

Piedras Blancas Clock Works

Sponsor:

Bureau of Land Management
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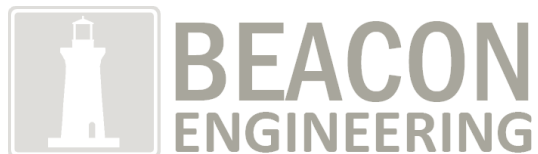


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Introduction

In 1875, the Piedras Blancas Lighthouse was built to warn ships sailing the California coast of the hazards of the rocky shore. In 1949 a fierce storm damaged the top portion of the lighthouse and the eight ton cast iron and brass assembly had to be replaced by a much lighter piece that still served the purpose of warning oncoming vessels. The former top portion came to rest in downtown Cambria and is still there today, enclosed in a glass room to be observed by visitors and townspeople. Today, the Piedras Blancas Light station is cared for by the Bureau of Land Management (BLM). A staff of mostly volunteers gives frequent tours of the light station and surrounding environment. In an attempt to give the people on the tour a better understanding of how the original light tower operated, the BLM has asked the Cal Poly Mechanical Engineering Department to design and build a working, scaled down model of the original top portion of the light house. It is desired to have a model that will demonstrate the way the original was gravity powered and how the gears worked to spin the massive first order lens. A working model is necessary because currently, the only remembrance of the original structure is a few pictures in the bottom of the lighthouse. Although helpful, these pictures do not clearly indicate the way ships were deterred from the jagged coast line. Beacon Engineering has taken on the project, and plans to have a working model of the original top portion of the light tower by December of 2010.



Background

The Mechanical Engineering Department at Cal Poly has assigned senior projects to students from the Piedras Blancas Light Station in previous quarters. One group designed a new water tower to act as housing for all of the communications equipments currently at the Light Station in order to restore the original historic appearance of the grounds. Another group worked to create full scale AutoCAD drawings of all of the components of the original top portion of the light tower. This group also created a digital working model of the light tower. Part of the Beacon Engineering project, titled "ClockWorks", is to create a physical scaled working model, and the previous CAD drawings will be used to help with the design, machining, and assembly of the model. By having digital renderings of each piece, we will be able to build any prototype of a part in the rapid prototyping machine on campus. The original piece rests in downtown Cambria, and there are a few other similar lighthouses along the California coast line that have been referenced in order to understand the way this particular mechanism worked. Although there are companies out there who create models of lighthouses, there are none to our knowledge who show the inner workings of spinning top portion, or show how gravity could power such an enormous device.



Objectives

The three members of Beacon Engineering, Andrew James, Andrew Jupin, and Matt Weber have taken on the project of Piedras Blancas Clock Works. The main goal of this project is to build a working model of original top portion of the Piedras Blancas light tower. This includes attempting to keep it as historically accurate as possible, using original materials, being self sufficient, and having the lens rotate at a constant speed of 1 RPM by gravity power. The model must clearly demonstrate the way the gears turn and how a large weight can cause the enormous first order Fresnel lenses to rotate. The model will very closely resemble the original seen in Figure 1 below.

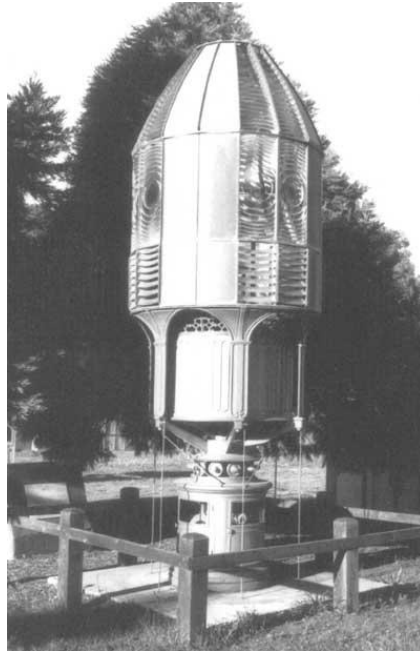


Figure 1. Original Piedras Blancas Top Portion

The scaling process is still under consideration. When first presented with the problem of building a working model, the idea of 8:1 was suggested. After visiting the light tower and seeing the old top portion, especially the gears, it has been decided a larger model is necessary. A 1:4 scale has been suggested. The original assembly is sixteen feet tall, so the model will be approximately four feet tall depending on the exact scaling option. Beacon Eng. is also considering using distorting the model, using different scales for different portions of the design. The sponsor has mentioned the emphasis should be on how the gears work and the mechanics of how the lens rotates. That being said, Beacon Eng. is considering making the lower part, where the gears are located, a 1:4 scale.

The original paddle governor on the light tower disappeared in its transportation from Piedras Blancas to its new location in Cambria and no pictures of it exist. A portion of this project will be to design a historically accurate paddle governor to keep the rotation as close to 1 RPM as possible.

Beacon Eng. plans to create prototypes for some of the parts before beginning to machine the parts out of the original materials. The point of doing this is to assemble some of the pieces and make sure that the gears mesh well and that all components fit together properly after being scaled down.

As seen in the Appendix A, there is a Gantt chart to help keep everything on schedule and to meet the appropriate deadlines on time. Also attached is a Quality Function Deployment table (QFD) that will be used to assist in decisions regarding the design of the model.

Project Goals

Our project of replicating the Piedras Blancas lighthouse top has both customer and engineering requirements. A full layout of requirements can be seen in appendix B. As defined:

- The lens must rotate at no more than 3 rpm
- The total model must appear historically accurate
- Lens operation must be safe and intuitive
- The lighthouse must last, and be easily maintained for at least 5 years

From our engineering standpoint, we have established additional guidelines:

- The model will be gravity powered with hand-crank operation
- All components will be made out of original or similar materials
- The fixture will use a battery powered light of scaled intensity
- We must keep the model under 400 lbs.

The main goal of this project is to create a working model of the original top portion of the Piedras Blancas Light House. All decisions made are based on creating a model that clearly depicts its operation as it was in the early 20th century. Aside from operation, aesthetics of the model will be very similar to that of the original.



Design Development

LENS

The original lighthouse had a first order Fresnel lens resting on top that rotated at 1 rpm in order to signal oncoming ships that they were approaching Piedras Blancas. The flashing light could be seen close to 25 miles away as a result of the Fresnel lens. Although an actual Fresnel lens is not required for the model, a similar looking piece is desired. A few options have been investigated. The option currently being pursued involves a square Fresnel lens sold as part of a ceiling light cover. This lens looks very similar to the original, a bull's eye in the middle with rings surrounding it, but is sold in square pieces. Rectangular lenses are needed for the model; therefore, methods of cutting the glass are being pursued. However, the surface contours of the lens might make conventional methods void.

CARRIAGE DESIGN

The original Fresnel lens is held by a large cast iron carriage that rotates about the bottom gear housing. The new carriage has been redesigned into a few aluminum pieces that will be assembled after fabrication. Below is a CAD model of the redesigned assembly.

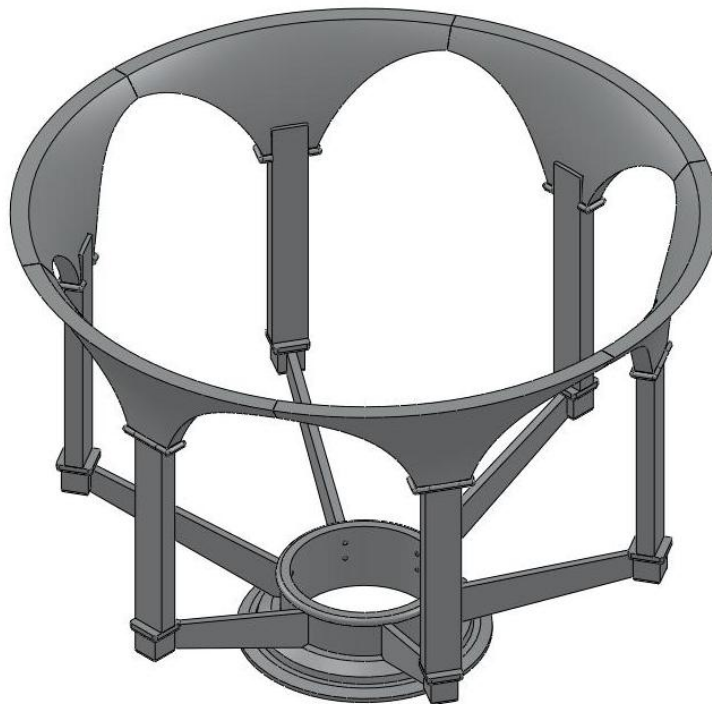


Figure 2. Redesigned Aluminum Carriage Assembly

The carriage will be assembled out of 2 large parts, the base and top arches, and the connecting arms. There are six base arms, connecting arms, and top arches as shown in Figure 1. Figures 2, 3, 4, and 5 below show each individual piece in greater detail.

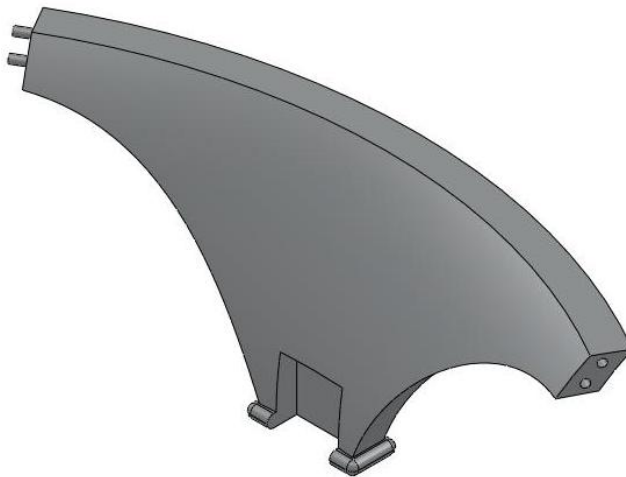


Figure 3. One of Six Identical Top Arches

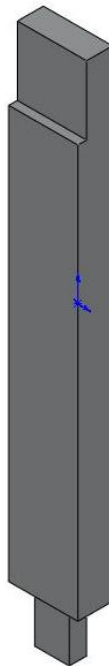


Figure 4. One of Six Identical Connecting Arms

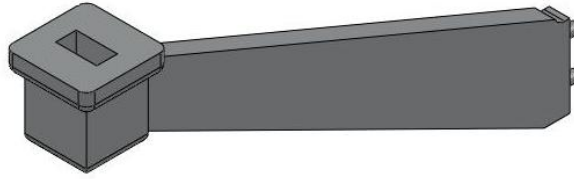


Figure 5. One of Six Identical Base Arms

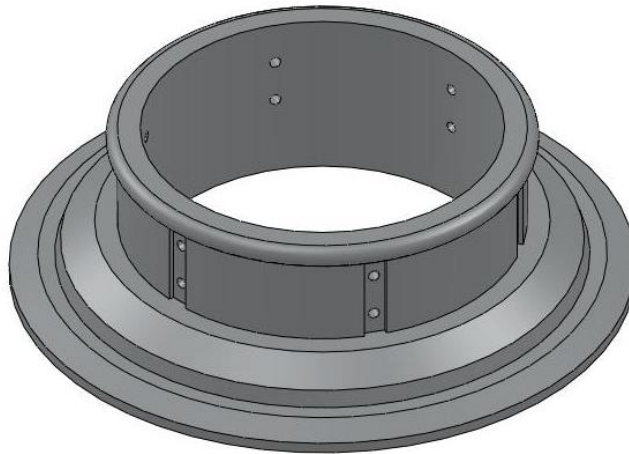


Figure 6. Carriage Base

The connecting arms, in Figure 4, will be machined from stock, while the other parts will each be rapid prototyped separately. Currently, we are planning on using Cal Poly's rapid prototyping machine to make the parts out of plastic. The plastic pieces will be put together to form their respective larger parts. Each larger part, except for the connecting arms, will be cast using the plastic parts as molds. The larger parts will then be assembled using fasteners and cast inserts to form the complete assembly.

GEARS

The carriage is spun by a series of gears. The gears have been scaled down to work in the model. Some of the ratios have been altered in order to keep the intricate meshing visible. Also, the original had several cage style gears to minimize friction and wear, but when scaling down, the pins become too small, and may compromise under the load. For this reason, many will be replaced with traditional spur gears.

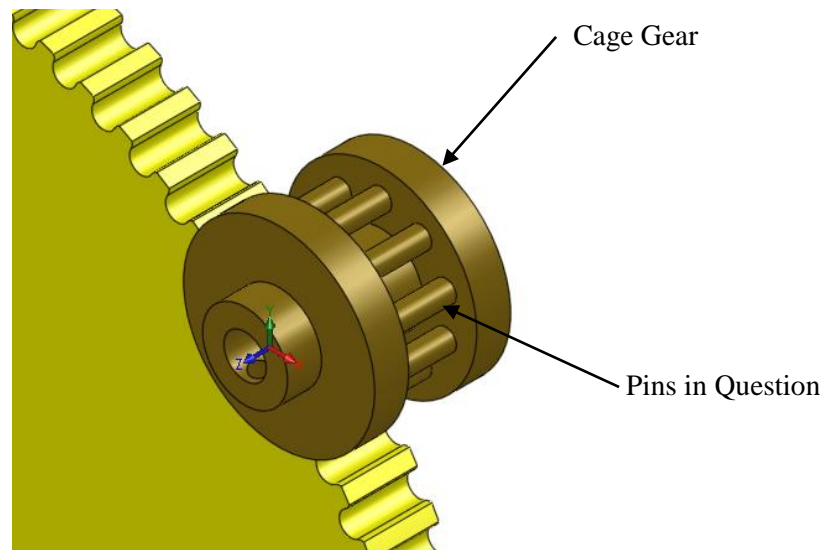


Figure 7. Cage-Gear Mesh

Many of the gears will be able to be purchased from online sources, while a couple as seen in Figure 7 will need to be machined. The gear fastened to the carriage is a custom gear and so is the cage gear it meshes with. The cage gear has ten pins that mesh together with the carriage gears 87 teeth.

HOUSING AND MOUNTING

The parts of the housing, doors and mounting pieces for the gears will all need to be cast separately out of this is the actual workings of the lighthouse and should not depend on any other pieces aluminum and then fastened together. The methods for casting these parts are still under consideration, but we are pushing toward investment casting from rapid prototype models. We have to do more research to know what it is the best course of action to create appropriate molds, but all of the tolerances required will be machined after the parts are cast in order to put the gears in correct position for good meshing. We are aiming for this assembly to be able to stand alone, because.

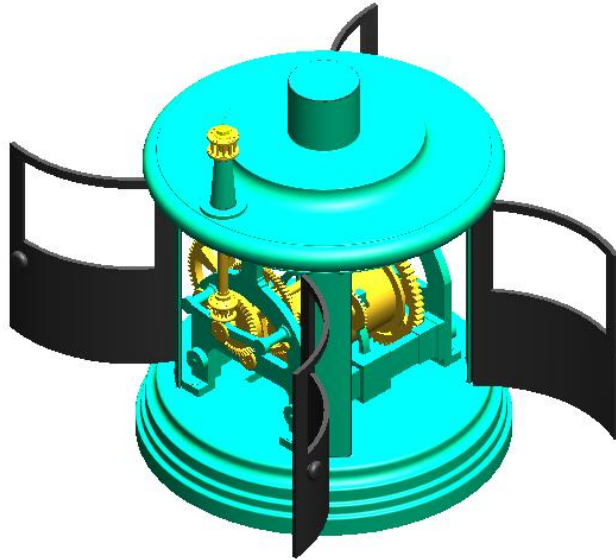


Figure 8. Gear Housing

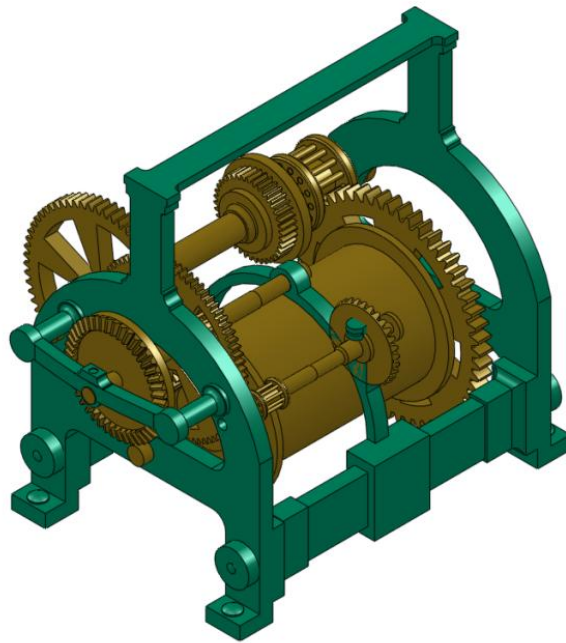


Figure 9. Gear Box



Final Design



Figure 10. Final Product

In the end, the product came together. Although there were many sleepless nights and times when team members fought, the final product was definitely something to be proud of. It came down to the end, and even some minor details were being changed up until the very last second, the pieces fit perfectly together. The lenses slid right in the and giant pizza pan and pot fit seamlessly into the lower housing. The table and brass support cased in the model perfectly even after being completed just barely the week before.

LENS

Although many ideas were considered for the construction of the lenses, it was decided to have all of the lenses made on campus in the Eden Rapid Prototype machine. By doing this, we were able to make the lenses the correct size and shape without having to cut them out of glass or other brittle materials.

At one point the lenses were going to be outsourced to a company in Florida. This company was going to have molds created from SolidWorks drawings made by us and then a clear plastic injected into the mold. Once the mold solidified these parts would need to be hand sanded and polished before having the correct finish. The original estimate for this to be done was over \$15,000 dollars. By creating all of the lenses created on



Figure 11. Rapid Prototyped Lenses and Bullseye

campus and sanded by light house volunteers we were able to create the lenses seen on the structure today for less than \$5,000. The only cost incurred was the actual material and necessary filler material needed by the objet machine. The parts took close to 100 hours in the Rapid Prototype Machine and over 500 hours to hand sand and polish.

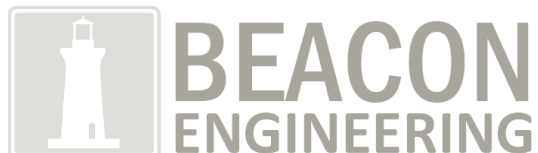
All pieces of the lens assembly were created by measuring and finding relations on the original structure located in Cambria. Each prism is unique and is shaped to accurately resemble the original Fresnel lens found in Cambria. The most interesting piece is in the center of the small triangular shaped lenses. This piece, titled the “bullseye” is a very intricate piece that was created in one piece. The original had different pieces for every ring, but in the process of using the Rapid Prototype Machine these multiple pieces could be consolidated into one.

Although all of the shapes are very close to the shape of the original, after scaling them down, using a different material than the original and some relations being altered, the lens structure does not create a perfect beam of light like the original piece did.

The lenses are intended to be held in with over the counter super glue. Due to the fact that there are very little forces will be trying to force these out of there carefully designed resting places, very little adhesive will be required to hold them in place.

LENS SUPPORT

The pieces used to support all the lenses are comprised of two major subsystems. The bottom portion bolts onto a special gear (discussed later) and then connected to the rest of the gear box. This subsystem has 13 parts that fit seamlessly together. At the bottom there is one piece, a hub of sorts where the carriage lower and upper arms are connected. All of these parts were also rapid prototyped, but instead of being done on the Eden machine with clear material, they were made with ABS plastic. This material is much harder and don't yield as easily under large loads.



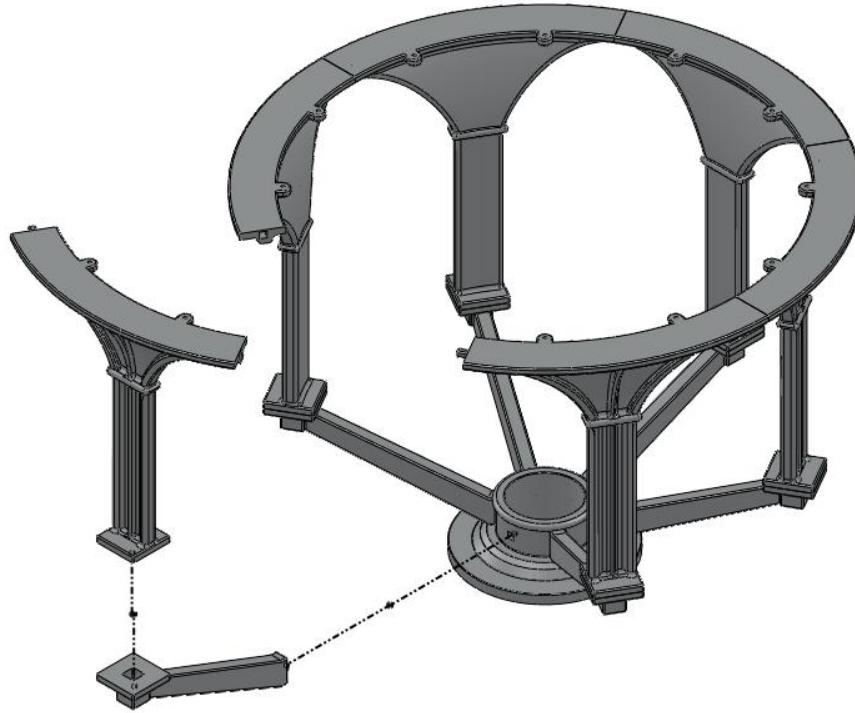


Figure 12. Lower Lens Support Assembly

The bottom hub is a unique piece. It was made in SolidWorks along with a majority of the other parts, but when it was done, it was shelled out to be hollow. This was done so that an aluminum powder epoxy could be poured into it. This was done in order to not only increase the strength of the piece, but also so that the bolts that would go through it to connect to the large brass gear below it. The six pieces that are attached to it support the six upper arms. The lower pieces experience most of the forces presented by all of the pieces above it. These six pieces support the weight of 8 bullseyes, 208 lens pieces, 1 square yard of sheet metal and almost five pounds of ABS material. The bottom piece was also designed perfectly for it to rest on top of the gear below it which had protruding bolts, which were not allowing the hub to nicely rest on the gear.





Figure 13. Bottom Hub for Lens Support

Directly above the six arms are six vertical members. These pieces not only add an artistic quality to the model but also a very structural part as well. The ribs going up the center of each piece helps keep the pieces from breaking outward as well as helping any compressive forces from the structure above. The flange along the top of these six pieces allows for the top assembly that contains all of the lenses to easily rest on a smooth surface. Also on the inside edge is 12 bolt holes which line up with top in order to secure the two together.

Resting on top of the lower assembly was a system comprised of 41 pieces. These 41 pieces hold all of the lenses in the correct orientation. Of these 41 pieces there are actually only 11 unique pieces. The reason why there are so many is because there had to be accommodations for the fact that every side to the 16 sided polygon for not the same, for every two sides comprised of lenses, there were two covered in sheet metal. Also, one arm could not be created to span all of the way from the base of the structure up to the capstone. This is because the parts had to be designed in order to fit inside of the rapid prototype machine. This machine was only 10" x 10" x 12" For this reason, there had to be some pieces that were able to hold onto the sheet metal and others only used for supporting the lenses.

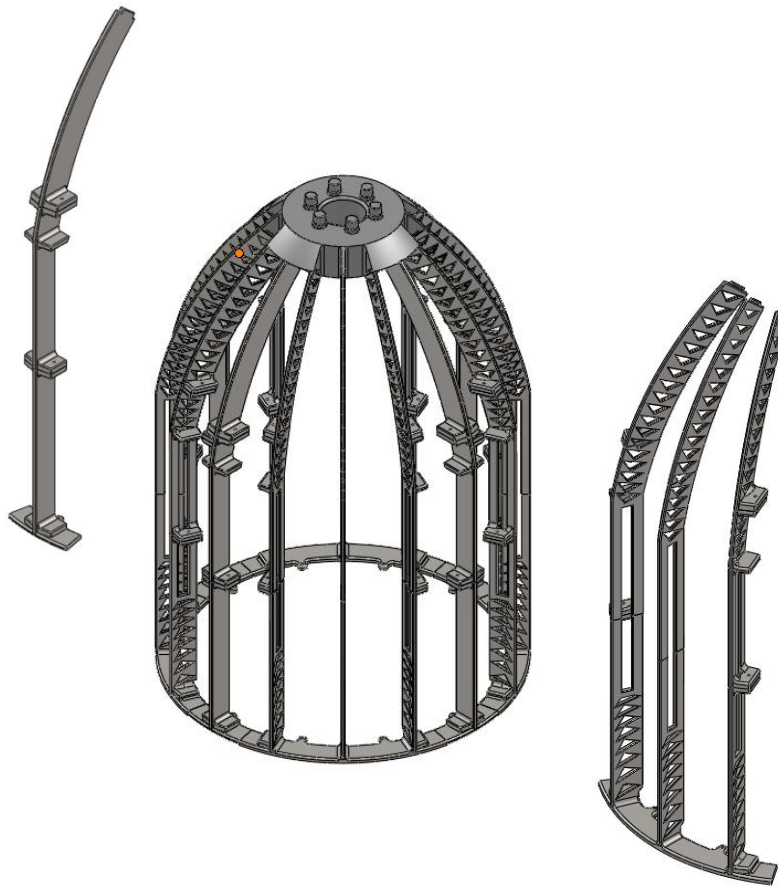


Figure 14. Upper Lens Support

The piece at the top, called the capstone, is used to bring all of the arms together. There were slots made in the top and tabs at the end of all of the arms in order to tie it all in together. Also, on the top of the capstone, there are six posts protruding up which bearings fit on. These bearings are used to spin about the cylinder which extends down from the base on which the model is mounted. The reason for this pipe is to add stability. Due to the fact that the lens support is rotating about the pot in the center, and the center of gravity is relatively high above point of rotation, this added stability is nice, especially in places with frequent earthquakes.

