Mechanized Advent Calendar (FDR)

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Team
Naughty and Nice

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Table of Contents

List of Tables

List of Figures

Abstract

Within this document, the “Naughty and Nice” team will describe the details associated with the completion of this project, which involves creating an animated advent calendar for the Cambria Christmas Market. The problem, the customers and stakeholders, and the general goals of the project are introduced. The team conducted background research; how this research helps in finding a solution or supporting the needs of the sponsor is illustrated. Initial research includes interviews with the sponsor and potential users, patent and existing product searches, and some technical research pertaining to the subject. The team found that there are not many existing products that are similar to this project, but there are some which will lend the team inspiration and ideas for implementation in the design process. The scope of the problem is assessed from the customer’s needs and wants, along with a defined problem statement and a Quality Function Development (QFD) table. The team illustrates the process of selecting a chosen Concept Design. The Final Design direction for the façade and each box theme is described in detail, including functionality, evidence that the design will meet specifications, a discussion of safety, maintenance, and repair considerations, and a detailed cost analysis. A Manufacturing Plan is delineated, describing procurement, manufacturing, and assembly of each box, especially with respect to moving components. The team introduces a Design Verification Plan, which describes how each design specification was satisfied via testing. The overall design process of the project is investigated including the key deliverables and their due dates. Finally, the conclusion summarizes the document.

1. Introduction

The Cambria Pines Lodge hosts the annual Cambria Christmas Market which is an extensive walkthrough holiday light display. The Cambria Christmas Market team, represented by Professor Lee McFarland, requested a new display to be designed and manufactured by the Cal Poly Senior Project Team consisting of Danny Clifton, Tyler Koski, Oma Skyrus, and Sigrid Derickson. The display will include a German-themed façade to house the advent calendar boxes, with 25 internal and external scenes that cycle through the 25 days of December leading up to Christmas. The display will also include a countdown clock illustrating how many real-time days are left until Christmas. Each scene will be heavily themed with static themed showpieces, moving showpieces, and display lighting. This document includes background research, objectives, the concept designs for the façade and internal theming, project management, and a conclusion.

2. Background

2.1 Cambria Christmas Market History

The main customer behind the project is the Cambria Christmas Market team, with the need to entertain guests with a new and exciting display. The Cambria Christmas Market has been presenting its light show for many years, and each year over 75,000 guests walk through the scenery, admiring the 2 million visible lights. Beyond just regular Christmas lights, the Market contains various displays with moving components. One of these displays was built by a previous Cal Poly Senior Project group, which was themed after the song “12 Days of Christmas” with each scene representing one of the days. The advent calendar display will be the newest display in the market and seeks to improve upon some of the shortcomings of the “12 Days Project.”

2.2 Research

In order to gain a better understanding of the problem, the team set out to find what solutions already exist that solve a similar need. Because of the unique nature of the project need, no consumer product exists that matches perfectly. The closest systems that solve the problem are found in theme parks such as Disneyland or Universal Studios. The products created by these companies are designed to entertain guests in a similar way to the goal of the advent calendar, albeit on a different scale.

2.2.1 Patents

During the patent research, five separate patented ideas were examined to understand the means by which other companies achieve similar effects. The team focused its efforts on patents and products which accomplish individual aspects of the overall problem, such as potential methods for controlling the mechatronics or different types of decorations. The five chosen patents represent very different and innovative ways of addressing individual system needs. Table 1 summarizes the five patents.

Table 1. Patent search related to mechatronic holiday decor.

Patent Name	Patent Number	Key Characteristics
Theme Park Ride with Ride-Through Screen System	US 7905790 B2	For shading each box until it is displayed
Expandable Three-Dimensional Display Device	US 6284330 B1	Collapsible 3D displays
Holiday Display Box With Moveable Figurines	US 6915604 B2	Animatronic display motions and 3D displays
System and Method For Computer-Controlled Animal Toy	US 7328671 B2	Shows the mechatronics behind a display
Outdoor Animated Holiday Light Display	US 5379202	Similar to what is already happening at Cambria Market
Interactive and Animated Mini-Theatre and Method of Use	US 6192215 B1	Comparable to the box displays for the advent calendar
Entertainment Display Systems	US20060096445A1	General collection of knowledge for our display system

2.2.2 Related Products

Another step in the background research was to look at competing products that solve similar problems. These items can be used to compare the final product to its competitors and to help differentiate the final product from what is already on the market. The related products fall into two categories. The first category identified overall competitors, such as Disney's "It's a Small World", the Cal Poly Rose Float, and the previous "12 Days of Christmas Display." These products are useful for benchmarking and are summarized in Table 2.

Table 2. Related products for benchmarking.

Product Name	**Product Manufacturer**	**Key Characteristics**
It's a Small World	Disney	Large, professional grade entertainment product featuring many animated props and figures.
Cal Poly Rose Float	Cal Poly	Parade float that is heavily themed with large scale animated figures.
12 Days of Christmas Display	Cal Poly Senior Project Team	Animated holiday display already installed at the Cambria Christmas Market

Similar to the patent search, many of the related products only correlate to a specific component of the overall problem. The other category of products contains features that are similar to individual elements of the Advent Calendar Display. The items that fall into this category are summarized in Table 3.

Table 3. Product search related to mechatronic holiday decor.

Product Name	**Supplier**	**Key Characteristics**
Snow Globe Display	Amazon	Flow of air causes white confetti to fly around and imitate snow.
Lights, sound, and action using Arduino	Instructable	Gives a basic tutorial of how to link together animatronic in the display
507 Mechanical Movements: Henry T. Brown:	Barnes and Nobles	Book that shows how Mechanical movements can be incorporated into the display.
Spinning Motions	Amazon	Different systems to animate a display spinning.
Vertical Up/Down Motion	Amazon	Different systems to animate a display moving up and down.

Many of the products that are alternatives to the Market's Advent calendar are not sold; rather, they are created with smaller components like motors or linear actuators, and some examples of which are seen in Table 3. The team needs to ensure that any products used are easily re-ordered so the sponsor can purchase replacements without long lead times or reliance on an undependable website; this is why many of the products are supplied by stores such as Amazon, Home Depot, or other mechatronic retailers that have an established and trustworthy reputation.

2.2.3 Journal Articles

The final step in the research phase involved reading journal articles that relate to the project needs. The articles outline ways to achieve various necessary aspects of the display. The articles found and their uses are summarized in Table 4.

Table 4. Journal articles related to mechatronic holiday display.

Journal Title	Author	Summary/Relevance
"Geometric Design of Linkages"	J. M. McCarthy	Book that outlines methods for achieving various mechanical motions with linkages.
"Dealing with religious differences in December: a school counselor's role"	Mina Ribak-Rosenthal and Todd T. Russell	Become more informed on multicultural December holidays and how they affect children.
"Construction and reconstruction of ethnicity in retail landscape: A case study in the Toronto Area"	Zhixi Cecilia Zhuang	Talks about sensitivity of displaying other cultures in retail displays.
"Water repellents and Water-repellent preservatives for wood"	R. Sam Williams and William C Fest.	Talks about preventing weather damage to wood in construction.
"Systems and method for synchronizing mechatronic devices"	Magnus Oddsson and Arinbjorn Clausen	Gives detailed example of projects using synchronized mechatronics.
"Animatronics: a guide to holiday displays"	Edwin Wise	A whole book on how to construct and operate a system very similar to what the team will be building.

2.2.4 Additional Research

After receiving feedback from the Scope of Work and initial renditions of the façade, the team found it necessary to conduct additional research on German medieval villages in order to gain a better understanding of the sponsor's vision. Images found during this research are shown in Figures 1 and 2.

Figure 1. Typical German Houses   Figure 2. Houses in a Medieval Village

These images were selected from various online searches. The scene in Figure 1 initially seemed too uniform, with little variation in the houses. The team found that the A-line roofs with varied house types and sizes in Figure 2 appealed greatly to the sponsor, and so the team continued to redesign the façade with this inspiration in mind.

3. Objectives

3.1 Problem Statement

The Cambria Christmas Market showcases many different holiday-themed displays for the enjoyment of visitors in November and December of each year. The management behind the Market would like to add a large, animated advent calendar display that captivates an audience for several minutes with a 25-day countdown to Christmas, including holiday music that coordinates to each scene's theme integrated into a German village facade. The system must be weatherproof and easily repairable, movable, and storable.

3.1.1 Project Needs and Wants

The project has the following needs which are the minimum criteria which must be met:

1. 25 boxes with a minimum opening of 2x2 feet
2. Each scene incorporates its respective number
3. Each box lights up in sync with a holiday song
4. At least 10 of the boxes include moving components
5. All boxes viewable by a six-year-old child's height (Approx. 3'9") all the way to an average adult height (Approx. 5'9")
6. All components are weatherproof
7. German themed façade
8. The dimensions of the façade do not exceed 24 feet in length and 9 feet in height

These are the basic requirements of the project. From the sponsor, it became clear that if this project is to be exemplary the team must add some additional features. These features make up the following wants:

1. Boxes of various shapes and sizes
2. Finale which incorporates all boxes for a photo-worthy finish
3. Music box melody for some of the songs
4. Include a diverse collection of winter holidays
5. Warm lights (avoid white/blue lights) for ambient lighting.

A sketch of a potential solution to the design requirements can be seen in Figure 3, showing the general idea of what the Market's advent calendar can look like. This image is provided so the reader has a benchmark idea of the end product while reading the report.

Figure 3. Sketch of a potential advent calendar design, German village themed.

It is important to recognize that while there are many different solutions to the problem the team is looking to solve, not all of them will progress as usable products for this project. With this in mind, the team will look to create as many different design iterations as possible in the early design phase built on the research that has been conducted. This will result in thorough and ample prototyping and testing, providing the team with a plethora of ideas for the product. Once the ideation process and some initial prototyping has been completed, the best solution can be chosen from the different prototypes and that solution may be able to advance as the team's preliminary design.

3.2 Quality Function Deployment (QFD)

The Quality Function Deployment process determined what specifications were needed for the new Advent Calendar. Parameters that reflect the customers' needs were taken into consideration: featured themes that remind the audience of the holidays, large enough dimensions that will give the audience a feeling of astonishment, and a performance that is exciting while still cycling in a short enough interval for onlookers to maintain interest. A general list of specifications and requirements is provided in Table 5. The customer's wants and needs as surmised from the initial user interview are included in Appendix A. The House of Quality was developed after the QFD process and is included in Appendix B.

Table 5. Specifications Table for the Advent Calendar

Specification	Parameter Description	Requirement or Target	Tolerance	Risk	Compliance*
1	Stationary Scenes	10 Scenes	Max.	M	I
2	Simple Motion Scenes	5 Scenes	Min.	L	I
3	Medium Motion Scenes	5 Scenes	Min.	M	I
4	Complex Motion Scenes	5 Scenes	Min.	H	I
5	Functions in Finale Scene	4 Functions	Min.	M	I
6	Calendar Dimensions	20 ft. x 12 ft. x 2 ft.	Max.	M	I
9	Scene Size	2 ft. x 2 ft.	Max.	L	I
10	Finale Scene Size	4 ft. x 4 ft.	Max.	M	I
11	Power Draw	Minimize	-	L	T, A
12	Cost	$14,000	Max.	H	A

*Test, Analysis, Inspection, or Similarity

4. Concept Design

4.1 Ideation

The team moved through an extensive ideation process to generate ideas for the themes of the boxes. In the first ideation session, each member of the team wrote several holiday-related themes and songs on different Post-Its. Then, the team assigned some form of movement or light complexity to each theme. Finally, the team matched up each theme, category of complexity, and song and displayed the results on the board according to the team's preference. Figure 4 shows the results of the first ideation session.

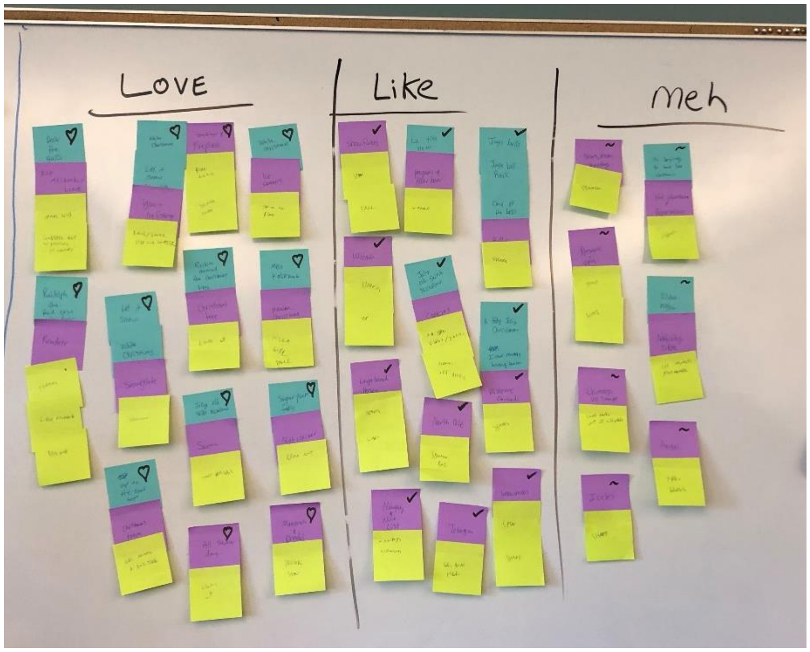


Figure 4. Ideation Session #1

Several ideation sessions were conducted until the team determined that enough ideas had been generated. In the second ideation session, the team created several broadly categorized lists of potential themes for each box to be designed around or to be integrated into the façade. Finally, in the third ideation session, the team recalled and researched holiday-related songs which could be played to accompany the scenes as they are viewed by the audience. See Appendix D for full idea and song lists.

Once ideation was concluded, each member of the team created Pugh matrices to begin the process of narrowing down the extensive lists of ideas, one of which is shown in Figure 5. This matrix allowed the team to visualize each idea and qualify it according to relevant criteria, such as needs/wants or specifications.

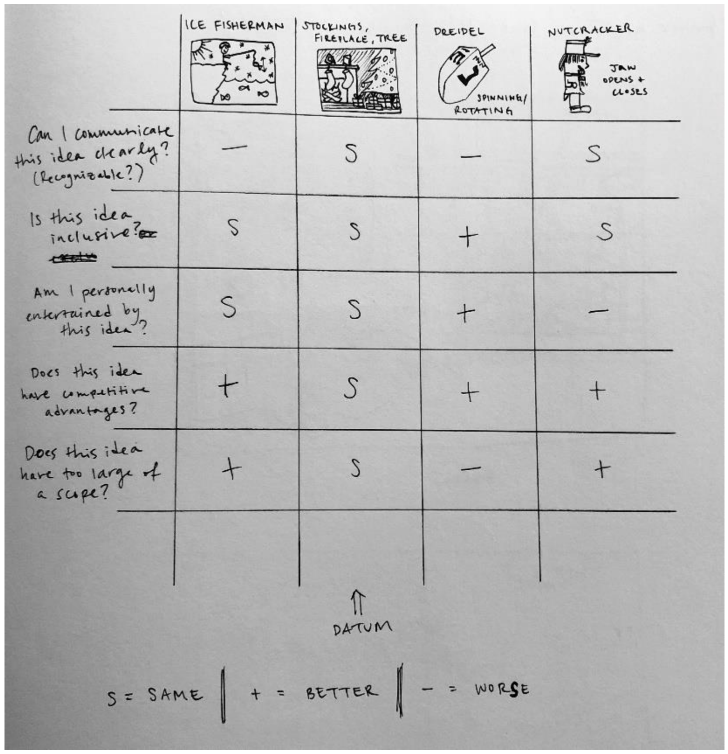


Figure 5. Example of Pugh Matrix

After the Pugh matrix phase, the team created a weighted decision matrix, shown in Appendix D, to help select light functions to use in the display.

The team limited the long list of ideas to the top twenty-five which could possibly be contained in the display. Finally, the team divided up the twenty-five box themes amongst each of the four group members, and each group member designed and dimensioned their assigned boxes. The preliminary list containing these assignments with each theme's song and type of motion is contained in Appendix D.

4.2 Concept Selection

Due to the sheer number of drawings for this project, the sketches and drawings are contained in Appendix E rather than the body of this report. During the first quarter, the team invested the most time in the design of the façade. Figure 6 illustrates the first attempt at a village that would contain all 25 boxes. At the time, the only parameters for the façade were as follows: be aesthetically pleasing, look like a German village, and enclose all 25 boxes. In the feedback on this drawing, the sponsor introduced a new constraint - the façade needed to fit within a length of 23 feet and a height of 9 feet.

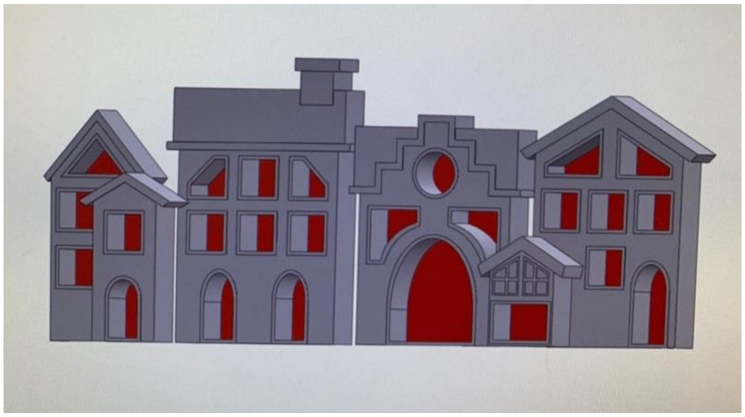


Figure 6. First Façade Design

A new design was created using this new information, and the result is illustrated by Figure 7. Note the addition of the windows which complement the stair step roof of the middle building. The sponsor expressed an opinion that the use of these windows and the stair step roof was not within their vision, and suggested that the group adhere to a design with only flat and A-shaped roofs.

Figure 7. Second Façade Design

Figure 8 is the result of these comments. In Figure 8 the buildings are more realistic, but the sponsor believed that the façade was too dull and lacked variety.

Figure 8. Third Façade Design

Finally, the drawing in Figure 9 was created as the final design of the façade. The final façade design is a combination of all the positive factors from the previous drawings, such as the flat and A-shaped roofs, the reindeer with the sleigh on the roof, the overlapping buildings, and the chimney where Santa Claus will emerge in the finale.

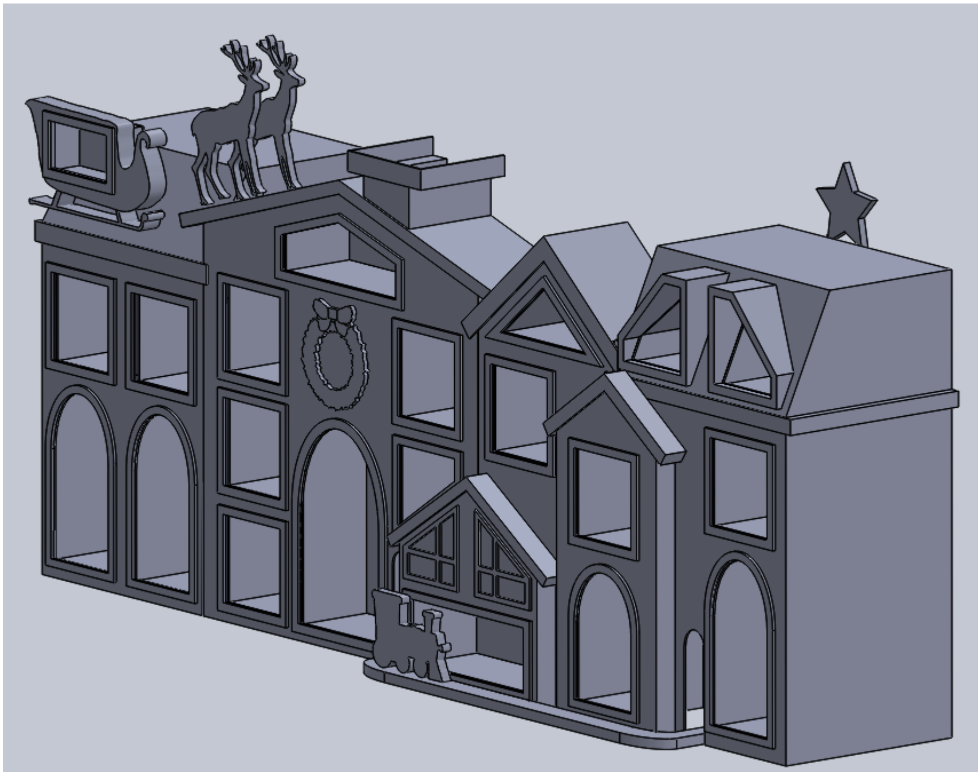


Figure 9. Final Façade Design Isometric View

Figure 9 shows an isometric view of the final façade design. The third dimension, depth, was not determined as crucial compared to the front view of the façade. The presentation will be viewed head on by the audience, and the depth will not be the main contributor to the show. The dimensions of the depth of the houses are still important, and we're designed appropriately. The plan for constructing the façade is to laser cut the façade out from sheets of wood. The façade will then be supported up into place, and act as a housing shell for the 25 events. The façade itself will not move, so it will only need to hold together as a supporting structure. The team will plan to manufacture this façade so that it is structurally stable through force analysis in SolidWorks.

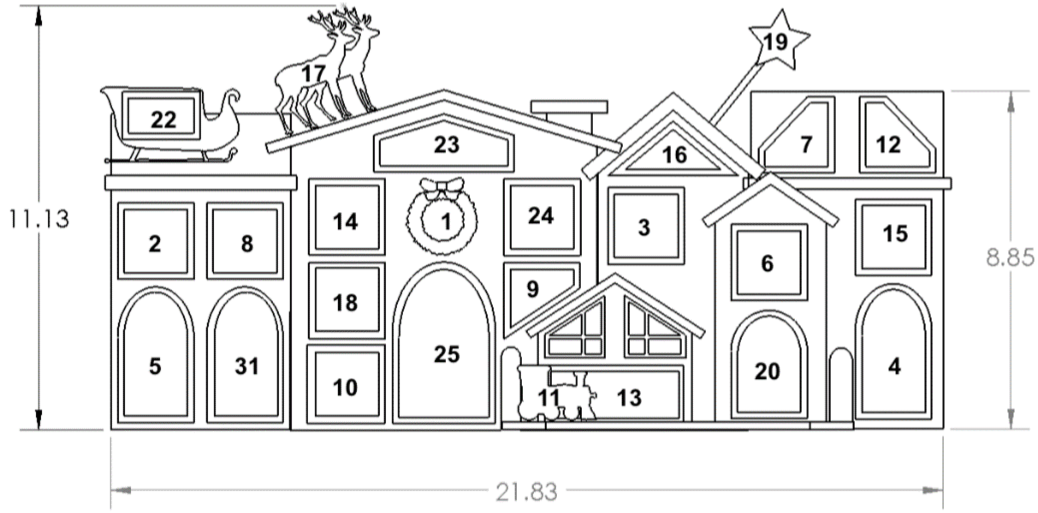


Figure 10. Final Location of Each Day in Facade

After the façade and the locations of each theme were finalized as shown in Figure 10, the contents of each box were sketched and modeled in SolidWorks. See Appendix F for the preliminary designs of each box's theme.

4.3 Design Hazards

The hazards for this project fall into three major categories: electrical potential, human error and nature. These three categories have various subtopics which are discussed in detail in Appendix G along with an action plan for counteracting these issues. In this section only the top issues from each of the three categories will be discussed.

The Advent Calendar has many moving and lit up parts, and as such they will all require power and wiring. If assembled incorrectly the wiring of electrical components could cause sparks and shock hazards. The team will prepare detailed and safe wiring procedures to ensure a high standard of safety when the electronics are installed and maintained.

Next to be discussed are the man-made hazards. Many of these hazards relate to maintenance or installation. Due to the size of the display, set-up will involve ladders and moving heavy boxes. It will be important to avoid slips, trips, falls, and sprains during installation and routine maintenance. Additionally, man-made hazards can occur when fastening the display to the foundation. This will need to be accomplished with strength and precision so the façade will not fall and hurt viewers during the winter season.

The final hazard is nature. This involves strong wind and rain interacting with the façade and components inside. Extreme weather could blow the façade down, which could fall onto viewers. Additionally, water interacting with electrical components could ruin them in addition to creating a shock hazard. Boxes will be constructed to a high standard of safety to withstand weather hazards.

4.4 Engineering Assessment

The largest concern for the engineering design is the forces acting upon the façade. The force that will affect the display the most is the winter wind storms in Cambria the advisor has warned about. To find the winter wind speeds in San Luis Obispo County the government weather data collection site gave a baseline measurement of about 39 mph [5]. In order to build in a safety factor this speed will round up to 45 mph for the wind force calculations. Knowing the largest side wind can hit on the façade, the 24'X9' face, and the wind speed the forces due to wind can be calculated. Equation 1 is used to calculate the wind force on the structure

$$F = (A)(P)(C_d) \tag{1}$$

$$F = (L*W)(.00256*V^2)(Cd) \tag{1.1}$$

Where A is area, P is wind pressure, and C_d is the drag coefficient. The area can be found by multiplying length by width of the façade. The wind pressure P is found using an equation from the American Society of Civil engineering code with a standardized coefficient of .00256 is multiplied by the velocity of wind in mph. Finally, the drag coefficient of 1.28 was found using a NASA data sheet on common drag coefficients of structure shapes as wind travels perpendicular to the surface [6]. During a wind storm the façade can expect a maximum force of 1,433.27 pounds across its surface. The detailed calculations to get this value can be found in Appendix H. Team Naughty and Nice can use this value to predict shearing forces in the bolts that anchor the façade to the foundation. The calculation will be modified once the final foundation location and material have been selected.

5. Final Design

5.1 Final Design Summary of Systems

5.1.1 Façade

The team designed the housing of all 25 events for pleasing aesthetics and a strong, sound structure. Figure 11 illustrates the final design of the display's full assembly housing.

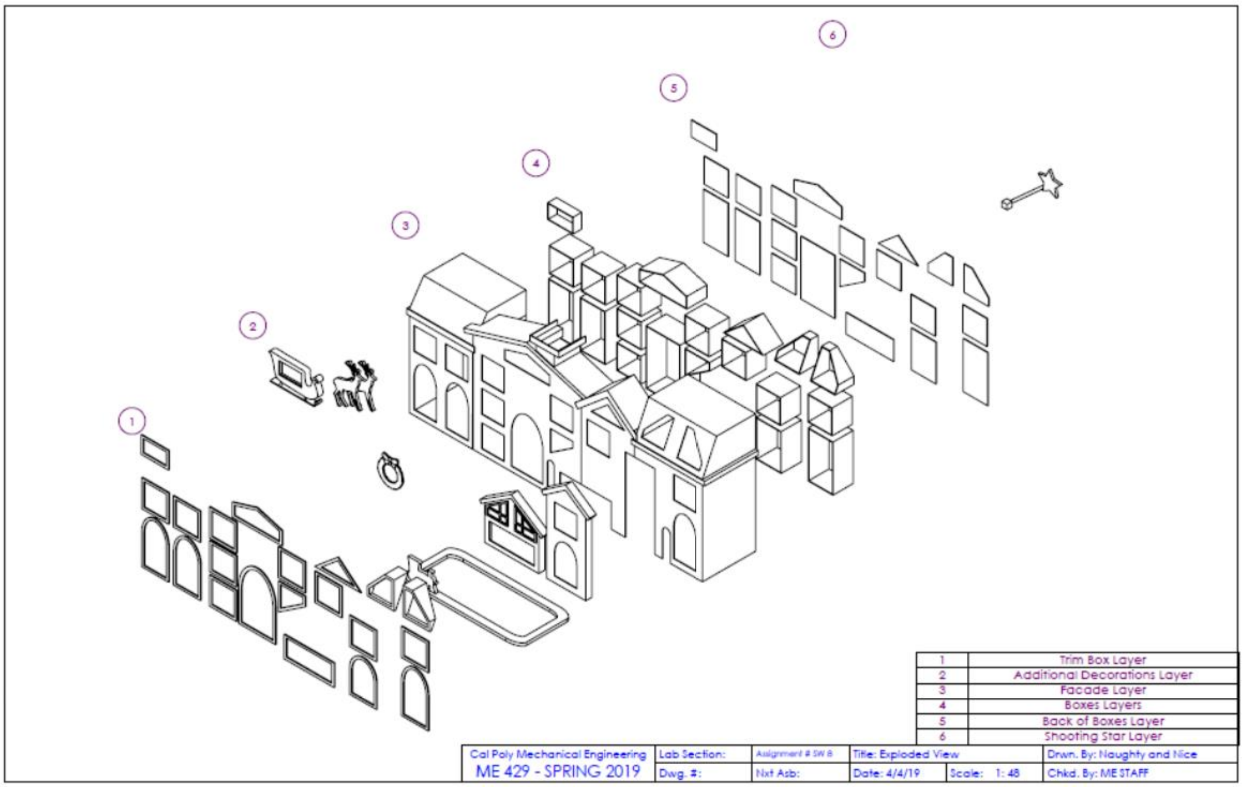


Figure 11. Exploded View of Façade

The team will manufacture the entire façade out of wood. The front layer, labeled as Layer 1, is the trimming layer. Each of the components of this layer are 1/4" thick framings which the team will place in front of the boxes. The planks of wood that the team will use for these frames have a width of two inches. The point of these framings is to imply that the boxes are thicker than they appear. Layer 2 includes the façade designs that are offset up to a few feet from the main layer of the façade, Layer 3. This layer adds a three-dimensional aspect to the façade. Layer 3 is made up of the houses that hold the boxes in place. Each of these houses is manufactured from 1/8" thick wood and the team will either nail or glue each house together. Layer 4 is the box layer; each box theme was designed to fit into its assigned box. Layer 5 includes the backing of each box. The team will manufacture these back pieces with hinges attached to the rim at the rear of the boxes once the events are all installed inside of their corresponding boxes. The hinge functionality of these backs is necessary in the event of a malfunction, allowing a technician to easily open the box and attempt to fix the problem. The final layer, Layer 6, is the star layer. The star will oscillate back and forth above the roofs of the houses, attached to the back panel.

Each box theme has its own final design direction, which are better illustrated in detailed drawings, located in Appendix M, and summaries, located in Appendix K, rather than going into detail for all 26 themes in the body of this report.

5.2 Functionality of the Design

The façade in Figure 11 is meant to house the boxes and protect the events from the outside elements. The enclosure of each box, once properly built, will include an acrylic material in the front, and a back door closed with a hinge. These boxes will then slide into their designated slots in the third layer of the facade. Once the whole system is installed, the team will install wooden supports underneath the boxes and on the inner sides of the houses so that the whole system is held to withstand natural forces like wind. The team expects easy installation of this structure as well as an easy take-down for storage after the Market is concluded each year.

5.3 Electrical Wiring

The team will incorporate electrical circuitry in almost all of the events. This project will mainly require wiring for lights and motors. The team will not determine the specific lights needed for the project until trials of testing take place. For now, wiring schematics are put on hold until the hardware of the project is fully built.

5.4 Software

The software needed for the project is incorporated with the lights. As Section 5.3 states, the team will not determine the design of the lights until many experiments with lights in certain boxes are tested. The team will also hold off on testing software until the lights are fully incorporated into the design.

5.5 Supporting the Design

Our project requires a low factor of safety since the functionality of our moving parts is very simple and are not exposed to high loads or pressures. The methods for manufacturing the façade are very straight forward and have been shown to work for any novice wood worker. The entire structure will be bolted to a large, permanent platform to be constructed by the sponsor on site. Most of the wood will be spot-nailed together. The team will use wood glue to attach planks of wood that need to be placed parallel to other planks. Since our design has minimal requirements for functionality, the team can easily assemble and inspect the façade on site. If any complications occur after it is built, mitigating these complications will come at a low cost because wood is cheap and it would be simple for those in charge of maintenance to build a similar component and substitute it for that complication.

5.6 Safety

Appendix I contains the Design Failure Mode and Effects Analysis, which includes a list of factors that could potentially cause the structure to fail. Those factors are acknowledged, and solutions are listed on how to avoid them. Appendix G contains the Design Hazard Checklist. This checklist goes over the many possible complications that the system could cause and then answers how the team will design the project to accommodate these risks.

5.7 Cost
Appendix J contains the breakdown of all parts that the team will purchase or manufacture in the form of an indented Bill of Materials. The level at which the component is contained in the assembly is listed for each part, as well as its part number. The cost per unit is listed next to each part, and the total cost for the total purchase of the specific item is calculated. At the very end of the list is the calculated total cost that is expected for the project, which is currently approximately $1,500. This value is below the initial total project cost that the team provided to the sponsor when the project first began, and assumes the sponsor will provide the materials for the façade and box structure outside the official budget.

6. Manufacturing Process

In order to create an entertaining display, the team designed each box to be unique on the guest-facing side with as many repeated and common parts as possible on the mechanical side. While many assemblies contain similar overall elements, a great variety exists in the specific execution of each system. This section gives an overview of processes that are generic for all systems as well as a brief summary of how boxes deviate from the generic case. All figures of drawings show rough sizing and overall concepts of the parts. For full dimensioned drawings see Appendix M.

6.1 Procurement
This project requires very few special components or materials. Therefore, the team will source almost all parts from vendors that provide quick fulfillment times with reasonable prices. The project requires short lead times because if a part breaks during the on-season, a speedy turnaround is required for a quick and easy fix. If a part requires a lead time of more than two days, then the team will provide a spare at the sponsor's request. The indented Bill of Materials in Appendix J provides the original vendor sourced for each part or material. A summary of vendors utilized is provided in Table 6.

Table 6. Summary of vendors.

Vendor	Parts/Materials Summary	Lead Times
McMaster-Carr	Motors, Bolts/Nuts/Washers, Bushings	2 Days
Online Metals	Aluminum Stock	1 Week
Home Depot	Plywood, 2"x4" Wood	N/A
Amazon	Sanding Belt, Raspberry Pi	2 Days

6.2 Manufacturing

6.2.1 Aluminum Stock Parts
The majority of the moving boxes use a three-bar linkage system created out of 0.5"x0.25" 6061 aluminum stock. An example of one of these linkages is shown in Figure 11.

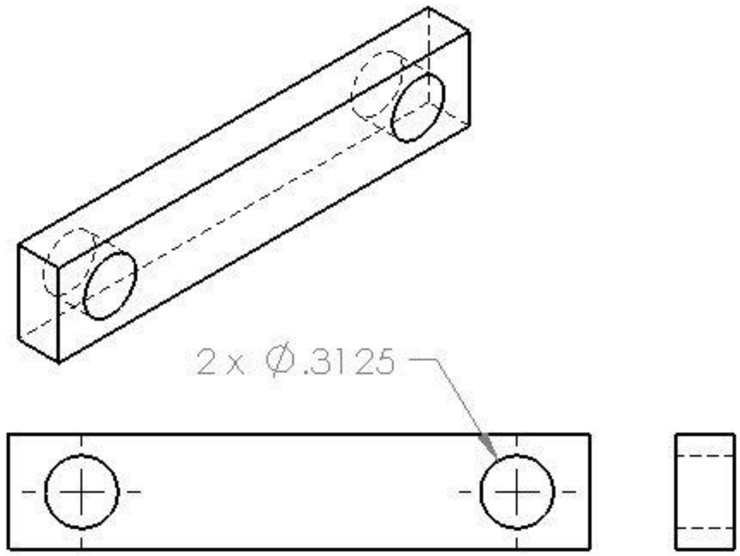


Figure 11. Aluminum linkage example from snowman box.

The manufacturing process for the aluminum linkages is laid out in Table 7.

Table 7. Aluminum linkage manufacturing steps.

Step	Process	Tool
1	Cut aluminum stock to length	Band Saw
2	Drill ∅5/16" through holes	Drill Press

A slight modification to the above process is required for the linkage interfacing with the motor's D-shaft. Acquiring the properly sized broach is currently cost prohibitive, so the team will require a less direct method of securing the pieces. The current solution is to drill and tap a through-hole for a set screw to push against the flat face of the D-shaft. The team will verify this method during the manufacturing and assembly of the first box. Figure 12 shows the additional hole required for the set screw with Table 8 showing the additional manufacturing steps for this piece.

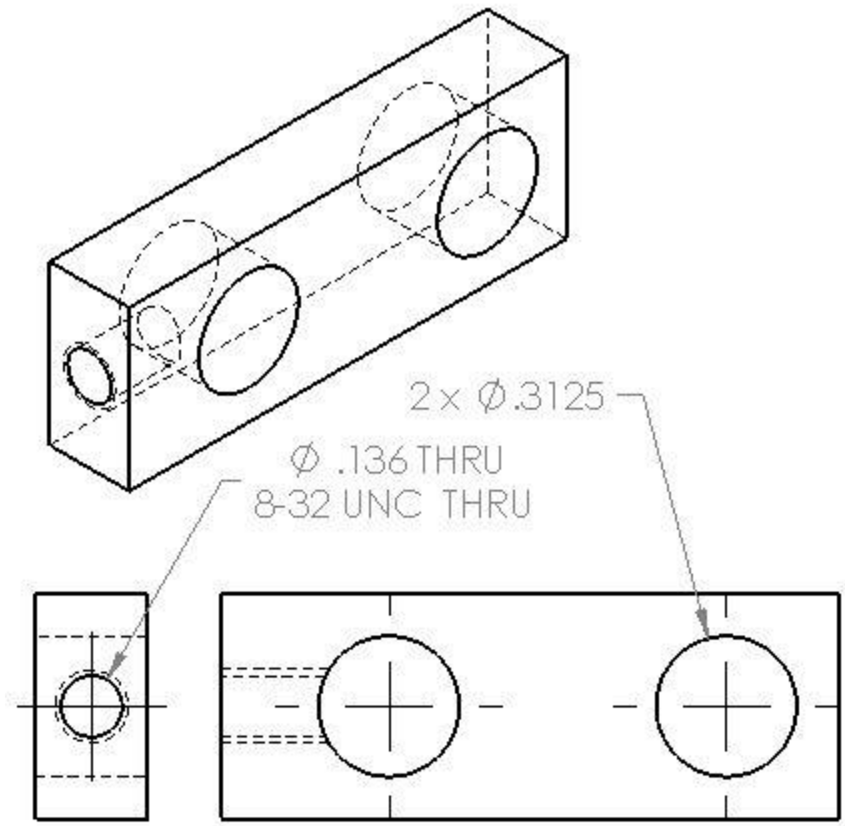


Figure 12. Aluminum motor linkage example from snowman box.

Table 8. Aluminum motor linkage manufacturing steps.

Step	Process	Tool
1	Cut aluminum stock to length	Band Saw
2	Drill ∅5/16" through holes	Drill Press
3	Drill #8 hole for set screw (#29 pilot drill size)	Drill Press
4	Tap 8-32 UNC threads	Tap

The final part created from aluminum stock is the rotating bar in the ice skaters box shown in Figure 13.

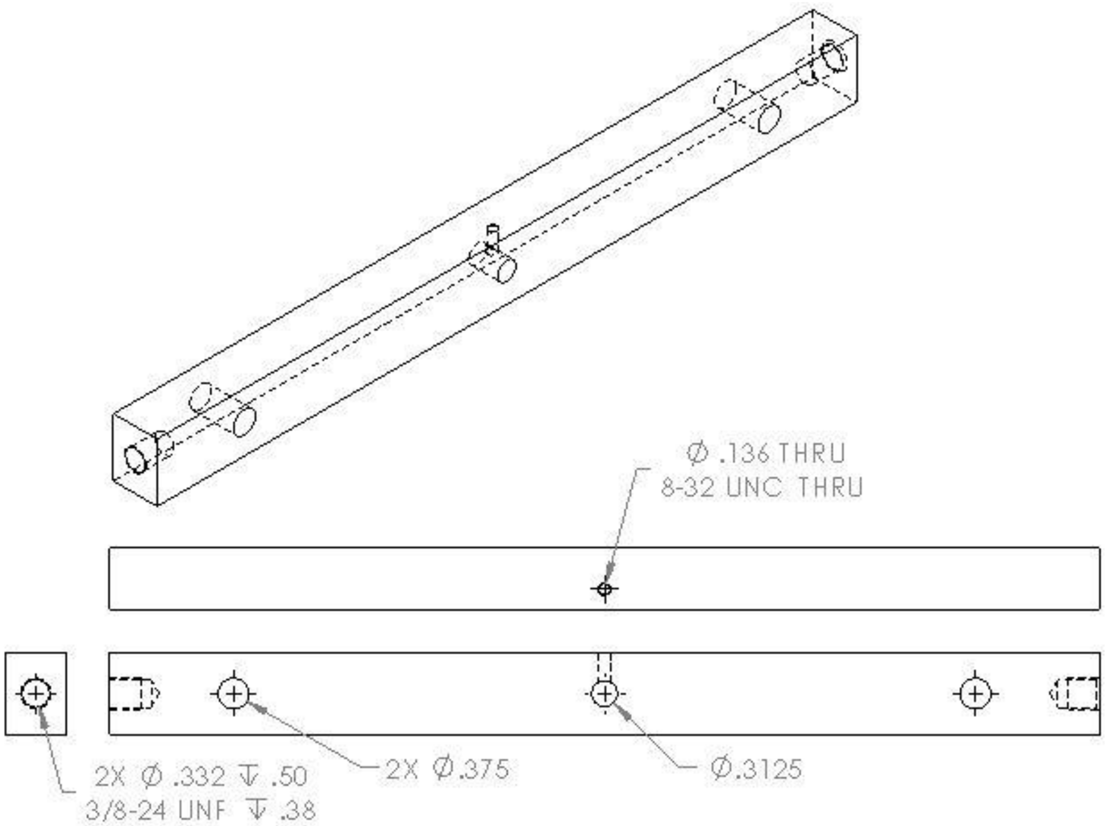


Figure 13. Ice skater's rotating aluminum bar.

This part is made from 1"x0.75" 6061 aluminum stock. The larger size is required because of the load carrying requirements as well as the orientation of the hardware. The manufacturing process for this element is described in Table 9.

Table 9. Aluminum rotating bar for ice skaters.

Step	Process	Tool
1	Cut aluminum stock to length	Band Saw
2	Drill outer 3/8" through holes	Drill Press
3	Drill 5/16" center hole	Drill Press

	to 0.5” depth	
4	Drill 0.332” holes on each end to 0.5” depth	Drill Press
5	Drill 0.136” hole for set screw	Drill Press
6	Tap 3/8-24 UNF threads into each end hole	Tap
7	Tap 8-32 threads for set screw	Tap

6.2.2 Laser Cut Wood Parts

All figures will be cut from 1/8” plywood by a laser cutter. This ensures that the artistic elements follow the exact patterns designed in SolidWorks. For figures that require additional support, the team will attach wood or metal supports behind the 1/8” plywood. For figures that require support throughout, such as the reindeer or Santa, the team will cut and attach thicker plywood behind the 1/8” plywood. The team is using 1/8” plywood for all artistic elements to ensure figures will all have the same surface finish when painted.

6.2.3 Motor Mount Parts

The team is utilizing the same 12V DC motor in all boxes that require rotational motion. This motor includes a fixed gear box to change the output RPM. The team will manufacture the motor mount face from 0.5” plywood. The basic template for the face plate is used in all boxes with the motor. Figure 14 shows the face plate for the snowman and Table 10 explains the general manufacturing process that the team will carry out for every face plate.

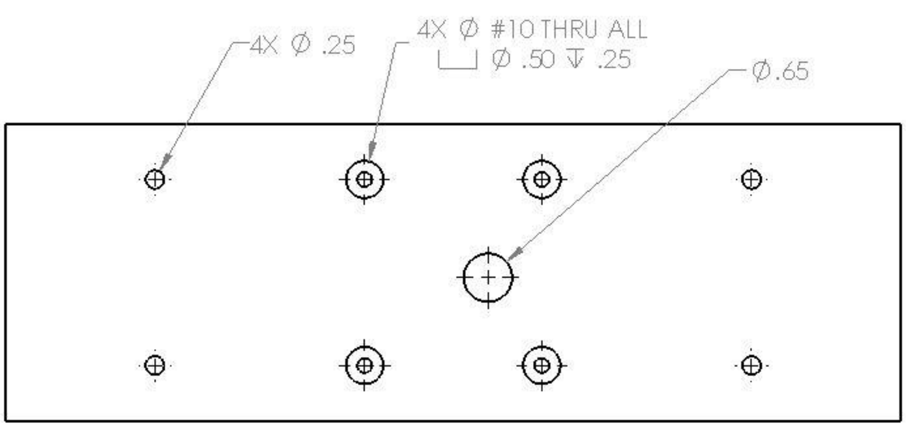


Figure 14. Motor mount face plate.

Table 10. Motor mount face plate manufacturing steps.

Step	Process	Tool
1	Cut wood to size	Table Saw
2	Drill #10 through holes for mounting bolts	Drill Press
3	Drill 0.65 " through hole for motor shaft	Drill Press
4	Drill 0.25" hole	Drill Press
5	Counterbore 0.5" hole to 0.25" depth.	Drill Press

The majority of deviations in the layout of holes on the face plates is in the mounting strategy. The exact mounting strategies are illustrated in Appendix M in each individual box's drawing package, and summarized in the box summaries in Appendix K. The deviations of motor mounts are delineated in Table 11.

Table 11. Motor mount deviations.

Day	Box	Deviation	Tools
7	Hawaiian Girl	The left side of the motor mount has a triangle cut off to allow it to fit inside of the box. The two horizontal holes are made vertical	Drill Press
15	Snowman	The team will drill an additional 1/4" through hole to mount the static linkage pivot point.	Drill Press

6.3 Assembly

6.3.1 Linkage System Assembly

All linkage systems will follow the same general assembly steps. The parts used in each system are similar to allow for unity in assembly and part replacement. An exploded view of the snowman linkage system is shown below in Figure 15 with an explanation of assembly steps provided in Table 12.

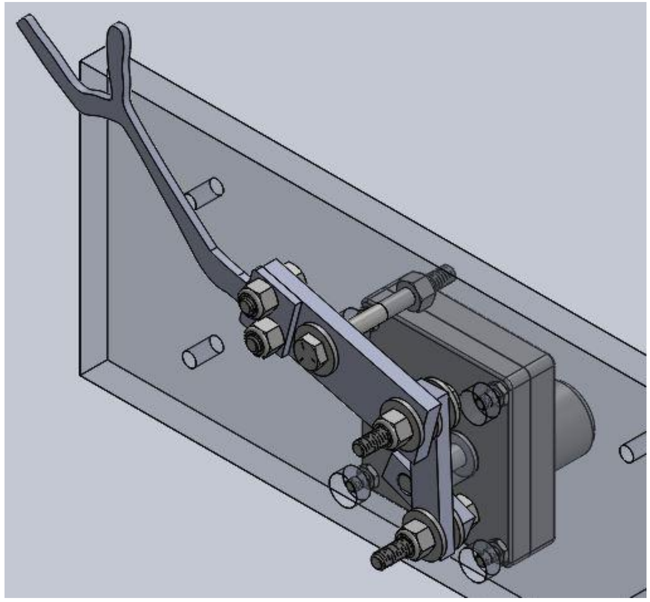


Figure 15. Linkage system for snowman.

Table 12. Motor mount face plate manufacturing steps.

Step	Process	Tool
1	Press fit bushings	Arbor Press
2	Secure motor linkage on motor D-shaft	By Hand
3	Screw and tighten set screw	Allen Key
4	Add bolts, washers, and lock nuts through corresponding linkages	Socket Wrench

6.3.2 Laser Cut Figure Assembly

The team will glue together laser cut figure pieces with wood glue, then glue them to a wood post that is screwed into its proper location within the box. Figures that require special mounting procedures are outlined in the individual descriptions of each theme in Appendix K, and illustrated in the detailed drawing packets in Appendix M.

6.3.3 Motor Mounts

The motor mounts will vary greatly depending on which box each one is utilized for. The general mounting process is outlined in Table 13.

Table 13. Motor mount face plate manufacturing steps.

Step	Process	Tool
1	Screw 2x4 to proper location in box.	Hand Drill
2	Bolt motor mount face plate onto 2x4	Socket Wrench
3	Bolt motor onto motor mount face plate	Socket Wrench

6.4 Outsources

The team will outsource the majority of the project's woodworking processes to a carpenter provided by the sponsor. These tasks include the boxes and the overall structural system. The team will provide a sample box and dimensioned drawings to the sponsor/carpenter. The sponsor will also carry out the decoration of the façade.

7. Design Verification Plan

7.1 Discussion of Design Specifications

For each box designed it must meet seven design requirements. In order to verify each box meets the standard it will need to pass the following tests before it can move on to the first phase of equipment testing. These standards were set in the QFD House of Quality located in Appendix B.

The first requirement is size. The boxes must fill a façade that is nine feet tall and 25-30 feet long without overcrowding the box density of the frame. The shape of each individual box is one of the basic shapes of a square, triangle, or rectangle. The boxes have a depth of 16 inches and are supported by a scaffolding system. Viewability of the box components from all visible angles is essential. Each box must fit all supports, three bar linkages, and equipment within the weather proof box. Visual inspections can verify these requirements.

The next requirement is cost and fitting within the posted budget. Each box has a max pricing limit for electrical hardware ($80), internal themes ($150), and fasteners ($20). The sponsor will subsidize the cost of the external box, which their outside contractor will build. The team will verify the box cost by tracking spending for each box in the budget and accounting excel spreadsheet.

After that, weight is considered. The team must track the weight of the boxes so the center of gravity of the advent calendar can be calculated to provide the most stable orientation for wind and other outside factors that could cause it to fall. The team will measure the weight of each fully-assembled box using a scale and recorded all results. If necessary, the team will add counter balances and extra scaffolding support to meet the desired balance.

Each box must meet a required complexity for the internal theming. There will be five complex boxes, including multiple motions, six medium boxes, including a single motion, five simple boxes, including a detailed light pattern, and 10 lights-only boxes, illuminated by a spotlight and nothing else. This adds up to 26 boxes, 25 for the advent calendar and one for the grand finale. The complexity of the motion is measured by counting the number of motors, actuators, degrees of freedom, and linkages used in each box.

The audience will view each box for a certain amount of time. Each of the 25 boxes runs for 10 seconds and the grand finale, in which all the boxes light up and Santa pops out of a roof, runs for 30 seconds. The team will measure this by writing the run length into the code and using a stop watch to time the boxes' run time to ensure that the code correlates to the correct length of time in the final display.

The aesthetic of the boxes is unified and meets the theme. This means the same color scheme of paint will be used to decorate all the boxes. The internal theming will include 2D cartoonish figures painted in the same style. The team will accomplish this by utilizing a separate team of artists who specialize in theme decorating. The project team will verify this by holding up a color swatch to each box to visually confirm that it follows the chosen palate color. The team will also visually inspect the artistic style.

Finally, the quantity of each box and number of parts in each must match up to the drawing packets used and the bill of materials provided. When the sponsor needs to perform routine maintenance, clear drawing packets are necessary to communicate the supplies and the original condition of the box. The team will draw the design in detail before manufacturing. After the box is created the team will compare it to the drawing using metrology tools such as dial calipers and measuring tape. The team can then add any unexpected deviations in the box construction to an updated drawing for future reference. The team will also record the part count.

7.2 Description of Testing

The major equipment testing is broken up into three phases and spread out over the course of six months before final installation in Cambria. The first series of testing, in the form of individual box assembly, will commence once the box has met the seven standards set in Section 7. Next is electrical testing, and last is the addition of music to the working model.

Individual boxes must work independently of the whole system. The internal theming must run without the linkages breaking or any interference between moving components. All the supports and mounts must fit within the dedicated box width, height, and depth. The team will conduct these inspections using metrology and by powering on the motors.

The team tested the electrical hardware and software once the boxes were arranged on the façade and distance to the power source origin was known in greater detail. The team ensured that all joins in electrical wiring are well insulated and have a solid connection. The rating of the wire must support the required current; the team inspected and measured the heat of the wires after the system has run for a few minutes to confirm this.

Finished façade assembly in preparation for final installation includes matching the music to the correct boxes and ensuring the Raspberry Pi controls each box to trigger on at the right time. The team will test this with visual inspection as well as an inspection checklist. During the varied time in seconds in which the box is lit, the light must come on, the action must take place, the correct music must play, and the box must go completely dark when its turn is over. The team will verify these requirements for each box and confirm that all transitions are smooth.

7.3 Detailed Testing

The team measured the voltage and current of each box using a digital multimeter to ensure that the source meets all the required power needs of the façade. The team can then use these measurements and the equivalent resistance and voltage source to make theoretical calculations. The team will follow a detailed electrical hazards checklist to ensure the wiring of the system meets safety standards.

7.4 DVP of System

The DVP in the Appendix L includes a cumulative list of tests and measurements for the system. This will act as a checklist to ensure that the systems are all tested and running smoothly and safely before final installation in Cambria.

8. Project Management

8.1 Process of Design and Deadlines

After speaking with the sponsor about what parameters they want the project to meet, the team started outlining what the project was going to be. Table 14 below summarizes the key deliverables and their due dates for the project. The team drew out ideas of what the project could look like and what features it was going to have. After analyzing each idea's positive and negative contributions, the team compared each idea to the others, and came to a compromise of what the best design-layout this project was going to be. At this point the division of labor was the next step. The team compromised on the work each member would contribute. Collaboration about each other's progress occurred regularly, along with new problems and solutions which came to the team's attention.

Table 14. Deliverables with Corresponding Relevant Dates

Key Deliverables	Relevant Dates
Conceptual Models	Due on: 02/12/19
Conceptual Prototypes	Due on: 02/28/19
Preliminary Design Review	Due on: 03/08/19
Structural Prototype	Due on: 04/18/19
Critical Design Review	Due on: 05/03/19

Manufacturing	05/07/19 - 10/04/19
Off-Site Assembly	09/24/19 - 10/15/19
Off-Site Testing	10/15/19 - 10/25/19
On-Site Assembly	Due on: 10/25/19
On-Site Testing	10/25/19 - 11/15/19
Final Design Review	Due on: 11/15/19

8.2 Gantt Chart

In order to better organize the key deliverables shown in Table 6, the team also created a Gantt chart using TeamGantt. With the use of this chart, the team now knows approximately how long each deliverable will take to complete, any dependencies between deliverables, and who is in charge of each deliverable. The Gantt chart can be seen in Appendix C.

8.3 Designating Roles

After establishing the given parameters that the project needs to fulfill, the team designated what roles each person on the team would focus on. Danny is concentrating his efforts on the artistic part of the designs, which will include items such as the design of the facade for the exterior of the structure, how lights and objects will be placed in each box, and when they will start moving. Tyler is leading the Mechatronics portion of the project, which puts him in charge of precisely how the project will be able to flash lights and move objects. Sigrid is in charge of the necessary CAD drawings for all individual components of the assembly. Finally, Oma will be in charge of keeping notes on what changes have been made to the project, what ideas were brought up during meetings, who is in charge of the tasks for each given week, and general manufacturing needs.

8.4 Critical Design Stage

The next major phase in the project is the Manufacturing and Test Status Review, which will be completed by May 31, 2019 towards the end of Spring Quarter. Now that the preliminary designs have been moved to fully fleshed-out designs and the team has begun manufacturing the non-mechanical elements, the team can begin preparing a Risk Assessment document and a Safety Review document. The Risk Assessment will consider the activities of different users when interacting with the design, assess the hazards they may be exposed to and the severity and likelihood of those risks, and include specific plans to deal with high risk hazards. The Safety Review will include previous documentation relating to safety such as the FMEA, the Hazard Checklist, and the Risk Assessment, and will also include a new Safety Plan which will list all recommended actions identified by the previous documents along with the responsible person and anticipated completion date.

8.5 Construction, Installation, and Testing

The primary construction of the façade, boxes, and mechanical elements took place in the Cal Poly Machine Shops. Some wood components, such as the boxes, were built by a carpenter at the Cambria Pines Lodge, then transported to Cal Poly for assembly. The theming is designed to be layered, two-dimensional plywood. The plywood was laser cut in the machine shops then assembled once all materials have been procured or manufactured. Due to the lack of storage space at Cal Poly, completed boxes were transported to Cambria in batches. Each box was manufactured, assembled, and tested individually at Cal Poly. Once all boxes were built and transported back to Cambria, they will be installed into their final placement at the Cambria Pines Lodge, at which point Final Testing will commence.

9. User's Manual: Electrical and Programming

9.1 Purpose of Incorporating Electrical and Programming into the Project

One of the given parameters for our Advent Calendar is for the boxes to turn on and off in a timed cycle. A real advent calendar reveals a day in December one after the other, our objective was to make the turning on of the boxes in the advent calendar resemble the process of revealing one day in December after the other. For example, when the cycle starts, Day 1 on the Advent Calendar Display will light up for approximately 20 seconds with music being played that is appropriate with that box's theme. Then Day 1 will turn off and Day 2 will light up. The days will increment in this pattern until the 25th day has turned on, which right after, will start the finale where every box stays on for about 20 seconds. Triggering the boxes to turn on and off in a timed sequence requires the use of a preprogrammed microcontroller and an electrical system in between the microcontroller and the boxes.

9.2 Programming Details

The Advent Calendar Display is timed by a Raspberry Pi 4 microcontroller. The boxes need to be turned on and off independent of one another, so that requires that each box correspond to an individual pin, at least in an ideal situation. The Advent Calendar's situation was not ideal, it needed 25 pins from the microcontroller, but almost all microcontrollers are limited to 20 GPIO pins. So, the lack of pins required support from additional electrical devices, which is explained more in depth in section 9.3. Since the microcontroller has enough pins by working with the added in electrical devices, the code was able to be written to perform the necessary timings of the boxes. The Raspberry Pi 4's code was written with the Python programming language. Turning on and off the pins of the Raspberry Pi involved toggling the 3.3 volt or electricity that can be produced by the GPIO pins. The rate at which these pins were toggled involved using a delay function, outsourced by an online Python library, and those delays were programmed to last as long as the segment of song that we chose that corresponds with the box that is on. Playing a playlist that we made from the Raspberry Pi involved outsourcing to another online Python library, which allows the microcontroller to have readable access to the MP3 file that we provided it. The Raspberry Pi does not, by default, execute written code once plugged in, although most other microcontrollers have this capability. So, some additional code found online was needed in order to allow the microcontroller to execute the Advent Calendar code once plugged into a power source.

9.3 Electrical Layout

The problem discussed in section 9.2, of the shortage of GPIO pins was solved by the incorporation of decoders and OR gates. Instead of making each pin of the Raspberry Pi correspond to each box, the arrangement of a select number of pins from the microcontroller can yield more outputs than the number of pins used, this is what the decoder was used for. Each decoder takes in 3 of the microcontroller's pins and translates the arrangement of which pins that are on and to which pins that are off, which yields 8 independent pin outputs. Since the Advent Calendar Display requires

25 individual outputs, we had to use 4 decoders, which use up 12 of the Raspberry Pi's pins, in order to have 28 individual outputs.

Two OR gates are assigned to each one of the decoders. The purpose of the 8 OR gates is to coordinate the finale, which involves turning every box on at the same time. 4 pins, one for each encoder, from the Raspberry Pi are needed to trigger the OR gates in such a way that all of the boxes turn on. Since the boxes run on 120 volts of electricity, sending 3.3 volts to the boxes alone won't turn on the boxes. Relays were installed right before the boxes, in order for a 3.3 volt surge to trigger a switch, which closes the line of electricity of 120 volts going to the boxes. The data sheets for the decoders, OR gates, and relays are included in Appendix O.

9.4 Safety and Precautions with Electrical Equipment

For workers at the Cambria Christmas Market that need to regularly maintain the quality and performance of the Advent Calendar Display, it is important to convey the hazards that are present in the display:

- Exposed wires are minimalized but still present, make sure that the power supply is turned off before coming into contact with any wires.
- The display is not waterproof, some water could short relays and outlets, be sure to turn of the power supply before assessing water-logged relays or outlets.
- Do not exceed the 5V power supply connected to the electrical system.
- Solders are fragile, be sure to handle the electrical system with care, or some soldered wires may break, which will disrupt the quality of the system performance.
- Always store electrical system in an enclosed water-proof container.
- To prevent prolonged heat exposure, store the boxes in a storage isolated from weather conditions in the off seasons.

10. Conclusion

This document discusses the team's plan to create the Advent Calendar structure for the Cambria Christmas Market. The plan includes the entire problem statement, the background information on the Market, preliminary and final design for the façade and the 25 themed boxes, detailed manufacturing, design verification, and the timeline to meet the project's accelerated deadline. This new attraction will add to the festivities at the Cambria Christmas market for years to come, the project must be built to be a lasting addition to the event. Team Naughty and Nice has shown the intentions of the design to meet these criteria through this report. Approximately 75,000 people attend the Cambria Christmas Market each year, and as such it is crucial that this project puts on an amazing performance in order to positively represent the values and high standards of the sponsor's event.

References

[1] “Info” *cambriachristmasmarket.com,* Cambria Christmas Market, 2019

[2] “NorthLight 5 Ft. Inflatable Santa Claus Snow Globe Lighted Christmas Yard Art Decoration.” *Amazon*, Amazon, www.amazon.com/NorthLight-Inflatable-Lighted-Christmas-Decoration/dp/B013GMQHZK/ref=sr_1_3?ie=UTF8&qid=1548188034&sr=8-3&keywords=snow%2Bglobe%2Blawn.

[3] Honus, and Instructables. “Arduino Animatronics- Make Your Awesome Costumes More Awesome!” *Instructables.com*, Instructables, 4 Nov. 2017, www.instructables.com/id/Arduino-animatronics-make-your-awesome-costumes-m/.

[4] Brown, Henry T. *507 Mechanical Movements: Mechanisms and Devices*. Dover Publications, Inc., 2005.

[5] https://www.weather.gov/media/wrh/online_publications/TMs/TM-223.pdf

[6] https://www.grc.nasa.gov/www/k-12/airplane/shaped.html

Appendices

Appendix A: User Interview

Appendix B: QFD House of Quality

Appendix C: Gantt Chart

Appendix D: Ideation and Concept Selection Materials

Appendix E: Detailed Sketches

Appendix F: Box Design Details

Appendix G: Design Hazards

Appendix H: Hand Calculations

Appendix I: FMEA

Appendix J: Bill of Materials

Appendix K: Box Theme Final Designs

Appendix L: Design Verification Plan

Appendix M: Detailed Drawing Packets

Appendix N: Electrical Schematic

Appendix O: Electrical Datasheets

Appendix A: User Interview

Questions for Sponsor:
(Lee McFarland, Shana McCormick, and Haak Pearson)

1. What is the facade going to look like?
    a. Images? Sketches of it for us to see?
    b. Permanent to our set or is it fastened?
    c. Flush to boxes, do we design how it mounts?

   Answer: Yes, it will be flush to your boxes. We want it to have a German facade. There are some images listed on the sheet we gave you to guide your aesthetic design. Make everything disassemble for storage but it should be attached to the boxes somehow.
2. Where would you want the number to display for each box?
    a. Color/design scheme to follow?

   Answer: Anywhere, have fun, be eccentric, just make sure the number is in there somewhere.
3. What decorations exactly do you want us to be in charge of (santa popping out, lights, adding colored-paint, streamers…)?
    a. Define where our roles ends and your role begin?

   Answer: We have a huge stockpile of Christmas decorations and you can use our lights. We have a Christmas supplier in LA that we can order in bulk from. We want the decorations to be OVER THE TOP!
4. Box Clarifications:
    a. At least 10 boxes with moving parts? Is it a minimum? Maximum?
    b. Have lighting count as motion?
    c. What do you expect the non-moving boxes to include.

   Answer: Yes, as much motion as can fit in the budget. We want this display to catch the eye of the viewer and make them say "wow!"
5. Potential or intended location? Can we visit it and take pictures?

   Answer: We are still thinking about where we want it to be, we will get back to you.
6. Other December holidays/themes to include?
    a. Our Lady of Guadalupe
    b. Hanukkah
    c. Mele Kalikimaka
    d. Kwanzaa

   Answer: Maybe not Kwanzaa but represent everything you want to dedicate a box to.
7. One big plexiglass sheet or embedded sheet in each box?

   Answer: Break it up into smaller pieces. We can have the contractor make all the boxes so that material wouldn't come out of your budget.
8. Does the Lodge already have a budget for copyrighted music (i.e. BMI, ASCAP, SESAC)?
    a. What songs are a must for you?

   Answer: They have no song preference and do not pay into a copyright group for music.
9. Delay between cycles?
    a. Length, announcement, sign?

Answer: Short off-time between cycles, 10ish seconds for each box. But - grand finale at end where everything is on and lit up with music so people can take pictures.

10. Transportation/storage requirements
    a. Size, Location of storage distance, method to move it (Wheels)

    Answer: Shed that it is stored in is very full so it needs to be compact and easy to move without breaking.
11. Power locations and outputs?

    Answer: Power is no problem, we can bring it to you wherever you are.
12. How often do you want to meet in person?
    a. How often do you want to skype/phone call?
    b. Weekly email updates?
    c. What are your expectations?

    Answer: No expectations, just give an update about every 2 weeks.
13. Improvements to the 12 days display?
    a. Decorations? Maintenance? Storage? Lifetime/longevity? Speaker sounds song blending?

    Answer: Needs better maintenance access and the wiring box needs to be more professional. Storage is also hard because it doesn't collapse very well.
14. Any closing remarks?

    Answer: Have fun with this, get creative and unique with designs.

Appendix B: QFD House of Quality

Correlations	
Positive	+
Negative	–
No Correlation	

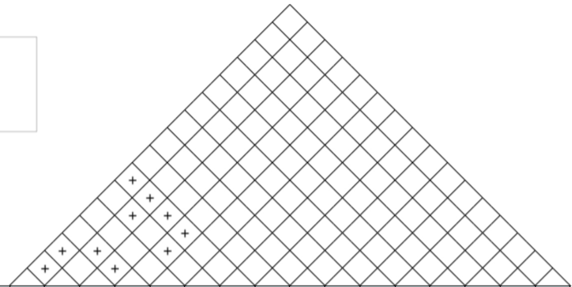
Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼

QFD House of Quality

Project: ______________________________

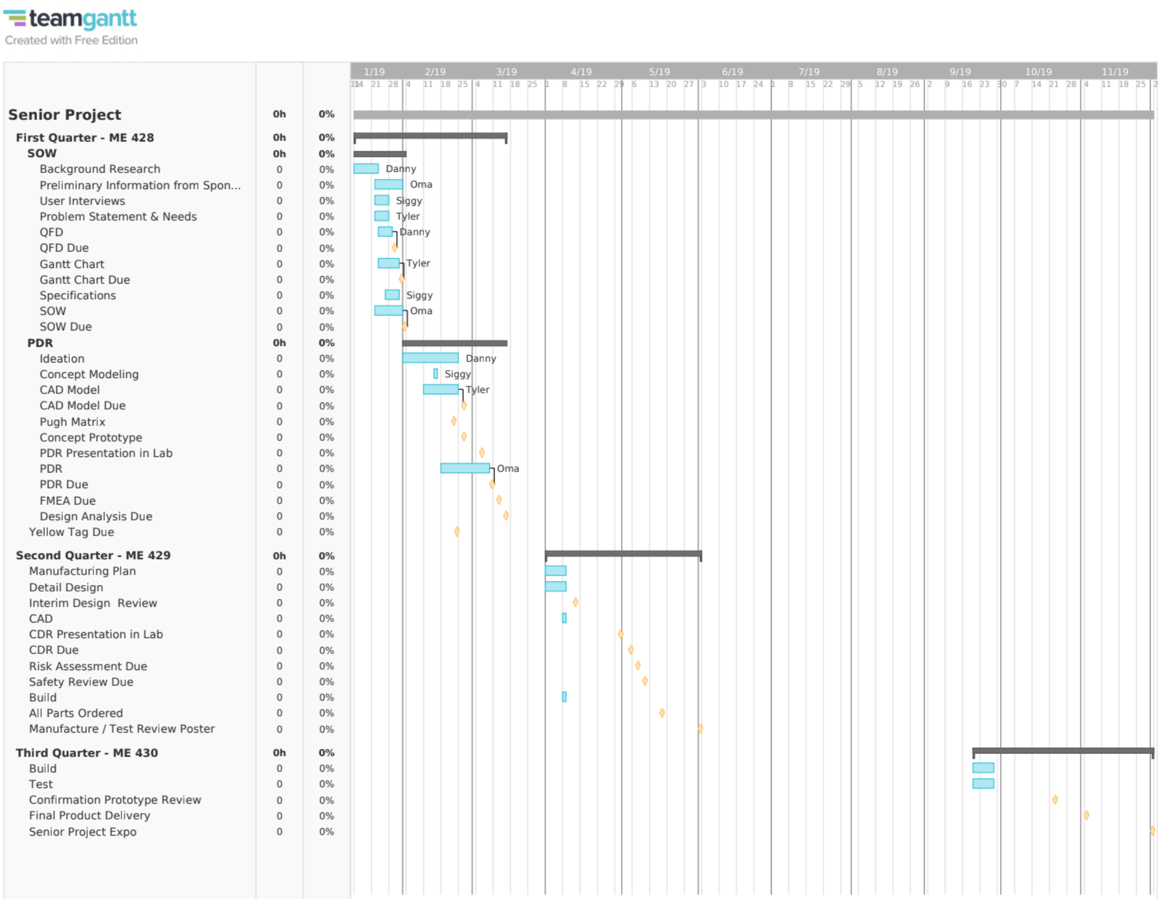
Revision Date: _________________



Row #	Weight Chart	Relative Weight	Guest	Owner	Operator		Maximum Relationship	WHAT: Customer Requirements (Needs/Wants) \ HOW: Engineering Specifications (Tests)	1 Size	2 Cost	3 Weight	4 Complexity	5 Time	6 Aesthetic	7 Quantity	8	9	10	11	12	13	14	15	16	Our Current Product	Competitor #1: *12 Days Display*	Competitor #2: Small World	Competitor #3: Rose Float		Row #
								Direction of Improvement	◇	▼	▼	▲	◇	▲	◇															
1		7%	7	9	6		9	Number of Stationary Scenes				▽		▽	●										?	2	4	4		1
2		7%	8	9	6		9	Number of Simple Moving Scenes				▽		▽	●										?	3	4	4		2
3		8%	9	9	6		9	Number of Medium Moving Scenes				▽		▽	●										?	3	2	4		3
4		8%	10	9	6		9	Number of Complex Moving Scenes				▽		▽	●										?	2	5	2		4
5		7%	5	10	8		9	Overall Dimensions	●		○			▽											?	4	5	4		5
6		4%	2	10	3		9	Cost		●					○										?	2	3	2		6
7		8%	8	8	7		9	Functions in Finale				○	▽	○	●										?	1	4	3		7
8		7%	8	8	5		9	Scene Size	●		▽			▽											?	4	4	4		8
9		5%	1	8	8		3	Power Draw		○					○										?	5	4	3		9
10		5%	0	8	10		3	Repairability		▽			○												?	1	2	1		10
11		5%	0	9	9		3	Storage	○						▽										?	1	5	2		11
12		5%	0	8	10		3	Assembly/Dissasembly			○		○												?	3	5	1		12
13		6%	10	10	0		9	"Wow" Factor				○		●											?	3	5	4		13
14		6%	10	10	0		9	Festivity				○		●											?	5	5	4		14
15		4%	8	5	0		9	Time					●												?	4	3	3		15
16		6%	0	9	10		3	Weather Proof		▽				○											?	3	5	1		16

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	HOW MUCH: Target Values	Size (20'x12'x2')	Cost ($8,000)	Weight (Minimize)	Complexity (More)	Time (5 secs/scene)	Aesthetic (Pleasing)	Quantity (Meet Requirements)									
	Max Relationship	9	9	3	3	9	9	9									
	Technical Importance Rating	141.7	64.73	44.7	90.47	78.99	196.8	373.9	0	0	0	0	0	0	0	0	0
	Relative Weight	14%	7%	5%	9%	8%	20%	38%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Curr. Products	Our Current Product	?	?	?	?	?	?	?									
	Competitor #1: 12 Days Display	0	2	3	2	4	3	5									
	Competitor #2: Small World	0	0	0	5	0	5	5									
	Competitor #3: Rose Float	0	0	0	4	0	5	5									
	Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Appendix C: Gantt Chart



Appendix D: Ideation and Concept Selection Materials

1. List of Box Ideas

Characters:

- Frosty the Snowman
- Jesus
- Rudolph
- Santa Claus
- Grinch
- Elves
- Gingerbread man
- Ballerina
- Jack Frost
- Scrooge "Bah Humbug"
- Jack Skellington
- Krampus

Religious Holiday:

- Christmas Tree
- Angel
- Carolers
- North pole
- Reindeer
- Stocking
- Santa sleigh
- Presents/Gift
- Christmas dinner
- Cookies and milk
- Hanukkah Menorah
- Dreidel
- Nativity Scene
- Three Wise Men

Winter:

- Snowman
- Icicles
- Mittens
- Jacket
- Snow
- Stars/shooting stars/moon
- Snow boots
- Fireplace
- Snowflake
- Penguins
- Polar Bears
- Snow angels
- Snowball fights
- Snowball
- Marshmallows by the fire
- Hot chocolate
- Peppermint
- Ice skating
- Chimney with smoke
- Chestnuts roasting
- Candles
- Shoveling snow
- Igloo
- Ice fishing

Items:

- Snow globe
- Sleigh / Sledding
- Bells
- Mistletoe
- Garland
- Ornaments
- Wreath
- Nutcracker
- Bells
- "'Twas the night before Christmas" poem
- Gingerbread house
- Eggnog
- Toboggan
- Naughty or nice list
- Candy Cane
- Wrapping Paper and Bows
- Christmas train

2. List of Song Ideas

1	"Santa Claus Is Coming to Town"	J. Fred Coots, Haven Gillespie	1934	Mythical
2	"Have Yourself a Merry Little Christmas"	Ralph Blane, Hugh Martin	1944	Celebratory/Sentimental
3	"Winter Wonderland"	Felix Bernard, Richard B. Smith	1934	Seasonal
4	"Let It Snow! Let It Snow! Let It Snow!"	Sammy Cahn, Jule Styne	1945	Seasonal
5	"The Christmas Song"	Mel Tormé, Robert Wells	1944	Traditions
6	"Jingle Bell Rock"	Joseph Carleton Beal, James Ross Boothe	1957	Celebratory/Seasonal
7	"It's the Most Wonderful Time of the Year"	Edward Pola, George Wyle	1963	Seasonal/Traditions
8	"Sleigh Ride"	Leroy Anderson, Mitchell Parish	1948	Seasonal/Birthday
9	"Rudolph the Red-Nosed Reindeer"	Johnny Marks	1939/1949	Mythical
10	"It's Beginning to Look a Lot Like Christmas"	Meredith Willson	1951	Traditions/Celebratory
11	"White Christmas"	Irving Berlin	1940	Seasonal/Sentimental
12	"A Holly Jolly Christmas"	Johnny Marks	1964/65	Traditions/Celebratory
13	"Carol of the Bells"	Peter J. Wilhousky	1936	Celebratory
14	"Rockin' Around the Christmas Tree"	Johnny Marks	1958	Traditions
15	"All I Want for Christmas Is You"	Mariah Carey, Walter Afanasieff	1994	Sentimental
16	"Frosty the Snowman"	Steve Nelson (songwriter), Walter E. Rollins	1950	Mythical
17	"Blue Christmas"	Billy Hayes, Jay W. Johnson	1957	Traditions
18	"(There's No Place Like) Home for the Holidays"	Bob Allen, Al Stillman	1954	Traditions/Sentimental

19	"The Little Drummer Boy"	Katherine K. Davis, Henry V. Onorati, Harry Simeone	1941	Christian-based
20	"Do You Hear What I Hear?"	Gloria Shayne Baker, Noël Regney	1962	Traditions
21	"Silver Bells"	Jay Livingston, Ray Evans	1950	Traditions
22	"Baby, It's Cold Outside"	Frank Loesser	1948	Seasonal
23	"I Saw Mommy Kissing Santa Claus"	Tommie Connor	1952	Novelty
24	"Feliz Navidad"	José Feliciano	1970	Celebratory
25	"Christmas Eve/Sarajevo 12/24"	Jon Oliva, Paul O'Neill, Robert Kinkel	1995	Instrumental (no lyrics)
26	"Last Christmas"	George Michael	1984	Sentimental
27	"Here Comes Santa Claus (Right Down Santa Claus Lane)"	Gene Autry, Oakley Haldeman	1947	Mythical/Christian-based
28	"Santa Baby"	Joan Ellen Javits, Philip Springer, Tony Springer, and Fred Ebb	1953	Novelty
29	"Happy Holiday"	Irving Berlin	1948	Celebratory
30	"Wonderful Christmastime"			

3. Preliminary Box Number, Theme, and Song Assignments

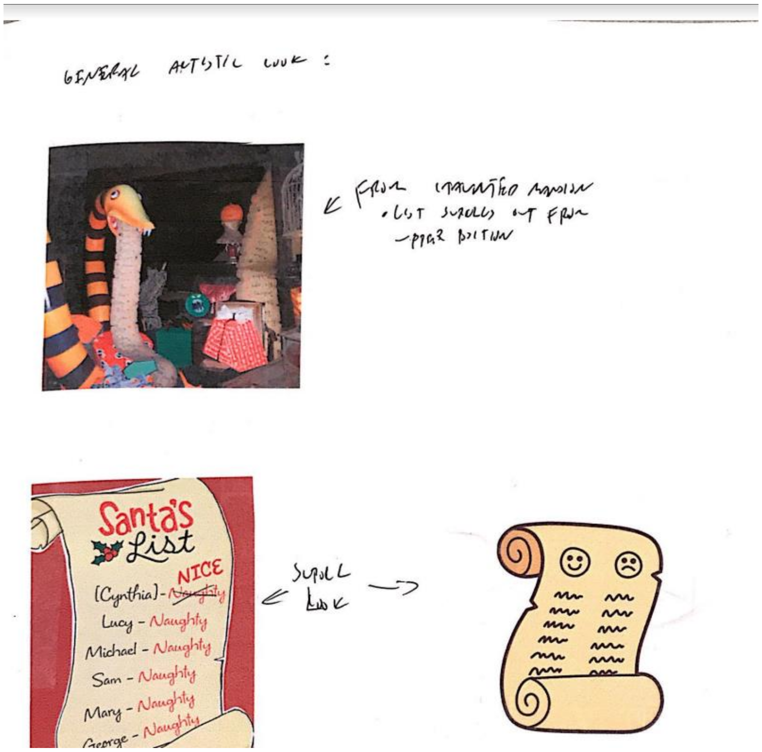
Day	Assignment	Idea(s)	Action(s)	Action Level	Song(s)
1	Siggy	Wreath	sits on building with number and then lights up	Lights Only	----
2	Danny	Penguins	waddle, head moves	Light Only	----
3	Tyler	Naughty and Nice List	unwraps, unfolds, falls down	Lights Only	I Saw Mommy Kissing Santa
4	Oma	Igloo and Icefishing	raise and lower fishing rod	Medium	White Christmas
5	Siggy	North Pole and Polar bears and snowglobe	spinning pole	Medium	Let It Snow
6	Tyler	Snowflakes and icicles	spin, fall	Simple / Light Only	Carol of the Bells
7	Danny	Hawaiian Christmas	hula girl dance	Lights Only	Mele Kalikimaka
8	Danny	Toboggan	toboggan goes down hill, scenery moves underneath	Complex	----
9	Siggy	Gingerbread person	shakes, walks, spins	Lights Only	----
10	Tyler	Ice Skaters	skate around rink	Complex	----
11	Siggy	Christmas Train	goes around building with number	Complex	Up on the Rooftop
12	Oma	Lady Guadalupe	lights up	Light Only	Las Apariciones de Guadalupe
13	Oma	Elf Assembly Line	make toys, conveyor belt of toys	Complex	Deck The Halls
14	Danny	Mistletoe Garlands	shakes	Medium	Deck The Halls
15	Tyler	Snowman	spin	Simple, Lights Only	----
16	Siggy	Menorah and Dreidel	dreidel spins	Simple	Dreidel Dreidel Dreidel
17	Danny	Reindeer	red nose light up, leg kicking	Simple	Rudolph the Red-Nosed Reindeer
18	Oma	Bells	shaking	Simple	Jingle Bell

19	Siggy	Shooting star	moves across roofs, lights up	Simple	
20	Oma	Ugly Christmas sweater	lights	Lights Only	
21	Danny	Nutcracker	crack nut, mouth opens and closes	Medium	Sugar Plum Fairy
22	Danny	Snowball Fight	Snowballs thrown back and forth	Complex	
23	Tyler	Nativity Scene	star lights up above scene	Lights Only	Joy to the World
24	Siggy	Cookies and milk	milk fills/empties from cup, cookies get bites taken out	Medium	Jolly Old Saint Nicholas
25	Oma	Christmas Tree with Presents, Fireplace w/ stockings	lights up	Lights Only	Rockin Around the Christmas Tree
Finale	Tyler	Santa	Comes out of chimney	Medium	We Wish You a Merry Christmas

4. Weighted Decision Matrix

Criteria	weight	Options																	
		Christmas String Lights		Individual LED lights		Spotlight		Light Up Hockey Pucks		Imitation Candle Light		Cold/Blue Light		Warm/Yellow Light		Theatre Stage Color lighting		LED Strip Lighting	
		Score	Total	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total	Score	Total
Ease to Code Off/On	8	1	8	-1	-8	1	8	2	16	1	8	1	8	1	8	1	8	1	8
Cost to Purchase	7	2	14	2	14	-1	-7	1	7	-1	-7	1	7	1	7	1	7	2	14
Light pleasurable to viewer	9	2	18	2	18	1	9	2	18	2	18	-2	-18	2	18	1	9	0	0
Ease to blend in with scenery	3	0	0	2	6	-1	-3	0	0	2	6	0	0	0	0	0	0	1	3
Installation	2	1	2	-2	-4	2	4	2	4	1	2	2	4	2	4	2	4	1	2
Life/Longevity	6	2	12	2	12	2	12	2	12	1	6	2	12	2	12	2	12	1	6
Easy to Purchase	4	2	8	2	8	1	4	1	4	0	0	1	4	1	4	-1	-4	0	0
Ability to iluminate a box	5	2	10	-1	-5	2	10	2	10	1	5	1	5	1	5	1	5	0	0
Maintanence	1	2	2	0	0	1	1	1	1	-2	-2	1	1	1	1	1	1	-2	-2
Final Totals:		74		41		38		72		36		23		59		42		31	

Appendix E: Detailed Sketches

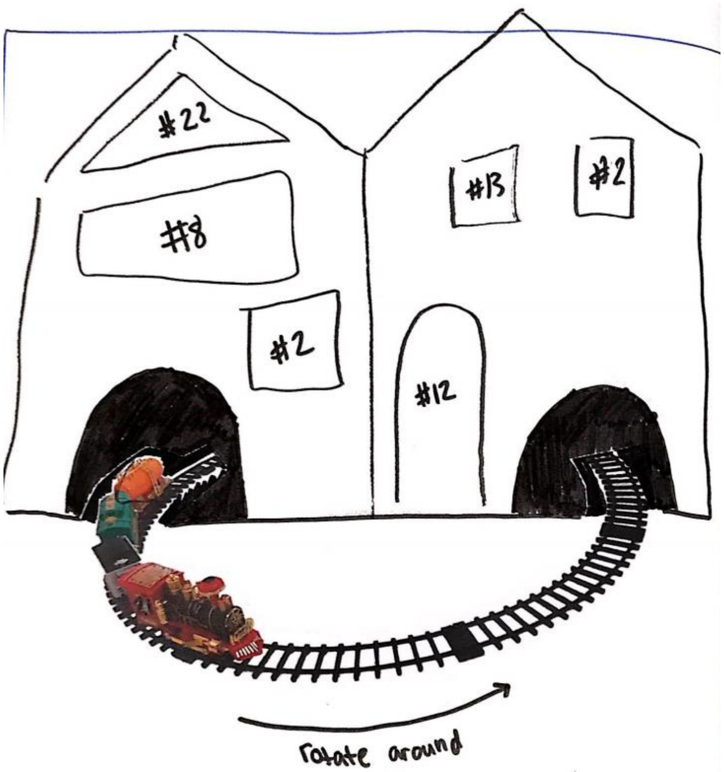


Drawing 1: Naughty and Nice List

Drawing 2: Wreath

Drawing 3: Snow globe

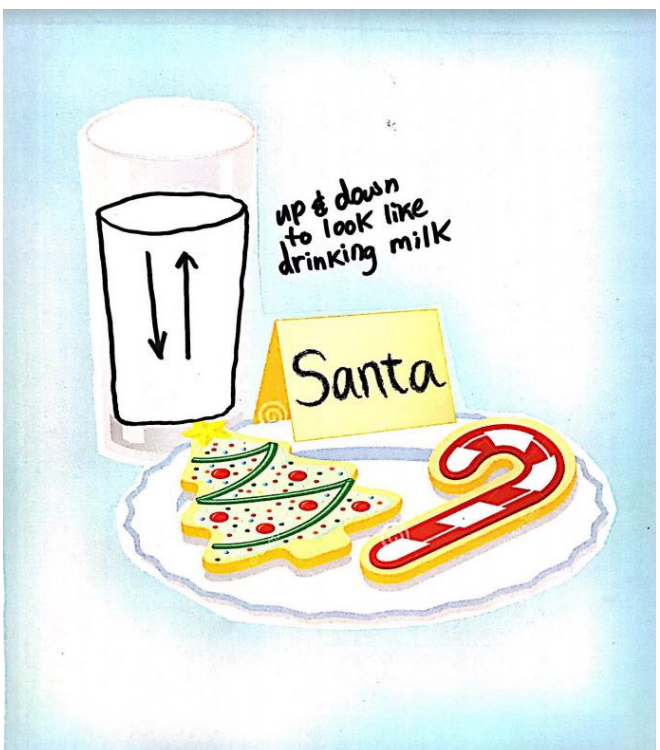
Drawing 4: Gingerbread Man



Drawing 5: Train

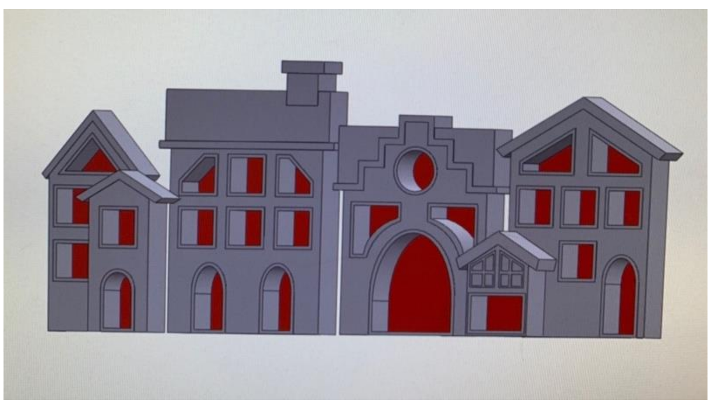
Drawing 6: Dreidel

Drawing 7: Ugly Sweater



Drawing 8: Milk and Cookies

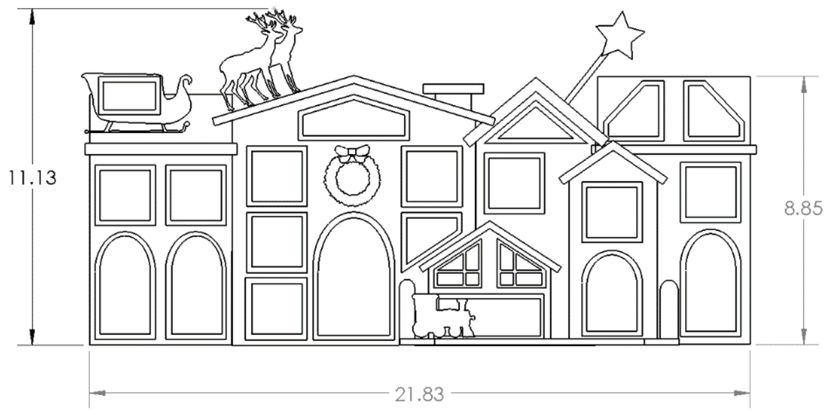
Drawing 9: Rough Sketch of Final Façade



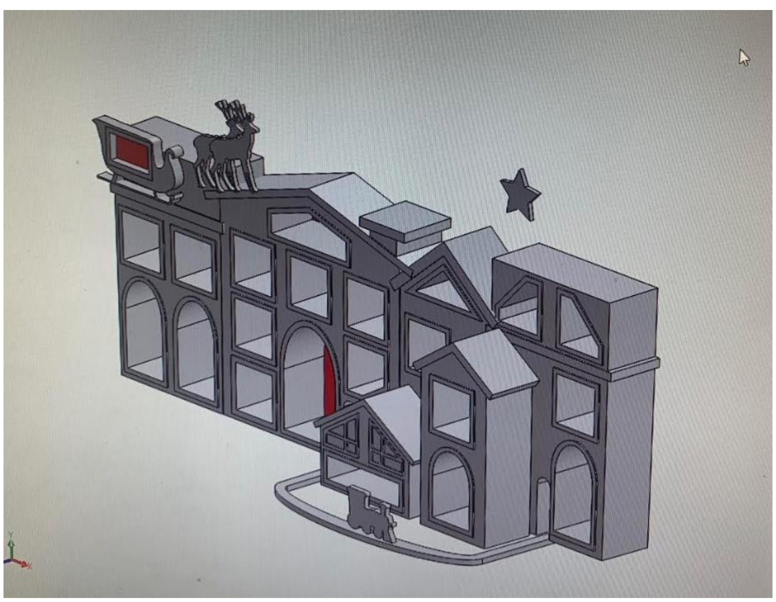
Drawing 10: First Façade Design

Drawing 11: Second Façade Design

Drawing 12: Third Façade Design



Drawing 13: Final Façade Design



Drawing 14: Isometric Final Façade Design

Appendix F: Preliminary Box Design Details

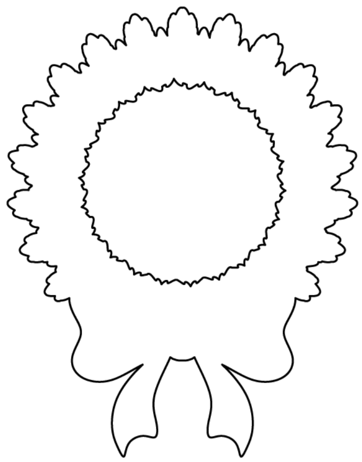
1. **Wreath**
2. **Penguins**
3. **Naughty and Nice List**
4. **Igloo and Ice Fishing**
5. **Snow Globe (Polar bear / North Pole / Igloo)**
6. **Snowflake**
7. **Hawaiian Christmas**
8. **Toboggan**
9. **Gingerbread Person**
10. **Ice Skaters**
11. **Christmas Train**
12. **Lady Guadalupe**
13. **Elf Assembly Line**
14. **Mistletoe**
15. **Snowman**
16. **Menorah and Dreidel**
17. **Rudolph**
18. **Bells**
19. **Shooting Star**
20. **Ugly Christmas Sweater**
21. **Nutcracker**
22. **Snowball Fight**
23. **Nativity Scene**
24. **Cookies and Milk**
25. **Christmas Tree Scene**

Finale. Santa

Day 1: Wreath

The wreath will be the first thing the audience sees as the advent calendar display begins. The wreath will be made of painted wood that is offset from the façade. It will be a lights-only display where the Christmas bulbs will light up in a slow pulsing random order.

