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Custom Glasses Cases

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By

Nikolas Klukas

Table of Contents

ABSTRACT

The modern market is centralized around technological advances that improve and better everyday life. With approximately 150 million Americans that use corrective eye-ware on a daily basis, the need for improved technology in glasses cases is inevitable. Current glasses cases work to either protect the glasses and are big and bulky, or are made smaller to be more easily transported. The concept is to take any pair of glasses and make a custom case for them. The programs being utilized to complete the project are solidworks and excel. The process is started by making a base layout of the glasses case in solidworks. Then a excel spreadsheet was made. Linking an excel spreadsheet to solidworks enables rapid input of new dimension to adjust solidworks drawing to the correct or new size. This provides a quick way to make my case fit any pair of glasses, no matter the dimensions. The solidworks model is then saved as a Stereolithography file and sent to the 3-d printer. The cases came out fully functional and open and close perfectly. From sit down to completed glasses case depends on the size of the glasses the case was modeled around. The more cubic inches the case is, the longer it takes to print. The first case took 10 hours to print.

INTRODUCTION

Project

The project is designing custom glasses cases personalized to any pair of glasses available. These cases will be designed, measured and started printing within an hour. For the project, the lead engineer will be taking advantage of the school's 3-D printer to produce these custom cases, along with excel and solid works.

There is a need for a glasses case that is not big and bulky so this will also factor into my design. Many pairs of glasses don't come with a case. The goal of this project is to produce custom, cheap glasses cases for any pair of glasses. This will be a smaller design than most glasses cases used today, and will be able to be transported in a pocket. Most cases on sale are one sided built for safety or size, not both. This case will be small, lightweight and strong enough for every day functions.

Function statement

I am designing a custom glasses case for any pair of glasses that can be produced in a certain amount of time. The glasses case must fit in a pocket or be compact, depending on the size of the glasses. They must also protect the glasses from the forces of bending. The case must also shut and remained so until the customer or recipient wants them to open.

Requirements

For the glasses cases to be successful they must maintain the following requirements.

- The custom case must be measured, designed and given to the customer within one hour.

- The design of the glasses is to be within 1/4" longer and wider than the glasses are all around. The glasses case 1/4" is designed around the inside fit and the thickness. This ensures the glasses cases are small as possible.
- The case must not bend .1 inches under a ten pound load. The most vulnerable part is the top of the case because it has the most surface area.
- The case must open with a 6 pound force.
- The case must stay closed until opened purposely.

Scope of Effort

A majority of the effort of this project will go into making an excel spreadsheet that simplifies changing the dimensions in solid works model. This is how the glasses case will be assured to be made quickly. The case must also be accurately measured to proper dimensions to fit any pair of glasses, so the values can be imputed into my spreadsheet/spreadsheets. The spreadsheet has to be simplified enough to be used in minutes, not hours, to produce a new custom glasses case.

Success Criteria

This will be determined by whether the custom glasses cases can be produced in the allowed time no matter the shape or size of glasses. The goal is to take a pair of glasses and be able to have a finished glasses case for a customer within an hour. This includes taking measurements of the customer’s glasses and re-making the model in solid works.

Success also includes whether the glasses fit into a pocket and are strong enough to protect the glasses to withstand certain situations, like dropping the case from a given height and compressive forces of a pocket. The case must also close and open correctly and smoothly.

Equations

The equations used come from statics. Bending stress equations can see how thick the case will need to be along with the deflection due to a force.

The equation for moment of inertia for a hollow pipe was used. It models the top of my case perfectly; the equation is $I= \pi/4(r_2\text{^}4-r_1\text{^}4)$. For bending stress, the equation Vmax= -PL^3/48EI was used, E being the modulus of elasticity and I being the moment of Inertia. The top of the glasses case has been evaluated as a beam with a given length, height and thickness to determine the deflection. The case was then modeled in solid works with these calculated values.

DESIGN AND ANALYSIS

Description of Analyses

Analysis began with creating the solid works model of the case. The dimensions changed when choosing a thickness and making sure the glasses fit in the case. Using the equation Vmax= -PL^3/48EI, different thicknesses were tested for deformation in the centroid of the top part of the case. This area is the widest and longest part of the case making it the most susceptible to bending. The values of length and width could not be changed very much so the value tinkered with is the desired thickness. The findings were for any deformation of less than .01 inch, the thickness needed to be .1 inches. This thickness can hold up to a 20 lb-force (89 Newtons). The calculations page is found in Appendix-A.

Finite element analysis was done on the solid works model. The case deflected .00618 millimeters, which is .000243 inches. This is close to my calculated values of deflection of .000389 inches under a 5 pound force. In both instances the calculations were done on the top part of the case, not the whole assembly. In solid works, the fixture was the bottom ring of the case, acting as it were closed or set on the ground. The 5 pound force, or 89Newton, was applied over the surface area of the top of the case.

Analysis was also done finding how much force it takes to open the case. It was evaluated as a force fit. The psi holding the case together was found to be 1.9 Psi. The surface area, between the top and bottom parts on the case, in contact was 3.02 inches^2. The Force needed to open the case came out to 5.85 pounds.

Failure mode

The failure of the case is based on the requirement of withstanding a .01 inch deflection. If the case is subjected to a 130 pound force my case will fail and deflect .0101. This is the limit for a load on the case. For calculations, go to appendix A.

Calculated Parameters

Based on my glasses dimensions, the wall thickness is .1 inches to avoid any bending on the top of the case, or anywhere else. With this thickness there was a calculated deflection of .000389 inches with a 5 pound force on the top of the case. It has a calculated deflection of .00155 inches with a 20 lb-force. With a lower thickness's the case would deflect up to .5 inches, touching the glasses inside and breaking the plastic. The width and length of the glasses are measured with a venier caliper and then .15 inches is added to make the dimensions of the case. This leaves .1 inch of error, for each side, for the measurements of the case. This satisfies my requirement of no than a .25 inch gap from the sides of the case.

The case is shown in figure1.

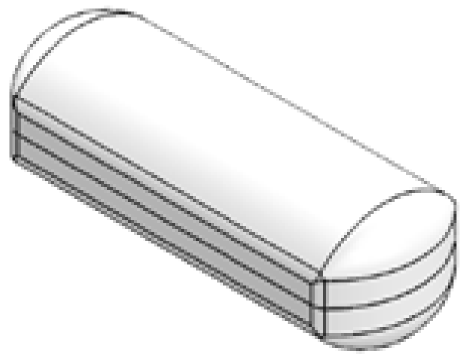

Figure 1- Finished Case

Performance Predictions

The prediction is that this case will not bend more than .01 inch with a 20 pound force threw the centroid of the top portion of the case. This is the area that is most susceptible to bending.

Tolerances

The tolerances for the case are going to be small because the glasses are already getting a .25 gap from the sides and top of the case. The tolerance for the dimensions is .05; this may change due to the tolerance given by the 3-d printer. These are set in place to keep the case as small as possible.

Benchmark

My benchmark is a startup company in Minnesota called foreverence that uses a 3-D printer to make custom urns for people. The customer can choose any object that holds value to themselves or the deceased and have a unique urn made in the objects shape. It takes one day which is fast for custom made, ceramic, urns of this quality. With shipping however it takes 7-10 business days to receive an urn. The cases in this project will take an hour to plus the time of the print which will be significantly less than one day.

The 3-D printer uses a ceramic-composite material that starts in powder form. The 3-D printer layers the material with coloring that bonds each layer to the next.

This is a picture of Co-founder Pete Saari and their 3-D printer along with some a custom urn they have produced. This is shown in figures 2 and 3.

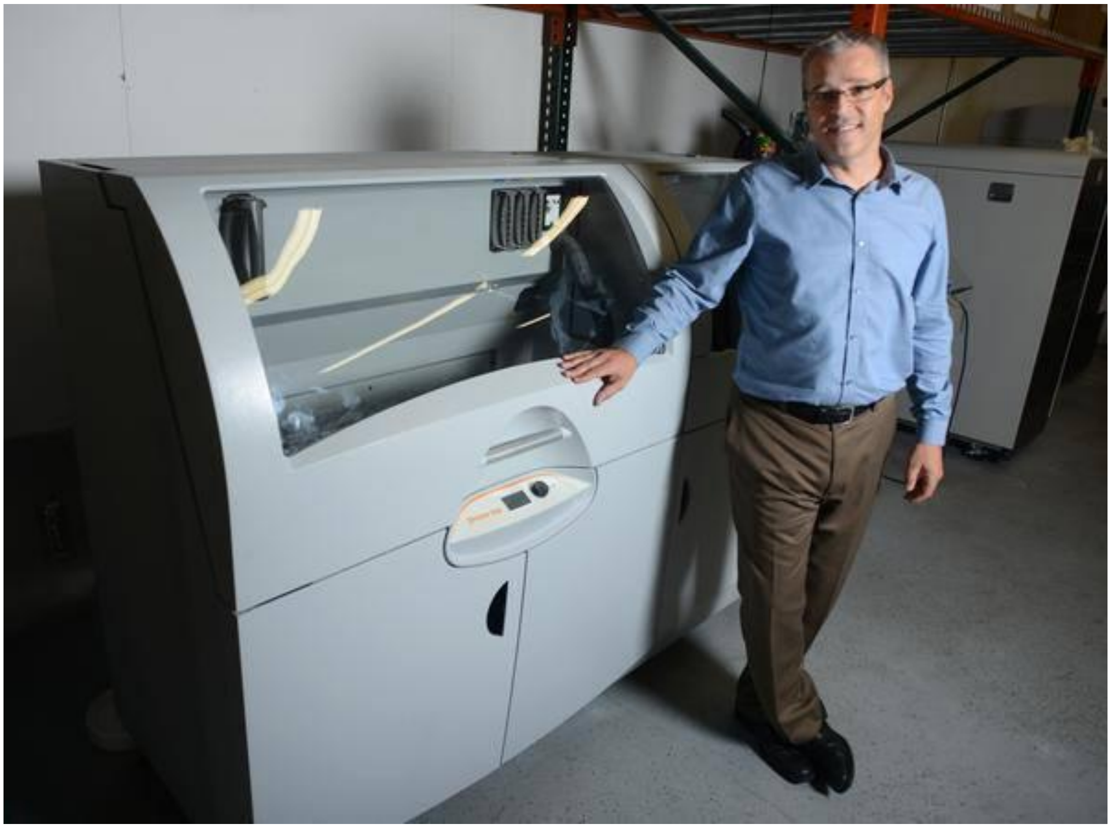

Figure 2-Pete Saari

Figure 3- Custom Urn

METHODS AND CONSTRUCTION

Description

The project will be designed in solid works and made with Central Washington Universities' 3-D printer located in the Hogue lab. An excel spreadsheet will be made to simplify changing dimensions in the already made solid works model. This ensures the custom case is made quickly to standards pre-determined. The engineer will be able to take any pair of glasses and quickly measure and apply the dimensions to solid works, making a new custom solid works model based on the new dimensions. This model will then be printed and given to the customer within minutes, not days. The material used in the printer is abs, a hard plastic. The part may need some touching up, or deburing depending on the quality of the 3-D printer.

