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Pivoting Motocross Foot Pegs

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Pivoting Motocross Foot Pegs

By

Michael LeBlanc

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Abstract

The ability to keep a dirt bike rider's feet in full contact with the foot pegs at all times is something all riders' face when riding their bike. The foot pegs that come factory and aftermarket today are universally static and non-rotational which prevent the ability for maximum contact to be maintained. During various riding positions, a rider's foot can partially become disconnected from the peg allowing for a loss of potential control and balance/stability. The solution devised was a set of pegs that have the ability to rotate with the rider's foot. The rotational ability of the pegs allow for the rider's feet to stay in full contact throughout various riding positions or conditions. The pivoting peg allows for full contact with the pegs provides more stability and control over the bike which improves capabilities of balance and speed/momentum. To accomplish the pivoting, a round shaft with limiting stops was created to rotate fifteen degrees forward and backwards on the bike. Based on the design concept that was created and calculations that were done on the design, such as deflection and load bearing calculations, these pegs will easily any issues support the weight of a 185 pound rider, while still having the capability to rotate without binding. More testing of these pegs is scheduled for spring quarter 2015. From the calculations that were prepared, the pegs will pivot fifteen degrees and support the minimum weight requirement of 185 pounds.

INTRODUCTION

Motivation

While riding dirt bikes, whether on track or trail, it is ideal to maintain maximum contact with the arch of your foot to the pegs. With the current stock and aftermarket pegs out on the market currently, this is simply not possible in all situations of riding. Many times the rider is forced to extend their weight forward or back and this forces' the riders' foot to loose maximum contact with the teeth of the foot peg as their foot rotates forward or back depending on the situation. The concept of a pivoting foot peg instead of the typical static peg would alleviate the contact issue. Allowing a peg to rotate a certain amount of degrees forward and backwards would allow the riders' foot to remain in maximum contact throughout the various movements made while on the bike. These pegs will rotate forward or backward when the weight is distributed in that direction but will return to flat when the riders' position is balanced on the pegs. This device will allow every rider to maintain maximum contact to the pegs throughout all body positions and improve riding ability.

Function Statement

A device is needed that will:

- Function as a normal foot peg to provide maximum grip to the riders foot
- Be able to rotate towards the front and back of the bike
- Effectively rotate back towards the center/normal position after frontward or backward rotation
- Be able to handle a distributed load to each peg

Requirements

The device must:

- Have each peg be able to not deform when a load of 185 pounds from the riders weight acting is placed upon them along with force of impact off of obstacles
- Have a total weight under two pounds
- Be able to be used universally on various brands of dirt bikes
- Be able to rotate 15 degrees frontward and backward
- After rotation in the frontward or backward direction, peg must rotate back to the center position
- Be able to withstand varying weather elements such as rain, snow, and extreme heat using an accelerated weather test
- Have a safety factor of 2.0 or better

Engineering Merit

Designing a set of foot pegs that pivot for a motocross bike require a great amount of analysis within the areas of weight reduction, material selection, peg design, strength, and durability. Analysis of weight reduction will focus on various configurations, design methods, and materials to determine a set up that has results in a total weight of under two pounds and as well as have less weight than most other foot pegs on the market. Material selection analysis ties in with the weight reduction analysis along with strength analysis. The material selected will have to be light in weight while not sacrificing very much strength characteristics. Analysis of peg design will include designs of a peg that can withstand forces such as rider weight and forces' acting upon them as a rider goes over obstacles and the weight shifts. The peg design will also include ways to reduce the overall weight of the peg by pushing limits of wall thicknesses. Design will also have analysis on how to maximize grip towards the riders' foot along with design of how to make the pegs rotate to a certain degree increment and be able to rotate back. Strength analysis will come with determining the forces acting upon the pegs in a standard position along with how they act when the pegs is in the rotated position. These values will be used then to help with material selection and fine tuning of the peg design to create the overall best product. Durability is going to be determined by the ability for the material to last under various conditions such as weather elements and structural elements due to repeated cycles of various loading.

Scope

The major portion of effort in completing this project will be in the initial design phase and the analysis on the components of the overall design. There will also be considerable effort, work, and time put into the machining and fabrication of a majority of the parts myself. Since a majority of the pieces will be needed to custom designed, extensive time will be needed creating cad files and cadcam files along with time in the machine shop to manufacture the components.

Success Criteria

This project will be successful if the device functions with smooth operation and withstand a force of 175 pounds at each peg and deflecting less than half an inch while being able to rotate front to back with fifteen degrees of motion in both direction and return to center position within the flow of rider movement. The success will also be displayed by using video showing the pivoting motion of the pegs along with video of the pegs at work on the track.

DESIGN & ANALYSIS

Approach

The approach of the task at hand is to create a pair of foot pegs for a dirt bike that not only function in the normal stationary position, but in a rotational matter as well. The proposed sequence is to create conceptual sketches of peg design along with rotational component design. Ideas for the peg design will be gathered from current oem[1] pegs on the dirt bike, along with viewing aftermarket designs off of friends' bikes as well as online. Conceptual ideas for a pivoting mechanism will come from viewing of pivoting designs for other applications as well with viewing the bike itself and sketching something that would potentially work. Creating a design for foot pegs that pivot will allow for better bike control for a rider in all potential riding positions that can occur while out on the track or in the woods such as being fully extended towards the rear of the bike. With normal pegs, the front half of a rider's foot would become disconnected with the pegs. With foot pegs that rotate with the rider's weight distribution, the rider's whole foot will remain connected at all times such as scenarios presented previously. Solidworks was used to model and create drawing files of the two best sketch designs in forms of parts, subassemblies, and final assembly. The FEA function of Solidworks will be used to check hand calculations as well as test predictions before any physical test is performed. The foot peg components will be constructed using CNC mills and manual lathes found in the Central Washington University Hogue machine shop. Outside tools and equipment will be used in conjunction with the Hogue machine shop for the subassemblies and final assembly construction.

Description

The foot pegs will consist of rectangular shape with a semicircle shape at one end as the main body construction of the pegs. The pegs will have jagged teeth pointing upright from the top surface for gripping points for the rider's motorcycle boot. The remaining box end of the peg will partially house pivoting cylinder that contains a bushing that allows for peg rotation to occur. This cylinder connects to the main body of the pivoting mechanism which will connect to the stock mounting location on the motorcycle. On the main body of the pivoting mechanism, there will be another extruded cylinder that goes through a cut out towards the bottom edge of the square side of the peg. The cutout here will have angled sides with a horizontal top that when the pegs pivot on the main cylinder, the bottom cylinder will hit these stops which will limit the rotational movement of the pegs themselves.

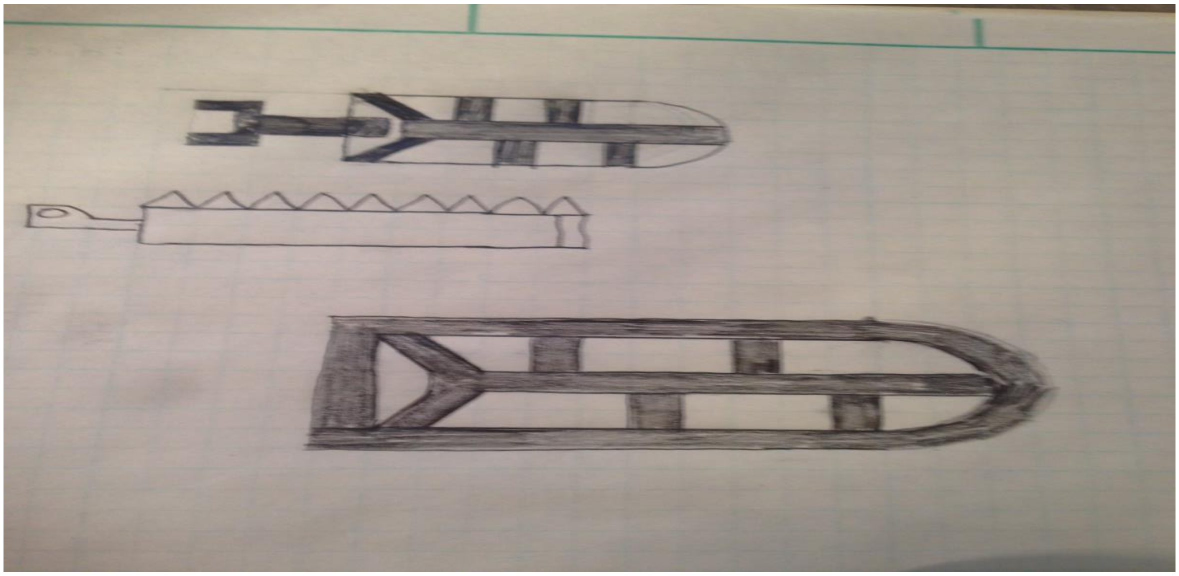

Figure B-1

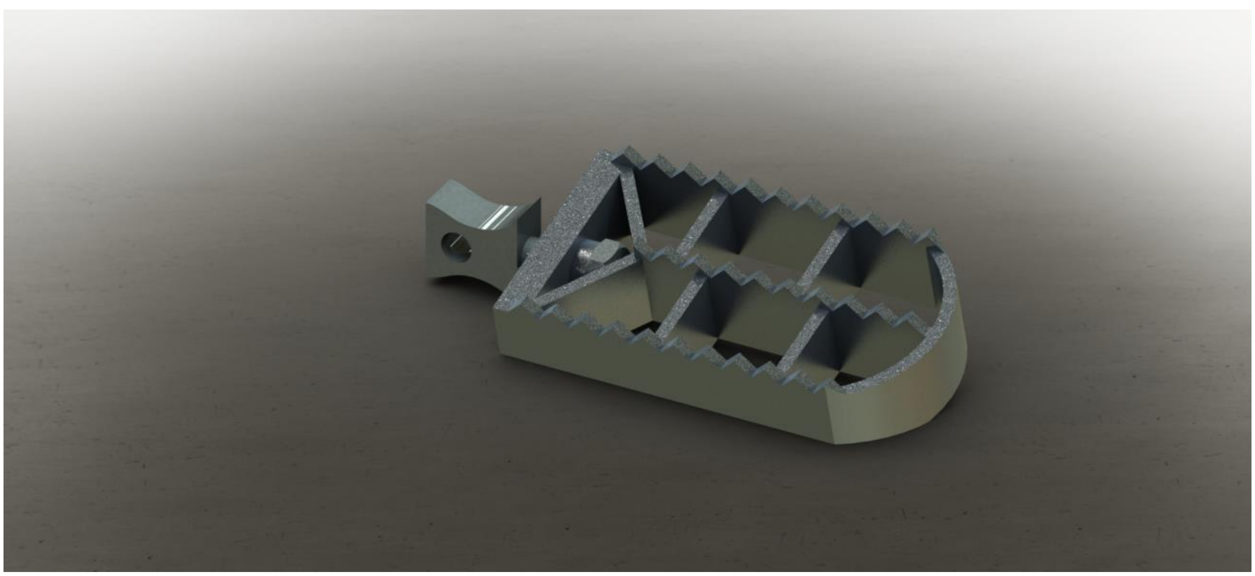

Figure B-2

Benchmark

These foot pegs should be able to be as functional as other foot pegs on the market (such as oem or msr) with the ability of pivoting motion without any compromises to strength, durability, or safety. There are many options out there for foot pegs along with one company that produces a set that pivot. The company that produces a pivoting set allows for greater rotation than what is necessary to create maximum contact. Their design also allows for more weight to be left on the peg material than what it can be reduced to and allow for proper function. The design that will be created will use a smaller angle of rotation (15 degrees instead of 25 degrees) to allow for maximum contact without the extra rotation of the pegs. The design will also use only the necessary material needed to operate smoothly while still providing superior performance. This will be accomplished by using the oem foot peg that is on the bike itself (see figure 1 below) and modifying its wall thicknesses and overall design. These pegs that will be used are the oem stock foot pegs found upon my 2008 Honda crf250r.

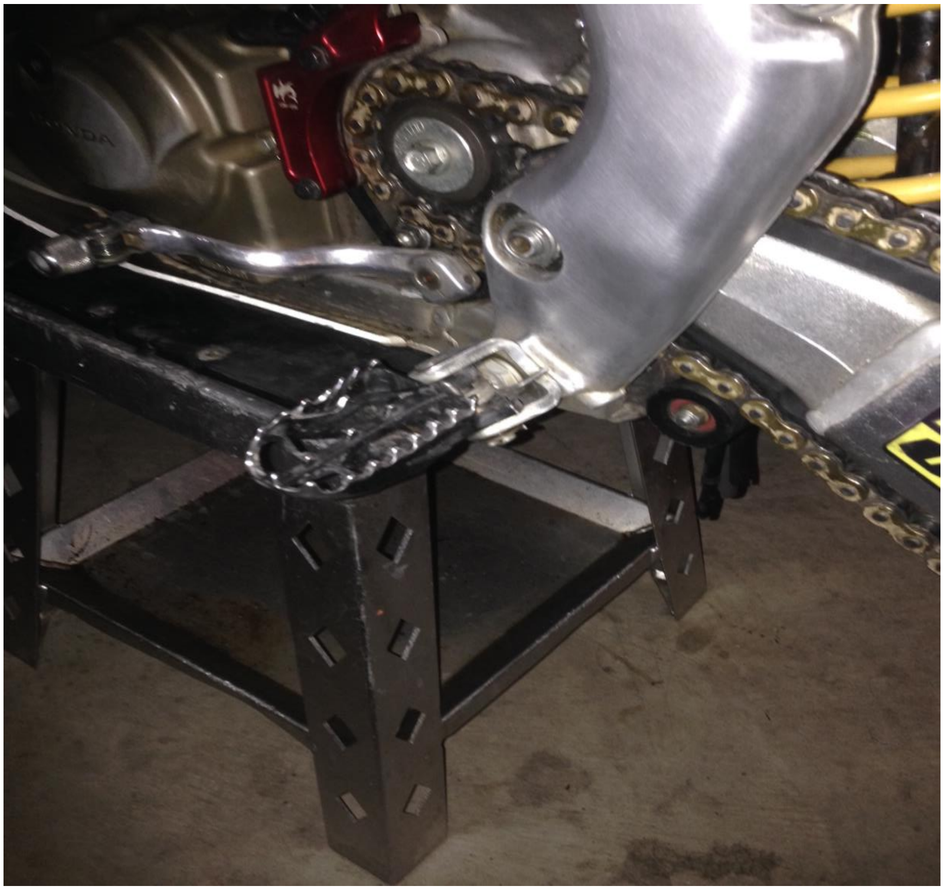

Figure 1 (Standard Peg Position and Fitment)

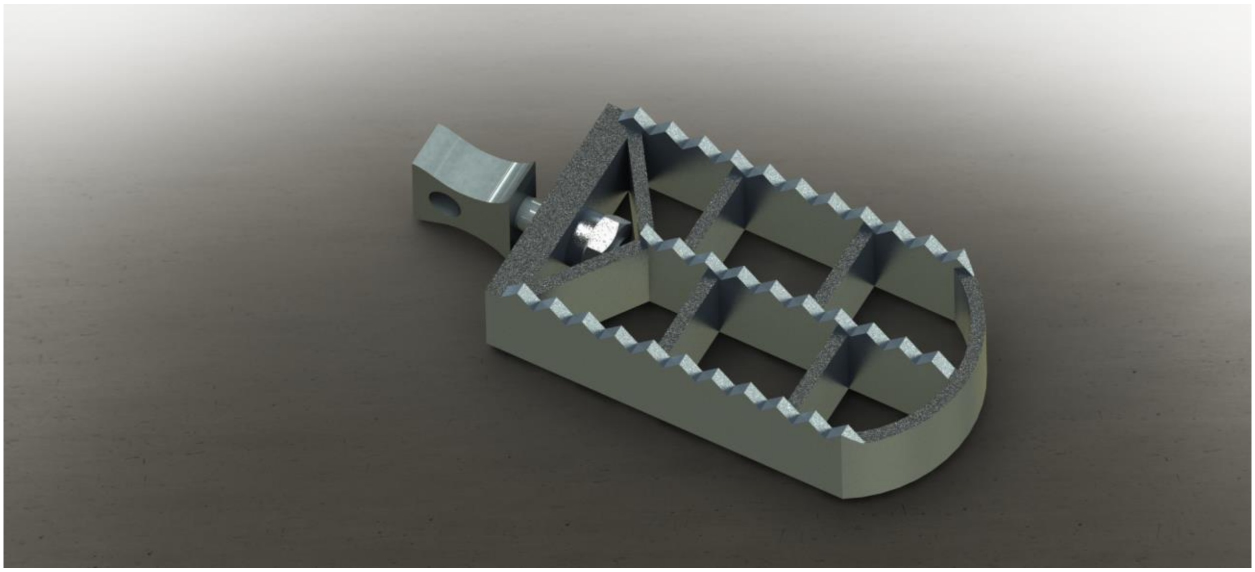

Figure 2 (Solidworks Rendering of Completed Assembly)

Performance Predictions

The device will be critiqued on performance, based on the following measures:

- Pegs will withstand a distributed load of 185 pounds applied across the face based on calculations completed
- The designed foot pegs will have a total weight of sixteen hundredths of a pound based on the SolidWorks mass properties feature
- The weight of the foot peg after being machined will have a weight of eleven hundredths of a pound based on the SolidWorks mass properties feature
- The weight of the pivoting mechanism is going to be five hundredths of a pound based on SolidWorks mass properties feature
- Have a deflection after the performance testing of four thousandths of an inch based on deflection calculations.

Description of Analyses

A vast amount of analysis needs to be conducted to guarantee the successful implementation of this design project. Analysis will need to be conducted in the following areas:

- Weight- Weight will need to be reduced as much as possible in certain areas. These areas will be determined via calculations of strength and material properties.
- Material- A suitable material will need to be chosen from examining potential materials and viewing their strength attributes, as well as their machinability, and the ability to withstand repeated loading.
- Shafts- Analysis will need to be conducted to determine proper design as they will have to resist some rotational forces as well as bending do to weight placed on the main peg body.
- Peg Body- Determining loads and resultant forces as well as deflection occurring at maximum moments upon the pegs will help with determining best possible design.

Scope of Testing and Evaluation

Two types of tests will be used to determine the overall success of the design project. These tests are stationary testing and full ability testing. Stationary testing will consist of the bike being placed upon a motorcycle stand with the rider aboard the bike. The rider will transfer their body to various positions forward, backward, and neutral on the bike to see how the pegs react to each movement and if fluid operation is applied. A second rider will be asked to perform the same tasks so that multiple sets of trials can be conducted to determine of operation is how it supposed to be along with variation in rider weight and movements. While each rider is upon the bike, the rotational angle will be measured at full rotation to determine if the pegs meet the requirement of fifteen degrees of rotation. Strain gauges will also be applied to measure the stress the pegs endure with rider weight.

The second test will result in the rider testing the functionality of the pegs out on a motocross track. The test will have the rider perform multiple twenty to thirty minute motos over various obstacles a track has to offer to observe and test the function ability and durability of the pegs. After each session, the rider will jot down any observations, failures, or possible improvements that could be made. Also after each session has been complete, functionality will be tested to make sure that the pegs still operate smoothly and have not failed.