<u>CAD Model</u>

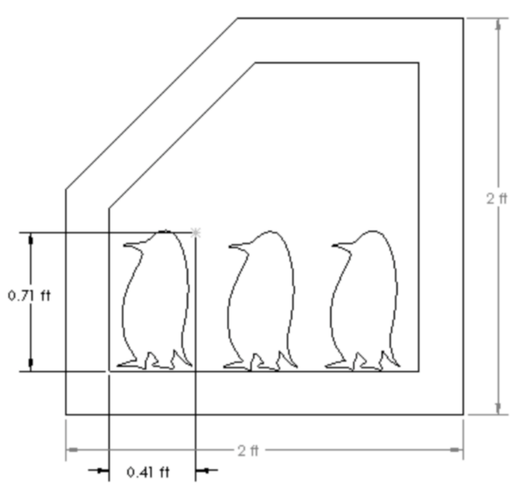


<u>Artistic Reference</u>

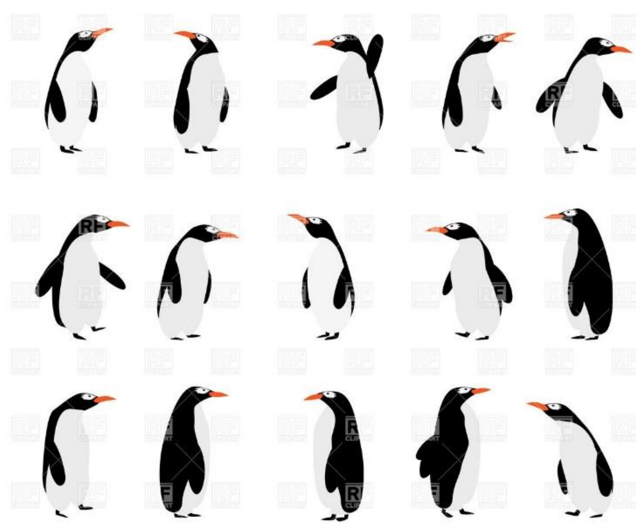
Day 2: Penguins

The Penguins box will be a lights-only box. It will show the penguins with slowly dimming in and then dimming out lights on to the penguins. The penguins will be made out of a sheet of wood and will be painted to resemble their features.

<u>CAD Model</u>



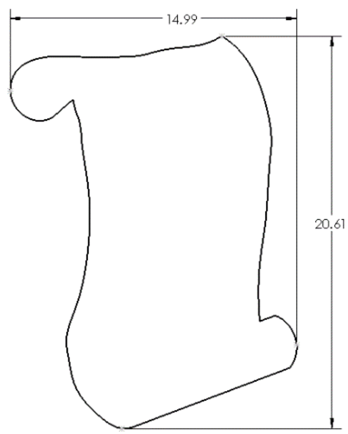
<u>Artistic Reference</u>



Day 3: Naughty and Nice List

The naughty or nice list will be a light only scene. The list will contain names made from a semi-opaque white acrylic and backlit by LEDs. The names will cycle between green and red indicating the child's status as "naughty" or "nice." The top of the list will have the words "Naughty" or "Nice" in their designated color to further the understanding of what the colors represent.

CAD Model

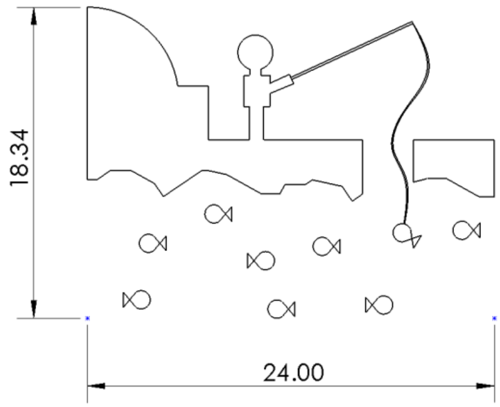


Artistic Reference

Day 4:

In the ice fisherman scene, a cross section of an igloo on a sheet of ice is shown. The fisherman is pictured fishing through a hole in the ice. The fishing pole will appear to move up and down with the fish on the line.

CAD Model

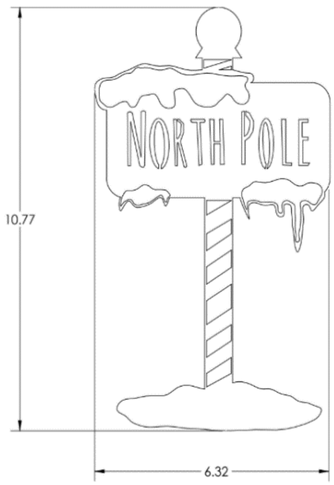


Artistic Reference

Day 5:

Snow globe will have many layers with a polar bear, igloo and north pole sign. The sloped internal ramps will send the poly urethane beads, similar to those found in a bean bag chair, back to the fan which will blow them back up into the air making it appear as if there is snow falling in the display.

CAD Model

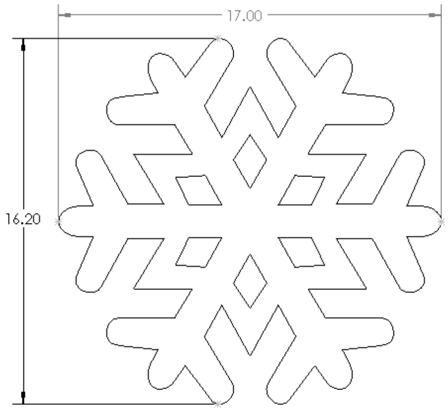


Artistic Reference

Day 6: Snowflake

The snowflake will be a light only scene. The snowflake will take up the full box. It will have a pattern of LEDs contained within it that will twinkle to the beat of the music playing.

CAD Model

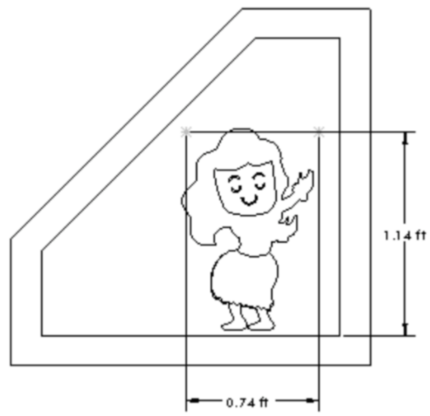


Artistic Reference

Day 7: Hawaiian Christmas

The Hawaiian Christmas box will have a girl dancing to Hawaiian Christmas themed music. The girl will have her leaf skirt able to move left and right to the beat of the music.

<u>CAD Model</u>

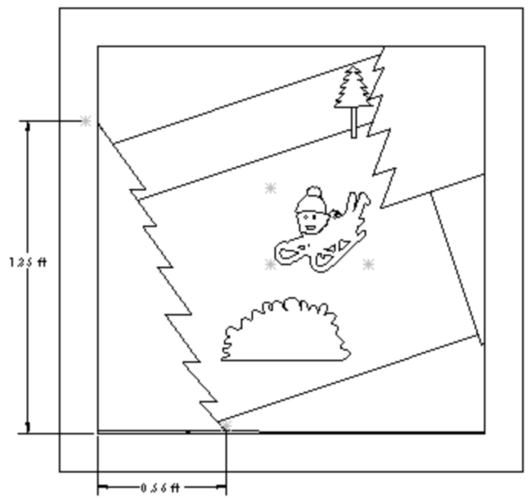


<u>Artistic Reference</u>

Day 8: Toboggan

The Toboggan box is one of the most complex boxes, in regard to the movement required. It will consist of stationary objects such as the kid on the toboggan, the two large trees in the front, a hill and the sky. There will be a paper background that revolves around two cylindrical motors like a treadmill, and the background will loop over and over, which will give off the impression that the child is sledding down a hill.

<u>CAD Model</u>

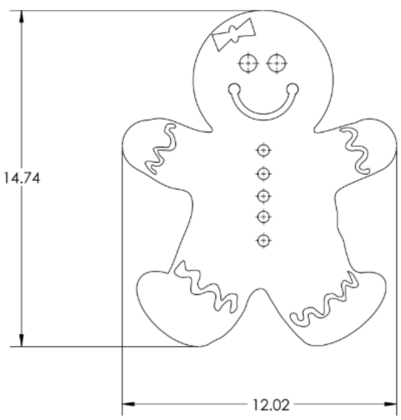


<u>Artistic Reference</u>

Day 9: Gingerbread Person

The gingerbread person will be a stationary display. The gingerbread person will be made out of several layers of wood stacked so it gives dimension to the display. Once the box is illuminated the gingerbread person will have its gumdrop buttons light up. It will be the main feature in its box at just over 1 foot tall.

CAD Model

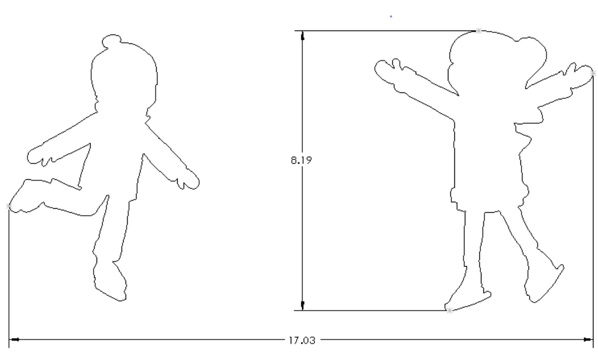


Artistic Reference

Day 10: Ice Skaters

The ice skater scene will have three functions. The skaters will be circling around a center axis. They will also be rotating about their own axis. The motion will be accomplished by a trio of DC motors. This will allow for three independent and variable spin rates. An alternate design considered incorporates a central rotating gear with two planetary gears that rotate around the central gear.

CAD Model

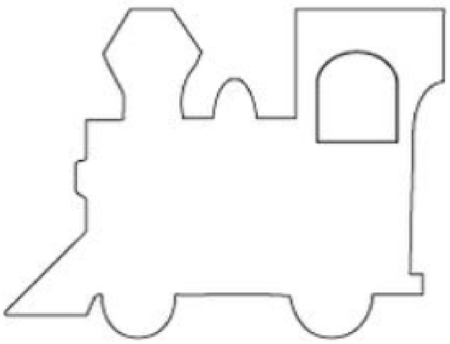


Artistic Reference

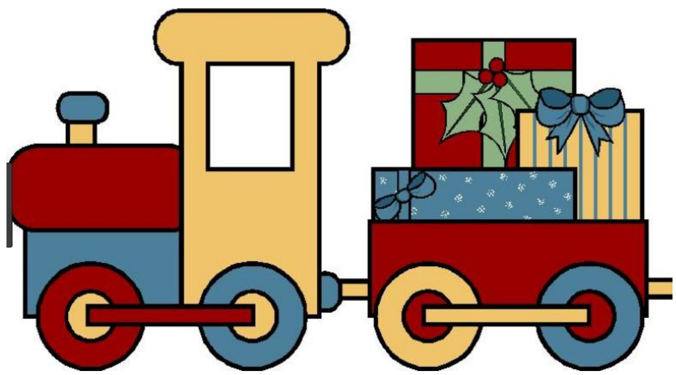
Day 11: Christmas Train

The Christmas train will circle on the platform on the exterior of the façade. The system will use a linear bearing instead of the traditional train tracks so it will not get derailed. The holiday train will have a light illuminating its path to let the audience members know it is the featured scene during day 11.

CAD Model



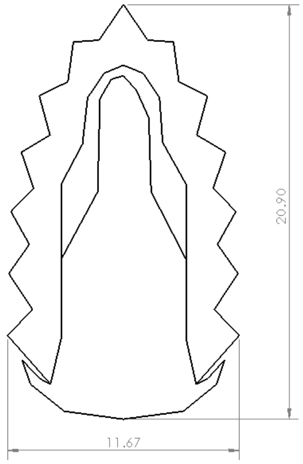
Artistic Reference



Day 12:

Day 12 is dedicated to our Lady of Guadalupe. There will be no moving parts on this day, but the Lady will be lit up with strategically placed lights to emphasize the background light that outlines her body.

CAD Model

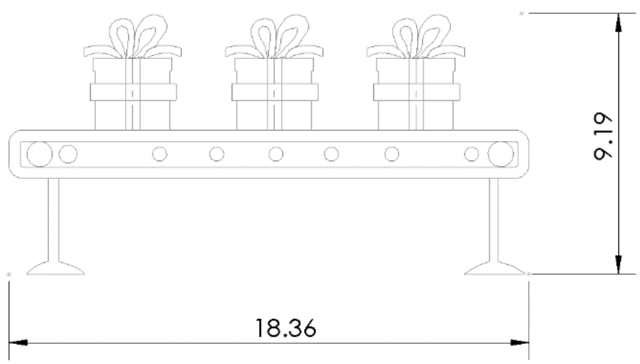


Artistic Reference

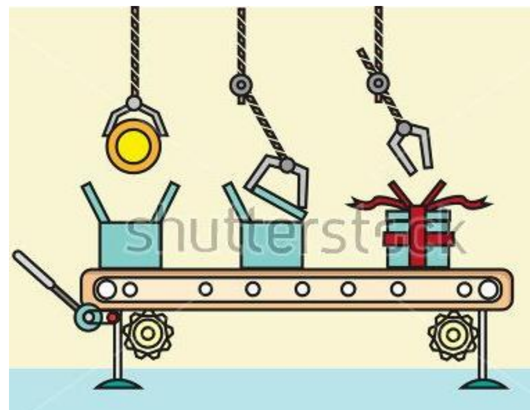
Day 13:

The elf assembly line will feature a conveyor belt with presents on it that moves through the scene. Elves will be featured popping up and down behind the belt, as if they are assembling the presents. The conveyor belt feature will move horizontally across the long scene.

CAD Model



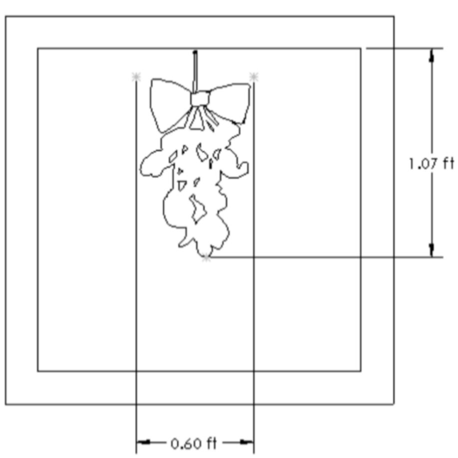
Artistic Reference



Day 14: Mistletoe

The mistletoe box will consist of a wooden sheet, laser cut and painted to look like a mistletoe. The mistletoe will be pinned to a motor which will oscillate the mistletoe clockwise and counter-clockwise very slightly.

CAD Model

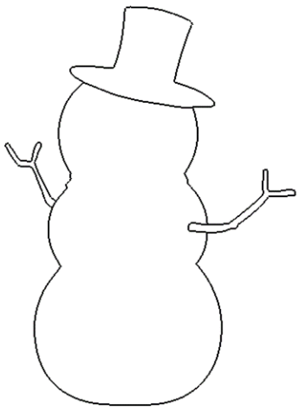


Artistic Reference

Day 15: Snowman

The snowman will contain one function. The snowman's right arm will wave at guests back and forth. This motion will be accomplished using a DC motor and simple linkage.

CAD Model

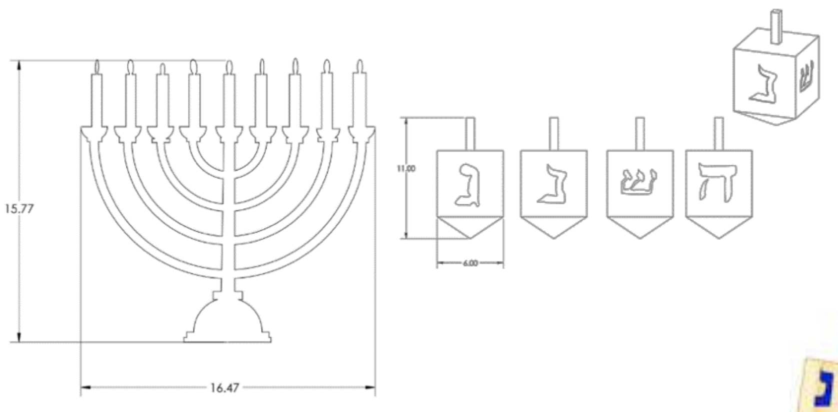


Artistic Reference

Day 16: Menorah and Dreidel

The menorah and dreidel will fill one box. The menorah will be in the background of the display and will have LED flames light up for the candles. In addition, in the foreground there will be a dreidel spinning on a slant.

CAD Model

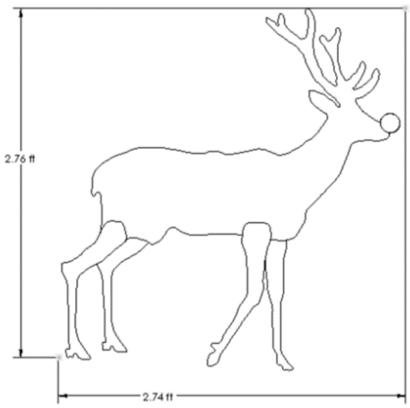


Artistic Reference

Day 17: Rudolph

Instead of being contained in a box, Rudolph will be present on the top of the roof of a house. When it is Rudolph's turn, it front right leg and its back left leg will give off the impression of kicking. They both will be attached to rotational motors.

CAD Model

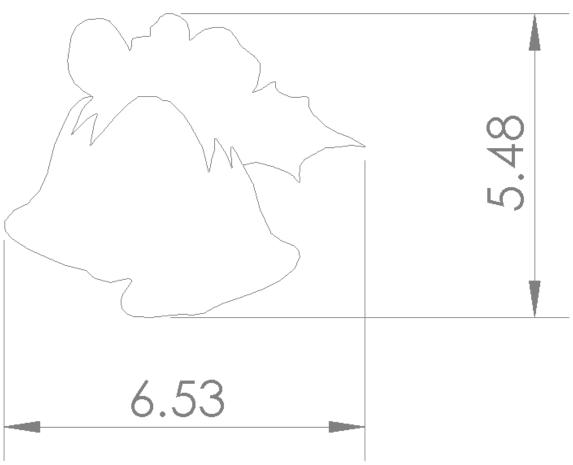


Artistic Reference

Day 18:

This day will contain several bell-shapes which all will sway back and forth, synchronized to the music of Jingle Bells or Chorus of the Bells.

CAD Model

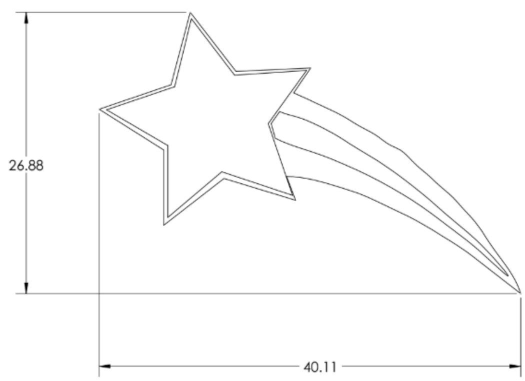


Artistic Reference

Day 19:

The shooting star display will be outside of a box. During Day 19 the star will appear in the upper right-hand corner of the display and audience members can see it travel across the sky behind the German village. The Star itself will be lit with little LEDs to give it a twinkling star effect.

CAD Model

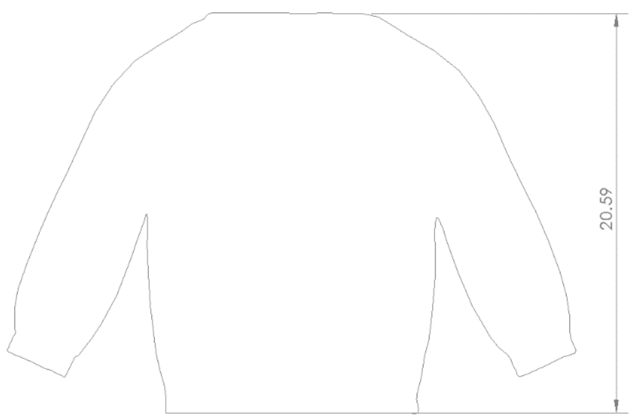


Artistic Reference

Day 20:

The ugly Christmas sweater will be stationary with various images on it which will light up or move in turn. Such images may include candy canes, bells, presents, and more.

CAD Model

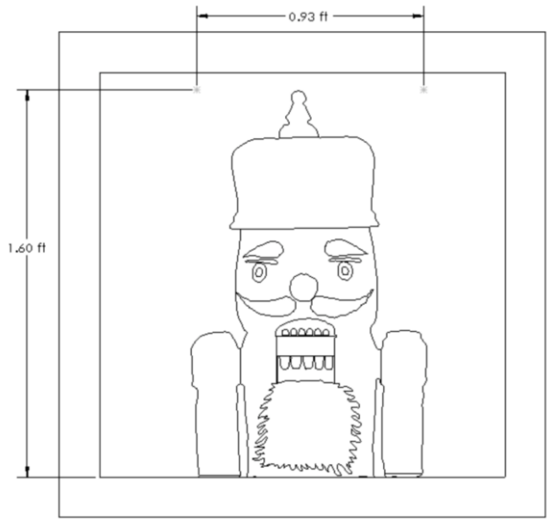


Artistic Reference

Day 21: Nutcracker

The nutcracker will be an actual nutcracker, where the movable mouth is connected to a linear actuator, and its jaw will move up and down.

CAD Model

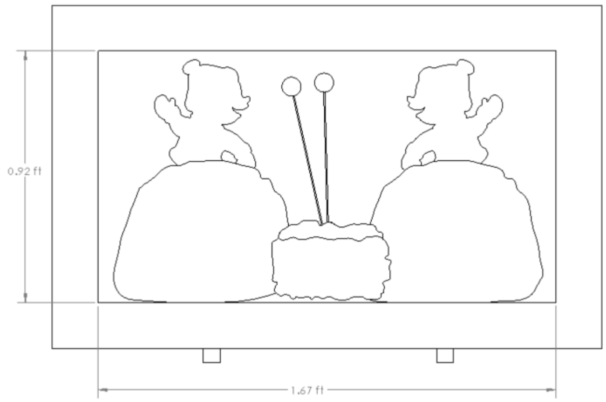


Artistic Reference

Day 22: Snowball Fight

The snowball fight would have three moving parts. One linear actuator for the left kid, one linear actuator for the right kid, and a motor attached to the rod connected to the snowball. The props and the kids will be made of sheets of wood, and will be painted in order to show their features.

CAD Model

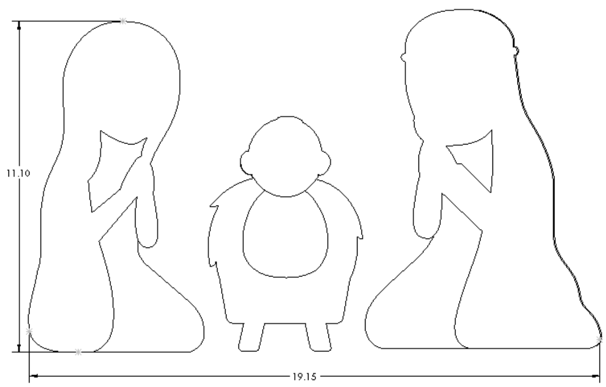


Artistic Reference

Day 23: Nativity Scene

The nativity scene will be a light only scene. It consists of Marry, Joseph, and baby Jesus. They will each be painted on wood. When the day comes on a light will turn on to illuminate them. If space allows a star may be placed above Jesus.

CAD Model



Artistic Reference

Day 24: Milk and Cookies

The plate of milk and cookies left out for Santa will be the first scene to que up the grand finale. The evening before Christmas a plate of cookies is left out for Santa, hence the 24th day display. This item will be made from layered wood and paint, and the milk will disappear and reappear as if the cup is being filled and drained. The glass will remain still but the milk inside, a wooden cut out, will move up and down giving the audience an illusion of milk being poured.

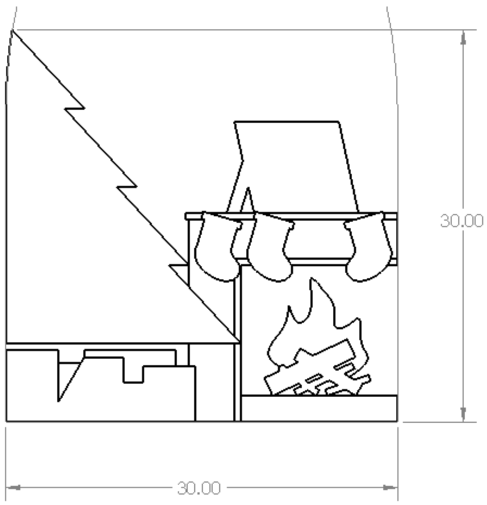
CAD Model

Artistic Reference

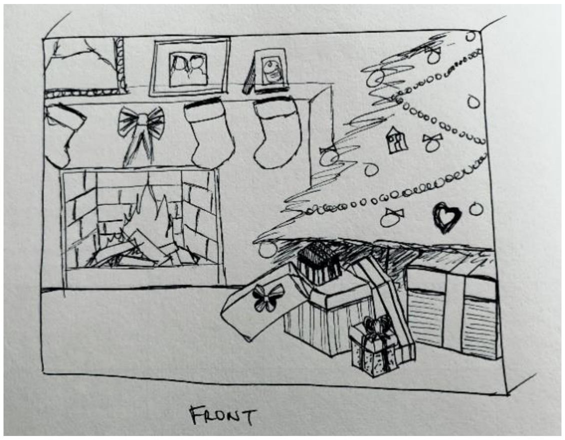
Day 25:

On the 25th day, a Christmas morning living room is displayed, with a tree, a pile of presents, and a fireplace with stockings and a lively fire. There will be no moving parts in this scene; rather, the cutout of the fire will be made of an opaque material with lights behind it which will turn on and off in pattern, simulating a flickering fire.

CAD Model



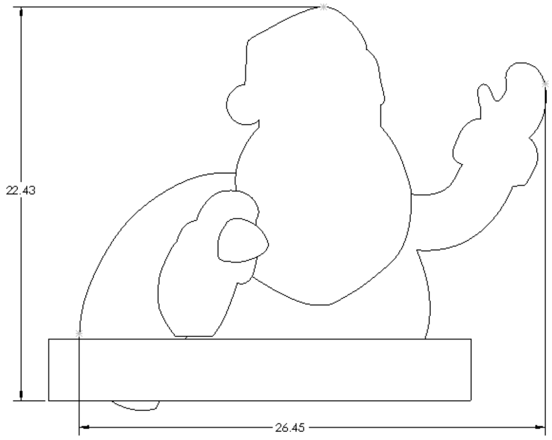
Artistic Reference



Finale: Santa

The Santa scene will be a single function scene. For the finale Santa will come out of the Chimney and all of the boxes will turn back on. This scene will be accomplished by an electric linear actuator with a stroke of approximately 24”. This will be the simplest way to accomplish this distance of travel. Santa will be behind the rest of the boxes so his platform does not interfere with any other element.

CAD Model



Artistic Reference

Appendix G: Design Hazards

Team: Naughty and Nice **Advisor:** Lee McFarland
Date: 2/27/19

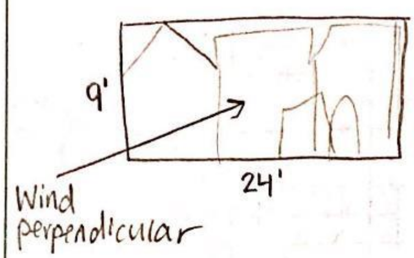
Y	N	
⦸	☐	1. Will the system include hazardous revolving, running, rolling, or mixing actions?
☐	⦸	2. Will the system include hazardous reciprocating, shearing, punching, pressing, squeezing, drawing, or cutting actions?
☐	⦸	3. Will any part of the design undergo high accelerations/decelerations?
☐	⦸	4. Will the system have any large (>5 kg) moving masses or large (>250 N) forces?
⦸	☐	5. Could the system produce a projectile?
⦸	☐	6. Could the system fall (due to gravity), creating injury?
☐	⦸	7. Will a user be exposed to overhanging weights as part of the design?
⦸	☐	8. Will the system have any burrs, sharp edges, shear points, or pinch points?
☐	⦸	9. Will any part of the electrical systems not be grounded?
☐	⦸	10. Will there be any large batteries (over 30 V)?
☐	⦸	11. Will there be any exposed electrical connections in the system (over 40 V)?
☐	⦸	12. Will there be any stored energy in the system such as flywheels, hanging weights or pressurized fluids/gases?
☐	⦸	13. Will there be any explosive or flammable liquids, gases, or small particle fuel as part of the system?
☐	⦸	14. Will the user be required to exert any abnormal effort or experience any abnormal physical posture during the use of the design?
☐	⦸	15. Will there be any materials known to be hazardous to humans involved in either the design or its manufacturing?
⦸	☐	16. Could the system generate high levels (>90 dBA) of noise?
⦸	☐	17. Will the device/system be exposed to extreme environmental conditions such as fog, humidity, or cold/high temperatures, during normal use?
⦸	☐	18. Is it possible for the system to be used in an unsafe manner?
⦸	☐	19. For powered systems, is there an emergency stop button?
☐	⦸	20. Will there be any other potential hazards not listed above? If yes, please explain on reverse.

For any "Y" responses, add (1) a complete description, (2) a list of corrective actions to be taken, and (3) date to be completed on the reverse side.

Description of Hazard	Planned Corrective Action	Planned Date	Actual Date
Revolving Spinning Motors	Enclose area so that when it is running humans cannot access the spinning devices.	11/1/19	
If bolting on the Santa or shooting star becomes loose the displays could be thrown into the crowd.	Use lock washers on all fastener systems, maintenance check list to be used before starting the display each year.	11/1/19	
Façade on hill falls due to Gravity	Anchor to the ground, make sure the base of the display is solid and sturdy that way the fasteners holding the display down make a strong connection.	11/1/19	
Pinch points on motor and moving parts of display.	Maintenance booklet has a procedure to disconnect power to systems and discharge any capacitors before interacting with components that have pinch points.	11/1/19	
Constant music being played, grand finale, or accidental noise feedback screech could reach high decibels.	Check volume at different locations where crowds stand to make sure the volume is a comfortable listening volume.	11/1/19	
Stored and run outside, must withstand wind rain and sun exposer for long periods of time.	Make sure exterior paint is used and wood is sturdy enough to be rigid without bending and warping. Water tight connections for boxes.	11/1/19	
Reaching all the boxes a person could climb the frame and the whole system could fall.	Make boxes removable so if long term maintenance needs to be done the box can be brought down for tabletop maintenance.	11/1/19	
Estop to quickly end display.	Computer code can have an emergency stop written into the code and the code can be written to have maintenance mode where you can jump between the boxes.	11/1/19	

Appendix H: Hand Calculations

WIND LOAD ON FACADE



Use a simplified rectangle which will over estimate forces which will give us a better safety factor.

$F = A \times P \times C_d$

F = Wind load

A = Area of surface

C_d = drag coefficient

P = Wind pressure

$A = L \times W$

$= 24' \times 9''$

$A = 216\ ft^2$

American society of civil engineering code

$P = 0.00256\ V^2$ [psf]

V = speed of wind in mph

https://www.weather.gov/media/wrh/online_publications/TMs/TM-223.pdf

Winter storm wind average >39mph W or SW

round to 45 for better safety factor

$P = 0.00256\ (45)^2$

$P = 5.184$ psf

C_d: for a flat plate is 1.28

https://www.grc.nasa.gov/www/k-12/airplane/shaped.html

$F = (A)(P)(C_d)$

$F = (216\ ft^2)(5.184\ \frac{lb}{ft^2})(1.28)$

$F = 1433.27\ lb$

A Peak Winter storm yields a Force of 1433.27 lb

Appendix I: FMEA

Product: Advent Calendar

Team: Naughty and Nice

Design Failure Mode and Effects Analysis

Prepared by: Tyler Koski

Date: 03/14/19 (orig)

System / Function	Potential Failure Mode	Potential Effects of the Failure Mode	Severity	Potential Causes of the Failure Mode	Current Preventative Activities	Occurence	Current Detection Activities	Detection	Priority	Recommended Action(s)	Responsibility & Target Completion Date	Action Results: Actions Taken	Action Results: Severity	Action Results: Occurence	Action Results: Criticality
Façade / Visually Appealing	Paint Fades	Guest experience diminished	5	1) sun fade 2) water damage	1) Use outdoor paints 2) Use sealant	6	Visual Detection	10	300	Annual touchup	N/A				
Façade / Stability	Structure degrades	risk of injury due to collapse	10	1) rust 2) wind 3) water weight 4) improper setup	1) protect metal 2) ensure strucutre is properly designed	2	Visual Inspection	8	160	Annual Inspection Add additonal support	N/A				
Support / Stability	Structure degrades	risk of injury due to collapse	10	1) rust 2) wind 3) water weight 4) improper setup	1) protect metal 2) ensure strucutre is properly designed	2	Visual Inspection	8	160	Annual Inspection Add additonal support	N/A				
Electrical Control / Individual Day Control	Loss of proper control of a day	Guest experience diminished	7	1) corrupt code 2) improper feedback 3) wiring issue	1) Allow for indidual boxes to be toggled in/out of overall show	4	a) Visual Inspection b) UI error message	5	140	Annual Inspection Troubleshoot Using Manual	N/A				
Electrical Control / All Control	Loss of Display control	Guest experience diminished	9	1) corrupt code 2) improper feedback 3) wiring issue	1) Have "lights only show" 2) Have "lights always on" show	4	a) Visual Inspection b) UI errors message	5	180	Annual Inspection Troubleshoot Using Manual	N/A				
Individual Day / Mechanical Funtion	Mechanical Component Failure	Guest experience diminished	5	1) Component designed improperly 2) component at end of life 3) component bumpedd	1) allow for individual box to be toggled in/out of show 2)have "lights only" show 3) provide maintenance manual	7	visual inspection	7	245	Annual Inspection Troubleshoot Using Manual	N/A				
Individual Day / Plexiglass	Plexiglass scratches / breaks	a)Guest experience diminished b) potential sharp edge	5	1) Object thrown at display 2) Object scratched on display	1) ensure guests are proper distance away from display 2) remove potential damaging items from surroudnig area	4	visual inspection	10	200	Annual Inspection Replace	N/A				

FMEA.xlsx

Page 1 of 2

Revision Date: 4/3/19

Appendix J: Bill of Materials

Vendor List	
Symbol	**Name**
MMC	McMaster Carr
AMZ	Amazon Retailer
HWH	Holiday Warehouse
SPT	Senior Project Team Creates Item
HD	Home Depot
OM	Online Metals
FP	Fright Props

Indented Bill of Material (BOM)

Cambria Christmas Market - Advent Calendar

Assembly Level	Part Number	Description Lvl0	Lvl1	Lvl2	Lvl3	Lvl4	Material	Vendor	Qty	Cost	Ttl Cost
0	100000	Final Assy									
1	101000		Day 1 Assy								
2	101100			Wreath base			1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
2	101200			String lights			Warm light 16'	AMZ	1	$ 6.99	$ 6.99
2	101300			Plastic wreath			Plastic Pine wreath	HWH	1	$ 19.00	$ 19.00
2	101400			Mount							
3	101410				2"X4" frame		1.5"X3.5" Lumber	HD	1	$ 0.25	$ 0.25
3	101420				Bolts		Dia 1.4"-1" steel	MMC	2	$ 0.07	$ 0.13
3	101430				Split washer		Dia 1.4" steel	MMC	2	$ 0.05	$ 0.10
3	101440				Lock nuts		Dia 1.4" Steel	MMC	2	$ 0.14	$ 0.28
1	102000		Day 2 Assy								
2	102100			Wood for Box				HD	4	$ 0.55	$2.20
2	102200			Façade			1/8" sheet plywood	HD	1	$ 0.28	$0.28
1	103000		Day 3 Assy								
2	103100			Painted Wood Features							
3	103110				List		1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
2	103200			Light Up Element							
3	103210				Acrylic		1/16" Sheet Semi Transparent Acrylic	HD	1	$ 32.75	$ 32.75
3	103220				LED Lights		Green/Red LED Lights	AMZ	1	$ 30.00	$ 30.00
1	104000		Day 4 Assy								
2	104100			Painted Wood Features							
3	104110				Iceberg/Igloo		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104120				Iceberg piece		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104130				Body		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104140				Left Arm		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104150				Right Arm		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104160				Left Arm		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104170				Box		1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
3	104180				Fish		1/8" sheet plywood	HD	8	$ 0.28	$ 2.20
2	104200			Linkage System							
3	104210				Fishing pole link		.25"x.5" Aluminum Stock 6061	OM	1	$ 3.25	$ 3.25
3	104220				Basic link		.25"x.5" Aluminum Stock 6061	OM	1	$ 3.25	$ 3.25
3	104230				Motor link		.25"x.5" Aluminum Stock 6061	OM	1	$ 3.25	$ 3.25
1	105000		Day 5 Assy								
2	105100			Painted Wood Features							
3	105110				Polar bear		1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	105120				North pole sign		1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	105130				Igloo		1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	105140				Mountain 1		1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	105150				Mountain 2		1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	105160				Mountain 3		1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	105170				Return Ramp		1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	105180				Return Base		1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
2	105200			"Snow" Beads			Plastic/Foam Bean Bag Chair	AMZ	1	$ 17.45	$ 17.45
2	105300			Silent Duct Fan			Plastic Duct Fan	AMZ	1	$ 27.99	$ 27.99
2	105400			Mount							
3	105410				2"X4" frame		1.5"X3.5" Lumber	HD	1	$ 0.25	$ 0.25
3	105420				Bolts		Dia 1.4"-1" steel	MMC	2	$ 0.07	$ 0.13
3	105430				split washer		Dia 1.4" steel	MMC	2	$ 0.05	$ 0.10
3	105440				lock nuts		Dia 1.4" Steel	MMC	2	$ 0.14	$ 0.28
1	106000		Day 6 Assy								
2	106100			Painted Wood Features							
3	106110				Snowflake		1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
2	106200			Lights			White LED Lights	AMZ	1	$ 8.30	$ 8.30
1	107000		Day 7 Assy								
2	107100			Wood for Box				HD	4	$ 0.55	$2.20
2	107200			Façade			1/8" sheet plywood	HD	1	$ 0.28	$0.28
2	107300			Back Drop			1/8" sheet plywood	MMC	1	$ 0.55	$0.55
2	107400			Links			.25"x.5" Aluminum Stock 6061	MMC	3	$ 0.50	$1.50
2	107500			Motor			Compact Square-Face DC Gearmotors	FP	1	$ 62.74	$62.74
2	107600			Motor Supports			1.5"X3.5" Lumber	MMC	2	$ 1.50	$3.00
2	107700			Screws/Nuts/Bolts			Dia 1.4"-1" steel	MMC	16	$ 0.10	$1.60

1	108000	Day 8 Assy						
2	108100	Wood for Box		HD	4	$	0.55	$2.20
2	108200	Façade	1/8" sheet plywood	HD	1	$	0.28	$0.28
2	108300	Back Drop	1/8" sheet plywood	MMC	1	$	0.55	$0.55
2	108400	Links	.25"x.5" Aluminum Stock 6061	MMC	3	$	0.50	$1.50
2	108500	Motor	Compact Square-Face DC Gearmotors	FP	1	$	62.74	$62.74
2	108600	Motor Supports	1.5"X3.5" Lumber	MMC	2	$	1.50	$3.00
2	108700	Screws/Nuts/Bolts	Dia 1.4"-1" steel	MMC	16	$	0.10	$1.60
1	109000	Day 9 Assy						
2	109100	Painted Wood Features						
3	109110	Gingerbread person	1/8" sheet plywood	SPT	1	$	0.28	$ 0.28
4	109111	Icing cutouts	1/8" sheet plywood	SPT	1	$	0.28	$ 0.28
3	109120	LED bulbs	LED Diode (variety of colors)	AMZ	15	$	0.03	$ 0.39
3	109130	Acrylic for diffusing		HD	1	$	1.50	$ 1.50
2	109200	Mount						
3	109210	2"X4" frame	1.5"X3.5" Lumber	HD	1	$	0.25	$ 0.25
3	109220	Bolts	Dia 1.4"-1" steel	MMC	2	$	0.07	$ 0.13
3	109230	split washer	Dia 1.4" steel	MMC	2	$	0.05	$ 0.10
3	109240	lock nuts	Dia 1.4" Steel	MMC	2	$	0.14	$ 0.28
1	110000	Day 10 Assy						
2	110100	Painted Wood Features						
3	110110	Girl Skater	1/8" sheet plywood	SPT	1	$	0.28	$ 0.28
3	110120	Boy Skater	1/8" sheet plywood	SPT	1	$	0.28	$ 0.28
3	110130	Ice	1/8" sheet plywood	SPT	1	$	0.28	$ 0.28
2	110200	Animation System						
3	110210	Motor	Compact Square-Face DC Gearmotors	MMC	1	$	62.74	$ 62.74
3	110220	Aluminum Bar	.25"x.5" Aluminum Stock 6061	OM	1	$	3.25	$ 3.25
3	110230	Wheels	Rubber Wheels	MMC	2	$	4.50	$ 9.00
3	110240	Lazy Susan Mount	Lazy Susan 200 lb Capacity	MMC	1	$	10.20	$ 10.20
1	111000	Day 11 Assy						
2	111100	Train Cut Out	1/8" sheet plywood	SPT	3	$	0.55	$ 1.65
2	111200	Motor	Compact Square-Face DC Gearmotors	MMC	1	$	62.74	$ 62.74
2	111300	Curved Track	Linear and Curved Rail Track	MMC	1	$	120.00	$ 120.00
2	111400	Linear Bearing	Steel Linear bearing with rail	MMC	1	$	64.00	$ 64.00
2	111500	Wire	Flexible Wire	HD	1	$	15.00	$ 15.00
2	111600	Spool casing	1/8" sheet plywood	SPT	1	$	0.55	$ 0.55
1	112000	Day 12 Assy						
2	112100	Painted Wood Features						
3	112110	Body	1/8" sheet plywood	HD	1	$	0.55	$ 0.55
3	112120	Background	1/8" sheet plywood	HD	1	$	0.55	$ 0.55
3	112130	Hood	1/8" sheet plywood	HD	1	$	0.28	$ 0.28
1	113000	Day 13 Assy						
2	113100	Rollers	Hard rubber	Michaels	2	$	17.00	$ 34.00
2	113200	Conveyor belt	60 grit sandpaper w/ cloth backing	AMZ	1	$	3.17	$ 3.17
2	113300	Painted Wood Features						
3	113310	Presents/Toys	1/8" sheet plywood	HD	6	$	0.28	$ 1.68

3	113320	Walls	1/8" sheet plywood		2	$ 0.55	$ 1.10
3	113320	Machine	1/8" sheet plywood		2	$ 0.55	$ 1.10
3	113320	Sack	1/8" sheet plywood		2	$ 0.55	$ 1.10
2	113400	Motor	Compact Square-Face DC Gearmotors	FP	1	$ 62.74	$ 62.74
1	114000	Day 14 Assy					
2	114100	Wood for Box		HD	4	$ 0.55	$2.20
2	114200	Façade	1/8" sheet plywood	HD	1	$ 0.28	$0.28
2	114300	Back Drop	1/8" sheet plywood	MMC	1	$ 0.55	$0.55
2	114400	Links	.25"x.5" Aluminum Stock 6061	MMC	3	$ 0.50	$1.50
2	114500	Motor	Compact Square-Face DC Gearmotors	FP	1	$ 62.74	$62.74
2	114600	Motor Supports	1.5"X3.5" Lumber	MMC	2	$ 1.50	$3.00
2	114700	Screws/Nuts/Bolts	Dia 1.4"-1" steel	MMC	16	$ 0.10	$1.60
1	115000	Day 15 Assy					$ -
2	115100	Painted Wood Features					$ -
3	115110	Snowman Body	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	115120	Snowman Hat	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	115130	Snowman Arms	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
2	115200	Acutation System					$ -
3	115210	Motor	Compact Square-Face DC Gearmotors	MMC	1	$ 62.74	$ 62.74
3	115220	Linkages	.25"x.5" 6061 Aluminum Bar	OM	2	$ 3.25	$ 6.50
3	115230	Wood Mounts	1/2" Plywood and 2x4	SPT	1	$ 4.75	$ 4.75
1	116000	Day 16 Assy					$ -
2	116100	Wooden Dreidel	1/8" sheet plywood	SPT	1	$ 55.00	$ 55.00
2	116200	Motor	Compact Square-Face DC Gearmotors	MMC	1	$ 62.74	$ 62.74
2	116300	Mount					
3	116310	2"X4" frame	1.5"X3.5" Lumber	HD	1	$ 0.25	$ 0.25
3	116320	Bolts	Dia 1.4"-1" steel	MMC	2	$ 0.07	$ 0.13
3	116330	split washer	Dia 1.4" steel	MMC	2	$ 0.05	$ 0.10
3	116340	lock nuts	Dia 1.4" Steel	MMC	2	$ 0.14	$ 0.28
1	117000	Day 17 Assy					
2	117100	Façade	1/8" sheet plywood	HD	1	$ 5.00	$5.00
2	117200	Light bulb		MMC	1	$ 15.00	$15.00
2	118000	Day 18 Assy					
2	118100	Painted Wood Features					
3	118110	Bells	1/8" sheet plywood	HD	8	$ 0.28	$ 2.24
3	118120	Support poles	1/8" sheet plywood	HD	2	$ 0.28	$ 0.56
1	119000	Day 19 Assy					
2	119100	Painted Wood Features					
3	119110	Large Wood Star with Tail	1/8" sheet plywood	SPT	1	$ 0.55	$ 2.20
4	119111	Medium Stars	1/8" sheet plywood	SPT	4	$ 0.28	$ 1.10
4	119112	Small Stars	1/8" sheet plywood	SPT	4	$ 0.28	$ 1.10
3	119120	LED Diodes	LED Diode (variety of colors)	AMZ	15	$ 0.03	$ 0.39
3	119130	Swing Arm	1/4" sheet plywood	SPT	1	$ 3.00	$ 3.00
2	119200	Motor	Compact Square-Face DC Gearmotors	MMC	1	$ 62.74	$ 62.74
2	119300	Mount					
3	119310	2"X4" frame	1.5"X3.5" Lumber	HD	1	$ 0.25	$ 0.25
3	119320	Bolts	Dia 1.4"-1" steel	MMC	2	$ 0.07	$ 0.13
3	119330	Split washer	Dia 1.4" steel	MMC	2	$ 0.05	$ 0.10
3	119340	Lock nuts	Dia 1.4" Steel	MMC	2	$ 0.14	$ 0.28
1	120000	Day 20 Assy					
2	120100	Painted Wood Features					
3	120110	Sweater	1/8" sheet plywood	HD	1	$ 0.55	$ 0.55
3	120120	Pole	1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
1	121000	Day 21 Assy					
2	121100	Wood for Box		HD	4	$ 0.55	$2.20
2	121200	Façade	1/8" sheet plywood	MMC	1	$ 0.28	$0.28
2	121300	Back Drop	1/8" sheet plywood	MMC	1	$ 0.55	$0.55
2	121400	Links	.25"x.5" Aluminum Stock 6061	MMC	3	$ 0.50	$1.50
2	121500	Motor	Compact Square-Face DC Gearmotors	FP	1	$ 62.74	$ 62.74
2	121600	Motor Supports	1.5"X3.5" Lumber	MMC	2	$ 1.50	$3.00
2	121700	Screws/Nuts/Bolts	Dia 1.4"-1" steel	MMC	16	$ 0.10	$1.60
1	122000	Day 22 Assy					
2	122100	Wood for Box		HD	4	$ 0.55	$2.20
2	122200	Façade	1/8" sheet plywood	HD	1	$ 0.28	$0.28
2	122300	Back Drop	1/8" sheet plywood	MMC	1	$ 0.55	$0.55
2	122400	Links	.25"x.5" Aluminum Stock 6061	MMC	3	$ 0.50	$1.50
2	122500	Motor	Compact Square-Face DC Gearmotors	FP	1	$ 62.74	$ 62.74
2	122600	Motor Supports	1.5"X3.5" Lumber	MMC	2	$ 1.50	$3.00
2	122700	Screws/Nuts/Bolts	Dia 1.4"-1" steel	MMC	16	$ 0.10	$1.60

1	123000	Day 23 Assy					
2	123100	Painted Wood Features					
3	123110	Mary Base	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	123120	Mary Top	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	123130	Jesus Head	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	123140	Jesus Body	1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	123150	Jesus Trough	1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	123160	Joseph Base	1/8" sheet plywood	SPT	1	$ 0.55	$ 0.55
3	123170	Joseph Top	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
1	124000	Day 24 Assy					
2	124100	Painted Wood Features					
3	124110	Cookie 1	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124120	Cookie 2	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124130	Base Plate	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124140	Santa Tag	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124150	Milk Glass	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124160	Milk	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	124170	Linkage Brace	1/2" sheet plywood	SPT	2	$ 1.00	$ 2.00
2	124200	Linkages	Aluminum Rectangle Bar 6061	OM	3	$ 3.23	$ 9.69
2	124300	Motor	Compact Square-Face DC Gearmotors	MMC	1	$ 62.74	$ 62.74
2	124400	Mount					
3	124410	2"X4" frame	1.5"X3.5" Lumber	HD	1	$ 0.25	$ 0.25
3	124420	Bolts	Dia 1.4"-1" steel	MMC	2	$ 0.07	$ 0.13
3	124430	split washer	Dia 1.4" steel	MMC	2	$ 0.05	$ 0.10
3	124440	lock nuts	Dia 1.4" Steel	MMC	2	$ 0.14	$ 0.28
1	125000	Day 25 Assy					
2	125100	Painted Wood Features					
3	125110	Tree	1/8" sheet plywood	HD	1	$ 0.55	$ 0.55
3	125120	Presents row 1	1/8" sheet plywood	HD	1	$ 0.55	$ 0.55
3	12530	Presents row 2	1/8" sheet plywood	HD	1	$ 0.55	$ 0.55
3	12540	Star	1/8" sheet plywood	HD	1	$ 0.28	$ 0.28
1	126000	Grand Finale Assy					
2	126100	Painted Wood Features					
3	126110	Santa Body	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	126120	Santa Head	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
3	126130	Santa Bag	1/8" sheet plywood	SPT	1	$ 0.28	$ 0.28
2	126200	Actuation System					
3	126210	Linear Actuator	Linear Actuator 24" Stroke	FP	1	$ 150.00	$ 150.00
3	126220	Base	1/2" Plywood	SPT	1	$ 2.45	$ 2.45
3	126230	Guiderails	Linear Bearings	MMC	2	$ 40.00	$ 80.00
	Total Parts				**356**		**$1,586.91**

Appendix K: Box Theme Final Designs

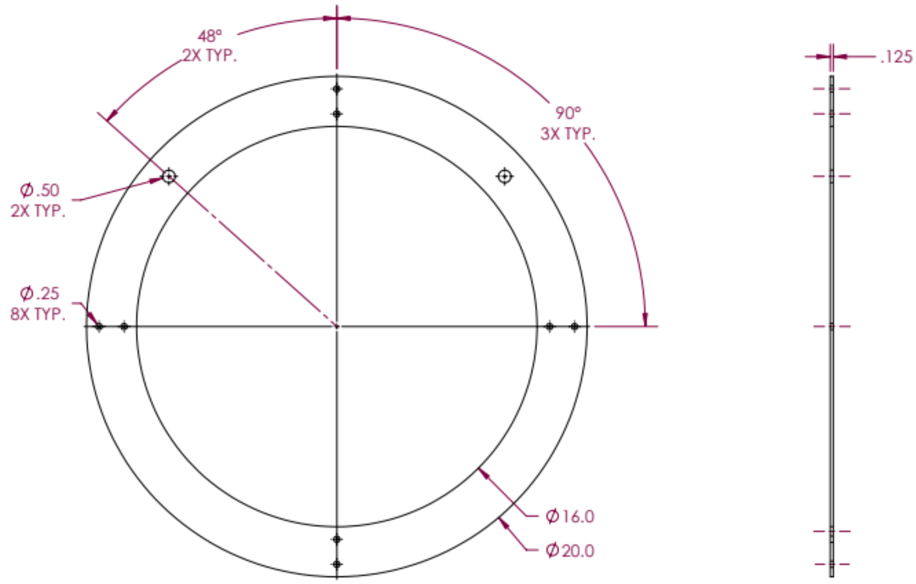
Only the bolded items on this list are included in this Appendix, as they have been updated from Appendix F. The bolded boxes will be the only boxes we discuss in Appendix K.

1. **Wreath**
2. Penguins
3. **Naughty and Nice List**
4. **Ice Fisherman**
5. **Snow Globe (Polar bear / North Pole / Igloo)**
6. Snowflake
7. **Hawaiian Christmas**
8. **Toboggan**
9. Gingerbread Person
10. **Ice Skaters**
11. **Christmas Train**
12. Lady Guadalupe
13. **Elf Assembly Line**
14. **Mistletoe**
15. **Snowman**
16. **Dreidel**
17. **Rudolph**
18. **Bells**
19. Shooting Star
20. Ugly Christmas Sweater
21. **Nutcracker**
22. **Snowball Fight**
23. Nativity Scene
24. **Cookies and Milk**
25. **Christmas Tree Scene**

Finale. Santa

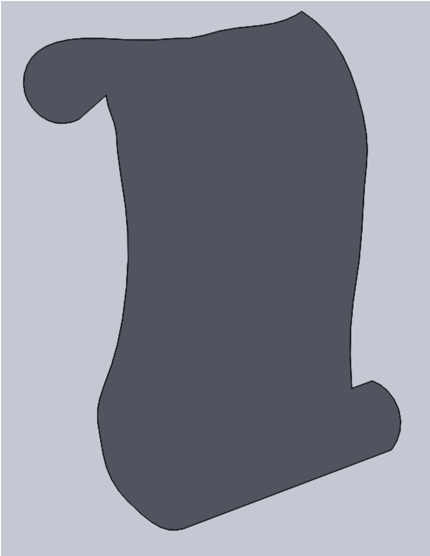
Day 1: Wreath

The wreath has changed so it will now be a wooden base that a plastic wreath is fastened on. There will be string lights that are controlled by the raspberry pi.



Day 3: Naughty or Nice List

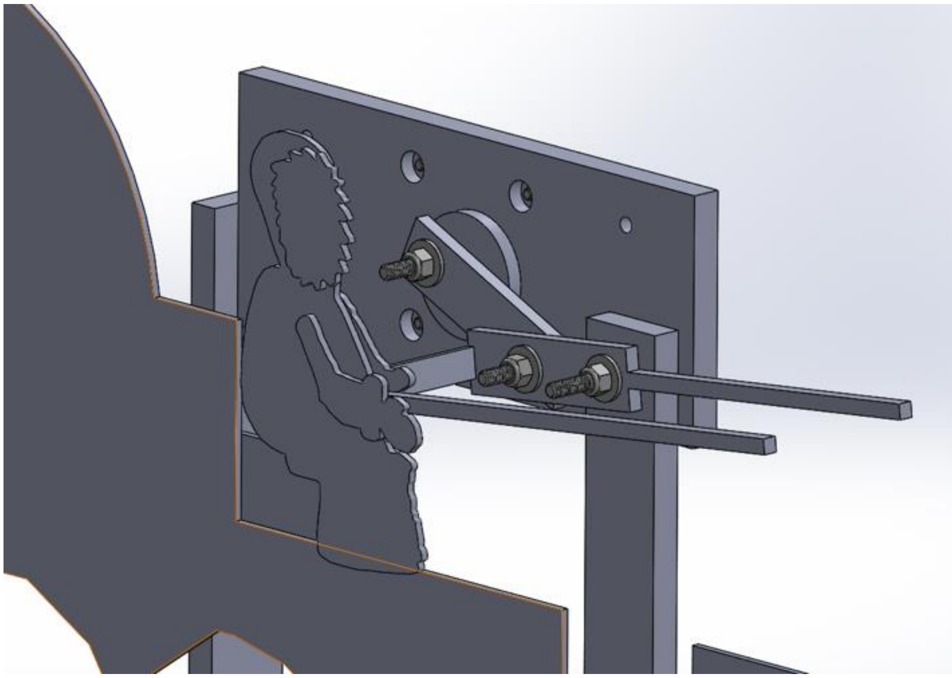
The general design of the naughty or nice list has remained the same as the design shown in Appendix F. The only difference is that day has been moved to one of the tall windows and therefore the height of the list has increased.

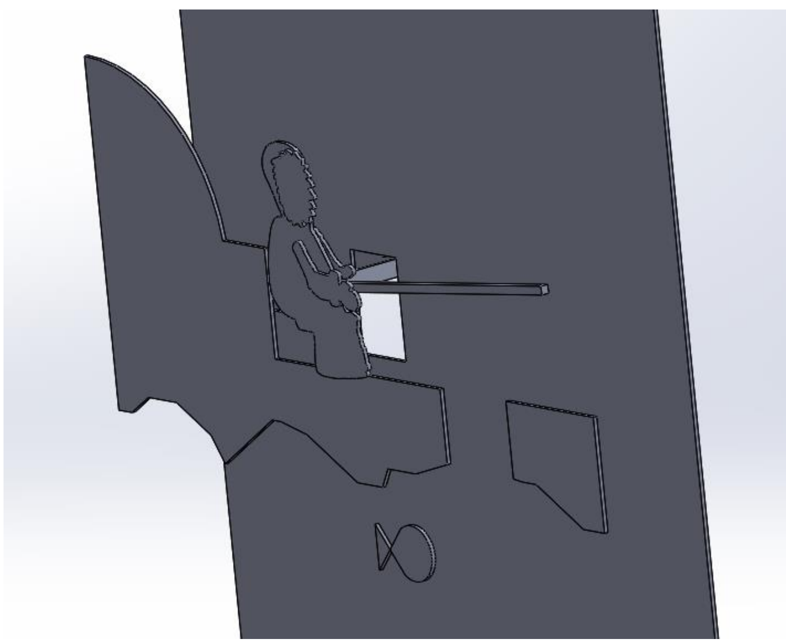


The list will be laser cut from wood. The names will be cut from semi-transparent white acrylic and slotted into the name holes. On the back of each name will be a box to contain and reflect light from the LEDs. There will be a set of red LEDs and a set of green LEDs behind each name. The control system will cycle through each name between green and red. The title of the list will follow a similar arrangement, but the colors will remain red for naughty and green for nice.

Day 4: Ice Fisherman

The fisherman has evolved in its linkage assembly to be attached to the motor mount and with various fasteners included. The linkages are hidden behind a backdrop with a cut-out for the mirrored link to move and be viewable.

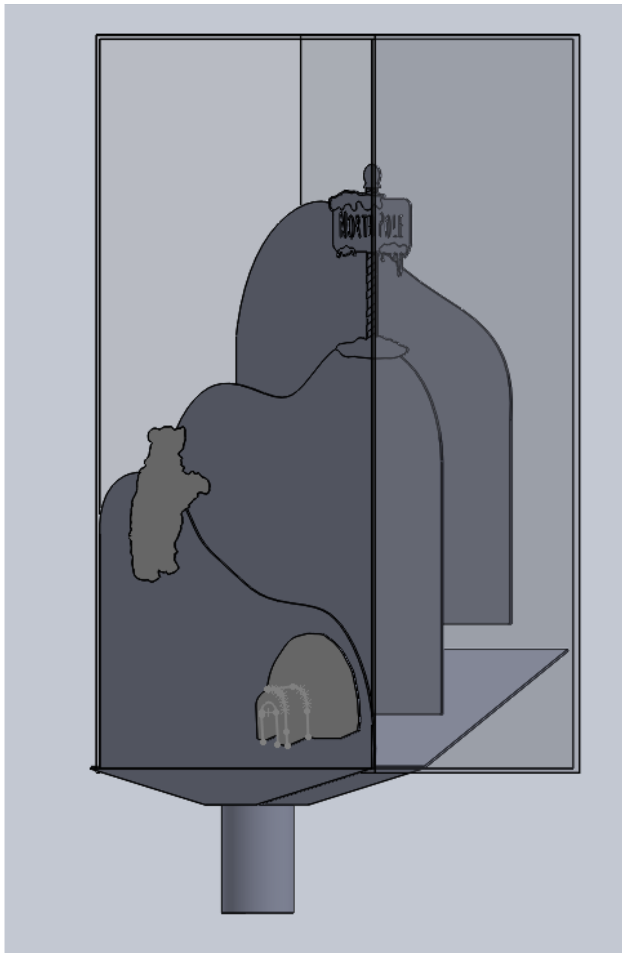




The fisherman layers, iceberg pieces, igloo, and fish will be laser cut from wood. The pole link, basic link, and round link will be machined from rectangular 6061 aluminum stock.

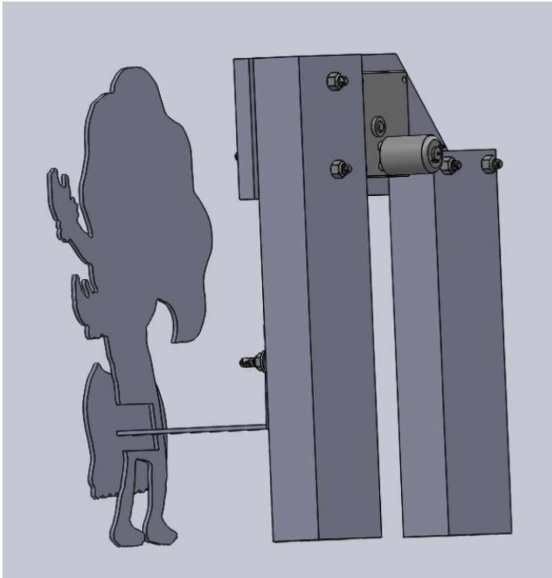
Day 5: Snow Globe

The snow globe design includes three hills, a polar bear, an igloo, and a NorthPole sign. The bottom will have a duct fan that will blow the beanbag polymer around the box giving the illusion of snowing.



Day 7: Hawaiian Girl

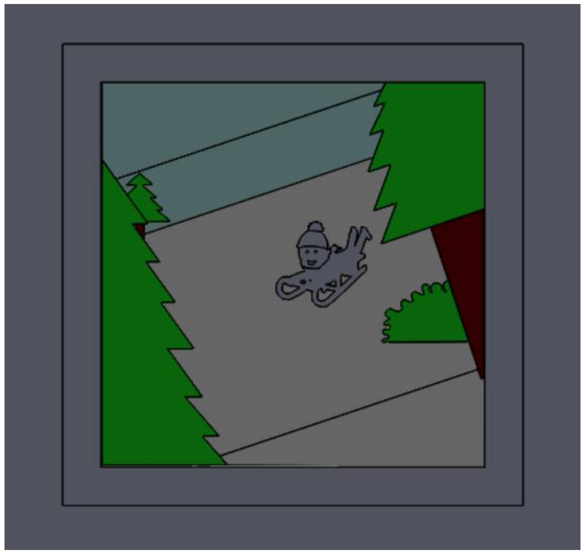
The Hawaiian Girl box is going to contain a three link system, powered by a motor, so that the hula skirt of the girl can oscillate back and forth in a way that makes it looks like she is dancing.

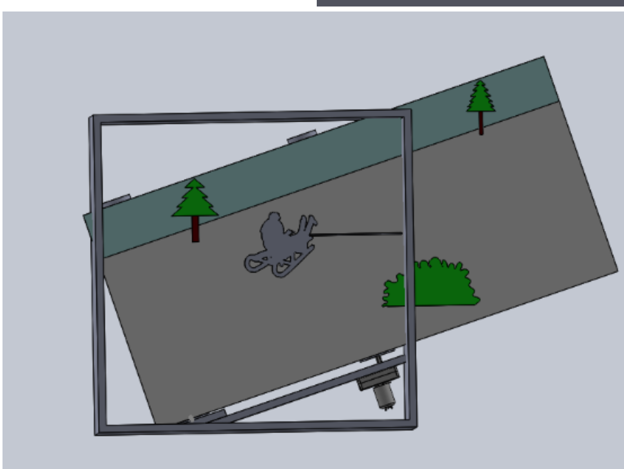


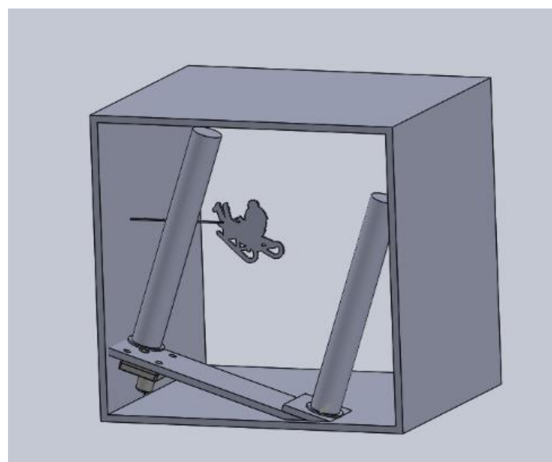
The Hawaiian girl, the skirt, and the extension stick are both cut out of thin sheets of wood. The three blocks and the motor back support are cut out of varying thicknesses and lengths of wood. The links are made out of aluminum stocks. All of these components are connected with nuts, bolts, washers, set screws, and glue.

Day 8: Toboggan

The Toboggan box is going to have an illusion of a child moving on a toboggan down a hill, the background will move due to a “treadmill effect”.



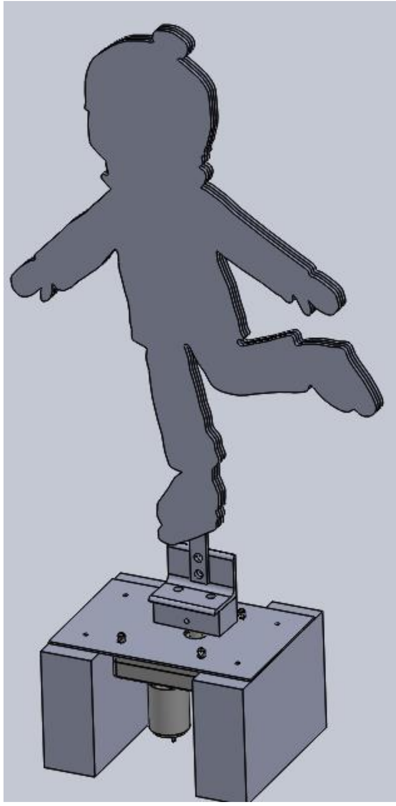




The background is going to be made out of sandpaper and the two ends are going to be connected to one another (not shown in the drawing). The paper will revolve around two cylindrical wooden rods. One rod will stay idle, where it is resting on a bearing. The rod connected to the tobogganer will be made out of a thin acrylic. The other rod will be driven by a motor.

Day 10: Ice Skaters

The ice skaters have changed from two rotating about a center point to a single ice skater spinning. The dual ice skaters were too small and the mechanism too complicated. The simplified version has a single skater that is much more visible with a greater motion.



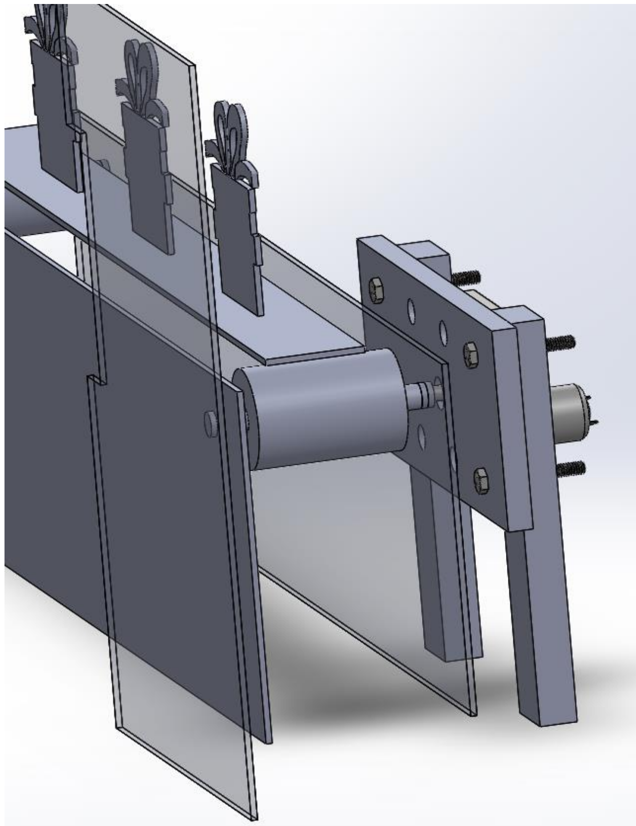
The motor will be mounted by two 2x4 wood posts and a piece of sheet aluminum. The motor will connect to the skater with a piece of aluminum bar and angle aluminum. The skater wood piece will be connected using another piece of aluminum that is bolted to the piece of angle aluminum.

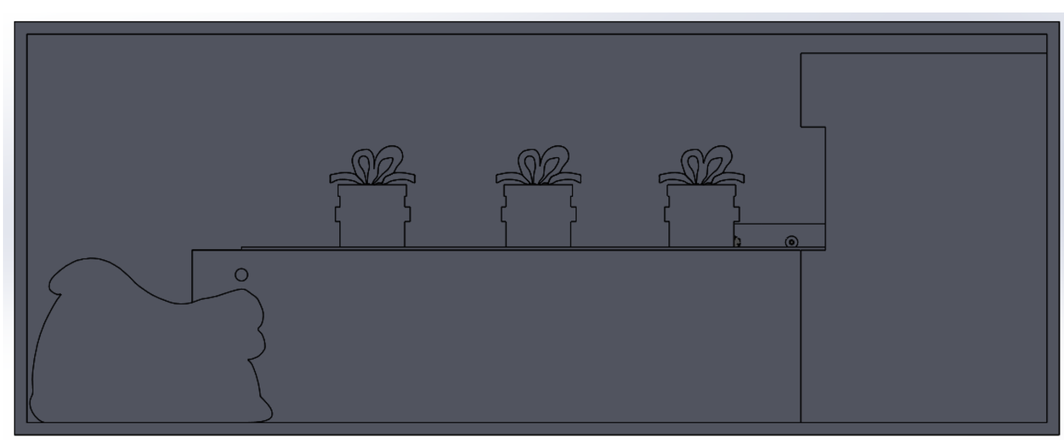
Day 11: Christmas Train

The Christmas train will now be an actual model train meant for the outdoors. The train can now have a custom track and will be easier to store and set up. The train is being selected with advice from central coast trains in Atascadero.

Day 13: Assembly Line

The assembly line has evolved in its linkage assembly to be attached to the motor mount and with various fasteners included. The team added a “toy sack” and “machine” for the toys to “drop into” the sack and come out of the machine. The motor system is hidden behind the machine.

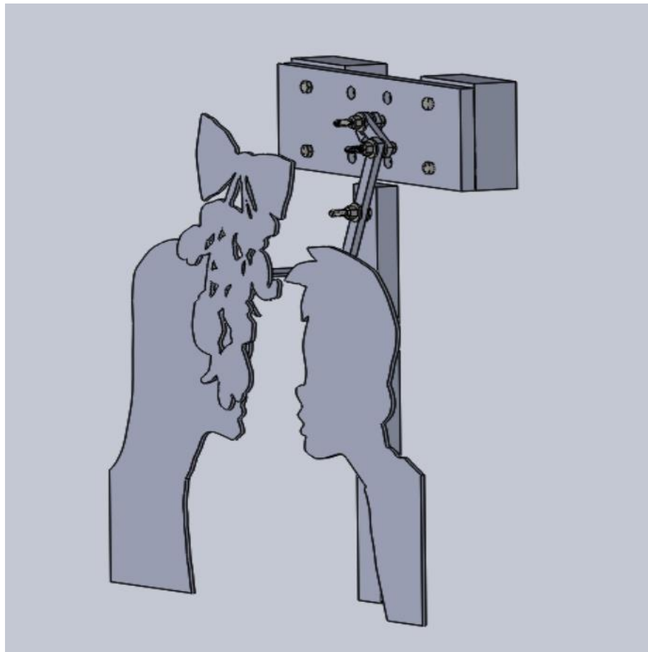


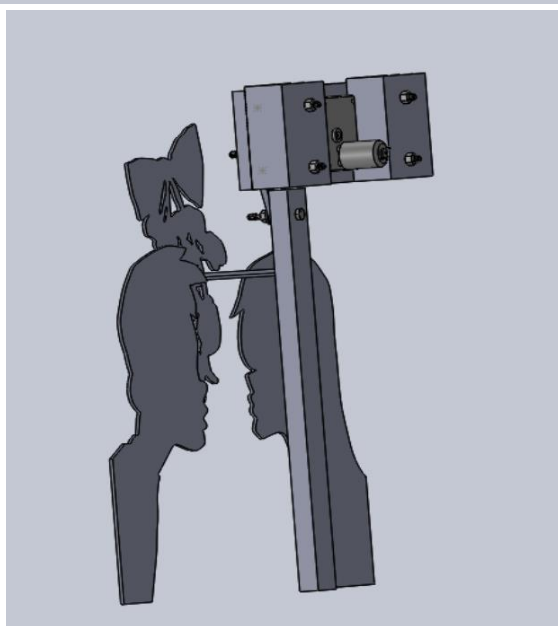


The fisherman layers, iceberg pieces, igloo, and fish will be laser cut from wood. The pole link, basic link, and round link will be machined from rectangular 6061 aluminum stock.

Day 14: Mistletoe and Kiss

The Mistletoe and Kiss box is going to contain a three link system, powered by a motor, so that the mistletoe can oscillate back and forth.

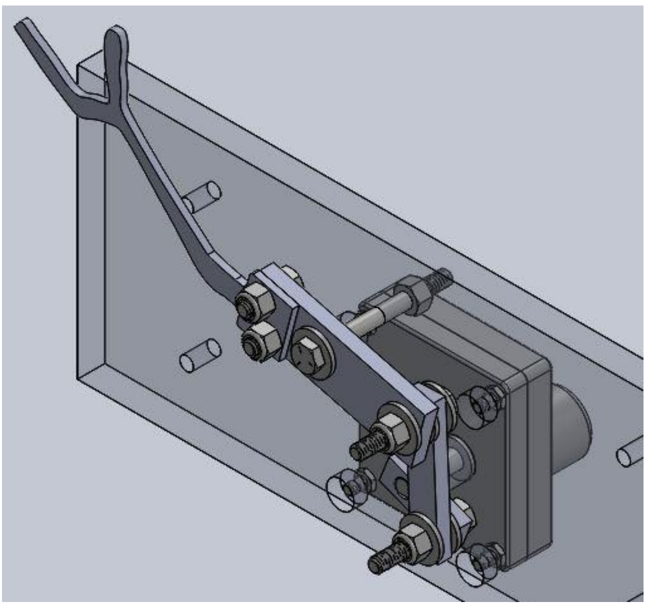


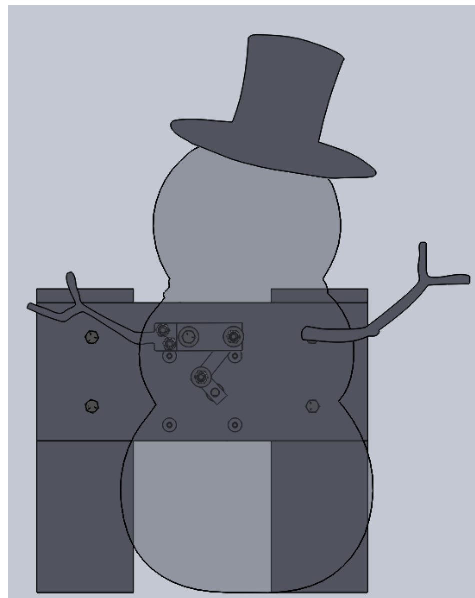


The people, the mistletoe, and the extension stick are going to be made out of thin pieces of wood. The blocks and the motor back support are going to be made out of varying thicknesses and lengths of wood. The links are made out of aluminum stocks. All of these components are connected with nuts, bolts, washers, set screws, and glue.

Day 15: Snowman

The overall design of the snowman still follows the designs shown in Appendix F. The main mechanical feature of the snowman is his waving arm. The waving will be accomplished by the three-bar linkage system shown below.

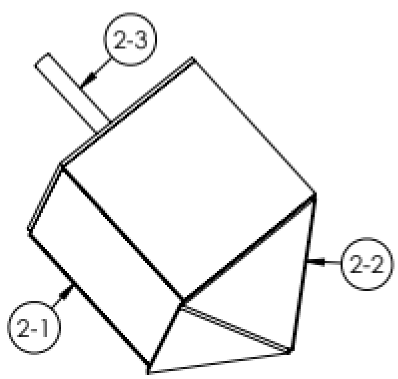




The motor is mounted behind the snowman by a 0.5” plywood face plate and wood posts. The linkage on the motor rotates causing the linkage with the arm attached to rock back and forth simulating a waving motion. The linkages are made from 0.25”x0.5” 6061 aluminum stock with 5/16” holes drilled for the sleeve bearings. All connections are made with 1/4” bolts and locknuts. Nylon washers are used between parts to minimize friction and wear on parts. The wood piece is bolted to the aluminum linkage to allow for easy replacement in case a piece breaks.

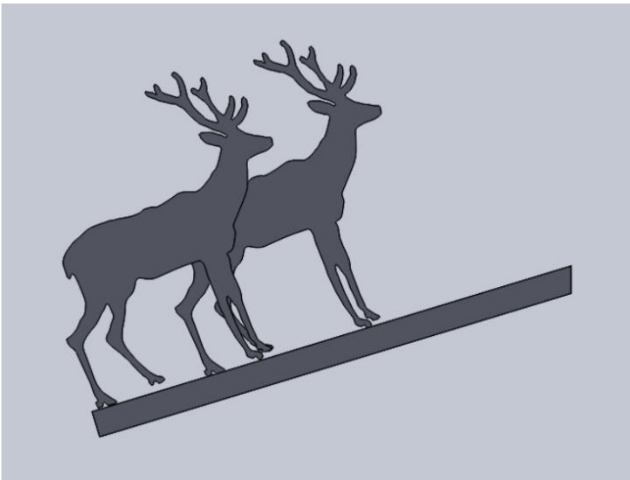
Day 16: Dreidel

The box was previously a menorah and dreidel combination but due to size restrictions of the box the menorah was eliminated, and it is now just a spinning dreidel.



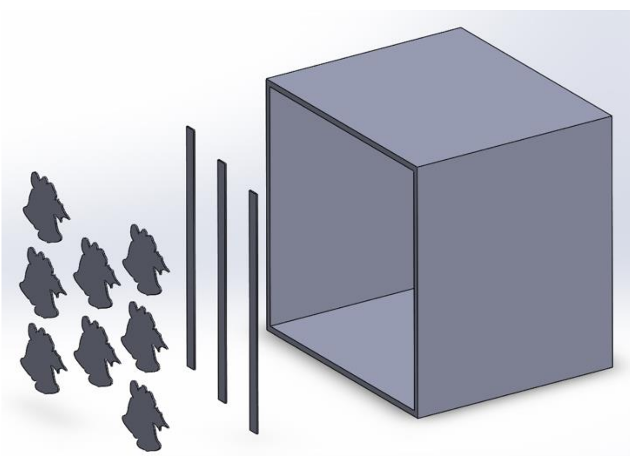
Day 17: Reindeer

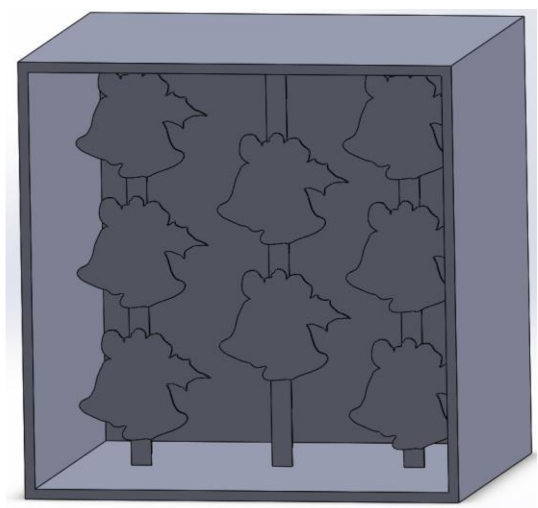
The Reindeer day is a design that has not changed since its initial preliminary design. The reindeer will be cut out from thin sheets of wood and will perch on top of one of the façades rooves. The front reindeer will have a red light at the tip of the nose, which will represent the Rudolph reindeer.



Day 18: Bells

The individual design of each bell remains the same as the designs shown in Appendix F. The bells have now been distributed onto poles, and will have drilled holes for lights to light up at different intervals.

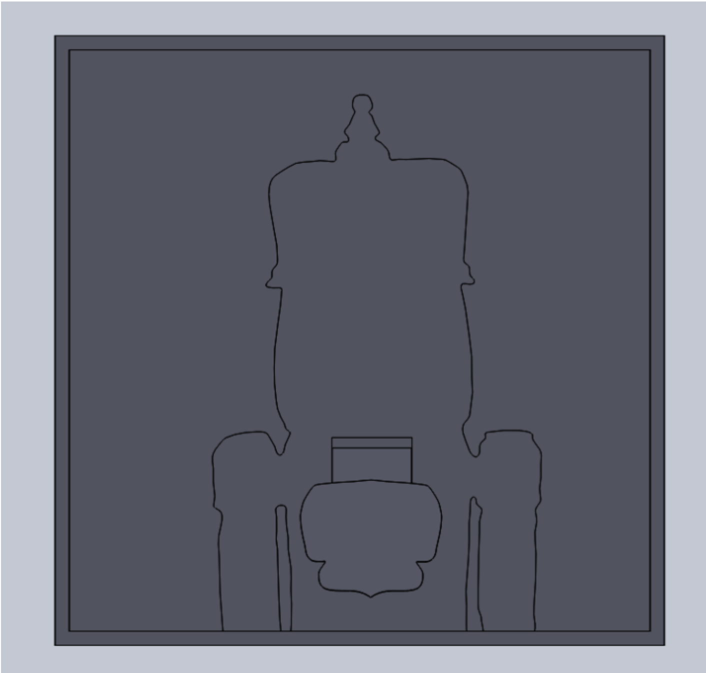


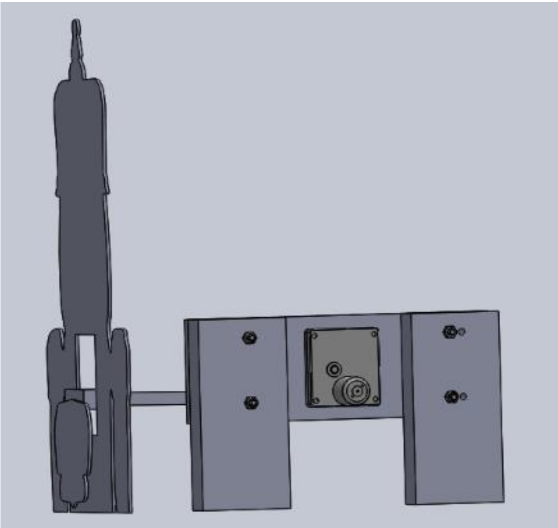


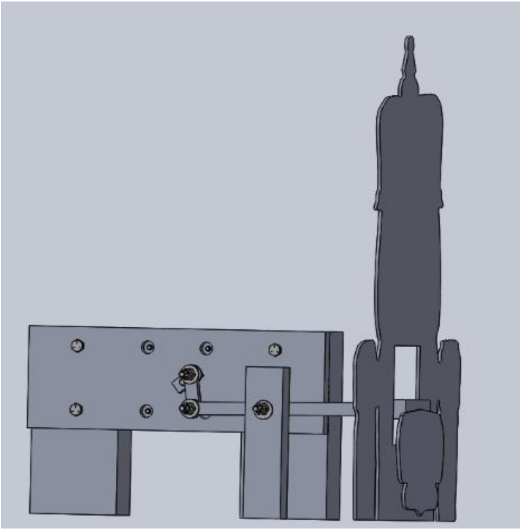
The poles and bells will be laser cut from wood.

Day 21: Nutcracker

The Nutcracker box is going to contain a three-link system, powered by a motor, so that the jaw of the nutcracker will go up and down.



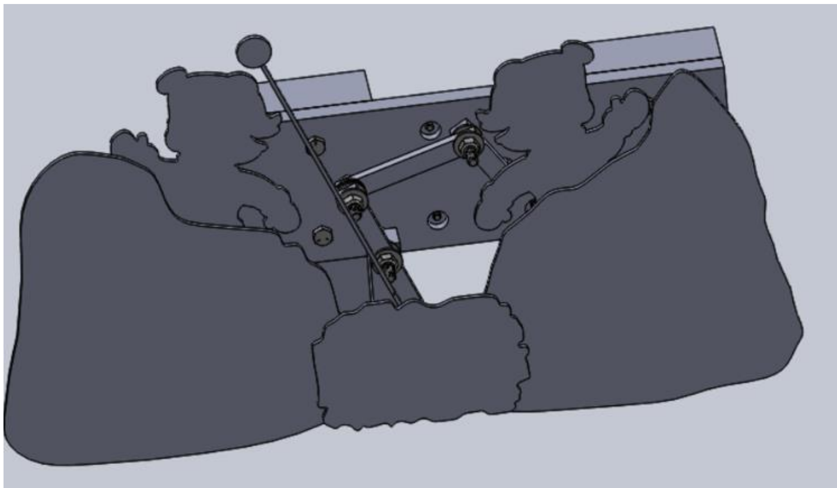


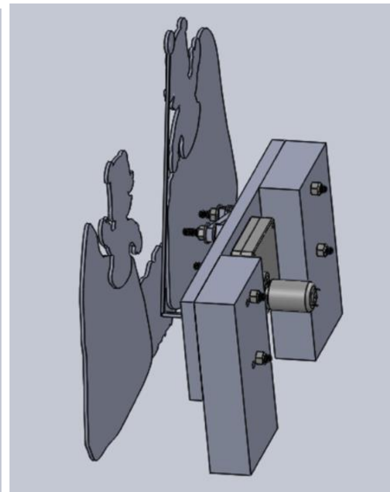


The Nutcracker, the beard, and the extension stick are both cut out of thin sheets of wood. The three blocks, the jaw and the motor back support are cut out of varying thicknesses and lengths of wood. The links are made out of aluminum stocks. All of these components are connected with nuts, bolts, washers, set screws, and glue.

Day 22: Snowball Fight

The Snowball fight box is going to contain a three link system, powered by a motor, so that the snowball can oscillate back and forth between the two kids.

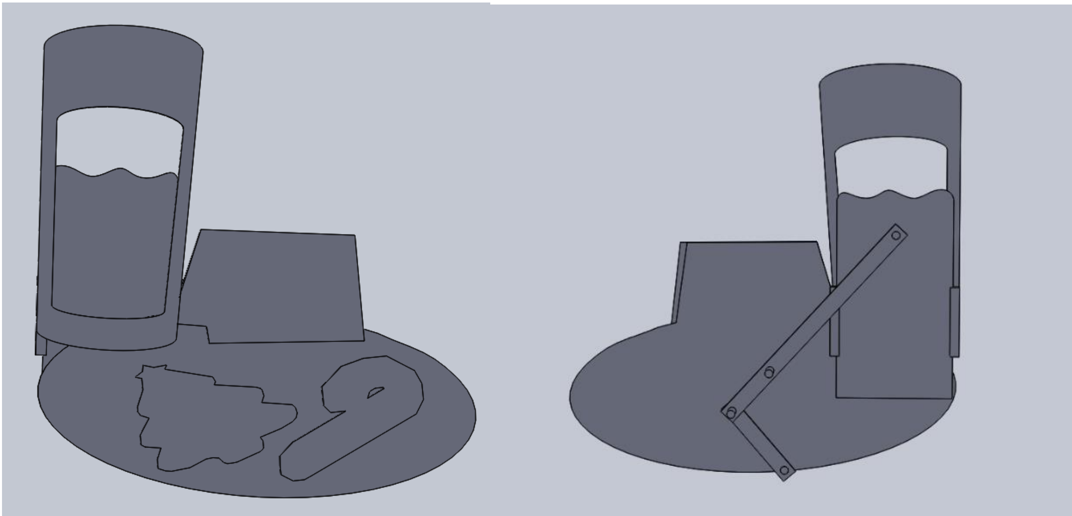




The kids, the snow forts, the bush, the snowball and the extension stick are cut out of thin sheets of wood. The three blocks and the motor back support are cut out of varying thicknesses and lengths of wood. The links are made out of aluminum stocks. The stick connected to the ball will be made out of a thin acrylic. All of these components are connected with nuts, bolts, washers, set screws, and glue.

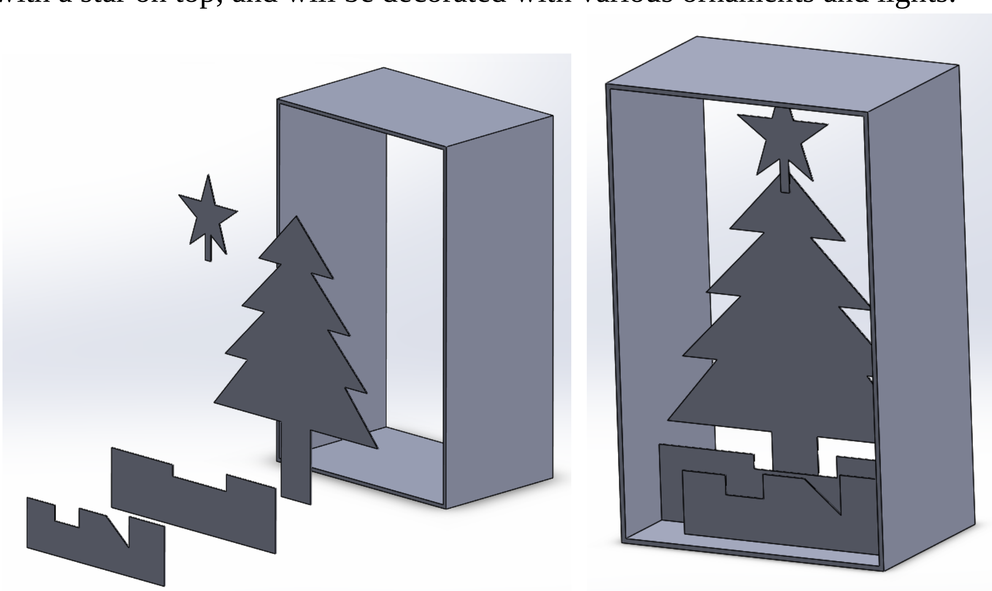
Day 24: Milk and Cookies

The design now uses a two-bar linkage to connect the motor to the milk. The linkage has a square dowel that holds the milk in place and converts rotational motion to linear motion.



Day 25: Christmas Tree

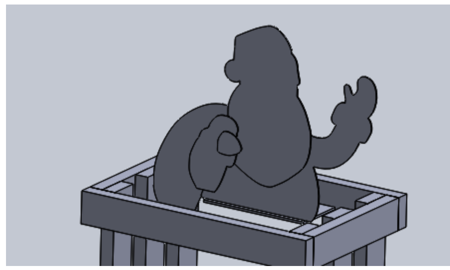
The entire layout of what was originally the "Living Room", as seen in Appendix F, has been redesigned per the sponsor's preference for a greater feature of the Christmas tree. The tree is now centered with a star on top, and will be decorated with various ornaments and lights.



The tree, star, and two presents layers will be laser cut from wood.

Finale: Santa

The overall design of Santa remains unchanged from Appendix F.



Santa will be mounted to a platform built using 2x4 wood posts to hold the whole assembly with 2x1 support posts.

