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Discrete Concealed Device Table

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SENIOR PROJECT

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Contents

Introduction

Description

A wooden coffee table is an appealing piece of furniture that is common is every house hold. What makes this table unique, is that it will function in a way to where one can hide devices inside. The top of the table will lift up revealing a back wall where people can hang items. In order for this table to reveal its self, one must use a key to unlock the secondary functions that are installed. This second function is two levers or buttons that need to be presses or pulled to release the table top.

Motivation

This issue at hand is that people don't have a discrete place to hide devices. This table will provide areas for people to hide things without making it obvious. Everyone can buy a safe to protect their desired items. But the issue is that everyone knows you are hiding things inside that safe. With this table, people who come inside your home won't be able to tell you are storing items inside.

Function Statement

This device will be able to operate both as a horizontal surface and a means of concealing a device.

Requirements

- The back wall must hold up to 10lbs without collapsing.
- The top of the table must be able to hold up to 50psi.
- The tables overall length must be 3.5ft long.
- The torsion spring must withstand a max stress of 150 psi.
- Must have 4 means of support

Engineering Merit

The things that will be engineered will be the forces that are required to make this table function properly. In addition, the weight distributions need to be calculated so that the table can hold not only cups of coffee, but it will hold different sized devices as well. Another part of this table that will be engineered is the part of trying to create a table with a giant hole cut out but still strong enough to preform properly.

Scope of Effort

- Pick out and cut the type of wood that is needed for this table.
- Create all the drawings to represent the design intended.
- Calculate all the different stress elements for the table
- Calculate the different weight loads that table can withstand.
- Install a torsion spring so that the table top will lift smoothly.

- Design a key hole function in the front of the table.
- Design a second safety feature (lever or button) that will release the table top.
- Insert lever arms to support the table top when its being lifted

Success Criteria

The table will be able to function as a multipurpose tool. One being that it will be able to successfully hold coffee, drinks, or any items that one might place on top of a table. The other portion of this multipurpose tool is that it will be able to hide devices in a safe manner without anyone knowing.

Design and Analysis

Approach: Proposed Solution

This table's design was conceived by the mixture of previously made discrete item holders and the struggle of having a truly discrete place to hide different objects. The solution is to have a wood coffee table that can secretly open to reveal areas to hide and hold different objects. This table to is to look nothing out of the ordinary, to look and act like a normal coffee table. The major point of this table is to be discrete when it comes to its ability to open and hold different objects.

Design Description

The design was made to withstand different weights, heights, and lengths. In addition, the design is made to have elite safety features. These include two separate forms of functions that need to be done before the table's top can be opened. One is to be a simple key lock. The second is a pin/number code that is battery operated. In addition, there will be two levers, one on each side of the table, that need to be pulled so that the table can be opened. Inside the table, there will be "U" shaped holders that are made to hold different objects. These "U" shaped holders can move up and down, still applying a strong enough force that will hold any length and shaped object in place. It is assumed that the objects being held are in relation to the size of the table, meaning that the object will not be longer the tables overall length.

Benchmark

Some of the major benchmarks that are a part of this project are getting the twelve analyses completed. Another major benchmark is getting the seven drawings completed including the parts that correspond with them. Getting the dimensions is also a huge benchmark for this project because the dimensions are what go along with about 90% of the analyses.

Performance Predictions

For this table, its predicted to work with nothing but perfection. The different safety systems that will be involved with the table will keep what's locked away safe and sound. The table will be able to hold the required maximum weight as well as operate in the since of opening and closing properly. Its predicted to look just like any normal coffee table. The main purpose of this table is to be discrete, and that is exactly what it's going to be.

Description of Analyses

Below will be detailed descriptions of the different analysis that are being done for this project. These analyses will be spring constants, forces being applied, forces needed to do a specific action, dimensional requirements based on load size, and analyses based on the screws being used. In these descriptions, the equations and methods will be explained, including why they were used and the calculated answer that came from them.

Scope of Testing and Evaluation

For the testing and evaluation's, the table will undergo different operations in different situations. Some of these situations will opening and closing with a different weight load each time. In addition, the table will undergo a test in which the table will try to be opened without releasing any of the security locks. This will test the force that it will take to break open the table. One of the last tests that this table will be performed in is a picture analysis. A picture will be taken of the table, as well as an ordinary wood coffee table. These pictures will be given to other students outside of the class to see if they can notice which one is the table holding devices. The main point of this table is to make it look discrete. If people outside the class can't tell which table is which, then the table has successfully preformed its duties.

Analyses

A-1

This analysis that was completed for this project was to calculate the force it would take to open the table's top from multiple angles. The requirements were to have the table's to be 3.5ft long and 2ft wide. Some of the engineering analysis that was done was Equilibrium and the Sum of the Forces. The design parameters that will be obtained from this analysis will be the thickness of the table's top. If the table takes too much force to open, the table will then need to be created in a lighter design. These parameters will be documented in technical drawings that will come as the table is being made. The force it takes to open the table is 5lbs. Please see appendix A: A-1 to see the analysis.

A-2

This analysis was done to calculate the spring constant (K) inside the metal "u" shaped holders. These holders are here to hold the devices in place inside the table's back wall. When you lift the bottom ring upwards (stretching the spring), you place the device inside. Releasing the ring, the spring will reduce and put compression on any device that is being held. For this analysis, Hooks law was used. After rearranging the equation, a calculation of 151.62NM was found. Please see appendix A: A-2 for the calculations.

A-3

This analysis was done to calculate the reaction force at the legs of the table. This calculation was to be done when the table is fully loaded with items and opened to a full 90 degrees. There was an assumption made about the max weight at the top of the tables top when opened. This assumption came out to be 15.5lbs. After all the calculations were completed, the reaction force that was calculated came to be 68.96N from the legs. Please see appendix A: A-3 for the calculations.

A-4

This analysis was done to calculate the diameter of each leg of the table. Assumptions were made during this calculation. The first being that the table will be (40%-90%) RH, the second was to use a safety factor of 6.0. This was found in the Mech. Design text book. A compressive yield strength was found on Matweb. After all the calculations were completed, a final diameter of the legs was found to be 10.75cm. Please see appendix A: A-4 for the calculations.

A-5

This analysis is done on the pin of the hinge show in Drawing 20-0002. The pins shear force came out to be much lower than the yield tensile strength that was provided in the material properties. The material is a low carbon steel. The shear force on the pin came to be 399.59 psi. Please see appendix A: A-5 for the calculations.

A-6

This analysis was done to calculate the stress area of a screw that would be used in the hinges. It was determined that a number 9 flat head screw would be used. The threads per inch for this screw is 14 and the bolt diameter is roughly 0.122. After using a complicated equation, an area of 0.00237 was calculated. This value is assumed to be per thread. Please see appendix A: A-6 for the calculations.

A-7

This analysis was done to calculate the spring constant (K) of a torsion spring. The torsion spring will be located on each side of the hinge that holds that table's top to its base. This spring is to help open the table when applying minimum amount of force, all while keeping the table's top from going too far backwards. Hooks law was used in this analysis. The equation was rearranged to kind the k factor. A delta (x) was assumed for this analysis. With this assumption, a 1357 N/m was calculated. Please see appendix A: A-7 for the calculations.

A-8

This analysis was done to calculate the force it would take to pull the lever on each side of the table. This lever will release the tables top and allow it to be opened. For this calculation I was able take the problem of having to have a reasonable force to pull the lever from its locking point. Using Hooks law, the equation can be used to find force needed to pull the lever. The k factor and the delta (x) were assumed in this analysis. With these assumptions, a force of 0.1524N is needed to pull the lever. Please see Appendix A: A-8 for the calculations.

A-9

This analysis was done to calculate the moment about the lever. The idea was to calculate the max moment for further calculations to be done. For this calculation, it was assumed that the height of the lever is 1.5 inches, and the length of the lever was 12 inches. The forces that were applied to the lever were from previous calculations. This force came to be 68.9 N. For this analysis, the force was transferred to pounds. After all the calculations were completed, the result for the moment came to be 93. Please see Appendix A: A-9 for the calculations.

A-10

This analysis was done to calculate the section modulus of the lever that needs to be pulled to release the tables top. The assumptions that were made for this was that there was a safety factor of 2. The max yield was needed for this analysis to find the section modulus. After going through the calculations, a section modulus of 6.2×10^{7} was found. Please see Appendix A: A-10 for the calculations.

A-11

This analysis was done to calculate the proper base size that is needed for the lever that will lock the table's top in place. This analysis requires the section modulus. When the proper equation is rearranged, the area can be used to find the required base. After further calculations were done, the base of the lever came to be 16.53×10^{-7}. This number came out this way based on the section modulus that was found in the previous analyses. Please see appendix A: A-11 for the calculations.

A-12

This analysis was done to calculate the normal stress of the lever including the Kt factor found in the given textbook. The normal stress that was calculated came out to be 99.2. This number is significantly below the max yield stress that was found in previous calculations. In a table provided in the textbook, a graph was shown to calculate the Kt factor. After finding the r/h and H/h ratios, a Kt factor of 10 was found. Please see appendix A: A-12 for the calculations.

Device: Parts, Shapes and Conformation

For this table to be complete it will need the following parts: the wooden table itself, two steel levers, lever holders, a battery-operated pin code lock system, steel "U" shaped hooks, hinge, 4 torsion springs, and screws to hold everything together. The listed items are essential for this table to operate with the most efficiency. Each item listed has a specific action of performance for this table.

Device Assembly, Attachments

For this project, the assembly that's being done is all the parts that are being made or modified. The list of parts is provided in Appendix C. The assembly that is presented contains the table's top and base, hinge, lever, lever holder, spring holder, and the areas for the hooks to be added. The table is presented in a way where its opened at a 180 degree. This is due because the hinge for the table is being bought from an outside source. The drawing that comes with it puts restrictions on how the assembly gets presented. There are going to be design changes to make this table more stable, cost efficient, and overall more discrete

Tolerances, Kinematics, Ergonomics

The tolerances for this project are around 0.01 for two decimal place dimensions. The way the table and the parts that are assembled with it are designed in a way to have more than enough room for error. Most of the parts that are being made, after being machined, can be 0.01 off in length or width and the table will still function the way its stated to. As of right now, the design is based more on the analyses that were created. After the table is fully built and modified, the parts can be re-analyzed to see if they still make the table function in a proper way. The dimensions and tolerances that are given as of right now are more benchmark/starter dimensions. As of right now they work for the project but there is always more to be re-designed.

Technical Risk Analysis, Failure Mode Analyses, Safety Factors, Operation Limits

The operation limits that come with this table are that the table can't exceed dimensions that would make the table un-realistically fit in a living area. The table's main purpose is to be discrete in hiding different devices. If the table becomes too long or too short, the main function is no longer plausible. For a safety factor, an assumption was made in Analyses-10, to use a safety factor of 2. This may be increased to 3 later into the project. At this point, the project will have a safety factor of 2.

A second technical risk is involved with the purchasing of this table. There is a risk that the owner of the table will sit on the table or place something on the table that will maximize the weight limit the table can withstand. Another risk that is involved is that the owner of the table will announce that it's a discrete concealed device table instead of an ordinary table. The main purpose of this table is to be discrete and if its known that this is not an ordinary table, it defeats the main purpose.

Methods and Construction

Methods

This project was conceived, analyzed, and designed at Central Washington University and other local shops in the area. With some constraints of the university, a portion of the parts for the table will be ordered and bought from outside companies. The wood table will be purchased but reformed and made to design in the university's wood shop. A majority of the tables design will be putting together the different parts to make a functioning device holder. This project has a number of different parts that will need to be machined and designed in Central Washington University's machine lab. One of the major benchmarks is to get all the machined parts designed and ready for assemble by the third week of winter quarter. Before this can all go down, the table needs to be modified and ready for assembling. This will mean that the table will need to have the holes cut out and have the screw holes ready and marked for the attachment of the other parts.