A measurement tool will be used to quickly measure the desired dimensions. This will help the process stay under one hour. The excel spreadsheet will have dimensions like length, height, but also formulas that can change the thickness of the case if need be. This spreadsheet will simplify all aspects of design and calculations. The excel spreadsheet will be able to calculated the needed thickness for the new glasses along with changing the desired dimensions of the new custom case.

Drawing Tree

The drawing tree is located in Appendix D. Starting at the bottom the engineer will receive a unique pair of glasses. These glasses will be measured in various areas and noted on dimensions. These values will then be imputed into a spreadsheet incorporated into solid works. The existing solid works model of a glasses case will be changed according to the new dimensions. The case will then be printed and given to the customer.

Parts list

The parts list is located in Appendix C. It tells a description of the part and how much the part will cost to produce. It also states the source of the part.

Manufacturing Issues

The biggest problem was in the designing of the case. The case has been redesigned and re-imagined many times before reaching its final design. Also the way the case is held together has changed and redesigned many times.

TESTING METHOD

This part of the report encompasses the testing done on produced glasses cases. The cases will be measured and compared to the standards set at the start of the project.

Testing Requirements

For the glasses cases to be successful they must maintain the following requirements during testing.

- The custom case must be measured, designed and given to the customer within one hour.

- The design of the glasses is to be within 1/4" longer and wider than the glasses are all around. The glasses case 1/4" is designed around the inside fit and the thickness. This ensures the glasses cases are small as possible.

- The case must not bend .1 inches under a ten pound load. The most vulnerable part is the top of the case because it has the most surface area.
- The case must open with a 6 pound force.
- The case must stay closed until opened purposely.

Parameters of Interest

Thickness of case is the main focus of the design. This is to make sure the case stays compact as possible. This also controls the price it takes to produce the case. If the thickness is too small, the case will bend and break. the lead engineer had to find a middle ground between price and strength. Available space inside the case. The case is supposed to be as compact as possible to possibly fit in a pocket, this parameter ensures that.

Predicted performance

The case will bend .1 inches under 128 pounds threw the top of the case. This is what was calculated for the case under a 3 point bend. Another calculation was the force to open the case. The calculated value was at 5.8 pounds.

Resources

Human Resources:

The lead Engineering student is responsible for the completion of this project. Teachers Dr. Craig Johnson, Mr. Charles Pringle, Mr. Roger Beardsley and Mr. Darryl Fuhrman have aided in the completion of this project.

Physical Resources:

The University granted permission to use the 3-D printer located in Hogue for this project. This is the main resource for building this project. Books have also played a role in completing the project; they are listed in Appendix D.

Soft Resources:

The CAD Labs at Central Washington University have been invaluable resources for the drafting and designing of this project. The software being utilized for modeling this project is solid works. Websites that were used have been mentioned in Appendix D.

Financial Resources:

There are no donators or sponsors for this project. The lead engineer is funding the entire project.

Test Procedure and Deliverables

The first test done was testing the requirement of open space in the case when the glasses are inside. My requirement was for .25 inches or less between the cases walls. This was meant to keep the design of the case tight to the glasses. In the X direction the case is out of tolerance. It is measured at about a .7 inch gap. The Y direction is perfect and is less than the .1 inch margin. Measuring the Z direction(up and down) took some imagination. The top part of the case was filled with modeling clay and then the cases were closed with the glasses inside. The mark made in the left picture shows were the glasses are touching and the leftover clay between the mark and the case show how much available space is left when the case is closed. this was measured with the depth part of a dial caliper to be about .14 inches. Upon second round of printing the case had no gap in the y and z directions. The case had less than a .1 inch gap in the x direction.

Figure 4 Test 1

Another test done was testing the Vmax or deflection under certain loads. The case was designed not to bend certain amounts under certain loads. The requirement is for the case to not bend .1 inch under 10 pounds. The test was done using a 25 pound dumbbell placed on top of the case. To simulate a point load, a dime was placed between the case and weight. Modeling clay was placed in the case making a mold of the case. The mold was measured and then placed back in the case. The weight was then placed on the case. Taking the modeling clay out and re-measuring showed how much the case bent during the test. This difference in height was the deflection the case experienced. I got values between .02 and .03 inches. This is significantly less than the requirement of .1 inch.

Another test done was testing the force it takes to open the case. The requirement was to open the case with a 6 pound force. The case should not be over this amount or it would be too hard to open and would not satisfy my requirements. The way the test was conducted took some imagination. Two holes were drilled into the top of the glasses case. Then a fish weighing scale is hooked threw the holes and is used to measure the weight it takes to separate the top and bottom of the case. These are the results of the test.

Required Force to Open Case	
Test #	**weight**
Attempt 1	**3.2 pounds**
Attempt 2	**4.1 pounds**
Attempt 3	**3.0 pounds**
Attempt 4	**3.5 pounds**
Attempt 5	**3.3 pounds**
Average value	**3.42 pounds**

Figure 5 Test 3

The last test was timing how long it took to measure and make a new model in solidworks. Using excel within solidworks it took 14 minutes to change my model. Just changing the individual parts took 17 minutes. Both under an hour as stated in the requirements and almost negligible when considering printing takes 8 hours.

Conclusion

In conclusion, the results for the force to open the case, deflection, space tolerance, and time to create a new case are all better than my predicted values and within my tolerances. All the tests were done within schedule but went over budget for testing due to the unknown filler/support material that cannot be calculated until the stl file is in the rapid prototyper.

BUDGET AND SCHEDULE

Parts and supplies

All the parts will come out of Central Washington Universities' 3-D printer. The material used in the 3-D is abs, acrylonitrile butadiene styrene. The plastic is priced in cubic inches. The material cost 6 dollars per cubic inch and is supplied directly by the school.

Total Cost

The Original estimating cost for each case was 60 dollars. Upon gathering more information about testing and the amount of material needed to produce a single case, more will be necessary. More than one case will be made so this will increase the amount of money needed for the project. One case will be made to show my teachers and two more will be made for testing data. After doing the solid works model I found the volume to be more than 4 cubic inches for my first case. The total for this case is 26.58 dollars. There is no external source funding the project. The cost for each case is measured by the cubic inches of the case. The price is 6 dollars per cubic inch.

Description

The schedule is in the form of a Gantt chart and is located in Appendix D. Each task has a start date and an estimated time to complete that task. Upon completion, the engineer will fill how many hours the task actually took. The dates are separated by ten days' time so any bars in-between will be less than that.

PROJECT MANAGEMENT

Tasks:

Task	Description
1a	Research spreadsheet
1b	Create the spreadsheet
1c	link to solidworks
2a	Measure part
3a	Create new part
4a	Print part

Human Resources:

The lead Engineering student is responsible for the completion of this project. Teachers Dr. Craig Johnson, Mr. Charles Pringle, Mr. Roger Beardsley and Mr. Darryl Fuhrman have aided in the completion of this project.

Physical Resources:

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Financial Resources:

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DISCUSSION

Design Evolution

The project started out as drawn ideas for case designs. There were a few different shape ideas. What created the shape used now is the close fit between the case and the glasses inside the case. The case does not leave more than a .25 inch gap from the case to the glasses on the inside. This is to make sure the case is as small as possible and also for the glasses to have little room to shake inside the case. The design is to have the glasses fit securely in the case.

The case also could have been opened in many ways. The original drawing had the case opening from the top. The case could have had a snapping cap that would fit to the case at the top of the body. However I am not aware of the tolerances of the 3-D printer on campus so I decided to go with a different design. This would have been a risk because if the lid would not stay on the case I would have to redesign the case or print new caps. I decided to go with a case that split down the middle, more like traditional hard cases.

The first design was a flat case and is shown in figure 4. It had sharp edges and had a clasp that needed force to open. This design also had a pin going through the case keeping the top and bottom parts together. The design looked clunky and was a rough prototype.

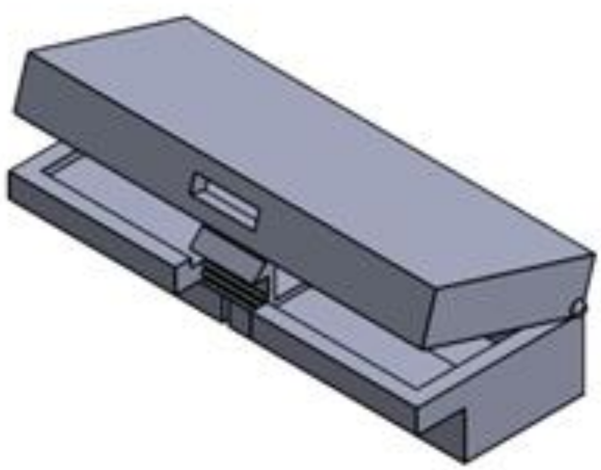


Figure 6- First Design

This was my second design. It has filets and has an arched top to better fit the natural curve of glasses. My final design took the flat surface on the bottom away, and is almost a mirror of the top part of the case. It is shown in figure 5.

