piece on the outside because it was too complicated to weld there. There was a slight extension from the vertical support that another triangular support piece could be added to. The added triangular piece went upwards instead of down meaning there would still be space to weld.
The load bearing lever is hollow. Proposal 13 increased the strength of the load bearing lever by adding a cap that was welded at the end of the piece, this was a small change that could increase the strength a significant amount.
Proposal 14

Looking at side-view of the lift, there were extra security support bars that are angled as seen in Figure 23 in the current design section. The security bars that were removed in Proposal 14 seemed as if they could be removed with virtually no downside. Removing the security bars also allowed for easier access to the inside of the lift for the boat driver.
Decision Matrix

Based on the proposals described previously, the decision matrix shown in Table 2 was created to help decide if further testing would be needed on each proposal. The decision matrix was created with the priority being on customer approval. If the proposal did not get the customers approval it was immediately dismissed from further testing. The next priority was on the safety factor. If it was felt that the design could fail it was given a -20, if it did not help it was given a 0, and if it would help it was given a 20. The remaining categories of the decision matrix were stress reduction, deflection reduction, ease of access and material, each with a maximum and minimum score of ±10 points. The colors in Table 2 were used to indicate the categories that the proposals would have an effect on, with orange (Proposals 1-6, 11, and 14) being interior changes, green (Proposals 7-10) being exterior changes, and blue (Proposals 12 and 13) being changes to the load bearing lever.

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Approval</th>
<th>Safety</th>
<th>Stress Reduction</th>
<th>Deflection Reduction</th>
<th>Ease of Access</th>
<th>Material</th>
<th>Total</th>
<th>Further Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-20</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>-30</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-5</td>
<td>35</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

*Table 2: Decision Matrix*
Proposal 14

Testing

Proposal 14 was tested using Ansys to understand the impact of removing the security bars, as seen in Figure 24 and 25. Comparisons before and after the elimination of the bars were made.

Figure 24: Before Suppression of Security Bars

Figure 25: After Suppression of Security Bars
Figure 26: Before Suppression of Security Bars Stress Analysis

Figure 27: After Suppression of Security Bars Stress Analysis
Figure 28: Before Suppression of Security Bars Deflection Analysis

Figure 29: After Suppression of Security Bars Deflection Analysis
Proposal 14 Results

The Ansys simulations gave the values shown in Table 3.

<table>
<thead>
<tr>
<th>Proposal 14</th>
<th>Max Stress (psi)</th>
<th>Max Deflection (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>15880</td>
<td>0.43843</td>
</tr>
<tr>
<td>After</td>
<td>15880</td>
<td>0.45649</td>
</tr>
</tbody>
</table>

Table 3: Proposal 14 Results

Based on Table 3, it can be seen that the security bars had a relatively negligible influence on the maximum stresses and deflections. However, after contacting the customer, it was agreed that while the security bars do relatively nothing in an ideal situation, when in non-ideal situations such as a strong current the bars gave horizontal support. Therefore, the security bars were considered to have an important impact on the design in the case of unpredictable circumstances.
Proposal 13

Testing

Proposal 13 was tested using Ansys to understand how significant the addition of a cap at the end of the supporting lever would be. A schematic of the cap can be seen in Appendix A.

Figure 30: Before (Left) and After (Right) Suppression Stress Analysis
Proposal 13 Results

The Ansys simulations gave the values shown in Table 4.

<table>
<thead>
<tr>
<th>Proposal 13</th>
<th>Max Stress (psi)</th>
<th>Change (psi)</th>
<th>Change (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>15880</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>After</td>
<td>7132.8</td>
<td>-8747.2</td>
<td>55.08%</td>
</tr>
</tbody>
</table>

Table 4: Proposal 13 Results

Based on Table 4, it can be seen that the cap had a significant change in the stress of the system. The cap added an extra support in the place that holds the most stress. The cap was a relatively small change that had a significant impact on the stress analysis, causing the maximum stress to decrease by more than half.
Proposal 12

Testing

Proposal 12 was analyzed using Ansys to understand how significant adding an extra supporting plate on the other side of the supporting lever would affect the stress. A schematic of the supporting plate can be seen in Appendix B.

