

Softball Bat Testing Method

by

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ABSTRACT

A growing problem in adult softball is the use of illegal bats. Bat manufacturers have begun to produce equipment that is made of composite materials instead of the previous commonly used material, aluminum. The problem with a composite bat is that it can be more easily altered compared to an aluminum bat. This is done by a process known as rolling. Rolling a bat causes a decrease in the diameter of the inner wall of the bat which, in turn, causes an increase in the compression. There are options used to test the bats, but most of them are performed in a lab, before the bat is regularly used. The current options that are available to test on-site are, often times, not very reliable. This device will allow softball park operators to check any composite bat and determine its validity directly on site.

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PROBLEM STATEMENT AND RESEARCH

STATEMENT AND BACKGROUND

Currently, at many softball parks there is not a quick and efficient way to check the compression of softball bats. A softball bat's compression level is based on its bat performance factor, or BPF. A common BPF rating for a bat is 1.2. This states that a softball struck by a bat can not travel at more than 1.2 times the velocity of the bat. An example would be if a bat being swung at 100 mph hits a ball, the ball can not rebound at more than 120 mph. The method that is used to rate softball bats involves firing a ball at a stationary bat and measuring the velocity at which the ball leaves the bat. This process must be performed in a lab and is not practical because it is too large in size for most parks to have and operate. Another problem with this test is that the results can vary due to the compression of the softballs being fired at the bat. Compression ratings for softballs are different depending on various factors, such as park rules and level of play. Aside from a test method that is impractical and often not repeatable, there is a growing problem with the use of altered bats. A common way that bats are altered is by increasing the compression in the barrel of the bat. This process is shown in Figure 1. This increased compression causes the ball to leave the bat at a greater speed than the bat was originally rated, and it increases the danger of fielding the ball, especially for the pitcher. The solution calls for a device that is accurate and efficient, as well as affordable and small enough that any softball park can operate it.



Figure 1 Bat Rolling Technique

RESEARCH, TECHNOLOGY, AND EXISTING PRODUCTS

The main objective of this product is to improve upon already existing products that can be used to check the validity of a softball bat. Until recently, compression in softball bats was not a heavily debated issue. It was more common for bats to be made of aluminum until after 2000 (1). After 2000, composite bats became more popular and they are now considered to be the most common material for high-performance softball bats. The problem with these composite bats is that they are able to be altered in order to increase their compression. This process is known as rolling. By rolling a bat, the compression inside, at the barrel, is increased, causing the ball to leave the bat at a greater speed than it is rated. Initially, bats are rated for certain speeds based on how fast a ball bounces off it after being fired at by a cannon (2). This is the standard method for determining the performance of a softball bat. The test begins with the bat being loaded into the clamp device. The bat is free to swing in the radial direction, but fixed in the vertical direction. A softball is then fired at the bat, using gas power, at 110 mph (2). A time reading is taken for when the ball passes a certain point, as well as for the time it takes for the bat to swing around. This will determine the speed at which the bat will be rated. This process is shown in Figure 2.

Another possible alternative in determining the performance of a softball is measuring the frequency of the bat. This can be done simply by using gravity. This test method uses a pendulum where the bat is clamped and set to fall until it hits a calibrated instrument that measures the vibration (3). An example of this test is shown in Figure 3 Pendulum Design. If there is less vibration, the bat will perform better. This is one reason composite bats have become more popular than aluminum bats. They do not have as much vibration as aluminum bats and do not have the typical “ping” sound that can be heard when they are used to hit a ball. The term for this is the damping rate. Composite bats have a higher damping rate compared to aluminum bats so the vibration will not last as long (1).

CUSTOMER NEEDS

The main customers for this product are the people that own or operate softball parks. The results of what the customers would desire of the new product are shown in Table 1. The results of how the

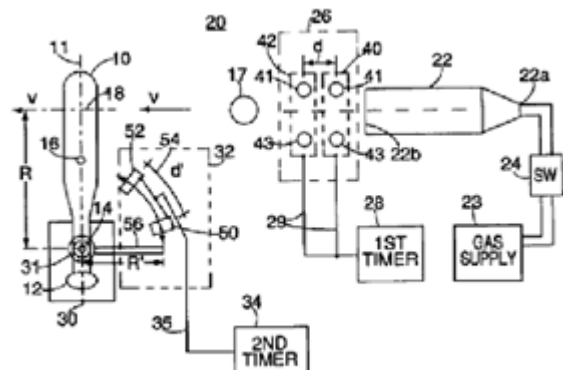


Figure 2 Performance Method and Apparatus



Figure 3 Pendulum Design

customer feels about the current model on the market are shown in Table 2. These results would then be incorporated into the quality function deployment (QFD) matrix. The QFD matrix can be seen in Appendix C. It is possible to see that high accuracy has been rated the highest with a relative weight of 0.28 out of 1. By analyzing the QFD matrix, it is possible to see that most customers are more concerned with the operation of the device than the appearance which received a relative weight of 0.03 out of 1.

Table 1 Customer Importance Results

Product Characteristic	Average Customer Rating
Accuracy	5.0
Ease of Operation	5.0
Compact Storage	4.9
Durability	4.8
Ease of Loading	4.8
Ease of Transport	4.4
Time to Operate	4.1
Low Cost	3.9
Power Source	3.7
Appearance	3.7

Table 2 Current Customer Satisfaction Results

Product Characteristic	Average Customer Rating
Accuracy	1.3
Ease of Operation	2.1
Compact Storage	2.1
Ease of Loading	2.4
Low Cost	2.7
Durability	2.8
Appearance	3.1
Ease of Transport	3.2
Time to Operate	3.3
Power Source	3.7

PRODUCT OBJECTIVES AND ENGINEERING FEATURES

The objective for this product is to design a device that can be used in any softball park where bat alterations may be a problem. In order to accomplish this, the following engineering features, in comparison to testing done in a lab, must be included:

- Accurate
- Small in size
- Short time to operate

- Low cost to manufacture
- Low force needed to operate
- Strong frame
- Simple actuation method
- Low number of components
- Easy to manufacture
- Lightweight device

The product needs to be very accurate because trust is being placed on the device to obtain an accurate measurement. It must be easy to use because the testing can not take a long time due to time constraints of typical softball games. It must also be compact as it will need to be stored somewhere when it is not in use. Finally, loading a bat into the device can not be a difficult task, also due to time constraints. Based upon these objectives, a weighted decision matrix was used to decide which of the three concepts would be the best alternative.

DESIGN

CONCEPTUAL DESIGNS

Based upon research and the conducted survey, three conceptual designs were generated for the final product. These concept drawings can be viewed in Appendix D. The first design allowed for the bat to swing like a pendulum, attached to a piece of channel steel and hit a sensor that would possibly compress like a strain gage. The problem with this design was that the gage would probably have to be custom made which would cost more than the desired amount. The second design allowed for the bat to be stationary and a ball attached to a cable would swing downward and hit the bat. The bat would still be attached to the channel steel, only not allowed to move. The problem with this design is that it would be difficult to attach an unaltered softball to a cable so that it can swing and hit the bat. The final concept design shows a bat attached to a hinge that swings from the steel channel. The bat swings downward and hits a ball resting on a tee. As the bat swings a sensor records the speed just before it hits the ball. Another sensor records the speed of the ball just after it has been hit. After forming a weighted decision matrix, which can also be seen in Appendix D, it was possible to choose which concept would be the best. The third concept was the design chosen because it had the highest total score.

COMPONENT SELECTION

After considering weight of the device and availability of materials, several components of the design have been altered. One instance is that four inch channel steel has replaced the six inch channel steel that is used to support the swinging hinge and the bat. The main reason four inch channel was used is because it greatly decreases the overall weight of the device. This is especially important when considering that the device may need to be transported from field to field. Instead of using wheels that could be mounted to the base plate, a handle was bolted to the channel. This was done because, being a prototype, it would not be necessary to carry the device long distances. The swinging hinge is mostly made of wood; however, a plastic wheel was added so that the device would swing easier. The wood plate is screwed into the wheel to provide a stable swing. Pictures of this device can be seen below. One change made in the design of the swinging hinge is that an aluminum angled strip is used as a stop for the end of the bat instead of the previously designed wooden stop.

The reason for this change is that it was easier to assemble compared to using brackets for the wood. It is also more stable than the wooden stop. The tee used to hold the ball was made of wood. This allowed for a custom shape that the ball could easily rest on. The sensors used for calculating the speed of the bat and the speed of the ball recorded the speeds based on a Doppler radar. This allowed for one sensor to record the speed of the bat and the other to record the speed of the ball.

FABRICATION AND ASSEMBLY

The fabrication initially began with collecting the vital materials that would be needed based on the original chosen concept drawing. This included cutting the channel steel to the specified length, also cutting the wooden pieces that would make up the swinging hinge, collecting the necessary hardware, and finding material that could be used for the handle. The first operation completed was welding the channel steel to the base plate. The result of this operation can be seen in Figure 5. Once it was welded, it was determined that the angled brackets, originally designed as extra support for the channel, would not be needed since the weld was strong enough to safely hold the channel upright. A hole was then drilled into the channel where the swinging hinge would be placed. The handle was then attached to the back side of the channel frame, which would be used to carry the device. The bolted handle can be seen in Figure 4. At this point, it was possible to begin fabrication of the swinging hinge.