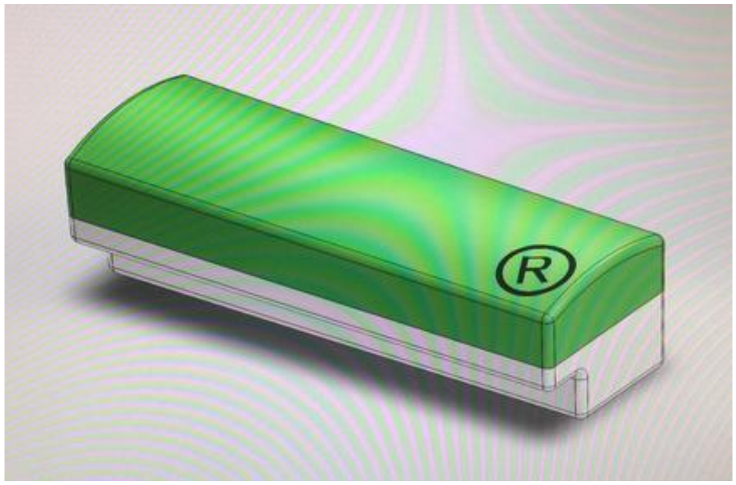


Figure 7-Second Design

Shown in figure 8 are old concept drawings for the case drawn in the brainstorming phase.

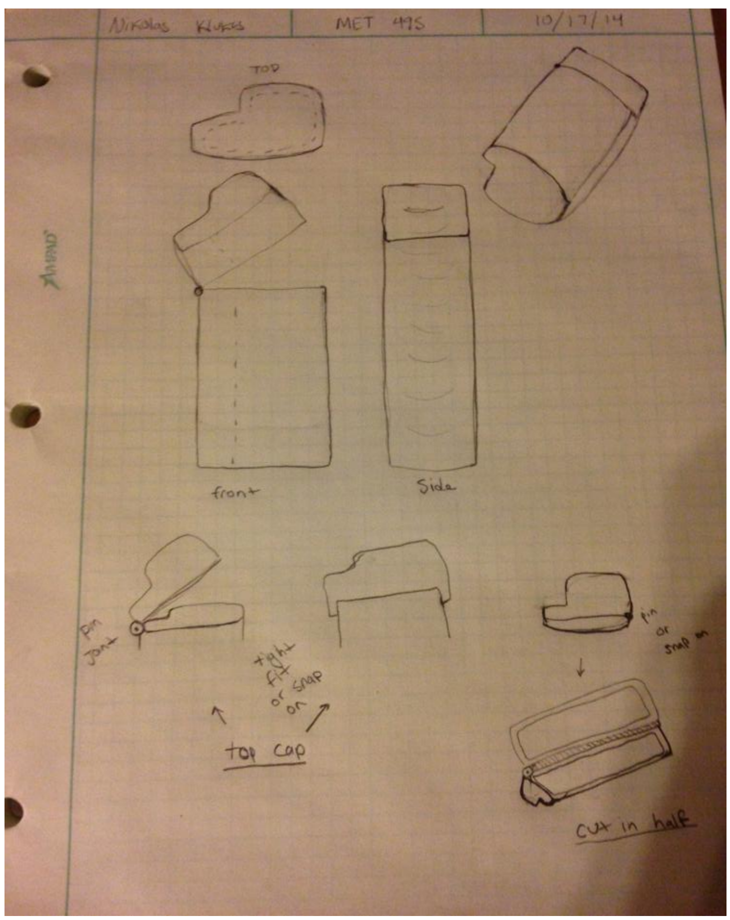


Figure 8- Old drawings

Project Risk Analysis

One risk in this project is finding a measurement tool to perform accurate measurements of all types of glasses. If this tool is not accurate, the case will not be to tolerance and it will cost money remaking the case. The cases are not very cheap to produce so accuracy is key.

Another risk is making the solid works model too complicated. Research has shown that it is possible to change overall lengths and heights to a solid works model but it’s not clear how far excel can change a complicated model. Research has not provided many examples or anybody trying to change angles and arcs using the excel method. If the model cannot be rebuilt using solid works and excel, I will not be able to build a custom glasses case within an hour.

Successful

The project will be successful if the glasses cases can be produced quickly and fit the glasses they were designed for. This is the primary objection for the success of this project.

CONCLUSION

The bending stress was calculated to ensure the case does not deflect more that the excess room in the case or break the case in the process. The bending calculated in the top, and largest area of the case, was less than .01 inch. This project has been a huge learning experience. The teachers and the Central Washington University MET department assisted with the completion of this project. Without the use of the lab programs, the 3D printer on campus, and the help and continual support of teachers, the project would not have been complete.

REFERENCES

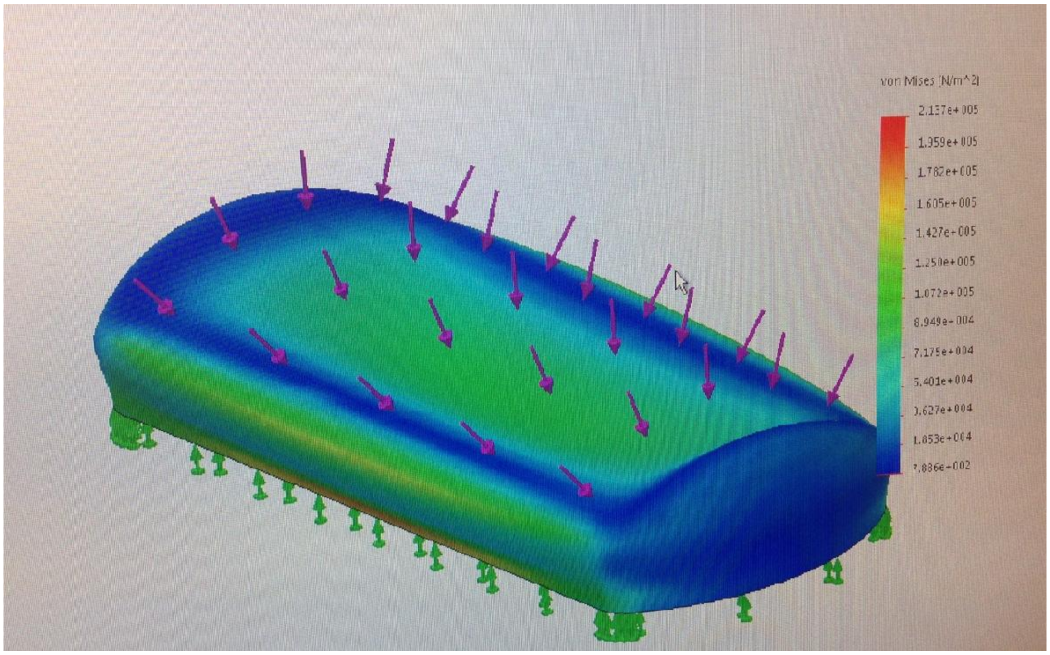
1. Mott, Robert L. *Machine Elements in Mechanical Design*. Upper Saddle River, NJ: Pearson/Prentice Hall, 2004. Print.

2. Hibbeler, R. C. *Statics and Mechanics of Materials*. Upper Saddle River, NJ: Pearson/Prentice Hall, 2004. Print.

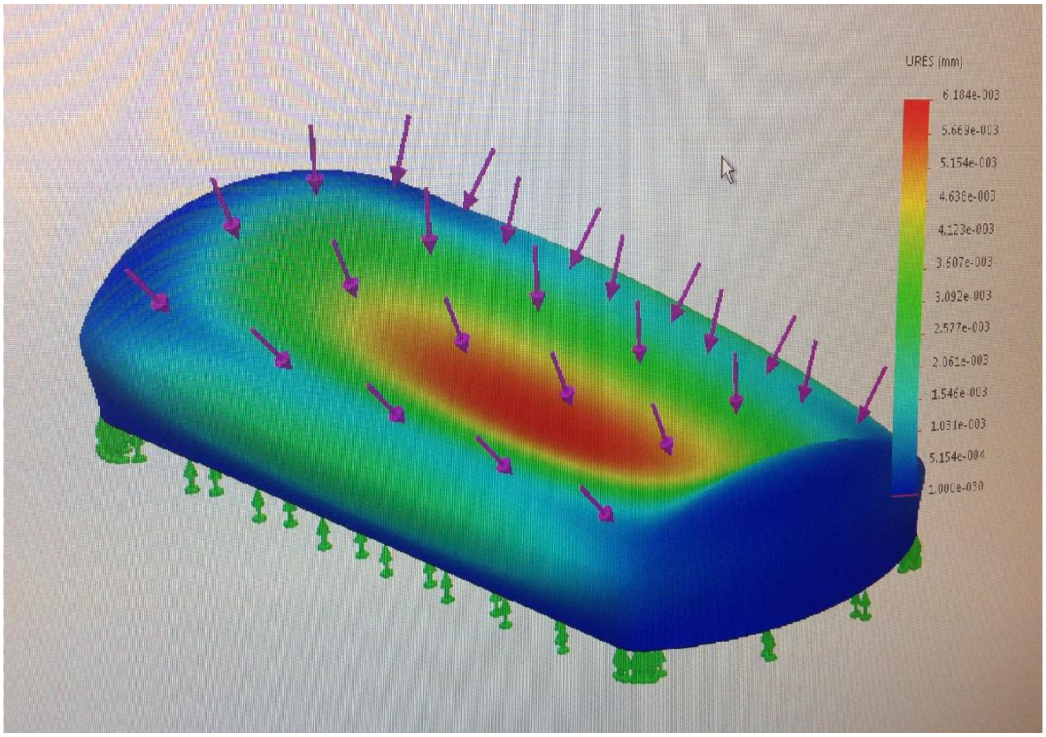
3. "Tensile Modulus - Modulus of Elasticity or Young's Modulus - for Some Common Materials." *Tensile Modulus - Modulus of Elasticity or Young's Modulus - for Some Common Materials*. N.p., n.d. Web. 11 Feb. 2015