Analysis

Proposed Sequence Approach

Design prototype calculations will need to be analyzed prior to anything else happening. All the other aspects of the project rely upon the design calculations being completed. The other analysis will need to be conducted as follows:

- Peg Design and Analysis
- Pivoting Mechanism Design and Analysis
- Material Comparison and Selection
- Final overall design geometry and analysis

Designs

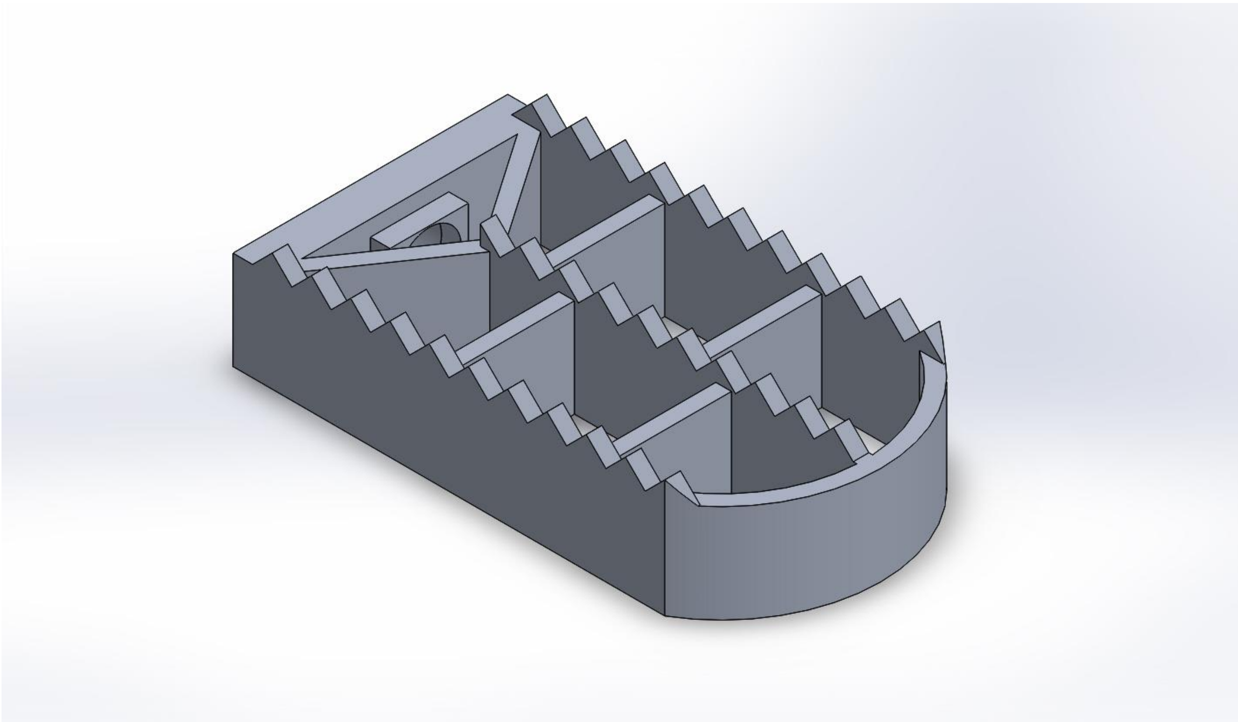

Figure B-10

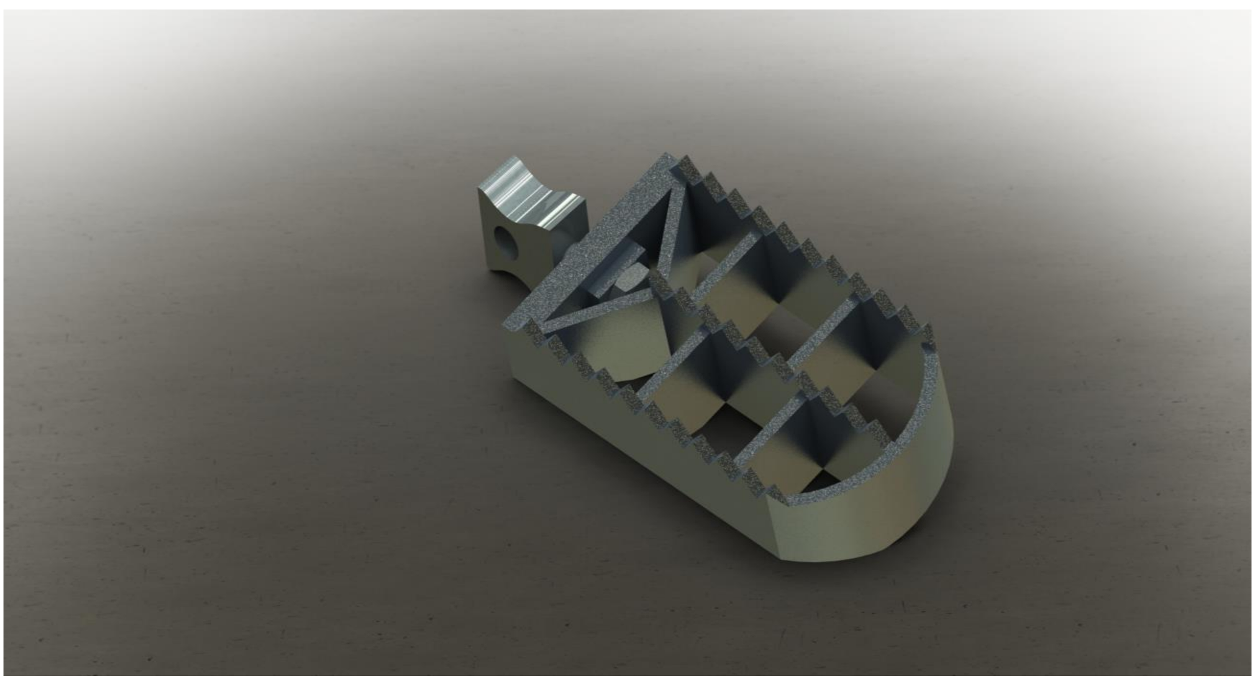

Figure B-11

Calculated Parameters

Based upon analysis and design of the pegs, the maximum force that the pegs will see in the neutral or stationary position is the 185 pounds of rider weight. With this force acting downwards at one end of the peg, the resulting moment force occurring at the fixed of the pegs is 50.1 foot pounds. Using the load of the rider's weight, the amount of deflection that would occur at the point the load is applied could be calculated. Since material selection is something that is critical for this design, five differing materials were chosen to analyze the deflection amounts. These materials included Aluminum 6061 T6, Aluminum 2024, 1020 Steel, Titanium Tl-5AI, and Aluminum 4032 T6. The deflections calculated were all way less than what the required limit of half an inch. Of the five materials analyzed, the three aluminum compositions each had the most deflection at 0.004 inches. Knowing the forces and deflections acting on the neutral position of the pegs, those components could be calculated when the peg was fully rotated to the fifteen degree angle. Since the peg geometry is symmetrical, only for one side of rotation will need to be calculated as is will be similar for the other degree of rotation. The forces calculated acting upon the peg when rotated were 179 pounds in the y-direction and 48 pounds in the x-direction. These values make absolute sense as the load of 185 pounds is acting at an angle of fifteen degrees towards the coordinate plane. Solving for the moment force acting in this rotational articulation, it was found to have a moment force of 61.3 foot pounds. This value compared to the neutral value moment force makes sense as there is more force applied in this configuration of the model. Using the resultant forces found, the deflection calculations for the same five materials could be completed. Again the aluminum alloys of 6061 and 2024 had the highest deflections with values of 0.005 inches of deflection. Again these values are way below the half inch requirement which can create the assumption that deflection is not a necessary issue that will have to be troubled about during the rest of the design and testing. Calculations of various design changes such as change in peg width and height were also performed. The deflection amount with a wider and taller peg decreased, but not by enough of a significant amount to justify a change in parameters. Full detailed calculations for these numbers can be found in Appendix A. On the pivoting mechanism, there is a concern of torsion acting upon the main shaft extruding from the main body. Knowing the angle of rotation to be fifteen degrees and the length of the main shaft design from the Solidworks model, torsion could be calculated.

The calculated maximum torsion that will act upon this shaft as it is accelerated towards the frontward or backwards position is 19.2 kips of force. Knowing these values of forces acting upon different aspects of the design, material can be selected for these main parts based upon density, ultimate and yield strength, machinability, and cost. For the pivot mechanism, the material was chosen to be 1020 steel do having high ultimate and yield strength values that will exceed the aspects of this design along with having a high machinability rate of 70%. Even though the steel is denser than an aluminum substitute that could have been chosen, do to design of needed the shafts to be welded into the main pivot mechanism body, steel was the better option as it is easier to weld steel than it is aluminum. Using online metals to gather pricing on the steel, it was not that much more expense than an aluminum block in the same size. The pegs material was chosen to be aluminum 2024 due to its high ultimate and yield strength compared to the other materials as well as its high level of machinability with a value of 70%. The density compared to the other materials was second to the aluminum 6061 alloy but only by twenty five thousandths of a pound per cubic inch. Even though the aluminum 6061 will cost about three times cheaper than the aluminum 2024, the 2024 composition has a greater ultimate strength with 60.2 ksi compared to 45.0 ksi for the 6061. Machinability of the 2024 is better than the 6061 by twenty percent which is huge since the peg will be machined completely using CNC milling machines. An excel table comparing various materials can be found in Appendix A as figure A-5.

Device Shape

The shape of the peg was modeled similar to an oem peg with modifications to thicknesses of the walls and overall design. The length of the peg was measured to be 3.25 inches, have a width of 1.75 inches, and overall height .75 inches. Wall thicknesses were 0.10 inches with the wall where the pivoting mechanism connects being 0.25 thick for structural stability. The main shaft length was designed to be 0.75 inches long so that it keeps the main pivot mechanism body far enough out away from the peg without having been too far out. The diameter of the main shaft was designed to be 0.25 inches so that it reduces weight but also isn’t to thin or to thick to conflict with the height of the peg.

Device Assembly

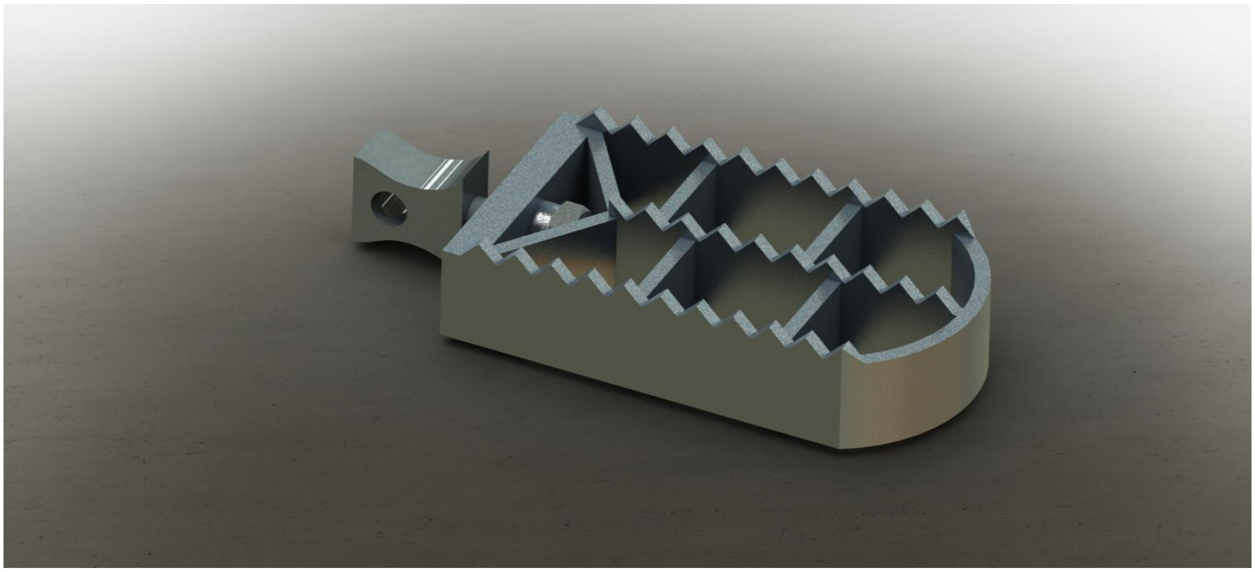

Figure 3

Tolerances

Tolerances will need to be tight tolerances to ensure proper fitment of all the components and to have little play in between them. Too much play or slop in the tolerances can set the part and assembly up for increased failure and possible non proper fitment. Based on prior machining knowledge from machining courses offered at Central Washington University, a tolerance of 0.005 inches will be applied to all parts that will be machined.

Kinematics

The kinematics of the foot pegs acts in multiple scenarios. First is the rotation of the foot peg about a cylindrical shaft towards a maximum allowable rotation of fifteen degrees in line with the front and back of the motorcycle. This motion is brought about with the movement of a rider's foot in varying scenarios. For instance, if the rider is heading to a left hand corner, the right foot would remain on the right peg and rotate forward to better position for the corner setup. As the riders right foot would rotate forward, so would the foot peg which would keep maximum contact whereas with standard foot pegs the heel of the foot can become disconnected with the pegs as shown in Figure 4.

Figure 4

The other kinematic part of the design project involves the weight of the rider's body pushing downward upon the pegs. This amount of downward force will fluctuating with different positioning the rider is in. While up on the pegs while blitzing a whoops section, the rider's feet will have maximum force against the pegs, thus exerting maximum force against the pegs. Whereas a scenario where the rider is in the air over a big jump, the force applied to the pegs is significantly less as they are not needing to exert a ton of force downward on the pegs as compared to gripping the frame of the bike.

Risk Analysis

This project is inclined to several risks including cost, manufacturability, and time. The risk of cost could possibly be a factor depending on the type of material the pegs get built out of and with how the pivoting mechanism gets assembled or purchased. Manufacturability risks involved include the ability for the whole assembly to mate up and attach properly to the bike. Since the pegs will be machined using the school machining lab, the ability to make sure tooling is taken care of is a necessity. Also the machining element of making sure the program created is perfect so that limited runs are needed to be made and limit the amount of scrap material which will increase the cost having to buy more material. I have experience running the CNC mill which will be needed the most for the project, however a vast amount of time will be necessary to write code, set up the machine, gather tooling, and run the operations. Time will be the biggest risk as the project needs to be completed before June which leaves limited time to build, design, calculate, and analyze everything needed.

Critical Failure Mode

The critical failure mode for the pivoting pegs will be when the design limit of 185 pounds of load is exceeded on the pegs as this was the weight that they were designed and intended to handle was. If the weight is exceeded, failure will occur upon the main shaft and the pivoting stop shaft. If the pivoting stop shaft fails, this will result in the ability for the pegs to freely rotate a full three hundred and sixty degrees around the main shaft similarly to a bicycle peg. This would defeat the purpose of the pegs rotational abilities and make it difficult to ride with. Overloading the pegs can also result with the failure of the main shaft which could shear the shaft apart from the pivoting mechanism which would cause the peg to detach and fall off the bike. This would cause the rider to not have a platform form to place that foot on for whatever side failed and would cause an unsafe riding condition. This can be extremely dangerous if this were to occur while the rider was in the air as they would be losing potential stability with the bike as they landed the jump and potentially causing a serious crash to occur.

METHODS & CONSTRUCTION

Description

This design project has a handful of components including the peg, the pivoting mechanism, jam nut, and a linear sleeve bearing. The components that will be constructed are the peg and the pivoting mechanism using manual and CNC machining. The jam nut and the linear sleeve bearing will both be pre-manufactured as they will be purchased from a source such as Grainger. The peg will have an extruded cut cylinder through the flat short face extending into the first cutout area in the peg. The extrusion will have the linear sleeve bearing sit inside of it to house the main shaft of the pivoting mechanism. The pivoting mechanism main shaft will then be slid though the bushing until the threads begin to display inside the first cutout area of the peg. A jam nut will be screwed onto the threads to hold the shaft from pulling back out of the bushing. The secondary shaft on the main body of the pivoting mechanism will need to be slid into the cutout at the bottom edge of the face will the main shaft is slid in to the bushing to provide proper fitment. After the peg and the pivoting mechanism have been connected and joined into an assembly, it can then be connected to the standard mounting point on the motorcycle by fitting the existing bolt through the through hole on the pivot mechanism body. The below figure is an assembly drawing that shows an exploded view of how the parts attach together in the main assembly.

Parts Lists and Drawings

A complete list of parts and drawings can be viewed in Appendix C. A total of four parts are currently needed to complete the entire design parts, with half being able to purchase and the other half having to be manufactured. For a complete set of drawings, refer to Appendix B.

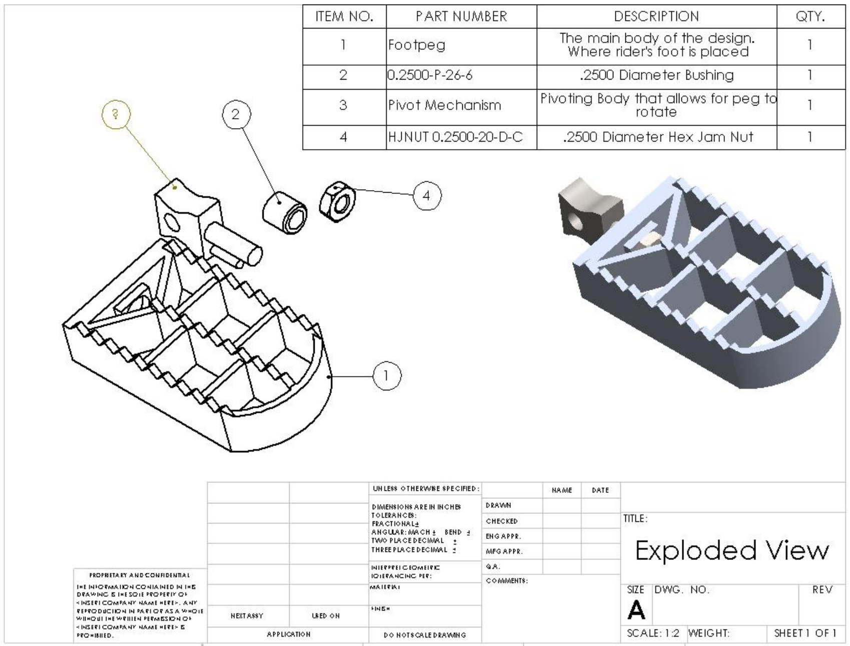

Figure B-7

Manufacturing Issues

Fabrication of the peg and pivoting mechanism will be required to complete the design. These pieces will need to be machined using a manual lathe or CNC milling machine. A potential issue that can occur would be the possibility of not removing enough or too much material which will alter fitment of other parts. If tolerances are not kept the fitment of the piece such as the extruded cut cylinder the linear sleeve bearing sits in may not fit properly to promote a tight fit or may be to loose so that the bushing won't stay seated in the cylinder. The pockets in the peg design will need to be CNC machined since manual milling will not provide the necessary tolerancing of the complex geometry for at least one of the pockets.

TESTING METHOD

Introduction

The testing of the pivoting foot pegs project will require thorough data acquisition based on strict requirements and parameters. The requirements of what is going to be tested are that the pegs are rotational to the fifteen degrees they were designed to, the amount of deflection that occurs upon the pegs is less than half of an inch, and how the material the pegs are made of reacts to weather elements. The main parameters of interest for testing are that of deflection and rotational amounts. These parameters are critical in the testing of these foot pegs because they determine the functional capabilities that the pegs will have. If either of those parameters does not meet the testing requirements, then the project will be deemed unsuccessful to an extent. Another parameter that is of interest is if the pegs can withstand impact from various obstacles such as jump landings and whoop sections. If this parameter was to not succeed, then the overall project would be considered a failure. The predicted performance of the pegs is that the pegs will rotate to the specified rotational angle of fifteen degrees in both directions, have a deflection of five thousandths of an inch, and withstand impact from up to a fifty foot jump. Data acquisition will be gathered by use of an angle finder, visual, measuring device, additional personal, and by video. The scheduled amount of time provided in the Gantt chart will allow for testing to begin on May 1st and be completed by the 30th of May. The total hour amount allotted for the completion of the testing phase is 27.5 hours based from the Gantt chart.

Method/Approach

Resources

For the testing to be completed for this project, various resources are needed for the gathering of accurate data. The resources needed for completion of the testing is various testing associates, angle finder, the pegs themselves, dirt bike, locations for testing, GoPro, measuring device, engineering paper, container of water, and a computer to log data. The first priority with the resources is to find locations to do the static and moving testing for the pegs. The stationary tests will be performed inside my garage as it limits the need to travel anywhere and accurate data can still be gathered from there. The location for the moving testing will be at the sand dunes. This location provides ample opportunities to put the pegs through a strenuous testing cycle. Using the location of sand dunes also provides an element of safety for the testing, so that if failure were to occur, the rider would ultimately stay relatively safe with less danger aspects than out on a motocross track. The testing associates are an important necessity for the testing success of the project. Having these testing associates will allow for testing to be performed quicker as an associate can be recording data while one person is performing the tests. These additional testing associates help provide additional testing data as they will be used to perform the stationary tests to determine the limits and the capabilities of the pegs at different weights. The angle finder will be a key resource needed for testing data. The angle finder will provide the angular readings that occur when the various weighted riders give when rotating the pegs to their full rotational capabilities. This will allow for the instant results to be gathered about the degrees of rotation so that they can be compared to the requirement of fifteen degrees for the project. A measuring device, such as a tape measure, will be needed to measure the deflection of the pegs after rider weight is applied. A tape measure will be used because it is of highest precision instrument to measure a height from the ground to the bottom middle of the pegs. A GoPro is a necessary resource for testing for the moving tests. Having the GoPro will allow for video to be taken so that the reaction of one side of the pegs can be monitored after taking the pegs through the various obstacles. A container of water is needed for testing so that the accelerated weathering test can be performed on the pegs. A computer is vital for testing as it will be needed to take the raw data wrote down on engineering paper and enter it into excel so tables and graphs can be made comparing the data. Cost is a key resource as money drives everything behind the project. For the testing of this project, the cost will be relatively low as most of the testing resources are items that are already owned or can be borrowed. The only cost that will be accounted for during the testing is the cost of fuel to drive to the sand dunes for the moving testing location. Having fuel being the only cost for testing helps out with the overall budget of the project by not adding multiple unnecessary costs.

Data Capturing/Processing

Data capturing will be performed using two methods. The first method will be using engineering paper and transferring that data to excel on a computer. The computer will also be used in conjunction with the second method as it will be needed for video editing software. Having a computer as a data capturing method allows for data and video to be stored in one location for quick and efficient access. The second method is use of a GoPro to record data from the testing. Use of a GoPro allows for continuous video to be recorded while the foot pegs are being tested. Having this continuous footage will allow for the ability to dissect the video to determine how the pegs responded while going the obstacles they were put through during the moving testing phase of the project. The use of a GoPro will also allow for a single individual to be needed during that portion of testing which makes it easier to collect that portion of data/video without needing an additional person to operate a camera.

