



Soft Target for Advanced Emergency Braking System Daimler Trucks

ME 428, 429, 430
2016-2017

2 June 2017

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Executive Summary

This report provides an overview of the AEBS Soft Target project delivered to Daimler Trucks North America as part of the 2016-2017 Mechanical Engineering Senior Design class at California Polytechnic State University, San Luis Obispo. The purpose was to build a soft target to test Advanced Emergency Braking Systems, or AEBS, on Daimler's large trucks. Though this design is for Daimler specifically, there may be other interested parties such as highway safety groups and rival auto manufacturers. Currently, there are no suitable alternative products that satisfy every requirement for Daimler to validate their systems. They require a target that must not damage their trucks, visible to their sensor systems, mountable to a moving frame, can be reset quickly, and is a cheaper long term testing solution than their current setup.

The team was able to build a target that had improved car profile and appearance compared to preexisting targets while producing the target for a very low cost. The truss, bumpers, and tarp proved durable in Cal Poly's testing environment. However, the base connections are a weak point of the design and failed when run over in testing. Fortunately these pieces are extremely quick and inexpensive to replace. Further full scale testing would better validate these results for truck impact.

1 Introduction

The team decided on a tube-frame design would best meet the specifications. The soft target will consist of a three dimensional truss structure made of foam tubes. These tubes will be stiffened with PVC tubing that will allow them to withstand both driving and wind loads. The surrounding foam will allow proper impact absorption to both protect the truck and the truss stiffeners upon impact. A modular outer covering will allow the target to be constructed as either an entire vehicle, or a portion of the vehicle for specific testing. Foam bumpers will be attached to key locations to give the covering a proper car shape. This will allow the increase in component life for pieces unnecessary in different tests as well as increase the reset time and target simplicity.

2 Background Research

A thorough development of the problem will allow for the most efficient design process. Therefore the team chose major topics to research as to understand where past solutions failed and what must be known to create a better system.

2.1 Benchmarking

There are already various designs for a soft target crash vehicle in use and on the market. Looking at the various designs and systems available allows an understanding of what other designs believed the best solution was as well as a look at what shortcomings the new design will need to overcome.

2.1.1 Soft Targets

Dynamic Research Inc. (DRI), a leader in vehicle dynamics and accidentology, created a guided soft target (GST) system titled the Soft Car. The entire GST comes with a dynamic motion platform and a soft target which sits on top. The soft target which is the primary concern for this project can be seen

in figure 2.1. The Target consists of interlocking internal panels forming the framework of a small sedan and a canvas covering which provides the exterior presentation of a car. The Soft Car is made entirely of soft materials like polyethylene foam, hook-and-loop closure, and flexible epoxy. The target is designed to minimize damage during a collision to both the oncoming vehicle and the target itself. DRI includes some performance specifications (Kelly et al). The top speed the soft target can travel without deforming is greater than 55 km/h. The reassembly time is 10 minutes, and the daylight visibility distance of the car is greater than 0.5 km. While data on actual collisions and durability of the design are not given, the soft target is capable of collisions from any angle giving it versatility in performable crash tests (Dynamic Research Inc).



Figure 2.1 GST Soft Car, Front View.

DRI also has two different test target designs, as seen in figures 2.2 and 2.3, marketed under the name Soft Car 360TM. This product is a more refined version of the soft car previously mentioned. The Soft Car 360TM uses foam pieces and per DRI's website, "In the event of a collision with the GST, the Soft Car 360TM separates into durable components, minimizing risk to test personnel and damage to expensive test vehicles." This product has similar performance specifications to the desired qualities expressed by Daimler. The target is rated to survive 100 impacts of a 45 mph speed differential from both a passenger car and truck with only minor in-field repairs needed. Test of radar, laser, and camera-based sensors conducted on the target from all angles appear similar to those of a car. The soft car can travel at speeds of 50 mph and turn at 0.5 Gs without losing form. It can be impacted at 70 mph head-on without substantial damage to the impacting car. The Soft Car 360TM can mimic many crash test situations and can take impacts from any side. Cost is the main component that limits this design. The low profile dynamic motion element of the car costs anywhere in the range of \$300,000-\$500,000 depending on the features. The soft target sells for \$22,300.



Figure 2.2 Micro Soft car 360™ by Dynamic Research Inc.



Figure 2.3 Hatchback Soft Car 360™ by Dynamic Research Inc.

Another type of soft car designed by AB Dynamics is the soft crash target vehicle. This target is mounted on a box like robot which serves as the dynamic control of the target as seen in Figure 2.4 . It is designed for low-speed collisions. Instead of breaking off into pieces on contact, this target absorbs the impact and uses that energy to roll away. It can travel at speeds of 70 km/h and withstands impacts of 50g. The cushion part of the vehicle weighs about 55 kg and is comprised of inflatable rods and cushions.



Figure 2.4 ABD Soft Crash Target Vehicle.

2.1.2 Balloon Cars

In 2009 Ford introduced a balloon car test target used to test their cars safety features. The inflatable target has a \$10,000 price tag and is a standalone target. It can be seen in Figure 2.5. Each weighs around 40 pounds but is still subject to being blown away at high winds. Once it is inflated there is little setup time between tests, only retrieving the balloon and resetting the position. The balloon itself is made out of a heavy tarp like material.



Figure 2.5 Balloon car used by Ford for testing.

In a crash test report balloon cars were tested on their ability to be picked up by radar and computer systems and compared to an actual passenger car (Department of Transportation). The results showed that radar and computer visual systems picked up balloon cars from the rear extremely similarly to an actual car. The frontal tests of the balloon were slightly worse as the targets representation of a car from the front side was not as exact. Tests from the side and 45 degree revealed that Computer visuals were unable to pick up the balloon test target at all. A balloon test target similar to the one designed by Ford would not be adequate for this project. A target that represents a car to sensors from all angles allows for versatility of testing and a better end product.

Other balloon models, such as the one in Figure 2.6, involve a carrier system like a cantilever truss holding them off of a moving car. Referred to as a balloon car carrier, these models are only strike-able from the rear and do potentially increase the risk to the driver inside the moving vehicle.



Figure 2.6 Suspended Balloon Vehicle.

2.1.3 Surrogate Strike Vehicle

Wolf Composites, along with the U.S. National Highway Traffic Safety Administration, created this rear target to be used in creating a standard test for vehicles emergency braking systems. Figure 2.7 shows the complete set up of the test target. This system must be towed by a guide car as it is not an independent vehicle. The maximum recommended vehicle speed is 40 mph. This system is only strike-able from the rear limiting the amount of tests able to be performed with it. The system very closely resembles the rear of a car. Compared to many of the other similar products it is a lot thicker and built with heavier material making it closely identical to a car in terms of its susceptibility to radar and computer visualization systems. This is the last line in testing and verifying the automated braking systems of a vehicle. This surrogate vehicle cannot withstand high impact without damage to both itself and to the colliding car. The maximum collision speed recommended is 25 mph which is well below the goal of this project (Composite Solutions).



Figure 2.7 The Strike-able Surrogate Vehicle.

2.2 Collision Modeling

The overarching demand of the project is for the target to withstand a high energy impact from a large truck. This puts an extra emphasis on understanding collision mechanics and their utilization in the geometry and material of the design. There are many approaches to solving these problems, from the use of impulse-momentum equations to the implementation of contact force models (Flores).

Impulse-momentum solves for the relative velocities both before and after the impact of two masses (Beer). However the method fails to model the mechanics of the collision itself, since it assumes that the masses are non-deforming during the impact. Contact force models takes care of this by treating the impact itself as a mass-spring-damper system. The deformation can be modeled and compared to known material properties to evaluate the permanence of the shape change.

In both methods, the use of experimental values is needed in order to predict accurate results. For the impulse-momentum method, a coefficient of restitution is used to determine the resulting kinetic energy loss. Contact force methods also require the coefficient of restitution as part of the materials damping constant as well as a generalized material stiffness in order to accurately predict the materials response to collision (Flores). Neither of these values can be easily predicted, therefore tests must be conducted to be able to model the entirety of the collision with any accuracy.

Another factor in the collision modeling is Daimler's use of grille guards, seen in Figure 2.8, on the front of their trucks during testing. Guards are made out of 3 in diameter 14 gallon steel. These guards provide the initial impact and help prevent damage to the front of their trucks. Unfortunately, these guards create a smaller impact target, which results in roughly the same impact force being transferred to the target only in a smaller contact area. The impact geometry of the frame must be taken into account for any collision analysis.



Figure 2.8 The grille guard used on Daimler's trucks during testing.

2.3 Materials

Materials research was conducted on the existing soft targets, as they have already been shown to work effectively. The current targets are either composed of a foam structure or an inflatable balloon.

2.3.1 Foam

The inside of the Soft Car 360™ by DRI consist of polyethylene foam panels that are joined together with Velcro. This allows the soft car to break apart during a collision and not damage the test vehicle.

Polyethylene foam has many physical properties that make it ideal for vehicle testing. Polyethylene foam is lightweight, shatterproof, non-dusting, and excellent at shock absorption. It can be bought in large sheets of foam and then cut to shape with a hot wire (The Foam Factory). Below in Figure 2.9 the Soft Car 360™ is shown assembled while in Figure 2.10 the target is shown as pieces.



Figure 2.9 AB dynamics soft guided soft target (GST).

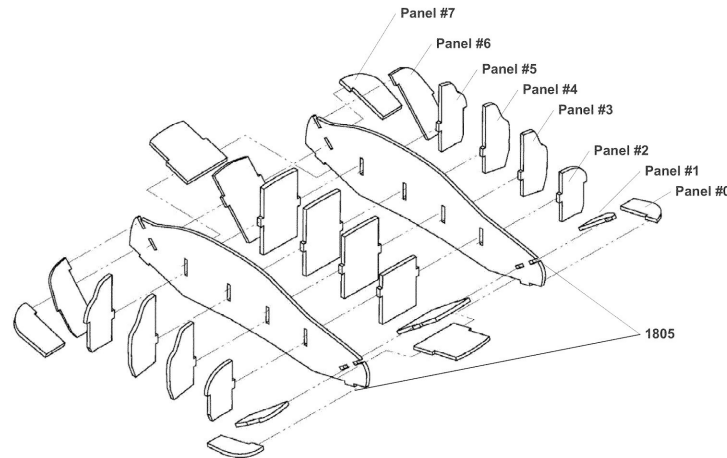


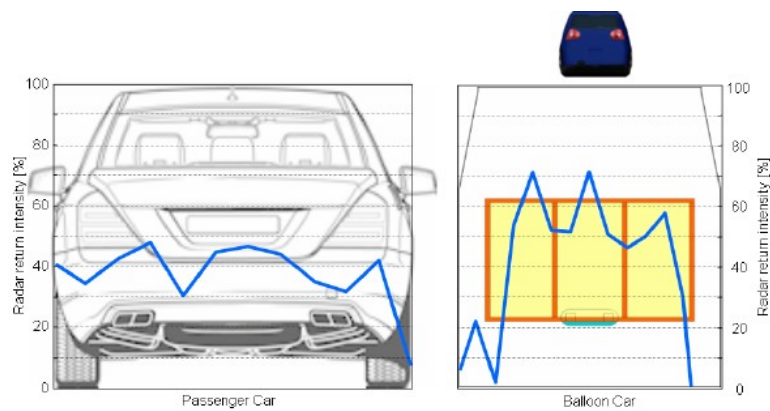
FIG. 18

Figure 2.10 GST foam structure.

2.3.2 Inflatables

Vinyl is used to make the inflatable balloons that Ford uses to test their vehicle safety systems. Vinyl is also used to make the covers for the Soft Car 360™. In both of these cases, the vinyl covers were painted to represent a vehicle. These vinyl sheets are lightweight and durable and can be used many times without being damaged.

The radar systems used to detect vehicles have trouble detecting balloon vehicles. In order to get around that issue, reflecting foils are implemented in the balloon cars. With the addition of the foils, radar bounces off of the balloon and is read by the test vehicle. Figure 2.11 shows the radar return intensity for a passenger vehicle and a balloon car with reflective foils.

**Figure 2.11 Rear-End radar signature of real car and balloon car.**

2.4 Computer Sensor Imaging

The use of any computer vision sensor can put constraints on available design choices. Particular limitations with radar, lidar, and optical cameras can limit the usefulness of the target in representing a car. In order for the soft target to most accurately represent the signature of standard cars, a solid understanding is needed on the current capabilities of these sensors.

Radar

Radars operate by sending out a radio wave pulse and measuring the strength of the wave after it has bounced back from a particular object. The lower the energy upon return, the further away the object is from the radar origin. The range and penetration is influenced by both the magnitude and length of the original pulse as well as the time gap between pulses (Norris et al). An example of automotive radar is shown in Figure 2.12. It has its limitations as radar needs a reflective material, such as an electrically conductive foil, and proper shape for the signal to bounce back. Both of these problems can and will be addressed during the design process. Weather can also impact readings, as dense fog or rain can inhibit clear readings and reduce the reliability of the sensor. However, the tests are all said to be conducted in sunny conditions so it may not be a limiter to the target design.

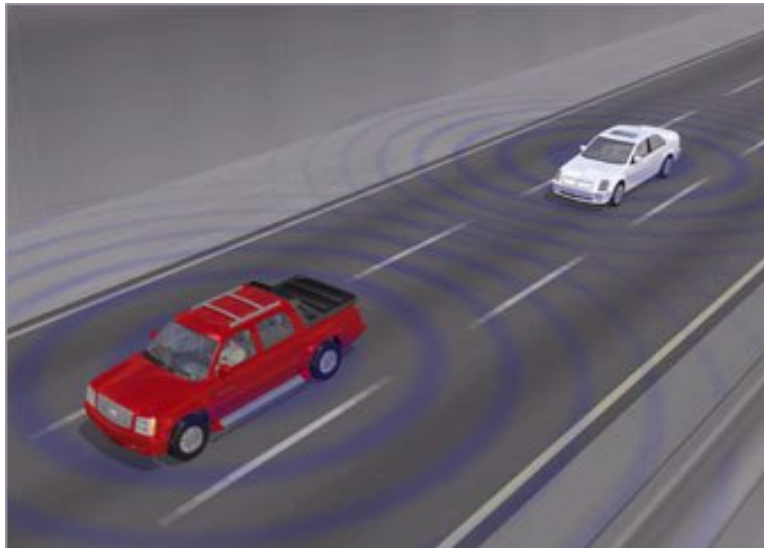


Figure 2.12 Radar example between two cars.

Lidar

Lidar systems utilize a spread of laser pulses to create a three dimensional map around the sensor. These lasers focus on certain directions away from the car and reflect back if the laser hits an object. By utilizing the precision of lasers and the directional output, lidars can pick up small objects with high geometric detail when a radar might miss it or just pick up the location (Ogawa et al). An example of automotive lidar driving through a crowded street is shown in Figure 2.13. However, lidar is a relatively new technology which creates a lot of engineering unknowns. For a lidar system to be effective, it must be trained to recognize certain shapes as objects. Therefore, the shape of the target becomes very important for the visual system to recognize it as a car. Also, any target that the lidar detects blocks it from seeing past the object. This can

be further noted in Figure 2.13. Material should not be a concern with lidar as long as the exterior material is opaque and dense enough to block the laser from passing through.

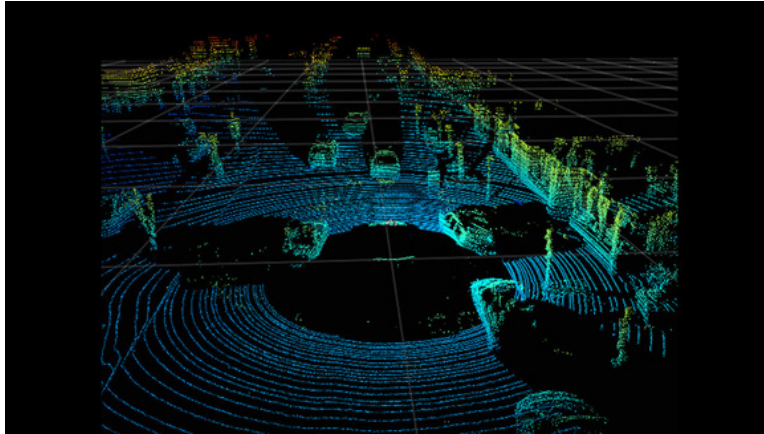


Figure 2.13 Lidar example between car and street.

Optical Cameras

Cameras utilize optical image processing for target detection. Unlike radar and lidar, the camera itself does not see the target and instead relies on software to break the image down to detect an object. Since the limitations here are almost completely on the sensor side, there are no real limitations to designing the target. The main criteria that is not present in the lidar or radar systems is the color of the target. If the camera cannot detect the edge of a target as being something different than the background, the software could decide that there is no object in view and do nothing to respond. Compared to the limitations of lidar and radar however, this is a minor limitation.

3 Objectives

3.1 Sponsor Needs

After initial discussions with Daimler, the team was able to set forth an initial set of requirements for the project.

3.1.1 Quality Function Deployment Matrix

A Quality Function Deployment (QFD) Matrix is a valuable tool in developing engineering specifications based on customer needs. It is also a good benchmarking tool in quantifying how a product completes requirements and matches up against competing products. The first step of the QFD was determining who this product was for. As the sponsor for the project and the group in need of this solution to test their trucks AEB systems, Daimler Trucks was easily identified as the primary customer. Furthermore, this product could benefit any other automotive company pursuing AEB testing. As most car companies and even tech companies such as Google and Uber are developing autonomous vehicles, there is a real need to be able to test many different driving scenarios in a repeatable and safe form. This solution is a viable option for them. Also, two other senior project teams working on the moving base and control systems are interested in the

outcome of the target. The last customer noted was the safety groups, such as the Insurance Institute for Highway Safety, that want to benchmark car safety systems and create a standard. The QFD is attached as Appendix [2].

3.1.2 Requirements and Specifications

Talks with Daimler trucks and research into the the problem helped develop the requirements of the QFD. The first requirement developed was a cost effective solution. All similar solutions are very expensive and with the budget of this project set at \$2,250, this condition came out to be the highest weighted requirement. Maintaining vehicle shape at 80 km/hr and being representative of a car to lidar, radar, and computer visuals were two other highly weighted specifications in our matrix. These target goals express the heart of the problem we are trying to solve for Daimler. The sensor visibility and the shape requirement both revolve around ensuring the target resembles a car during testing which is a high priority in validating that AEB systems will work in reality. This project must resemble a car while not physically being a car because of the impact involved when testing a braking system fails. Because of this impact and durability specifications were necessary. Talks with Daimler revealed that an average test day involved around 100 test with about half of them hitting the test target with their 80,000 lb truck, the majority of which were at higher speeds. Daimler requested the top impact speed the test target be able to withstand without breaking be 80 km/hr bringing about the impact goal. This goal present a high risk because it is tough to test without the proper resources. Additionally this is the defining problem to be solved. The other impact specification is the durability goal of surviving at least 50 impacts, a full day's worth of testing. This too presents a high risk, because of the limited testing resources and time, the high degree of difficulty in achieving this, and early failure would result in a delay in testing schedule. This solution is meant to aid in testing and not detract from the testing time, this is why the specification of setting up the test target in less than 10 minutes was added. The 10 minute setup time was a target goal set by Daimler in addition it is a standard time found in a couple of competing test target products. The last engineering specification comes from information on Daimler's test site. Frequently winds at the facility are measured at 48 km/hr laterally to the track and 32 km/hr in line with the track. The test target must be able to withstand these wind forces without significantly deforming.

A summary of these specifications can be seen in Table 3.1. The risk column lists the level of risk as low (L), medium (M), and high (H). The compliance column shows how the spec will be verified as: analysis (A), test (T), similarity to existing design (S), and inspection (I).

Table 3.1 Engineering Specifications

Spec	Parameter Description	Requirement or Target (units)	Tolerance	Risk	Compliance
1	Speed	Maintains shape at 80 km/hr	Max	M	A, T, S
2	Impact	80k lbs at 80 km/hr	Max	H	A, T
3	Cost	\$2250	Max	M	A
4	Set up	10 minutes	Max	L	T
5	Tests till failure	50 impacts	Min	H	A, T
6	Sensor visibility	Shows up on Radar, Lidar, and Camera	Min	M	T, S, I
7	Operate in lateral winds	48 km/hr	Min	M	T, I
8	Weight	35 lbs	Max	M	A, T, I

3.1.3 Feasibility

Testing the speed criteria for maintaining shape at 80 km/hr presents moderate risk. The challenge is building the frame of the target strong enough to resist winds but soft enough to avoid damage in a crash. The other challenge in this is testing a full size model without a proper test track. A scaled model of the target can be tested in the Cal Poly wind tunnel, as the possibility of winds reaching 80 km/hr is very low in San Luis Obispo which limits testing options. One solution for testing a full size target for wind resistance is to partner with the guided target team when their project is complete, assuming their frame can reach this speed. This test would come very late in the design process meaning time to modify the solution would be scarce if this goal was not met. As mentioned earlier the impact requirement has the highest risk.

Testing for impact will once again use scale models. Another testing solution if permissible through the school is a drop test. Some weight will have to be added to the vehicle to help increase the terminal velocity. Daimler has also talked about the possibility of shipping this solution to them for testing however this would be late in the year and testing would be geared towards verification of their AEBS instead of verification of the target. Cal Poly has also proposed using the Santa Maria airport with an old utility van in order to simulate a lower energy impact.

Cost is a requirement that is believed to be achievable because the only costs are for materials. After reviewing many other products the set up time is a low risk target and is easily validated through testing. For the durability requirements some material analysis can be used but drop testing or repeated impacts will be the best test method even though these tests will be at lower than the maximum impact. Sensor visibility may present a challenge because the exact cameras and radar Daimler uses are not available. To counteract this, tests will be done with available radar and lidar equipment and designs will be based off the information gathered about lidar and computer camera systems. The lateral wind requirement, similarly to the speed requirement, will be tested in the wind tunnel using a scale model. Additional tests using a track and pulley system may be conducted as well to verify the concept.

Following these alternative tests, the team will be able to scale and compare the results against a full size prototype. Added as a deliverable will be a report that specifies the total number of tests the target can be hit at the deliverable speed, the maximum speed the target can be hit and at what angle, the maximum speed the target can drive at, and the maximum wind conditions the target can operate in.

3.1.4 Deliverables

At the conclusion of the project schedule, the team will deliver to Daimler the following items:

- The final constructed prototype with an operators manual
- A final report which will include the operating parameters of the soft target
- A Bill of Materials and CAD drawings for the entire assembly

3.2 Problem Statement

Daimler Trucks is developing automated collision avoidance systems to increase the safety of their trucks. The company's current test targets are expensive and limited in function. Their need is a test target that can be mounted to a moving frame, is visible to newer sensor systems, non-damaging to their trucks, can be reset quickly, and is a cheaper long term testing solution to fine tune their trucks and save lives.

3.3 Limitations

Many factors can limit the overall scope of the project, as certain things cannot be done at Cal Poly nor can they be completed in the allotted time.

3.3.1 Capability

Since this project involves high energy impacts, there is an obvious safety issue involved. Cal Poly does not have the facilities or personnel necessary to run such tests, therefore changing how the project can be validated. One workaround is a scaled down prototype that can be tested with an equally scaled impact. Another solution is to proof the impact at a lower energy and use the test results to extrapolate the actual impact results.

Another limitation is manufacturing capabilities. While there are no apparent tools that are lacking from the machine shops, the design will have to incorporate manufacturing methods already available at Cal Poly.

3.3.2 Outside Scope Requests

One outside scope request is to have the impact be at a higher velocity. The team is incapable of reaching this goal simply because there is no way to test it. The original goal of 80 kph is already troublesome for testing at Cal Poly so trying to proof any higher impact speed here is too much for the team to do. Another stretch goal is to have the target testable to impacts from all angles. The rear impact test in the scope is the most pressing goal while side and 45 degree impacts are an additional goal.

A summary of the overall scope, compared to the Soft Car 360™ is shown as Figure 3.1. Another team is working on the mobile platform, leaving this project with the responsibility of creating a soft target compatible with their base.

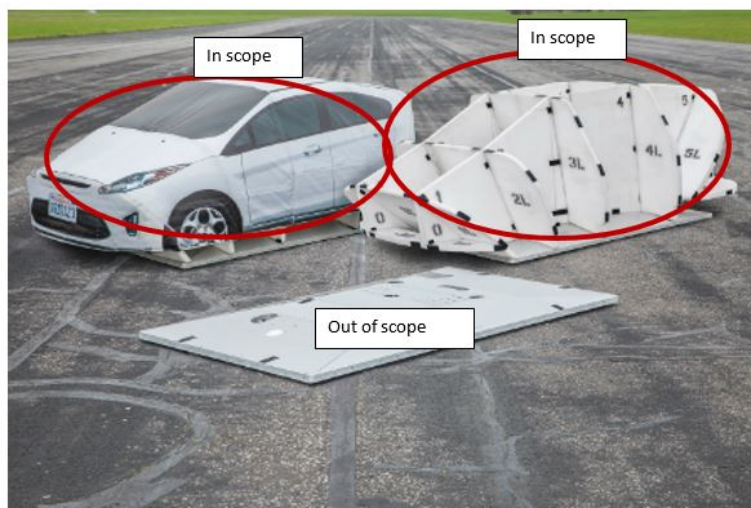


Figure 3.1 Scope compared to the Soft Car 360™.

4 Design Development

4.1 Concept Generation

The first ideation session consisted of a brain drawing activity. Each member drew ideas rapidly onto a whiteboard for 10 minutes. No words were said and team members were allowed to freely express their ideas in the medium of pictures without any criticism or feedback. Following this was a 5 minute addition period where the team used sticky notes to add and build onto ideas already on the board. Again no words were spoken and members freely put input to each idea. After this, a discussion and recap session broke down each drawing and sticky note, giving an overview of each expressed idea. In this discussion, multiple views on same drawing were expressed, creating additional thought on a single drawing. Some of the recorded ideas are shown below.

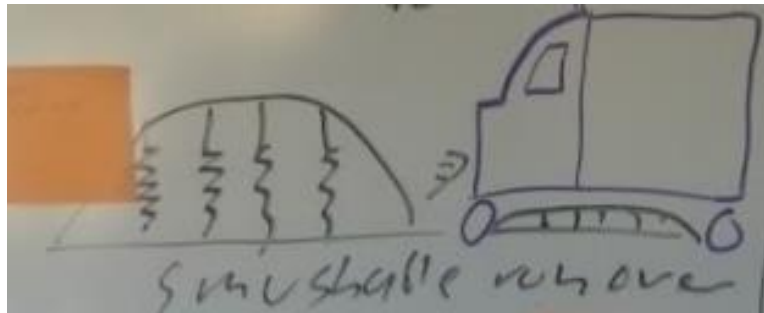


Figure 4.1 Flattened spring car.

The car in Figure 4.1 would be able to be flattened entirely and have the passing truck simply run over the whole device. One of the add-on ideas was to have it be made of springs that would compress under the truck. Problems with this idea involved the springs being run over and damaged by the truck and the target wanting to spring up underneath the carriage of the truck possibly getting caught. Benefits of this idea were that the reset time would be extremely quick and simple. Additional modifications could be having the target flatten and stay flat until reset.

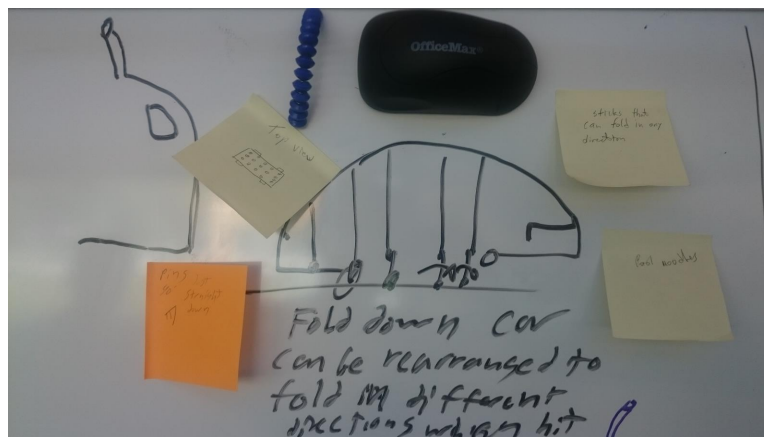


Figure 4.2 Fold-able car.

Similar to the flattened car, Figure 4.2 shows a fold down idea that consists of attached beams or panels that would fold on some sort of hinge when hit, allowing the car to be run over. A positive quality of this design is the quick reset time as there would be no chasing of pieces. Concerns of this design are stability when driving and stability under wind loads.

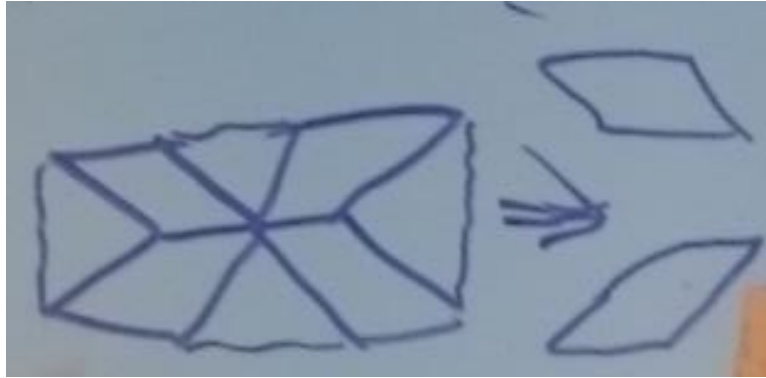


Figure 4.3 Foam X car.

The concept in Figure 4.3 was a foam pieced car consisting of large foam pieces oriented in a design that would allow for the splitting of pieces in opposite directions when contacted. Benefits included less parts, easy setup, shape, and stability. Drawbacks were cost of getting large foam blocks and impact points would be limited.



Figure 4.4 Balloon car.

The balloon car in Figure 4.4 is similar to the design Ford uses, shown previously in Figure 2.5. This involved a magnetic or Velcro tether to keep the target attached to the base during driving. This idea allows for quick setup. Possible problems with this design include impact resistance and repair.

Further ideas from this session included: a house of cards like internal set up where stacked pieces would easily fall apart upon contact, a wheel based target that would be hit and energy would translate into the target rolling away, a magnetic target that would stick to the car on impact, a ejector target that would eject just before impact, and a large slanted foam target that would take impacts and bounce off over the truck.

The second and third ideation sessions used solo brain drawing sessions. Each member was given 10 minutes to draw and sketch out as many ideas as they could. After ten minutes, each notebook of sketches was rotated to a partner and 5 minutes were allotted to expand on any drawings. This was repeated until all members had added ideas to each set of drawings. Following this, a group discussion was performed on each set of sketches. Lastly, the top 4 ideas were given 10 more minutes each of whiteboard ideation and sketching. These sessions produced ideas with more depth and thought-out components than the first session.

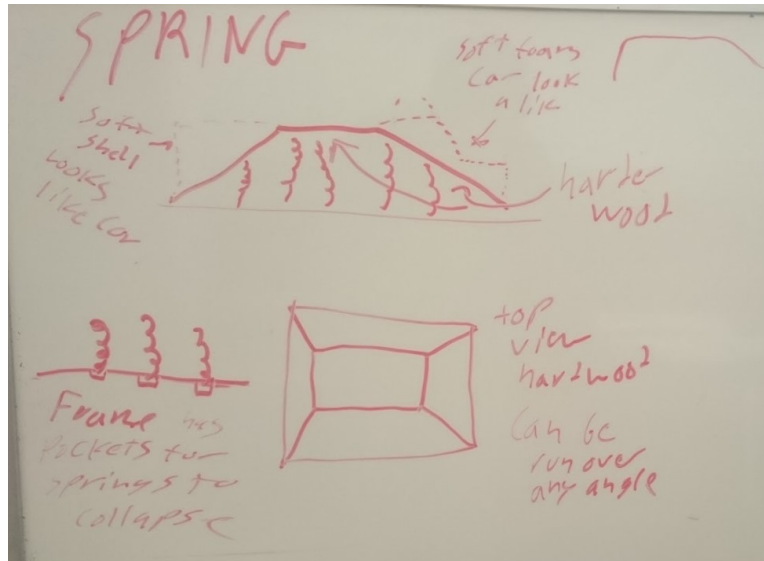


Figure 4.5 Detailed spring car.

In Figure 4.5 above, a more detailed ideation session of the spring car idea is shown. Springs would hold up a pyramid like frame which would be compressible to slide underneath the car. The spring idea would have solid boards attached together that would all deflect downward together upon impact. This idea revolved around quick reset and compression of pieces under the truck instead of absorbing all the impact.

Additional ideas chosen to expand upon were a foam panel design and a pool noodle design. One design using the foam panels had stacked sheets of foam all with equivalent thickness but varying dimensions to form the outline of a car. Another foam panel design used pieces similar to the soft car but in an orientation where a rear impact would hit panels at a 45 degree angle instead of at 90 degrees and head on.

Concept modeling was the next step in the design process. Models were used to test various aspects of the ideation sessions. Models of the foam panel target, pool noodle target, and fold down car were all created. One of these can be seen in Figure 4.6.

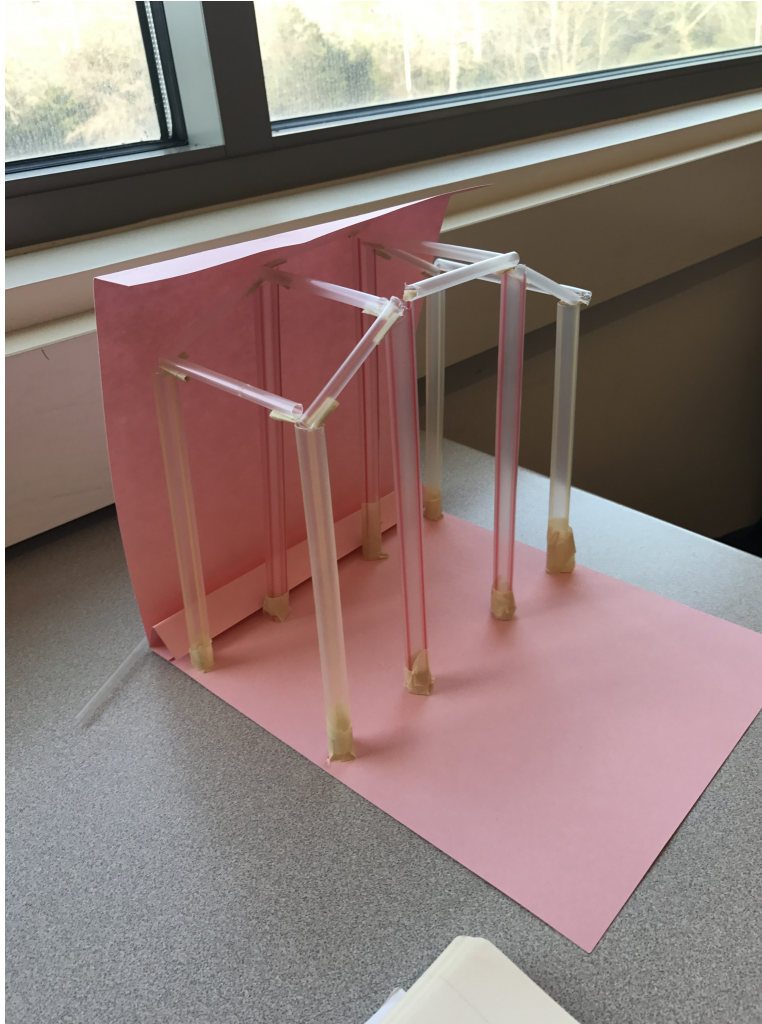


Figure 4.6 Early Prototype Example

In the foam panel car different connection types were modeled to verify what would hold together and what separate easily upon impact. Simple square male and female connectors held together well but tended to resist separating on impact causing pieces to break. By creating curves and non square male pieces that fit into square slots connections dislodged much easier upon impact. Another connection type that proved valuable was Velcro. Calculations and testing are still needed on Velcro in order to apply enough force to hold connections while still splitting in impact. Another realization with foam panels was that setting an angle which would lift the car out of the base upon impact helped with scattering of the panels.

4.2 Design Selection

In order to select a final design from all of the ideation sessions, each team member created a Pugh Matrix. The Pugh matrix is a tool used to facilitate a disciplined, team-based process for concept generation and selection (iSixSigma). Several concepts are evaluated according to their strengths and weaknesses against a reference concept called the datum. The datum used in the Pugh matrix was the Soft Car 360. Appendix [3] shows a copy of the combined Pugh matrix. The Pugh matrix allowed the team to see which ideas were the strongest and which ones would be unreasonable. Following this, the team selected the top 3 ideas from the Pugh matrix and engineering judgment and then constructed a decision matrix.

The decision matrix is similar to the Pugh matrix except for the fact that a weight is assigned to each

category. A rating from 1-10 is then placed to each category for each idea, 10 being the best and 1 being the worst. The top three ideas that were included in the decision matrix were: the soft car or foam panel car, a pool noodle car, and a balloon car. Figure 4.1 is a copy of the decision matrix and it shows that the soft car has the highest weighted rating of 7.42. The pool noodle design had a weighted rating of 7.29 while the balloon car had a rating of 5.66.

Table 4.1 Decision matrix of top 3 ideas rated out of ten

Spec	Weight	Soft Car		Pool Noodle		Balloon	
		Rating	Wgt Rtg	Rating	Wgt Rtg	Rating	Wgt Rtg
Cost efficient	8%	8	0.64	9	0.72	6	0.48
Visible to Lidar	7%	8	0.56	7	0.49	4	0.28
Visible to Radar	6%	7	0.42	7	0.42	7	0.42
Visible to cameras	7%	7	0.49	7	0.49	6	0.42
Reset Time	5%	5	0.25	6	0.3	9	0.45
Safety	7%	7	0.49	7	0.49	5	0.35
Lightweight	6%	7	0.42	8	0.48	3	0.18
Ease of manufacturing	5%	7	0.35	8	0.4	4	0.2
Versatile tests	6%	7	0.42	8	0.48	8	0.48
Large impacts	6%	8	0.48	7	0.42	5	0.3
Durable	6%	7	0.42	8	0.48	5	0.3
No damage to vehicle	7%	8	0.56	8	0.56	6	0.42
withstands winds	5%	8	0.4	6	0.3	5	0.25
withstands dynamic motion	7%	8	0.56	6	0.42	5	0.35
Resembles car shape	6%	9	0.54	7	0.42	6	0.36
Compatible with base	6%	7	0.42	7	0.42	7	0.42
Total	100%		7.42		7.29		5.66

A second matrix, shown in Figure 4.2 was created to verify the results of the first, shown. This one rated the ideas against one another, with the category best receiving a 3 and the category worst receiving a 1. The results of this show the pool noodle design as the highest with a 2.25, the panel car following with a 2.07, and the balloon car in last with a 1.22.

Based on the results on these two matrices, the team decided to completely eliminate the balloon idea as a possibility. The remaining two ideas, the foam panel car and the pool noodle, both had merit and reason as to why they would be the final choice. Ultimately the team decided to go with the pool noodle design once preliminary calculations proved that it could withstand the driving and wind loads. The team believed that this would perform better than a panel car as it would be easier to reset, modular, cheaper, and easier to fix or replace if a part broke.

4.3 Material selection

Based on the background research and benchmarking certain materials were researched further in order to narrow down selections for the design.

Polyethylene is made with a variety of densities and manufacturing techniques which all greatly affect the material properties. The density of polyethylene greatly affects the use. Ultra-high-molecular-weight polyethylene (UHMWPE) is an extremely tough material commonly used in implants and bulletproof vests because of its toughness and resistance. While this material resists wear through impacts very well it is very dense and brings a lot of weight. The weight and cost of UHMWPE rule out heavy use of it in the design.

Polyethylene foam is the same material used in pool noodles and the soft car. It has low strength and hardness but is extremely ductile and has great impact strength. Polyethylene foams exhibit great energy

Table 4.2 Decision matrix of top 3 ideas rated against one another

Spec	Weight	Soft Car		Pool Noodle		Balloon	
		Rating	Wgt Rtg	Rating	Wgt Rtg	Rating	Wgt Rtg
Cost efficient	8%	2	0.16	3	0.24	1	0.08
Visible to Lidar	7%	3	0.21	2	0.14	1	0.07
Visible to Radar	6%	3	0.18	2	0.12	1	0.06
Visible to cameras	7%	1	0.07	1	0.07	1	0.07
Reset Time	5%	1	0.05	2	0.1	3	0.15
Safety	7%	2	0.14	3	0.21	1	0.07
Lightweight	6%	2	0.12	3	0.18	1	0.06
Ease of manufacturing	5%	2	0.1	3	0.15	1	0.05
Versatile tests	6%	1	0.06	3	0.18	2	0.12
Large impacts	6%	2	0.12	3	0.18	1	0.06
Durable	6%	2	0.12	2	0.12	1	0.06
No damage to vehicle	7%	2	0.14	2	0.14	1	0.07
withstands winds	5%	3	0.15	2	0.1	1	0.05
withstands dynamic motion	7%	3	0.21	2	0.14	1	0.07
Resembles car shape	6%	3	0.18	2	0.12	1	0.06
Compatible with base	6%	1	0.06	1	0.06	2	0.12
Total	100%		2.07		2.25		1.22

absorption. This type of foam, however, is not very stiff and deflects easily under loading. The group believes polyethylene foam will work well as a shock absorber for the high impacts required in this project.