To get this all to work, many equations and analyses came into play. The main calculations were calculating force and using Hook's law to calculate the force or "K" factor of a spring. One area of interest that needs to be closely looked at is how the table is going to shut completely. As of right now, the table will just barely sit about 0.25 inches above the base of the table. This is due to the different hinges and holders that are placed upon the top of the table. Some areas such as the lever holder have a cut out that will help hide the top of the holder. This method needs to be put into place for the spring holders. The four spring holders are what cause the table to not close completely.

a. Construction

i. Description

For this table to be properly assembled, other parts will need to be manufactured. The separate parts will be attached to the table to help hold, lock, or make more discrete. The body of the table will made in the wood shop that Central provides. The rest of the parts will be manufactured in the machine shop that Central provides as well.

ii. Manufacturing Issues

Some of the main issues that will come about when it comes to manufacturing the parts that are required are the shapes. One of the parts that is needed is the "U" shaped device holders. This will be a difficult shape to conduct. The material has to be a solid sphere that is bent in a smooth fashion to represent a "U". This part will also need to have two springs attached that will connect to the tables top. This portion of the part is a whole new issue that will come about. Another manufacturing issue that comes into play for all the parts that will be manufactured in the machine lab, is the material. It is still unknown to the material that will be used. The material will range from aluminum to steel. A third manufacturing issue that comes to this project is the accuracy and precision it takes to make these parts. Relying on the few years of practice this will be a challenge when it comes to accurately making these parts.

iii. Drawing Tree, Drawing ID's

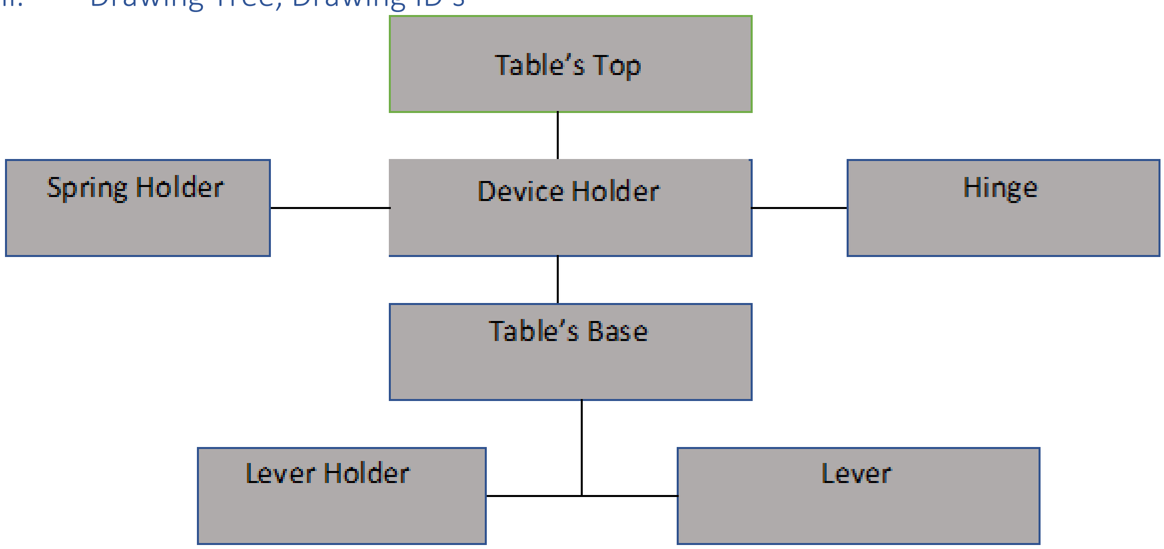


FIGURE 1. Drawing tree.

iv. Parts and labels

In the assembly of this table, there are multiple parts that are going to be manufactured and or bought from outside sources. These parts are listed in the drawing tree provided above. The only part that is being bought is the hinge. This part will be provided from McMaster-Carr. The drawing for this part is included in Appendix B. The remaining parts that are listed, such as the spring holder, lever, and lever holder, will be built and manufactured in the machining lab that Central provides. These parts will all be screwed in will #10 screws. These screws will be bought from a local hardware store in Ellensburg. The table's top and base are recorded to be made from oak. This material is subjected to change after getting a final cost from the local hardware stores. For the time being, oak is the material that will be used. For the parts that are going to be manufactured, they will be made from steel or aluminum. This material is dependent on the machine lab where the manufacturing will take place. The parts names and drawing

Discussion of assembly, sub-assemblies, parts, drawings

Figure 2 shows the assembly of the table. The table is shown open at a 180-degree angle. When the table gets manufactured, the table's top will open only to about a 90-degree angle. The hinge, and spring will provide the correct amount of tension to keep the table's top from flipping open. This calculation and design also help prevent the table from tipping over completely. If the table's top was fully loaded with devices and opened to a 180-degree angle, the table will completely collapse. There will also be device holders attached to the tables top. These will be located where the holes are located on the table's top. These parts are not added to the assembly because it's a work in progress on how to get the "U" shaped hooks to attach to the table without losing any of the strength and tension that the springs provide. All of the drawings for the parts that go into this assembly can be seen in Appendix B. Below is the picture of the assembly in isometric view. The drawing is in Appendix B as-well under drawing 20-0008.

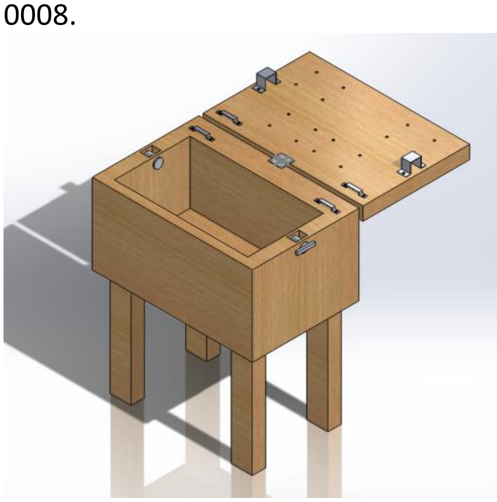


Figure 2: Table Assembly

One of the drawings that will be listed in Appendix B, is the lever holder. The lever holders' main purpose is to prevent the table from opening. This part will be attached to the table's top on each side. When the table is fully closed, a lever will be inserted through the holder. The lever is inserted through the base of the table. When the lever is inside the holder, the table will not be able to be lifted open. The base of the table will have square cut outs where the lever holder can go inside. This allows the table to close completely. Without the holes the lever holders would prevent the table from closing completely. Overall this part is very important when it comes to the assembly of the table because it's one of the main safety features. This drawing is listed in Appendix B: 20-0006.

For this project, a majority of the time will be spent in the machine shop that Central is providing. Inside the shop is where the drill press, lathes, and mills will be used to construct and manufacture the parts for the table. The table's top and base will be worked on in the wood shop provided by Central. Here is where the holes will be drilled and cut out for optimal performance and holders for parts.

Mid-Construction, Problems and Corrections

As of right now in the beginning stages of the construction of the table, multiple changes are arising. The first change that is happening is there will no longer be torsion springs attached to the bottom of the tables top and the top of the tables base. The main purpose of these springs was to prevent the table from opening past a 95-degree angle. The new method that will prevent this from happening is placing gas shocks on each side of the table. This will allow the table to open at a slower pace. To prevent the table from going past that 95-degree there will be a stopper placed on the back of the hinge. The hinge will still be bought from an outside source but the hinge will be modified to meet the new requirements being placed upon the table. Another modification that is being made is the device holders. The "U" shaped mechanism that was previously created is showing signs of not being able to function properly. A new design was created to hold the devices in place on the inside of the tables top. The new design consists of a metal bracket attached to the tables top. Below the bracket will be a "L" shaped edged that will hold the base of the devises. The bracket is to hold the top portion of the device. The bracket will not be tightly secured upon the device. There will be room to be able to grab the device and slide it out of the holder. This is done so that the device can still be accessed in a timely manner yet not slip out when the table is being closed. One of the last changes that is being made is to the levers on the side of the table. The levers need to have a more secure system to make sure that not everyone (especially kids) can open the table. The new design is to use spring activated pins that make it so that the lever must be pressed or twisted in a way where the pins will move out of the locking position.

After getting further into the construction process of this table, new designs have come into place. The levers were last thought to be pin activated. The new design is to have an electronic locking system that will attach to the top of the tables lid and will lock into the side of the tables base. This will be activated with a 9V battery. A magnetic device will allow the deadbolt to lock and unlock.

The process of the device holders is being changed as well. The design is staying the same but the process to get the final part is changing. The first thing is the order of operations. The order to bend the aluminum needs to change so that the material can fit into the 90-degree bender. The first (tester) part that was created was not able to be created with the correct dimensions due to not fitting in the machine. The part is going to need to change in dimension. The part will need to get larger to not only fit in the machine but also in consideration of size being added or lost due to bending. Three different bending machines that are provided in the machine lab at CWU will be used. The first machine is for the two-side bends. These two bends have the smallest amount of material to bend making it very difficult to get to 90-degrees. The other two machines will be decided later in the process to see which provided the cleaner bend in the material.

A large change when it comes to the device holders is the position of the springs. The springs will be placed on the outside of the device. They will be wrapped around a screw. The screw will go through the device holder and into the tables lid. Having the spring on the outside will provide the right amount of tension. The tension will push the devise holder up against the table. When the device wants to be removed, one would need to just pull the device holder back and remove the device. This will compress the spring. Then when released the spring will attempt to expand, which causes the tension back against the table. There will be three different sized device holders but the spring and screw will be the same size for each of them.

A challenge that arose with the table is the hinges. The hinges were thought to be solved, but after attempting to assemble the new hinges, it was clear that the hinges were ½ inch to small. The new solution is to use barn door hinges. These will be much more successful because they are created to carry hey loads and to be attached to larger scaled items. This is the issue that the table is still having. The tables walls are to thick to place a concealed cabinet hinge on. The barn door hinges will be placed on the outside of the table. A decorative piece will need to be bought and made to hide the hinges location. This will help keep the table as discrete as possible.

Testing Method

a. Introduction

This table will undergo many different tests to make sure that it's in its top condition and design to meet each of the requirements. The different tests will analyze the force to open a fully loaded table. The amount of weight that the table can withstand. The max weight the device holders can withstand. Finally, the most important test is to see if it passes the discrete test. The main goal for this table is to be able to hold items in a discrete manner.

b. Method/Approach

For the testing, each test will undergo three times. Each being recorded either on an excel spreadsheet or just on engineering paper. After each test is finished, the data will be analyzed and put into thought for redesigning or fixing the analyzes that have been previously made.

c. Test Procedure description

One of the main tests that will be completed will to have a picture of an ordinary table and a picture of the finalized product of this project. Random people will be selected to try and figure out which table holds items inside. This is the test that will see how discrete the table really is. The second test that will be completed is the test to see how much weight the table can withstand. This will be done with further analyzes with the final dimensions of the product. The two numbers, the weight limit from the first analyses to the final one will be compared and documented. The third test will be the force it will take to open the table with all the different devices inside. The fourth test that will be performed will be to try and open the table when the levers are locked inside the base of the table. These tests will determine if the table passes all the requirements that we listed in the analyses and in the introduction provided above.

d. Deliverables

For the deliverables, the excel work sheet will have the different max weights that the table can withstand. This will have three different answers because the test will be preformed 3 different times. The test that is going about the table being discrete will be described in a memo format.

Mid Construction Testing

Once the table is completed, it shall go through a series of tests to make sure that what was analyzed and calculated in the beginning is still accurate. One of the tests that will be conducted is the amount of force that it will take to remove a device from the device holder. This will be done with a tool that the machine shop at CWU is providing. A second test that will be conducted will be the force it takes to open the lid. This test will be done when the table is locked and unlocked. The table needs to be able to withstand a certain amount of fore before breaking open when its locked. When the table is not locked, it should be easily opened even with the added weight of the devices.

Mid Testing

The plan has been to have the first test for the table be how much force it takes to open the tables lid to 90 degrees. Within this test, time was being recorded in addition to the forces. After further elaboration with other students, it’s been decided that time will be a separate test. This means that a test will be conducted to see how much time it takes to open the table, remove a device, and be fully prepared to use it. This test is important because it will demonstrate how the table will be used in life. This test will be conducted multiple times to get an accurate reading on how long it takes to operate the table. Making time its own test improves the first test that was being conducted because no all the focus is on the force. Before, it made it difficult to conduct the test when force and time were both being managed at the same moment. Doing this made the first test unreliable and inaccurate. Overall, testing will be broken down into separate parts to help insure that all are being done correctly. This also helps eliminate any errors that could possibly happen.