![Figure 32: Before (Left) and After (Right) Suppression Stress Analysis](image)
Proposal 12 Results

The extra plate support actually increased the maximum principle stress by about 750 psi, but “shifted” the stress to a more ideal area. By removing the maximum principle stress from the junction corner of the supporting lever to the center of the new support plate, there is a lower chance of failure, even with a higher principle stress value.
Proposals 7 and 8

Test

Proposals 7 and 8 were very similar, except Proposal 8 had an extended vertical support. Therefore, the proposals were tested independently from the actual lift to simply analyze which design produced better results.

Figure 34: Before (Left) and After (Right) Extension Deflection Analysis
Figure 35: Before (Left) and After (Right) Extension Stress Analysis
Proposals 7 and 8 Results

It can be seen that there was no significant changes in the overall deflection. The stress was slightly higher in the extended vertical analysis, it was a change from the current design, and it increased material, therefore it was decided that Proposal 7 was superior to Proposal 8.
Proposal 7

Test

Proposal 7 was tested using Ansys to determine the effect that a support truss on the outside of the lifts frame had. A schematic of the exterior truss can be seen in Appendix C.

![Figure 37: Before Addition of Exterior Truss](image1)

![Figure 38: After Addition of Exterior Truss](image2)
Figure 39: Before Addition of Exterior Truss Deflection Analysis

Figure 40: After Addition of Exterior Truss Deflection Analysis
Figure 41: Before Addition of Exterior Truss Stress Analysis

Figure 42: After Addition of Exterior Truss Stress Analysis
Figure 43: Before (Left) and After (Right) Addition of Exterior Truss Stress Analysis

Figure 44: Before (Left) and After (Right) Addition of Exterior Truss Stress Analysis
Figure 45: Before Addition of Exterior Truss Safety Factor Analysis

Figure 46: After Addition of Exterior Truss Safety Factor Analysis
Proposal 7 Results

Proposal 7 produced significant changes in the deflection by decreasing the maximum deflection by about 72% or 0.31 inches. The maximum stress seen by the lift was also decreased by about 12% or 900 psi. With all of the improvements, the safety factor was increased by about 13% or 0.7. Table 5 shows the values of the before and after along with the changes. It can be seen that Proposal 7 significantly helped the lift by improving important categories. Another important note is the location of the maximum stress. Due to limitations in the Ansys program, it didn’t account for the lack of weld at the join (seen in green in Figure 47) and therefore assumed a higher stress than would actually occur.

<table>
<thead>
<tr>
<th>Proposal 7</th>
<th>Max Deflection (in.)</th>
<th>Max Stress (psi)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0.43664</td>
<td>7736.6</td>
<td>5.1742</td>
</tr>
<tr>
<td>After</td>
<td>0.12032</td>
<td>6832.3</td>
<td>5.859</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.31632</td>
<td>-904.3</td>
<td>0.6848</td>
</tr>
<tr>
<td>Percent Difference</td>
<td>-72.44%</td>
<td>-11.69%</td>
<td>13.23%</td>
</tr>
</tbody>
</table>

*Table 5: Proposal 7 Results*
Proposal 10

Test

Proposals 10 was tested using Ansys to determine the effect that adding material at the vertical supports had. A schematic of adding material can be seen in Appendix D.