Polyurethane is another foam that is available in a variety of stiffness and densities. It is commonly used in bedding, upholstery, and packaging because of its high resilience. Polyurethane is more expensive than polyethylene and does not have as high of an impact strength. For these reasons, the team considers polyethylene to be the better choice for our impact applications, however, consultation with material engineering consultants and professors is ongoing.

Based on the results of the Pugh and Decision matrices, the team chose a design similar to the pool noodle car. The vehicle structure will be composed of hollow foam cylinders with stiffening rods in the center. The structure of the vehicle will be covered by either a tarp or foam panels which will be broken up into small sections.

The original design using pool noodles was to have rows of vertical poles which would support foam panels. Upon inspection of this design calculations showed that the foam poles would deflect too much in the wind on their own and would not meet the requirement of maintaining shape while driving at 80 km/hr. The team tried adding stiffeners inside the foam poles to help with the wind loads. The amount of material added to pass the wind requirement caused the target to go over the weight limit of 35 lbs. In order to alleviate this while still using the pool noodle design a new geometry was needed. The truss system was the answer decided upon. It can take the horizontal wind loads with less overall deflection better than the vertical poles could. Additionally it uses less of the denser stiffening material in taking those loads which equates to a lighter overall design.

further unexpected problems will arise as the design process continues. In order to tackle these the team plans to think in a similar style as when solving this design problem. The team will creatively brainstorm solutions, Evaluate solutions against each other, and use engineering calculations to justify or disprove the concept.

5 Final Design

A rendering of the final design can be seen below in Figure 5.1. The design utilizes four subsystems; the base for stand alone assembly and mounting to the driving frame of which another Daimler senior project team is designing, a truss understructure for support and rough car shape, foam blocks for key car features, and covering to create a "car" shape. The total dimensions for the test target and frame are 72 inches wide by 168 inches long, with a max height of 55.8 inches. These dimensions and the car shape are taken from the Volkswagen Golf.

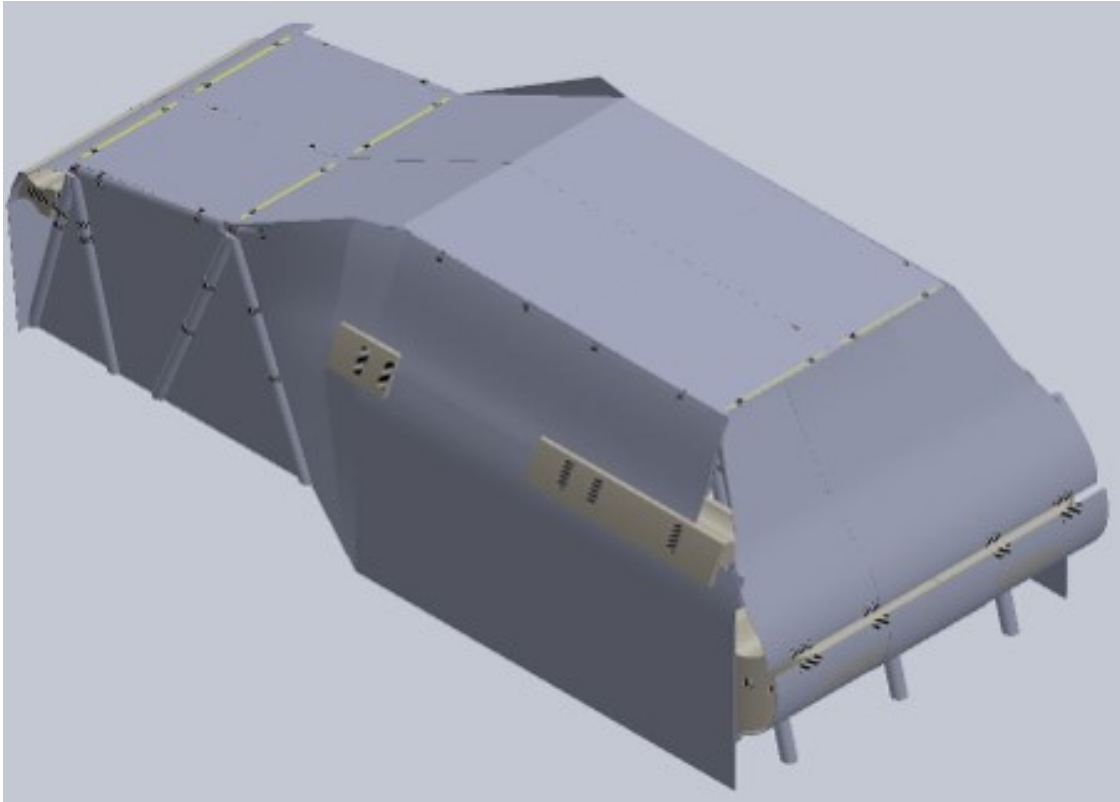


Figure 5.1 Overview views of the soft target design

Dimensioned drawings and assembly drawings can be found at the end of this report in Appendix [9].

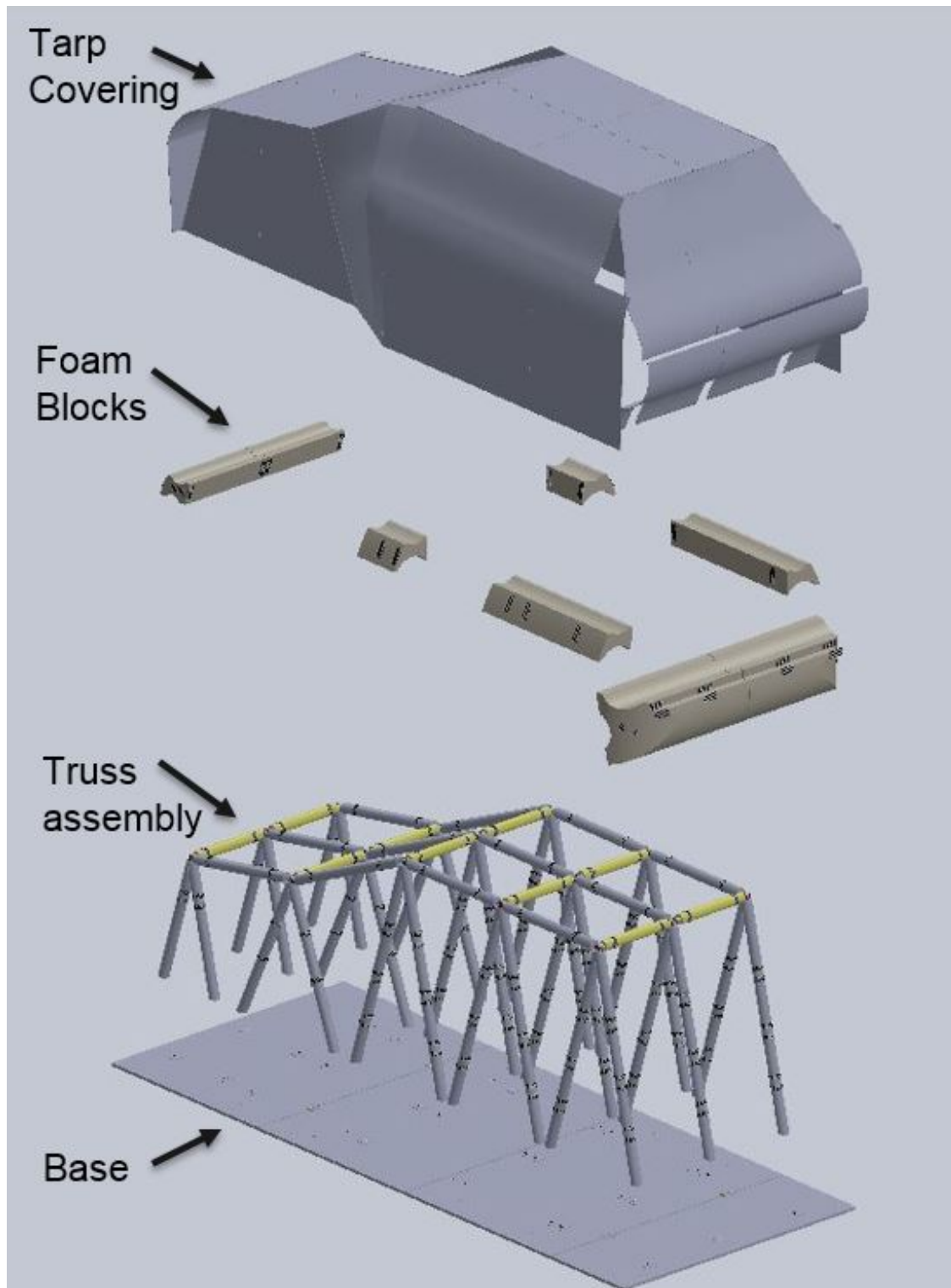


Figure 5.2 Exploded view of the soft target design

5.1 Truss Assembly

The truss Design is made primarily of PVC, polyethylene foam noodles, and Velcro. The truss is designed to be able to fall apart upon impact and reassembled for the next crash test. Components of the truss assembly are put together using hook and loop Velcro. The built sections which will be manufactured prior to crash testing are shown below in Figure 5.4. The truss helps give the car the overall shape and strength. The truss is able to stand up to wind speeds of 48 kph laterally and 80 kph on the front. Another unique feature of the truss is that it allows for modular set up. The rear portion of the car could be assembled and stand on its own without needed the front two rows of triangles

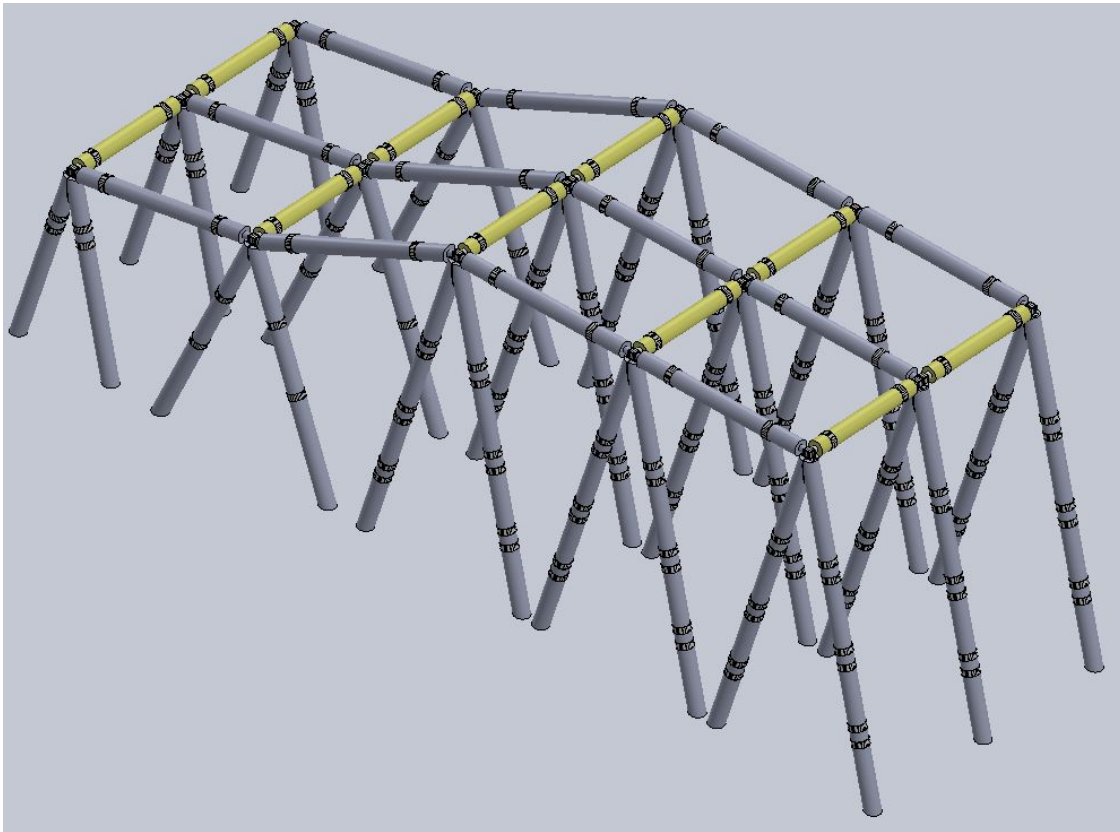


Figure 5.3 Assembled truss design

There are 7 different components which make up the truss assembly. Each of the three columns of the vehicle that span the length of the car are identical. This helps to improve assembly time as the overall number of different pieces are limited. Pieces can be set up in any of the three columns meaning the operator will not have to search as long for the exact spot for each assembly item. Color coding is also an are of the truss not pictured which will be implemented. Using colored tapes and foam tubes an operator will quickly be able to tell which pieces go together.

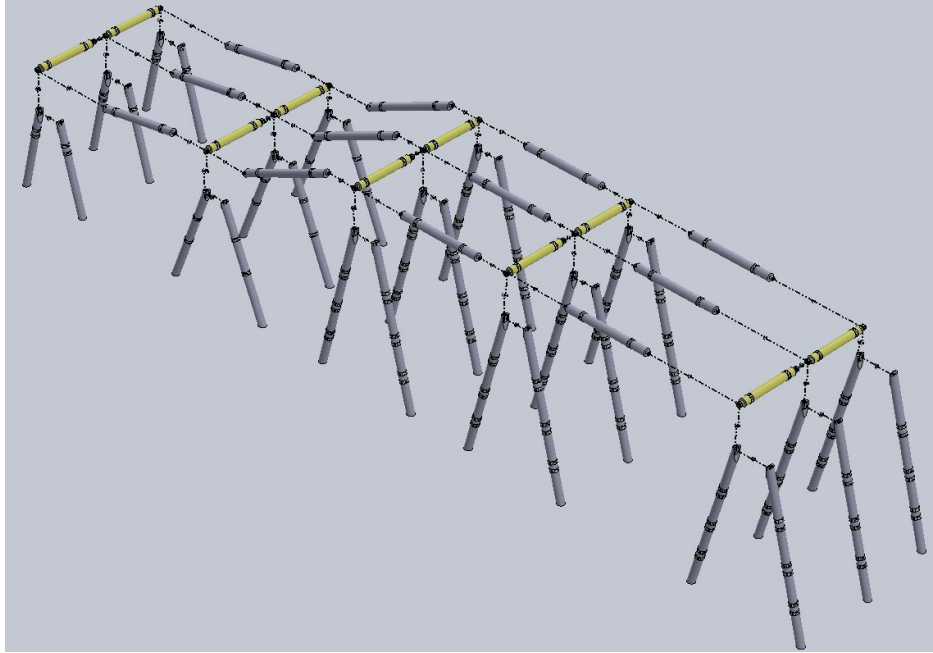


Figure 5.4 Exploded view of the truss design

5.1.1 Truss Members

Each member of the truss will have two layers. The core will be made of 3/4" PVC pipe with an actual outer diameter of 1.005 in. Surrounding the pipe will be a 1.5" layer of lightweight polyethylene foam that will protect it during operation. The ends of the PVC pipe are exposed past the foam as to not interfere with the adjacent connecting pieces. Along the foam tube, depending on the particular truss member, a wrapping of Velcro is added to allow the foam blocks to attach to the exterior of the truss frame. A diagram showing these components is found below as Figure 5.5.



Figure 5.5 Exploded view of one of the truss members

5.1.2 Truss Connections

The truss joints make use of square rubber endcaps to allow flat connection surfaces between each of the adjoining pipes. These endcaps are designed for PVC 1 in square tubing, and therefore have an small interference fit between the round PVC and the rubber. The endcaps are then completely enclosed by five pieces of Velcro to allow the other members of the truss to attach together. This can be seen below in Figure 5.6.

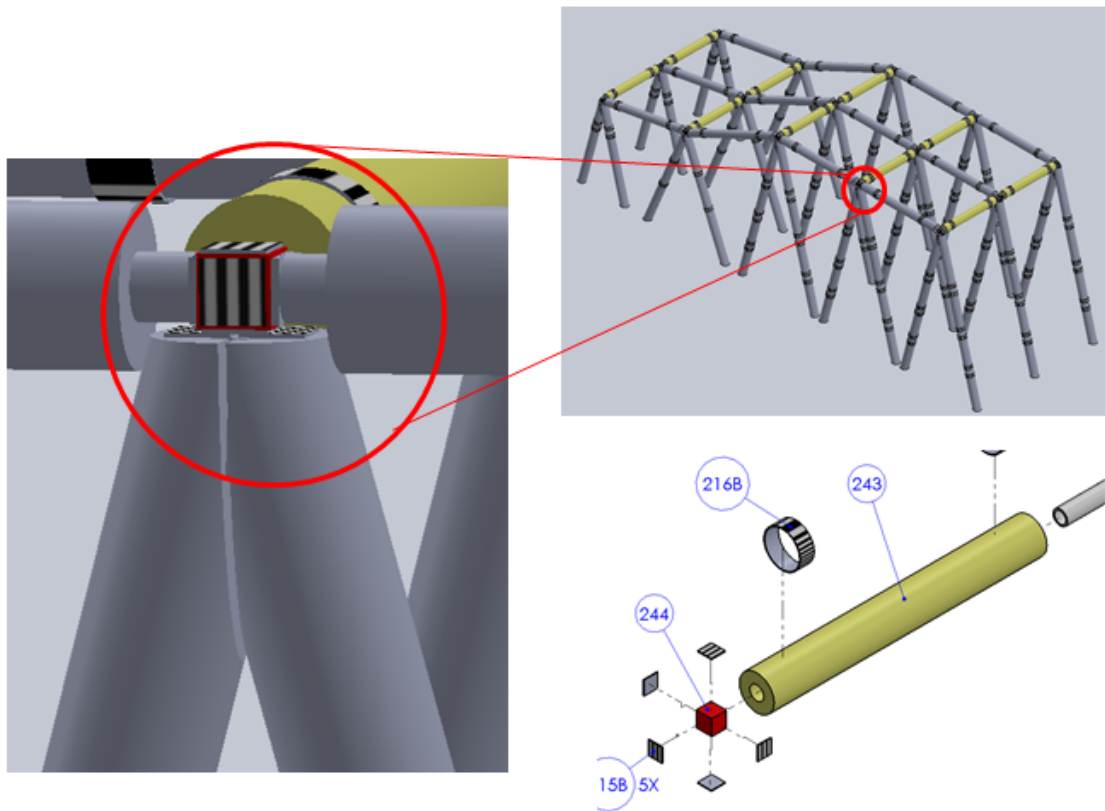


Figure 5.6 Close up view of one of the main connection points

5.2 Foam Blocks

The foam blocks are used to improve the overall shape of the target so it resembles a car. An overview of their size and location can be found below in Figure 5.7. Each of these blocks are made of a low density expanded polystyrene (EPS). This allows the blocks to maintain a level of rigidity and shape of a vehicle when supporting the tarps. Each block is very lightweight in order to reduce the overall weight of the entire structure. Each bumper piece is shaped to give definition to a key car feature for the VW Golf. An example of the rear bumper is shown below in Figure 5.8.

get from exploded foam block view

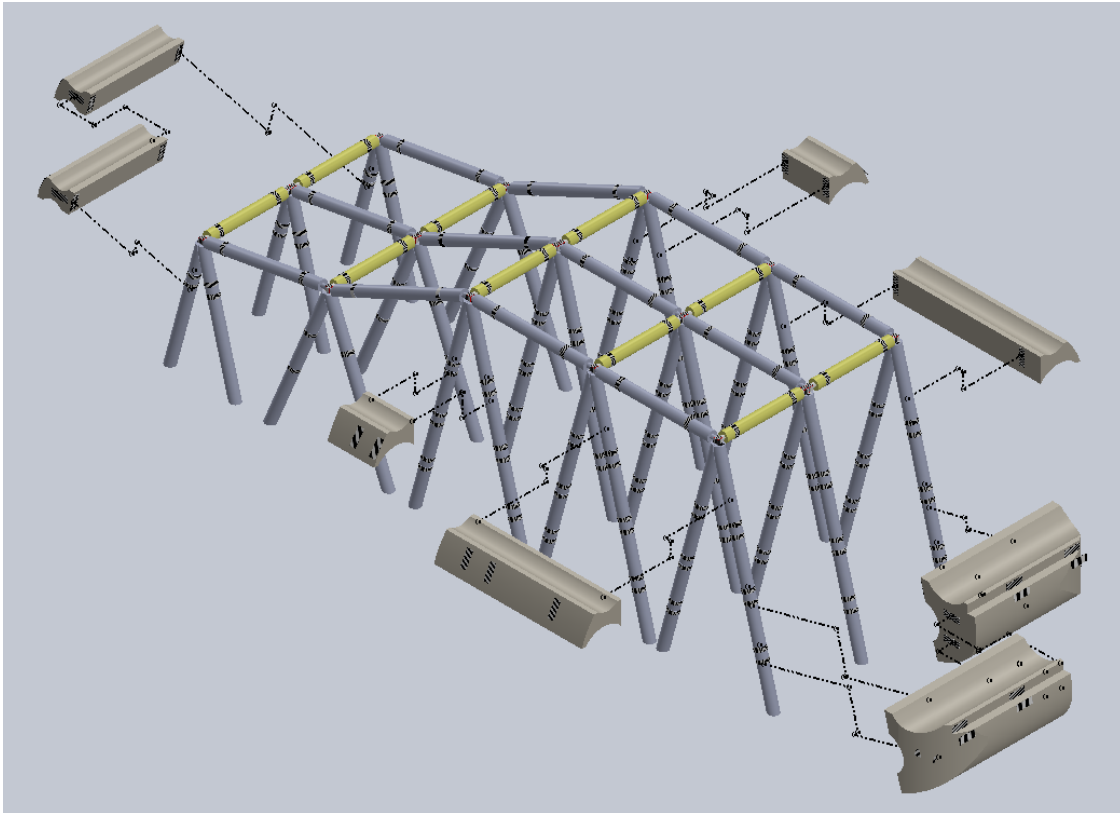


Figure 5.7 Exploded view of the foam block design

get from exploded foam block view

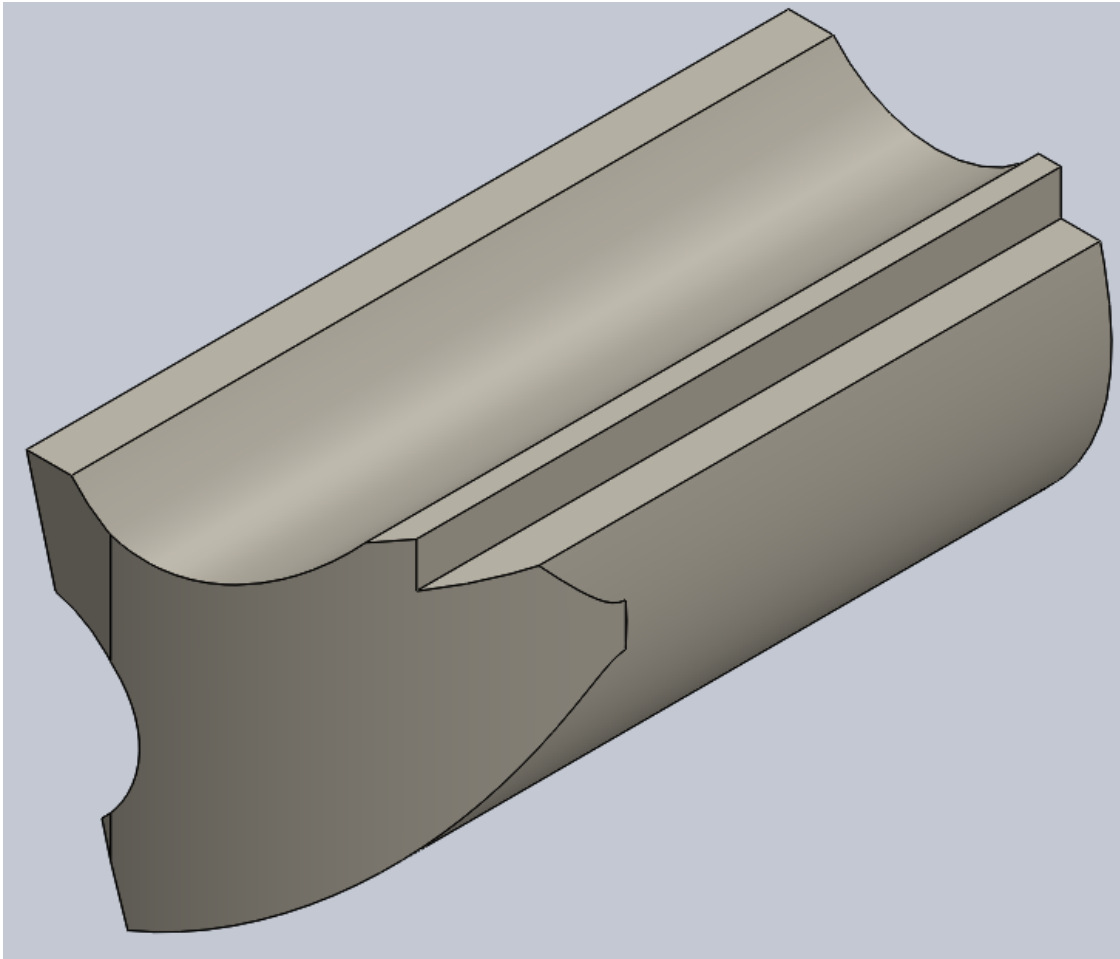


Figure 5.8 Foam back bumper design

5.3 Tarp Covering

The covering is designed to be multiple small pieces of tarp that connect to one another to give the outer appearance of a car. An exploded view of this setup can be seen below in Figure 5.9. The largest piece measures 40 in by 36 in, which is below the recommended limit of 48 in by 36 in that could become stuck in the truck wheel well.

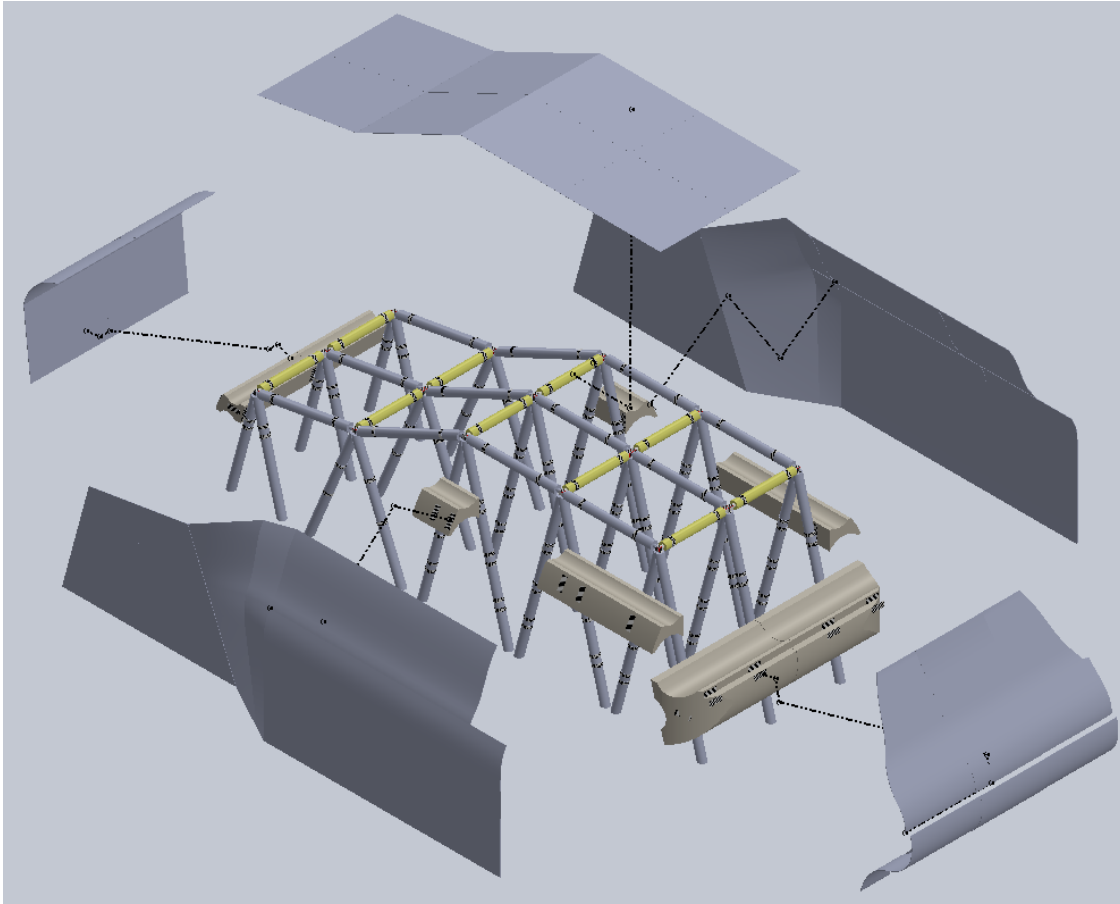


Figure 5.9 Exploded view of the tarp covering design

The tarp pieces will overlap with each other and be connected with Velcro pieces. The tarp will also be connected to the truss through Velcro pieces. Like the truss the tarp is made to be modular so the entirety of pieces do not have to be set up if only a section of the truss is set up. The tarp will connect to the base with pieces of Velcro as well. the base connections especially in the rear of the car are meant to have the tarp wrap under the car prior to attaching to the base. This will help with the visual representation of a car as the bottom connection of tarp to base should be out of the line of sight from the truck cameras. Thus giving the appearance that the car is on wheels instead of being a flat wall that connects to the ground.

5.4 Base

The base that the truss assembly attaches to is made up of four sheets of plywood that are joined together with hinges. Figure 5.10 shows the color coded locations where the truss assembly will mount. The color coded locations will help reduce the time it takes to assemble the truss assembly by matching each tube with their corresponding color. There are also four holes on each side of the base that will allow the entire Soft Target assembly to mount on top of the other Daimler base team.

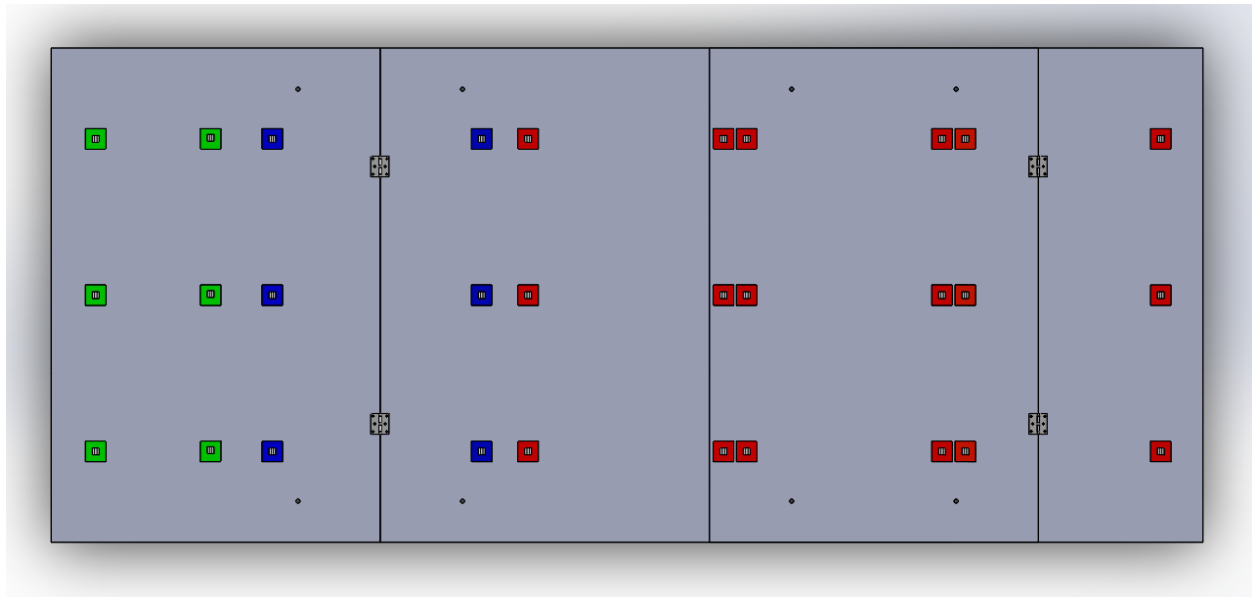


Figure 5.10 Top view of base

Figure 5.11 shows the base being folded, resulting in a reduction in storage space. The hinges help locate each plywood sheet with respect to each other and reduce setup time by not having to line up separate plywood sheets.

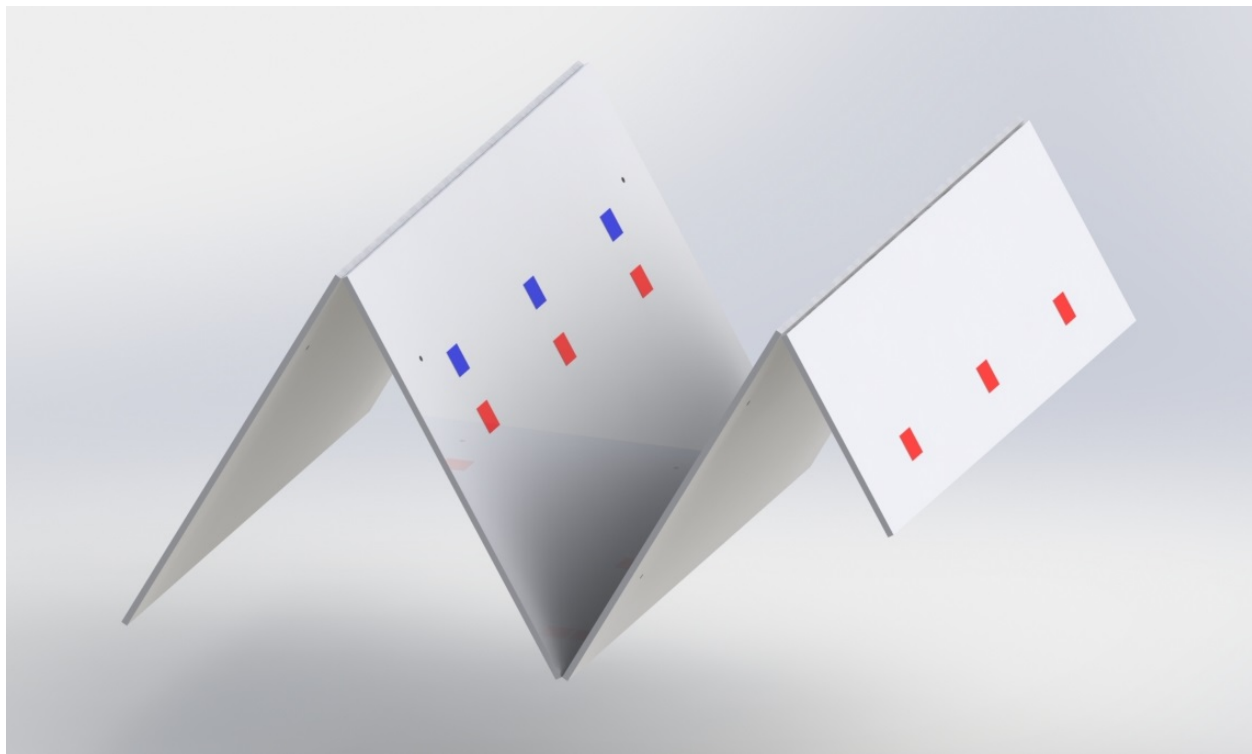


Figure 5.11 Base being folded

5.4.1 Base Connections

The connections are a plug system that is inserted into the ends of the PVC tubes. A stock PVC insert is screwed onto a flat plate and then pressed into the end of the pipe. This allows the connection surface area to be increased without increasing the diameter of the supporting pipes. The image in Figure 5.12 shows one of these attachment pieces separated from the rest of the truss (Velcro isn't shown to scale). Using a circular area of 4 in^2 , the attaching Velcro needs a strength of 15 psi.

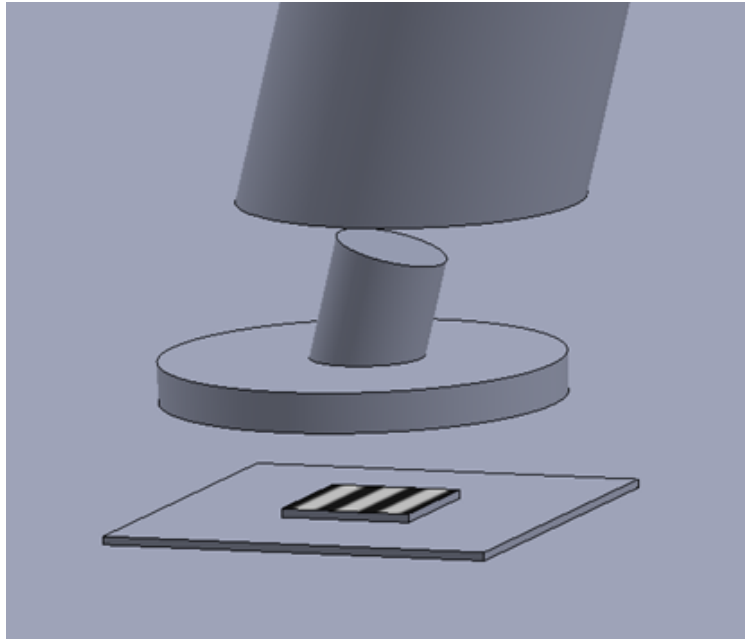


Figure 5.12 Close up view of the truss connection to the base

5.5 Assembly

The entire assembly is designed to be easy to assembly and modular in its construction. First the base is unfolded and laid out flat either on the ground or the mobile platform. Then the truss is assembled by placing one row of triangles up and connecting them across. This is repeated until the total truss is assembled. Then the foam blocks are attached to their corresponding sides. Finally, the tarp pieces are connected around to finalize the car shape.

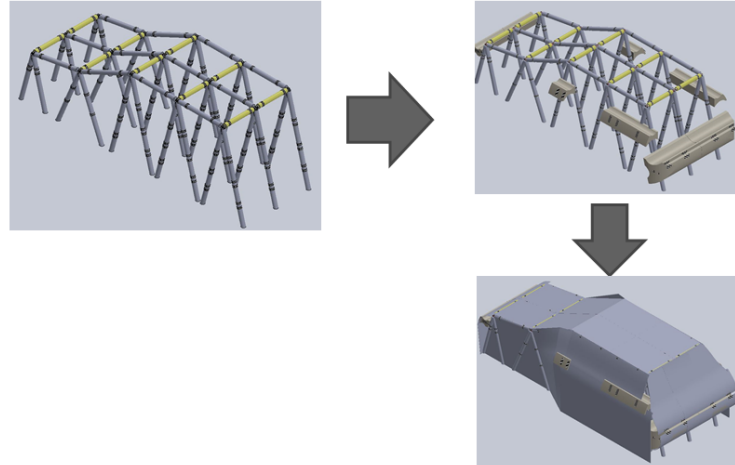


Figure 5.13 Summary of assembly construction

6 Design Justification

To size the various components of the design, a series of calculations were performed. Different methods were utilized to verify that each component would perform as expected.

6.1 Wind Analysis

A key feature in the design was determining if the soft target could be strong enough to stand up to the wind loads. At the same time the target has to be able to come apart upon impact. The first step in this process was understanding the wind loads affecting the target.

Wind loads were calculated using the worst case scenario of a 48 km/hr wind speed. This load was the max cross wind under which Daimler would still run tests. The equation for wind force can be seen below in equation 1. In this equation, C_D is the coefficient of drag. This value which is around .3 for a smaller sedan was estimated at 1 which is representative of a rectangular box. This value was chosen because this crash test target would not have the same exact contours as a sedan but be closer to the worst case of a rectangular box. ρ is the density of the fluid, air in this case. A_f represents the frontal area of the car. v is representative of the speed of the fluid moving by the test target.

$$F = \frac{1}{2} C_D * \rho * A_f * v^2 \quad (1)$$

A max wind force of just over 215 Newtons is applied to the side of the car. By breaking this force down to act upon a single beam, the worst case of 25.2 N was analyzed for one of the back triangle poles. Simplifying this model as a cantilever beam the shear and moment were found at the base. Using this data, the base plate of the tubes were sized at 4 inches. This allowed enough distance of the centroid and area of the circle for the Velcro to have a normal force of less than 15 psi while still keeping the pole in place.