4. "MatWeb - The Online Materials Information Resource." *MatWeb - The Online Materials Information Resource*. N.p., n.d. Web. 18 Feb. 2015

Appendix A – FEA Analyses



Stresses



Deflection

Appendix A-Price and Speed of 3D Print

Nikolas Kukas | Sr Project | 2/25/15 | 1/1

given: Volume of glasses case = 4.43 cubic inches FROM SOLIDWORKS DWG.
mass = .16 pounds
material = abs
price school charges = \$6/cubic inch

find: a) price of 3D print

b) Speed of 3D print

Solve: a)

$$\text{total cost} = \text{Volume (cubic inch) of case} \times \text{Price/cubic inch}$$

$$\text{total cost} = (4.43 \text{ cubic inches}) \times 6\,\$/\text{cubic inch} =$$

$$\underline{\text{total cost} = 26.58\,\$}$$

b) The 3D printer can print

$.67\ in^3/58$ minutes (pringle)

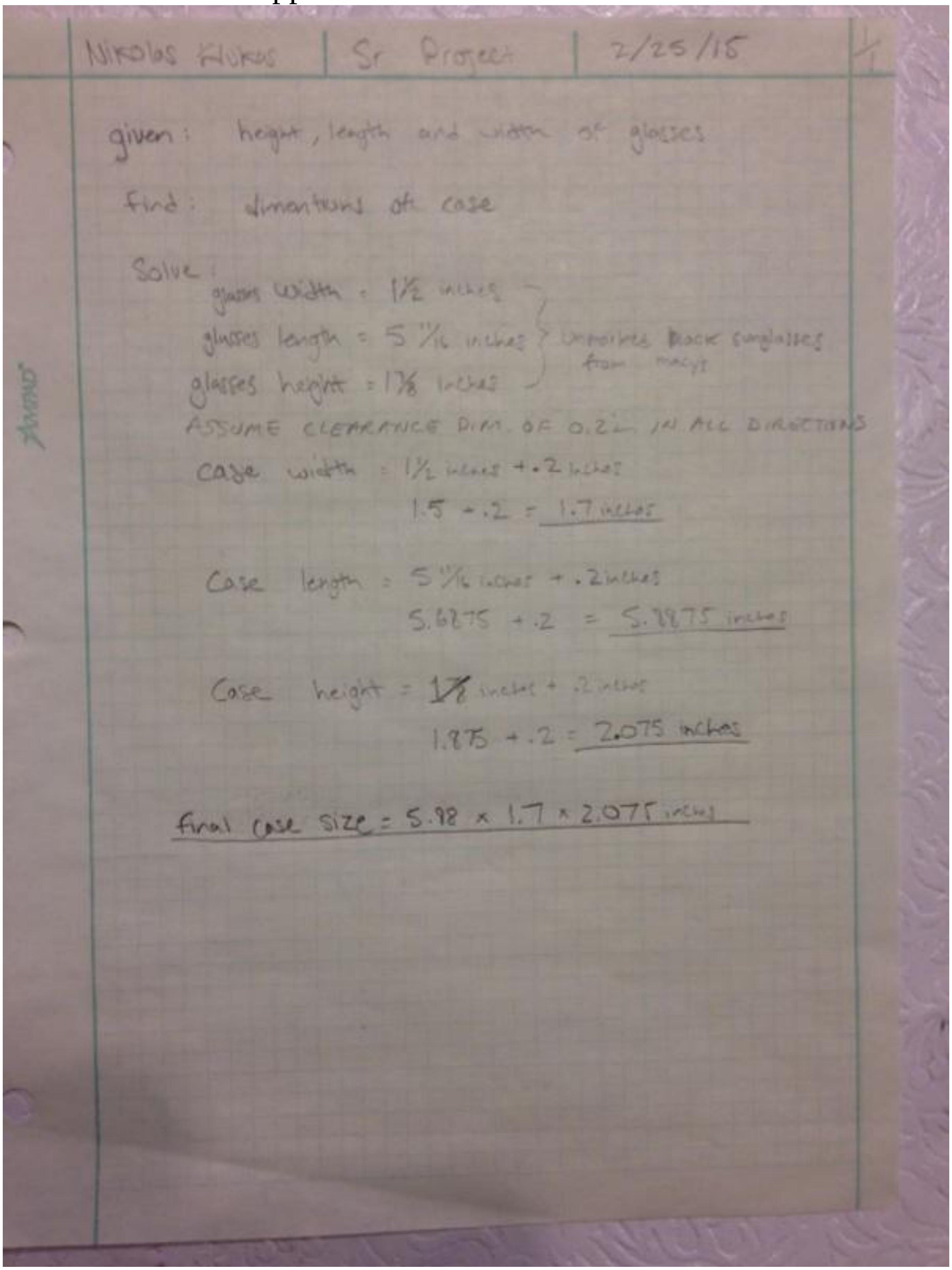
my case is $4.43\ in^3$

$$\frac{4.43\,in^3}{.67\,in^3} = 6.612 \times 58\,\text{minutes} = 383.5\,\text{min}$$

$$383.5\,\text{min}\left(\frac{1\,\text{hour}}{60\,\text{min}}\right) = \underline{6.4\ \text{hours}}$$

$\boxed{\text{6.4 hours to print my case}}$

Appendix A- Dimensions of Case



Nikolas Klukos | Sr Project | 2/25/15 | 1/1

given: height, length and width of glasses

find: dimentions of case

Solve:

glasses width = 1½ inches

glasses length = 5 11/16 inches

glasses height = 1⅞ inches

$\}$ Unpolarized Black sunglasses from macys

ASSUME CLEARANCE DIM. OF 0.2in IN ALL DIRECTIONS

case width = 1½ inches + .2 inches

1.5 + .2 = 1.7 inches

Case length = 5 11/16 inches + .2 inches

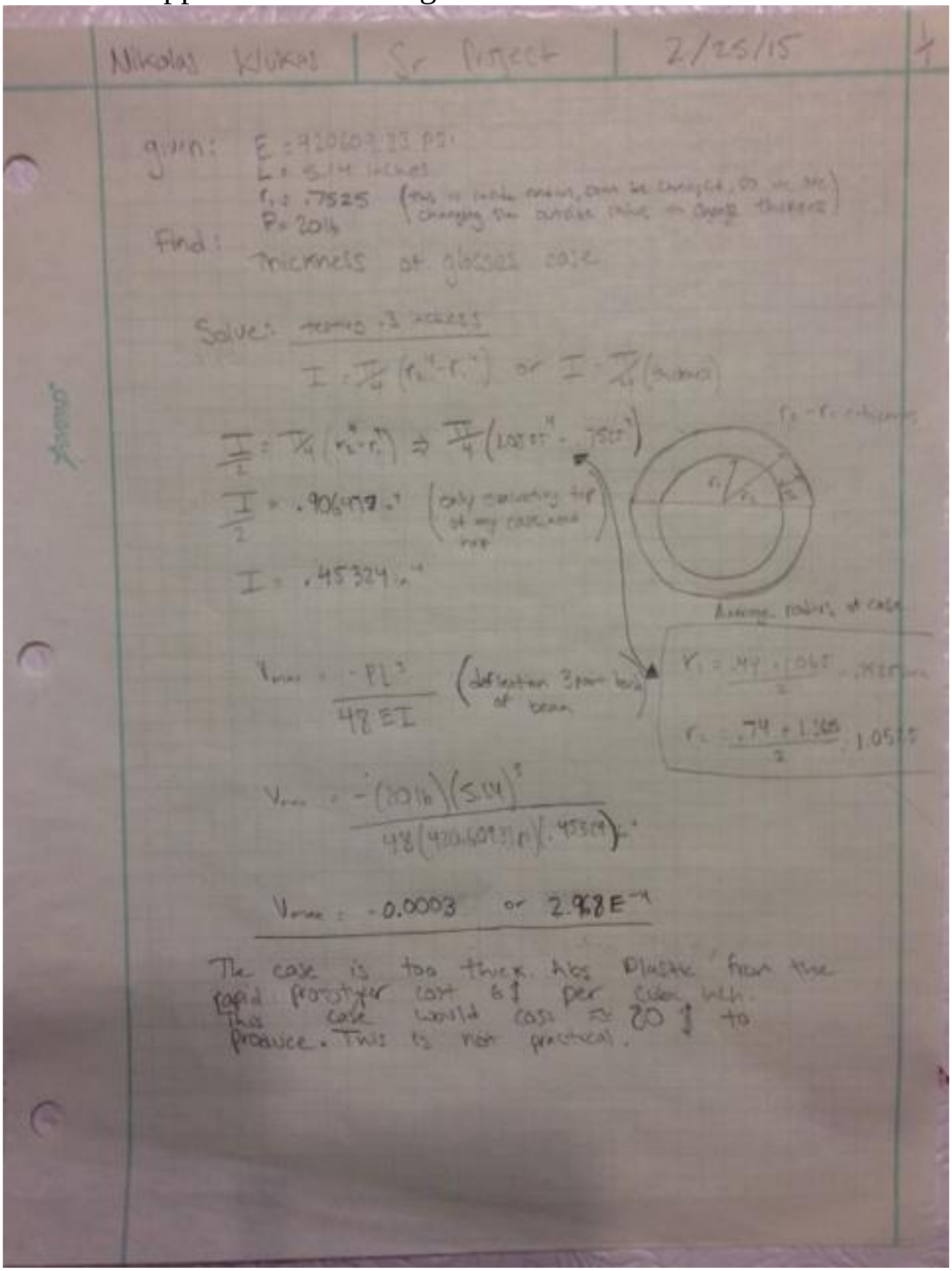
5.6875 + .2 = 5.8875 inches

Case height = 1⅞ inches + .2 inches

1.875 + .2 = 2.075 inches

final case size = 5.98 x 1.7 x 2.075 inches

Appendix A- Finding Thickness of Glasses Case



Nikolas Klukas | Sr Project | 2/25/15 | 1/1

given: $E = 420609.33$ psi
$L = 5.14$ inches
$r_1 = .7525$
$P = 20$ lb

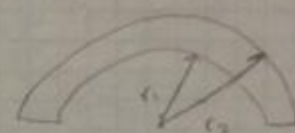
(r_1 is the average radius, taken at this point to increase accuracy. It is no perfectly round [illegible])