Budget

a. Part suppliers, substantive costs and sequence or buying issues

A majority of the parts that will be supplied for this project will be bought at a local hardware store. This includes wood, and other metals that will help in the manufacturing process of the table. The only buying issues that are presented at the moment are in the case of failure. Buying material twice will be on the expensive side of things. This makes it very important to get all the parts made correctly the first time. The first thing that will need to be bought will be the wood. This will be for modifying the table to fit the needs for the rest of the parts that will be attached at later times. The second set of items that will need to be purchased will be the material of aluminum or steel for the lever, and other holders. The two different metals are going to be bought at the local hardware store if the metals cannot be donated from the university's machine shop.

b. Determined labor or Outsourcing rates and estimated costs

For this project there will only be one other part that will be bought from an outside source. This is the hinge. This part will be bought from McMaster-Carr. The projected coast for this item will be listed In Appendix C and D.

c. Labor

There will be no outside labor costs for this project. All manufacturing will be done personally.

d. Estimate total project cost

The estimated total cost for this project will be $400. The major cost will be the material. This estimate is projected higher then what the actual cost will be. This cost is with failure in mind. Having to re-purchase material will be the difference in how high or low the final cost will be.

e. Funding sources

There are no founding sources for this project. The material at most will be donated from family members and or companies. Other than the possibly donations, there will be no outside funding for this project.

Mid-Construction Budget

In the middle of the construction phase, only about 29% of the budget has been used. A majority of the materials and parts have been donated from the CWU machine shop. Some of the parts were donated by friends and family. The projected budget for this project was $400. The table will not go over this budget in the slightest. The final spent budget will be projected to be $200 below the estimated budget. As of right now, most of the money that is being spent is on the hinges. This is due to reordering the parts due to error. Four new hinges will be bought this week.

Mid-Testing Budget

Coming to the end of the testing phase, the budget for the table has not increased or been used. The last use of the budget was for re-making the table legs after the table fell. Sense then, the budget has remained the same and has not been used. Over all, the table did great in terms of saving money. Like stated earlier in the report, a good majority of the materials were donated by outside sources or were given by the machine shop at Central Washington University. The table had the opportunity to be a very expensive project, but with the help of others, the price was able to stay much lower.

Schedule

In the Gantt chart provided in Appendix E, it shows the different subdivisions and the time it took to complete each task. For fall quarter, the analyses, drawings, and proposal were completed. The analyses and drawings were started in the end of September and were projected to end towards the end of November. The work that was completed on these two tasks went into the beginning of December. This was due to poor time management. Two analyses and 1 drawing were to be completed each week. The first 4 weeks, these tasks were completed on time. As the quarter got closer to an end, the work to complete these tasks began to get longer and longer. When it came to the proposal its self, the report took all the way from the start of September to the beginning of December. Some of the sections took longer then others. The introduction and outline took the least amount of time and work. When it came to the design, methods, and construction, time and work began to get longer and longer. These sections along with some of the drawings and analyses went over the estimated due date. For fall quarter it was estimated to complete the tasks at hand in 80 hours. When it came to the actual time to complete the tasks for this quarter, it took about 177 hours to complete.

For the testing side of this project, the table was originally set back one week. This was due to a transportation issue. When transporting the table, the legs broke off and the table collapsed. During this week, new legs were created and attached to the table. The new and improved legs are three times as stronger and more sturdy. The new legs go up the sides of the table instead of being attached to the bottom. After the legs were fixed, the table then when through each of the tests that were required. The project was able to get back onto schedule and the testing section was finally completed.

Project Management

a. Human resources

Some of the human resources that are used in this project are the professors that are provided by Central Washington University. In addition to the professors, there are lab technicians that are extremely resourceful especially when it comes to the machine shop. The other human resource is the manufacturer of this project.

b. Physical resources

For physical resources, Central Washington University provides a woodshop, machine shop, and computer lab. Each of these labs and shops come fully equipped with the different machines that would need to be used to complete this project.

c. Soft resources

The main soft resources that will be used are SolidWorks and McMaster-Carr. These two programs or sights help in the design of each product that is needed for the assembly of the project.

d. Financial resources

This project will be paid completely out of pocket. There is ademption to get some of the material donated by outside sources. This would be considered a bonus. As of right now, the project will be completely paid for personally.

Discussion

Over the time of the project the design changed more than a few times. When it came to design changes, they were all minor. These changes were to help the efficiency of the table. One example of a change that occurred is to place a hole on the two sides of the tables base. This way the lever holders had a slot to go into. These holes allowed for the table to close completely. At the beginning of the project the table had no dimensions and no set locations for where each part was going to be installed. After going through each part and creating the drawings in solid works, the dimensions of the next part would come about. This means that when the lever holder was created, then the dimensions range was created as well for the lever its self. This would go on for all the parts in the project. When it came to building the assembly of the project, that is when some of the issues came about. Some of the parts would be designed to large to fit in the spot on the table efficiently. When this issue came to attention, redesigning all the different parts that corresponded with that area were needed. Over the course of the drawings, going back to the parts drawing happened 6 different times. Each time having to change a portion of the dimensions.

When it came to doing the analyses, going back and changing was not an issue. Each analysis build offs one another. This means that the farther down the number of analyses that have been done, more and more start to reference a number or calculations that came from previous analysis. After the 8^{th} analyses, a struggle happened to get more completed. At a certain point the analyses start to lack a certain amount of value. This all could have been fixed if the analyses were completed in time. Instead the final portions were rushed to complete on time.

The next phase for the project is to manufacture all the parts needed to build the table. These parts will be essential for the project success. After all the parts have been bought and or designed, the next part will be to assemble it all together. After all building and assembling have been completed the next phase is to test the product. This is where the table will be tested to see if it meets the requirements to pass as a discrete concealed weapon table.

The table is completely assembled at this point. The only thing that needs to be added is decoration items for personal reasons. During the last step of the assembly process there was an issue that came up. Gas shocks were purchased to help lift the table's top open and to keep it form tipping over. The shocks did not work because there was not enough (psi) to get the shocks to engage and work. The new process was to take a chain and a hook and install them to the inside of the table and the bottom of the tables lid. This worked perfectly. It keeps the table's lid from opening to a 180-degree angle. This also helps with the table not flipping over when opened. In addition, the chain adds to the rustic western look.

Currently in the middle of the testing section of the project, some modifications had to be done. Starting with the legs of the table. The previous legs broke off in a transportation incident. Due to this happening, legs that were stronger and more sturdier were made. In addition, new testing methods have been created to make sure the table is working in its perfect condition. The new testing is involving time. How much time it takes to operate the table. This means opening and pulling a device out. Overall, all the changes that happened have benefited the table in the end. The legs making it stronger and the new testing is going to prove that this table can fully function under its conditions.

Testing has been completed at this point of the project. The three tests involved the force to open the table, the force to remove a device, and the time to operate the table. The tests results came out very accurate. One of the tests was off compared to the calculated value, this was due to a change in the design. This was the test to remove a device from the holders. The holders changed half way through the construction time. Due to this change, the calculated value was a lot smaller than the tested value. What makes this work is that the requirement changed for the table. The requirement changed to that the device cannot be pulled out unless more than 25lbs is applied. This added to the safety side of things because a small child would not be able to remove one of these devices.

Conclusion

Over the course of this project many parts are being designed, manufactured, bought, and assembled to get a final product. This table will come out to be successful because:

- Money is set off to the side for this project so all the materials will be purchased
- All the drawing and designs are finished and ready to be manufactured
- Central Washington University provides work shops full of the machines and tools that will be needed to complete the project

When it comes to the project, it is projected to be completed and preform the requirements that make it function as a discrete concealed device table. With the tools and materials provided there is no reason this project will not be completed.

Acknowledgement

This project would not be possible without the help of the machine lab and the woodshop that are provided by Central Washington University. In addition to these work areas, the mentors and professors are greatly appreciated for the advice and guidance to get this project done and completed on time. These people and places have helped make this project an engineer’s dream come true. Listed below are the human resources used in this project:

- Professor Charles Pringle
- Dr. Johnson
- Dr. Choi
- Ted Bramble
- Matt Burvee
- Jacob VanBlaricom
- Courtney Lehrman

These people listed have helped in some form of way to get this project completed in the time given.

Appendix A:

A-1: Force to lift the tables top open

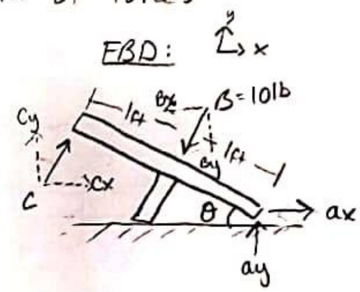
Shyne McKay	MET 489a	2019/10/17

Given: Overal length: 3.5 ft
width = 2 ft

Find: The force it takes to lift the tables top open
Assume: Force B is 10 lb. forces act ⊥ to table top
Method: 1) FBD 2) Equilibrium 3) sum of forces

Solution:

FBD:



$GM_A = \emptyset = 10lb(1ft) - C(2ft)$

$\frac{-10\ lb\ ft}{2\ ft} = \frac{-C(2ft)}{2ft}$

$-5lb = -C$

$\boxed{C = 5lb}$

@ 5° $\uparrow \Sigma F_y : 0 = 5\cos(5) - 10(\cos 5) + R_y$

$4.9809 - 9.961 + R_y$

$\boxed{R_y = 4.9801}$

@ 5° $\rightarrow \Sigma F_x = 0 : 5(\sin 5) - 10(\sin 5) + R_x$

$0.4357 - 0.8715 - R_x$

$\boxed{0.4358 = R_x}$

@ 45° $\uparrow \Sigma F_y = 0 = 5\cos(45) - 10(\cos 45) + R_y$

$3.535 - 7.071 + R_y$

$\boxed{R_y = 3.536}$

@ 45° $\rightarrow \Sigma F_x = 0 = 5(\sin 45) - 10(\sin 45) + R_x$

$3.535 - 7.071 + R_x$

$\boxed{R_x = 3.536}$

@ 80° $\uparrow \Sigma F_y = 0 = 5(\cos 80) - 10(\cos 80) + R_x$

$0.8682 - 1.7364 + R_x$

$\boxed{R_x = 0.8682}$

@ 80° $\rightarrow \Sigma F_x : 0 = 5(\sin 80) - 10(\sin 80) + R_x$

$4.924 - 9.8480 + R_x$

$\boxed{R_x = 4.924}$

A-2: Spring constant in device holder

Shyne McKay | MET 489a | 2019/10/18 | 1/

Given: mass of device = 2.6 lb
Length of device = 8.54 in
ΔX of spring = 3 in

Find: Spring constant (K)

Assume: Homogeneous material
Distance of ΔX is 3 in

Method: 1) FBD 2) Hooks law

Solution: 2.6 lb = 1.179 kg

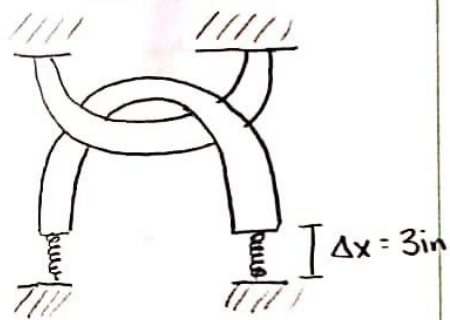
$F = mg$
$= 1.179\,kg(9.8\,m/s^2) = 11.55\,N$

$F = K\Delta X \Rightarrow K = \frac{F}{\Delta X}$

3 in = 0.0762 m

$K = \frac{11.55\,N}{0.0762\,m} = \boxed{151.62\,Nm}$

FBD:



A-3: Max force in the legs

Shyne McKay | MET489a | 2019/10/23 | 1/1

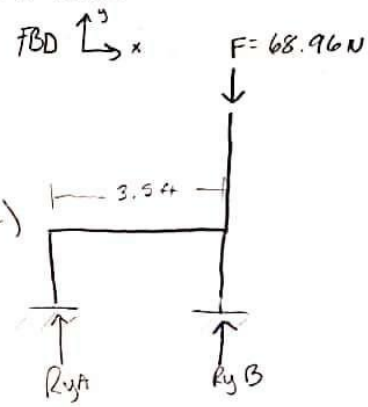
Given: length = 3.5 ft
width = 2 ft

Find: The max force within the legs of the table

Assume: Axial load, max weight of top = 15.5lb, neglecting weight of table

Method: 1) FBD 2) Equilibrium 3) max force

Solution:



15.5 lb = 7.03 kg
$7.3kg\,(9.81\,m/s^2) = 68.96N$

$\circlearrowright \Sigma M_A = \emptyset = -68.96(3.5ft) + R_{yB}(3.5ft)$

$\frac{R_{yB}(3.5ft)}{3.5ft} = \frac{241.36}{3.5ft}$

$\boxed{R_{yB} = 68.96N}$

A-4: Diameter of the legs

Shyne mckay | MET489a | 2019/10/25 | 1/1

Given: length = 3.5 ft
Width = 2 ft

Find: Required Diameter for table legs

Assume: Axial loaded, table will be cedar, treated (40% - 90% RH)
N = 6.0

Method: 1) FBD 2) material properties 3) force allowable 4) Area

Solution:

compressive yield strength = 6240 psi (Matweb)

$$F_{allowable} = \frac{\text{max force}}{N}$$

$$F_{allowable} = \frac{68.96}{6} = 11.49\,N$$

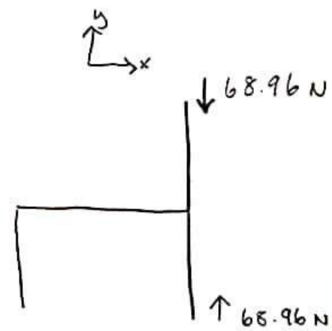
$$\frac{N}{m^2} \quad \frac{P}{2A} = \text{yield} \Rightarrow \frac{11.49\,N}{2A} = 6240\,psi$$

$$A = 0.0009206\,m^2$$

$$\left(\frac{\pi}{4}\right)D^2 = A \quad : \quad \frac{\pi}{4}D^2 = 0.0009206\,m^2$$

$$D = 0.10756\,m$$

D = 10.75 cm each



A-5: Shear force on the pin in the hinge

Shyne mckay	MET489a	11/1/19	1/

Given: Pin diameter = 15/64"
Force from table: 68.96 N

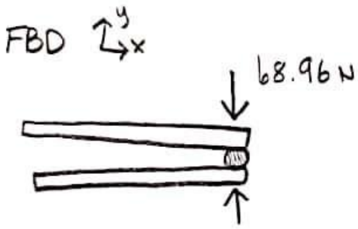
Find: Shear force on pin

Assume: Homogeneous material
Rigid body

Method: 1) FBD 2) Material properties 3) shear force

Solution:

FBD



* Yield tensile strength = 370 MPa or 53700 psi from material properties

$$\frac{\left(\frac{V}{4}\right)}{A} = \frac{\left(\frac{68.96}{4}\right)}{\pi r^2} = \frac{\left(\frac{68.96}{4}\right)}{\pi (0.117)^2} = \boxed{399.59 \text{ psi}}$$

$r = 0.117"$

* The shear force is extreamly below the yeild strength.

A-6: Tensile stress area of the screw

Shyne mckay	MET489a	11/1/19	1/

Given: Threads per inch = 14
Bolt Diameter = 0.122

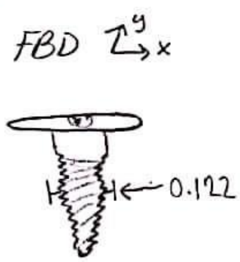
Find: The Tensil stress area of the bult.

Assume: #9 flat Head screw

Method: 1) FBD 2) TPI 3) Stress area

Solution:

FBD



$$A_s = \frac{\pi}{4} \times \left(D - (0.938194\, p)\right)^2 \qquad p = \frac{1}{TPI}$$

$$= \frac{\pi}{4} \times \left(0.122 - \left(0.938194\left(\frac{1}{14}\right)\right)\right)^2$$

$$= 0.00237$$

A-7: Spring constant of the torsion spring

[redacted]

Shyne mckay	MET489a	2019/11/11	1/

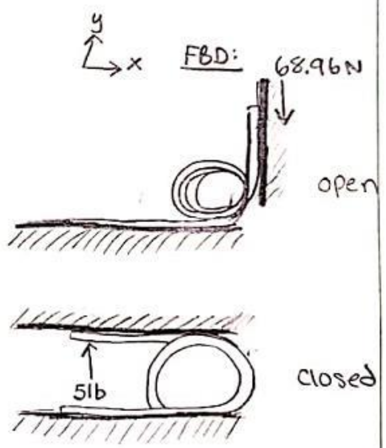
Given: Force of Top = 68.96 N
Force to open top = 5 lb
Δx of spring = 2 inches

Find: Spring Constant (K) (Torsion spring)

Assume: Homogenious material
Distance Δx = 2 in

Method: 1) FBD 2) Hooks Law

Solution:



$F = K\Delta X$

$K = \frac{F}{\Delta X}$

$K = \frac{68.96\,N}{2\ in}$

$2in = 0.0508m$

$K = \frac{68.96\ N}{0.0508\ m}$

$\boxed{K = 1357\ \frac{N}{m}}$

[redacted]

A-8: Force to open the lever

Shyne McKay | MET489a | 2019/11/14 | 1

Given:

Find: Force takes to open lever

Assume: Homogeneous material
Distance ΔX is 2 in
K factor of spring 3 N/m

Method: 1) FBD 2) Hooks law

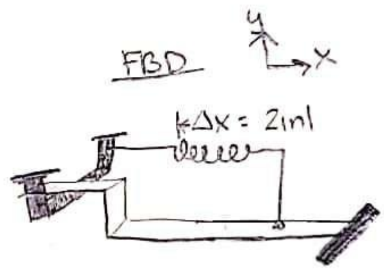
Solution:

$F = K\Delta X$ 2in = 0.0508 m

$= 3\frac{N}{m}(0.0508\ m)$

$\boxed{F = 0.1524\ N}$

FBD



A-9: Moment on the lever

Shyne Mckay	MET489a	2019/11/21	1/

Given: Forse applied: 68.96 N

Find: Moment on the lever

Assume: Saftey factor of 2
Height of lever: 1.5 in
length of lever: 12 in
Homogeneous material
Rigid Body

Method: 1) FBD 2) Moment

Solution:

$\circlearrowright + \Sigma M_A = 0 = 68.96(9in) - 68.96(3in)$

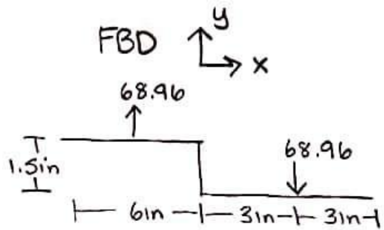
$M_A = 413.76$

↓

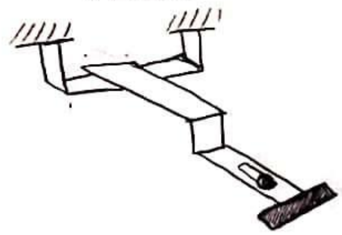
$68.96N \Rightarrow 15.50$ pounds

$15.50(9in) - 15.50(3in)$

$\boxed{M_A = 93 \text{ lb in}}$



Picture



A-10: Section Modulus

Shyne McKay	MET489a	2019/11/21	1/

Given: Yield of steel = 30×10^7
Moment = 43 P*in

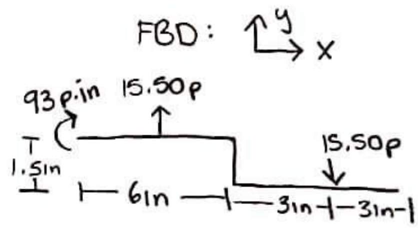
Find: Section of modulus

Assume: Safety factor of 2
Homogeneous material
Rigid Body

Method: 1) FBD 2) max yield 3) section of modulus

Solution:

FBD:



max yeild ⇒ $\frac{30 \times 10^7}{2}$

$= 15 \times 10^7$ psi

$S = \frac{\text{max moment}}{\sigma d}$

$S = \frac{93 \text{ psi}}{15 \times 10^7 \text{ psi}}$

$\boxed{S = 6.2 \times 10^7}$

A-11: Base of the lever

Shyne McKay	MET489a	2019/11/21	1/

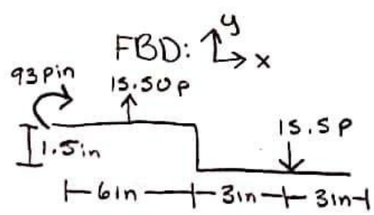
Given: Section of modulus = 6.2×10^{-7}

Find: Required Base of lever

Assume: Height = 1.5 in

Method: 1) FBD 2) Equation from textbooks

Solution:



$$S = \frac{BH^2}{6}$$

$$6.2\times10^{-7} = \frac{B(1.5in)^2}{6}$$

$$B = \frac{6.2\times10^{-7} \times 6}{(1.5in)^2}$$

$$\boxed{B = 0.000001653}$$

A-12: Normal stress and factor K_t

Shune McKay	MET489a	2019/77/21	1

Given: Force = 15.50 pounds
Base = 0.000001653
Height = 1.5 in
Length = 12 in

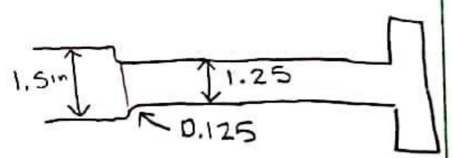
Find: K_t and σ_{nom}

Assume: fillet radius = 0.125
Smaller Height = 1.25 in
Homogeneous material
Rigid Body
thickness = 0.125 in

Methods: 1) FBD 2) r/h 3) H/h 4) graph out K_t

Solution:

FBD: y, x



$r/h = 0.083$

$H/h = 1.2$

★ Based on graph $K_t = 10$

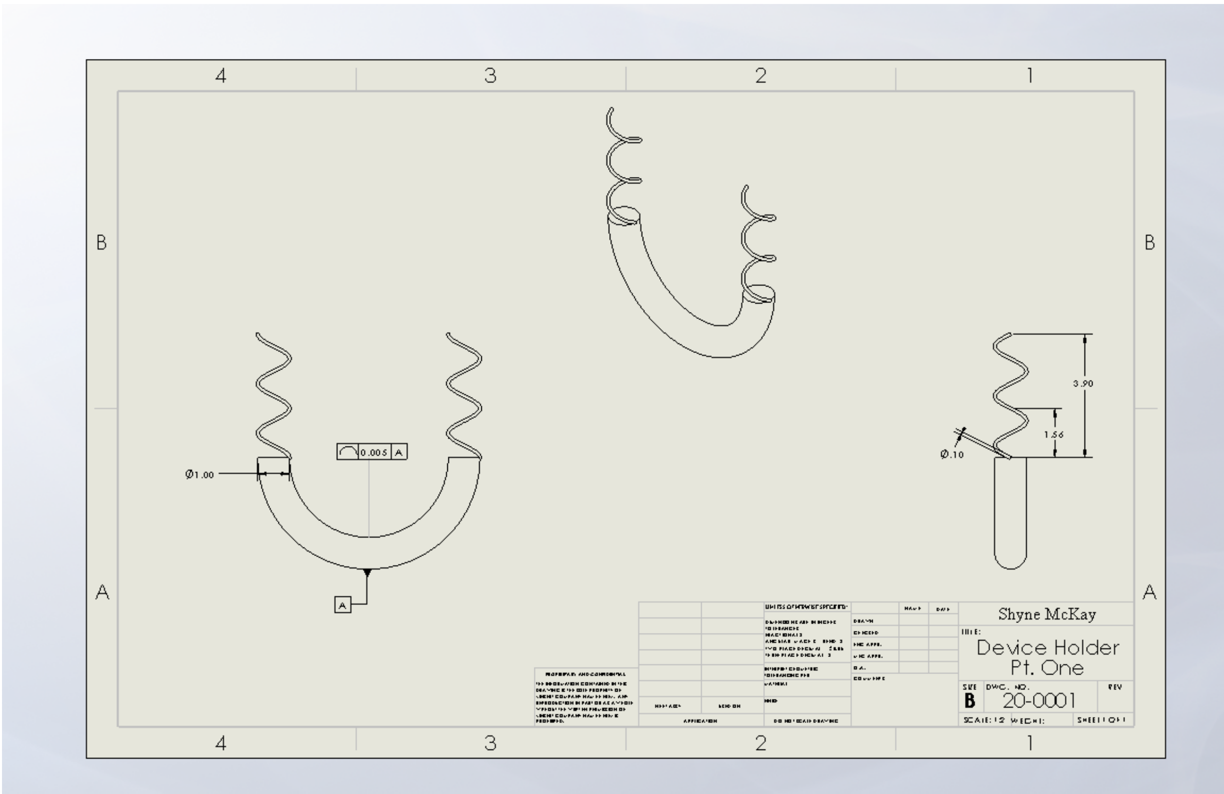
$$\sigma_{nom} = \frac{F}{A_{min}} = \frac{15.50 \text{ pounds}}{1.25 \times 0.125} \approx \boxed{99.2}$$