The other wind load analyzed was the wind force of 80 kph acting on the front of the car. This force was a combination of the car driving forward at the maximum speed of 50 kph and a frontal wind speed of 30 kph. Using the same wind load equation, we found a frontal wind force of 777 N. Knowing the wind loads on the truss, a Finite Element Analysis, or FEA, could be run to analyze the truss structure. This was done by creating a pipe truss representation in ABAQUS and fixing it to the ground. The ABAQUS model was created to represent a singular row of the car (1/3 of the total truss) as the other 2 rows are identical. The wind load was split to be 1/3 the total and was applied to the stop surfaces of the pipes that would feel the wind load. The pipes could be quickly resized to allow for different manual iterations of the pipe sizing to

determine which pipe size offered the best deflection to weight value. A screenshot of the front wind loading condition can be seen below in Figure 6.1. The pipe size resulted as the nominal 3/4" stock PVC pipe.

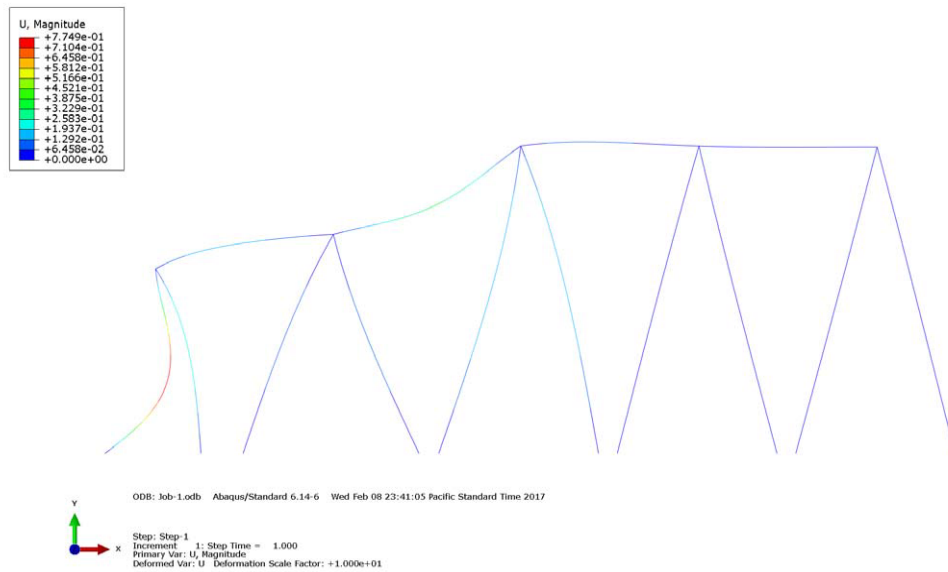


Figure 6.1 Finite Element Analysis Deflection Results

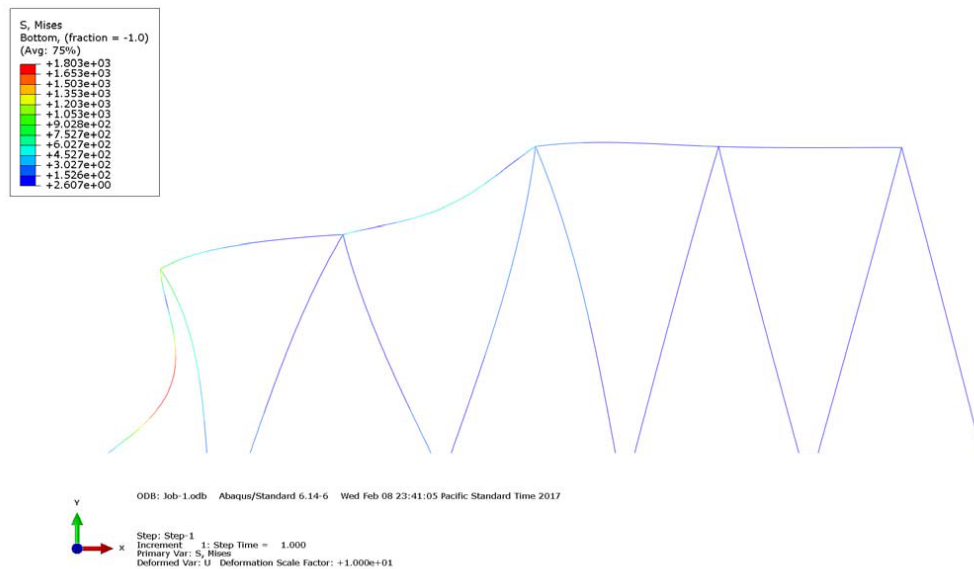


Figure 6.2 Finite Element Analysis Von Mises Results

The ABAQUS probe tool was also used to evaluate the stresses in the joint connections. By measure both the normal and shear stress, an appropriate Velcro strength could be found that would best hold the structure under wind loading but would fail upon a higher stress load. Using the face size of one square inch, it was found that the Velcro would need to hold 15 psi of shear force to withstand the wind loads. The normal force was negligible in comparison do to the direction of the forces compared to the attachment method of the Velcro.

6.2 Impact Modeling

The team needed a way to calculate the thickness of foam needed to surround the PVC pipes. Assuming that the foam would absorb most of the impact energy, contact mechanics could be used to compare the amount of material indentation to the impact force. These models rely on empirical relationships that have been generalized to fit to mathematical models. Therefore, there are many assumptions that need to be considered before these calculations can be considered as actual relationships. The main assumption for this impact was based on the case of two cylinders colliding perpendicularly, as seen in Figure 6.3. Since a brace is put on the front of the test vehicle, the actual impact point was assumed to be a cylinder that would impact the cylinders found in the truss system of the frame.

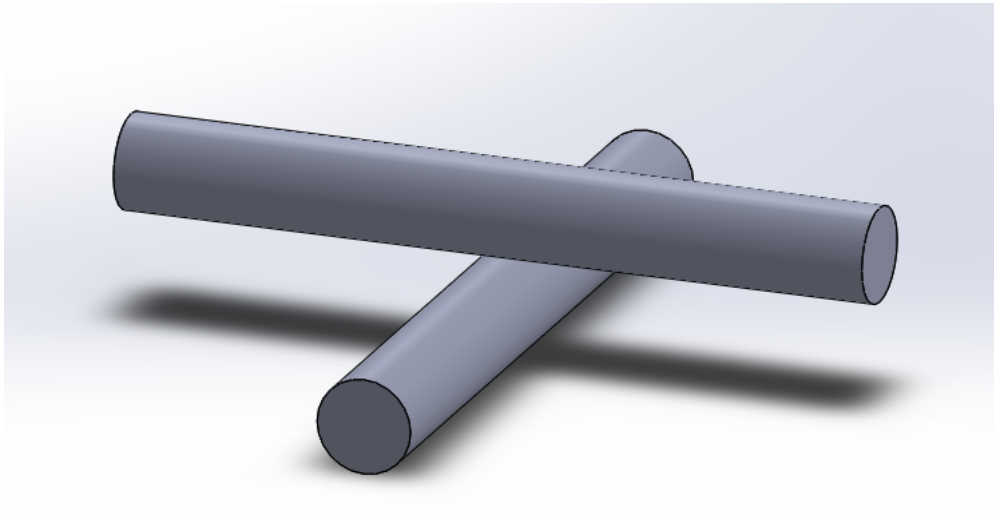


Figure 6.3 Two perpendicular cylinders colliding

The equation for two cylinders colliding can be seen below in Equation 2. In this equation, E^* is a hybrid Young's Modulus found using Equation 3, R is the resulting radius of comparing the two cylinders using Equation 4, F is the impact force, and d is the indentation depth. This model only considers one of the two materials deforming while the other stays perfectly rigid. This is a valid assumption for the impact being modeled here, since the material attached to the truck would be a metal and the corresponding material would be a foam that is chosen to deform.

$$F = \frac{4}{3} E^* R^{1/2} d^{3/2} \quad (2)$$

$$\frac{1}{E^*} = \frac{1 - \nu_1^2}{E_1} + \frac{1 - \nu_2^2}{E_2} \quad (3)$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} \quad (4)$$

The complications of using this model arise when the comparison between the measured speed and mass of the truck to a quantifiable impact force. This was done by first computing the kinetic energy of the truck using the known impact speed of 80 kph and weight of 80,000 lbs. Then an impact time was estimated to determine over what distance the kinetic energy was dissipated into the foam. It was assumed that the target frame would absorb a much greater percentage of the impact energy compared to the truck, and therefore all energy was considered when running the model. It was first assumed that the three rear poles would be the first to be struck, and therefore were the only impact locations considered. The truck was modeled as steel, since most cattle guards for trucks use steel for their material. Since the intention was to find the thickness of foam, an iterative approach would be used since the thickness is factored both into the overall radius of the tube and the depth of compression. The inputs of the model are summarized in Table 6.1.

Table 6.1 Inputs needed for the force contact model

Steel Bar	Diameter	3	[in]
	Elastic Modulus	2.07E+11	[Pa]
	Poisson's Ratio	0.3	
Foam Cover	Elastic Modulus	1.59E+08	[Pa]
	Poisson's Ratio	0.5	
PVC Tube	Diameter	1.05	[in]
Truck	Weight	80000	[lb]
	Velocity	80	[kph]
	Contact Distance	1	[m]

The target was to find a compressive depth of foam equivalent to the thickness of the foam. The results of the first run can be seen below in Table 6.2. As one can see the foam thickness was quite high, requiring a refinement of the original assumptions.

Table 6.2 Results from first run of impact model

Energy	8.96E+06	[J]
Impact Force	7.76E+06	[N]
E*	2.12E+08	[Pa]
Total Tube Radius	0.15	[m]
R*	0.031	[m]
Foam Thickness	5.51	[in]

Obviously the resulting 5.5 in. of foam would be too thick to reasonably wrap around the PVC pipe. Later assumptions distributed the impact energy throughout the frame based on the FEA model, resulting in the values shown in Table 6.3. It was also assumed that the PVC tubing would absorb a percentage of the impact, resulting in a 25% energy reduction to the back three tubes.

The final foam thickness resulted in the value of 2.25 in of padding needed. Since there were still some unknowns about energy distribution and the manufacturing considerations, the team felt that a 2 in. thickness of foam surrounding the PVC pipe would be adequate for the purposes of the initial prototype.

6.3 Comparing the FEA Results

To compare the FEA test to another model, a simple cantilever model was used to predict the wind deflection. This model was created using Equation 5, which corresponds to the maximum stress a cantilever

Table 6.3 Results from final run of impact model

Energy	6.27E+06	[J]
Impact Force	1.81E+06	[N]
E*	2.12E+08	[Pa]
Total Tube Radius	0.07	[m]
R*	0.025	[m]
Foam Thickness	2.24	[in]

beam has under a distributed load. This analysis considered the side wall to be supported by six equal pipe oriented vertically. The wind loads were considered to be the same as the FEA model, with a 30 mph wind and a C_D of 1. This model was considered an absolute worst case since the "truss" would receive a higher wind load than the actual prototype would experience and the pipes could not support each other and distribute the load.

$$\sigma = \frac{wLr_o}{2\pi(r_o^4 - r_i^4)} \quad (5)$$

To look at the shear stress at the base, Equation 6 was used. Again the same assumptions as the maximum normal stress were assumed.

$$\tau = \frac{wL}{\pi(r_o^2 - r_i^2)} \quad (6)$$

For the final part, the deflection of the entire wall was calculated using Equation 7.

$$\delta = \frac{8wL^3}{E\pi(r_o^4 - r_i^4)} \quad (7)$$

The results of this analysis, and a estimate of the total weight of the truss structure, are shown below in Table 6.4.

Table 6.4 Deflection of Hollow Tubes of PVC

Outer Diam [in]	Inner Diam [in]	σ_{Base} [MPa]	τ_{Base} [MPa]	δ_{Max} [in]	Total Weight [lbf]
0.63	0.50	55.1	17.12	16.76	6.4
0.75	0.63	30.3	9.91	7.68	7.8
0.88	0.75	18.4	6.24	4.00	9.2
1.00	0.88	12.0	4.18	2.28	10.6
1.13	1.00	8.2	2.94	1.39	12.0
1.25	1.13	5.9	2.14	0.90	13.4
1.38	1.25	4.4	1.61	0.61	14.9
1.50	1.38	3.3	1.24	0.42	16.3
1.63	1.50	2.6	0.97	0.30	17.7
1.75	1.63	2.1	0.78	0.22	19.1

These results greatly overestimate the values compared to the FEA model. Again, the limited assumptions mentioned earlier underrepresented the truss structure and overestimated the wind loads. To rectify these discrepancies, future empirical testing will need to be done to proof the design in the appropriate loads.

7 Product Realization

7.1 Bill of Materials

A summary of the bill of material can be seen in Table 7.1. The part numbers and quantity for each item are included in addition to the suppliers.

Table 7.1 Overall Bill of Materials

BILL OF MATERIALS				
CATEGORY	ITEM DESCRIPTION	PART NUMBER	QTY	SUPPLIER
TRUSS	3/4" schedule 40 PVC 10' length	57471	17	http://www.homedepot.com/
	Foam Swim Noodles 2.5" OD 1" ID 55" length, pack of 35	N/A	2	https://www.amazon.com
	Rubber End Caps 1"x1" ID 1" length, pack of 50	9092K35	1	https://www.mcmaster.com/#
	Hook & Loop velcro Adhesive backing 1" width 75' length	9273K46	2	https://www.mcmaster.com/#
	Colored roll of electrical tape, 8 pack	76455A95	1	https://www.mcmaster.com/#
	Barbed PVC Pipe Fitting	48315K12	30	https://www.mcmaster.com/#
	Hook & Loop velcro Adhesive backing 2" width 5' length	9273K16	1	https://www.mcmaster.com/#
FOAM BUMPERS	Fabric Covering 18' x5'	N/A	1	Beverlys craft store
	3" HD36-HQ Foam - Full Sheet 82x76	N/A	1	http://www.thefoamfactory.com/
	3" HD36-HQ Foam - half Sheet 82x36	N/A	1	http://www.thefoamfactory.com/
	adhesive spray	9335K3	6	https://www.mcmaster.com/#
COVER	tarp glue	202203979	1	http://www.homedepot.com/
	blue cover 10'x12'	206197416	1	http://www.homedepot.com/
	Nylon thread .025" diameter, 138 yards	87695k32	1	https://www.mcmaster.com/#
BASE	3/4" PVC end Caps	100345011	30	http://www.homedepot.com/
	Flat Head Screws, Pack of 6	204274670	5	https://www.mcmaster.com/#
	4'x8' Plywood board	431178	4	http://www.homedepot.com/
	nylon plate	8539k35	1	https://www.mcmaster.com/#

7.2 Cost

A summarized cost breakdown can be seen below in Table 7.2. The production cost have been estimated in Figure 7.3.

Table 7.2 Actual Spending Cost Breakdown

CATEGORY	ITEM DESCRIPTION	QTY	COST/UNIT	SUBTOTAL	TAX & SHIPPING	TOTAL COST
TRUSS	3/4" schedule 40 PVC 10' length	17	\$1.96	\$33.32	\$3.62	\$36.94
	Foam Swim Noodles 2.5" OD 1" ID 55" length, Pack of 35 (43 needed)	2	\$56.79	\$113.58	\$8.80	\$122.38
	Rubber End Caps 1"x1" ID 1" length, Pack of 50 (20 needed)	1	\$11.22	\$11.22	\$2.90	\$14.12
	Hook & Loop velcro Adhesive backing 1" width 75' length (135 ft needed)	2	\$74.38	\$148.76	\$13.90	\$162.66
	Barbed PVC Pipe Fitting	1	\$12.81	\$12.81	\$3.02	\$15.83
	Colored roll of electrical tape, 8 pack	1	\$4.27	\$4.27	\$2.34	\$6.61
	Hook & Loop velcro Adhesive backing 2" width 5' length (2.25 ft needed)	1	\$14.45	\$14.45	\$3.16	\$17.61
	Total			\$338.41	\$37.74	\$376.15
FOAM BUMPERS	Fabric Covering 18' x5'	1	\$55.64	\$55.64	\$4.45	\$60.09
	3" HD36-HQ Foam - Full Sheet 82x76	1	\$123.99	\$123.99	\$9.92	\$133.91
	3" HD36-HQ Foam - half Sheet 82x36	1	\$61.99	\$61.99	\$4.96	\$66.95
	adhesive spray	1	\$7.47	\$7.47	\$0.60	\$8.07
	Total			\$193.45	\$14.88	\$269.02
COVER	Nylon threa .025" diameter, 138 yards	1	\$7.97	\$7.97	\$0.64	\$8.61
	tarp glue	1	\$3.98	\$3.98	\$0.32	\$4.30
	blue cover	3	\$14.48	\$43.44	\$3.48	\$46.92
	Total			\$0.00	\$0.00	\$0.00
BASE	4'x8' Plywood board	4	\$15.43	\$61.72	\$4.94	\$66.66
	caps	36	\$0.49	\$17.64	\$1.41	\$19.05
	Flat Head Screws, Pack of 6 (30 needed)	6	\$1.98	\$11.88	\$0.95	\$12.83
	nylon plate	1	\$42.63	\$42.63	\$10.08	\$52.71
	Total			\$133.87	\$17.38	\$151.25
TESTING EQUIPMENT	50' nylon Rope	1	\$42.50	\$42.50	\$10.87	\$53.37
	pententimeter	1	\$17.00	\$17.00	\$8.00	\$25.00
	Total			\$59.50	\$18.87	\$78.37
Grand Total				\$665.73	\$70.00	\$874.79

The greatest costs are found in both the large foam sheets and the covering tarp. Large blocks of foam are expensive to buy in small quantities, so smaller sheets will be purchased and glued together to reduced cost. The other expensive item is the tarp covering since a large roll of it is required to completely cover the car. The parts that are more likely to fail from multiple impacts are the PVC and Velcro which are the two of the cheaper components. There will be extra material for iterations and testing. Most notably, the proposed cost falls under the \$2250 allotted budget at the beginning of the project.

Table 7.3 Cost of Production

CATEGORY	ITEM DESCRIPTION	QTY	COST/UNIT	SUBTOTAL	TAX & SHIPPING	TOTAL COST
TRUSS	3/4" schedule 40 PVC 10' length	17	\$1.96	\$33.32	\$3.62	\$36.94
	Foam Swim Noodles 2.5" OD 1" ID 55" length, Pack of 35 (43 needed)	2	\$56.79	\$113.58	\$8.80	\$122.38
	Rubber End Caps 1"x1" ID 1" length, Pack of 50 (20 needed)	1	\$11.22	\$11.22	\$2.90	\$14.12
	Hook & Loop velcro Adhesive backing 1" width 75' length (135 ft needed)	2	\$74.38	\$148.76	\$13.90	\$162.66
	Barbed PVC Pipe Fitting	1	\$12.81	\$12.81	\$3.02	\$15.83
	Colored roll of electrical tape, 8 pack	1	\$4.27	\$4.27	\$2.34	\$6.61
	Hook & Loop velcro Adhesive backing 2" width 5' length (2.25 ft needed)	1	\$14.45	\$14.45	\$3.16	\$17.61
	Total			\$338.41	\$37.74	\$376.15
FOAM BUMPERS	3" HD36-HQ Foam - Full Sheet 82x76	1	\$123.99	\$123.99	\$9.92	\$133.91
	3" HD36-HQ Foam - half Sheet 82x36	1	\$61.99	\$61.99	\$4.96	\$66.95
	Fabric Covering 18' x5'	1	\$55.64	\$55.64	\$4.45	\$60.09
	adhesive spray	1	\$7.47	\$7.47	\$0.60	\$8.07
	Total			\$193.45	\$14.88	\$269.02
Cover	Heavy Duty Vinyl 10'x18'	2	\$102.99	\$205.98	\$60.80	\$266.78
	Nylon threa .025" diameter, 138 yards	1	\$7.97	\$7.97	\$0.64	\$8.61
	Total			\$213.95	\$61.44	\$275.39
BASE	4'x8' Plywood board	4	\$15.43	\$61.72	\$4.94	\$66.66
	caps	30	\$0.49	\$14.70	\$1.18	\$15.88
	Flat Head Screws, Pack of 6 (30 needed)	5	\$1.98	\$9.90	\$0.79	\$10.69
	nylon plate	1	\$42.63	\$42.63	\$10.08	\$52.71
	Total			\$128.95	\$16.99	\$145.94
Grand Total				\$874.76	\$131.04	\$1,066.49

The total spent is much less than the material cost to produce as can be seen below. This is due to the heavy duty vinyl which was unfortunately ordered but never delivered and the ordered refunded. Because of this the actual spending was less even with testing equipment accounted for. For future runs the heavy duty vinyl should be ordered as it is a better material that is why it has been included in the production cost.

7.3 Manufacturing

Each component needs a unique method for construction and fabrication. The following sections detail each manufacturing process that was used to create each individual component, as well as the necessary tools and equipment utilized.



Figure 7.1 Completed Soft Target

7.3.1 Truss

The truss consisting of PVC pieces surrounded by foam noodles and Velcro along with the base connections caps were the first pieces manufactured.



Figure 7.2 Assembled Truss

The PVC pieces required specific angles and lengths. A miter saw was used in cutting the PVC to the correct angles and lengths. In order to accomplish this the pieces were first measured to the specific lengths required and marked on the top surface. A 2x4 piece of wood was used as a fixture to which the PVC was clamped. This gave a flat surface to clamp to the miter saw and prevented the PVC from rotating in order maintain the parallel cuts needed.

The PVC was fitted with the foam noodles which had already been cut to length by a knife. No angles were cut into the noodles before it was fitted on the PVC. The foam required some force and twisting in order to fit onto the PVC. Once the foam was on the correct angles were cut to align with the direction of the cuts in the PVC. Finally, Velcro was added to the foam.

The base connection pieces were an assembly of screws, nuts, PVC end caps, nylon plates, and Velcro.

The nylon plate was first cut to the correct dimensions. Through holes and a chamfer were added to allow clearance for the screw and screw head. Enough chamfer was added so that the screw head would be flush with the bottom of the nylon plate. A nut was added to the screw and tightened down to the plate locking the screw from rotating. The end cap was drilled at the appropriate angle using a special fixture which set the angle and helped minimize the amount of walk on the drilling operation. The fixture along with the drill press used can be seen in Figure 7.3. The end cap was then tapped using a screw and then added to the screw extending from the base plate and adjusted to the correct angle. A second nut was then used to tighten the cap in place. Lastly, Velcro was applied to the underside of the base plate and the cap was fitted onto the end of the correct PVC triangle piece.



Figure 7.3 Drilling Fixture for End Cap Angle

7.3.2 Foam Bumpers

The low density foam from foam factory, used for side and bumper blocks, came in large 3" tall blocks. These blocks were first measured and marked into the layers that would make up each bumper. The blocks were cut using saws and knives. The layers that make up each block were then fixed to each other using adhesive spray and let sit. Once the glue had dried the dimensions and shape of each bumper were cut. Then the bumpers were covered by a fabric to improve life and connections. The fabric was sewn on to the foam. Velcro connections were then applied with adhesive.



Figure 7.4 Completed Foam Block

7.3.3 Tarp

The chosen vinyl tarp material was cut with common safety scissors, seen in Figure 7.5, allowing the covering parts to easily be cut from a large piece of stock material. Velcro pieces in the correct location were sewn into place to ensure proper connection and better life.

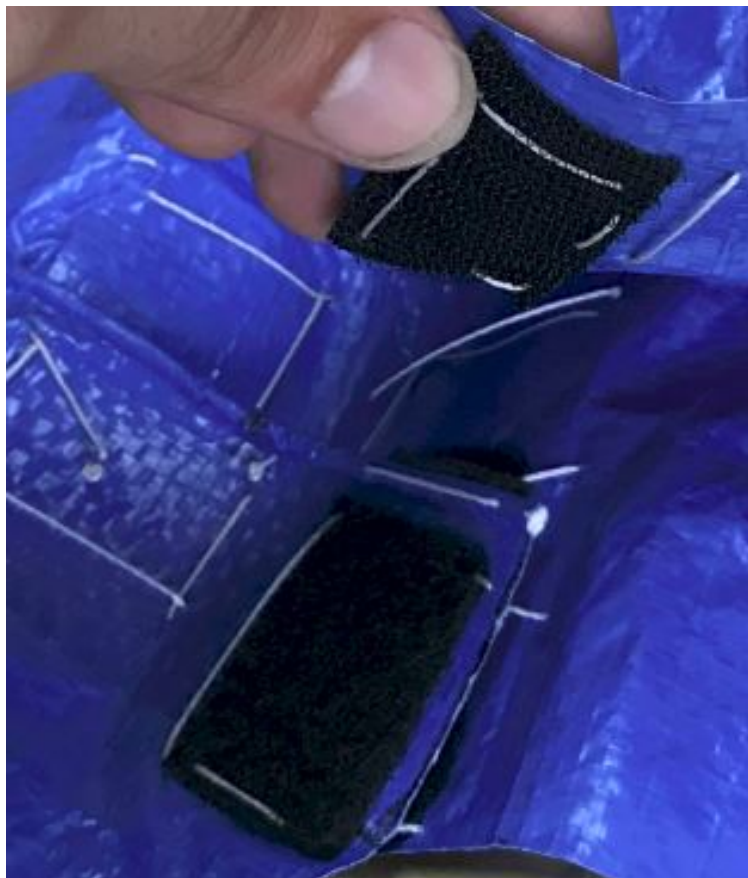


Figure 7.5 Sewn Velcro pieces

8 Design Verification

8.1 Design Verification Plan

The following list summarizes the tests that were completed. A full breakdown of each test plan can be found in Appendix [7].

- **Pendulum Impact Test:** A weight will swing into the rear of the car to observe the breakdown of the target in a controlled setup
- **Van Impact Test:** An old Cal Poly ME van will do rear impact tests at 32km/hr
- **Car Shape:** Utilize the Cal Poly AERO wind tunnel or a static load test to measure the target deflection in winds.
- **Assembly Time Trial:** The car will be assembly as separate pieces in less than ten minutes.
- **Base Compatibility:** Ensure Target attaches appropriately to the base.

There are many present hazards in both construction and testing of the target system. A checklist list the hazards and prevention methods can be found in Appendix [3].

8.2 Results

8.2.1 Pendulum Impact Test

Before the van impact test could be run, the team wanted to ensure that the target would collapse in an appropriate manner. A pendulum test was devised to allow a controlled mass to impact the rear section of the target. Using a steel box-beam weighing approximately 40 lbs, a nylon rope was attached to a roof beam and allowed to swing. An image of this setup shown mid-impact can be found below in Figure 8.1.

**Figure 8.1 Pendulum Impact**

The test was repeated multiple times at different heights to correspond to different impact energies. At first the impact location was too close to the bottom of the arc swing, causing the weight to stop before it could swing through the whole target. To better replicate the motion of the van running through the target, this was fixed in later tests by shifting the target closer to the pendulum starting point. A summary of the qualitative tests results can be seen below in Table 8.1.

Table 8.1 Results of Pendulum Test

Energy [J]	Results
100	Frame parts fall over slowly and "clump" together rather than fully separating
200	Frame triangles fall over but interconnecting parts do not fall with the main frame
300	All parts fall well out of the way but may pile on top of one another

8.2.2 Van Impact Test

Following the pendulum test, a proper impact test could be done using a 6k lbs Cal Poly passenger van. In order to protect the van and ensure some similarity with Daimler's trucks, a steel guard was attached to the front, seen below in Figure 8.2. A sheet of plywood was also included to add extra protection.



Figure 8.2 Steel cattle guard attached to the department van

To ensure the survival of the target components, on the rear two rows of frame pieces were set up. This way, the other rows could be used as spares if there was some non-repairable damage. The first test involved stepping the van forward as slow as it could move to observe the collapse of the frame. An image of this can be seen in Figure 8.3. An inspection following this found very little damage to all of the parts.



Figure 8.3 Slow rolling impact of the test target

Now satisfied that the target would fall over appropriately, the last two rows were set up again. This time the van would attempt to impact the whole target around five miles per hour. However, the speedometer began at ten miles per hour, so the actual speed was estimated by the driver. An image of the impact can be seen below in Figure 8.4. Following this test, it was found that some of the end caps had broken off from their feet. This damage is captured in Figure 8.5 as was likely caused by the van tire directly driving over the end cap.



Figure 8.4 Impact of the test target at 5 mph



Figure 8.5 Damaged base connections following the 5 mph impact

For the final test, the damaged parts were replaced with other elements of the frame that hadn't been tested yet and the target was set up again. This time, the rear bumpers and covering were included and the driver was instructed to hit the target at ten miles per hour. This setup and the corresponding impact are shown below in Figure 8.6. Again, some base connections broke after the van ran them over. Due to limited time, no further tests could be completed.



Figure 8.6 Impact of the test target at 10 mph

Overall the impact tests were considered successful, as the target was tested in multiple impact tests. The only considerable damage were the base connection end caps. These would likely also break under the weight of a semi truck, pointing toward a potential area of improvement.

8.2.3 Wind Tunnel

The Cal Poly AERO low speed wind tunnel was used to apply a constant wind load to the target and check for deflection. Due to available ground space, only the lateral deflection could be checked. The setup of the test is shown below in Figure 8.7.



Figure 8.7 Wind Tunnel Setup

It was decided that a string potentiometer would be the best method to measure the total deflection of the target. A low-cost option, provided by First Robotics supplier AndyMark, was chosen to allow for quick setup and assembly. The parts kit from AndyMark is shown below in Figure 8.8.



Figure 8.8 String Potentiometer Kit from AndyMark

The potentiometer was wired to an Arduino UNO board, which acted as both a power source and a DAQ system. The housing was attached to a rigid pole, as seen in Figure 8.9, and the end of the string was clipped onto the top of with target frame. A ruler was also attached as a secondary source of deflection measurement. The wind was measured using a handheld anemometer, and was allowed to stabilize before measurements were taken.



Figure 8.9 String Potentiometer connection

The deflection results as a function of wind speed can be seen below in Figure 8.10. For both trials, the target collapsed at a wind speed of roughly 16 miles per hour. The maximum deflection just before this moment was found to be 2.5 inches.

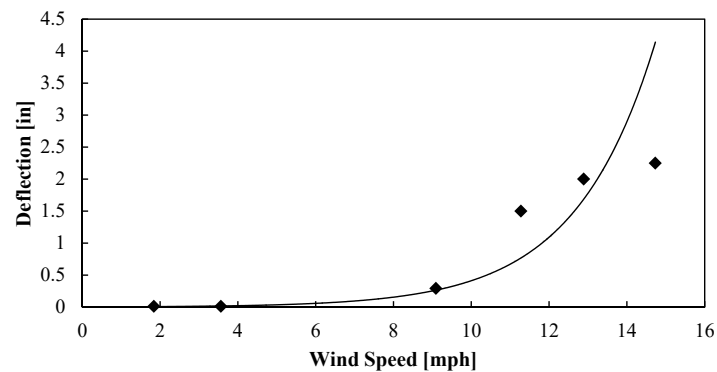


Figure 8.10 Lateral deflection as a function of wind speed

Since the main measuring device was homemade, an uncertainty analysis was performed to verify that the measured values were within a reasonable tolerance. The Arduino measured the change in voltage, allowing the calculation of a conversion constant of $4.84 \frac{\text{in}}{\text{V}}$. Knowing the voltage could only be measured to the hundredths place, the uncertainty is ± 0.05 in. This results in a 2% error at the collapse speed.

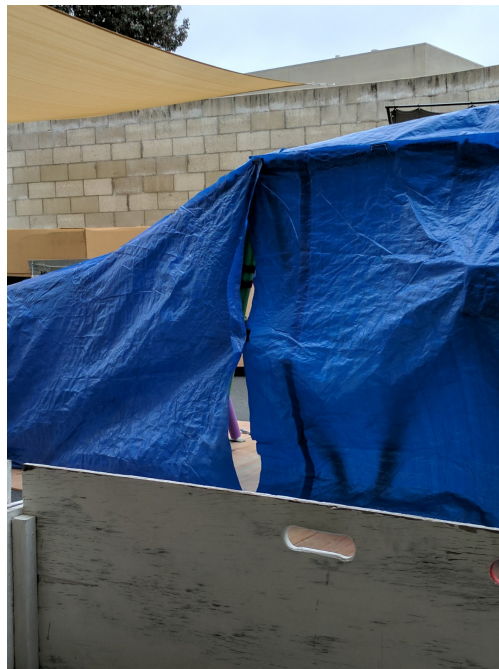


Figure 8.11 Separation of the side tarps due to the wind

For the duration of the test, it was found that various tarps were not attached well to their neighboring parts. This caused the tarp to flap and move as seen in Figure 8.11. While the allowable wind speed of 16 mph is lower than the wind spec of 30 mph, modifications were made post-test to allow for reduced flapping of the covering tarps.

8.2.4 Assembly

The assembly of the test target was done both during manufacturing of the components as well as for location changes for testing. The team became increasingly skilled at improving their setup time, with a final setup time of about 15 minutes with two people. This would assume that the parts would be easily accessible and sorted beforehand. If the parts, including the plywood base, started in a large clump, there would be an additional 2-3 minutes of setup time required.

8.2.5 Base Compatibility

It was determined that a modified version of the test target would be used to mount on top of the movable base. This would consist of the two back rows of triangles and the two front rows of triangles. However, the base team expressed concern that while their motors could handle the weight of the target, the strength of the frame was worrisome. At this recommendation, the test target was not included in their driving tests nor formally mounted to the moving frame.

8.3 Results Summary

Below is a list of the original project specifications and whether or not they were met. Green text represents a passed specification, red text represents a fail specification, and orange represents a specification which was partially met or was not testable with campus resources.

- **Maintains Shape at 80 km/hr:** Unable to Test
- **Impact of 80k lbs at 80 km/hr:** Impact of 6k lbs at 16km/hr
- **Cost \$2250:** \$850
- **Survive 50 impacts:** Only did 3 impacts
- **Operate in 48 km/hr lateral winds:** Can operate up to 26 km/hr lateral winds
- **Weight under 35 lbs:** Weight at 45 lbs, but assured this was OK by base team

9 Conclusion and Recommendations

Future developments to the project would improve the performance and allow further specifications to be met. The largest improvement area would be in the base connection design. Since the tire of the van destroyed these when they were run over, a non-rigid design would allow the vehicle to apply pressure without fear of breaking. Daimler has mentioned improving the tarps as their sensor systems change, so those will be continuously improved if use of the target continues.

This project has presented an exciting challenge for the Target Practice team. They want to thank David Smith and his team at Daimler and Dr. Birdsong for their support and guidance throughout the project. They hope that this project will assist in the testing of AEBS's and create a solid base for any future projects.

10 Appendices

- [1] Works Cited
- [2] QFD Diagram
- [3] Pugh Matrix
- [4] Hazard Checklist
- [5] Gantt Chart
- [6] DMFEA Chart

[7] DVP Chart

[8] Operator's Manual

[9] Drawing Package

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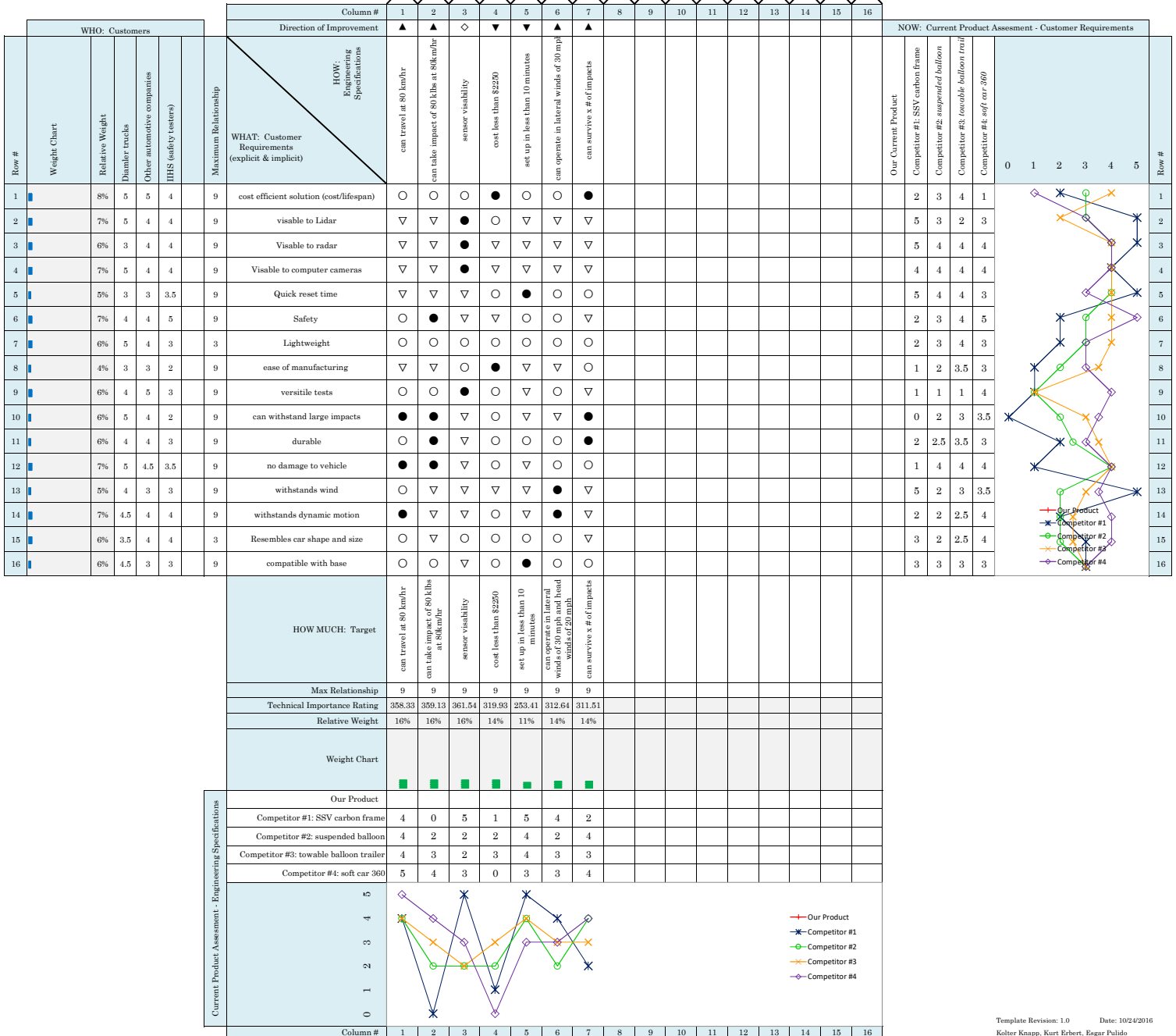
Appendix 2



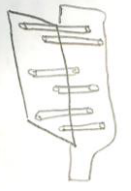
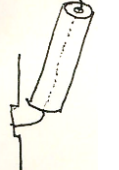
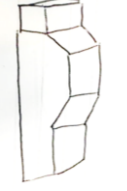

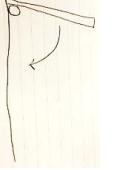

QFD: House of Quality
Project: Aebis test target
Revision: 1.0
Date: 10/24/16

Correlations	
Positive	+
Negative	-
No Correlation	

Relationships	
Strong	●
Moderate	○
Weak	▽

Direction of Improvement	
Maximize	▲
Target	◇
Minimize	▼



Concepts								
	Soft car	Balloon	Pool noodle	Pool noodle w/tent connectors	Solid foam block	Spring car	Hinge car	Horizontal foam layers
Criteria	Datum	2	3	4	5	6	7	8
Cost efficient	S	-	+	+	-	-	-	S
Visible to Lidar	S	-	-	-	+	S	S	+
Visible to Radar	S	S	S	S	S	S	S	S
Visible to cameras	S	S	S	S	+	S	S	S
Reset Time	S	+	S	+	+	+	+	-
Safety	S	S	S	S	-	-	S	-
Lightweight	S	+	+	+	-	-	-	-
Ease of manufacturing	S	-	+	S	S	-	-	+
Versatile tests	S	S	S	S	S	-	-	S
Large impacts	S	S	S	S	-	-	-	S
Durable	S	+	+	+	S	-	-	S
No damage to vehicle	S	S	S	S	S	-	-	S
withstands winds	S	-	-	-	+	+	S	S
withstands dynamic motion	S	-	-	-	+	+	S	S
Resembles car shape	S	-	S	S	S	-	S	S
Compatible with base	S	S	S	S	S	-		S
Σ+	0	3	4	4	5	3	1	2
Σ-	0	6	3	3	4	10	7	3
ΣS	16	7	9	9	7	3	7	11
Total	0	-3	1	1	1	-7	-6	-1

DESIGN HAZARD CHECKLIST
























Team: AEBS Target Team**Advisor:** Professor Birdsong

- | Y | N | |
|-------------------------------------|-------------------------------------|---|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | 1. Will any part of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points? |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | 2. Can any part of the design undergo high accelerations/decelerations? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 3. Will the system have any large moving masses or large forces? |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | 4. Will the system produce a projectile? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 5. Would it be possible for the system to fall under gravity creating injury? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 6. Will a user be exposed to overhanging weights as part of the design? |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | 7. Will the system have any sharp edges? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 8. Will any part of the electrical systems not be grounded? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 9. Will there be any large batteries or electrical voltage in the system above 40 V? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 10. Will there be any stored energy in the system such as batteries, flywheels, hanging weights or pressurized fluids? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 11. Will there be any explosive or flammable liquids, gases, or dust fuel in the system? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 12. Will the user of the design be required to exert any abnormal effort or physical posture during the use of the design? |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | 13. Will there be any materials known to be hazardous to humans involved in either the design or the manufacturing of the design? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 14. Can the system generate high levels of noise? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 15. Will the device/system be exposed to extreme environmental conditions such as fog, humidity, cold, high temperatures, etc? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 16. Is it possible for the system to be used in an unsafe manner? |
| <input type="checkbox"/> | <input checked="" type="checkbox"/> | 17. Will there be any other potential hazards not listed above? |

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.