find: Thickness of glasses case

Solve: testing .2 inches

$$r_1 = \frac{.44 + 1.065}{2} = .7525 \text{ in}$$

$$r_2 = \frac{.65 + 1.265}{2} = .9575$$



$$\frac{I}{2} = \frac{\pi}{4}\left(r_2^4 - r_1^4\right) \Rightarrow \frac{\pi}{4}\left(.9575^4 - .7525^4\right)$$

$$\frac{I}{2} = .40830$$

$$I = .20415$$

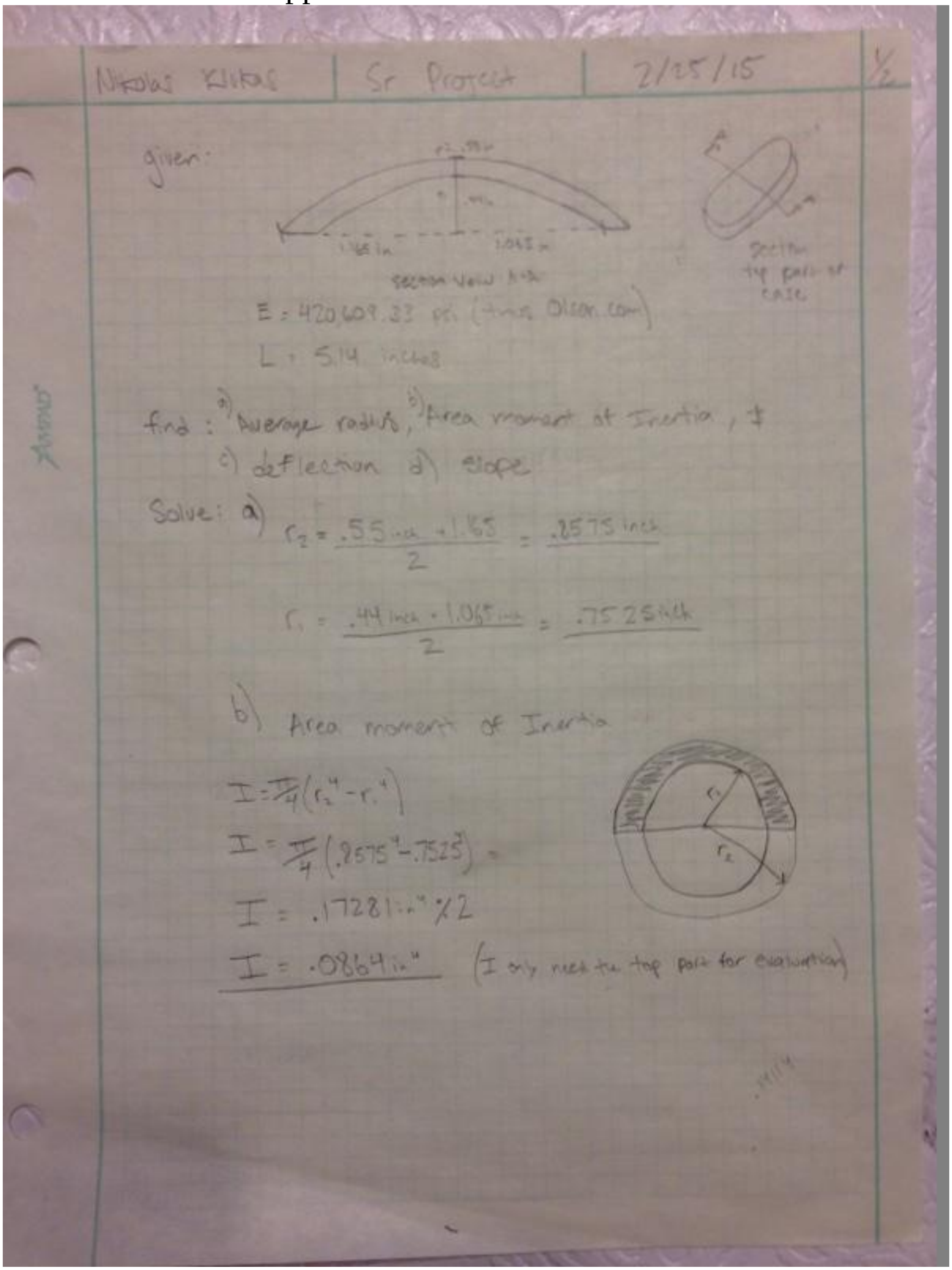
$$V_{max} = \frac{-PL^3}{48EI}$$

$$V_{max} = \frac{-(20 \text{ lb})(5.14)^3}{48(420609.33 \text{ psi})(.20415) \text{ in}^4}$$

$V_{max} = -0.0006$ or $6.5845 E^{-4}$

still to much material and not close to my target bending. This case would cost ≈ 53 $ to produce. Customer won't like this.

Appendix A- Deflection of case



Nikolas Kikas | Sr Project | 2/25/15 | 1/2

given:

E = 420,609.23 psi (from Olsen.com)

L = 5.14 inches

find: a) Average radius, b) Area moment of Inertia, I

c) deflection d) slope

Solve: a)

$$r_2 = \frac{.55\text{ inch} + 1.165}{2} = \underline{.8575\text{ inch}}$$

$$r_1 = \frac{.44\text{ inch} + 1.065\text{ inch}}{2} = \underline{.7525\text{ inch}}$$

b) Area moment of Inertia

$$I = \frac{\pi}{4}(r_2^4 - r_1^4)$$

$$I = \frac{\pi}{4}(.8575^4 - .7525^4) =$$

$$I = .17281\text{ in}^4 \div 2$$

$$\underline{I = .0864\text{ in}^4}$$

(I only need the top part for evaluation)

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continued

c) 

(Analysis on top part of case using 3 point bend)

$$V_{max} = \frac{-PL^3}{48EI}$$ (Statics and mechanics of materials)

deflection under 5 lbs

$$V_{max} = \frac{-(5\,lb)(5.14\,in)^3}{48(420{,}609.33\,psi)(.0864)\,in^4} = -0.000389\,in$$

deflection under 20 lbs

$$V_{max} = \frac{-(20\,lb)(5.14)^3}{48(420{,}609.33\,psi)(.0864)\,in^4} = .00155\,in$$

d) Slope

$$\theta_{max} = \frac{-PL^2}{16EI}$$

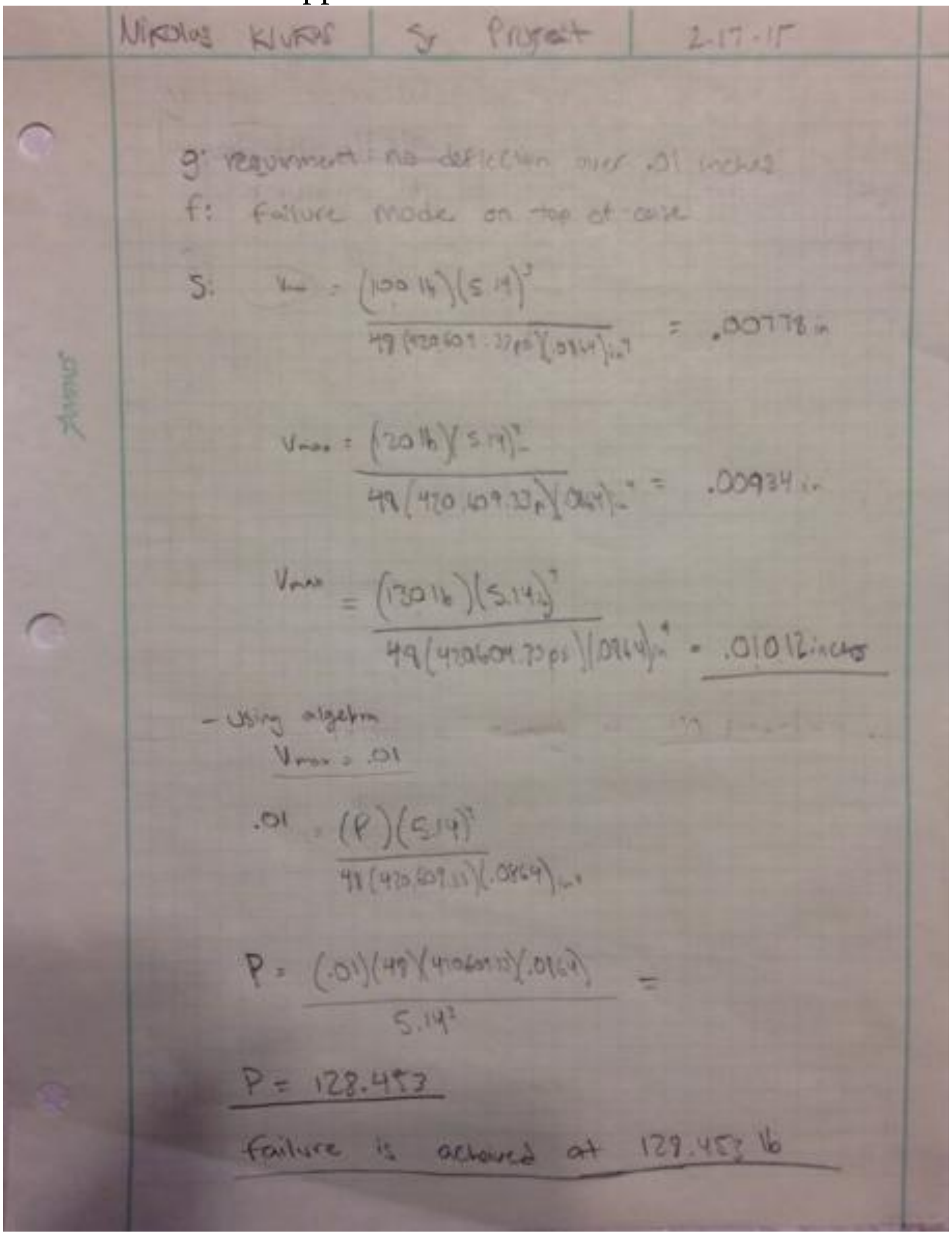
$$\theta_{max} = \frac{-(5\,lb)(5.14)^2}{16(420{,}609.33\,psi)(.0864)\,in^4} = .00117\ rads$$