Figure 48: Before Addition of Material

Figure 49: After Addition of Material (Green)
Figure 50: Before Addition of Material Deflection Analysis

Figure 51: After Addition of Material Deflection Analysis
Figure 52: Before Addition of Material Stress Analysis

Figure 53: After Addition of Material Stress Analysis
Figure 54: Before Addition of Material Stress Analysis

Figure 55: After Addition of Material Stress Analysis
Figure 56: Before (Left) and After (Right) Addition of Material Stress Analysis

Figure 57: Before (Left) and After (Right) Addition of Material Stress Analysis
Figure 58: After Addition of Material Important Stress Areas
Figure 59: Before Addition of Material Safety Factor Analysis

Figure 60: After Addition of Material Safety Factor Analysis
Proposal 10 Results

Proposal 10 made significant improvements in the deflection, maximum stress, and safety factor. The deflection was decreased by about 43% or 0.19 inches. The maximum stress was decreased by about 29% or 2200 psi. The safety factor was increased by about 41% or 2.1. Table 6 shows the values of the before and after along with the changes. It can be seen that Proposal 10 significantly helped the lift by making improvements to important categories.

<table>
<thead>
<tr>
<th>Proposal 10</th>
<th>Max Deflection (in.)</th>
<th>Max Stress (psi)</th>
<th>Safety Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>0.43664</td>
<td>7736.6</td>
<td>5.1742</td>
</tr>
<tr>
<td>After</td>
<td>0.24904</td>
<td>5490.2</td>
<td>7.2912</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.1876</td>
<td>-2246.4</td>
<td>2.117</td>
</tr>
<tr>
<td>Percent Difference</td>
<td>-42.96%</td>
<td>-29.04%</td>
<td>40.91%</td>
</tr>
</tbody>
</table>

*Table 6: Proposal 10 Results*
Final Modification Proposals

The theoretical models show that there were changes that could be made to improve the structural integrity of the boat lift. The proposed changes ranged from adding a small piece to adding a large exterior structure. Table 7 shows possible variations along with the recommendations from the design team.

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Description</th>
<th>Deflection</th>
<th>Max Stress</th>
<th>Safety Factor</th>
<th>Difficulty of Assembly</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Exterior Truss</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Increased</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>More Material at Vertical Support Bars</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Increased</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Extra Plate at Supporting Lever</td>
<td>No Change</td>
<td>Increased</td>
<td>No Change</td>
<td>Slightly increased</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Cap at Supporting Lever</td>
<td>No Change</td>
<td>Decreased</td>
<td>Increased</td>
<td>Slightly increased</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Removal of Security Bars</td>
<td>Increased</td>
<td>No Change</td>
<td>No Change</td>
<td>Decreased</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 7: Results Summary and Recommendations

Proposal 7 and 10 were not tested together due to the fact that both produced results that made the lift very structurally sound and combining the two would result in over engineering. The designs chosen were based solely on the theoretical results based on decreasing the deflection the lift underwent and the maximum stress that the lift would be subjected to, while also on increasing the safety factor.
Conclusion/Recommendations

The design team was able to successfully analyze the initial design that is currently in production and find areas that could be improved. The design team suggested modifications that could greatly improve the design of the lift. The customer now has a better understanding of the areas that can be improved to increase the life of the lift. The customer also has multiple recommendations that if used were shown to greatly increase the quality of the lift.

While simulation is a tool that helps to understand how the design will work, it is not guaranteed to match the experimental results. Simulation should only be done as a way to understand how the design could react to the function it will perform. However, simulation allows the user to gather important information that could otherwise not be seen or ignored.
References


Appendix A – Cap

Figure 62: Cap Top View (inches)

Figure 63: Cap Side View (inches)
Appendix B – Plate

Figure 64: Plate Side View (inches)

Figure 65: Plate Front View (inches)
Appendix C – Exterior Truss Schematic

Figure 66: Truss Support Side View (inches)

Figure 67: Truss Support Side View (inches)
Figure 68: Truss Support Front View (inches)
Figure 69: Horizontal Truss Support Side View (inches)

Figure 70: Horizontal Truss Support Front View (inches)
Appendix D – More Material at Vertical Support

Figure 71: More Material Side View (inches)

Figure 72: More Material Front View (inches)
Figure 73: More Material Top View (inches)
INTRODUCTION