Hazard #	Description of Hazard	Corrective Action	Completion Date
1	Will any part of the design create hazardous revolving, reciprocating, running, shearing, punching, pressing, squeezing, drawing, cutting, rolling, mixing or similar action, including pinch points and sheer points?	Ensure that all points which could injure are appropriately covered as to protect the user	2/7
2	Can any part of the design undergo high accelerations/decelerations?	Ensure that the base separation is accurate through both tests and analysis	3/21
4	Will the system produce a projectile?	In the operator's manual, a minimum safe distance will be stated. This will be found through analysis and initial testing.	3/2
7	Will the system have any sharp edges?	If a part fails, a sharp edge may be exposed through the tube of foam. It will be documented in the operator's manual how to handle damaged pieces.	3/2
13	Will there be any materials known to be hazardous to humans involved in either the design or the manufacturing of the design?	If chosen materials are found to be hazardous to human health, the proper MSDS's will be read and consultation will be done into safe manufacturing procedures. Particular considerations are foam and carbon fiber	1/18

Appendix 5

ID	 Task Mode	Task Name	Duration	Start	Finish	Feb 12, '17	Mar 26, '17	May 7, '17
1		Critical Design	51 days	Mon 11/28/16	Mon 2/6/17	Critical Design		
39		CDR	0 days	Tue 2/7/17	Tue 2/7/17			
40		Manufacturing/Test Review	22 days	Tue 2/14/17	Wed 3/15/17			
41		Order Parts	1 wk	Tue 2/14/17	Mon 2/20/17			
42		Manufacturing Plan	7 days	Tue 2/21/17	Wed 3/1/17			
43		Operators Manual	2 days	Thu 3/2/17	Fri 3/3/17			
44		Final Test Plan	3 days	Mon 3/6/17	Wed 3/8/17			
45		Report Preparation	5 days	Thu 3/9/17	Wed 3/15/17			
46		Manufacturing and Test Review	0 days	Thu 3/16/17	Thu 3/16/17			
47		Spring Break	7 days	Sat 3/25/17	Sun 4/2/17			
48		Hardware/Safety Demo	20 days	Tue 4/4/17	Mon 5/1/17			
49		Component Testing	5 days	Tue 4/4/17	Mon 4/10/17			
50		Prototype Construction	10 days	Tue 4/11/17	Mon 4/24/17			
51		Demo Preparation	5 days	Tue 4/25/17	Mon 5/1/17			
52		Hardware and Safety Demo	0 days	Tue 5/2/17	Tue 5/2/17			
53		Final Design	21 days	Thu 5/4/17	Thu 6/1/17			
54		Assembly Testing	5 days	Thu 5/4/17	Wed 5/10/17			
55		Wind Testing	2 days	Thu 5/4/17	Fri 5/5/17			
56		Pendulum Test	5 days	Thu 5/11/17	Wed 5/17/17			
57		Van Impact	1 day	Thu 5/18/17	Thu 5/18/17			
58		Final Report Preparation	10 days	Fri 5/19/17	Thu 6/1/17			
59		Expo	0 days	Fri 6/2/17	Fri 6/2/17			

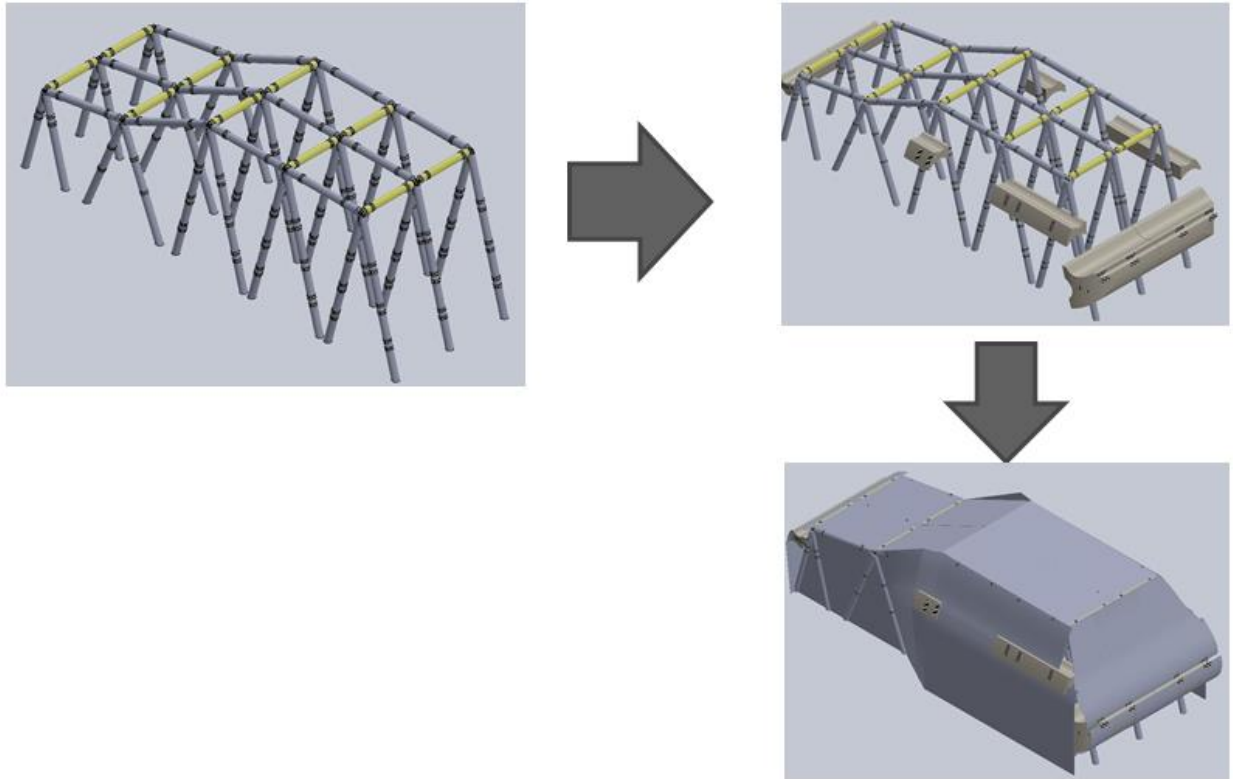
Item / Function	Potential Failure Mode	Potential Cause(s) / Mechanism(s) of Failure	Occurrence	Potential Effect(s) of Failure	Severity	Criticality	Recommended Action(s)	Responsibility & Target Completion Date	Action Results			
									Actions Taken	Severity	Occurrence	Criticality
Can be reset after test (Target survives impact)	Connections to base broken	Impact shears off connection	4	Longer reset time due to repair Adds expenses Not replaced	6 6 8	24 24 32	Find minimum velcro strength needed for operation, consider attaching velcro directly to stiffener	Kurt 1/10/17	Velcro Caclulations completed and tested			
		Truck runs over connection	2	Cancels testing for the day Longer reset time due to repair Adds expenses	8 6 6	16 12 12						
	Tubes break in half	Piece breaks on impact	5	Cancels testing for the day Longer reset time due to repair Adds expenses Not Replaced	8 6 6 8	40 30 30 40	Material testing for both daily fatigue and max tensile/compressive forces	Kolter 1/24/17	Material research conducted and FEA models run to ensure below stress limit			
		Foam does not absorb enough energy	3	Cancels testing for the day Longer reset time due to repair Adds expenses Not Replaced	8 6 6 8	24 18 18 24	Material Testing for daily fatigue (50 Tests)	Kolter 1/24/17	Material research conducted and FEA models run to ensure below stress limit			
		Rod is run over and not strong enough	2	Need to replace tube	7	14	Material tesing for max tensile/compressive forces	Kolter 1/24/17	Material research conducted and FEA models run to ensure below stress limit			
	Cover Breaks	Piece breaks on impact	5	Cancels testing for the day Longer reset time due to repair Adds expenses	8 6 6	40 30 30	Material impact tests	Esgar 4/17/17	Initial impact tests have good results			
	Pieces do not separate	Velcro connection is too strong	4	Large forces on certain pieces Large projectile hazard	6 2	24 8	Velcro tests and analysis	Kurt 1/10/17	Ran initial tests, concluded "feet" were needed			
Maintains car shape	Deforming car shape	Aerodynamics	8	Poor Sensor visibility Target lifting Increased chance of high damage Harder to control base	7 7 6 6	56 56 48 48	Look into modelling aerodynamics, find material that best meets deflection criteria, scaled model testing with wind tunnel	Kurt-modelling 1/10/17 Kolter-material 1/10/17 Wind tunnel TBD	Used drag to determine PVC, need more coordination to run actual wind analysis			
		Rods themselves deflect in wind	6	Poor Sensor visibility Increased chance of high damage Collapses (whole target falls apart)	7 6 8	42 36 48						
		Connections between rods aren't strong enough	2	Collapses (whole target falls apart) Increased chance of high damage	8 6	16 12						
	Car Falls off base	Base connection isn't strong enough Sudden movement change due to base	3 3	Collapses (whole target falls apart) Collapses (whole target falls apart)	8 8	24 24	Talk to experts for structure design help, ensure velcro connections	Esgar 1/17/17	Consulted with professors who pointed towardlibrary resources			
	Structual failure	Connections are not strong enough	2	Target does not stay together and car does not recongnize target causing large impact	8	16	Check truss loading conditions and size velcro appropriately	Kolter 1/17/17	FEA model			
		rod buckles under own weight	2	Target does not stay together and car does not recongnize target causing large impact	8	16	Check truss weight and loading conditions	Kolter 1/17/17	FEA Model			
	Attaches to base	Incompatible with base design	3	Target can't be used with base Presents base operation hazard	8 7	24 21	Consulting with base team	Esgar 1/17/17	Confirmed initial size estimate			
			4	Presents base operation hazard	7	28						
		Incorrect size for base	4	Target can't be used with base Presents base operation hazard	8 7	32 28	Apply base team's dimensions to connection joint layout	Kolter 5/24/17	Overlayed wooden base pieces on metal ones, awaiting assembly to drill holes			
			4	Target can't be used with base Presents base operation hazard	8 7	32 28						
		Aerodynamic forces make base unusable	4	Base is undriveable Base runs out of power too quickly	7 6	28 24	Include an operating conditions section in the manual and perofrm previously shown aerodynamic tests	Kurt 5/28/17	Evaluating measurement options and awaiting coordination from the wind tunnel technicians			
			2	Base is pushed around by wind Target collapses	7 8	14 16						
				Truck fails to apply brakes	8	80						

[illegible]

ME428 DVP&R Format

Report Date		Sponsor Daimler		Component/Assembly		REPORTING ENGINEER:			
TEST PLAN							TEST REPORT		
Item No	Specification or Clause Reference [1]	Test Description [2]	Acceptance Criteria [3]	Test Respons ibility [4]	Test Stage [5]	TEST RESULTS			NOTES
					SAMPLES TESTED	TIMING	Test Result [7]	Quantity Pass	
					Quantity/Type	Start date/Finish date			
1	Maintains structure and shape in wind	Put full size prototype on outlet of aero wind tunnel. Run tunnel at 80 km/hr for frontal test. Run tunnel at 48 km/hr for test of cars side profile apply strain gauge to one pvc rod	Minimum car stays together no pieces come apart. Stretch goal: deflection is not significant less than 3 inches. Compare to FEA model	Kurt	AERO Wind Tunnel/ SM Test track	5/24/2017/5/24/2017	Target fell over at 16 mph lateral wind		
2	Test track impact testing	Drive cal poly van into rear of target at 25 mph constant speed. Start off with test at 10 mph and increase by 5 mph until 25 mph	parts are not broken	Kolier	SM Test track	5/26/2017/5/26/2017	Target rear survived up to 8000lb van at 10 mph, some end caps were broken by tire weight		
3	Set up	Time full assembly One person assembly vs two	<10 min	Kurt	Cal Poly/SM Test track	5/26/2017/5/26/2017	Able to set up in 15 minutes		
4	Base Compatibility	Assemble vehicle with other teams base	All parts are compatible	Kolier	Cal Poly	5/15/2017/5/15/2017	Ran in to difficulties with base deflection and dynamics before compatibility was completed		
5	Pendulum test	use cattle guard on pendulum to enact contact similar to truck impact.	Rod does not break	Kolier	Cal Poly	5/10/2017/5/10/2017	The faster the impact speed, the more likely the target would fall apart out of the way of the pendulum rather than clump together		

AEBS Test Target Frame Setup Guide



Pre setup

Consult drawing package for part names
Check each piece make sure none are damaged
Ensure you have each piece needed
Ensure pieces are sorted by type for ease of assembly

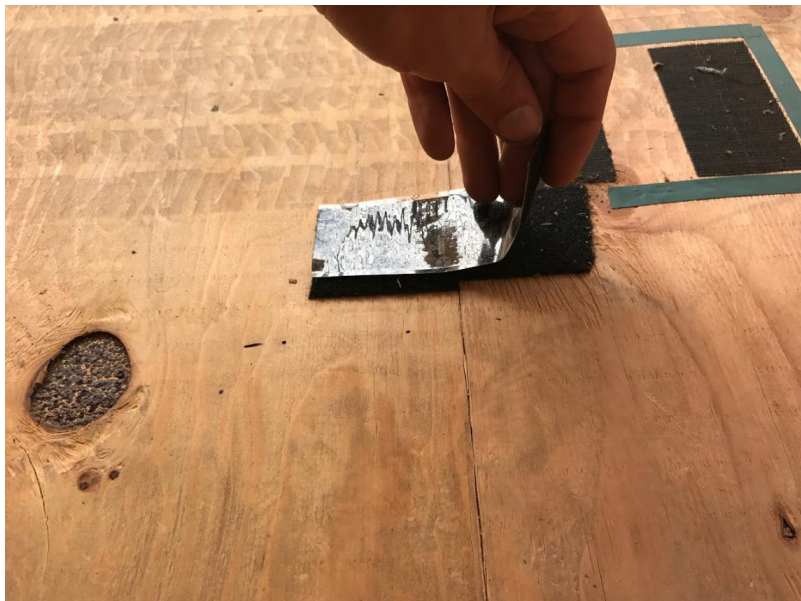
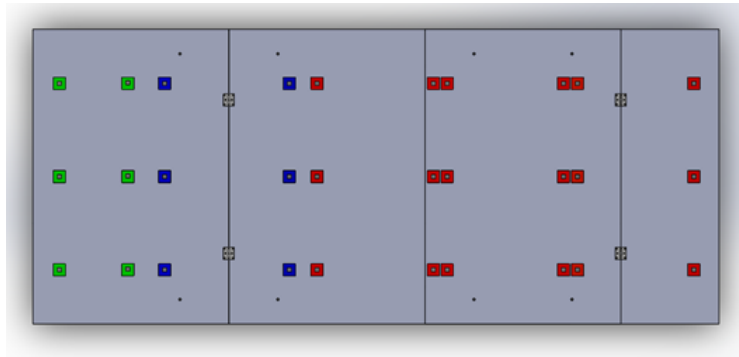
Pieces needed

A x 6
B x 6
C x 18 (Green)
AB x 3
BC x 3
CC x 6 (Blue)
Cross beam x 10
Bumpers x 8
Tarp x 33
Base x 4

Set Up

Base

- First lay each individual base part flat on the ground in ascending order. Use Velcro strips to connect each base with each other.



Truss

- Build three C (green) triangles by connected a male C with a female C



- Insert the three triangles into the adjacent color coded base spots starting in the rear

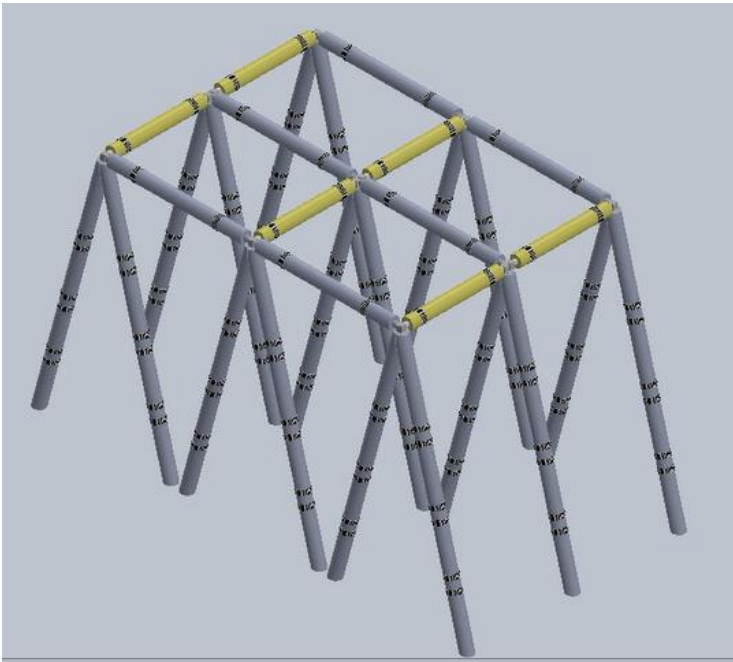


- Connect the 3 C (green) triangles with 2 cross beams (yellow)



Repeat for the next two rows.

- Use CC (Blue) beams to connect between the rows



NOTE: Middle triangle is rotated 90°



- Build three B (Purple) triangles by connected a male B with a female B

- Insert the three B (Purple) triangles into the adjacent color coded base spots
- Repeat for three A (Red) Triangles

NOTE: Middle triangles are rotated 90°

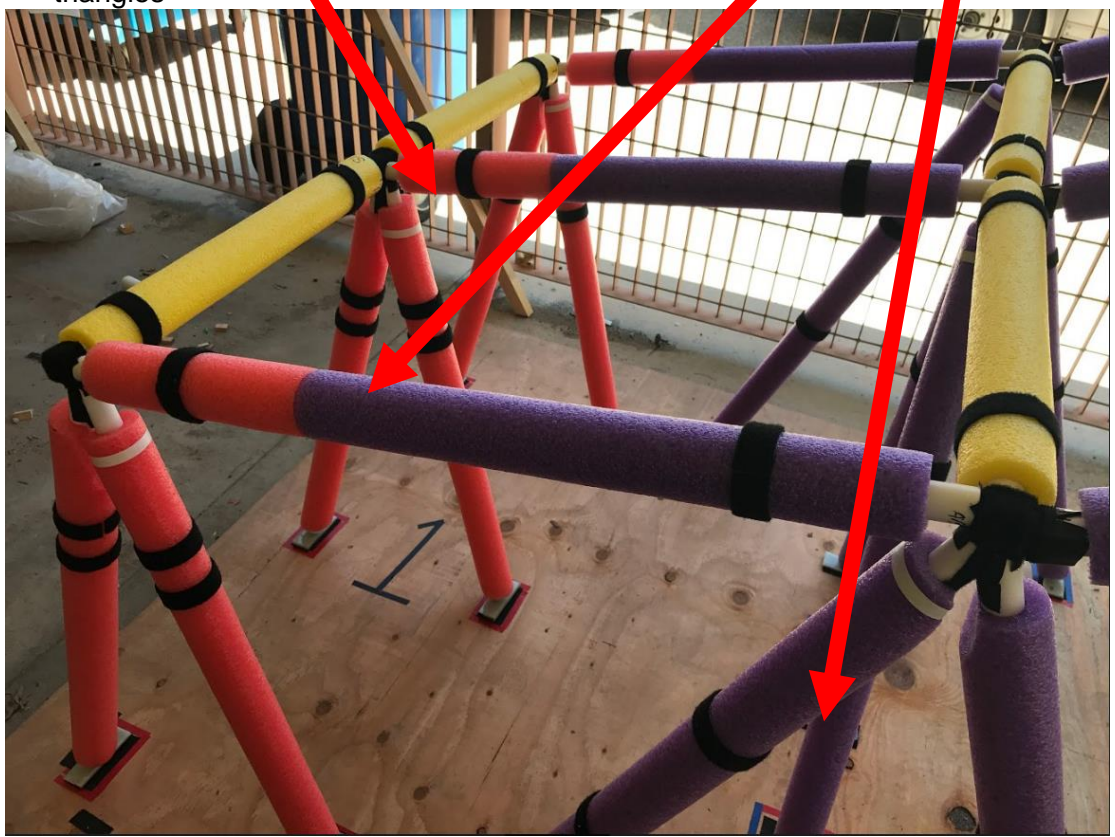


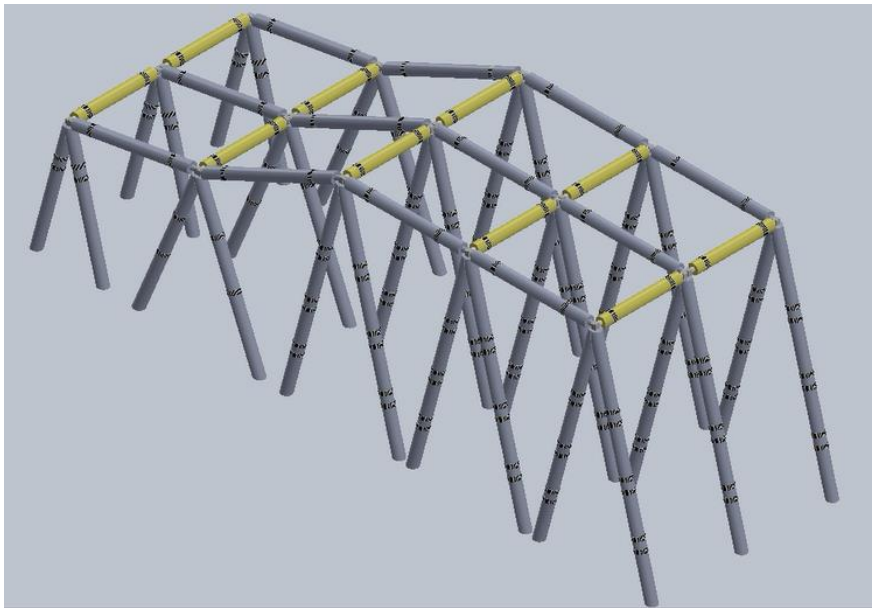
- Connect two cross beams (yellow) end to end ensuring male to female velcro
- Place cross beams (yellow) on top of the three B (Purple) triangles connecting them

- Use the three BC (Purple & Blue) pieces to connect the B (Purple) and C (Green) triangles



- Use the 3 AB (Red & Purple) pieces to connect the A (Red) and B (Purple) triangles





Foam Bumpers

- Attach bumper pieces
- Begin with rear pieces, align to the bottom two sets of Velcro on the C (green) triangles
- Ensure rear pieces are horizontal and level with each other



- Connect both sides of the rear bumpers using the Velcro between them



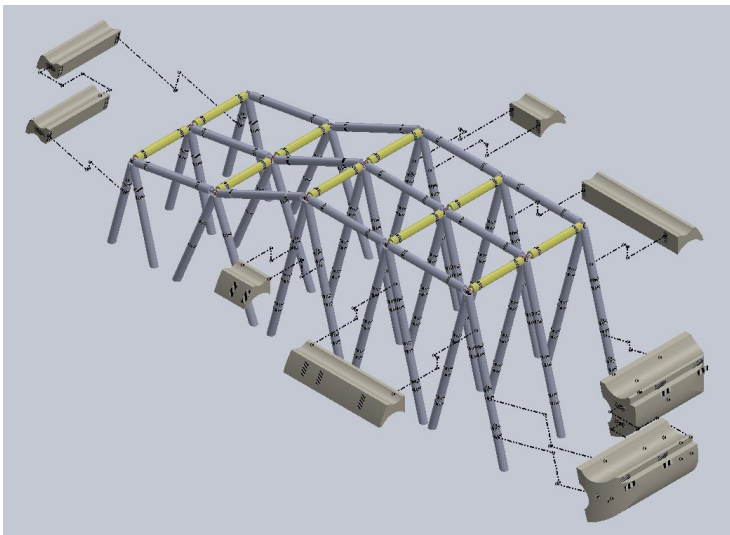
- Repeat steps for front bumpers



- Attach side bumpers to the top Velcro set of the C (green) triangles

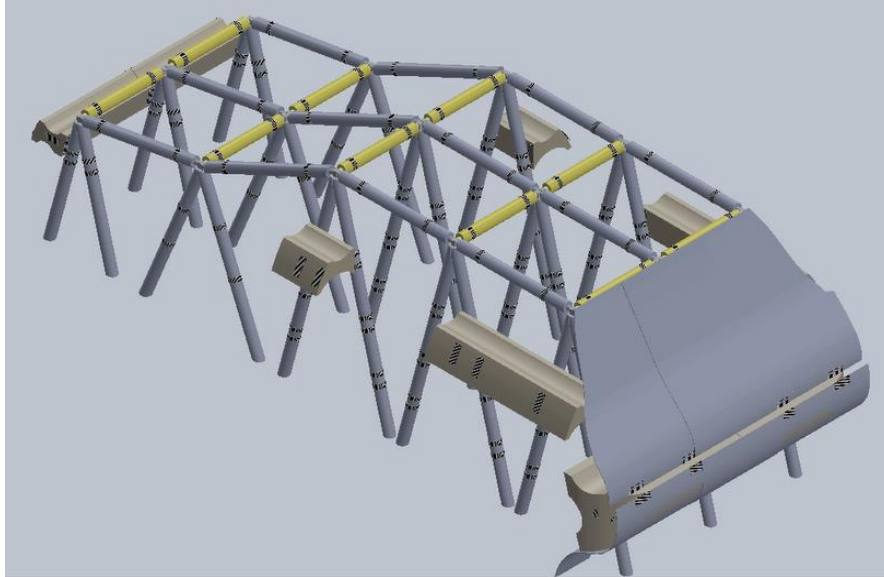


- Ensure side pieces are horizontal and level with each other

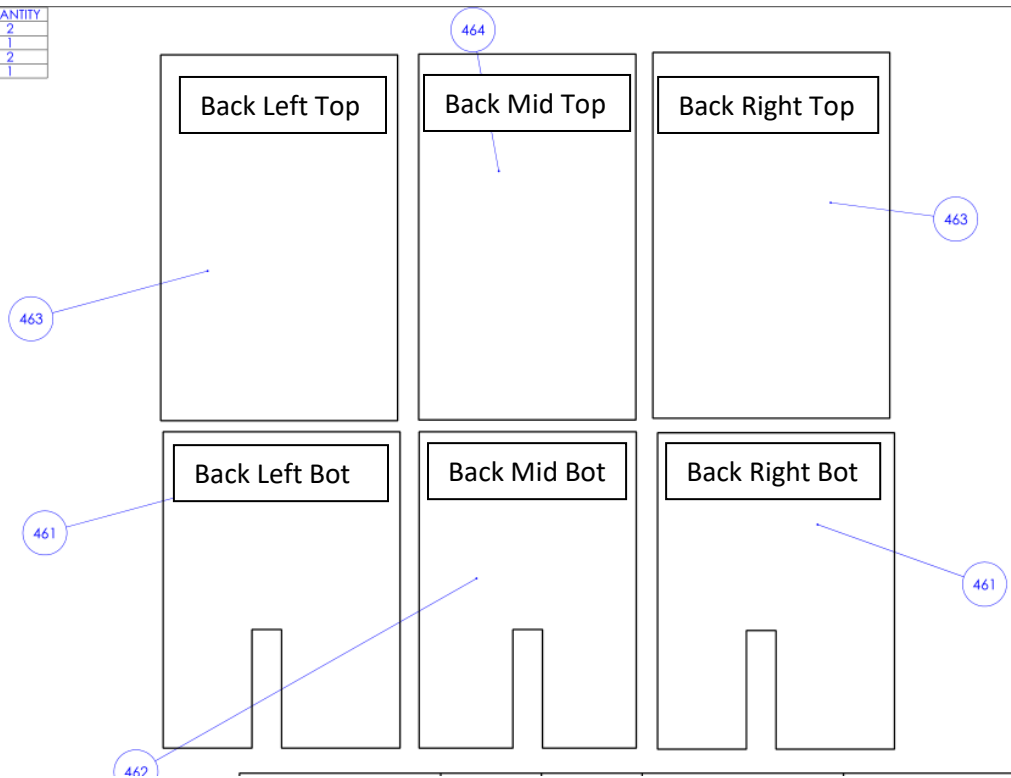


Tarp

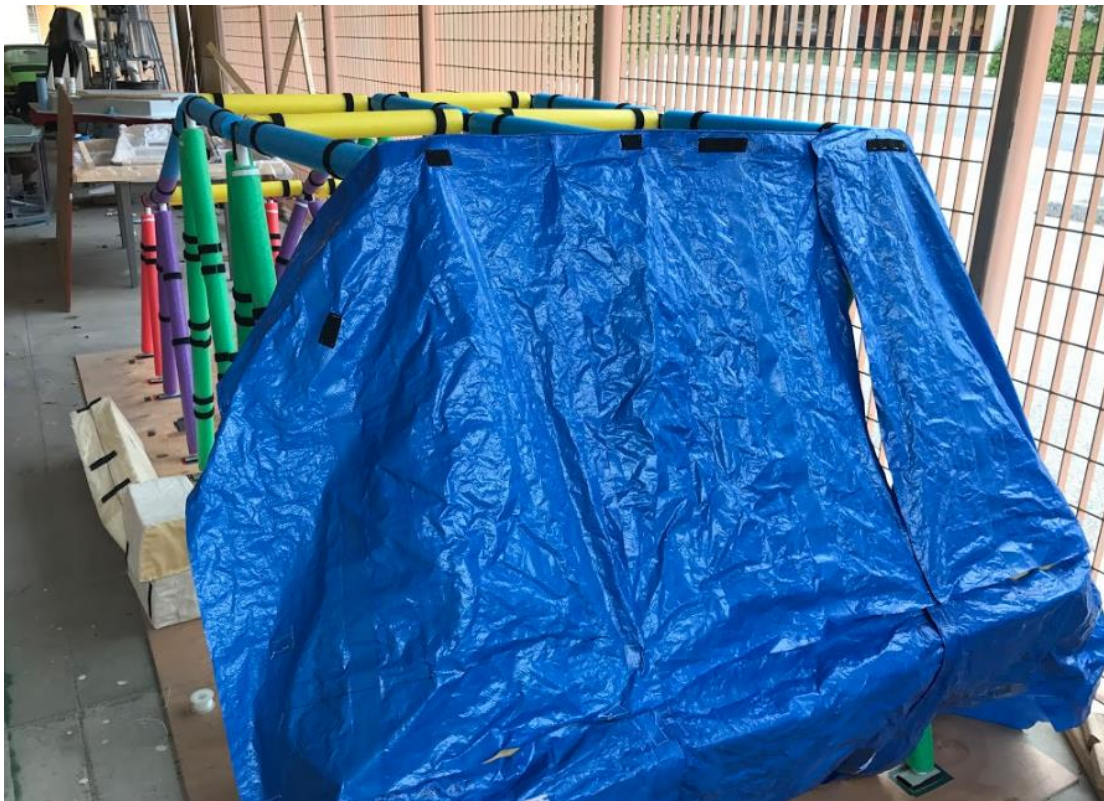
- Attach rear panelling according to the rear panel layout image below



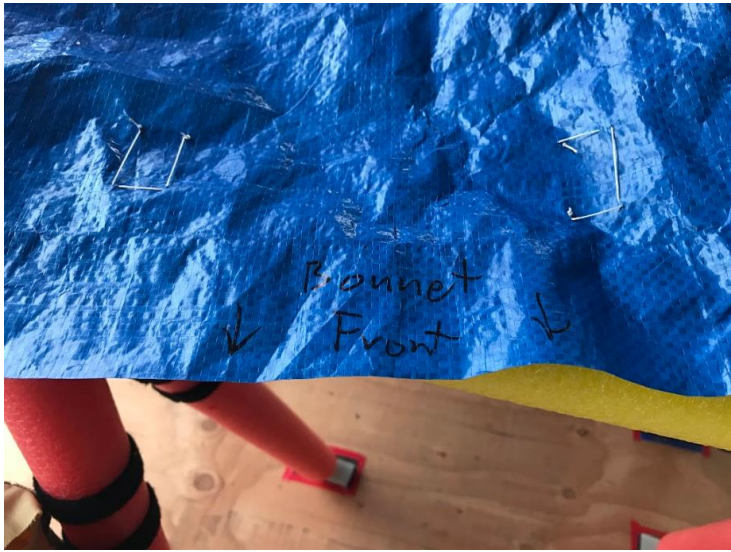
PART NO.	PART NAME	QUANTITY
461	B1 CUTOUT	2
462	B2 CUTOUT	1
463	B3 CUTOUT	2
464	B4 CUTOUT	1



- Attach bottom of tarp to base using the Velcro



- Attach "Front Bonnet" tarp



- Attach "Front Grill" tarp



- Attach "Wind Shield" tarp



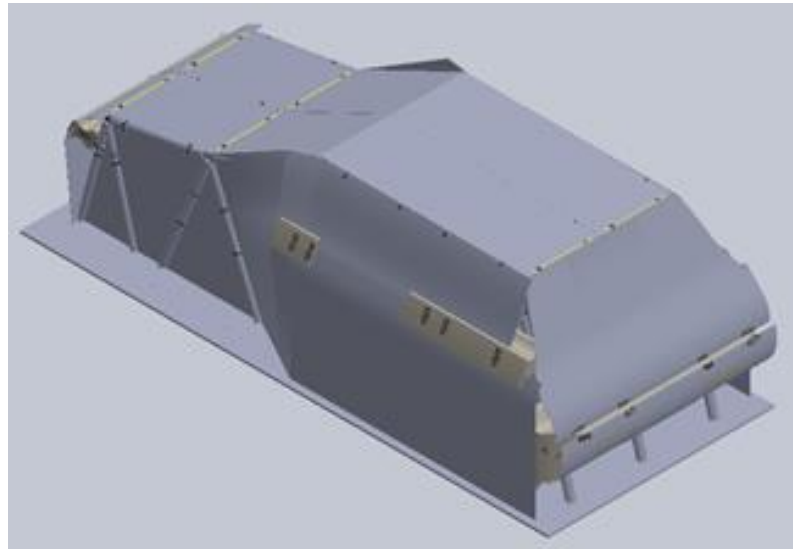
- Attach "Forward Left/Right Side Cab" tarps



- Attach “Top of Car” tarp to the top surface of the vehicle



- Attach “Back Left/Right Side Cab” tarps to finish assembly



Clean Up

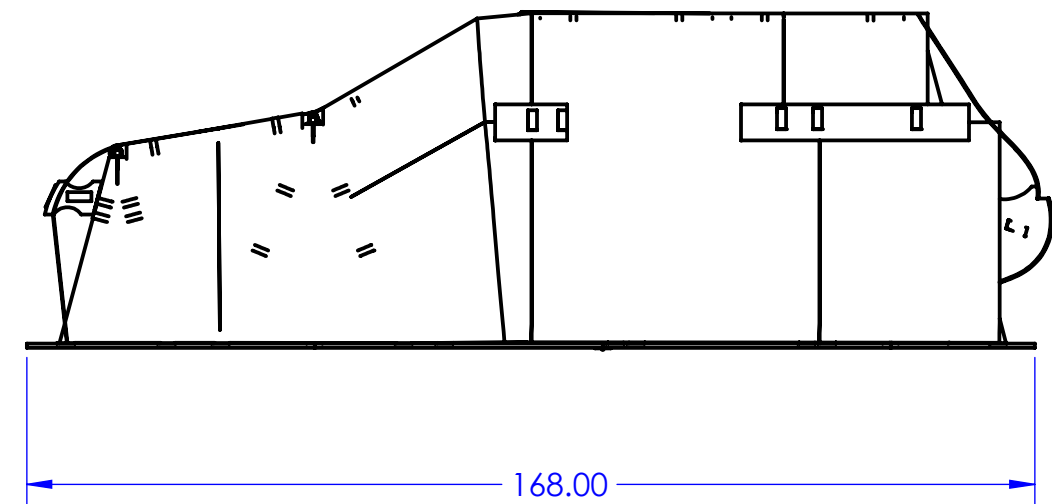
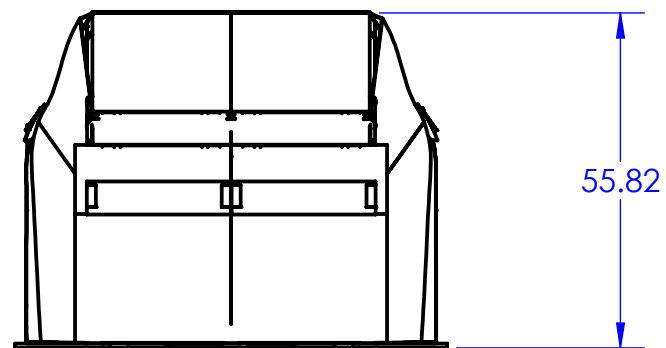
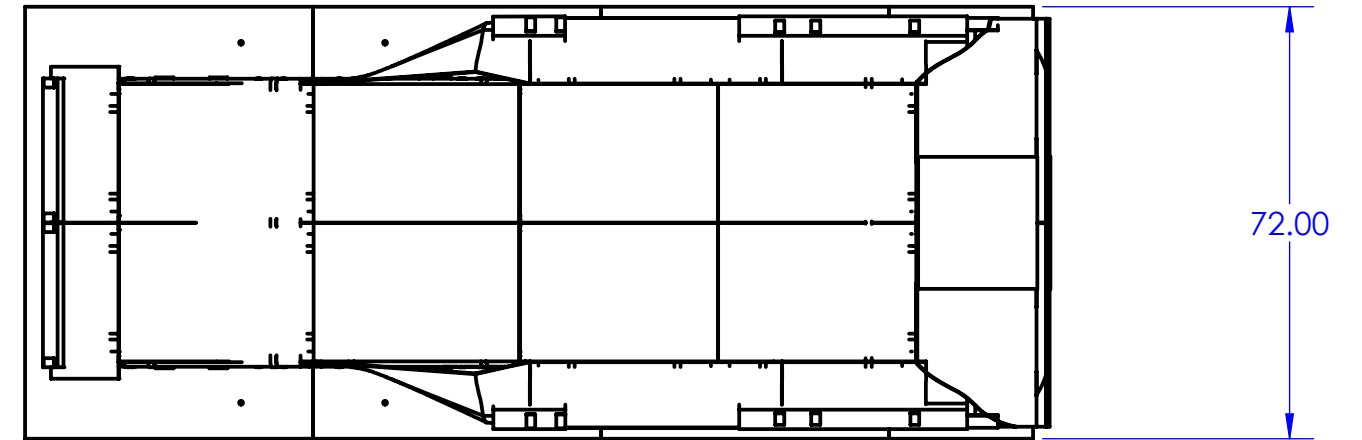
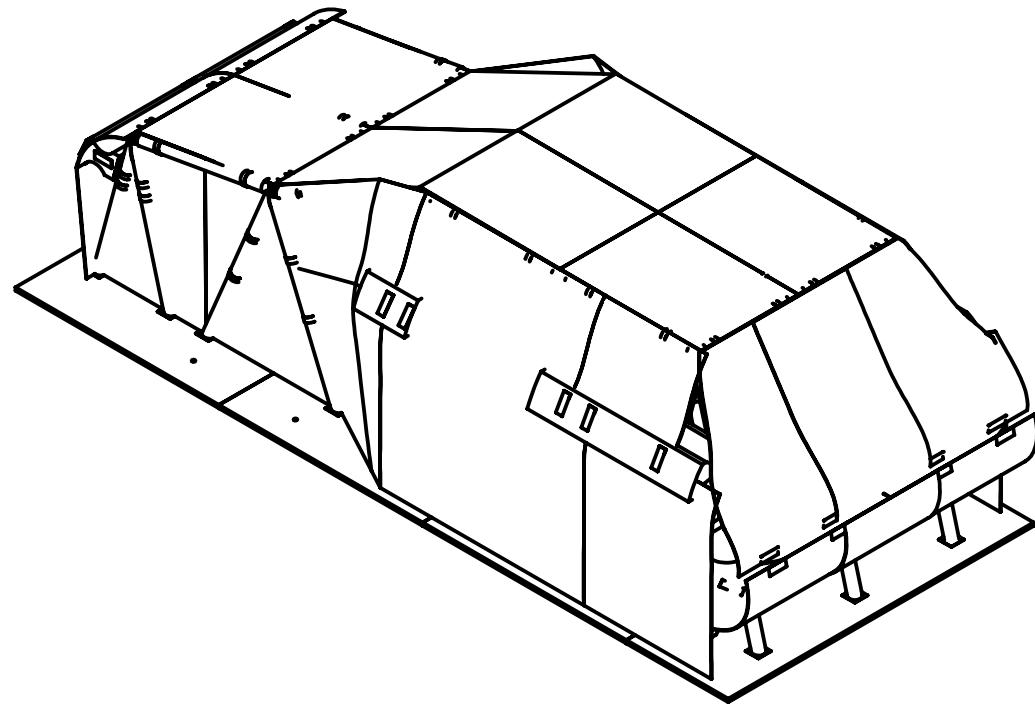
- If still assembled after testing, break down the assembly
- Sort out pieces
- Use bungee cords to bundle similar pieces together