★ much smaller then the max yield stress ★

Appendix B:

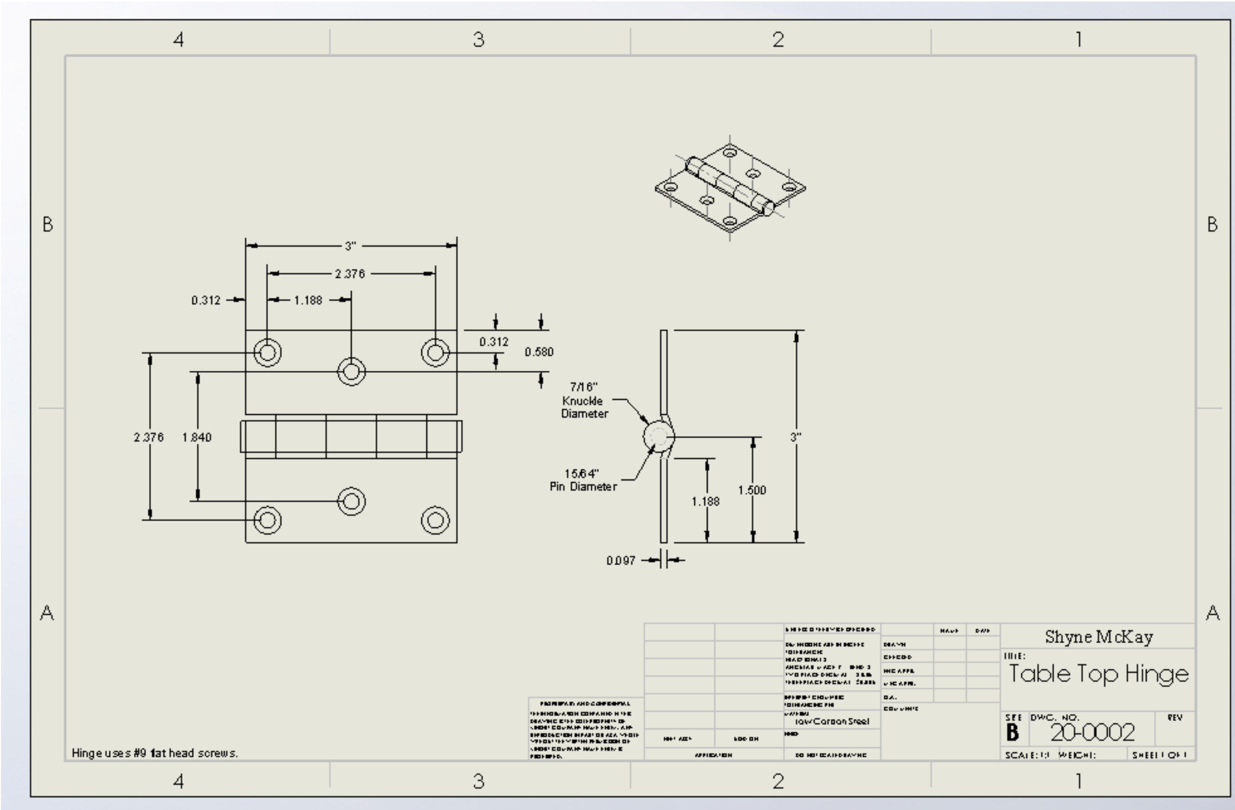
20-0001 (metal hook drawing)

This drawing is for the metal hook that connects on the tables top. This is the devise that helps hold items to the tables top when it opens and closes. This metal hook shape is currently upside down. There will be a very similar shape in (u) shape intertwined with this part. An analysis was done in Appendix A, that helps describe the springs and purpose of this device.

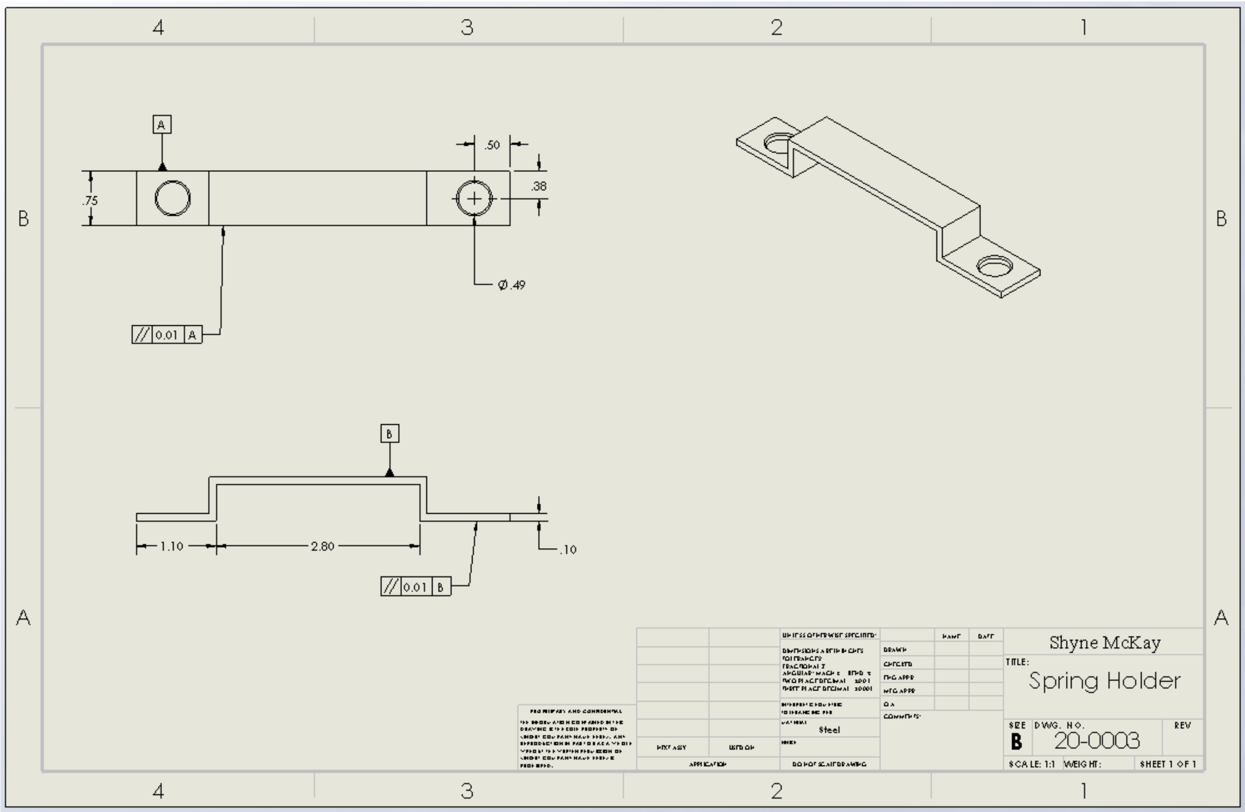


55-0002 (Hinge)

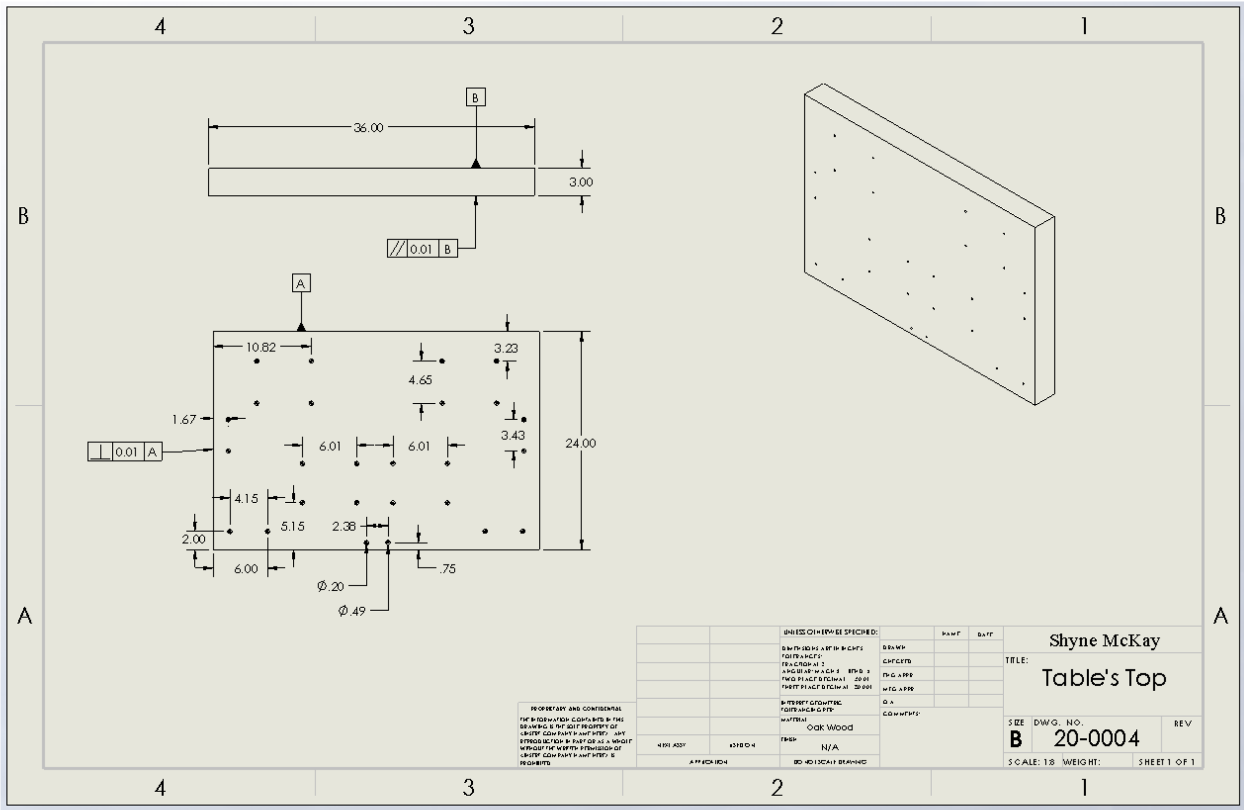
This drawing is for the hinge that will connect to the tables top. This will allow the table top to open and close from the tables base. There will be two of these provided. There will need to be an additional part as a stopper so that the tables top has a 90-degree stopping point.