All of the top and bottom support pieces are held together a couple different techniques. The first is one in which tabs and slots were placed at the end of each piece. This is seen in all of the bottom support pieces as well as where the arms meet the capstone. The other technique is seen in the upper lens support. There are large flat spots at the ends of several pieces with small holes in them. This was done so that a bolt can be put through and nut at the bottom. In both scenarios, all points in contact were coated in a plastic epoxy in order to allow a secure bond between the two parts. All of the lenses are held in by a strong clear adhesive, and the sheet metal is held on by the same epoxy which holds all of the pieces together.

The paneling is made of sheet metal that was hand cut specifically for the model. There was one template originally made and fit to the top which the rest are copies of. The sheet metal is held on in two ways, it was first put in place with metal to plastic epoxy and then the cracks were filled with silicon calking.

Charriot and special gears

Connected to the hub is a large special gear that was custom made for the soul purpose of this project. It was designed in SolidWorks and was made in the machine shop at Cal Poly out of Brass. This special gear was not hand cut but was programmed into the CNC machine and was perfectly cut to the exact dimensions specified. This was necessary because it needed to mesh with another custom gear that resembled a cage. This gear is made up of 10 small pins that are held in place by two outer rings. The outer rings were cut so that the pins would sit perfectly in place, but with enough tolerance so that the pins could freely spin. The shaft leaving the cage gear goes straight into the gear box through a hole in the top of the housing. The array of holes on the large gear is there for both fastening it to the bottom of the lens support but also to attach the eight bearings which allow the gear to spin about the center.

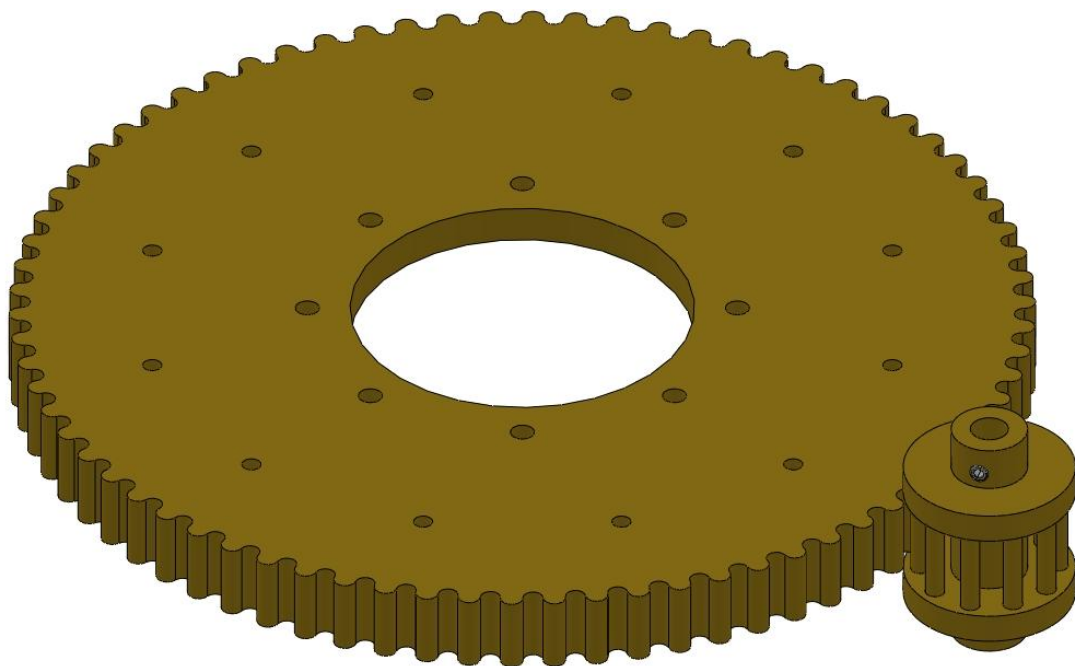


Figure 15. The Special Gear and Cage Gear

The special gear is able to freely spin because it rests on top of something called the chariot. The chariot has eight bearings on two different axis. The first, the horizontal allows a surface for the large gear to spin upon, and since the chariot too is spinning it has eight more bearings on a vertical axis to spin inside the top of the housing.

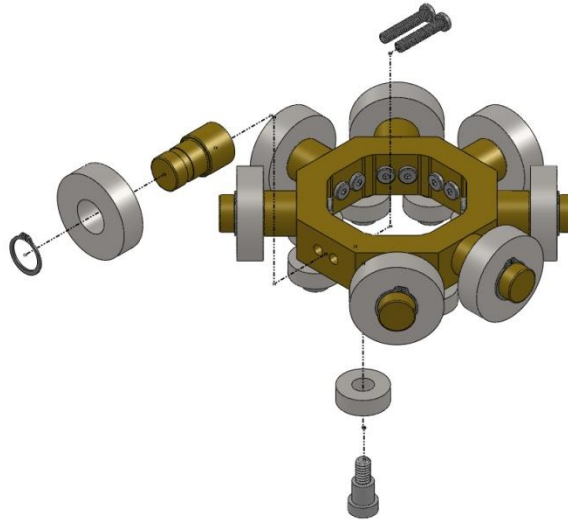


Figure 16. Charriot

As seen in figure 14, the bearings on the horizontal axis are held on by two bolts which connect with a unique shoulder. The shoulder was custom machined on site as well. It was made to just barely fit the bearings on. Also the octagonal shaped base was custom made and threaded to hold all bearings in place.

Gears and Gear Box

All gears in the gear box were scaled down from the original. The original gear ratios were attempted to be maintained in all circumstances. Aside from the large special gear and cage gear, all of the gears were bought online. This was done to ensure proper gear meshing. One gear that was bought was cut into. This was done so that it could properly work with a bike free hub cassette, which was also bought. The assembly of the two can be seen in figure 16. This had to be done in order to create the ratcheting mechanism for the gravity powered turning. The ratchet had to engage the gears when the weight is falling but then disengage when winding the weight back up. Instead of designing an entire ratcheting system we found a bike hub to work perfectly and be the exact right shape. The wheel did need to have all spokes and unnecessary pieces removed. The wheel also connected to a drum which was custom made from aluminum stock. It was first milled to cut out the necessary areas and was then turned down by a lathe to the correct diameter.



Figure 17. Bike Hub and Gear Assembly



Figure 18. Ratcheting Drum

Every shaft in which the gears are mounted was custom machined in the Cal Poly machine shop. Their lengths were carefully calculated and diameters perfectly planned so that the gears would work together and fit in the house. Some key features to the gear box include: the bevel gear seen in the figure 19 meshes with a gear that is on the same shaft which comes down from the cage gear above, the large aluminum drum is where the cable which is attached to the weight wraps around and the shaft which protrudes the farthest out is where the detachable crank connects in order to raise the weight. The crank is removable, and was designed so in order to be able to see the gears better. The door must remain closed when winding the weight up, but once the weight begins to fall the crank can be removed and the

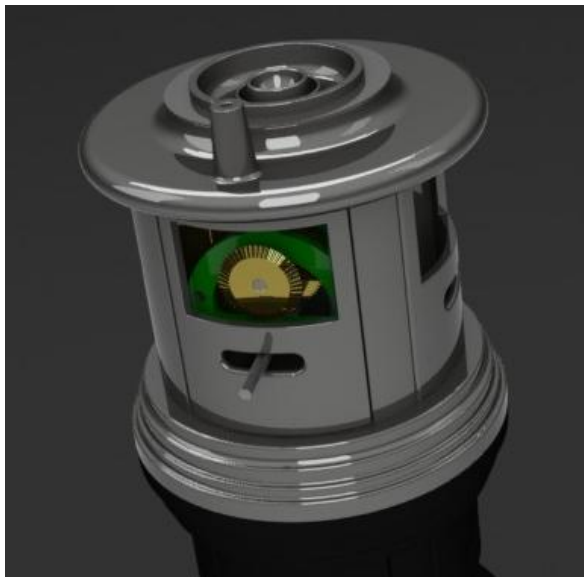


Figure 19. Gear Box Housing



Figure 20. Gear Box

doors may be opened.

The gear box fits precisely within a housing which very closely resembles the one found in Cambria. The housing is comprised of four legs, the top and bottom. These six pieces were first designed in SolidWorks, built in the rapid prototype machine and then filled with the same aluminum based epoxy that filled the hub in the bottom of the lens support. The epoxy was absolutely necessary here to give a firm foundation for the entire model. This part had to be massive in order to anchor everything. Also, it has to be able to withstand all of the compressive forces being felt from above. Pouring the epoxy was relatively simply. It came in two containers, and once the two liquids combined they would solidify within 24 hours.

Repair and Maintenance Considerations

Due to the fragile nature of this model, all parts can be rerapid prototyped on campus. All parts are stored in the accompanying CD. Also, all paint is Rustoleum brand over the counter spray paint. This was intentionally done so that in the future, paint can be easily touched up.

The gears in the gear box do need maintenance over the next few years. They will need lubrication from time to time in order to keep the gears running smoothly. Also, if the gears do appear to bind, there is some extra weight being left at the light station that can easily be added to the bottom to make the gears start moving again. Also, if it appears to move too fast, the weights will need some adjusting over time, so if need be, weight can be removed. Included with the model are a few different sizes and weights.

In order to keep the model in as good of condition possible, it is recommended that this be treated as a very fragile device. It should not be spun quickly or jostled around. The only way it should be spun is by the weight fall, or by nudging the crank. It is not designed to have someone spinning the top carriage or lens support. Doing so, may cause the wire to bind up in the gear housing or the plastic to break. With all this in mind, the only people manipulating the model should be light station tour guides or docents, and people who know the model and how it works. We recommend it be kept out of reach from any of the public.

Project Management

The model was created by breaking it into three major components and divided among the team. Andrew James was in charge of doing the entire middle section including: the pot/pan combination which holds the LED, the chariot and lower lens support. Andrew Jupin designed and created the Fresnel Lenses, and the upper lens support. Matt Weber worked to build the gear box and it's housing.

In all, each section had it's own major challenges to overcome and was an equally daunting task. Although previously stated, that each had their own section, each just headed their own section and saw through the completion. In reality, all three worked hard together and was there for support. When obstacles arose, the other team mates were there to help problem solve and get the work done.

In this project, each team member contributed something different. Due to this fact, the project was able to come out an enormous success. If three identical engineers were working on this, nothing would have gotten done. In the eyes of the team, these three worked tremendously well together.



Cost Analysis

When the proposal was given for how much this project would cost, the numbers were highly inflated. There was room to build bigger and better and the estimate factored in outsourcing the production of almost every part. The estimate included a company in Florida creating molds to form the lenses and then sanding them that totaled over \$12,000. In the end the total budget for the project was close to \$27,000.

Due to the fact that instead of outsourcing everything, all parts were made on the Cal Poly campus not even half of the budget was used. The most costly part of the project was creating the lenses. The material for those was \$5,000. All of the plastic pieces that were rapid prototyped took 800 hours in the machine, and at \$5 a cubic inch of material, the total cost of all of the parts added up to \$2,400. Of that, many were test pieces, and some were broken and had to be replaced. In all, after many trips to the hardware store and Home Depot, the project came in over \$17,000 under budget and cost close to \$10,000.



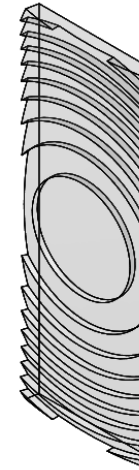
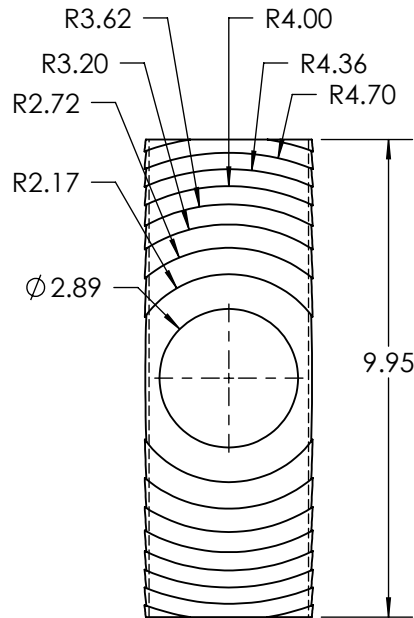
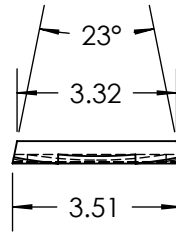
Analysis and Conclusion

Throughout the design and production of this model there was much iteration and changes. Initially everything was intended to be cast, then only a few pieces, and finally nothing. Looking back many things would be different than how the ended. The arms that support the lenses and the entire lens support structure would have been made hollow and filled with the same aluminum epoxy that the housing was filled with. The center piece which holds the light would have also been rapid prototyped and had extra artistic qualities to it in order to better represent the original piece. The LED which is in the center of the light structure should also be omnidirectional. The one that is currently in there only points straight up. The refraction through the Fresnel lens would be greatly enhanced if this light was one that radiated light out in all directions.

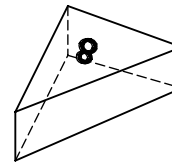
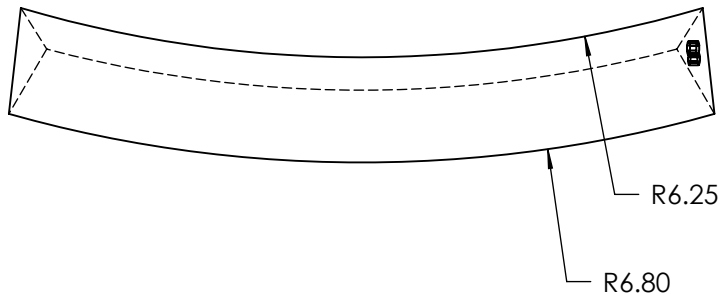
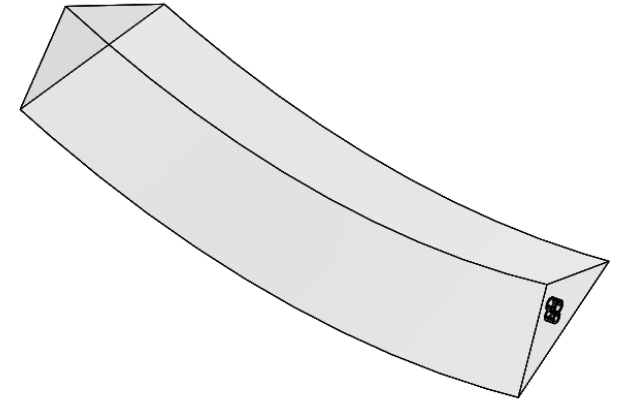
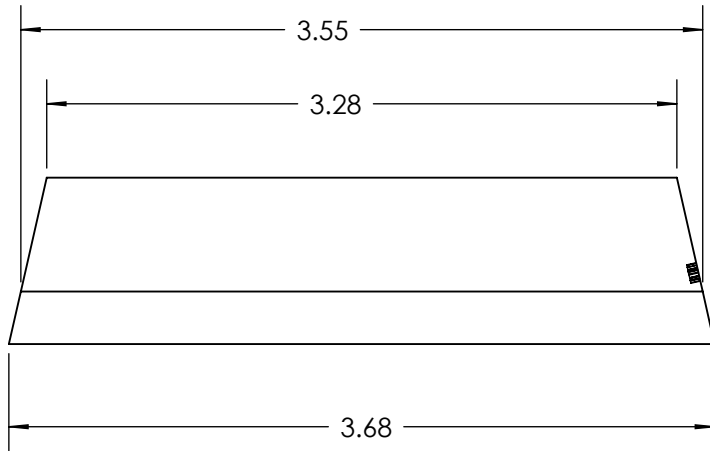
This entire model is very fragile: everything from the tiny doors in the bottom to the delicately polished lenses in the top. Docents are intended to run the model. The crank should be delicately turned by someone familiar with the model. In times where the model doesn't begin to spin right away, only the docent or tour guide should give the model a light push. It does not take a lot of energy to get the model moving, but sometimes the static friction is a little much for the gears to overcome. Also, the crank should only be turned when the door is closed. If the door is left open, the crank may run into the door and break it off. Once the model begins to move the crank can be removed and the door can be opened in order to see all of the moving components inside. If in any case a piece should break, the cd accompanying this report has all of the 3D modeling files. The file that should be taken to the Cal Poly campus ends with .stl. This stl format is what the rapid prototype machines can read. All file names can be found in the appendix on the appropriate drawing.

Appendix: SolidWorks Drawings

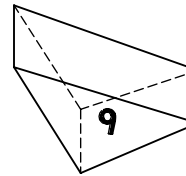
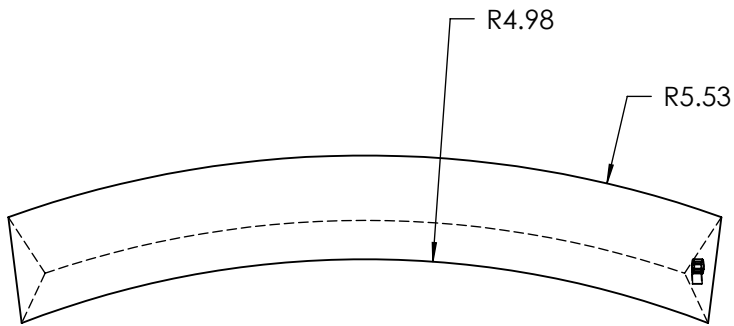
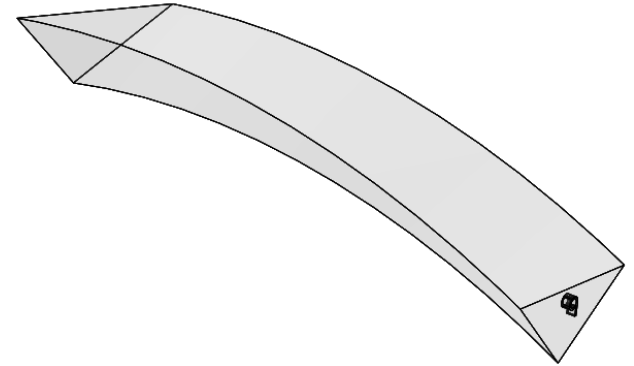
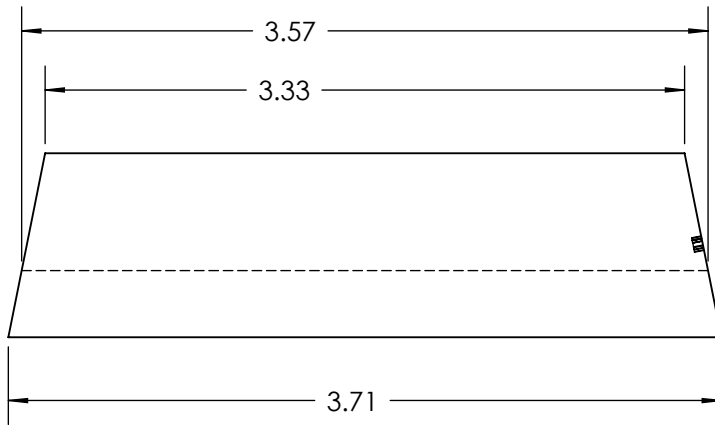




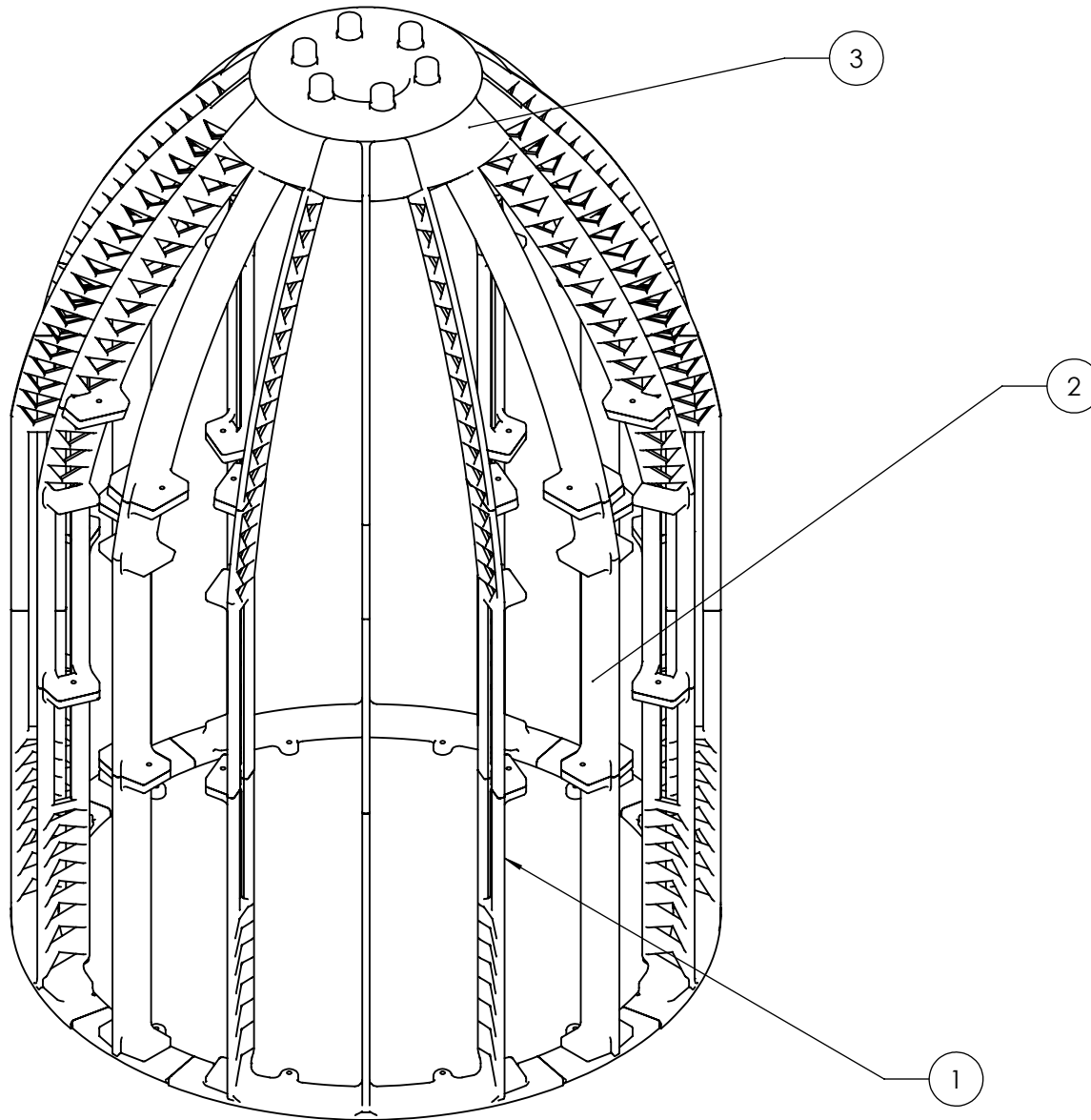
DIMENSIONS: INCHES	MATERIAL: ACRYLIC		<div>BULLSEYE</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 8	FILE NAME: bulleyenew_5		PART NUMBER: PB0501	SHEET 1 OF 3



DIMENSIONS: INCHES	MATERIAL: ACRYLIC		<div>BOTTOM PRISM 1</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
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SCALE: 1:1	CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 8	FILE NAME: bottomprism1_5		PART NUMBER PB0502	SHEET 2 of 3

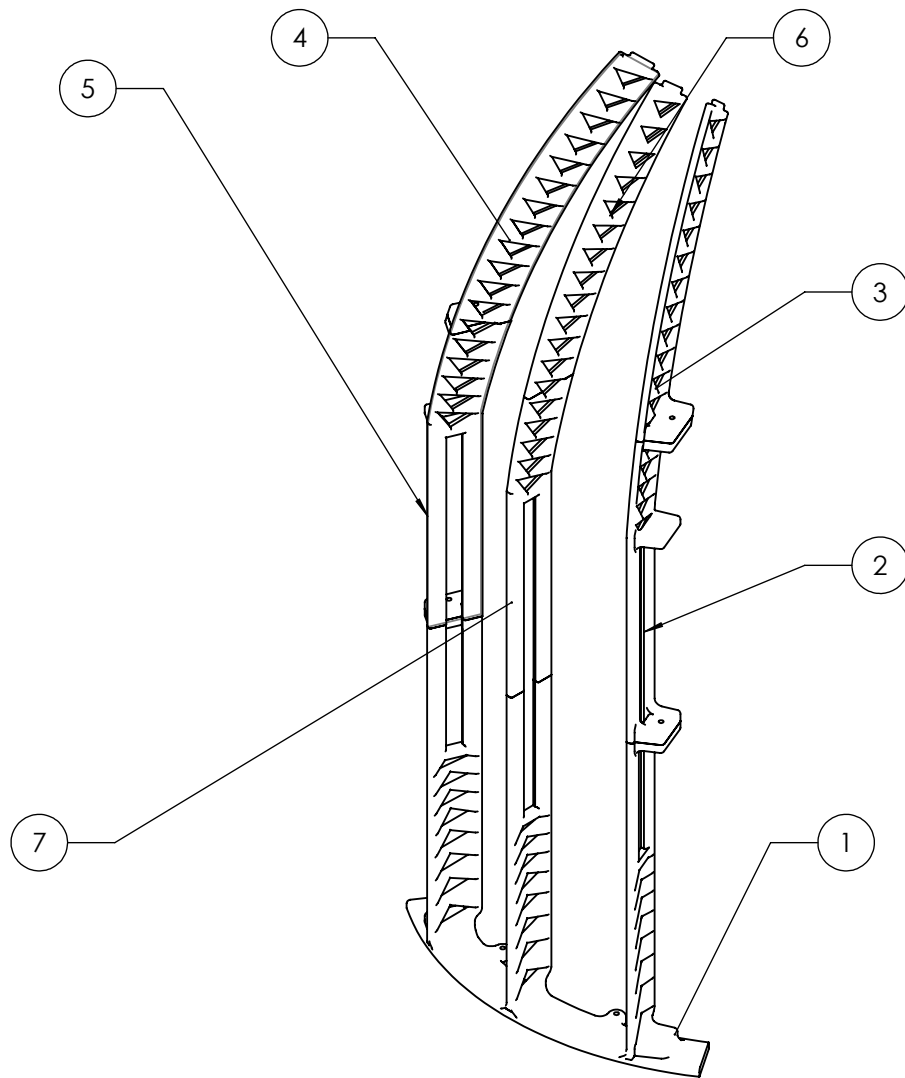


DIMENSIONS: INCHES	MATERIAL: ACRYLIC		TOP PRISM 1 CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
TOLERANCES:	DESCRIPTION:			
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SCALE: 1:1	CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 8	FILE NAME: topprism1_5		PART NUMBER: PB0503	SHEET 3 of 3