Drawing List

- 100 – Final assembly**
 - 101 – Final assembly exploded view**
- 200 – Truss Assembly**
 - 201 – Exploded Truss Assembly**
 - 210 – A Triangle Assembly**
 - 211 – Exploded A Triangle Assembly**
 - 212 – A AND C Triangle PVC**
 - 213 – A AND C Triangle Foam**
 - 214 – Triangle Side Velcro**
 - 215 – Triangle Top Velcro**
 - 216 – Wrap velcro**
 - 220 – B triangle assembly**
 - 221 – Exploded B Triangle Assembly**
 - 222 – B Triangle PVC**
 - 223 – B Triangle Foam**
 - 230 – C Triangle Assembly**
 - 231 – Exploded C Triangle Assembly**
 - 240 – Column Cross Beam Assembly**
 - 241 – Exploded Column Cross Beam Assembly**
 - 242 – Column Cross Beam PVC**
 - 243 – Column Cross Beam Foam**
 - 244 – Column Cross Beam End Caps**
 - 250 – AB Cross Beam**
 - 251 – Exploded AB Cross Beam**
 - 252 – AB Cross Beam PVC**
 - 253 – AB Cross Beam Foam**
 - 260 – BC Cross Beam**
 - 261 – Exploded BC Cross Beam**
 - 262 – BC Cross Beam PVC**
 - 263 – BC Cross Beam Foam**
 - 270 – CC Cross Beam**
 - 271 – Exploded CC Cross Beam**
 - 272 – CC Cross Beam PVC**
 - 273 – CC Cross Beam foam**
- 300 – Foam Assembly**
 - 301 – Exploded Foam Assembly**
 - 310 – Front Bumper**
 - 311 – Front Bumper Foam Block**
 - 312 – Bumper Velcro**
 - 320 – Back Bumper Left**
 - 321 – Left Back Bumper Foam Block**
 - 330 – Back Bumper Right**

- 331** – Right Back Bumper Foam Block
- 340** – Side Front Bumper Right
 - 341** – A and B Side Bumper Foam Block
- 350** – Side Back Bumper Right
- 360** – Side Front Bumper Left
- 370** – Side Back Bumper Left
- 400** – Tarp Assembly
 - 401** – Exploded Tarp Assembly
- 410** – Rear Tarp Assembly
 - 411** – Left B1 Assembly
 - 412** – Right B1 Assembly
 - 413** – Left B2 Assembly
 - 414** – Right B2 Assembly
 - 415** – B3 Assembly
 - 416** – B4 Assembly
- 420** – Top Tarp Assembly
 - 421** – T1 Assembly
 - 422** – T2 Assembly
 - 423** – T3 Assembly
- 430** – Front Tarp Assembly
 - 431** – Left F1 Assembly
 - 432** – Right F1 Assembly
- 440** – Right Side Tarp Assembly
 - 441** – Right S1 Assembly
 - 442** – Right S2 Assembly
 - 443** – Right S3 Assembly
 - 444** – Right S4 Assembly
 - 445** – Right S5 Assembly
 - 446** – Right S6 Assembly
 - 447** – Right S7 Assembly
 - 448** – Right S8 Assembly
- 450** – Left Side Tarp Assembly
 - 451** – Left S1 Assembly
 - 452** – Left S2 Assembly
 - 453** – Left S3 Assembly
 - 454** – Left S4 Assembly
 - 455** – Left S5 Assembly
 - 456** – Left S6 Assembly
 - 457** – Left S7 Assembly
 - 458** – Left S8 Assembly
- 460** – Rear Tarp Cutouts
 - 461** – B1 Cutout
 - 462** – B2 Cutout

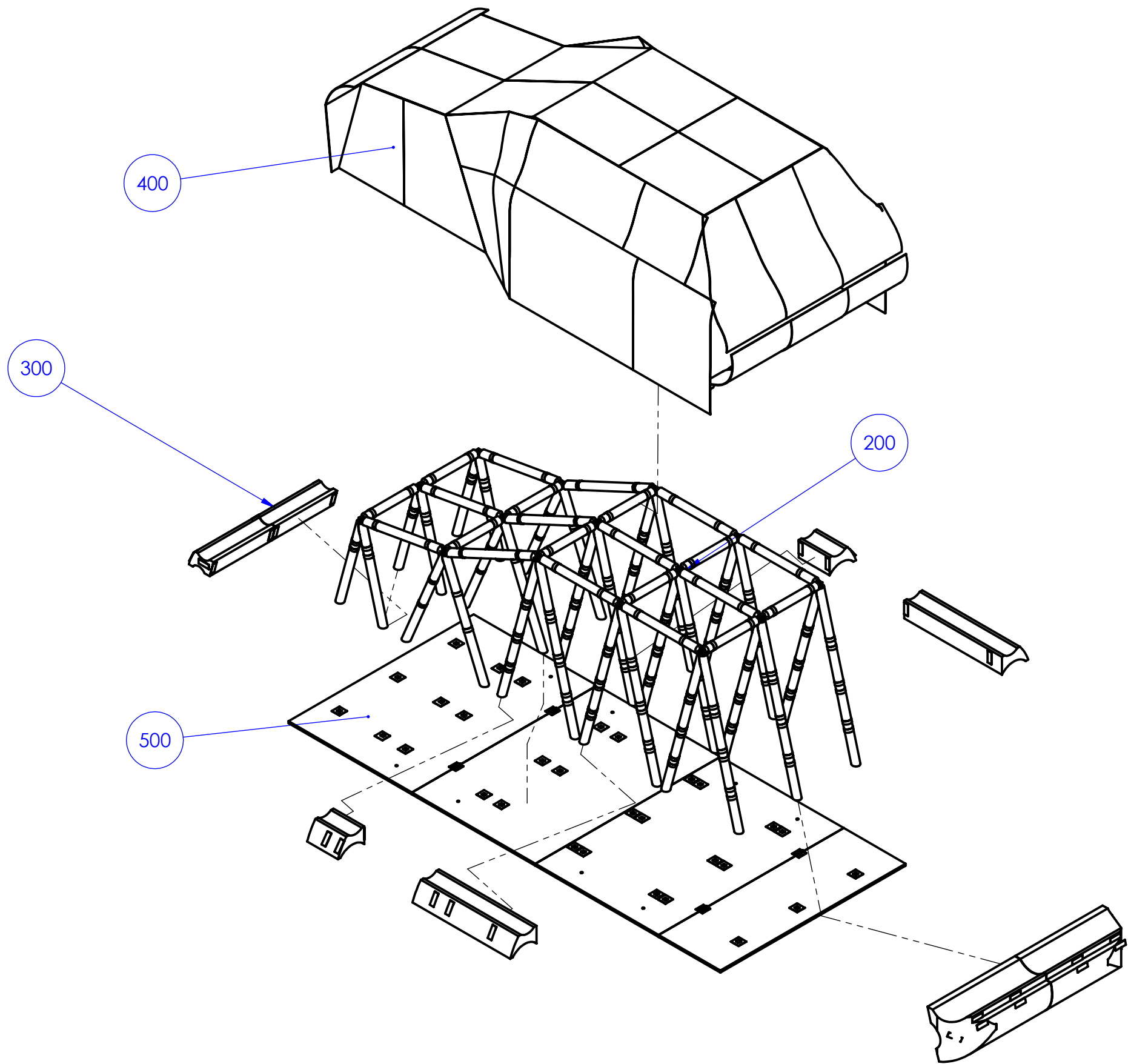
	463 – B3 Cutout
	464 – B4 Cutout
470 – Top Tarp Cutouts	
	471 – T1 Cutout
	472 – T2 Cutout
	473 – T3 Cutout
480 – Front Tarp Cutouts	
	481 – F1 Cutout
490 – Side Tarp Cutouts	
	491 – S1 Cutout
	492 – S2 Cutout
	493 – S3 Cutout
	494 – S4 Cutout
	495 – S5 Cutout
	496 – S6 Cutout
	497 – S7 Cutout
	498 – S8 Cutout
500 – Base Assembly	
	501 – Exploded Base Assembly
	511 – Platform Base 1
	512 – Platform Base 2
	513 – Platform Base 3
	514 – Platform Base 4
	515 – Surface-Mount Hinge
	516 – Phillips Flat Head Screw Data Sheet
	517 – A Base Velcro
	518 – B Base Velcro
	521 – V plug 75 deg
	522 – V plug 65.50 deg



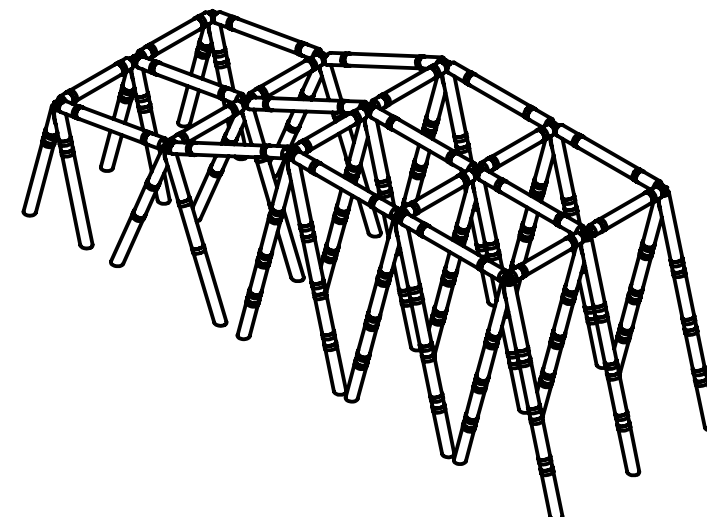
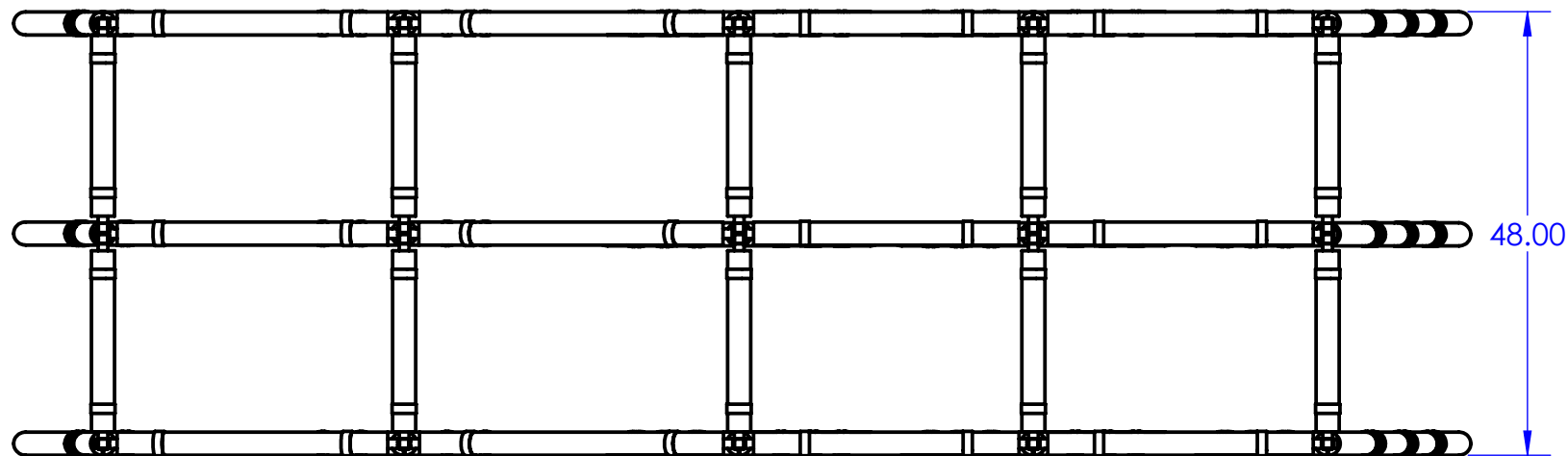
NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX \pm 0.1
 XX° \pm 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: FINAL ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 100	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:32	Chkd. By: ME STAFF

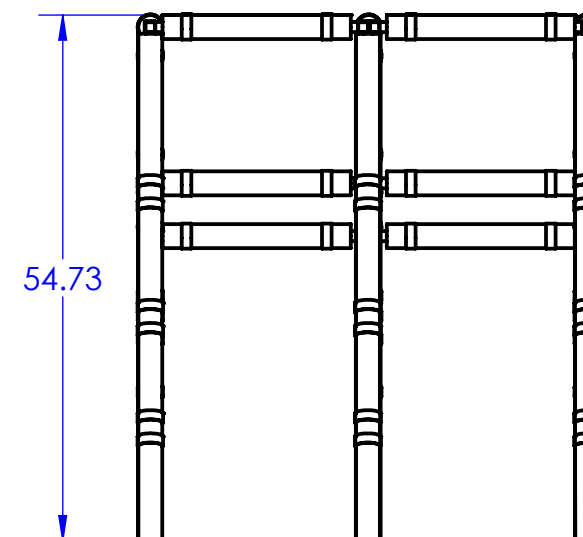
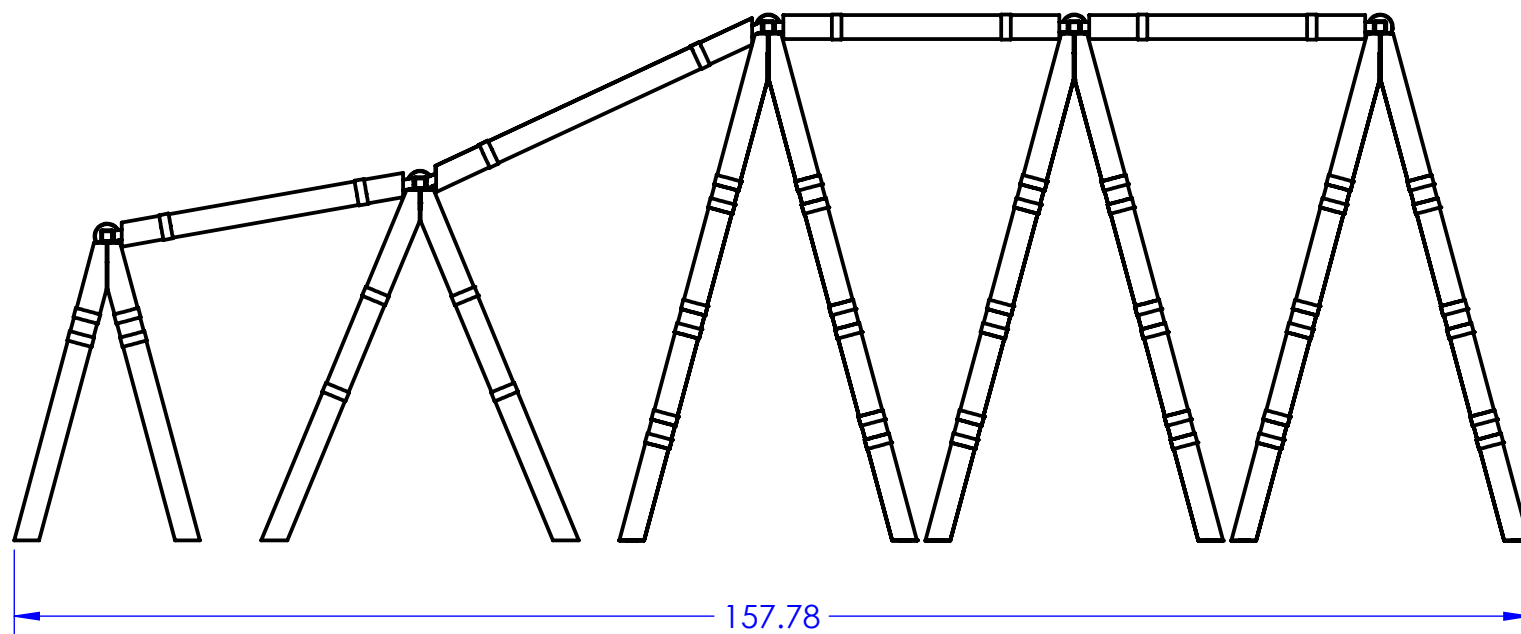
PART NO.	PART NAME	QUANTITY
200	TRUSS ASSEMBLY	1
300	FOAM ASSEMBLY	1
400	TARP ASSEMBLY	1
500	BASE ASSEMBLY	1



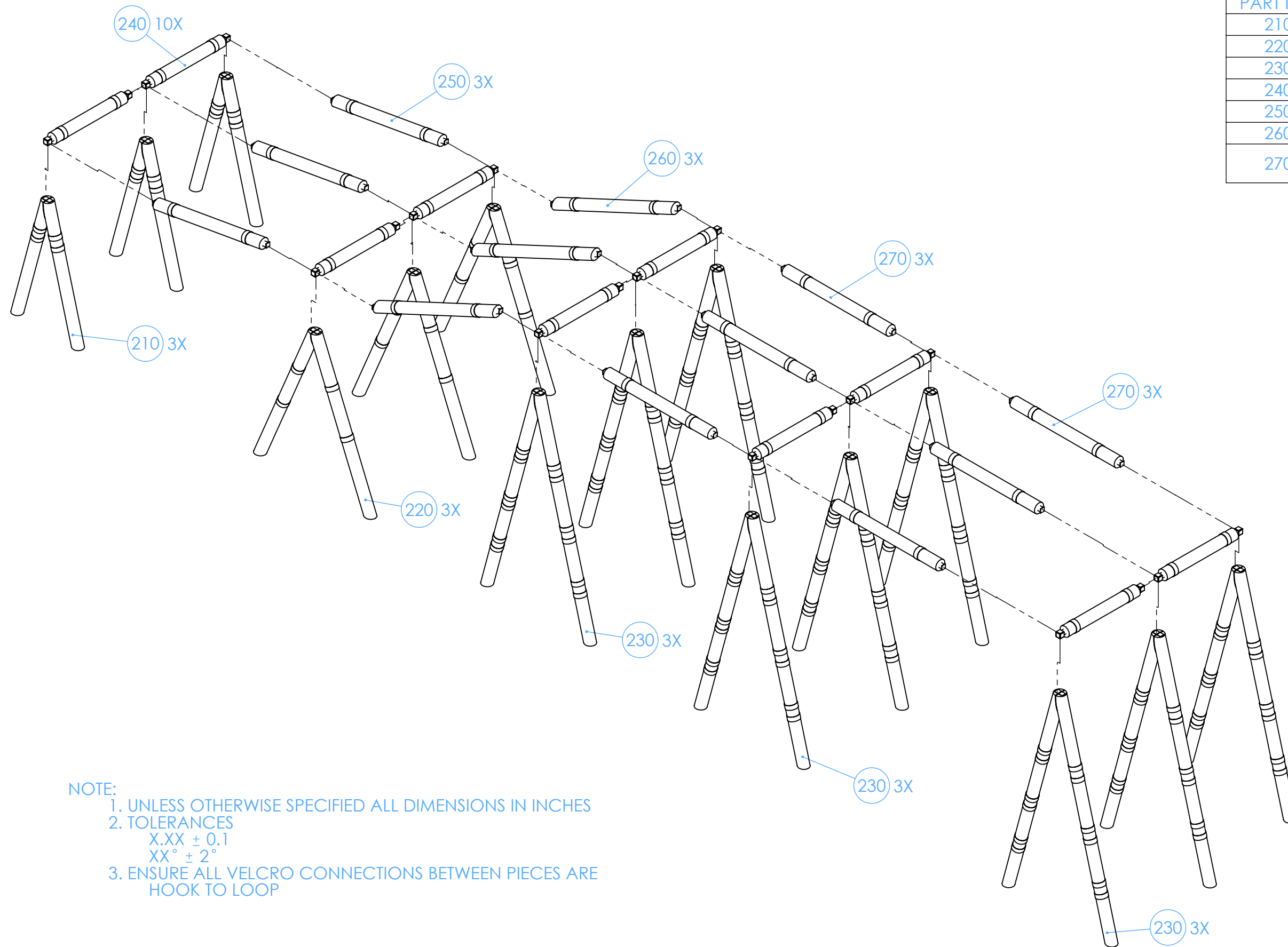
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	Dwg. #: 101	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:32	Chkd. By: ME STAFF



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°



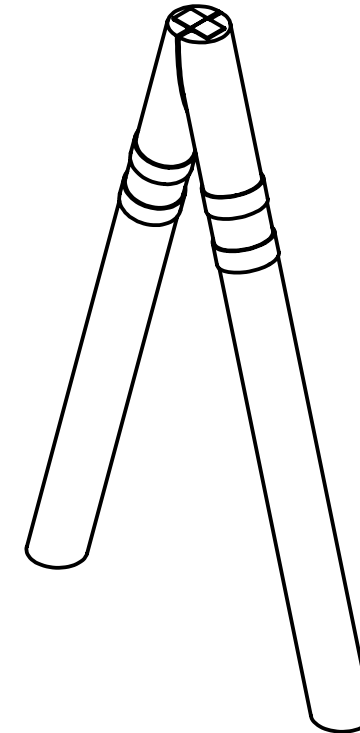
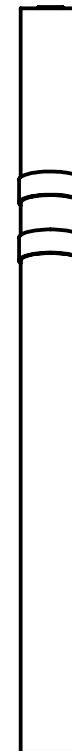
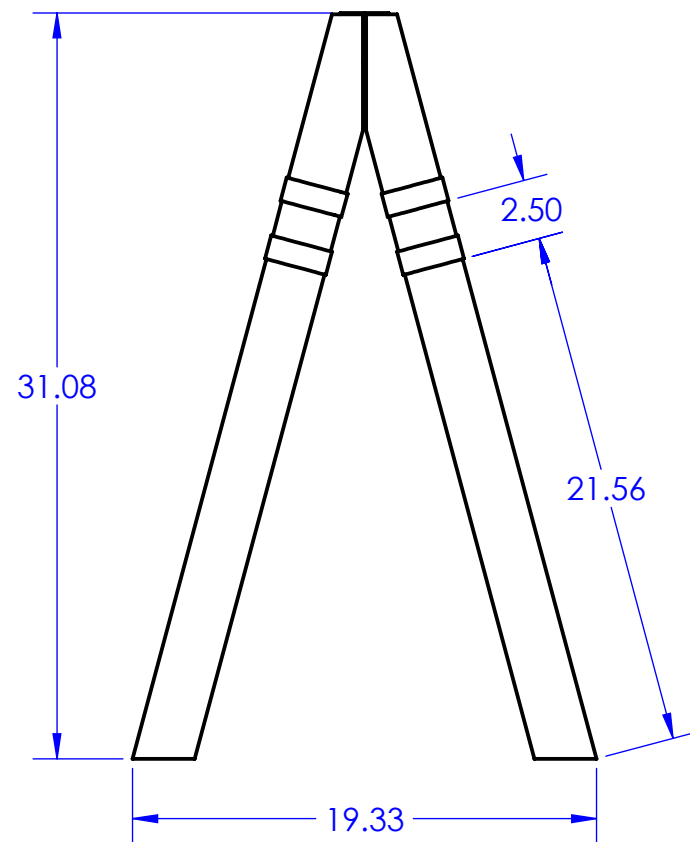
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	Dwg. #: 200	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:20	Chkd. By: ME STAFF



PART NO.	PART NAME	QTY.
210	Final Assem A	3
220	Final Assem A_B	3
230	Final Assem B	9
240	Final assem B_C	10
250	Final Assem C	3
260	Final assem C_C	3
270	CC CROSS BEAM ASSEMBLY	6

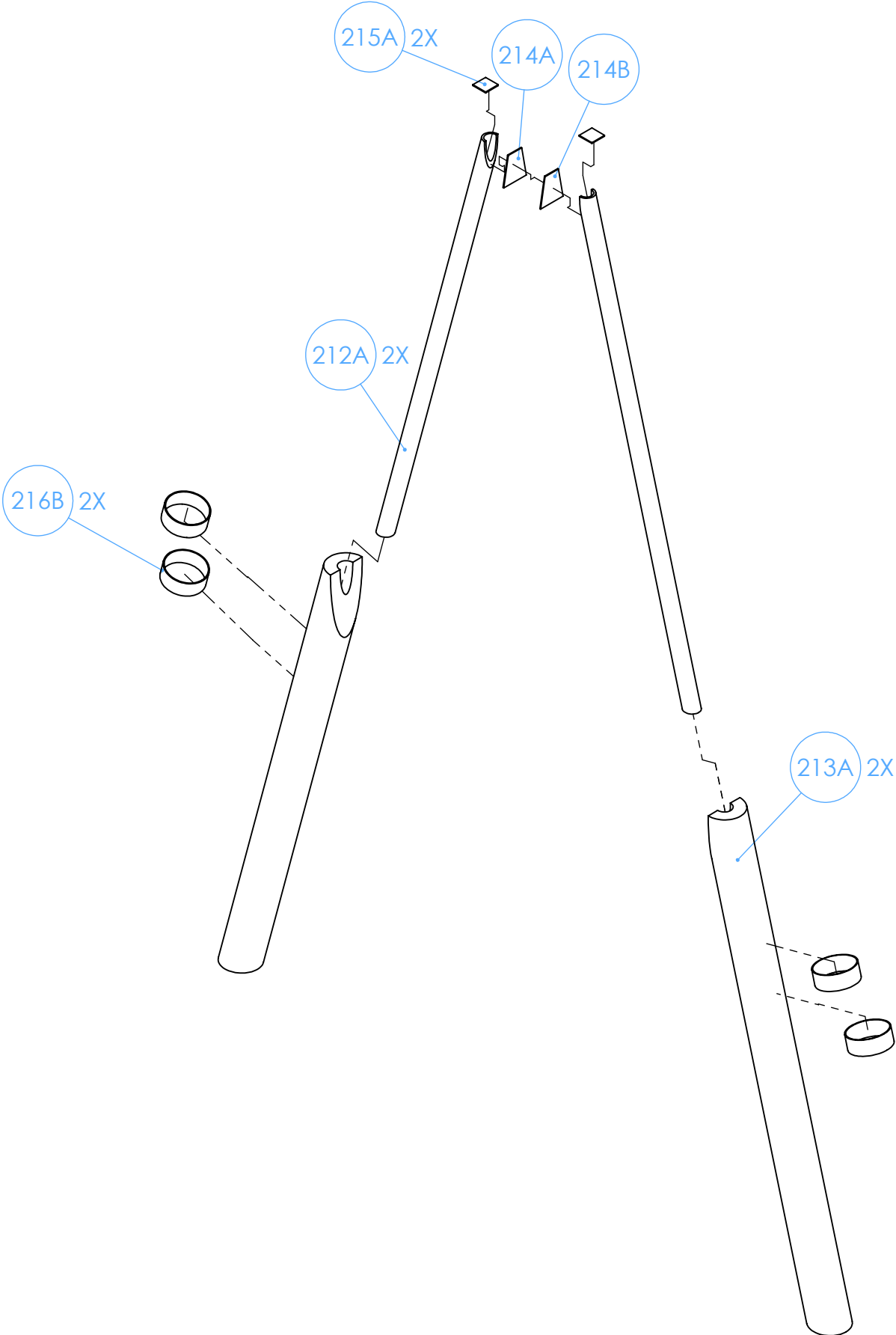
NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
3. ENSURE ALL VELCRO CONNECTIONS BETWEEN PIECES ARE
HOOK TO LOOP

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09 Dwg. #: 201	Assignment: CDR Nxt Asb: NONE	Title: EXPLODED TRUSS ASSEMBLY Date: 2/9/17	Scale: 1:20	Drwn. By: TARGET PRACTICE Chkd. By: ME STAFF
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NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°

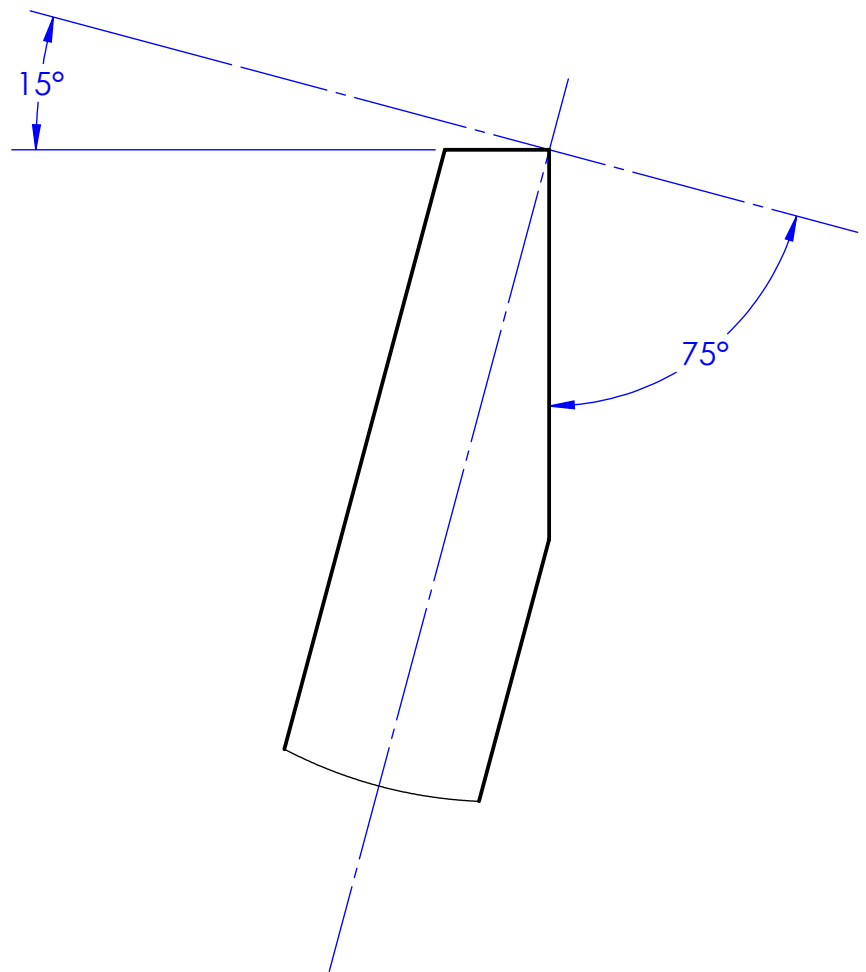
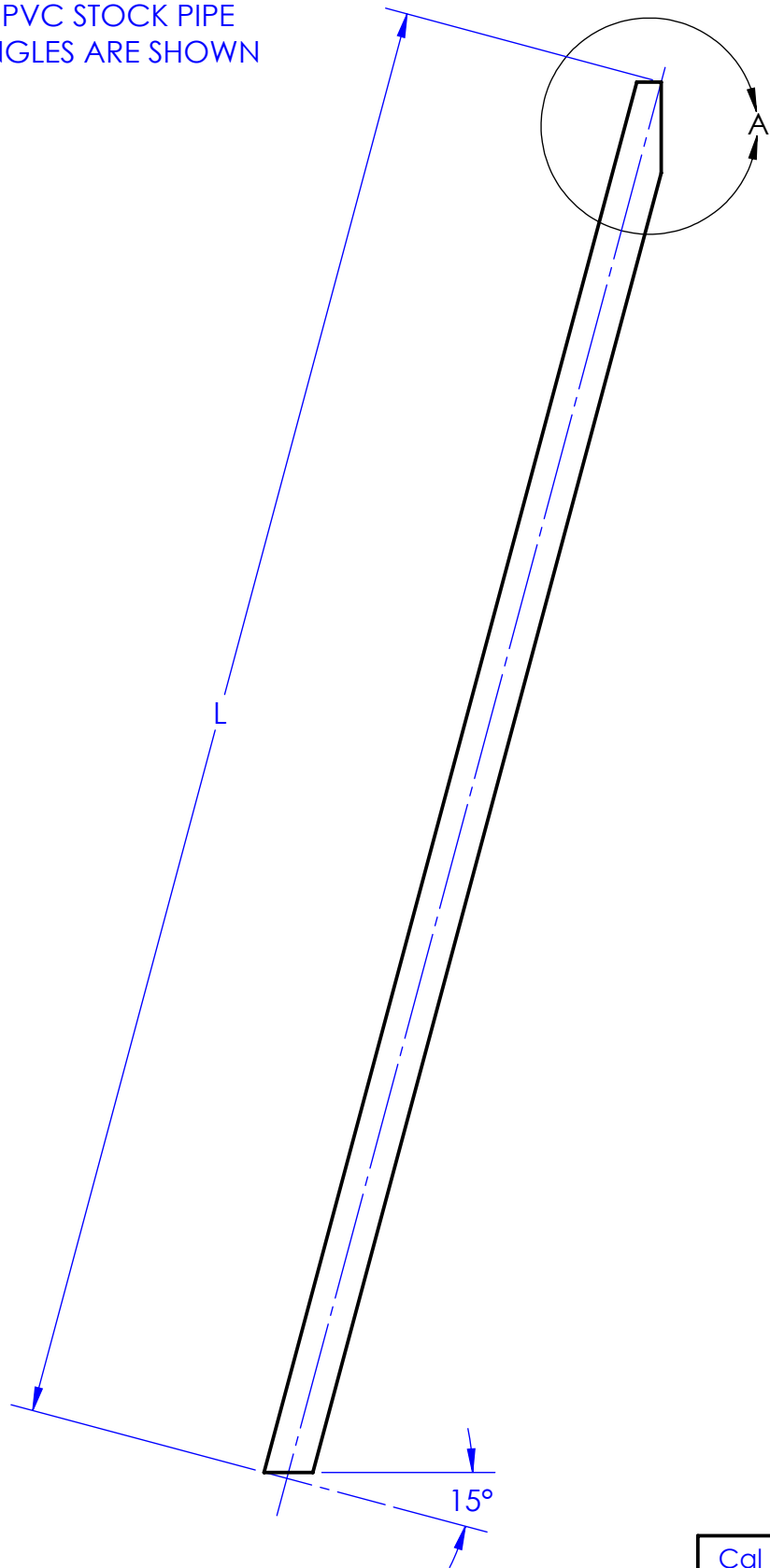
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: A TRIANGLE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 210	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF



PART NO.	PART NUMBER	QTY.
212A	A TRIANGLE PVC	2
213A	A TRIANGLE FOAM	2
214A	TRIANGLE SIDE VELCRO HOOK	1
214B	TRIANGLE SIDE VELCRO LOOP	1
215A	SQUARE VELCRO HOOK	2
216B	WRAP VELCRO LOOP	2

NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
5. WRAP OVERHANGING VELCRO

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. SCHEDULE 40 3/4" PVC STOCK PIPE
 - 4. CUTS AND CUT ANGLES ARE SHOWN

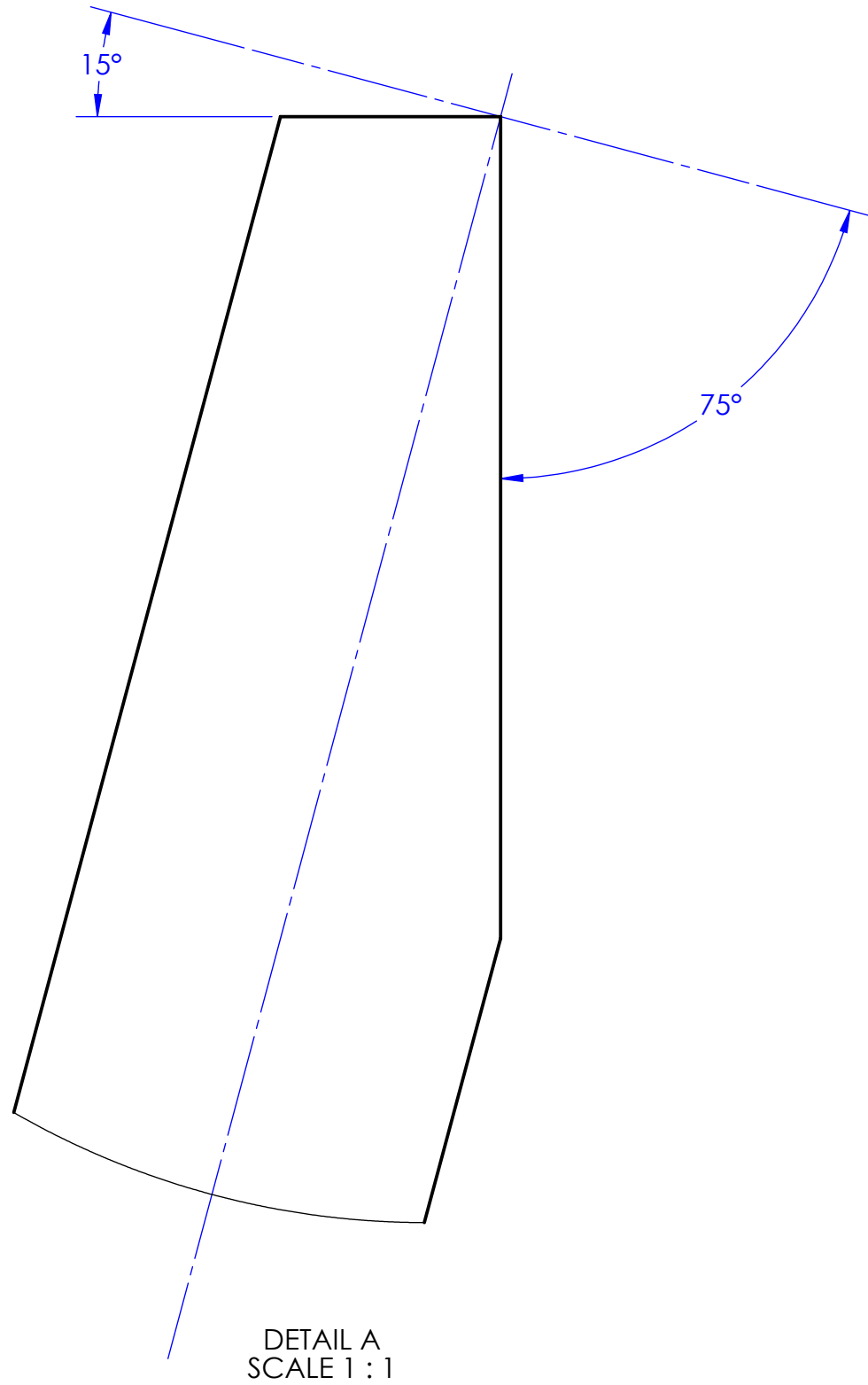
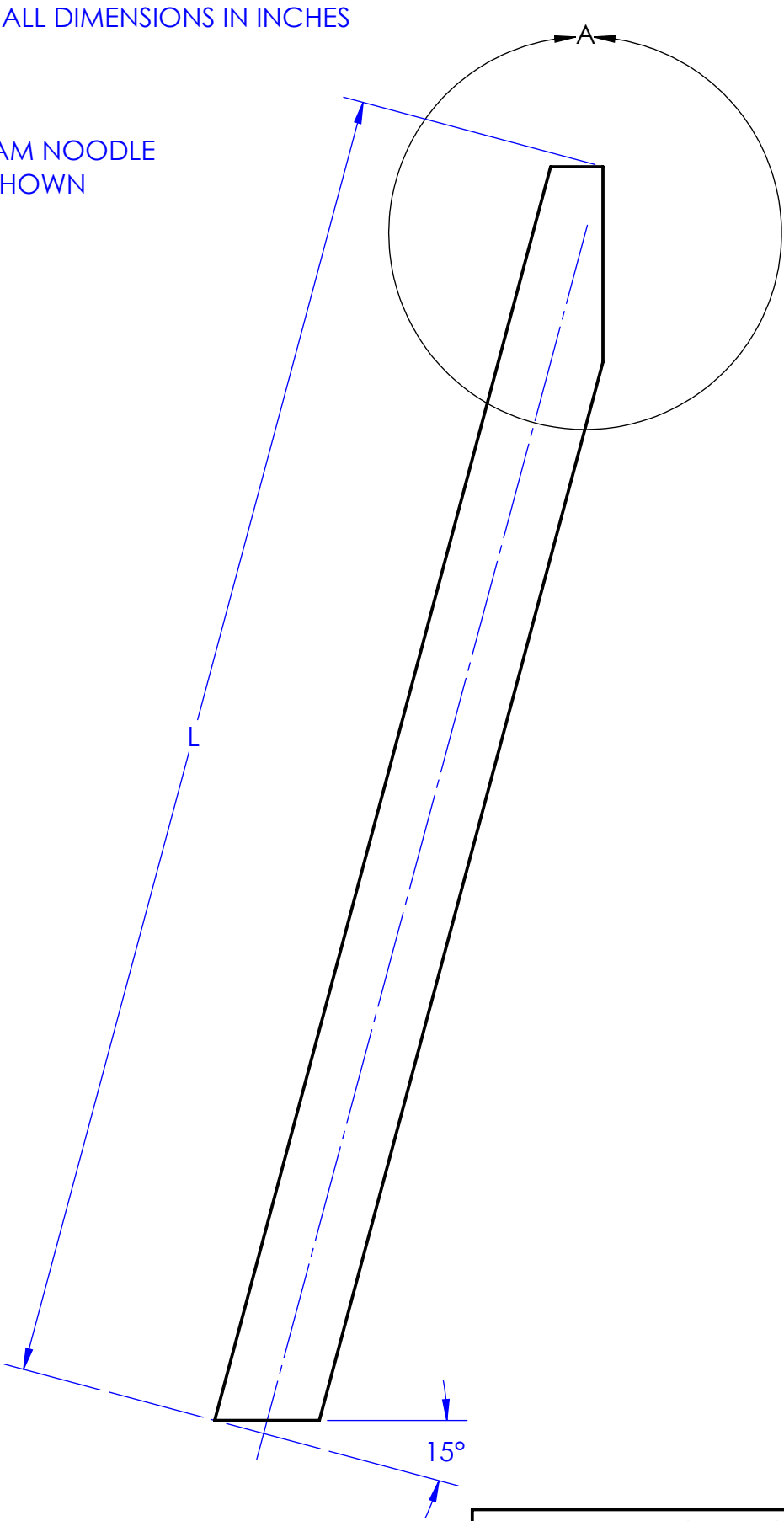