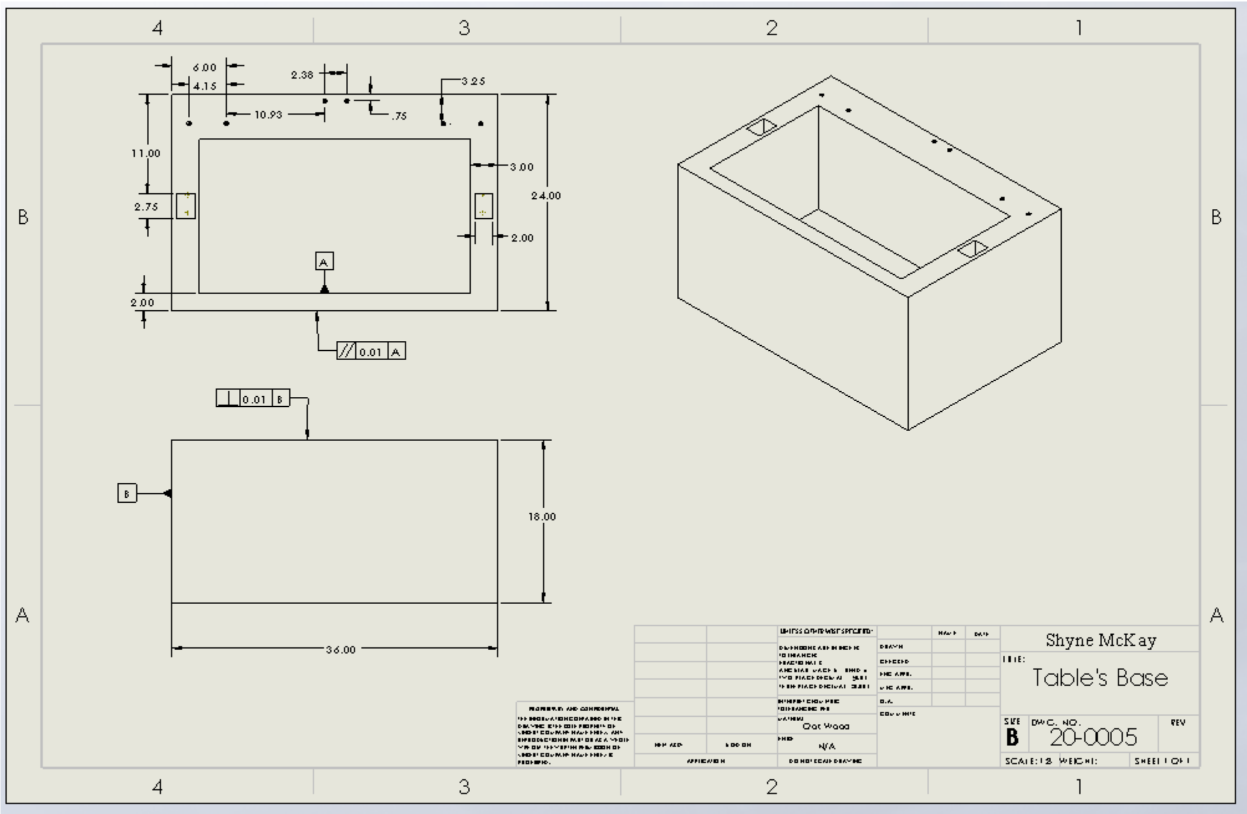
20-0003 (Spring Holder)



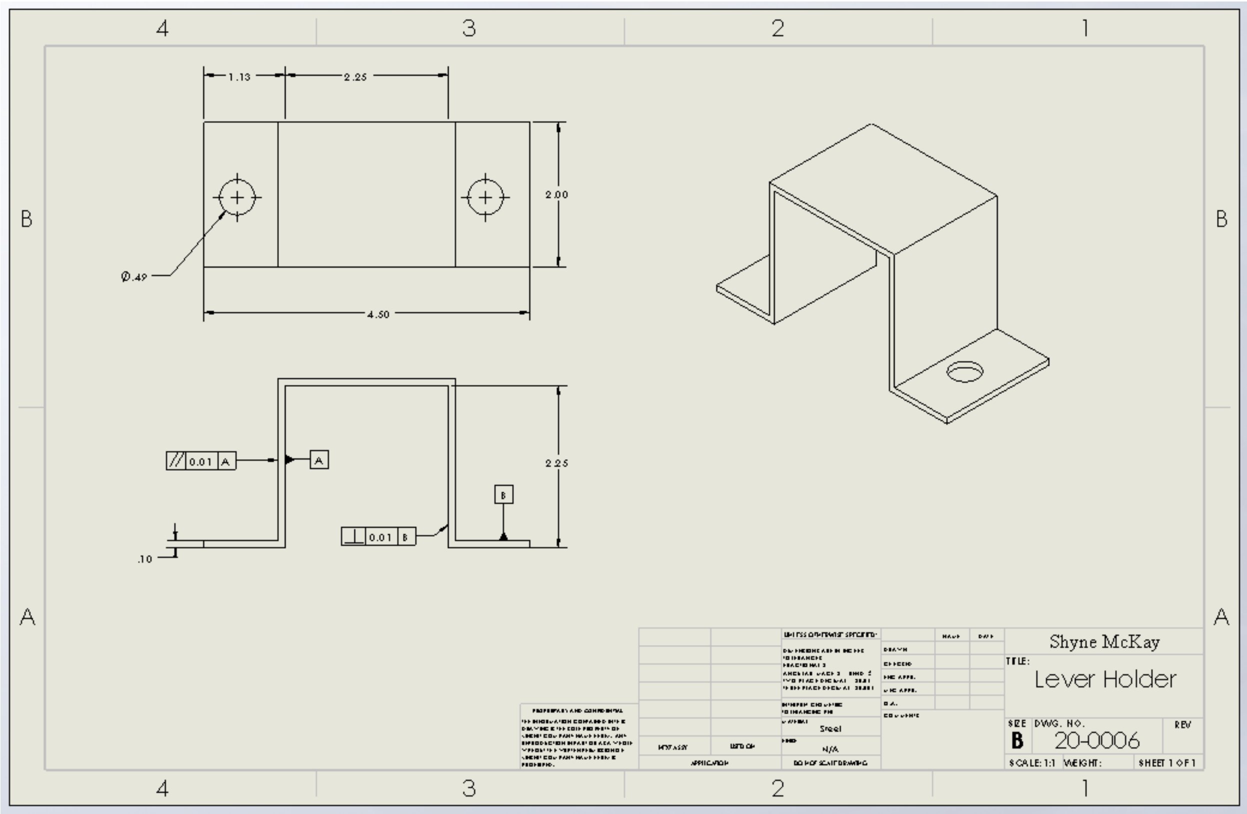
20-0004 (Table's Top)



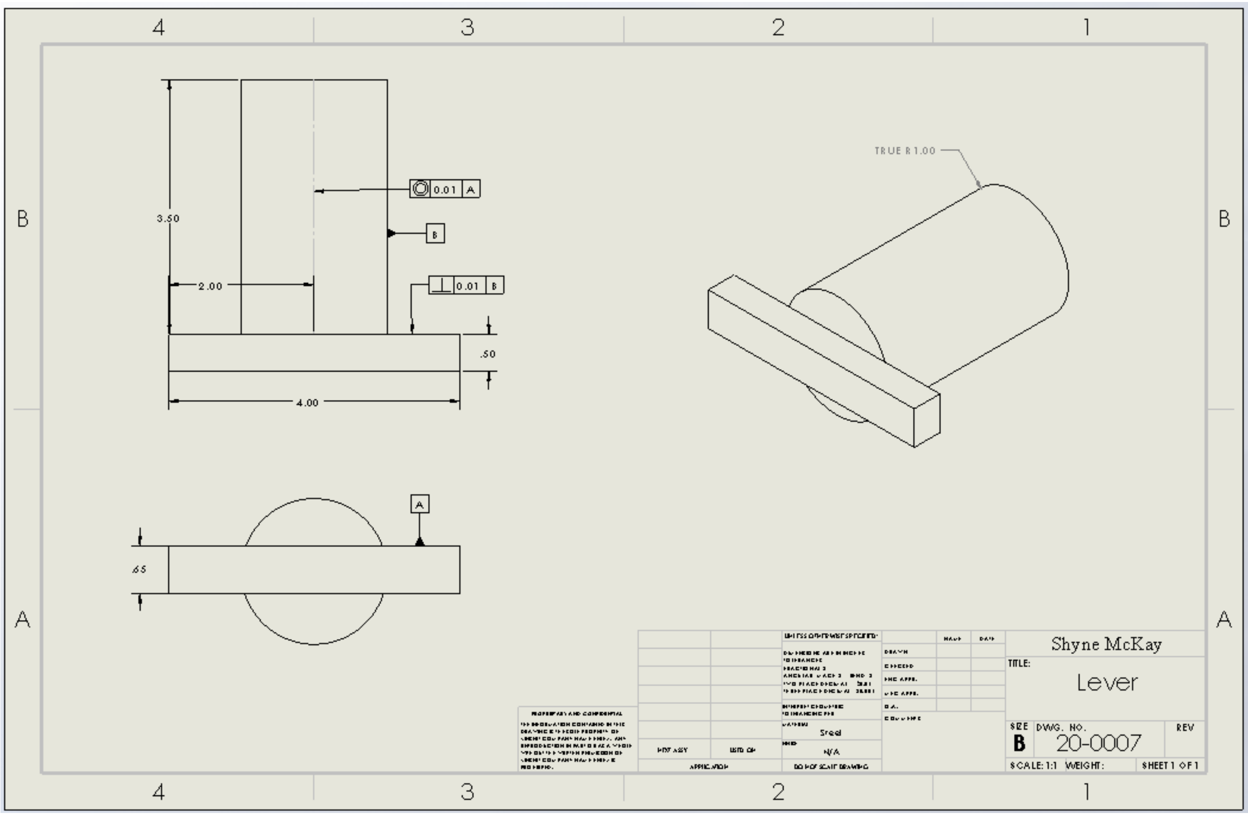
20-0005 (Table's Base)



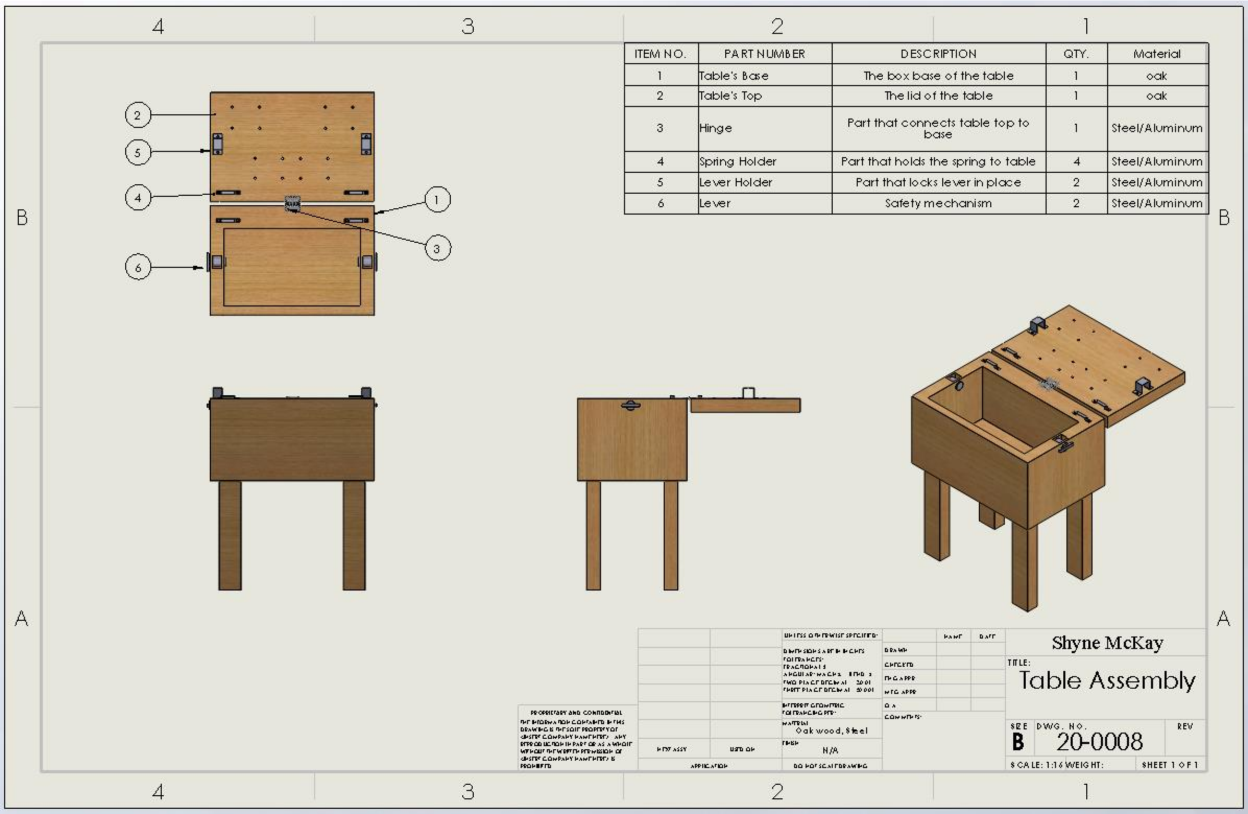
20-0006 (Lever Holder)