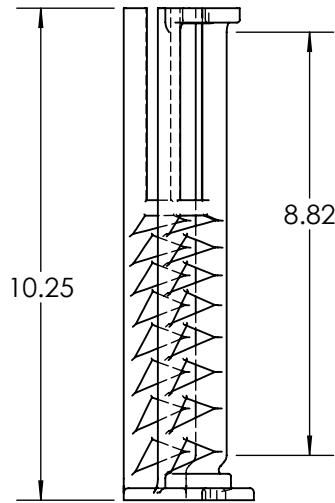
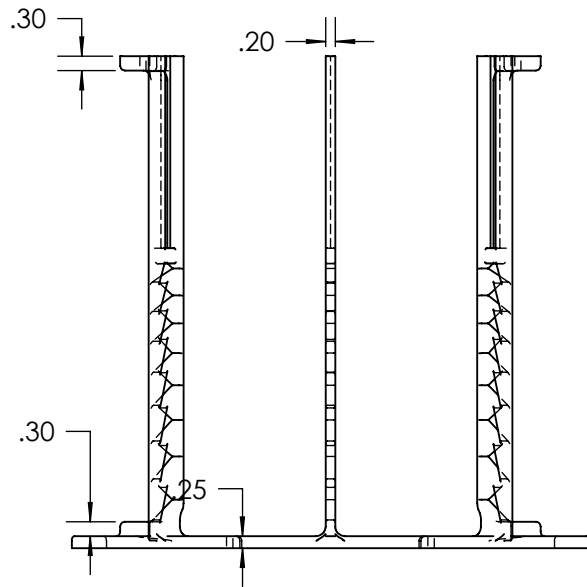
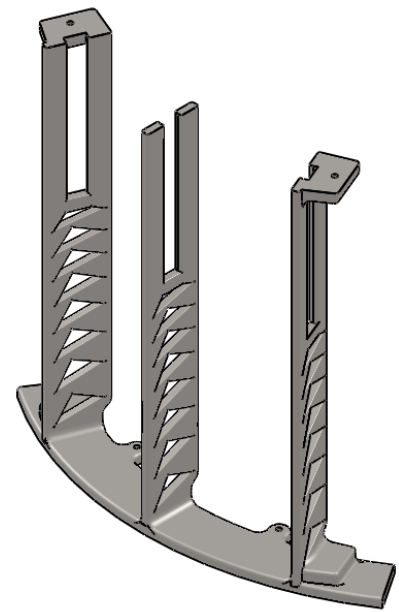
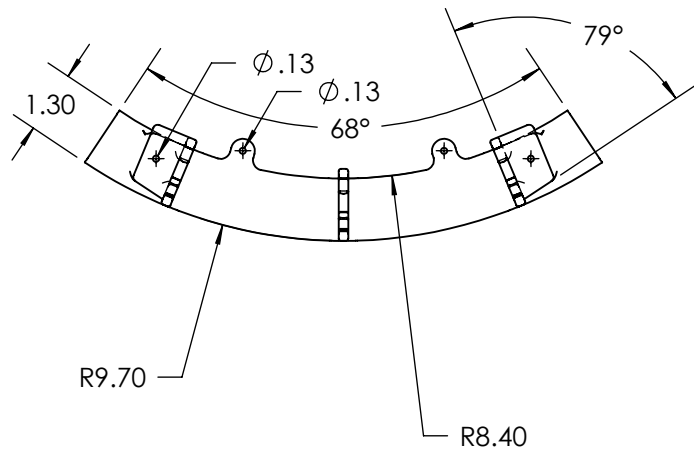
ITEM NO.	PART NUMBER	QTY.
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2	PB1020	4
3	PB1030	1

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TOLERANCES:		DESCRIPTION:					
		DRAWN BY: ANDREW JUPIN		DATE: 11/23/10		CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:5		CHECKED BY: MATT WEBER		DATE: 11/23/10			
Quantity: 1		FILE NAME: lens_support		ART NUMBER: PB1000		SHEET 1 of 14	



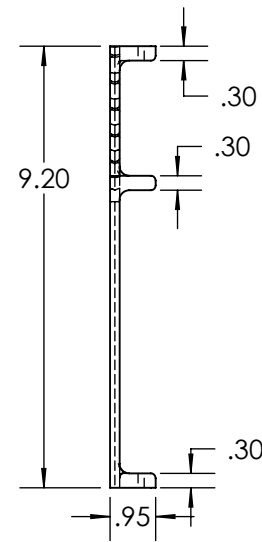
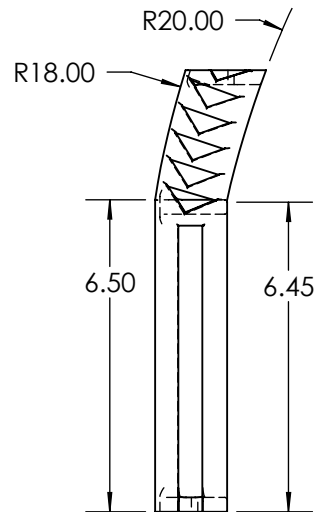
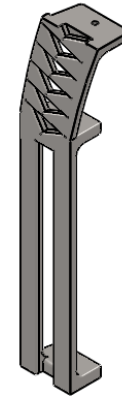
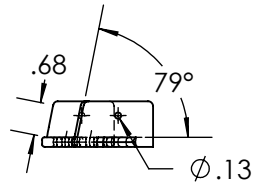
ITEM NO.	PART NUMBER	QTY.
1	PB1011	4
2	PB1012	4
3	PB1013	4
4	PB1014	4
5	PB1015	4
6	PB1016	4
7	PB1017	4

DIMENSIONS: INCHES		MATERIAL: ABS PLASTIC		LENS SUPPORT BOTTOM AND TOP CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
TOLERANCES:	DESCRIPTION:				
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10			
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10			
Quantity: 4	FILE NAME: lenssupportbottomandtop			PART NUMBER: PB1010	SHEET 2 of 14

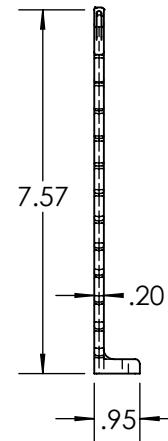
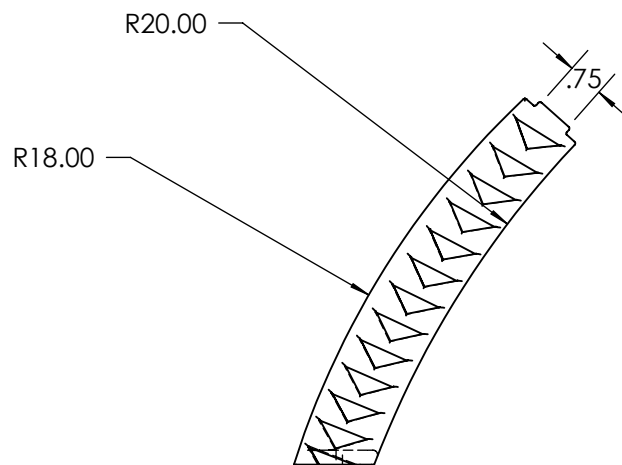
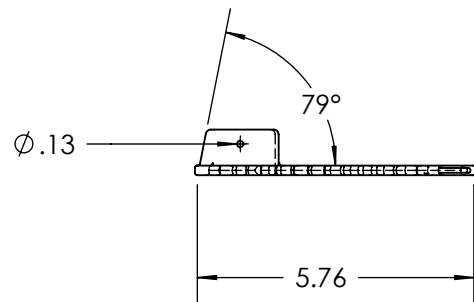


DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		LENS STRUCTURE BASE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: lens structurebase			

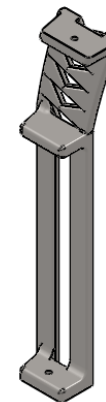
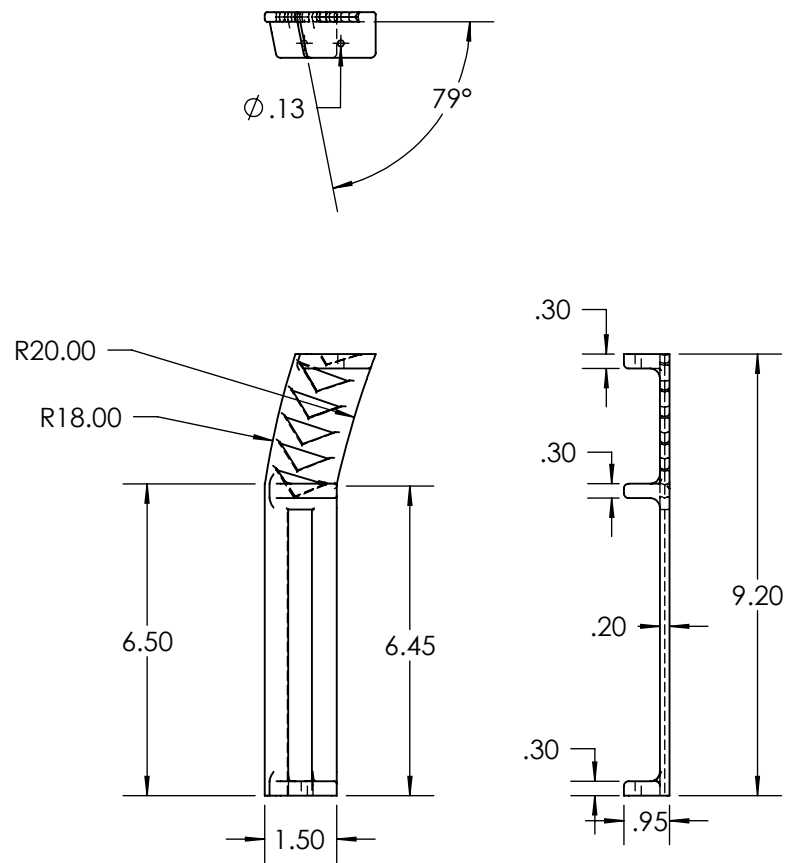
CAL POLY SAN LUIS OBISPO
ME DEPARTMENT



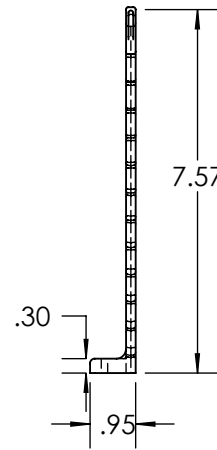
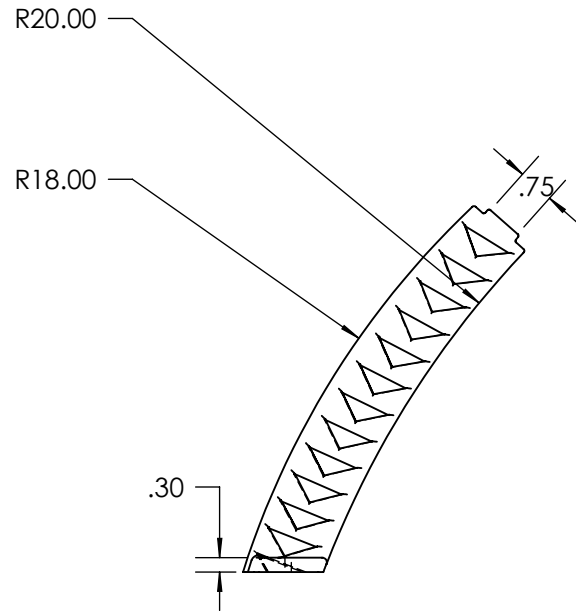
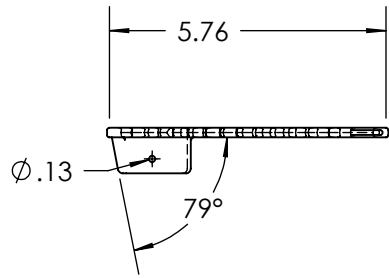
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TOLERANCES:	DESCRIPTION:			
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SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: l_topsupport2			
			PART NUMBER: PB1012	SHEET 4 of 14



DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		LEFT TOP SUPPORT 1	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: L_topsupportsweep1			
			PART NUMBER: PB1013	SHEET 5 of 14

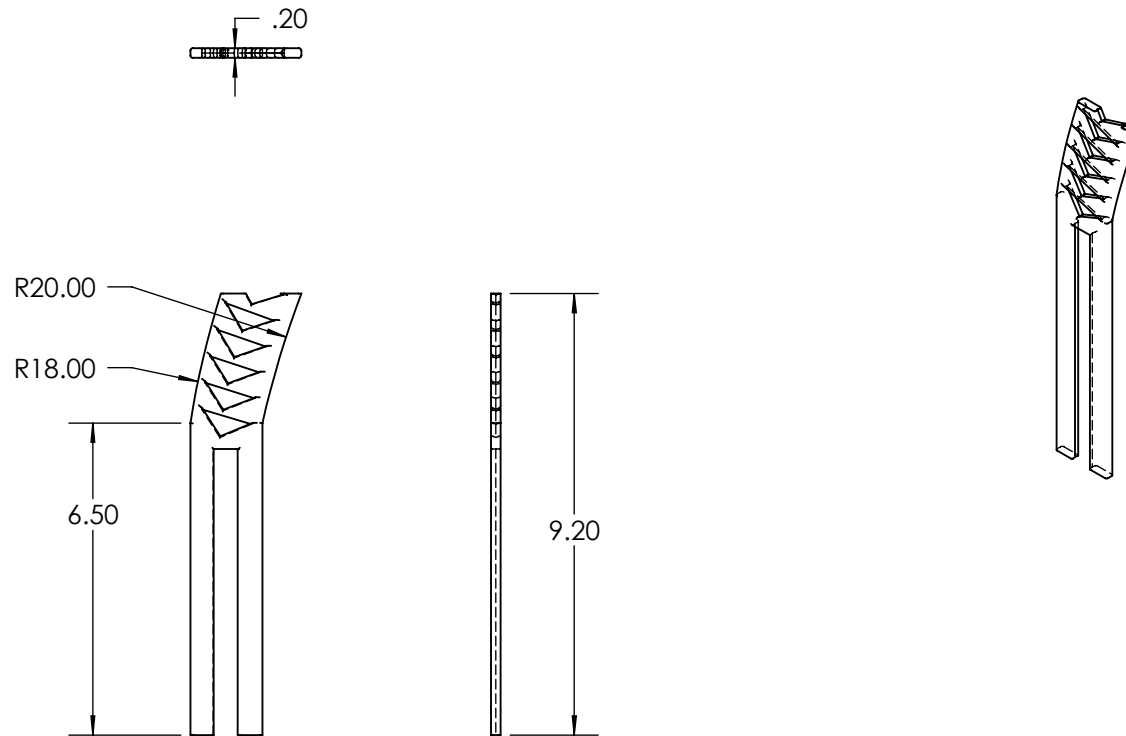


DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		RIGHT TOP LENS SUPPORT 2	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 4	FILE NAME: R_topsupportsweet2		PART NUMBER: PB1014	SHEET 6 of 14

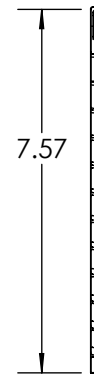
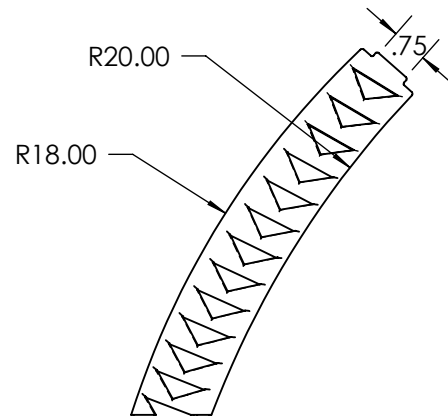
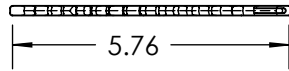


DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		RIGHT TOP SUPPORT 1	
TOLERANCES:	DESCRIPTION:			
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SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: R_topsupportsweep1			
			PART NUMBER: PB1015	SHEET 7 of 14

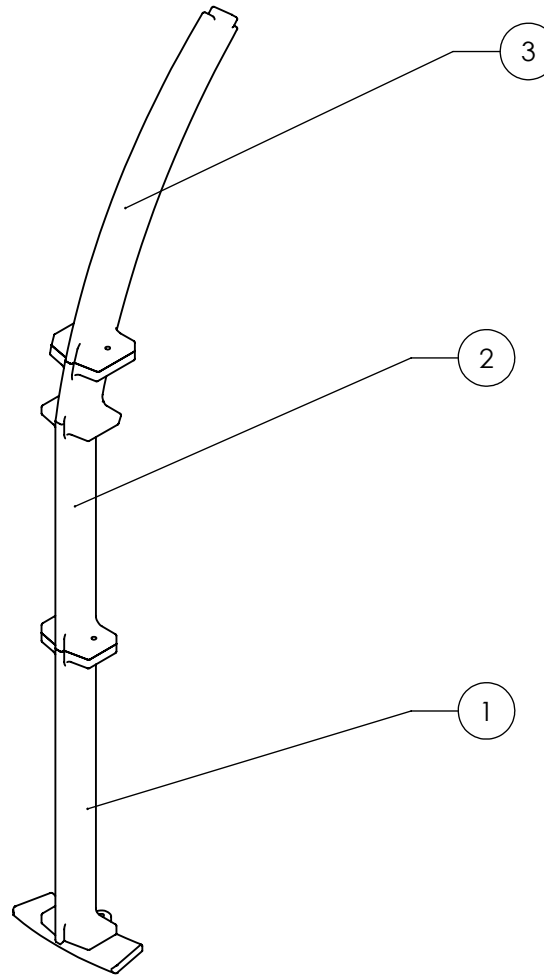
CAL POLY SAN LUIS OBISPO
ME DEPARTMENT



DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		TOP SUPPORT 2	
TOLERANCES:	DESCRIPTION:			
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SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: topsupportsweep2			

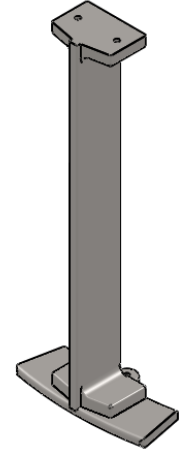
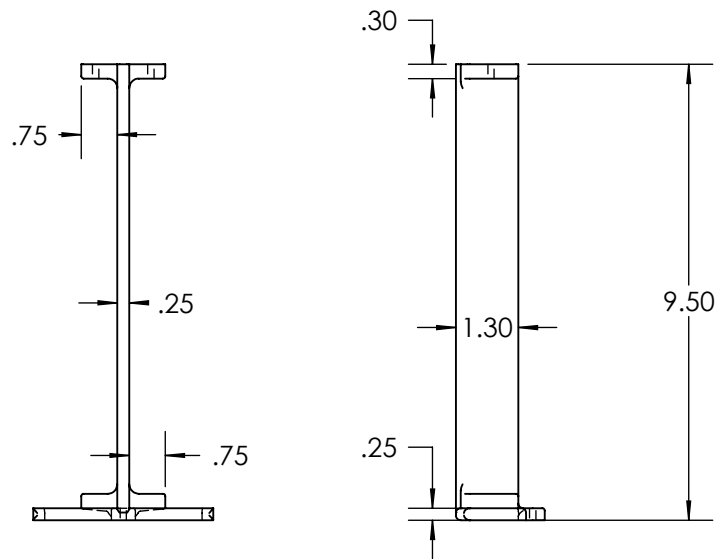
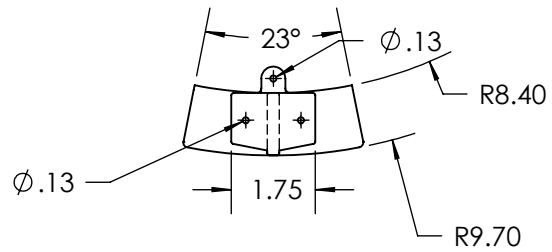


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TOLERANCES:	DESCRIPTION:			
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SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: topsupportsweep1			
			PART NUMBER: PB1017	SHEET 9 of 14

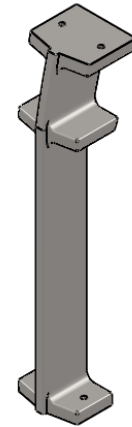
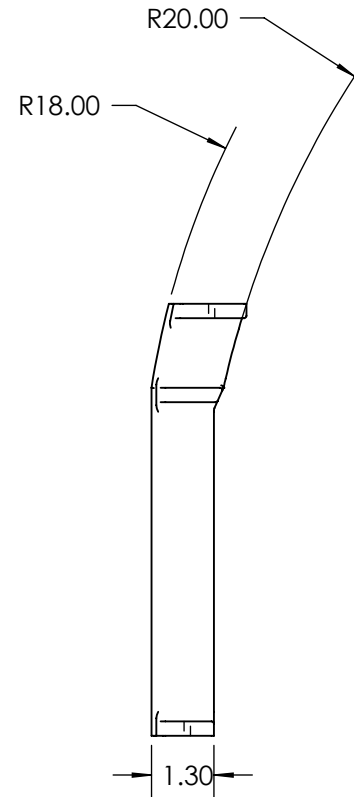
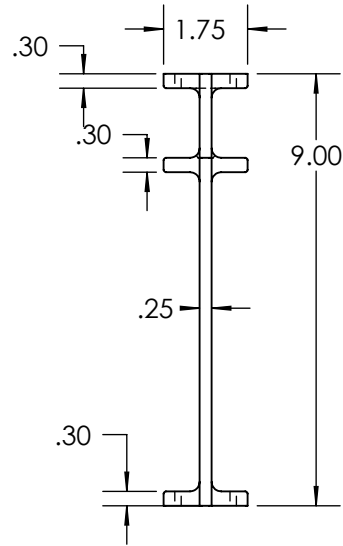
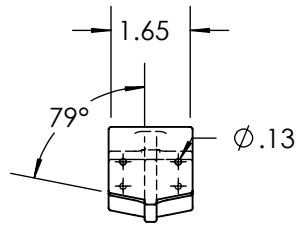


ITEM NO.	PART NUMBER	QTY.
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2	PB1022	4
3	PB1023	4

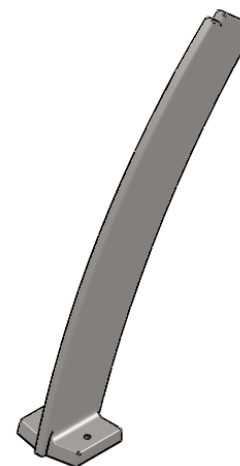
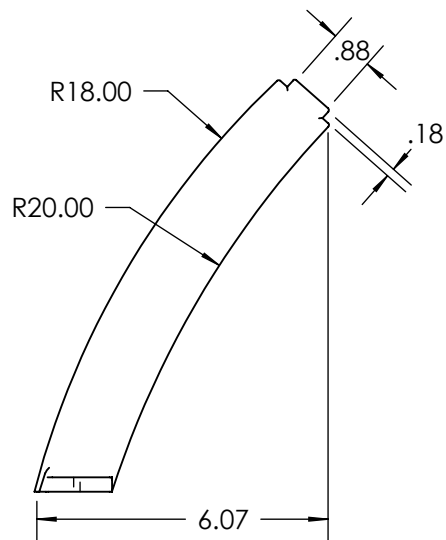
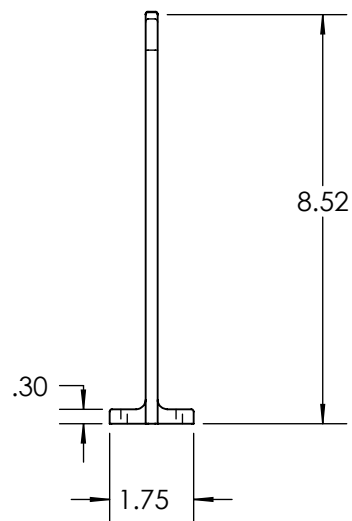
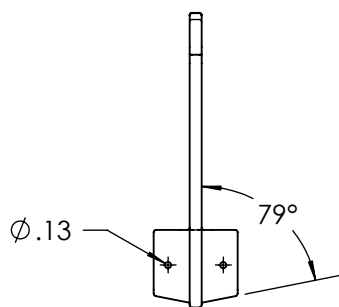
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TOLERANCES:		DESCRIPTION:			
		DRAWN BY: ANDREW JUPIN	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:5		CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 4		FILE NAME: lenssupport bottomandtopnoholes		PART NUMBER: PB1020	SHEET 10 of 14