Test Procedure Overview

The testing procedure can be broken into three main parts, a stationary test, a moving test, and a weather test. The stationary section of testing consists of three separate parts. The first part is determining if the pegs will actually rotate with four different weight riders standing upon them. The second part is to measure the angle of rotation of the pegs to each extreme amount using an angle finder with four different weight riders to determine the amount of rotation and the average amount of rotation per various weight riders. The third part is to measure the amount deflection that occurs on the pegs from four different weighted riders. This will be done by measuring the distance from the ground to the bottom the peg while unloaded, then from the ground to the bottom of the peg while a rider's weight is applied to the pegs, and then taking the difference in the heights to determine the amount of deflection.

The second main part of the testing is the moving test. This will be performed by transporting the bike to a sand dune location where the bike with the pegs mounted on can be ridden at. The bike will be equipped with a GoPro that is pointed towards the pegs on one side, so that video can be recorded of the pegs operational over various obstacles. The test will determine of the pegs can withstand impact from the various obstacles as speed and distance increases.

The third and final main part of testing is the accelerated weather test. This test will be performed by placing a complete peg assembly into a tray of water for a total of one hundred and twenty hours of time. This will simulate the wear that the pegs can potential endure for a Year while attached to a bike riding every weekend. As the pegs are inside the tray of water, notes will be made a few times a day to document any changes in the material property.

Operational Limitations

The operational limitations of the pivoting foot pegs occur at a few different points. The first limitation of the pegs is how far they will rotate. Based on the manufacturing and design of the pegs, they will only rotate to a certain degree. Another limitation that the pegs have is the amount of weight they can support. The pegs were designed for a rider of 185 pounds, but could handle a rider of up to 250 pounds. If that weight limit is exceeded, the pegs could fail.

Precision and Accuracy

The testing of this project will need precision and accuracy to ensure the best results. Precision will be needed to make sure that the tests can be performed repeatedly so that the best data can be taken. Precision will be necessary with measuring the defection so that the spot measuring to on the peg is repeatable for better results. Accuracy will be important for the rotational measurements in the testing portion. Accuracy is needed here because it determines how close the pegs were able to reach the rotational amount of fifteen degrees. Accuracy will also be needed for the deflection testing as well so that the amount of actual deflection can be compared to the target of less than half an inch.

Data Storage/ Manipulation/Analysis

For testing data recorded, the data will be stored using various methods. The first method will be having the testing data written down into tables on engineering paper. This will allow for data to be kept in a notebook for quick access at later dates, as well as being able to make necessary calculations for proper analysis. Data will also be stored on a computer using excel and word documents. Data will be manipulated using both hand and computer programs. Hand manipulation of the data will be converting data values so that they can be easily viewed and analyzed. Computer manipulation of data will be done in excel for organizing the data and altering data points so that the data can be placed into tables and put into graphs. The data will be analyzed by using excel spreadsheets to compare the results from the different categories, along with placing them into tables and graphs so it can be viewed how the data compares to what was expected and between the different weighted riders.

Data Presentation

Data will be presented in multiple ways. The main way the data will be presented is in presentations during two events. The first event will be using the bike and a poster to present in front of peers at the Source event at Central Washington University. The second event will be presenting in front of peers inside the classroom using our website to walk the class through the project and display the results that were found during the testing section. Another way that the data will be presented is the use of tables and graphs. This will allow for the results to be in one spot on each so that they can be compared to the different weighted riders that were used and how the results are similar or different and how close that they were to the predicted values. The final way the data will be represented will be through use of video. Video will allow a motion visual of how the project reacts to the tests that it was put through as well as being used as a mode to reach more people. This allows for a broader range of audience to become in tune with the project and the results that were compiled.

Test Procedure

Stationary Testing

Stationary testing will be completed in the month of May. The time allotted for the completion of this portion of testing is two hours and must be completed before May 25th. Two hours of duration was allotted so that if any problems arose such as a testing associate was running late, the testing could have plenty of time to be completed in that day and not need a separate day to be completed. The location that the stationary testing will occur is in my personal garage. This location was decided because it provides a better meeting location for the various testing associated that will be used as well with giving a quiet environment where testing will not be disrupted by possible bystanders. The actions that will be performed for this portion of testing can be summarized as follows for the four test subjects:

1. Measuring the distance from the floor to the bottom of the foot peg for a base height and record in table on engineering paper
2. Have a rider get on the bike and put their weight onto the peg
3. Measure the height from the ground to the bottom of the peg and record result

4. Next have the rider rotate the peg frontwards and backwards and record whether the peg is rotational
5. Next have the rider rotate the peg all the way forward and place and angle finder underneath the peg to view the reading. Then have the rider rotate the peg all the way backwards and view that reading. Take the amount of change in readings and divide that value in two for the amount of rotation the peg is capable of. Record the value
6. Repeat steps 1-5 with the same rider for three trials so that an average value can be gathered.
7. Repeat steps 1-6 for each of the remain testing associates

Safety and risk are very low for this testing evaluation. Since the bike will be upon a stand and there will be no moving motion, the tester will have very little possibility of any safety concerns. Evaluation readiness will be fairly quick as all the data will be recorded as it is gathered during the testing. This will allow for the data to be compared during and after the testing is finished. The purpose of performing this test will allow for determination if the pegs are operational and if they perform to the capabilities they were designed to. This test will also test the limitations that are present with various weight riders and how the data can be repeated.

Motion Testing

The motion testing will be performed in the month of May and must be completed by May 25th. The time allotted for this portion of testing is four hours. Having this amount of time allows for drive time to the testing location and for time to perform the test. The place that the testing will be performed at is a sand dune location inside Washington State near the city of Ellensburg. This allows for a shorter travel time and more testing time. The actions for performing this test are as follows:

1. Haul bike to testing location
2. Mount GoPro to swingarm to record video of the testing
3. Ride in the sand dunes over various obstacles such as jumps and whoops to testing the ability of the pegs.
4. Stop periodically to record observations and mental notes on how the pegs are performing

5. Repeat steps 1-4 until adequate testing is completed

Unlike the stationary testing, this section of testing has higher risk and safety concerns. While riding, if the pegs were to fail over an obstacle it could cause a crash resulting in a potential injury. With this added safety and risk factor, proper steps will be taken to reduce possibilities of injury by wearing all the proper riding gear so that the rider is as safe as they possibly can be. Evaluation readiness will be both instantly and be completed at a later time. The results of the testing will be recorded using video so that instant data will be taken. However this data will not be able to be accessed until later when the video files are downloaded to a computer and analyzed. The purpose of performing this test is so that it can be determined if the rider feels comfortable while using the pegs along with if the pegs withstand the impact of hitting larger jumps and long whoop sections.

Accelerated Weather Testing

For the accelerated weather testing, the time allotted to perform the test is 120 hours and must be completed by May 25th. This amount of time simulates a year worth of riding time through various weather elements that can potentially be endured by the foot pegs. The location of the test will take place in the same garage used for the stationary testing. This allows for no possible disruptions while the test is taking place. The actions that will be taken to perform the test can be shown as followed:

1. Fill container with water
2. Place peg assembly into container of water and allow to sit in tray for 120 hours
3. Periodically check the pegs throughout the duration and document any noticeable changes, if any, to the peg assembly
4. After the time period has elapsed, remove the assembly from the water and document results

This test has no risk or safety concerns while being performed. The evaluation readiness of this testing phase is instantaneous as the data results can be collected after the assembly has been placed inside the container of water. This test is important to perform because it allows observing of how the assembly will react to the wet conditions that are faced when riding in the state of Washington.

Deliverables

Parameter Values

There are parameter values that will need to be observed and reached during the testing phases. First the pegs will need to rotate and be able to rotate to the fifteen degrees that they were designed to rotate. Another parameter value that will need to be met is that the deflection does not exceed half of an inch when a 185 pound rider is placed upon the pegs. The pegs will also need to withstand an impact from a jump of up to fifty feet and the impact from a section of whoops of up to fifty feet in length.

Calculated Values

The calculated values that this project will be based off for testing values can be seen in the analysis section of the appendix. These values include that the deflection will be five thousandths of an inch when a 185 pound rider is placed upon the pegs. The other calculated values that will be considered in testing is that the pegs will have a moment force of 61.3 foot pounds acting at the outer most point along with 47.9 pounds of force acting in the x-direction and 178.7 pounds of force acting in the y-direction upon the pegs when a 185 pound rider is riding the bike.

Success Criteria Values

The values necessary for the project to be deemed a success come from multiple areas. The pegs will need to rotate to fifteen degrees in both the forward and backward direction. The project will also be successful if the pegs can withstand the weight of a 185 pound rider while deflecting less than a half of an inch. Video will be captured showing the pegs work and are smoothly operational.

Conclusion

Knowing the values for parameters, calculated, and success criteria, the testing of the project can be performed. Using these values, the testing should be performed and meet all the expectations that are provided for the project. Using these values, it allows for a known list of guidelines going into the testing phase that will allow for a quicker analysis of whether the project operates to its potential.

BUDGET/SCHEDULE/PROJECT MANAGEMENT

Budget

The budget for the project includes the items that are to be purchased such as the aluminum stock, steel stock, hex jam nut, and the bushing. The total budget amount that is estimated the project will cost is $78.89. The total amount for the materials needed should not be close to that budget total but it allows for any possible mishaps that could potentially occur during the project along with the ability to purchase more material to make more pegs in the occurrence that everything works smoothly once assembled. The budget of cost for the aluminum stock will cover the cost of all potential material needed to manufacture the pegs along with extra in case of unforeseen circumstances. The estimated cost of the aluminum material needed is $47.22. The cost of the steel stock to be used for the pivoting mechanism is $8.03. The rods that will be connecting into the pivoting mechanism will be steel round bar and for a foot long piece the cost will be $0.53. Based on the budget, the material will be the most expensive portion for the project as it is the main component needed along with the price of aluminum 2024 for the size that needs to be purchased with what metal suppliers offer. The potential cost of shop time would become costly for the project, however this cost will be minimized as the parts will be machined myself in the Central Washington University machine shop. A detailed list of material and hardware can be found in the budget section of the Appendix (See Appendix D).

Schedule

The schedule for the year of this project is roughly as follows. A detailed schedule can be found in the schedule portion of the Appendix (See Appendix E).

For fall quarter, the selection of a project will need to be made. After the project has been selected, a design can be created for the part(s). As the initial part design has been created a material selection can be made so that an analysis on the project can be completed. Once a thorough initial analysis is done, and definitive material choice can made along with an initial estimate of how the design will perform.

Winter quarter will focus on the machining and assembly of the project. All necessary materials will need to be purchased so that construction can begin. Materials include non-fabricated parts and parts that will need to be fabricated. Once material arrives, the part(s) of the project can be constructed so that they meet design specifications. When parts are to the proper dimensions and tolerances, the component assembly(ies) can then be put together. After the sub-assemblies have been assembled, the complete device can be constructed and checked for any flaws or imperfections.

Spring quarter will bring upon the testing of the project. Testing will need done on the final assembly along with the parts that compose the assembly. Performance analysis of the assembled project will need to be completed. The manufacturing practicability of the project will be determined and fine-tuned to create best project design possible and ease of possible sales implications. Final analysis and manufacturing data will be placed into the report and discussed thoroughly.
The total estimated time in hours for completion of the project from start to finish is 372.0 hours. This estimation includes proposal write up time, design time, machining time, and testing time.

Project Management

Personal Resources

Success in this project will be achieved do to the engineering student having the required knowledge, skills, and resources to complete the project. The engineering student has completed a bulk of a bachelor program in Mechanical Engineering Technology at Central Washington University. The student also has background knowledge with the project along with necessary skills needed to complete the design and fabricating of the project. A portion of the completed courses and skills are located in the resume at the end of the Appendix section.

Physical Resources

Physical resources that will have access to, is a full machine shop located at Central Washington University along with at personal shop.

Human Resources

Human resources available are Doctor Beardsley, Doctor Johnson, and Professor Pringle at Central Washington University. These three individuals possess vast knowledge in engineering matter and networking to other possible resources that could assist in project building. Other human resources include insiders familiar to the project at hand and can offer helpful insight along with networking to others that can help maximize potential in the project.

DISCUSSION

Design Evolution

Throughout the course of design portion of the design project, there were two major design concepts that were created and design variation that occurred between the two of them. Ultimately one design for the peg was chosen and had multiple design evolutions applied to it. The first design evolution was varying the thicknesses of the walls of the peg. Varying thickness was chosen between 0.10 inches and 0.375 inches. Upon Solidworks modeling design, it was determined that anything above 0.25 inches would not work in terms of fitment for some parts such as the main shaft as well as weight reduction. Having thicker walls added more weight than was necessary for the pegs to have. Thickness modifications also came into play with where the shaft connects through the one side of the peg. A thicker wall was necessary there to for more support for that structure with an extrusion coming through the middle of t which would weaken that wall leaving it 0.10 inches like the other walls.

The second design evolution came with the design of the pivoting mechanism. With updating the thicknesses of the walls, the shaft length and diameters were even more crucial to fit within the confines of the peg. Different size shafts were modeled in Solidworks and tested within an assembly with the peg to ensure proper fitment and clearance for proper operation of the overall project.

Project Risk Analysis

The risks that the project can endure are costs, manufacturability, and time. Timing risk can affect all aspects of the project. If a piece of material doesn't show up on time or the time it takes to machine a certain part takes longer than expected, it can affect other areas of the project where you may need to cut time form to make everything work which deteriorates overall project performance and design. If the manufacturability is not conducted to the highest of tolerances or production, the overall design will not be as structurally sound as it was designed to be. .If the overall project that gets constructed is not up to the full potential, it can become dangerous for the rider if the project were to fail while attempting a large jump or obstacle and causing raised potential of a painful crash.

Next Phase

The next batches of possible designs of a pivoting mechanism and peg have already been considered. Upon completion of this design project, possible design flaws and improvements will be discussed and documented for design improvement and implications into future designs. Design improvements or innovations such as wall thicknesses or geometry will be considered and analyzed to determine how they would affect the overall performance of the project. Third party members with similar interest will be gathered to gain additional insight on further developing the concept.

CONCLUSION

While the project of designing a set of foot pegs for a motocross bike that not only function as normal pegs but also pivot provided a both challenging and enriching design project to complete. As designed, each component should act in a cohesive matter and perform at necessary levels due to the analysis performed and design modeling in a modeling software. The analyses of forces and moments acting upon the pegs at the different positions allow for support in the design of the project. Specific analyses contribute to success of the project by determining critical points of loads and how they act up components. The predicted performance of the design is have weight reduction of a weight under two pounds, withstand of weight applied across the surface, and flawless rotation of fifteen degrees front and back with smooth return to the neutral position.

ACKNOWLEDGEMENTS

Thanks are extended to those that have helped and continue to help make sure that this design project is successful and completed. Thanks to Dr. Johnson, Professor Beardsley, and Professor Pringle for their knowledge and insightful help in ways to accomplish various goals of this project. Thanks as well to Matt Burvee for providing machining help as well with material discounts from suppliers. Thanks to Jordan Olson and Geoff Gibson for their provided help in testing and construction of the design project. A huge thanks to Central Washington University for providing workspace, tooling, software, references, and other resources necessary for the completion of this project.

REFERENCES

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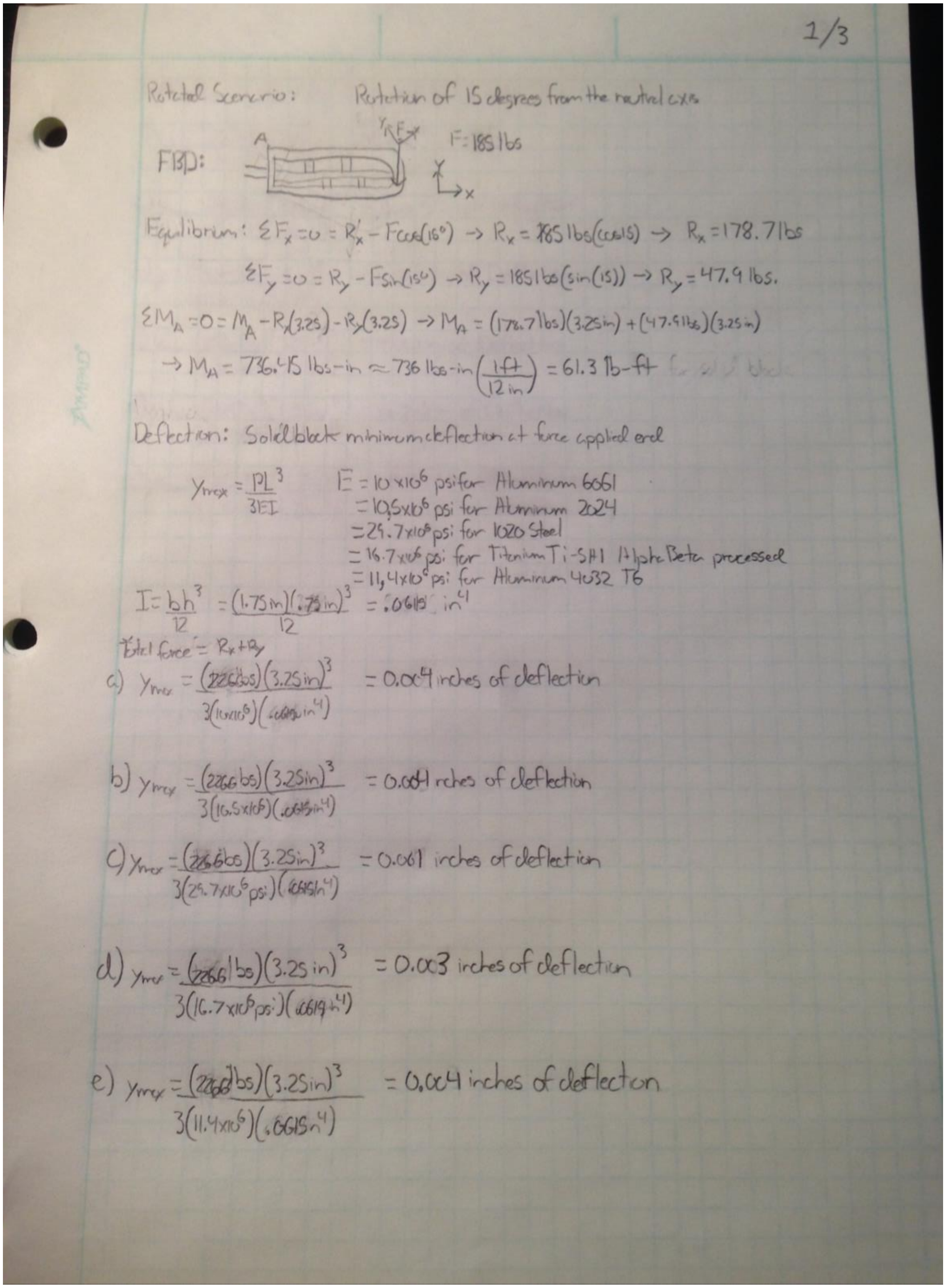
1. Mott, R. (2004). *Machine elements in mechanical design* (4th ed.). Upper Saddle River, N.J.: Pearson/Prentice Hall.
2. Avallone, E. (1996). *Marks' standard handbook for mechanical engineers* (10th ed.). New York: McGraw-Hill.
3. Hibbeler, R. (2010). *Engineering mechanics Dyanamics* (12th ed.). Upper Saddle River, NJ: Prentice Hall.
4. Hibbeler, R. (2011). *Mechanics of Materials* (8th ed.). Upper Saddle River, NJ: Prentice Hall.
5. ASTM D5744-13e1, Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell, ASTM International, West Conshohocken, PA, 2013

APPENDIX A – Analyses



1/3

Rotated Scenario: Rotation of 15 degrees from the neutral axis

FBD: F = 185 lbs

Equilibrium: $\Sigma F_x = 0 = R_x' - F\cos(15°) \rightarrow R_x = 185\text{ lbs}(\cos 15) \rightarrow R_x = 178.71\text{ lbs}$

$\Sigma F_y = 0 = R_y - F\sin(15°) \rightarrow R_y = 185\text{ lbs}(\sin(15)) \rightarrow R_y = 47.9\text{ lbs.}$

$\Sigma M_A = 0 = M_A - R_x(3.25) - R_y(3.25) \rightarrow M_A = (178.71\text{ lbs})(3.25\text{ in}) + (47.9\text{ lbs})(3.25\text{ in})$

$\rightarrow M_A = 736.45\text{ lbs-in} \approx 736\text{ lbs-in}\left(\frac{1\text{ ft}}{12\text{ in}}\right) = 61.3\text{ lb-ft}$

Deflection: Solid block minimum deflection at force applied end

$Y_{max} = \frac{PL^3}{3EI}$

E = 10×10^6 psi for Aluminum 6061
= 10.5×10^6 psi for Aluminum 2024
= 29.7×10^6 psi for 1020 Steel
= 16.7×10^6 psi for Titanium Ti-5Al1 Alpha Beta processed
= 11.4×10^6 psi for Aluminum 4032 T6