The hinge design was altered due to concerns about strength and ability to turn on the supporting bolt. Instead of the initial design, the circular plate was screwed into a plastic wheel which turned easier. The pieces of wood that were to hold the bat could then be mounted to the wooden plate using screws, along with the aluminum stop used to position the handle of the bat. The final swing hinge can be seen in Figure 7. Finally, the tee was assembled from wood and placed on the base plate so that the bat would be free to swing through it without being disturbed. The tee is shown in Figure 6.



Figure 4 Bolted Handle



Figure 5 Welded Frame



Figure 6 Tee Design



Figure 7 Swing Hinge

TESTING METHODS

The device was tested using a softball bat that had been altered and a softball bat that had not been altered. Each bat was placed into the clamp on the swing hinge and allowed to swing at the ball placed on the tee. The sensors were placed so that the first recorded the speed of the bat, just before it hit the ball, and the other recorded the speed of the ball, just after it had been hit by the bat. For the official testing, each bat was tested 12 times. The results of each bat can be seen in Tables 3 and 4. As it can be seen in Table 3, the altered bat fell out of the range of 1.2 BPF five times and had an average BPF of 1.14. The five occurrences where it fell outside of 1.2 BPF are highlighted. Table 4 shows that the unaltered bat fell within the 1.2 BPF range every time it was tested and had an average BPF of 1.03.

Table 3 Altered Bat Test Results

Bat Compression Test Results	
Altered Bat: Miken NRG	
Bat Speed	Ball Speed
22	24
22	26
23	24
24	26
20	25
23	24
21	26
22	23
23	29
24	25
22	27
23	29
22.42	25.67
Ratio: 1.14	

Table 4 Unaltered Bat Test Results

Bat Compression Test Results	
Unaltered Bat: Easton Stealth Comp	
Bat Speed	Ball Speed
21	22
22	22
20	22
22	26
21	25
20	22
21	22
20	22
23	20
24	20
21	20
22	21
21.42	22.00
Ratio: 1.03	

PROJECT MANAGEMENT

The updated preliminary budget can be seen in Appendix G. The total cost has decreased from \$370 to \$249. The primary reasons for this are the decrease in number of components and the amount of components that were donated. The only increase on cost was for the velocity sensors. The original estimate for the cost of the sensors was \$150. The current cost is now \$200. The schedule has been altered slightly as it can also be seen in Appendix G. The main reason for the change in schedule was that manufacturing was pushed back due to collecting all the necessary components. The important dates can be seen in Table 3 Important Dates.

Table 5 Important Dates

Event	Date
Final Testing / Demo	May 7, 2008
Tech Expo	May 22, 2008
Oral Presentation Due	June 4, 2008
Written Presentation Due	June 4, 2008

CONCLUSION AND RECOMMENDATIONS

The most advantageous path toward designing a new test method for softball bat performance is to improve upon already used techniques. The results obtained through the customer survey show that great improvements must be made in areas such as accuracy, compact storage, and ease of operation. By choosing the concept where the bat will be free to swing and hit the ball, it allows the user to operate the device without using any type of power source. This will be beneficial in reducing the total cost. Based on these desired features, a new product will be designed at an estimated cost of \$249.00.

With this design, there is room for improvement. The first and most important area that could be improved is with the velocity sensors. Since they were sensors that used Doppler radar to record speed, they would pick up any speed within a certain area. That is why they needed to be placed far enough apart so that one sensor did not pick up the ball speed and the bat speed. The solution for this could possibly be some kind of custom made sensor that would have two displays, one for the bat speed and one for the ball speed. Another area for improvement would be in the swing hinge, aside from finding a quicker clamping method; it is likely that using a wheel with bearings would allow for the bat to swing without any sway. Currently, there is the possibility that the bat may hit the tee as it swings downward. This could be dangerous to the operator and it may cause the bat to crack. One other area where the device could be improved is with the tee design. There should be some other method where the ball is held so that the barrel of the bat hits it and the bat continues to swing through.

REFERENCES

1. **Russell, Daniel A.** Are Composite Bats Better than Aluminum Bats? *Physics and Acoustics of Baseball and Softball Bats*. [Online] Science and Mathematics Department, Kettering University, Flint, MI, March 21, 2005. [Cited: September 30, 2007.] <http://www.kettering.edu/~drussell/bats-new/compalum.html>.
2. **Brandt, Richard A.** *Method and Apparatus for Determining the Performance of Sports Bats and Similar Equipment*. 5672809 New York, February 29, 1996.
3. **Hibbard, Dawn.** The Science of Softball. *News and Information About Kettering*. [Online] April 20, 2005. <http://www.kettering.edu/visitors/storydetail.jsp?storynum=253>.
4. **Ultrasonic-Thickness-Gauges.com.** NovaScope 5000. *NovaScope 5000, Precision Ultrasonic Thickness Gauge*. [Online] Ultrasonic-Thickness-Gauges.com. <http://www.ultrasonic-thickness-gauges.com/html/novascope.html>.

APPENDIX A: RESEARCH



<http://www.kettering.edu/visitors/storydetail.jsp?storynum=253> 4/20/05
Pendulum Frequency Tester

Pendulum design allows for bat to fall by gravity and hit the frequency sensor. Bat is held in vice so that the “sweet spot” of the barrel hits the sensor.

Durable-made with steel
Not easy to carry
Has to be near electrical outlet
Not easily adjusted for different bat sizes
Small in size
No price given-not for sale



<http://www.ultrasonic-thickness-gauges.com/html/novascope.html>

9/28/07 NovaScope 5000 High Speed, Precision Thickness Gauge

- Displays English and metric units
- Thickness Amplitude Compensation for noise suppression
- Outputs: Alarm, Analog Thickness, Digital
- 0.0001" Digital Resolution

Small in size
 Lightweight and easy to transport
 Very expensive
 Greater than \$1000.00
 Easy to read display
 Color display
 Has many functions

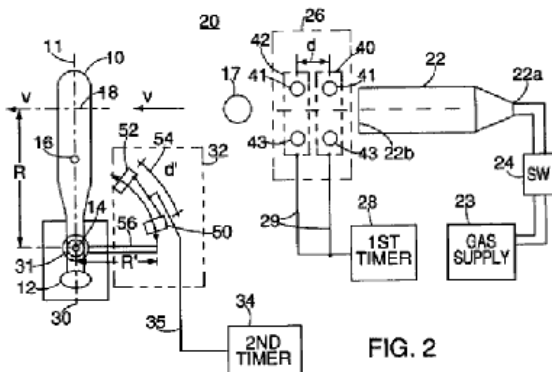


FIG. 2

<http://www.google.com/patents?id=GwhAAAAEBAJ&printsec=abstract&zoom=4&dq=softball+bat+test+method#PPP2,M1>

10/15/07 Method and Apparatus for Determining the Performance of Sports Bats and Similar Equipment

- Bat is held by device but is free to swing
- Ball is fired at bat using gas power
- First timer records time for ball to pass after being fired
- Second timer records time for bat to swing around after being hit by ball

Large set-up area
Requires high pressure, gas system
No standardized ball used to test bat
Expensive equipment
Can not be used on-site
Price not given



CincySoftball.com > Softball > Softball
Bat Alterations

User Name ☐ Remember Me?
Password

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September 25th, 2007, 08:54 PM

#1

[mfozz](#)

Registered User

Join Date: Sep 2007
Location: North College Hill
Posts: 2

Bat Alterations

I am beginning my senior project design for my engineering degree and have chosen to design and build a device that could efficiently and accurately check softball bats for any alterations in the compression rating. The main feature that I would like this device to have is that it can be quickly operated at the softball park instead of in a lab. Does anyone have any suggestions, ideas, or thoughts on this project? If anyone has seen a device similar to what I have explained or has any design ideas, please let me know how it worked and possibly how it could be improved. Any feedback is greatly appreciated.

[Quote](#)

September 25th, 2007, 10:20 PM

#2

[slamit93](#)

Registered User

Join Date: Feb 2007
Posts: 78



a cordless sawzall should work just fine

What's in the bag:

A bat that doesn't hit the ball very well (lots of pop ups)
A weight bat (so I look like a ringer)
A glove with a hole in it
A couple of warm beers from last season
A few moldy pairs of socks
A green spot in the corner that seems to be growing

[Quote](#)

September 27th, 2007, 07:31 AM

#3



[8 Ball](#)
Registered User

Join Date: Aug 2005
Location: White Oak
Posts: 100



You can use ultrasonics to check for thickness of the bat walls.
A simple hand held device. It can also spot other objects inside the bat.

Tim

Worst lower E Player in the City, next to Ufreak!

[Quote](#)

September 27th, 2007, 08:33 AM
#4

DT04
Registered User
Join Date: Mar 2004
Location: West Side- Go Panthers!!!
Posts: 138



Quote:

Originally Posted by mfozz

I am beginning my senior project design for my engineering degree and have chosen to design and build a device that could efficiently and accurately check softball bats for any alterations in the compression rating. The main feature that I would like this device to have is that it can be quickly operated at the softball park instead of in a lab. Does anyone have any suggestions, ideas, or thoughts on this project? If anyone has seen a device similar to what I have explained or has any design ideas, please let me know how it worked and possibly how it could be improved. Any feedback is greatly appreciated.

mfozz... I know at the Big tourneys they do have some sort of tester. Although i have never seen it used I have seen a post here before by Brian Wegman about this process...he'd be the one to ask I think he is BB10.

It would be good to have these at the parks...Would eliminate any doubts. Good luck buddy.