$$\theta_{max} \frac{-(20\,lb)(5.14)^2}{16(420{,}609.33\,psi)(.0864)\,in^4} = .00467\ rads$$

$$.00117\,rad\left(\frac{57.2957795\ degrees}{1\ rad}\right) = .08881\ degrees$$

$$.00467\,rad\left(\frac{57.2957795\ degrees}{1\ rad}\right) = .26356\ degrees$$

Appendix A- Failure Mode



Nikolas Kluver | Sr Project | 2-17-15

g: requirement: no deflection over .01 inches

f: failure mode on top of case

S: $v_{max} = \dfrac{(100\text{ lb})(5.14)^3}{48(420609.33\text{ psi})(.0864)\text{ in}^4} = .00778\text{ in}$

$v_{max} = \dfrac{(120\text{ lb})(5.14)^3}{48(420{,}609.33\text{ psi})(.0864)\text{ in}^4} = .00934\text{ in}$

$v_{max} = \dfrac{(130\text{ lb})(5.14)^3}{48(420609.33\text{ psi})(.0864)\text{ in}^4} = \underline{.01012\text{ inches}}$

– using algebra

$\underline{v_{max} = .01}$

$.01 = \dfrac{(P)(5.14)^3}{48(420609.33)(.0864)\text{ in}^4}$

$P = \dfrac{(.01)(48)(420609.33)(.0864)}{5.14^3} =$

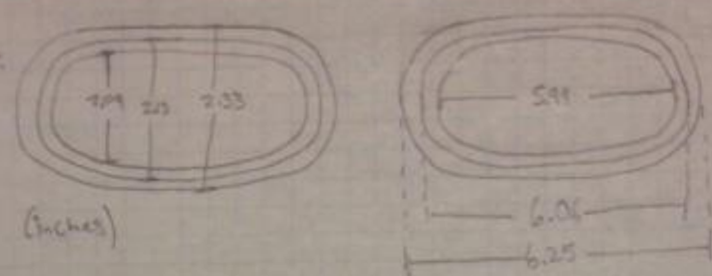
$\underline{P = 128.453}$

$\underline{\text{failure is achieved at } 128.453\text{ lb}}$

Appendix A- Force Fit

Nikolas Klukas | Sr Project | 2/22/15 | ½

given:



find: a) average radius, b) limits of interference, c) pressure of slide/force fit, D) surface area, E) force to open case

Solve:

(avg dia) ÷ 2 = radius

a) $\frac{2.09 + 5.99}{2} = 4.04 \div 2 = \underline{2.02 = r_i}$

$\frac{2.13 + 6.06}{2} = 4.09: \div 2 = \underline{2.0475 = r_s}$

$\frac{2.33 + 6.25}{2} = 4.29 \div 2 = \underline{2.145 = r_o}$

b) E = 420,609.33 N

Top part of case is outside

Bottom part of case is on inside, mate at 2.0475

outside peice = 2.0475 + .07 = 2.0482 in
− 0 = 2.0475 in

inside peice =

2.0475 + 1.8 = 2.0493
+ 1.3 = 2.0488

limits of interference = $\underline{.0006 \text{ to } .0018}$

$\underline{.0018 \text{ max}}$

Nikolas Klukas | Sr. Project | 2/22/15 | 2/2

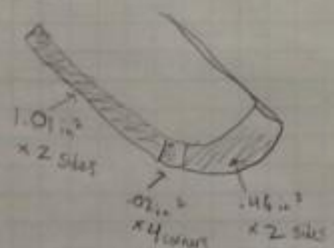
continued C)

$$P = \frac{E\delta}{2b}\left[\frac{(c^2-b^2)(b^2-a^2)}{2b^2(c^2-a^2)}\right]$$

$$P = \frac{(420{,}609.37)(.0018\,\text{in})}{2(2.0475)\,\text{in}}\left[\frac{(2.135^2-2.0475^2)(2.0475^2-2.02^2)}{2(2.0475)^2(2.135^2-2.02^2)}\right]$$

$\underline{P = 1.9366 \text{ psi}}$

D) <u>surface area of contact</u>



surface areas given by solidworks

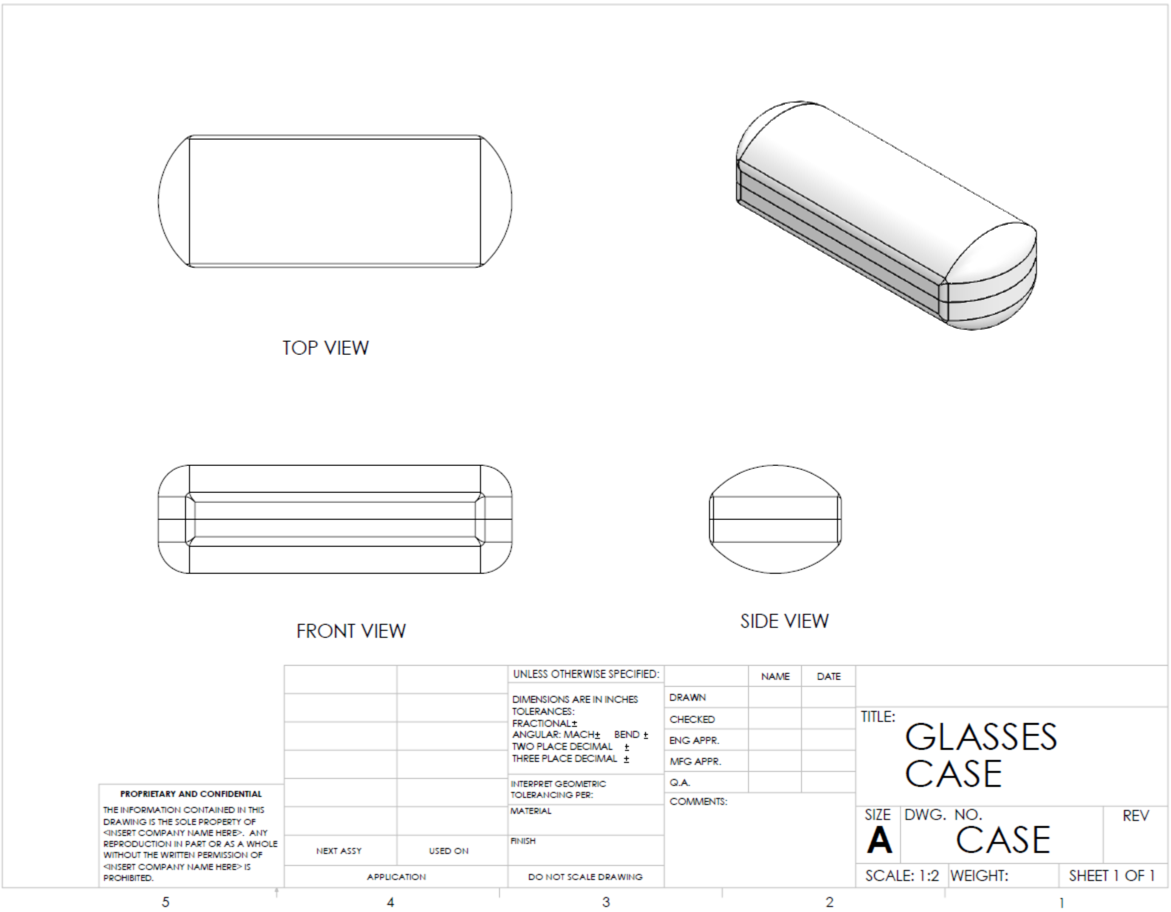
surface area = $\underline{3.02 \text{ in}^2}$