• “Great Lakes Lift”
  • Located in Caro, Michigan
  • Boat-lifts and docks

• Boat-Lifts
  • Range in size (up to 6000 lb.)
  • Lifts boat out of water
  • Permanently placed in water
OBJECTION

- There has never been any simulations performed
- Simulate current 6000 lb. lift
- Find potential trouble areas
  - High deflection and/or stress
  - Low factor of safety
- Theoretically modify and simulate possible changes
  - Improve quality of lift
- Give final recommendations based on data

INITIAL DESIGN
INITIAL DESIGN - DEFLECTION

INITIAL DESIGN - STRESS
INITIAL DESIGN – SAFETY FACTOR

- Maximum Deflection of 0.43846 inches
- Maximum Stress of 15880 psi
- Safety Factor of 2.5216

INITIAL DESIGN – CONCLUSION
INITIAL MODIFICATION PROPOSALS

Proposal 1

Proposal 2

Proposal 3

Proposal 4

Proposal 5

Proposal 6

Proposal 7

Proposal 8

Proposal 9

Proposal 10

Proposal 11

Proposal 12

Proposal 13

Proposal 14
### DECISION MATRIX

<table>
<thead>
<tr>
<th>Proposal</th>
<th>Approval</th>
<th>Safety</th>
<th>Stress Reduction</th>
<th>Defection Reduction</th>
<th>Ease of Access</th>
<th>Material</th>
<th>Total</th>
<th>Further Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-20</td>
<td>No</td>
</tr>
<tr>
<td>3</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>No</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>-20</td>
<td>-10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>-30</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>30</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-10</td>
<td>10</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>-5</td>
<td>35</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>No</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No</td>
</tr>
<tr>
<td>12</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Yes</td>
<td>20</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>-2</td>
<td>28</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>10</td>
<td>20</td>
<td>20</td>
<td>Yes</td>
</tr>
</tbody>
</table>

### PROPOSAL 14 – REMOVING SECURITY BARS

Before

After
PROPOSAL 14 – REMOVING SECURITY BARS - STRESS

Before

![Before Stress Image]

After

![After Stress Image]

PROPOSAL 14 – REMOVING SECURITY BARS - DEFLECTION

Before

![Before Deflection Image]

After

![After Deflection Image]
PROPOSAL 13 – CAP

Before

After

PROPOSAL 13 – CAP – STRESS

Before

After
PROPOSAL 12 – EXTRA PLATE

Before

After

PROPOSAL 12 – EXTRA PLATE

Before

After
PROPOSALS 7 & 8 – DEFLECTION

Proposal 7

Proposal 8

PROPOSALS 7 & 8 – STRESS

Proposal 7

Proposal 8
PROPOSAL 7 – EXTERIOR TRUSS

Before

After

PROPOSAL 7 – EXTERIOR TRUSS – DEFLECTION
PROPOSAL 7 – EXTERIOR TRUSS - STRESS

Before

After

PROPOSAL 7 – EXTERIOR TRUSS – SAFETY FACTOR

Before

After
PROPOSAL 10 – ADDED MATERIAL

Before

After

PROPOSAL 10 – ADDED MATERIAL – DEFLECTION
PROPOSAL 10 – ADDED MATERIAL – STRESS

Before

After

PROPOSAL 10 – ADDED MATERIAL

Before

After
<table>
<thead>
<tr>
<th>Proposal</th>
<th>Description</th>
<th>Deflection</th>
<th>Max Stress</th>
<th>Safety Factor</th>
<th>Difficulty of Assembly</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Exterior Truss</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Increased</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>More Material at Vertical Support Bars</td>
<td>Decreased</td>
<td>Decreased</td>
<td>Increased</td>
<td>Increased</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>Extra Plate at Supporting Lever</td>
<td>No Change</td>
<td>Increased</td>
<td>No Change</td>
<td>Slightly increased</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>Cap at Supporting Lever</td>
<td>No Change</td>
<td>Decreased</td>
<td>Increased</td>
<td>Slightly increased</td>
<td>Yes</td>
</tr>
<tr>
<td>14</td>
<td>Removal of Security Bars</td>
<td>Increased</td>
<td>No Change</td>
<td>No Change</td>
<td>Decreased</td>
<td>No</td>
</tr>
</tbody>
</table>