 Quote

September 27th, 2007, 10:46 AM
#5

BB10
Registered User
Join Date: Sep 2004
Location: Ross
Posts: 143



Not sure what help i can be, but i have seen the machine in action. Shoot me a private message and i'll try my best to help explain this gizmo!!

 Quote

September 27th, 2007, 11:52 AM
#6


8 Ball
Registered User
Join Date: Aug 2005
Location: White Oak
Posts: 100



<http://www.ultrasonic-thickness-gauges.com/>

This works great on Bats! I know a little about the subject! LOL

Worst lower E Player in the City, next to Ufreak!

 Quote

September 27th, 2007, 11:58 AM
#7

BB10
Registered User
Join Date: Sep 2004
Location: Ross
Posts: 143



Testing the wall thickness will only stop the shaving, it won't detect if a bat is too broken in or has been pressed.



September 27th, 2007, 01:22 PM
#8

Woodyfan83
Registered User
Join Date: Sep 2007
Posts: 4



Is it really fair to say a bat is too broken in? I mean I know that I've never had a bat rolled, but it's my understanding that bat manufacturers make these bats to push the limits right outta the wrapper, which would lead me to believe that a fully broken in bat (one that has been used for about a season) would fail these tests.

So who's fault would it be? The player who bought a legitimate bat or the bat manufacturer for pushing the limits with their production of said bat?

On a side note: I've heard of people running a well used Syn2 through those machines and it coming back as exceeding the legal limit. Nothing had been done to this bat other than repetitive ball contact.



September 27th, 2007, 01:56 PM
#9


8 Ball
Registered User
Join Date: Aug 2005
Location: White Oak
Posts: 100



Quote:

Originally Posted by BB10 

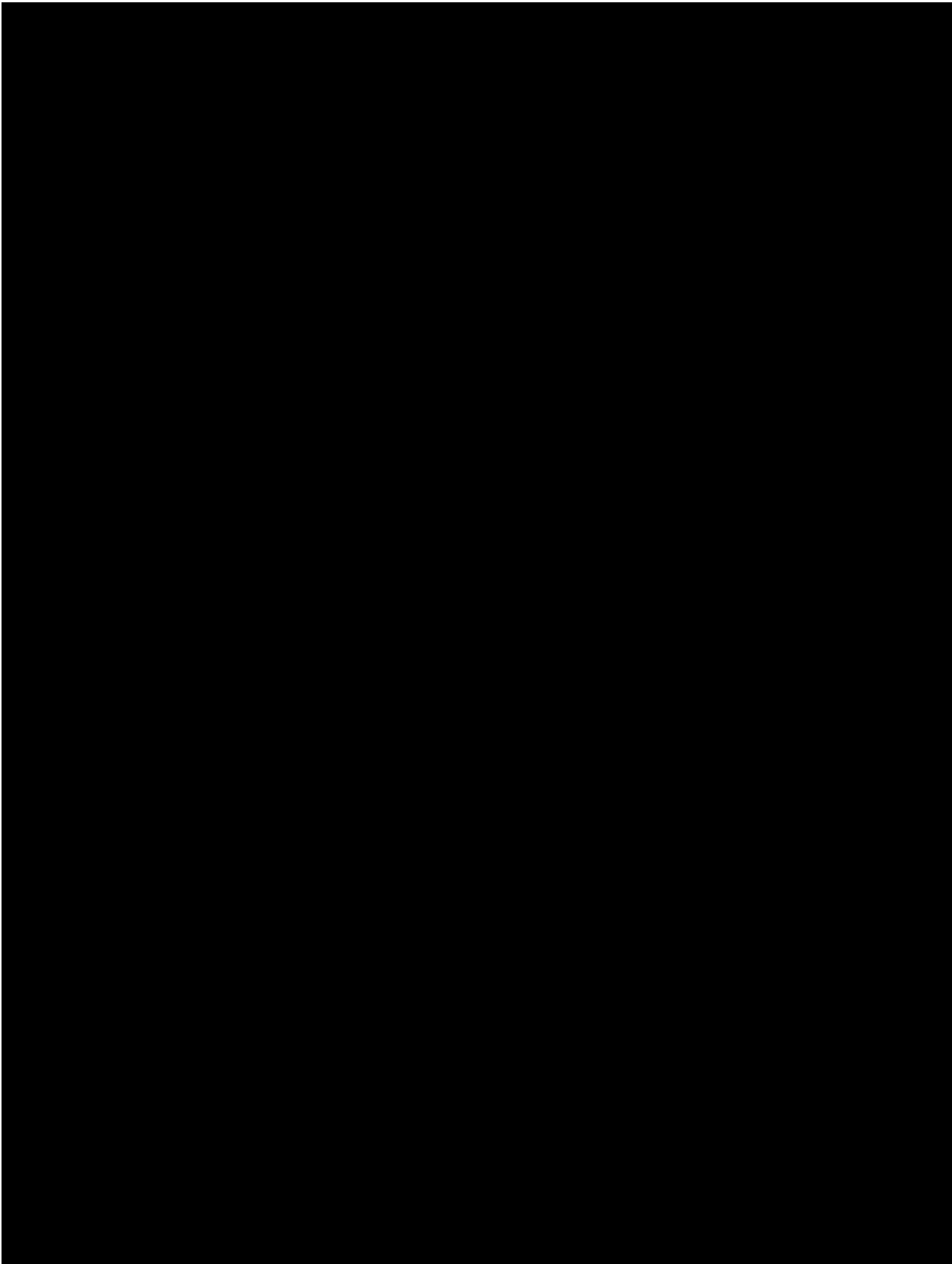
, it won't detect if a bat is too broken in or has been pressed.

Yes it will! I don't feel like going into the whole explanation! But it will!

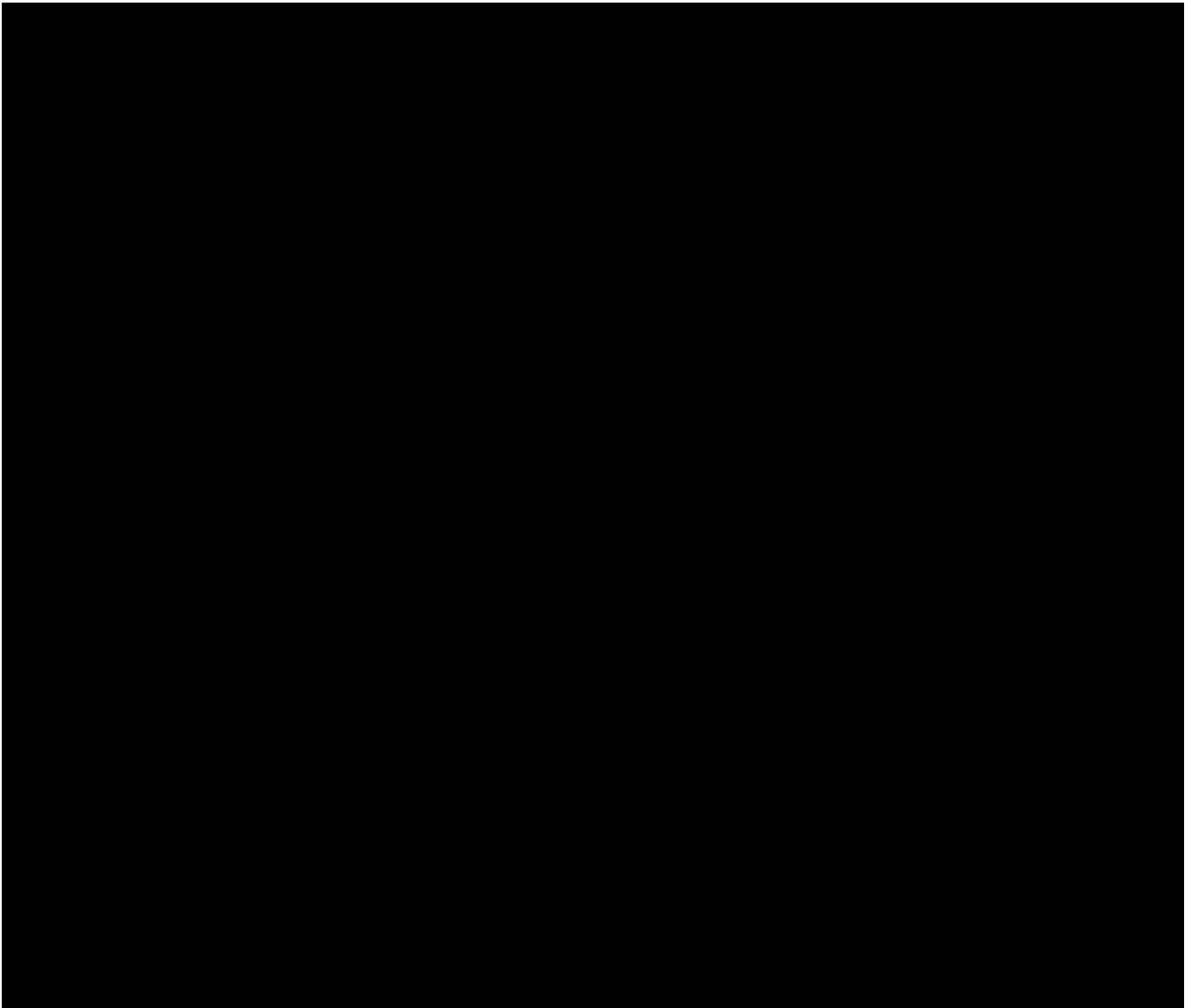
Worst lower E Player in the City, next to Ufreak!