Appendix L: DVP&R

Senior Project DVP&R

Date: 12/12/19 | **Team:** Naughty and Nice | **Sponsor:** Lee McFarland | **Description of System:** Mechatronic Advent Calendar | **DVP&R Engineer**: Sigrid Derickson

TEST PLAN										TEST REPORT			
Item No	Specification #	Test Description	Acceptance Criteria	Test Responsibility	Test Stage	SAMPLES		TIMING		TEST RESULTS			NOTES
						Quantity	Type	Start date	Finish date	Test Result	Quantity Pass	Quantity Fail	
1	Team Requirement	Max deflection of support system under load of full box row.	<1inch deflection	SD	FP	5	SUB	11/1/19	11/7/19	Pass	All	None	
2	Team Requirement	Motor response time with code	+/- .5 second response	OS	SP	12	C	5/7/19	5/30/19	-	-	-	Test not yet conducted
3	OSHA 1910.302 thru 1910.308	Electrical Hazards Check List	Meet all electrical standards	TK	FP	1	SYS	11/1/19	11/7/19	Pass	All	None	
4	Team Requirement	Water resistant boxes	< .5 ounce per gallon of H2) enters box	SD	SP	2	SUB	5/20/19	5/30/19	Pass with Exception	24	2	Lady Quadalupe and Snowball Fight fog up
5	Sponsor Requirement	Size of system	Largest box must be <2'X4'X2' cubic feet	SD	SP	25	SUB	5/7/19	5/20/19	Pass	All	None	
6	Sponsor Requirement	Cost of boxes	Box must cost <$250	SD	FP	25	SUB	11/1/19	11/7/19	Pass	All	None	
7	Sponsor Requirement	Weight of boxes	boxes must weigh < 50 pounds	DC	FP	25	SUB	11/1/19	11/7/19	Pass	All	None	
8	Sponsor Requirement	Complexity	minimum of 12 boxes with moving components	OS	FP	12	SUB	11/1/19	11/7/19	Fail	10	2	Snowball Fight and Cookies&Milk converted to static in the interest of time but relatively easy to become moving again
9	Sponsor Requirement	Time of system Operations	The lights music and action must remain on for 10 seconds +/- 1 second	DC	SP	3	SUB	5/7/19	5/20/19	Fail	None	All	Spec has changed, each box has varying time delay to match music cut length
10	Sponsor Requirement	Aestetic of boxes and Facade	Color match and style match to base example	OS	FP	25	SUB	11/1/19	11/7/19	Pass	All	None	
11	Sponsor Requirement	Quantity	Active track progress and supplies, must not create any red cells	TK	SP	25	SUB	5/7/19	5/20/19	Pass	All	None	
12													
15													
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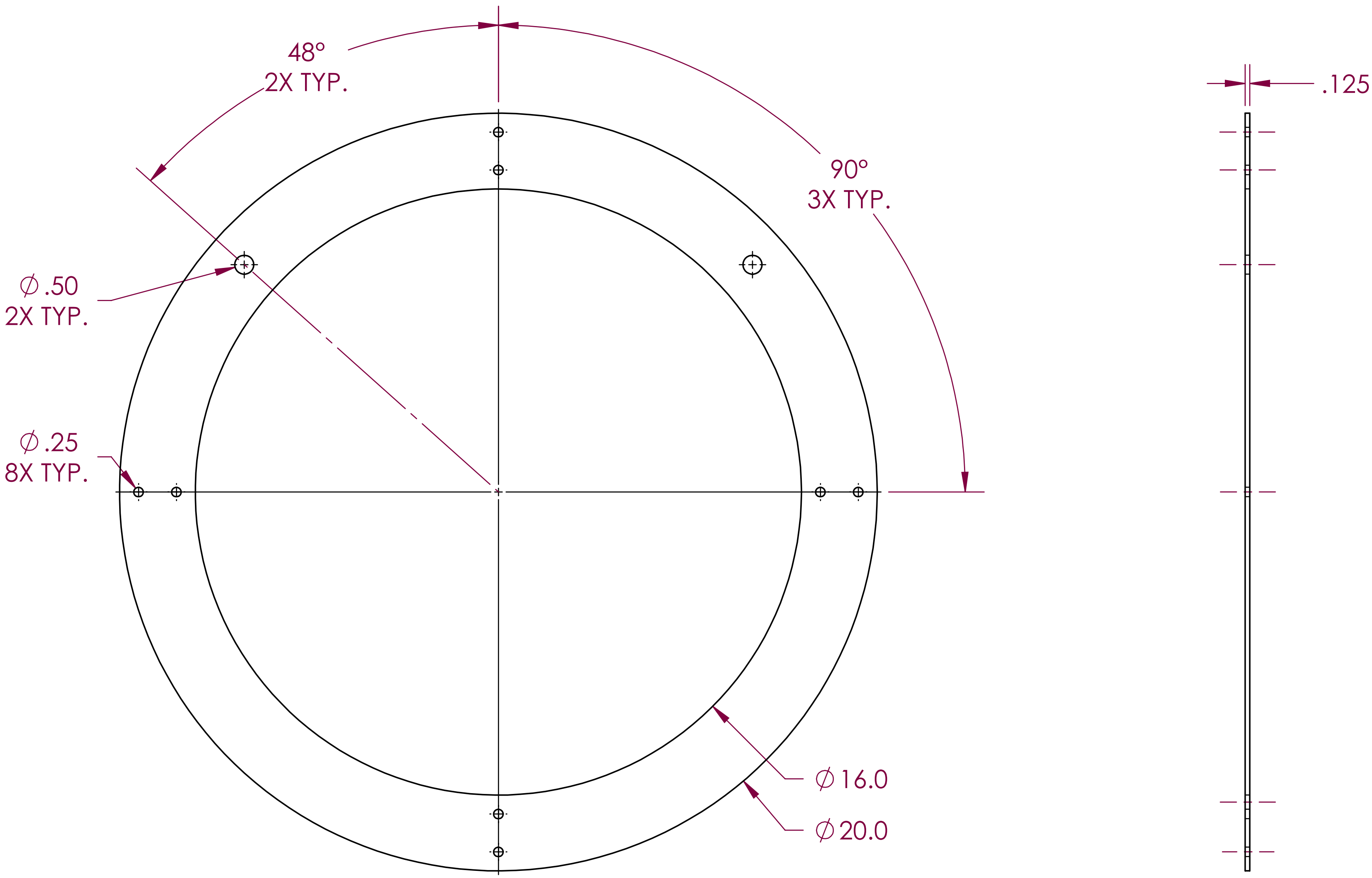
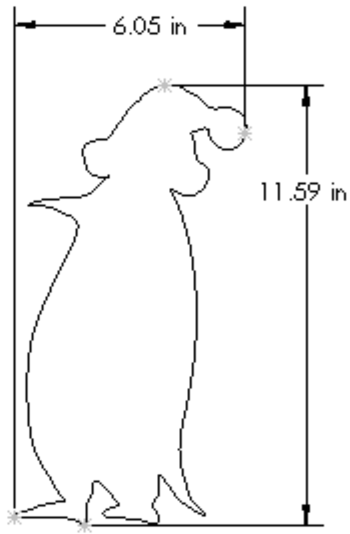
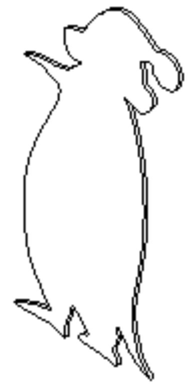
Appendix M: Detailed Drawing Packets



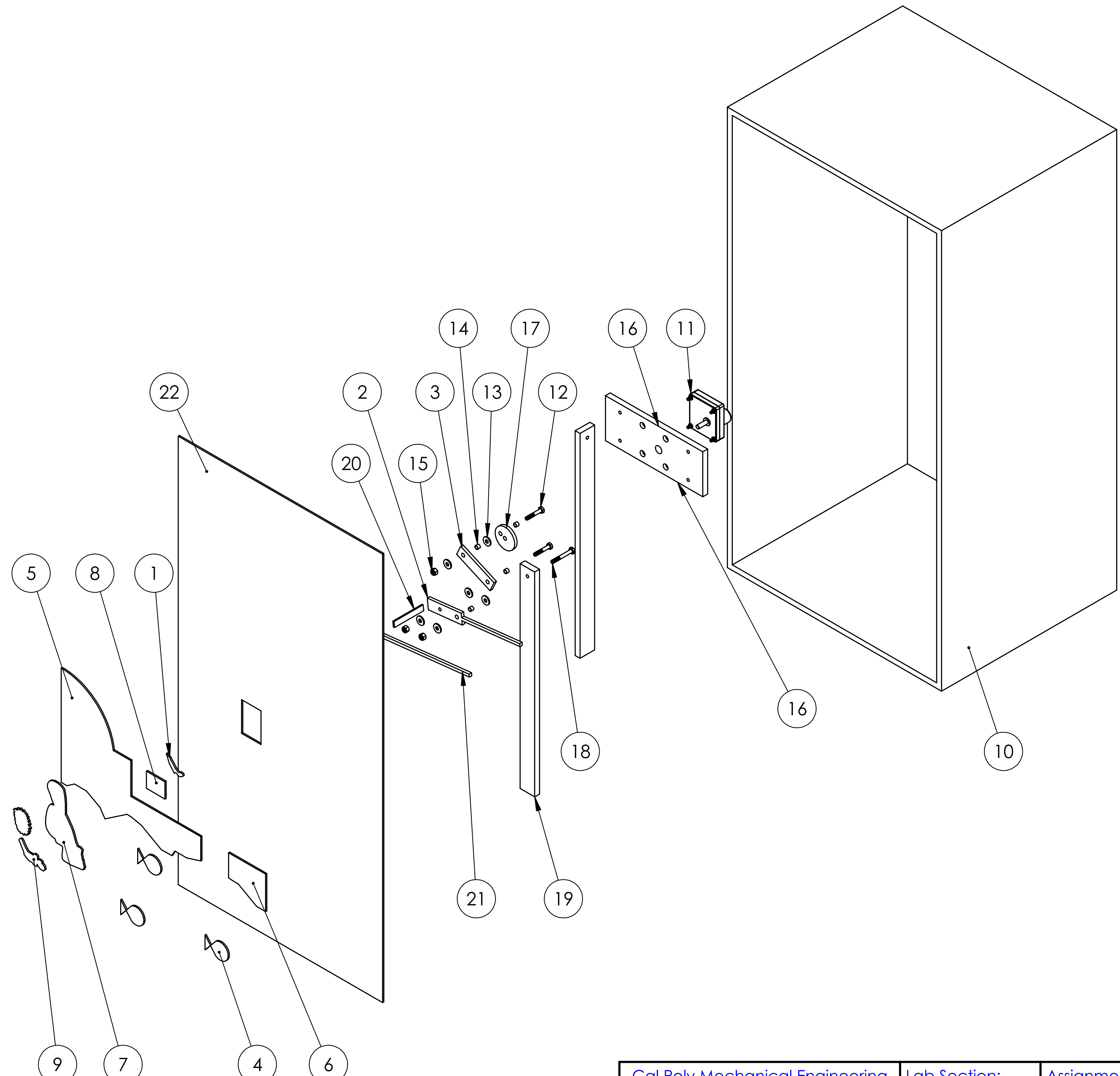
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Wreath Base		Drwn. By: Sigrid Derickson
ME 429 - Spr. 2019	Dwg. #:	Nxt Asb:	Date: 4/25/19	Scale: 1/4	Chkd. By: ME STAFF





These cutouts are to be made of 1/8 inch thick wood

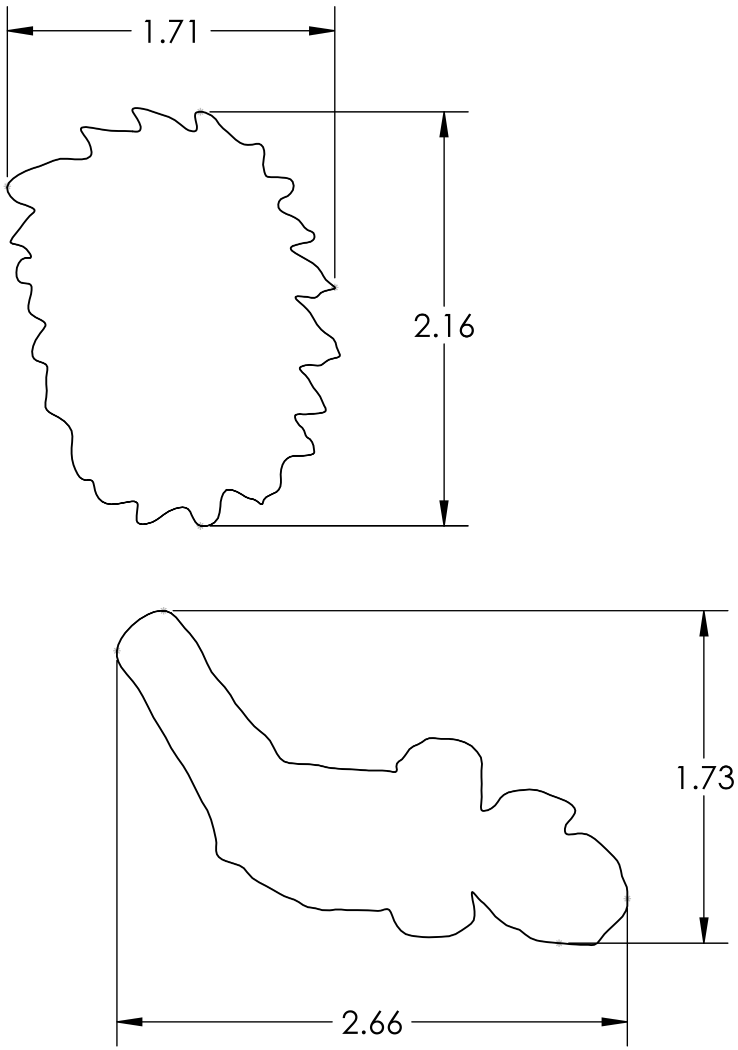
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:Day2_Penguins		Drwn. By: Danny Clifton
ME ### - Qtr Year	Dwg. #:	NxtAsb:	Date:04/27/19	Scale:1:4	Chkd. By: ME STAFF

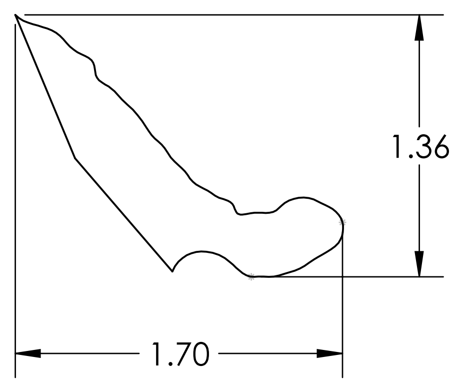


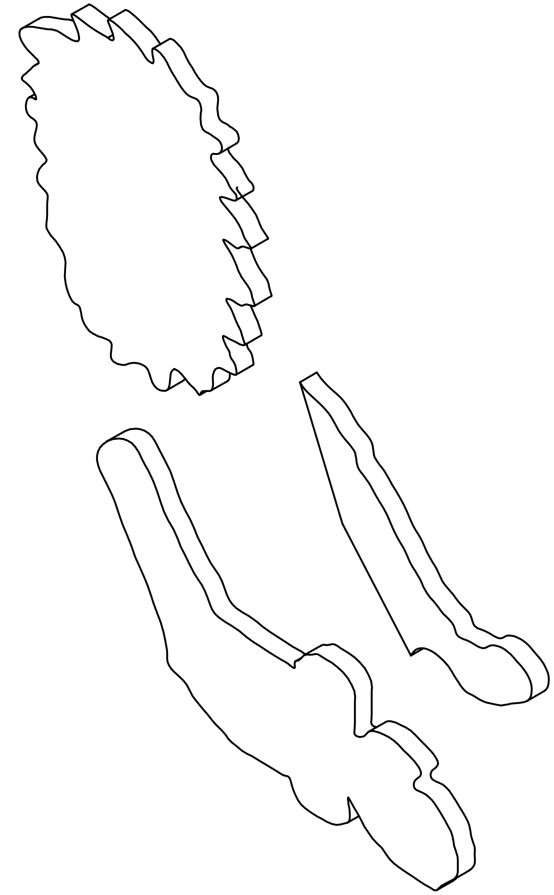
ITEM NO.	PART NUMBER	QTY.
1	FishermanPart1_LeftArm(Day4)	1
2	FishermanPart3_PoleLink(Day4)	1
3	FishermanPart5_BasicLink(Day4)	1
4	FishermanPart6_Fish(Day4)	3
5	FishermanPart7_IceIgloo(Day4)	1
6	FishermanPart8_IcePiece(Day4)	1
7	FishermanPart9_Body(Day4)	1
8	FishermanPart10_Box(Day4)	1
9	FishermanPart12_HoodRightArm(Day4)	1
10	Day4,5,21_Box_Reference	1
11	6409K17	1
12	91247A546	2
13	90295A155	6
14	6391K126	4
15	95615A120	3
16	FishermanMotorBackSupport	1
17	FishermanPart4_Round(Day4)	1
18	91247A550	1
19	FishermanPart14_PinSupport(Day4)	2
20	FishermanPart15_ExtensionRod(Day4)	1
21	FishermanPart16_PoleLinkWood(Day4)	1
22	FishermanPart13_Background(Day4)	1

Cal Poly Mechanical Engineering ME ### - QTR YEAR	Lab Section:	Assignment #	Title: FISHERMAN ASSEMBLY		Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale: 1:8	Chkd. By: ME STAFF

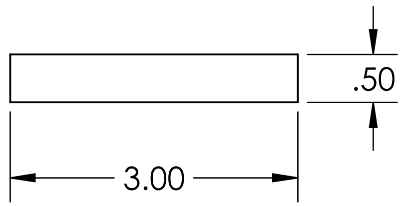
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED



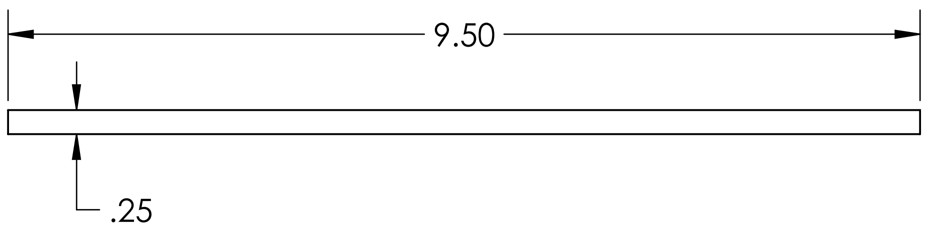




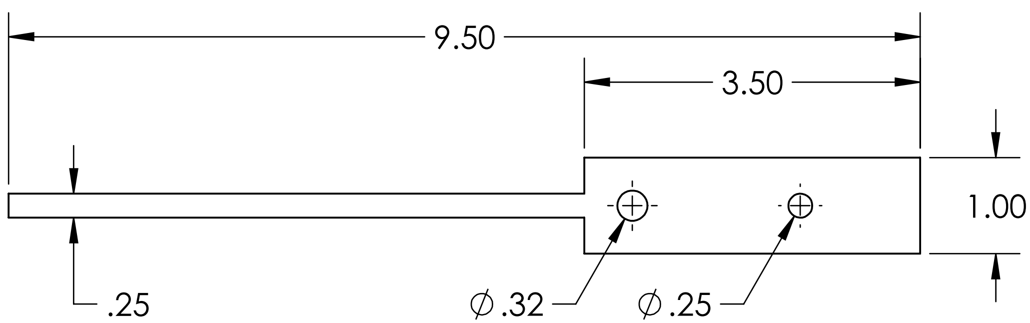
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: FISHERMAN ARMS AND HOOD		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale: 1:1	Chkd. By: ME STAFF



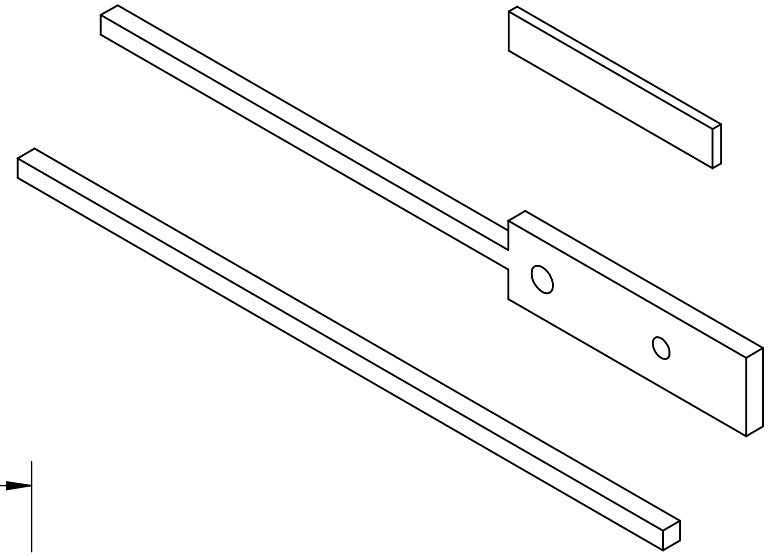
WOOD EXTENSION ROD: 1/8" THICK



WOOD POLE: 1/8" THICK

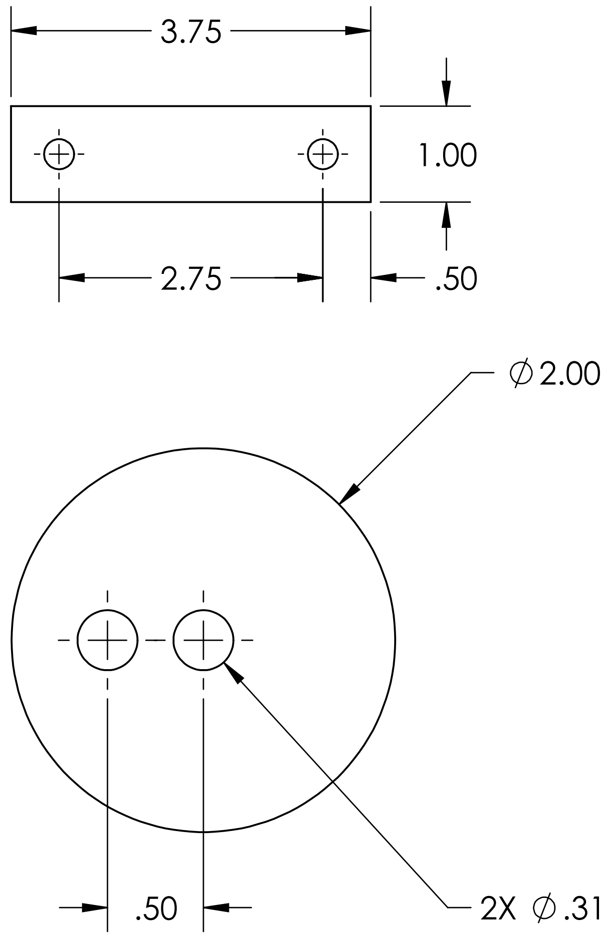


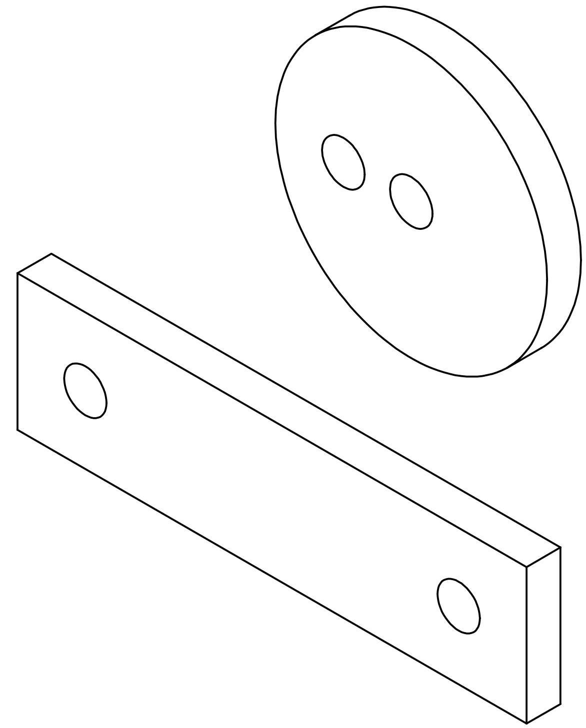
METAL POLE: 1/4" THICK



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: TWO POLES & EXT. ROD	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19 / Scale: 1:2	Chkd. By: ME STAFF

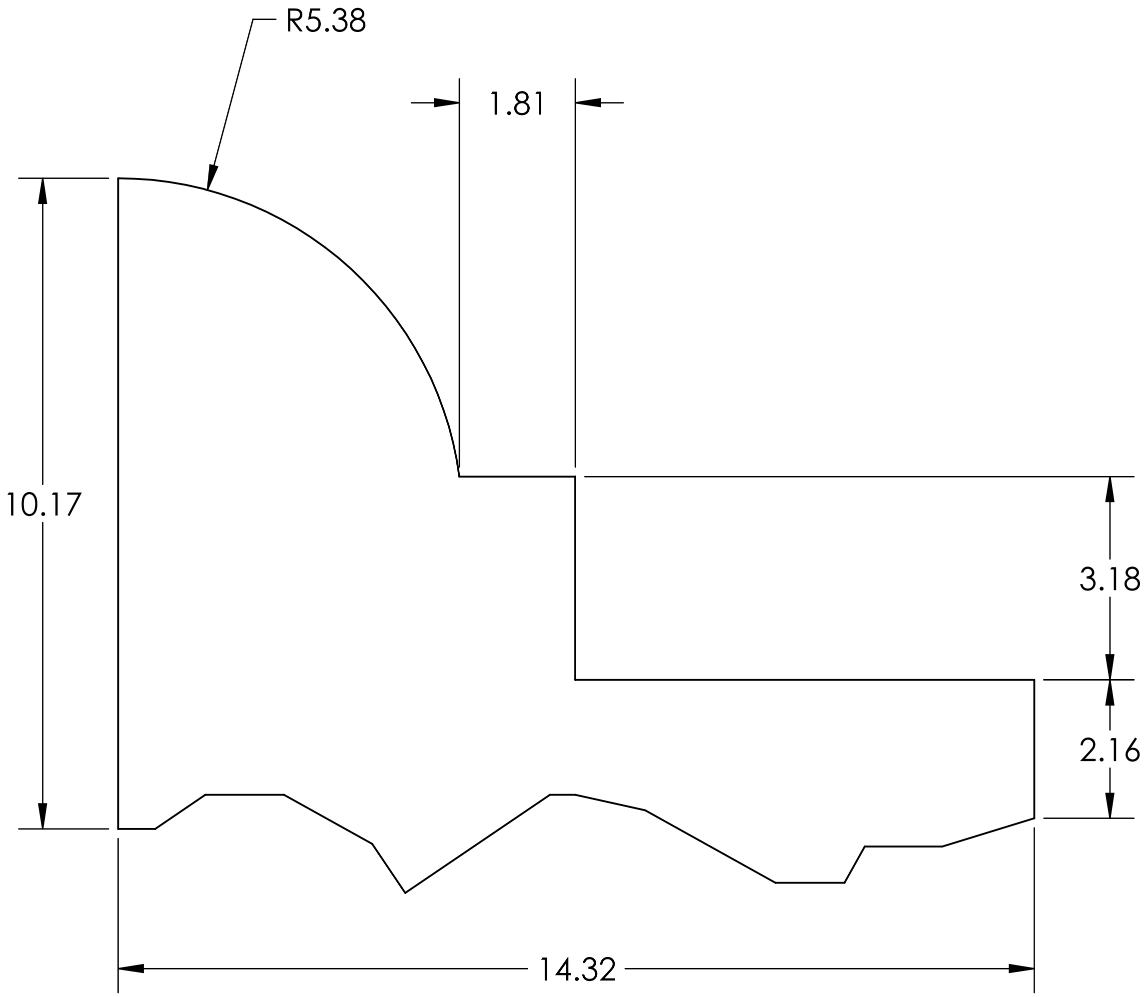
NOTE:
ALL PARTS 1/4" THICK UNLESS
OTHERWISE SPECIFIED

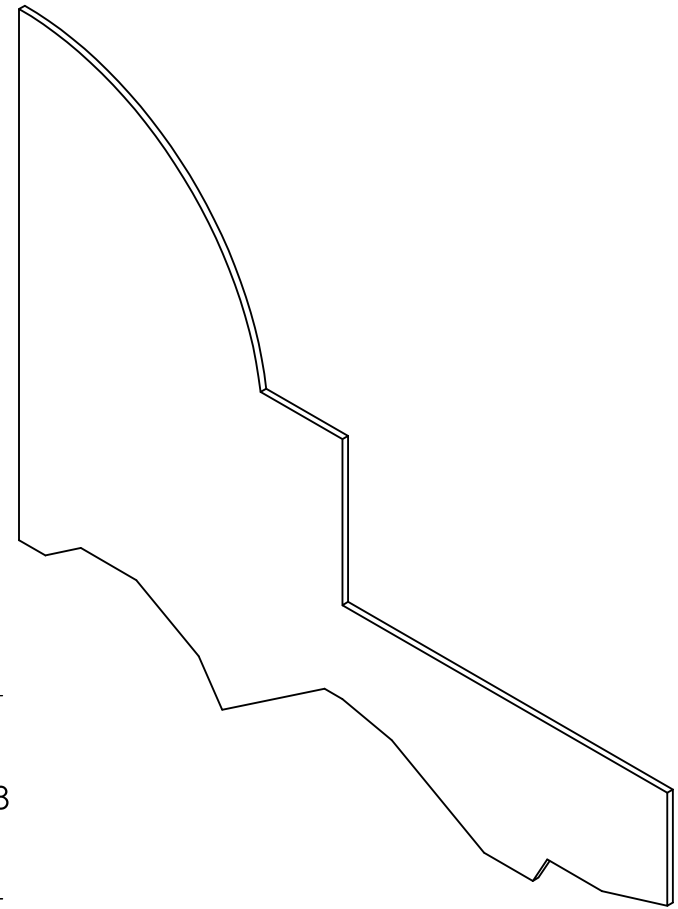




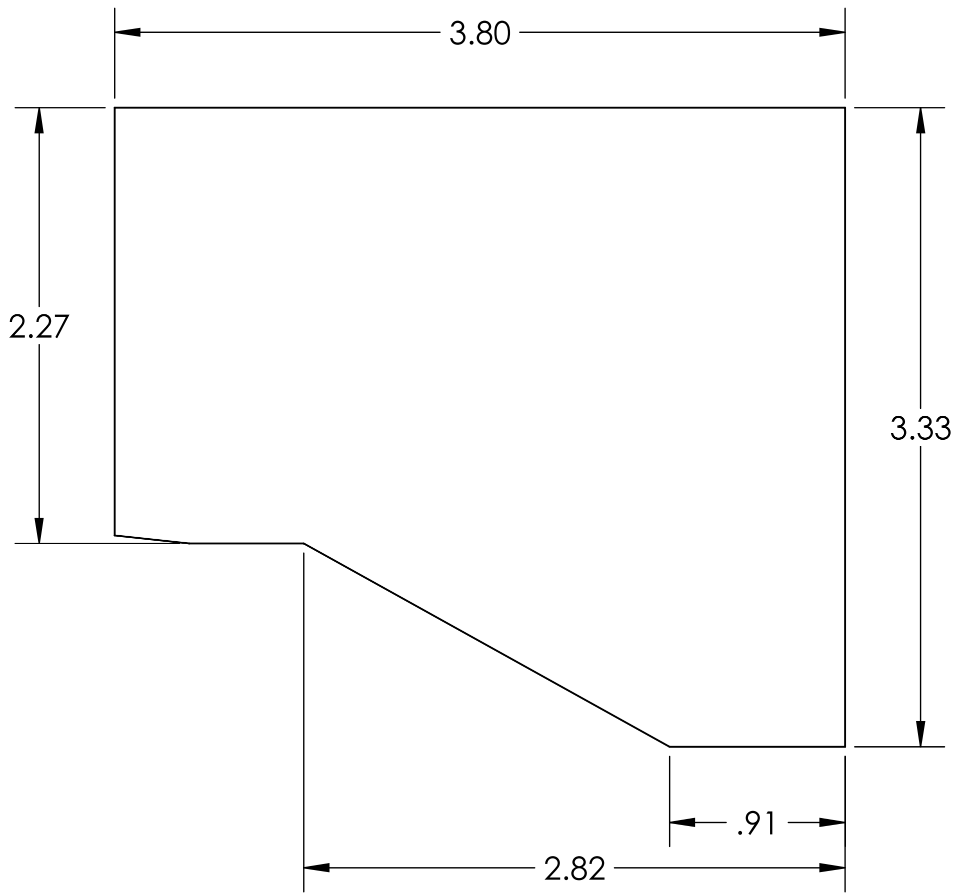
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: ROUND AND BASIC LINK	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19 / Scale: 1:1	Chkd. By: ME STAFF

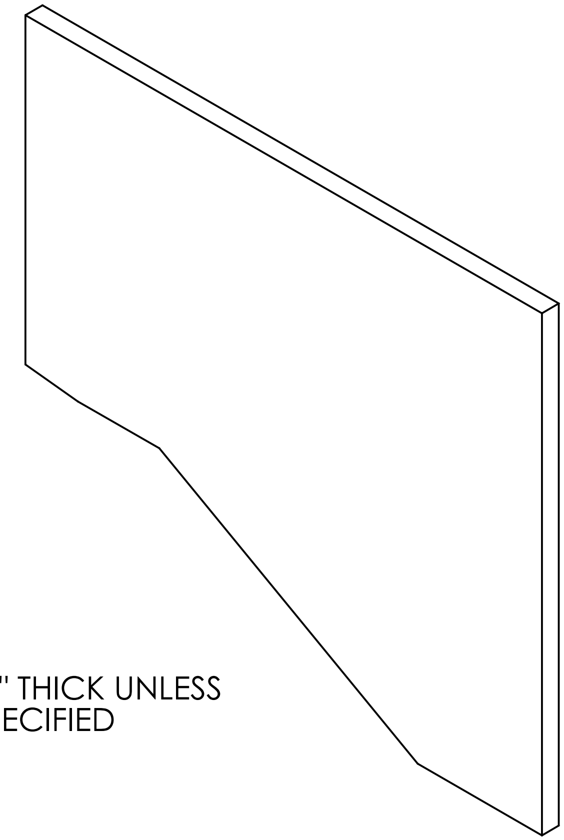
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED



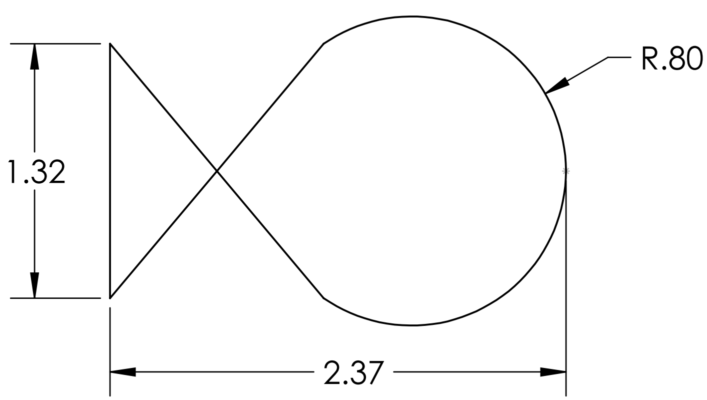


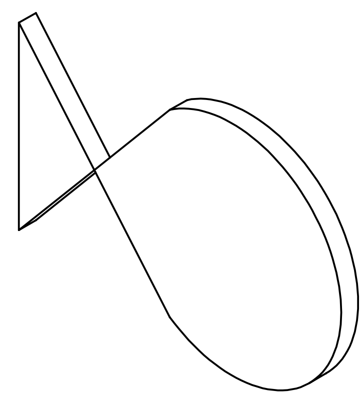
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: FISHERMAN IGLOO ICEBERG	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale: 1:3	Chkd. By: ME STAFF





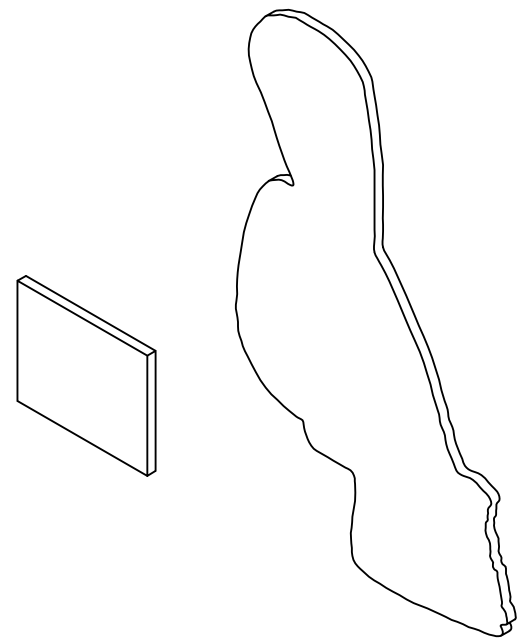
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

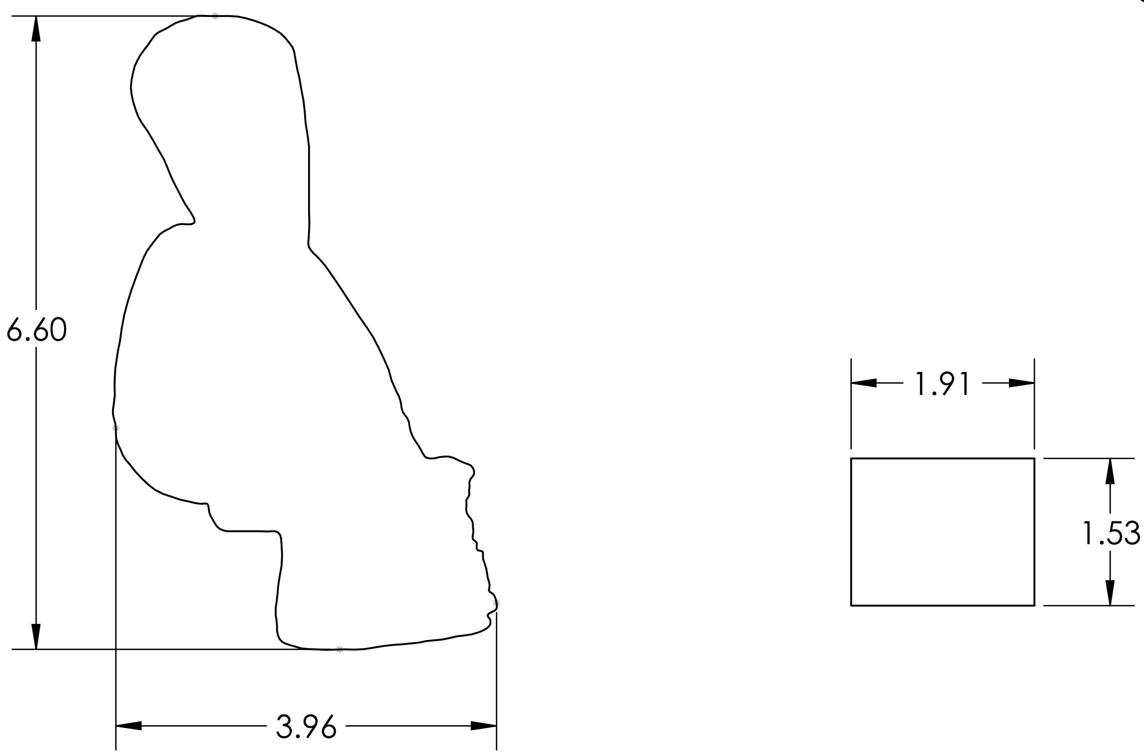




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

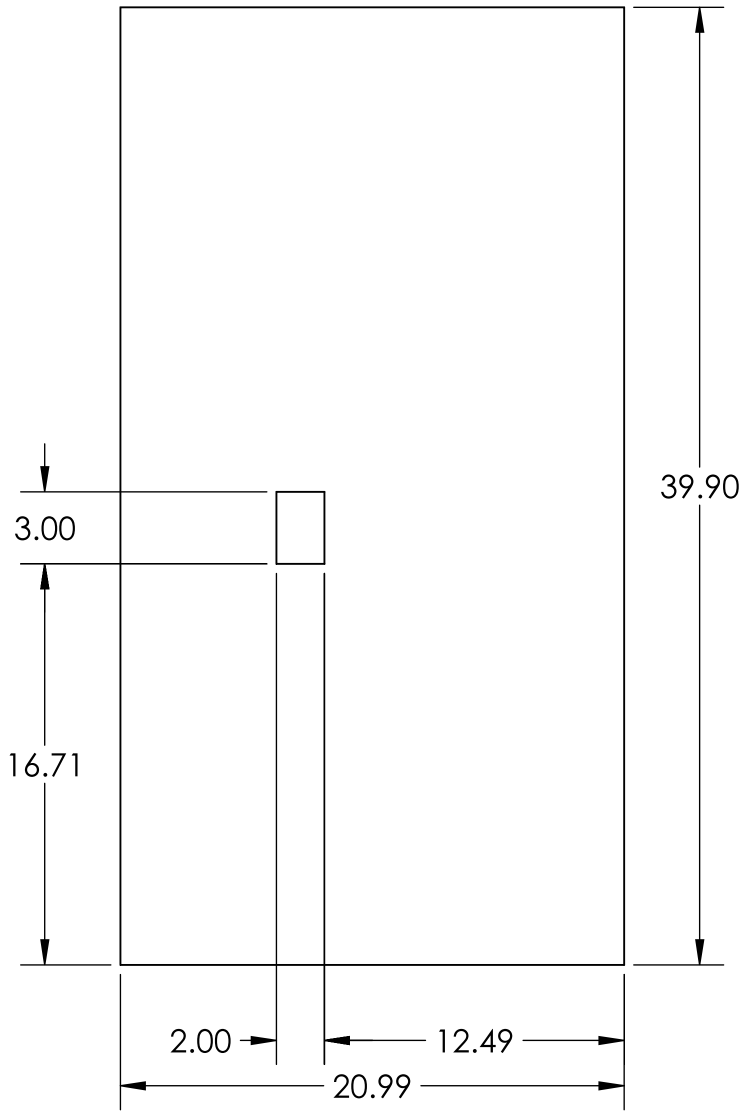
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

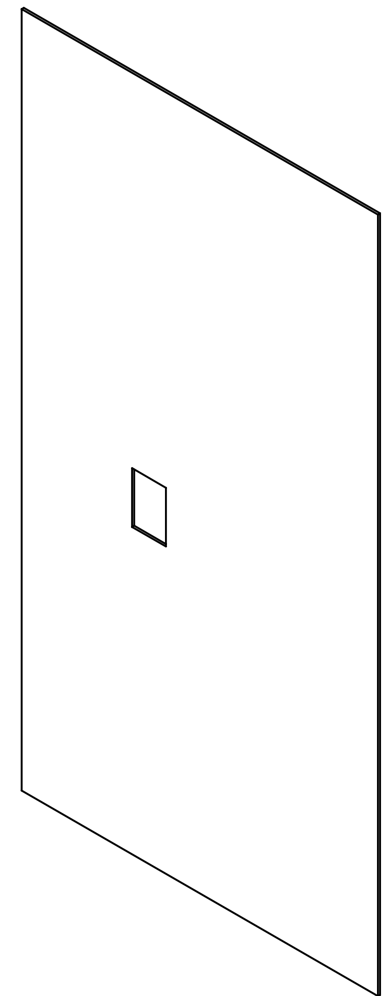




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: FISHERMAN BODY & BOX	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale: 1:2	Chkd. By: ME STAFF

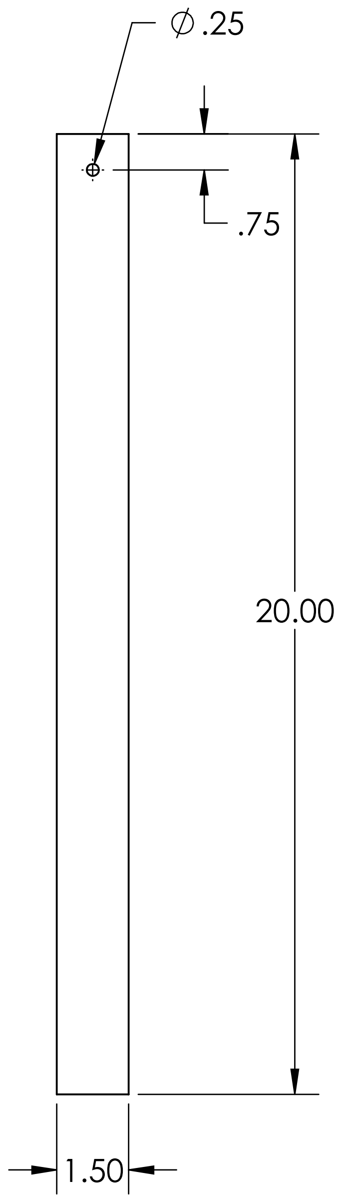
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

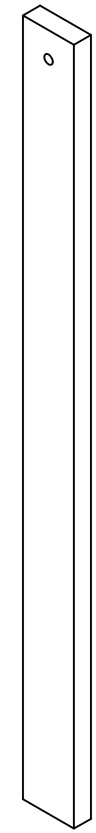




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: FISHERMAN BACKGROUND		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale: 1:8	Chkd. By: ME STAFF

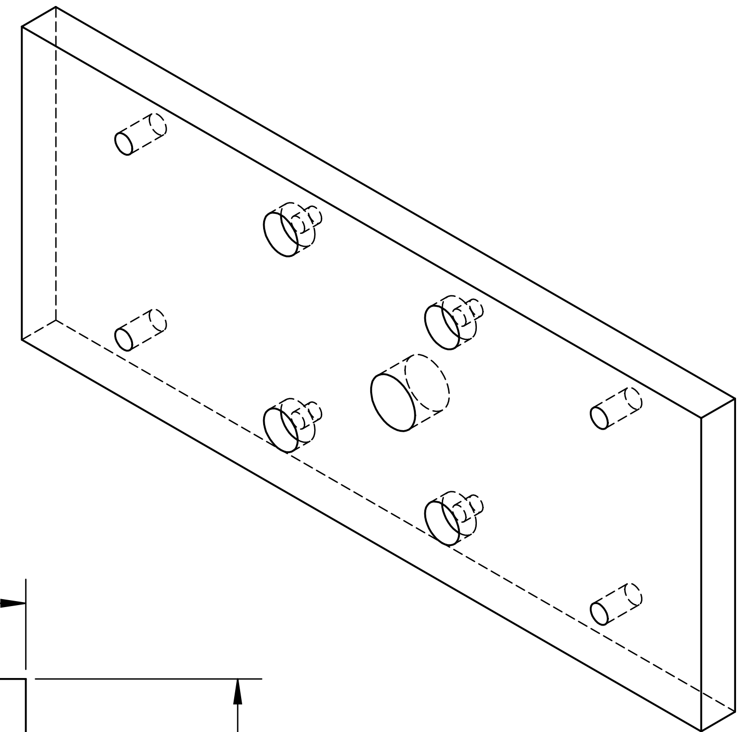
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

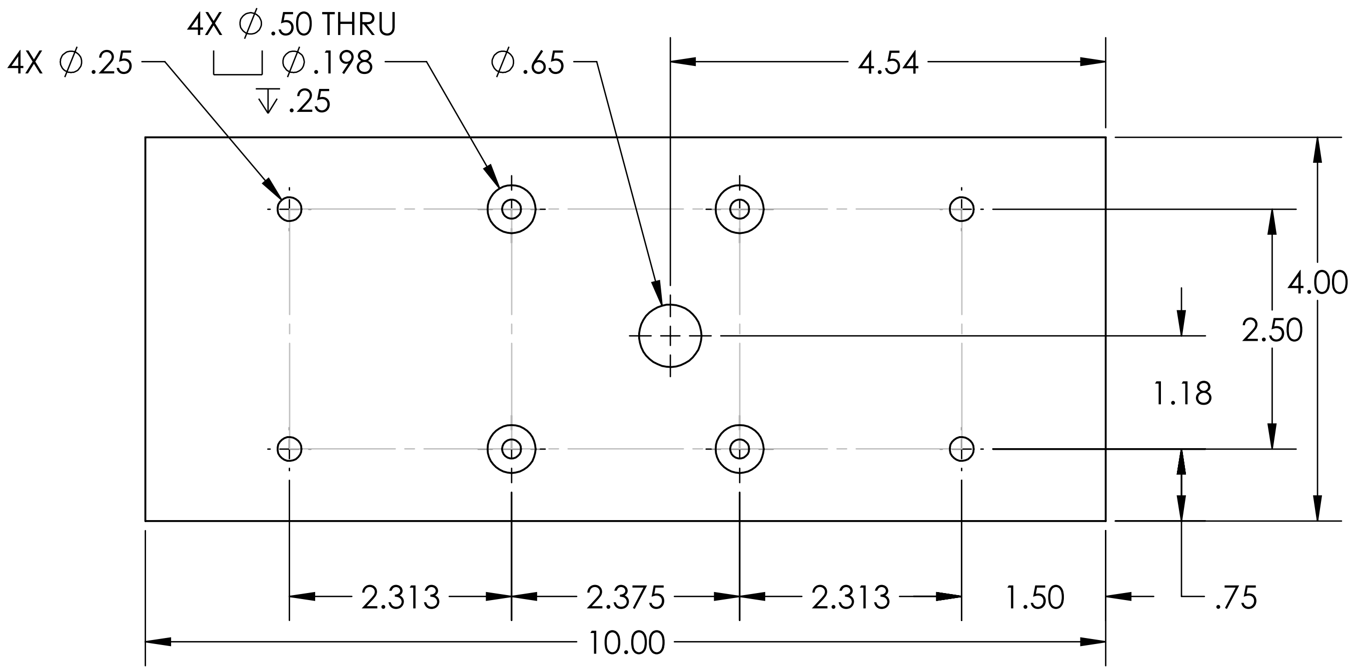




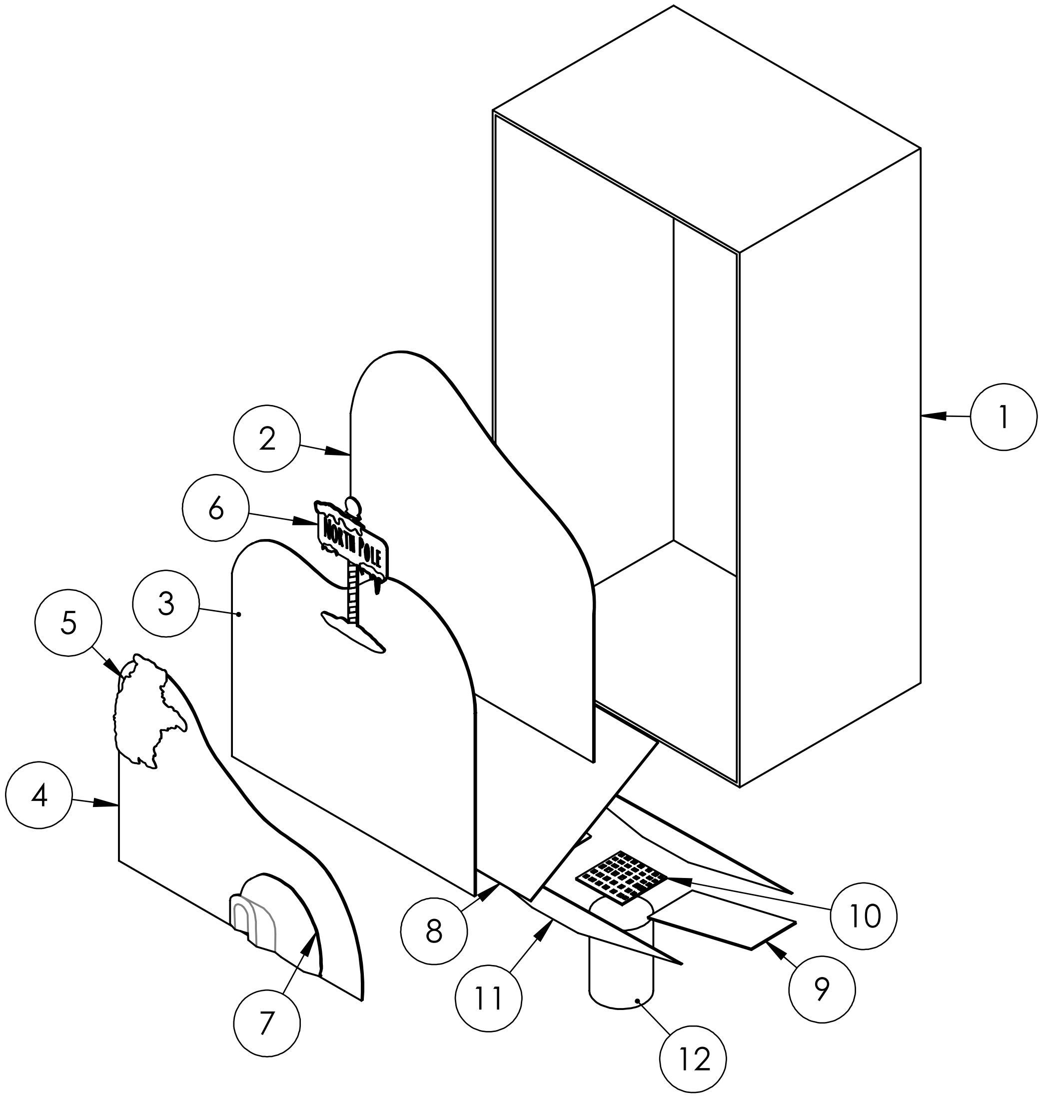
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: FISHERMAN PIN SUPPORT	Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/28/19 / Scale: 1:4	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/2" THICK UNLESS
OTHERWISE SPECIFIED

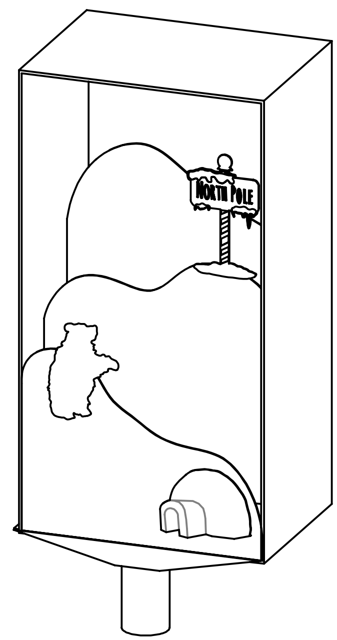




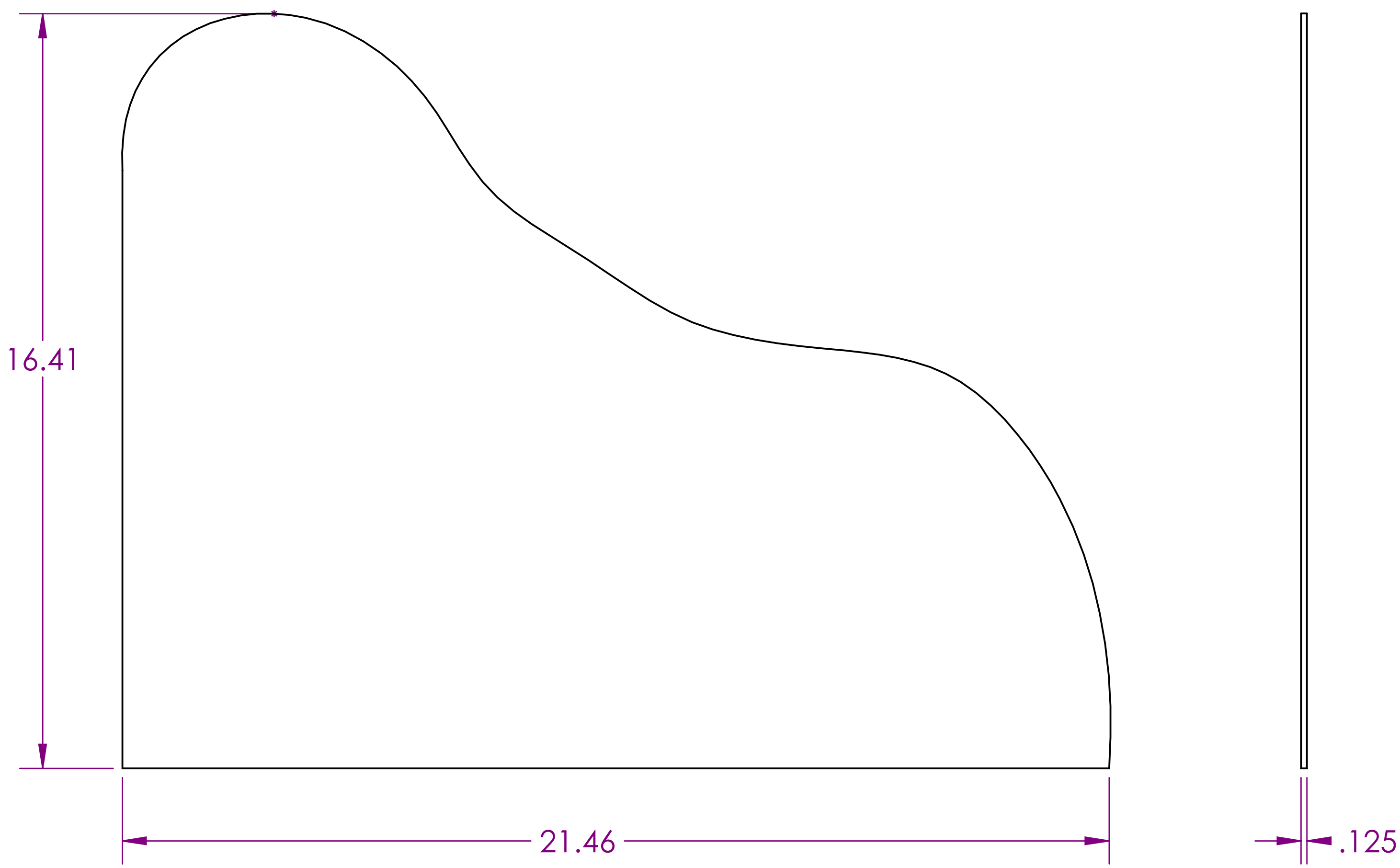
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: MOTOR SUPPORT BLOCK		Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/28/19	Scale:	Chkd. By: ME STAFF



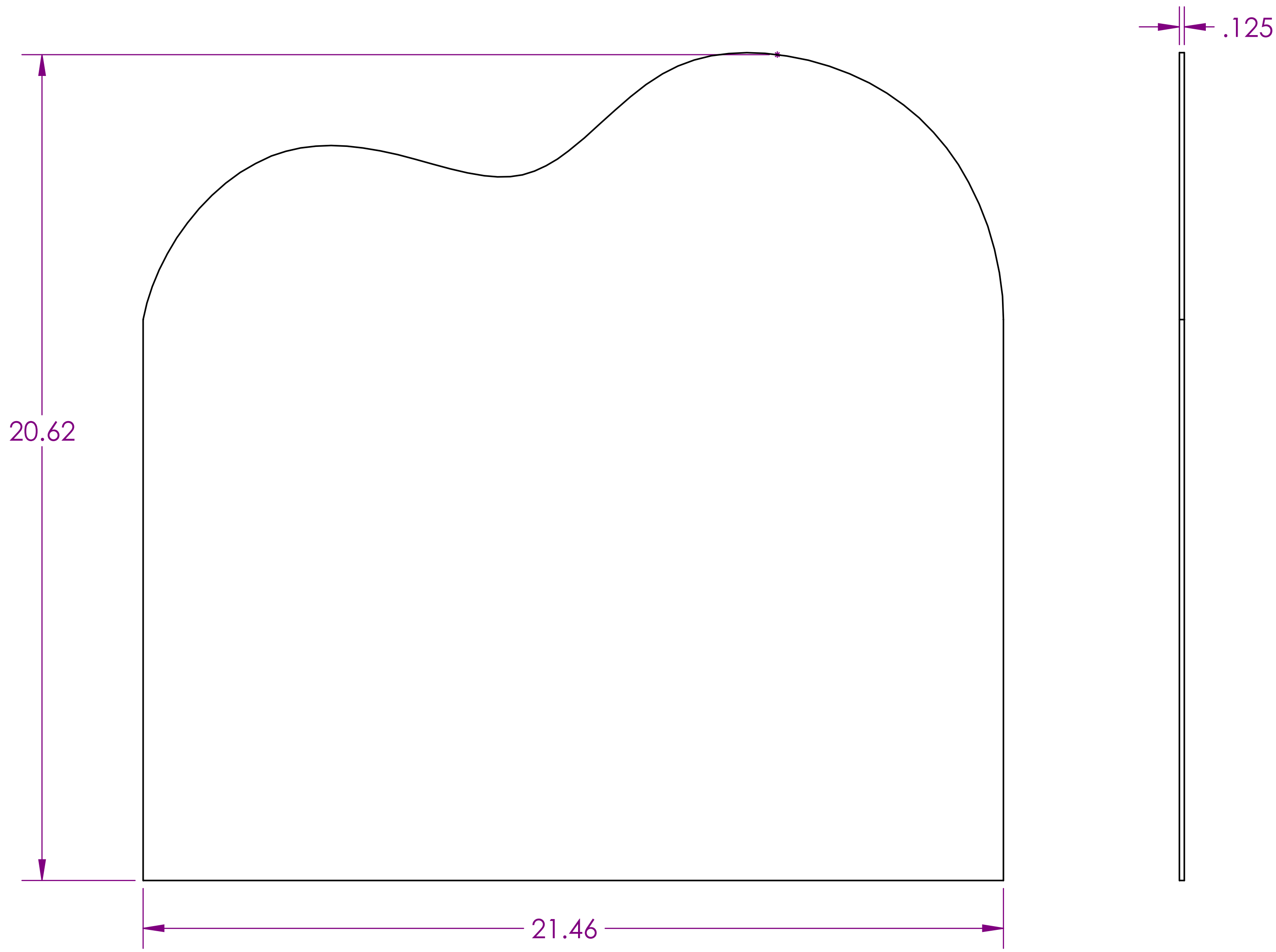
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Box #5	1/8" Wood	1
2	snowbank three	1/8" Wood	1
3	snowbank two	1/8" Wood	1
4	snowbank one	1/8" Wood	1
5	Polar Bear	1/8" Wood	1
6	north pole sign	1/8" Wood	1
7	igloo	1/8" Wood	1
8	Return Board	1/8" Wood	1
9	ramp (X2)	1/8" Wood	2
10	Mesh Placeholder	1/8" Wood	1
11	real base (X1)	1/8" Wood	2
12	Fan Place Holder	1/8" Wood	1



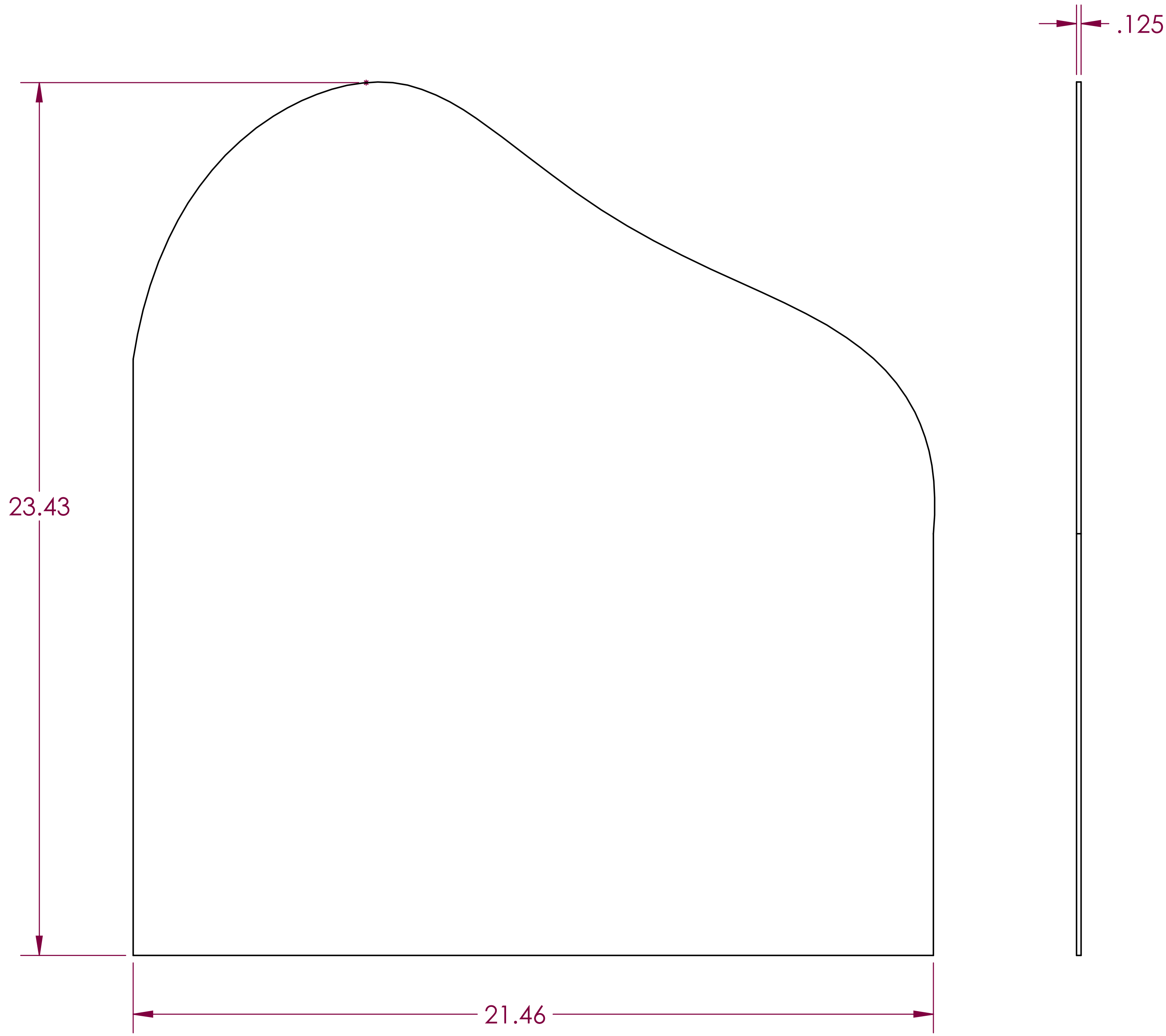
Cal Poly Mechanical Engineering ME 429 - Spring 2019	Lab Section:	Assignment #	Title: Snow Globe Assembly	Drwn. By: Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date: / Scale: 1/8	Chkd. By: ME STAFF



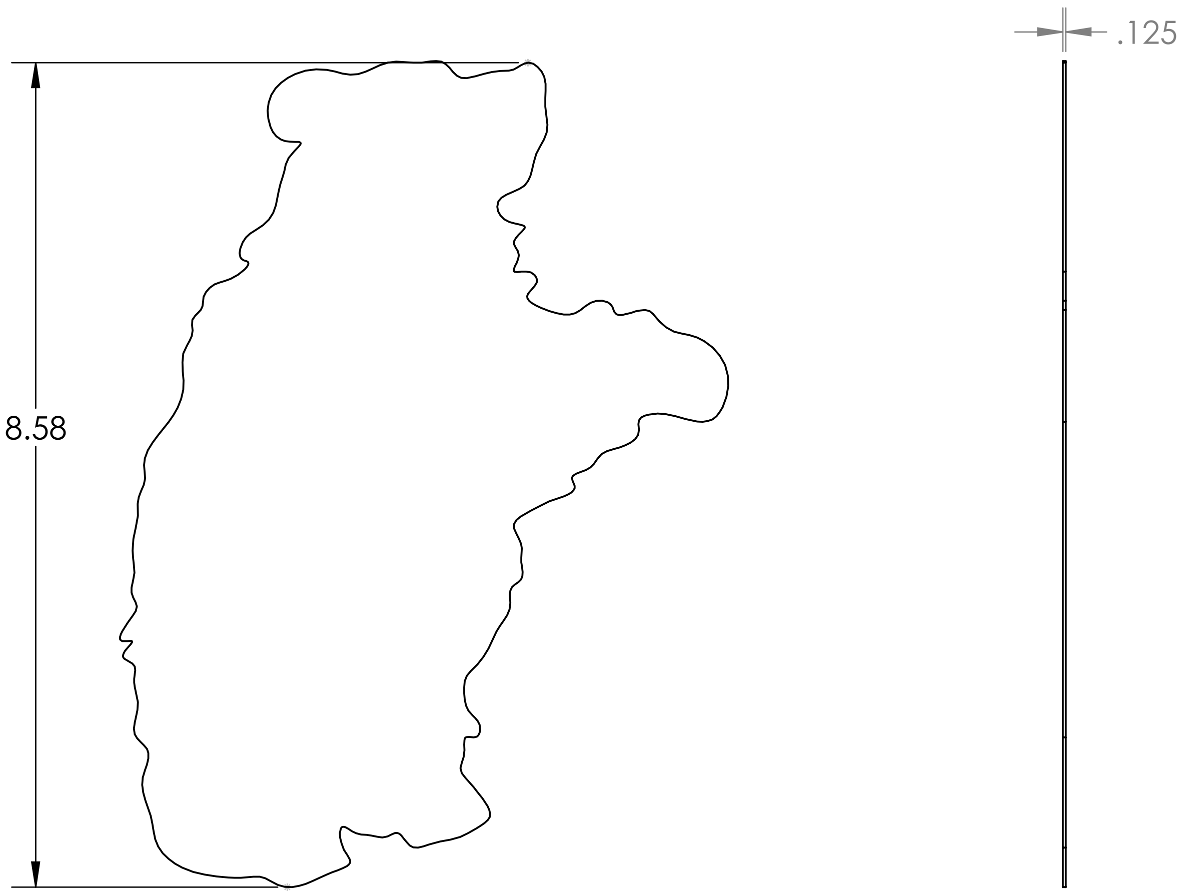
Cal Poly Mechanical Engineering ME 429 - Spring 2019	Lab Section:	Assignment #	Title: Snowbank One	Drwn. By:Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date: 4/25/19	Scale:1/4	Chkd. By: ME STAFF



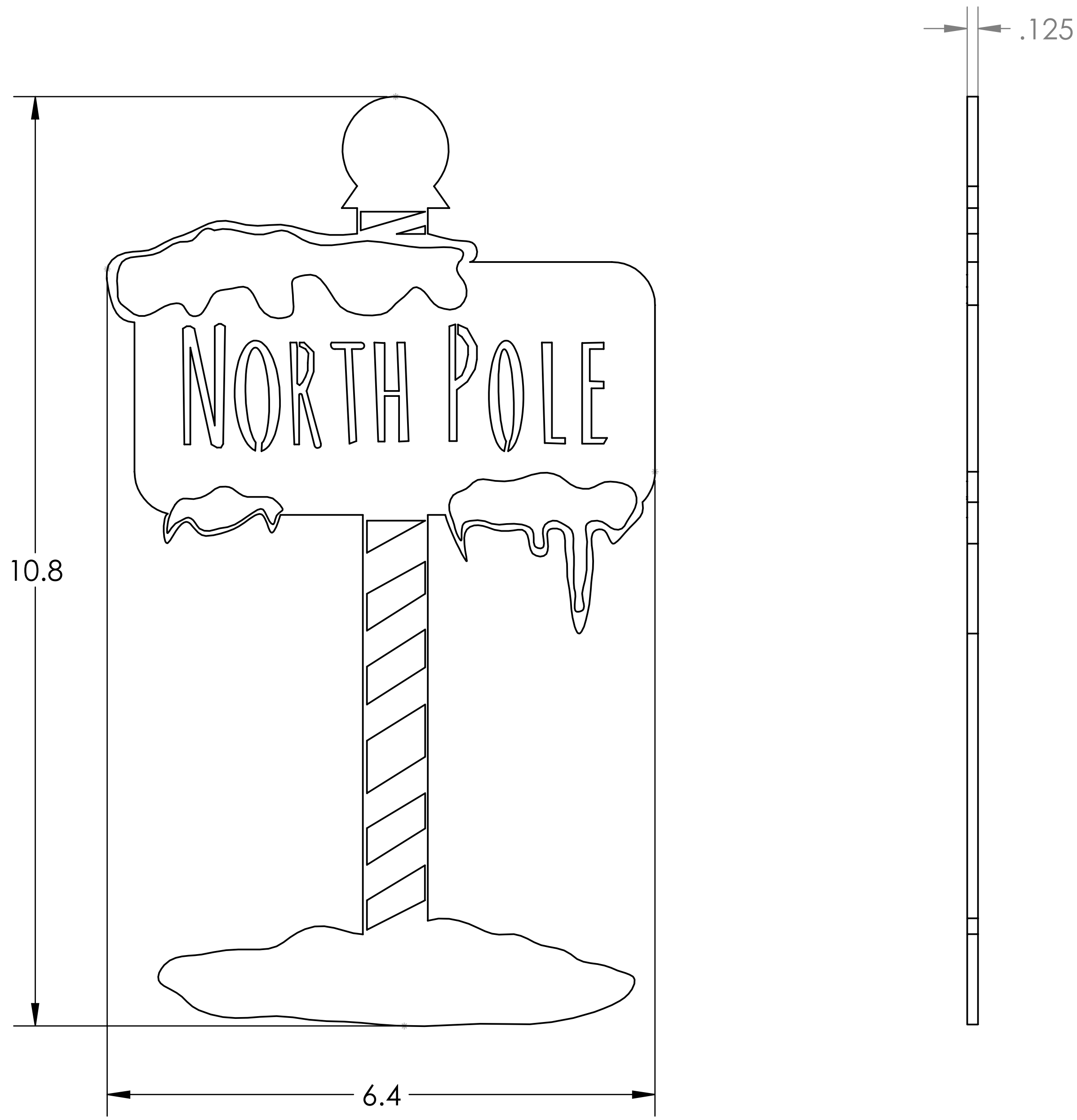
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Snowbank Two	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: 4/25/19 / Scale: 1/4	Chkd. By: ME STAFF



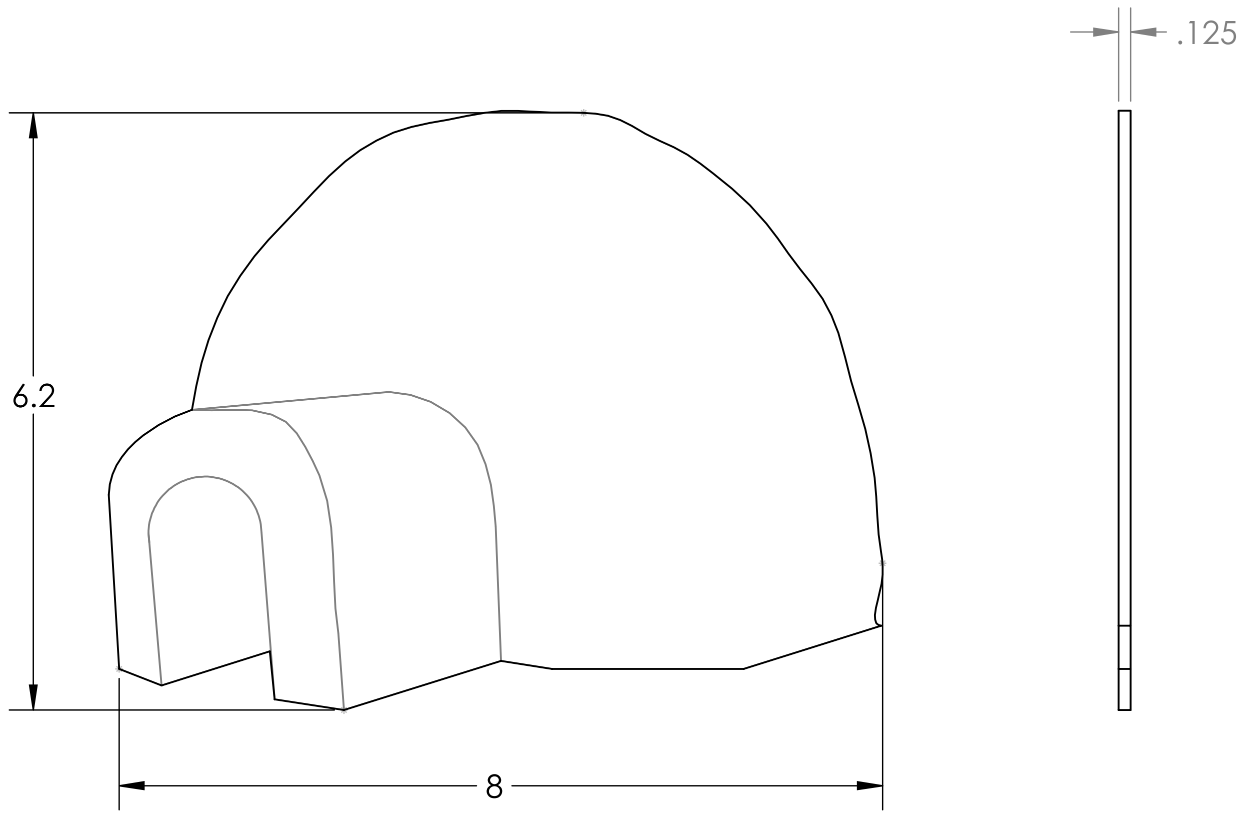
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:Snowbank Three	Drwn. By: Sigrid Derickson
ME 429 - Spring 2019	Dwg. #:	Nxt Asb:	Date:4/25/19 / Scale: 1/8	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Polar Bear	Drwn. By: Sigrid Derickson
ME 429 - Spring 2019	Dwg. #:	Nxt Asb:	Date:4/25/19 Scale:1/4	Chkd. By: ME STAFF

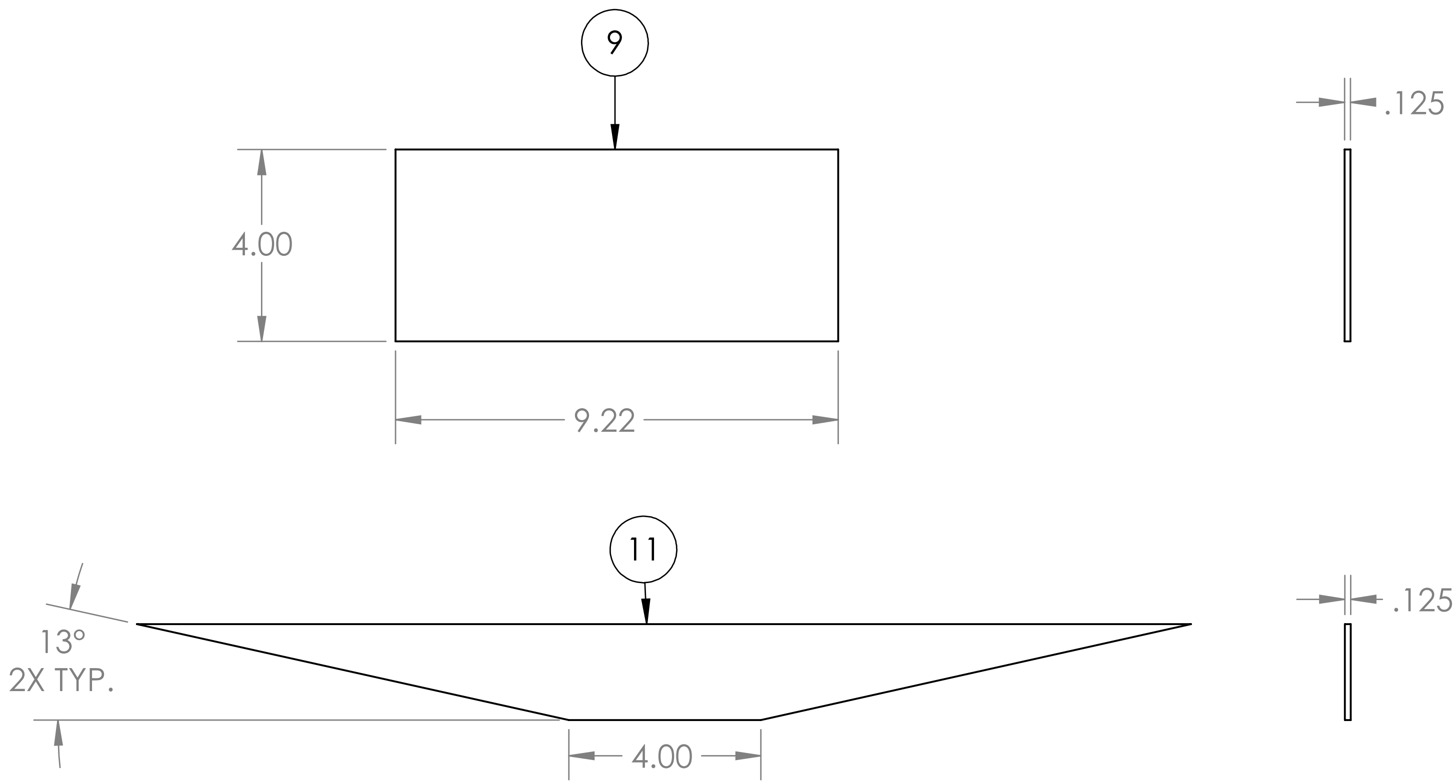


Cal Poly Mechanical Engineering ME 429 Spring 2019	Lab Section:	Assignment #	Title: North Pole Sign	Drwn. By: Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date:4/25/19	Scale:1/2	Chkd. By: ME STAFF



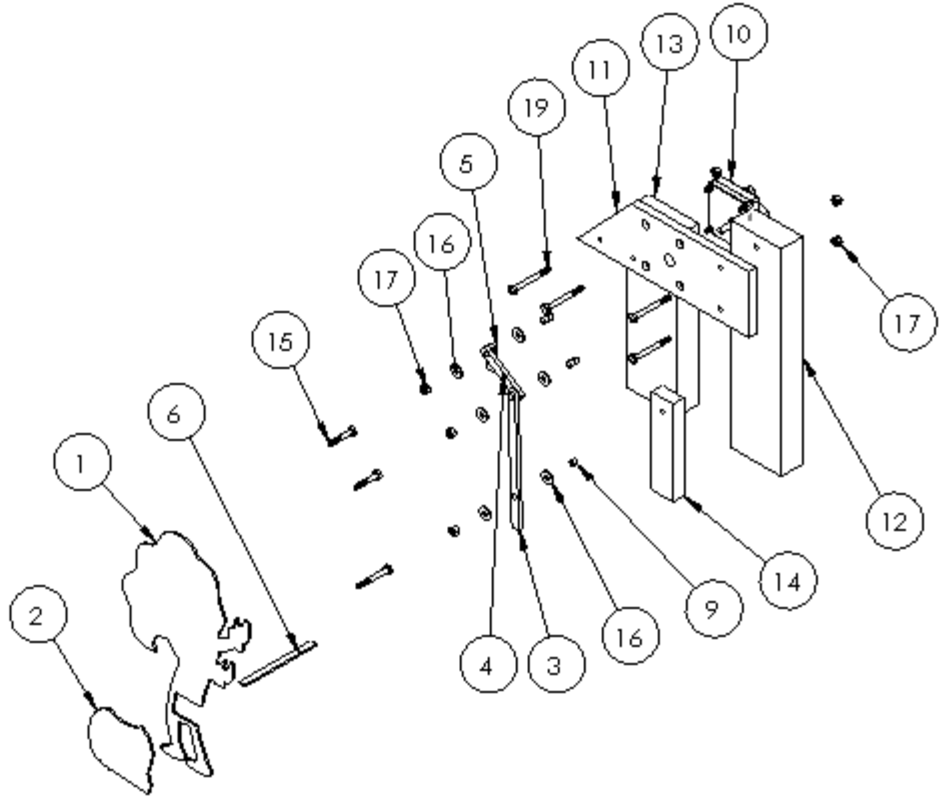
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Igloo	Drwn. By:Sigrid Derickson
ME 429 - Spring 2019	Dwg. #:	Nxt Asb:	Date: 4/25/19 · Scale: 1/2	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
9	Ramp	1/8" Wood	2
11	Real Base	1/8" Wood	2



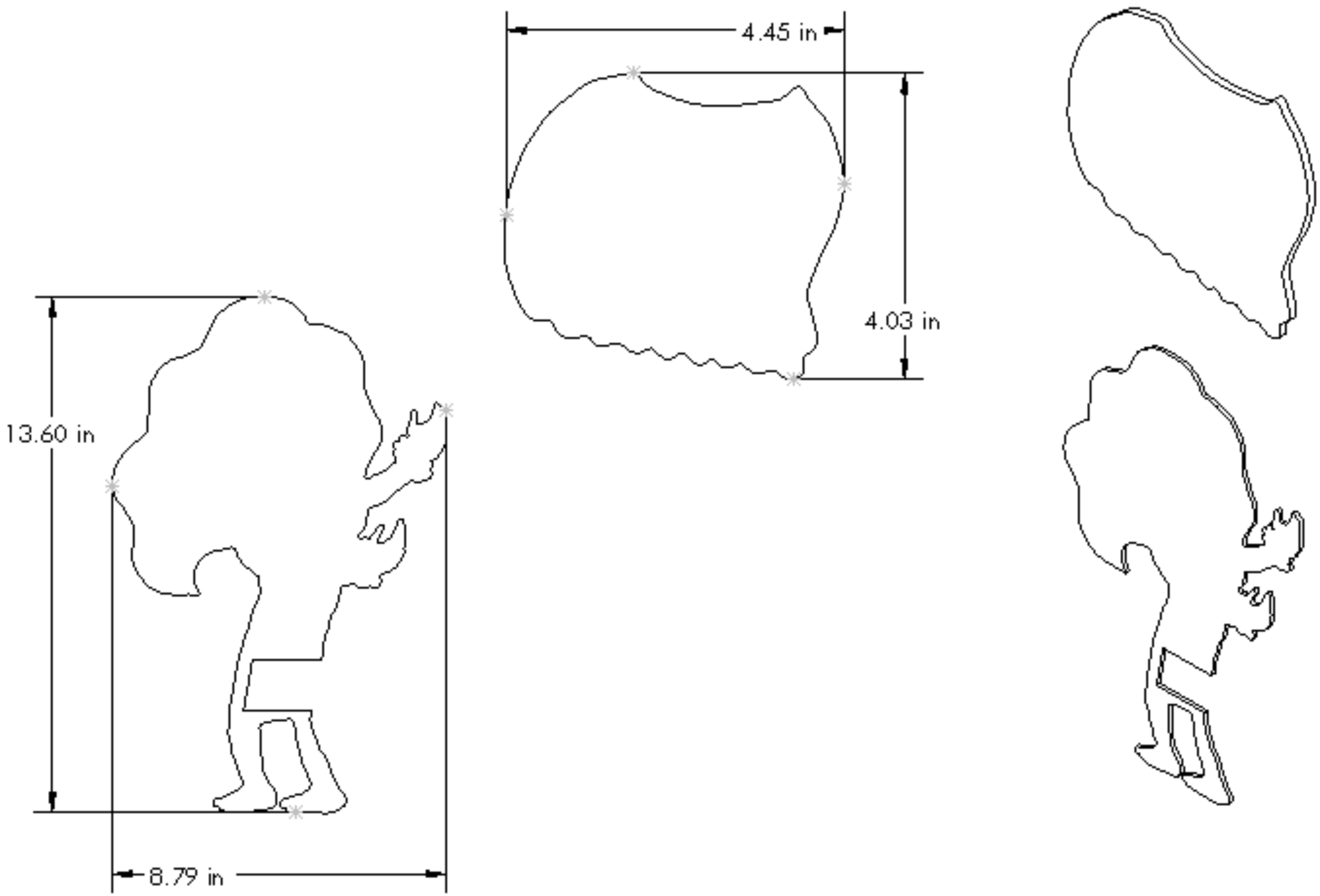
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:Fan Bead Return System	Drwn. By Sigrid Derickson:
ME429 - Spring 2019	Dwg. #:	Nxt Asb:	Date: 4/25/19 / Scale:1/4	Chkd. By: ME STAFF

Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Ball Return Plate	Drwn. By:Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: Scale:1/2	Chkd. By: ME STAFF



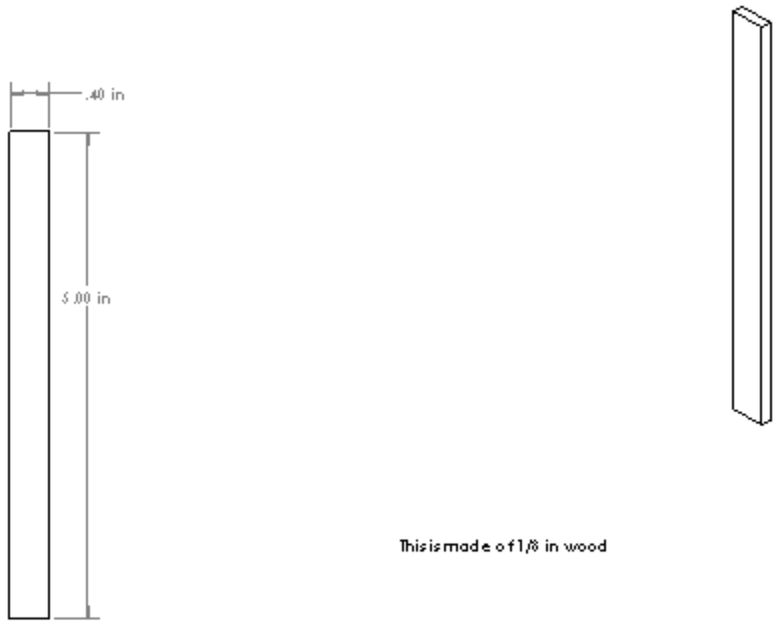
ITEM NO.	PART NUMBER	QTY.
1	Day7_HawaiianGirl(Part1)	1
2	Day7_HawaiianGirl(Part2)	1
3	Day7_HawaiianGirl(Linkage1)	1
4	Day7_HawaiianGirl(Linkage2)	1
5	Day7_HawaiianGirl(Linkage3)	1
6	Day7_HawaiianGirl(Block1)	1
7	Day7_Box_Reference	1
8	Day7_HawaiianGirl(BackDrop)	1
9	6391K126	5
10	6409K17	1
11	Day7_HawaiianGirl(MotorBackSupport)	1
12	Day7_HawaiianGirl(WoodSupport1)	1
13	Day7_HawaiianGirl(WoodSupport2)	1
14	Day7_HawaiianGirl(WoodSupport3)	1
15	91247A546	2
16	90295A155	6
17	95615A120	7
18	91247A550	1
19	91247A552	4
20	94105A190	1

Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: Hawaiian Girl Assembly	Drwn. By: Danny Clifton
	Dwg. #:	Nxt Asb:	Date: 04/27/19 Scale: 1:8	Chkd. By: ME STAFF



These cutouts are to be made of 1/8 inch thick wood

Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: Hawaiian Girl Part 1 & 2		Drwn. By: Danny Clifton
	Dwg. #:	Nxt Asb:	Date: 04/27/19	Scale: 1:4	Chkd. By: ME STAFF