$I = \frac{bh^3}{12} = \frac{(1.75\text{ in})(.75\text{ in})^3}{12} = .0615\text{ in}^4$

Total force = $R_x + R_y$

a) $Y_{max} = \frac{(226\text{ lbs})(3.25\text{ in})^3}{3(10\times10^6)(.0615\text{ in}^4)}$ = 0.004 inches of deflection

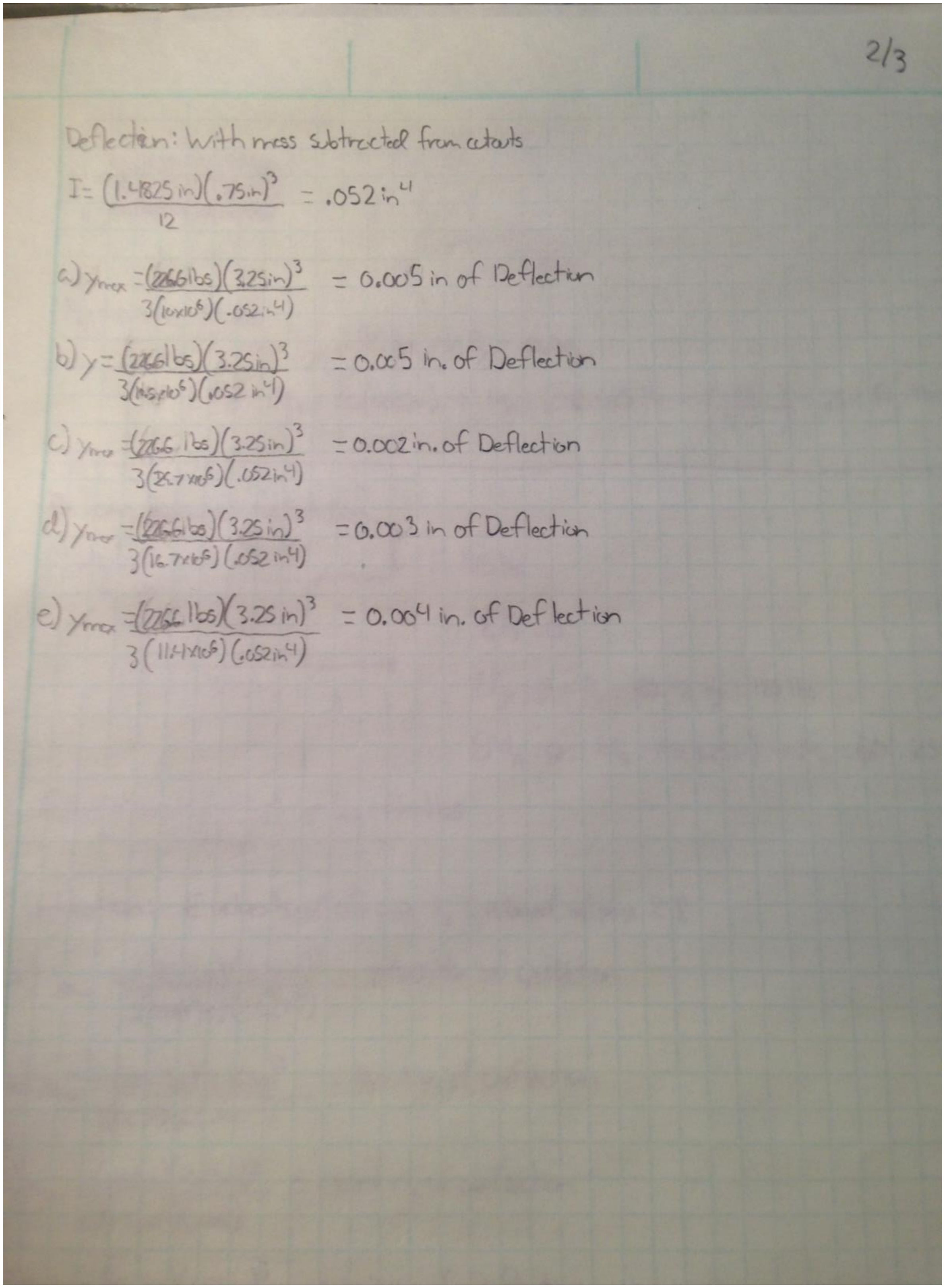
b) $Y_{max} = \frac{(226\text{ lbs})(3.25\text{ in})^3}{3(10.5\times10^6)(.0615\text{ in}^4)}$ = 0.004 inches of deflection

c) $Y_{max} = \frac{(226\text{ lbs})(3.25\text{ in})^3}{3(29.7\times10^6\text{ psi})(.0615\text{ in}^4)}$ = 0.001 inches of deflection

d) $Y_{max} = \frac{(226\text{ lbs})(3.25\text{ in})^3}{3(16.7\times10^6\text{ psi})(.0619\text{ in}^4)}$ = 0.003 inches of deflection

e) $Y_{max} = \frac{(226\text{ lbs})(3.25\text{ in})^3}{3(11.4\times10^6)(.0615\text{ in}^4)}$ = 0.004 inches of deflection

Figure A-1



2/3

Deflection: With mass subtracted from cutouts

$$I = \frac{(1.4825\,in)(.75\,in)^3}{12} = .052\,in^4$$

a) $$y_{max} = \frac{(22.66\,lbs)(3.25\,in)^3}{3(10\times10^6)(.052\,in^4)} = 0.005 \text{ in of Deflection}$$

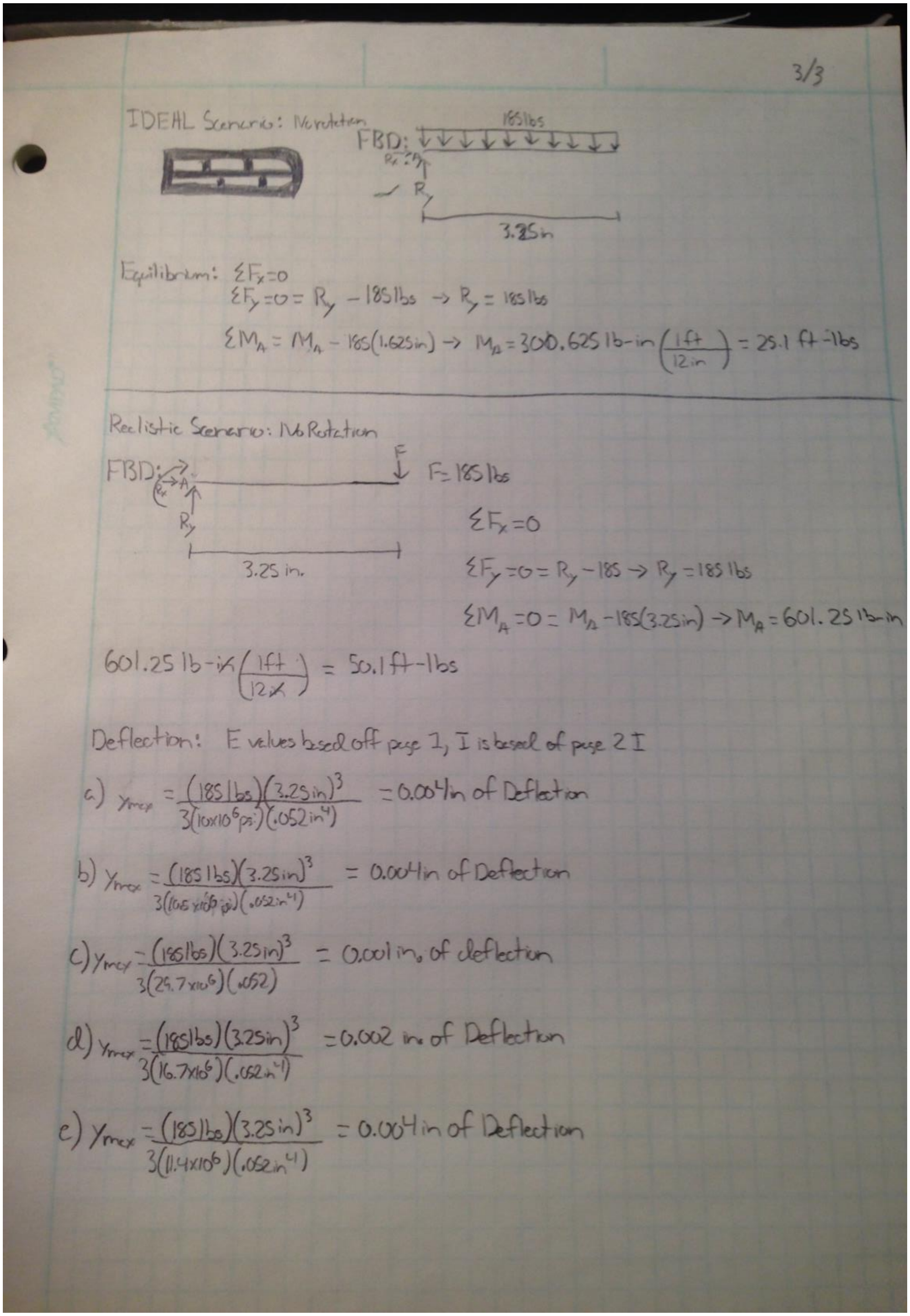
b) $$y = \frac{(22.66\,lbs)(3.25\,in)^3}{3(14.5\times10^6)(.052\,in^4)} = 0.005 \text{ in. of Deflection}$$

c) $$y_{max} = \frac{(22.66\,lbs)(3.25\,in)^3}{3(25.7\times10^6)(.052\,in^4)} = 0.002 \text{ in. of Deflection}$$

d) $$y_{max} = \frac{(22.66\,lbs)(3.25\,in)^3}{3(16.7\times10^6)(.052\,in^4)} = 0.003 \text{ in of Deflection}$$

e) $$y_{max} = \frac{(22.66\,lbs)(3.25\,in)^3}{3(11.4\times10^6)(.052\,in^4)} = 0.004 \text{ in. of Deflection}$$

Figure A-2



3/3

IDEAL Scenario: No rotation

FBD: 185 lbs (distributed), R_x, A, R_y, 3.25 in

Equilibrium: $\Sigma F_x = 0$

$\Sigma F_y = 0 = R_y - 185\text{ lbs} \rightarrow R_y = 185\text{ lbs}$

$\Sigma M_A = M_A - 185(1.625\text{in}) \rightarrow M_A = 300.625\text{ lb-in}\left(\frac{1\text{ft}}{12\text{in}}\right) = 25.1\text{ ft-lbs}$

Realistic Scenario: No Rotation

FBD: R_x, A, R_y, F, 3.25 in.

$F = 185\text{ lbs}$

$\Sigma F_x = 0$

$\Sigma F_y = 0 = R_y - 185 \rightarrow R_y = 185\text{ lbs}$

$\Sigma M_A = 0 = M_A - 185(3.25\text{in}) \rightarrow M_A = 601.25\text{ lb-in}$

$601.25\text{ lb-in}\left(\frac{1\text{ft}}{12\text{in}}\right) = 50.1\text{ ft-lbs}$

Deflection: E values based off page 1, I is based of page 2 I

a) $y_{max} = \frac{(185\text{ lbs})(3.25\text{in})^3}{3(10\times10^6\text{psi})(.052\text{in}^4)} = 0.004\text{in}$ of Deflection

b) $y_{max} = \frac{(185\text{ lbs})(3.25\text{in})^3}{3(10.5\times10^6\text{psi})(.052\text{in}^4)} = 0.004\text{in}$ of Deflection

c) $y_{max} = \frac{(185\text{lbs})(3.25\text{in})^3}{3(29.7\times10^6)(.052)} = 0.001\text{ in.}$ of deflection

d) $y_{max} = \frac{(185\text{lbs})(3.25\text{in})^3}{3(16.7\times10^6)(.052\text{in}^4)} = 0.002\text{ in.}$ of Deflection

e) $y_{max} = \frac{(185\text{lbs})(3.25\text{in})^3}{3(11.4\times10^6)(.052\text{in}^4)} = 0.004\text{in}$ of Deflection

Figure A-3

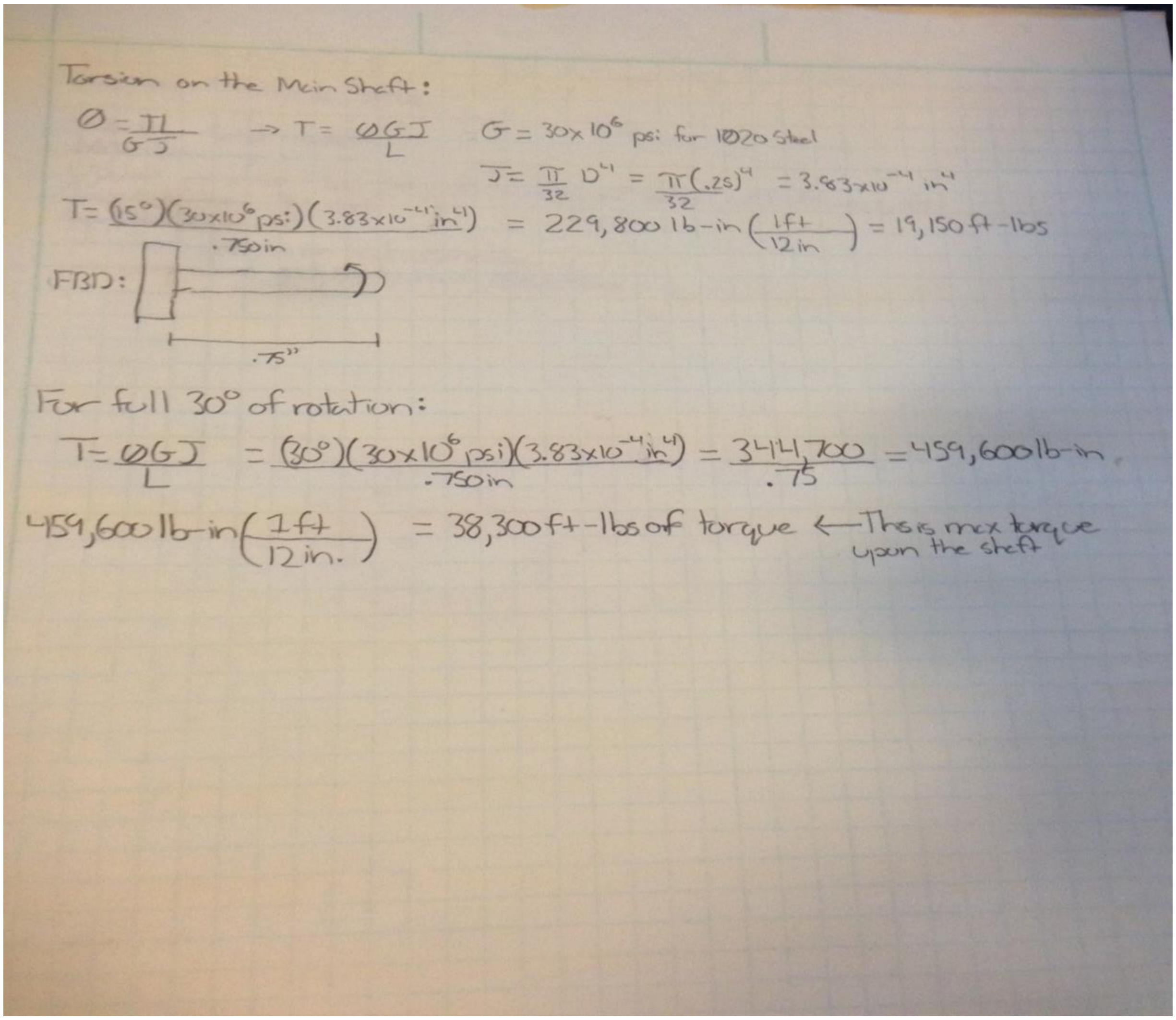


Figure A-4

Material Comparison and Selection for Pegs					*Material Properities Gathered From Matweb *Cost based from Online Metals for 1.75x.75 Rectangle stock at a foot length		
Material	Density (lb/in3)	Ultimate Strength (psi)	Yield Strength (psi)	Machinabilty	Shear Strength (psi)	Modulus of Elasticity (psi)	Cost
Aluminum 2024	0.100	60,200	50,000	70%	41,000	10,500,000	$24.59
Aluminum 6061	0.0975	45,000	40,000	50%	30,000	10,000,000	$8.34
1018 Steel	0.284	63,800	53,700	70%	11,600ksi (shear modulus)	29,700,000	$15.35
Titantium TI-5Al	0.168	1,719,000	165,000		6270ksi (shear modulus)	16,700,000	$591.21
Aluminum 7075	0.102	83,000	73,000	70%	48,000	10,400,000	$29.26
AISI 4024 Steel	0.284	72,500	N/A via Matweb	75%	11,600ksi (shear modulus)	29,700,000	N/A via Online Metals

Figure A-5

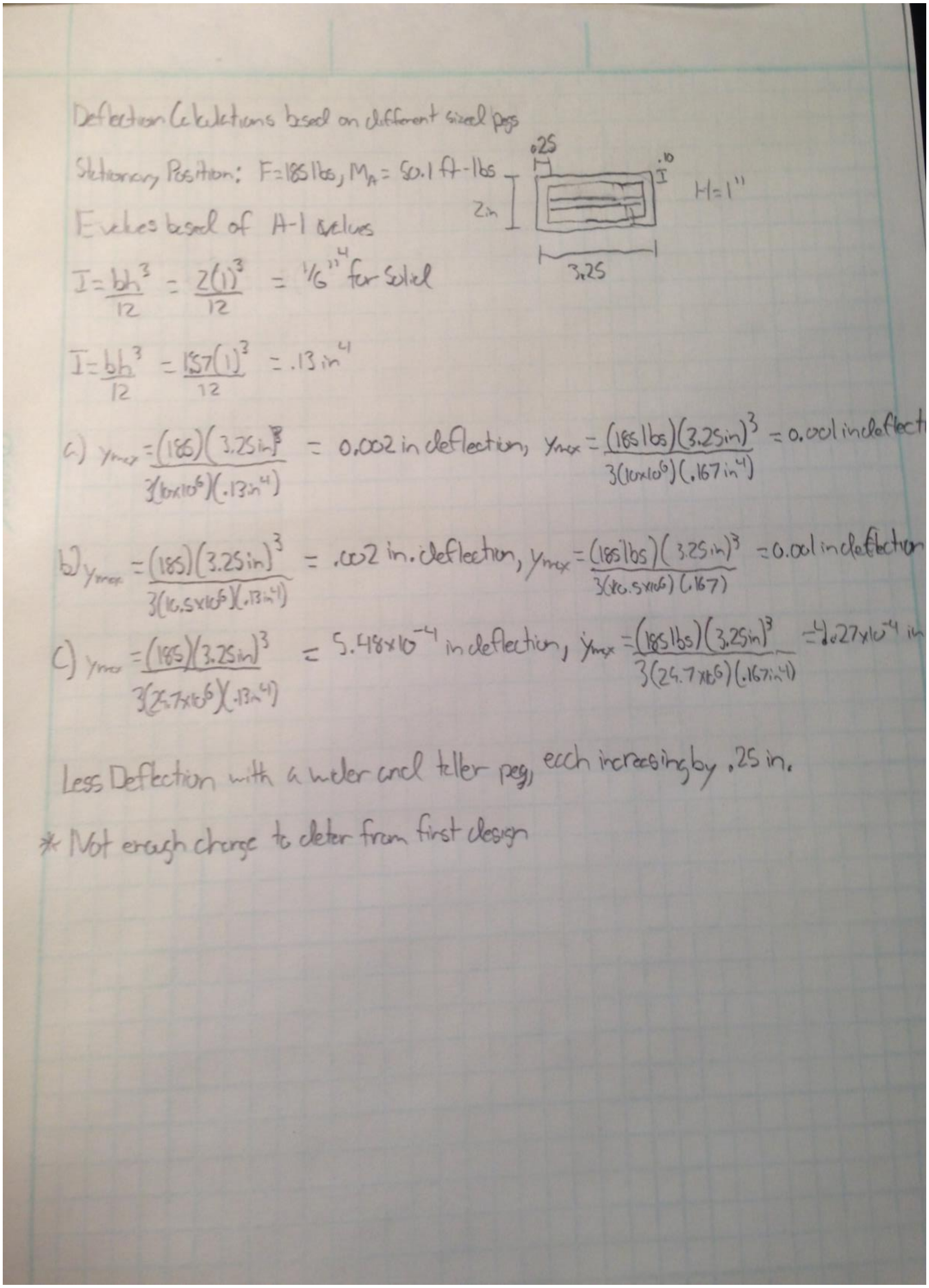
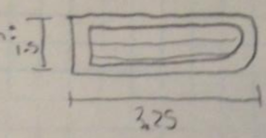