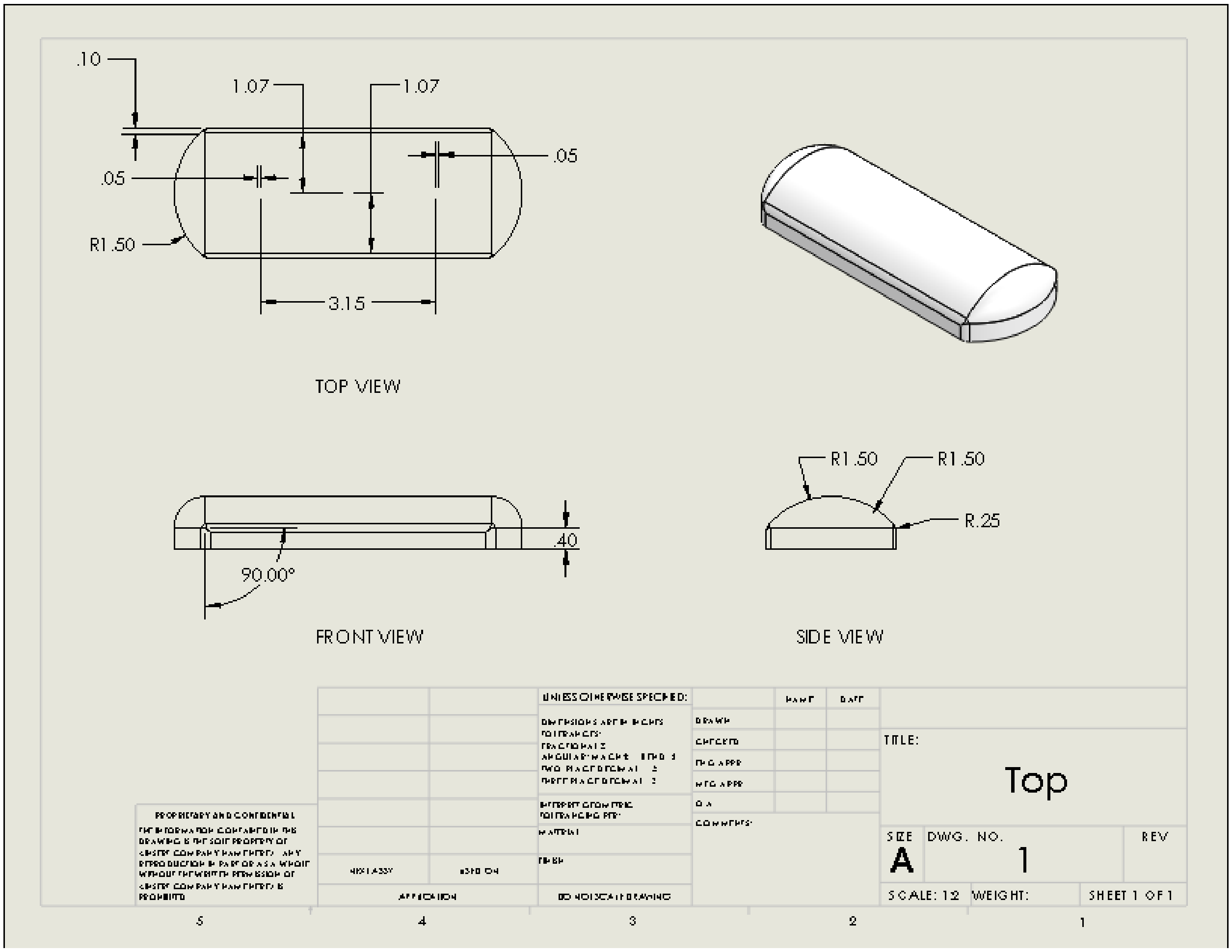
E) force to open case $\quad \frac{F}{A} \times A = F$

$1.9366 \text{ psi} \times 3.02 \text{ in}^2 = \boxed{5.8485 \text{ lb}}$

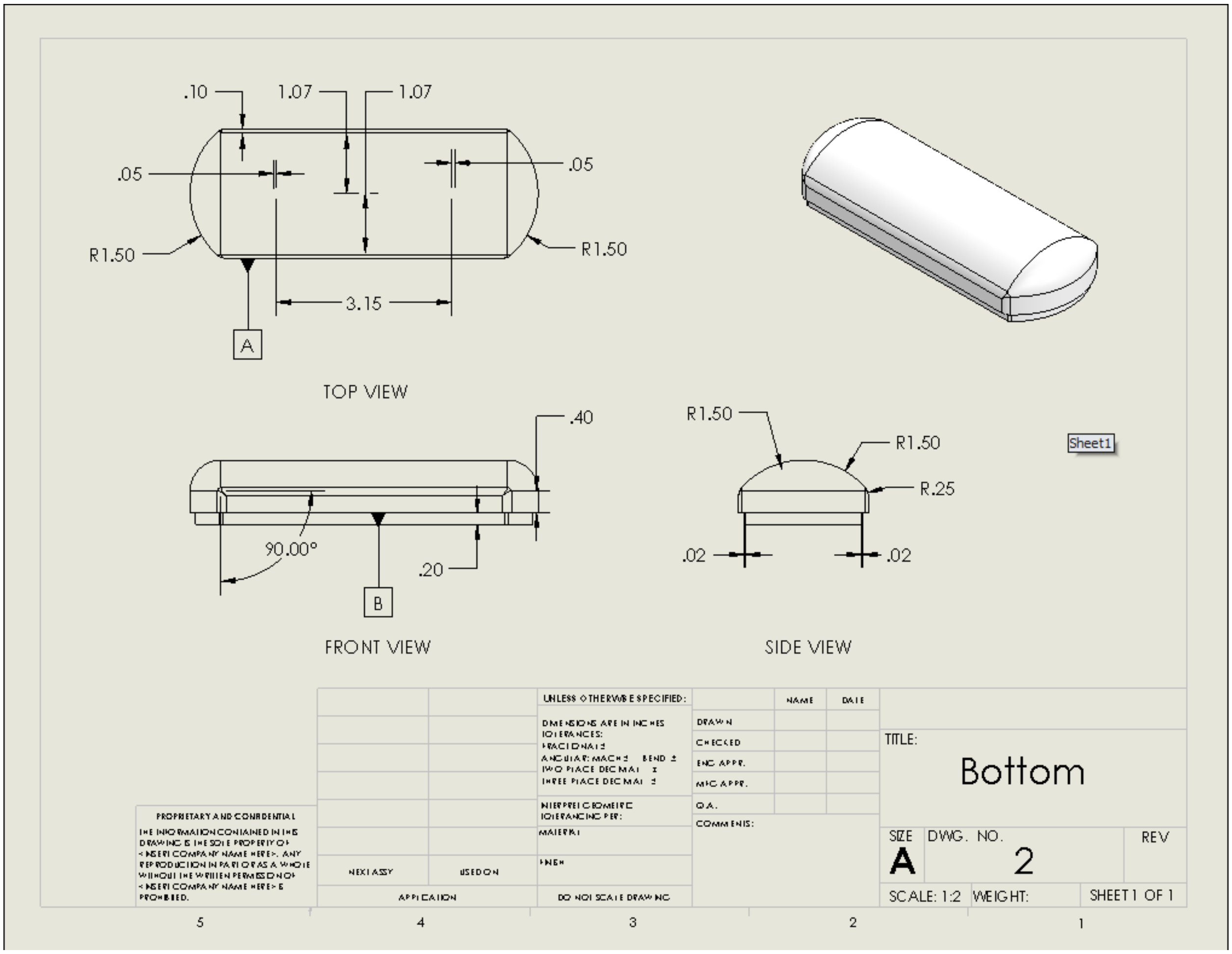
lb to open case

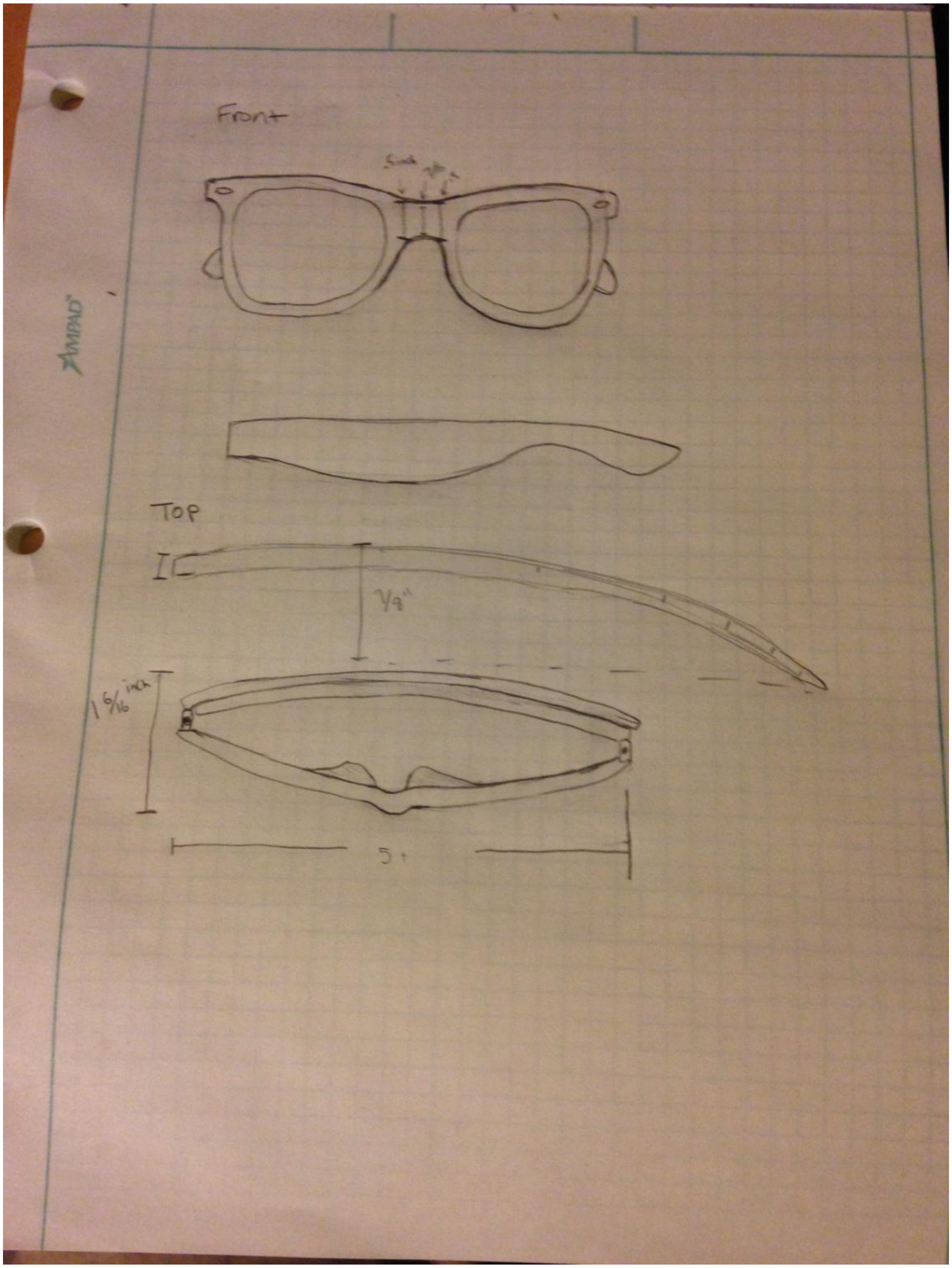
Appendix B – Drawings





.10
1.07
1.07
.05
.05
R1.50
3.15
TOP VIEW
R1.50
R1.50
R.25
.40
90.00°
FRONT VIEW
SIDE VIEW
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
MATERIAL
FINISH
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL
TITLE:
Top
SIZE
A
DWG. NO.
1
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1