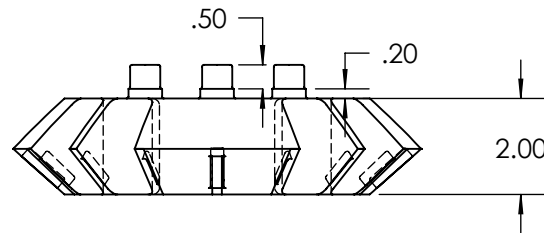
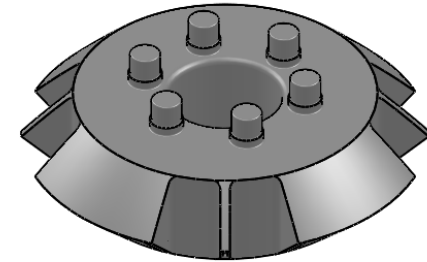
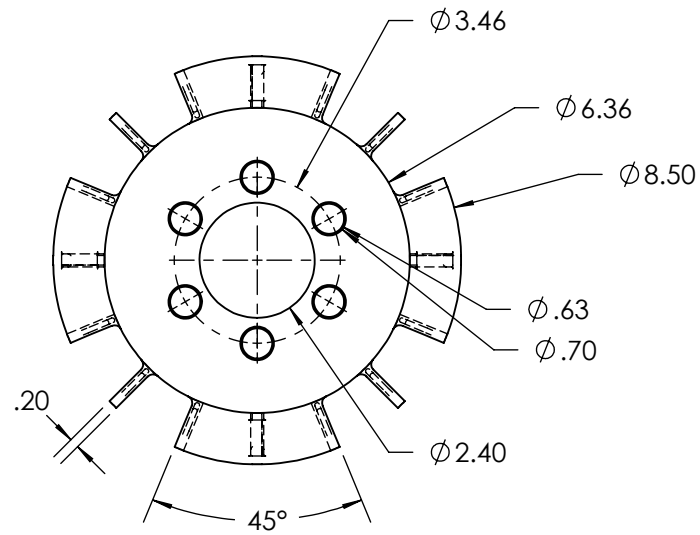
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TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: structure base no lens			



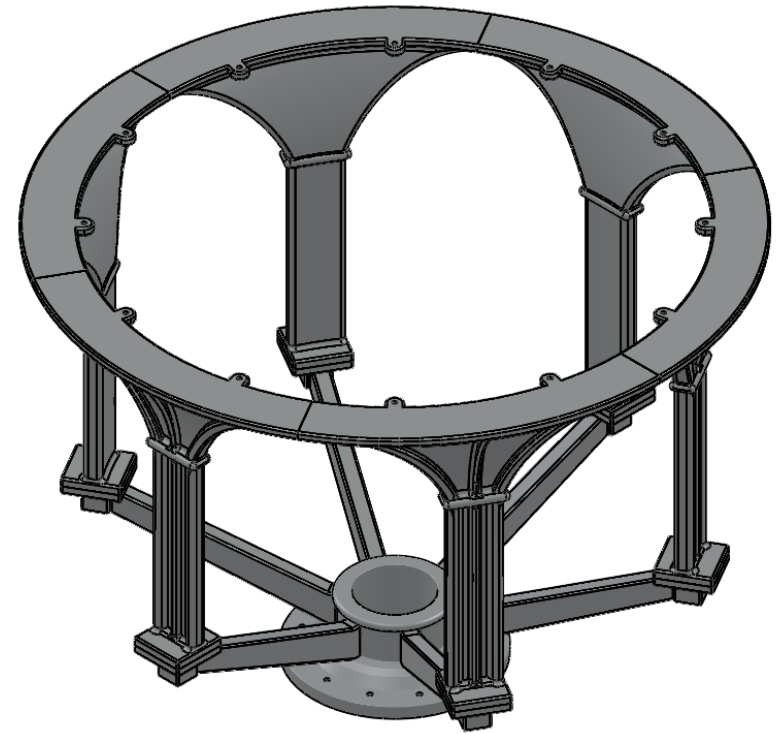
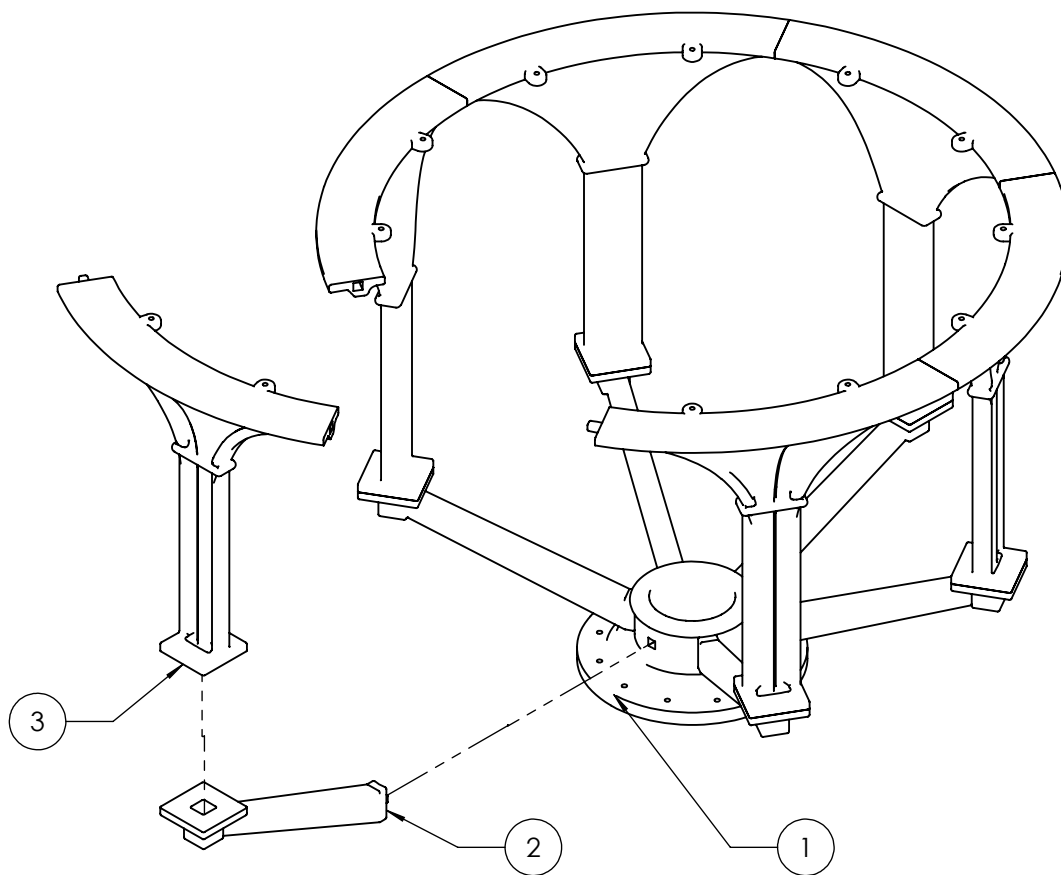
DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		TOP SUPPORT 1NO HOLES	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10		
Quantity: 4	FILE NAME: topsupportsweep1noholes		PART NUMBER PB1022	SHEET 12 of 14



DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		TOP SUPPORT 2 NO HOLES	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JUPIN	DATE: 11/23/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: topsupportsweep2			
			PART NUMBER: PB1023	SHEET 13 of 14

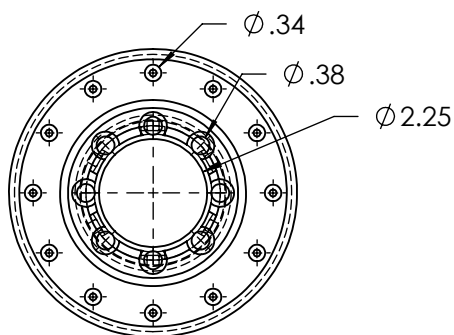
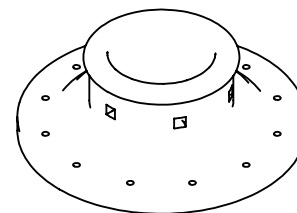
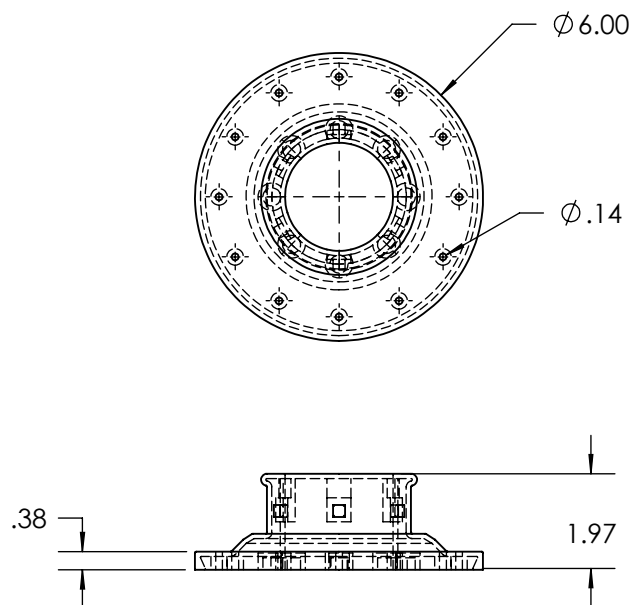


DIMENSIONS: INCHES	MATERIAL: ABS PLASTIC		CAPSTONE	
TOLERANCES:	DESCRIPTION:			
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SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 11/23/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: capstone2.0			

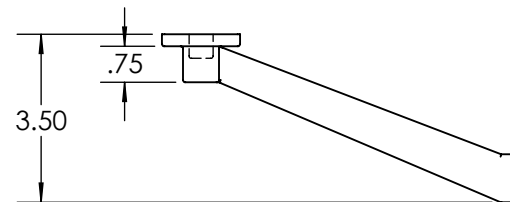
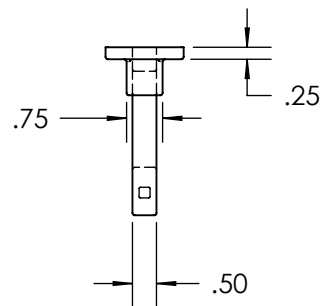
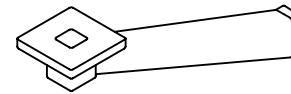
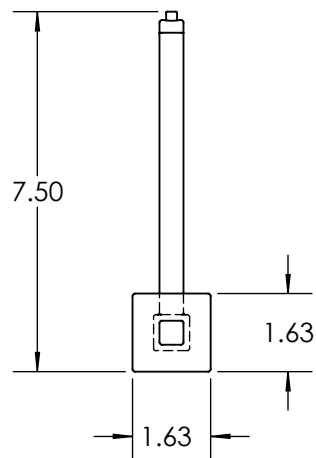


Carriage Assembly		
ITEM NO.	PART NUMBER	QTY.
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2	PB2002	6
3	PB2003	6

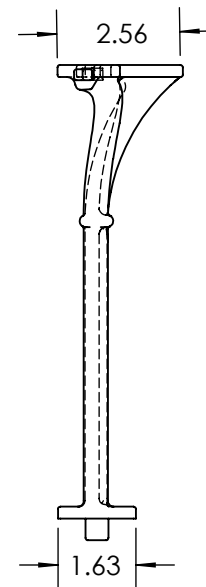
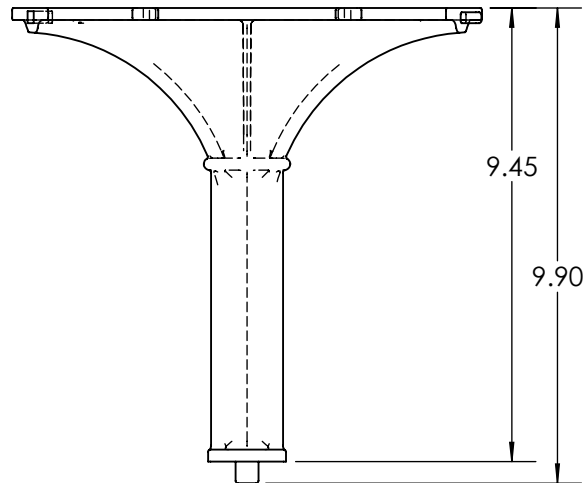
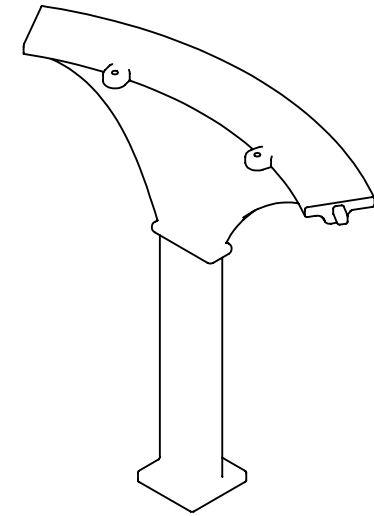
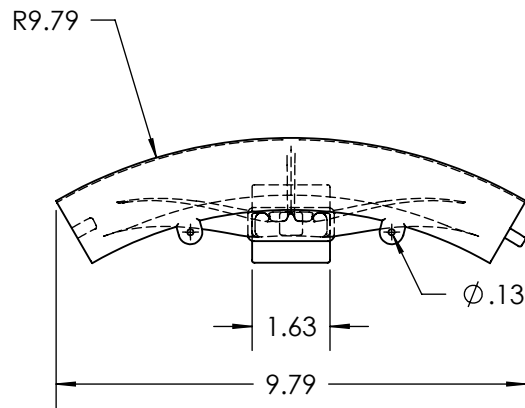
DIMENSIONS: INCHES		MATERIAL: ABS (Base Filled with Aluminium)		<h1>Carriage Assembly</h1> CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
TOLERANCES:		DESCRIPTION:			
		DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:5		CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 1		FILE NAME: Carriage Assem		PART #: PB2000	SHEET 1 of 4



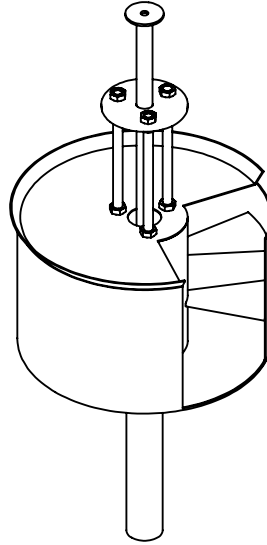
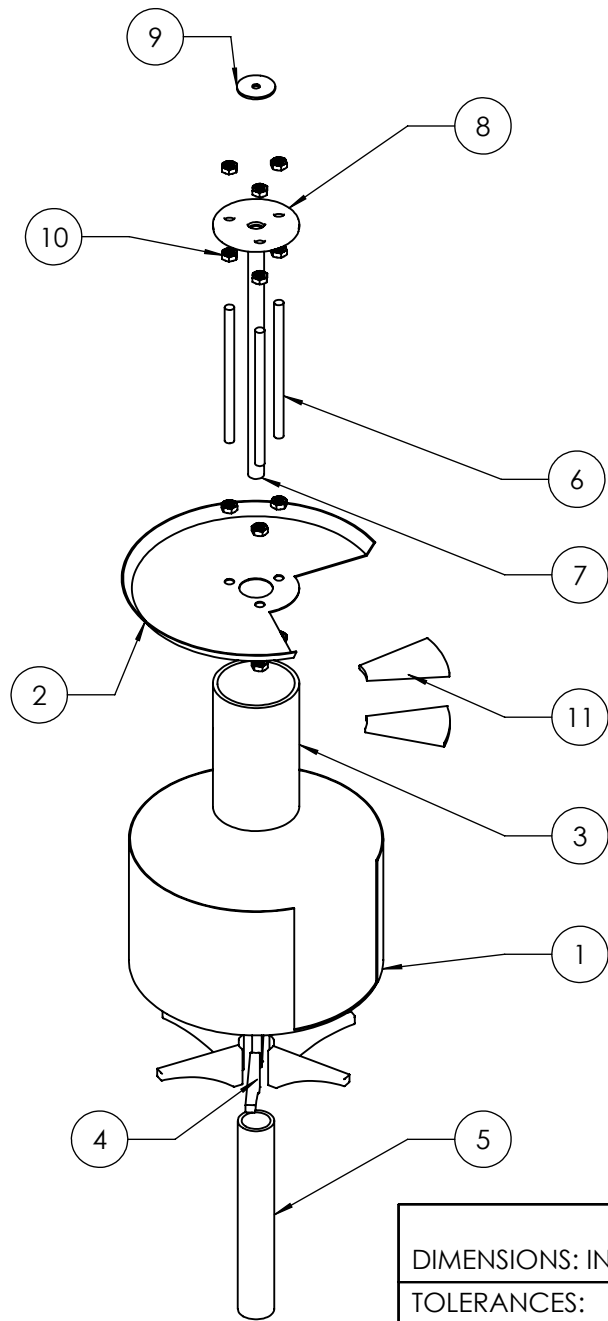
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TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 1	FILE NAME: Carriage New Base		PART #: PB2001	SHEET 2 of 4



DIMENSIONS: INCHES	MATERIAL: ABS		<div>Carriage Arm</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 6	FILE NAME: Carriage New Base Arm		PART #:PB2002	SHEET 3 of 4

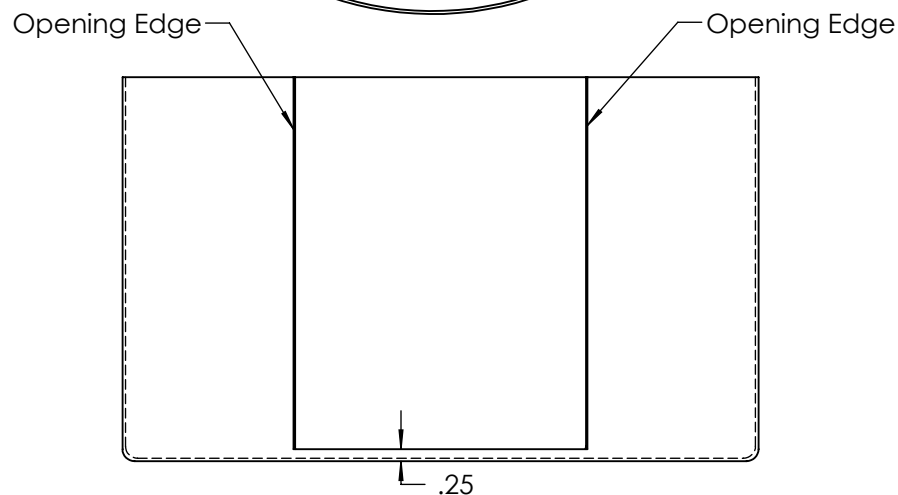
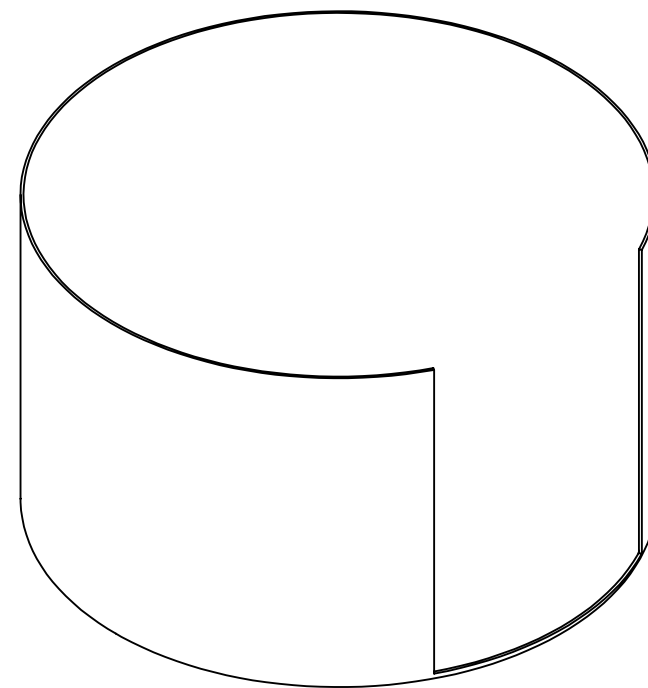
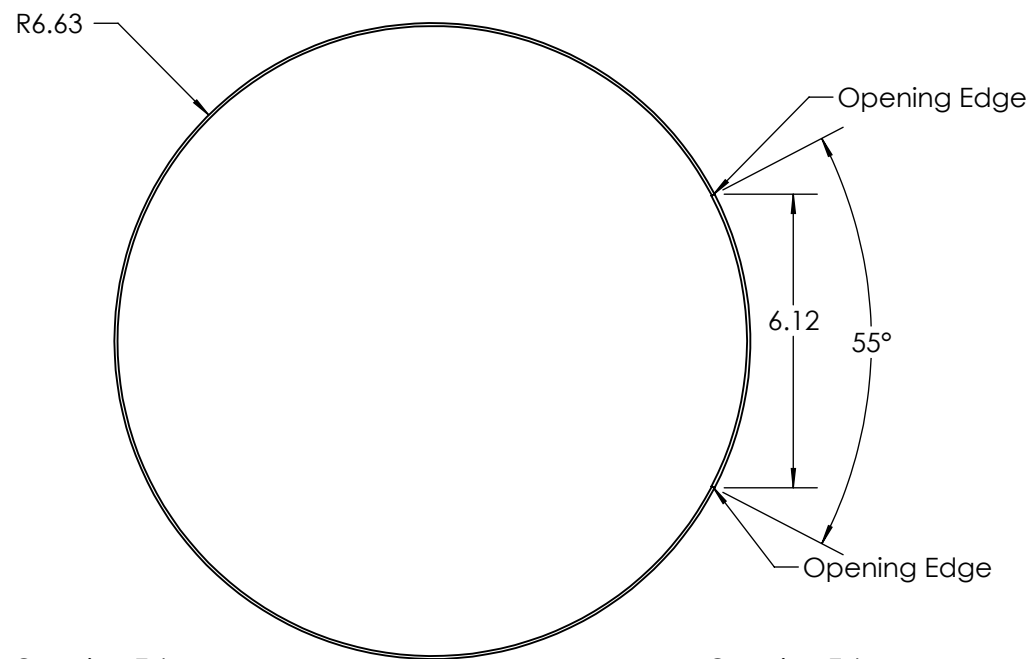


DIMENSIONS: INCHES	MATERIAL: ABS		<div>Carriage Top</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 6	FILE NAME: New Carriage Top		PART #:PB2003	SHEET 4 of 4

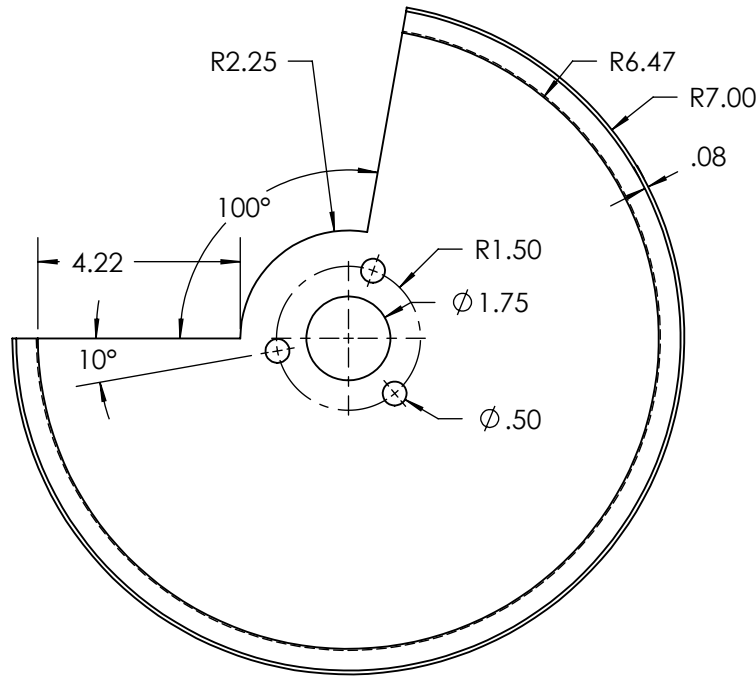
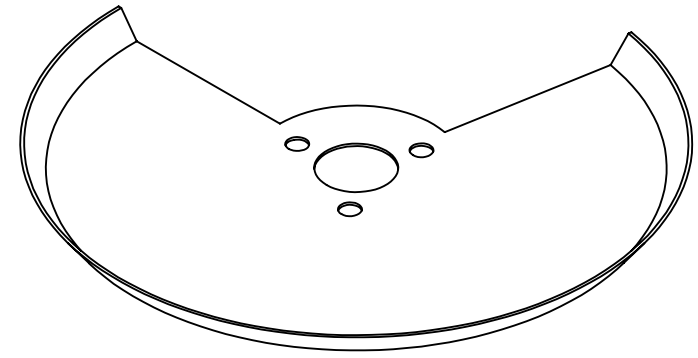
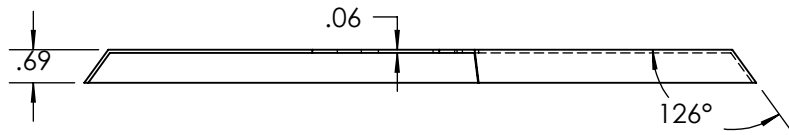


ITEM NO.	PART NUMBER	QTY.
1	PB3001	1
2	PB3002	1
3	PB3003	1
4	PB3004	6
5	PB3005	1
6	PB3006	3
7	PB3007	1
8	PB3008	1
9	PB3009	1
10	PB3010	12
11	PB3011	2