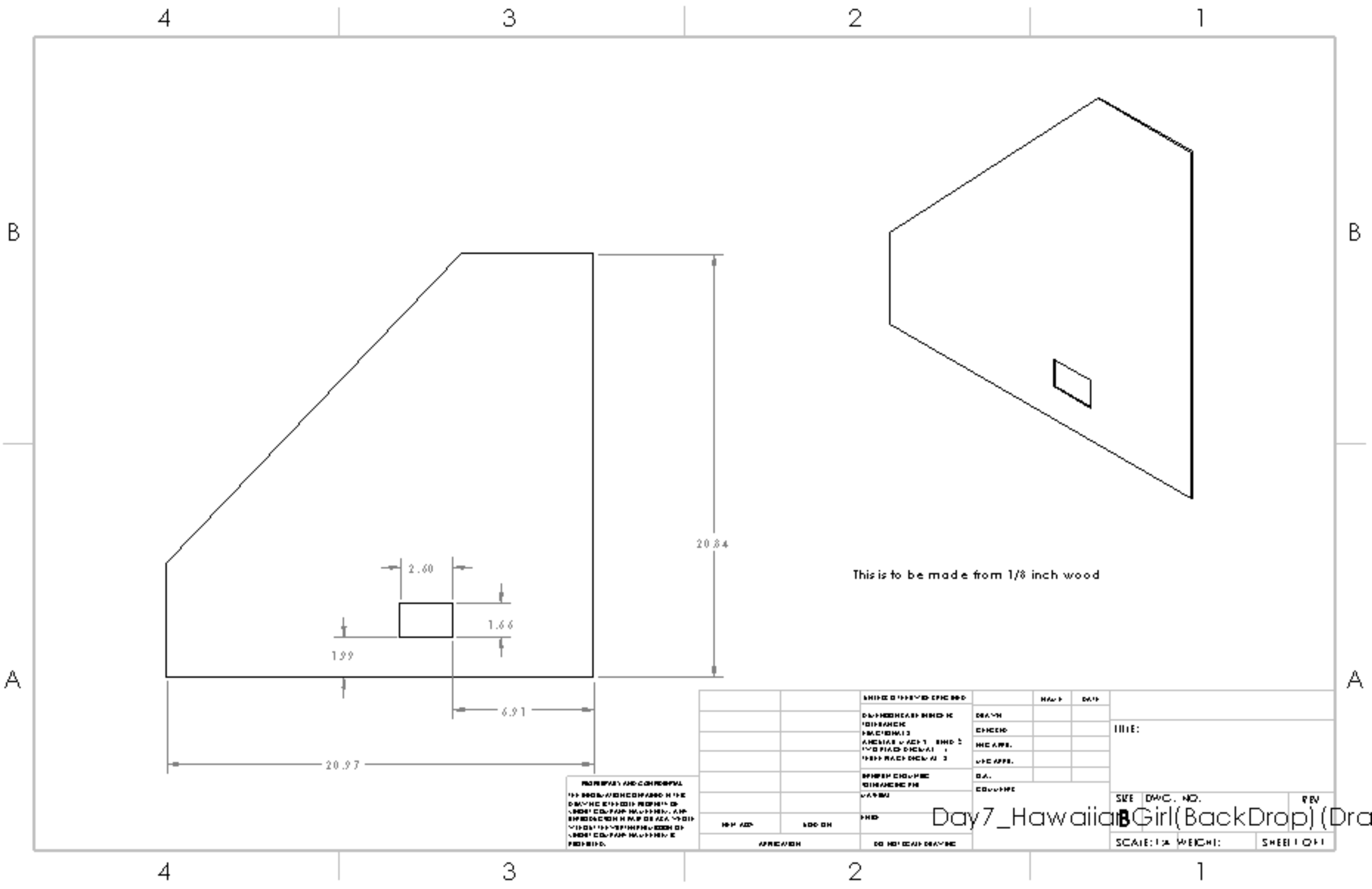
This is made of 1/8 in wood

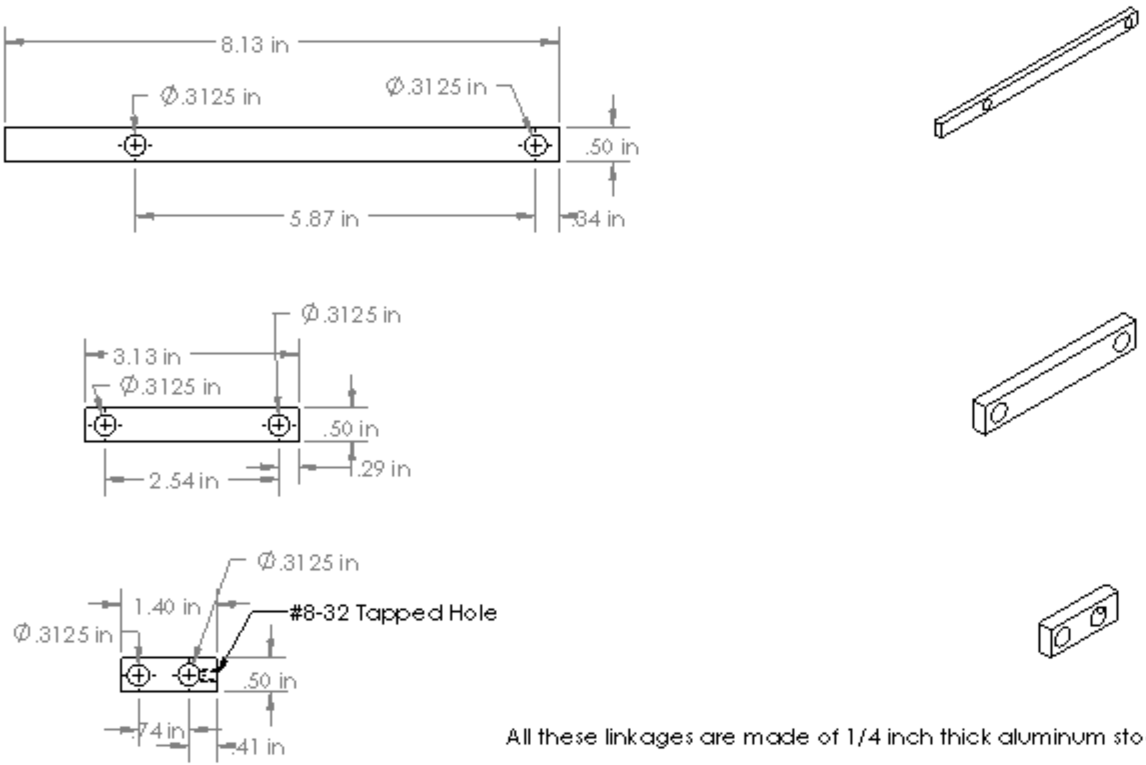
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

SIZE B DWG. NO. Day7_HawaiianGirl(Block1)(Draw REV

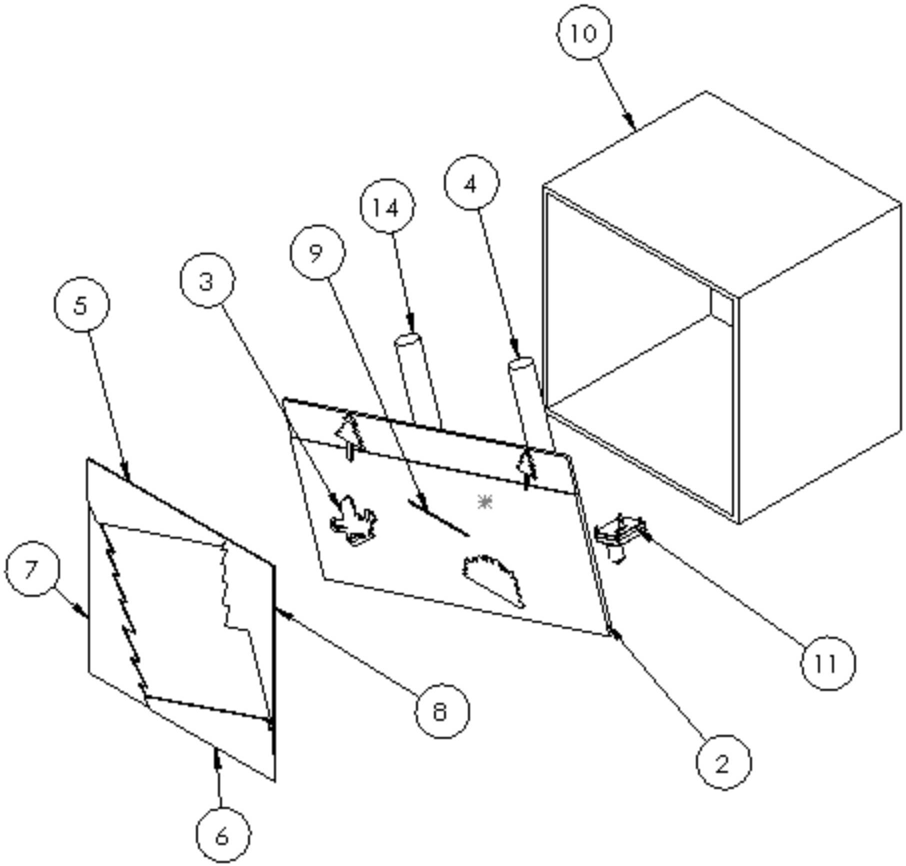
SCALE: 1:1 WEIGHT: SHEET 1 OF 1


2.60
1.66
1.99
20.84
6.91
20.97
This is to be made from 1/8 inch wood
TITLE:
SIZE
DWG. NO.
REV
B
Day7_HawaiianGirl(BackDrop)(Dra
WEIGHT:



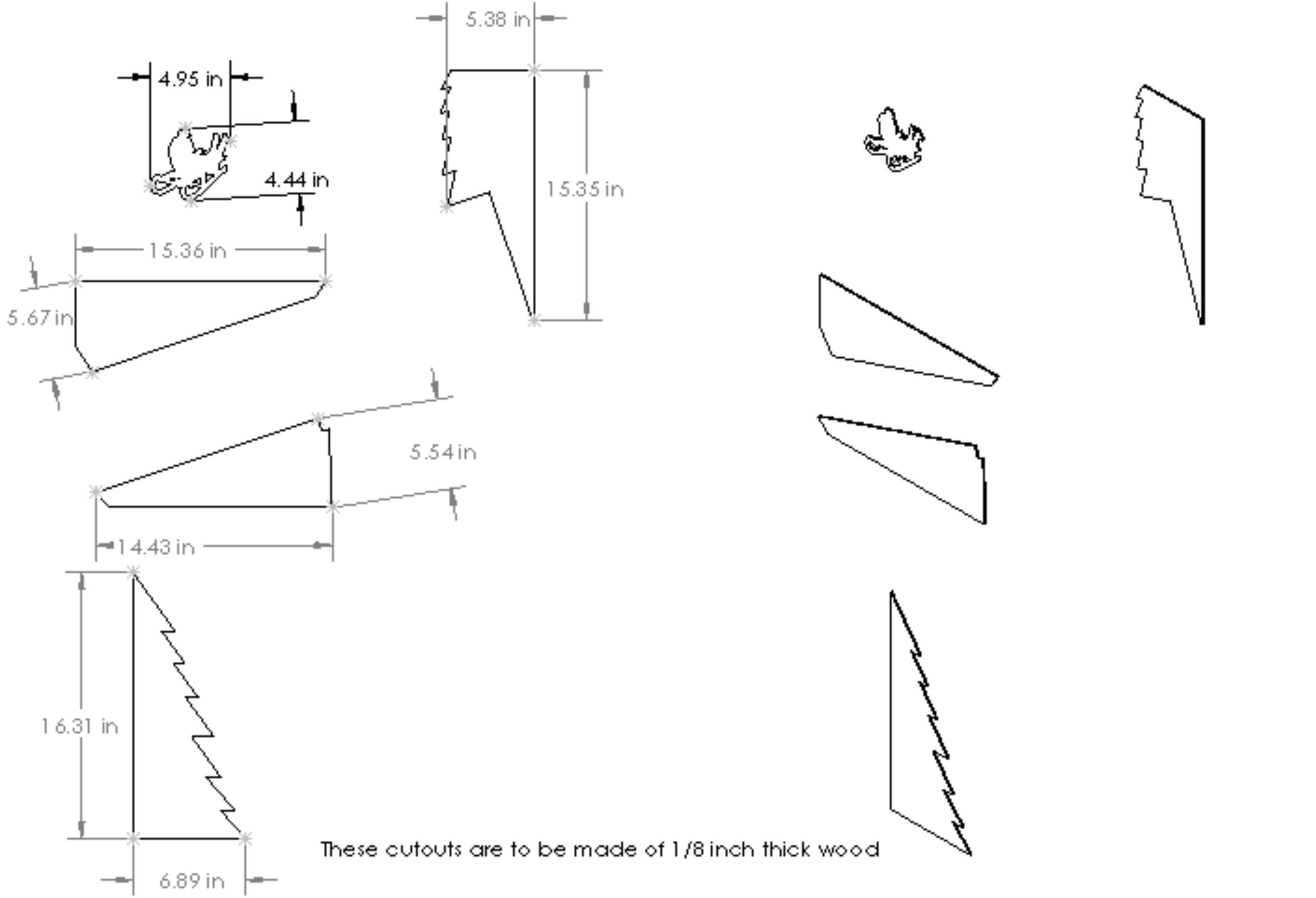
All these linkages are made of 1/4 inch thick aluminum stock

Cal Poly Mechanical Engineering	Lab Section:	Assignment#	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



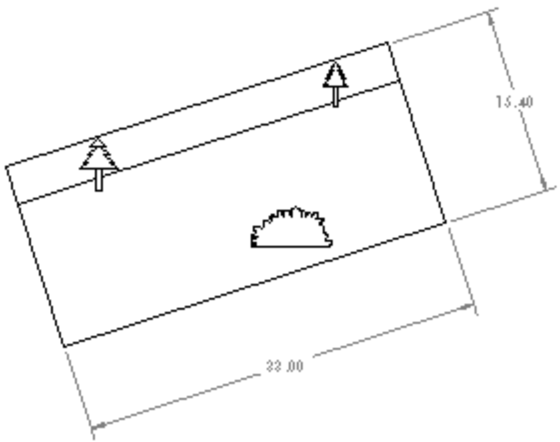
ITEM NO.	PART NUMBER	QTY.
1	Day8_Toboggan(Part1)	1
2	Day8_Toboggan(Part2)	1
3	Day8_Toboggan(Part3)	1
4	Day8_Toboggan(RotationRod1)	2
5	Day8_Toboggan(Hill1)	1
6	Day8_Toboggan(Hill2)	1
7	Day8_Toboggan(Tree1)	1
8	Day8_Toboggan(Tree2)	1
9	Day8_Toboggan(TobogganHolder)	1
10	Day2,3,6,8,10,14,15,18,24_Box_Reference	1
11	6409K17	1
12	Day8_Toboggan(MotorBackSupport)	1
13	Day8_Toboggan(RotatingRodSupport)	1
14	Day8_Toboggan(RotationRod2)	1
15	60355K505	1
16	Day8_Toboggan(FixedRod1)	1

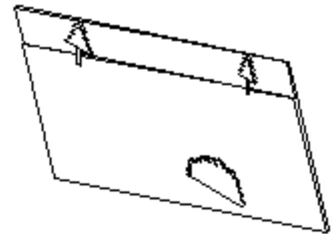
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



These cutouts are to be made of 1/8 inch thick wood

Cal Poly Mechanical Engineering	Lab Section:	Assignment#	Title: Part 3, Hill 1&2, Tree 1&2	Drwn. By: Danny Clifton
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/27/11	Scale: 1:8	Chkd. By: ME STAFF





This is going to be assembled from strips of sand paper

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

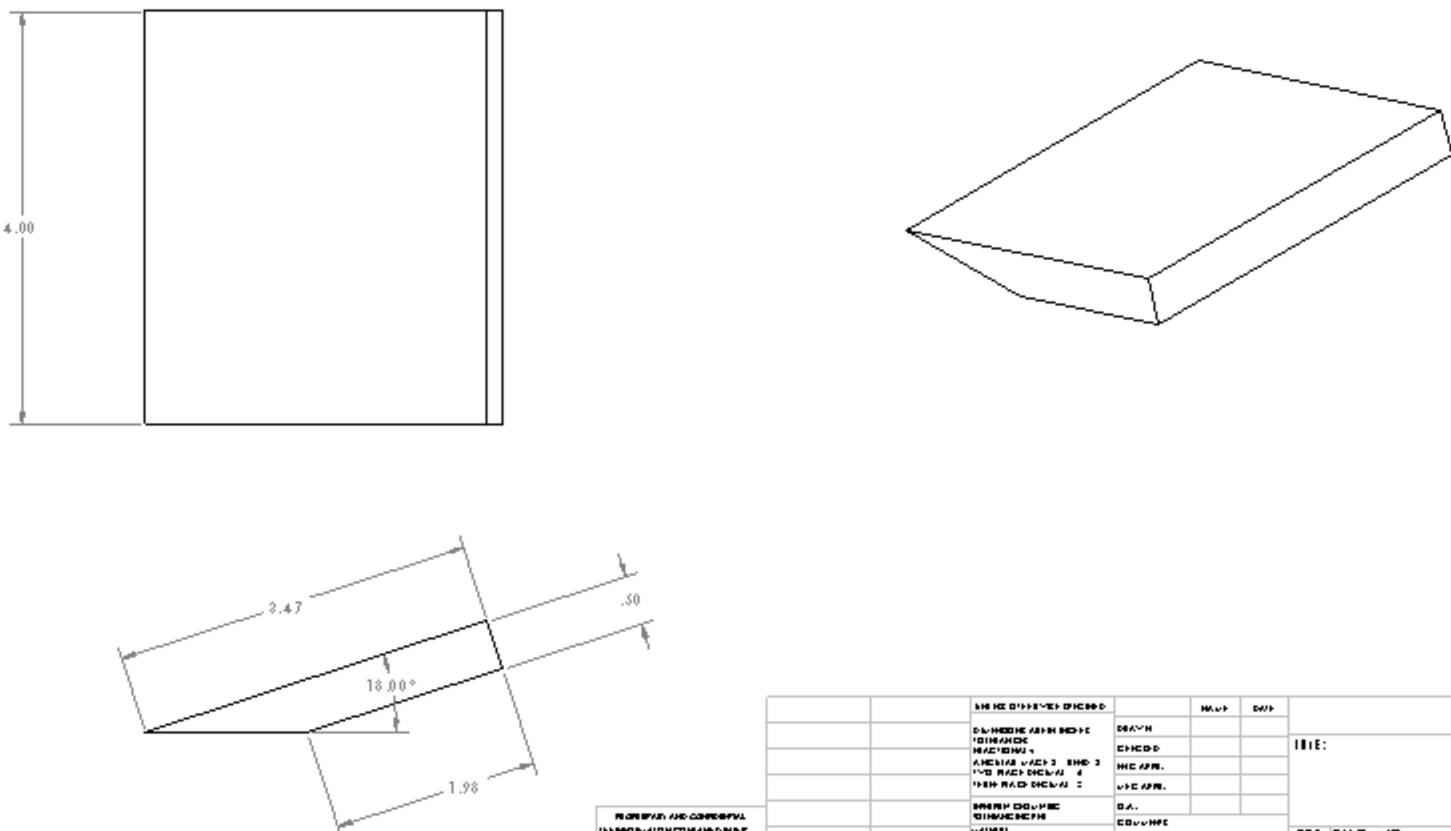
SIZE	DWG. NO.	REV
B	Day8_Toboggan(Part2) (Drawin	

SCALE: 1:8 WEIGHT: SHEET 1 OF 1

NEXT ASSY | USED ON

APPLICATION

DO NOT SCALE DRAWING



TITLE:	
SIZE	B
DWG. NO.	Day8_Toboggan(RotatingRodSupport)
REV	
SCALE: 1:1	
WEIGHT:	
SHEET 1 OF 1	

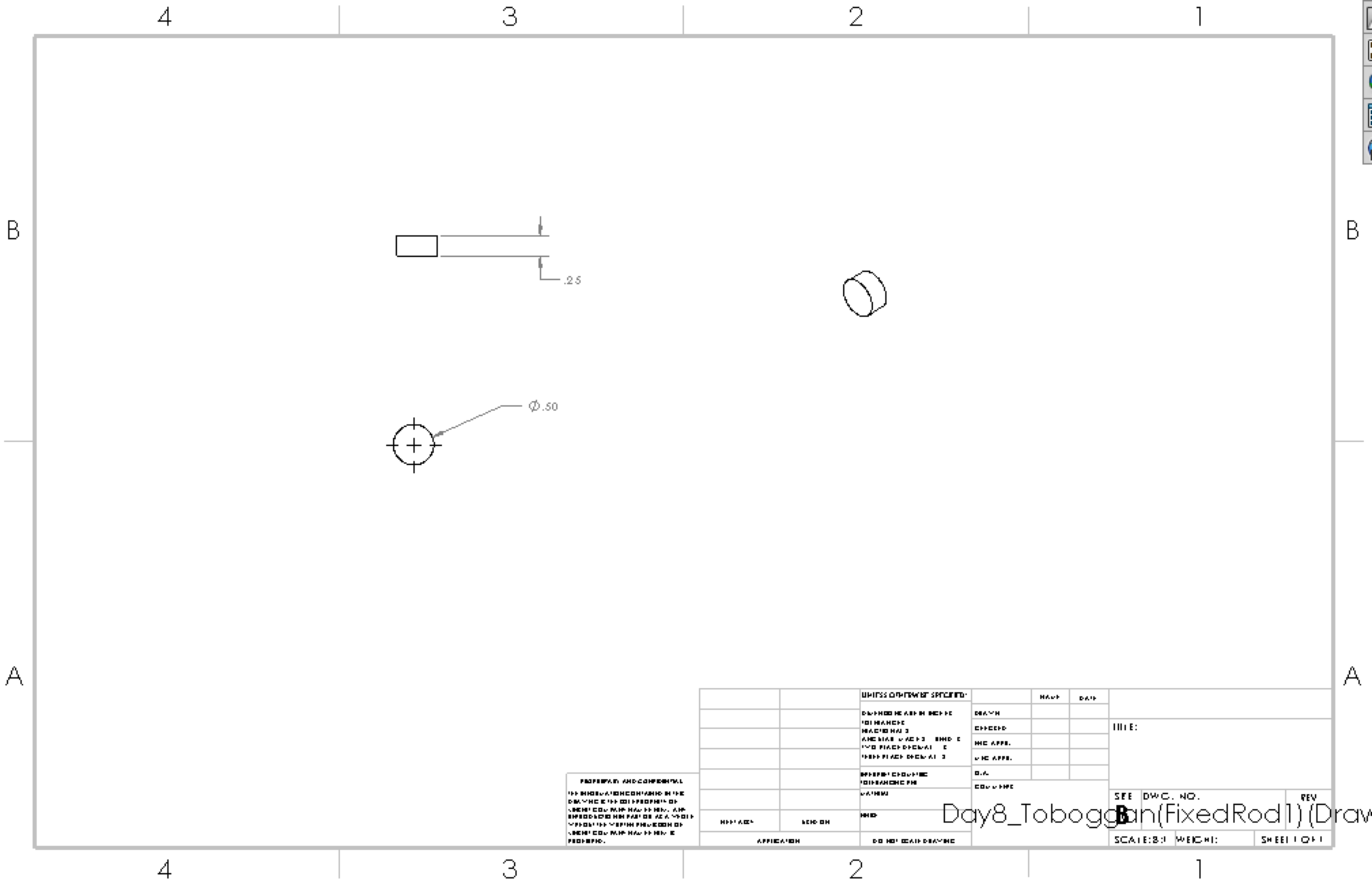
	NAME	DATE
DRAWN		
CHECKED		

NEXT ASSY | USED ON

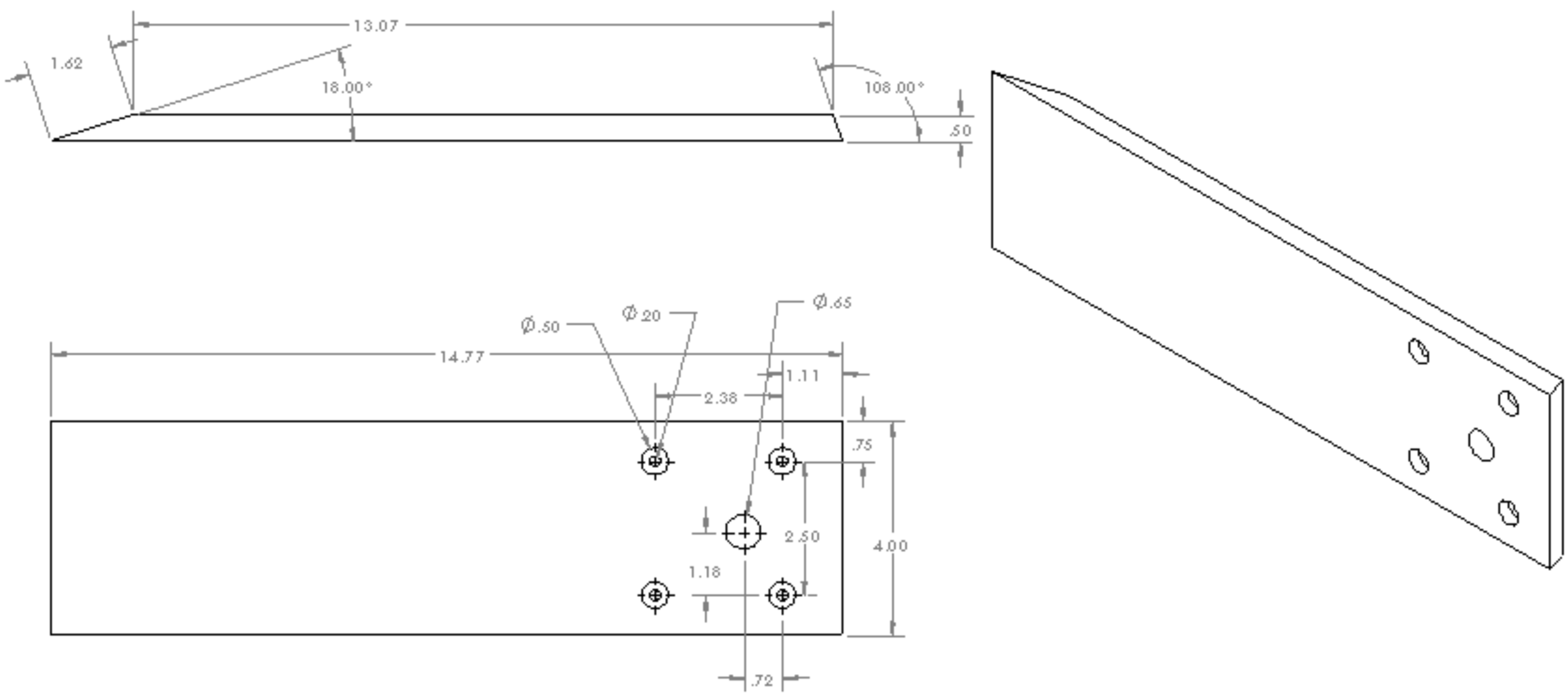
APPLICATION

DO NOT SCALE DRAWING

PROPRIETARY AND CONFIDENTIAL



.25
Ø.50
NAME
DATE
DRAWN
CHECKED
TITLE:
SIZE
B
DWG. NO.
REV
Day8_Toboggan(FixedRod1) (Draw
SCALE:8:1
WEIGHT:
SHEET 1 OF 1



UNLESS OTHERWISE SPECIFIED:

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

PROPRIETARY AND CONFIDENTIAL

NEXT ASSY | USED ON

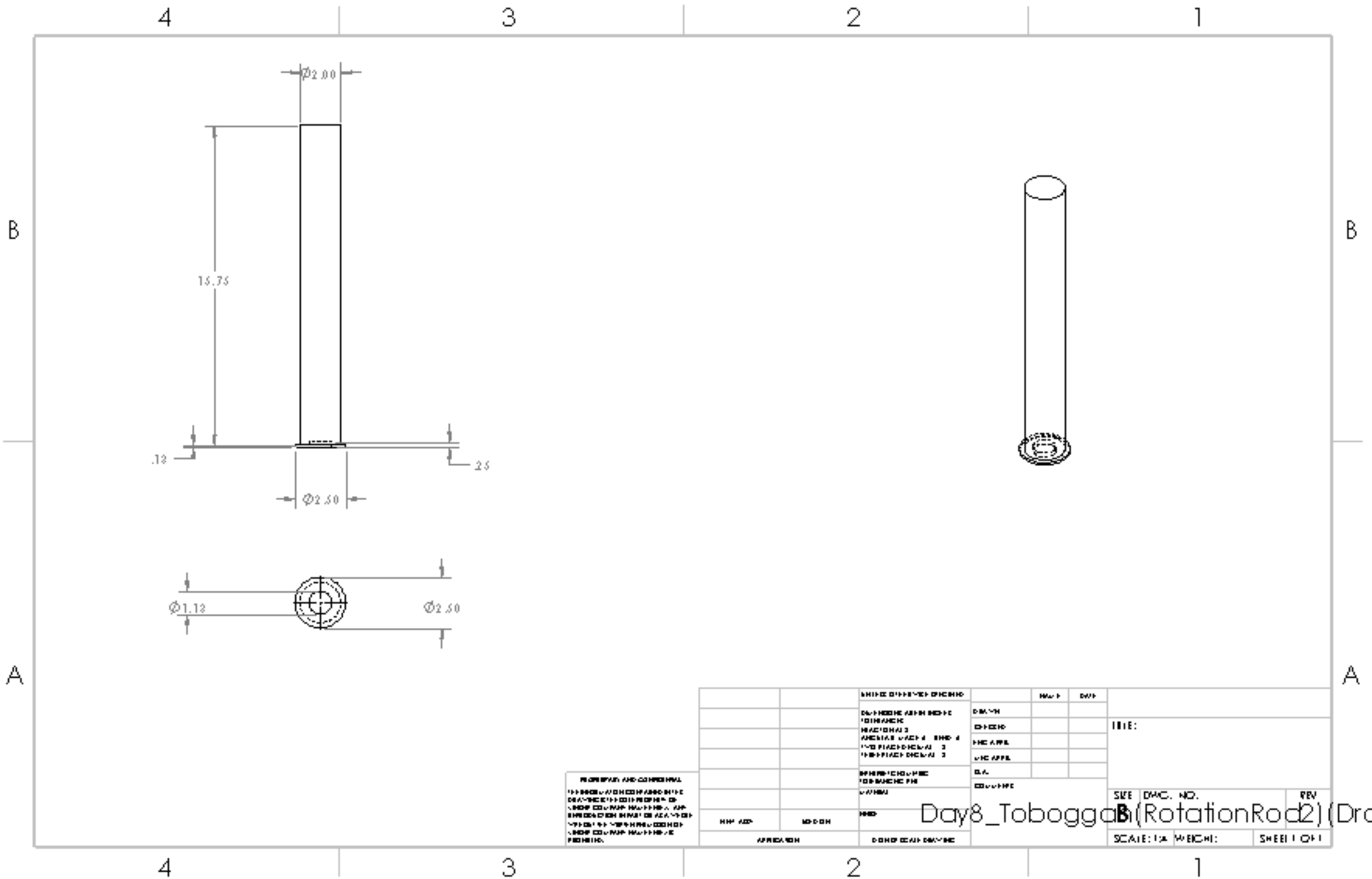
APPLICATION

DO NOT SCALE DRAWING

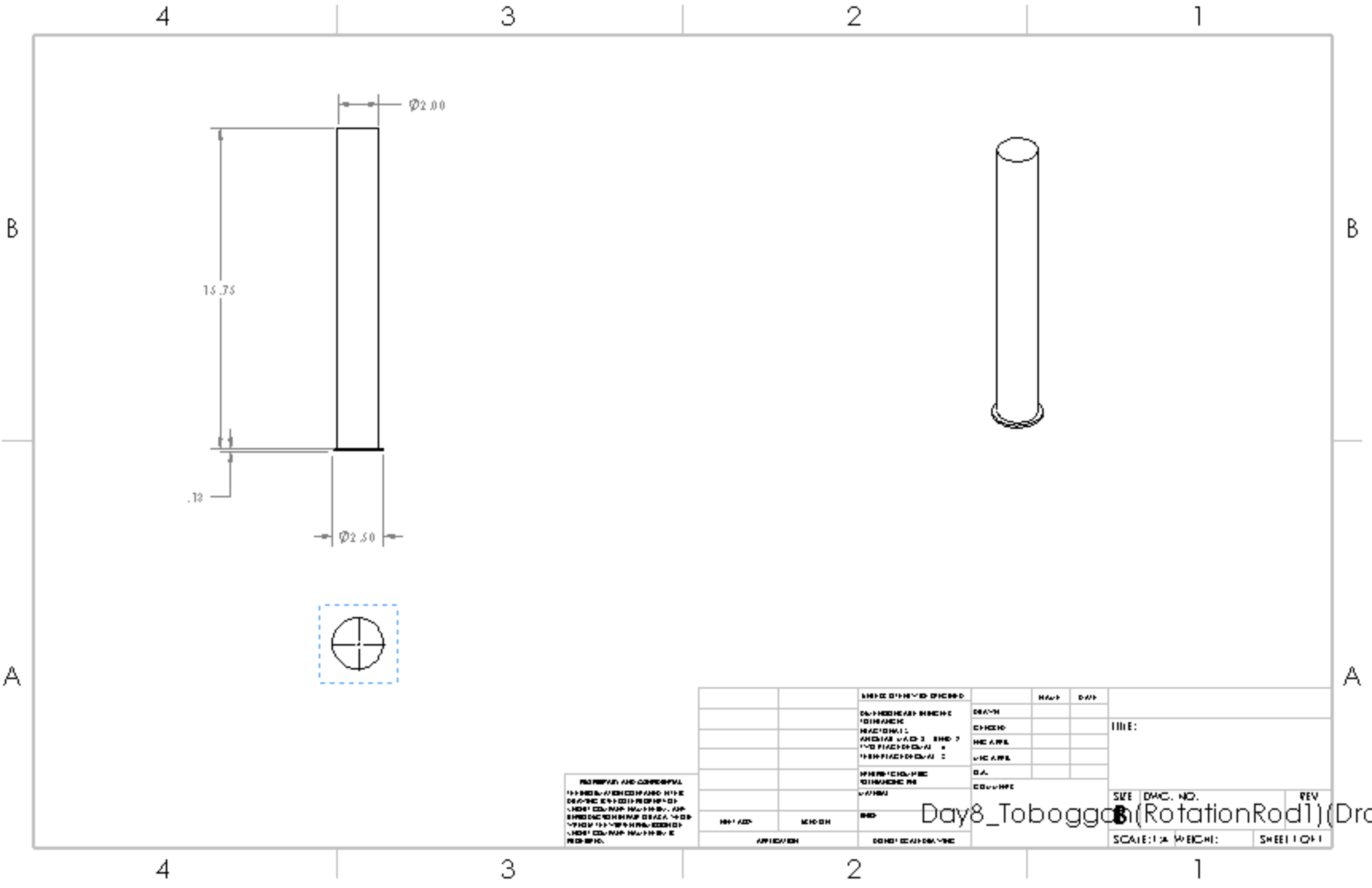
TITLE:

SIZE B | DWG. NO. Day8_Toboggan(MotorBackSupport) | REV

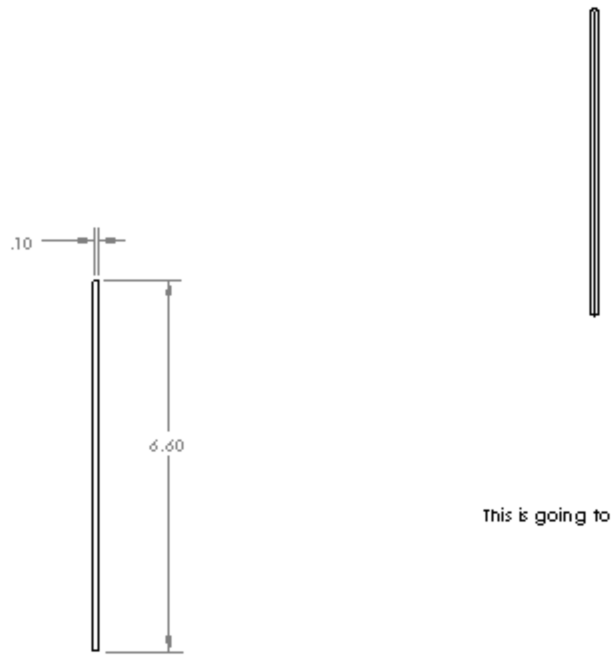
SCALE: 1:2 | WEIGHT: | SHEET 1 OF 1



4
3
2
1
B
A
Ø2.00
15.75
.13
.25
Ø2.50
Ø1.13
Ø2.50
TITLE:
SIZE
DWG. NO.
REV
B
Day8_Toboggan(RotationRod2)(Dra
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1



Ø2.00
15.75
.13
Ø2.50
NAME
DATE
DRAWN
TITLE:
SIZE
DWG. NO.
REV
B
Day8_Toboggan(RotationRod1)(Dra
SCALE: 1:4
WEIGHT:
SHEET 1 OF 1

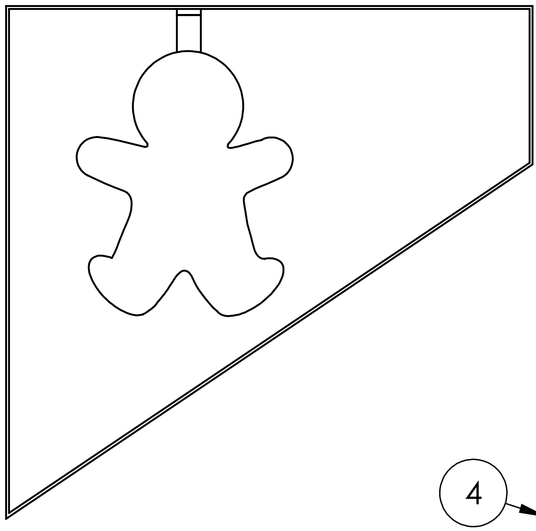


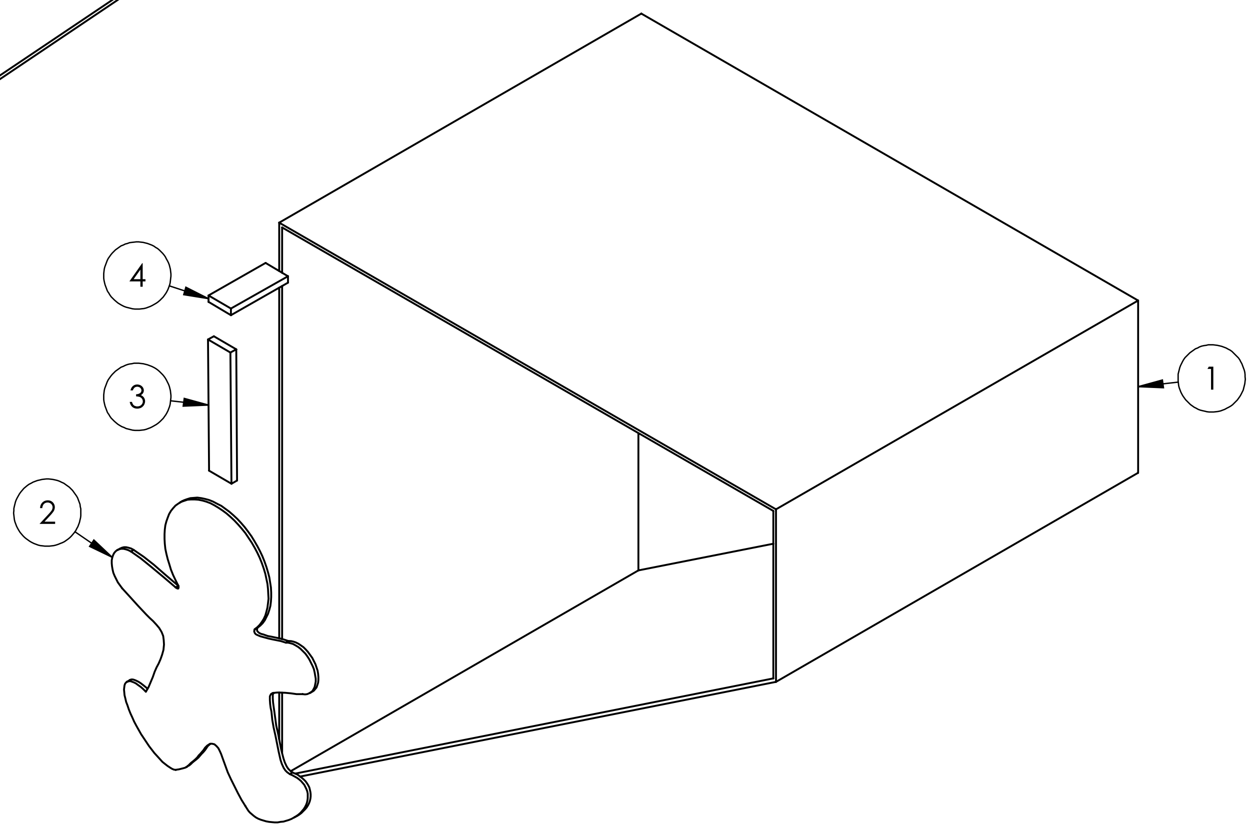
This is going to be an acrylic rod

TITLE:			
SIZE	DWG. NO.		REV
B	Day8_Toboggan(TobogganHolder)(D		
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1	

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Case	1/2" Wood	1
2	gingerbread person	1/8"Wood	1
3	Mount 1	1/8" Wood	1
4	Mount 2	1/8" Wood	1

Front View

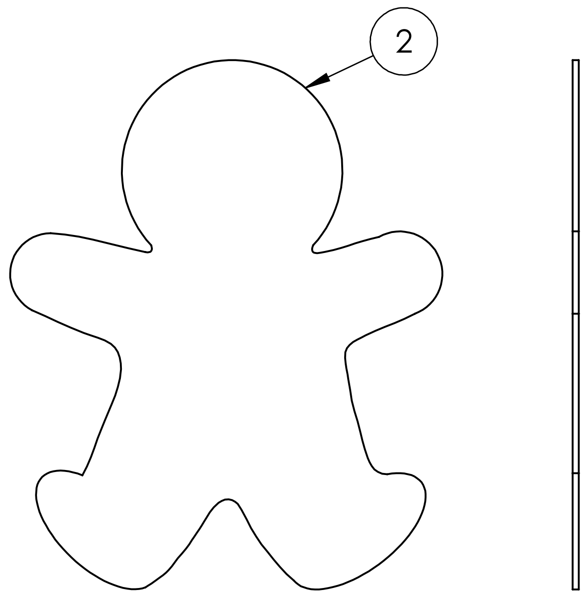


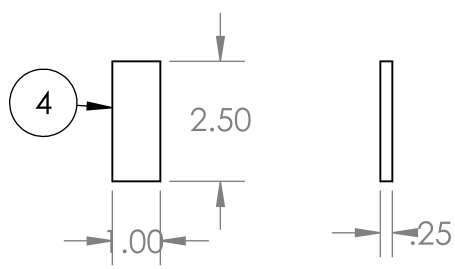


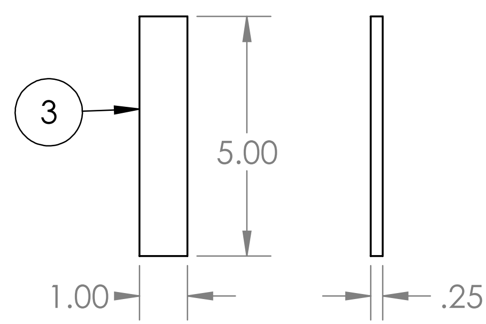
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Gingerbread Person	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date:4/28/19 Scale: 1:6	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
2	Gingerbread person	1/8" Wood	1
3	Mount 1	1/8" Wood	1
4	Mount 2	1/4" Wood	1

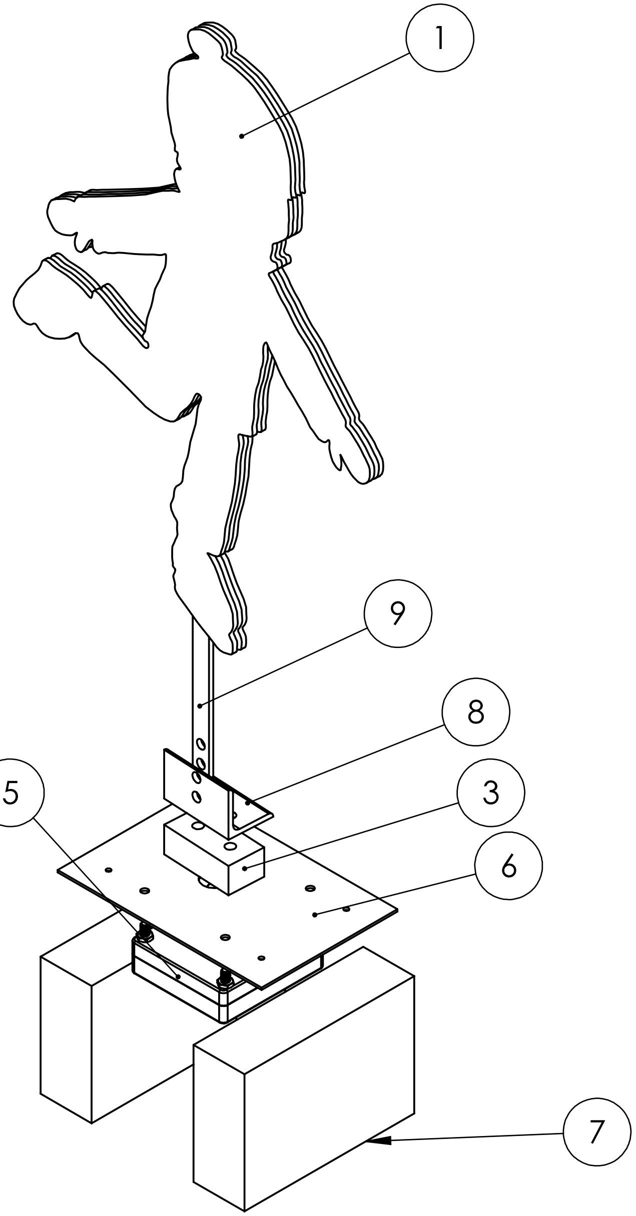
NOTE:
Laser cut item 2





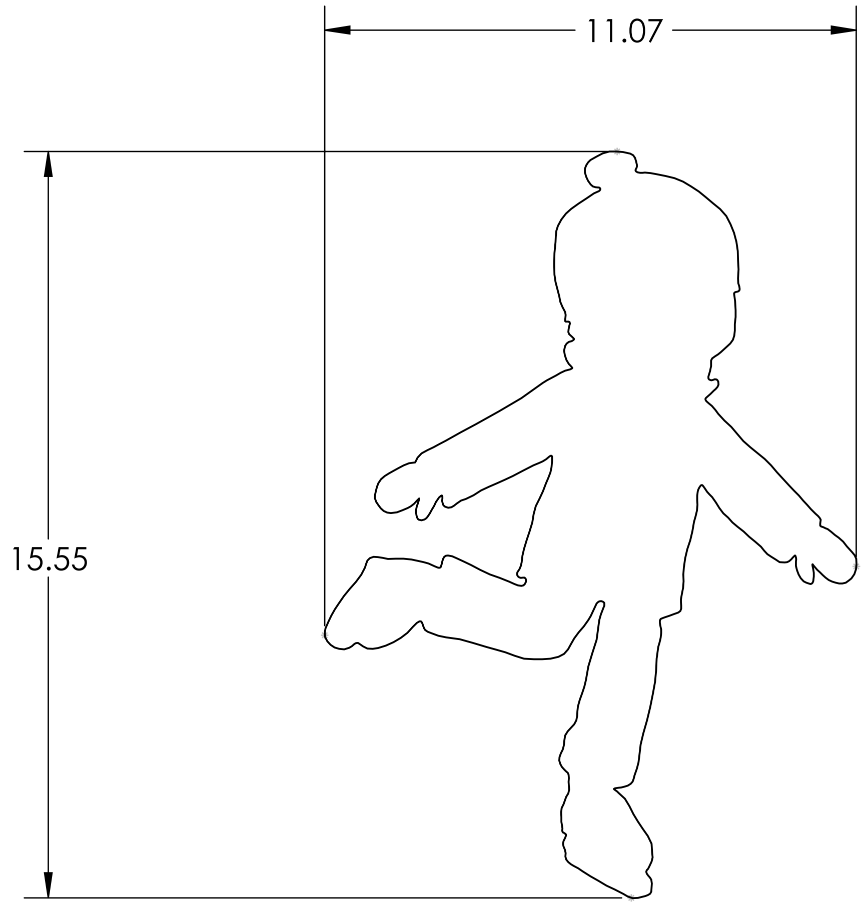


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Gingerbead Person & Support	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: / Scale: 1/4	Chkd. By: ME STAFF

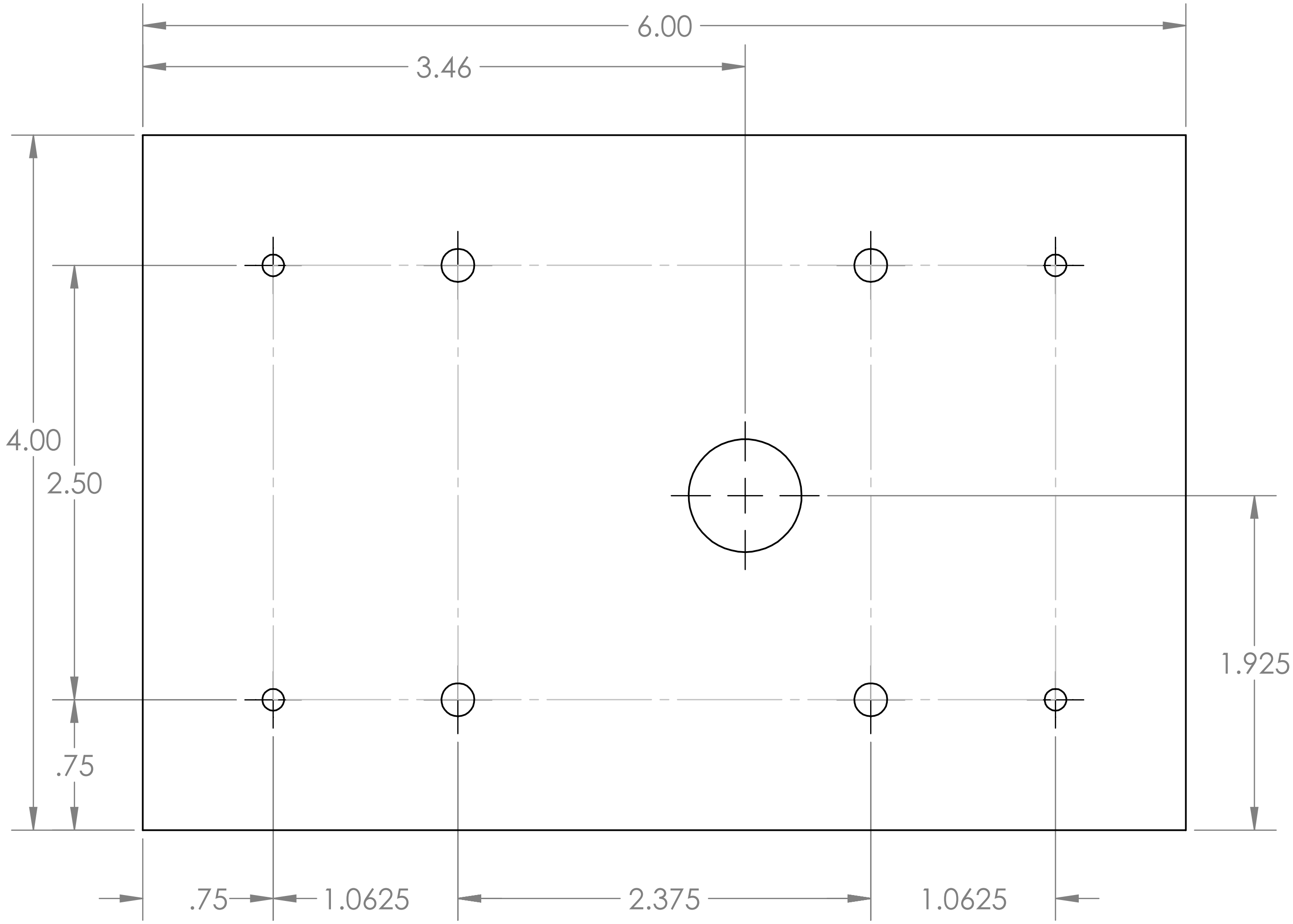


ITEM NO.	PART NUMBER	QTY.
1	Boy	2
3	Mounting Bar	1
4	Day2,3,6,8,10,14,15,18 ,24_Box_Reference	1
5	6409K16	1
6	Metal Sheet	1
7	Wood Mount	2
8	Skater Connecting Plate	1
9	Skater Foot Support	1

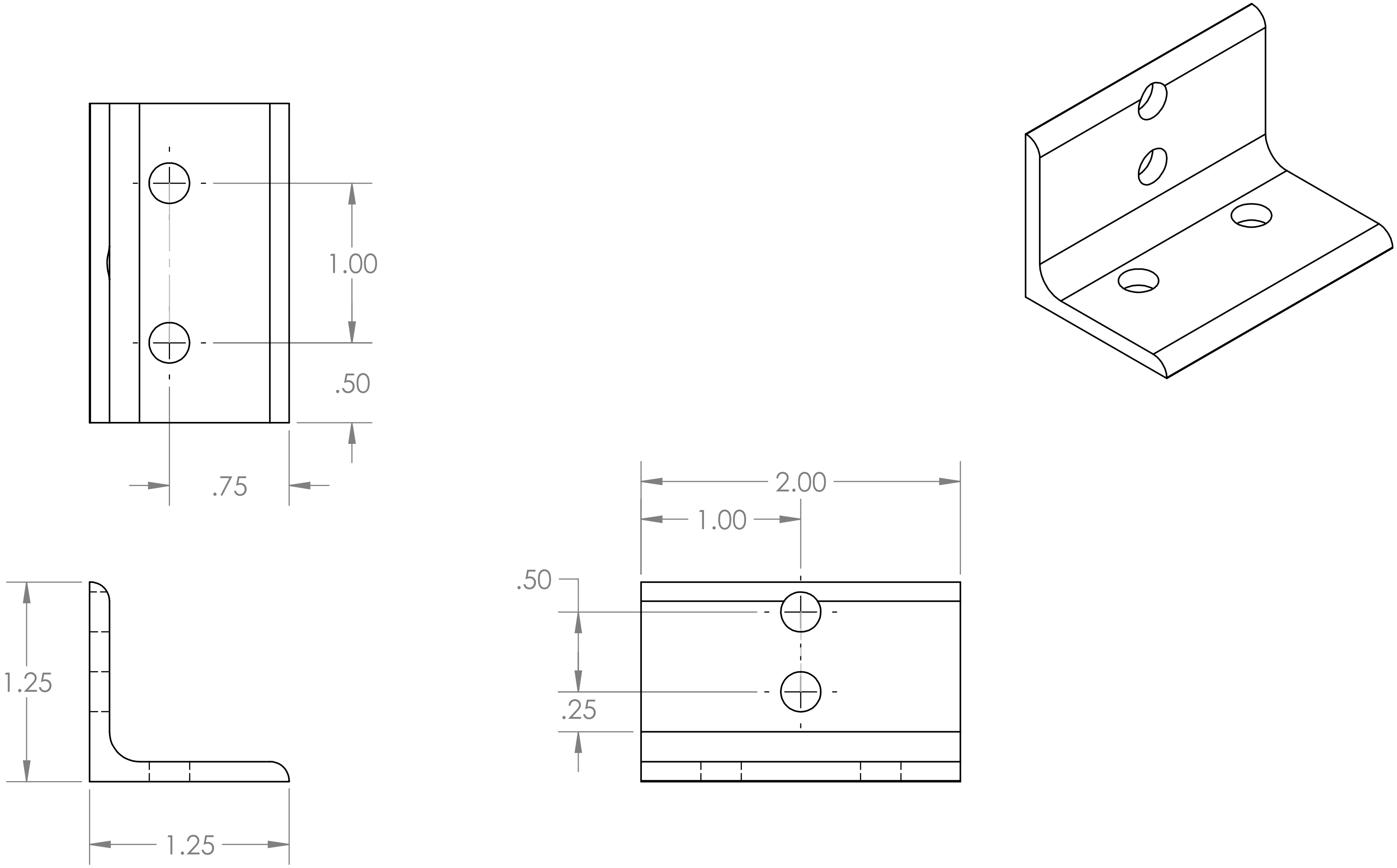
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: Scale:	Chkd. By: ME STAFF



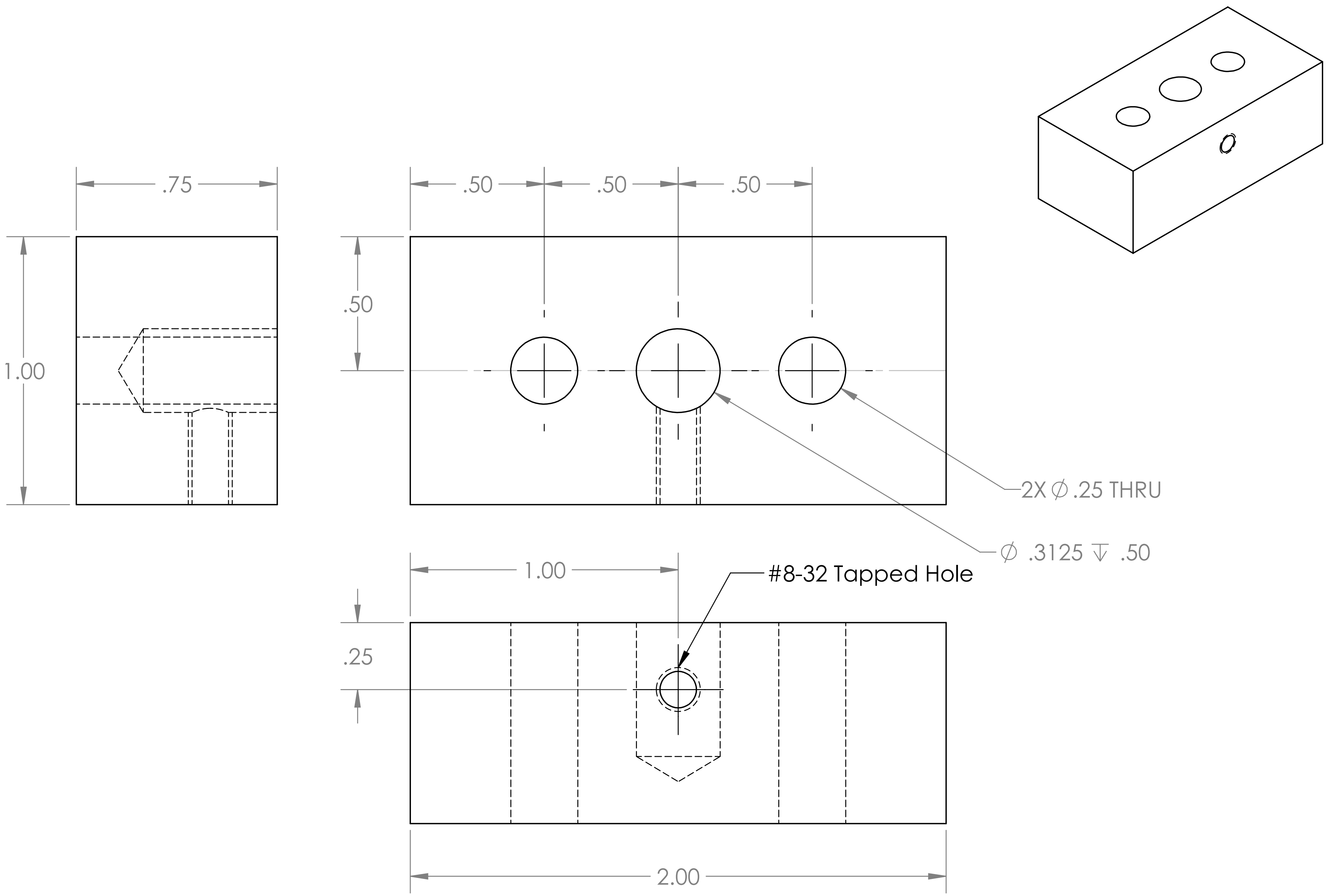
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By: Tyler Koski
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale: 1:4	Chkd. By: ME STAFF



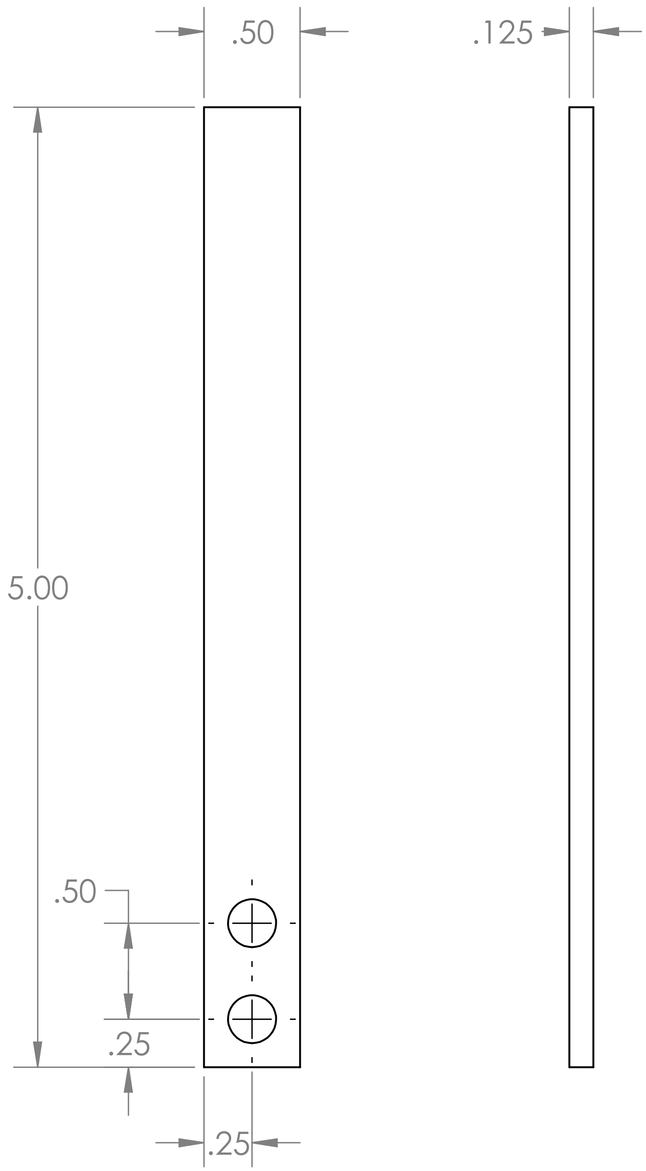
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



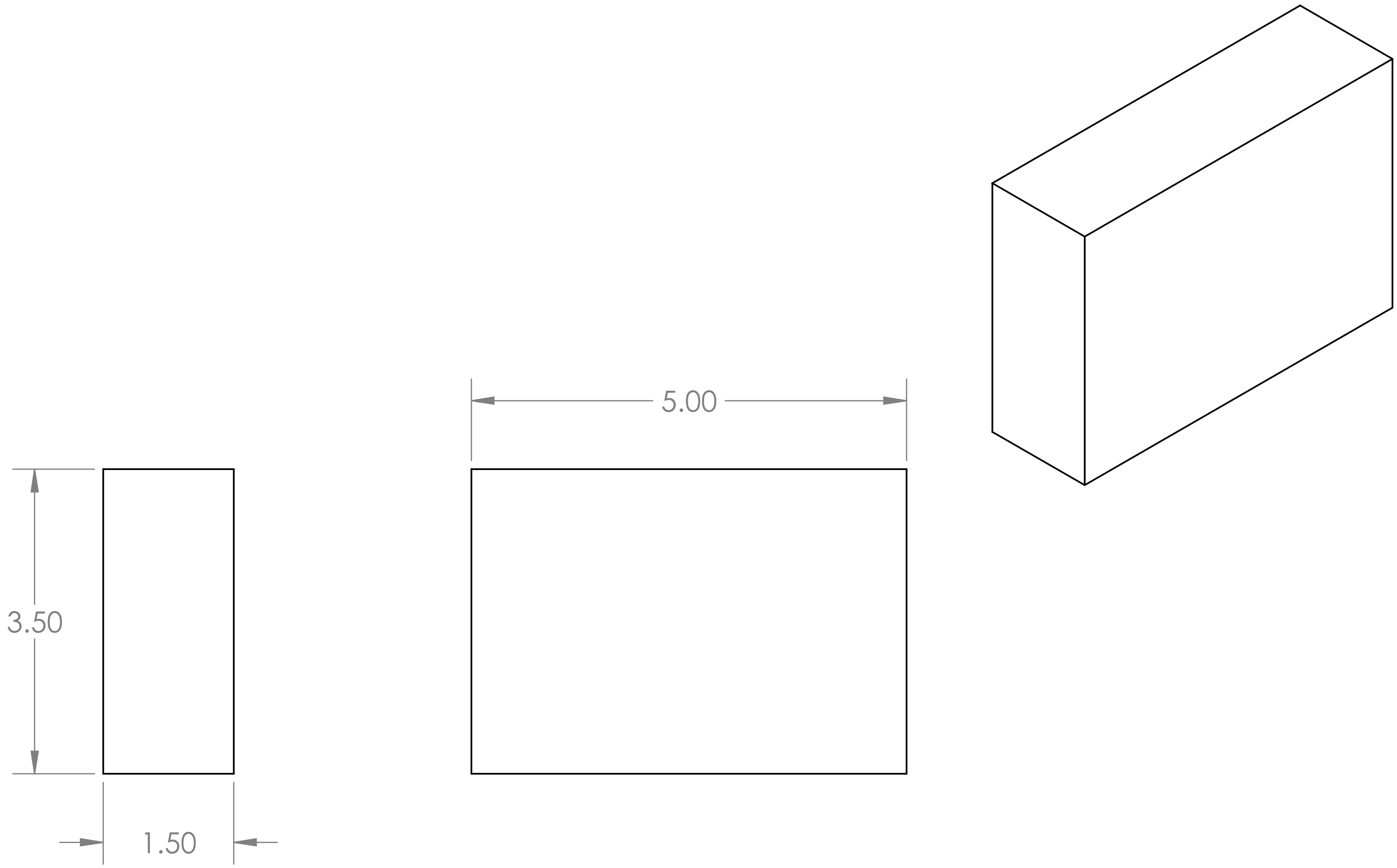
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



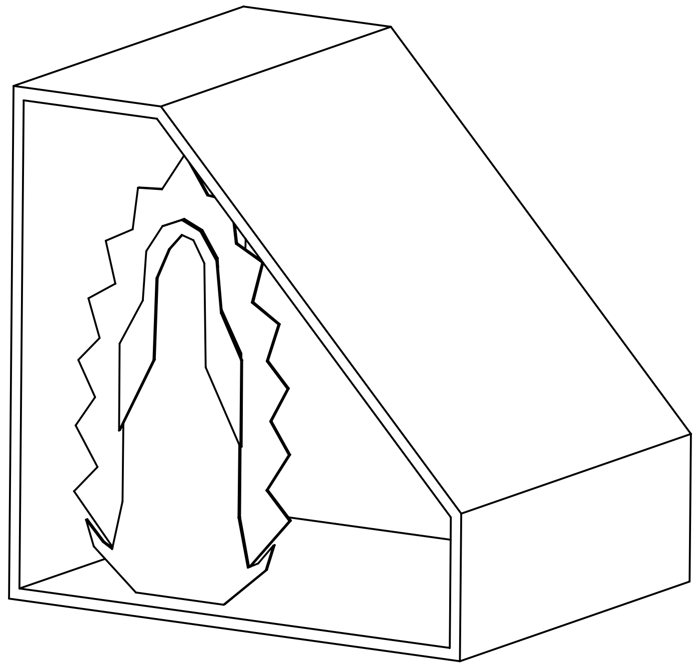
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: Scale:	Chkd. By: ME STAFF

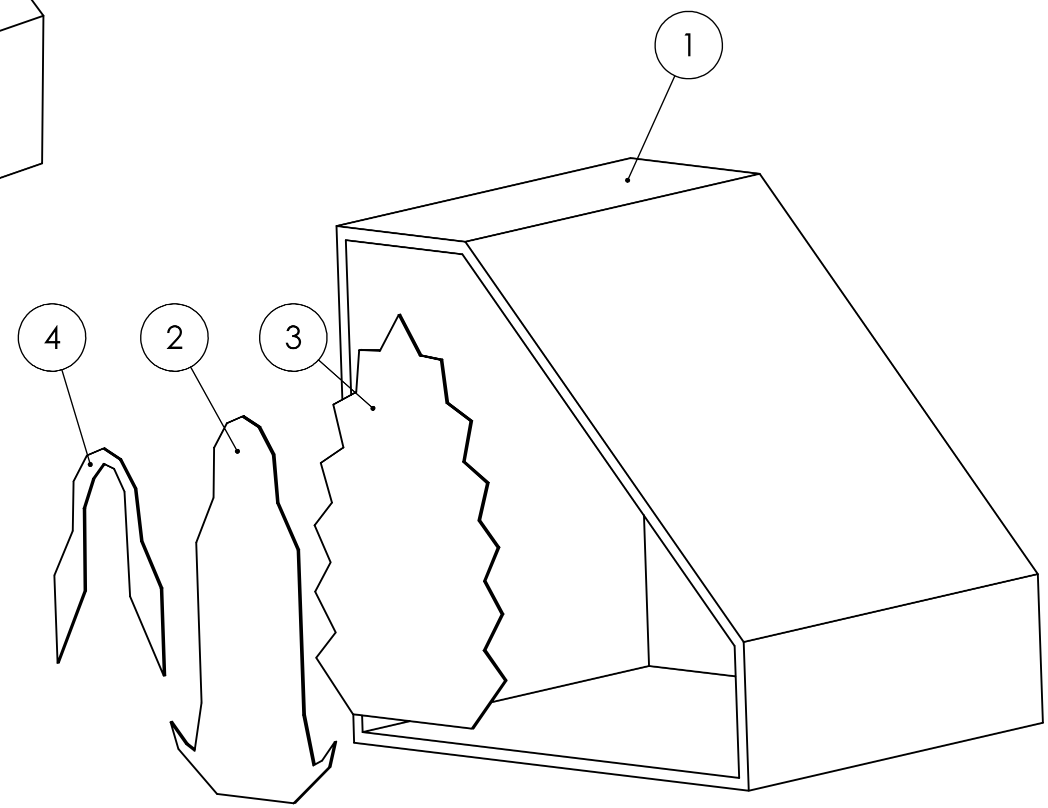


Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

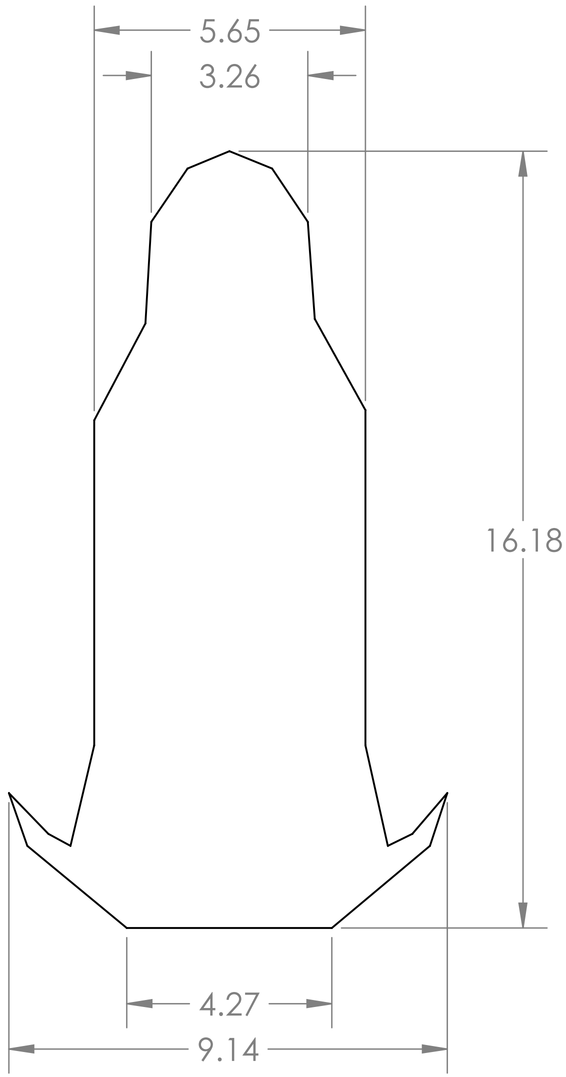


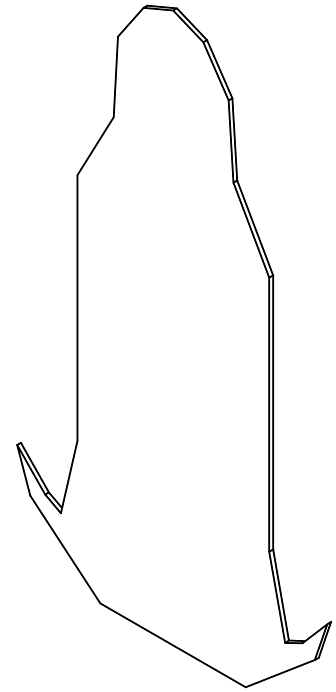


ITEM NO.	PART NUMBER	QTY.
1	Day12_Box_Reference	1
2	LadyGuadalupePart1_Body(Day12)	1
3	LadyGuadalupePart2_Background(Day12)	1
4	LadyGuadalupePart3_Hood(Day12)	1

Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: LADY GUADALUPE ASSEMBLY	Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/25/19 · Scale: 1:8	Chkd. By: ME STAFF

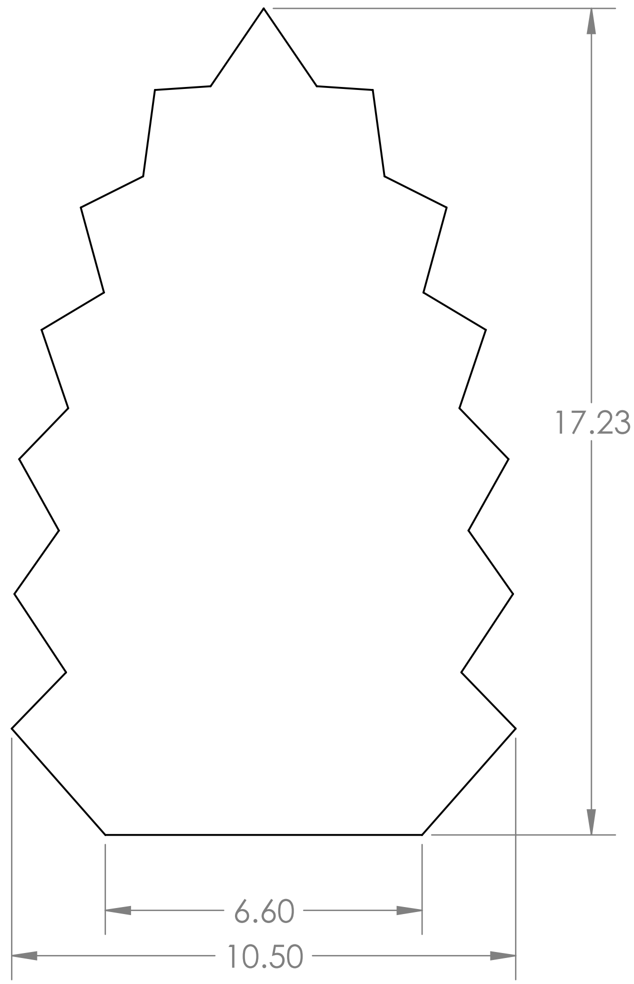
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

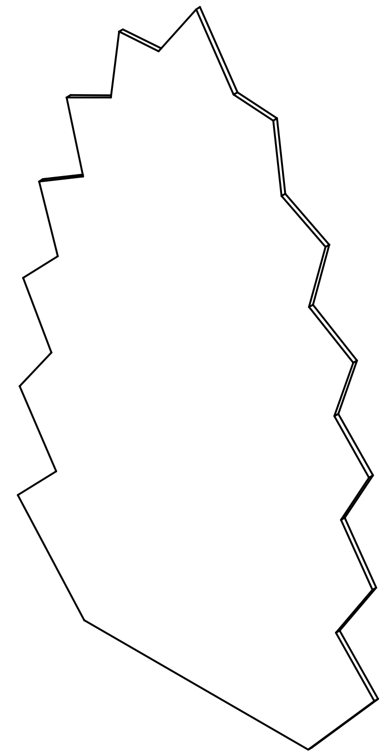




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:LADY GUADALUPE BODY	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 / Scale: 1:4	Chkd. By: ME STAFF

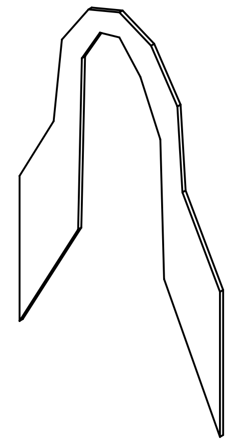
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

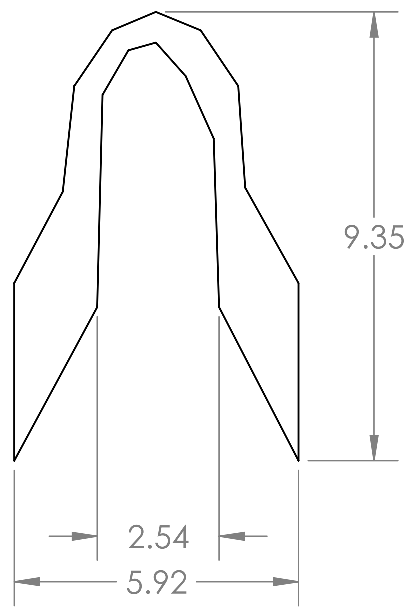




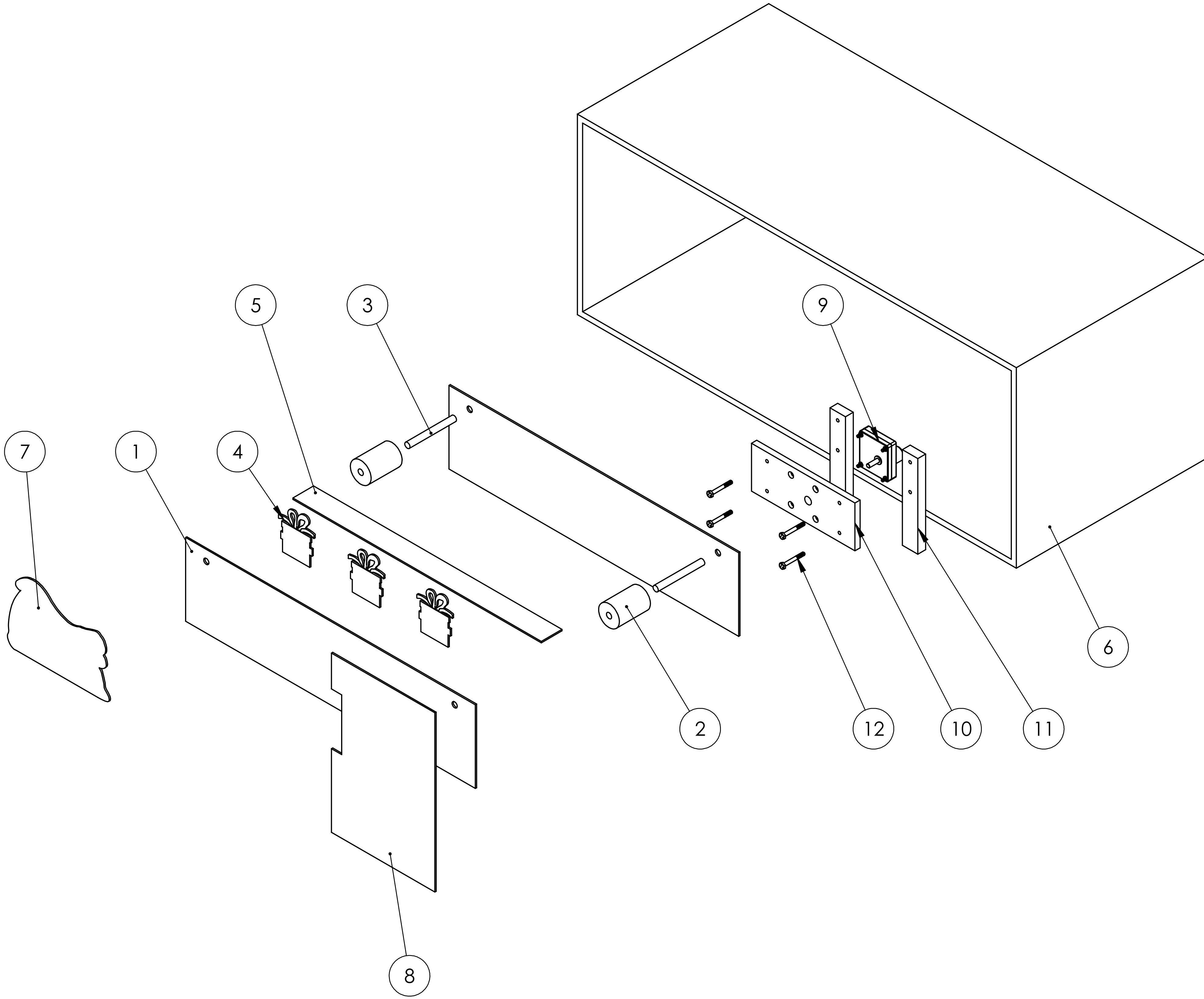
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: LADY G. BACKGROUND	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 / Scale: 1:4	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED





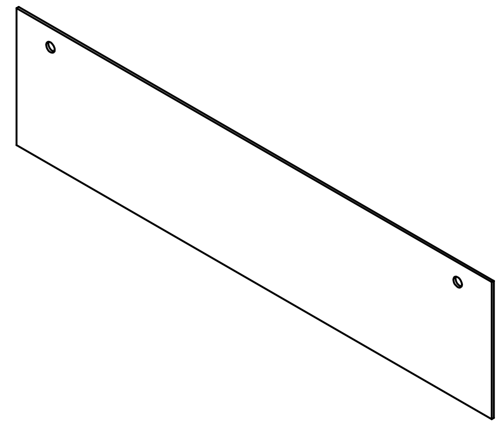
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:LADY GUADALUPE HOOD		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19	Scale: 1:4	Chkd. By: ME STAFF

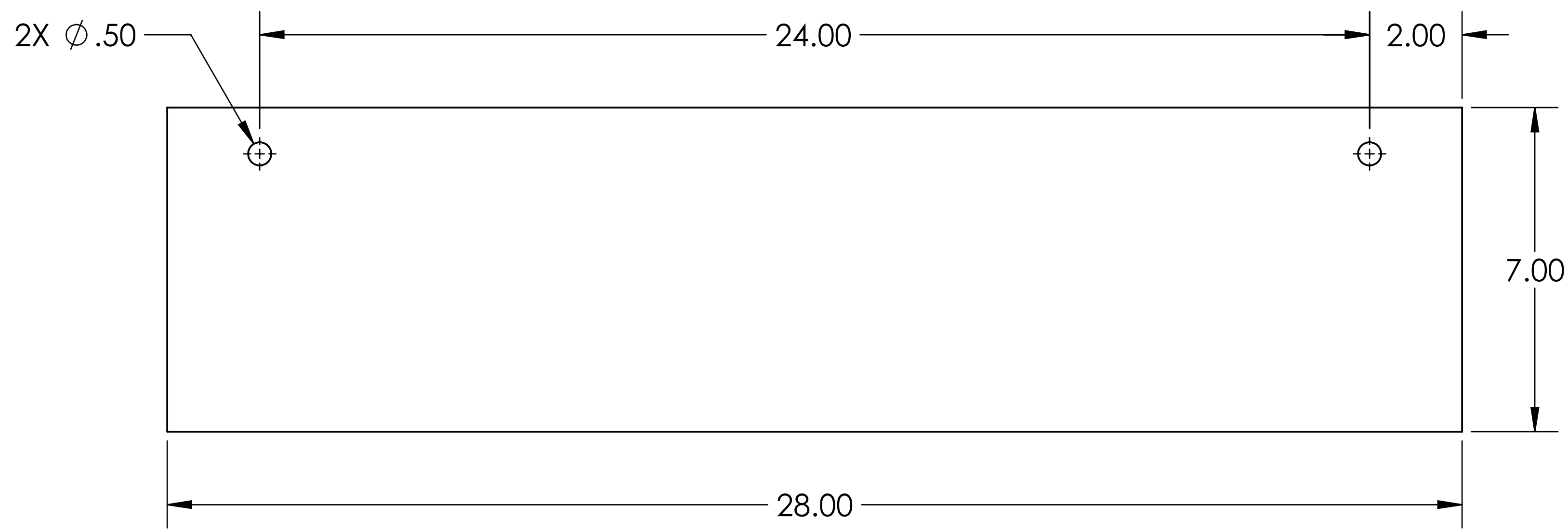


ITEM NO.	PART NUMBER	QTY.
1	AssemblyLinePart1_Walls(Day13)	2
2	AssemblyLinePart3_Roller(Day13)	2
3	AssemblyLinePart4_Axle(Day13)	2
4	AssemblyLinePart2_Present(Day13)	3
5	AssemblyLinePart5_Belt(Day13)	1
6	Day13_Box_Reference	1
7	AssemblyLinePart6_Sack(Day13)	1
8	AssemblyLinePart7_Machine(Day13)	1
9	6409K17	1
10	AssyLineMotorBackSupport	1
11	AssemblyLinePart8_MotorLegSupport(Day13)	2
12	91247A550	4

Cal Poly Mechanical Engineering ME ### - QTR YEAR	Lab Section:	Assignment #	Title: ASSEMBLY LINE ASSY	Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/29/19 — Scale: 1:8	Chkd. By: ME STAFF

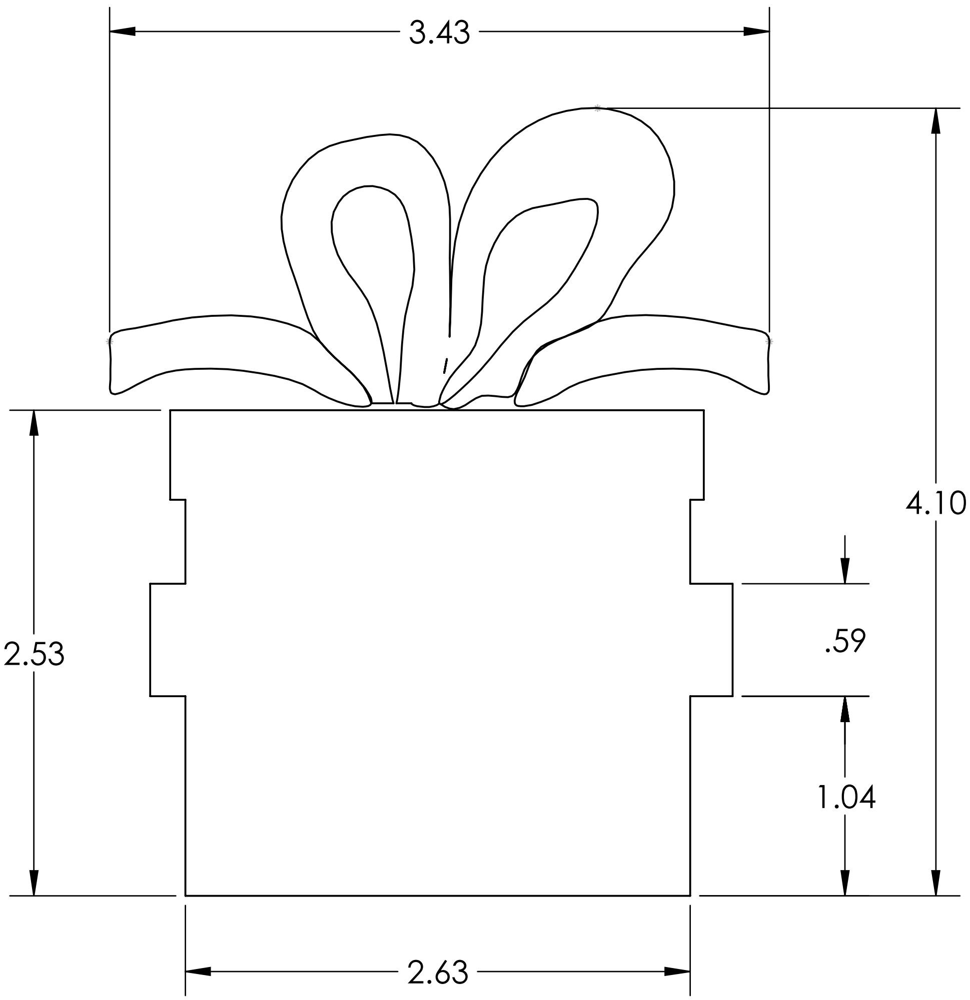
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

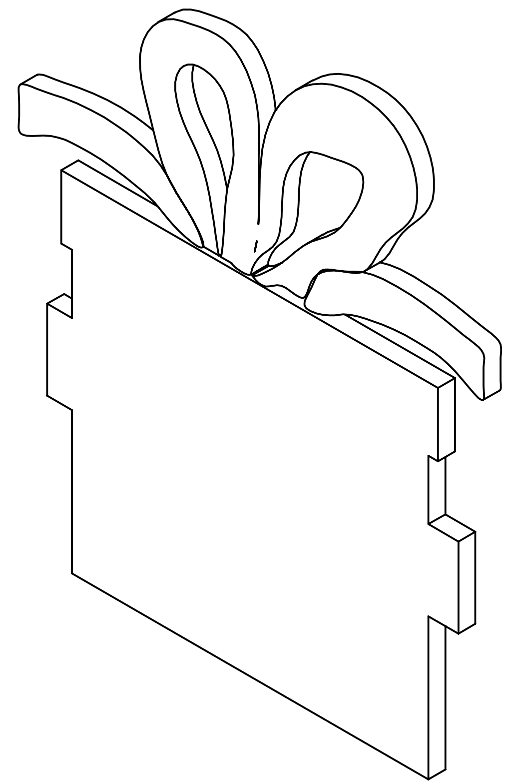




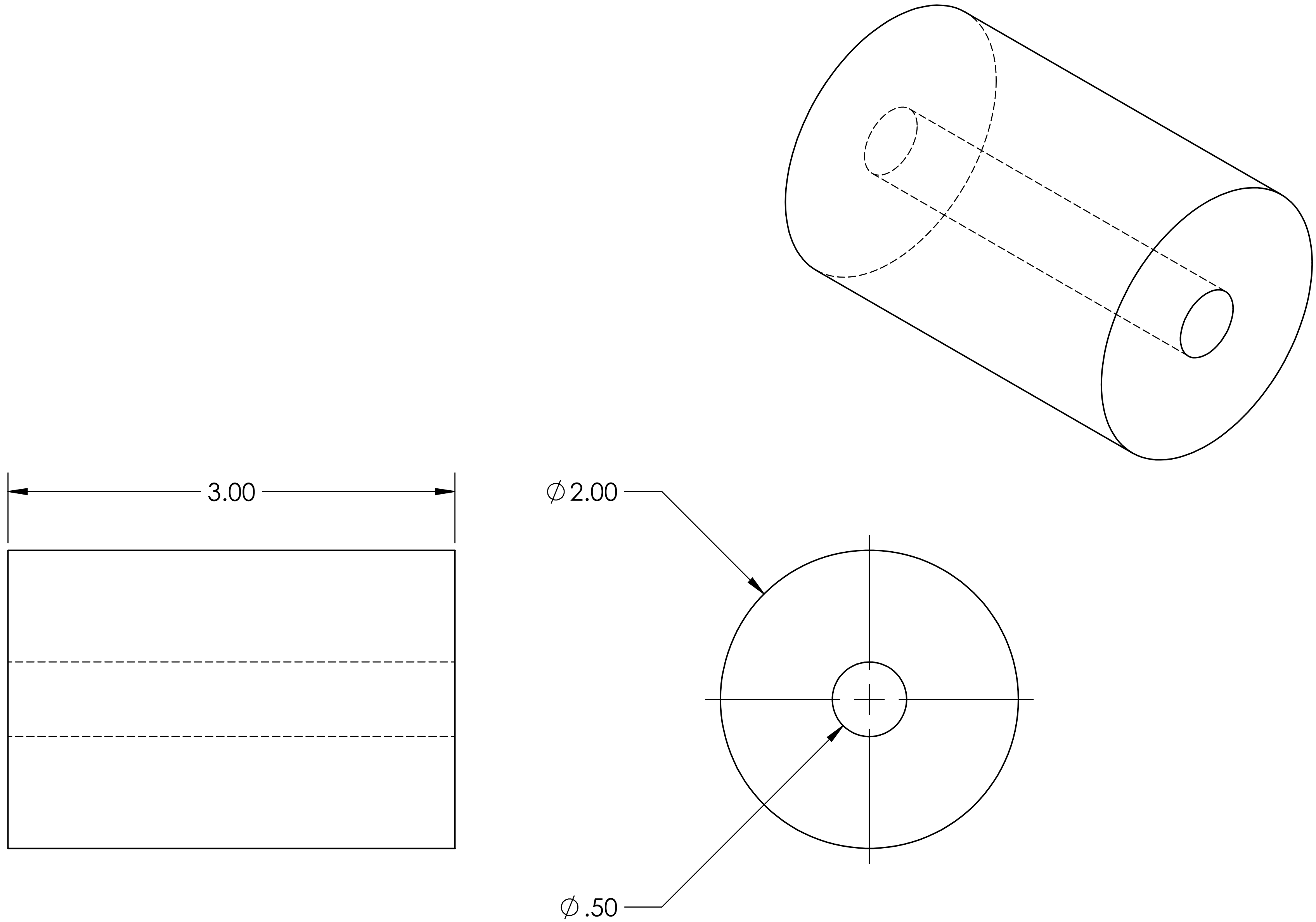
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: ASSEMBLY LINE WALLS		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19	Scale: 1:4	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED



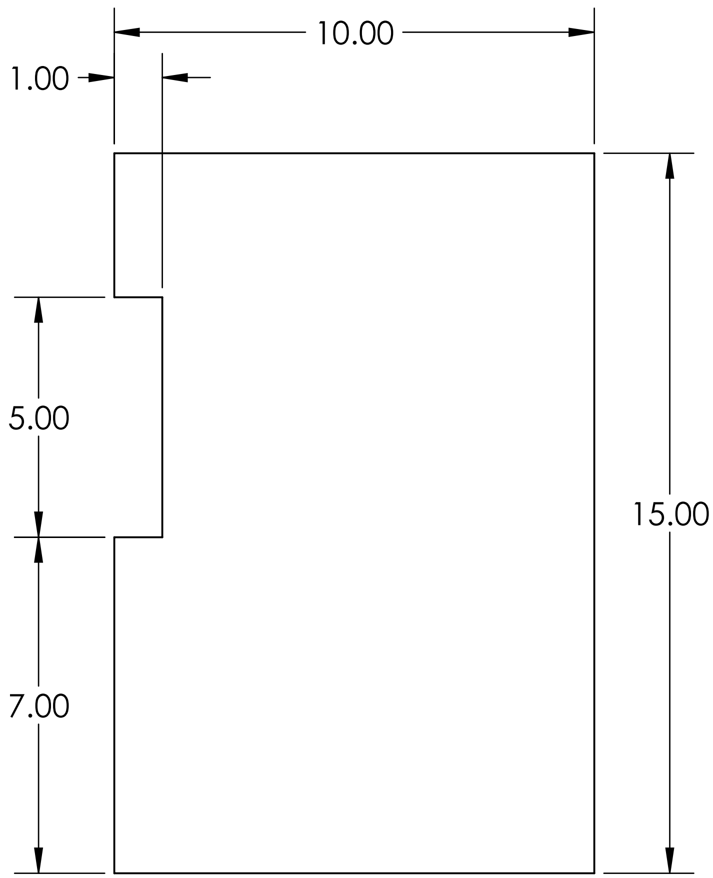


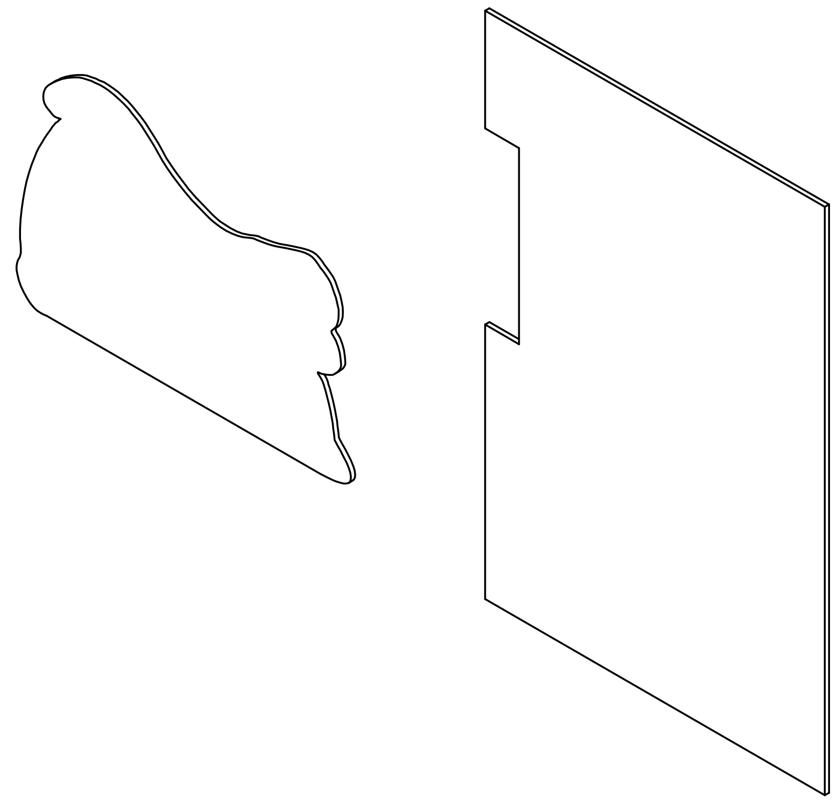
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: ASSEMBLY LINE PRESENTS	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19 Scale: 1:1	Chkd. By: ME STAFF

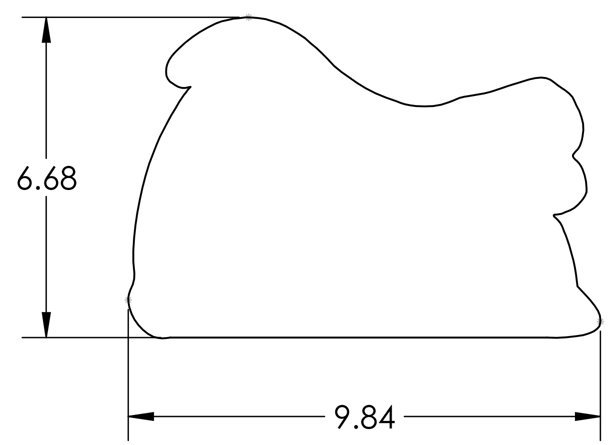


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: ASSEMBLY LINE ROLLER		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19	Scale: 1:1	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

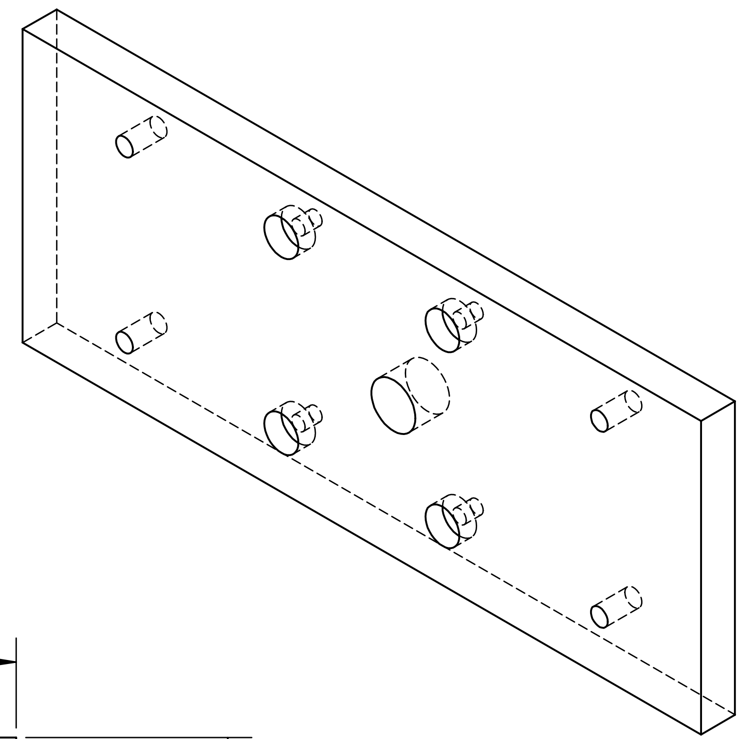


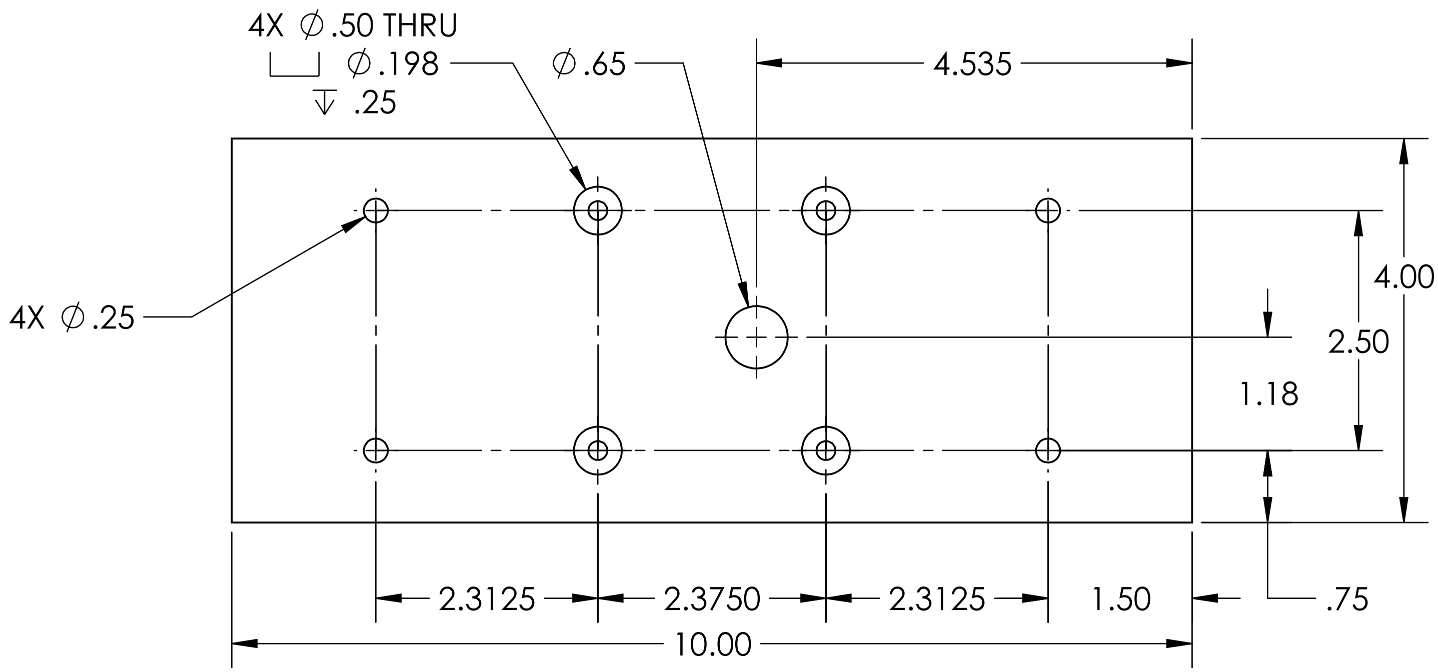




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: MACHINE AND SACK WALLS	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19 Scale: 1:4	Chkd. By: ME STAFF

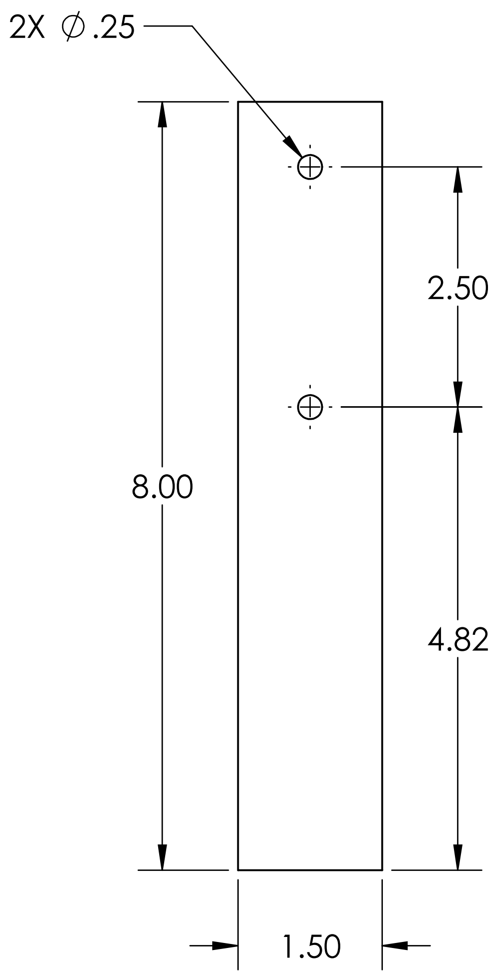
NOTE:
ALL PARTS 1/2" THICK UNLESS
OTHERWISE SPECIFIED

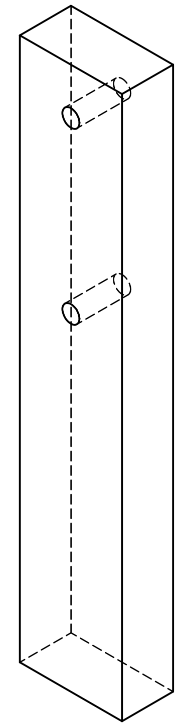




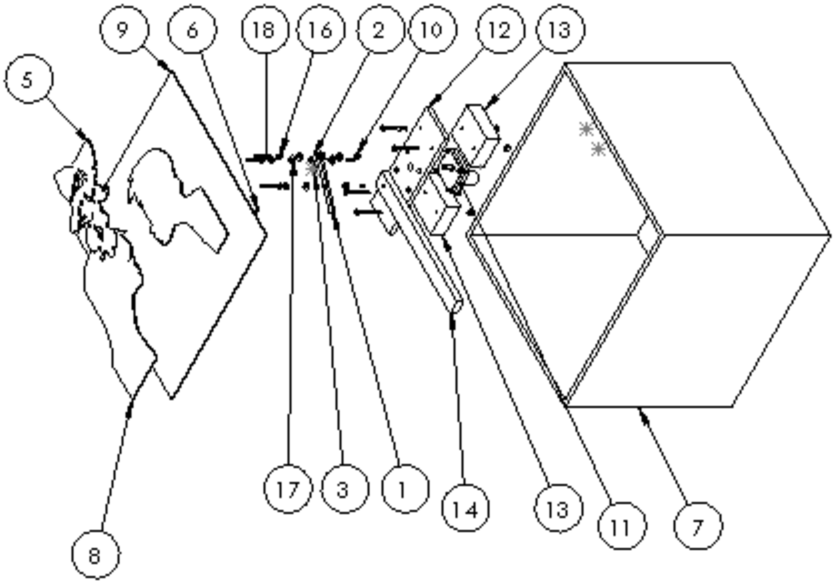
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: MOTOR BACK SUPPORT	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19 / Scale: 1:2	Chkd. By: ME STAFF

NOTE:
ALL PARTS 3/4" THICK UNLESS
OTHERWISE SPECIFIED



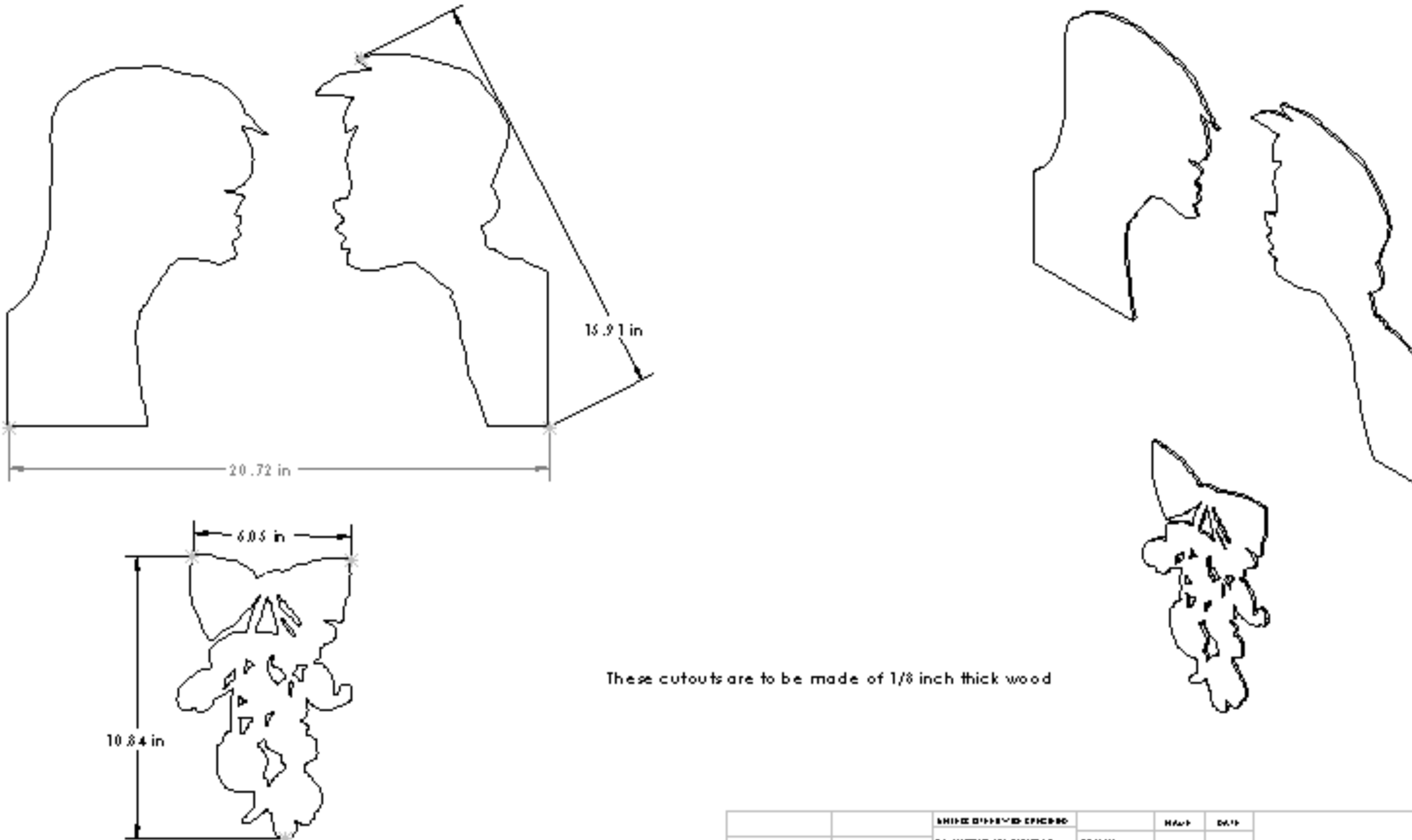


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: MOTOR LEG SUPPORT		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/29/19	Scale: 1:2	Chkd. By: ME STAFF



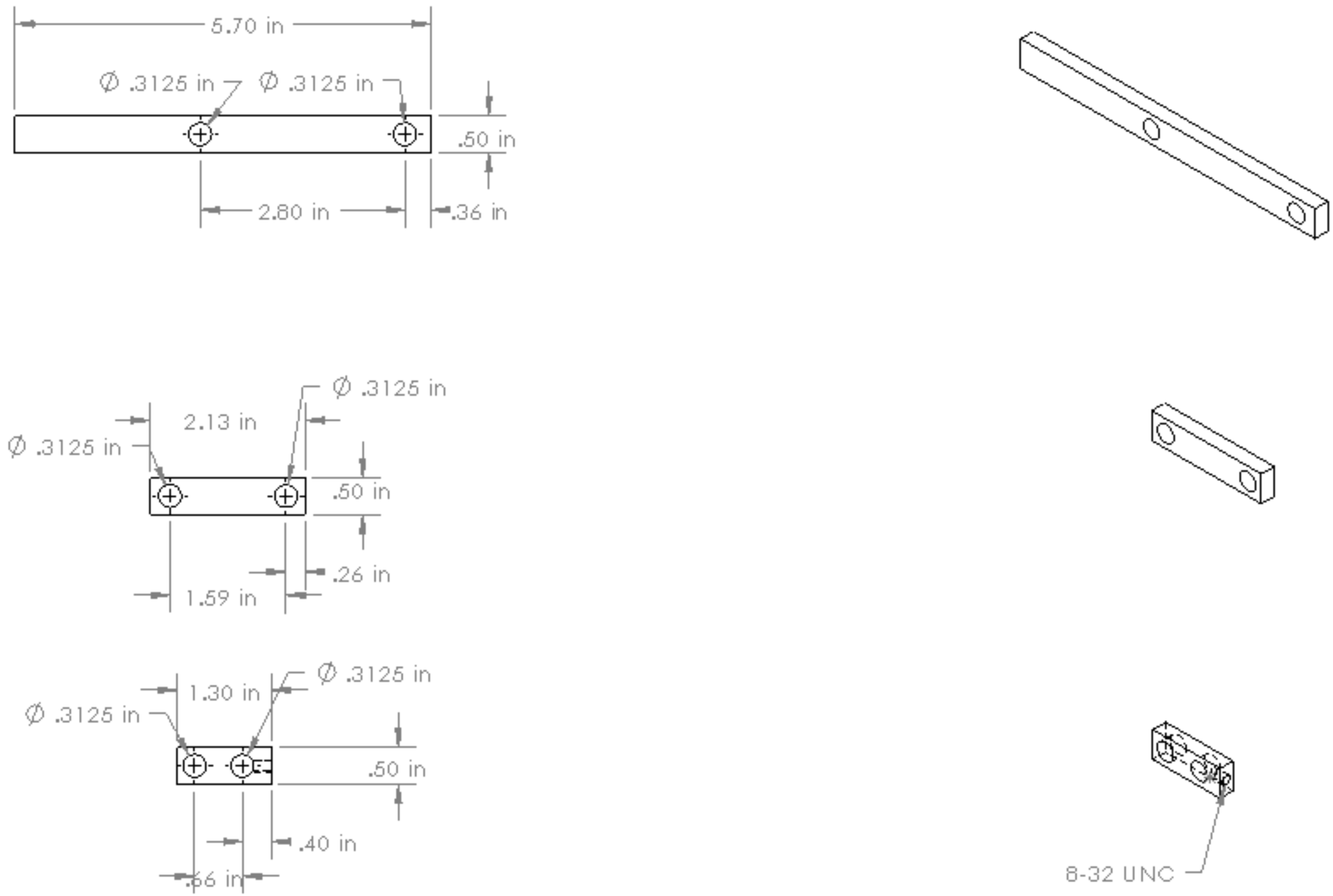
ITEM NO.	PART NUMBER	QTY.
1	Day14_Mistletoe(Linkage1)	1
2	Day14_Mistletoe(Linkage2)	1
3	Day14_Mistletoe(Linkage3)	1
4	Day14_Mistletoe(Shaft1)	1
5	Day14_Mistletoe(Part2)	1
6	Day14_Mistletoe(Block1)	1
7	Day2,3,6,8,10,14,15,18,24_Box_Reference	1
8	Day14_Mistletoe(Kissing)	1
9	Day14_Mistletoe(BackDrop)	1
10	6391K126	5
11	6409K17	1
12	Day14_Mistletoe(MotorBackSupport)	1
13	Day14_Mistletoe(WoodSupport1)	2
14	Day14_Mistletoe(WoodSupport3)	1
15	91247A552	4
16	95615A120	7
17	90295A155	6
18	91247A546	2
19	91247A550	1
20	94105A190	1

Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment#	Title: Mistletoe Assembly	Drwn. By: Danny Clifton
	Dwg. #:	Nxt Asb:	Date: 04/27/1? Scale: 1:12	Chkd. By: ME STAFF



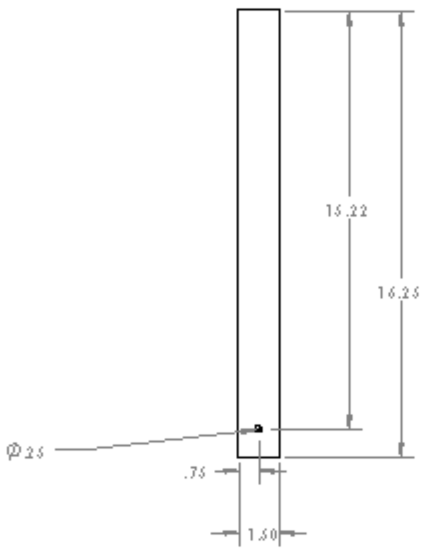
These cutouts are to be made of 1/8 inch thick wood

TITLE:	
SIZE B	DWG. NO. Day14_Mistletoe(Kissing)(Drawin
REV	
SCALE: 1:4	WEIGHT:
SHEET 1 OF 1	



All these linkages are made of 1/4 inch thick aluminum stock

Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



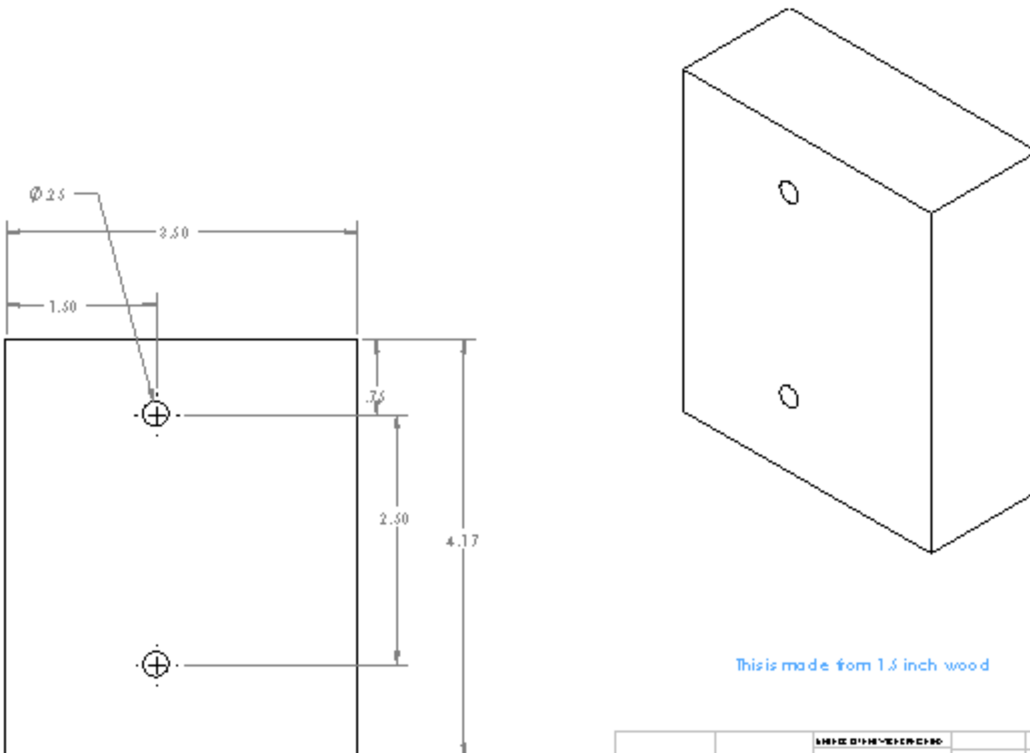
This is made from 3/4 inch wood

TITLE:

SIZE B DWG. NO. REV

Day14_Mistletoe (WoodSupport3) (Dr

SCALE: 1:4 WEIGHT: SHEET 1 OF 1



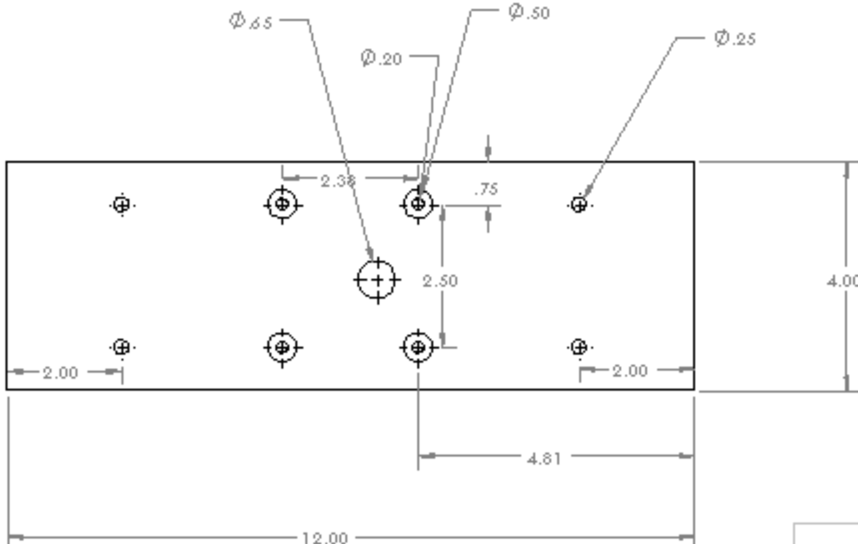
This is made from 1.5 inch wood

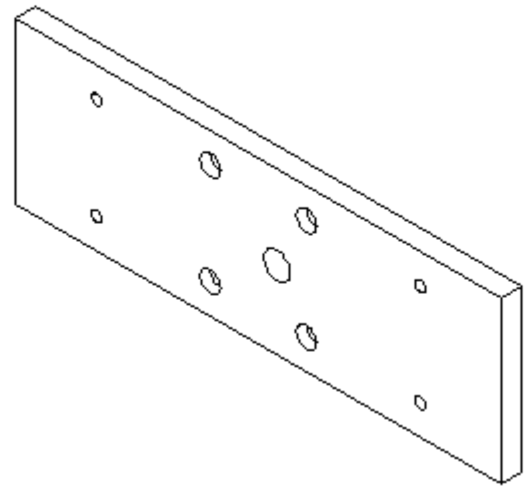
TITLE:

SIZE B DWG. NO. REV

Day14_Mistletoe(WoodSupport1)(Dr

SCALE: 1:1 WEIGHT: SHEET 1 OF 1





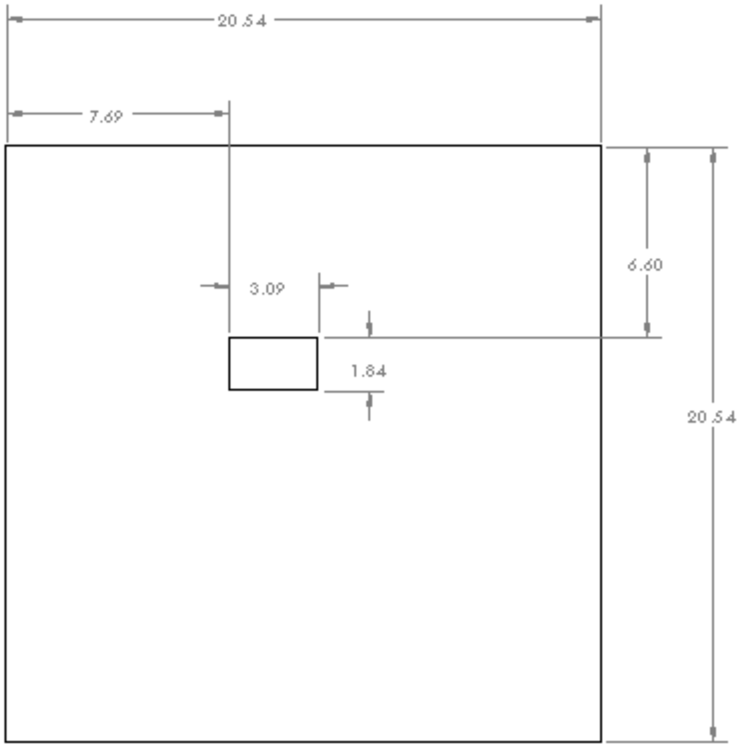
This is made with 1/2 inch wood

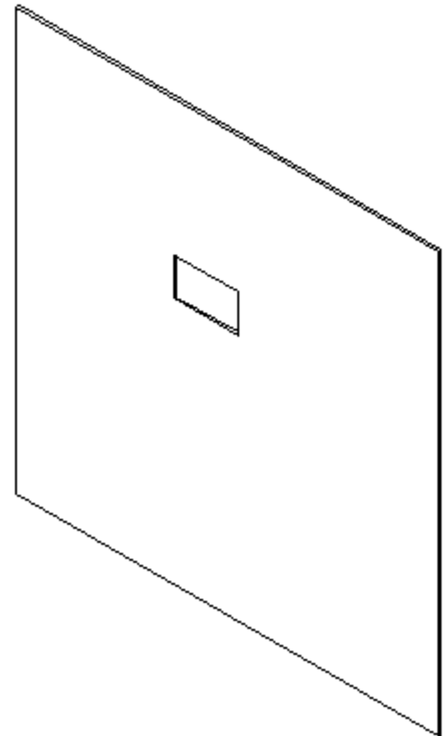
TITLE:

SIZE B DWG. NO. REV

Day14_Mistletoe(MotorBackSupport)(

SCALE: 1:2 WEIGHT: SHEET 1 OF 1





This is made from 1/8 inch wood

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

UNLESS OTHERWISE SPECIFIED:

PROPRIETARY AND CONFIDENTIAL

NEXT ASSY | USED ON

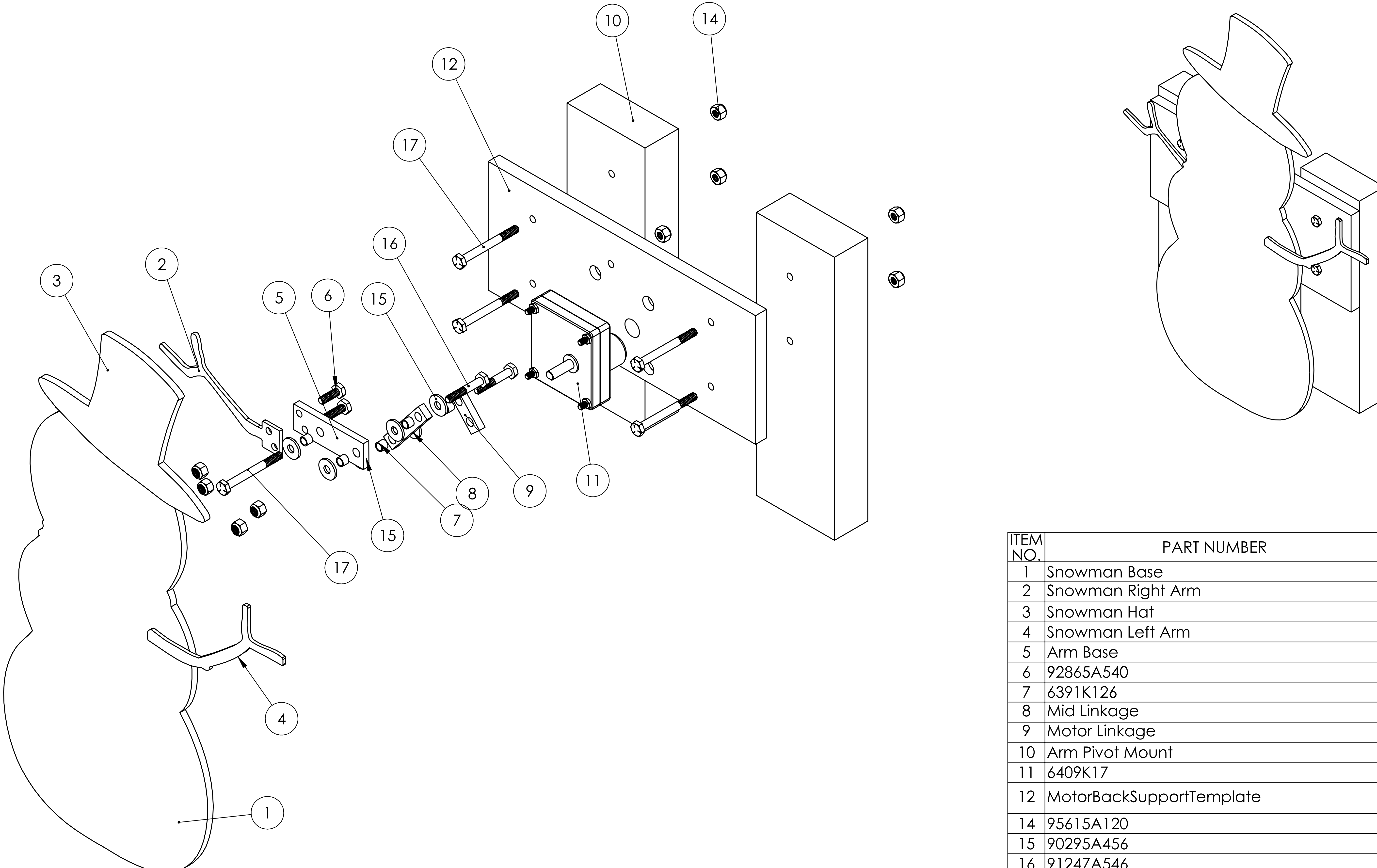
APPLICATION

DO NOT SCALE DRAWING

TITLE:

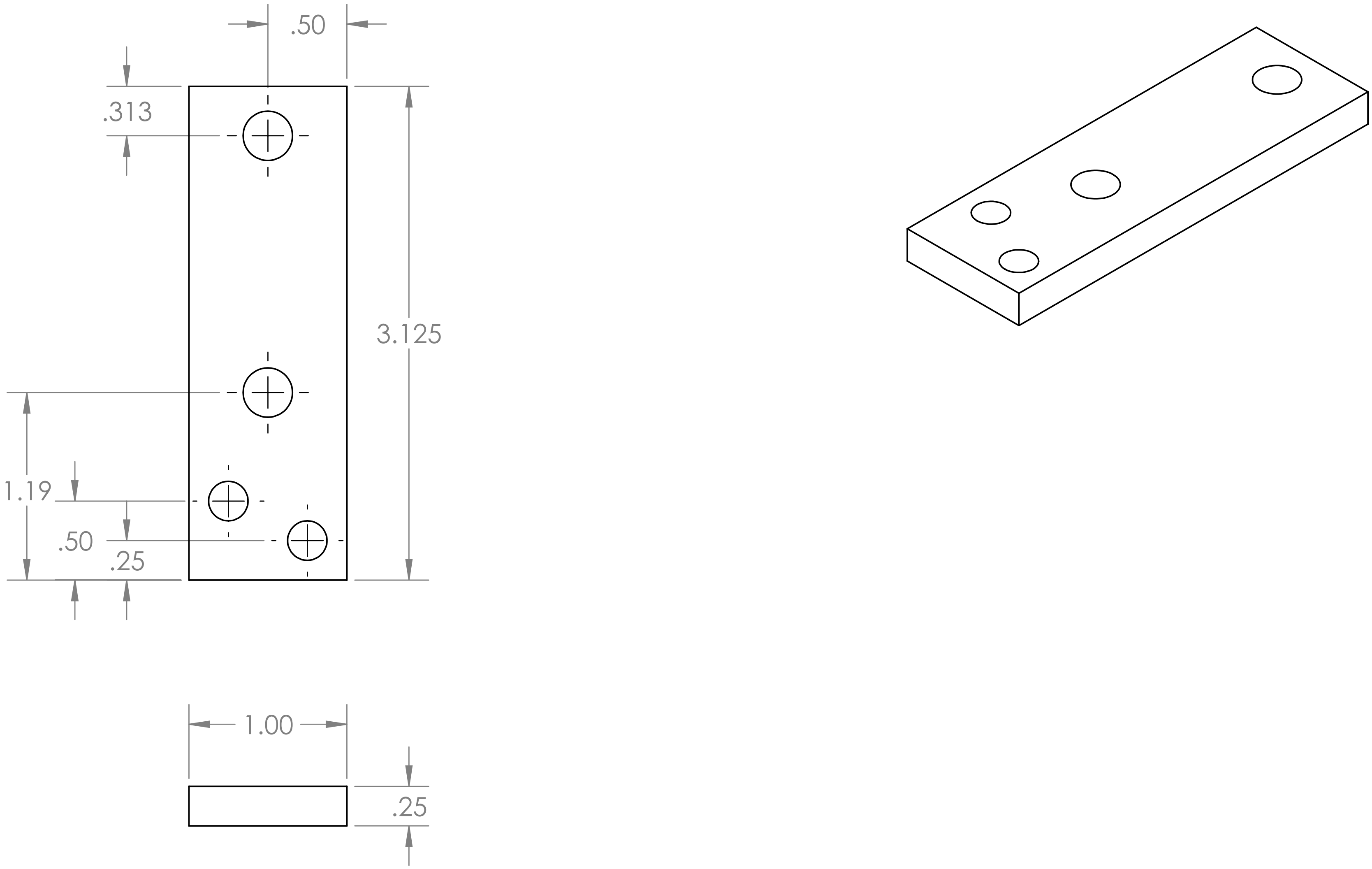
SIZE B | DWG. NO. Day14_Mistletoe (BackDrop) (Draw | REV

SCALE: 1:4 | WEIGHT: | SHEET 1 OF 1

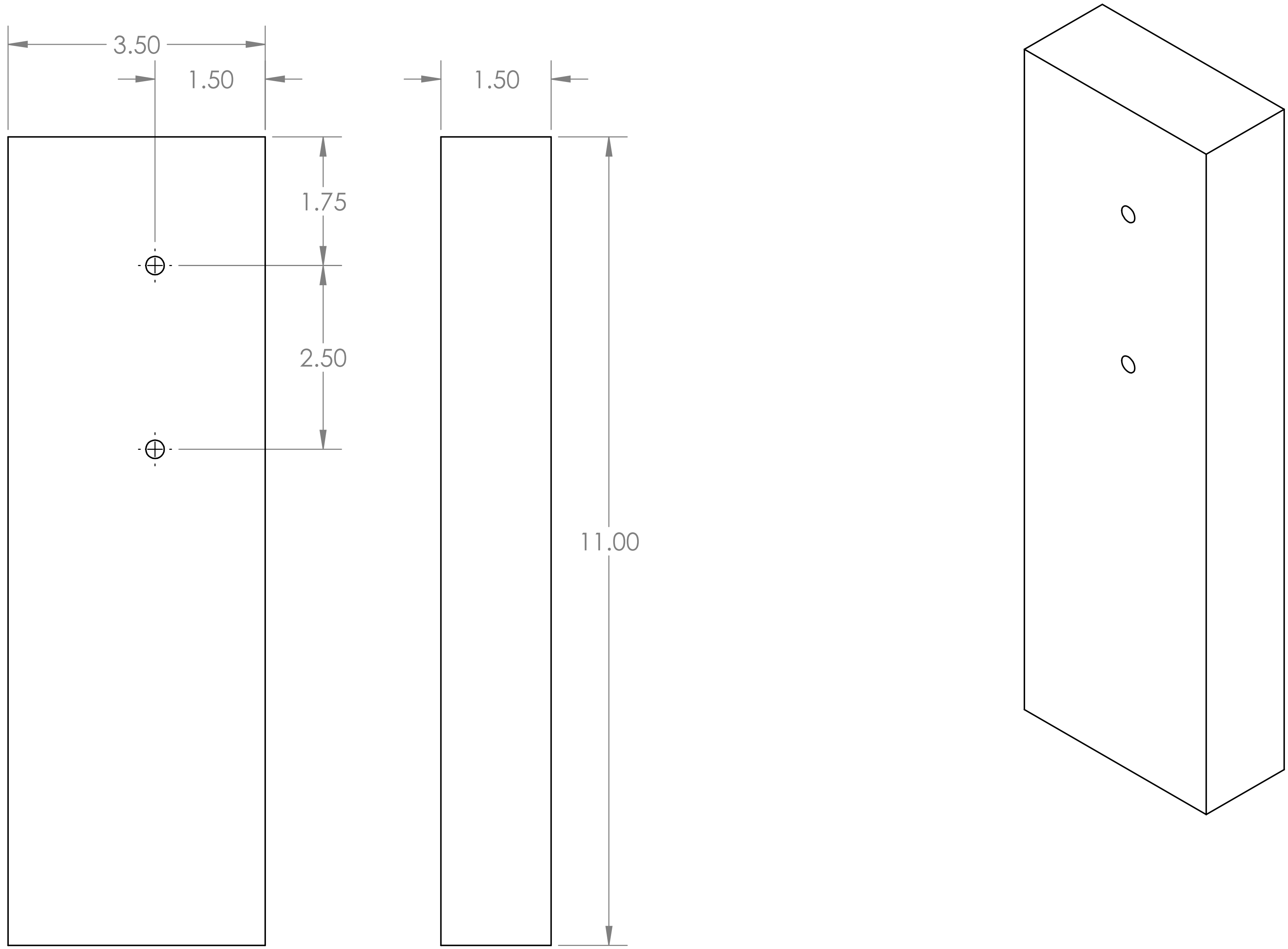


ITEM NO.	PART NUMBER	QTY.
1	Snowman Base	1
2	Snowman Right Arm	1
3	Snowman Hat	1
4	Snowman Left Arm	1
5	Arm Base	1
6	92865A540	2
7	6391K126	5
8	Mid Linkage	1
9	Motor Linkage	1
10	Arm Pivot Mount	2
11	6409K17	1
12	MotorBackSupportTemplate	1
14	95615A120	9
15	90295A456	6
16	91247A546	2
17	91247A552	5

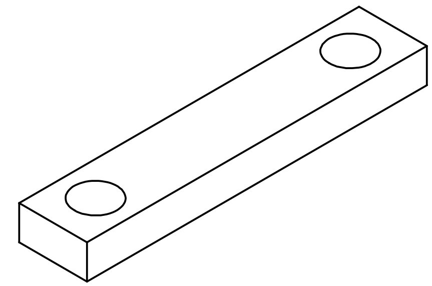
Cal Poly Mechanical Engineering ME ### - QTR YEAR	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

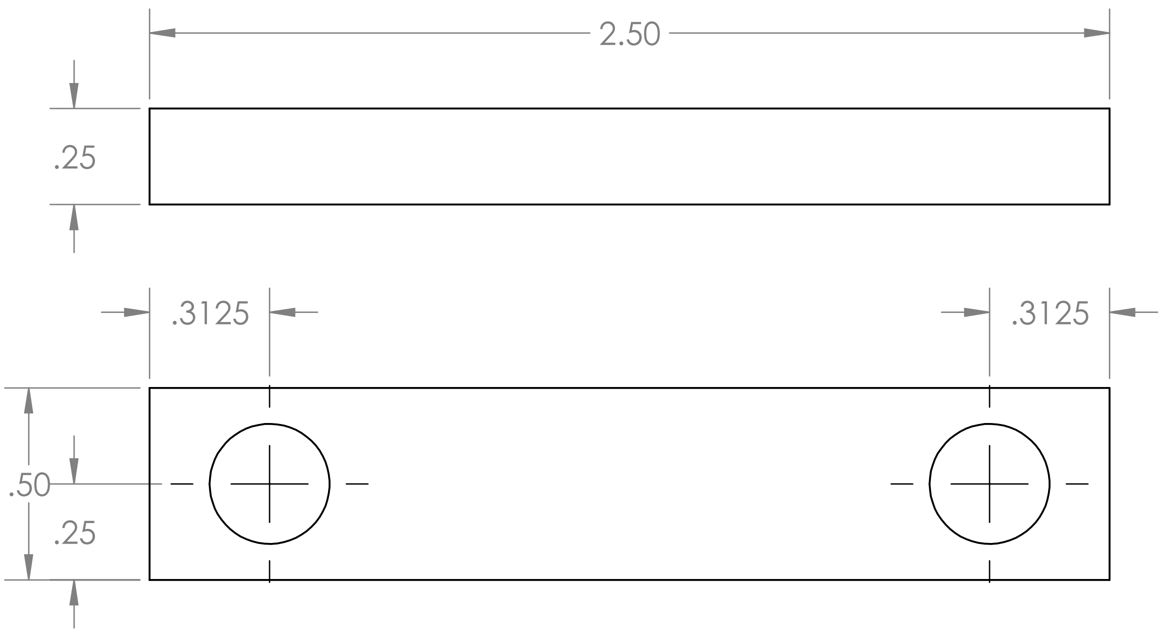


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

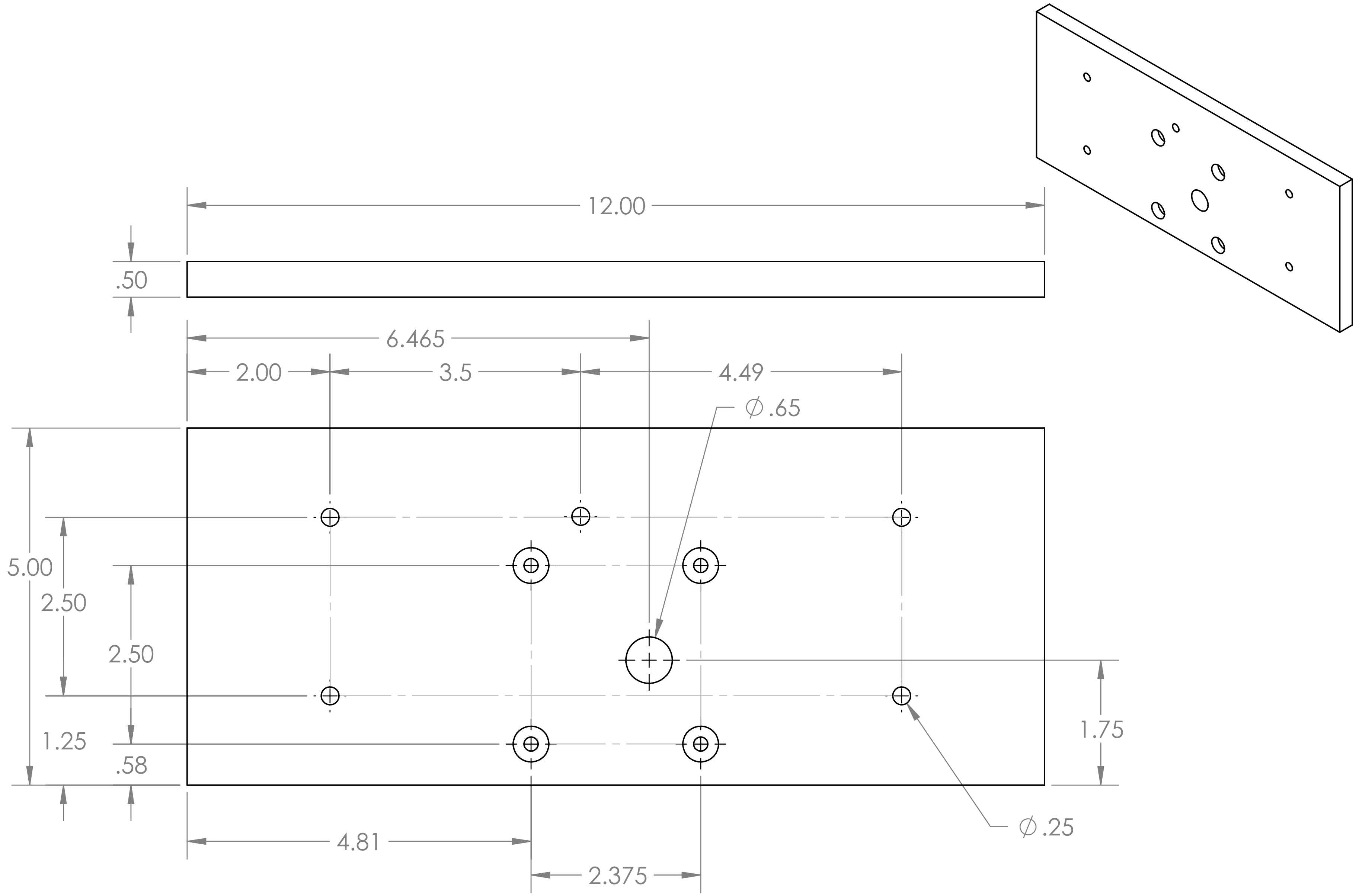


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

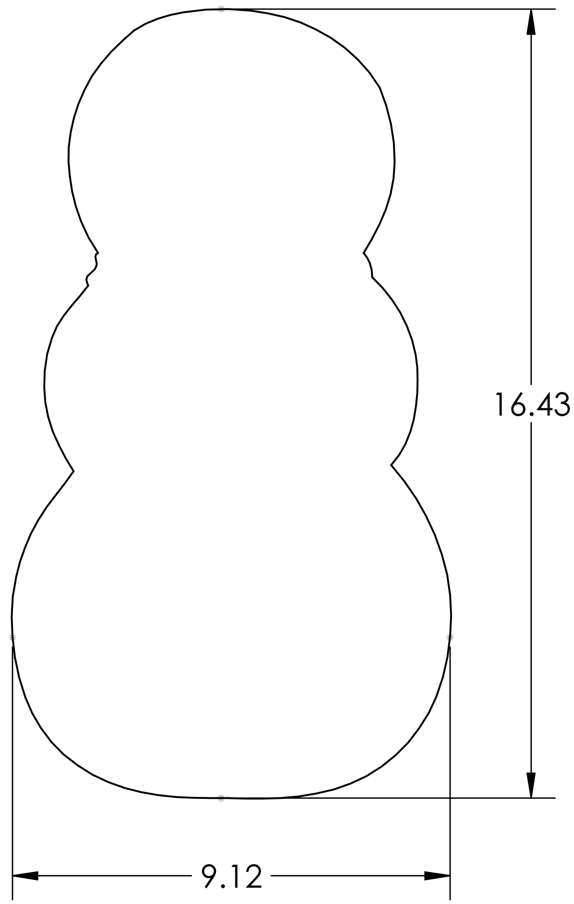




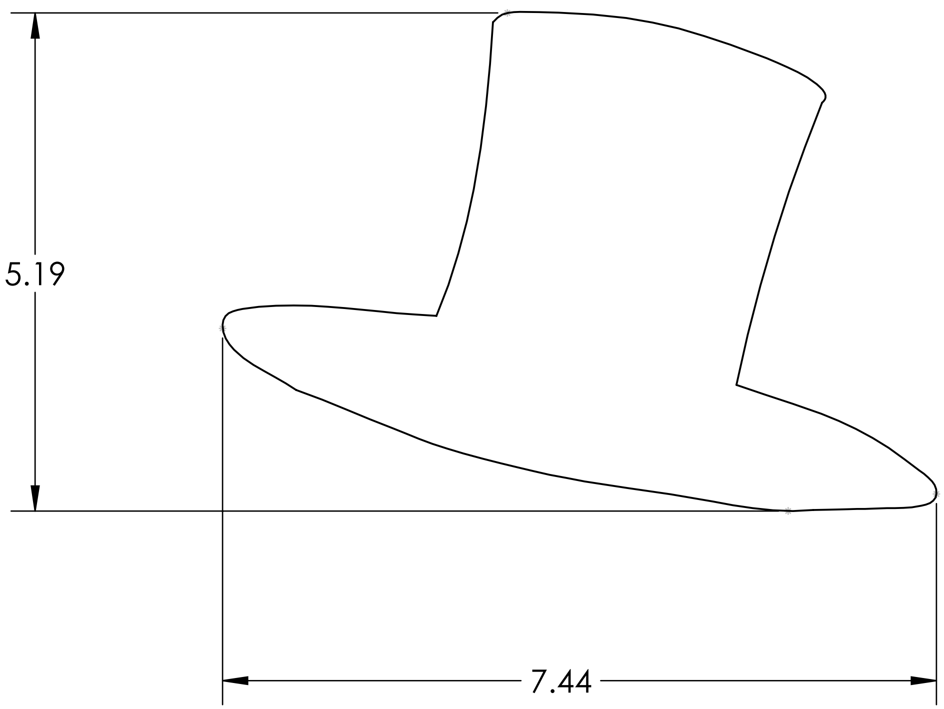
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



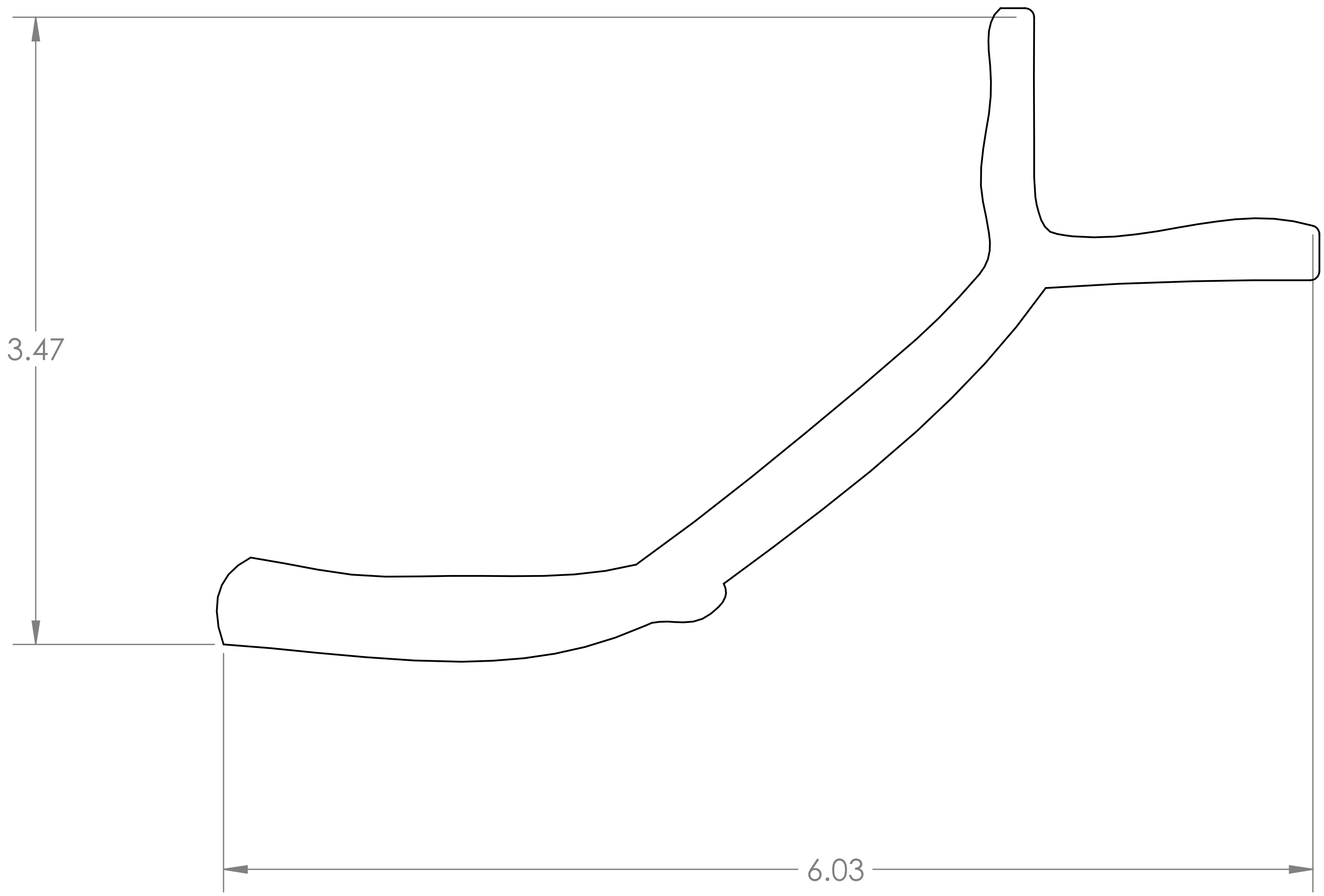
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



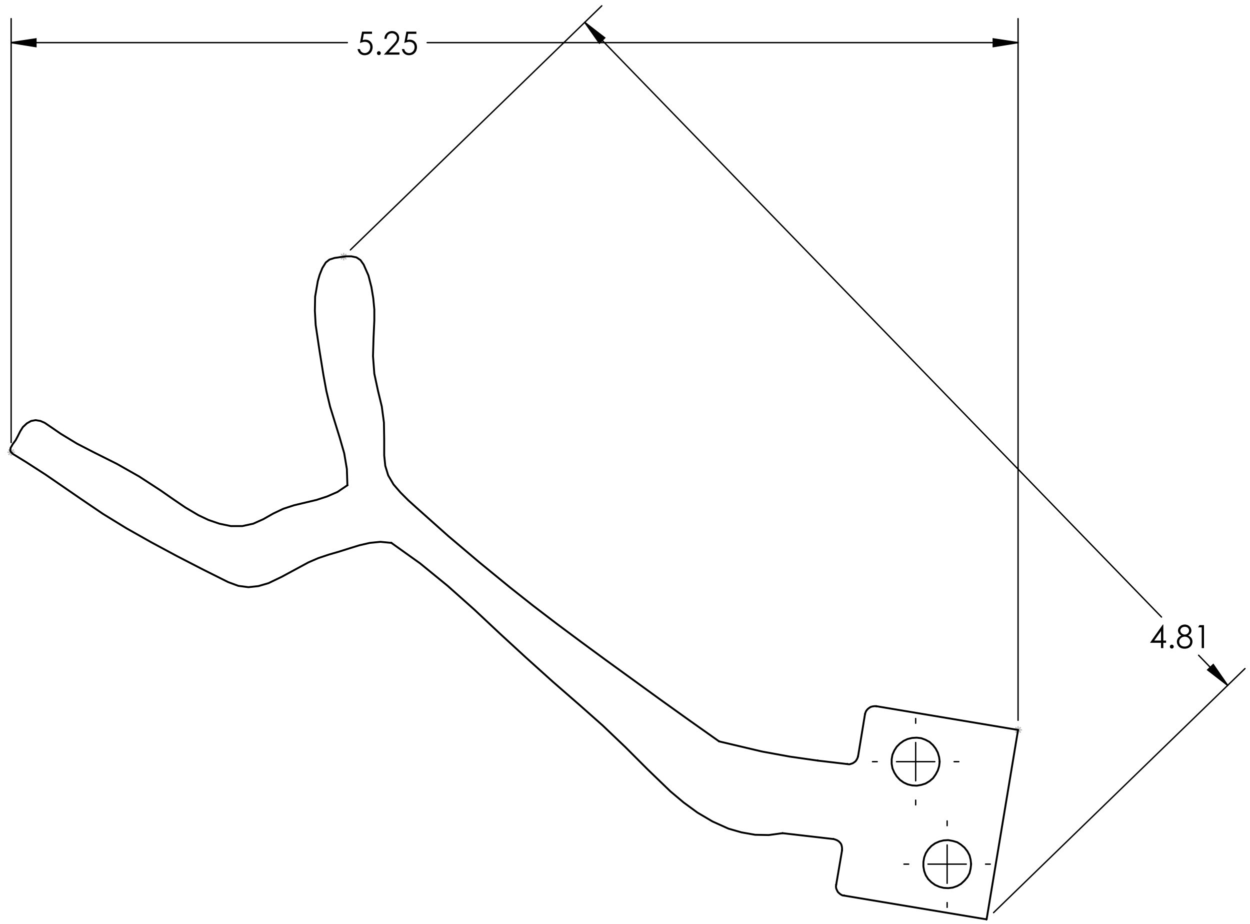
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



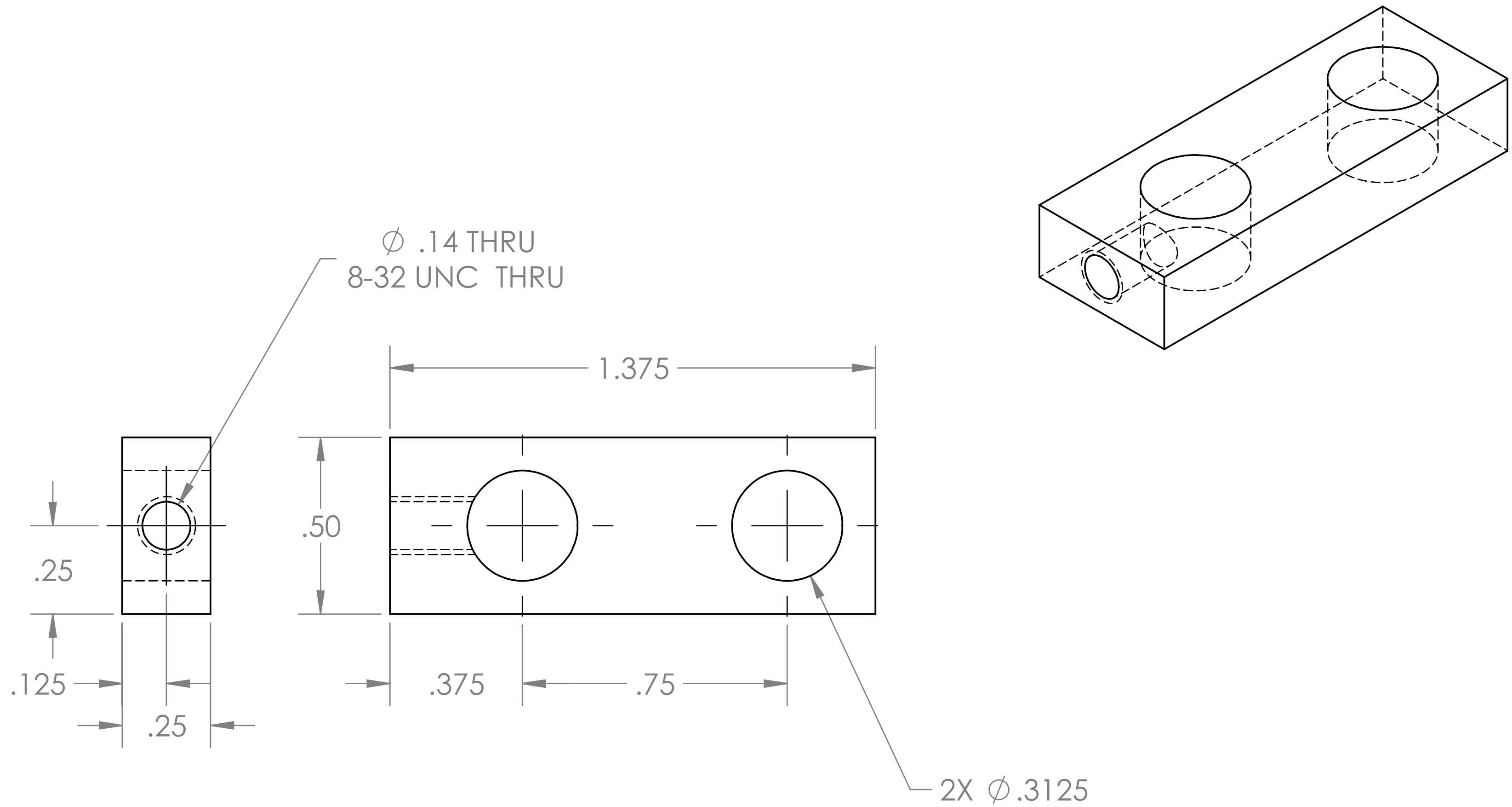
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

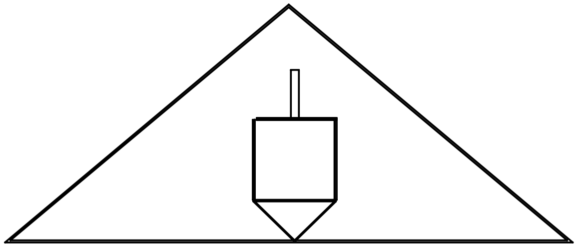


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

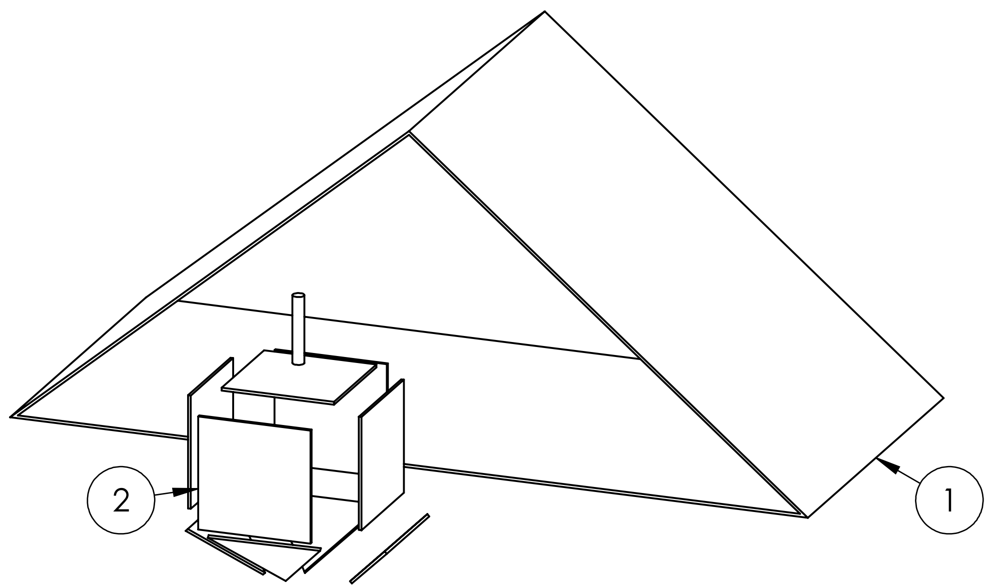


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Box #16	1/4" Wood	1
2	Dreaidel Assembly	1/8" Wood	1

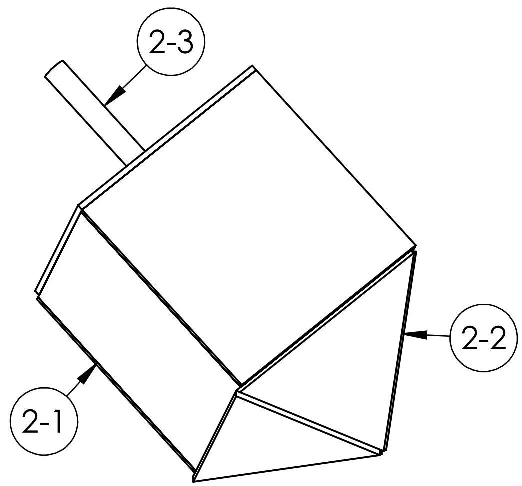


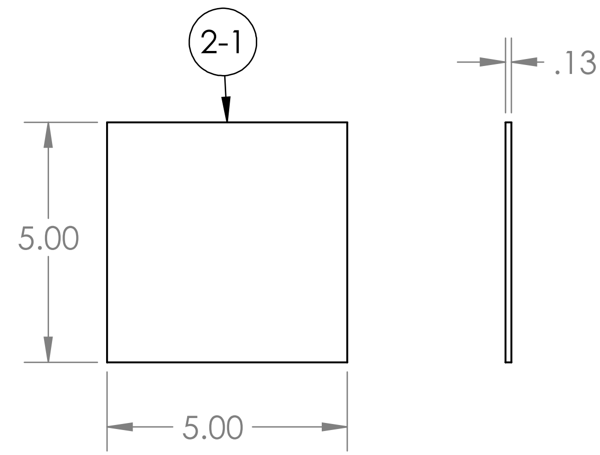
Front View

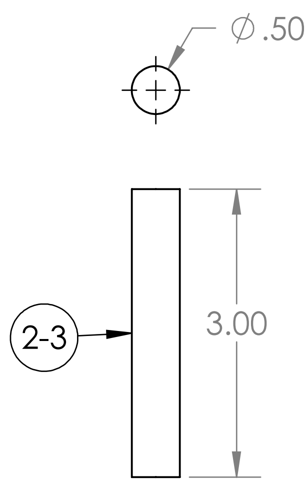


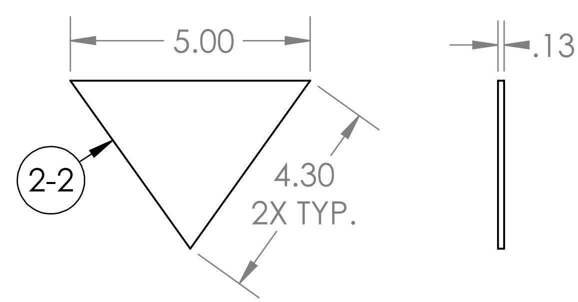
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Dreidel	Drwn. By: Sigrid Derickson
ME 429 Spirng 2019	Dwg. #:	Nxt Asb:	Date: / Scale: 1/8	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
2-1	Dreidel Side	1/8" Wood	5
2-2	Dreidel Triangle	1/8" Wood	4
2-3	Dreidel Top	1/4" Dowel	1

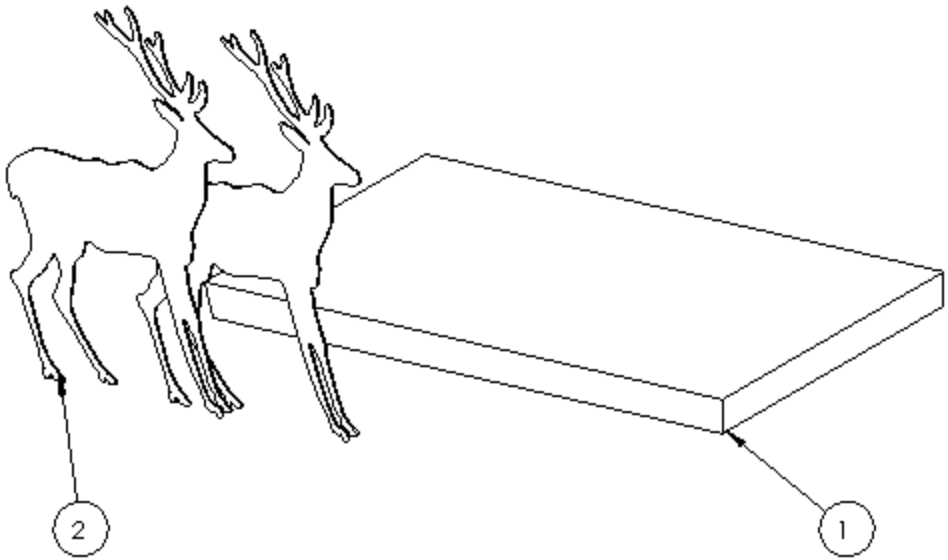






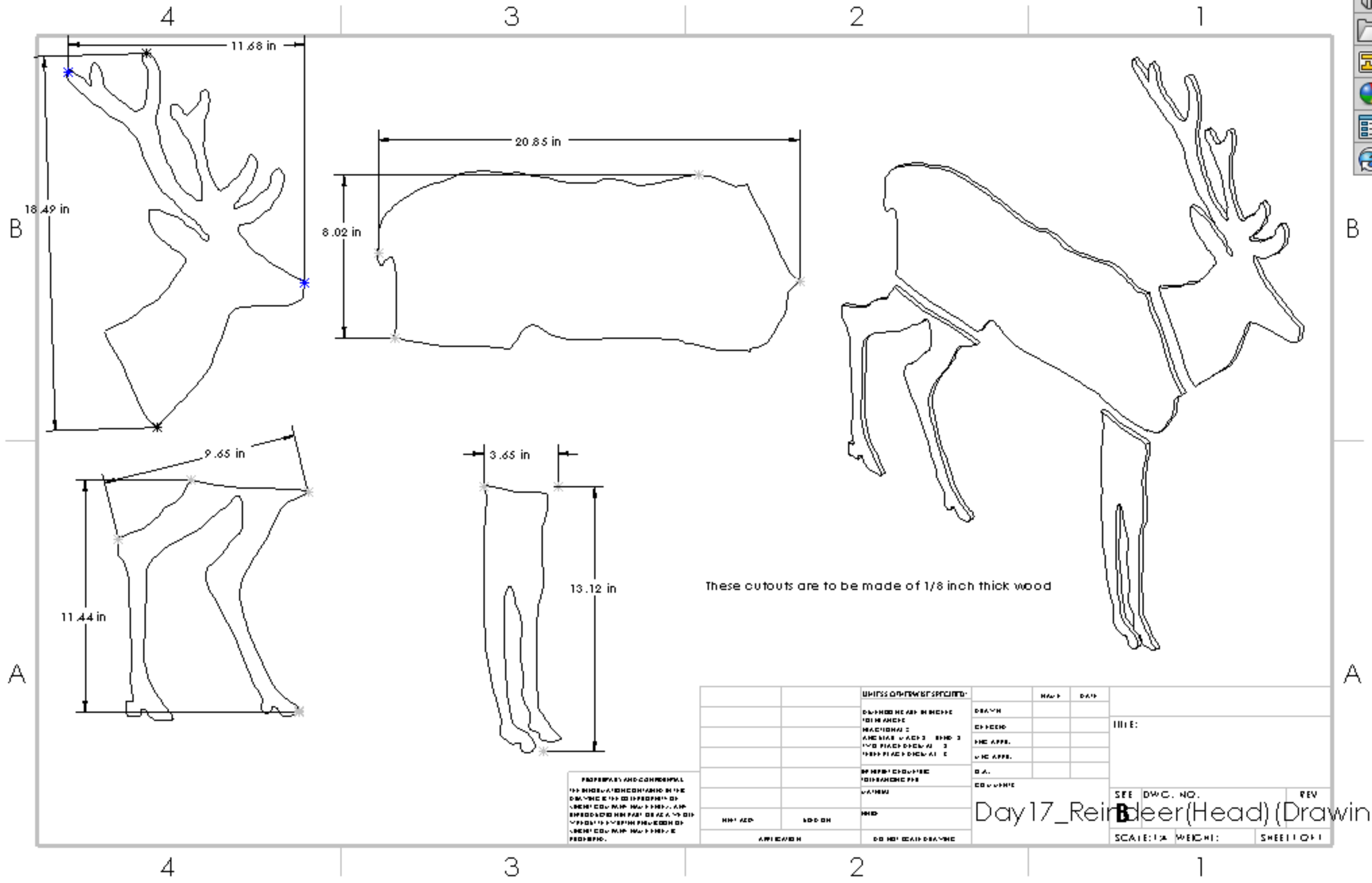


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Dreidel Components	Drwn. By: Sigrid Derickson
ME 429 SPRING 2019	Dwg. #:	Nxt Asb:	Date: 4/28/19 Scale: 1/4	Chkd. By: ME STAFF



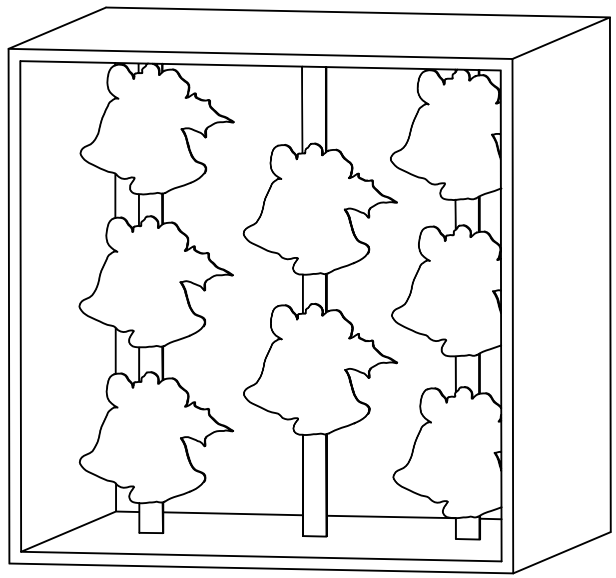
ITEM NO.	PART NUMBER	QTY.
1	Day17_Reindeer(Roof)	1
2	Day17_Reindeer(Part1)	2

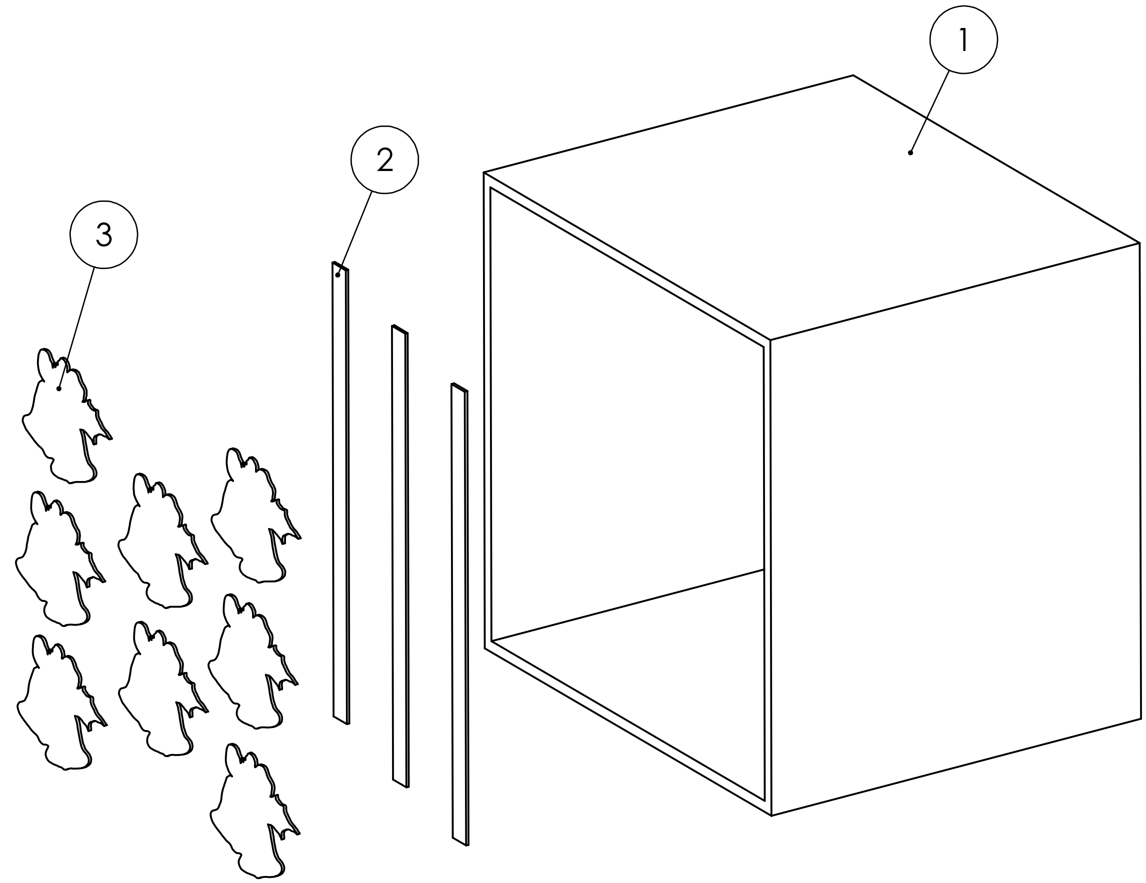
Cal Poly Mechanical Engineering	Lab Section:	Assignment#	Title: Reindeer Assembly	Drwn. By: Danny Clifton
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/27/19	Scale: 1:12	Chkd. By: ME STAFF



11.68 in
18.49 in
20.85 in
8.02 in
9.65 in
11.44 in
3.65 in
13.12 in
These cutouts are to be made of 1/8 inch thick wood
TITLE:
SIZE
B
DWG. NO.
REV
Day17_Reindeer(Head)(Drawin
WEIGHT:

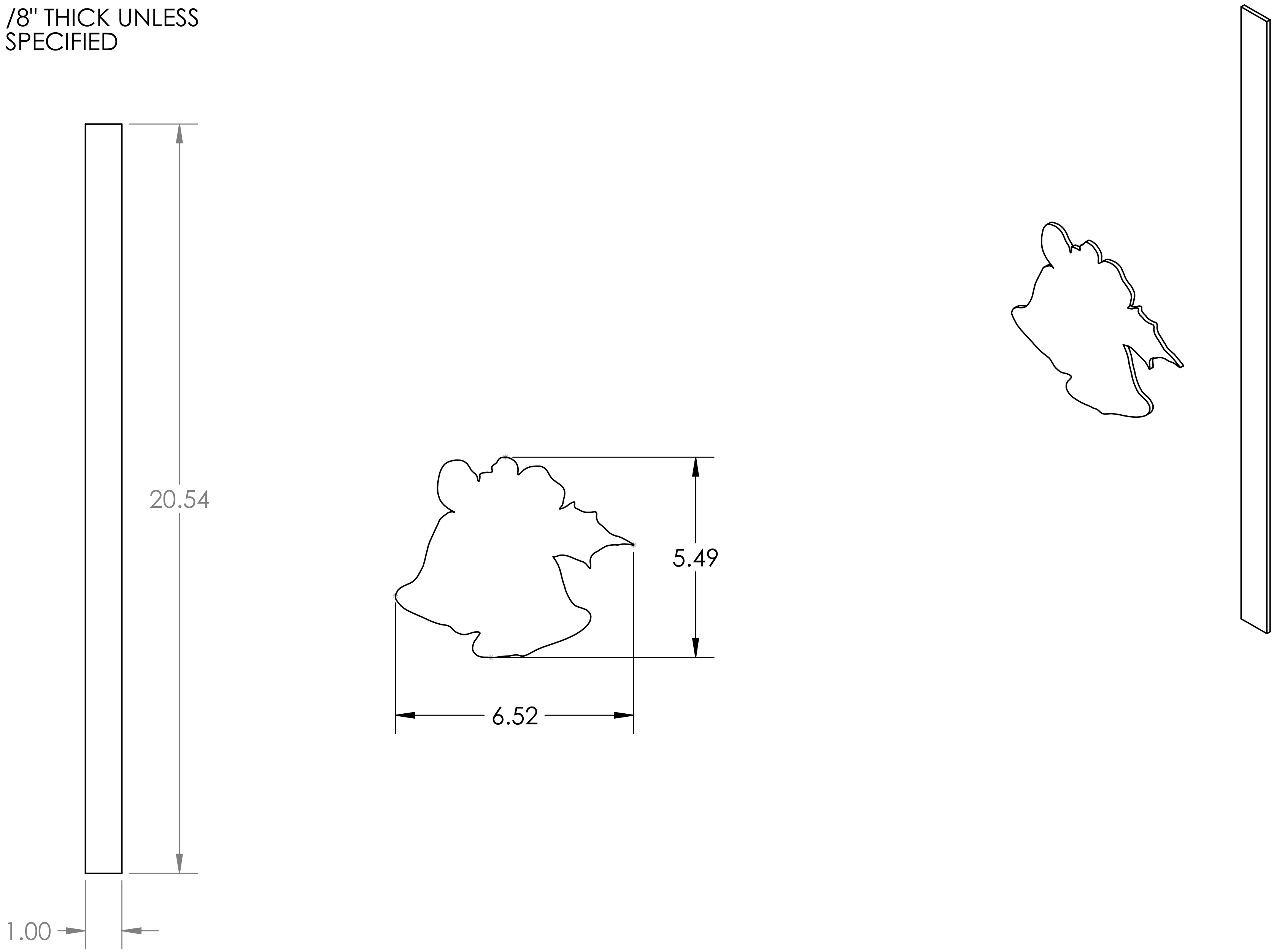
ITEM NO.	PART NUMBER	QTY.
1	Day2,3,6,8,10,14,15,18,24_Box_Reference	1
2	BellsPart2_Pole(Day18)	3
3	BellsPart1(Day18)	8





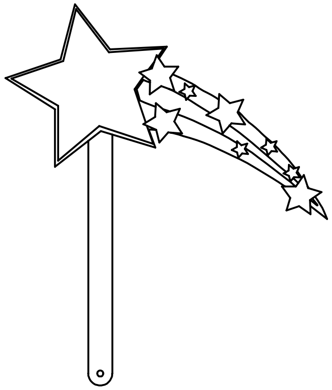
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: BELLS ASSEMBLY	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 / Scale: 1:8	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

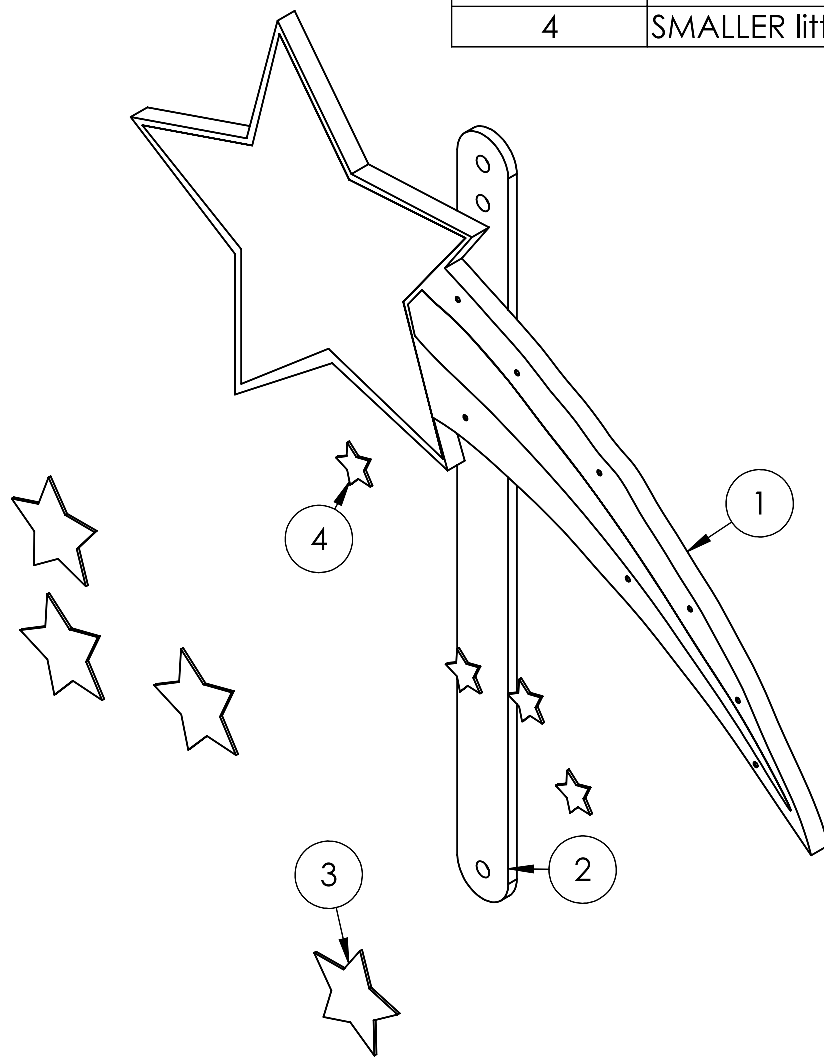


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: BELL AND POLE		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19	Scale: 1:8	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	shooting star	1/8" Wood	1
2	Shooting arm	1/4" Wood	1
3	little star	1/8" Wood	4
4	SMALLER little star	1/8" Wood	4

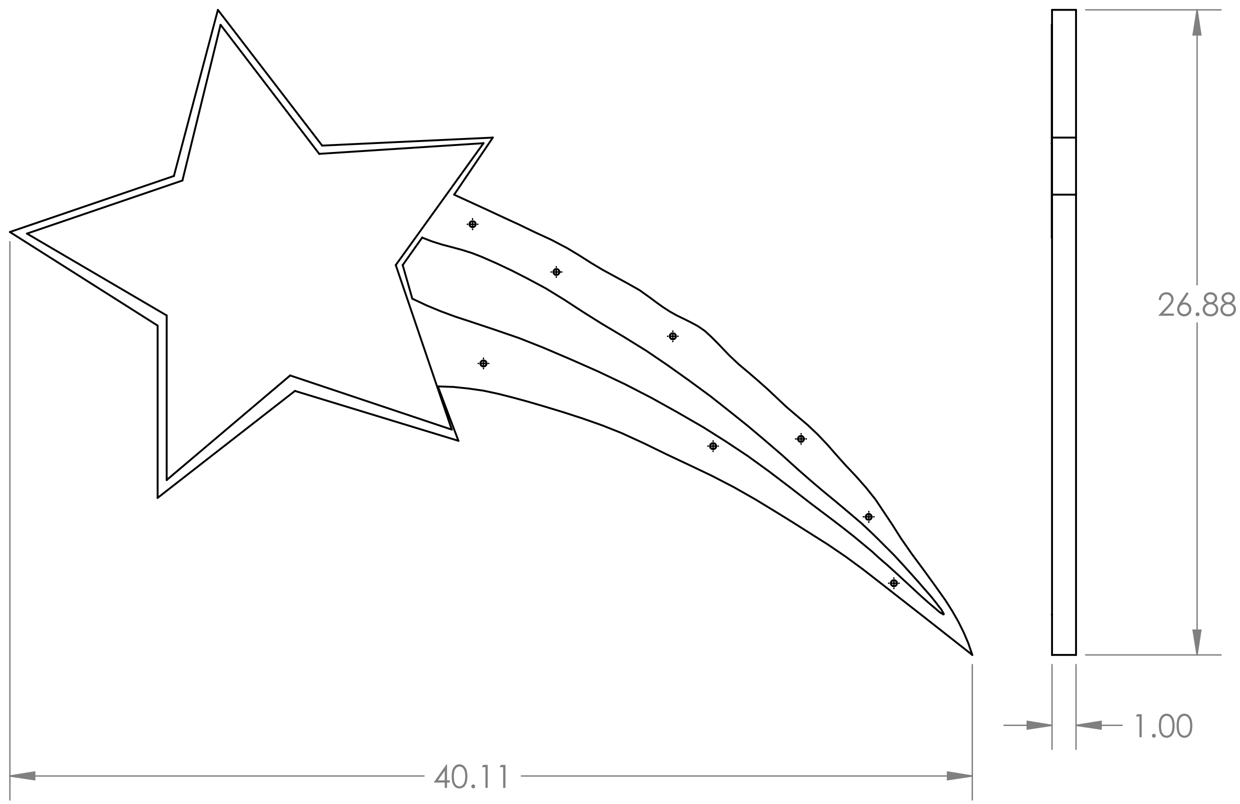


Front View



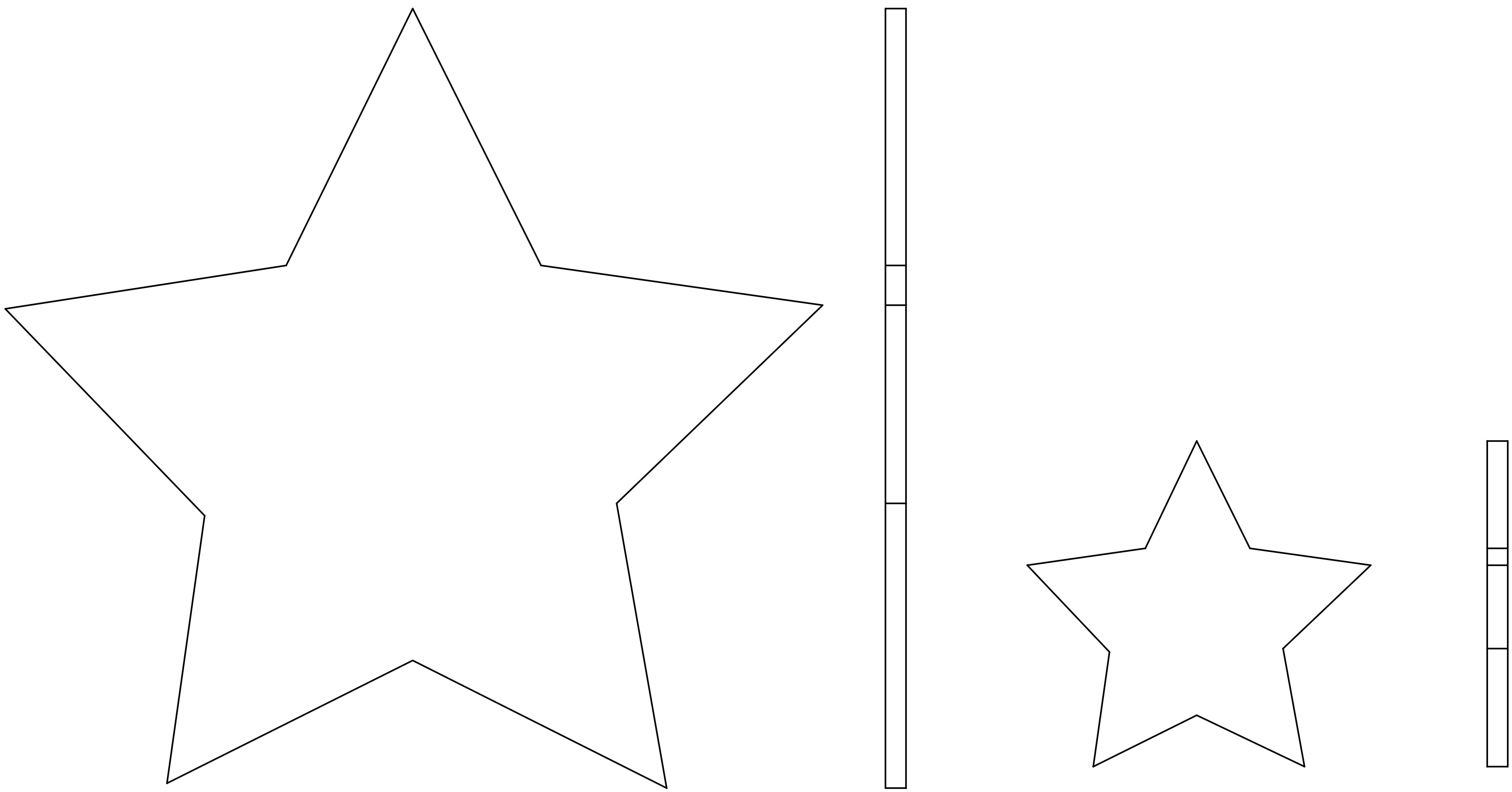
Cal Poly Mechanical Engineering ME 429 SPRING 2019	Lab Section:	Assignment #	Title: Shooting Star Assembly	Drwn. By: Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date:4/28/19	Scale:1/8	Chkd. By: ME STAFF