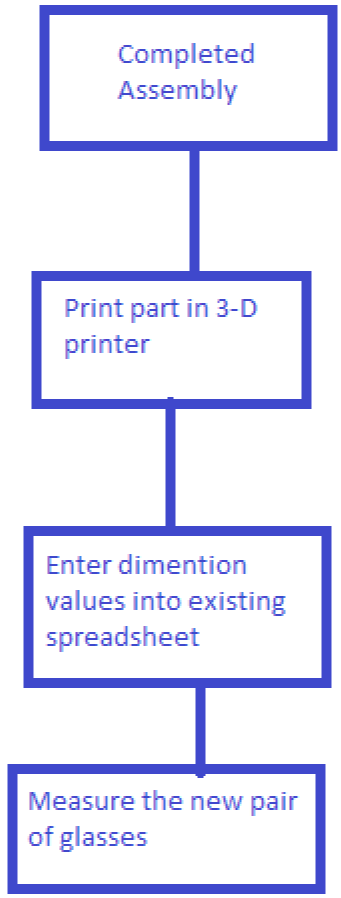

.10
1.07
1.07
.05
.05
R1.50
R1.50
3.15
A
TOP VIEW
.40
R1.50
R1.50
R.25
90.00°
.20
.02
.02
B
FRONT VIEW
SIDE VIEW
Sheet1
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
Bottom
PROPRIETARY AND CONFIDENTIAL
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
SIZE
A
DWG. NO.
2
REV
SCALE: 1:2
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1


Front
Top
1/8"
1 6/16 inch
5+

Appendix C-Parts list

Nikolas Klukas	Senior Project Parts and Cost			
Glasses Case				
Part Identification	Part Description		Source	Cost
Lower body	6.4375''x2.625''		Created in solid works	
Upper body	6.4375''x2.625''		Created in solid works	$45.72
Lower body	5.7375''x2.600		Created in solid works	
Upper body	5.7375''x2.600		Created in solid works	$40.35
			Total cost	$86.07

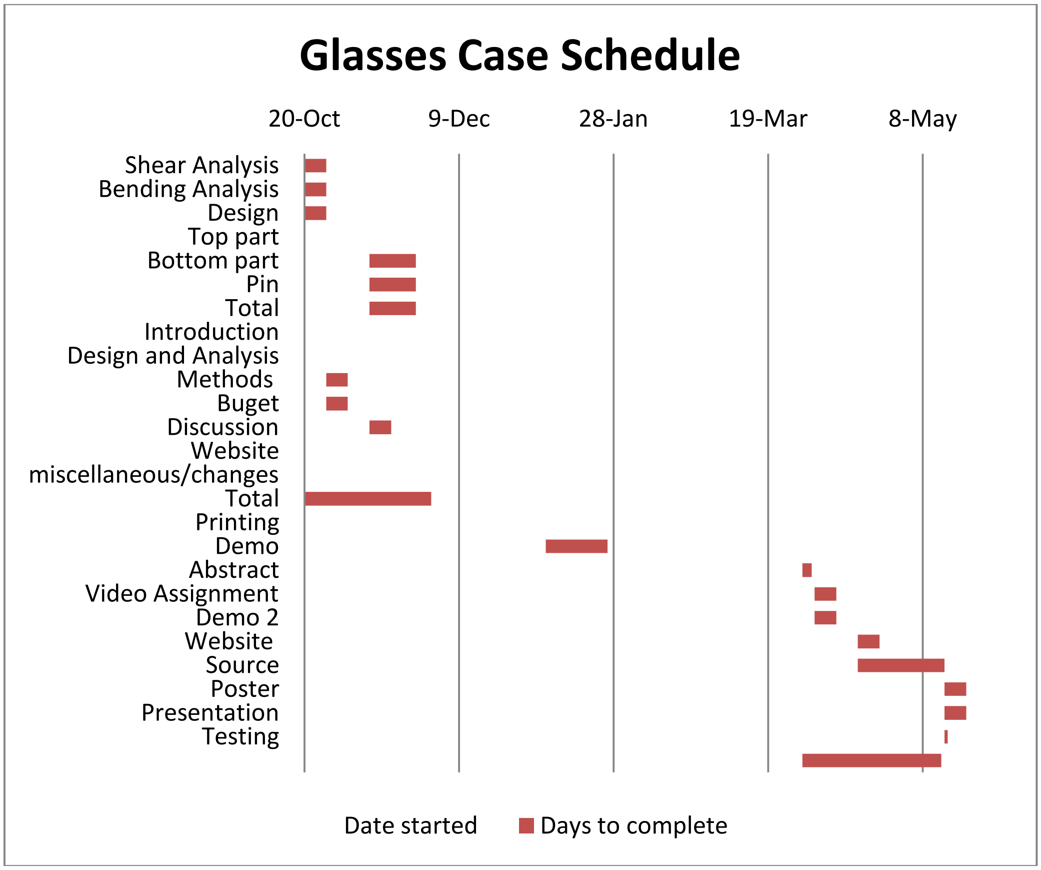
Appendix D- Drawing Tree



Appendix E-Schedule

Milestones	Milestone Parts	Estimated Time	Actual Time	Date started	Date finished
Analysis	Shear Analysis	3	2.1	20-Oct	27-Oct
	Bending Analysis	5	5.6	20-Oct	27-Oct
	Design	5	20.7	20-Oct	27-Oct
	Total	13	28.4		
Drawings/modeling	Top part	2	12.3	10-Nov	25-Nov
	Bottom part	3	16.5	10-Nov	25-Nov
	Total	5.5	28.8		
Proposal	Introduction	4	7.2	13-Oct	20-Oct
	Design and Analysis	3	15.9	27-Oct	3-Nov
	Methods	3	3.5	27-Oct	3-Nov
	Budget	2	3.4	10-Nov	17-Nov
	Discussion	1	4.6	13-Oct	20-Oct
	Website	3	2.1	24-Sep	30-Sep
	miscellaneous/changes	5	18.3	24-Sep	30-Nov
	Total	21	55		
Construction	Total	30	40	6-Jan	13-Mar
Testing	Demo 1	2	3.5	30-Mar	3-Apr
	Abstract	2	2.7	3-Apr	10-Apr
	Video assignment	6	8	3-Apr	11-Apr
	Demo 2	2	3.5	17-Apr	24-Apr
	Website	5	6.4	17-Apr	15-May
	Source	5	6	15-May	22-May
	Poster	2	4	15-May	22-May
	Presentation	2	3.8	15-May	15-May
	Testing	10	7.4	30-Mar	15-May
	Total	40	45.3		
	Complete Total	145.5	197		

Appendix F- Gantt Chart



Appendix J- Testing data

Deflection Testing

Initial clay movement - 1.885 inch

After the 25 pound weight was applied to the top of the case.

Atempt	1	1.862	$= \Delta .023$
Atempt	2	1.864	$= \Delta .021$
Atempt	3	1.860	$= \Delta .025$

This is a success and is under my requirement of .1 inch deflection for this load.

Appendix J- Testing data

Measurments of my first case

was the case in tolerence acording to my requirment of .25 inch from the glasses to the case.

y direction = within tolerence, less than .1 inch gap

x direction = .71 inch gap, out of tolerence

Z direction = .14 inch, within tolerence

(measured with clay)

This flaw in the x direction was due to my redesign and the rounded sides of my case.

Measurements of my second case

y = direction = No gap

x = direction = less than .1 inch

z = direction = No gap

all in tolerence

Appendix K- Resume

Nikolas I Klukas

klukasn@cwu.edu

2214 202nd Pl. SW - Lynnwood, WA 98036
206-473-9480

Qualifications

I am a highly motivated and dedicated individual who is dependable and hard working. Extremely detail oriented with exceptional problem solving skills. I love working with my hands and am training to become a Mechanical Engineer.

Work Experience

Landscaping and Hardscaping – 2012

- I worked for a company named New Earth landscaping. They had me working under a journeyman carpenter doing anything from designing and building retaining walls, fences and arbors, swing sets and patios.

Education

- Central Washington University - Ellensburg, WA
  B.S. –Mechanical Engineer – Expected Graduation, Spring 2015

- Edmonds Community College - Edmonds, WA
  Running Start
  September 2009-2010

- Archbishop Murphy – Everett, WA
  September 2006-2010

Skills

- Landscaping and Hardscaping
- Advanced Math and analytical skills
- Woodworking, Machining and CNC Programming, Sheet Metal Fabrication, and Welding
- Thermo and fluid dynamics, Heat transfer, Statics, Strength of Materials, Metallurgy, Machine Design

Volunteer Experience

- Boys and Girls Club – Lynnwood, WA 2006-2010 – Assisted in the care and supervision of children
- First Robotics competition – 2012-2014 – Worked in the machine shop and was a core values judge

Activities

- Working on cars
- Track and Field for Archbishop Murphy 2006-2010
- Swim Team for Archbishop Murphy 2009-2010