**QUESTIONS?**
REFERENCES


Appendix F – ABET Forms

Form 1
To be completed by student

Assessment of Student Outcome # c
ME 4800

“An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political ethical, health and safety, manufacturability, and sustainability” is listed in ABET General Criterion 3. Student Outcomes as one of the student outcomes to be assessed for both Mechanical and Aerospace Engineering programs. As part of your design project, you are required to fill out this form and include it in your ME4800 Final Report, please include the page numbers where the questions following are addressed.

Evaluation of student outcome “An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political ethical, health and safety, manufacturability, and sustainability”

1. This project involved the design of a: system / component / process
   Description:
   The redesign of a current boat-lift.

2. The need:
   Help a customer understand the problems in the current design and fix them.

3. The constraints: (discuss the constraints that were relevant to the project. At least 3 constraints must be addressed.)

   Economic:
   Cannot over engineer the design or change material to something more expensive that will be better suited for this design because the cost would out way the profit

   Environmental:
   Must be able to withstand the environment of Michigan all year round

   Social:

   Political:

__________________________________________________________________________
4. Is there a potential for a new patent in your design? Explain and compare to similar patents.

No
Form 2
To be completed by student

Assessment of Student Outcome #j

ME 4800

“A knowledge of contemporary issues” is listed in ABET General Criterion 3. Student Outcomes as one of the student outcomes to be assessed for both Mechanical and Aerospace Engineering programs. The Mechanical Engineering Faculty Members have defined “A knowledge of contemporary issues” as knowledge and application of new technologies or recent innovations, satisfaction of the company’s existing customers, comparison of the proposed design with the competitor’s products, well-being and performance of other employers, safety and legal issues, new standards or recent product regulations, and possibility of product patent. As you work on your senior design project, we ask you to answer the following questions. These questions will help you to create the ideas needed to successfully complete your project and hence your ME4800 final report. You are required to fill out this form and submit it with your final report. Please include the page numbers where the following questions are addressed.

Evaluation of student outcome “A knowledge of contemporary issues”

1. Why is this project needed now?

The current product has never had any theoretical analysis performed on the design.

2. Describe any new technologies and recent innovations utilized to complete this project and how will it improve satisfaction of the company’s existing customers?

Manufacturing processes that may increase life.

3. If this project is done for a company – how will it expand their potential markets?

By updating the design, more customers will choose this product over their competitors. This may not expand the market, but rather capture more of the existing customers.

How will it improve satisfaction of the company’s existing customers?

An updated product make their product more appealing, giving the existing customers the option for a better product.
Identify the competitors for this type of product, and compare the proposed design with the products of the company’s competitors.

Most competitors use a dock, the difference is that the lift is permanently in the water and will allow the user to go under the boat if they wish and get it completely out of the water.

4. How did you address any safety and/or legal issues pertaining to this project? (e.g., OSHA, EPA, Human Factors, etc.)

Fortunately, there are very few regulations that have to do with the product we are redesigning. But since this is a redesign, we will follow the existing regulations.

5. Are there any foreseeable future standards or regulations on the horizon that could impact the development of the project?

None that we are aware of.


No, there is not really a potential product.
Form 3
To be completed by student

Assessment of Student Outcome # h
ME 4800

“An understanding of the impact of engineering solutions in a global, environmental and societal context” is listed in ABET General Criterion 3. Student Outcomes as one of the student outcomes to be assessed for both Mechanical and Aerospace Engineering programs. As you work on your senior design project, we ask you to answer the following questions. These questions will help you to create the ideas needed to successfully complete your project and hence your ME4800 final report. You are required to fill out this form and submit it with your final report. Please include the page numbers where the following questions are addressed.