DETAIL A
SCALE 1 : 1

PART NAME	Part Number	Length, L [in]
A TRIANGLE PVC	212 A	32.25
C TRIANGLE PVC	212 C	54.80

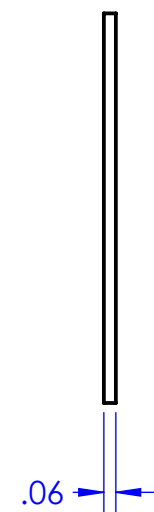
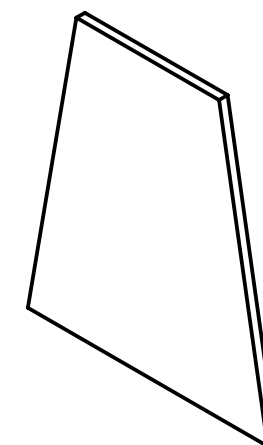
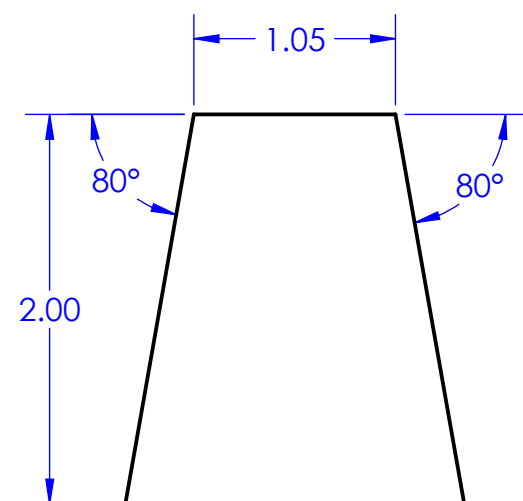
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: A AND C TRIANGLE PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 212	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK POLYEUTHATHANE FOAM NOODLE
 - 4. CUTS AND CUT ANGLES ARE SHOWN



PART NAME	Part Number	Length, L [in]
A TRIANGLE FOAM	213 A	32.44
C TRIANGLE FOAM	213 C	54.99

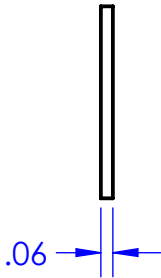
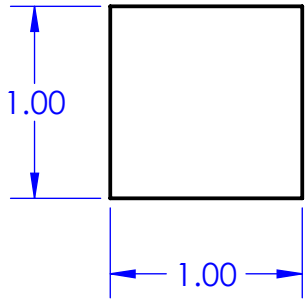
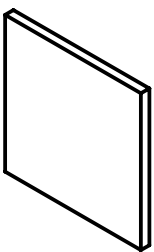
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: A AND C TRIANGLE FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 213	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
 - 3. MATERIAL IS STANDARD 2 INCH WIDE HOOK AND LOOP VELCRO WITH ADHESIVE BACKING
 - 4. SEPERATE HOOK SIDE FROM LOOP SIDE BEFORE CUTTING
 - 5. CUTS AND CUT ANGLES ARE SHOWN

PART NAME	Part Number	VLECRO SIDE
TRIANGLE SIDE VELCRO HOOK	214 A	HOOK
TRIANGLE SIDE VELCRO LOOP	214 B	LOOP

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: TRIANGLE SIDE VELCRO		Drwn. By: TARGET PRACTICE
	Dwg. #: 214	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF

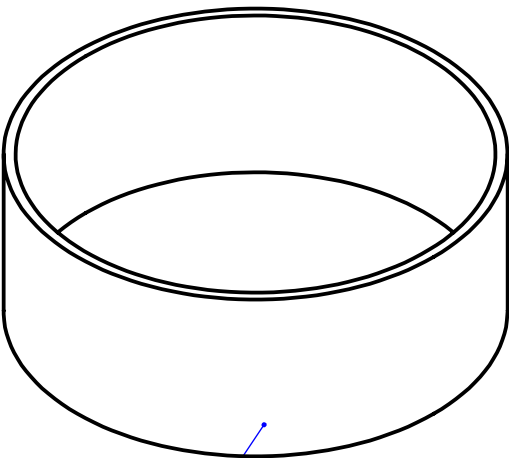
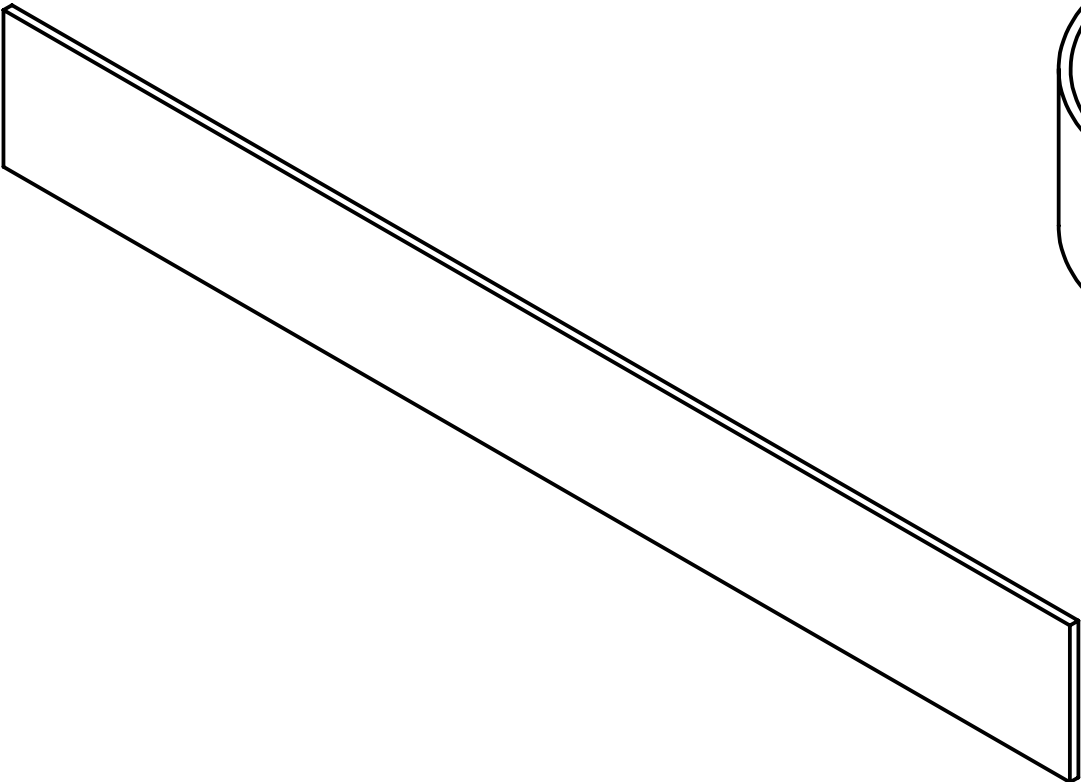


- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
 - 3. MATERIAL IS STANDARD 1 INCH WIDE HOOK AND LOOP VELCRO WITH ADHESIVE BACKING
 - 4. SEPERATE HOOK SIDE FROM LOOP SIDE BEFORE CUTTING
 - 5. CUTS AND CUT ANGLES ARE SHOWN

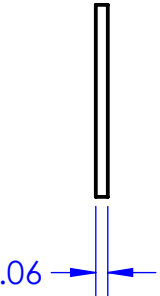
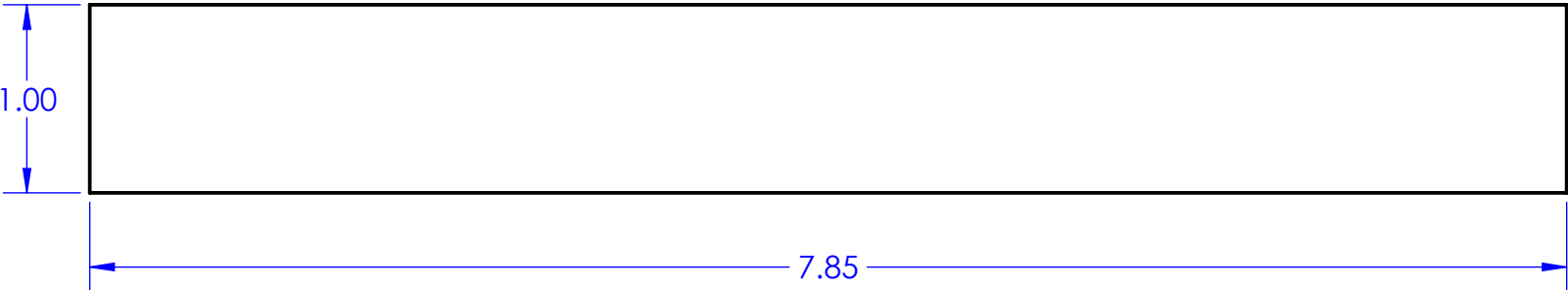
PART NAME	Part Number	VLECRO SIDE
SQUARE VELCRO HOOK	215 A	HOOK
SQUARE VELCRO LOOP	215 B	LOOP

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SQUARE VELCRO		Drwn. By: TARGET PRACTICE
	Dwg. #: 215	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. MATERIAL IS STANDARD 1 INCH WIDE HOOK AND LOOP VELCRO WITH ADHESIVE BACKING
 - 4. SEPERATE HOOK SIDE FROM LOOP SIDE BEFORE CUTTING
 - 5. CUTS AND CUT ANGLES ARE SHOWN

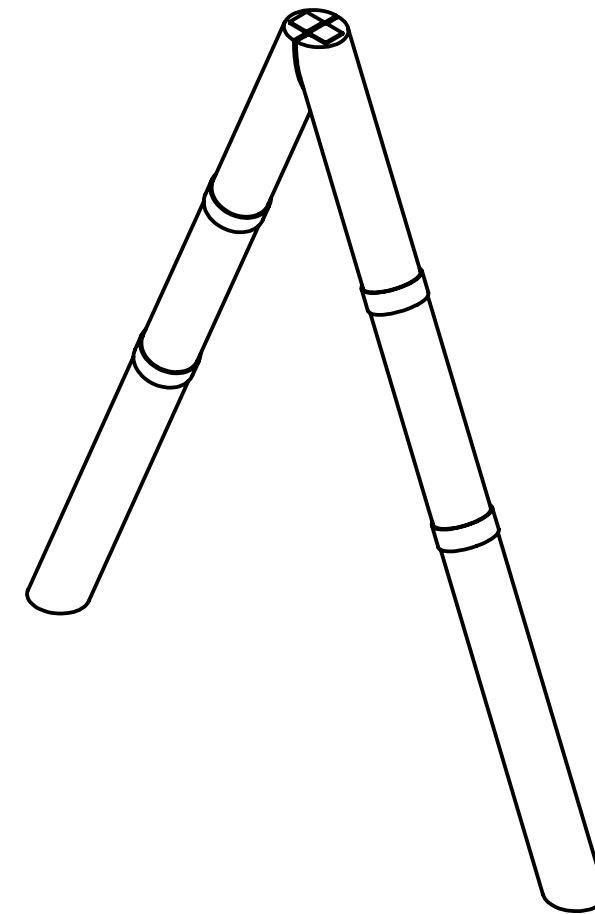
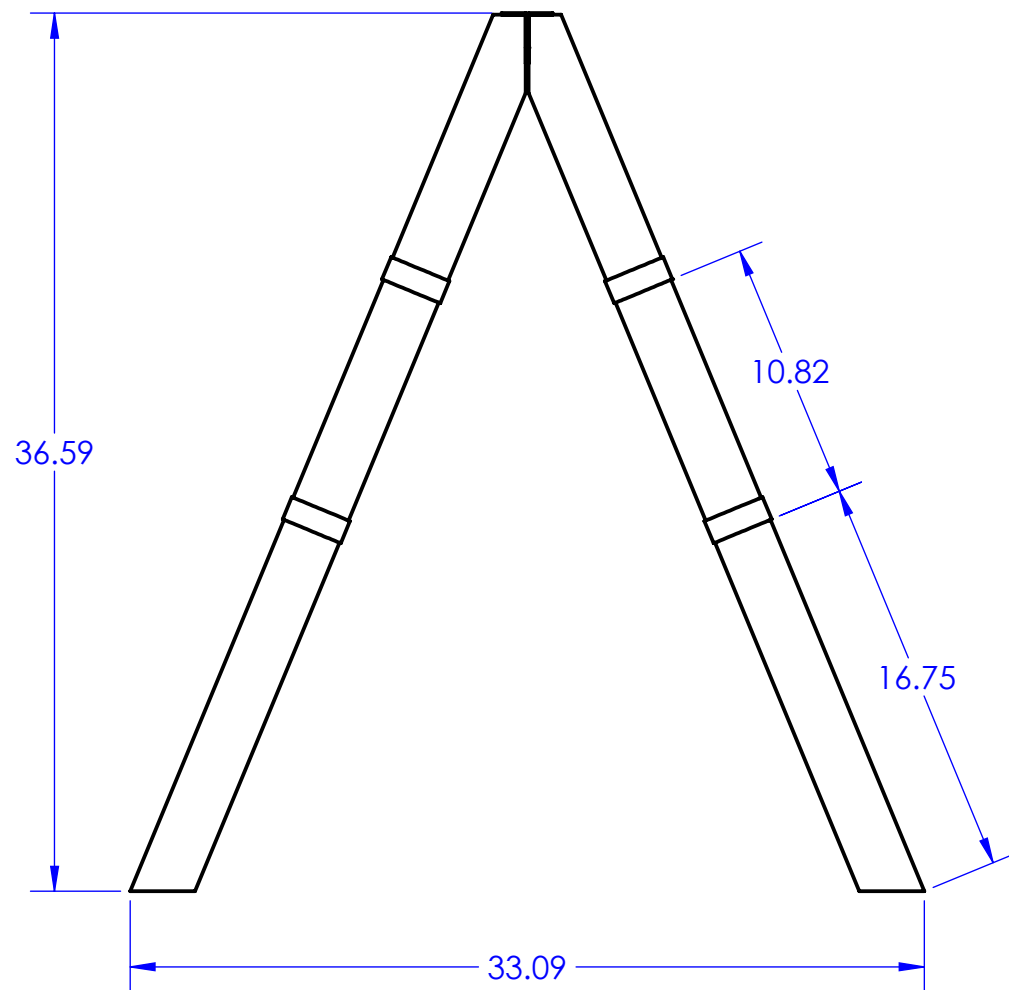


WRAPPED VIEW OF VELCRO



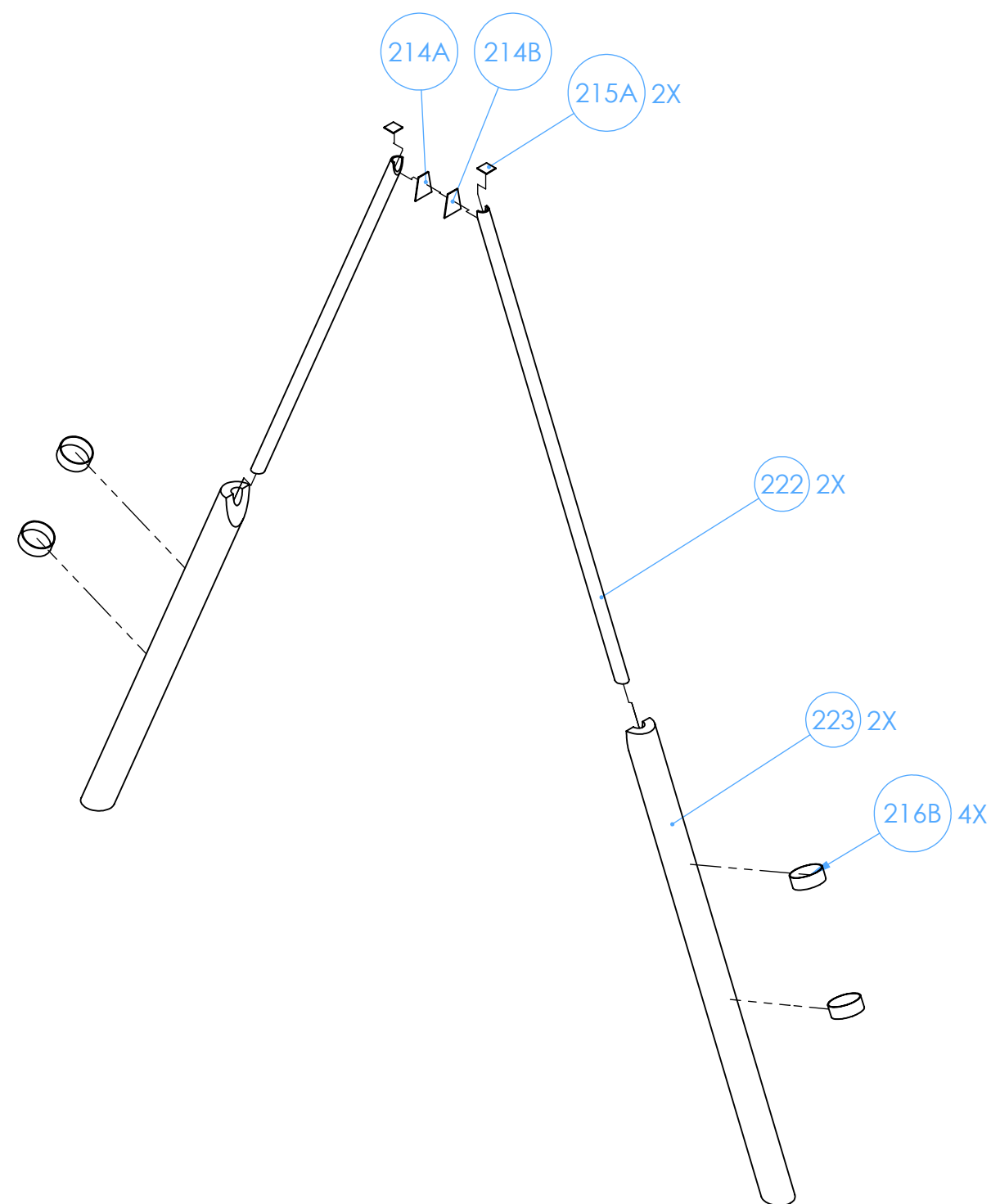
PART NAME	Part Number	VLECRO SIDE
WRAP VELCRO HOOK	216 A	HOOK
WRAP VELCRO LOOP	216 B	LOOP

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: WRAP VELCRO		Drwn. By: TARGET PRACTICE
	Dwg. #: 216	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B TRIANGLE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 220	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF



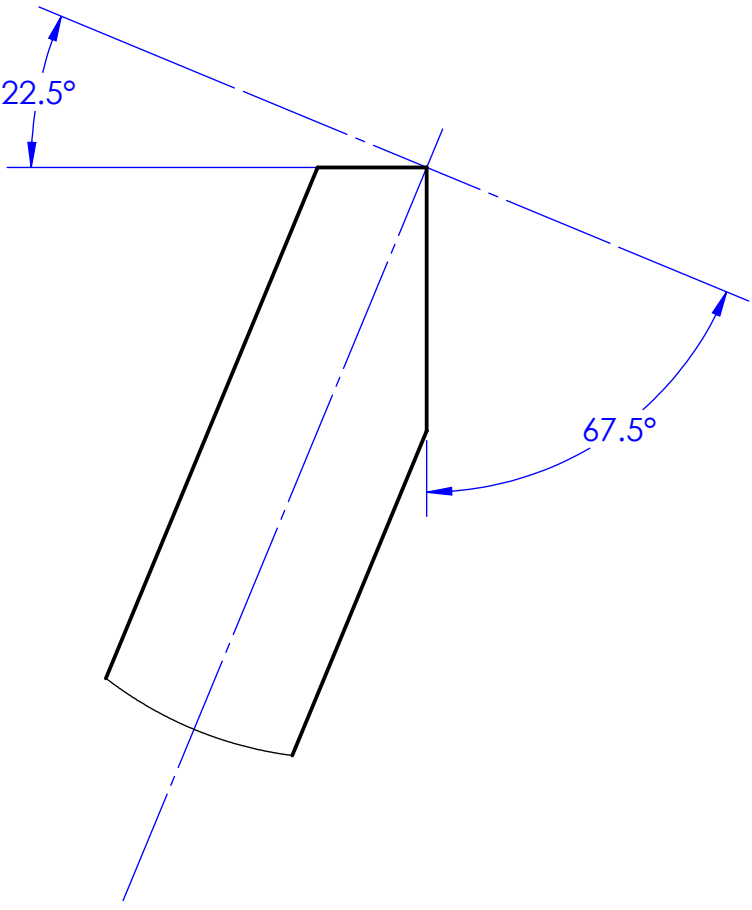
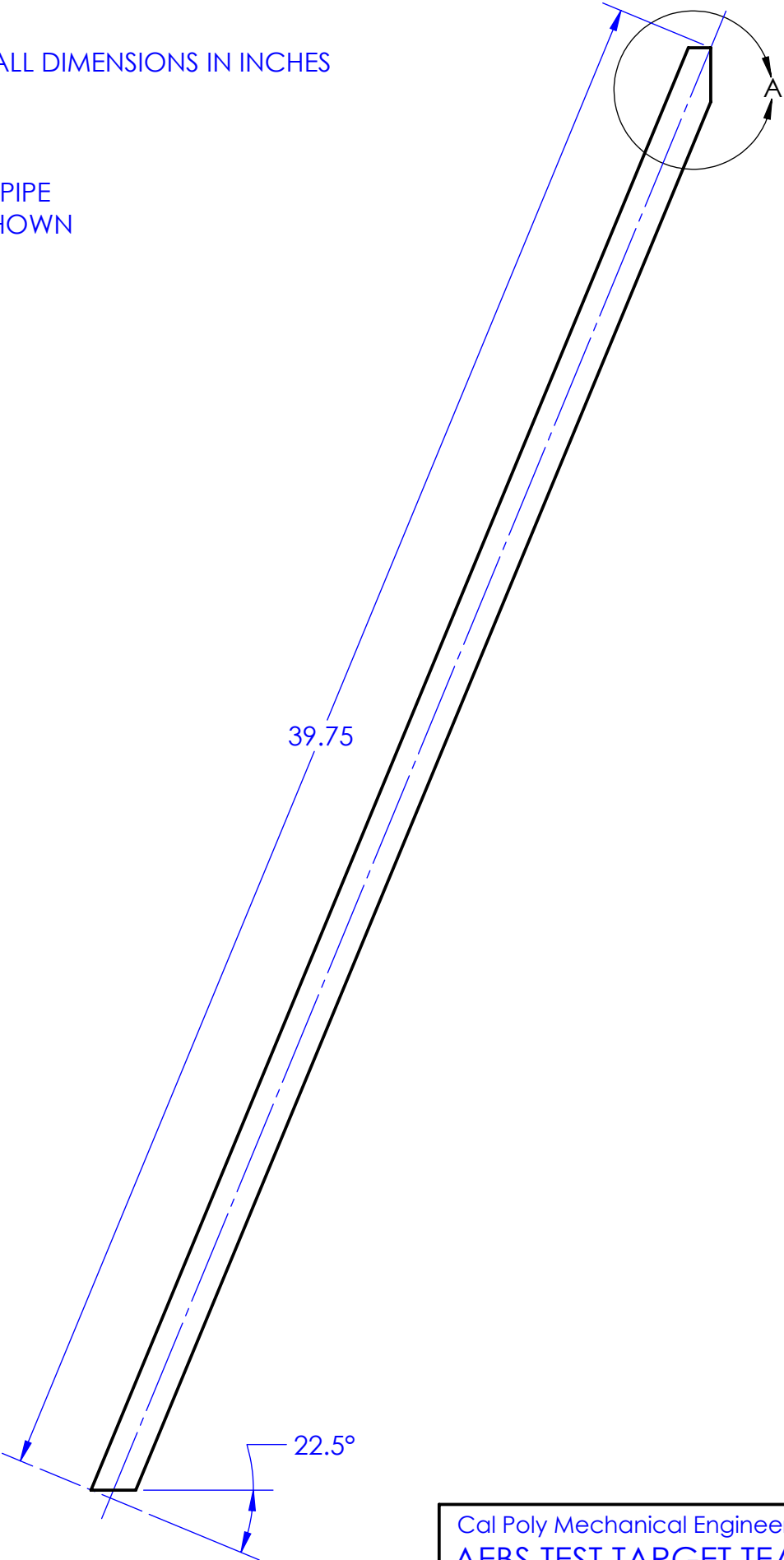
PART NO.	PART NUMBER	QTY.
222	C TRIANGLE PVC	2
223	B TRIANGLE FOAM	2
214A	TRIANGLE SIDE VELCRO HOOK	1
214B	TRIANGLE SIDE VELCRO LOOP	1
215A	SQUARE VELCRO HOOK	2
216B	WRAP VELCRO LOOP	4

- NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
 3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
 4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
 5. WRAP OVERHANGING VELCRO

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED B TRIANGLE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 221	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF

NOTE:

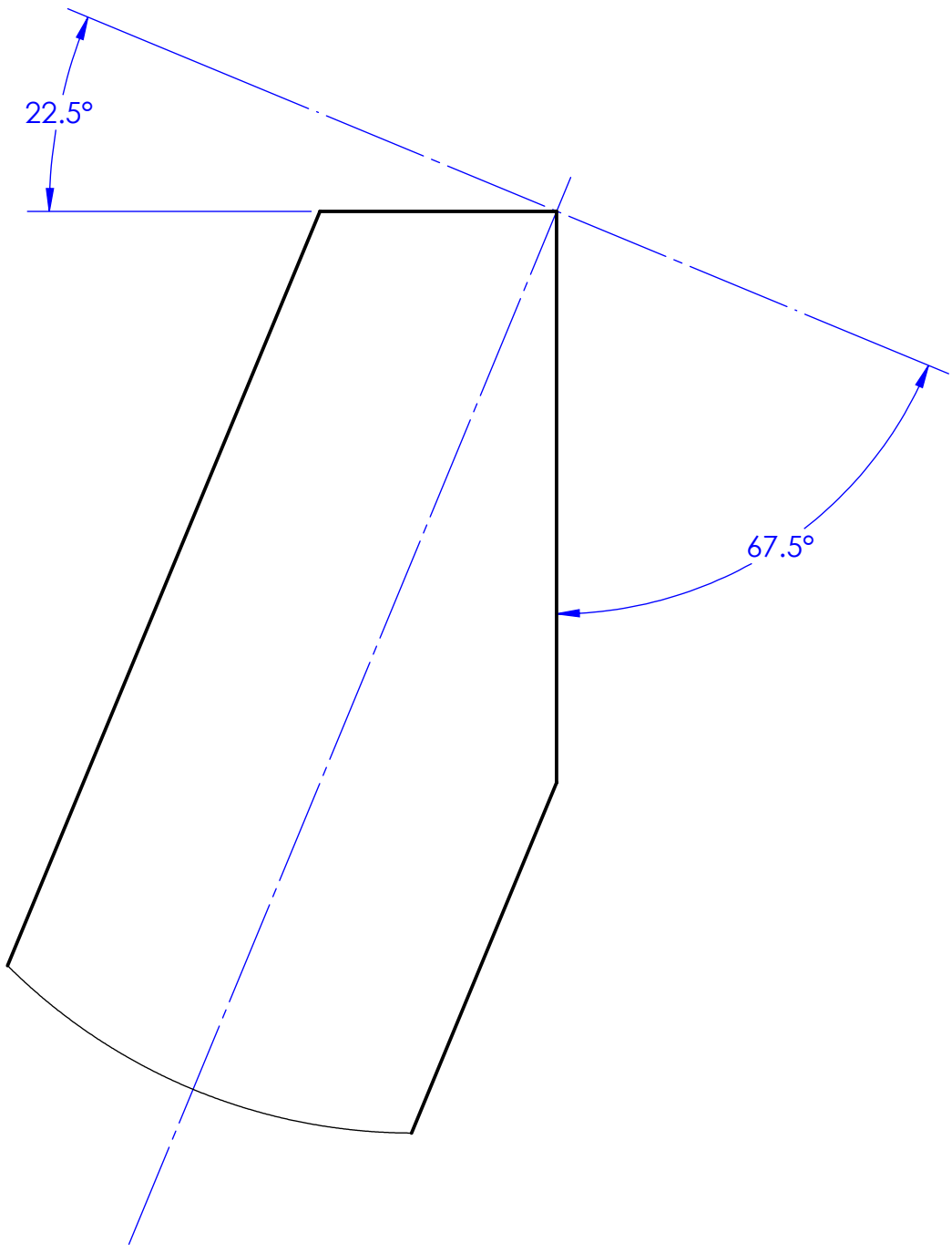
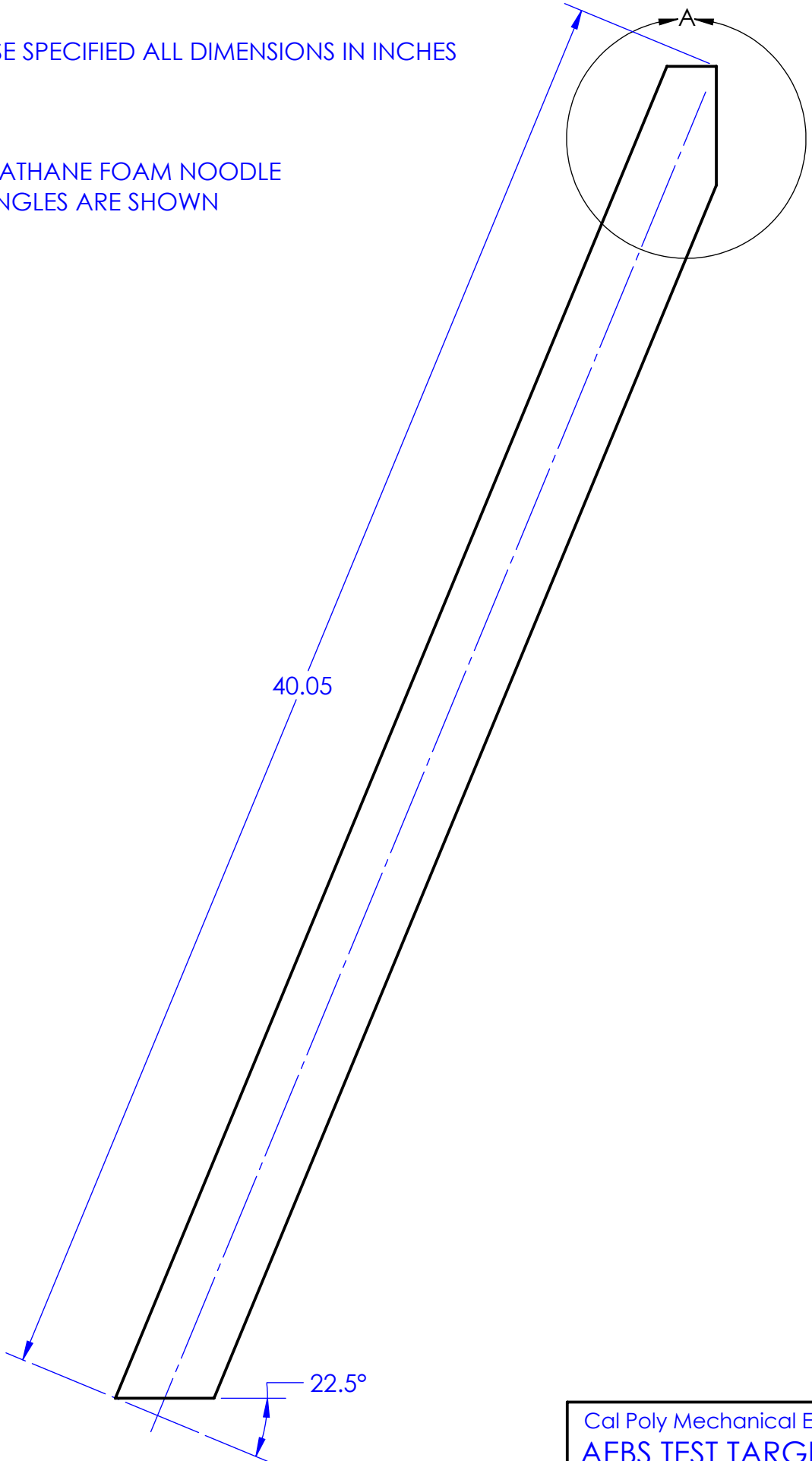
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
- 2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
- 3. SCHEDULE 40 3/4" PVC STOCK PIPE
- 4. CUTS AND CUT ANGLES ARE SHOWN



DETAIL A
SCALE 1 : 1

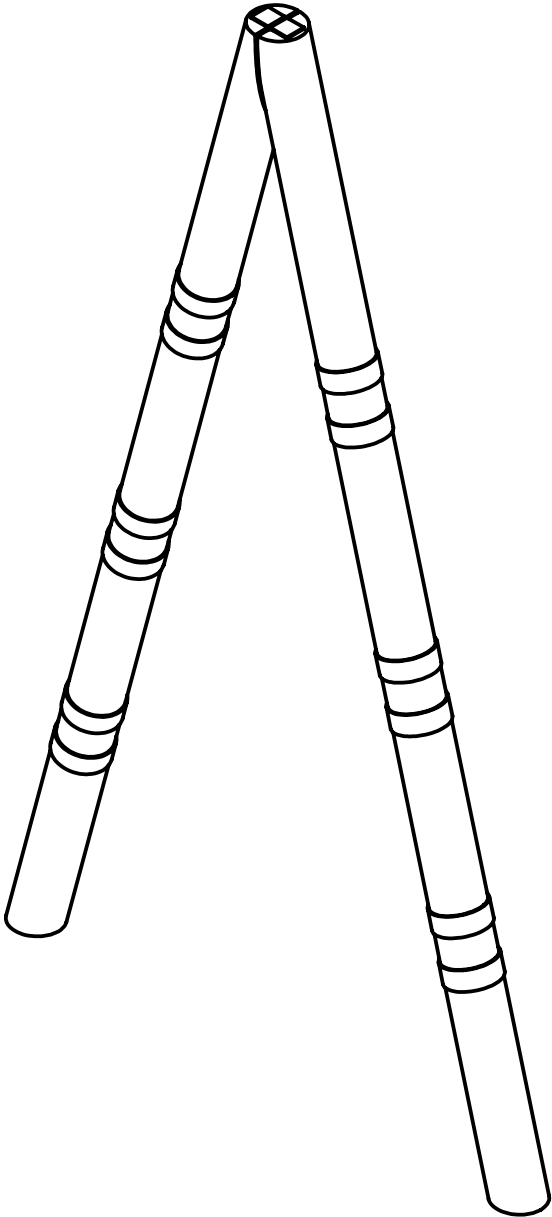
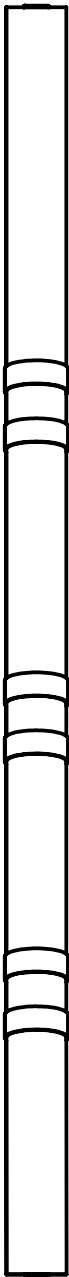
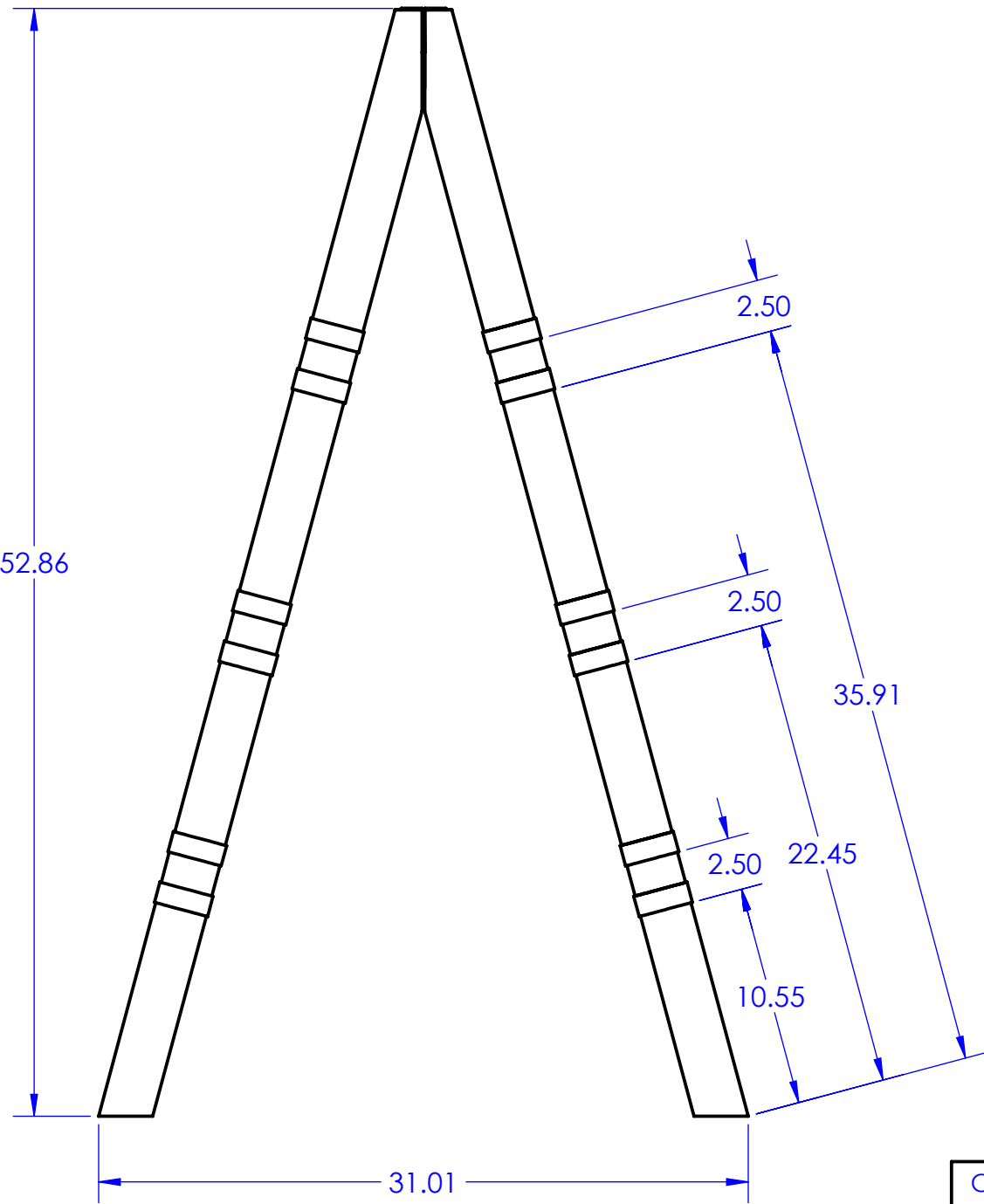
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B TRIANGLE PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 222	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK POLYEUTHATHANE FOAM NOODLE
 - 4. CUTS AND CUT ANGLES ARE SHOWN