NOTE:
Item is laser cut

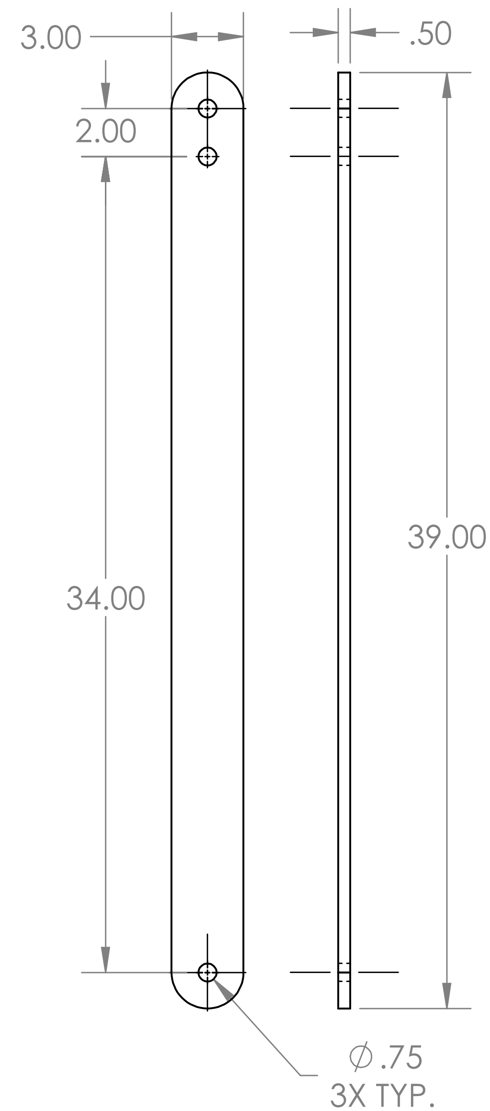


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Star base	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: 4/28/19 / Scale: 1/8	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Little Star	1/8" Wood	4
2	Smaller Little Star	1/8" Wood	4

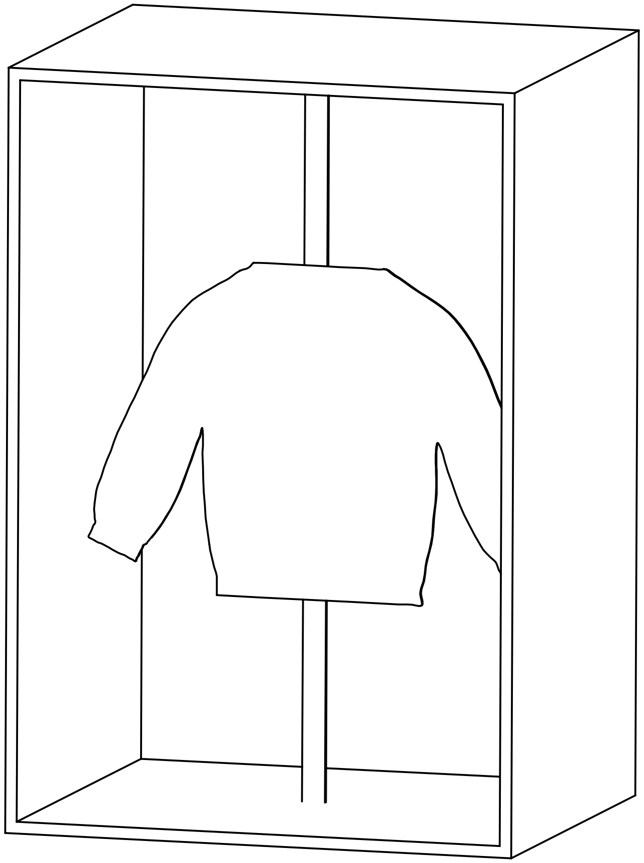


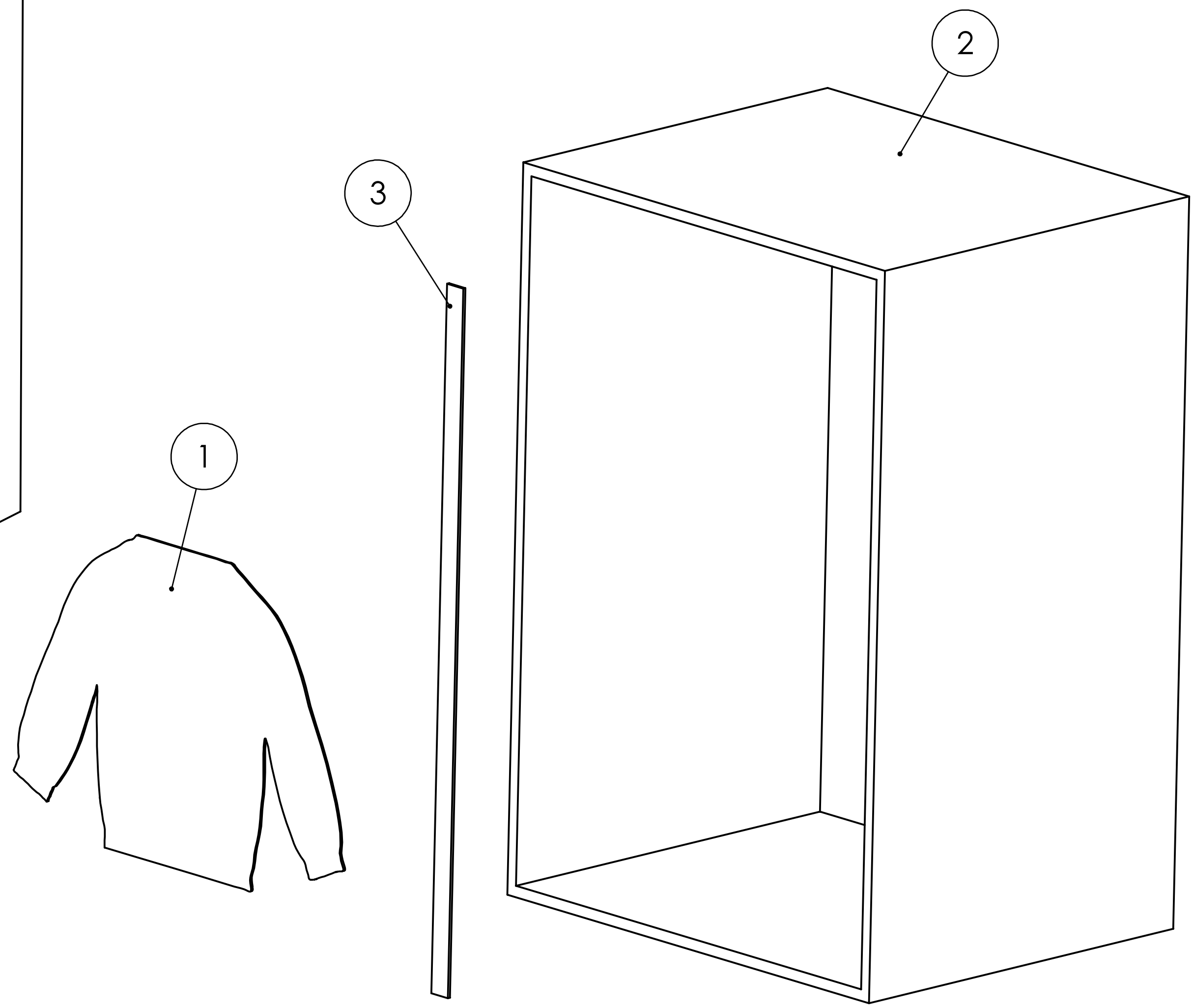
Cal Poly Mechanical Engineering ME 429 SPRING 2019	Lab Section:	Assignment #	Title: Stars		Drwn. By: SIGRID DERICKSON
	Dwg. #:	Nxt Asb:	Date: 4/28/19	Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Star Arm	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: / Scale:1/8	Chkd. By: ME STAFF

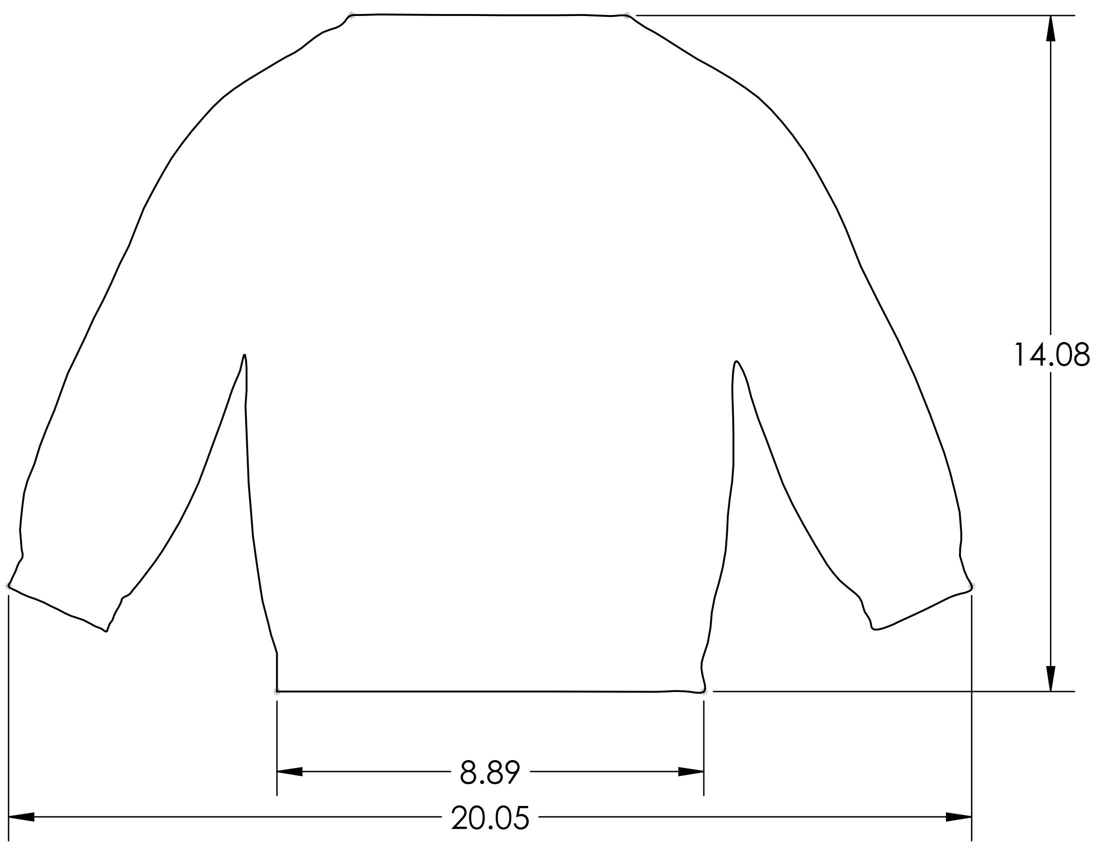
ITEM NO.	PART NUMBER	QTY.
1	SweaterPart1(Day20)	1
2	Day20_Box_Reference	1
3	SweaterPart2_Pole(Day20)	1

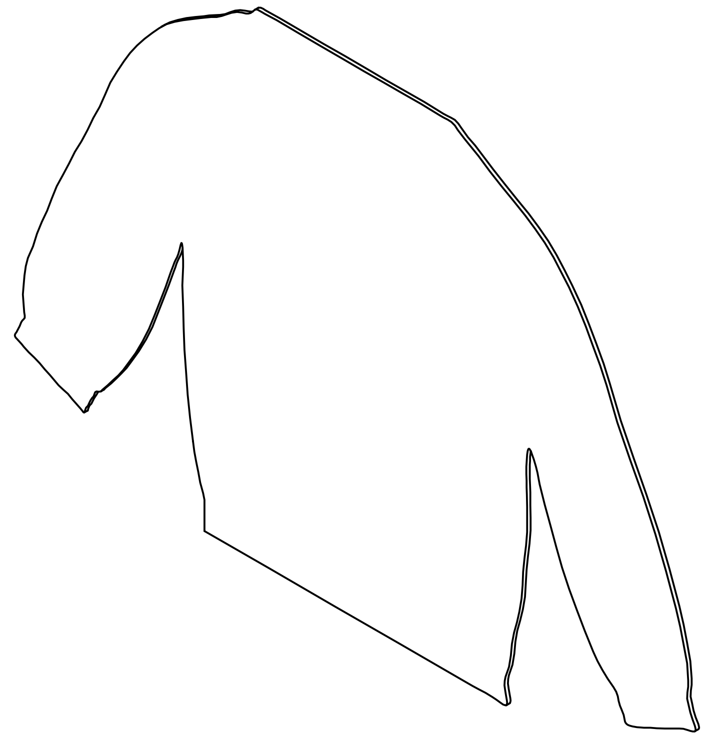




Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: UGLY SWEATER ASSEMBLY	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 Scale: 1:8	Chkd. By: ME STAFF

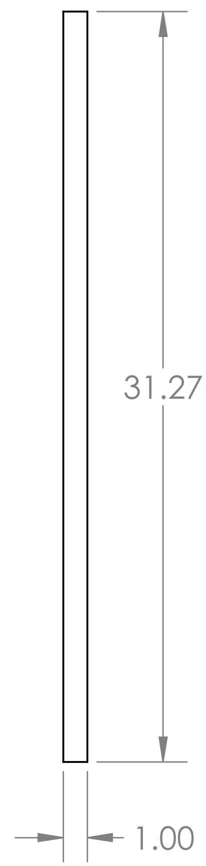
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

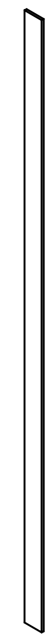




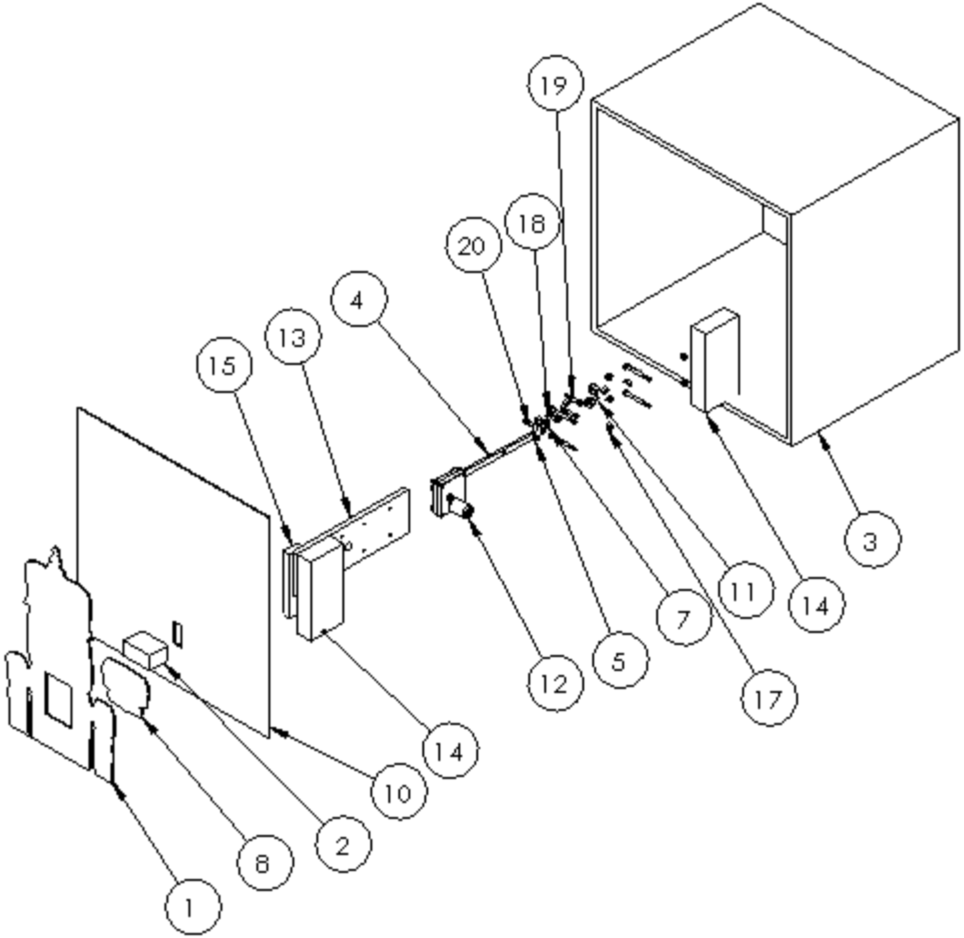
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: UGLY SWEATER PART	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 / Scale: 1:4	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED



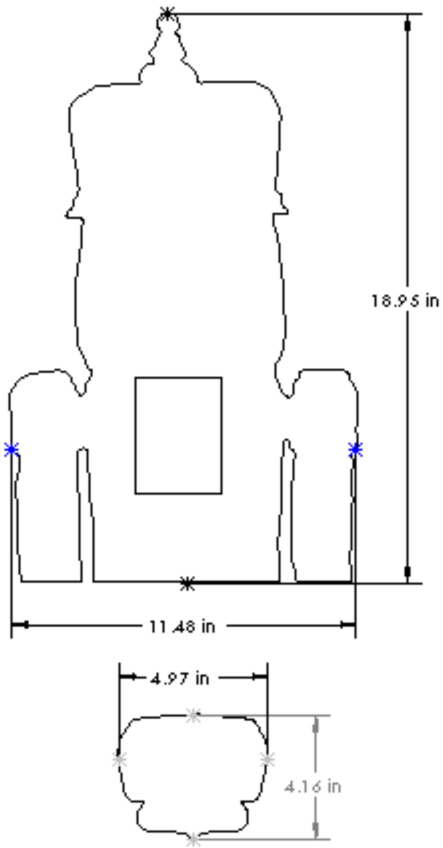


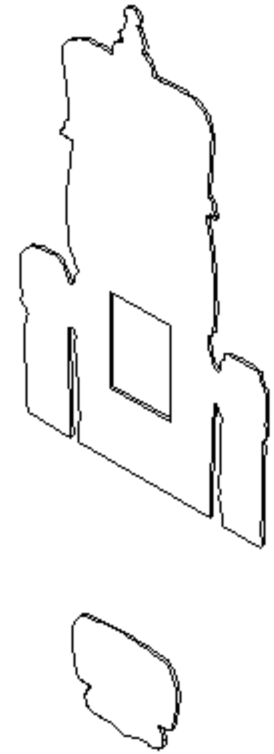
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: UGLY SWEATER POLE		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19	Scale: 1:8	Chkd. By: ME STAFF



ITEM NO.	PART NUMBER	QTY.
1	Day21_Nutcracker(Part1)	1
2	Day21_Nutcracker(Part2)	1
3	Day2,3,6,8,10,14,15,18,24_Box_Reference	1
4	Day21_Nutcracker(Linkage1)	1
5	Day21_Nutcracker(Linkage3)	1
6	Day21_Nutcracker(Shaft1)	2
7	Day21_Nutcracker(Linkage4)	1
8	Day21_Nutcracker(Beard1)	1
9	Day21_Nutcracker(ShaftHolder1)	1
10	Day21_Nutcracker(BackDrop)	1
11	6391K126	5
12	6409K17	1
13	Day21_Nutcracker(MotorBackSupport)	1
14	Day21_Nutcracker(WoodSupport1)	2
15	Day21_Nutcracker(WoodSupport3)	1
16	91247A552	4
17	95615A120	7
18	90295A155	6
19	91247A546	2
20	91247A550	1
21	94105A190	1

Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Nutcracker Assembly	Drwn. By: Danny Clifton
ME ### - Qtr Year	Dwg.#:	Nxt Asb:	Date: 04/27/19 — Scale: 1:12	Chkd. By: ME STAFF





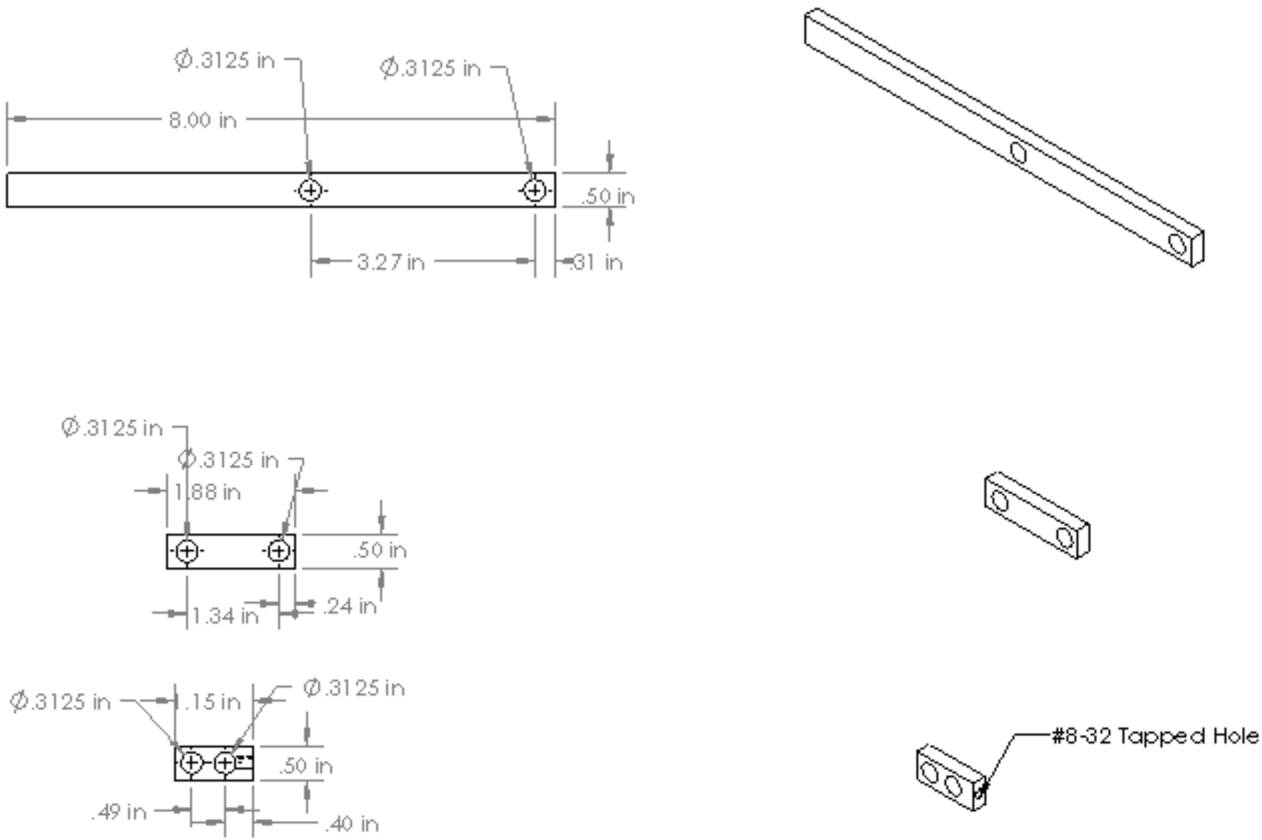
These cutouts are to be made of 1/8 inch thick wood

UNLESS OTHERWISE SPECIFIED:		NAME	DATE	
	DRAWN			
	CHECKED			TITLE:
	ENG APPR.			
	MFG APPR.			
	Q.A.			
	COMMENTS:			SIZE B DWG. NO. Day21_Nutcracker(Part1)(Drawin REV
MATERIAL				
FINISH				
DO NOT SCALE DRAWING				SCALE: WEIGHT: SHEET 1 OF 1

PROPRIETARY AND CONFIDENTIAL

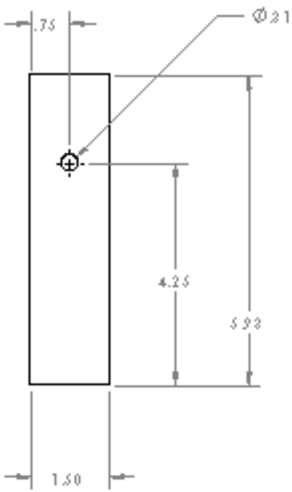
NEXT ASSY | USED ON

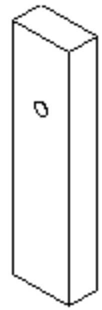
APPLICATION



All these linkages are made of 1/4 inch thick aluminum stock

Cal Poly Mechanical Engineering	Lab Section:	Assignment#	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF





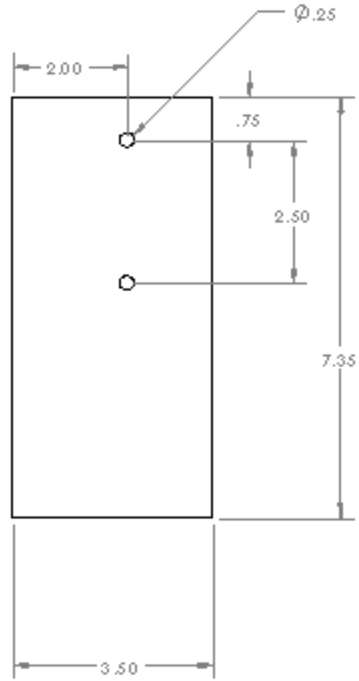
This is made from 3/4 inch wood

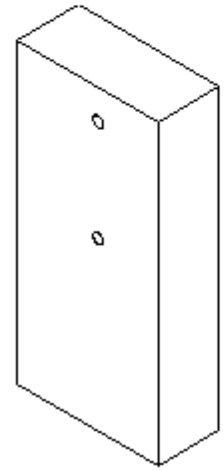
TITLE:

SIZE B DWG. NO. REV

Day21_Nutcracker(WoodSupport3)(D

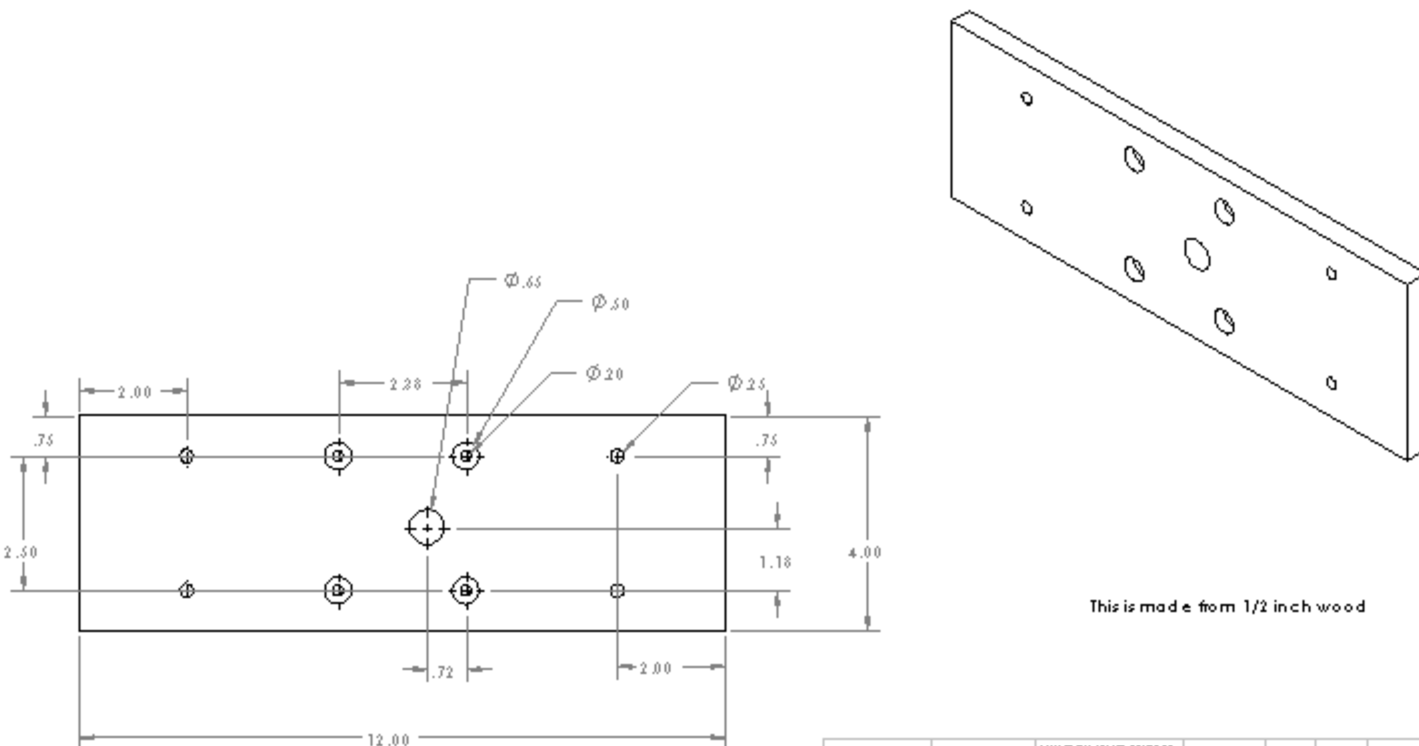
SCALE: 1:2 WEIGHT: SHEET 1 OF 1





This is made from 1.5 inch wood

TITLE:	
SIZE	B
DWG. NO.	Day21_Nutcracker(WoodSupport1) (D
REV	
SCALE: 1:2	WEIGHT:
SHEET 1 OF 1	

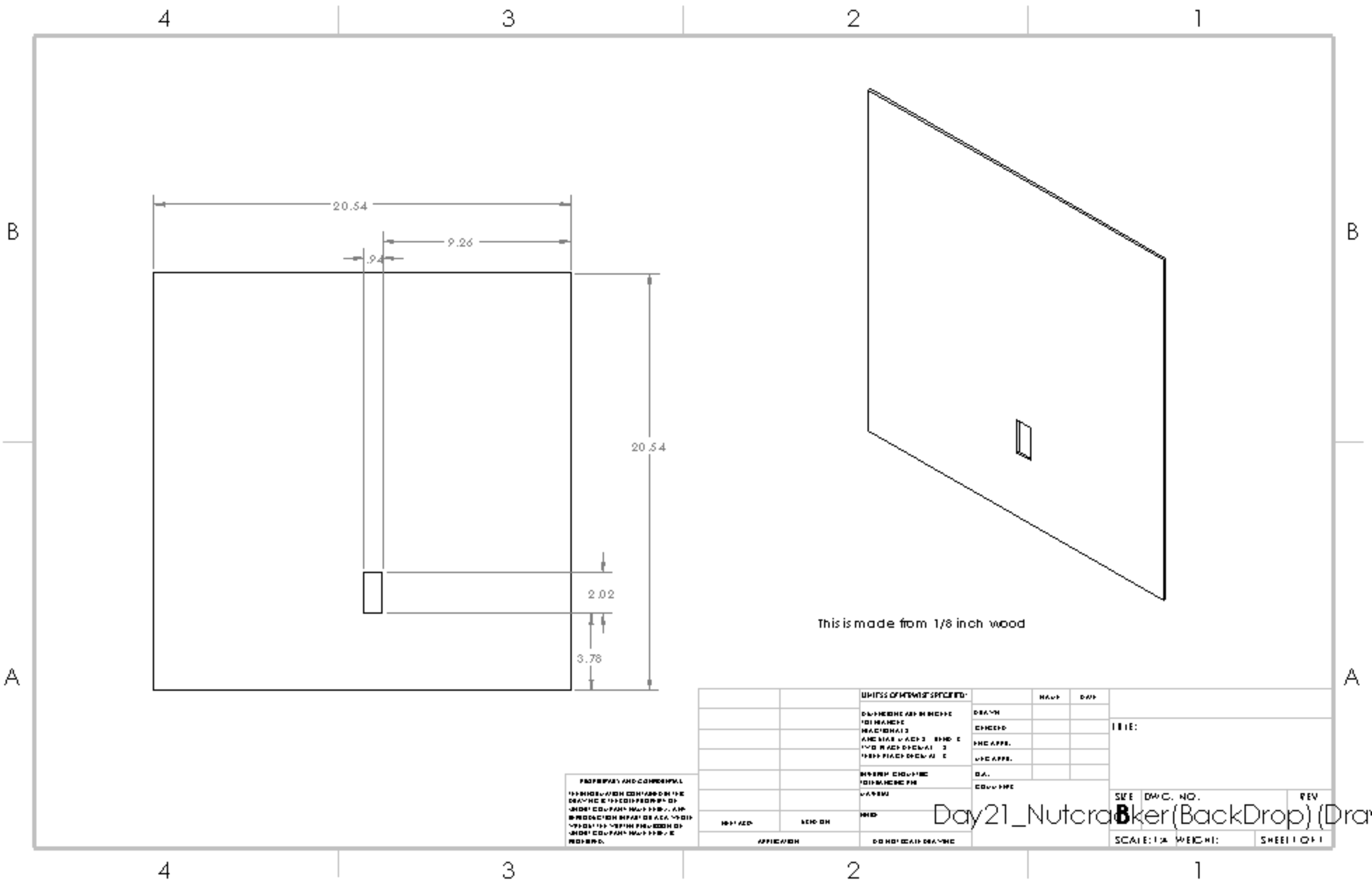


This is made from 1/2 inch wood

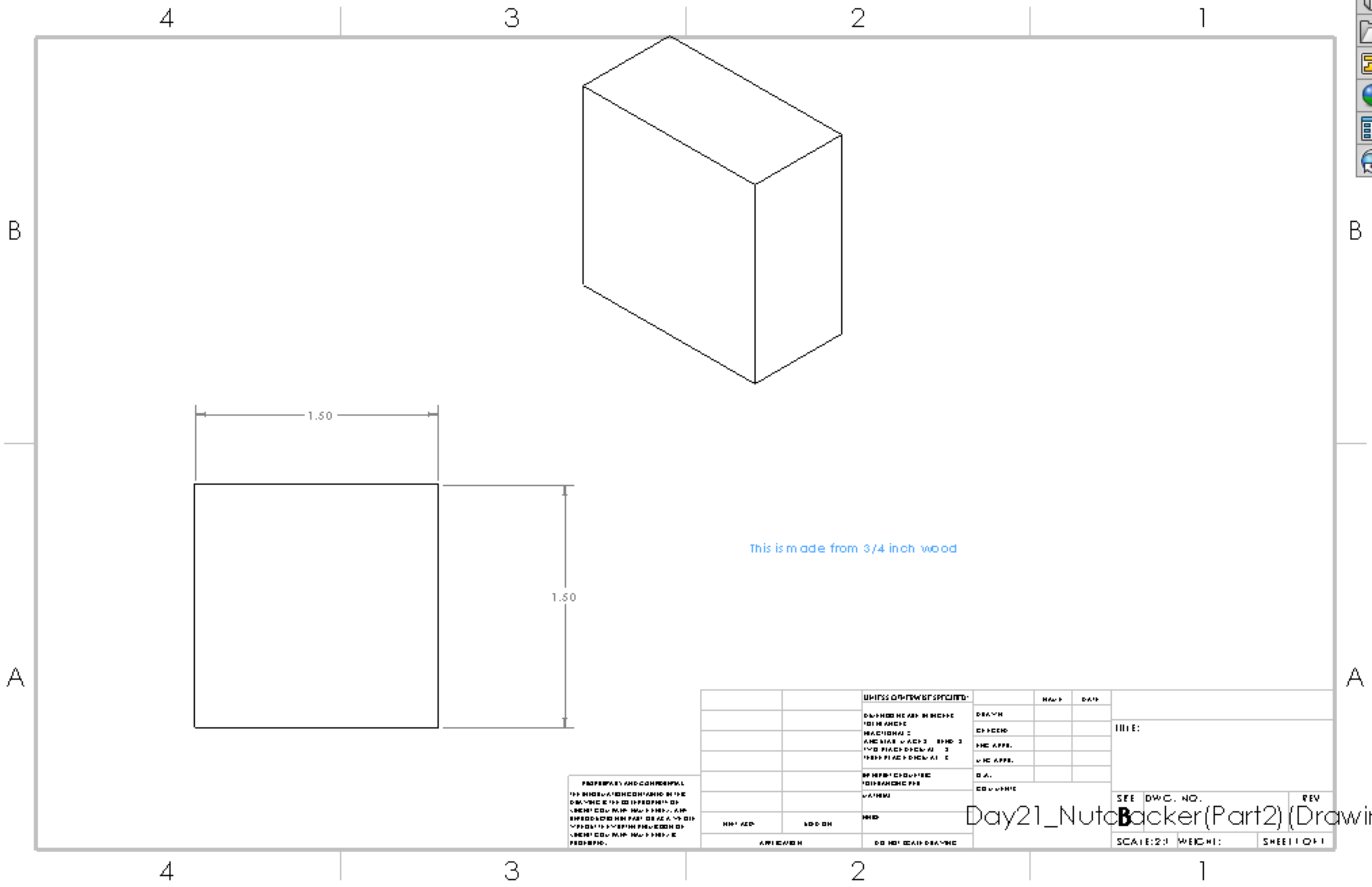
TITLE:

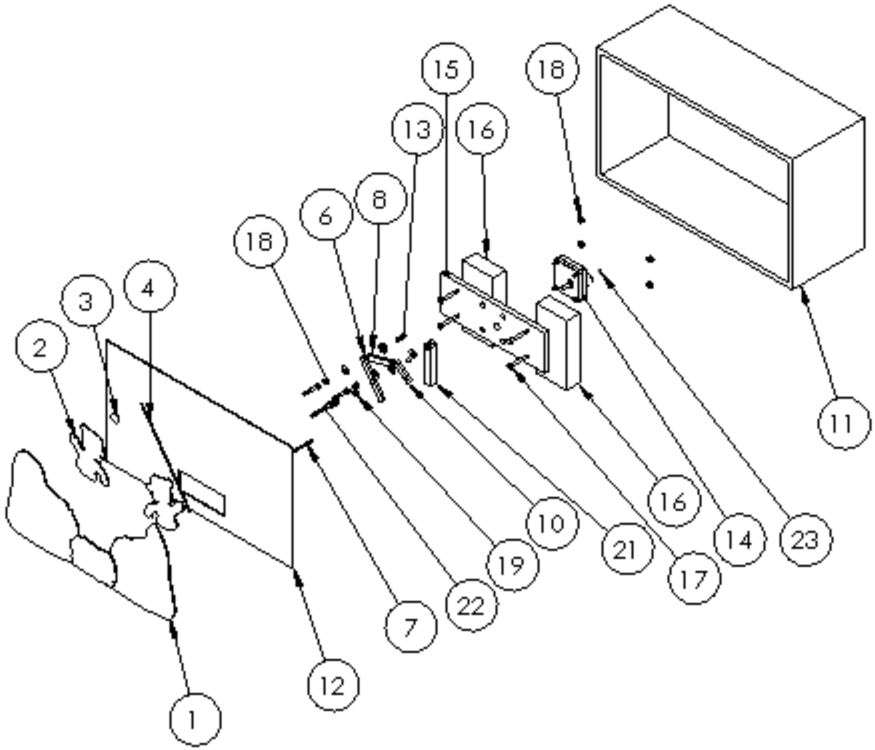
SIZE B DWG. NO. Day21_Nutcracker(MotorBackSupport)(Mo REV

SCALE: 1:2 WEIGHT: SHEET 1 OF 1



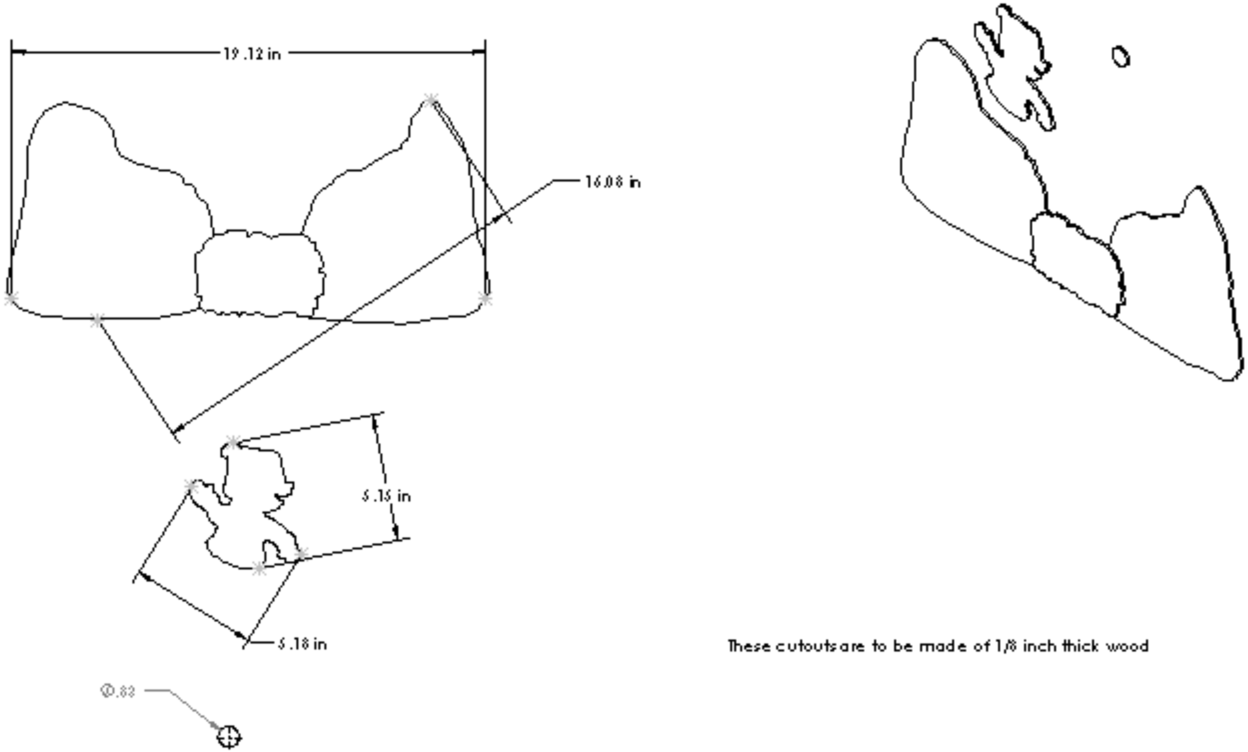
20.54
9.26
.94
20.54
2.02
3.78
This is made from 1/8 inch wood
UNLESS OTHERWISE SPECIFIED:
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
TITLE:
PROPRIETARY AND CONFIDENTIAL
NEXT ASSY
USED ON
APPLICATION
DO NOT SCALE DRAWING
SIZE
DWG. NO.
REV
B
Day21_Nutcracker(BackDrop) (Dra
WEIGHT:
SHEET 1 OF 1


1.50
1.50
This is made from 3/4 inch wood
TITLE:
SIZE
B
DWG. NO.
REV
Day21_Nutcracker(Part2)(Drawi
SCALE:2:1
WEIGHT:
SHEET 1 OF 1
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
COMMENTS:
NAME
DATE
UNLESS OTHERWISE SPECIFIED:
PROPRIETARY AND CONFIDENTIAL
DO NOT SCALE DRAWING
APPLICATION



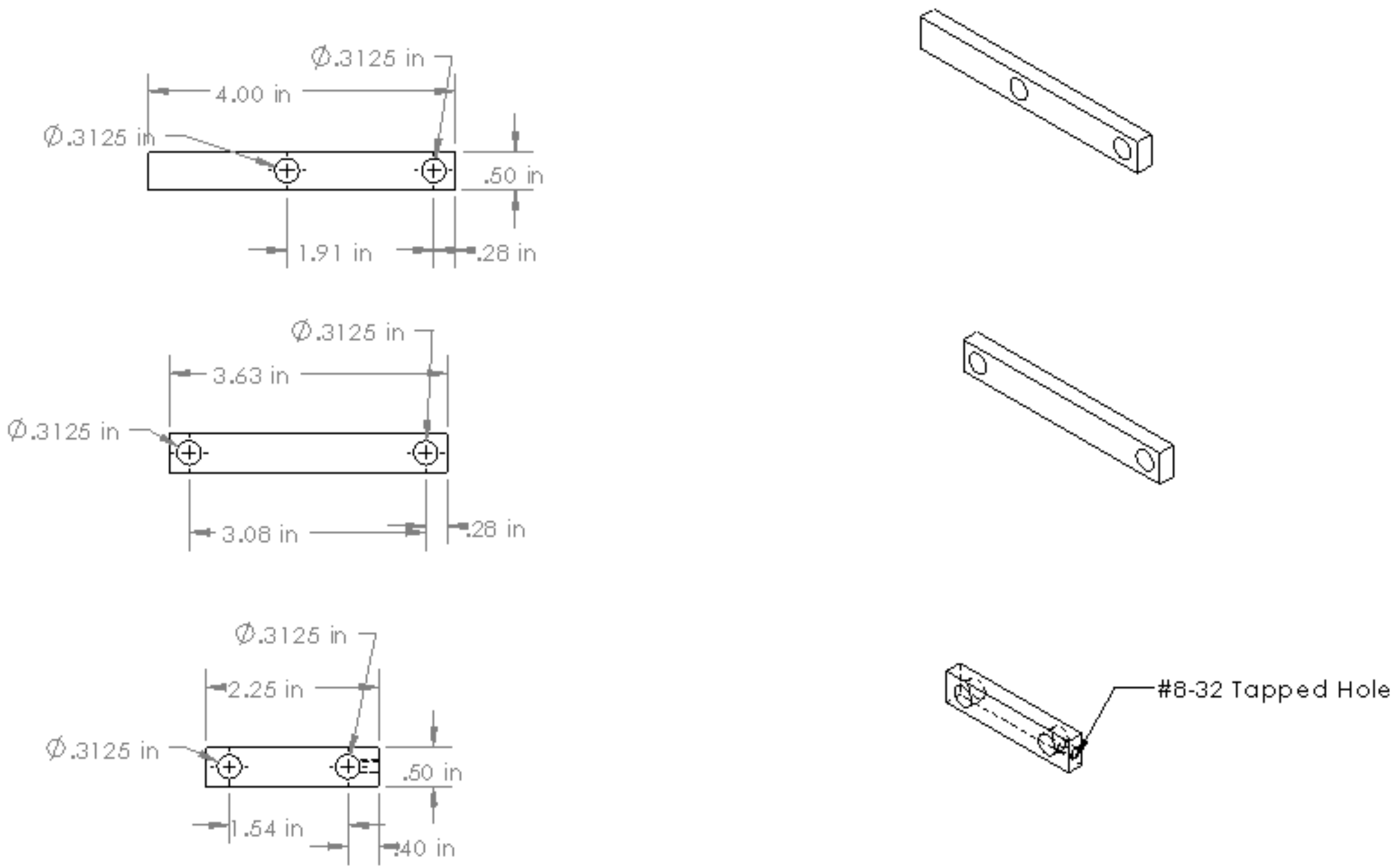
ITEM NO.	PART NUMBER	QTY.
1	Day22_Snowballfight(Part2)	1
2	Day22_Snowballfight(Part3)	2
3	Day22_Snowballfight(Part5)	1
4	Day22_Snowballfight(Part6)	1
5	Day22_Snowballfight(Shaft2)	1
6	Day22_SnowballFight(Linkage1)	1
7	Day22_SnowballFight(Block1)	1
8	Day22_SnowballFight(Linkage2)	1
9	Day22_Snowballfight(Shaft3)	2
10	Day22_Snowballfight(Linkage4)	1
11	Day22_Box_Reference	1
12	Day22_Snowballfight(BackDrop)	1
13	6391K126	5
14	6409K17	1
15	Day22_Snowballfight(MotorBackSupport)	1
16	Day22_Snowballfight(WoodSupport1)	2
17	91247A552	4
18	95615A120	7
19	90295A155	8
20	91247A546	2
21	Day22_Snowballfight(WoodSupport3)	1
22	91247A550	1
23	94105A190	1

Cal Poly Mechanical Engineering	Lab Section:	Assignment#	Title: Snowballfight Assembly	Drwn. By: Danny Clifton
ME ### - Qtr Year	Dwg.#:	Nxt Asb:	Date: 04/27/19 Scale: 1:12	Chkd. By: ME STAFF



These cutouts are to be made of 1/8 inch thick wood

Day22_SnowBallfight(Part2)(Draw



All these linkages are made of 1/4 inch thick aluminum stock

Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

This will be made from an acrylic rod

TITLE:

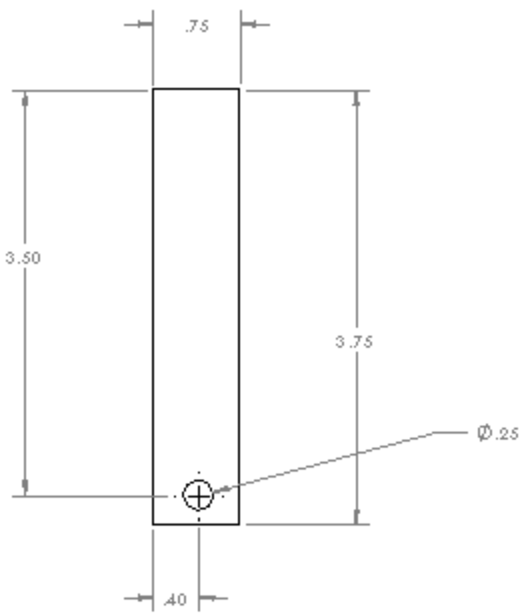
SIZE B

DWG. NO.

Day22_Snowballfight(Part6)(Draw

REV

SCALE: 1:2 WEIGHT: SHEET 1 OF 1



This will be made from 3/4 inch wood

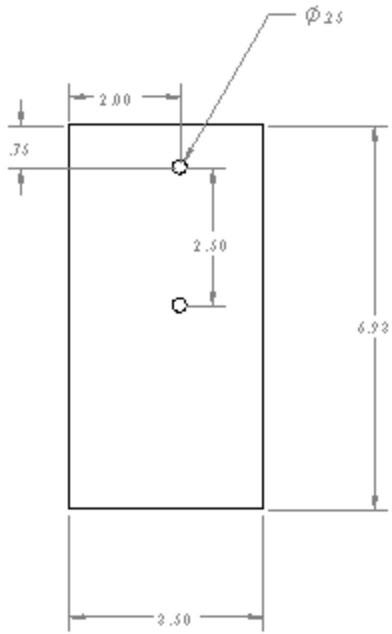
UNLESS OTHERWISE SPECIFIED:	
	NAME / DATE
DRAWN	
CHECKED	
ENG APPR.	
MFG APPR.	
Q.A.	
COMMENTS:	
NEXT ASSY / USED ON	
APPLICATION	DO NOT SCALE DRAWING

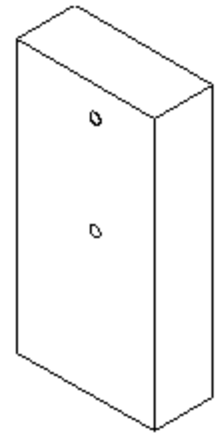
PROPRIETARY AND CONFIDENTIAL

TITLE:

SIZE B DWG. NO. Day22_Snowballfight (WoodSupport3) REV

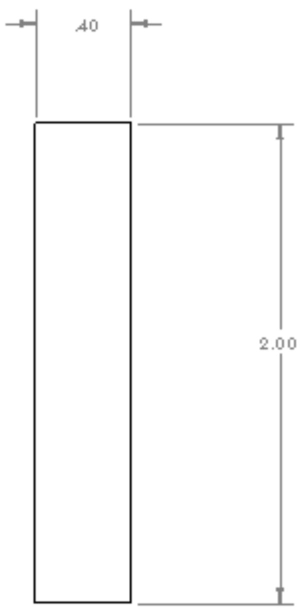
SCALE: 1:1 WEIGHT: SHEET 1 OF 1





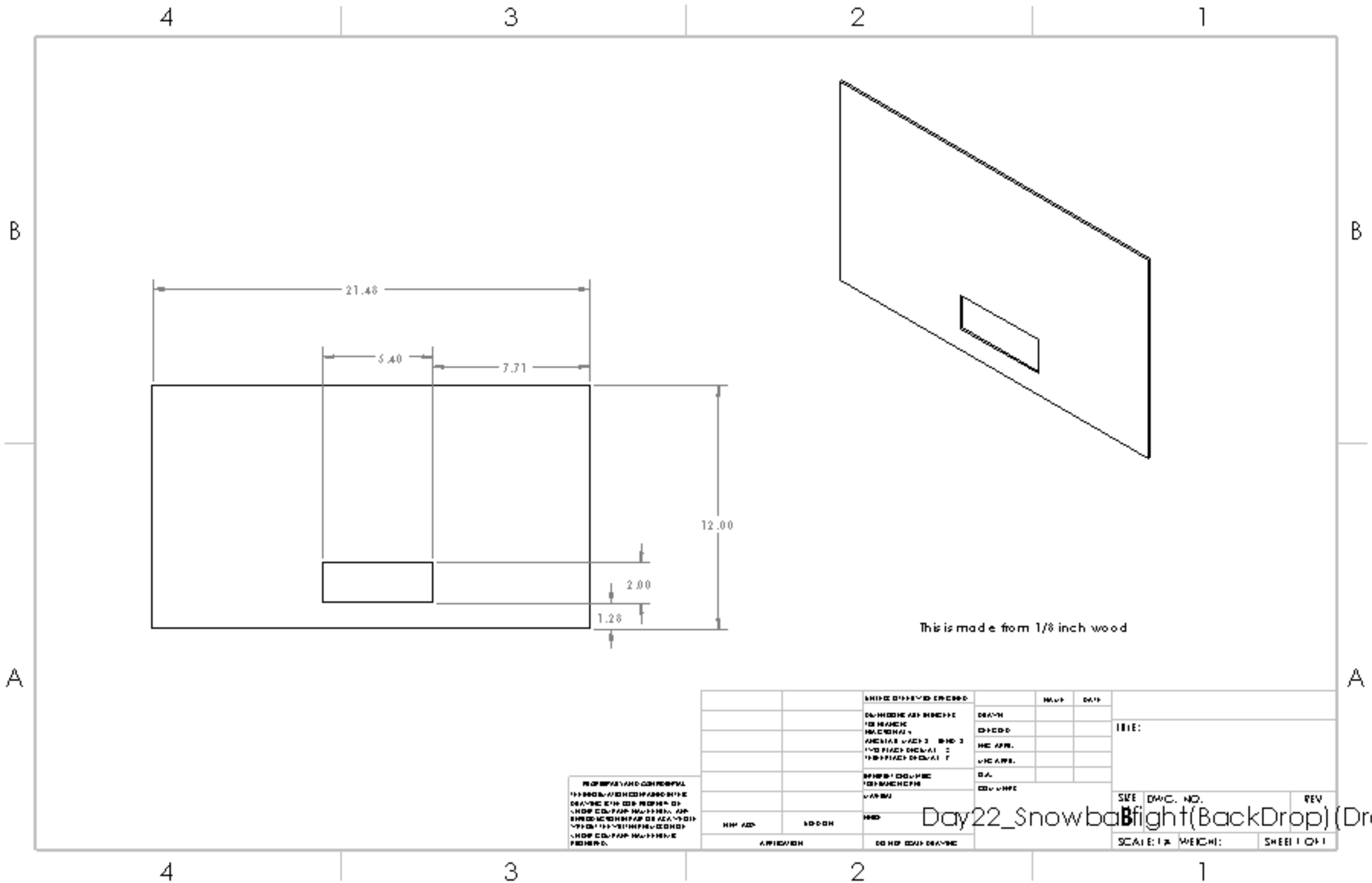
This will be made from 1.5 inch wood

TITLE:		
SIZE	DWG. NO.	REV
B	Day22_Snowballfight(WoodSupport1)(	
SCALE: 1:2	WEIGHT:	SHEET 1 OF 1

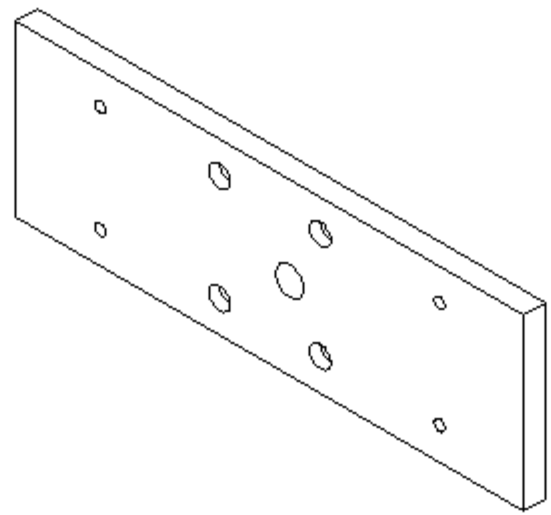


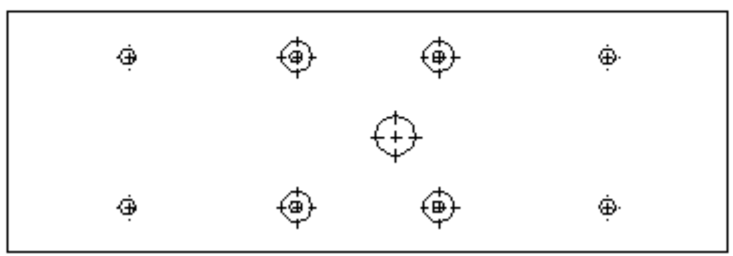
This will be made from 1/8 inch wood

TITLE:	
SIZE	B
DWG. NO.	Day22_Snowballfight(Block1)(Drav
REV	
SCALE: 2:1	WEIGHT:
SHEET 1 OF 1	



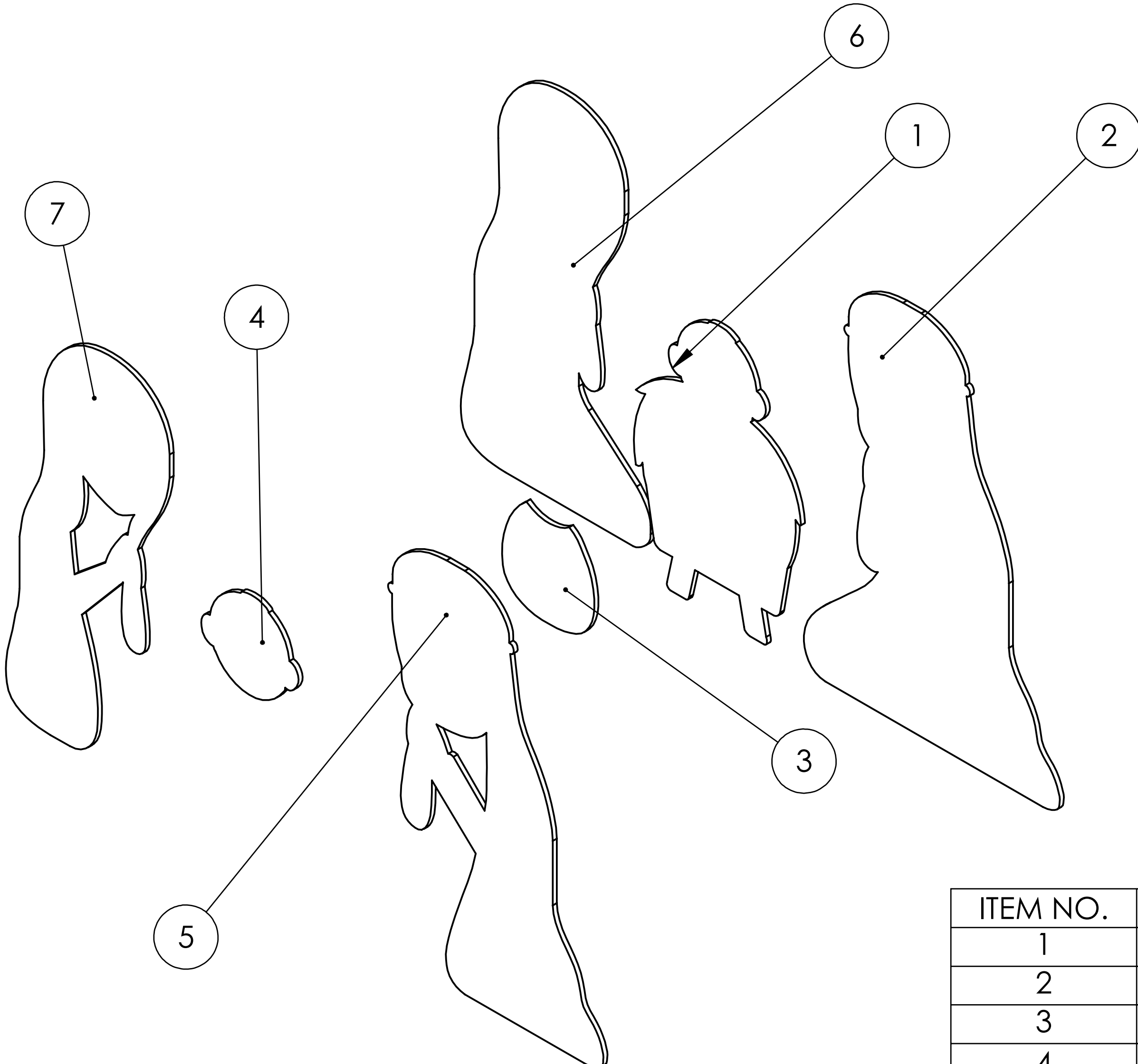
4
3
2
1
B
A
21.48
5.40
7.71
12.00
2.00
1.28
This is made from 1/8 inch wood
TITLE:
SIZE
B
DWG. NO.
REV
Day22_Snowballfight(BackDrop)(Dr
WEIGHT:





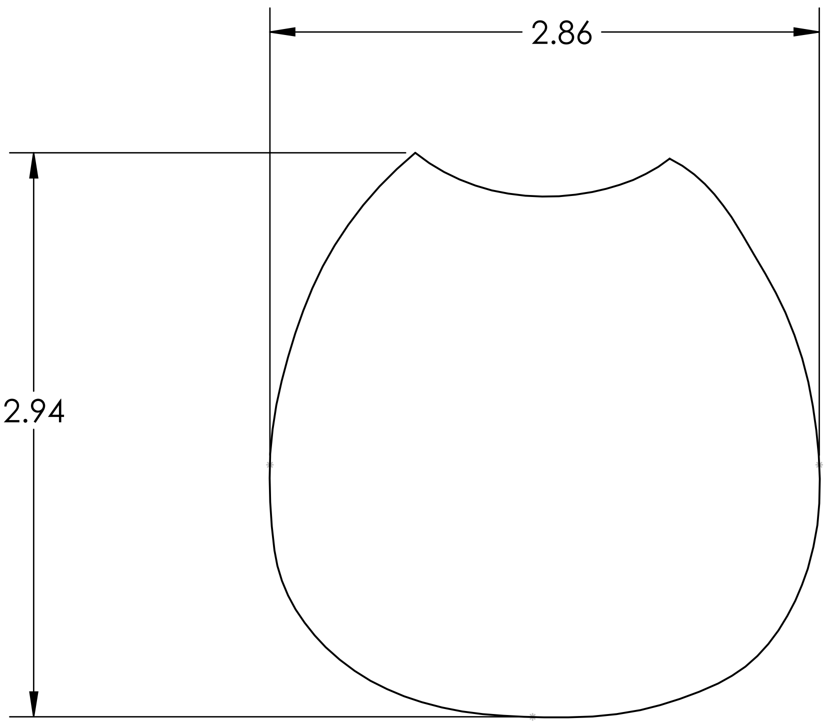
Refer to Day21_Nutcracker(MotorBackSupport)

UNLESS OTHERWISE SPECIFIED:	
DRAWN	
CHECKED	
ENG APPR.	
MFG APPR.	
Q.A.	
COMMENTS:	
TITLE:	
SIZE B	DWG. NO. Day22_Snowballfight(MotorBackSuppor
REV	
SCALE: 1:2	WEIGHT:
SHEET 1 OF 1	
APPLICATION	DO NOT SCALE DRAWING
PROPRIETARY AND CONFIDENTIAL	

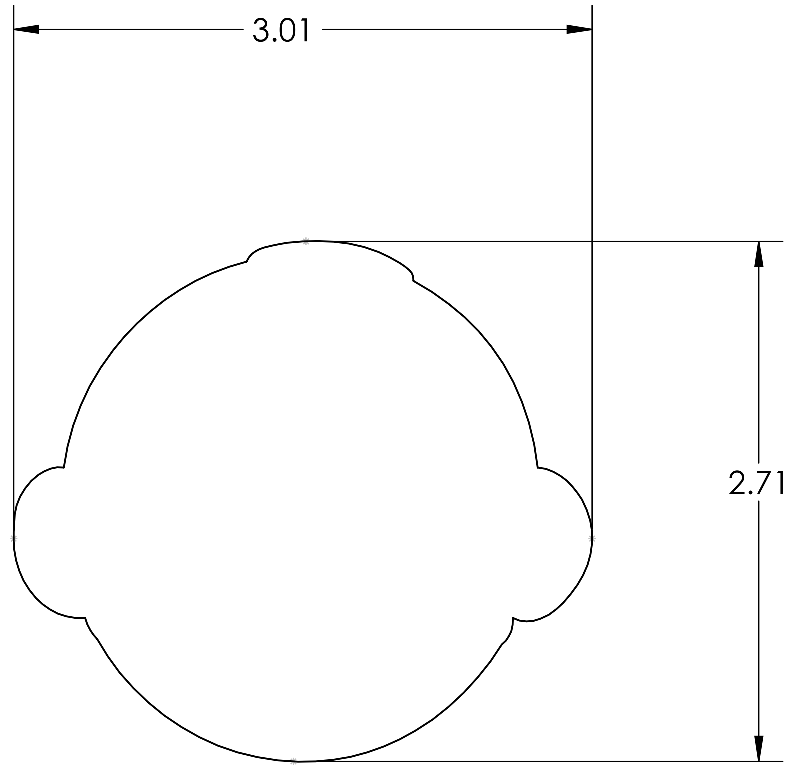


ITEM NO.	PART NUMBER	QTY.
1	Jesus Trough	1
2	Joseph Body	1
3	Jesus Body	1
4	Jesus Head	1
5	Joseph Scarf&Head	1
6	Marry Body	1
7	Marry Scarf&Head	1
8	Day23_Box_Referenc e	1
9	Mount Post	2

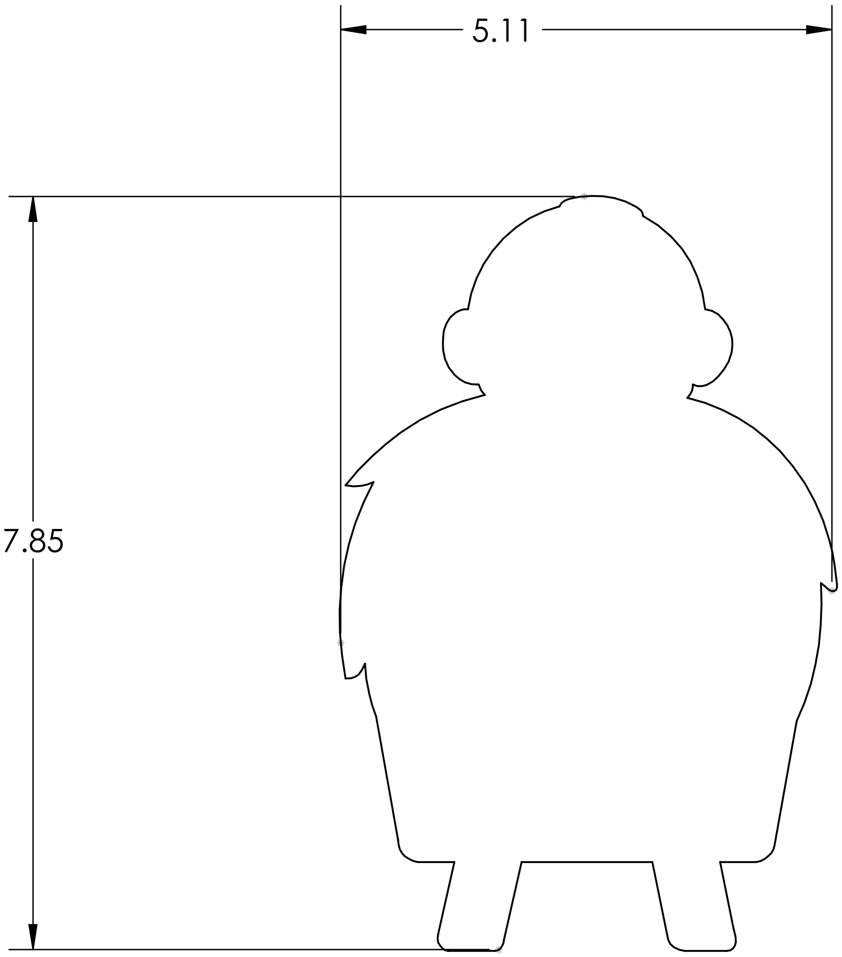
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



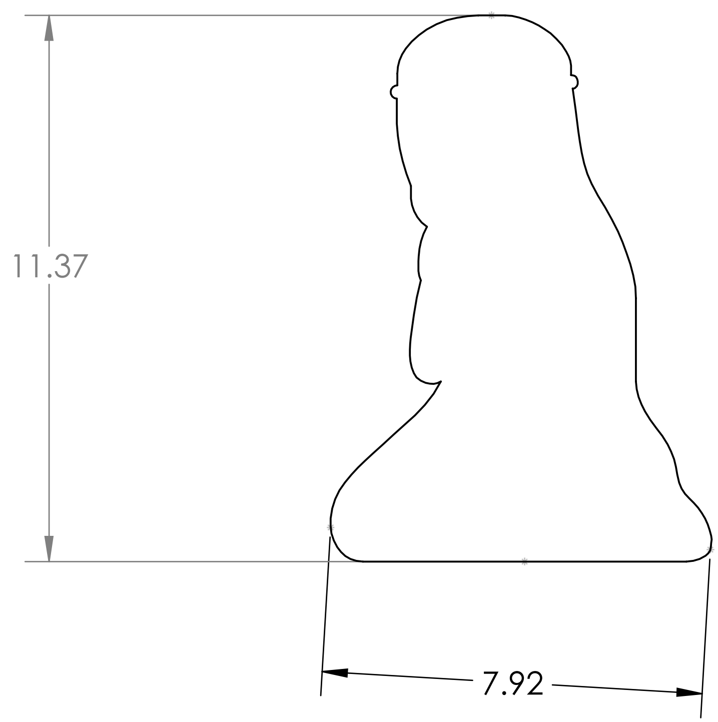
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



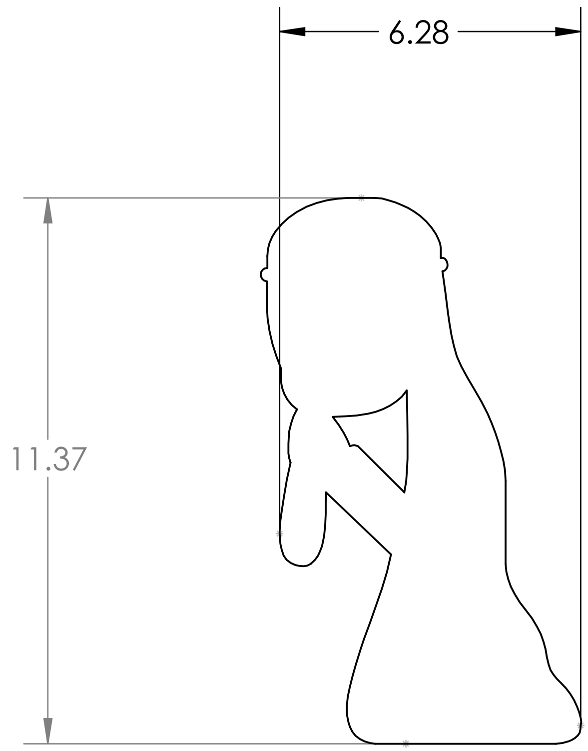
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



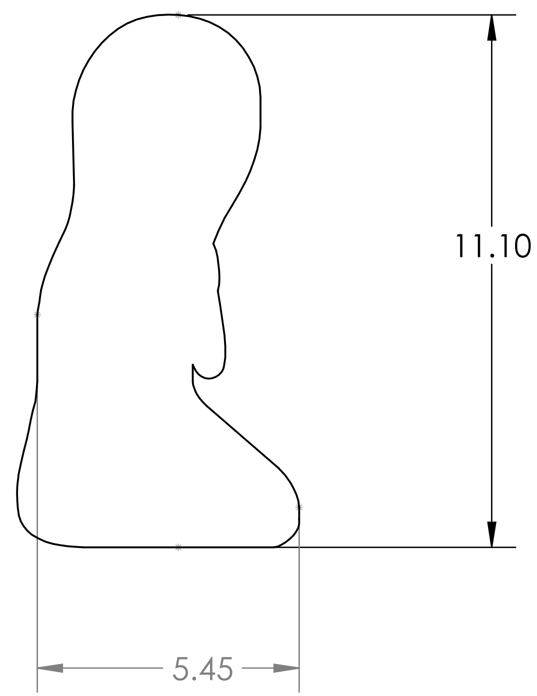
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



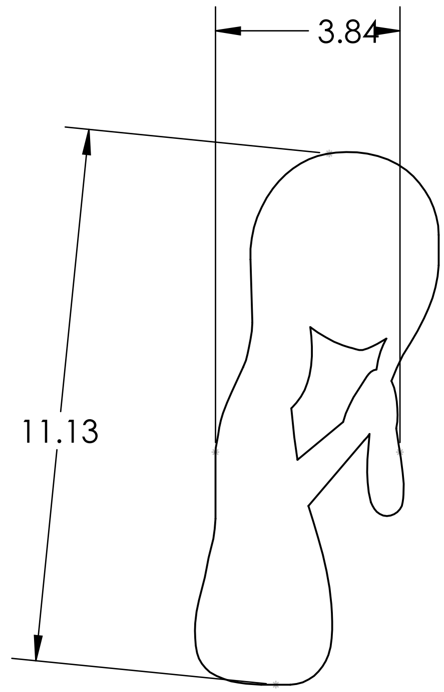
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

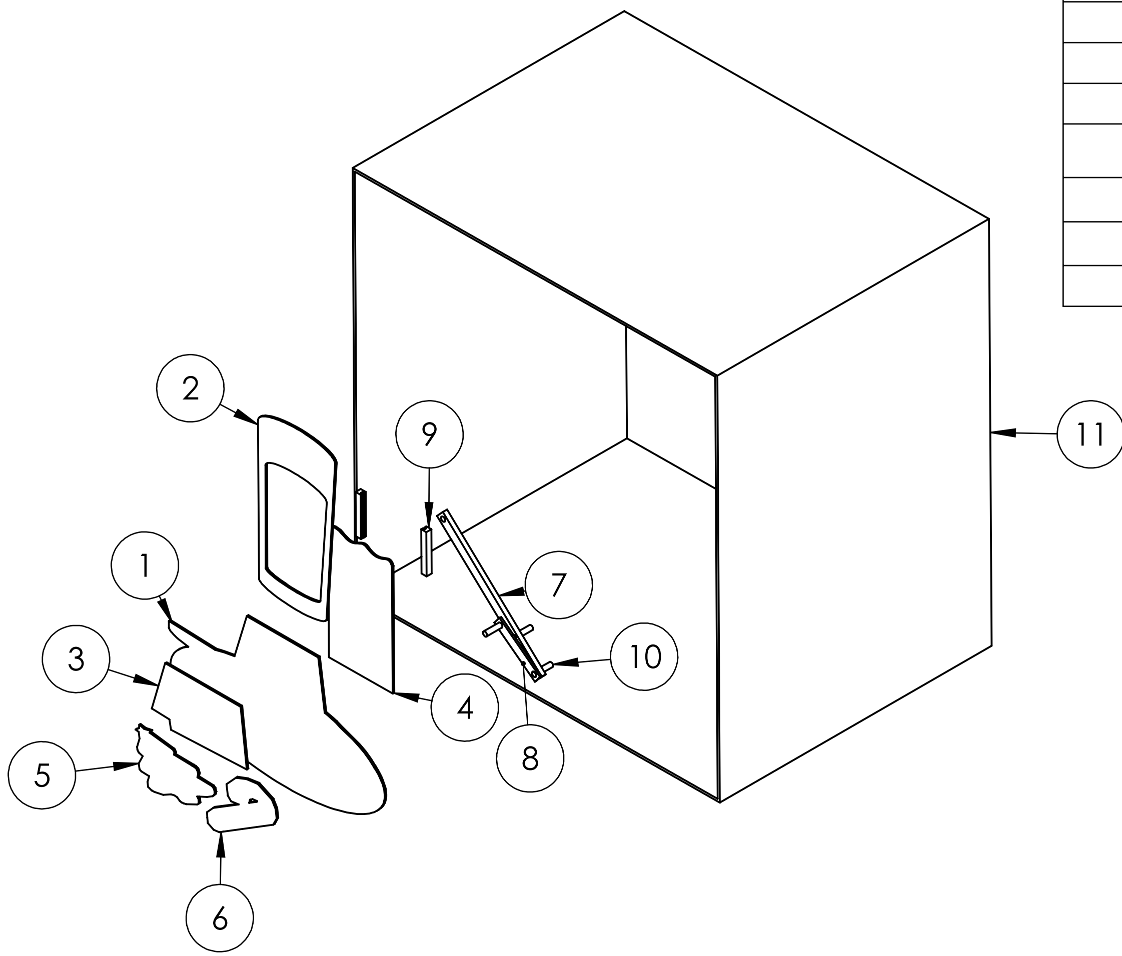


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: Scale:	Chkd. By: ME STAFF

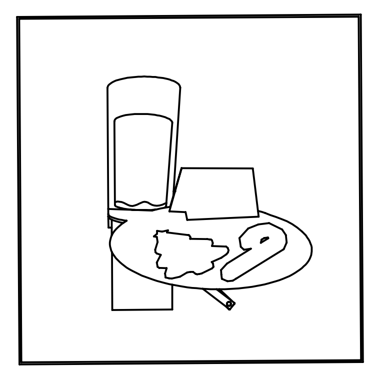


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Cookie Tray Base	1/8" Wood	1
2	milk cup	1/8" Wood	1
3	santa tag	1/8" Wood	1
4	milk	1/8"Wood	1
5	cookie 1	1/8" Wood	1
6	cookie 2	1/8" Wood	1
7	Arm 1	1/8" Wood	1
8	arm 2	1/8" Wood	1
9	brace	1/8" Wood	2
10	dowel	1/8" Wood	3
11	box 24	1/8" Wood	1



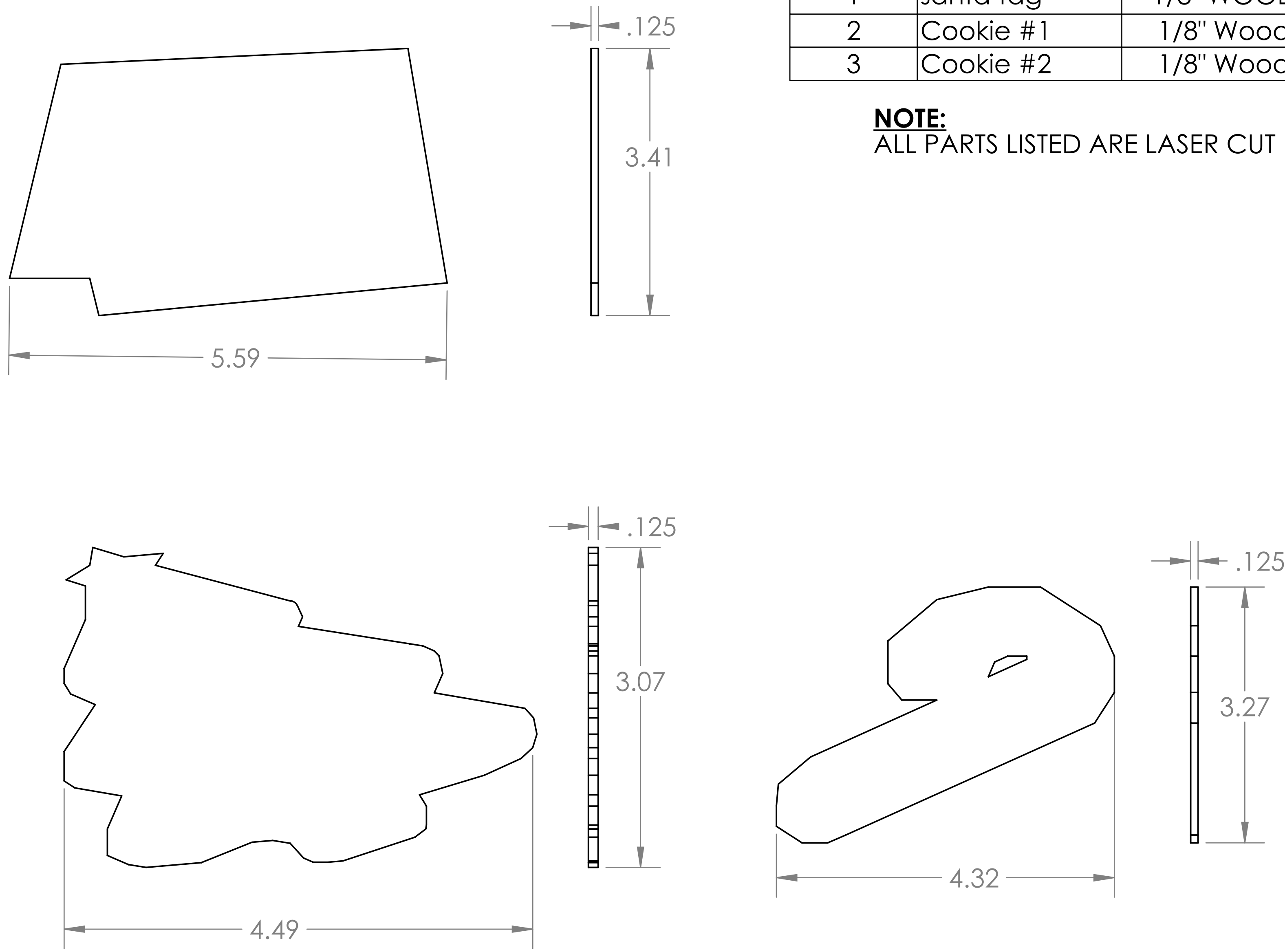
Front View



Cal Poly Mechanical Engineering ME 429 Spring 2019	Lab Section:	Assignment #	Title: Milk and Cookies Assembly	Drwn. By: Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date: 4/28/19 · Scale: 1/8	Chkd. By: ME STAFF

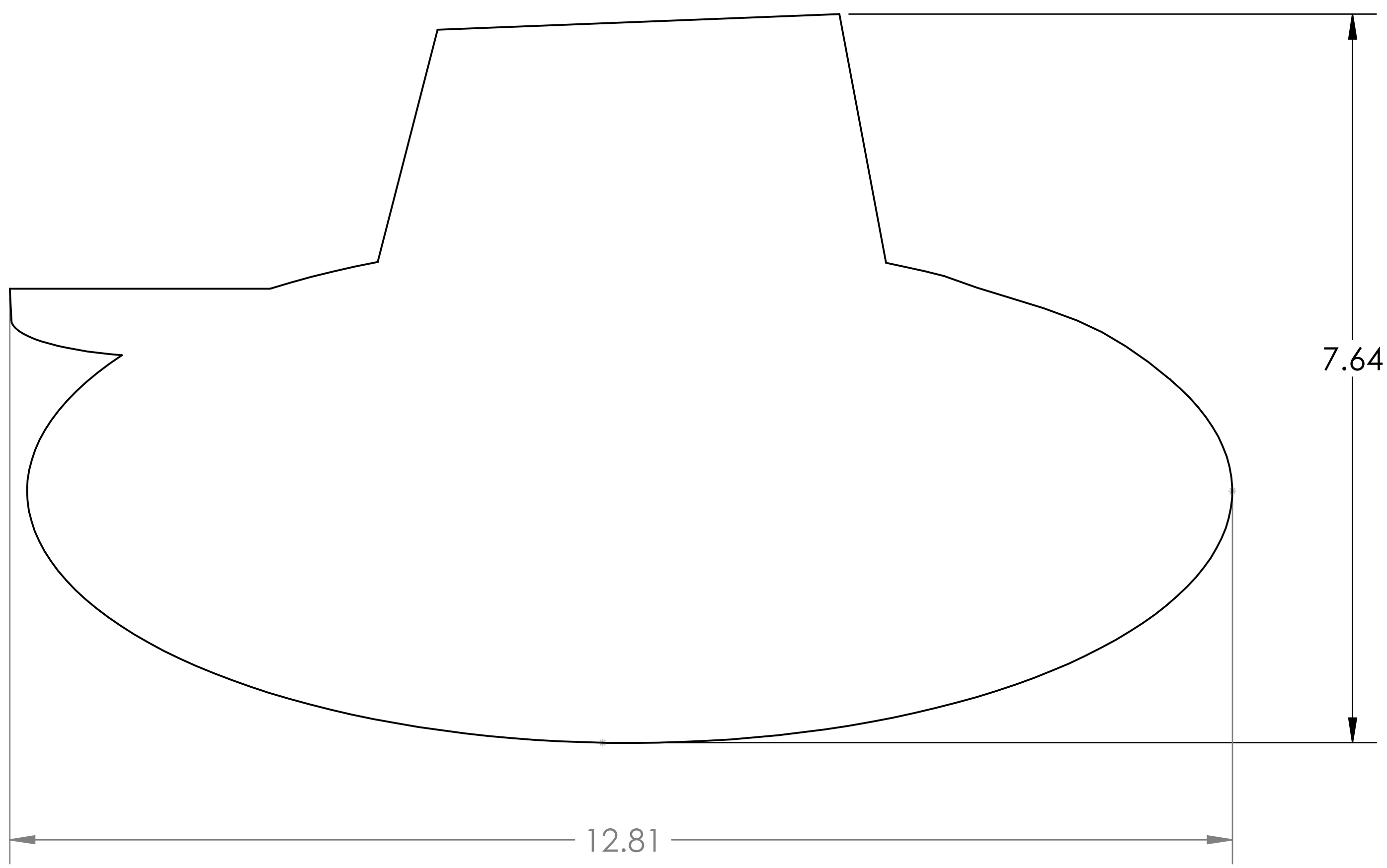
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	santa tag	1/8" WOOD	1
2	Cookie #1	1/8" Wood	1
3	Cookie #2	1/8" Wood	1

NOTE:
ALL PARTS LISTED ARE LASER CUT



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: Cookies and Santa Tag	Drwn. By: Sigrid Derickson
ME 429 Spring 2019	Dwg. #:	Nxt Asb:	Date: / Scale:2:3	Chkd. By: ME STAFF

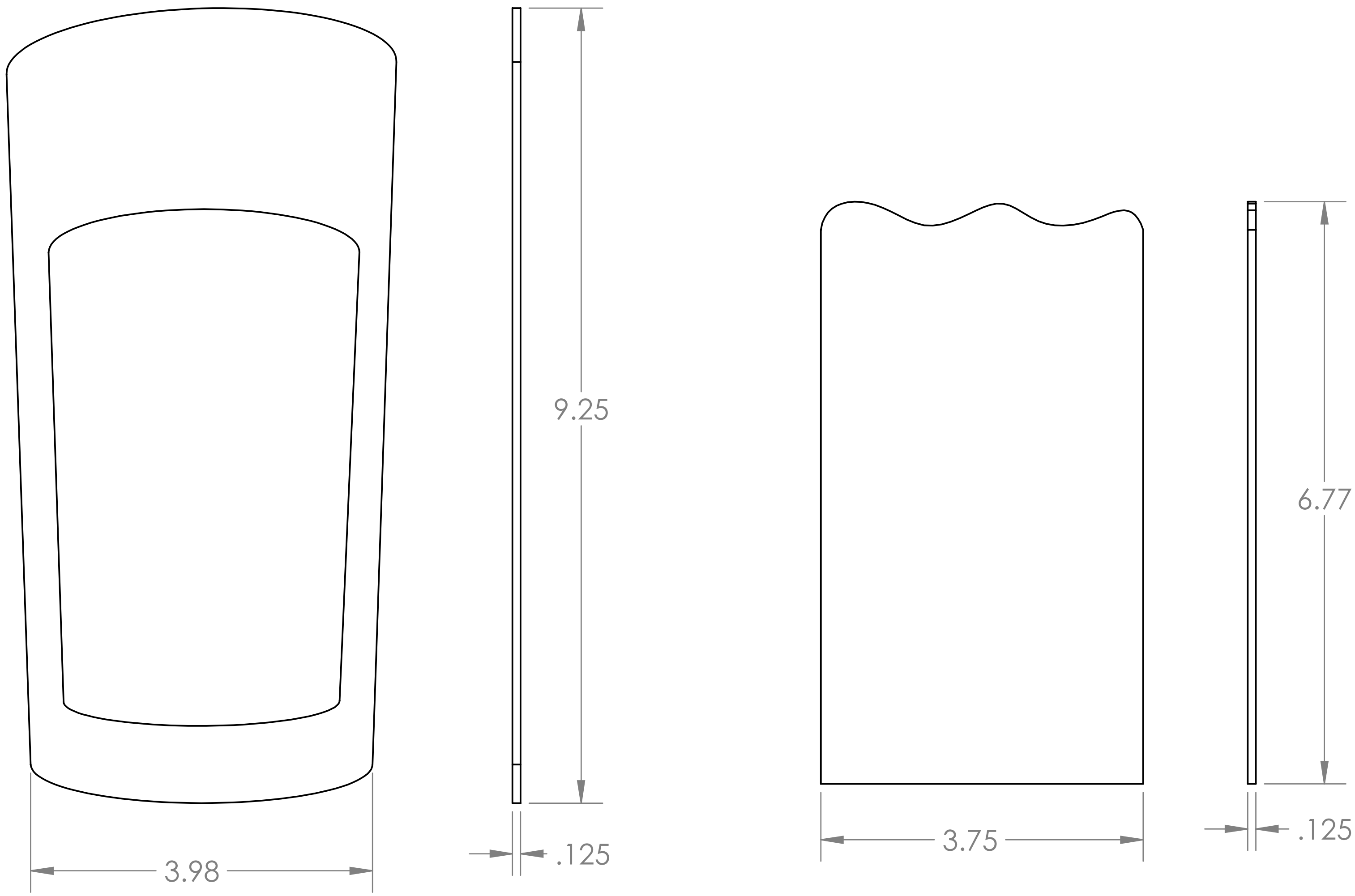
NOTE:
PART IS LASERCUT
MATERIAL IS 1/8" WOOD