20-0007 (Lever)



20-0008 (Assembly)



Appendix C: Parts list

Item	Quantity	Description	Part number	Material
Spring	8	Spring attached to device holder	001	Steel/Aluminum
Hinge	1	Bought from McMaster-Carr	002	Steel/Aluminum
Solid metal tube	4	The material for device holder	003	Steel/Aluminum
Lever	2	Safety system	004	Steel/Aluminum
Lever holder	2	Safety system	005	Steel/Aluminum
Torsion Spring	2	Stability of table top	006	Steel/Aluminum
Spring Holder	2	Holds spring to table	007	Steel/Aluminum
Table top	1	Top of the table	008	Oak
Table base	1	Base of table	009	Oak
Screws	30	#10 size	010	Steel/Aluminum

Appendix D: Budget

Item	QTY	Description	Part number	Material	Estimated Cost	Actual Cost	Source
Oak	TBD	Material to modify the table		Oak	$250		Hardware store
Aluminum	TBD	Material for manufactured parts		Aluminum	$200		Hardware store
Steel	TBD	Material for manufactured parts		Steel	$150		Hardware store
Torsion Spring	2	Stability of table top	006	Steel Aluminum	$50		Hardware store
Hinge	1	Table top and base connector	002	Steel Aluminum	$20		McMaster-Carr
Screws	30	#10 size	010	Steel Aluminum	$30		Hardware store

Appendix E: Schedule

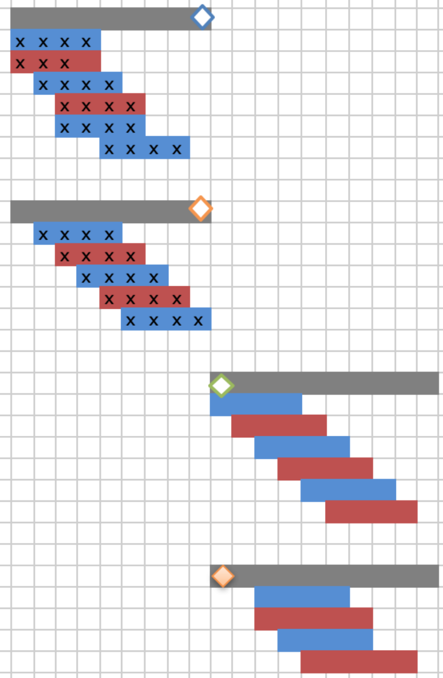
PROJECT TITLE: Discrete Conceled Device Table

Principal Investigator.: Shyne McKay

TASK: ID	Description	Duration Est. (hrs)	Actua (hrs)	%Com
1	Proposal*			
1a	Outline	0.5	1.5	100
1b	Intro	1	3	100
1c	Methods	3	16	100
1d	Analysis	20	29.5	100
1e	Discussion	3	10	100
1f	Parts and Budget	1	6	100
1g	Drawings	17	33.5	100
1h	Schedule	0.5	8	100
1i	Summary & Appx	1	2	100
	subtotal:	47	110	
2	Analyses			
2a	Force to open table	1	2	100
2b	Spring constant in holders	0.5	1.5	100
2c	Max force in the legs	1	3	100
2d	Diameter of the legs	1	2	100
2e	Shear force on the hinge	2	2	100
2f	Tensile stress area of screw	2	3	100
2g	Spring constant in torsion spring	0.5	2	100
2h	Force to open the lever	1	3	100
2i	Moment on the lever	2	2	100
2j	Section Modulus	2	3	100
2k	Base of the lever	1	3	100
2l	Normal stress and k factor	1	3	100
	subtotal:	15	29.5	
3	Documentation			
3a	Device Holder	2	3	100
3b	Hinge	4	0.5	100
3c	Spring Holder	1	5	100
3d	Table's top	2	5	100
3e	Table's base	2	5	100
3f	Lever holder	1	5	100
3g	Lever	1	5	100
3h	Assembly	3	5	100
	subtotal:	16	33.5	
4	Proposal Mods			
4a	Budget list	0.5	1	100
4b	Parts list	0.5	1	100
4c	safety hazard	1	2	100
	subtotal:	2	4	

Continued next page!

TASK:	Description	Duration Est.	Actua	%Con	S	October	November	Dec	January	February	March	April	May	June
PROJECT TITLE: Discrete Conceled Device Table														
Principal Investigator.: Shyne McKay														
7	<u>Part Construction</u>			100										
7a	Tables top	10	8											
7b	Tables base	10	14											
7c	Device holders	8	13											
7d	Chain System	3	3											
7e	Locking system 1	3	7											
7g	hinge	2	3											
	subtotal:	36	48											
9	<u>Device Construct</u>			100										
9a	Table top and base assemble	2	18											
9b	Device holder assemble	7	9											
9c	Holders attachment	3	2											
9d	Chain System	2	4											
9e	Locking system	1	3											
	subtotal:	15	36											
10	<u>Device Evaluation</u>			0										
10a	weight test	2												
10b	Force to open test	1.5												
10c	Lever force	1.5												
10d	Discreteness test	3												
10i	Take Testing Pics	0.5												
10h	Update Website	2												
	subtotal:	10.5	0											
11	<u>495 Deliverables</u>			0										
11a	excel workbook	2												
11b	Discrete pictures	1												
11c	Memo of discrete data	1												
11f	Update Website	3												
	subtotal:	7	0											
	Total Est. Hours=	3038.5	3054				=Total Actual Hrs							
Labor:	100	303850												



Appendix F: Expertise and Resources

List of resources used or plan to use in future tasks:

- University Professors
- Lab Technicians
- Course Textbooks
- University Machine Shop
- University Wood Shop

Appendix G: Testing Report

Introduction:

For the concealed device table, there are three main requirements. The first requirement is to be able to open the table using under 10lbs of force. The second requirement is to be able to remove a device from a holder using more than 20lbs of force. The third requirement is to be able to operate the table under 10 seconds. Each requirement has a purpose for the table, whether this is safety or strength, the requirements listed are important because without them, the table would not be able to function properly. When it comes to the force to open the table, the table needs to be able to open smoothly and without a lot of pressure. The more weight the table's top has, the chances of it tipping over are a lot greater. In addition, one must have the strength to open the table. The parameters for the device holders is making sure that a small child will not be able to release the device. Having 20lbs or more to remove the device will make sure that a younger child will not be able to remove the device easily. The main purpose for this table is to discreetly hide devices in plain sight. The predicted amount of force to open the table is 5lbs. The predicted amount of force to remove a device is 25lbs. For the time aspect, a predicted amount is 7 seconds. The data for the two force tests will be calculated by a spring scale. When you pull on the device it reads how much force it being applied. The last test will be calculated with a stop watch. In reference to the schedule, the testing will be completed by the beginning of May. Starting with the two force tests, and finishing up with the time requirement.

Method/Approach:

For these tests to be completed, professors at Central Washington University provided the spring scale. Without this device, the majority of the testing would not be able to be completed. In addition, for the timing test, a second person Is required. This is because one can start the timer as the other begins to operate the table. There will be less room for error if a second person helps with the timer. Each test will be recorded on an excel work sheet. After three trials are completed an average will be taken. This will allow there to be an accurate reading for each test. For the testing to be done, no additional costs came from the budget. All resources were donated from outside sources. The testing's will be completed with 3 trials each and recording the data after each trial. Starting with the force to open the table, then proceeding to the force to remove a device, then ending with the amount of time it takes to fully operate the table. The reason for the three trials is because the spring scale reading can change with the slighted movements. Getting an accurate reading will need to come from getting multiple trials and then gathering an average. This goes for time as well. Stopping a stopwatch and reading a spring scale has a lot of room for human error. The more trials that are done the chances get lower for that to happen. The data will be recorded into an excel sheet and transferred into three different bar graphs. Making it easy and clear what the numbers are and for which trial.

Test Procedure:

Test One: Force to Open the Table

The purpose of this test is to dictate how much force is needed to open the table's lid when it has its max weight inside. Below is an image of the table being opened. This is how the testing will look when its being completed. This test will be completed within one hour. The time will consist of multiple tests so that an average will be available. This test will be completed by the middle of this week. The location of where the test will be located in unknown due to underlying circumstances going on in the world. As of right now, the test will be held in Ellensburg. The resources needed for this test is a force gauge and the table its self. The test gauge will provide an accurate number of pounds it takes to open the lid.

Specific Actions:

Step One: Get all resources ready and near the table.

Step Two: Unlock the table with the key card.

Step Three: Place the hook on the end of the force gauge and place it on the tables lid so that it is hook onto the side portion of the table.

Step Four: Begin pulling on the force gauge. This will make the gauge reader begin moving and the table's lid will begin to open.

Step Five: Repeat this task three times so that an average can be taken for the pounds.

The risk in this test is having the force gauge slide of the table's lid and having the table small shut. This is a risk because one's fingers or hand can be crushed by the lid. To avoid this from happening, pull the table open by standing behind the table. One must be ready for the evaluation of this test. The person pulling the force gauge must also be watching not only the table but the number the gauge is reading.

Test Two: Force to Remove Device from Holder

The purpose of this test is to dictate the amount of force needed to remove an object from the spring holders. The testing will be completed in the exact same way as test one, only difference is that the spring scale will be placed on the holders instead of the tables top. The time to complete this test will be within one hour. The test will be completed in multiple trials, making sure that an average will be taken. When it comes to the location for this test, it will be completed in Ellensburg. The locations for each test will remain the same because that's where the tables located. The resources needed for this test are the spring scale used in the first test and the table its self.

Specific Actions:
Step One: Get all the resources ready and near the table.
Step Two: Open the table
Step Three: Place the hook on the spring scale on the device holder.
Step Four: Begin pulling on the spring scale until the device can easily slide out from the holder, read the scale when it opens the distance needed.
Step Five: Repeat this test three more times to get an average for the amount of force needed to remove the device.
The risk in this test is having the table close while pulling on the device holder. This can smash hands and or fingers. Being that the table is very top heavy this can damage one's hands. One must be ready to read the spring scale when the device is pulled out. If one waits to long, force can be applied to the spring scale after the device has been removed. This would cause an in accurate reading.

Test Three: Time to Operate the Table
The purpose of this test is to see how long it takes to open the table and remove a device. One of the main purposes of this table is to have quick and easy access to the devices in emergency situations. This test will be completed within an hour. There will be three trials to this test so that an accurate time can be recorded. The location of this test will be in Ellensburg with the table. The resources needed for this test is a stop watch and a partner. The partner will be the one timing while the other operates the table.
Specific Actions:
Step One: Get all resources near the table and ready to go.
Step Two: Get the stopwatch ready and the partner ready to begin.
Step Three: Start the timer when one goes to unlock the table.
Step Four: Unlock the table, open the table, pull the device holders, and remove a device. Once the device has been removed the timer can be stopped.
Step Five: Repeat this test three times to get an accurate reading for the time needed to operate the table.
The risk for this test is the same for the two previous tests. Having the table close or fall can cause serious damage. For the test, the partner must be ready at all times to start and stop the timer. Being late to stop the timer will alter the average time to operate the table. The goal is to get as close and precise to when the device is pulled out of the holder.