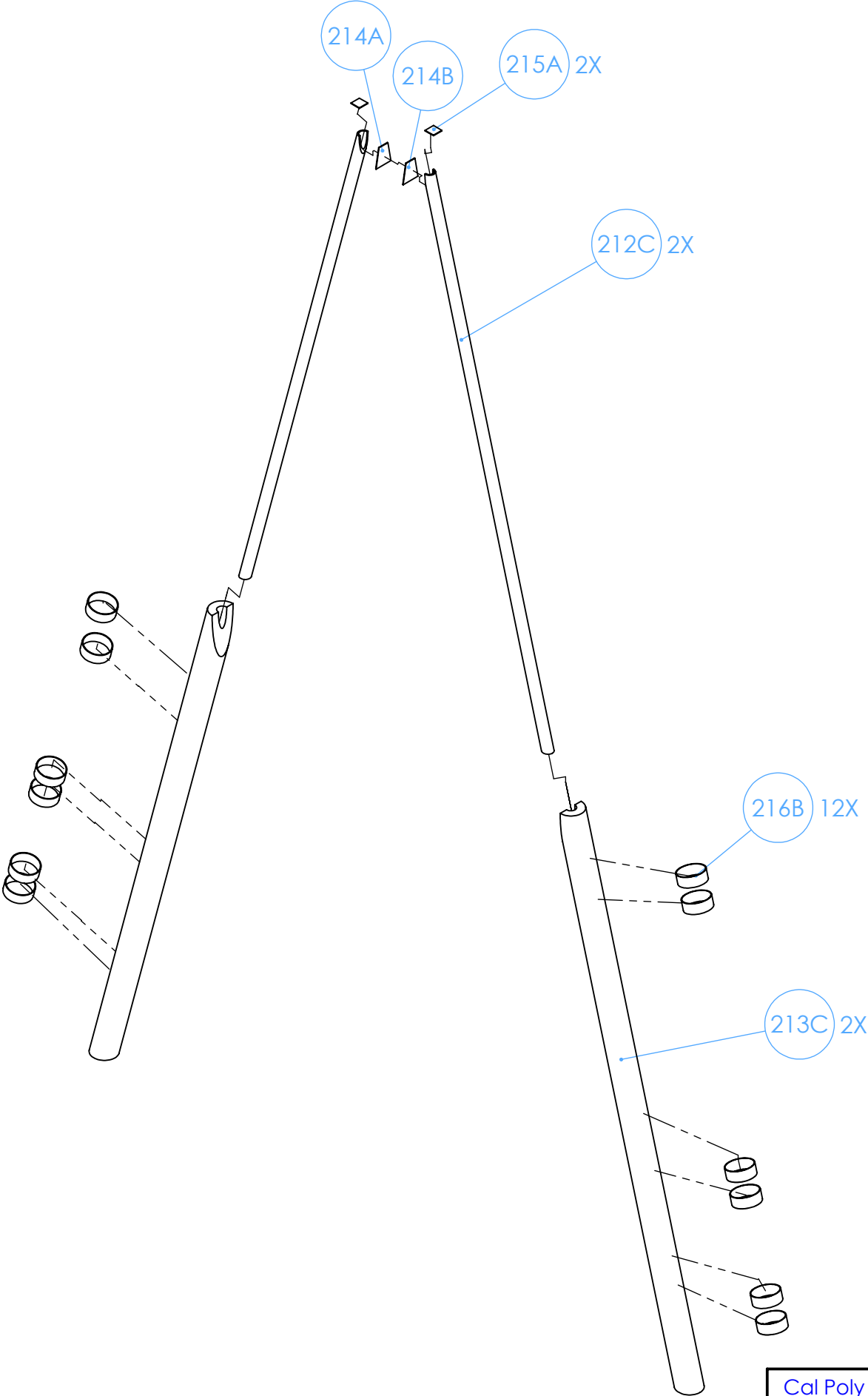
DETAIL A
SCALE 1 : 1

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B TRIANGLE FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 223	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°

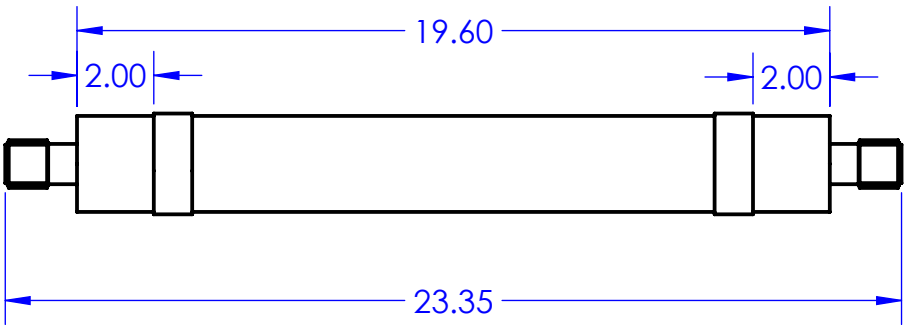
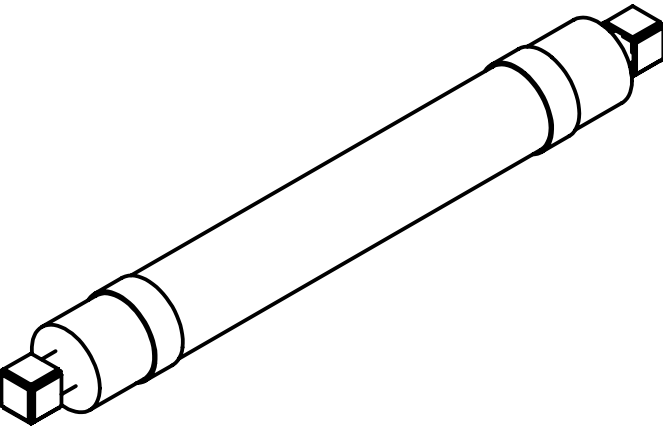
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: C TRIANGLE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 230	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF



PART NO.	PART NUMBER	QTY.
212C	C TRIANGLE PVC	2
213C	C TRIANGLE FOAM	2
214A	TRIANGLE SIDE VELCRO HOOK	1
214B	TRIANGLE SIDE VELCRO LOOP	1
215A	SQUARE VELCRO HOOK	2
216B	WRAP VELCRO LOOP	12

NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
5. WRAP OVERHANGING VELCRO

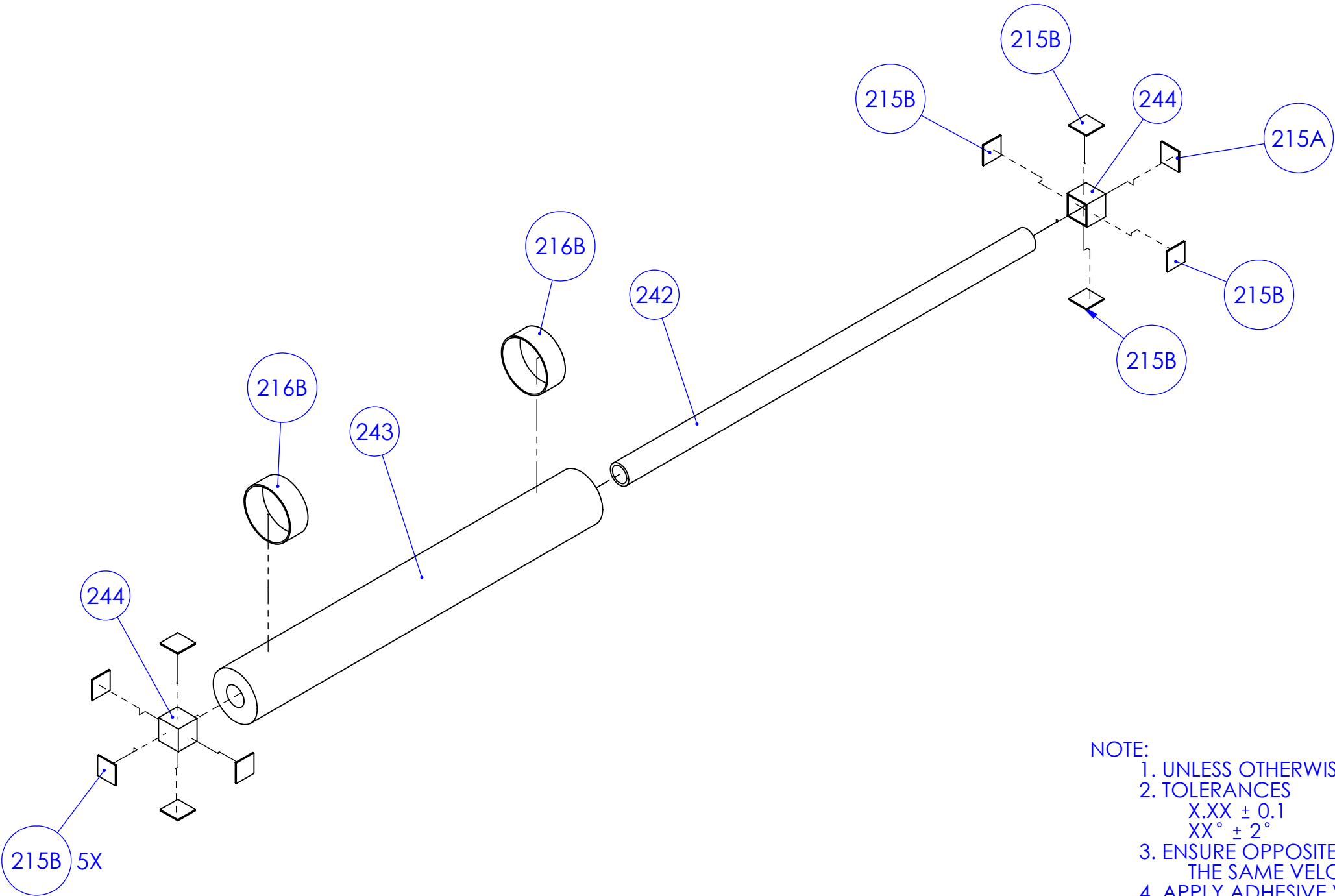
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED C TRIANGLE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 231	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

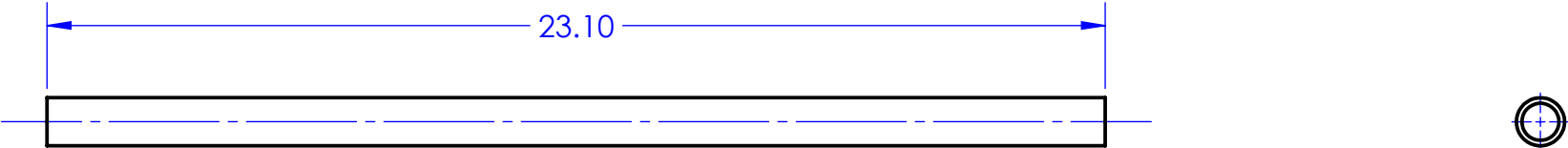
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: COLUMN CROSS BEAM ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 240	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

PART NO.	PART NUMBER	QTY.
242	COLUMN CROSS BEAM PVC	1
243	COLUMN CROSS BEAM FOAM	1
244	1x1 SQUARE END CAPS	2
215A	SQUARE VELCRO HOOK	1
215B	SQUARE VELCRO LOOP	9
216B	FOAM VELCRO LOOP	2



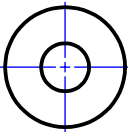
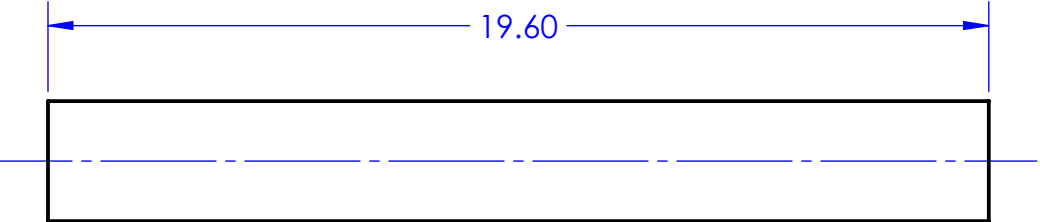
- NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 3. ENSURE OPPOSITE ENDS OF COLUMN CROSS BEAM ARE NOT THE SAME VELCRO CONNECTION TYPE
 4. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
 5. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
 6. WRAP OVERHANGING VELCRO

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. SCHEDULE 40 3/4" PVC STOCK PIPE
 - 4. CUTS AND CUT ANGLES ARE SHOWN

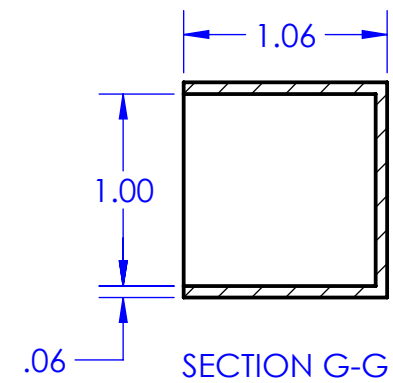
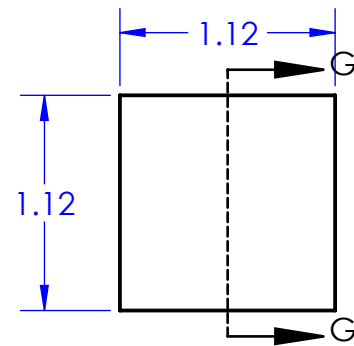
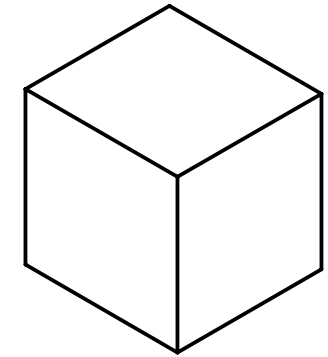


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: COLUMN CROSS BEAM PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 242	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK POLYEUTHATHANE FOAM NOODLE
 - 4. CUTS AND CUT ANGLES ARE SHOWN

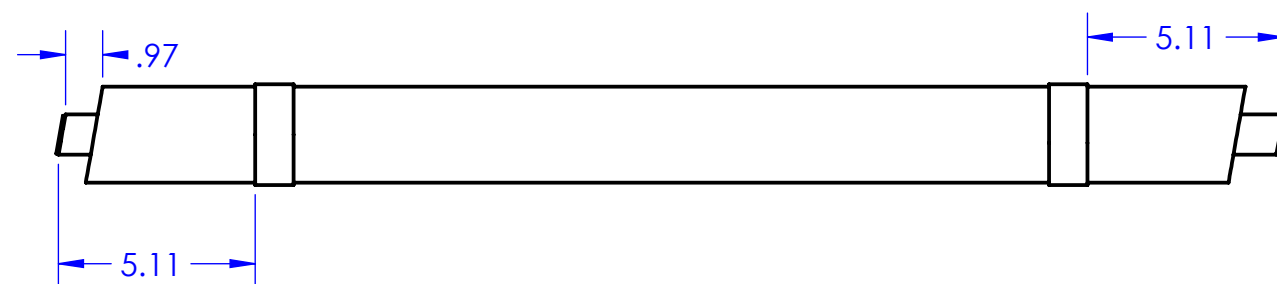
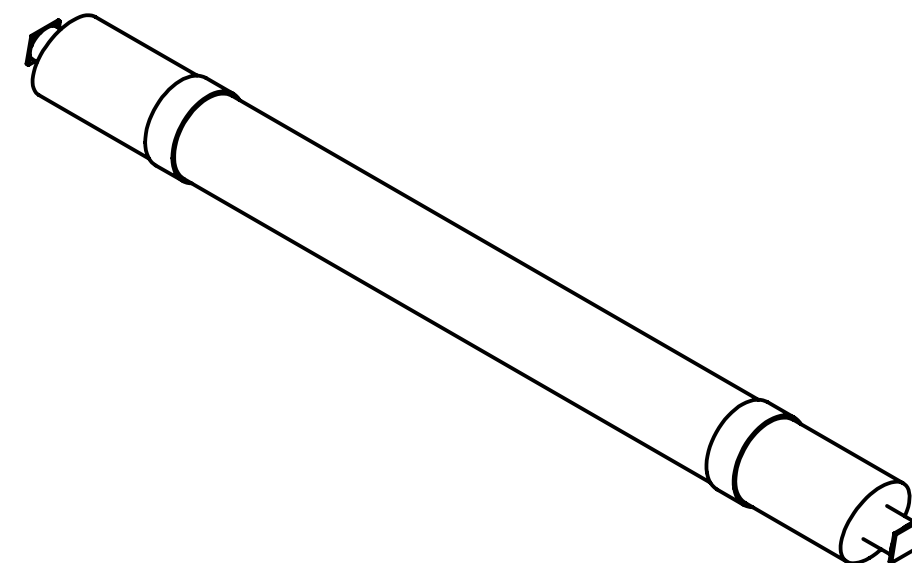
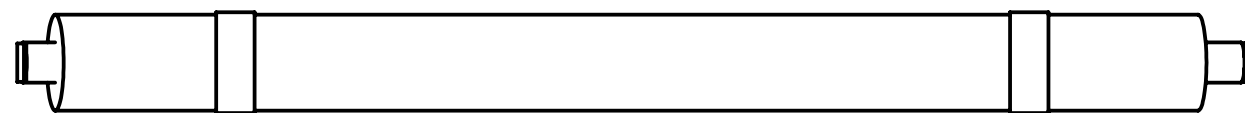


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: COLUMN CROSS BEAM FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 243	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



- NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
 3. PART IS STOCK PLASTIC END CAP WITH 1X1X1 INNER DIMENSION

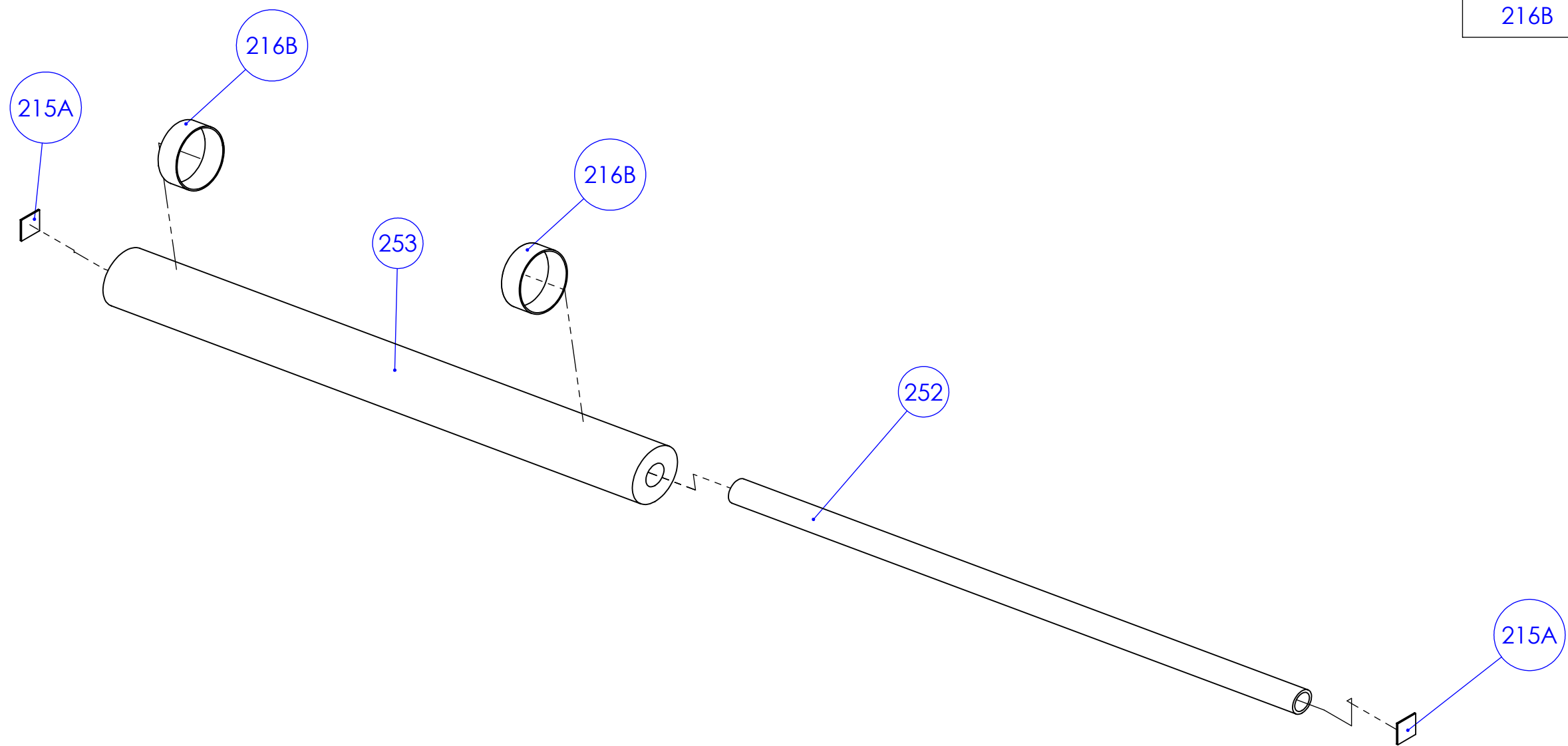
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: 1X1 SQUARE END CAP		Drwn. By: TARGET PRACTICE
	Dwg. #: 244	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2
3. MEASURE FROM END OF PVC BEFORE ADDING END VELCRO
PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: AB CROSS BEAM ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 250	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

ITEM NO.	PART NUMBER	QTY.
252	AB CROSS BEAM PVC	1
253	AB CROSS BEAM FOAM	1
215A	male velcro 1x1	2
216B	FOAM VELCRO LOOP	2

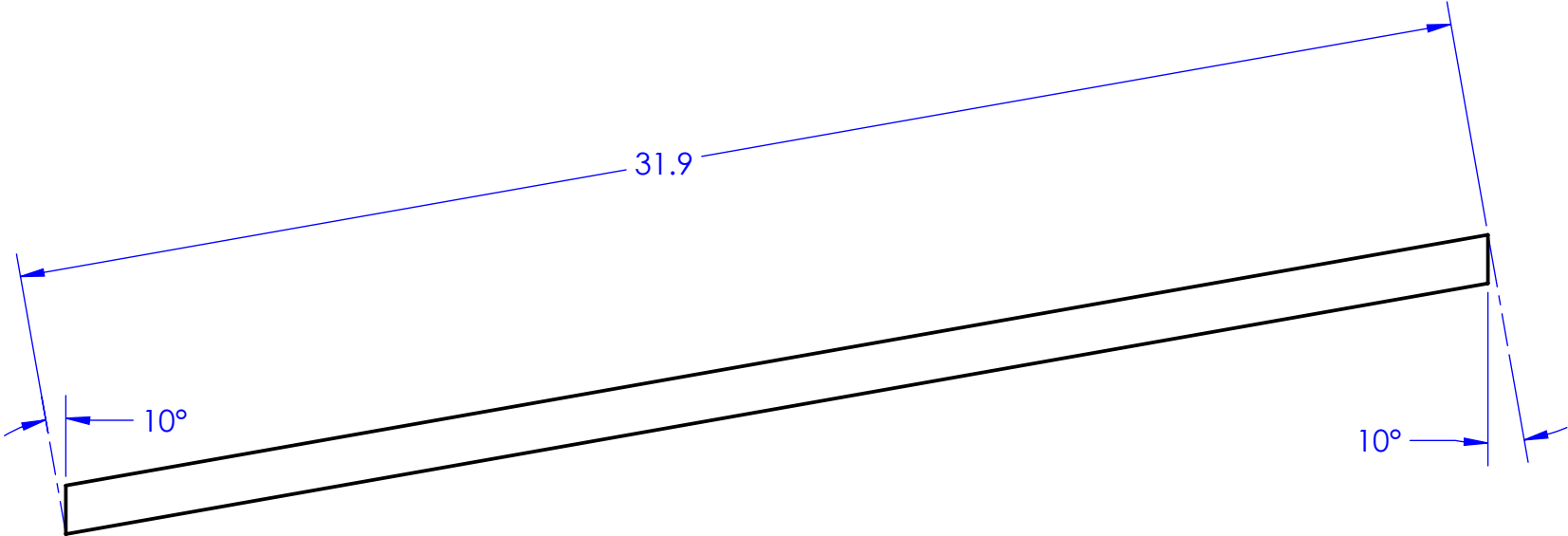


NOTE:

- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
- 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
- 3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
- 4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
- 5. WRAP OVERHANGING VELCRO

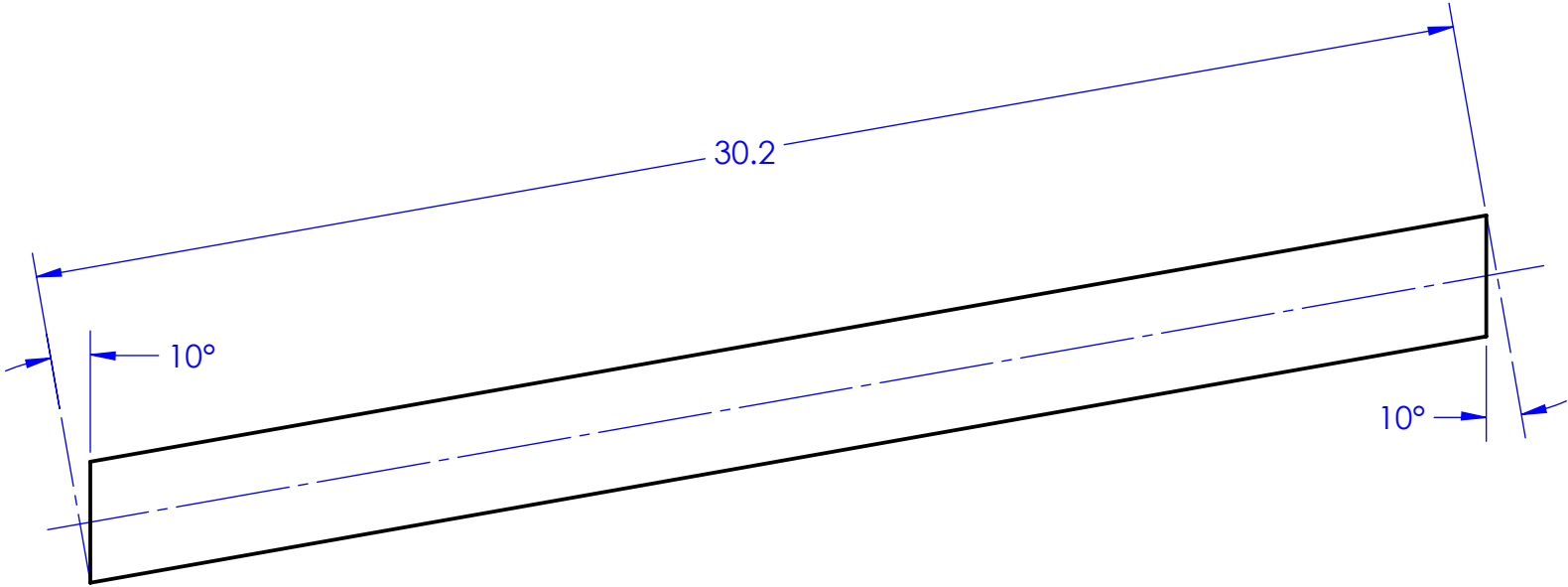
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED AB CROSS BEAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 251	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. SCHEDULE 40 3/4" PVC STOCK PIPE
 - 4. CUTS AND CUT ANGLES ARE SHOWN

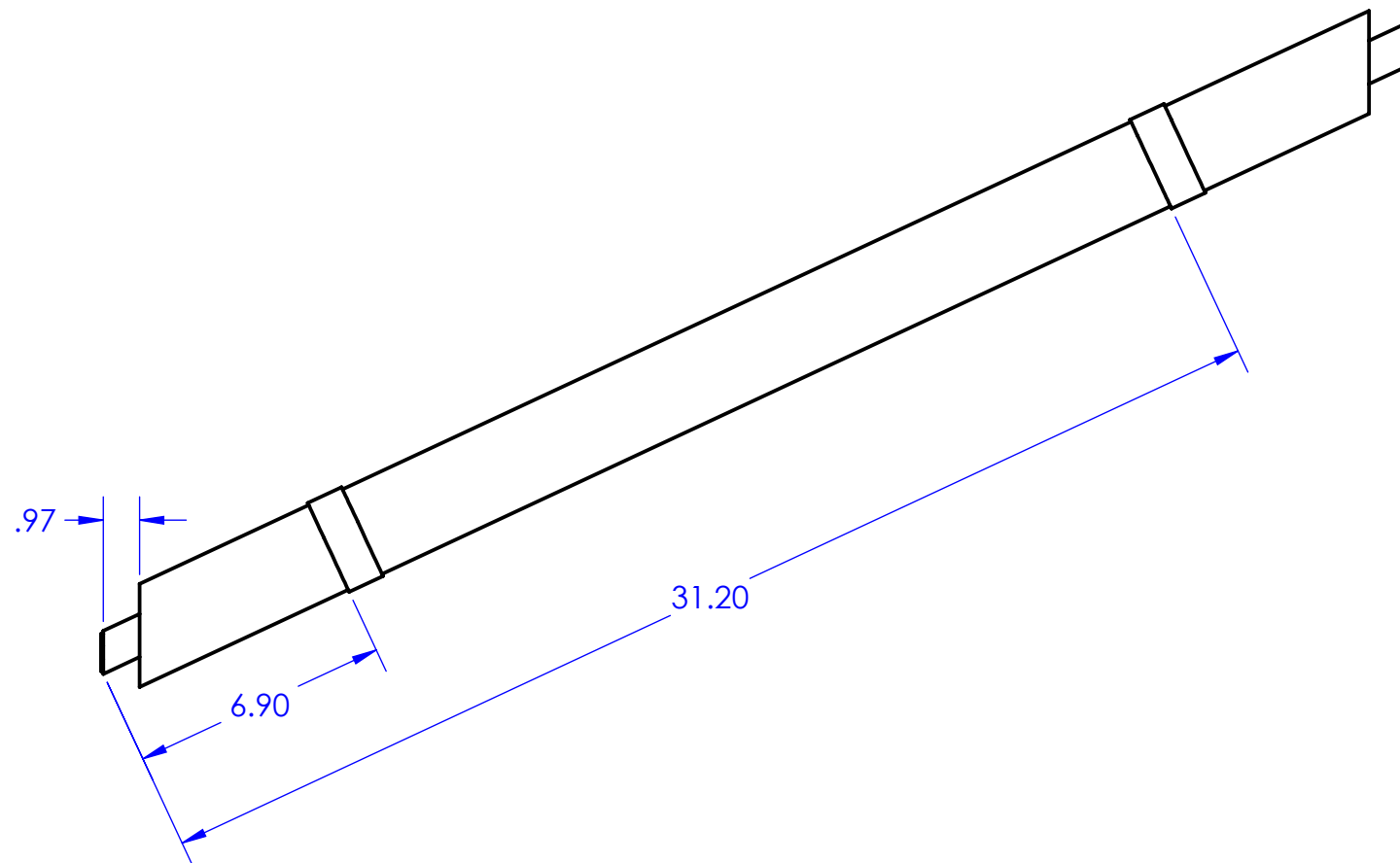


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: AB CROSS BEAM PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 252	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK POLYEUTHATHANE FOAM NOODLE
 - 4. CUTS AND CUT ANGLES ARE SHOWN



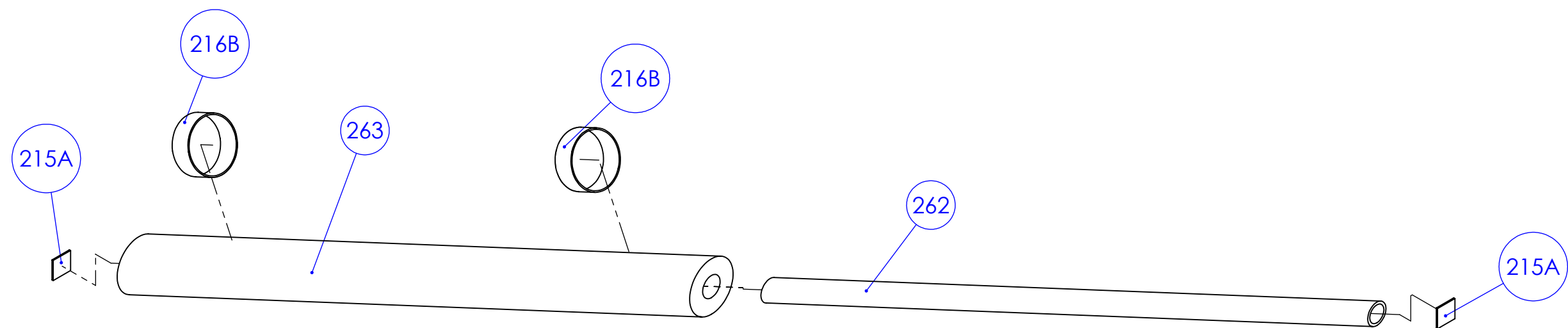
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: AB CROSS BEAM FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 253	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2
3. MEASURE FROM END OF PVC BEFORE ADDING END VELCRO
PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: BC CROSS BEAM ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 260	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

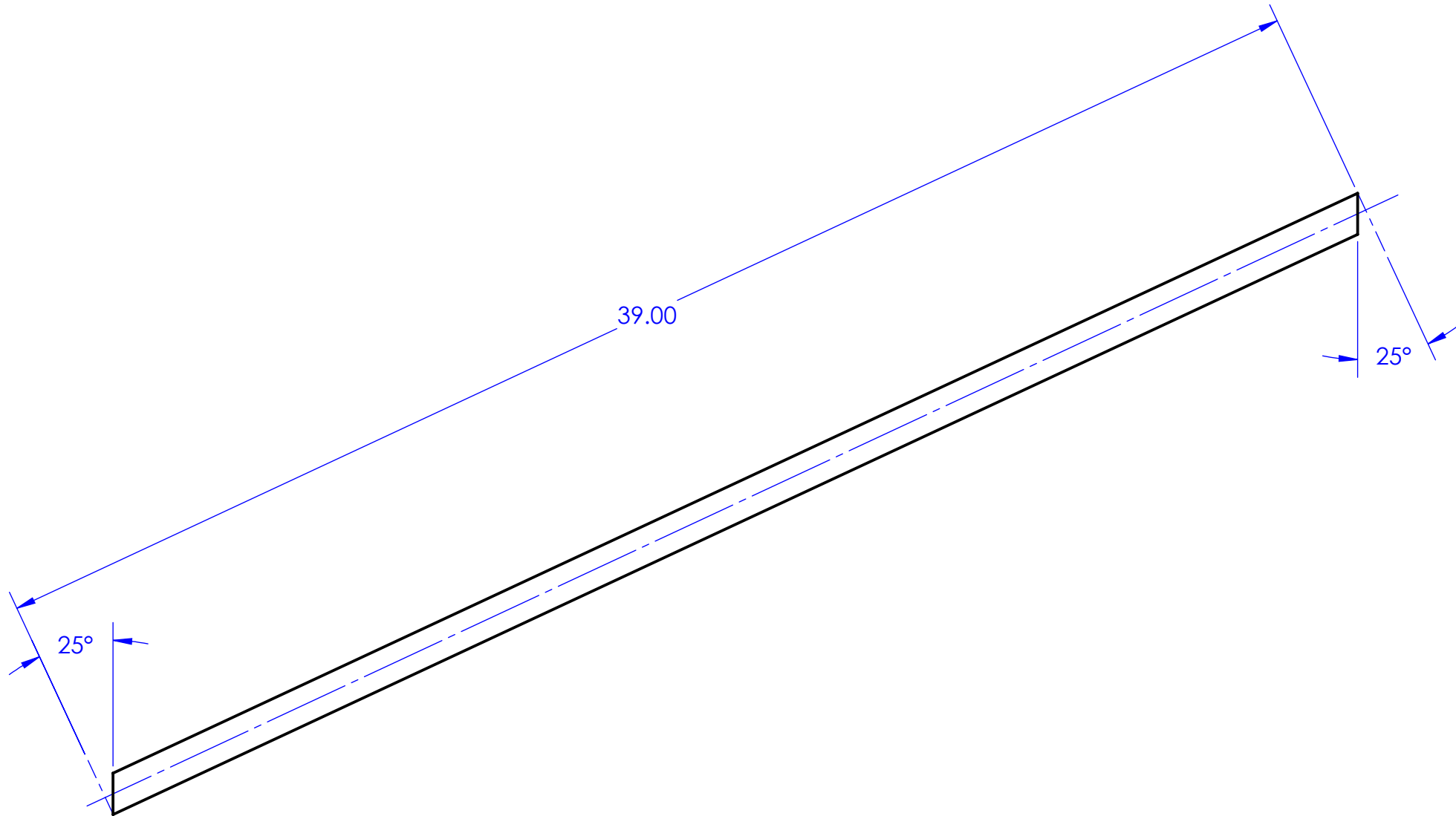
ITEM NO.	PART NUMBER	QTY.
262	BC CROSS BEAM PVC	1
263	BC CROSS BEAM FOAM	1
215A	male velcro 1x1	2
216B	FOAM VELCRO LOOP	2



- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
 - 4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
 - 5. WRAP OVERHANGING VELCRO

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED BC CROSS BEAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 261	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

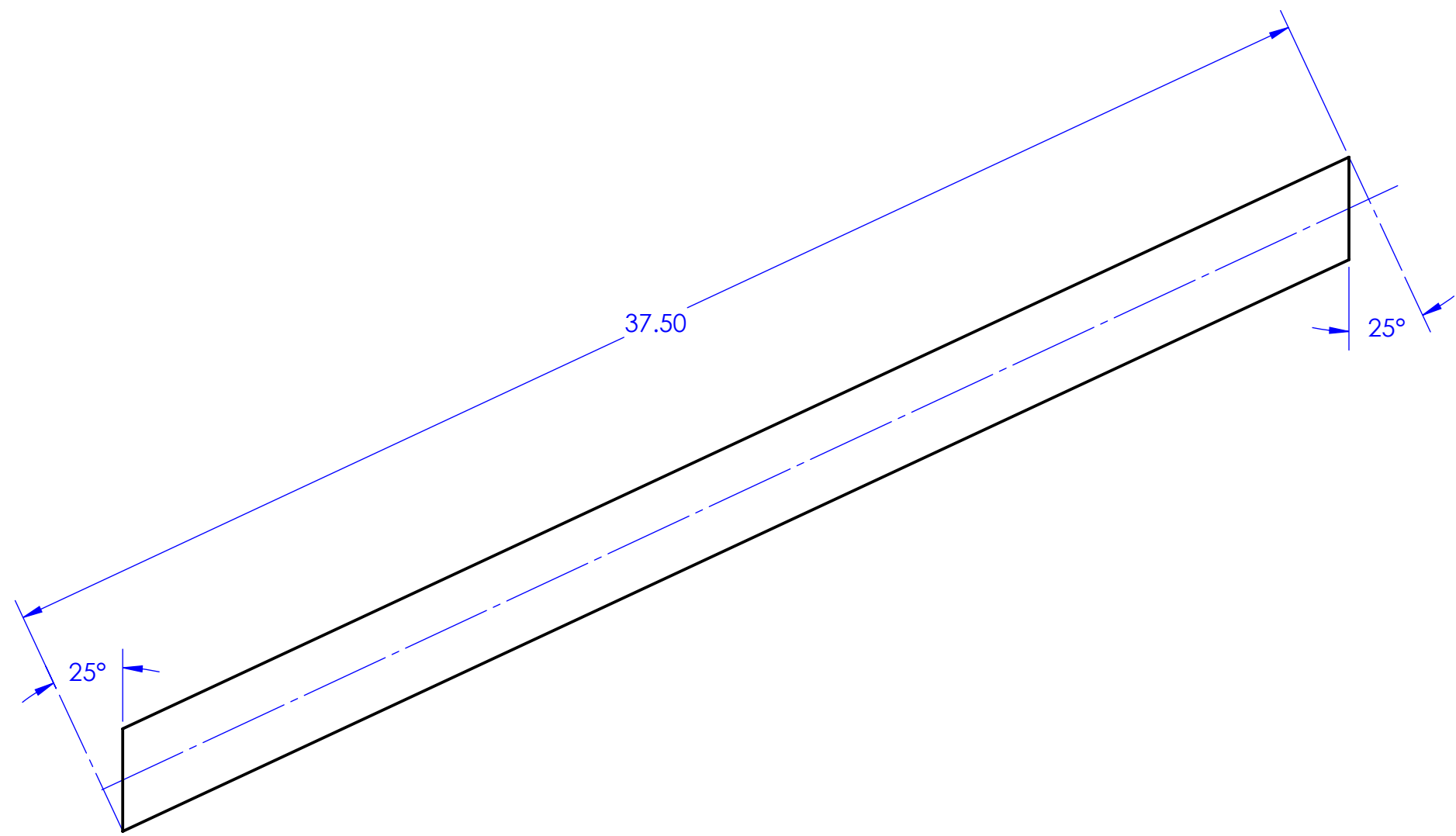
- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. SCHEDULE 40 3/4" PVC STOCK PIPE
 - 4. CUTS AND CUT ANGLES ARE SHOWN