Evaluation of student outcome “An understanding of the impact of engineering solutions in a global, environmental and societal context”

1. Is this project useful outside of the United States? Explain why.
   Yes, this project is useful anywhere that has a body of water, however it is made for fresh water and has not been tested in salt water.

2. Does your project comply with U.S. and/or international standards or regulations? Which standards are applicable?
   Yes, the boat lifts will be redesigned, therefore they have already been sold, and we will simply update them.

3. Is this project restricted in its application to specific markets or communities? To which markets or communities?
   Yes, this project will only help those who have boats of a specific size and weight range.

4. If the answer to any of the following items is affirmative, explain how and where, when relevant. What actions did you take to address the issues?
   The major impact is the efficiency of making the product, reducing size, cost, and weight while increasing strength and life.
Design is focused on serving human needs. Design also can either negatively or positively influence quality of life. Address the impact of your project on the following areas.

**Air Quality?**  
N/A

**Water Quality?**  
N/A

**Food?**  
N/A

**Noise Level?**  
N/A

Does the project impact:

**Human health?**  
N/A

**Wildlife?**  
N/A

**Vegetation?**  
N/A

Does this project improve:

**Human interaction?**  
N/A

**Well-being?**  
Yes, it will make it easier to dock a person’s boat.

**Safety?**  
Yes, it increases the safety factor of the lift

**Others?**  
It will improve the longevity of the lifts
Form 4
To be completed by student

Assessment of Student Outcome # i
ME 4800

“A recognition of the need for, and ability to engage in life-long learning” is listed in ABET General Criterion 3. Student Outcomes as one of the student outcomes to be assessed for both Mechanical and Aerospace Engineering programs. As you work on your senior design project, we ask you to answer the following questions. These questions will help you to create the ideas needed to successfully complete your project and hence your ME4800 final report. You are required to submit the completed form in the last appendix of your final report.

Your responses will be used in the Evaluation of student outcome “A recognition of the need for, and ability to engage in life-long learning.”

A well-organized team brings together the necessary backgrounds and talents needed to successfully develop and complete the design process. Each team member plays an important role on the design team. Team members must be prepared to acquire any new additional skills, and improve existing ones during the development of the project. Your answers to the questions below will be used to evaluate a) your understanding of the need for life-long learning and b) your ability to recognize the need of acquiring new knowledge/skills when required.

ME 4800
Mechanical and Aerospace Engineering Design Project

For each team member:
NAME: Nathan Schick

1. List the skills you needed to execute your responsibilities on the project as outlined in ME 4790.

   Finite-element analysis as well as drafting and design.

2. Explain how you acquired or improved the skills needed for the completion the project.

   Practice and meet with people who have experience in modeling and testing.
Form 4
To be completed by student

Assessment of Student Outcome # i
ME 4800

“A recognition of the need for, and ability to engage in life-long learning” is listed in ABET General Criterion 3. Student Outcomes as one of the student outcomes to be assessed for both Mechanical and Aerospace Engineering programs. As you work on your senior design project, we ask you to answer the following questions. These questions will help you to create the ideas needed to successfully complete your project and hence your ME4800 final report. You are required to submit the completed form in the last appendix of your final report.

Your responses will be used in the Evaluation of student outcome “A recognition of the need for, and ability to engage in life-long learning.”

A well-organized team brings together the necessary backgrounds and talents needed to successfully develop and complete the design process. Each team member plays an important role on the design team. Team members must be prepared to acquire any new additional skills, and improve existing ones during the development of the project. Your answers to the questions below will be used to evaluate a) your understanding of the need for life-long learning and b) your ability to recognize the need of acquiring new knowledge/skills when required.

ME 4800
Mechanical and Aerospace Engineering Design Project

For each team member:
NAME: Jacob Tussey

1. List the skills you needed to execute your responsibilities on the project as outlined in ME 4790.

   3D modeling, FEA analysis, customer communication

2. Explain how you acquired or improved the skills needed for the completion the project.

   Hard work, putting in the time, as well as lots of tutorial videos and practicing.
Appendix G - Résumés

Nathan Schick
20312 Maxine, St. Clair Shores, Michigan 48080
T: (586) 218-0247    E: nsn3615@wmich.edu

Objective
To secure an engineering position that will utilize my knowledge of engineering while working in an environment that will allow for continued personal and professional growth.