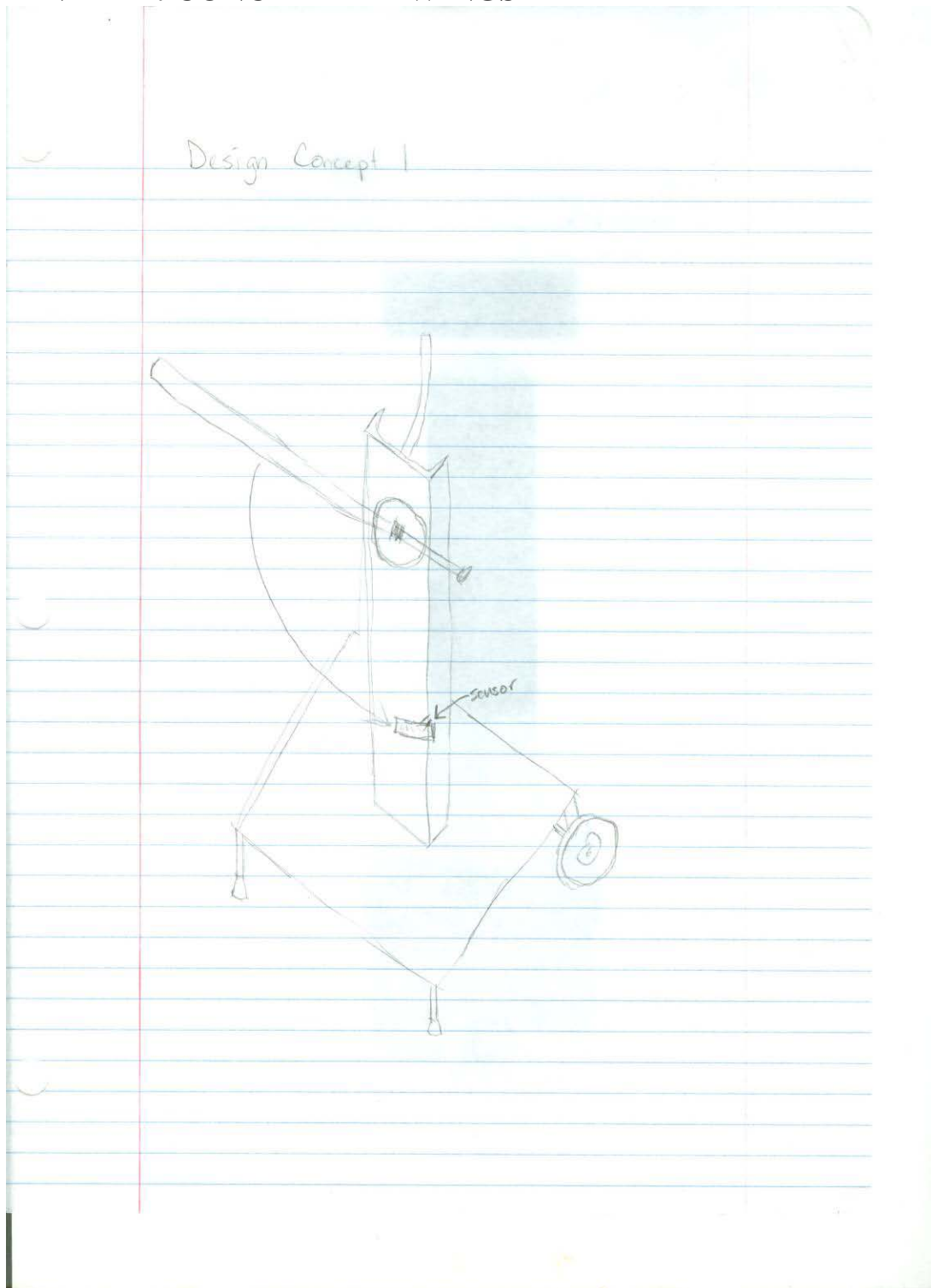
APPENDIX B: CUSTOMER SURVEY



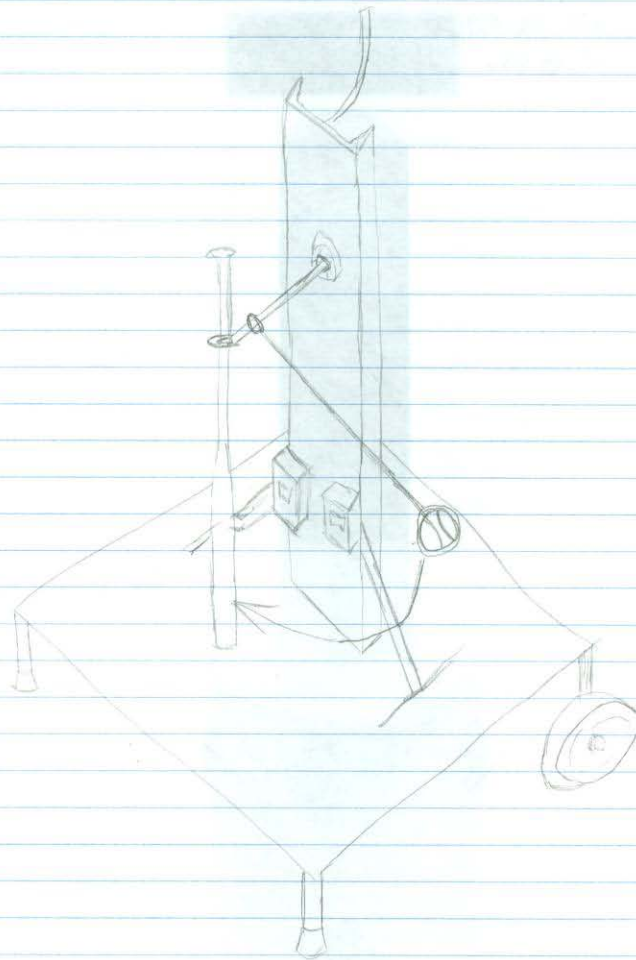
APPENDIX C: QUALITY FUNCTION DEPLOYMENT MATRIX