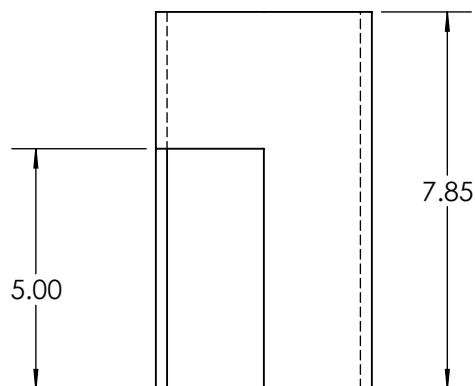
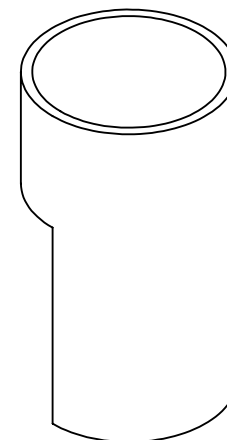
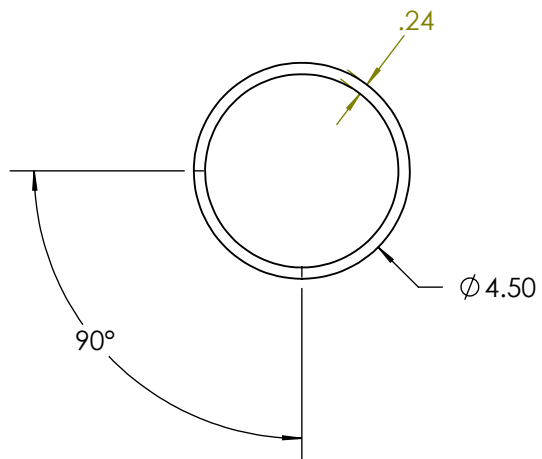
DIMENSIONS: INCHES	MATERIAL:		<div>Light Stand</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:10	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 1	FILE NAME: Stationary Light Stand Assem		PART #: PB3000	SHEET 1 of 12



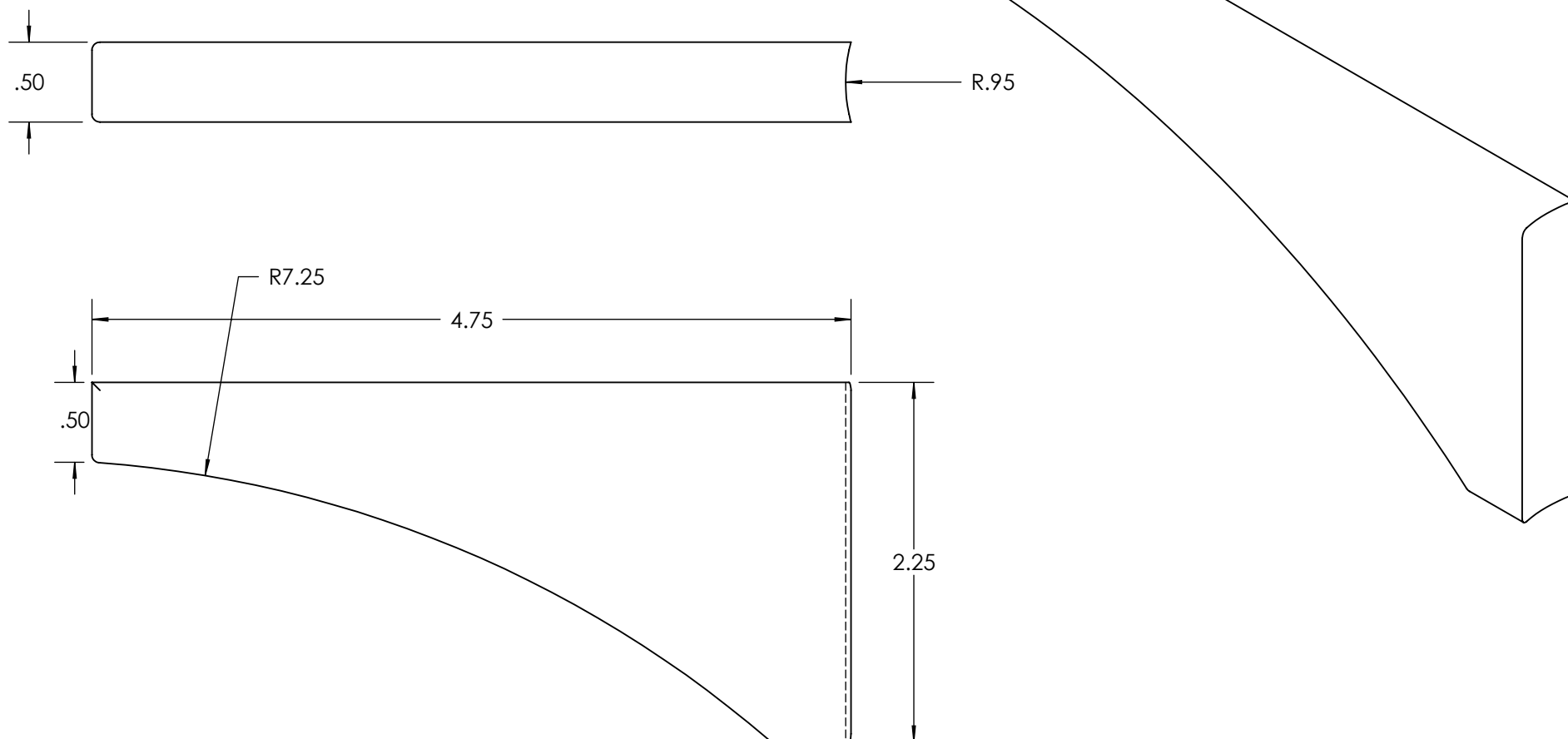
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		<div>Stand Pot</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/1/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 6/2/10		
Quantity: 1	FILE NAME: SAUCE POT		PART #: PB3001	SHEET 2 of 12



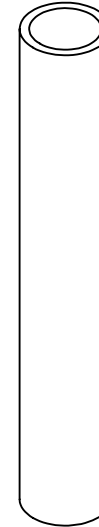
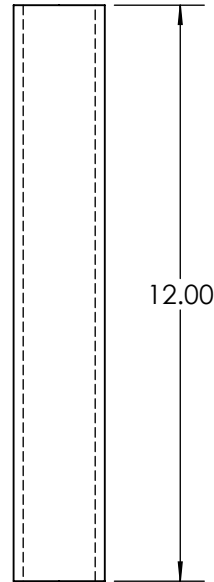
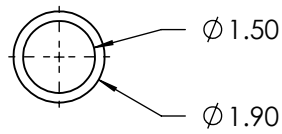
DIMENSIONS: INCHES	MATERIAL: ALUMINIUM		PIZZA PAN	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 6/2/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: PIZZA PAN			



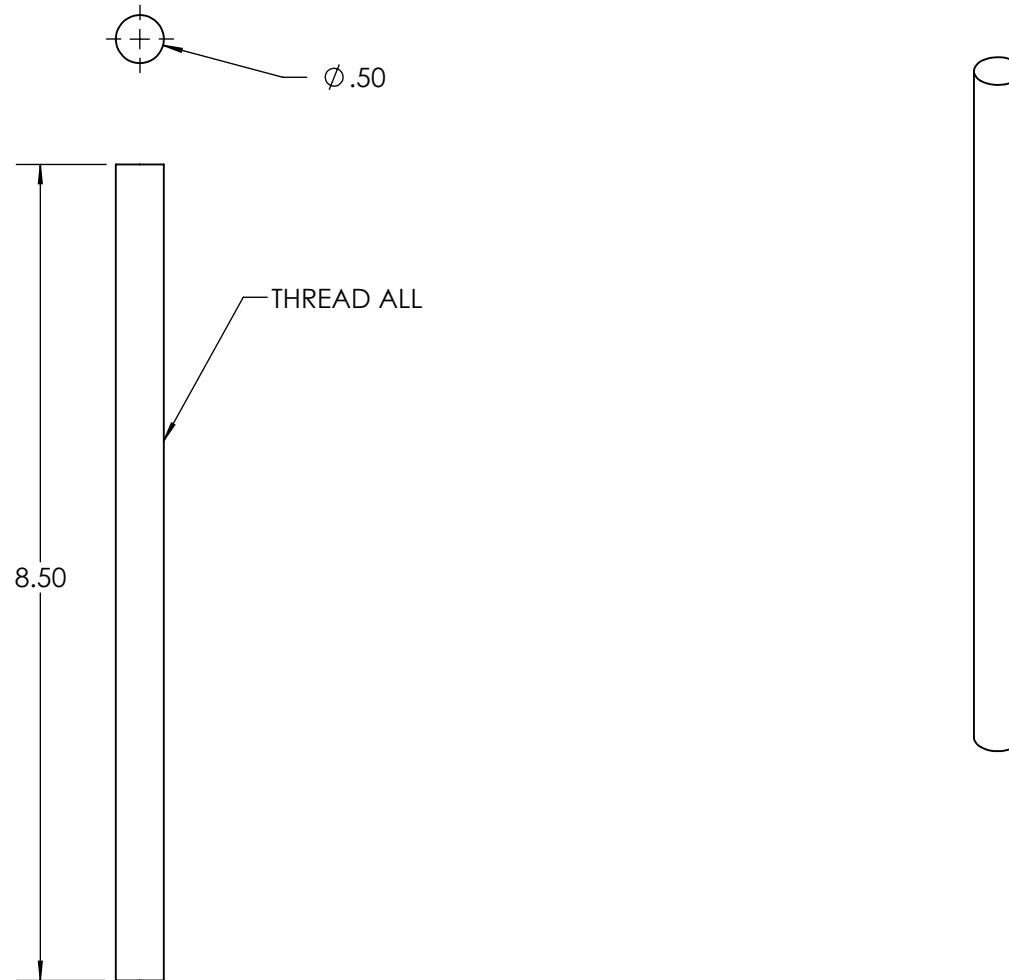
DIMENSIONS: INCHES	MATERIAL: PVC		INSIDE CYLINDER	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 6/2/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: INSIDE CYLINDER			



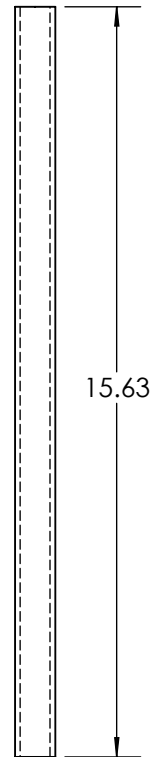
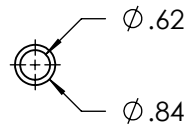
DIMENSIONS: INCHES	MATERIAL: ABS		FLANGE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:1	CHECKED BY: MATT WEBER	DATE: 6/2/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 6	FILE NAME: FLANGE			



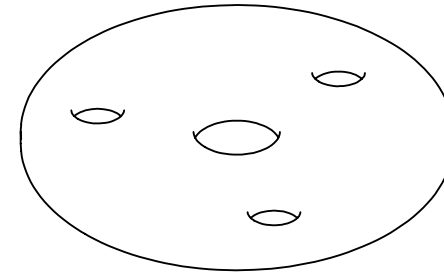
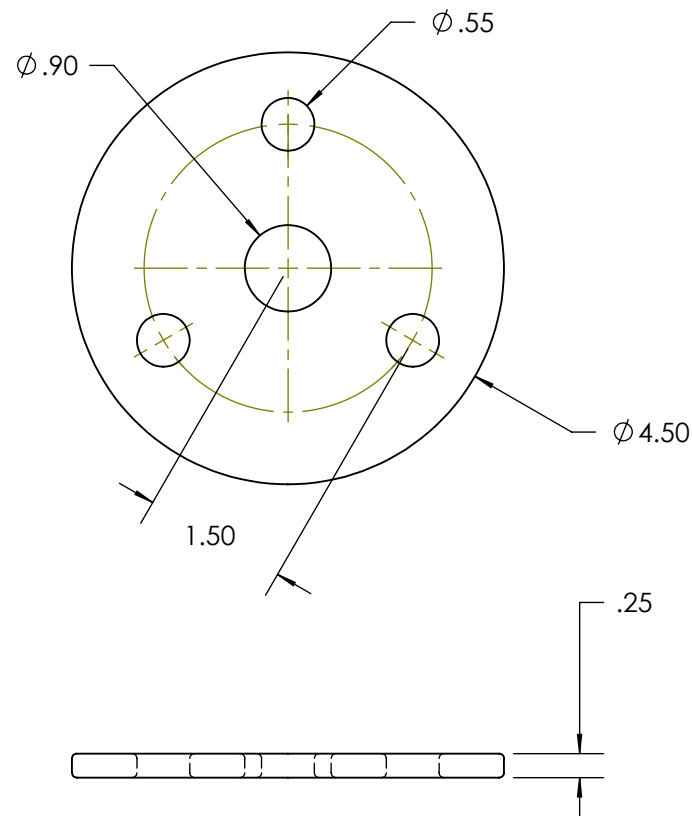
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		BASE CONNECTOR	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 6/2/10		
Quantity: 1	FILE NAME: FEMALE PIPE BASE CONNECTOR		PART #: PB3005	SHEET 6 of 12



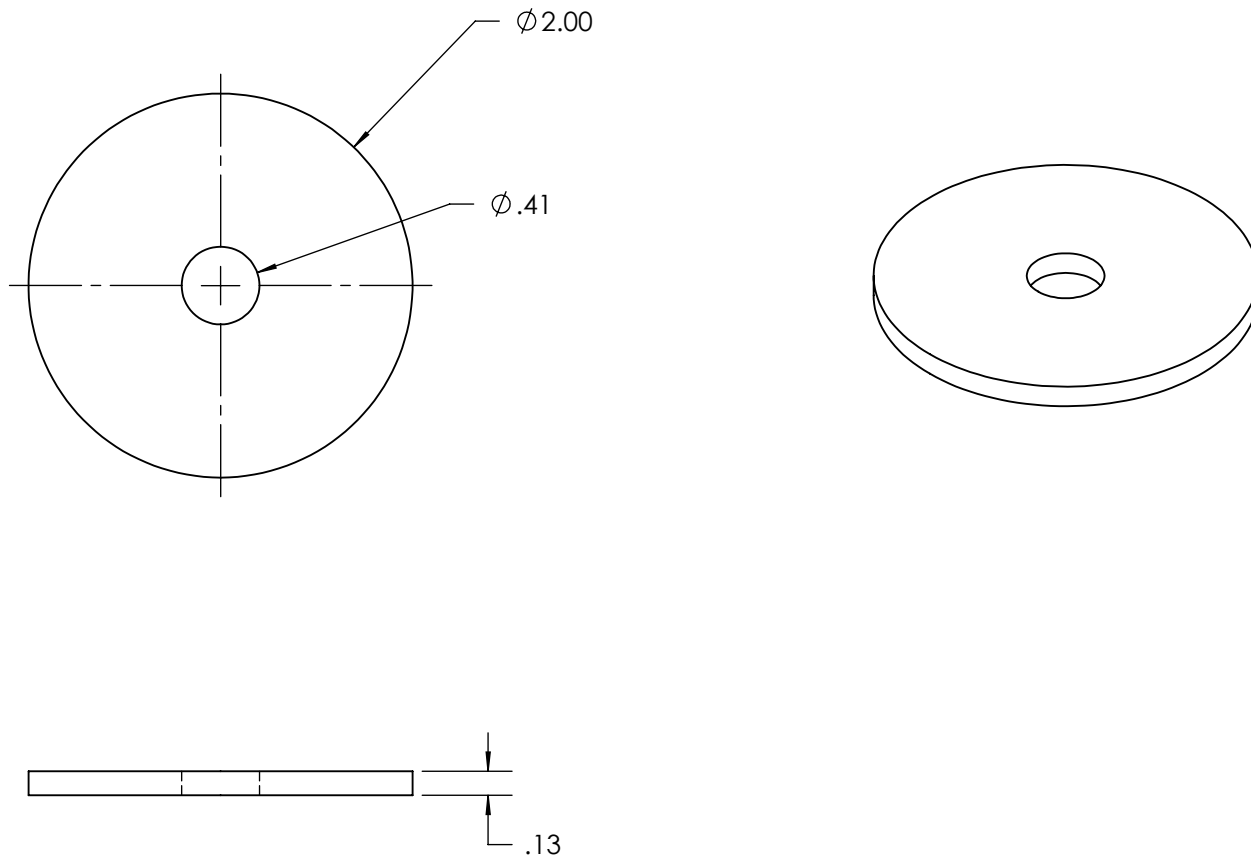
DIMENSIONS: INCHES	MATERIAL: ALUMINIUM		SUPPORT ROD	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 5/21/10		
SCALE: 1:2	CHECKED BY: MATT WEBER	DATE: 5/21/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 3	FILE NAME: LIGHT STAND SUPPORT ROD			



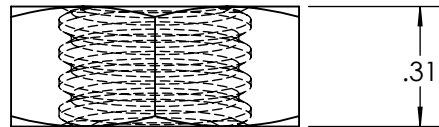
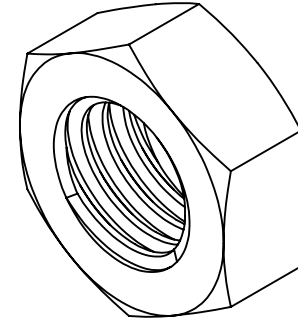
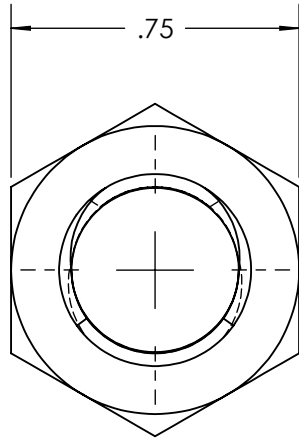
DIMENSIONS: INCHES	MATERIAL: PVC		<div>LIGHT STAND WIRE HOUSING</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 5/21/10		
Quantity: 1	FILE NAME: LIGHT STAND WIRE HOUSING		PART #: PB3007	SHEET 8 of 12



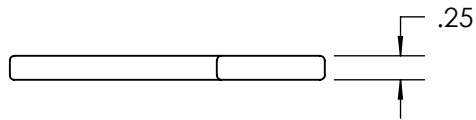
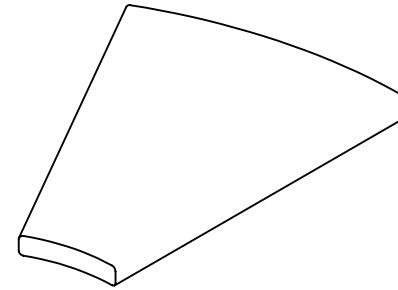
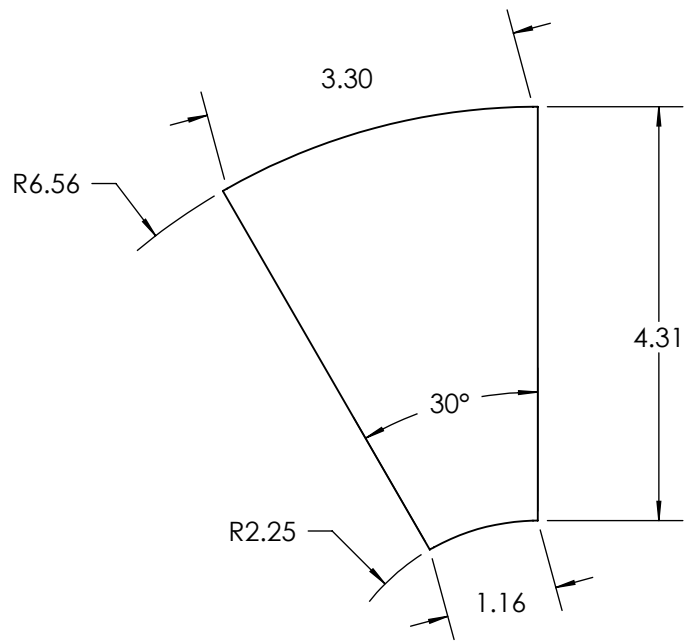
DIMENSIONS: INCHES	MATERIAL: ABS		BOTTOM STAND DISK	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:2	CHECKED BY: MATT WEBER	DATE: 6/2/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: BOTTOM STAND DISK			



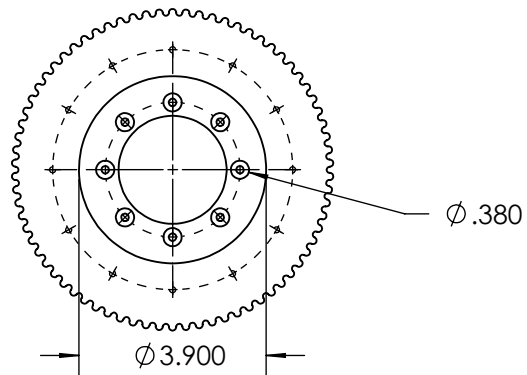
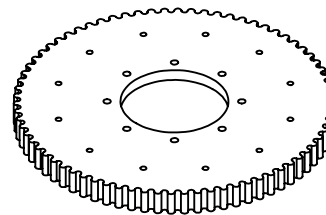
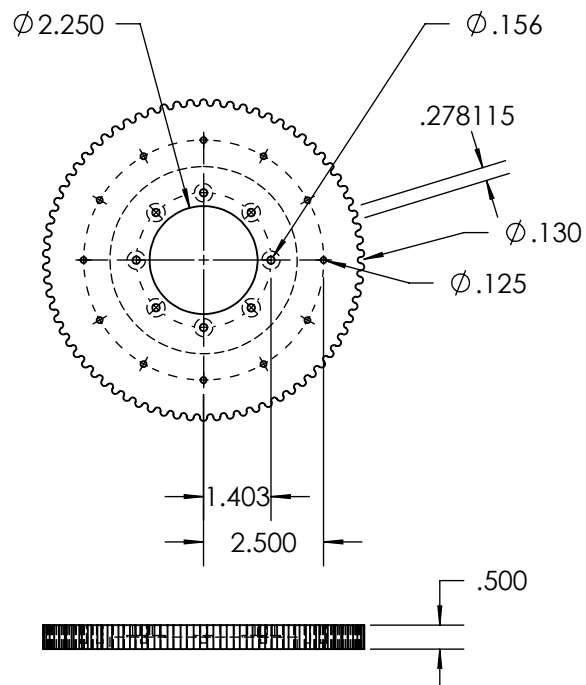
DIMENSIONS: INCHES	MATERIAL: Plastic		<div>Top Stand Disk</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 1	FILE NAME: Top Stand Disk		PART #: PB3009	SHEET 10 of 12



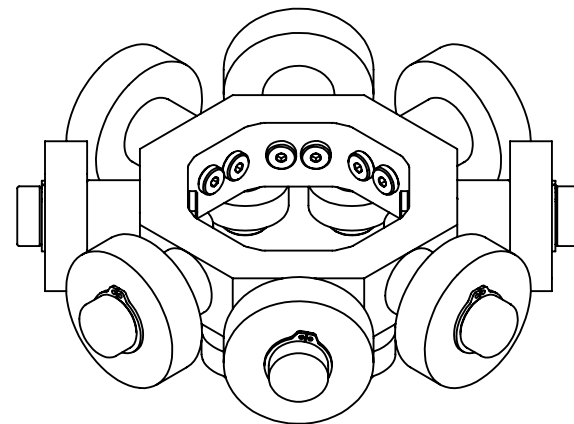
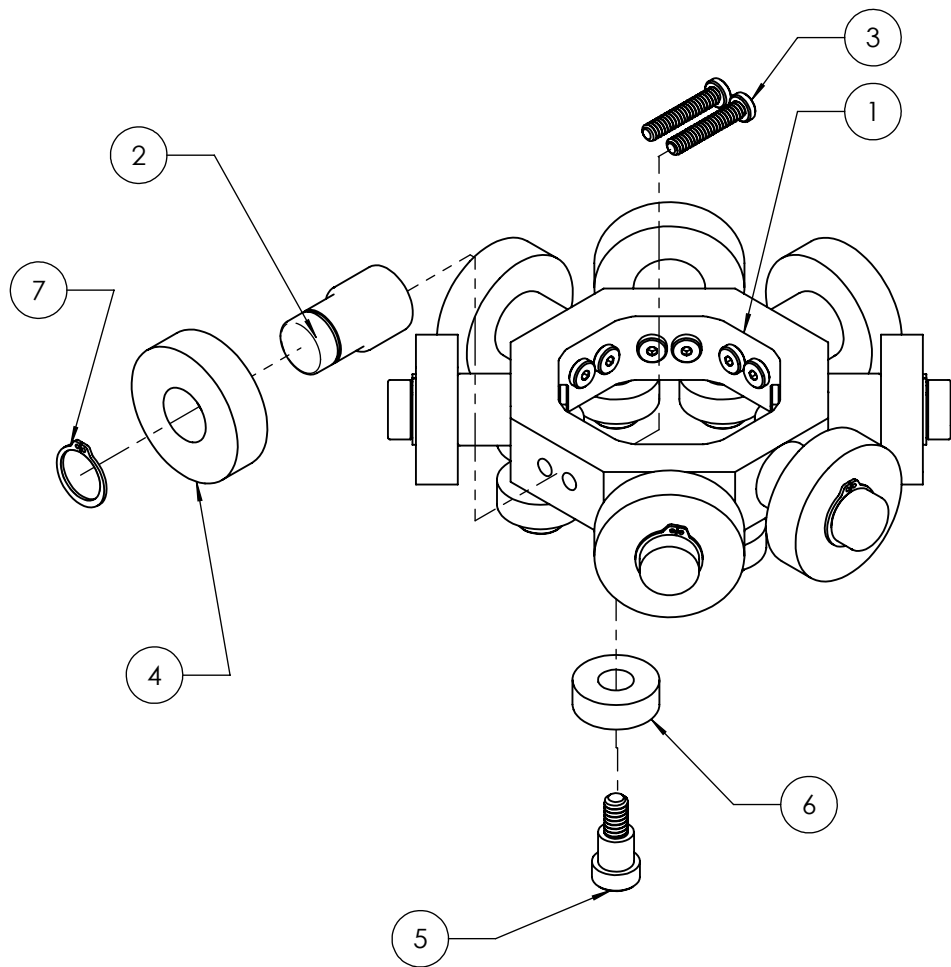
DIMENSIONS: INCHES	MATERIAL: STAINLESS STEEL		STAND HEX NUT CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 2:1	CHECKED BY: MATT WEBER	DATE: 6/2/10		
Quantity: 12	FILE NAME: HUX NUT		PART #: PB3010	SHEET 11 of 12