Deflection Calculations based on different sized pegs
Stationary Position: F=185 lbs, M_A = 50.1 ft-lbs
E values based of A-1 values
.25
.10
H=1"
2in
3.25
I = bh^3/12 = 2(1)^3/12 = 1/6 in^4 for Solid
I = bh^3/12 = 1.57(1)^3/12 = .13 in^4
a) y_max = (185)(3.25in)^3 / 3(10x10^6)(.13in^4) = 0.002 in deflection, y_max = (185 lbs)(3.25in)^3 / 3(10x10^6)(.167 in^4) = 0.001 in deflecti
b) y_max = (185)(3.25in)^3 / 3(10.5x10^6)(.13in^4) = .002 in. deflection, y_max = (185 lbs)(3.25in)^3 / 3(10.5x10^6)(.167) = 0.001 in deflection
c) y_max = (185)(3.25in)^3 / 3(25.7x10^6)(.13in^4) = 5.48x10^-4 in deflection, y_max = (185 lbs)(3.25in)^3 / 3(25.7x10^6)(.167in^4) = 4.27x10^-4 in
Less Deflection with a wider and taller peg, each increasing by .25 in.
* Not enough change to deter from first design

Figure A-6

6356.70

Deflection Calculations based on smaller sized pegs:

Stationary position:



$I = \frac{bh^3}{12} = \frac{1.5(.5)^3}{12} = 0.016\ in^4$

$I = \frac{1.395(.5)^3}{12} = .015\ in^4$

a) $y_{max} = \frac{(185\,lbs)(3.25\,in)^3}{3(10\times10^6)(.015\,in^4)} = 0.014$ in deflection, $y_{max} = \frac{(185\,lbs)(3.25\,in)^3}{3(10\times10^6)(.016)} = 0.013$

b) $y_{max} = \frac{(185)(3.25\,in)^3}{3(10.5\times10^6)(.015\,in^4)} = 0.013$ in deflection, $y_{max} = \frac{(185)(3.25\,in)^3}{3(10.5\times10^6)(.016\,in^4)} = 0.013$ in

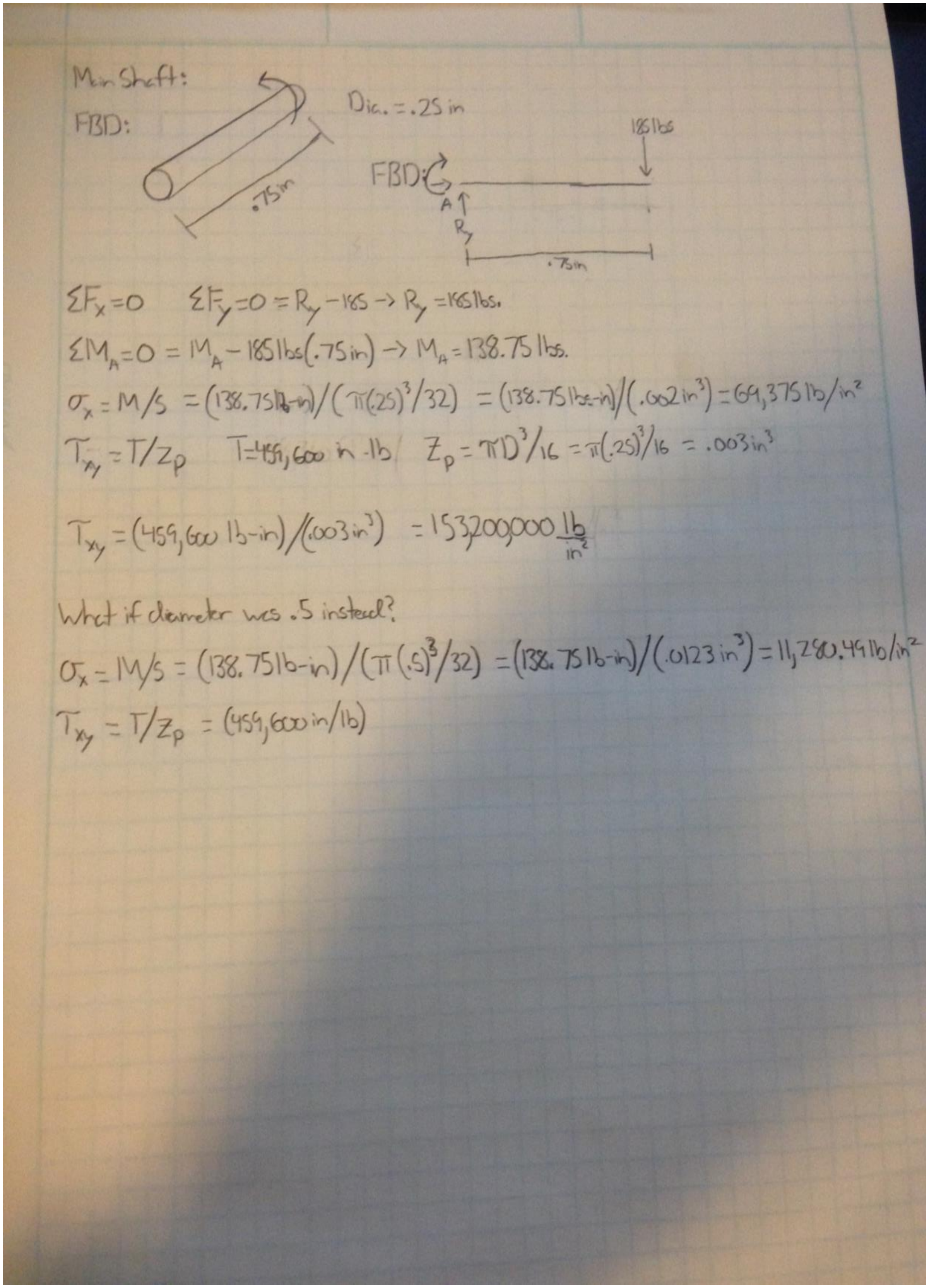
c) $y_{max} = \frac{(185\,lbs)(3.25\,in)^3}{3(29.7\times10^6\,psi)(.015\,in^4)} = 0.005$ in. deflection, $y_{max} = \frac{(185\,lbs)(3.25\,in)^3}{3(29.7\times10^6)(.016\,in^4)}$

$= .004$ in deflection

More deflection with smaller width and height, reduced by .25"

* Not ideal because the skinnier the peg the less contact area

Figure A-7


Min Shaft:

FBD:

Dia. = .25 in

.75in

FBD:

A

R_y

185lbs

.75in

$\Sigma F_x = 0 \quad \Sigma F_y = 0 = R_y - 185 \rightarrow R_y = 185\,lbs.$

$\Sigma M_A = 0 = M_A - 185\,lbs(.75\,in) \rightarrow M_A = 138.75\,lbs.$

$\sigma_x = M/S = (138.75\,lb\text{-}in)/(\pi(.25)^3/32) = (138.75\,lbs\text{-}in)/(.002\,in^3) = 69{,}375\,lb/in^2$

$\tau_{xy} = T/Z_p \quad T = 459{,}600\ in\text{-}lb \quad Z_p = \pi D^3/16 = \pi(.25)^3/16 = .003\,in^3$

$\tau_{xy} = (459{,}600\,lb\text{-}in)/(.003\,in^3) = 153{,}200{,}000\,\frac{lb}{in^2}$

What if diameter was .5 instead?

$\sigma_x = M/S = (138.75\,lb\text{-}in)/(\pi(.5)^3/32) = (138.75\,lb\text{-}in)/(.0123\,in^3) = 11{,}280.49\,lb/in^2$

$\tau_{xy} = T/Z_p = (459{,}600\,in/lb)$

Figure A-8

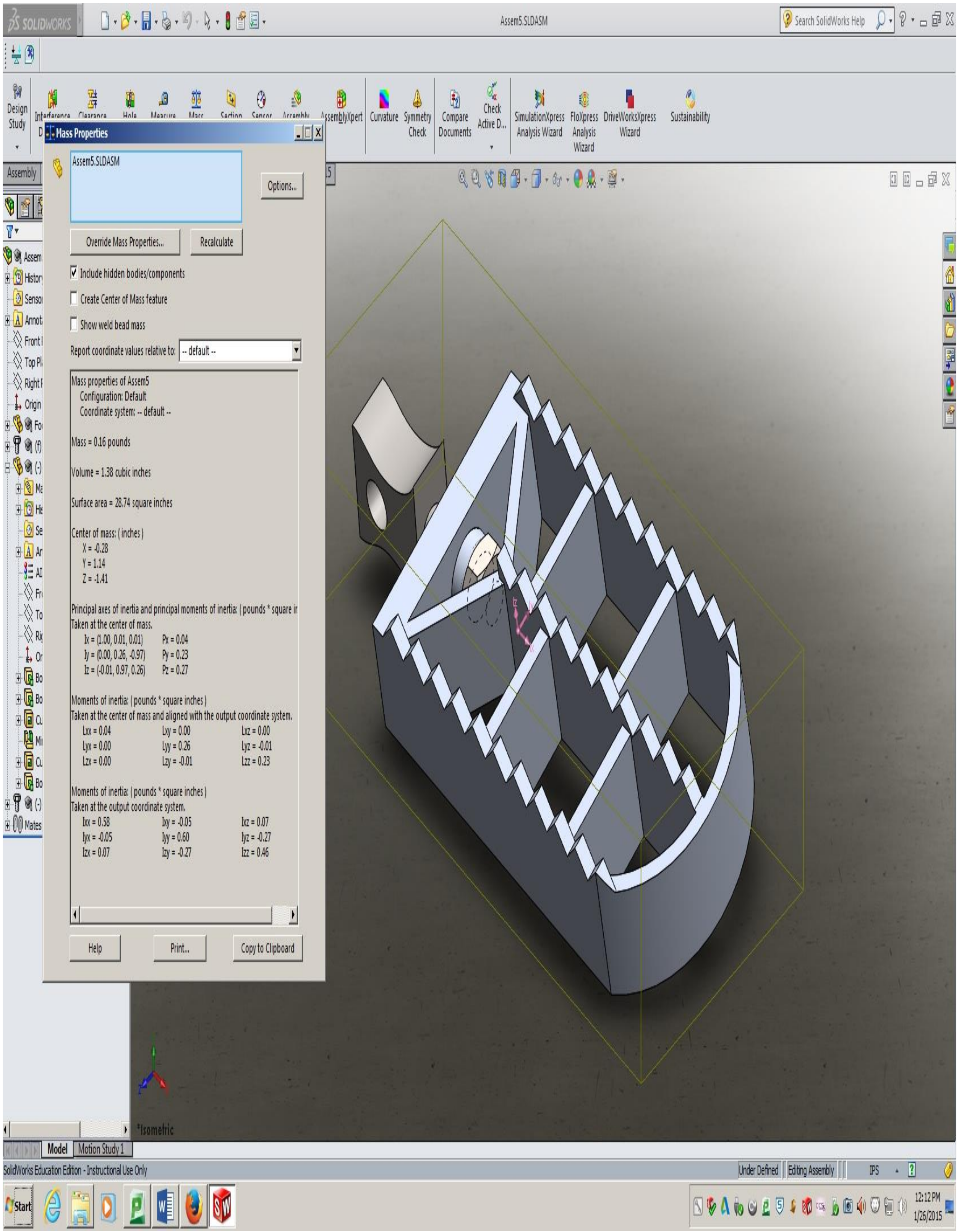

Assem5.SLDASM
Mass Properties
Assem5.SLDASM
Options...
Override Mass Properties...
Recalculate
Include hidden bodies/components
Create Center of Mass feature
Show weld bead mass
Report coordinate values relative to: -- default --
Mass properties of Assem5
Configuration: Default
Coordinate system: -- default --
Mass = 0.16 pounds
Volume = 1.38 cubic inches
Surface area = 28.74 square inches
Center of mass: (inches)
X = -0.28
Y = 1.14
Z = -1.41
Principal axes of inertia and principal moments of inertia: (pounds * square in
Taken at the center of mass.
Ix = (1.00, 0.01, 0.01) Px = 0.04
Iy = (0.00, 0.26, -0.97) Py = 0.23
Iz = (-0.01, 0.97, 0.26) Pz = 0.27
Moments of inertia: (pounds * square inches)
Taken at the center of mass and aligned with the output coordinate system.
Lxx = 0.04 Lxy = 0.00 Lxz = 0.00
Lyx = 0.00 Lyy = 0.26 Lyz = -0.01
Lzx = 0.00 Lzy = -0.01 Lzz = 0.23
Moments of inertia: (pounds * square inches)
Taken at the output coordinate system.
Ixx = 0.58 Ixy = -0.05 Ixz = 0.07
Iyx = -0.05 Iyy = 0.60 Iyz = -0.27
Izx = 0.07 Izy = -0.27 Izz = 0.46
Help
Print...
Copy to Clipboard
*Isometric
Model
Motion Study 1
SolidWorks Education Edition - Instructional Use Only
Under Defined
Editing Assembly
IPS
12:12 PM
1/26/2015

Figure A-9

APPENDIX B – Sketches and Drawings

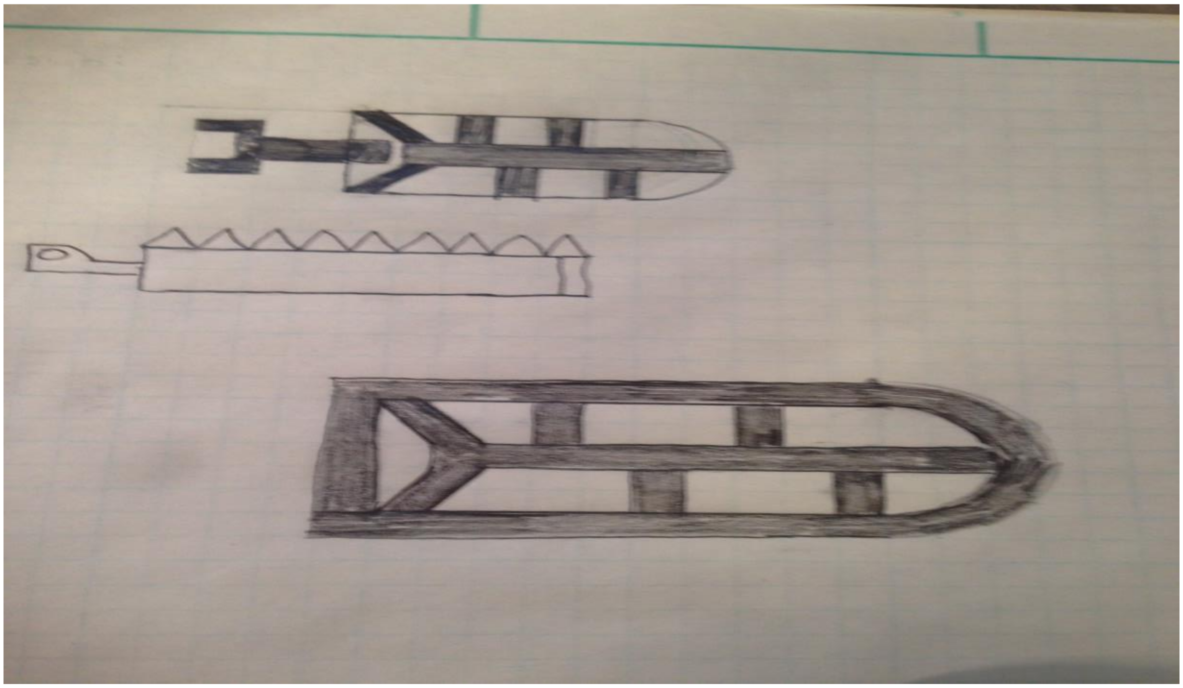


Figure B-1

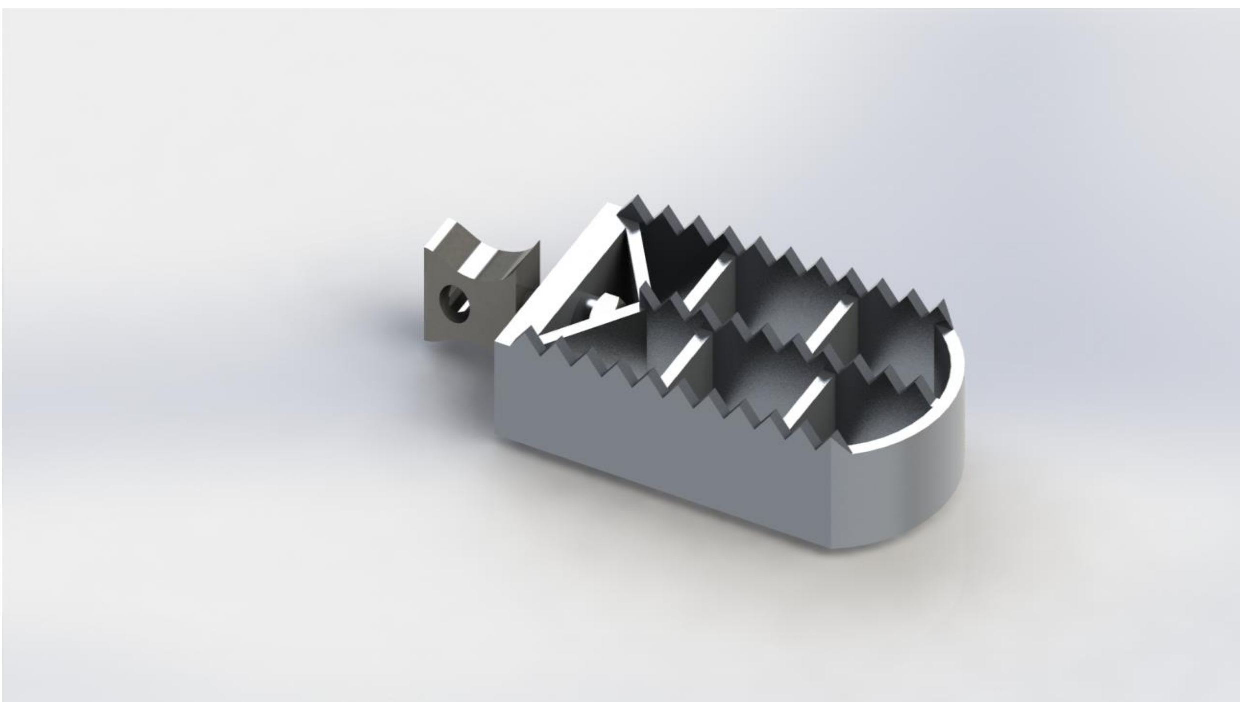
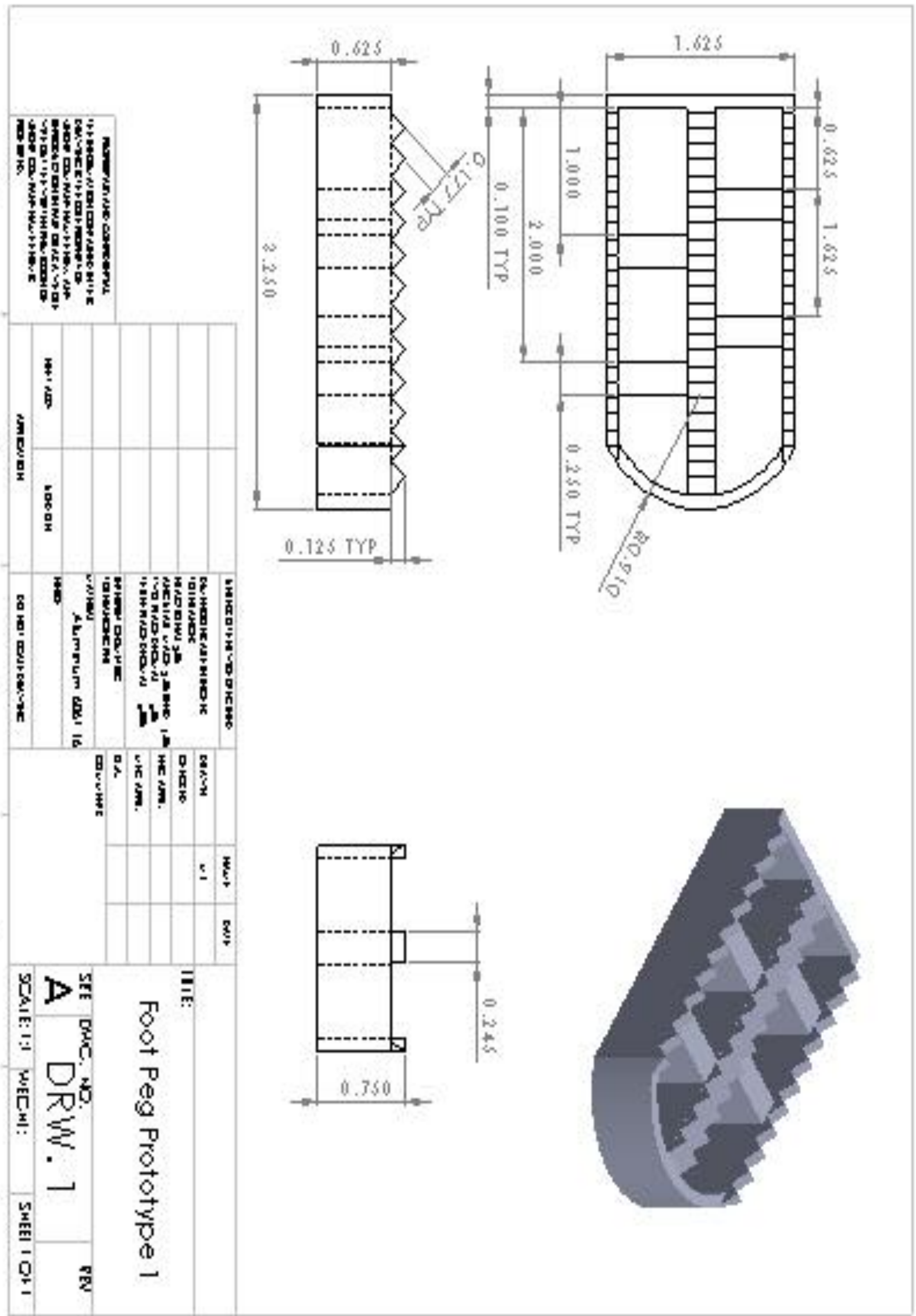