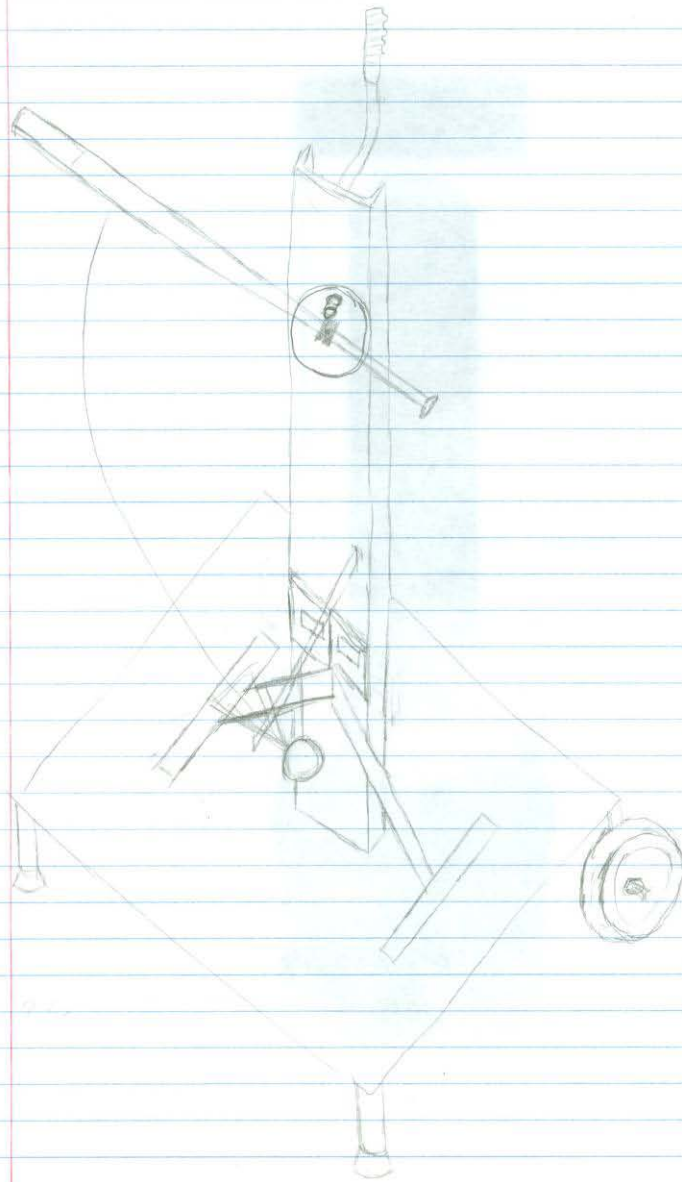
APPENDIX D: CONCEPT DRAWINGS



Design Concept 2

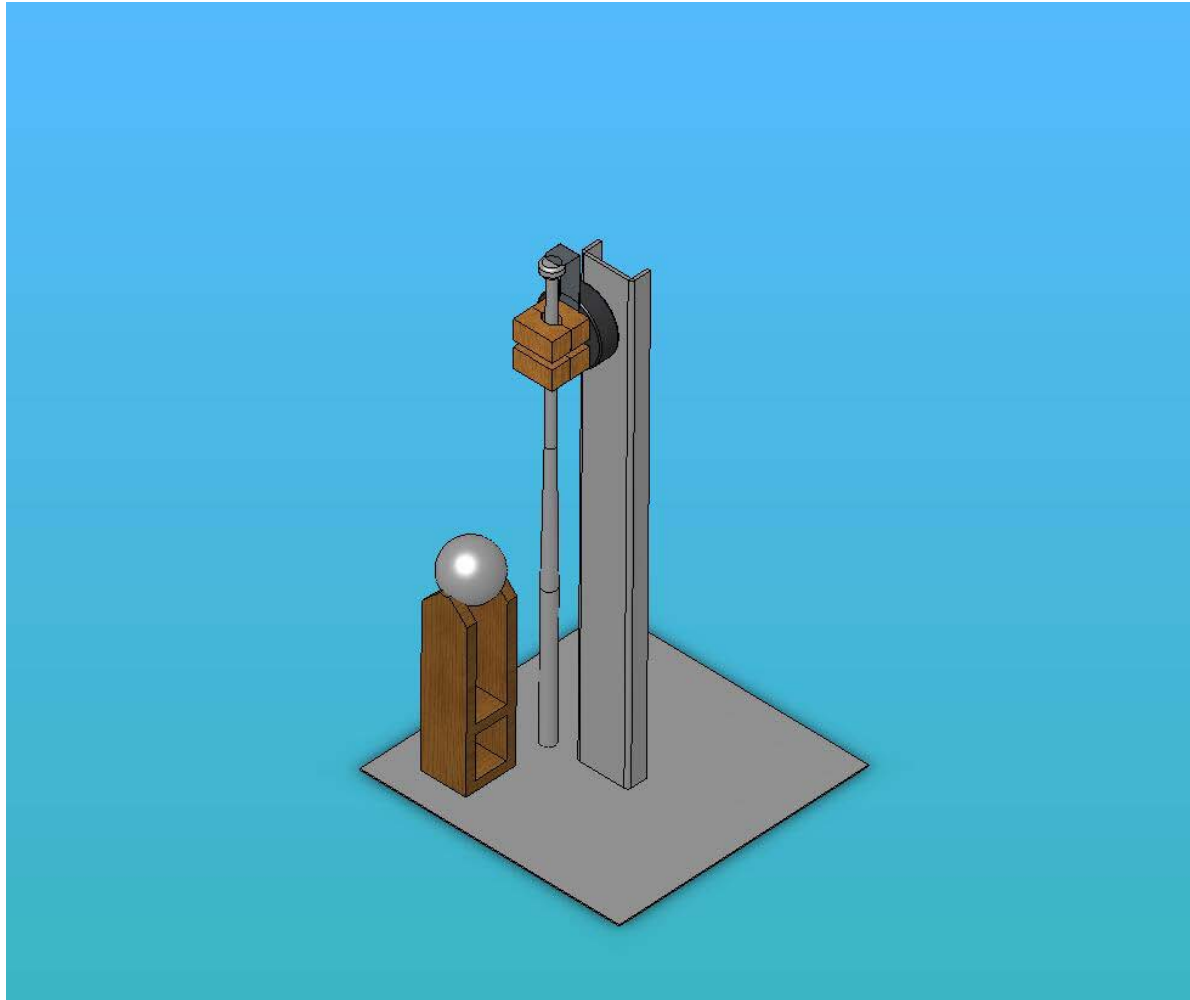


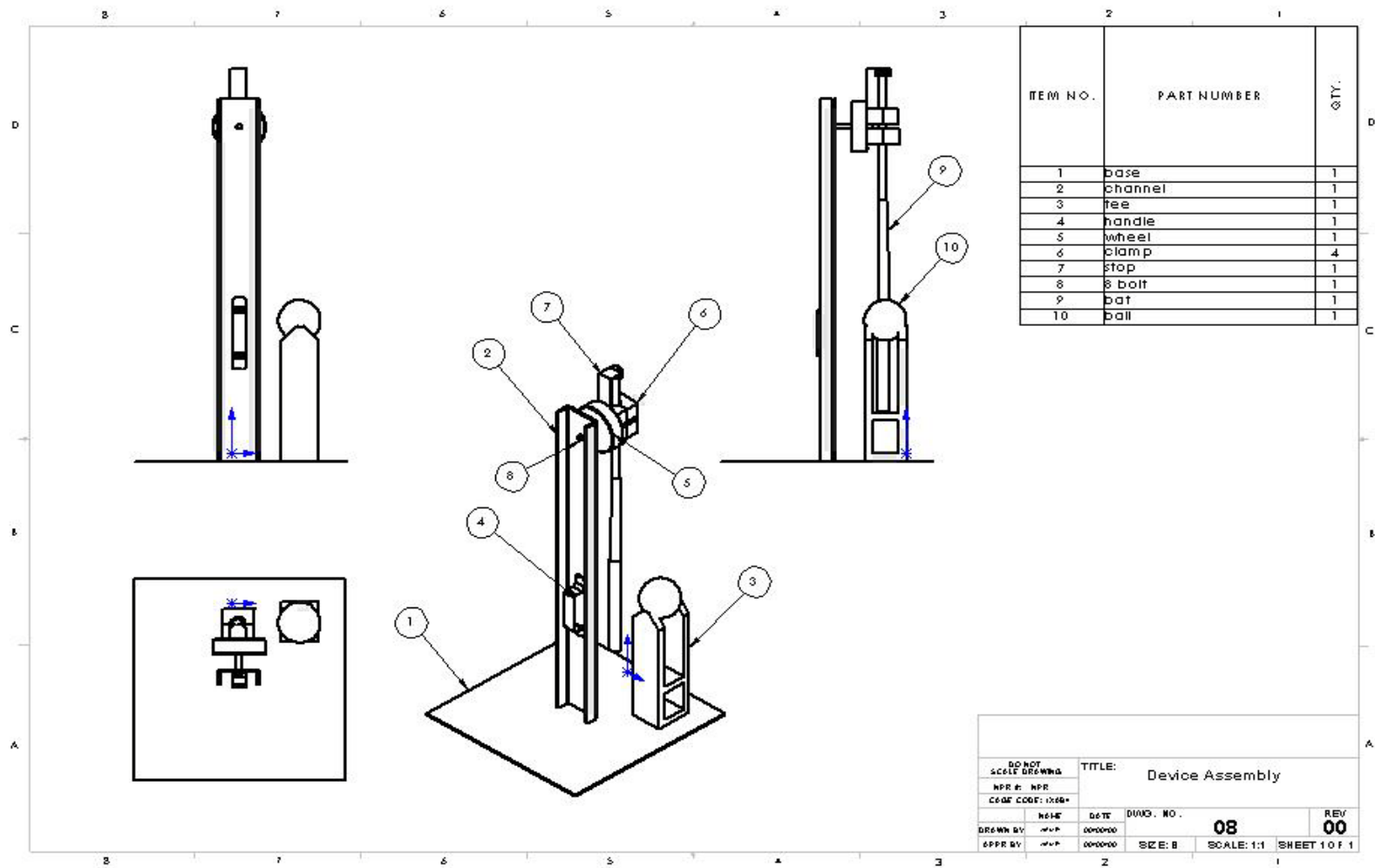
Design Concept 3

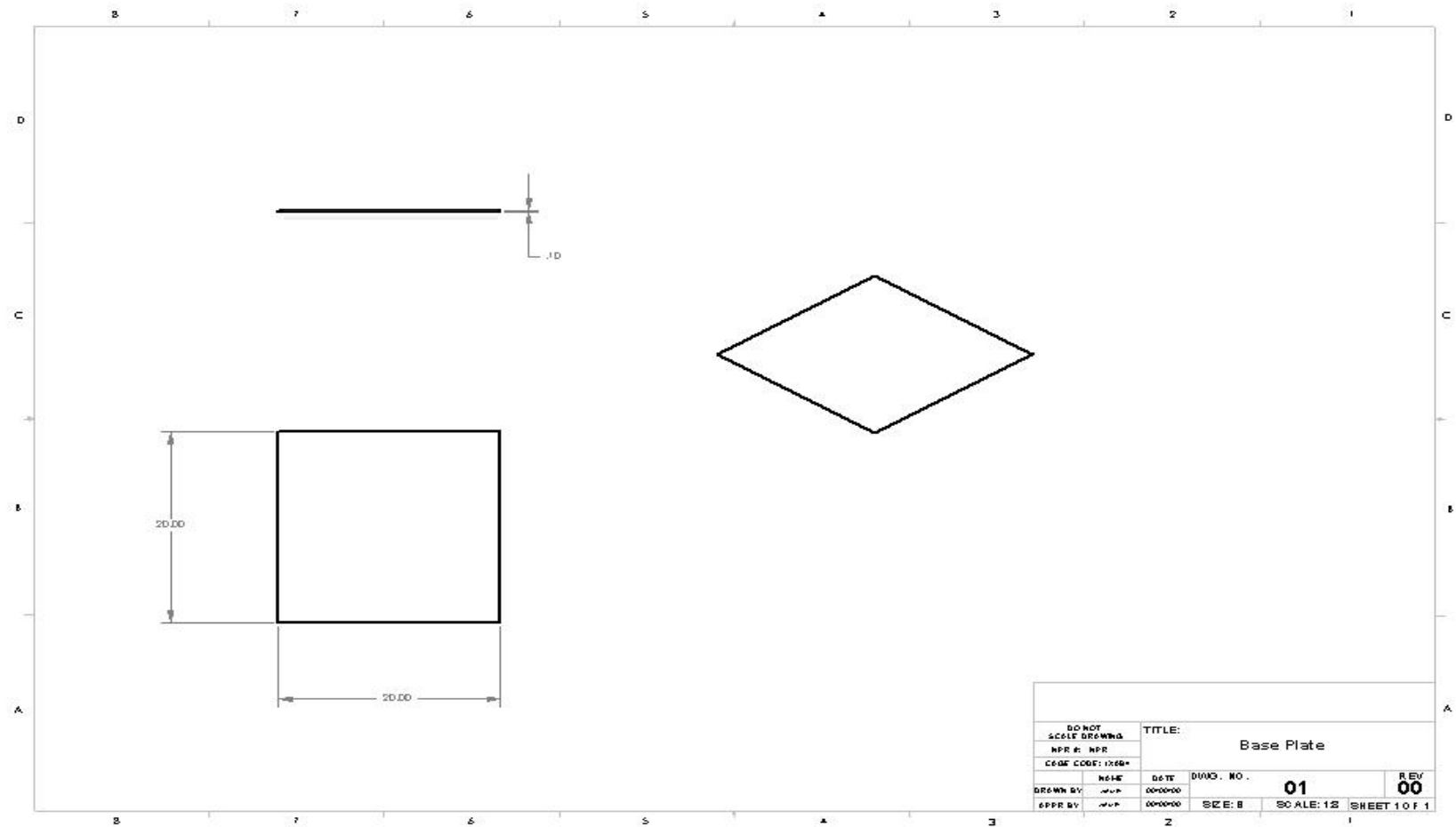


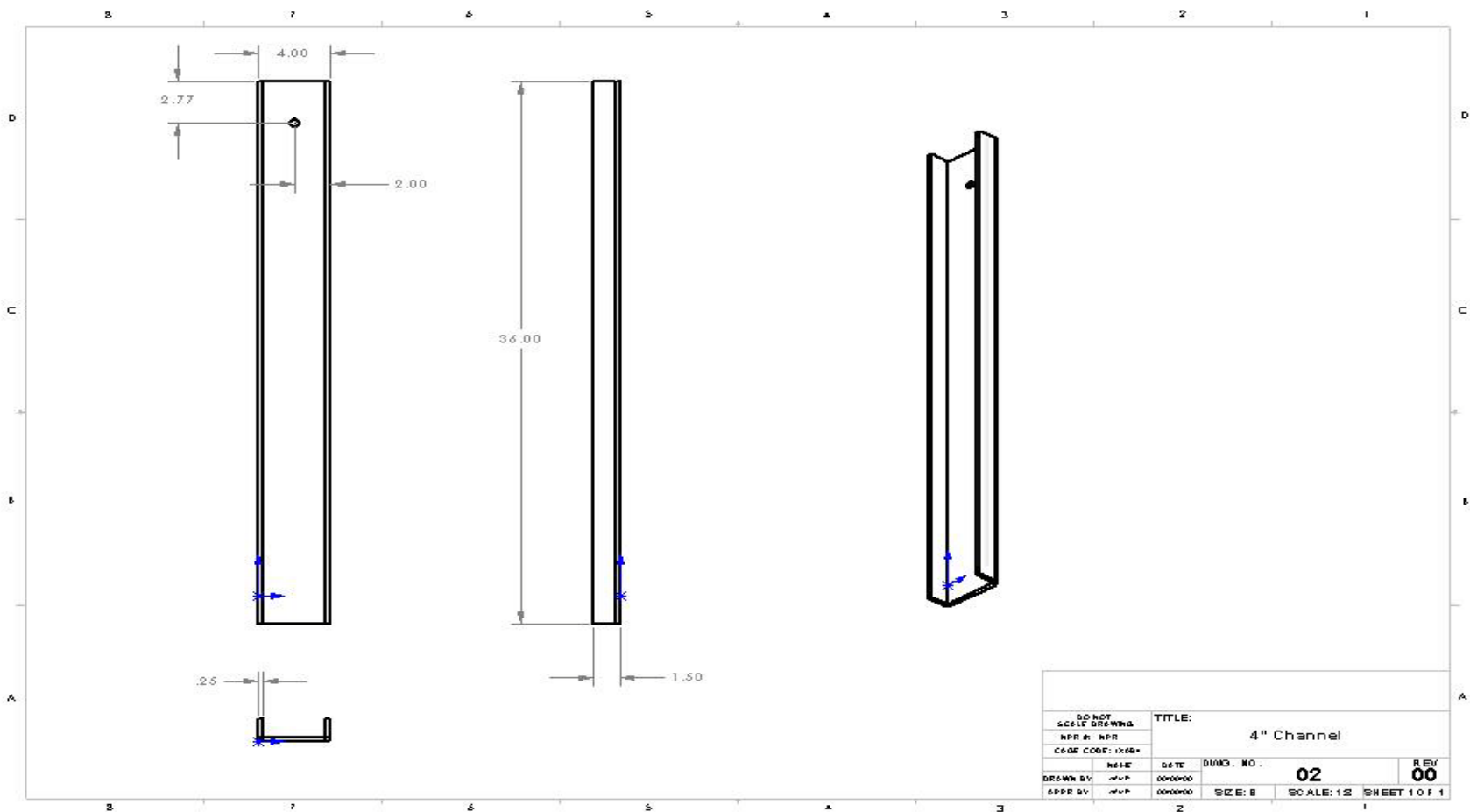
Weighted Decision Matrix								
Design Criterion	Weight Factor	Units	Bat Hits Sensor		Sensor Hits Bat		Use Velocity Sensor	
			Score	Rating	Score	Rating	Score	Rating
Size of Device	0.22	in	8	1.76	8	1.76	8	1.76
Time to Operate	0.11	s	8	0.88	8	0.88	8	0.88
Cost to Manufacture	0.41	\$	6	2.46	6	2.46	7	2.87
Force Needed to Operate	0.04	lb	7	0.28	8	0.32	7	0.28
Strength of Frame	0.08	psi	9	0.72	9	0.72	9	0.72
Actuation Method	0.05		6	0.3	6	0.3	7	0.35
Number of Components	0.06	#	6	0.36	7	0.42	8	0.48
Ease to Manufacture	0.02	experience	7	0.14	6	0.12	8	0.16
Weight of Device	0.01	lb	8	0.08	8	0.08	8	0.08
				6.98		7.06		7.58