Cal Poly Mechanical Engineering ME 429 SPRING 2019	Lab Section:	Assignment #	Title: MILK BASE		Drwn. By: SIGRID DERICKSON
	Dwg. #:	Nxt Asb:	DATE: 4/28/19	Scale:1:2	Chkd. By: ME STAFF

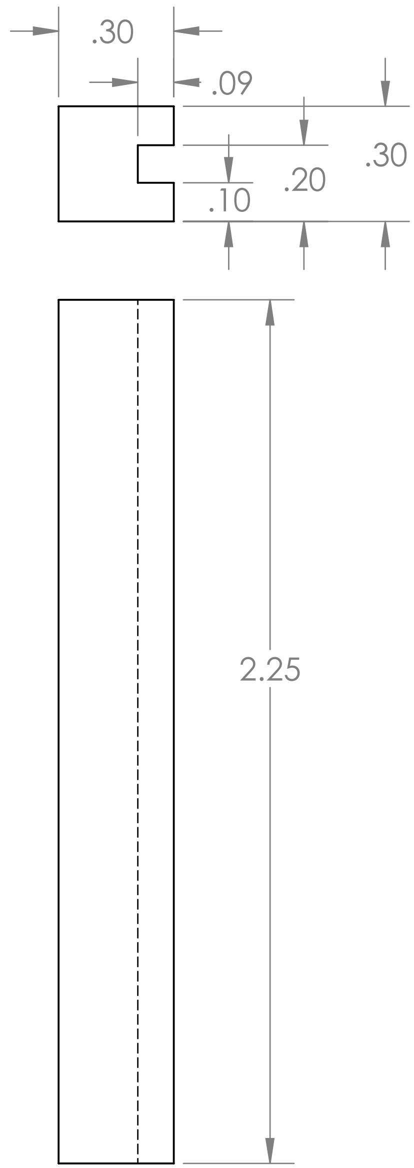
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	milk cup	1/8" Wood	1
2	milk	1/8" Wood	1

NOTE:
ALL PARTS WILL BE LASER CUT



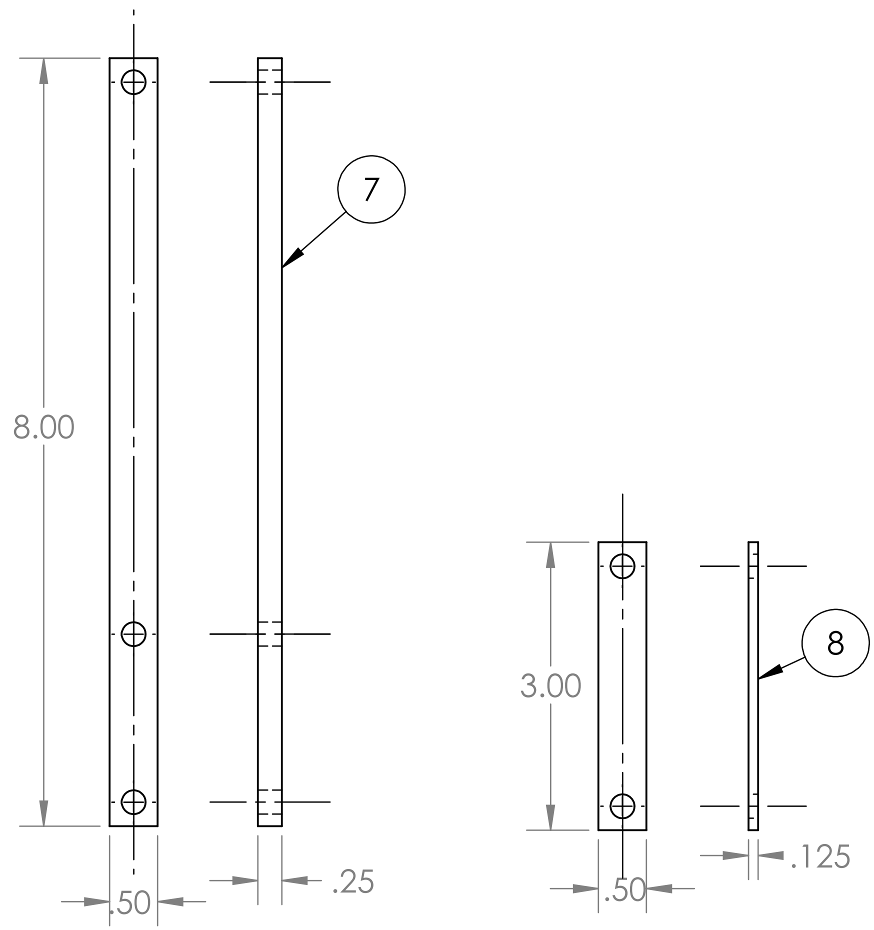
Cal Poly Mechanical Engineering ME 429 Spring 2019	Lab Section:	Assignment #	Title: Milk Cup and Milk	Drwn. By: Sigrid Derickson
	Dwg. #:	Nxt Asb:	Date: 4/28/19 · Scale: 1/2	Chkd. By: ME STAFF

NOTE:
PART IS A MODIFIED MADISON MILL SQUARE WOOD POPLAR DOWEL

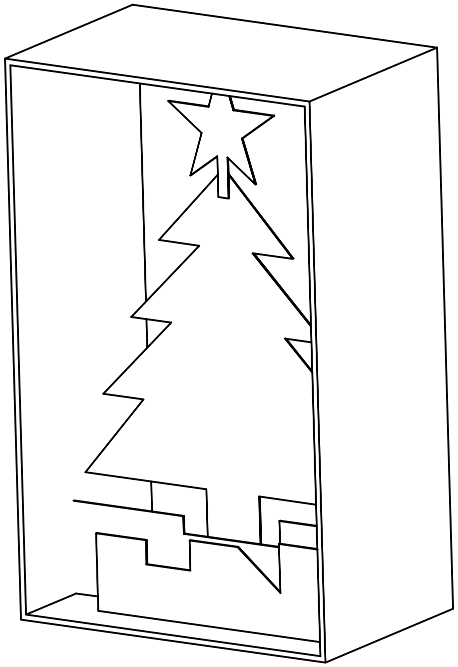


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: SUPPORT BRACE		Drwn. By: SIGRID DERICKSON
ME 419 SPRING 2019	Dwg. #:	Nxt Asb:	Date: 4/28/19	Scale: 2:1	Chkd. By: ME STAFF

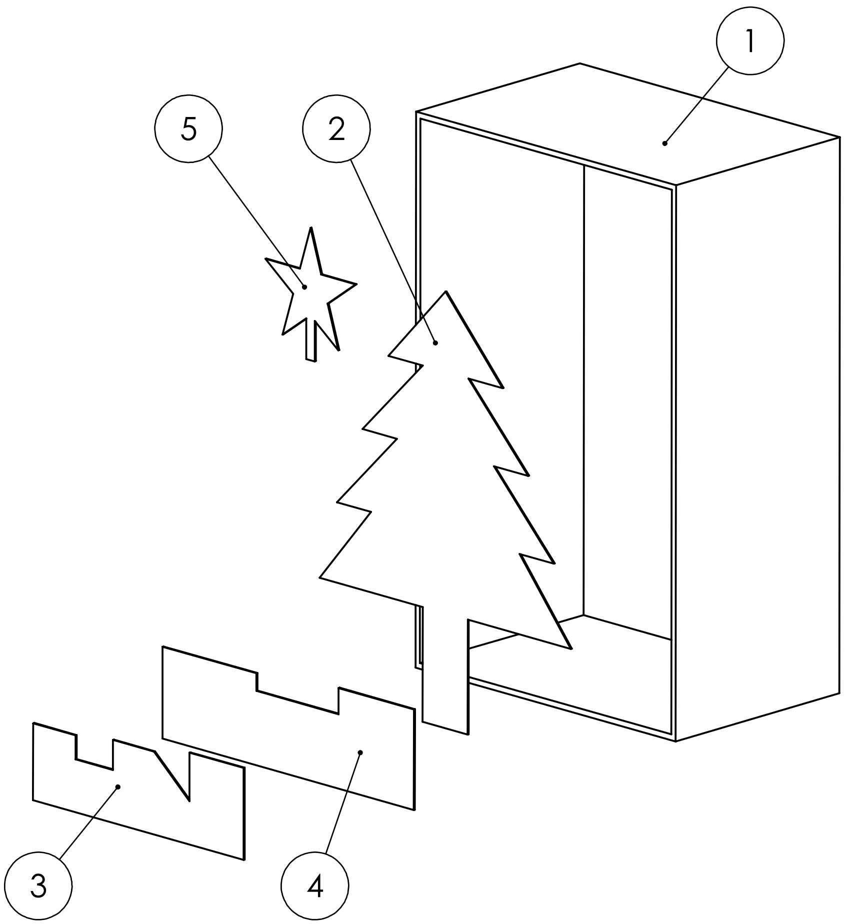
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
7	Arm 1	ALUMINUM FLAT BAR	1
8	ARM 2	ALUMINUM FLAT BAR	1



Cal Poly Mechanical Engineering ME 429 SPRING 2019	Lab Section:	Assignment #	Title: ALUMINUM LINKAGES	Drwn. By: SIGRID DERICKSON
	Dwg. #:	Nxt Asb:	Date:4/28/19 | Scale: 1/2	Chkd. By: ME STAFF

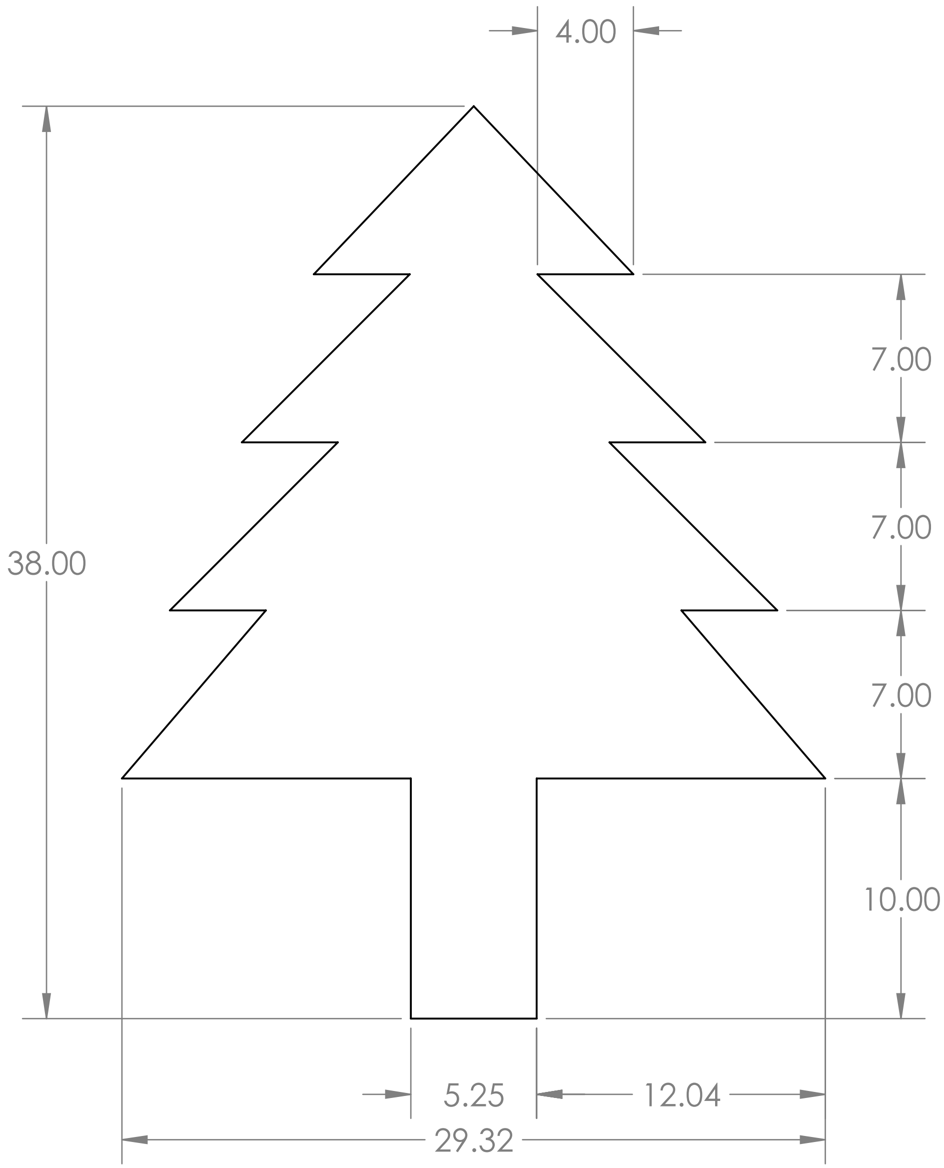


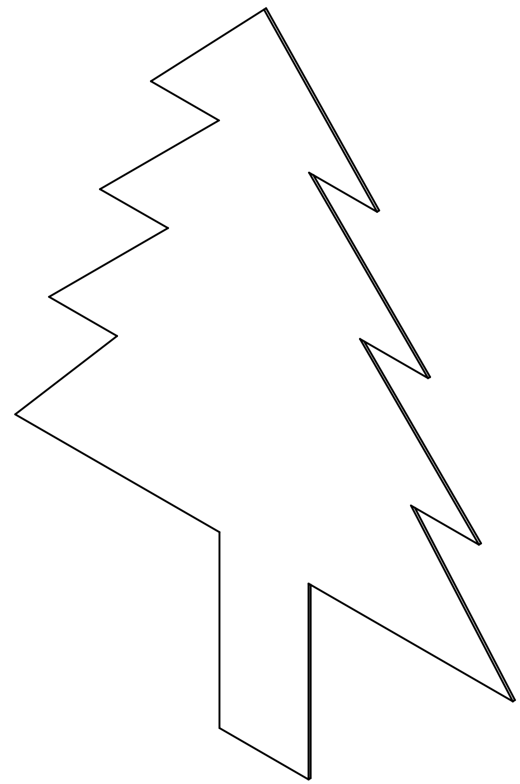
ITEM NO.	PART NUMBER	QTY.
1	Day25_Box_Reference	1
2	LivingRoomPart1_Tree(Day25)	1
3	LivingRoomPart2_Presents1(Day25)	1
4	LivingRoomPart3_Presents2(Day25)	1
5	LivingRoomPart4_Star(Day25)	1



Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title: CHRISTMAS TREE ASSEMBLY	Drwn. By: OMA SKYRUS
	Dwg. #:	Nxt Asb:	Date: 04/25/19 · Scale: 1:16	Chkd. By: ME STAFF

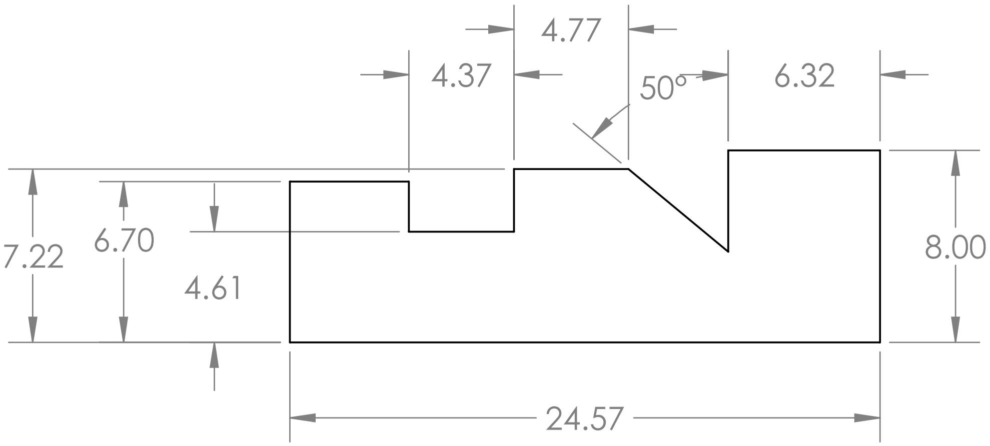
NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

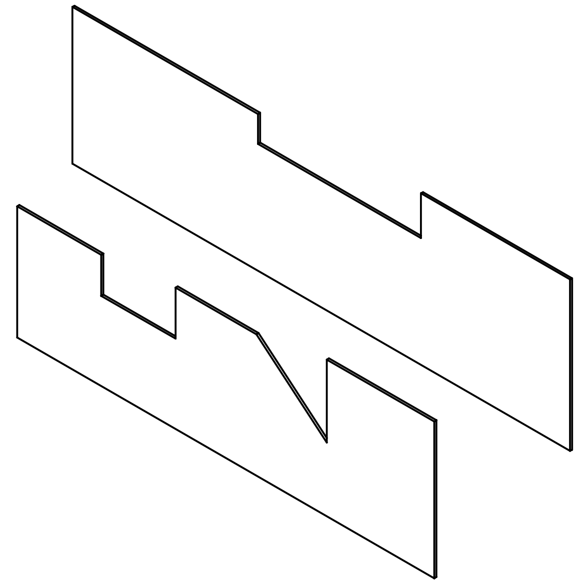


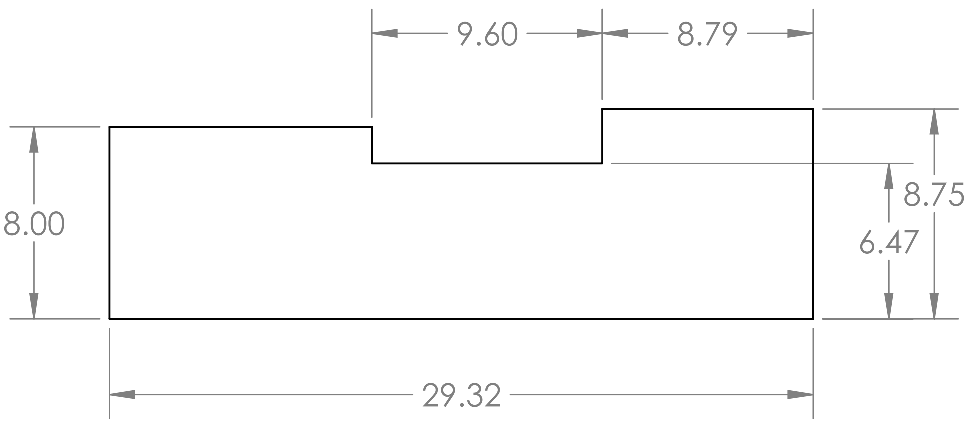


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: CHRISTMAS TREE	Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19 / Scale: 1:8	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED

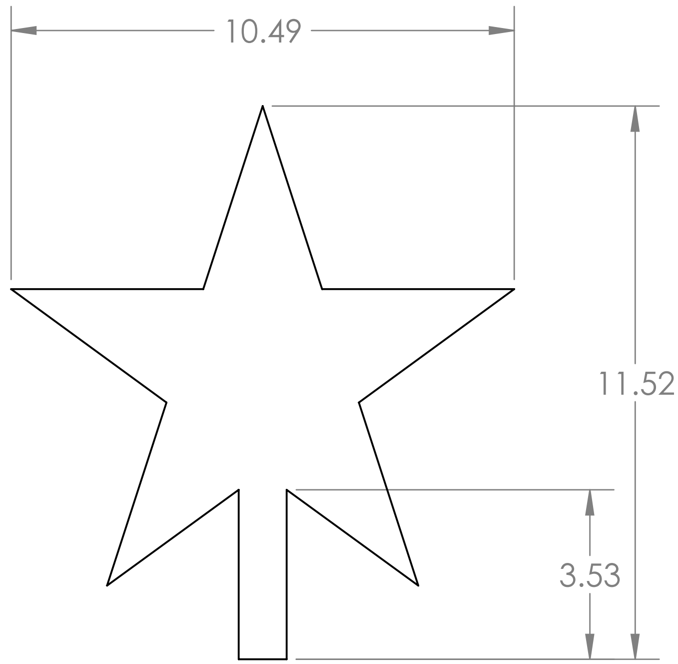


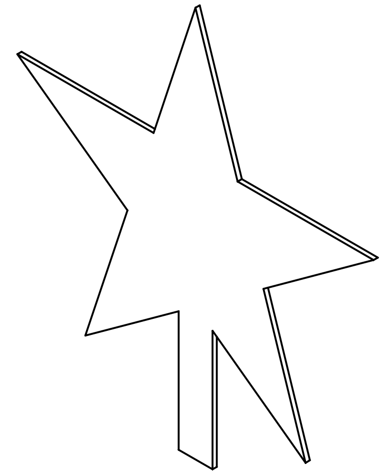




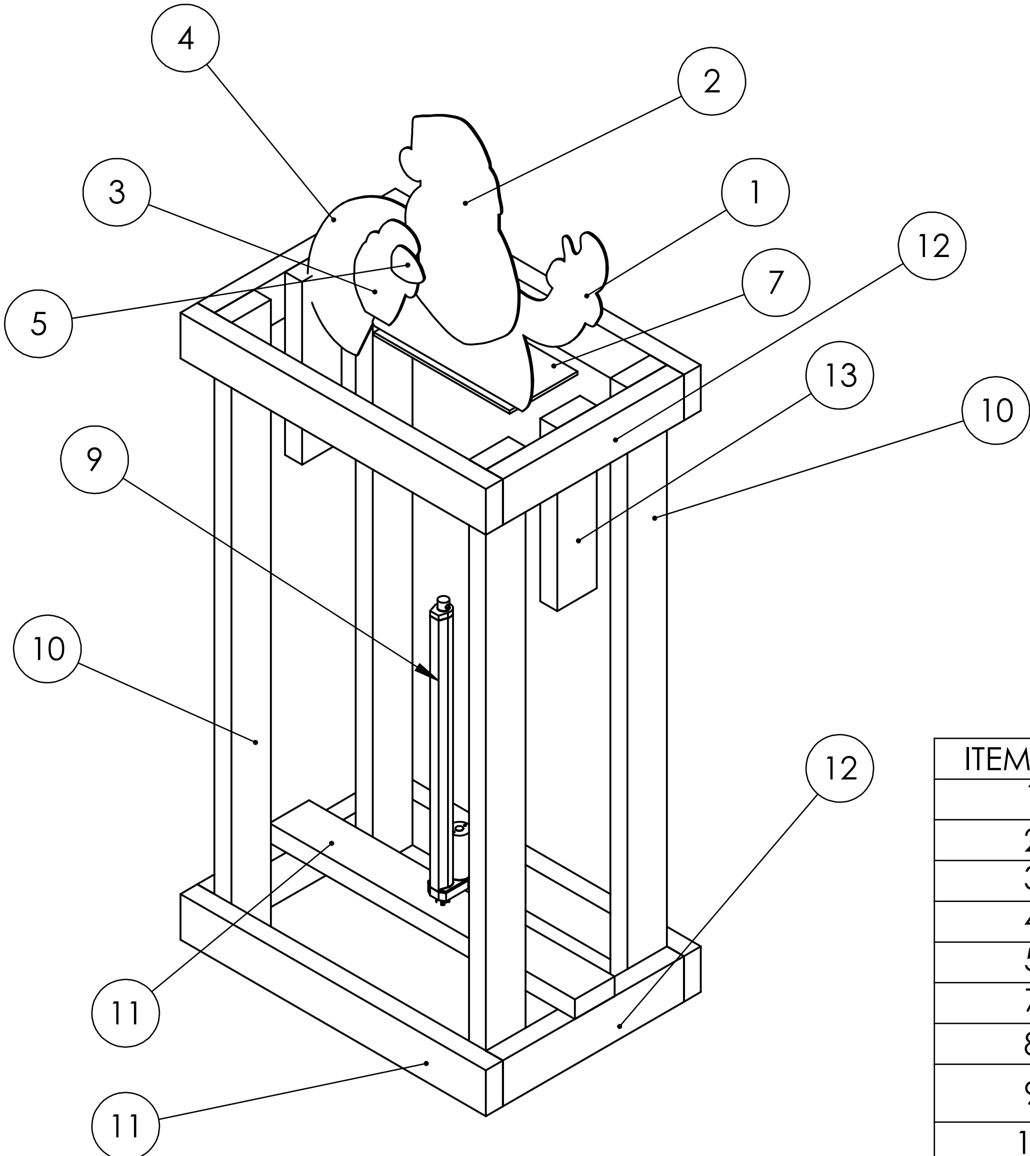
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: CHRISTMAS TREE PRESENTS		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19	Scale: 1:8	Chkd. By: ME STAFF

NOTE:
ALL PARTS 1/8" THICK UNLESS
OTHERWISE SPECIFIED



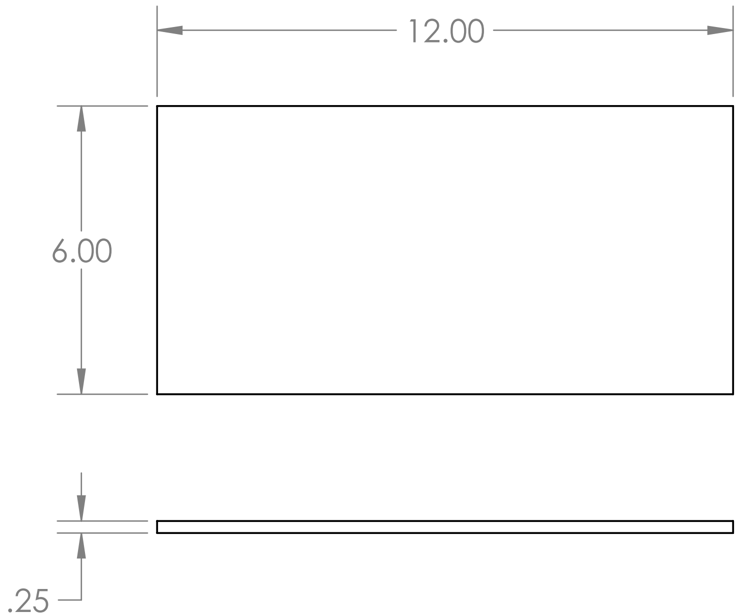


Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title: CHRISTMAS TREE STAR		Drwn. By: OMA SKYRUS
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: 04/25/19	Scale: 1:4	Chkd. By: ME STAFF

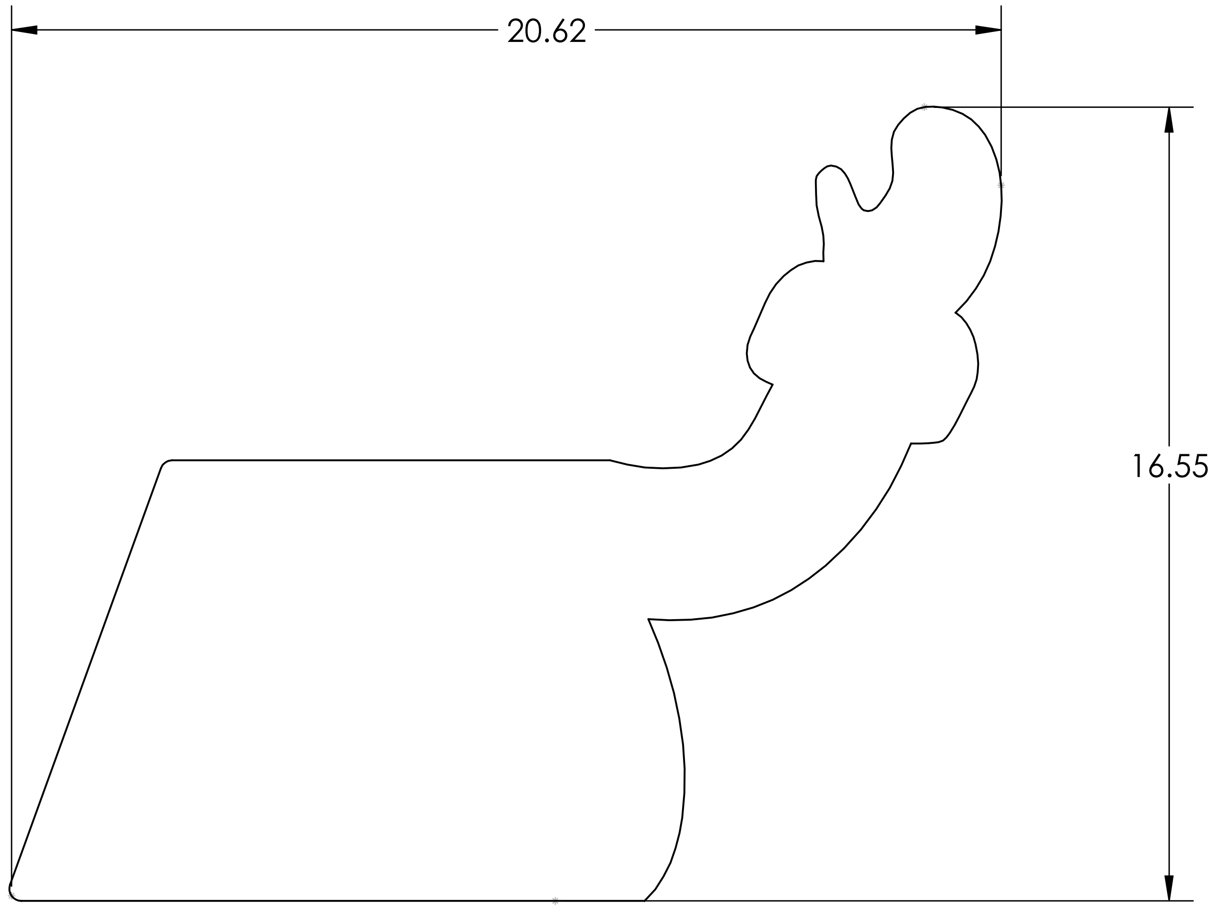


ITEM NO.	PART NUMBER	CUT LIST	QTY.
1	Santa Body		1
2	Santa Head		1
3	Santa Right Arm		1
4	Santa Bag		1
5	Santa Bag Flap		1
7	Plywood Base		1
8	Santa Mount		2
9	Linear Actuator FA-150-S-12-18		1
10	Frame Post	48 in.	4
11	Frame Long Top	27 in.	5
12	Frame Short Top	16 in.	4
13	Slider Mount	14 in.	2

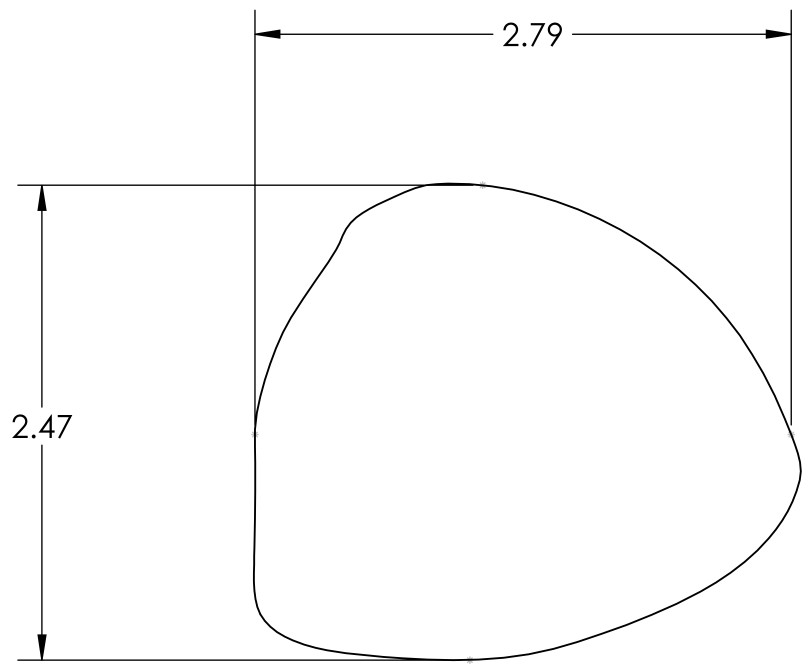
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



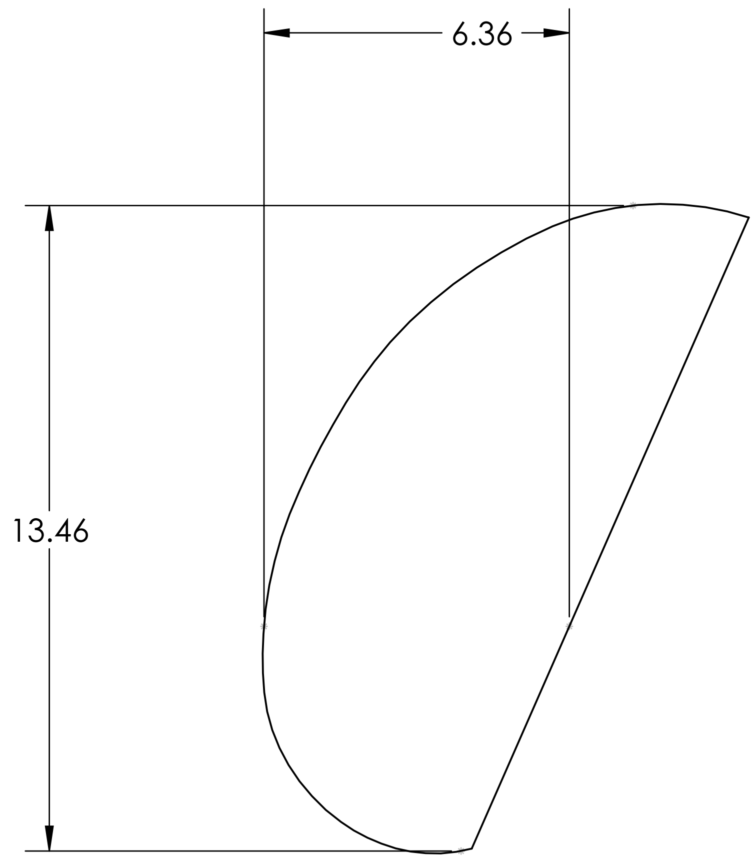
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



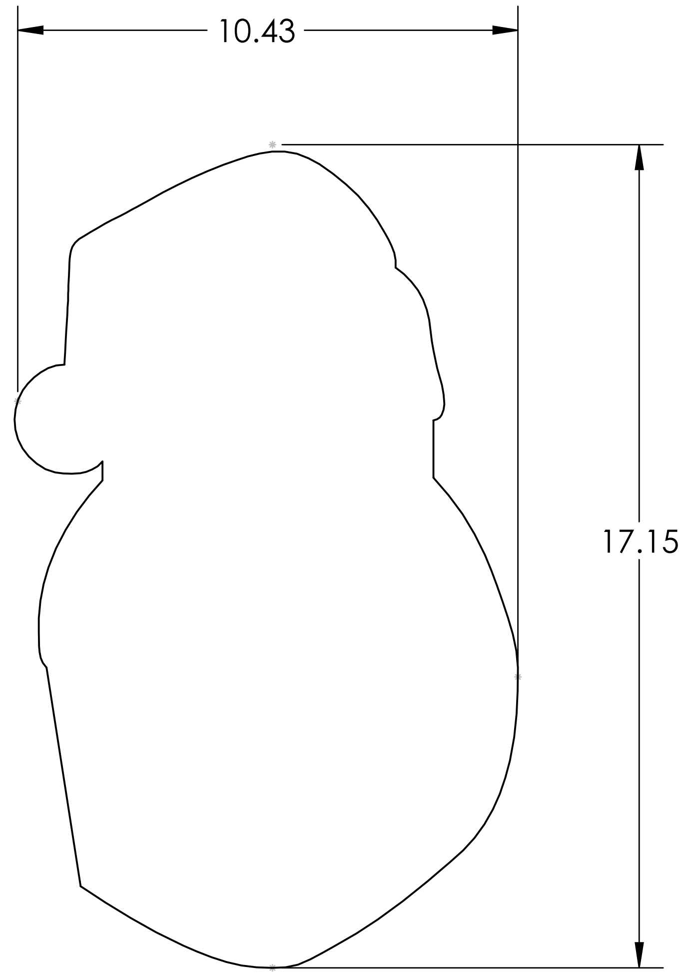
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



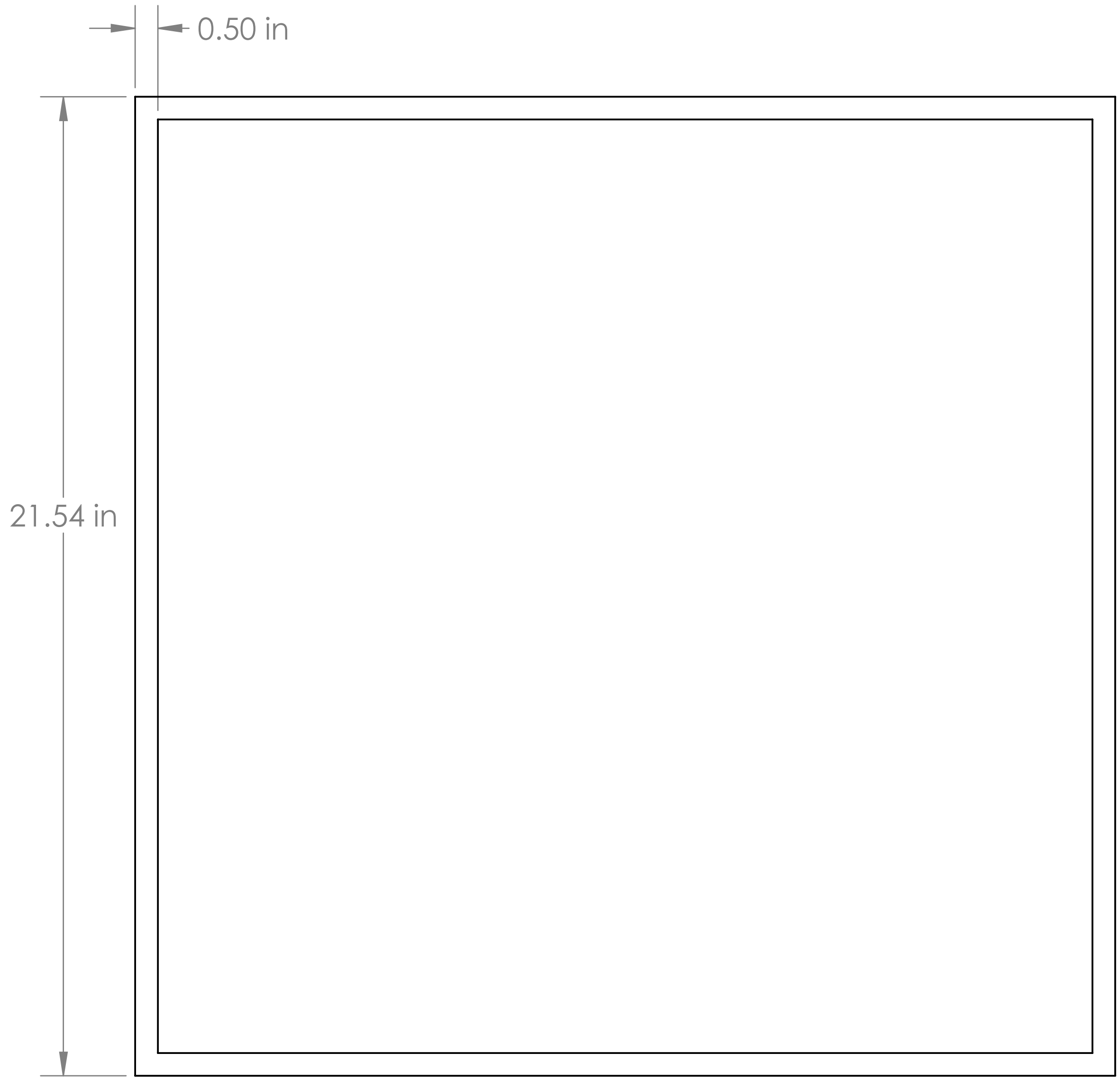
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



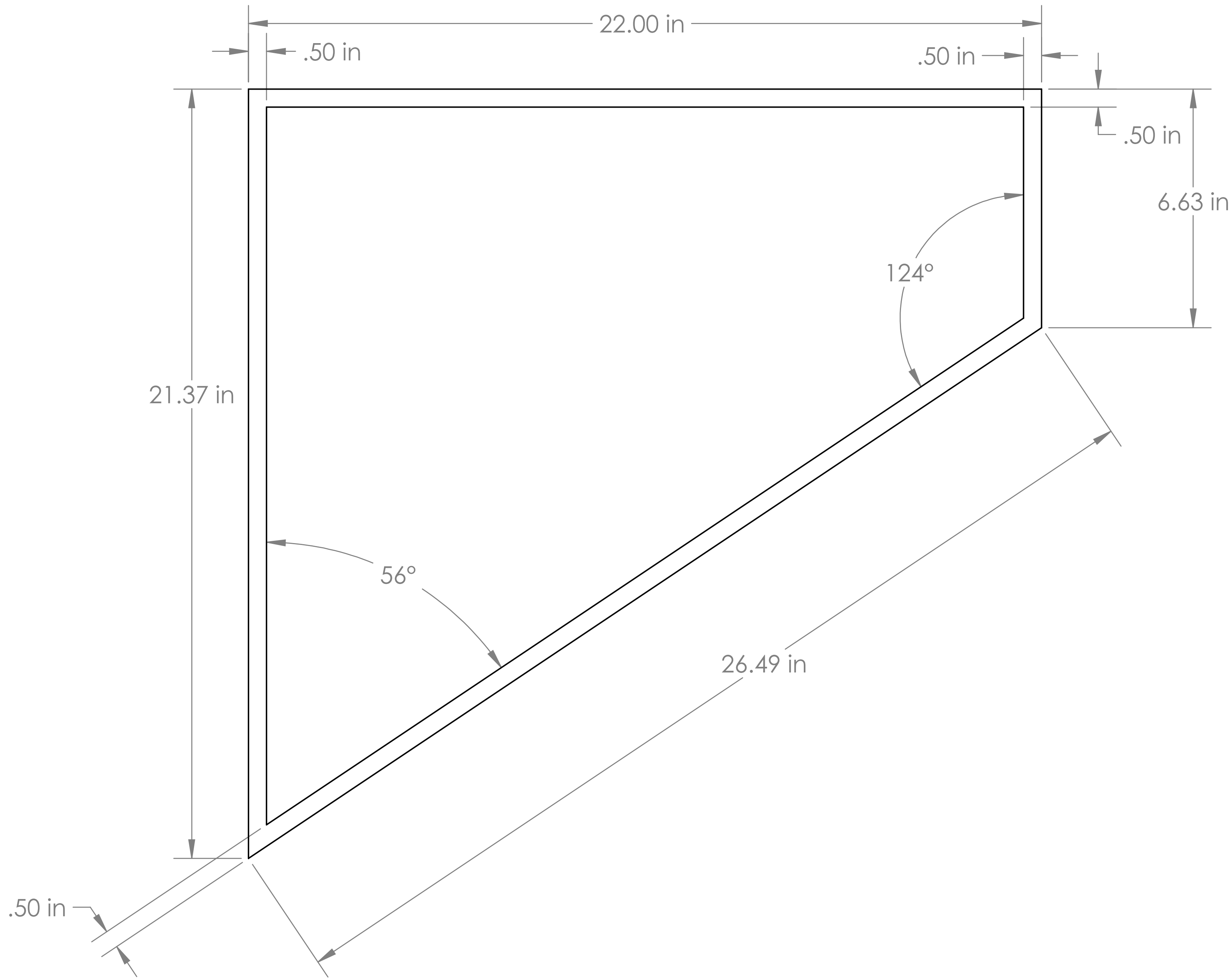
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



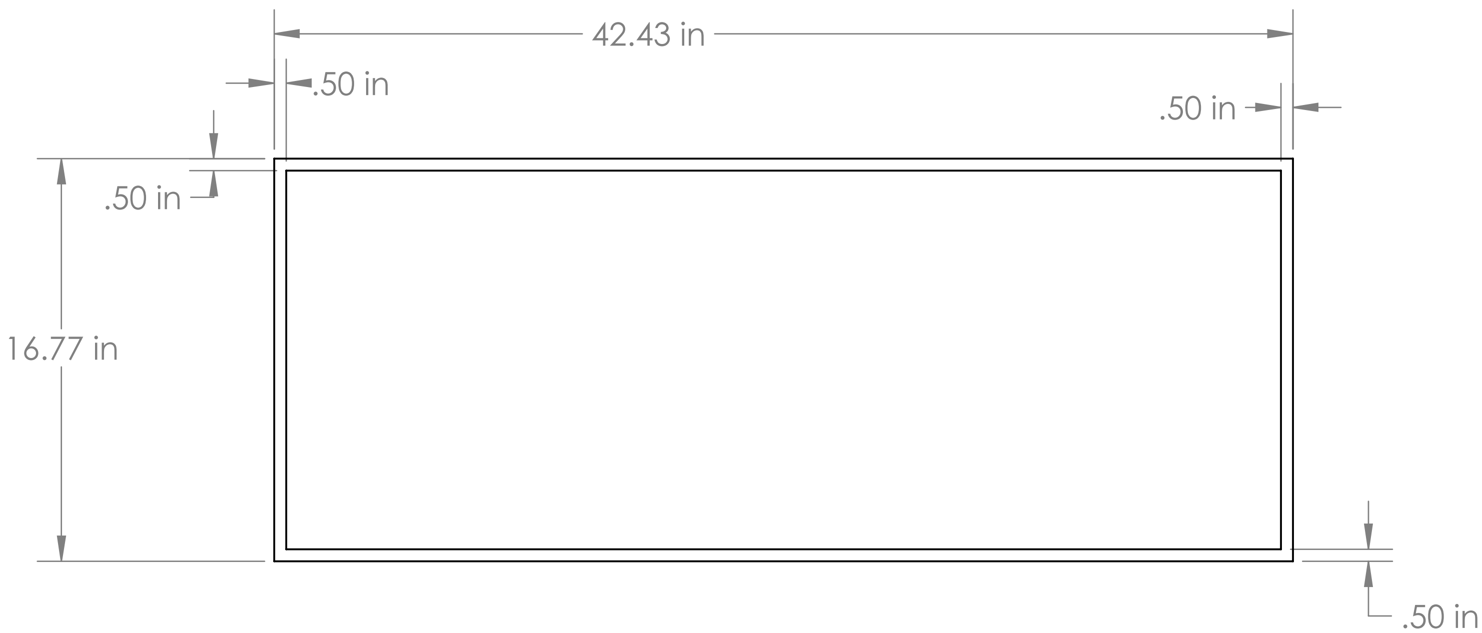
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



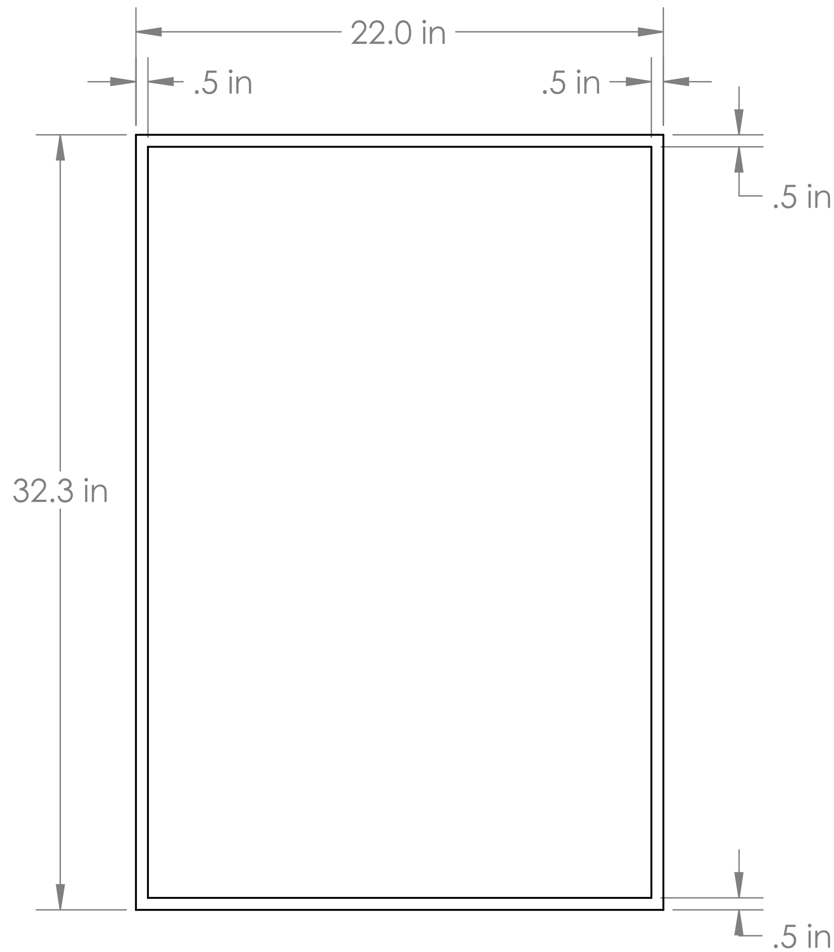
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



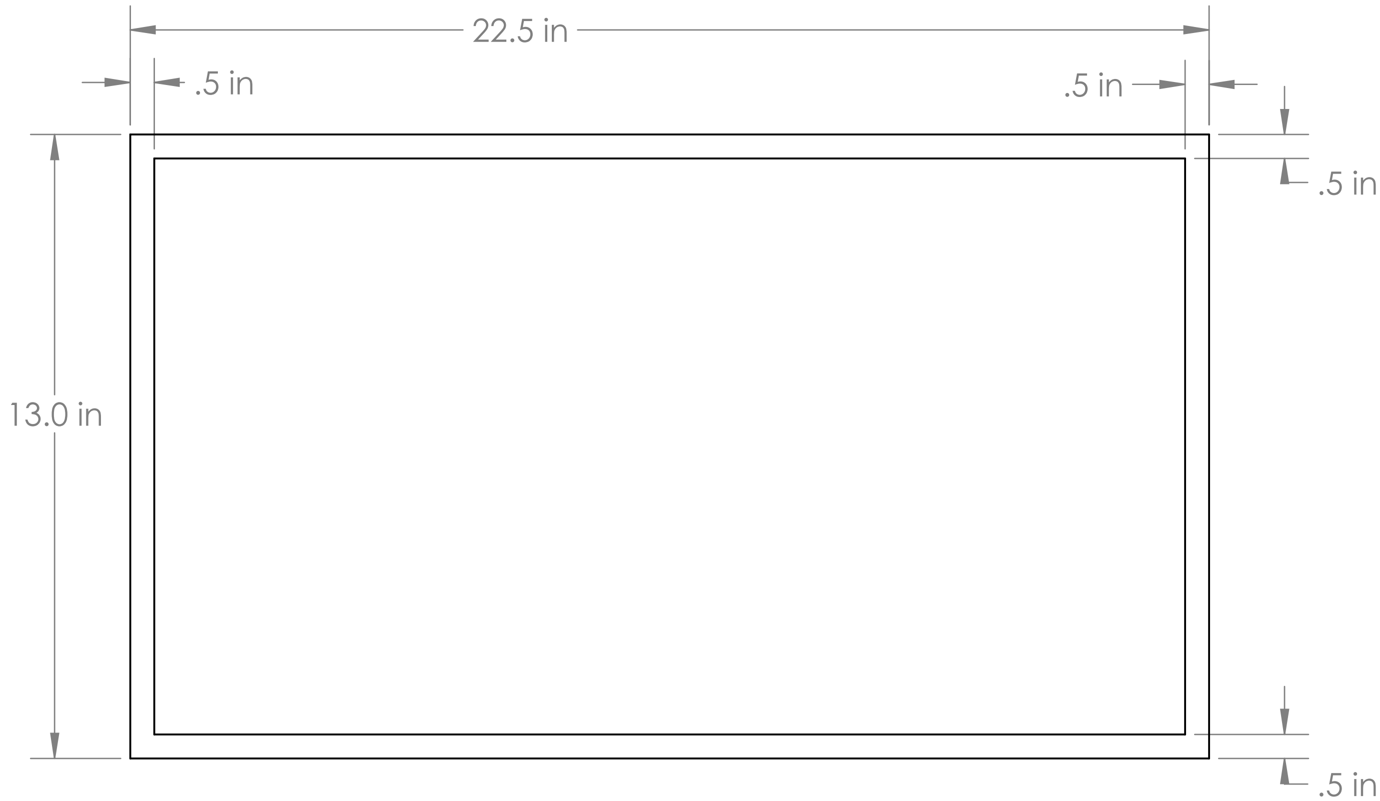
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



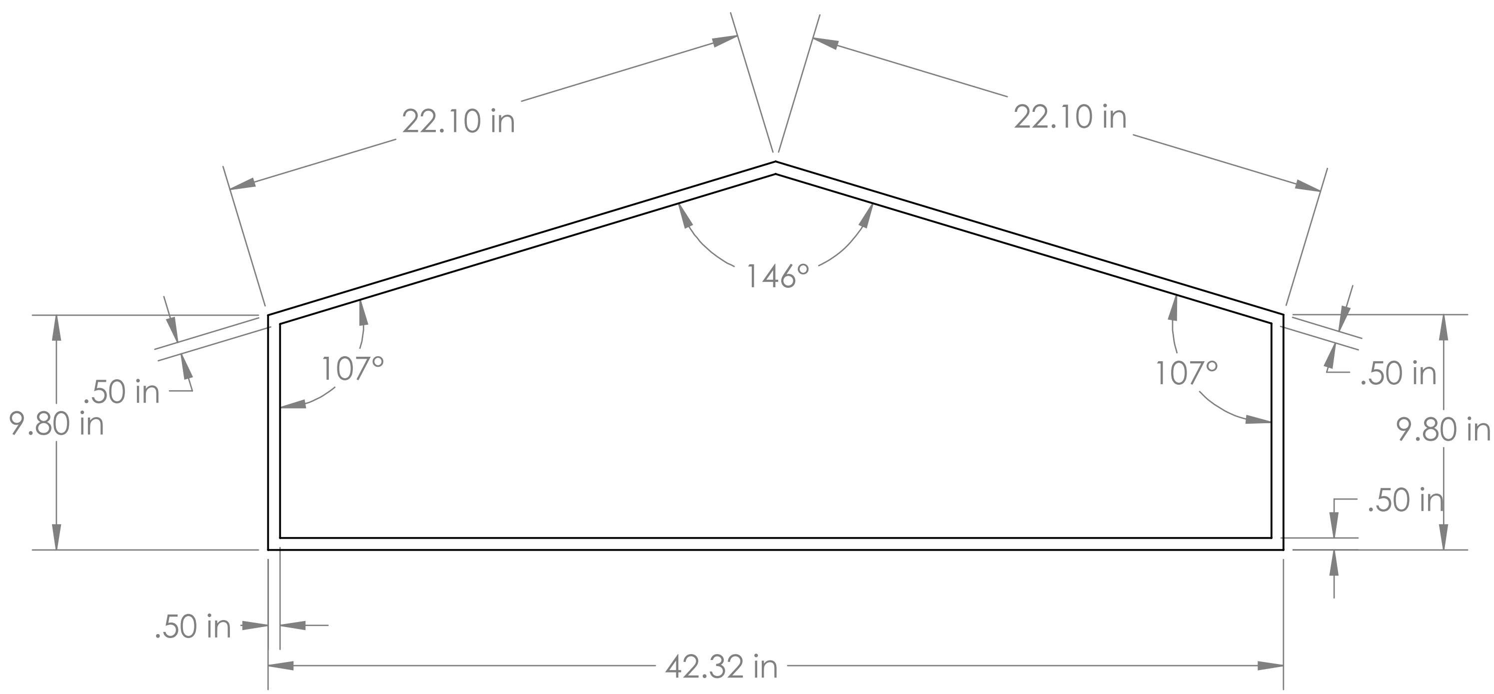
Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



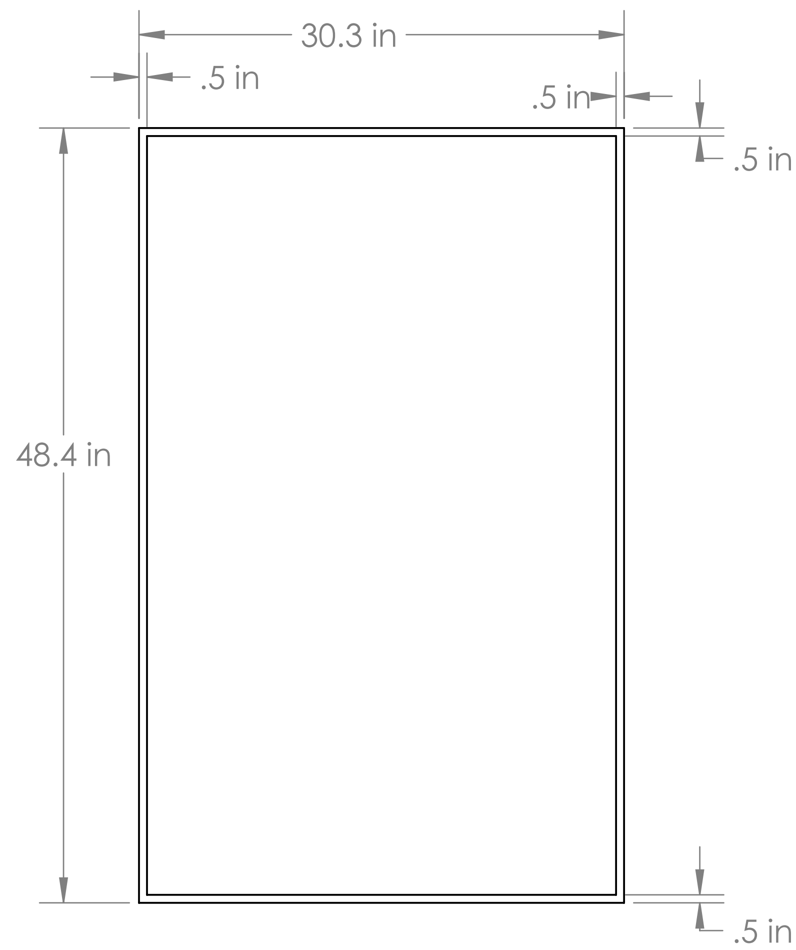
Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:	Drwn. By:
	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:		Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF

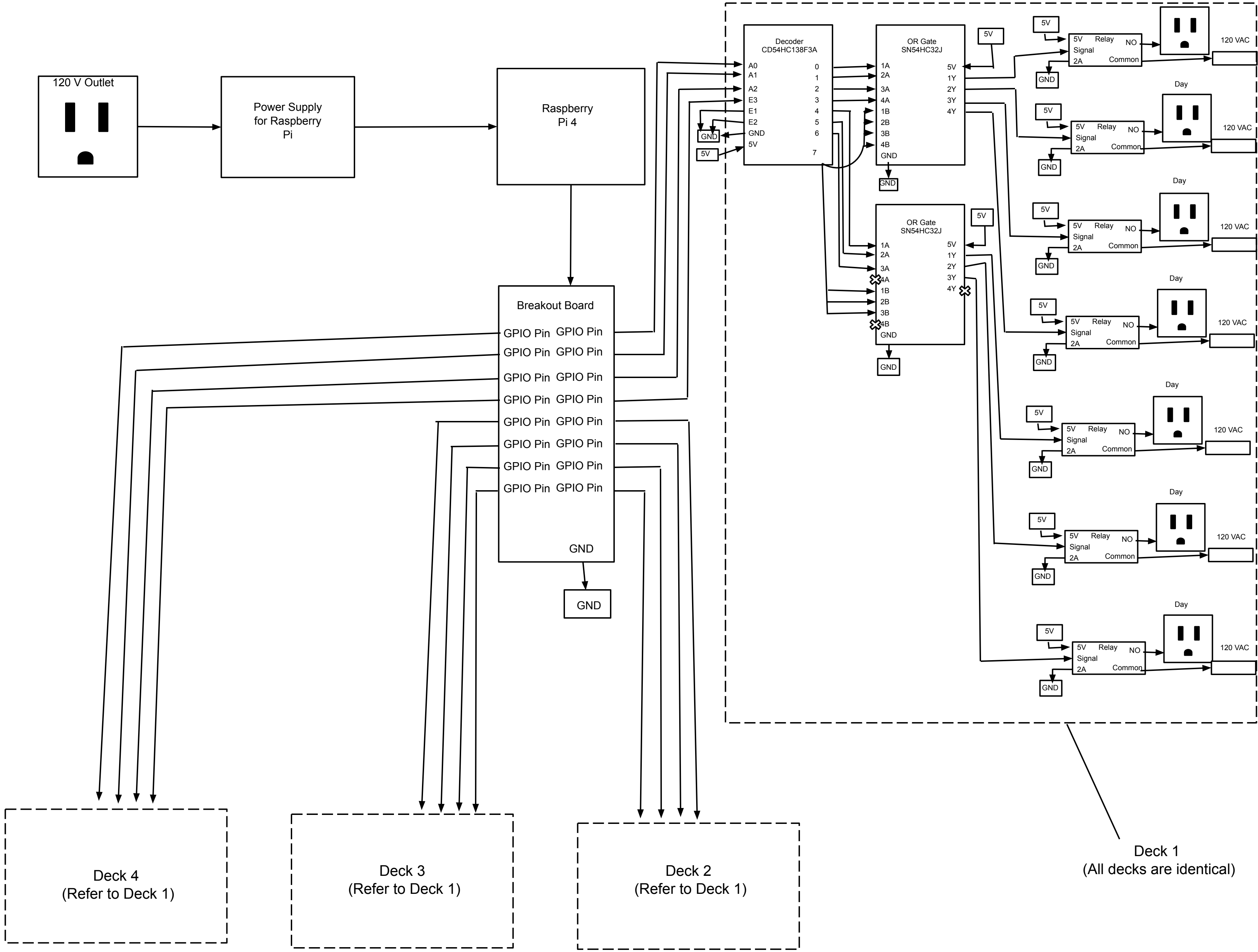


Cal Poly Mechanical Engineering ME ### - Qtr Year	Lab Section:	Assignment #	Title:		Drwn. By:
	Dwg. #:	Nxt Asb:	Date:	Scale:	Chkd. By: ME STAFF



Cal Poly Mechanical Engineering	Lab Section:	Assignment #	Title:	Drwn. By:
ME ### - Qtr Year	Dwg. #:	Nxt Asb:	Date: / Scale:	Chkd. By: ME STAFF

Appendix N: Electrical Schematic



120 V Outlet
Power Supply for Raspberry Pi
Raspberry Pi 4
Breakout Board
GPIO Pin
GND
Decoder CD54HC138F3A
A0
A1
A2
E3
E1
E2
GND
5V
0
1
2
3
4
5
6
7
OR Gate SN54HC32J
1A
2A
3A
4A
1B
2B
3B
4B
5V
1Y
2Y
3Y
4Y
5V
Relay
NO
Signal
2A
Common
GND
Day
120 VAC
Deck 1
(All decks are identical)
Deck 2
(Refer to Deck 1)
Deck 3
(Refer to Deck 1)
Deck 4
(Refer to Deck 1)

Appendix O: Electrical Datasheets

Texas Instruments

CD54/74HC138, CD54/74HCT138, CD54/74HC238, CD54/74HCT238

Data sheet acquired from Harris Semiconductor
SCHS147I

October 1997 - Revised August 2004

High-Speed CMOS Logic 3- to 8-Line Decoder/ Demultiplexer Inverting and Noninverting

Features

- **Select One Of Eight Data Outputs Active Low for 138, Active High for 238**
- **I/O Port or Memory Selector**
- **Three Enable Inputs to Simplify Cascading**
- **Typical Propagation Delay of 13 ns at V_{CC} = 5 V, C_L = 15 pF, T_A = 25^oC**
- **Fanout (Over Temperature Range)**
  - **Standard Outputs . . . . 10 LSTTL Loads**
  - **Bus Driver Outputs . . . . 15 LSTTL Loads**
- **Wide Operating Temperature Range . . . -55^oC to 125^oC**
- **Balanced Propagation Delay and Transition Times**
- **Significant Power Reduction Compared to LSTTL Logic ICs**
- **HC Types**
  - **2 V to 6 V Operation**
  - **High Noise Immunity: N_{IL} = 30%, N_{IH} = 30% of V_{CC} at V_{CC} = 5 V**
- **HCT Types**
  - **4.5-V to 5.5-V Operation**
  - **Direct LSTTL Input Logic Compatibility, V_{IL}= 0.8 V (Max), V_{IH} = 2 V (Min)**
  - **CMOS Input Compatibility, $I_I \leq 1\mu A$ at V_{OL}, V_{OH}**

Description

The ’HC138, ’HC238, ’HCT138, and ’HCT238 are high-speed silicon-gate CMOS decoders well suited to memory address decoding or data-routing applications. Both circuits feature low power consumption usually associated with CMOS circuitry, yet have speeds comparable to low-power Schottky TTL logic. Both circuits have three binary select inputs (A0, A1, and A2). If the device is enabled, these inputs determine which one of the eight normally high outputs of the HC/HCT138 series go low or which of the normally low outputs of the HC/HCT238 series go high.

Two active low and one active high enables ($\overline{E1}$, $\overline{E2}$, and E3) are provided to ease the cascading of decoders. The decoder’s eight outputs can drive ten low-power Schottky TTL equivalent loads.

Ordering Information

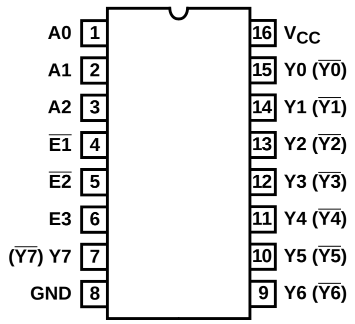
PART NUMBER	TEMP. RANGE (^oC)	PACKAGE
CD54HC138F3A	-55 to 125	16 Ld CERDIP
CD54HC238F3A	-55 to 125	16 Ld CERDIP
CD54HCT138F3A	-55 to 125	16 Ld CERDIP
CD54HCT238F3A	-55 to 125	16 Ld CERDIP
CD74HC138E	-55 to 125	16 Ld PDIP
CD74HC138M	-55 to 125	16 Ld SOIC
CD74HC138MT	-55 to 125	16 Ld SOIC
CD74HC138M96	-55 to 125	16 Ld SOIC
CD74HC238E	-55 to 125	16 Ld PDIP
CD74HC238M	-55 to 125	16 Ld SOIC
CD74HC238MT	-55 to 125	16 Ld SOIC
CD74HC238M96	-55 to 125	16 Ld SOIC
CD74HC238NSR	-55 to 125	16 Ld SOP
CD74HC238PW	-55 to 125	16 Ld TSSOP
CD74HC238PWR	-55 to 125	16 Ld TSSOP
CD74HC238PWT	-55 to 125	16 Ld TSSOP
CD74HCT138E	-55 to 125	16 Ld PDIP
CD74HCT138M	-55 to 125	16 Ld SOIC
CD74HCT138MT	-55 to 125	16 Ld SOIC
CD74HCT138M96	-55 to 125	16 Ld SOIC
CD74HCT238E	-55 to 125	16 Ld PDIP
CD74HCT238M	-55 to 125	16 Ld SOIC
CD74HCT238M96	-55 to 125	16 Ld SOIC

NOTE: When ordering, use the entire part number. The suffixes 96 and R denote tape and reel. The suffix T denotes a small-quantity reel of 250.

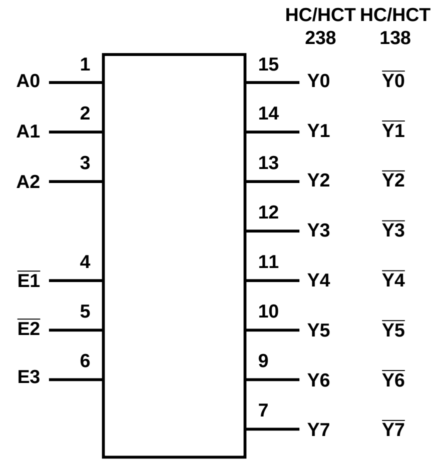
CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

Pinout

CD54HC138, CD54HCT138, CD54HC238, CD54HCT238
(CERDIP)
CD74HC138, CD74HCT138, CD74HCT238
(PDIP, SOIC)
CD74HC238
(PDIP, SOIC, SOP, TSSOP)
TOP VIEW



Functional Diagram



Signal names in parentheses are for ’HC138 and ’HCT138.

TRUTH TABLE ’HC138, ’HCT138

INPUTS						OUTPUTS							
ENABLE			ADDRESS										
E3	**$\overline{E2}$**	**$\overline{E1}$**	**A2**	**A1**	**A0**	**$\overline{Y0}$**	**$\overline{Y1}$**	**$\overline{Y2}$**	**$\overline{Y3}$**	**$\overline{Y4}$**	**$\overline{Y5}$**	**$\overline{Y6}$**	**$\overline{Y7}$**
X	X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	X	H	H	H	H	H	H	H	H
X	H	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	L	H	H	H	H	H	L	H	H	H	H
H	L	L	H	L	L	H	H	H	H	L	H	H	H
H	L	L	H	L	H	H	H	H	H	H	L	H	H
H	L	L	H	H	L	H	H	H	H	H	H	L	H
H	L	L	H	H	H	H	H	H	H	H	H	H	L

H = High Voltage Level, L = Low Voltage Level, X = Don’t Care

TRUTH TABLE ’HC238, ’HCT238

INPUTS						OUTPUTS							
ENABLE			ADDRESS										
E3	**$\overline{E2}$**	**$\overline{E1}$**	**A2**	**A1**	**A0**	**Y0**	**Y1**	**Y2**	**Y3**	**Y4**	**Y5**	**Y6**	**Y7**
X	X	H	X	X	X	L	L	L	L	L	L	L	L
L	X	X	X	X	X	L	L	L	L	L	L	L	L
X	H	X	X	X	X	L	L	L	L	L	L	L	L
H	L	L	L	L	L	H	L	L	L	L	L	L	L
H	L	L	L	L	H	L	H	L	L	L	L	L	L
H	L	L	L	H	L	L	L	H	L	L	L	L	L
H	L	L	L	H	H	L	L	L	H	L	L	L	L
H	L	L	H	L	L	L	L	L	L	H	L	L	L
H	L	L	H	L	H	L	L	L	L	L	H	L	L
H	L	L	H	H	L	L	L	L	L	L	L	H	L
H	L	L	H	H	H	L	L	L	L	L	L	L	H

H = High Voltage Level, L = Low Voltage Level, X = Don’t Care

Absolute Maximum Ratings

DC Supply Voltage, V_{CC} . . . . -0.5V to 7V
DC Input Diode Current, I_{IK}
For $V_I < -0.5V$ or $V_I > V_{CC} + 0.5V$ . . . . ±20mA
DC Output Diode Current, I_{OK}
For $V_O < -0.5V$ or $V_O > V_{CC} + 0.5V$ . . . . ±20mA
DC Output Source or Sink Current per Output Pin, I_O
For $V_O > -0.5V$ or $V_O < V_{CC} + 0.5V$ . . . . ±25mA
DC V_{CC} or Ground Current, I_{CC} or I_{GND} . . . . ±50mA

Operating Conditions

Temperature Range (T_A) . . . . -55^{o}C to 125^{o}C
Supply Voltage Range, V_{CC}
HC Types . . . . 2V to 6V
HCT Types . . . . 4.5V to 5.5V
DC Input or Output Voltage, V_I, V_O . . . . 0V to V_{CC}
Input Rise and Fall Time
2V . . . . 1000ns (Max)
4.5V. . . . . 500ns (Max)
6V . . . . 400ns (Max)

Thermal Information

Package Thermal Impedance, θ_{JA} (see Note 1):
E (PDIP) Package . . . . 67^{o}C/W
M (SOIC) Package. . . . . 73^{o}C/W
NS (SOP) Package . . . . 64^{o}C/W
PW (TSSOP) Package . . . . 108^{o}C/W
Maximum Junction Temperature . . . . 150^{o}C
Maximum Storage Temperature Range . . . . -65^{o}C to 150^{o}C
Maximum Lead Temperature (Soldering 10s) . . . . 300^{o}C
(SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating, and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

1. The package thermal impedance is calculated in accordance with JESD 51-7.

DC Electrical Specifications

PARAMETER	SYMBOL	TEST CONDITIONS V_I (V)	TEST CONDITIONS I_O (mA)	V_{CC} (V)	25^{o}C MIN	25^{o}C TYP	25^{o}C MAX	-40^{o}C TO 85^{o}C MIN	-40^{o}C TO 85^{o}C MAX	-55^{o}C TO 125^{o}C MIN	-55^{o}C TO 125^{o}C MAX	UNITS
HC TYPES												
High Level Input Voltage	V_{IH}	-	-	2	1.5	-	-	1.5	-	1.5	-	V
				4.5	3.15	-	-	3.15	-	3.15	-	V
				6	4.2	-	-	4.2	-	4.2	-	V
Low Level Input Voltage	V_{IL}	-	-	2	-	-	0.5	-	0.5	-	0.5	V
				4.5	-	-	1.35	-	1.35	-	1.35	V
				6	-	-	1.8	-	1.8	-	1.8	V
High Level Output Voltage CMOS Loads	V_{OH}	V_{IH} or V_{IL}	-0.02	2	1.9	-	-	1.9	-	1.9	-	V
			-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
			-0.02	6	5.9	-	-	5.9	-	5.9	-	V
High Level Output Voltage TTL Loads			-	-	-	-	-	-	-	-	-	V
			-4	4.5	3.98	-	-	3.84	-	3.7	-	V
			-5.2	6	5.48	-	-	5.34	-	5.2	-	V
Low Level Output Voltage CMOS Loads	V_{OL}	V_{IH} or V_{IL}	0.02	2	-	-	0.1	-	0.1	-	0.1	V
			0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
			0.02	6	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			-	-	-	-	-	-	-	-	-	V
			4	4.5	-	-	0.26	-	0.33	-	0.4	V
			5.2	6	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I_I	V_{CC} or GND	-	6	-	-	±0.1	-	±1	-	±1	µA
Quiescent Device Current	I_{CC}	V_{CC} or GND	0	6	-	-	8	-	80	-	160	µA

DC Electrical Specifications (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS V_I (V)	TEST CONDITIONS I_O (mA)	V_{CC} (V)	25°C MIN	25°C TYP	25°C MAX	-40°C TO 85°C MIN	-40°C TO 85°C MAX	-55°C TO 125°C MIN	-55°C TO 125°C MAX	UNITS
HCT TYPES												
High Level Input Voltage	V_{IH}	-	-	4.5 to 5.5	2	-	-	2	-	2	-	V
Low Level Input Voltage	V_{IL}	-	-	4.5 to 5.5	-	-	0.8	-	0.8	-	0.8	V
High Level Output Voltage CMOS Loads	V_{OH}	V_{IH} or V_{IL}	-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
High Level Output Voltage TTL Loads			-4	4.5	3.98	-	-	3.84	-	3.7	-	V
Low Level Output Voltage CMOS Loads	V_{OL}	V_{IH} or V_{IL}	0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			4	4.5	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I_I	V_{CC} and GND	0	5.5	-		±0.1	-	±1	-	±1	µA
Quiescent Device Current	I_{CC}	V_{CC} or GND	0	5.5	-	-	8	-	80	-	160	µA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load	ΔI_{CC} (Note 2)	V_{CC} -2.1	-	4.5 to 5.5	-	100	360	-	450	-	490	µA

NOTE:

2. For dual-supply systems, theoretical worst case (V_I = 2.4V, V_{CC} = 5.5V) specification is 1.8mA.

HCT Input Loading Table

INPUT	UNIT LOADS
A0-A2	1.5
$\overline{E1}$, $\overline{E2}$	1.25
$\overline{E3}$	1

NOTE: Unit Load is ΔI_{CC} limit specified in DC Electrical Table, e.g., 360µA max at 25°C.

Switching Specifications Input t_r, t_f = 6ns

PARAMETER	SYMBOL	TEST CONDITIONS	V_{CC} (V)	25°C MIN	25°C TYP	25°C MAX	-40°C TO 85°C MIN	-40°C TO 85°C MAX	-55°C TO 125°C MIN	-55°C TO 125°C MAX	UNITS
HC TYPES											
Propagation Delay	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	150	-	190	-	225	ns
Address to Output			4.5	-	-	30	-	38	-	45	ns
		C_L = 15pF	5	-	13	-	-	-	-	-	ns
		C_L = 50pF	6	-	-	26	-	33	-	38	ns

Switching Specifications Input t_r, t_f = 6ns **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	V_{CC} (V)	25°C MIN	25°C TYP	25°C MAX	-40°C TO 85°C MIN	-40°C TO 85°C MAX	-55°C TO 125°C MIN	-55°C TO 125°C MAX	UNITS
Enable to Output HC/HCT138	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	150	-	190	-	265	ns
			4.5	-	-	30	-	38	-	53	ns
			6	-	-	26	-	33	-	45	ns
Output Transition Time (Figure 1)	t_{TLH}, t_{THL}	C_L = 50pF	2	-	-	75	-	95	-	110	ns
			4.5	-	-	15	-	19	-	22	ns
			6	-	-	13	-	16	-	19	ns
Power Dissipation Capacitance (Notes 3, 4)	C_{PD}	C_L = 15pF	5	-	67	-	-	-	-	-	pF
Input Capacitance	C_{IN}	-	-	-	-	10	-	10	-	10	pF
HCT TYPES											
Propagation Delay Address to Output	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	35	-	44	-	53	ns
		C_L = 15pF	5	-	14	-	-	-	-	-	ns
Enable to Output HC/HCT138	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	35	-	44	-	53	ns
Enable to Output HC/HCT238	t_{PLH}, t_{PHL}	C_L = 15pF	4.5	-	-	40	-	50	-	60	ns
Output Transition Time (Figure 2)	t_{TLH}, t_{THL}	C_L = 50pF	4.5	-	-	15	-	19	-	22	ns
Power Dissipation Capacitance (Notes 3, 4)	C_{PD}	C_L = 15pF	5	-	67	-	-	-	-	-	pF
Input Capacitance	C_{IN}	-	-	-	-	10	-	10	-	10	pF

NOTES:

3. C_{PD} is used to determine the dynamic power consumption, per gate.
4. $P_D = V_{CC}^2 f_i (C_{PD} + C_L)$ where f_i = Input Frequency, C_L = Output Load Capacitance, V_{CC} = Supply Voltage.

Test Circuits and Waveforms

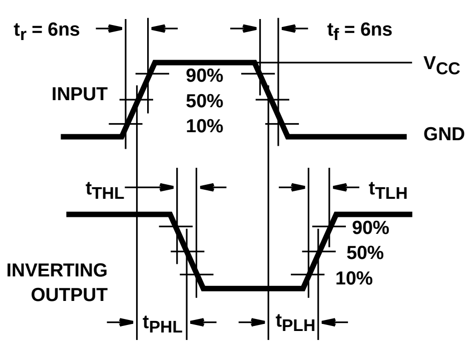


FIGURE 7. HC AND HCU TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

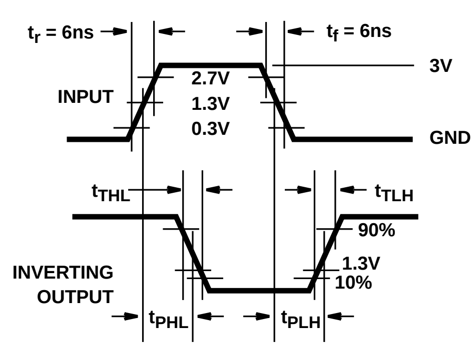


FIGURE 8. HCT TRANSITION TIMES AND PROPAGATION DELAY TIMES, COMBINATION LOGIC

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-8688401EA	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	5962-8688401EA CD54HC238F3A	Samples
CD54HC138F	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	CD54HC138F	Samples
CD54HC138F3A	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	8406201EA CD54HC138F3A	Samples
CD54HC238F3A	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	5962-8688401EA CD54HC238F3A	Samples
CD54HCT138F	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	CD54HCT138F	Samples
CD54HCT138F3A	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	8550401EA CD54HCT138F3A	Samples
CD54HCT238F3A	ACTIVE	CDIP	J	16	1	TBD	A42	N / A for Pkg Type	-55 to 125	5962-8974501EA CD54HCT238F3A	Samples
CD74HC138E	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HC138E	Samples
CD74HC138EE4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HC138E	Samples
CD74HC138M	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC138M96	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC138M96E4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC138ME4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC138MT	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC138MTG4	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC138M	Samples
CD74HC238E	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HC238E	Samples
CD74HC238EE4	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HC238E	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD74HC238M	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC238M	Samples
CD74HC238M96	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC238M	Samples
CD74HC238M96E4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC238M	Samples
CD74HC238MT	ACTIVE	SOIC	D	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC238M	Samples
CD74HC238NSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HC238M	Samples
CD74HC238PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HJ238	Samples
CD74HC238PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HJ238	Samples
CD74HC238PWRE4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HJ238	Samples
CD74HC238PWRG4	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HJ238	Samples
CD74HC238PWT	ACTIVE	TSSOP	PW	16	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HJ238	Samples
CD74HCT138E	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HCT138E	Samples
CD74HCT138M	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT138M	Samples
CD74HCT138M96	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT138M	Samples
CD74HCT138M96G4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT138M	Samples
CD74HCT238E	ACTIVE	PDIP	N	16	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-55 to 125	CD74HCT238E	Samples
CD74HCT238M	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT238M	Samples
CD74HCT238M96	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT238M	Samples
CD74HCT238M96G4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HCT238M	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
CD74HCT238PW	ACTIVE	TSSOP	PW	16	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HK238	Samples
CD74HCT238PWR	ACTIVE	TSSOP	PW	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-55 to 125	HK238	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF CD54HC138, CD54HC238, CD54HCT138, CD54HCT238, CD74HC138, CD74HC238, CD74HCT138, CD74HCT238 :

- Catalog: CD74HC138, CD74HC238, CD74HCT138, CD74HCT238

- Automotive: CD74HC138-Q1, CD74HC138-Q1

- Military: CD54HC138, CD54HC238, CD54HCT138, CD54HCT238

NOTE: Qualified Version Definitions:

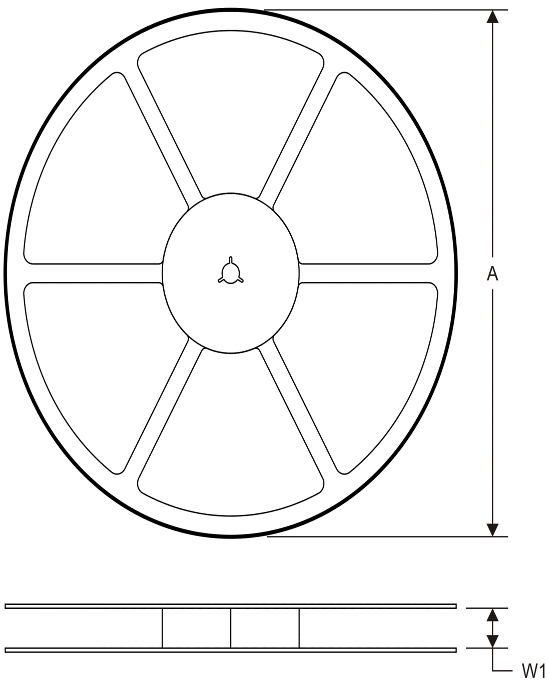
- Catalog - TI's standard catalog product

- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

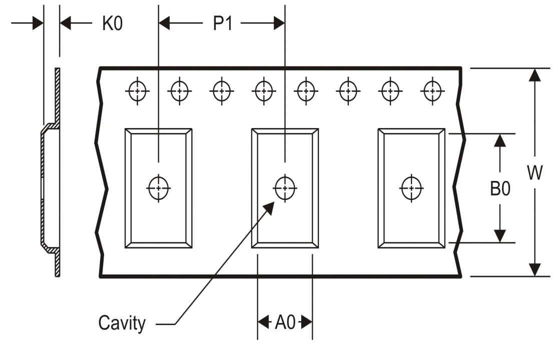
- Military - QML certified for Military and Defense Applications

TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSIONS



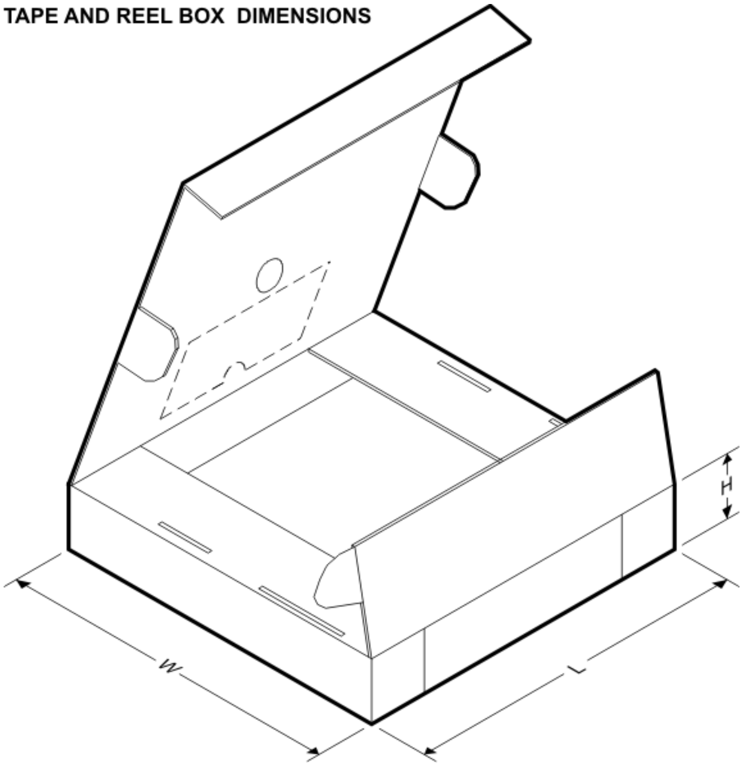
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
CD74HC138M96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
CD74HC238M96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
CD74HC238NSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1
CD74HC238PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD74HC238PWT	TSSOP	PW	16	250	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
CD74HCT138M96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
CD74HCT238M96	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
CD74HCT238PWR	TSSOP	PW	16	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

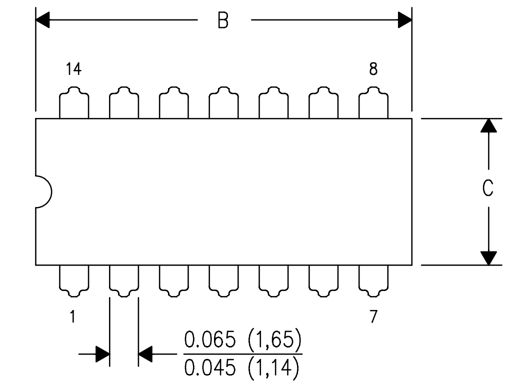


*All dimensions are nominal

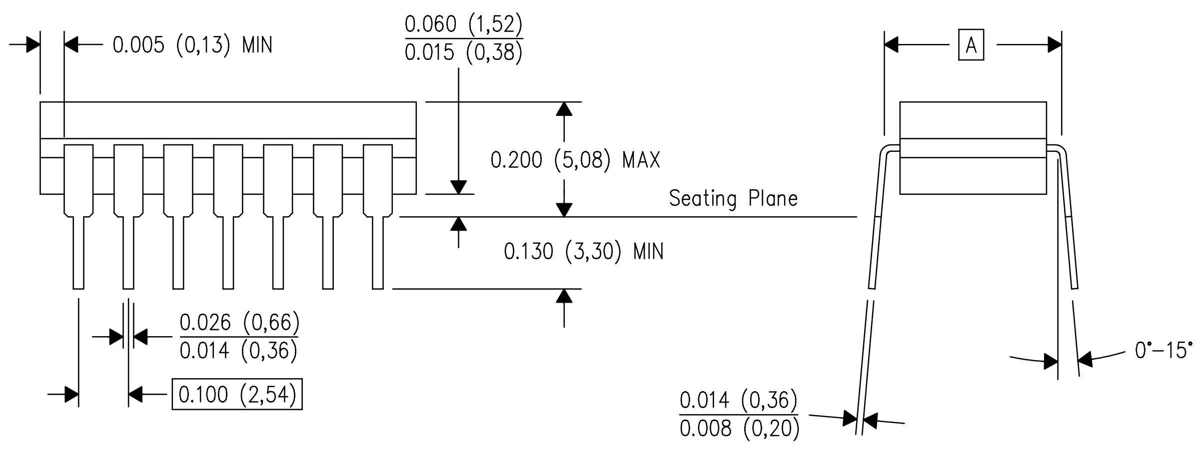
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
CD74HC138M96	SOIC	D	16	2500	333.2	345.9	28.6
CD74HC238M96	SOIC	D	16	2500	333.2	345.9	28.6
CD74HC238NSR	SO	NS	16	2000	367.0	367.0	38.0
CD74HC238PWR	TSSOP	PW	16	2000	367.0	367.0	35.0
CD74HC238PWT	TSSOP	PW	16	250	367.0	367.0	35.0
CD74HCT138M96	SOIC	D	16	2500	333.2	345.9	28.6
CD74HCT238M96	SOIC	D	16	2500	333.2	345.9	28.6
CD74HCT238PWR	TSSOP	PW	16	2000	367.0	367.0	35.0

J (R–GDIP–T**)   CERAMIC DUAL IN–LINE PACKAGE

14 LEADS SHOWN



DIM \ PINS **	14	16	18	20
A	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC	0.300 (7,62) BSC
B MAX	0.785 (19,94)	.840 (21,34)	0.960 (24,38)	1.060 (26,92)
B MIN	—	—	—	—
C MAX	0.300 (7,62)	0.300 (7,62)	0.310 (7,87)	0.300 (7,62)
C MIN	0.245 (6,22)	0.245 (6,22)	0.220 (5,59)	0.245 (6,22)

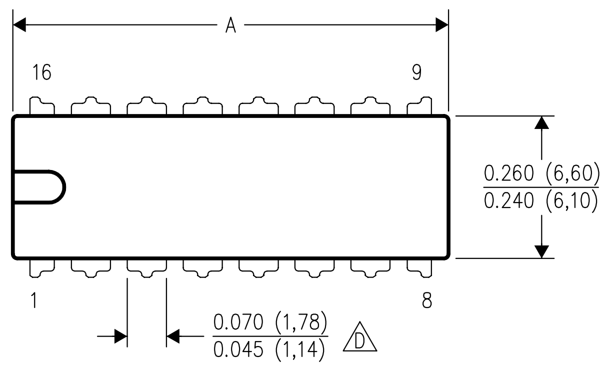


4040083/F 03/03

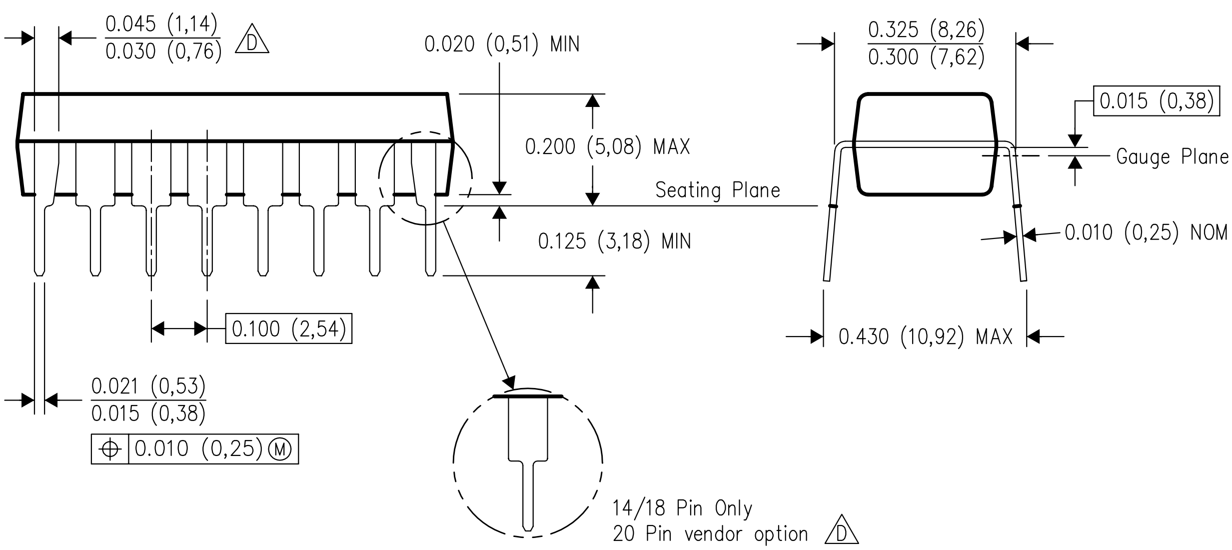
NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. This package is hermetically sealed with a ceramic lid using glass frit.
- D. Index point is provided on cap for terminal identification only on press ceramic glass frit seal only.
- E. Falls within MIL STD 1835 GDIP1–T14, GDIP1–T16, GDIP1–T18 and GDIP1–T20.