Figure B-2



Foot Peg Prototype 1
DRW. 1
SIZE
A
REV
0.625
1.625
1.000
2.000
0.100 TYP
0.250 TYP
0.125 TYP
R0.910
0.750
0.245

Figure B-3

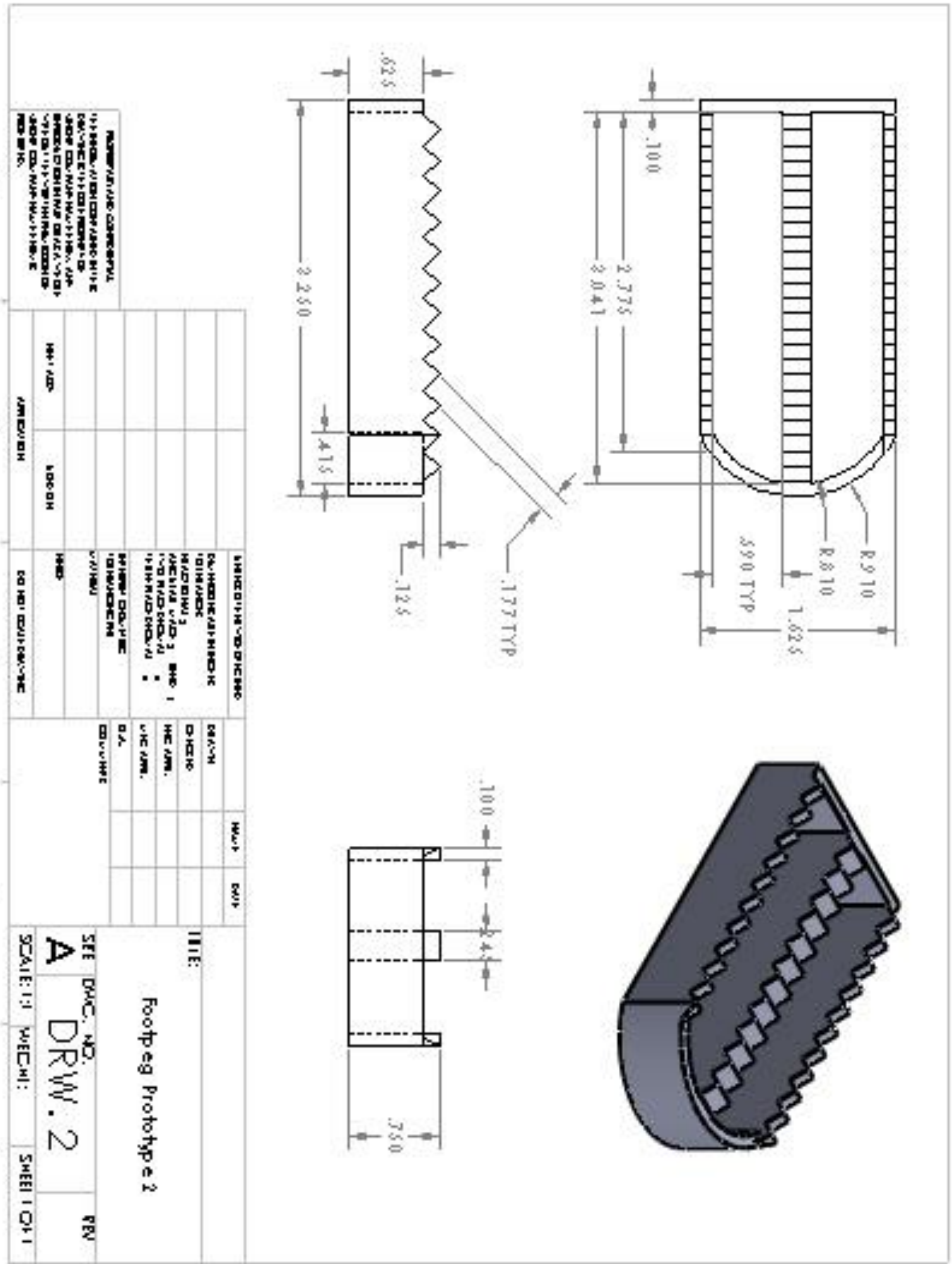

.625
.100
2.250
2.775
2.041
.415
R.910
R.810
.590 TYP
1.625
.125
.177 TYP
.100
.245
.750
TITLE:
Footpeg Prototype 2
SIZE
A
DWG. NO.
DRW. 2
REV
SCALE: 1:1
SHEET 1 OF 1

Figure B-4

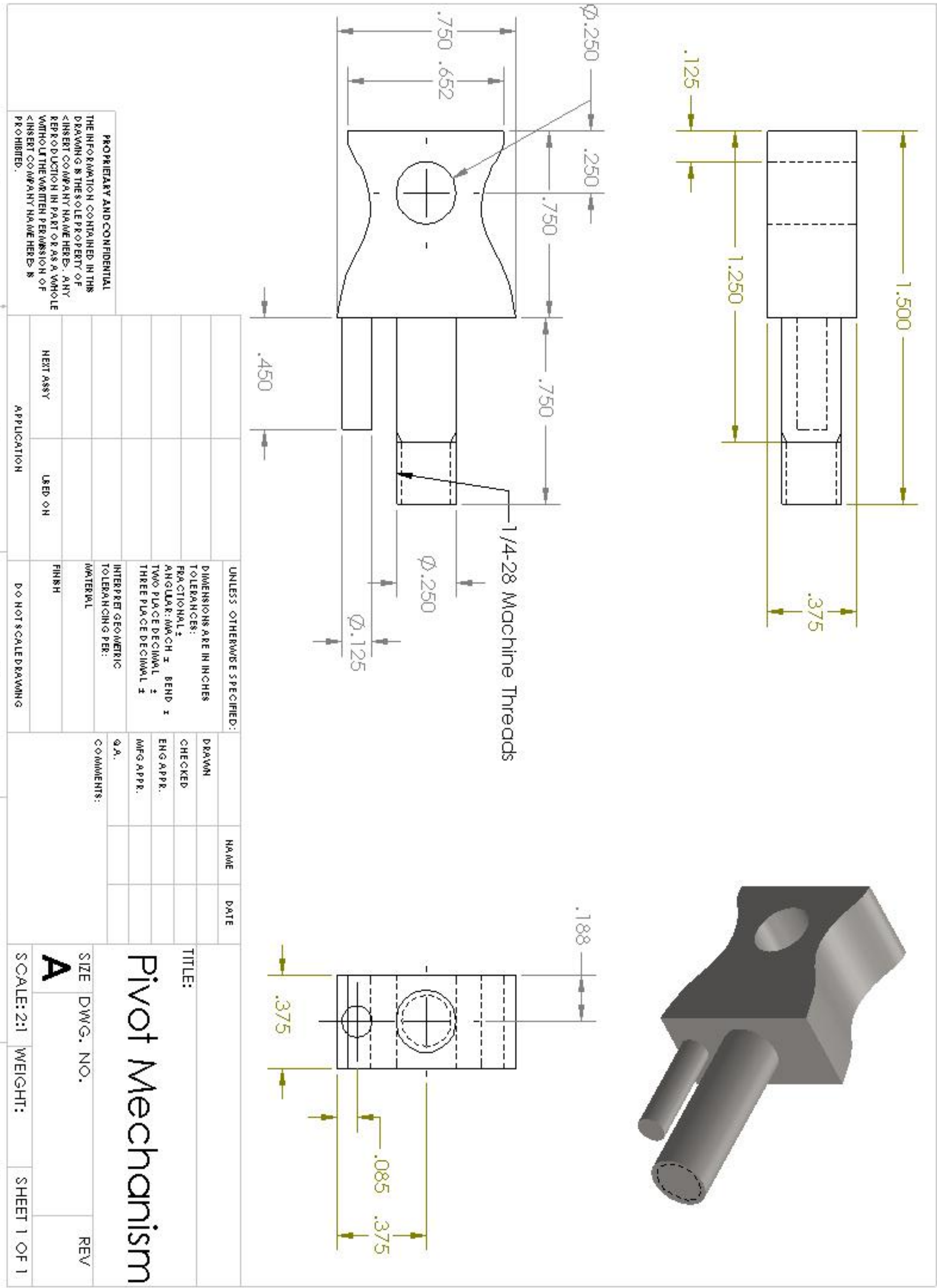

Pivot Mechanism
1/4-28 Machine Threads
SCALE: 2:1
WEIGHT:
SHEET 1 OF 1
SIZE
DWG. NO.
REV
TITLE:
UNLESS OTHERWISE SPECIFIED:
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL

Figure B-5

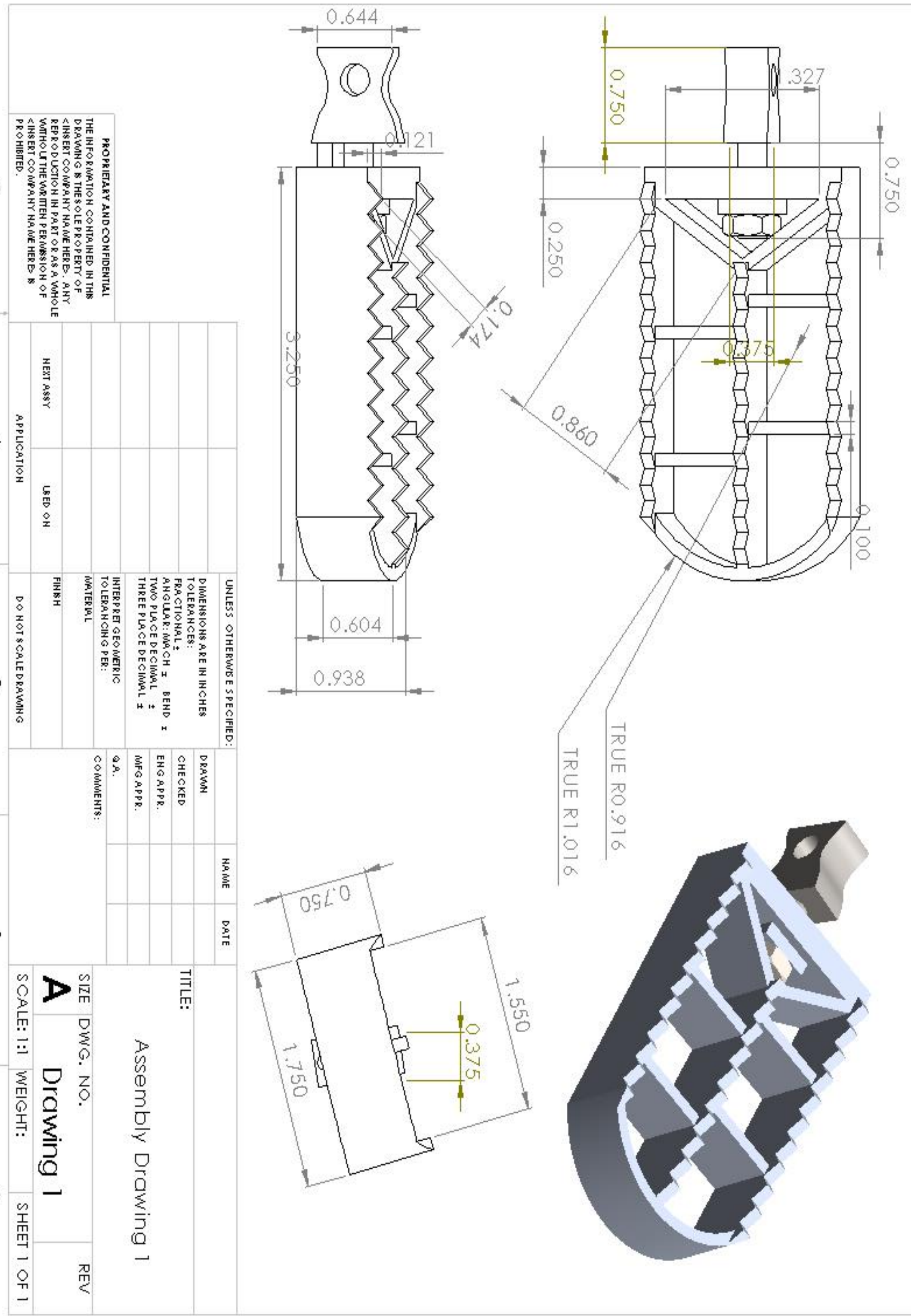

0.644
.327
0.750
0.121
0.750
0.250
0.174
3.250
0.375
0.860
0.100
0.604
0.938
TRUE R0.916
TRUE R1.016
0.750
1.550
0.375
1.750
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC
TOLERANCING PER:
MATERIAL
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
Assembly Drawing 1
SIZE
A
DWG. NO.
Drawing 1
REV
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL
THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF <INSERT COMPANY NAME HERE>. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF <INSERT COMPANY NAME HERE> IS PROHIBITED.
5
4
3
2
1

Figure B-6

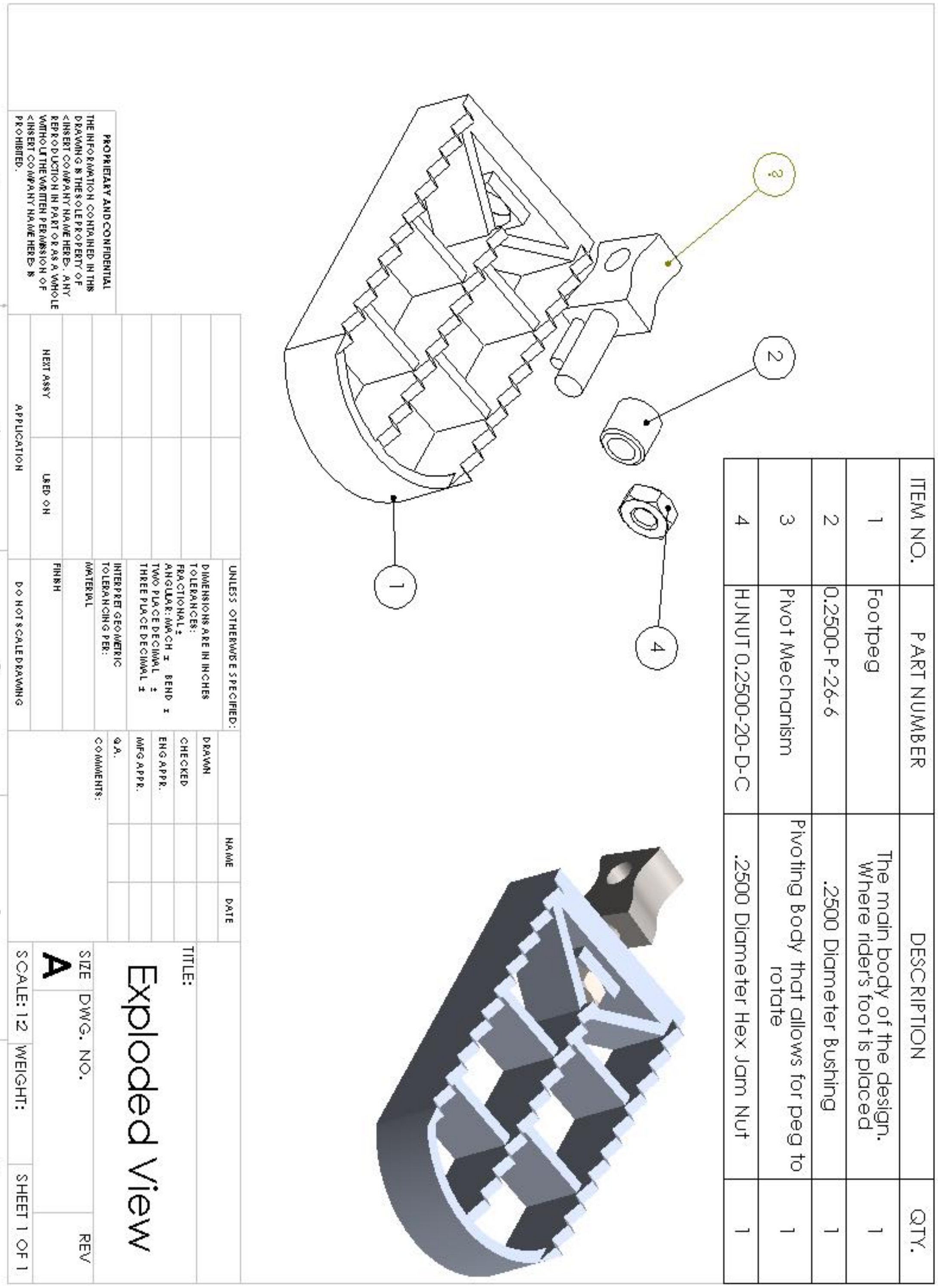
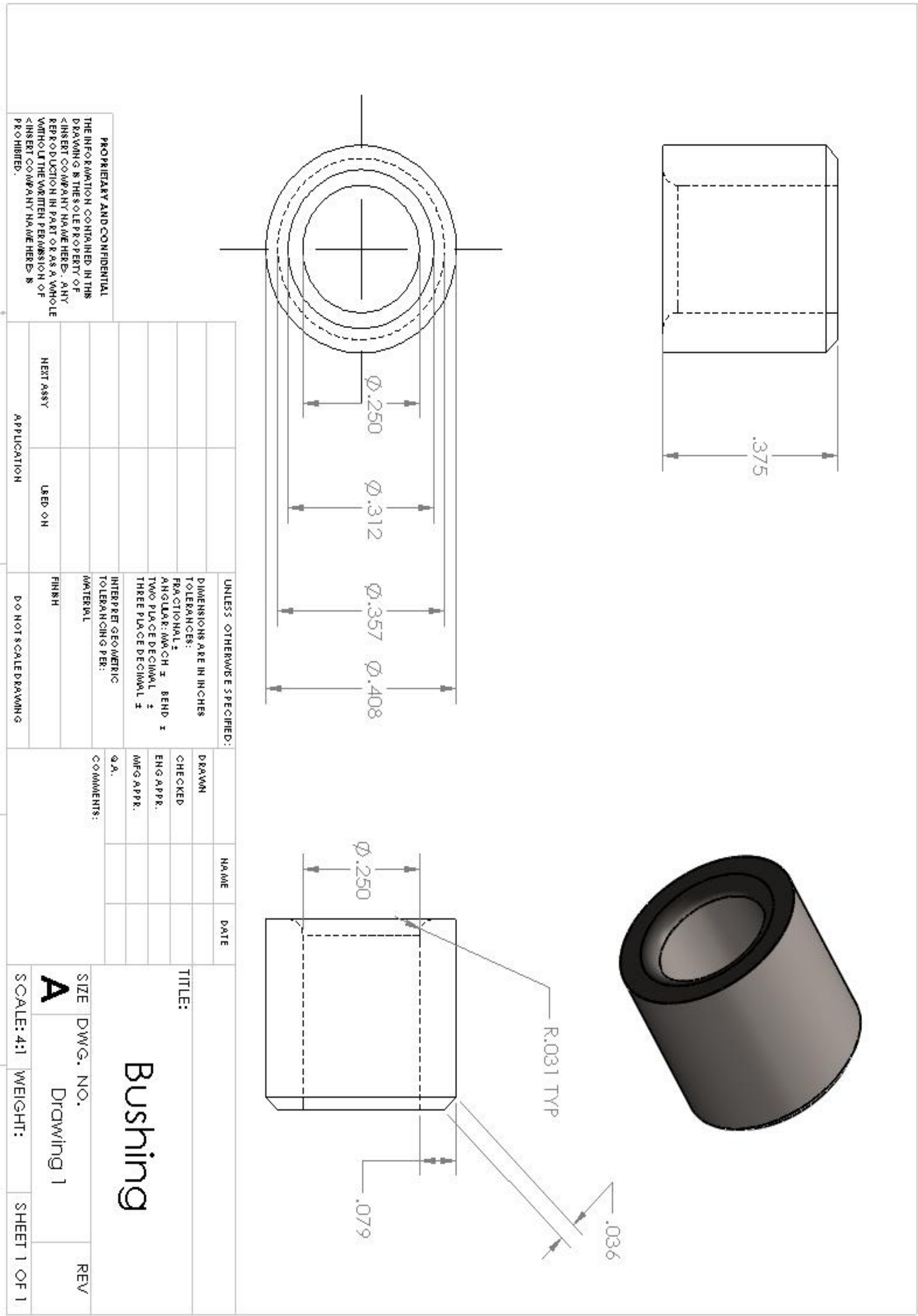