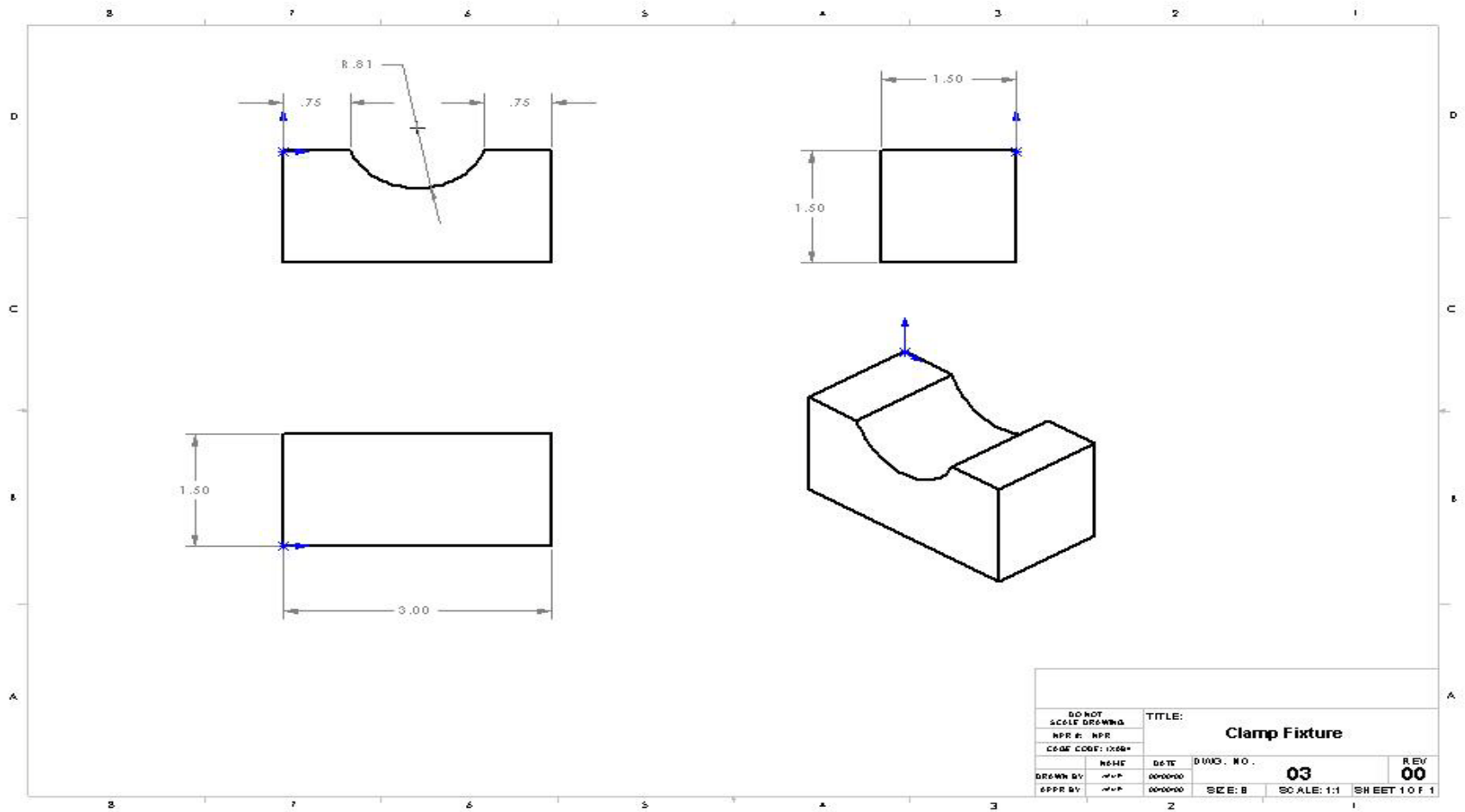
APPENDIX E: DRAWINGS

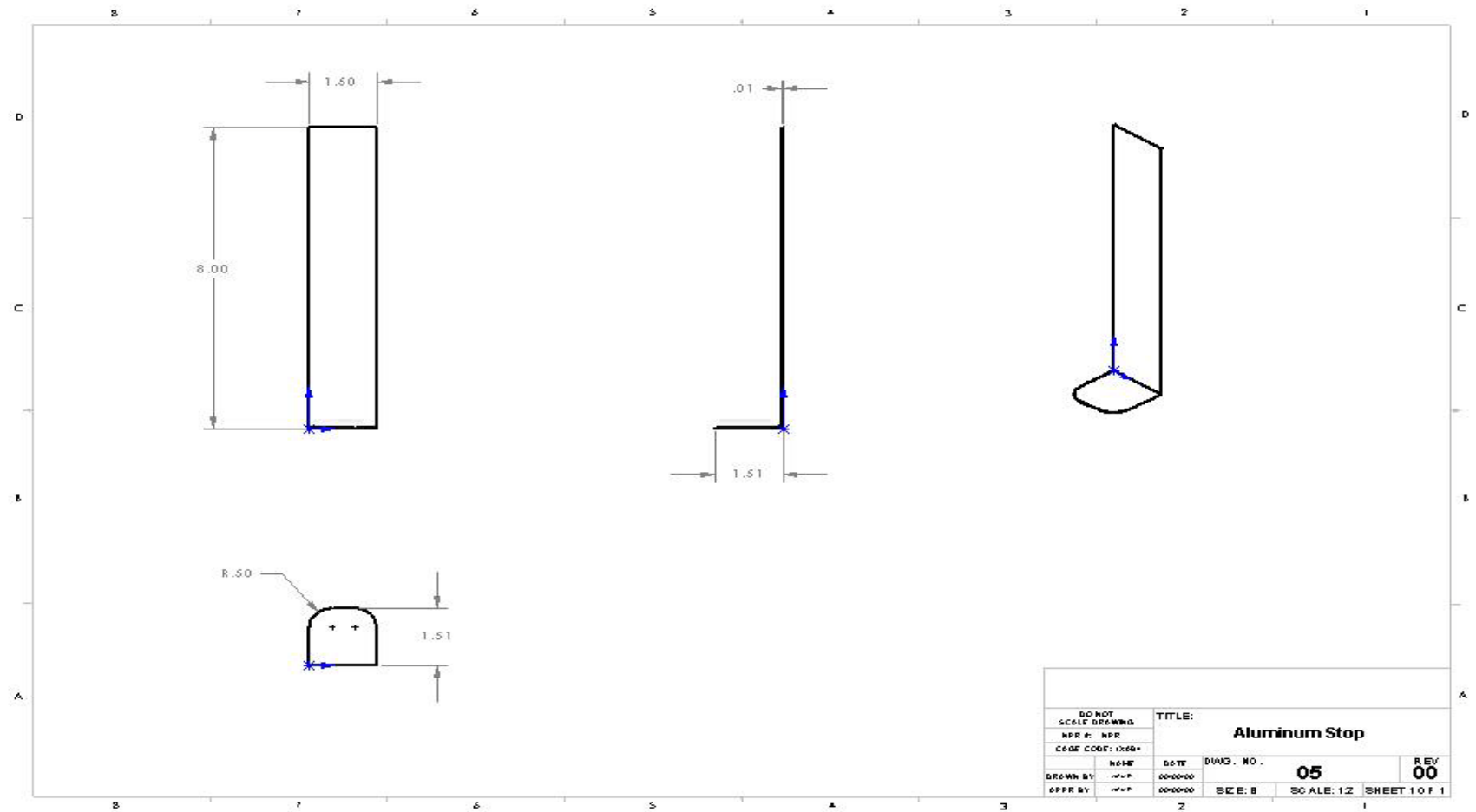


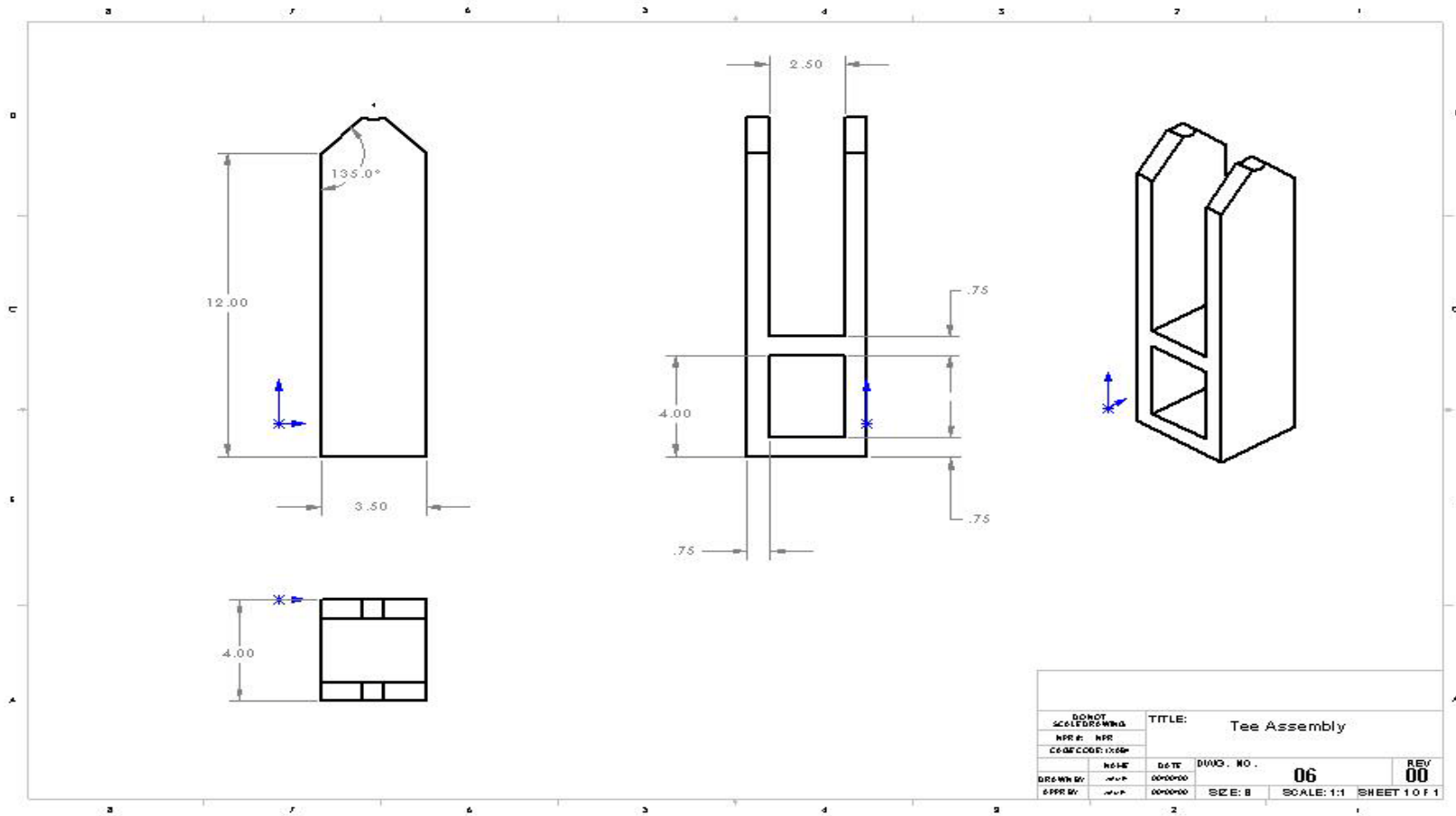


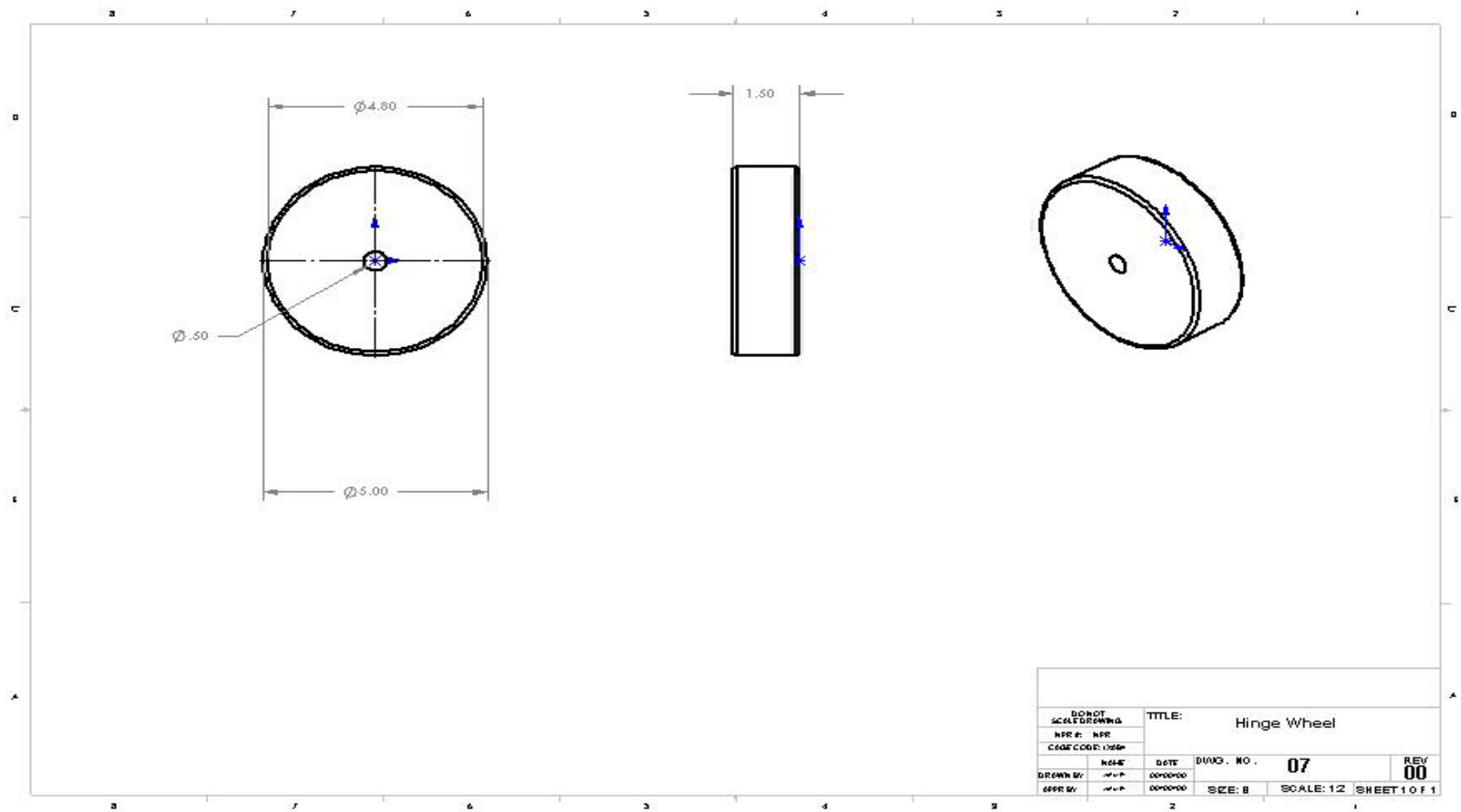












APPENDIX F: LOAD ANALYSIS

Stress Analysis of Swing Hinge

No.	Part Name	Material	Mass	Volume
1	swing hinge assy EXPLODE-1/cup-1	Balsa	0.000510659 kg	3.19182e-006 m ³
2	swing hinge assy EXPLODE-1/cup-2	Balsa	0.000510659 kg	3.19182e-006 m ³
3	swing hinge assy EXPLODE-1/hinge base-1	Balsa	0.0183442 kg	0.000114658 m ³
4	swing hinge assy EXPLODE-1/hinge base-3	Balsa	0 kg	0 m ³
5	swing hinge assy EXPLODE-1/spacer-1	Balsa	0.000195617 kg	1.22269e-006 m ³

Restraint	
Restraint-1 <swing hinge assy EXPLODE-1/hinge base-1, swing hinge assy EXPLODE-1/spacer-1>	on 2 Face(s) fixed.
Description:	

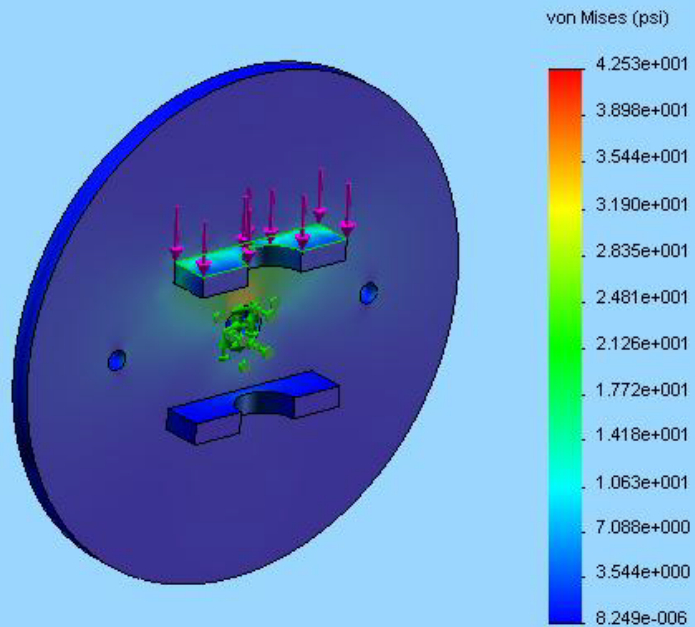
Load		
Force-1 <swing hinge assy EXPLODE-1/cup-1>	on 1 Face(s) apply normal force 1.6875 lb using uniform distribution	Sequential Loading
Description:		

Mesh Information	
Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	On
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	0.39093 in
Tolerance:	0.019546 in
Quality:	High
Number of elements:	7383
Number of nodes:	10144
Time to complete mesh(hh:mm:ss):	00:00:07
Computer name:	A704D-MET-013

Solver Information	