DIMENSIONS: INCHES	MATERIAL: ALUMINIUM		<div>Stand Step</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 6/2/10		
SCALE: 1:2	CHECKED BY: MATT WEBER	DATE: 6/2/10		
Quantity: 2	FILE NAME: STEP		PART #: PB3011	SHEET 12 of 12

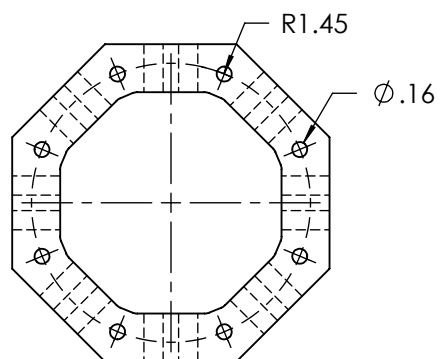
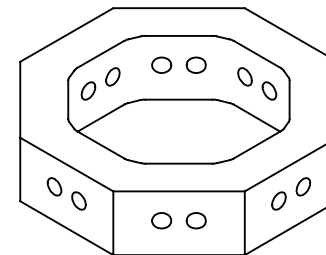
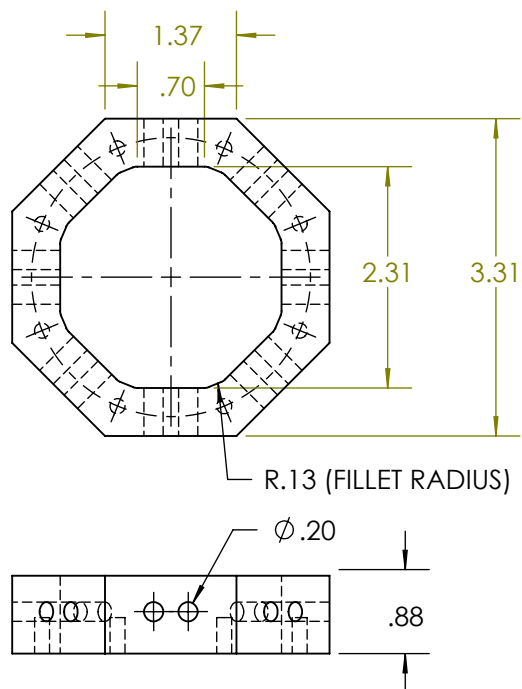


DIMENSIONS: INCHES	MATERIAL: BRASS		<div>Special Gear</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 9/30/10		
SCALE: 1:4	CHECKED BY: MATT WEBER	DATE: 9/30/10		
Quantity: 1	FILE NAME: New Special Gear		PART #: PB4000	SHEET 1 of 1

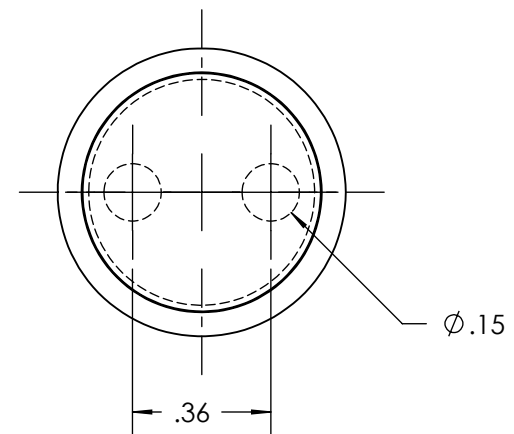
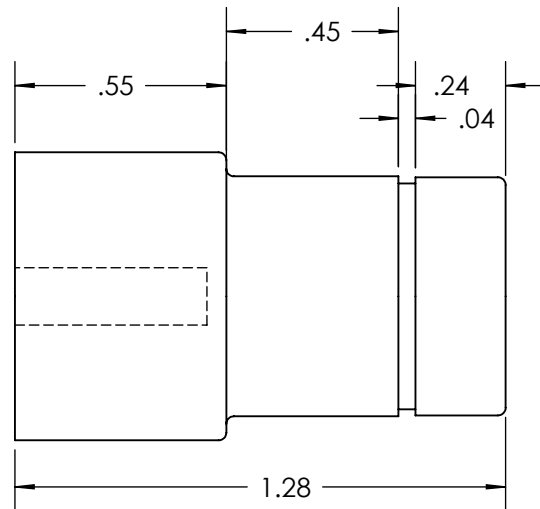
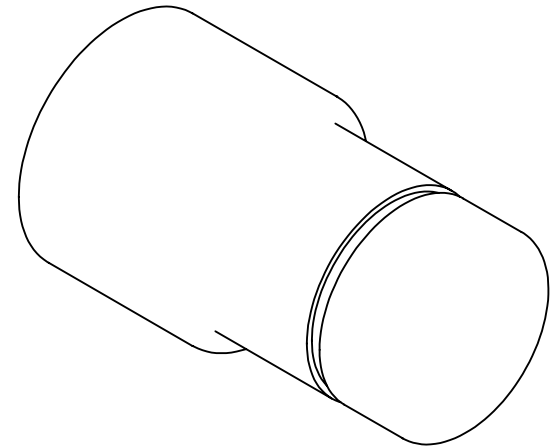
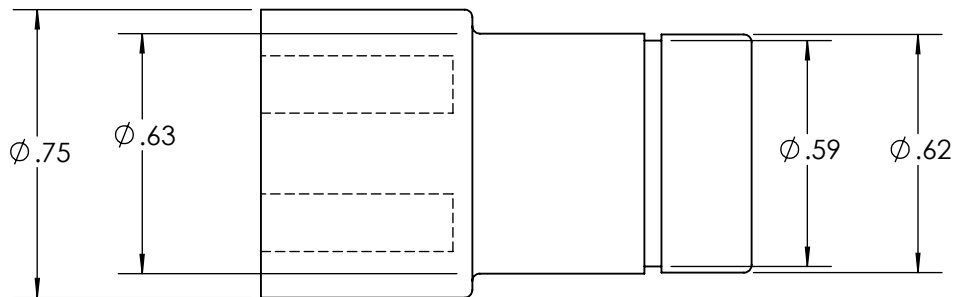


ITEM NO.	PART NUMBER	QTY.
1	PB5001	1
2	PB5002	8
3	PB5003	16
4	PB5004	8
5	PB5005	8
6	PB5006	8
7	PB5007	8

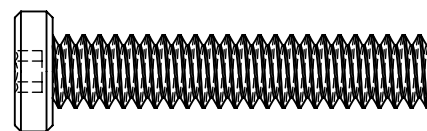
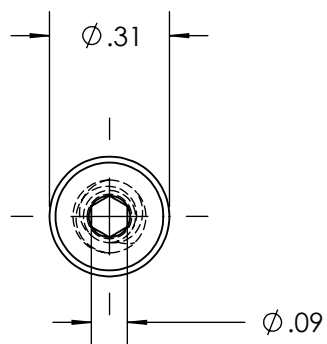
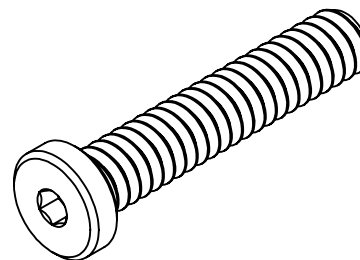
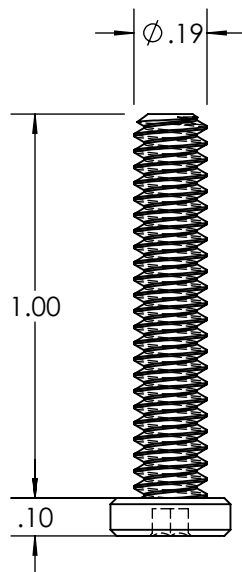
DIMENSIONS: INCHES	MATERIAL:		<div>CHARIOT ASSEMBLY</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:2	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 1	FILE NAME: New Chariot Assem		PART #: PB5000	SHEET 1 of 8



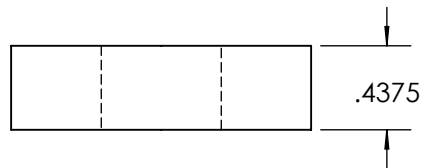
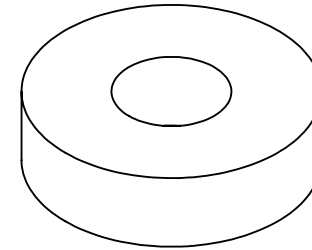
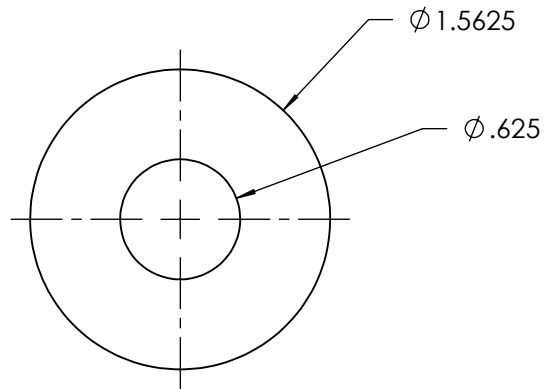
DIMENSIONS: INCHES	MATERIAL: BRASS		CHARIOT RING	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:2	CHECKED BY: MATT WEBER	DATE: 10/1/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Mod Chariot Ring 2			



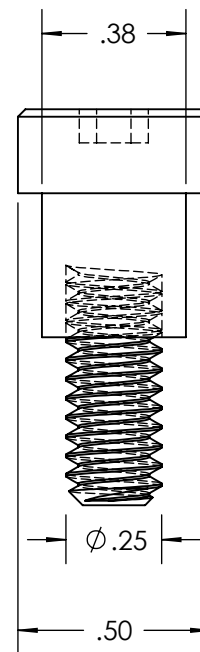
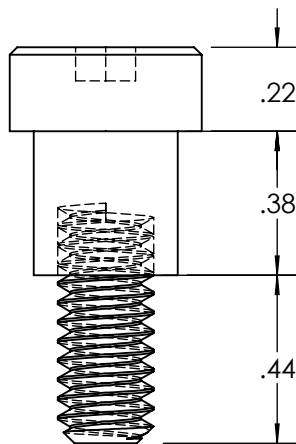
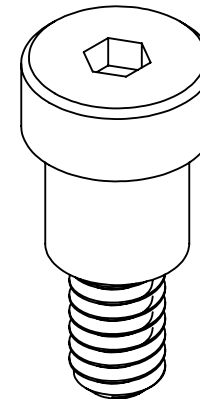
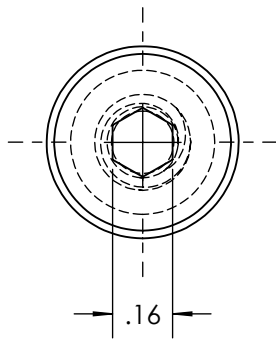
DIMENSIONS: INCHES	MATERIAL: BRASS		CHARIOT AXEL	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 2:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 8	FILE NAME: Mod New Axel		PART #: PB5002	SHEET 3 of 8



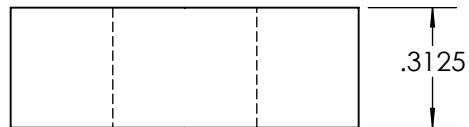
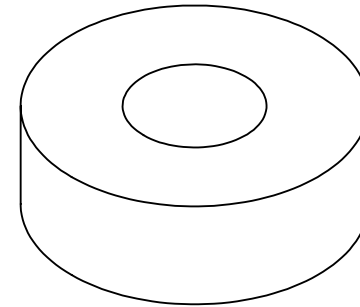
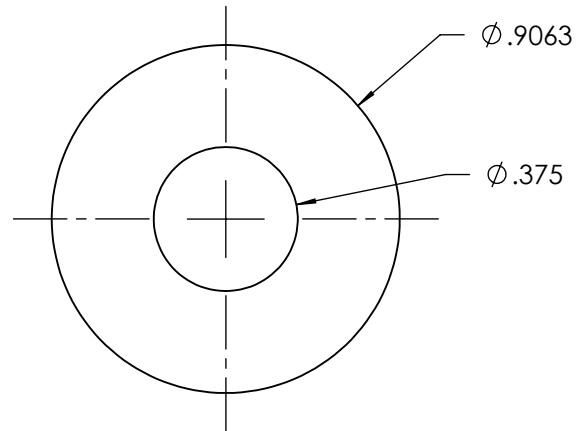
DIMENSIONS: INCHES	MATERIAL: Stainless Steel		<div>Axle Screw</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 4:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 16	FILE NAME: Outer Wheel Hub Screw		PART #: PB5003	SHEET 4 of 8



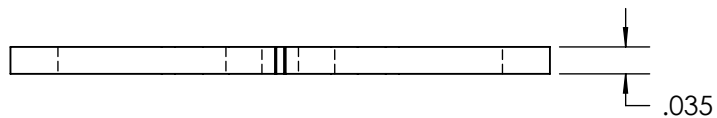
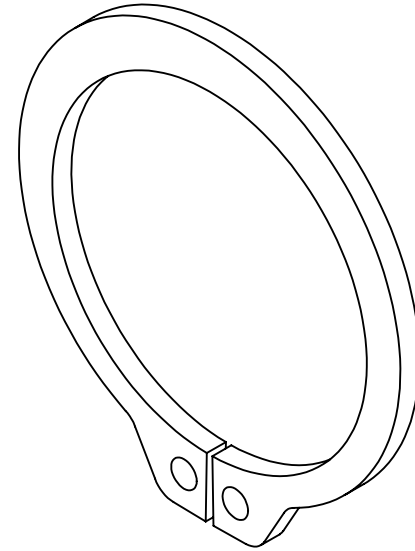
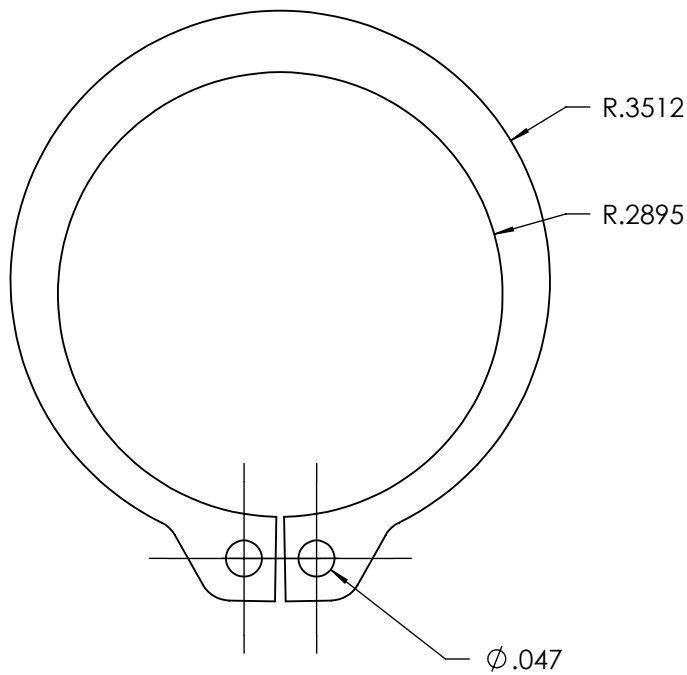
DIMENSIONS: INCHES	MATERIAL: Stainless Steel		<div>Chariot Outer Wheel</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 1:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 8	FILE NAME: Outer Wheel		PART #: PB5004	SHEET 5 of 8



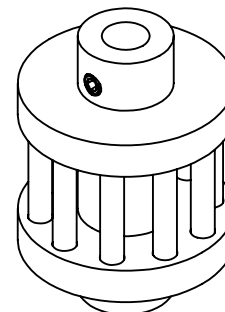
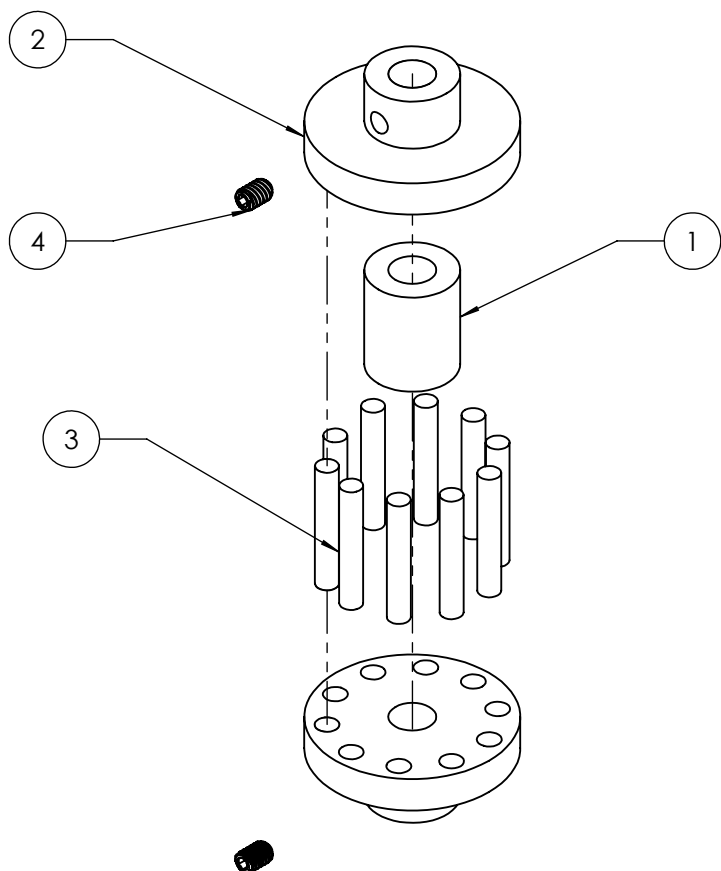
DIMENSIONS: INCHES	MATERIAL: Stainless Steel		<div>Shoulder Screw</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 2:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 8	FILE NAME: Inner Wheel Shoulder Screw		PART #: PB5005	SHEET 6 of 8



DIMENSIONS: INCHES	MATERIAL: Stainless Steel		<div>Chariot Inner Wheel</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 2:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 8	FILE NAME: Inner Wheel		PART #: PB5006	SHEET 7 of 8

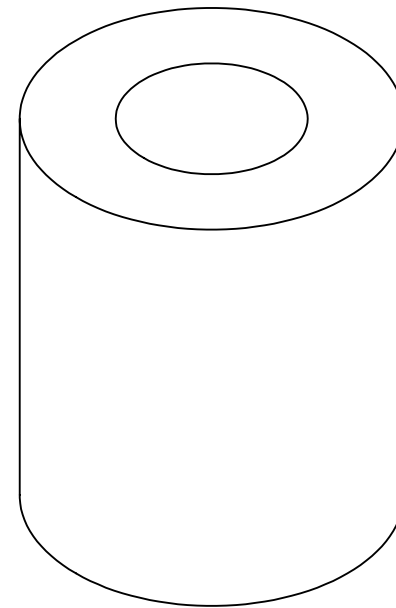
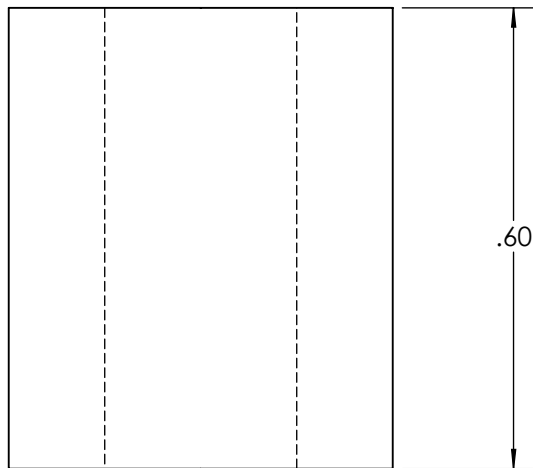
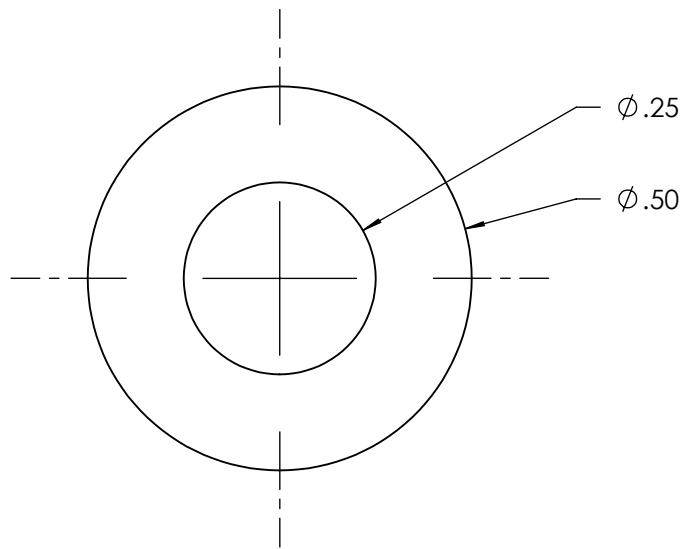


DIMENSIONS: INCHES	MATERIAL: Stainless Steel		<div>Lock Ring</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10		
SCALE: 4:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 8	FILE NAME: Lock Ring 5_8th		PART #: PB5007	SHEET 8 of 8

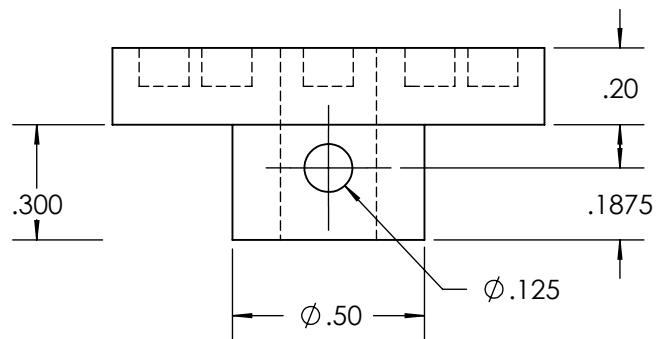
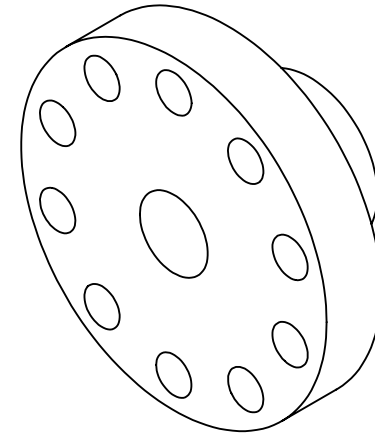
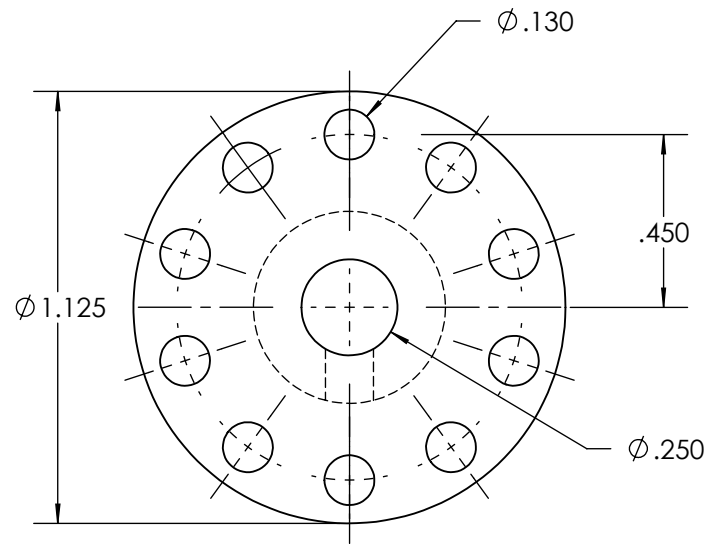


ITEM NO.	PART NUMBER	QTY.
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2	PB6002	2
3	PB6003	10
4	PB6004	2

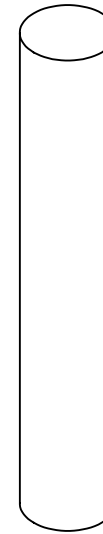
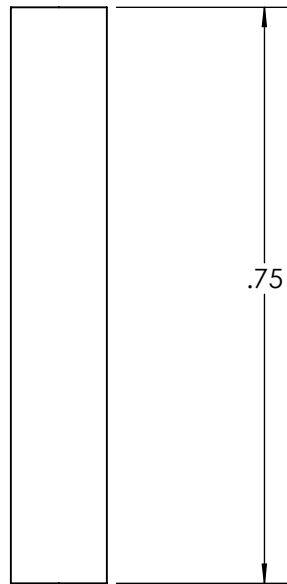
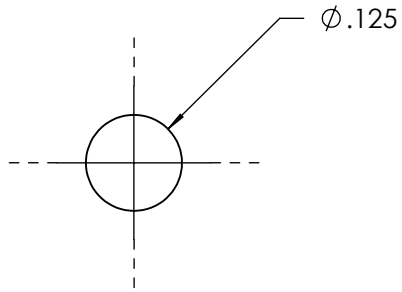
DIMENSIONS: INCHES		MATERIAL:		<div>Cage Gear</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>			
TOLERANCES:		DESCRIPTION:					
		DRAWN BY: ANDREW JAMES	DATE: 9/30/10				
SCALE: 1:1		CHECKED BY: MATT WEBER	DATE: 9/30/10				
Quantity: 1		FILE NAME: Cage Gear Assem		PART #: PB6000		SHEET 1 of 5	