N (R–PDIP–T**) PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN



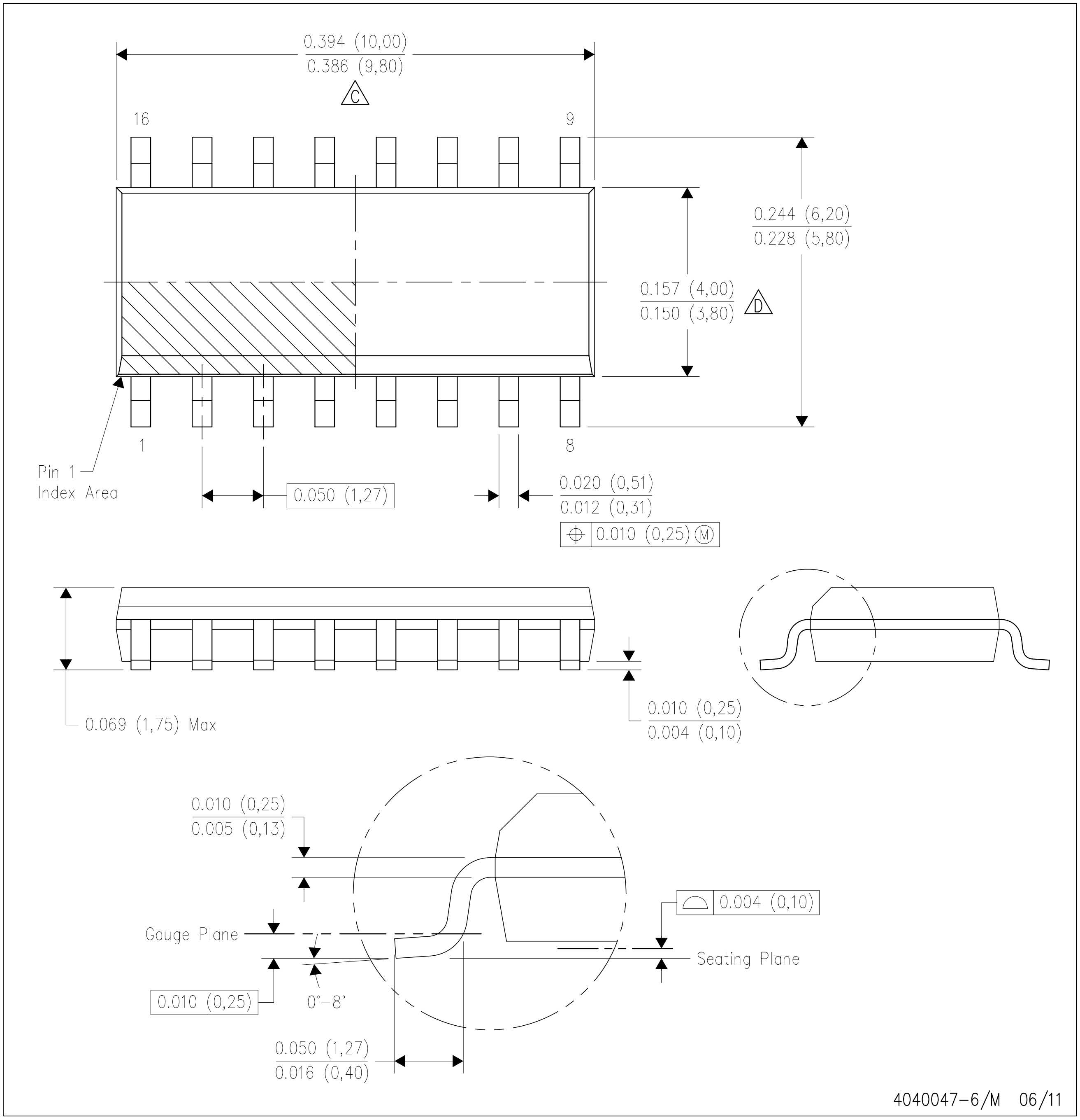
DIM \ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
C MS–001 VARIATION	AA	BB	AC	AD



4040049/E 12/2002

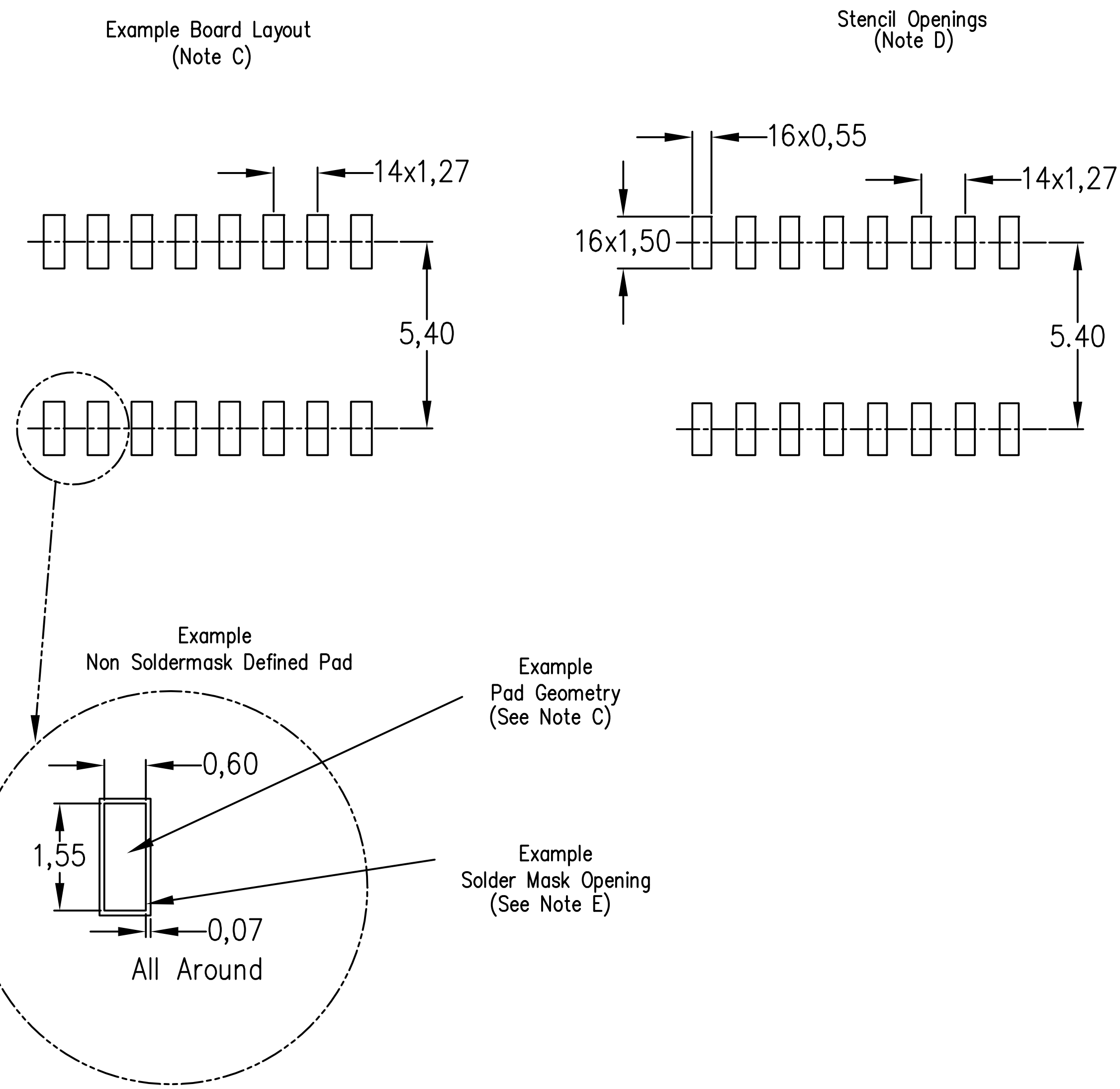
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R–PDSO–G16) PLASTIC SMALL OUTLINE



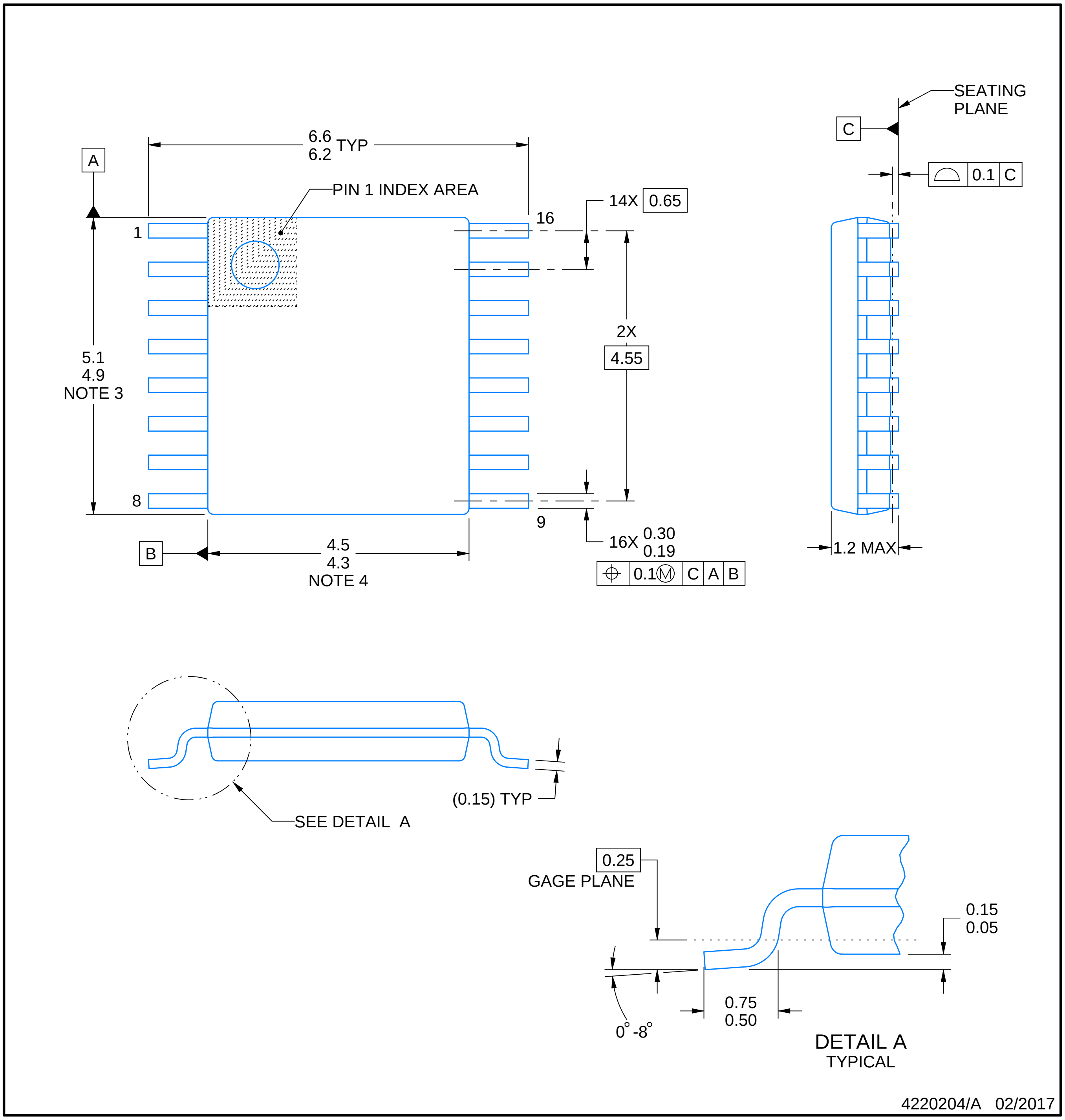
NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AC.

D (R-PDSO-G16) PLASTIC SMALL OUTLINE



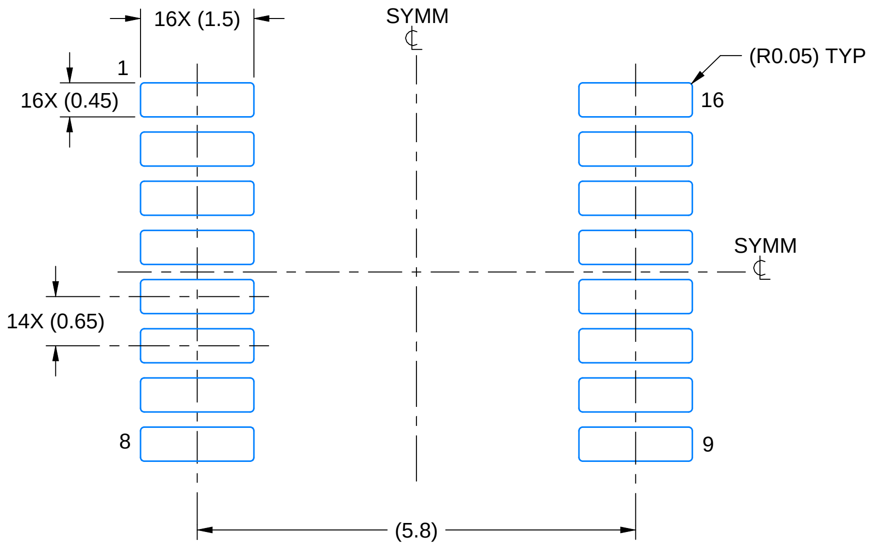
4211283-4/E 08/12

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

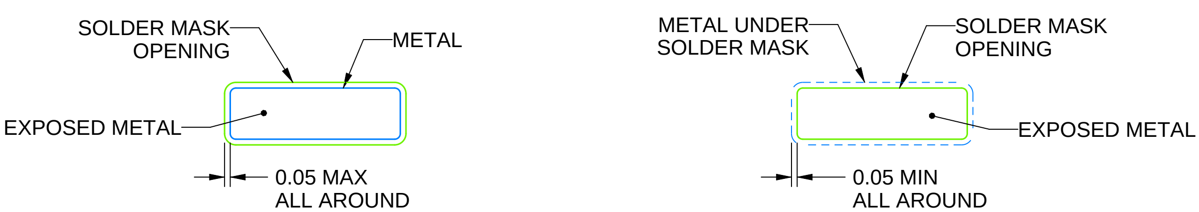


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This dimension does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 mm per side.
4. This dimension does not include interlead flash. Interlead flash shall not exceed 0.25 mm per side.
5. Reference JEDEC registration MO-153.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 10X



NON-SOLDER MASK DEFINED (PREFERRED)

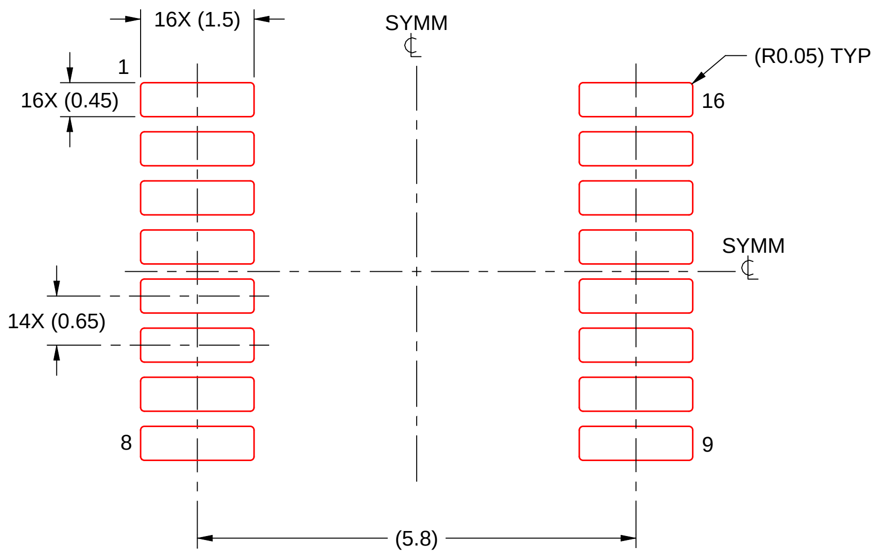
SOLDER MASK DEFINED

SOLDER MASK DETAILS

4220204/A 02/2017

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE: 10X

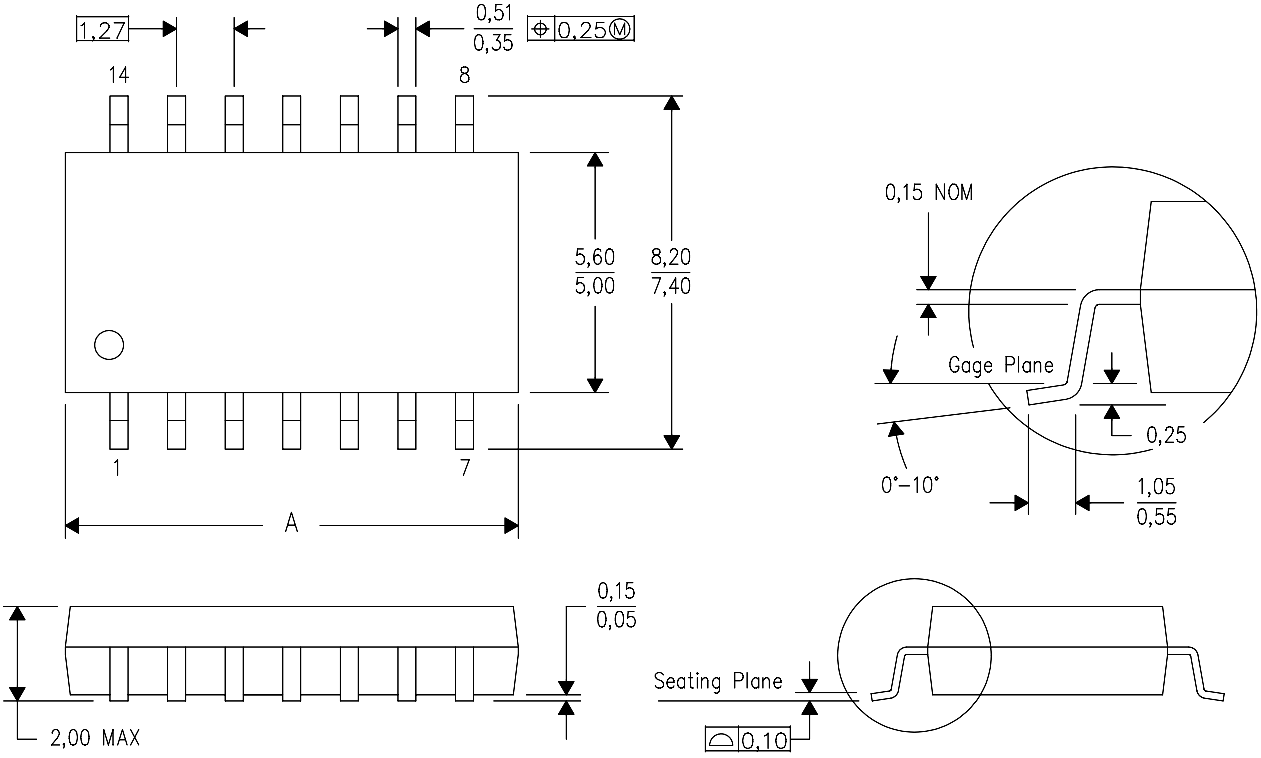
4220204/A 02/2017

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

NS (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14-PINS SHOWN



PINS ** / DIM	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265

SNx4HC32 Quadruple 2-Input Positive-OR Gates

1 Features

- Wide Operating Voltage Range: 2 V to 6 V
- Outputs Can Drive Up to 10 LSTTL Loads
- Low Power Consumption I_{CC}: 20 µA (Maximum)
- Typical t_{pd}: 8 ns
- ±4-mA Output Drive at 5 V
- Low Input Current: 1 µA (Maximum)

2 Applications

- Education
- Toys
- Musical Instruments
- Medical Healthcare and Fitness
- Grid Infrastructure
- Electronic Point of Sale
- Test and Measurement
- Factory Automation and Control
- Building Automation

3 Description

The SNx4HC32 devices contain four independent 2-input OR gates. They perform the boolean function $Y = \overline{\overline{A} \bullet \overline{B}}$ or $Y = A + B$ in positive logic.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
SN54HC32J	CDIP (14)	19.94 mm × 7.62 mm
SN54HC32W	CFP (14)	9.21 mm × 7.11 mm
SN54HC32FK	LCCC (20)	8.89 mm × 8.89 mm
SN74HC32D	SOIC (14)	4.90 mm × 3.91 mm
SN74HC32DB	SSOP (14)	6.20 mm × 5.30 mm
SN74HC32N	PDIP (14)	19.30 mm × 6.35 mm
SN74HC32NS	SO (14)	10.30 mm × 5.30 mm
SN74HC32PW	TSSOP (14)	5.00 mm × 4.40 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Logic Diagram (Positive Logic)

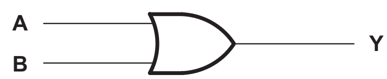


Table of Contents

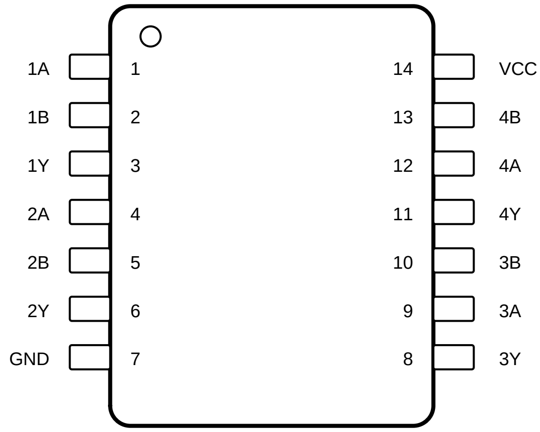
4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision D (August 2003) to Revision E	Page
• Added *ESD Ratings* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section	1
• Removed Ordering Information table	1
• Updated values in the *Thermal Information* tables to align with JEDEC standards	5

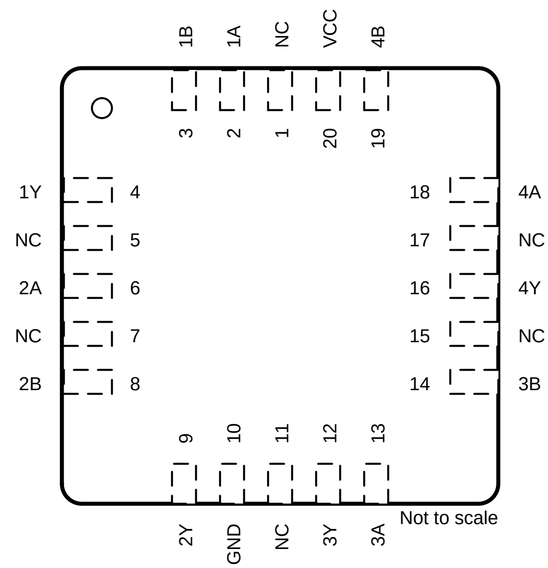
5 Pin Configuration and Functions

D, DB, J, N, NS, PW, W Package
14-Pin SOIC, SSOP, CDIP, PDIP, SOP, TSSOP, CFP
Top View



Not to scale

FK Package
20-Pin LCCC
Top View



Not to scale

Pin Functions

PIN			I/O	DESCRIPTION
NAME	D, DB, J, N, NS, PW, W	FK		
1A	1	2	I	Gate 1 input A
1B	2	3	I	Gate 1 input B
1Y	3	4	O	Gate 1 output
2A	4	6	I	Gate 2 input A
2B	5	8	I	Gate 2 input B
2Y	6	9	O	Gate 2 output
3A	9	13	I	Gate 3 input A
3B	10	14	I	Gate 3 input B
3Y	8	12	O	Gate 3 output
4A	12	18	I	Gate 4 input A
4B	13	19	I	Gate 4 input B
4Y	11	16	O	Gate 4 output
GND	7	10	—	Ground
NC	—	1, 5, 7, 11, 15, 17	—	No internal connection
V_{CC}	14	20	—	Power supply

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range		–0.5	7	V
I_{IK}	Input clamp current(2)	$V_I < 0$ or $V_I > V_{CC}$		±20	mA
I_{OK}	Output clamp current(2)	$V_O < 0$ or $V_O > V_{CC}$		±20	mA
I_O	Continuous output current	$V_O = 0$ to V_{CC}		±25	mA
	Continuous current through V_{CC} or GND			±50	mA
T_J	Operating virtual junction temperature			150	°C
T_{stg}	Storage temperature range		–65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The input negative-voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.

6.2 ESD Ratings: SN74HC32

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±750	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		2	5	6	V
V_{IH}	High-level input voltage	V_{CC} = 2 V	1.5			V
		V_{CC} = 4.5 V	3.15			
		V_{CC} = 6 V	4.2			
V_{IL}	Low-level input voltage	V_{CC} = 2 V			0.5	V
		V_{CC} = 4.5 V			1.35	
		V_{CC} = 6 V			1.8	
V_I	Input voltage		0		V_{CC}	V
V_O	Output voltage		0		V_{CC}	V
$\Delta t/\Delta v$	Input transition rise or fall time	V_{CC} = 2 V			1000	ns
		V_{CC} = 4.5 V			500	
		V_{CC} = 6 V			400	
T_A	Operating free-air temperature	SN54HC32	–55		125	°C
		SN74HC32	–40		85	

(1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to *Implications of Slow or Floating CMOS Inputs* application report.

6.4 Thermal Information: SN54HC32

THERMAL METRIC[(1)]		SN54HC32 CDIP (J) 14 PINS	SN54HC32 CFP (W) 14 PINS	SN54HC32 LCCC (FK) 20 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	—	—	—	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	54.9	88.3	61	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	80.1	156	59.6	°C/W
ψ_{JT}	Junction-to-top characterization parameter	—	—	—	°C/W
ψ_{JB}	Junction-to-board characterization parameter	—	—	—	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	25.1	15.2	11.7	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.5 Thermal Information: SN74HC32

THERMAL METRIC[(1)]		SN74HC32 SOIC (D) 14 PINS	SSOP (DB) 14 PINS	PDIP (N) 14 PINS	SOP (NS) 14 PINS	TSSOP (PW) 14 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	90.1	105.4	54.9	88.8	119.6	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	50.3	57.3	42.5	46.5	48.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	44.4	52.7	34.7	47.6	61.3	°C/W
ψ_{JT}	Junction-to-top characterization parameter	17.9	22.6	27.9	16.8	5.6	°C/W
ψ_{JB}	Junction-to-board characterization parameter	44.1	52.2	34.6	47.2	60.7	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	—	—	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.6 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{OH}	$V_I = V_{IH}$ or V_{IL}	$I_{OH} = –20\ \mu A$	$V_{CC} = 2\ V$	1.9	1.998		V
			$V_{CC} = 4.5\ V$	4.4	4.499		
			$V_{CC} = 6\ V$	5.9	5.999		
		$I_{OH} = –4\ mA$, $V_{CC} = 4.5\ V$	$T_A = 25°C$	3.98	4.3		
			SN54HC32	3.7			
			SN74HC32	3.84			
		$I_{OH} = –5.2\ mA$, $V_{CC} = 6\ V$	$T_A = 25°C$	5.48	5.8		
			SN54HC32	5.2			
			SN74HC32	5.34			

Electrical Characteristics (continued)

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	TYP	MAX	UNIT
V_{OL}		$V_I = V_{IH}$ or V_{IL}	I_{OL} = 20 µA	V_{CC} = 2 V		0.002	0.1	V
				V_{CC} = 4.5 V		0.001	0.1	
				V_{CC} = 6 V		0.001	0.1	
			I_{OL} = 4 mA, V_{CC} = 4.5 V	T_A = 25°C		0.17	0.26	
				SN54HC32			0.4	
				SN74HC32			0.33	
			I_{OL} = 5.2 mA, V_{CC} = 6 V	T_A = 25°C		0.15	0.26	
				SN54HC32			0.4	
				SN74HC32			0.33	
I_I		$V_I = V_{CC}$ or 0, V_{CC} = 6 V		T_A = 25°C		±0.1	±100	nA
				SNx4HC32			±1000	
I_{CC}		$V_I = V_{CC}$ or 0, I_O = 0, V_{CC} = 6 V		T_A = 25°C			2	µA
				SN54HC32			40	
				SN74HC32			20	
C_i		V_{CC} = 2 V to 6 V				3	10	pF
C_{pd}	Power dissipation capacitance per gate	T_A = 25°C, no load				20		pF

6.7 Switching Characteristics

over operating free-air temperature range (unless otherwise noted; see Figure 4)

PARAMETER	TEST CONDITIONS			MIN	TYP	MAX	UNIT
t_{pd}	C_L = 50 pF, from A or B (input) to Y (output)	V_{CC} = 2 V	T_A = 25°C		50	100	ns
			SN54HC32			150	
			SN74HC32			125	
		V_{CC} = 4.5 V	T_A = 25°C		10	20	
			SN54HC32			30	
			SN74HC32			25	
		V_{CC} = 6 V	T_A = 25°C		8	17	
			SN54HC32			25	
			SN74HC32			21	
t_t	C_L = 50 pF, to Y (output)	V_{CC} = 2 V	T_A = 25°C		38	75	ns
			SN54HC32			110	
			SN74HC32			95	
		V_{CC} = 4.5 V	T_A = 25°C		8	15	
			SN54HC32			22	
			SN74HC32			19	
		V_{CC} = 6 V	T_A = 25°C		6	13	
			SN54HC32			19	
			SN74HC32			16	

6.8 Typical Characteristics

T_A = 25°C and C_L = 50 pF

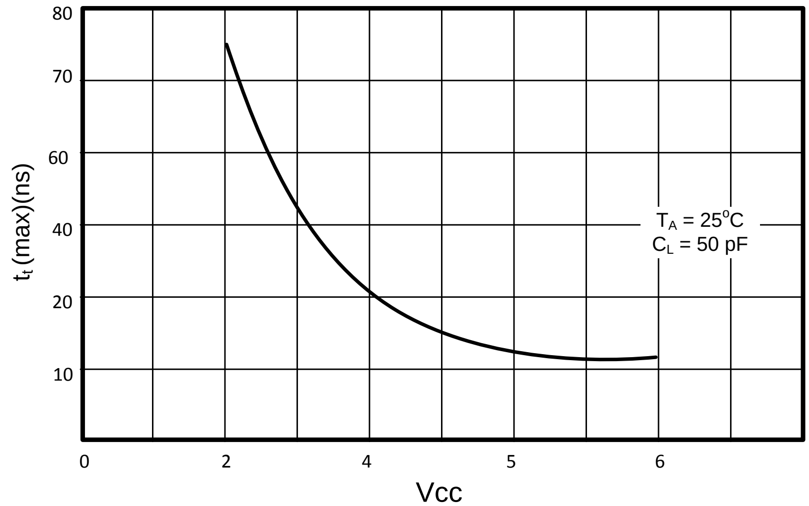


Figure 1. t_t vs V_{CC}

7 Parameter Measurement Information

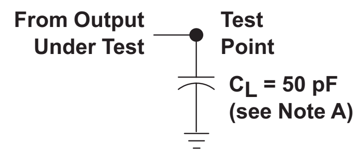


Figure 2. Load Current

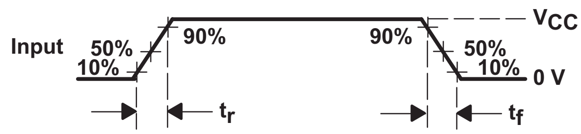
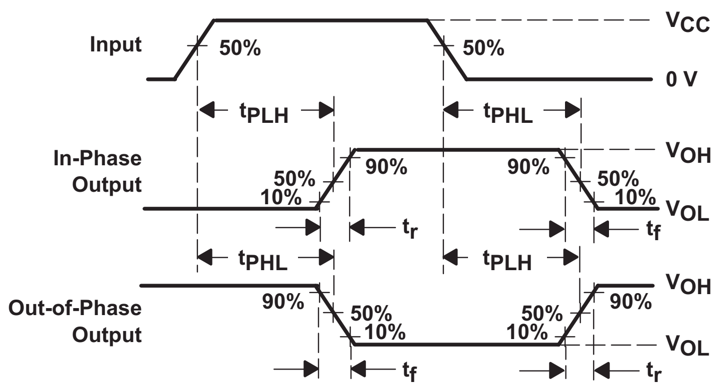


Figure 3. Input Rise and Fall Times



NOTES: A. C_L includes probe and test-fixture capacitance.

B. Phase relationship between waveforms were chosen arbitrarily. All input pulses are supplied by generators having the following characteristics:
PRR ≤ 1 MHz, ZO = 50 Ω, t_r = 6 ns, t_f = 6 ns.

C. The outputs are measured one at a time with one input transition per measurements.

D. t_{PLH} and t_{PHL} are the same as t_{pd}.

Figure 4. Propagation Delay and Output Transition Times

8 Detailed Description

8.1 Overview

The SNx4HC32 devices are quad 2-input OR gates. These devices are members of the High-Speed CMOS (HC) logic family. The HC family of logic is optimized to operate with a 5-V supply, is low noise without characteristic overshoot and undershoot, has low power consumption, small propagation delay, balanced propagation delay and transition times, and operates over a wide temperature range.

8.2 Functional Block Diagram

Figure 5. Logic Diagram (Positive Logic)

8.3 Feature Description

8.3.1 Operating Voltage Range

The SNx4HC series of devices offer a wide operating voltage range from 2 V to 6 V.

8.3.2 LSTTL Loads

The outputs of the SNx4HC series can drive up to 10 LSTTL loads.

8.3.3 Low Power Consumption

The SNx4HC32 offers low power consumption of 20 μA (maximum).

8.3.4 Output Drive Capability

At 5 V, the outputs have ±4 mA of output drive capability.

8.3.5 Low Input Current Leakage

Inputs have low input current leakage of 1 μA (maximum).

8.4 Device Functional Modes

Table 1 lists the functional modes of SNx4HC32.

Table 1. Function Table (Each Gate)

INPUTS		OUTPUT
A	B	Y
H	X	H
X	H	H
L	L	L

9 Application and Implementation

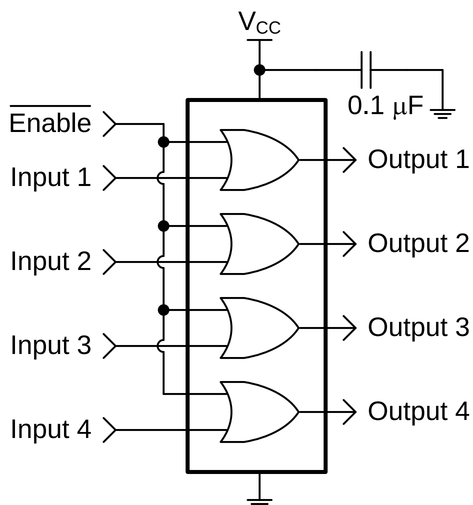
NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

9.1 Application Information

The SNx4HC32 is an extremely versatile device with far more available applications than could be listed here. The application chosen as an example is using all four OR gates in a single package to provide a four channel output enable from a single active low enable signal ($\overline{\text{Enable}}$). This circuit outputs a logic HIGH on all channels when disabled ($\overline{\text{Enable}}$ is HIGH), and passes the input signals when enabled ($\overline{\text{Enable}}$ is LOW).

9.2 Typical Application



Using a quad OR gate as a 4-channel active low enable with high output off state.

Figure 6. Typical Application Schematic

9.2.1 Design Requirements

This device uses CMOS technology and has balanced output drive. Take care to avoid bus contention because it can drive currents that would exceed maximum limits. The high drive also creates fast edges into light loads, so routing and load conditions must be considered to prevent ringing.

The minimum output pulse time is approximately three times t_{pd} from *Switching Characteristics* for the selected V_{CC}, device, and temperature range.

9.2.2 Detailed Design Procedure

Logic

- All four input channels are to be enabled or disabled simultaneously
- The enable signal is active low (LOW = enabled, HIGH = disabled)
- All four outputs are to output logic HIGH while disabled

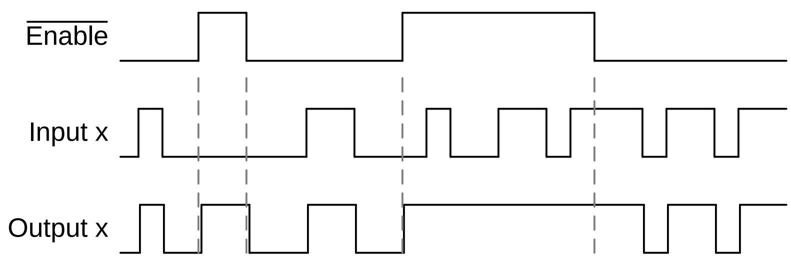
Inputs

- Each input must follow requirements specified in *Absolute Maximum Ratings*:
  – Avoid exceeding input voltages

Typical Application (continued)

  – If input voltages ratings must be exceeded, ensure that the maximum input current ratings are not exceeded.
  – Ensure that the input signals have edge rates that are equal to or faster than that listed in *Recommended Operating Conditions*. Slower signals can cause incorrect behavior and possibly damage to the part.
- Each output must also follow requirements in *Absolute Maximum Ratings*:
  – Avoid bus contention by only connecting outputs together when inputs are tied together directly.
  – Avoid forcing output voltages outside those specified in *Absolute Maximum Ratings*.
  – If output voltage ratings must be exceeded, ensure that the maximum output current ratings are not exceeded.
  – Ensure that the total current output does not exceed the continuous current through V_{CC} or GND listed in *Absolute Maximum Ratings*.

9.2.3 Application Curves



Dotted lines indicate $\overline{\text{Enable}}$ signal changes

Figure 7. Application Timing Diagram

10 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating located in *Recommended Operating Conditions*. Each V_{CC} pin must have a good bypass capacitor to prevent power disturbance. For devices with a single supply, TI recommends a 0.1-μF bypass capacitor. If there are multiple V_{CC} pins, TI recommends a 0.01-μF or 0.022-μF bypass capacitors for each power pin. It is acceptable to parallel multiple bypass capacitors to reject different frequencies of noise. Two bypass capacitors of value 0.1-μF and 1-μF are commonly used in parallel. For best results, install the bypass capacitor(s) as close to the power pin as possible.

11 Layout

11.1 Layout Guidelines

When using multiple bit logic devices, inputs must not float. In many cases, functions or parts of functions of digital logic devices are unused. Some examples are when only two inputs of a triple-input AND gate are used, or when only 3 of the 4-buffer gates are used. Such input pins must not be left unconnected because the undefined voltages at the outside connections result in undefined operational states. Specified in *Absolute Maximum Ratings* are rules that must be observed under all circumstances. All unused inputs of digital logic devices must be connected to a high or low bias to prevent them from floating. The logic level that must be applied to any particular unused input depends on the function of the device. Generally they are tied to GND or V_{CC}, whichever makes more sense or is more convenient. It is acceptable to float outputs unless the part is a transceiver. If the transceiver has an output enable pin, it disables the outputs section of the part when asserted. This does not disable the input section of the I/Os so they also cannot float when disabled.

11.2 Layout Example

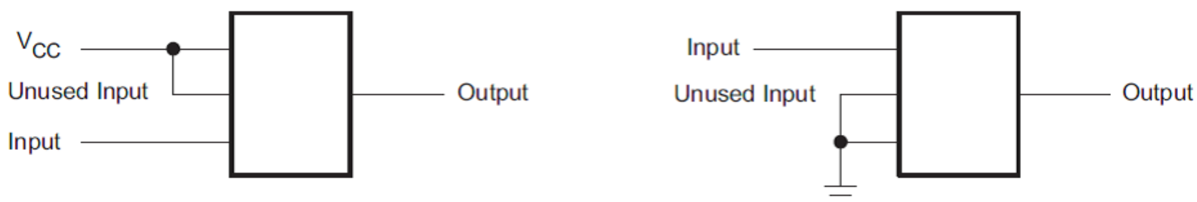


Figure 8. Layout Recommendation

12 Device and Documentation Support

12.1 Documentation Support

12.1.1 Related Documentation

For related documentation see the following:
- *Implications of Slow or Floating CMOS Inputs* (SCBA004)

12.2 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 2. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
SN54HC32	Click here	Click here	Click here	Click here	Click here
SN74HC32	Click here	Click here	Click here	Click here	Click here

12.3 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

12.4 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community ***TI's Engineer-to-Engineer (E2E) Community.*** Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

12.5 Trademarks

E2E is a trademark of Texas Instruments.
All other trademarks are the property of their respective owners.

12.6 Electrostatic Discharge Caution

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

12.7 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

13 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
5962-8404501VCA	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	5962-8404501VC A SNV54HC32J	Samples
5962-8404501VDA	ACTIVE	CFP	W	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	5962-8404501VD A SNV54HC32W	Samples
84045012A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	84045012A SNJ54HC 32FK	Samples
8404501CA	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	8404501CA SNJ54HC32J	Samples
8404501DA	ACTIVE	CFP	W	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	8404501DA SNJ54HC32W	Samples
JM38510/65201B2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	JM38510/ 65201B2A	Samples
JM38510/65201BCA	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	JM38510/ 65201BCA	Samples
JM38510/65201BDA	ACTIVE	CFP	W	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	JM38510/ 65201BDA	Samples
M38510/65201B2A	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	JM38510/ 65201B2A	Samples
M38510/65201BCA	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	JM38510/ 65201BCA	Samples
M38510/65201BDA	ACTIVE	CFP	W	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	JM38510/ 65201BDA	Samples
SN54HC32J	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	SN54HC32J	Samples
SN74HC32D	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32DBR	ACTIVE	SSOP	DB	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32DE4	ACTIVE	SOIC	D	14	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32DR	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 85	HC32	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74HC32DRE4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32DRG4	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32DT	ACTIVE	SOIC	D	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32N	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	SN74HC32N	Samples
SN74HC32NE4	ACTIVE	PDIP	N	14	25	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type	-40 to 85	SN74HC32N	Samples
SN74HC32NSR	ACTIVE	SO	NS	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PW	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PWG4	ACTIVE	TSSOP	PW	14	90	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PWR	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU | CU SN	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PWRG4	ACTIVE	TSSOP	PW	14	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PWT	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SN74HC32PWTG4	ACTIVE	TSSOP	PW	14	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	-40 to 85	HC32	Samples
SNJ54HC32FK	ACTIVE	LCCC	FK	20	1	TBD	POST-PLATE	N / A for Pkg Type	-55 to 125	84045012A SNJ54HC 32FK	Samples
SNJ54HC32J	ACTIVE	CDIP	J	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	8404501CA SNJ54HC32J	Samples
SNJ54HC32W	ACTIVE	CFP	W	14	1	TBD	A42	N / A for Pkg Type	-55 to 125	8404501DA SNJ54HC32W	Samples

[1] The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF SN54HC32, SN54HC32-SP, SN74HC32 :

- Catalog: SN74HC32, SN54HC32
- Military: SN54HC32
- Space: SN54HC32-SP

NOTE: Qualified Version Definitions:

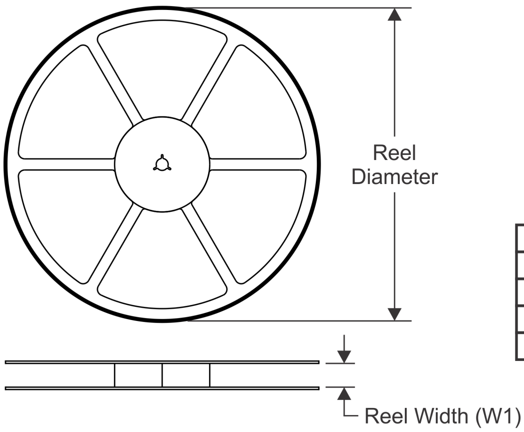
- Catalog - TI's standard catalog product

- Military - QML certified for Military and Defense Applications

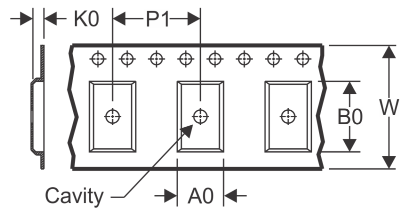
- Space - Radiation tolerant, ceramic packaging and qualified for use in Space-based application

TAPE AND REEL INFORMATION

REEL DIMENSIONS

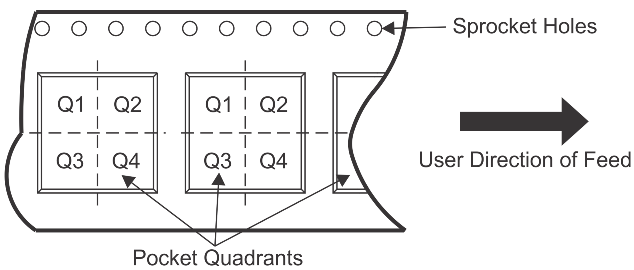


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

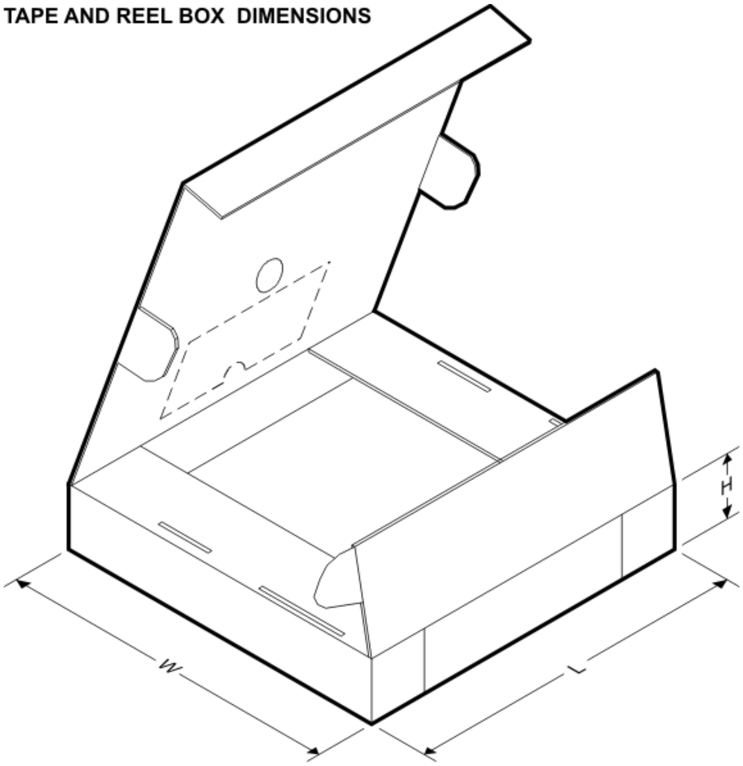
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74HC32DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN74HC32DR	SOIC	D	14	2500	330.0	16.8	6.5	9.5	2.1	8.0	16.0	Q1
SN74HC32DR	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN74HC32DRG4	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN74HC32DRG4	SOIC	D	14	2500	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN74HC32DT	SOIC	D	14	250	330.0	16.4	6.5	9.0	2.1	8.0	16.0	Q1
SN74HC32PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74HC32PWR	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74HC32PWRG4	TSSOP	PW	14	2000	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1
SN74HC32PWT	TSSOP	PW	14	250	330.0	12.4	6.9	5.6	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS

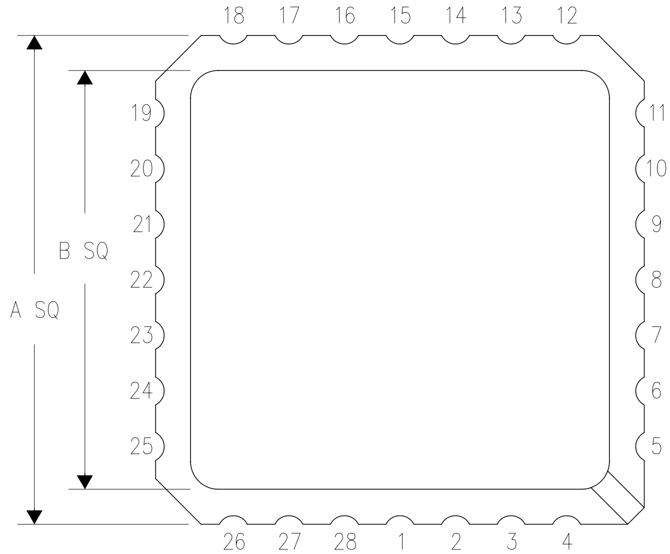


*All dimensions are nominal

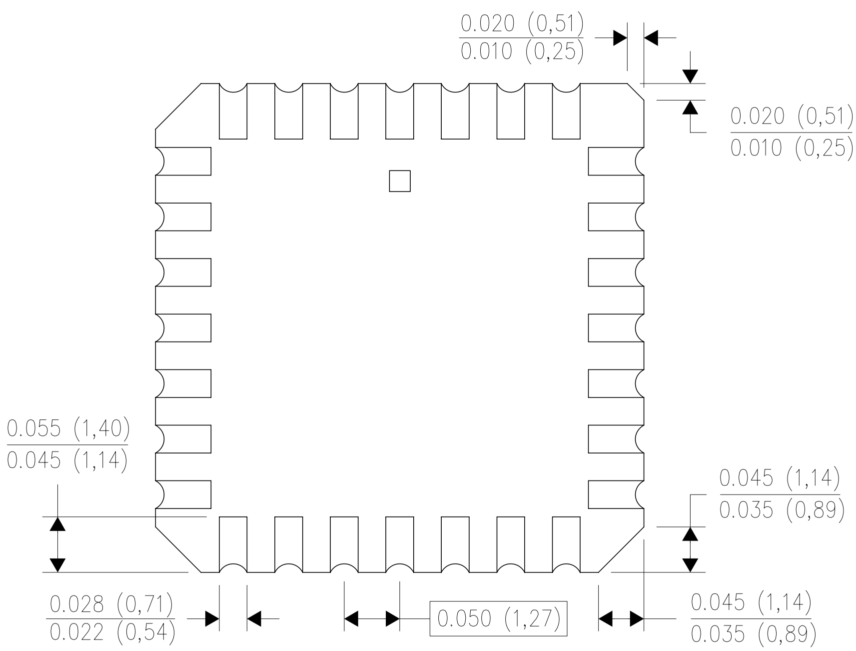
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74HC32DR	SOIC	D	14	2500	333.2	345.9	28.6
SN74HC32DR	SOIC	D	14	2500	364.0	364.0	27.0
SN74HC32DR	SOIC	D	14	2500	367.0	367.0	38.0
SN74HC32DRG4	SOIC	D	14	2500	367.0	367.0	38.0
SN74HC32DRG4	SOIC	D	14	2500	333.2	345.9	28.6
SN74HC32DT	SOIC	D	14	250	210.0	185.0	35.0
SN74HC32PWR	TSSOP	PW	14	2000	367.0	367.0	35.0
SN74HC32PWR	TSSOP	PW	14	2000	364.0	364.0	27.0
SN74HC32PWRG4	TSSOP	PW	14	2000	367.0	367.0	35.0
SN74HC32PWT	TSSOP	PW	14	250	367.0	367.0	35.0

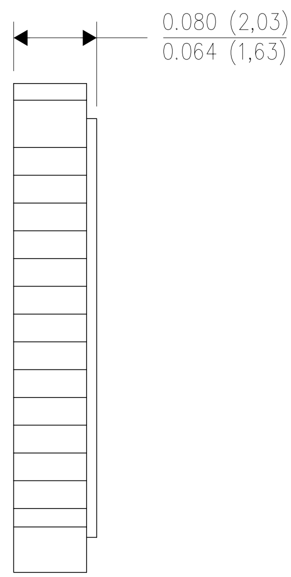
FK (S–CQCC–N**) LEADLESS CERAMIC CHIP CARRIER

28 TERMINAL SHOWN



NO. OF TERMINALS **	A		B	
	MIN	MAX	MIN	MAX
20	0.342 (8,69)	0.358 (9,09)	0.307 (7,80)	0.358 (9,09)
28	0.442 (11,23)	0.458 (11,63)	0.406 (10,31)	0.458 (11,63)
44	0.640 (16,26)	0.660 (16,76)	0.495 (12,58)	0.560 (14,22)
52	0.740 (18,78)	0.761 (19,32)	0.495 (12,58)	0.560 (14,22)
68	0.938 (23,83)	0.962 (24,43)	0.850 (21,6)	0.858 (21,8)
84	1.141 (28,99)	1.165 (29,59)	1.047 (26,6)	1.063 (27,0)



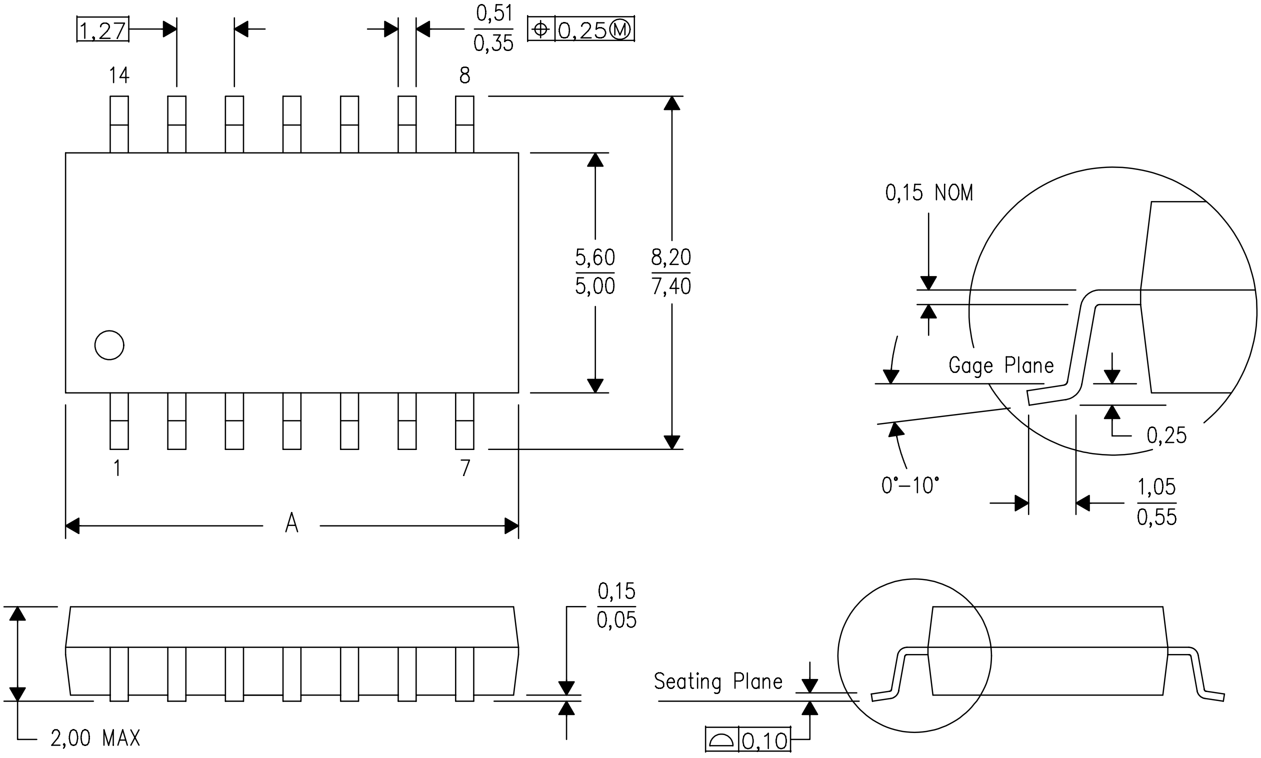


4040140/D 01/11

NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a metal lid.
D. Falls within JEDEC MS–004

NS (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14-PINS SHOWN

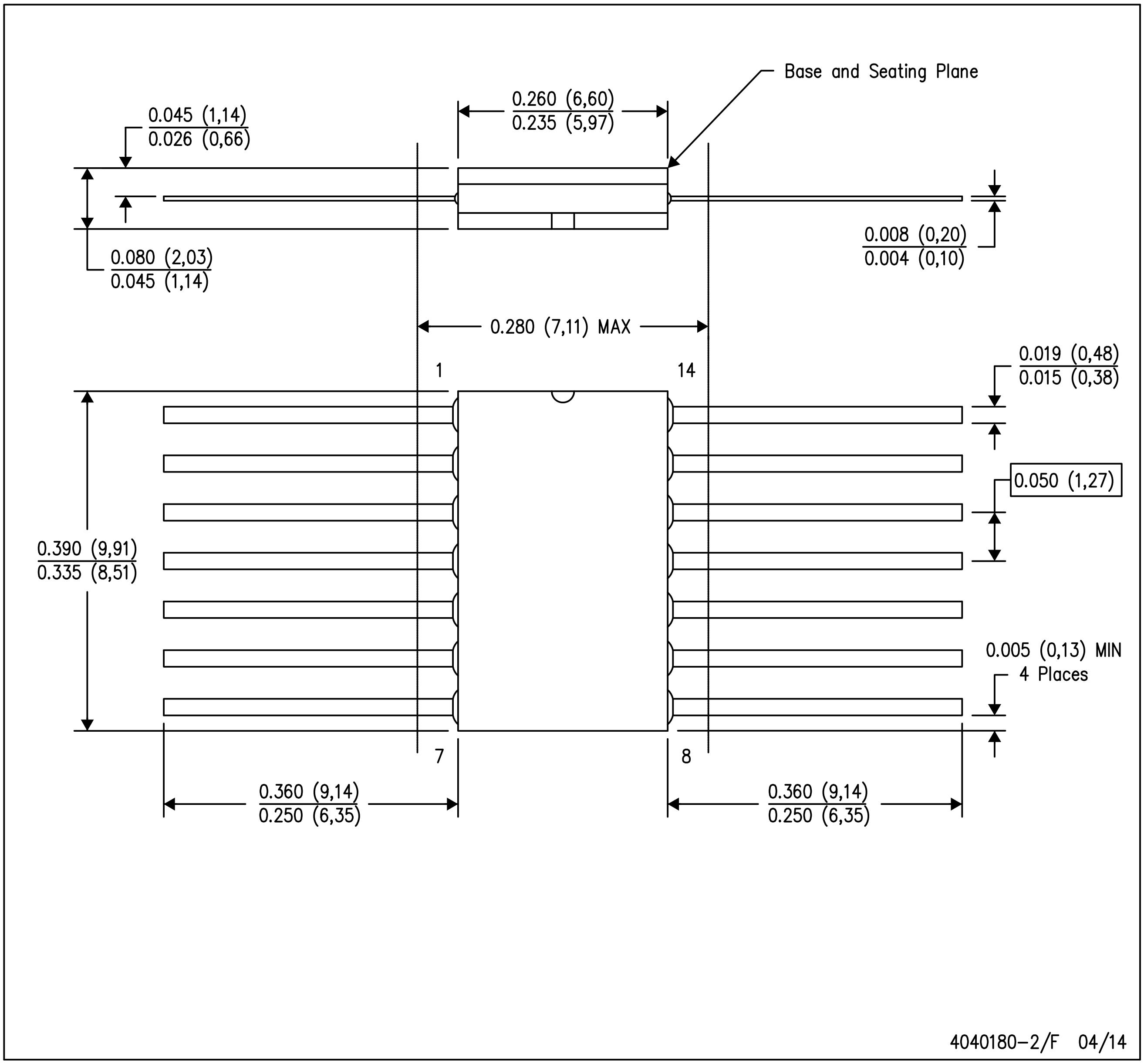


DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

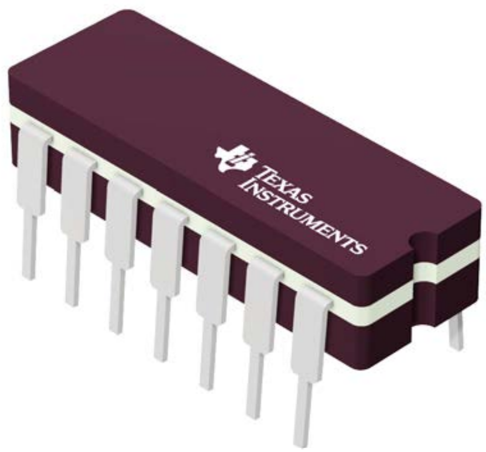
W (R–GDFP–F14) CERAMIC DUAL FLATPACK



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. This package can be hermetically sealed with a ceramic lid using glass frit.
D. Index point is provided on cap for terminal identification only.
E. Falls within MIL STD 1835 GDFP1–F14

J 14 CDIP - 5.08 mm max height

CERAMIC DUAL IN LINE PACKAGE



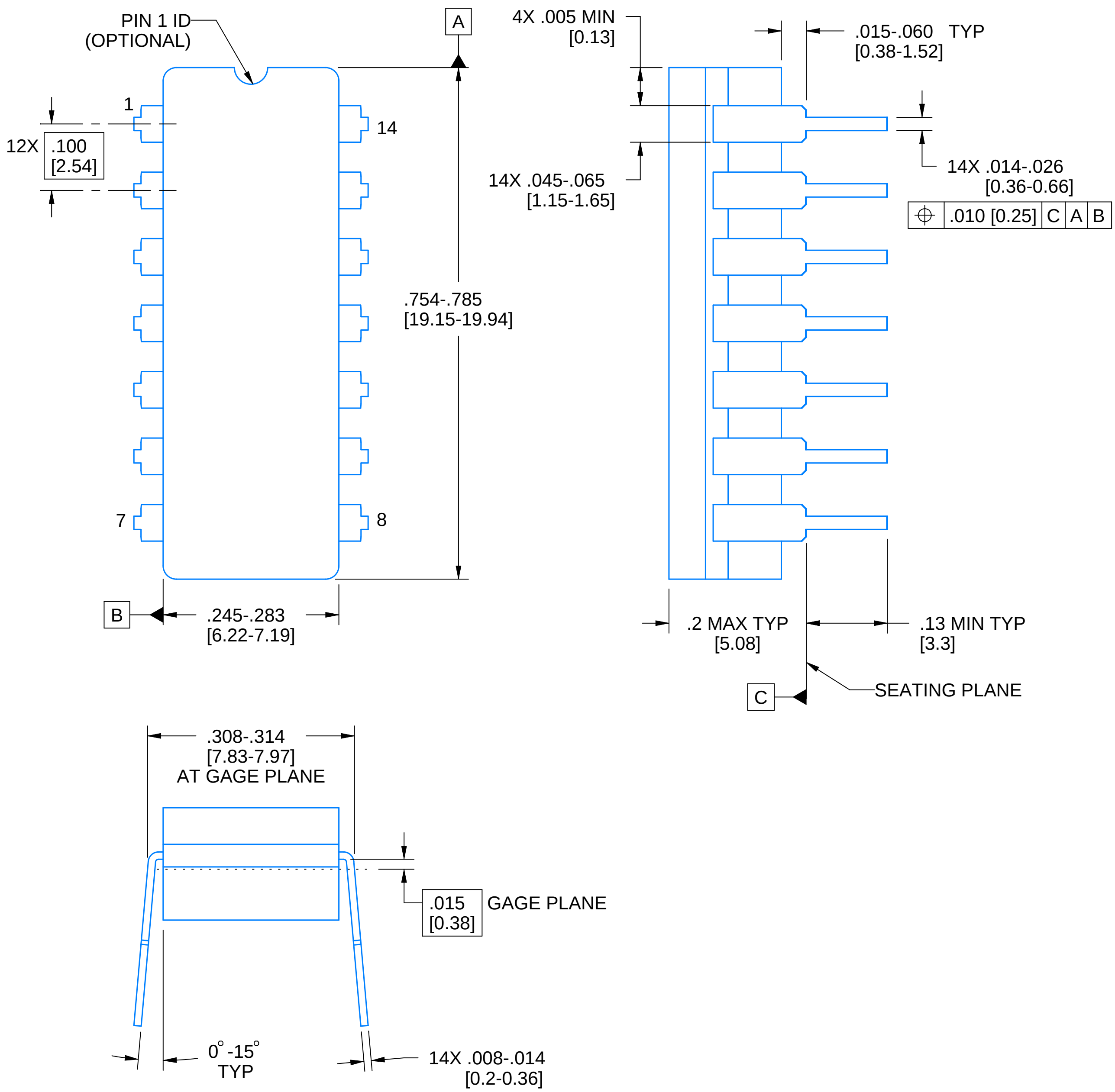
Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4040083-5/G

PACKAGE OUTLINE

CDIP - 5.08 mm max height

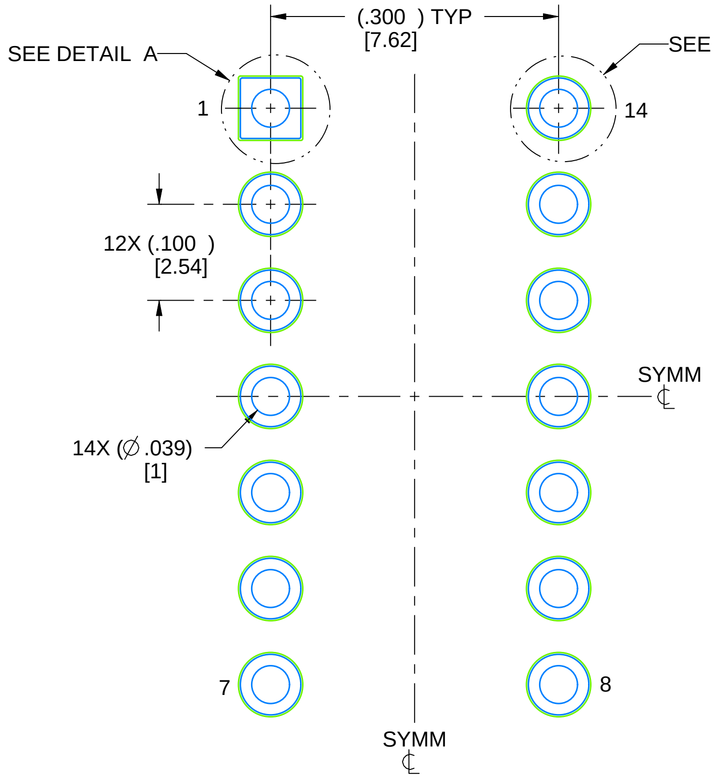
CERAMIC DUAL IN LINE PACKAGE



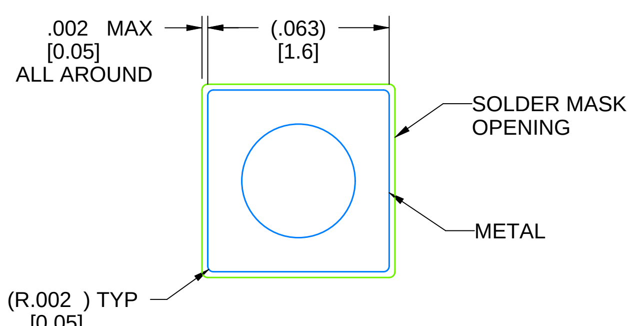
4214771/A 05/2017

NOTES:

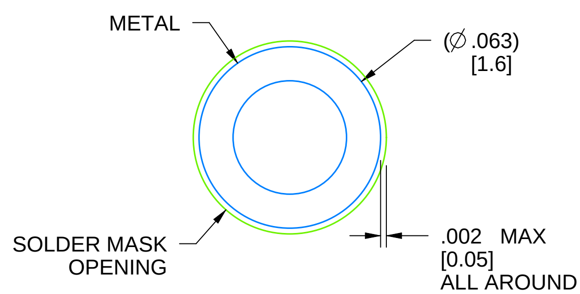
1. All controlling linear dimensions are in inches. Dimensions in brackets are in millimeters. Any dimension in brackets or parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. This package is hermitically sealed with a ceramic lid using glass frit.
4. Index point is provided on cap for terminal identification only and on press ceramic glass frit seal only.
5. Falls within MIL-STD-1835 and GDIP1-T14.



LAND PATTERN EXAMPLE
NON-SOLDER MASK DEFINED
SCALE: 5X



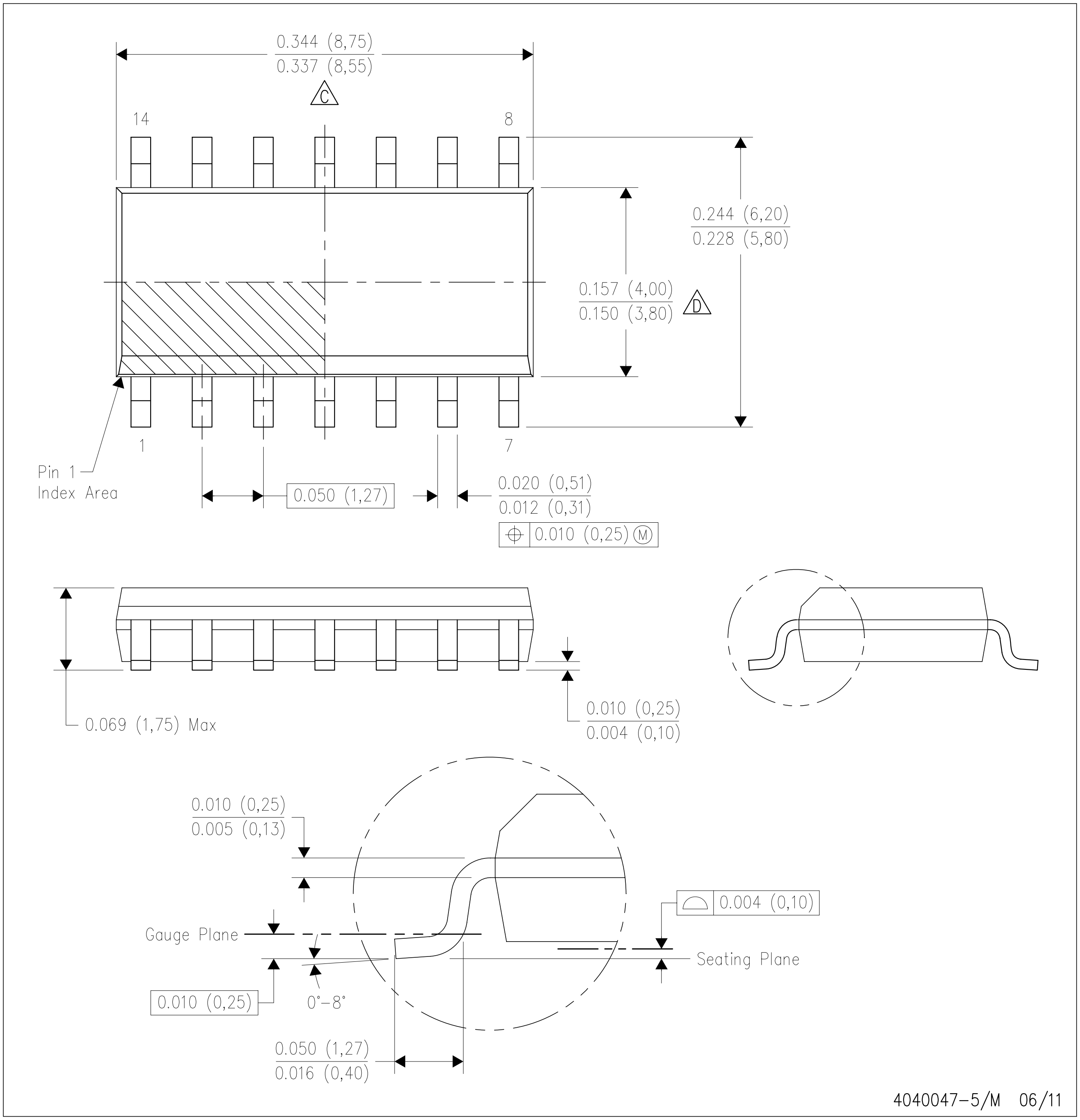
DETAIL A
SCALE: 15X



DETAIL B
13X, SCALE: 15X

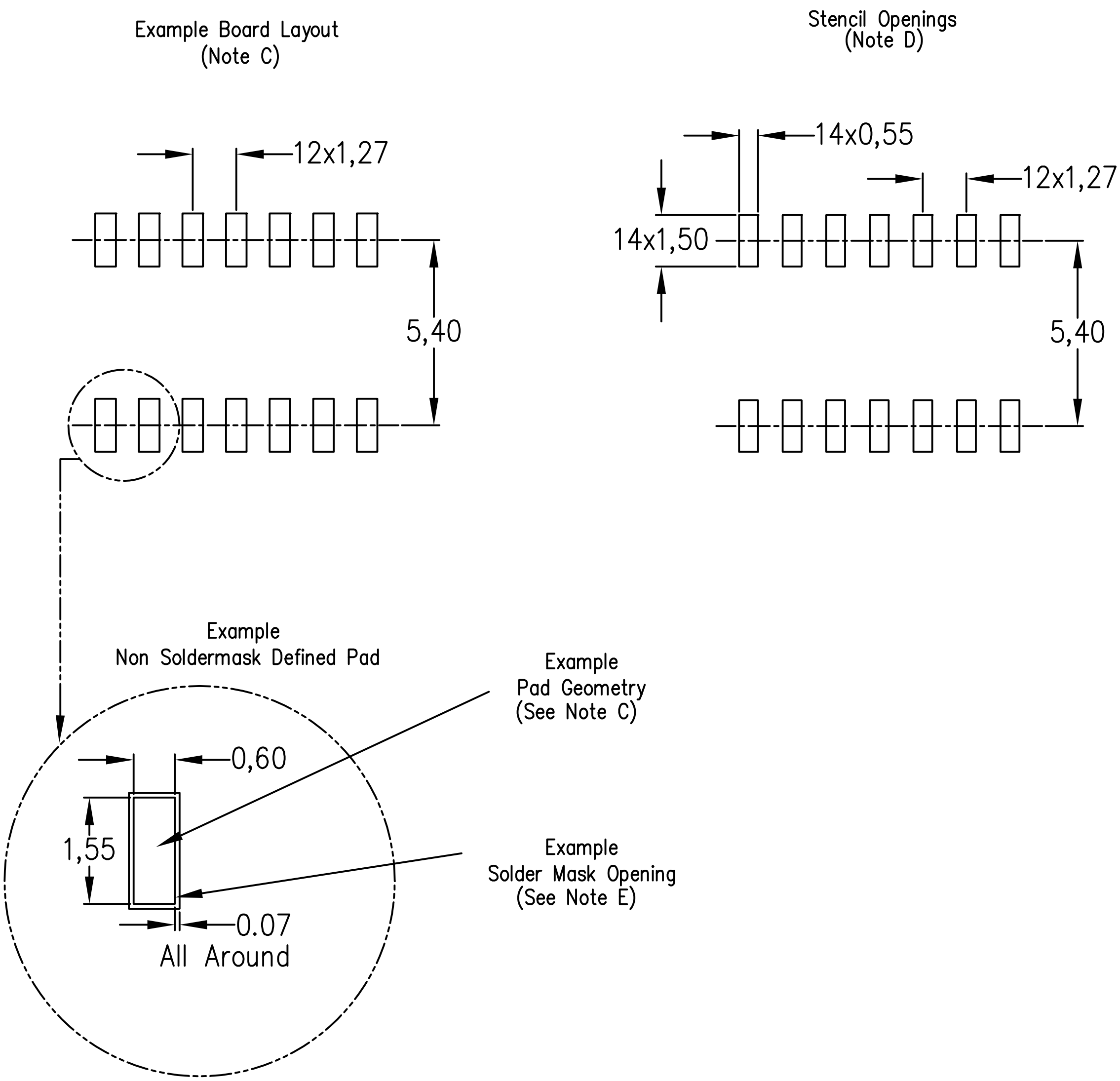
4214771/A 05/2017

D (R–PDSO–G14) PLASTIC SMALL OUTLINE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
E. Reference JEDEC MS-012 variation AB.

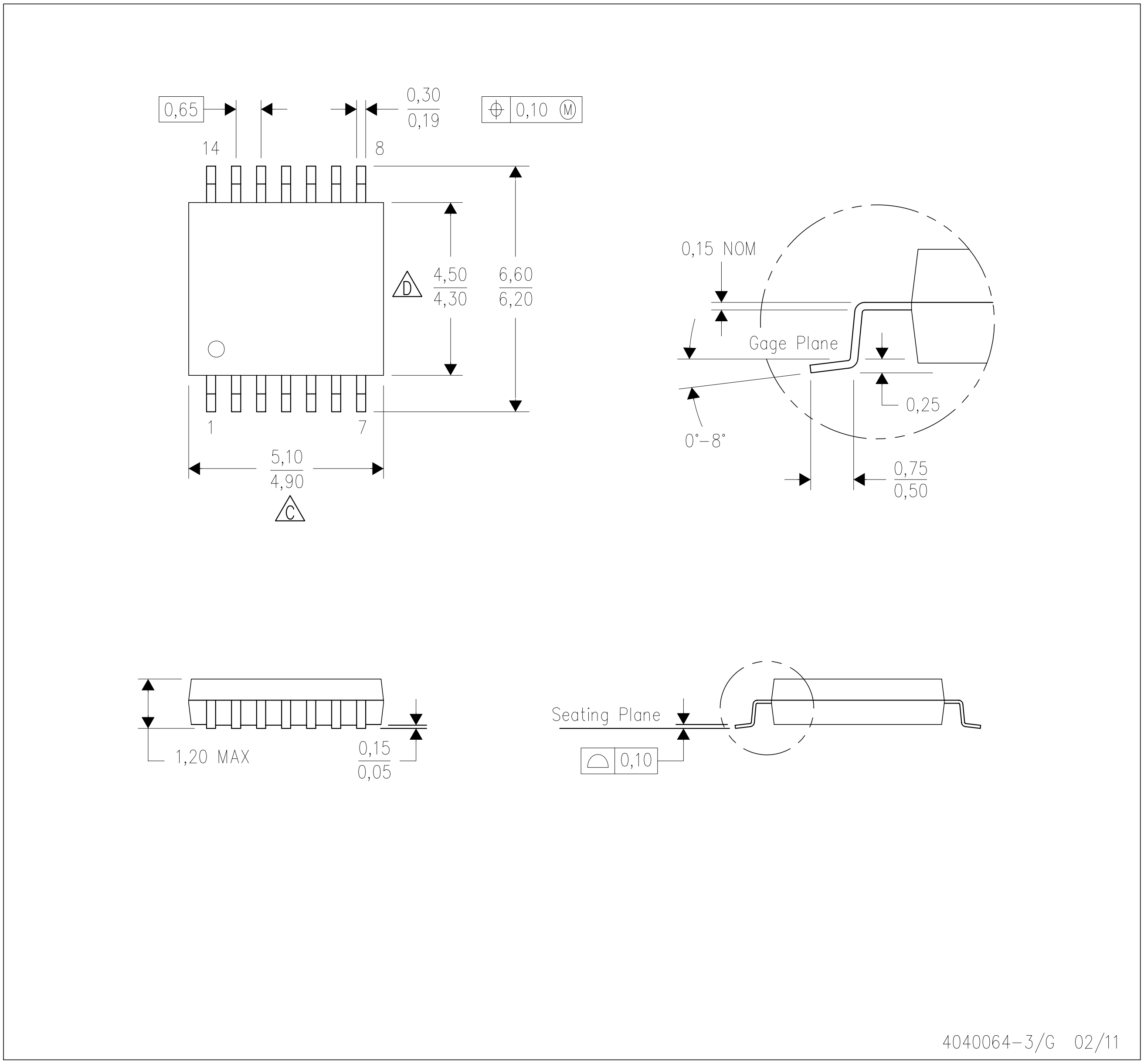
D (R-PDSO-G14) PLASTIC SMALL OUTLINE



4211283-3/E 08/12

NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

PW (R-PDSO-G14) PLASTIC SMALL OUTLINE



NOTES:

A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.

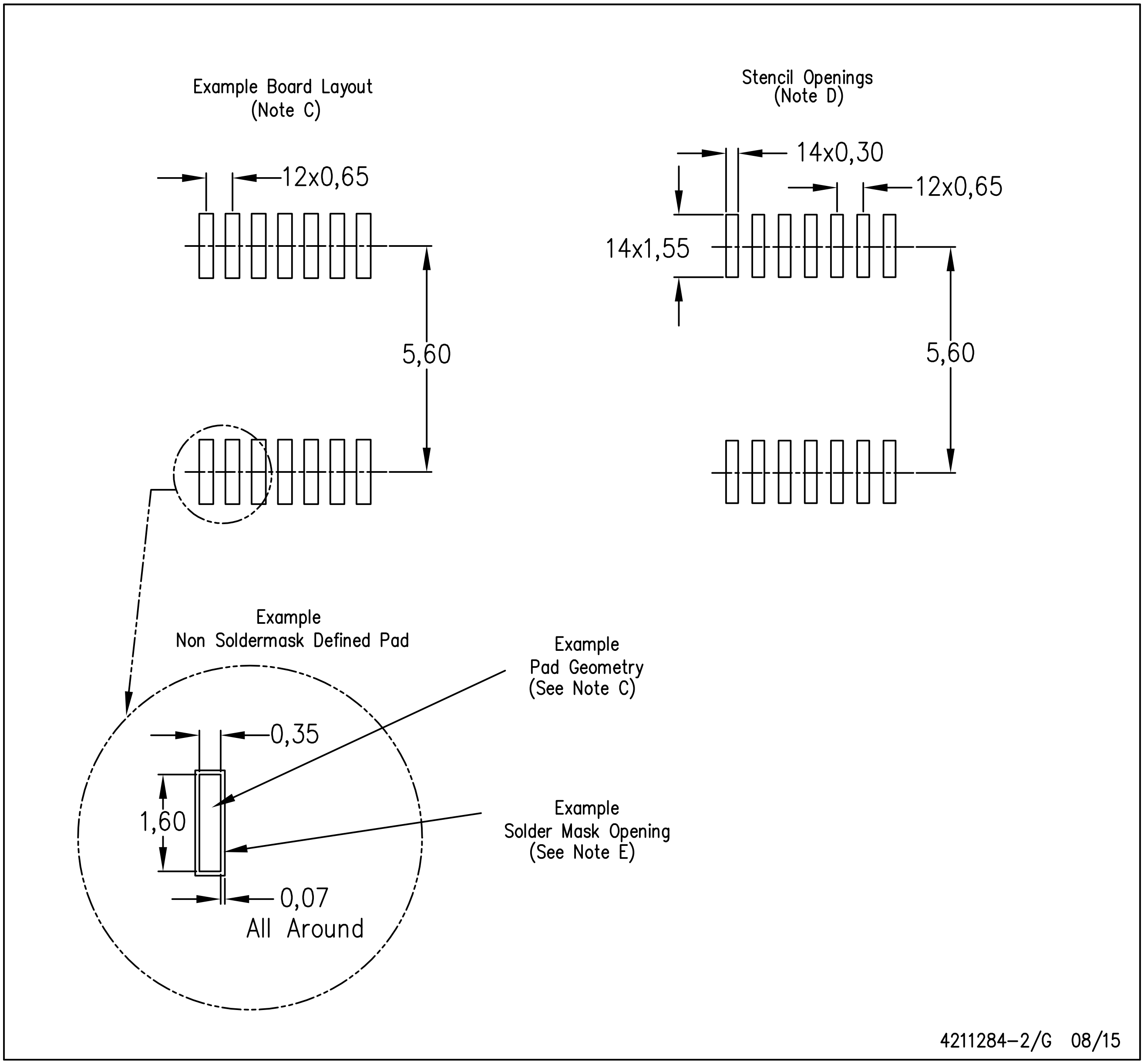
B. This drawing is subject to change without notice.

C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.

D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.

E. Falls within JEDEC MO-153

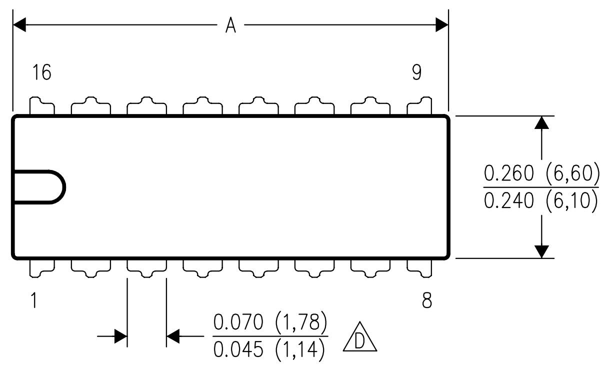
PW (R-PDSO-G14) PLASTIC SMALL OUTLINE



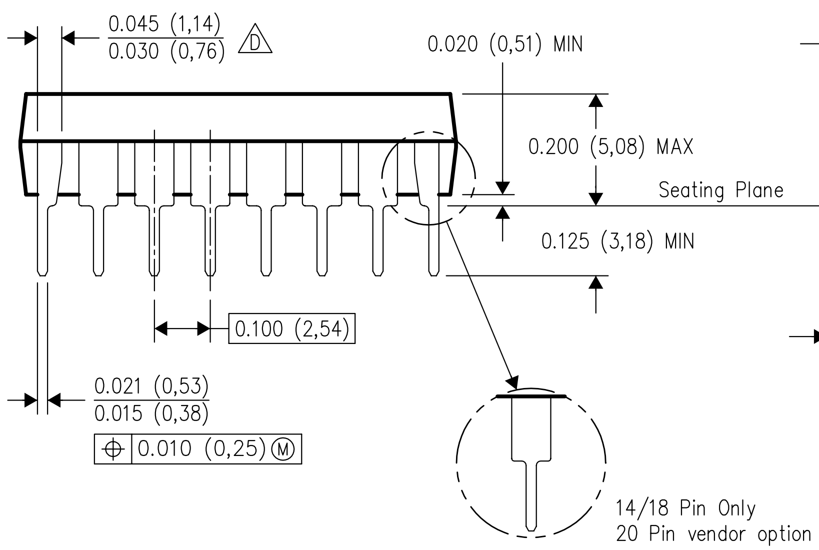
NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC-7351 is recommended for alternate designs.
D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

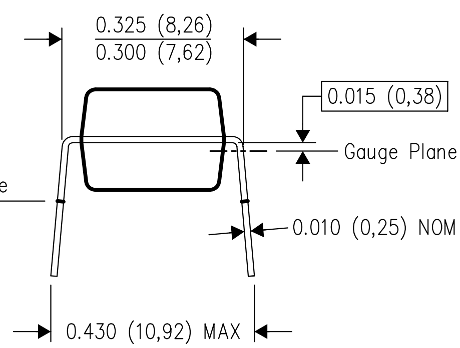
N (R–PDIP–T**) PLASTIC DUAL–IN–LINE PACKAGE

16 PINS SHOWN



PINS ** / DIM	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS–001 VARIATION (C)	AA	BB	AC	AD



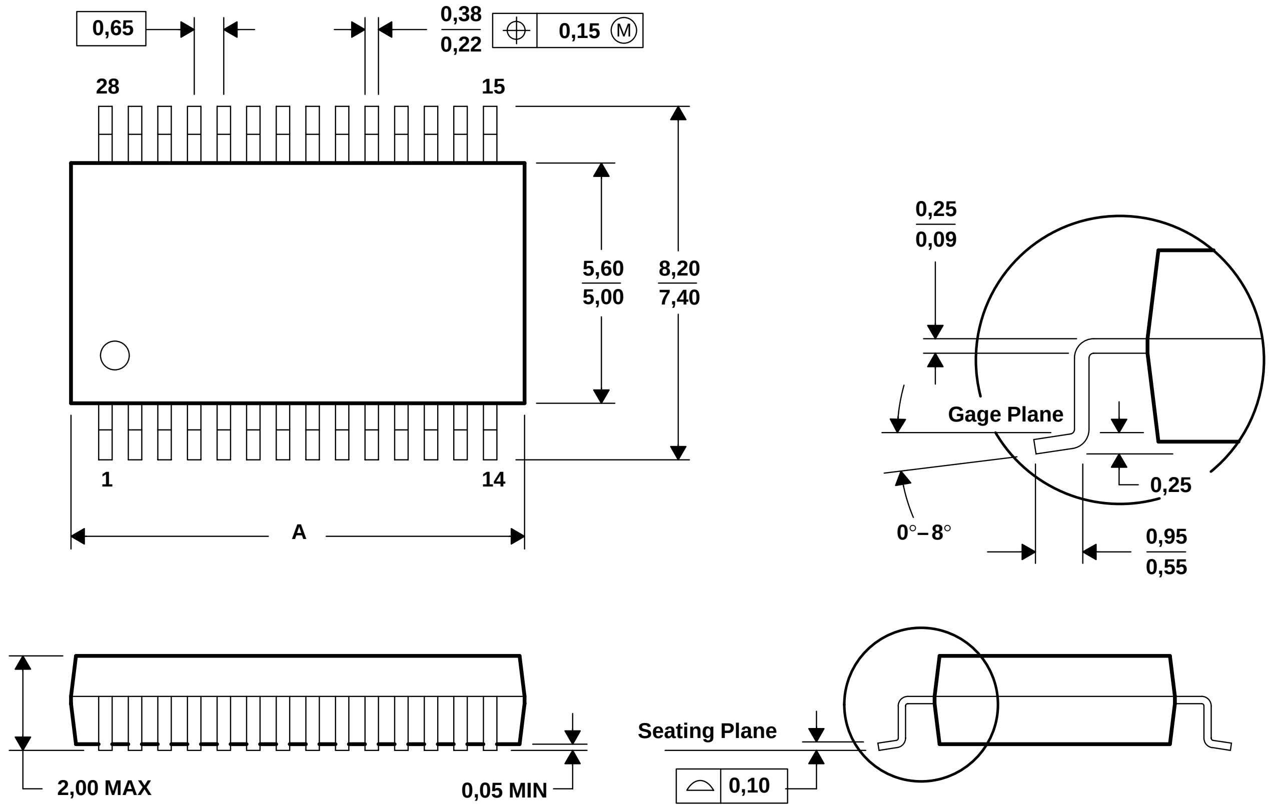


4040049/E 12/2002

NOTES:
- A. All linear dimensions are in inches (millimeters).
- B. This drawing is subject to change without notice.
- C. Falls within JEDEC MS–001, except 18 and 20 pin minimum body length (Dim A).
- D. The 20 pin end lead shoulder width is a vendor option, either half or full width.

DB (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

28 PINS SHOWN



PINS ** / DIM	14	16	20	24	28	30	38
A MAX	6,50	6,50	7,50	8,50	10,50	10,50	12,90
A MIN	5,90	5,90	6,90	7,90	9,90	9,90	12,30

4040065 /E 12/01

NOTES:
- A. All linear dimensions are in millimeters.
- B. This drawing is subject to change without notice.
- C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
- D. Falls within JEDEC MO-150

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265