ITEM NO.
PART NUMBER
DESCRIPTION
QTY.
1
Footpeg
The main body of the design. Where rider's foot is placed
1
2
0.2500-P-26-6
.2500 Diameter Bushing
1
3
Pivot Mechanism
Pivoting Body that allows for peg to rotate
1
4
HJNUT 0.2500-20-D-C
.2500 Diameter Hex Jam Nut
1
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
Exploded View
SIZE
DWG. NO.
REV
A
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
FINISH
MATERIAL
PROPRIETARY AND CONFIDENTIAL

Figure B-7



.375
Ø.250
Ø.312
Ø.357
Ø.408
R.031 TYP
.036
.079
Bushing
DWG. NO.
Drawing 1
SIZE
A
REV
SCALE: 4:1
WEIGHT:
SHEET 1 OF 1
TITLE:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
MATERIAL
FINISH
DO NOT SCALE DRAWING
NEXT ASSY
USED ON
APPLICATION
PROPRIETARY AND CONFIDENTIAL

Figure B-8

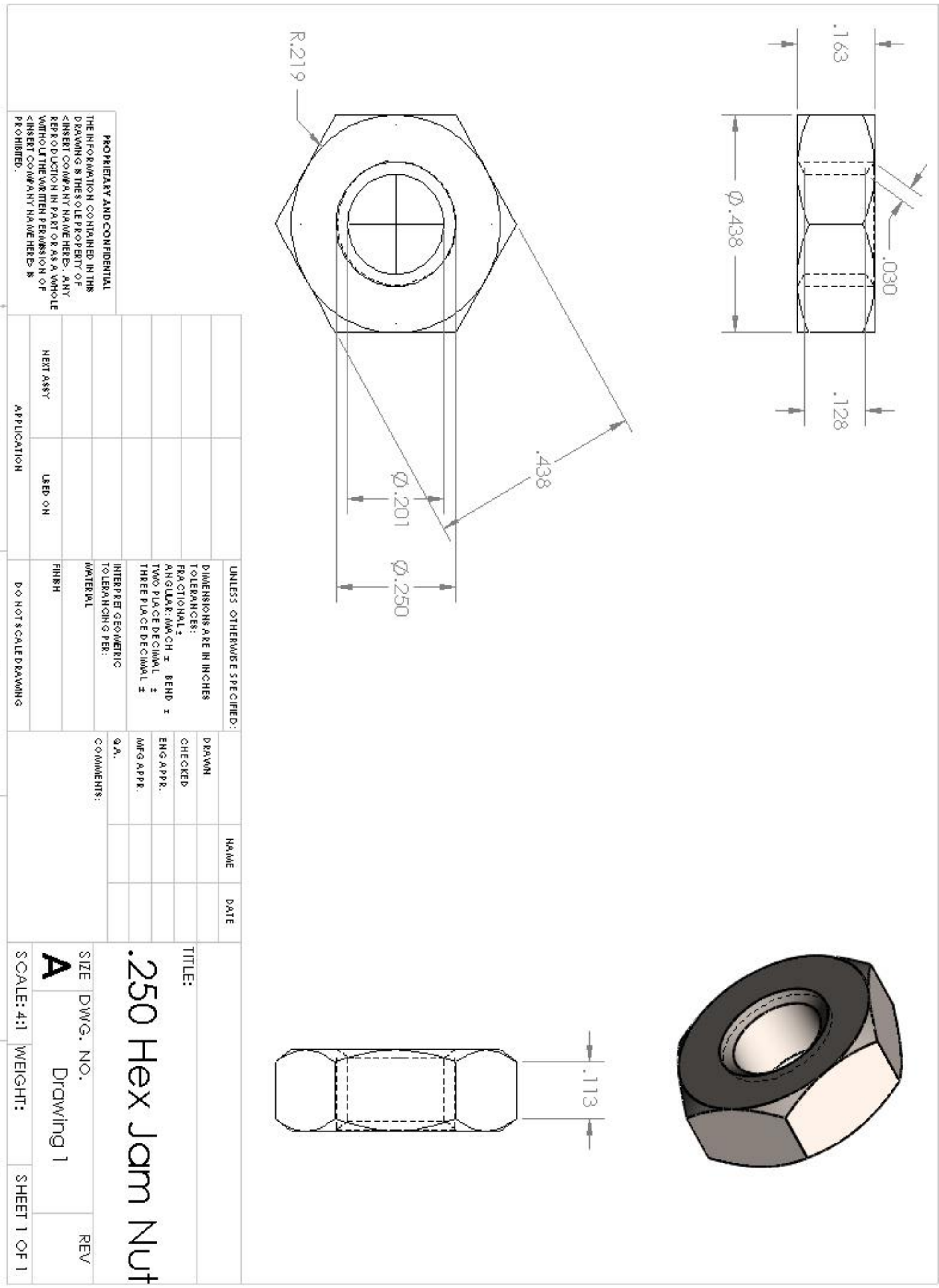

.163
R.219
Ø.438
.030
.128
.438
Ø.201
Ø.250
.113
PROPRIETARY AND CONFIDENTIAL
UNLESS OTHERWISE SPECIFIED:
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
FINISH
MATERIAL
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
TITLE:
.250 Hex Jam Nut
SIZE
A
DWG. NO.
Drawing 1
REV
SCALE: 4:1
WEIGHT:
SHEET 1 OF 1

Figure B-9

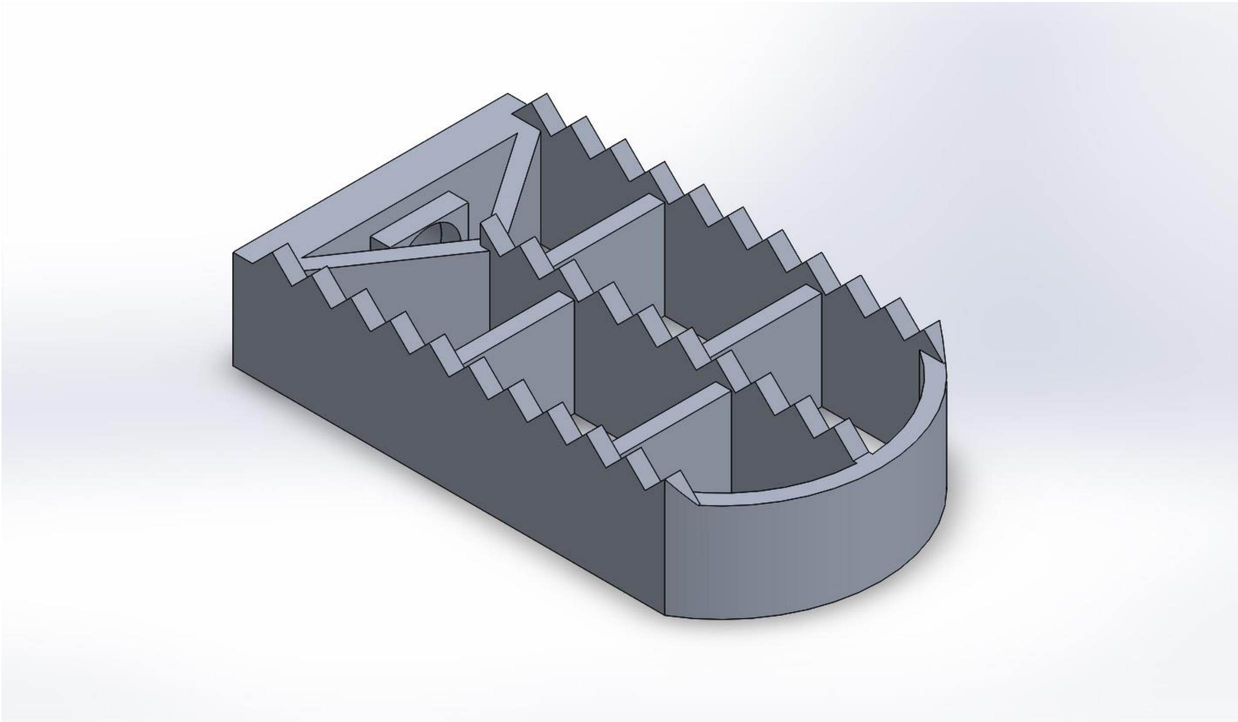


Figure B-10

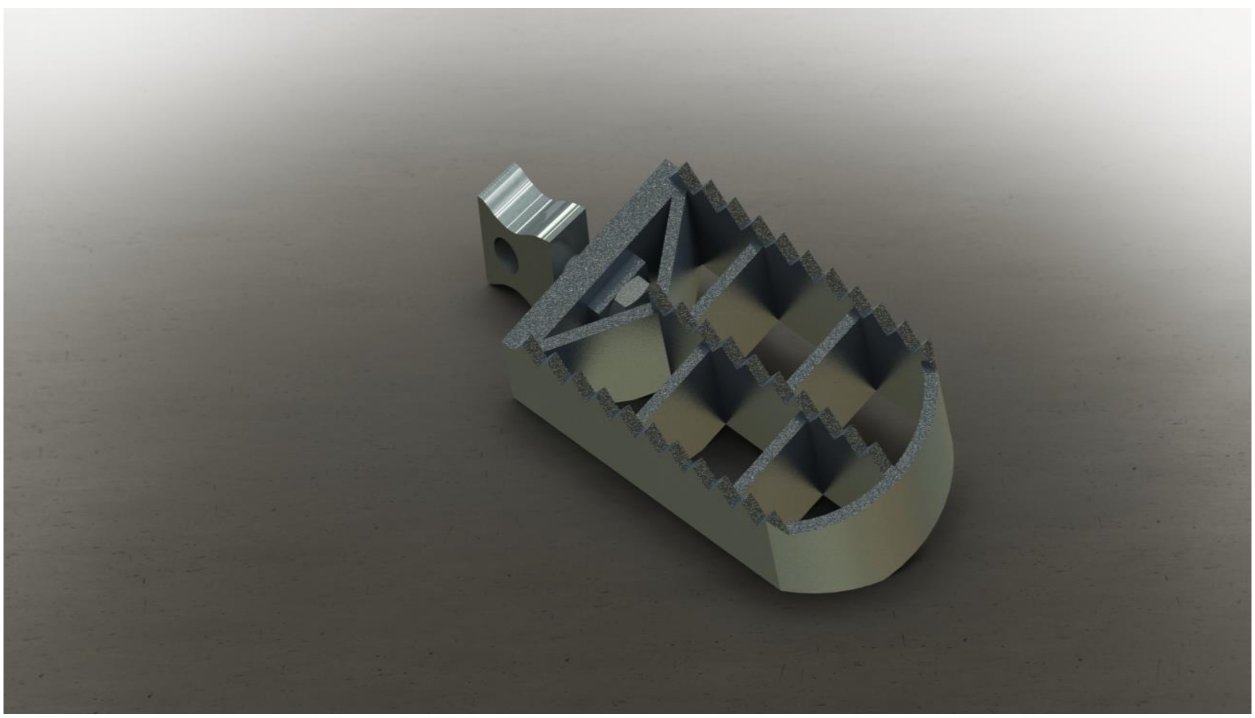


Figure B-11

APPENDIX C – Parts List and Costs

Michael LeBlanc	Senior Project Cost Sheet
Project Name	Pivoting Foot Pegs

Item Number	Part Number	Part Identification	Part Description	Model Number	Source	Projected Cost	Actual Cost
1	A1	Foot Peg	Aluminum Flat Bar 2024 T351 .75x2.00x24 inches		Online Metals	$47.22	$47.22
2	A2	Pivoting Mechanism	Steel Flat Bar 1018 Cold Rolled .75x1x<12 Inch		Online Metals	$8.03	$9.03
3	A3	Rods for Pivot Mechanism	Steel Round Bar 1018 Cold Rolled .25 in diameter, 1 foot long		Online Metals	$0.53	$0.53
4	A4	Rods for Pivot Mechanism	1018 Cold Rolled .125 in diameter, 1 foot long		Online Metals	$0.41	$0.40
5	# 2LFP5	Bushing	Plain Bushing Bearing, Closed, ID 0.375 in.	FNYBU06L	Grainger	$17.76	
6	A6	Hex Jam Nut	.2500 inch Hex Jam Nut		Grainger	$5.35	
7	Tool 1	.25 Inch Chamfer Bit	.2500 Inch 90 degree Chamfer Drill Milling Bit	291872	MSCDirect	$42.22	$42.22
					Estimated Total Cost	$121.52	$99.40

APPENDIX D – Budget

Michael LeBlanc		Senior Project Cost Sheet	
Project Name		Pivoting Foot Pegs	
Part Identification	Part Description	Source	Cost
Foot Peg	Aluminum Flat Bar 2024 T351 .75x2.00x24 inches	Online Metals	$47.22
Pivoting Mechanism	Steel Flat Bar 1018 Cold Rolled .75x1x<12 Inch	Online Metals	$8.03
Rods for Pivot Mechanism	Steel Round Bar 1018 Cold Rolled .25 in diameter, 1 foot long	Online Metals	$0.53
Rods for Pivot Mechanism	1018 Cold Rolled .125 in diameter, 1 foot long	Online Metals	$0.40
Bushing	Plain Bushing Bearing, Closed, ID 0.375 in.	Grainger	$17.76
Hex Jam Nut	.25" Hex Jam Nut	Grainger	$5.35
Chamfer Milling Bit	.2500" 90 degree Chamfer Milling Drill Bit	MSCDirect	$42.22
		Estimated Total Cost	$121.51
		Budget Amount:	$500.00
		Cost from Budget	$378.49

APPENDIX E – Schedule

Senior Project Schedule:
NOTE:
PROJECT TITLE:_Pivoting Foot Pegs_
Principal Investigator:Michael LeBlanc

Note: March x Finals
Note: June x Presentation
Note: June y-z Spr Finals

TASK: ID	Description	Duration Est. (hrs)	Actual (hrs)	November / Dec / January / February / March / April / May / June
1	Proposal*			
1a	Outline	2	2	
1b	Intro	2	2	
1c	Methods	1	2	
1d	Analysis	2	4	
1e	Discussion	2	2	
1f	Parts and Budget	1	1.5	
1g	Drawings	6	6	
1h	Schedule	2	4	
1i	Summary & Appx	1	0.5	
	subtotal:	19	24	
2	Analyses			
2a	Accelerated Weather Test=>Geo	120	130	May. 31
2b	Stress Anal=>Geo	5	6	May. 31
2c	Performance Test=>Geo	4	5	May. 31
2d	Beam Anal=>Geo	2	2	May. 31
2e	Kinematic => Geo	4	4.5	May. 31
2f	Tolerance => Geo	4	3	May. 31
	subtotal:	139	150.5	
3	Documentation			
3a	Foot Peg Drawing	1	1.3	Feb. 16
3b	Pivoting Mechanism Drawing	1	1	Feb. 16
3c	Subassembly Foot Peg and Pivot Mech.	2	1.5	Feb. 16
3d	Bushing Drawing	1	1	Feb. 16
3g	Subassembly Pivot Mech. And Subparts	1.5	1	Feb. 16
3h	Final Assembly Drawing	1.5	1.5	Feb. 16
3i	Kinematic Check	2	2.5	Feb. 16
3j	ANSIY14.5 Compl	2	3	Feb. 16
3l	Make Object Files	2	5	Feb. 16
	subtotal:	14	17.8	
4	Proposal Mods			
4a	Project Pivoting Peg Schedule	2.5	4	Feb. 16
4b	Project Foot Peg Part Inv.	2	2.5	Feb. 16
4c	Critical Design Review	4	6	Feb. 16
	subtotal:	8.5	12.5	
7	Part Construction			
7a	Buy Material Stock	1	1	Feb. 4
7b	Machine Pegs	4	20	Feb. 21
7c	Buy Parts for Pivoting Mechanism	1	2	Feb. 8
7d	Machine Pivoting Mechanism	4	4.1	Feb.28
7e	Make Pivot Mechanism Sub Assembly	2	4	Mar. 3
7f	Make Final Assembly	2	1	Mar. 6
7g	Take Pictures of Final Assembly	1	2	Mar. 7
7h	Update Website	1	1.5	Mar. 10
7i	Manufacture Plan	1	1.5	Mar. 15
	subtotal:	17	37.1	

9	Device Construct			
9a	Assemble Pivot Mechanism	2	4	Mar. 1
9b	Assemble Pivoting Pegs	2	1	Mar. 6
9c	Take Device Pictures	1	1	Mar. 7
9d	Update Website	1	1	Mar. 10
	subtotal:	6	7	
10	Device Evaluation			
10a	List Parameters	2	1.5	Mar. 28
10b	Design Test & Scope	5	6	May. 1
10c	Obtain resources	1.5	2	May. 1
10d	Make test sheets	3	2	May. 1
10e	Plan analyses	2	2.5	May. 1
10f	Instrument Pivoting Pegs	2	2	May. 3
10g	Test Plan	6	8	May. 3
10h	Perform Evaluation	4	6	May. 25
10i	Take Testing Pics	1	1	May. 30
10h	Update Website	1	2.5	May. 30
	subtotal:	27.5	33.5	
11	495 Deliverables			
11a	Get Report Guide	1	0.5	Sep. 24
11b	Make Rep Outline	1	3	Oct. 15
11c	Write Report	110	130	Feb. 16
11d	Make Slide Outline	10	10	May. 30
11e	Create Presentation	5	8	May. 30
11f	Make CD Deliv. List	5	6	May. 30
11e	Write 495 CD parts	5	5	May. 30
11f	Update Website	2	1.5	May. 31
11g	Project CD*	2	2.5	May. 31
	subtotal:	141	166.5	May. 31
	Total Est. Hours=	372	448.9	=Total Actual Hrs
Labor$	100	37200	44890	
Note:	Deliverables*			
	Draft Proposal			
	Analyses Mod			
	Document Mods			
	Final Proposal			
	Part Construction			
	Device Construct			
	Device Evaluation			
	495 Deliverables			

Appendix F – Expertise and Resources

- The Central Washington University Machine Shop
- The Central Washington University Cad Labs
- The Central Washington University Mechanical Engineering Technology Faculty
- Fellow Classmates