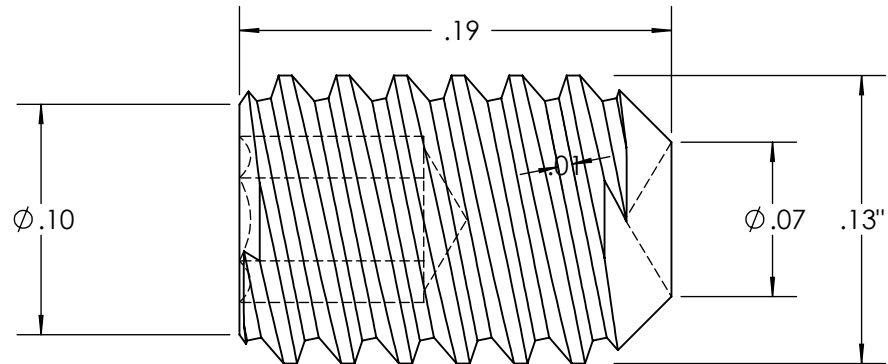
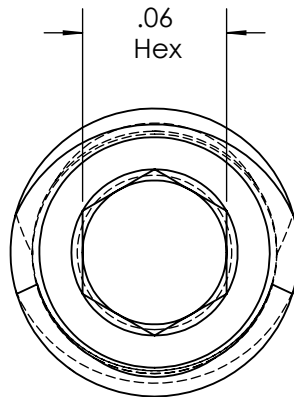
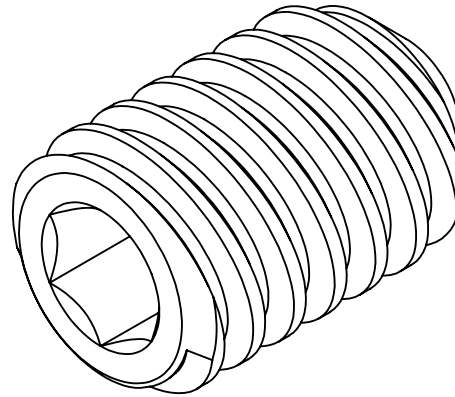
DIMENSIONS: INCHES	MATERIAL: BRASS		<div>CAGE GEAR PRESSURE CYLINDER</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 9/30/10		
SCALE: 4:1	CHECKED BY: MATT WEBER	DATE: 9/30/10		
Quantity: 1	FILE NAME: Cage Pressure Cylinder		PART #: PB6001	SHEET 2 of 5



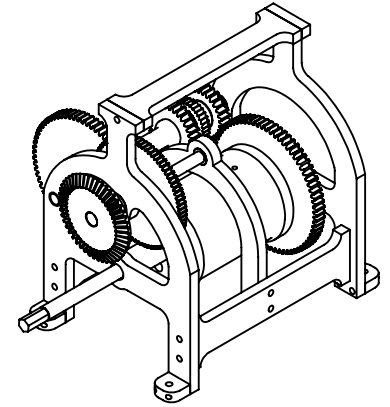
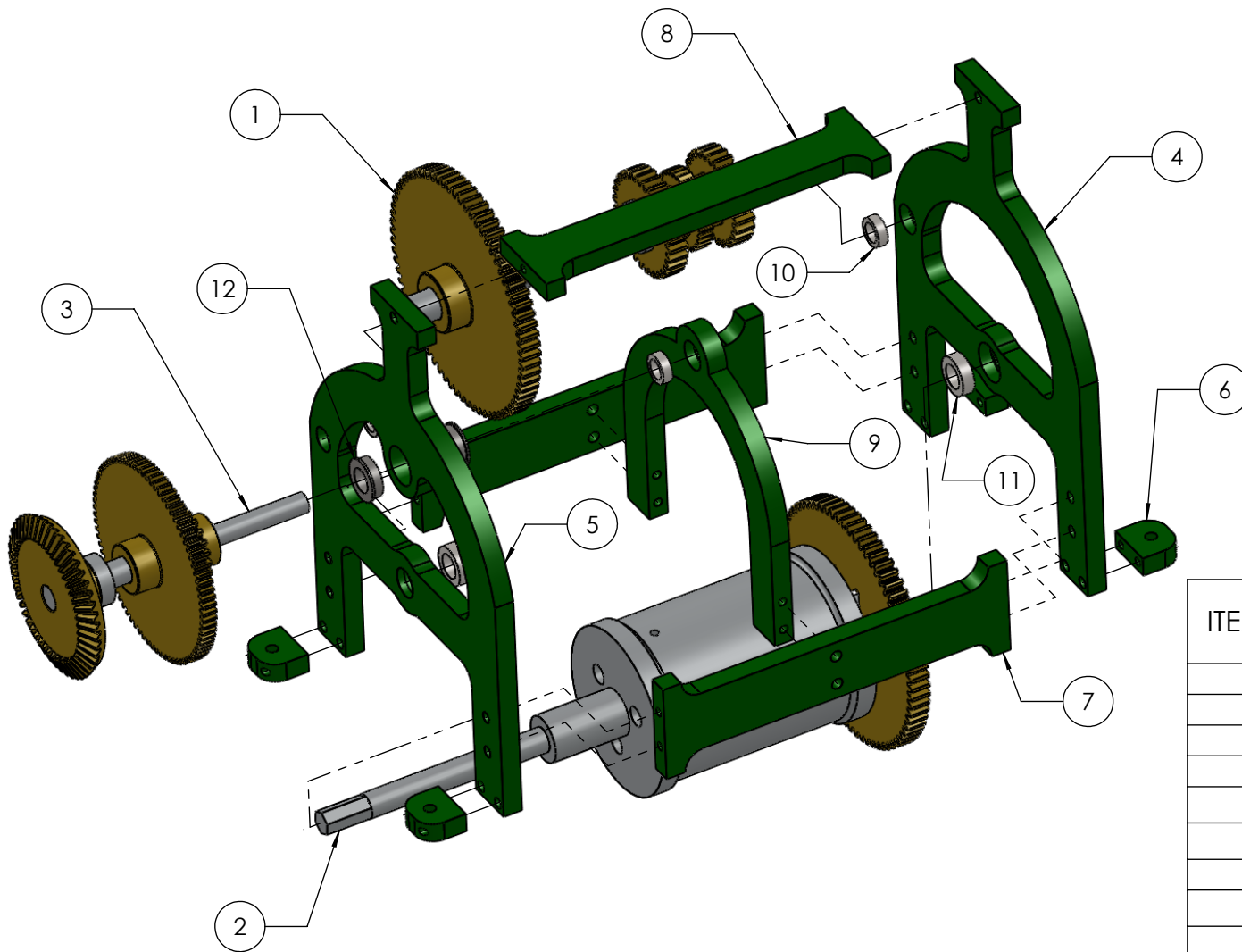
DIMENSIONS: INCHES	MATERIAL: BRASS		<div>Cage Gear Base Plate</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 9/30/10		
SCALE: 2:1	CHECKED BY: MATT WEBER	DATE: 9/30/10		
Quantity: 2	FILE NAME: Cage Gear Base Plate		PART #: PB6002	SHEET 3 of 5



DIMENSIONS: INCHES	MATERIAL: BRASS		<div>Cage Gear Pin</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 9/30/10		
SCALE: 4:1	CHECKED BY: MATT WEBER	DATE: 9/30/10		
Quantity: 10	FILE NAME: Cage Gear Pin		PART #: PB6003	SHEET 4 of 5

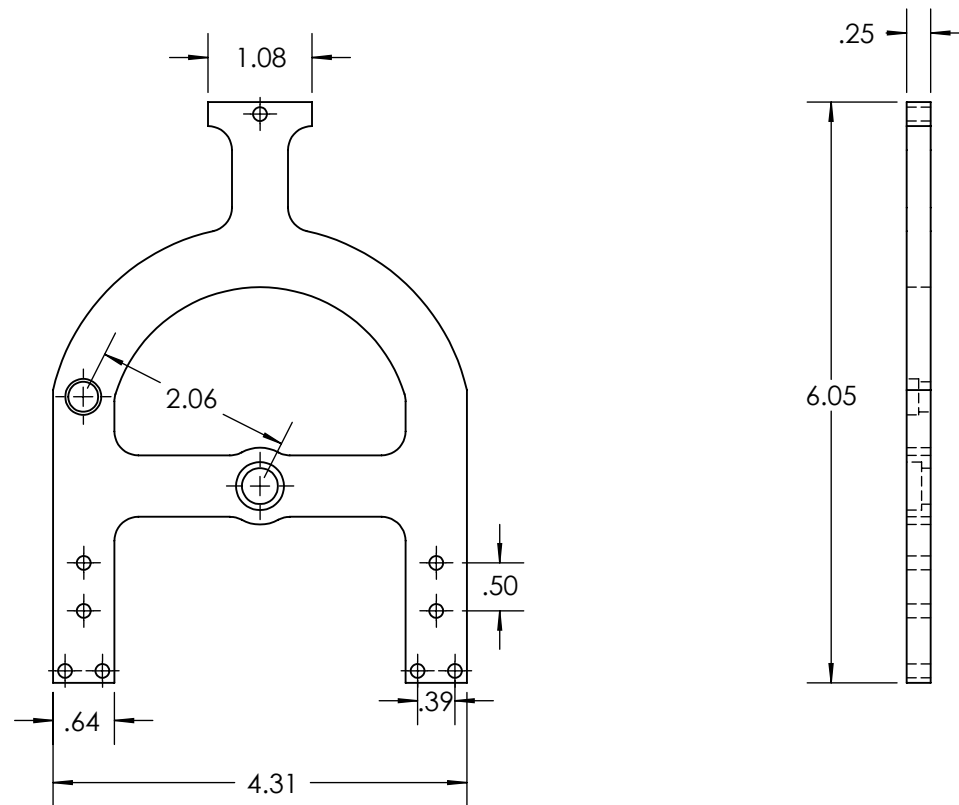


DIMENSIONS: INCHES	MATERIAL: Stainless Steel		Set Screw	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: ANDREW JAMES	DATE: 10/1/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 12:1	CHECKED BY: MATT WEBER	DATE: 10/1/10		
Quantity: 2	FILE NAME: Set Screw		PART #: PB6004	SHEET 5 of 5

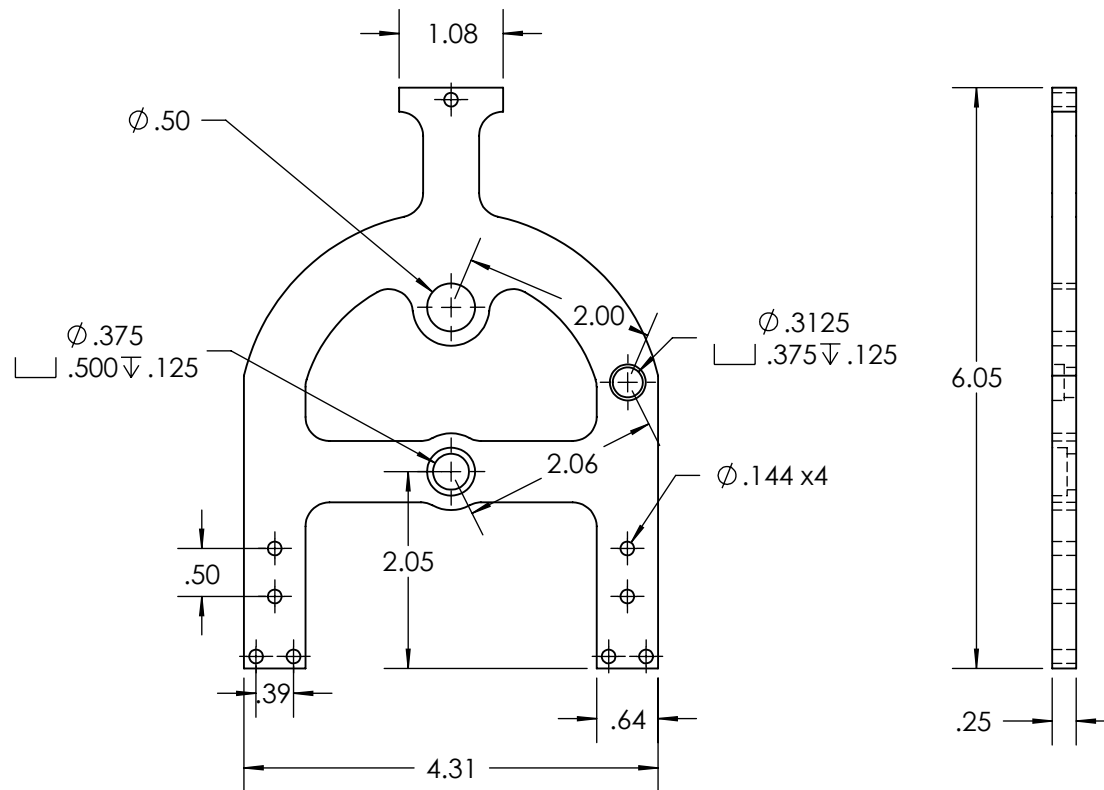


ITEM NO.	PART NUMBER	QTY.
1	PB7100	1
2	PB7200	1
3	PB7300	1
4	PB7401	1
5	PB7402	1
6	PB7403	4
7	PB7404	2
8	PB7405	1
9	PB7406	1
10	PB7407	3
11	PB7408	2
12	PB7409	2

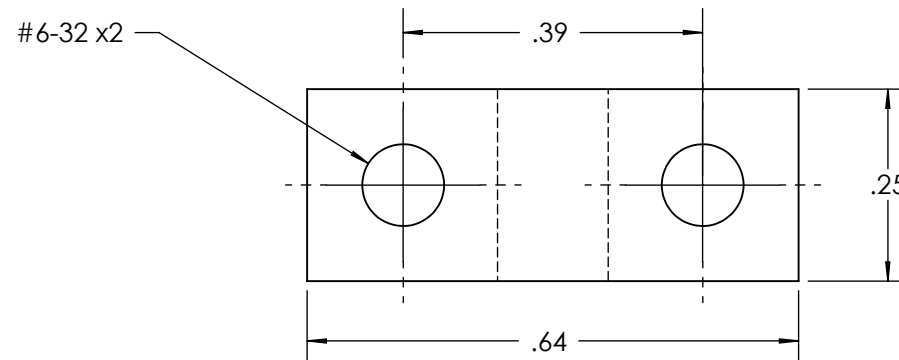
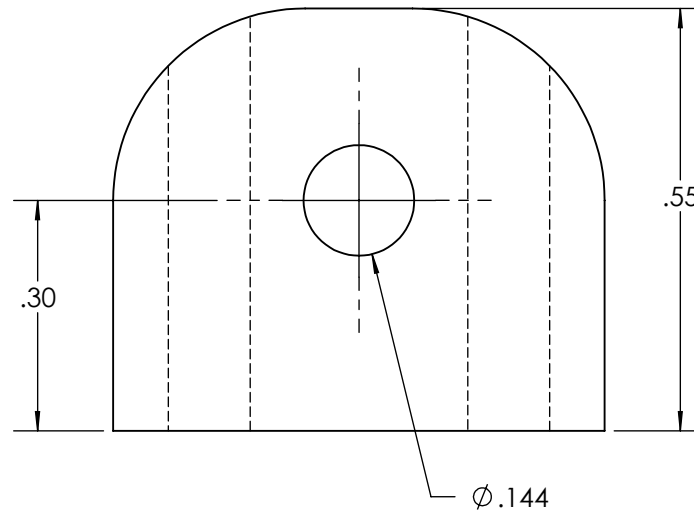
DIMENSIONS: INCHES	MATERIAL:		<div>GEAR BOX</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Final Box		PART NO. PB7400	SHEET 1 of 14



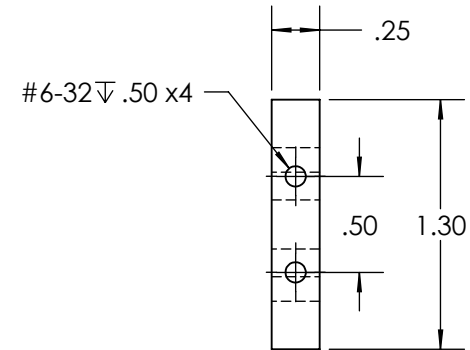
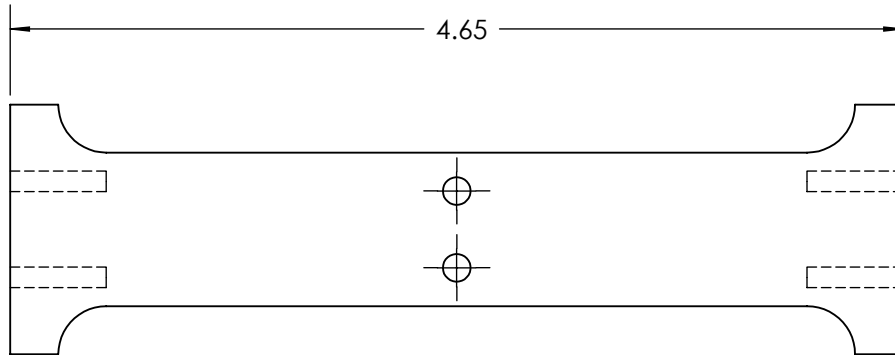
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		BACK PLATE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Back Plate			



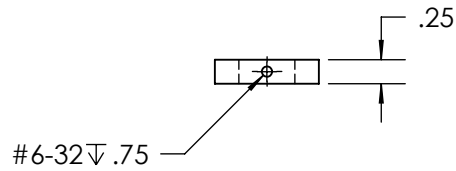
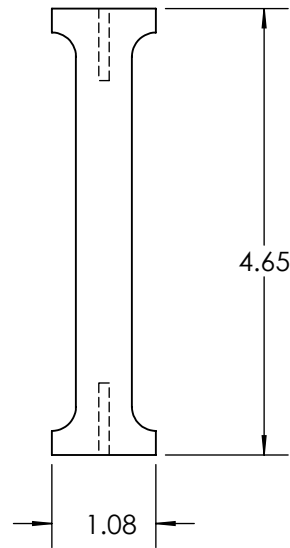
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		<div>FRONT PLATE</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Front plate		PART NO. PB7402	SHEET 3 of 14



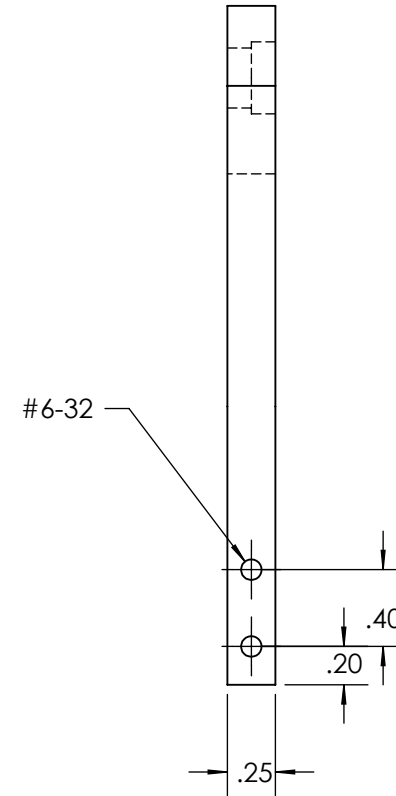
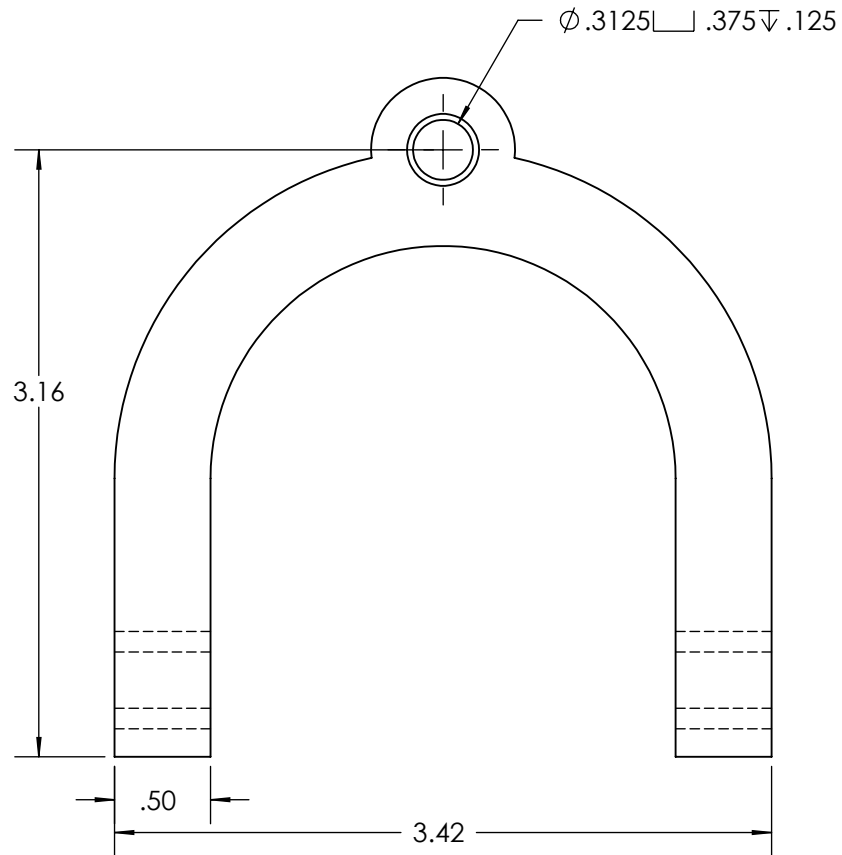
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		FOOT PLATE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 4:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: FootPlate			



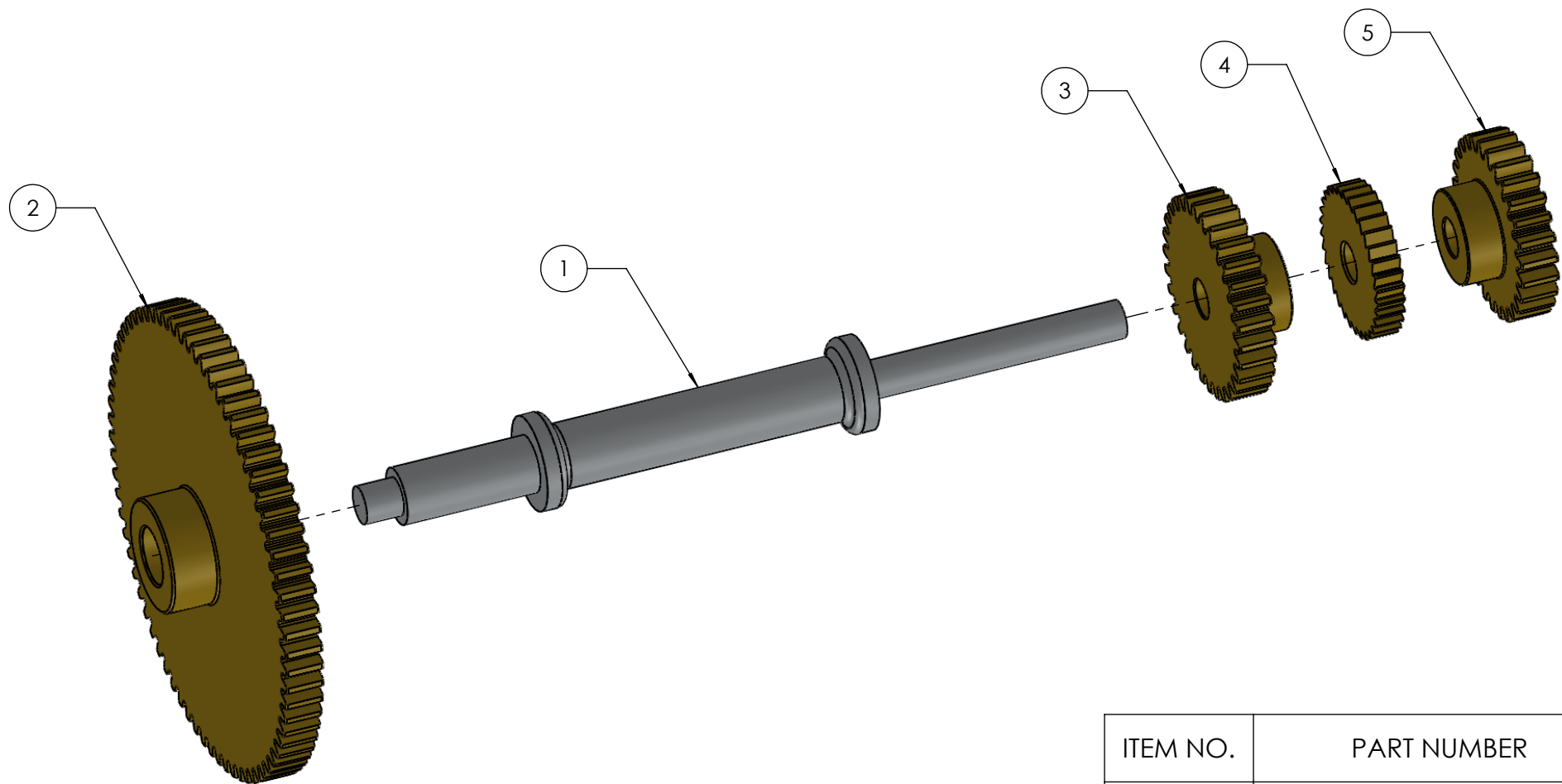
DIMENSIONS: INCHES	MATERIAL: ALUMINUM		SIDE PLATE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 2	FILE NAME: Side Plate			



DIMENSIONS: INCHES	MATERIAL: ALUMINUM		TOP PLATE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: TopPlate			

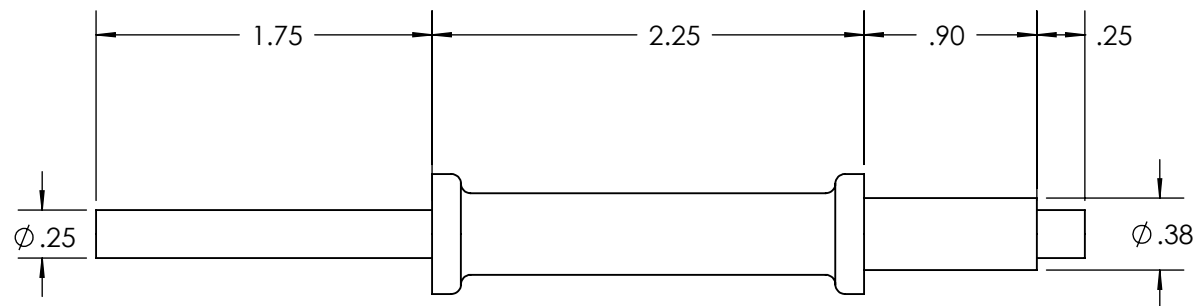


DIMENSIONS: INCHES	MATERIAL: ALUMINUM		BRIDGE PLATE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Bridge			