Quality:	High
Solver Type:	FFEPlus
Option:	Include Thermal Effects
Thermal Option:	Input Temperature
Thermal Option:	Reference Temperature at zero strain: 298 Kelvin

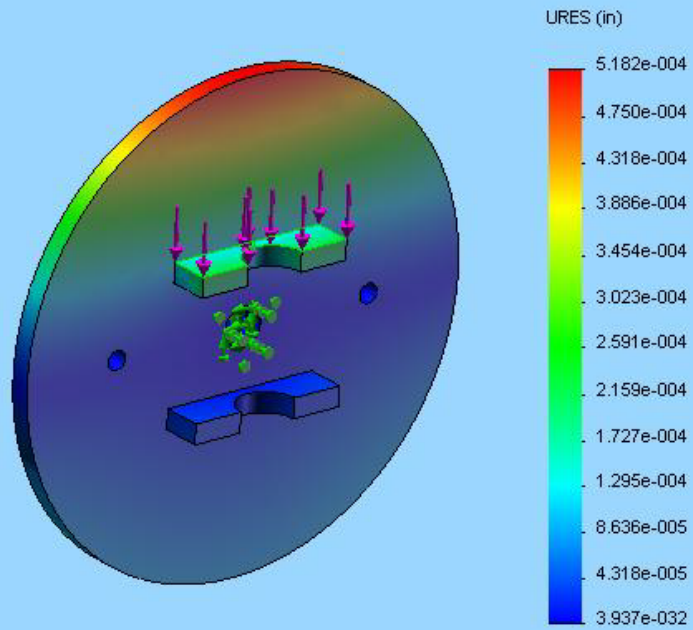
Contact Set-1	Surface contact pair: Between selected faces of swing hinge assy EXPLODE-1/spacer-1 and swing hinge assy EXPLODE-1/hinge base-1
Description:	

Model name: Assembly cosmos
Study name: Study 1
Plot type: Static nodal stress Stress1
Deformation scale: 1



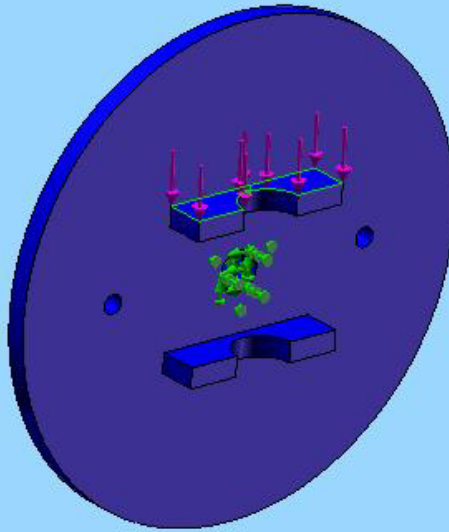
Educational Version. For Instructional Use Only

Model name: Assembly cosmos
Study name: Study 1
Plot type: Static displacement Displacement1
Deformation scale: 1



Educational Version. For Instructional Use Only

Model name: Assembly cosmos
Study name: Study 1
Plot type: Design Check Design Check1
Criterion : Max von Mises Stress
Red < FOS = 2 < Blue



Educational Version. For Instructional Use Only

APPENDIX G: SCHEDULE AND BUDGET



Final Budget

Materials and Components	Forcasted Amount	Updated Amount
Velocity Sensor	\$150.00	\$190.00
Frame	\$50.00	Donated
Bat Holding Device	\$40.00	\$10.00
Wiring	\$20.00	N/A
Wheels (2 total)	\$30.00	N/A
Wheel Shaft	\$15.00	N/A
Tee	N/A	\$3.00
Handle Grip	N/A	\$4.00
Miscellaneous Services or Parts	\$65.00	\$42.00
Total	\$370.00	\$249.00