Professional Development
- Field Experience Working in both Office and Manufacturing Plant Environments
- General Member of Sun-seeker, Mechanical Engineering Team
- Outstanding Knowledge of Science Award recipient
- Oakland Math Competition Winner 2010, 2013
- General Member of Honors Engineering Fraternity (Tau Beta Pi)
- Education Committee Member, in National Honor Society, 2012-2014
- Parkway Christian School Basketball Captain 2013, 2014
- Parkway Christian School Football Captain 2013

Education
Western Michigan University, Kalamazoo, MI
- Major in Mechanical Engineering
- Minor in Mathematics
- Masters in Mechanical Engineering
- 3.76 Cumulative GPA
- Enrolled in Lee’s Honor College
  December 2017
  December 2018

Internship Experience
Manufacturing Engineer Intern, General Motors, Warren, MI
- Gained field experience working in plants and offices
- Showed initiative by taking on additional tasks
- Presented findings that changed processes in stamping plants
  May 2016-August 2016

Work Experience
Busser/Food Runner, Mike’s On The Water, St. Clair Shores, MI
- Performed critical duties in the establishment to increase productivity
- Assisted servers by providing food to patrons
- Administered knowledge of restaurant and surrounding areas to better the experience for patrons
  June 2013-August 2015

Special Olympics, Macomb County, MI
- Arranged a fun and safe environment for those that are differently abled
- Exuded a positive and encouraging attitude to increase morale during difficult tasks
- Observed patterns and changed coaching methods to help foster skills in individuals that were unable to acquire skills traditionally
  April 2012-May 2014

References available upon request
Jacob Tussey
4174 Hawthorne Ridge, Apt 101 Kalamazoo, MI 49006
jake@caromotorsports.com
(989)-912-9984

OBJECTIVE
Obtain an engineering position in which I can help the team succeed. As a soon-to-be Mechanical Engineering graduate with previous work history as a foundation, I believe I am well suited to learn, master and complete projects and duties as they are assigned. I understand long days and know the difference between working on a job, and finishing a job.

ACADEMIC BACKGROUND
Western Michigan University (WMU) - College of Engineering and Applied Sciences (CEAS)
Graduation: December 2017
Major: Bachelor of Science in Mechanical Engineering. Current Upper Level GPA: 3.68
Minor: Mathematics

KEY ENGINEERING CLASSES
- Vehicle Structures
- Heat Transfer
- Mechanics of Materials
- Fluid Mechanics
- Solid Mechanics
- Engineering Economics

WORK EXPERIENCE
Caro Motorsports Yamaha Dealership and Speed Shop 
June 2011 - Present
Overview: Worked several years full time before returning to college. Continued to work school breaks throughout college.
- Bore-hone, Head Mill, Seat & Guide
- Sales Manager Assistant (2016)
- Oversee parts orders and check-ins
- Manage coworkers and part time high school students
- Manage new product lines
- Service Technician (2011-2015)
- Diagnose and repair power sport vehicles such as motorcycles, ATVs, snowmobiles and side-by-sides
- Perform warranty work on new units
- Dynamometer test and tune
- Special Projects
- Lead a team charged with researching, coordinating and managing a 20,000sqft floor treatment of epoxy and polished concrete.
- Extra skills required: Electrical, Material Application, Forklift, Power Tools

Laursen Veterinary Clinic
May 2009 - August 2010
- Technician Assistant
- Overview: Learned how to answer and process phone calls.
- Aided veterinary technicians with animal care
- Handled incoming calls and appointments

PERSONAL CHARACTERISTICS
- Timely
- Thorough
- Even tempered
- Respectful
- Detail oriented