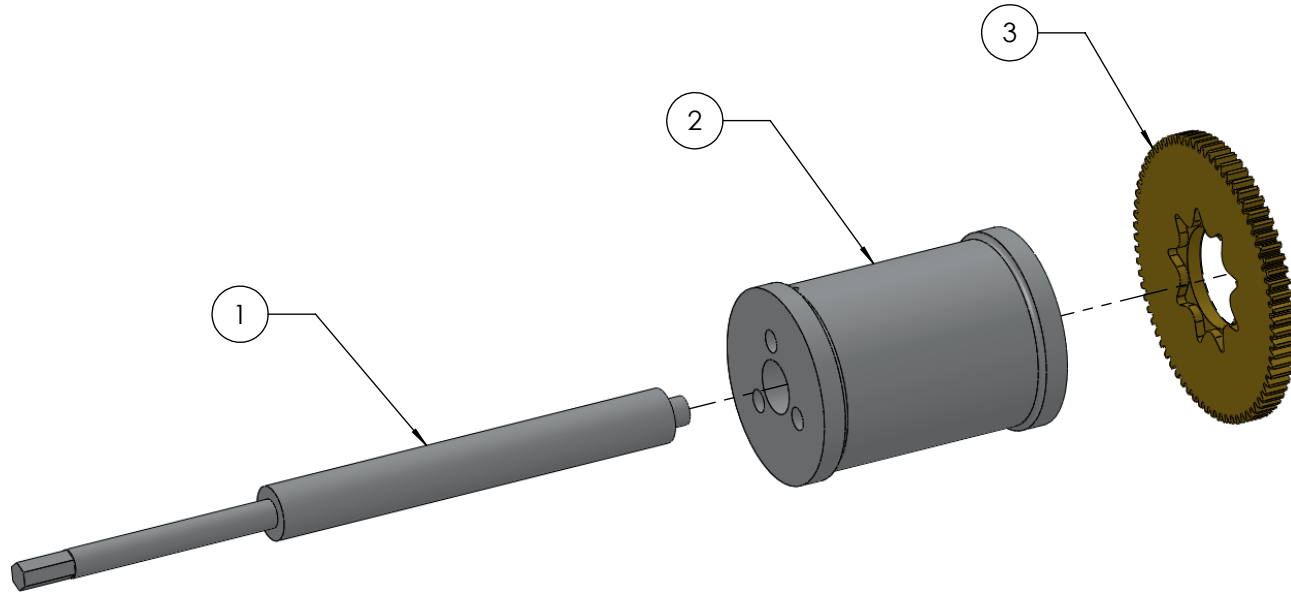


ITEM NO.	PART NUMBER	QTY.
1	PB7101	1
2	PB7102	1
3	PB7103	1
4	PB7104	1
5	PB7105	1

DIMENSIONS: INCHES		MATERIAL:		SHAFT 1 ASSEMBLY	
TOLERANCES:		DESCRIPTION:			
		DRAWN BY: MATT WEBER		DATE: 12/6/10	
		CHECKED BY: ANDREW JUPIN		DATE: 12/6/10	
SCALE: 1:1				CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1		FILE NAME: Shaft 1 Assembly			
				PART NO. PB7100	
				SHEET 8 of 14	

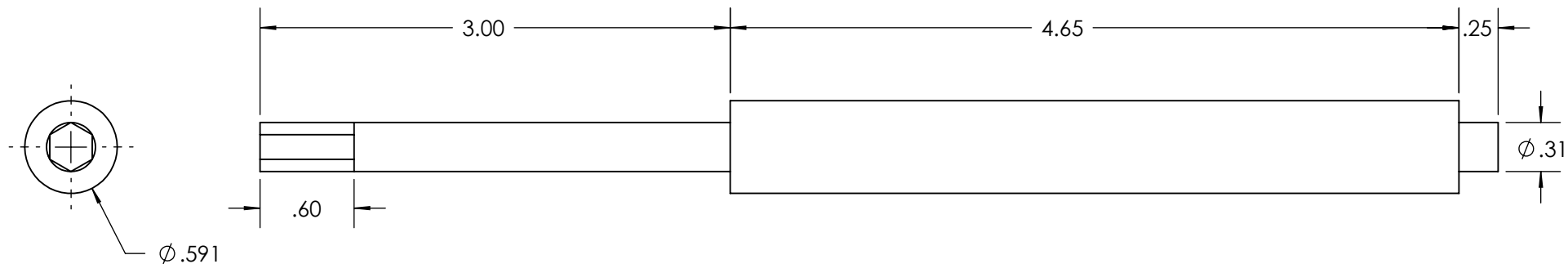


DIMENSIONS: INCHES	MATERIAL: ALUMINUM		SHAFT 1	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Shaft1			

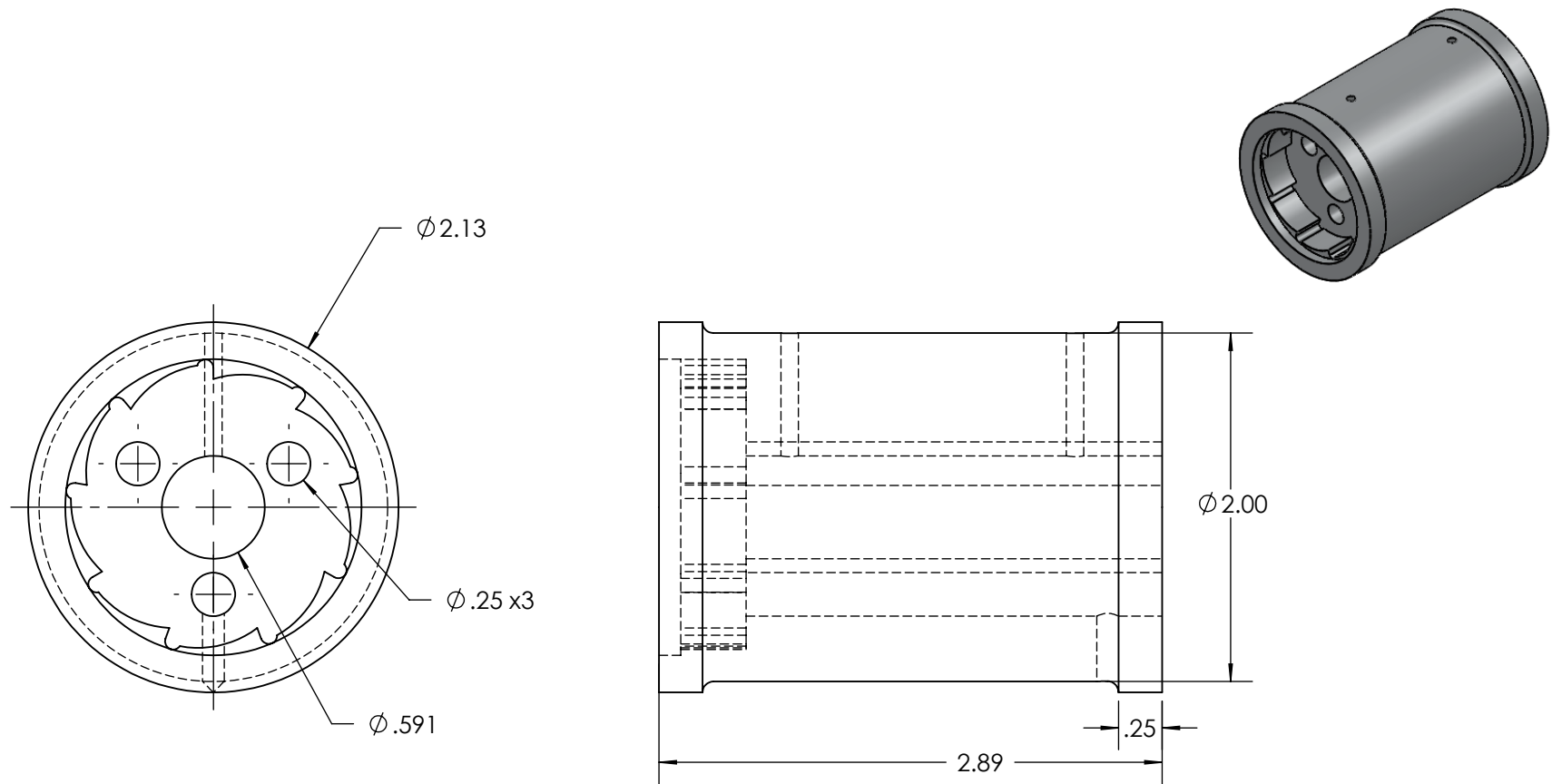


ITEM NO.	PART NUMBER	QTY.
1	PB7201	1
2	PB7202	1
3	PB7203	1

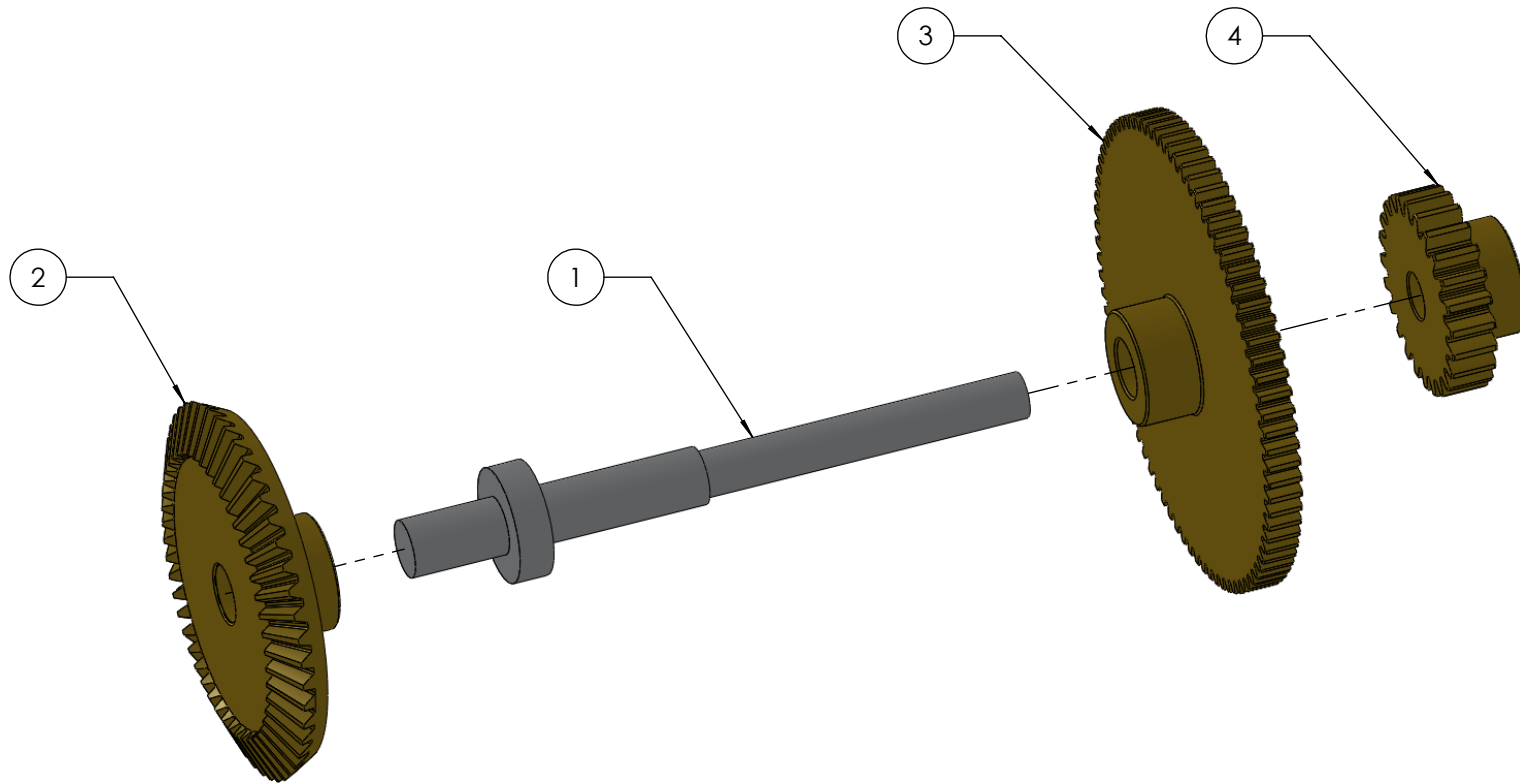
DIMENSIONS: INCHES	MATERIAL:		<div>DRUM SHAFT ASSEMBLY</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Drum Shaft Assembly		PART NO. PB7200	SHEET 10 of 14



DIMENSIONS: INCHES	MATERIAL: ALUMINUM		DRUM SHAFT	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: DrumShaft			

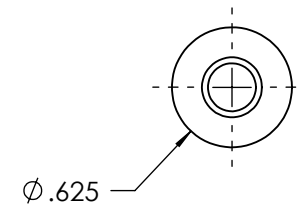
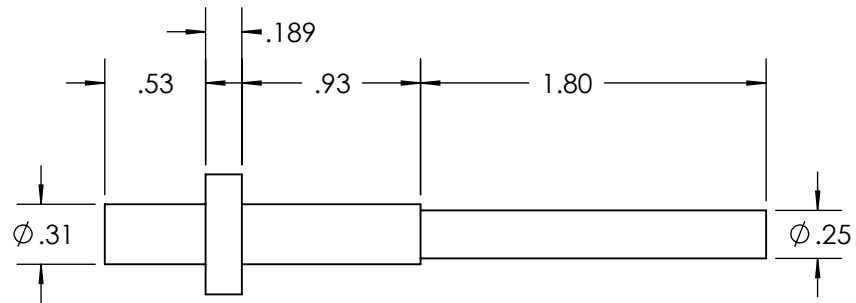


DIMENSIONS: INCHES	MATERIAL: ALUMINUM		DRUM	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Drum			

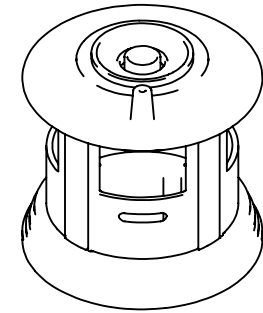
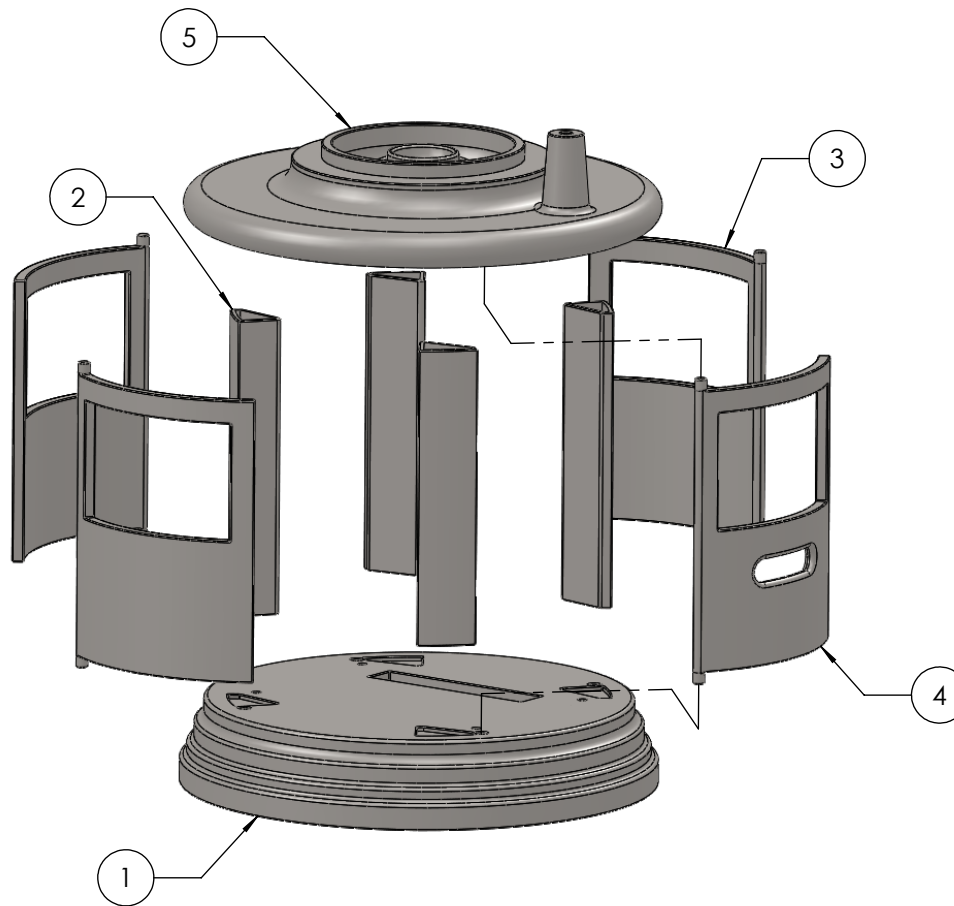


ITEM NO.	PART NUMBER	QTY.
1	PB7301	1
2	PB7302	1
3	PB7303	1
4	PB7304	1

DIMENSIONS: INCHES		MATERIAL:		<div>SHAFT 3 ASSEMBLY</div> <div>CAL POLY SAN LUIS OBISPO ME DEPARTMENT</div>	
TOLERANCES:		DESCRIPTION:			
		DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:1		CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Shaft 3 Assembly			PART NO. PB7300	SHEET 13 of 14

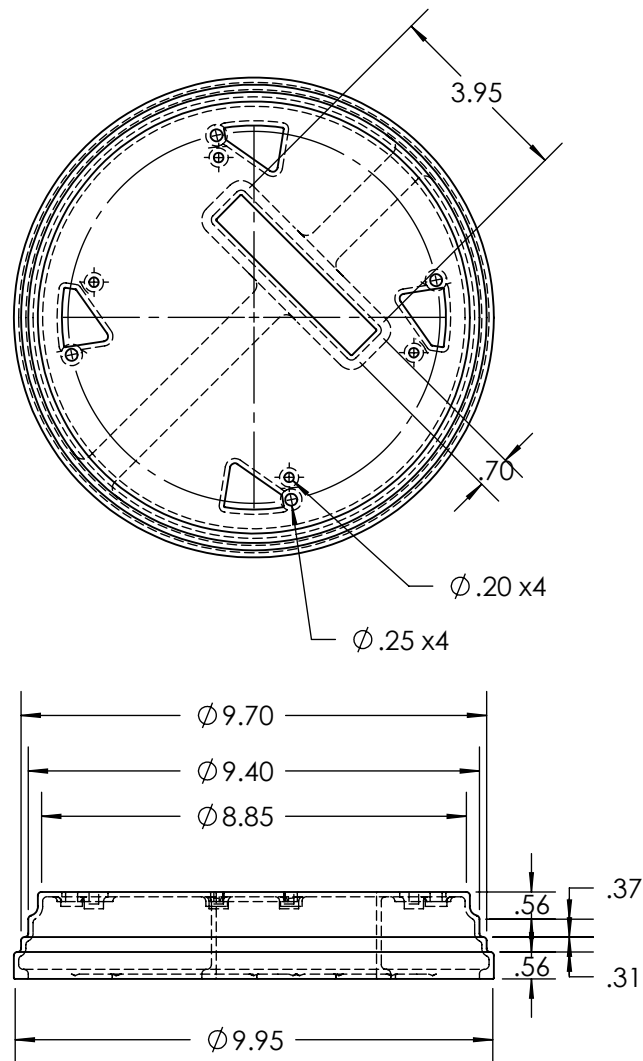


DIMENSIONS: INCHES	MATERIAL: ALUMINUM		SHAFT 3	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:1	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Shaft 3		PART NO. PB7301	SHEET 14 of 14

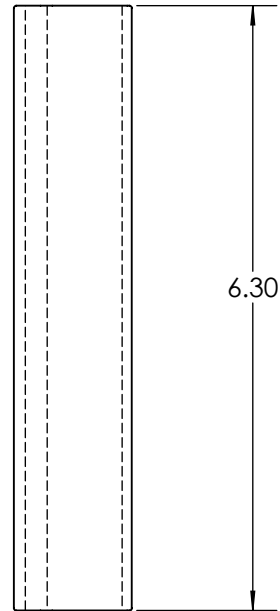
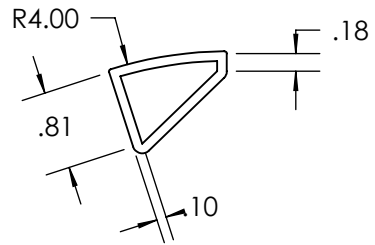


ITEM NO.	PART NUMBER	QTY.
1	PB8001	1
2	PB8002	4
3	PB8003	3
4	PB8004	1
5	PB8005	1

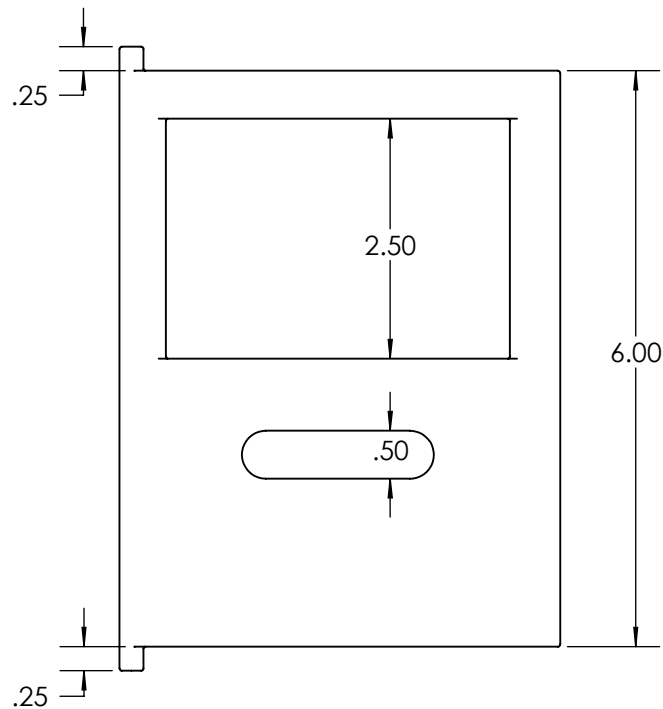
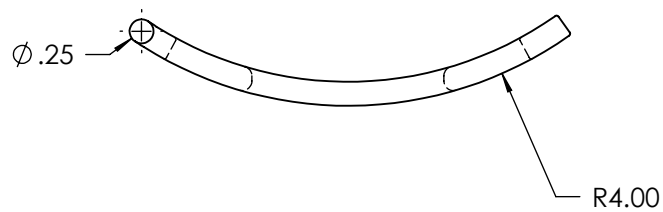
DIMENSIONS: INCHES	MATERIAL:		GEAR HOUSING	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:4	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Shaft 3 Assembly			



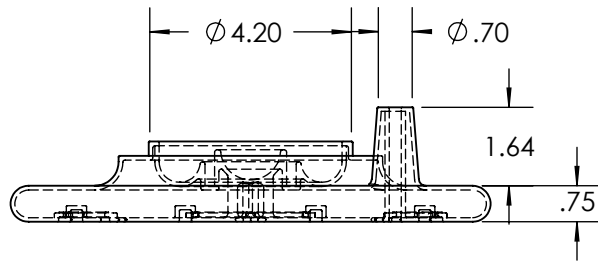
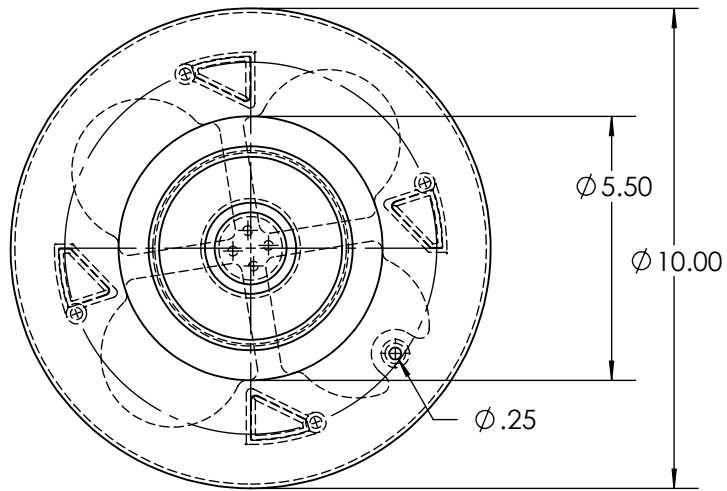
DIMENSIONS: INCHES	MATERIAL: ABS		BASE	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
SCALE: 1:4	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10		
Quantity: 1	FILE NAME: Base		PART NO. PB8001	SHEET 2 of 5



DIMENSIONS: INCHES	MATERIAL: ABS		SLAT	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 4	FILE NAME: Slat			



DIMENSIONS: INCHES	MATERIAL: ABS		DOOR	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:2	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1(+3)	FILE NAME: Door			



DIMENSIONS: INCHES	MATERIAL: ABS		TOP	
TOLERANCES:	DESCRIPTION:			
	DRAWN BY: MATT WEBER	DATE: 12/6/10		
SCALE: 1:4	CHECKED BY: ANDREW JUPIN	DATE: 12/6/10	CAL POLY SAN LUIS OBISPO ME DEPARTMENT	
Quantity: 1	FILE NAME: Top			