Appendix G- Pictures

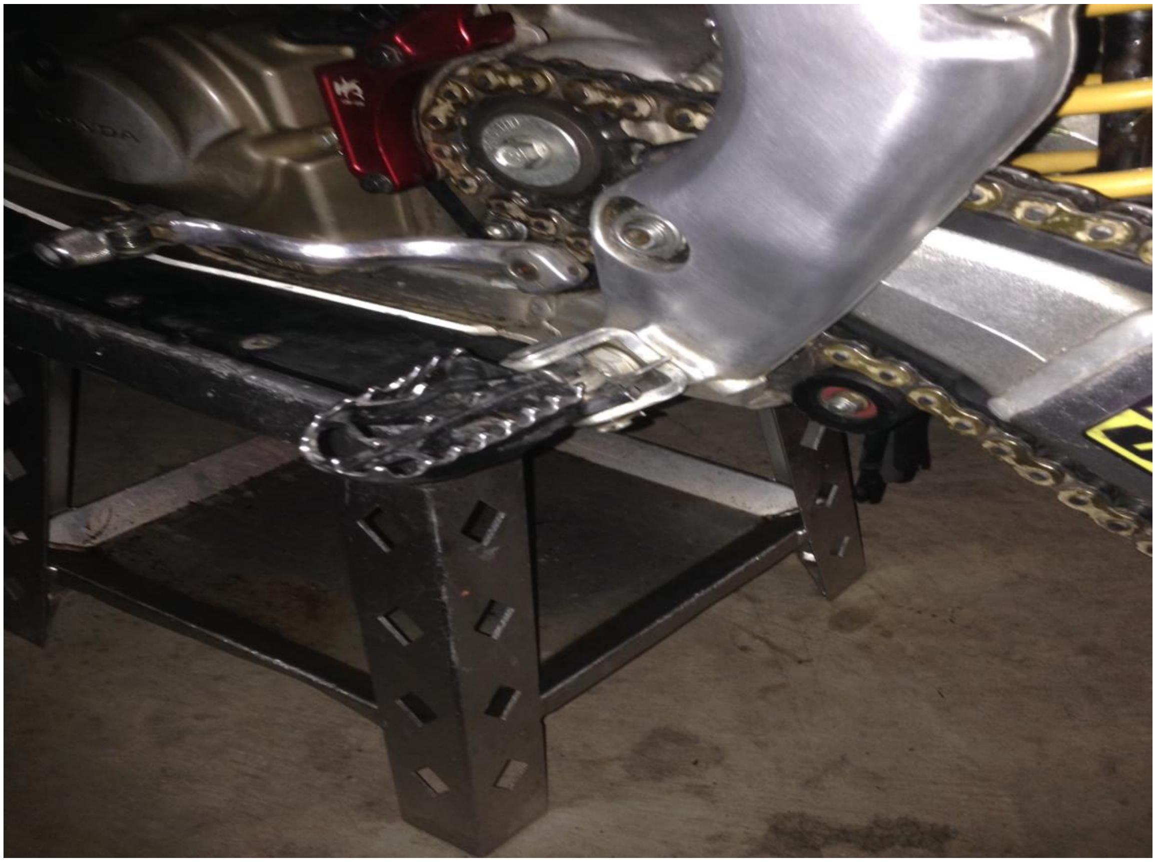


Figure 1

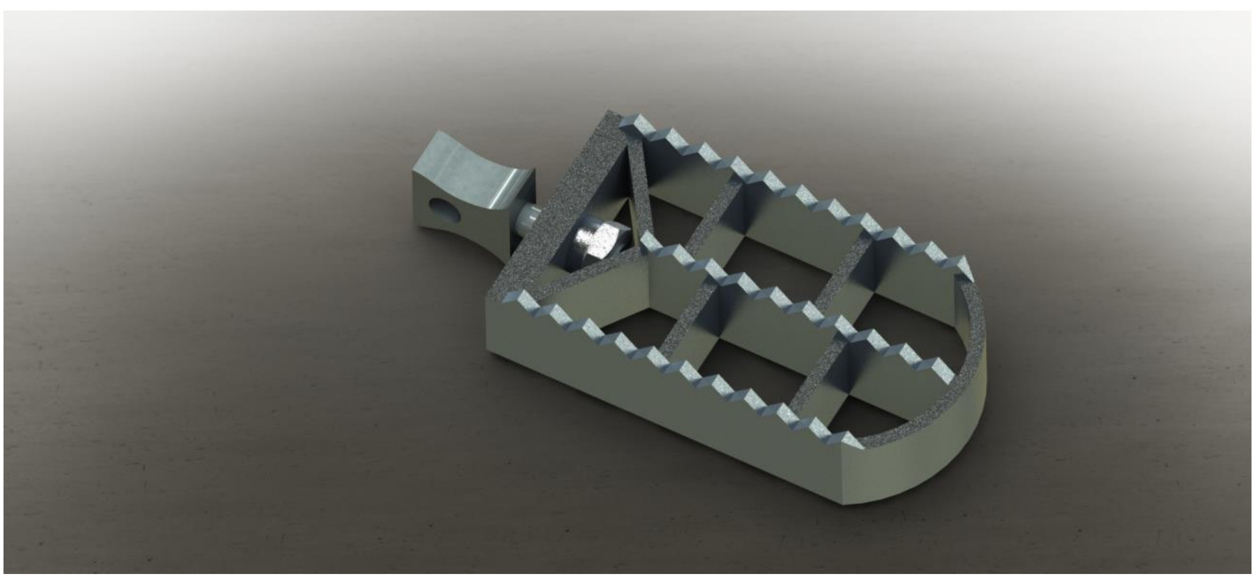


Figure 2

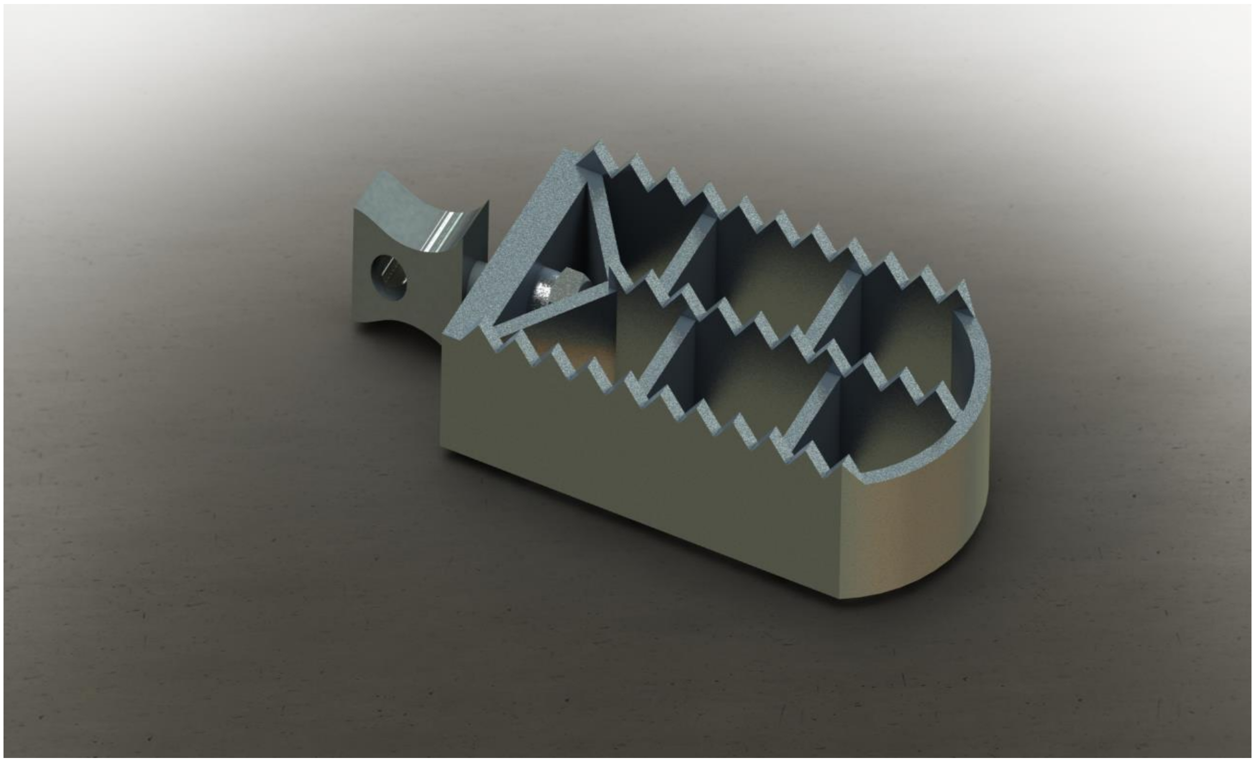


Figure 3

Figure 4

Appendix H – Evaluation Sheet

Pivoting Foot Pegs Evaluation Sheet

Stationary (on Stand)

Test #	Strain	Deflection (Inches)	Successful Rotation	Non-Successsful Rotation	Rotation Degrees
Load (Pounds)					
170			Yes		22.5 Each Way
185			Yes		13 Each Way
185			Yes		22.5 Each Way
200					
300					

Moving Test (Track Test)

	Strain	Deflection (After Trial)	Successful Operation	Non-Successful Operation	Part Failure?
Load (Pounds)					
185					
185					
170					
170					

After Machining Operational Test

	Yes	No
Rotational?	√	
Tolerances Met?	√	
Dimensions Met?	√	
Bike Fitment	√	

Accelerated Weather Testing

Time (Weeks)	Material Property Changes?	Comments	Temperature
1			
2			
3			
4			
5			
6			
7			
8			

Appendix I –Testing Report

Types of Testing

In order to observe the effectiveness of this design project, various test will need to be performed to compare experimental data with the calculated design values. As previously stated in the testing method section, there is four focal areas of the designed product that will need to be tested. These areas include the weather durability, the stationary and dynamic stress and strain, and the overall functionality and operability. Additional test will be performed to confirm the ergonomics of the assembly, such as size, tolerances, and weight.

Testing Resources and Set Up

Numerous tools and resources will be needed to conduct the tests required to determine if the project design is a successful one or a failure. Testing resources necessary include the following:

- Open Motocross Track/Woods Testing Location
- Hogue Technology Building
- Operational Dirt Bike
- Digital Calipers
- Strain Gauges
- Multiple Testing Associates
- Digital Angle Gauge
- Depth Micrometer
- Dial Indicator
- Stop Watch

Recording of the data measure for the tests can be difficult due to the precision of the testing instruments used along with the accuracy per person reading and recording the results. Since multiple trials with different weights will be partaken, the possibility for multiple people to be reading the data results from the utensils creates a great risk in altering values. To help minimize this potential risk is running each test multiple times and taking the average of the trials for the best possible data result.

Accelerated Weather Testing Set Up

The accelerated weather test is the first test that will be started for the design project. This requires the assembly to be subject to the testing guidelines of ASTM D5744, Standard Test Method for Laboratory Weathering of Solid Materials Using a Humidity Cell. Procedure is as follows:

1. Create two environmentally controlled enclosures that have temperature and relative humidity maintained in a constant range.

a. Each environment will be set to different temperatures to view how the different temperatures affect the material properties.

2. Each enclosure will remain constant for six days.

3. Weekly a leach of 500-1000mL of water will be introduced to each environment

4. Observations need to be recorded each week on any noticeable changes to the materials of the assembly.

5. Test will occur for a time of four weeks.

a. If no noticeable or severe changes in the material are noticed by the end of the time period, testing will be continued for additional weeks but not to exceed eight total weeks.

Test 2 Set up

The second test to be performed on the design project is a stationary test that determines the strain, deflection, and operational ability of the project. The Procedure is as follows:

1. The bike the pegs will be placed on will need to be placed on a stand in Hogue Room 127.

2. Strain gauges will be applied to both pegs to measure the strain acting when a load is applied.

3. Mount a dial indicator on a spot on the frame underneath the pegs, and set a zero point for the start of the test.

4. Have the first rider step upon the pegs and stand in a riding position for an elapsed time of two minutes.

a. Time will be measured using a stopwatch.

5. Have an additional helper record the readings from the strain gauges and the dial indicator.

a. These values will be recorded in the testing sheets

b. The reading on the dial indicator will be how far the pegs deflected with load applied.

6. Repeat procedure for the desired load three times so an average result value can be obtained.

7. After the three trials are completed for the current load, repeat procedure for the next indicated load until each desired load to be tested is completed.

Test 3 Set up

The third test to be performed will be similar to that of test two, but will be performed while the bike is being ridden out on a closed course. The procedure is as follows:

1. Bike will need to be brought to a closed course to be operated at.

a. This includes either a motocross track or any additional areas where permissible to ride at.

2. Strain gauges will need to be applied to the pegs so that strain data can be recorded.

3. The rider will then take the bike out onto the course and perform a trial that has an elapsed time of fifteen minutes.

a. An additional helper will use a stopwatch to measure the time and for when trial starts and stops.

4. Once stopped, strain gauge readings will be recorded onto the testing sheet.

5. Repeat procedure for an additional two times and record values gathered.

a. An average of the data results will then be taken and added to the evaluation sheet.

6. After the three trials are completed, repeat procedure and trials with a different weight rider and record the results.

a. Compare results and averaged result between the two different riders.

Test 4 Set Up

The fourth test will test the operation of the pegs in general. This test will be tested after the pegs are first assembled, along with in conjunction with tests two and three. The procedure for the test is as follows:

1. After the project is assembled, test the design for is operational capabilities.

a. This includes the rotational capabilities, along with how well the ability is for them to do the movements.

b. Note all comments on how operations were completed and any flaws or perfections noticed. Report all comments onto the evaluation sheet.

2. Repeat this procedure for when test two is being conducted.

3. Repeat this procedure for when test three is being conducted.

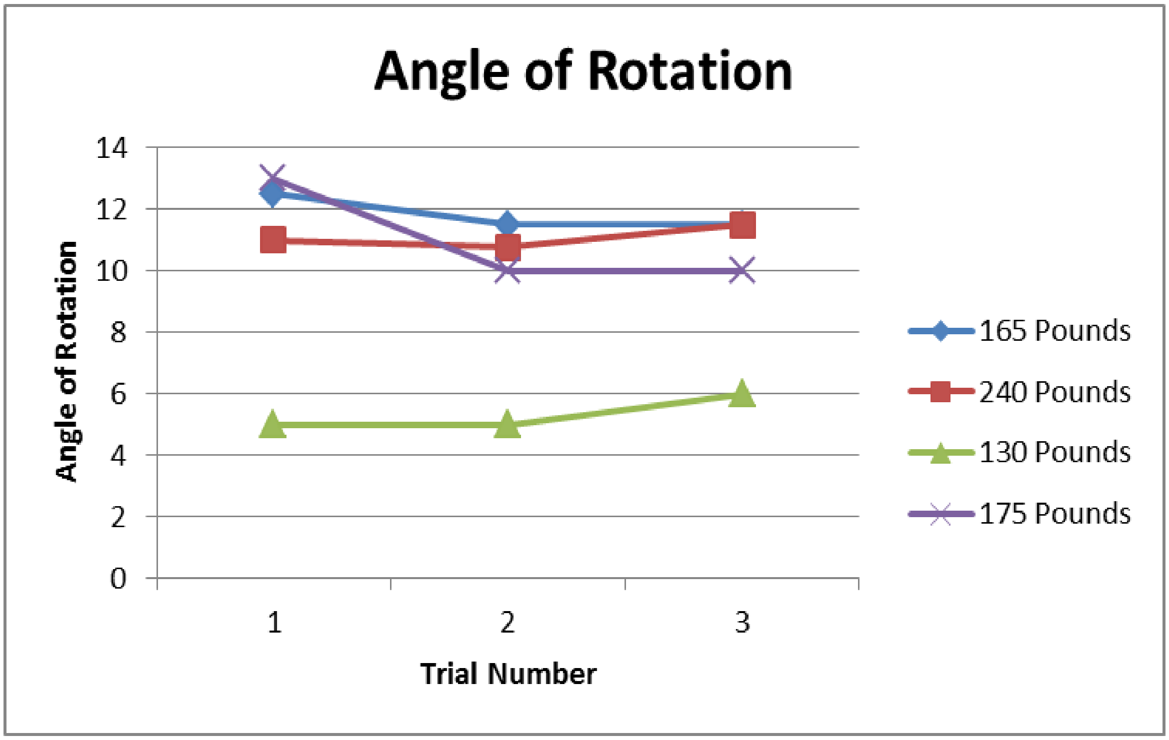
Other Tests

Further tests that will be conducted to determine the overall success of the project include measuring the parts to determine if they met the requirements specified in the drawings. The total assembly will weighed as well to determine if the weight met what the expected value was determined to be. The results from these tests in conjunction with the four previous tests performed will determine if this design project was a success or a failure.

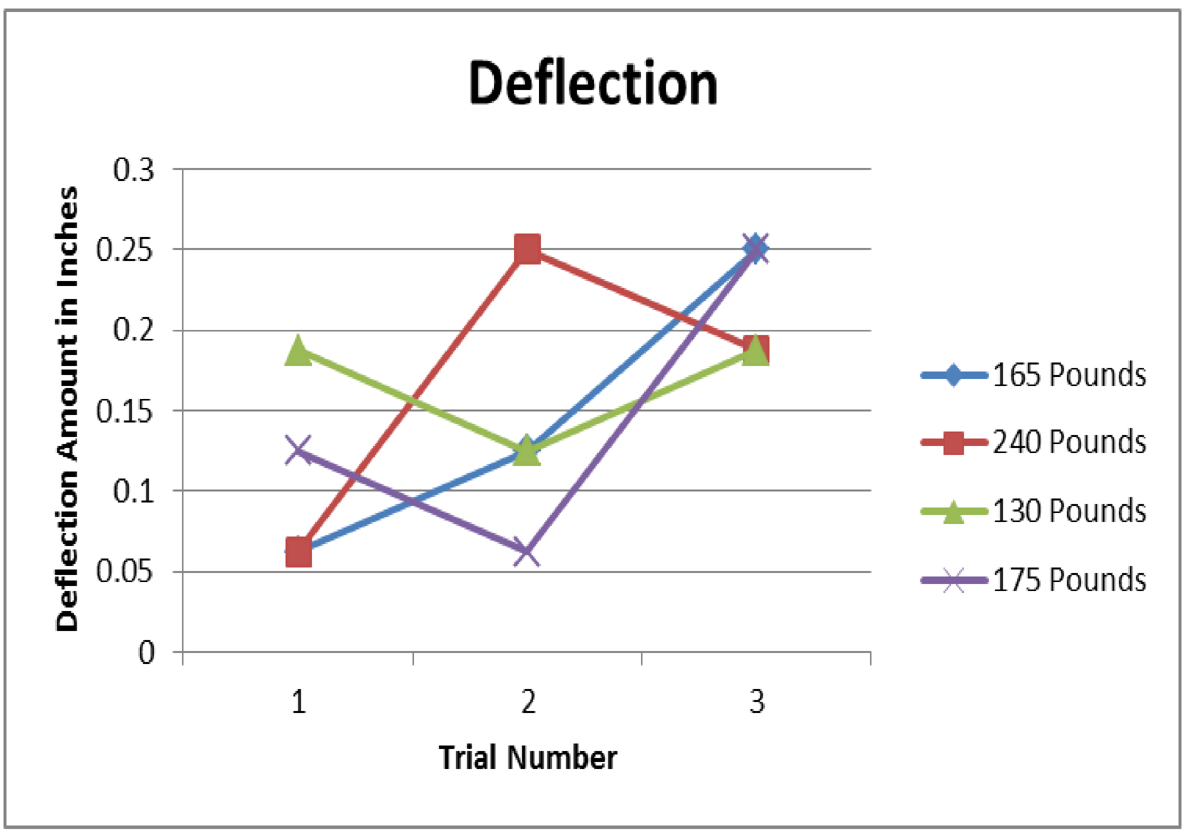
Appendix J – Testing Data

Stationary Bike Testing					
Rider Weight	Start Height	Height with weight	Deflection	Angle of Rotation	Rotate?
165	18.1875	18.125	0.0625	12.5	Yes
165	18.25	18.125	0.125	11.5	Yes
165	18.25	18	0.25	11.5	Yes
Average	18.23	18.08	0.1458	11.83	Yes
240	18.1875	18.125	0.0625	11	Yes
240	18.25	18	0.25	10.75	Yes
240	18.1875	18	0.1875	11.5	Yes
Average	18.21	18.04	0.1667	11.08	Yes
130	18.1875	18	0.1875	5	Yes
130	18.0625	17.9375	0.125	5	Yes
130	18.125	17.9375	0.1875	6	Yes
Average	18.13	17.96	0.1667	5.33	Yes
175	18.125	18	0.125	13	Yes
175	18.0625	18	0.0625	10	Yes
175	18.25	18	0.25	10	Yes
Average	18.15	18	0.1458	11	Yes

Table of Stationary Testing Values



Graph 1 (Rotational Angle at Various Weights)



Graph 2 (Deflection in Pegs with Various Weight Riders)

Accelerated Weather Testing			
Time (Days)	Material Property Changes?	Comments	Temperature
1	No	No changes after first day	70 Farenheit
2	No	No changes to notice after second day	71 Farenehit
3	No	No noticable changes after the third day	68 Farenheit
4	No	Starting to notice a little change but not enough to say property change	72 Farenheit
5	Yes	Started to notice physical property changes with material	71 Farenheit
6	Yes	Aluminum on pegs is oxidizing do to uncoating from machining processes. Steel on pivoting bracket is rusting	75 Farenheit
7	Yes	Oxidation and rusting is continuing to accumalate	73 Farenheit
8	Yes	Pivoting bracket is partially rusted. Aluminum peg has oxidation occurred to various areas on the peg	72 Farenheit

Table of Weather Testing Data

After Machining Operational Test		
	Yes	No
Rotational?	√	
Tolerances Met?	√	
Dimensions Met?	√	
Bike Fitment	√	

Table of Post Machining Assembly Checklist

Appendix H – Resume

Michael LeBlanc

425.359.8607 | 15803 1st St SE, Snohomish, WA 98290 | mleblanc360@gmail.com

Professional Experience:

Premier Field Development *Snohomish, WA* **Summer 2014**

Laborer/Operator

- Intensive use of laser and grade rod to establish grade for sub grade, slab prep, footing drains, pipe trenches, and fields
- Aided in building football and track activity fields at the local high school
- Responsible for operating excavators, loaders, and rollers weekly

Mickelo Construction *Monroe, WA* **Summer 2013**

Laborer/Operator

- Performed multiple deep hole excavations in Seattle area
- Responsible for operating excavators, loaders, and rollers weekly
- Intensive use of laser and grade rod to establish grade for sub grade, slab prep, footing drains, pipe trenches, and fields

Lowes Home Improvement *Monroe, WA* **December 2009 – December 2012**

Lumber Department Senior Customer Service Associate

- Achieved certifications on forklift, reach trucks, and order pickers
- Aided in helping customers find products on sales floor, order products, and takeoff's for the customers needs
- Promoted from stocking shelves to senior associate in the lumber department

Nelson and Sons Construction *Woodinville, WA* **June 2006 – September 2009**

Laborer/Operator

- Responsible for cleaning various pieces of work equipment including rollers, excavators, trucks, and construction equipment
- Actively operated excavators, loaders, rollers, and dozers

Education:

Central Washington University *Ellensburg, WA* **Expected Graduation - June 2015**

Bachelor of Science Mechanical Engineering Technology

Major: Mechanical Engineering Technology | GPA: 3.1 | Member of ASME Student Chapter

Related Coursework: Thermodynamics, fluids, hydraulics, heat transfer, CADD, and machining

Everett Community College *Everett, WA* **Graduated – December 2012**

Associates of Science Mechanical Engineering Technology

Skill Sets:

Practical knowledge in multiple CADD Formats:

- Rhinoceros 4.0 2+ years experience
- Solidworks 3 years experience
- Autocad 1 year experience
- Catia 1 year experience
- MasterCam 1 year experience

Manufacturing:

- Proficient in CNC mill code and operation experience, manual mill and lathe experience

References Available Upon Request