Deliverables:

For test one the force to open the table had an average of 6.41lbs. For the second test, the force to remove a device form the holders, the average came to be 33.33lbs. For the final test, the time to operate the table, the average came to be 9.3 seconds. When it comes to the calculated values, done before testing, the first test had a calculated value of 5lbs. This is different from the tested value because the weight and size of the table changed from the time the calculated value was completed. In addition, the spring force was calculated for the device holders, this came to be 11.5N. When converted to pounds, this would be 2.5lbs. Clearly this is not correct. The design of the holders and the size of the spring was changed when the purpose changed to make sure that a small child would not be able to pull the holder open. This is when the requirement came to be that the holder must take more than 20lbs to open. For the last test, the time was never calculated. This test was created towards the end of the project. It was originally paired with the first test, but this made it so that there were more room for human error. Separating the two allowed for the data to be more accurate. Over all the testing went great. There were no issues and things went smoothly. The table met all the requirements needed and is a fully functioning discrete concealed device table.

Appendix:

Appendix G1: Required Items

- Spring scale
- Stopwatch
- Partner
- Table
- Key card (unlocks the table)

Appendix G2: Data Forms

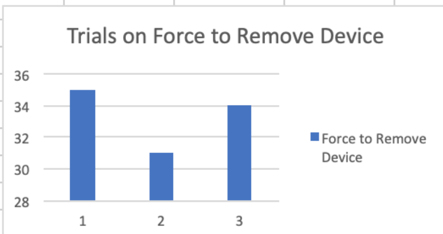
18				
19	Test One: Force to Open Table			
20	Trial One		lbs	
21	Trial Two		lbs	
22	Trial Three		lbs	
23	Average		lbs	
24				
25	Test Two: Force to Remove Device			
26	Trial One		lbs	
27	Trial Two		lbs	
28	Trial Three		lbs	
29	Average		lbs	
30				
31	Test Three: Time to Operate the Table			
32	Trial One		seconds	
33	Trial Two		seconds	
34	Trial Three		seconds	
35	Average		seconds	
36				

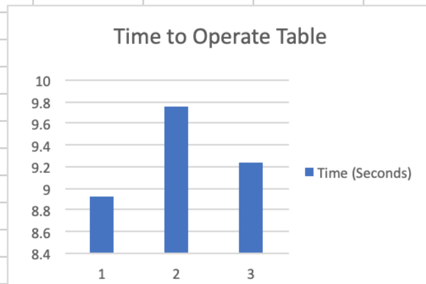
Appendix G3: Raw Data

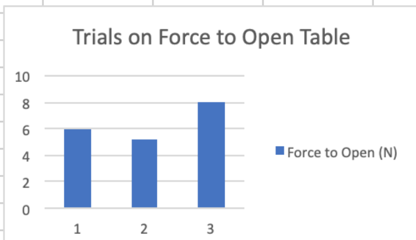
Test One: Force to Open Table			
Trial One	6	lbs	
Trial Two	5.25	lbs	
Trial Three	8	lbs	
Average	6.41	lbs	
Test Two: Force to Remove Device			
Trial One	35	lbs	
Trial Two	31	lbs	
Trial Three	34	lbs	
Average	33.33	lbs	
Test Three: Time to Operate the Table			
Trial One	8.92	seconds	
Trial Two	9.76	seconds	
Trial Three	9.24	seconds	
Average	9.3	seconds	

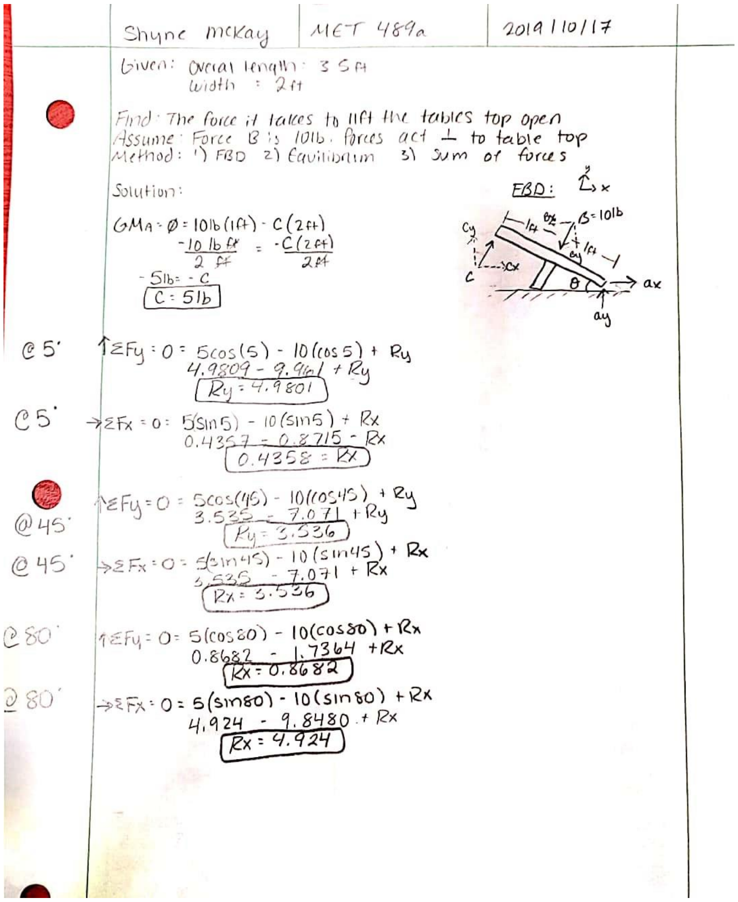
Appendix G4: Evaluation Sheets

Test One: Force to Open Table		
Trial One	6	lbs
Trial Two	5.25	lbs
Trial Three	8	lbs
Average	6.41	lbs
Test Two: Force to Remove Device		
Trial One	35	lbs
Trial Two	31	lbs
Trial Three	34	lbs
Average	33.33	lbs
Test Three: Time to Operate the Table		
Trial One	8.92	seconds
Trial Two	9.76	seconds
Trial Three	9.24	seconds
Average	9.3	seconds









Shyne McKay | MET 489a | 2019/10/17

Given: Overal length : 3.5 ft
width : 2 ft

Find: The force it takes to lift the tables top open
Assume: Force B is 10lb. forces act ⊥ to table top
Method: 1) FBD 2) Equilibrium 3) Sum of forces

Solution:

FBD:

$\circlearrowleft M_A = 0 = 10lb(1ft) - C(2ft)$

$\frac{-10 \text{ lb ft}}{2 \text{ ft}} = \frac{-C(2ft)}{2ft}$

$-5lb = -C$

$C = 5lb$

@ 5° $\uparrow \Sigma F_y : 0 = 5\cos(5) - 10(\cos 5) + R_y$
$4.9809 - 9.961 + R_y$
$R_y = 4.9801$

@ 5° $\rightarrow \Sigma F_x = 0 : 5(\sin 5) - 10(\sin 5) + R_x$
$0.4357 - 0.8715 - R_x$
$0.4358 = R_x$

@ 45° $\uparrow \Sigma F_y = 0 = 5\cos(45) - 10(\cos 45) + R_y$
$3.535 - 7.071 + R_y$
$R_y = 3.536$

@ 45° $\rightarrow \Sigma F_x = 0 = 5(\sin 45) - 10(\sin 45) + R_x$
$3.535 - 7.071 + R_x$
$R_x = 3.536$

@ 80° $\uparrow \Sigma F_y = 0 = 5(\cos 80) - 10(\cos 80) + R_x$
$0.8682 - 1.7364 + R_x$
$R_x = 0.8682$

@ 80° $\rightarrow \Sigma F_x = 0 = 5(\sin 80) - 10(\sin 80) + R_x$
$4.924 - 9.8480 + R_x$
$R_x = 4.924$

Green Sheet of calculated values for test one

Appendix H: Resume

S.M.

SHYNE MCKAY

MECHANICAL ENGINEERING TECHNOLOGY MAJOR
CENTRAL WASHINGTON UNIVERSITY

OBJECTIVE

A dedicated and detail-oriented engineering student who thrives in a fast-paced environment. Seeking an engineering intern position that integrates coursework to build field experience.

SKILLS

Knowledge and experience with large machines such as lathes, mills, CNC's, drill press. Knowledge in complex calculations such as finding different stresses in a variety of materials. Experience and skill with computers and technology such as AutoCAD, Solidworks, and G code for CNC programing.

EXPERIENCE

PROJECT ENGINEER INTERNSHIP • LEASE CRUTCHER LEWIS AND CLARK CONSTRUCTION • JUNE 2019- SEPTEMBER 2019
Managed mechanical and food service submittals, shop drawings, and RFI's, for the new Washington State Convention Center. Attended superintendent meetings throughout the project.

SNOWBOARD AND SKI TECHNICIAN • SNOQUALMIE SUMMIT • NOVEMBER 2017-MAY 2019
Prep and repair snowboards and skis so they are safe for public use. Responsible for repairing client's personal equipment. I work with a team and am always involved with costumer service.

GRAVEYARD BARISTA • 1891 BISTRO • SEPTEMBER 2018 – CURRENT
Computer lab/coffee shop. I make coffee and other drinks for customers as well as assist with computer problems and/or technical issues that clients may have.

GENERAL LABORER • L&C TRUCKING COMPANY • SEPTEMBER 2014– JUNE 2015
Assisting with repair of large diesel trucks -mainly dump trucks and semi-trucks. We also worked on and sold classic cars like a 1955 Chevy Belair. I learned basic welding skills and took care of and cleaned the shop.

EDUCATION

MECHANICAL ENGINEERING TECHNOLOGY (ABET ACCREDITED) • CURRENT (SENIOR) • CENTRAL WASHINGTON UNIVERSITY
HIGH SCHOOL DIPLOMA • JUNE 2016 • ARLINGTON HIGH SCHOOL

EMAIL: SHYNE.MCKAY@CWU.EDU PHONE: (360)454-3413 ADDRESS: 4211 220TH NW STANWOOD WA 98292

Appendix J: Safety

Engineering Technologies, Safety, and Construction Department

JOB HAZARD ANALYSIS
{Discrete Wood Coffee Table}

Prepared by: Shyne McKay	Reviewed by: Approved by:

Location of Task:	Hogue Technology Building, CWU, WA, USA
Required Equipment / Training for Task:	Experience with advanced machine shop tools. Band Saws, Bending Press, Torch, Hai drills, Drill press, PPE for machine shop and wood shop.
Reference Materials as appropriate:	https://www.dri.edu/images/stories/editors/ehs/ehsdocs/Occ_Safety_Machine_Shop_2(

Personal Protective Equipment (PPE) Required (Check the box for required PPE and list any additional/specific PPE to be used in "Controls" section)						
Gloves	Dust Mask	Eye Protection	Welding Mask	Appropriate Footwear	Hearing Protection	Protective Clothing
☒	☐	☒	☒	☒	☐	☒
Use of any respiratory protective device beyond a filtering facepiece respirator (dust mask) is voluntary by the user.						

TASK DESCRIPTION	HAZARDS	CONTROLS
Band Saw: Check condition of blade	**Cutting fingers and hands**	**Avoid contact with blade teeth.**
Band Saw: Align materials flat on table.	**Pinching fingers or hands**	**Keep fingers and hands away from pinch points.**
Band Saw: Start Blower and saw	**Cutting fingers and hands. Injuries from flying material.**	**Keep fingers and hands away from blade. Use push bar for smaller materials. Wear safety glasses.**
Drill Press:	**Foot injury if vise falls.**	**Secure the**

Load the vise	**Finger pinching while sliding vise.**	**vise on the table with T-pins.**
Drill Press: Load the bit	**Hand injury from bit.**	**Wear gloves, don't hold the end of the bit.**
Drill Press: Feed the drill with the feed	**Injury caused by breaking the bit. Eye or skin damage from cutting oil. Hand injury from exposed pulley near the feed handle.**	**Feed with appropriate pressure. Wear eye protection. Use lowest RPM. Make sure pully guard is in place.**
Hand operated power tools: Changing blade/bit/other tool parts	**Lacerations**	**Ensure tool is unplugged before changing any part of the tool.**
Operating power tool	**Lacerations and other injuries**	**Wear safety glasses. Evaluate surroundings. Make sure blade or bit is not binding into the material. Make material secure.**
Metal Brake: Feed sheet metal into the rollers	**Lacerations to hand. Pinching hand. Muscle strain.**	**Wear gloves. Deburr the edges. Keep fingers from pinch point. Position body in relation to the crank handle to avoid reaching.**