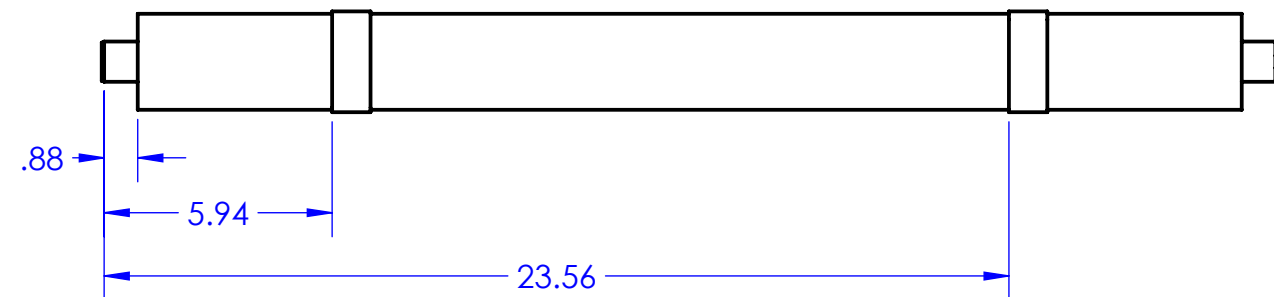
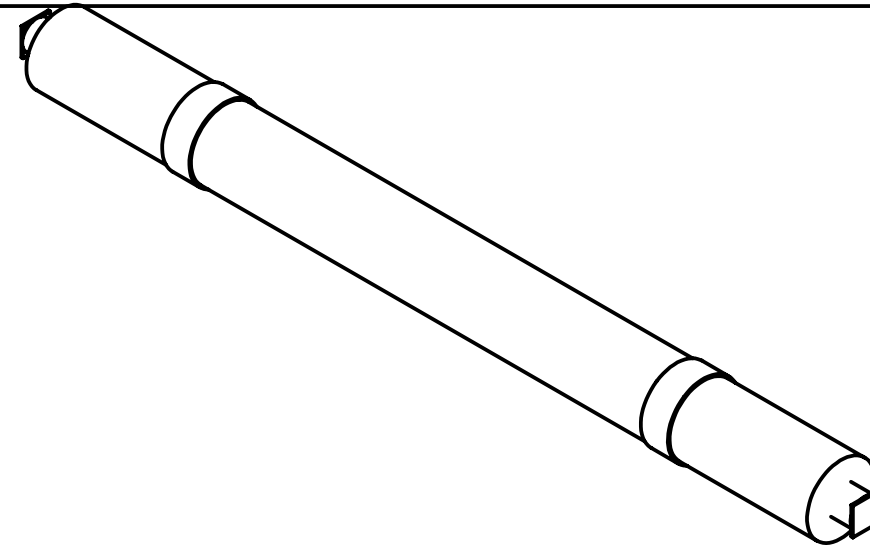
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: BC CROSS BEAM PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 262	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

NOTE:

- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
- 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
- 3. STOCK POLYEUTHATHANE FOAM NOODLE
- 4. CUTS AND CUT ANGLES ARE SHOWN



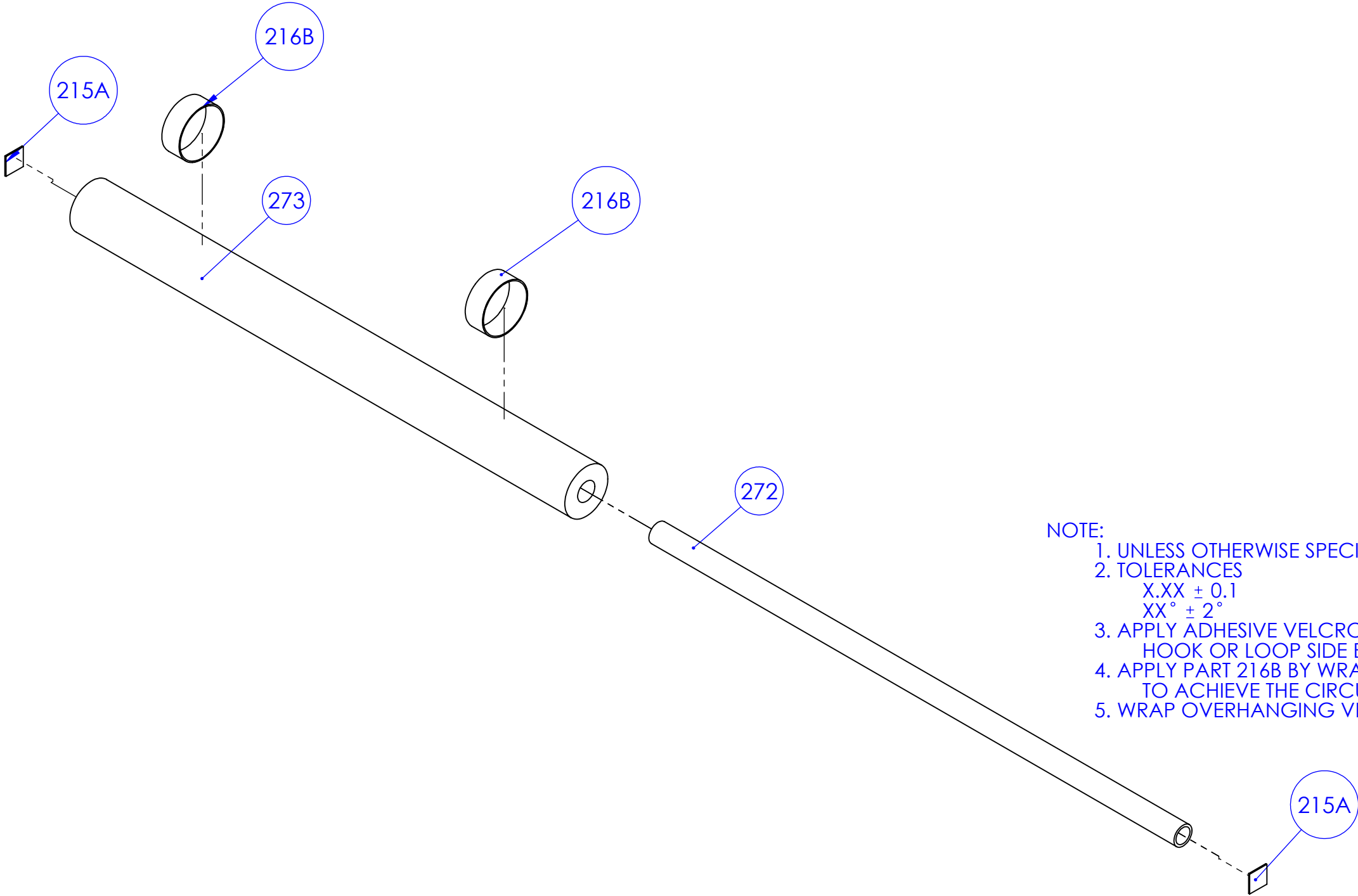
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: BC CROSS BEAM FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 263	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX \pm 0.1
 XX° \pm 2
3. MEASURE FROM END OF PVC BEFORE ADDING END VELCRO
 PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: CC CROSS BEAM ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 270	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

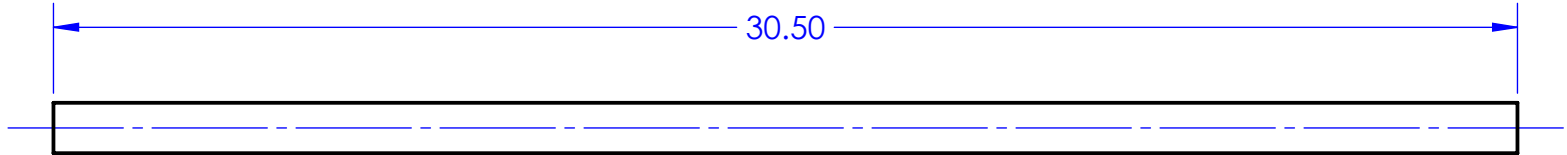
ITEM NO.	PART NUMBER	QTY.
272	CC CROSS BEAM PVC	1
273	CC CROSS BEAM FOAM	1
215A	male velcro 1x1	2
216B	FOAM VELCRO LOOP	2



- NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
 3. APPLY ADHESIVE VELCRO SIDE TO PVC OR FOAM LEAVING HOOK OR LOOP SIDE EXPOSED
 4. APPLY PART 216B BY WRAPPING FLAT STRIP OF VELCRO AROUND FOAM TO ACHIEVE THE CIRCULAR PATTERN SHOWN
 5. WRAP OVERHANGING VELCRO

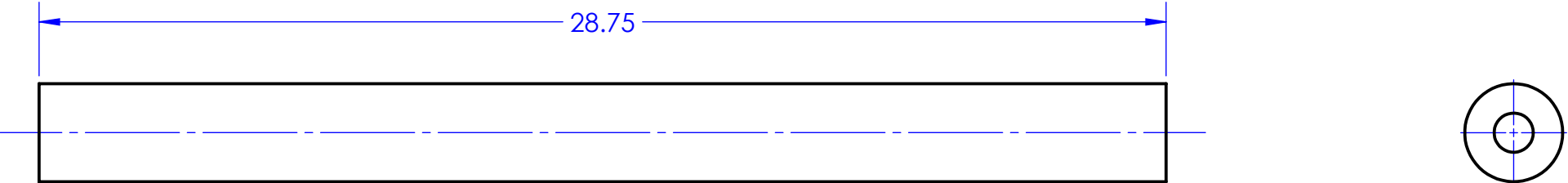
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED CC CROSS BEAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 271	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:5	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. SCHEDULE 40 3/4" PVC STOCK PIPE
 - 4. CUTS AND CUT ANGLES ARE SHOWN

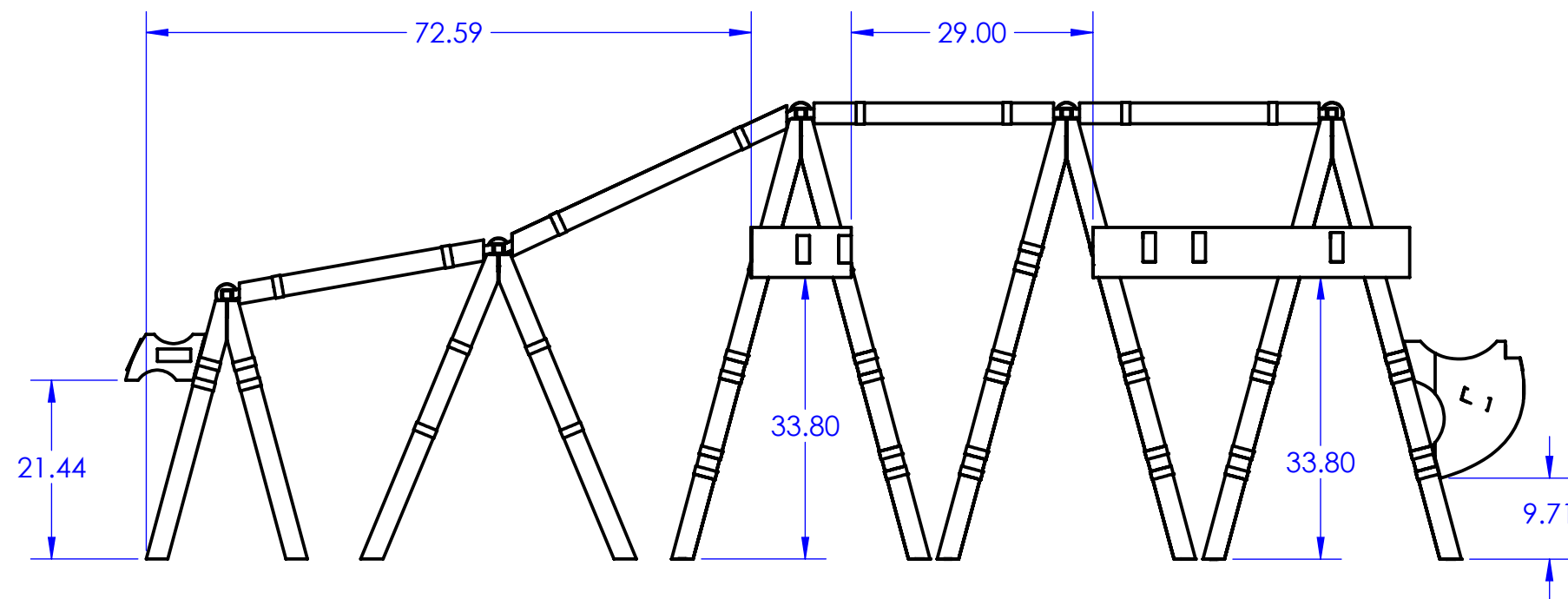
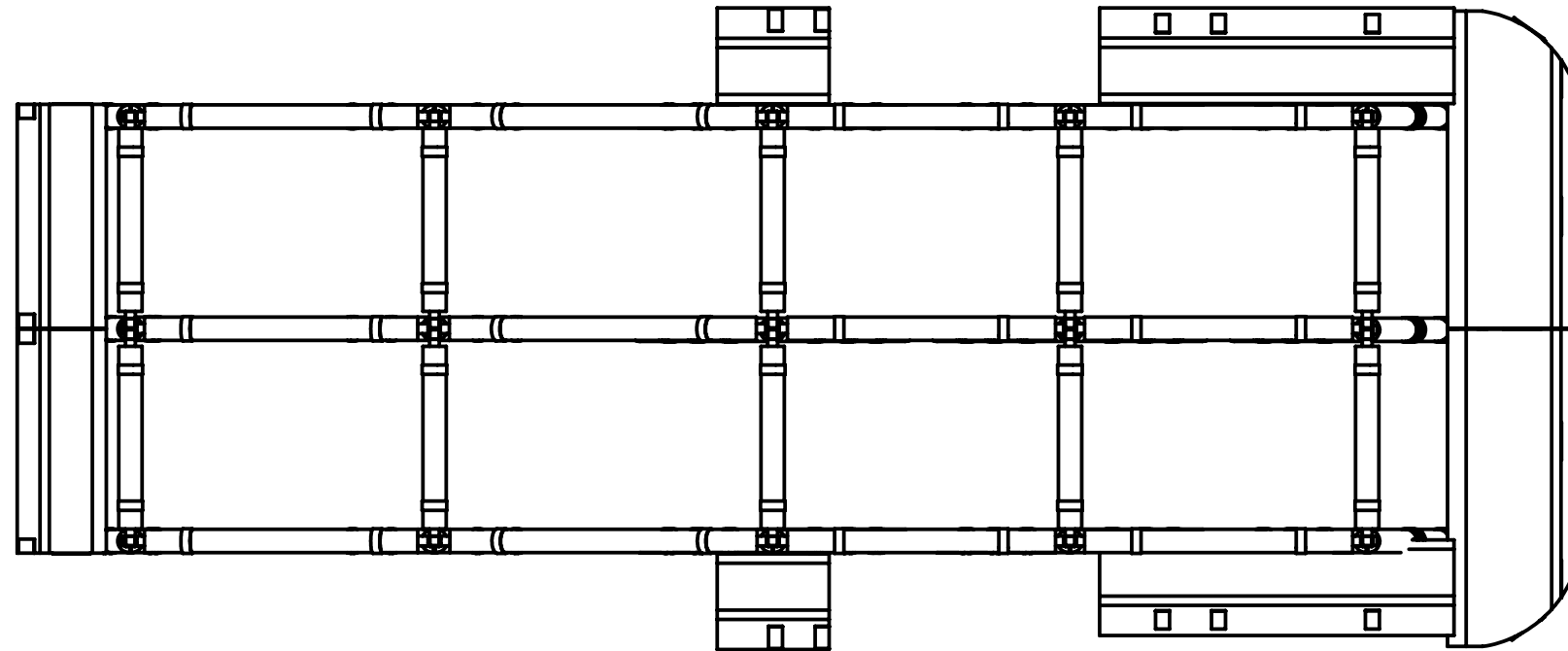


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: CC CROSS BEAM PVC		Drwn. By: TARGET PRACTICE
	Dwg. #: 272	Nxt Asb: NONE	Date:2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK POLYEUTHATHANE FOAM NOODLE
 - 4. CUTS AND CUT ANGLES ARE SHOWN



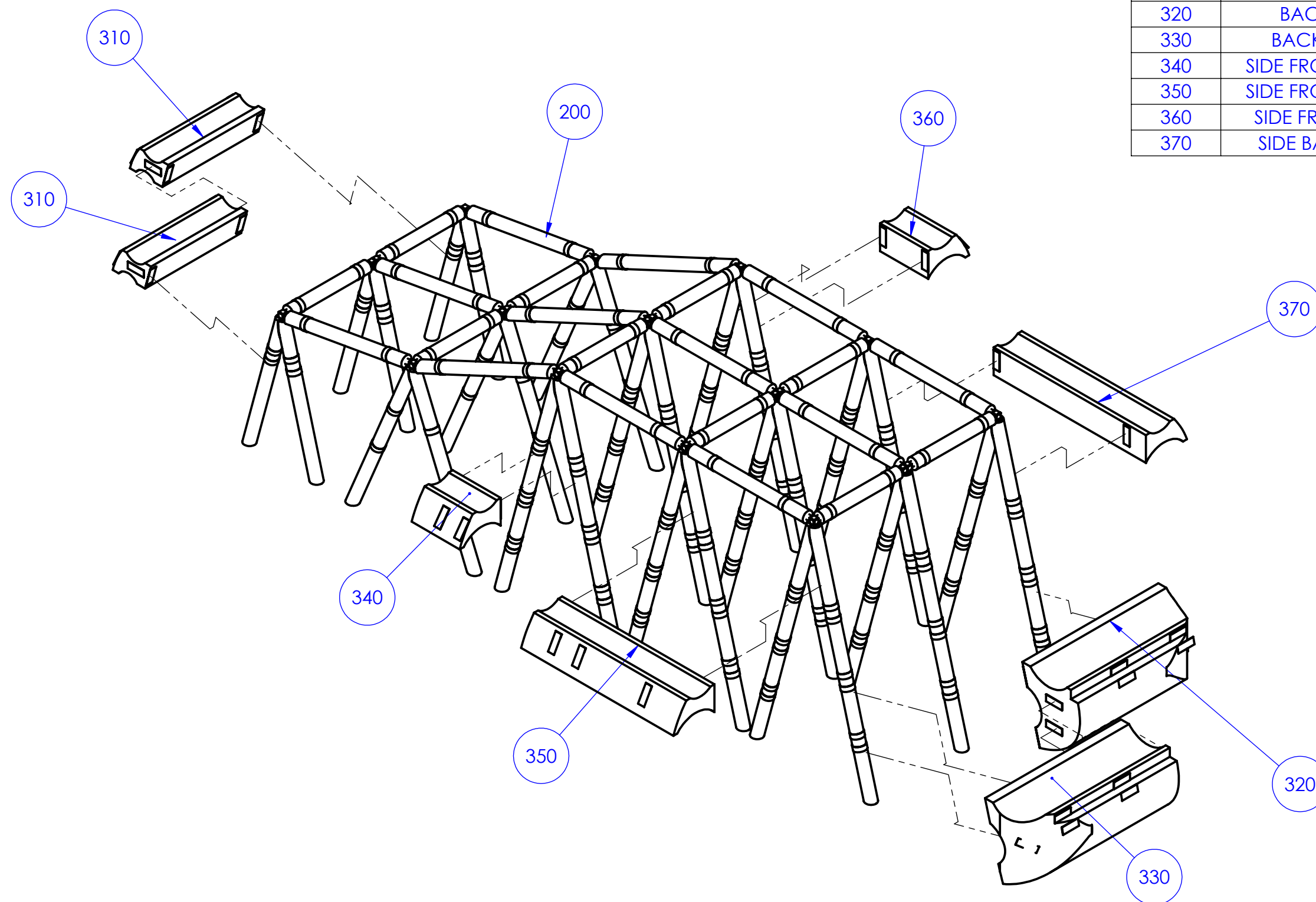
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: CC CROSS BEAM FOAM		Drwn. By: TARGET PRACTICE
	Dwg. #: 273	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
3. VELCRO SHOULD ALIGN

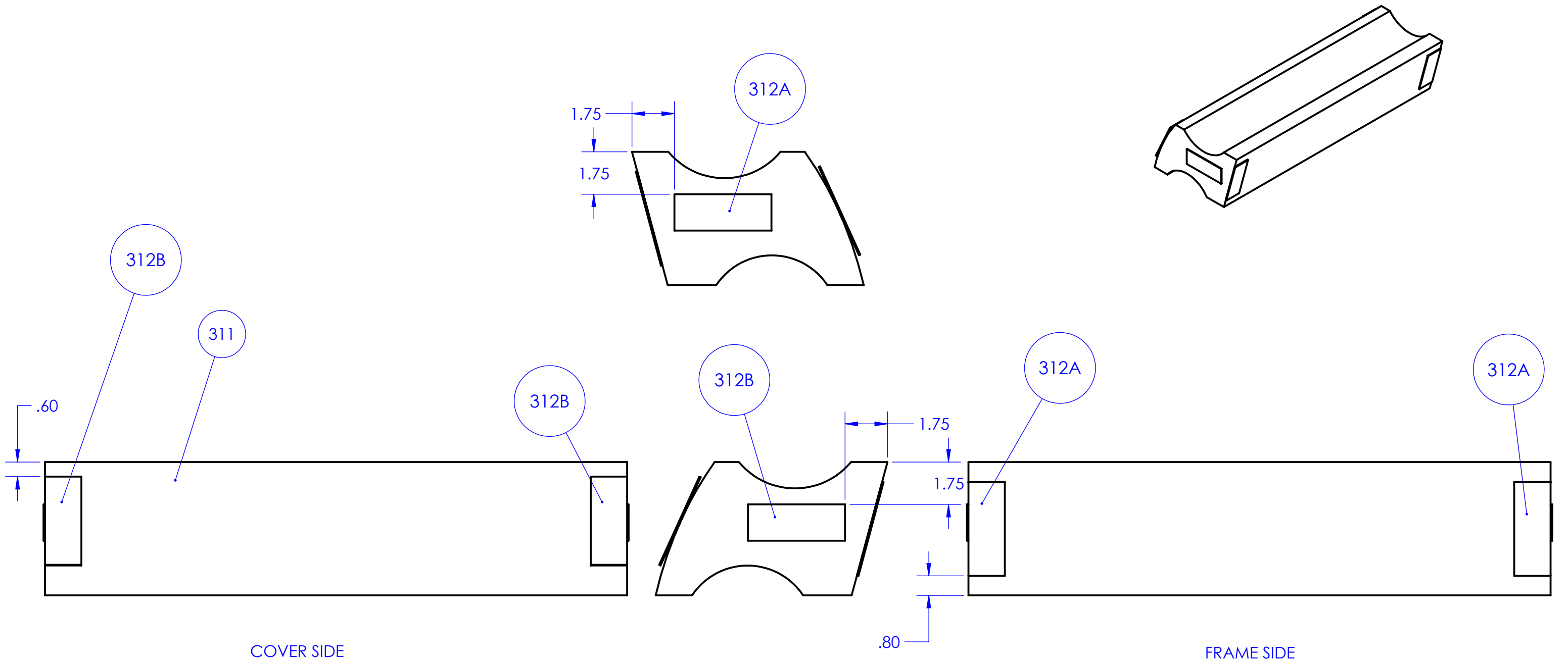
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: FOAM ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 300	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:20	Chkd. By: ME STAFF



PART NO.	PART NAME	QUANTITY
200	TRUSS ASSEMBLY	1
310	FRONT BUMPER	2
320	BACK BUMPER LEFT	1
330	BACK BUMPER RIGHT	1
340	SIDE FRONT BUMPER RIGHT	1
350	SIDE FRONT BUMPER RIGHT	1
360	SIDE FRONT BUMPER LEFT	1
370	SIDE BACK BUMPER LEFT	1

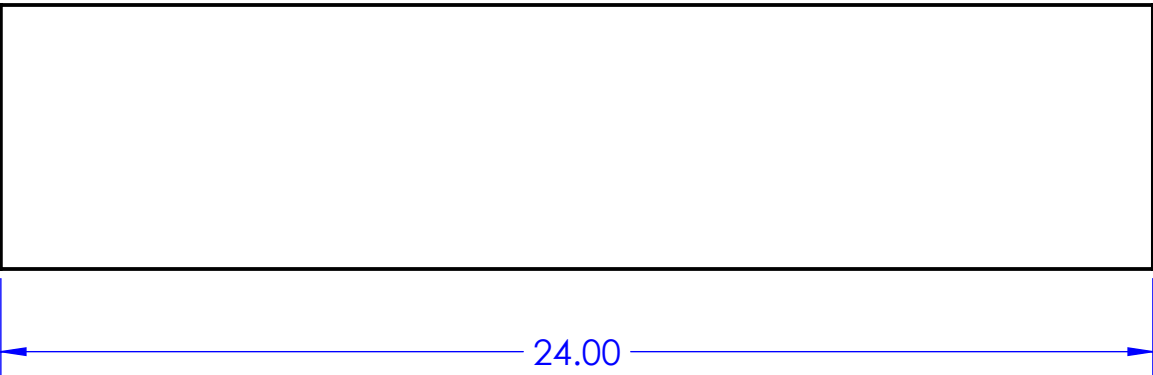
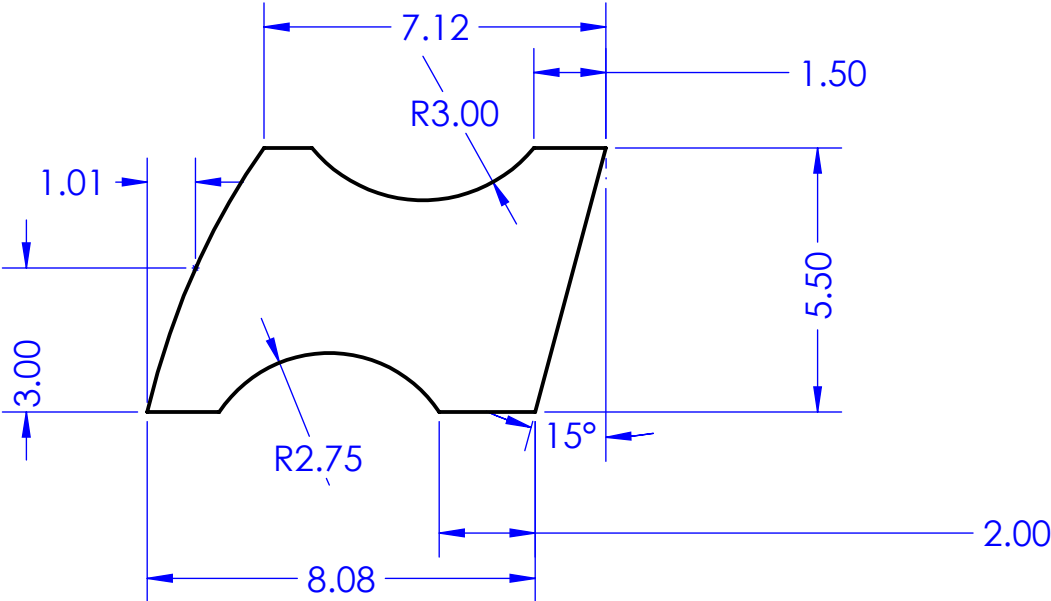
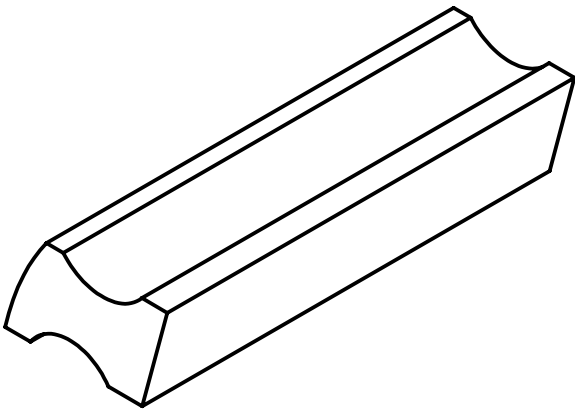
NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

PART NO.	PART NAME	QTY.
311	FRONT BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	3
312B	BUMPER VELCRO LOOPS	3



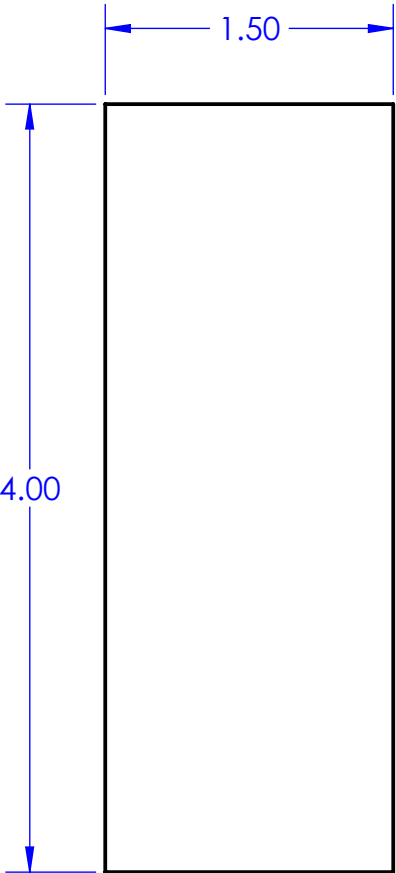
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: FRONT BUMPER ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 310	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK EXPANDED POLYSTYRENE FOAM BLOCK
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: FRONT BUMPER FOAM BLOCK		Drwn. By: TARGET PRACTICE
	Dwg. #: 311	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. CUT FROM XXXXXXXX BRAND VELCRO
 - 4. CUTS AND CUT ANGLES ARE SHOWN



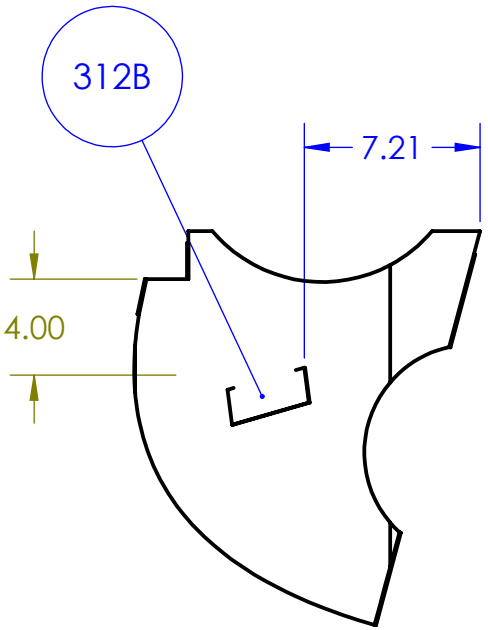
VERSION	TYPE
312A	HOOKS
312B	LOOPS

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: BUMPER VELCRO		Drwn. By: TARGET PRACTICE
	Dwg. #: 312	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF

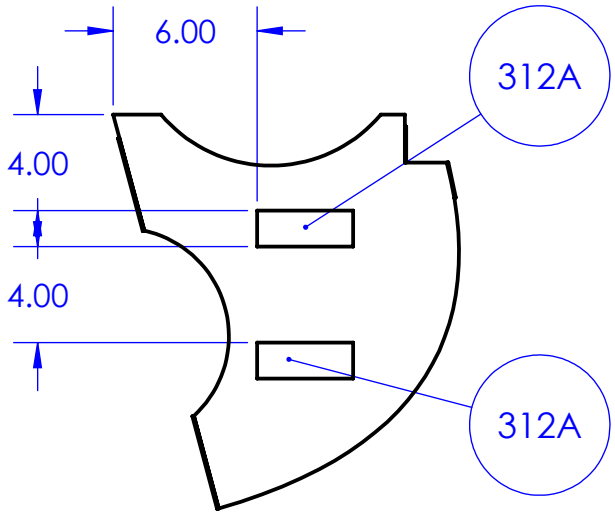
NOTE:

- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
- 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
- 3. WRAP OVERHANGING VELCRO

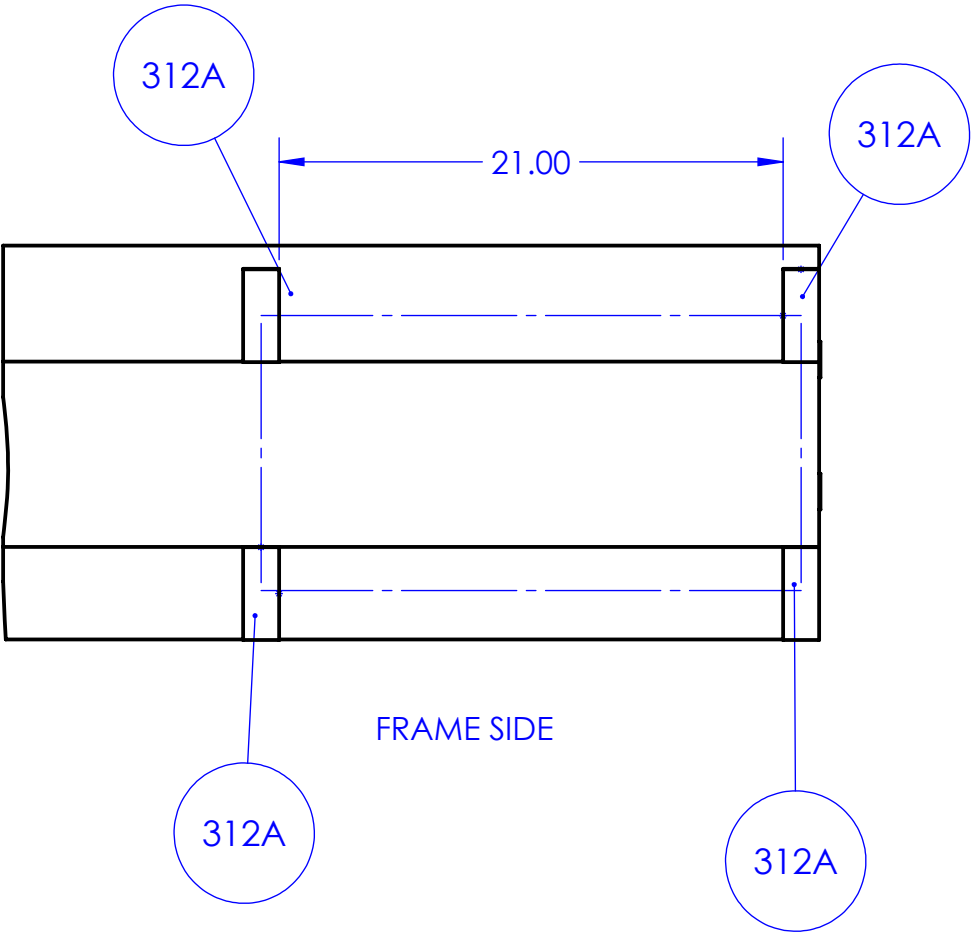
PART NO.	PART NAME	QTY.
321	LEFT BACK BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	6
312B	BUMPER VELCRO LOOPS	5



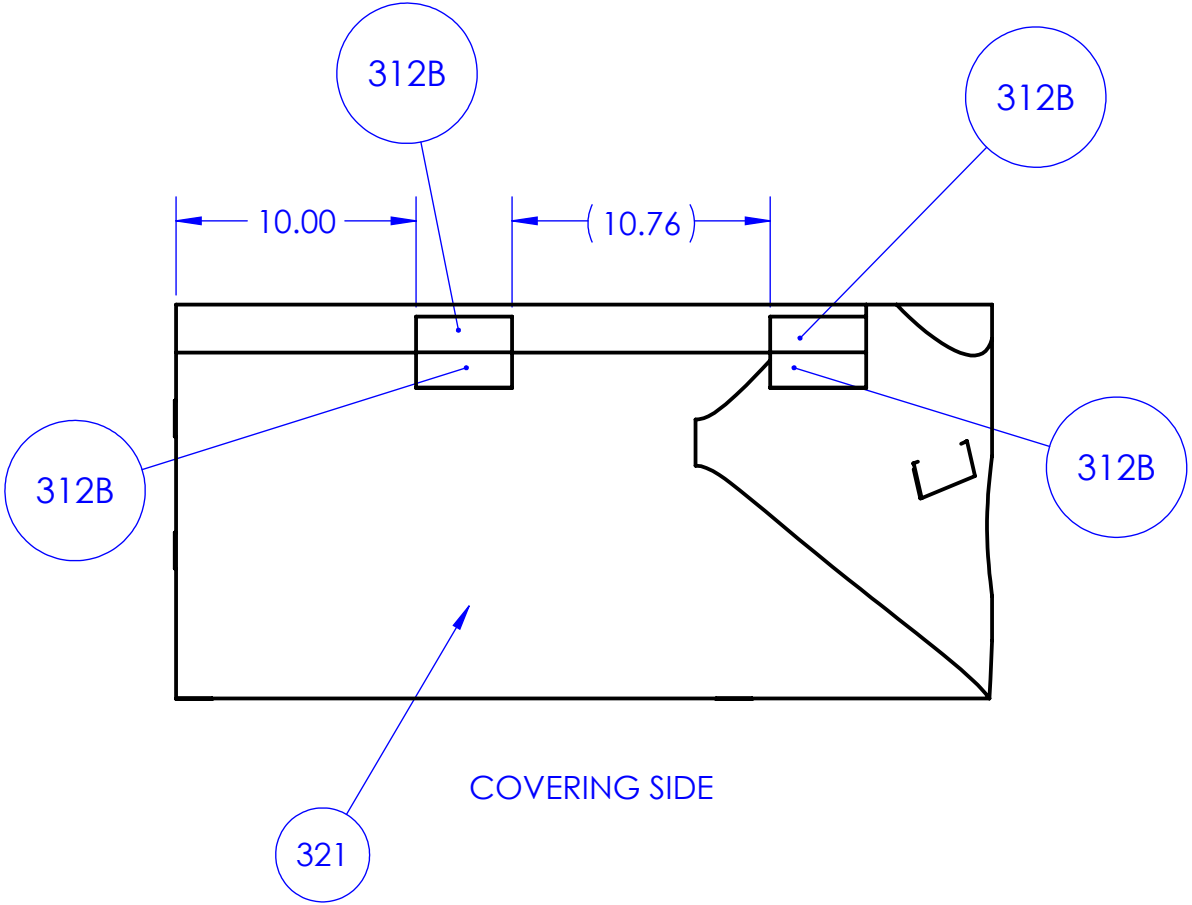
CURVED SIDE



FLAT SIDE



FRAME SIDE

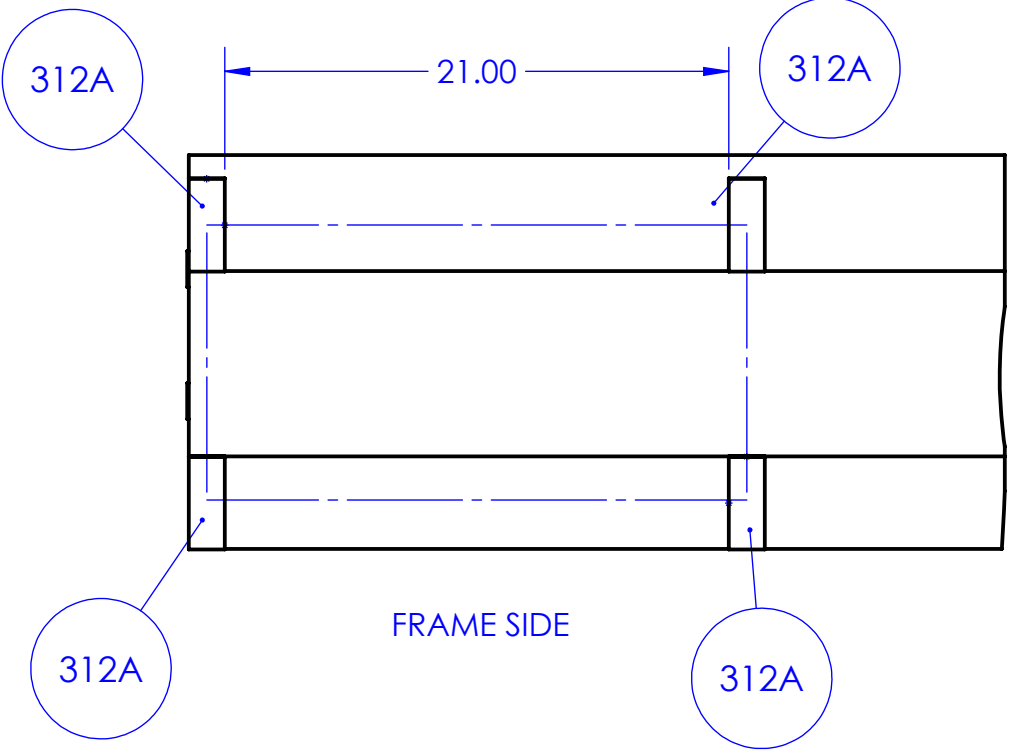
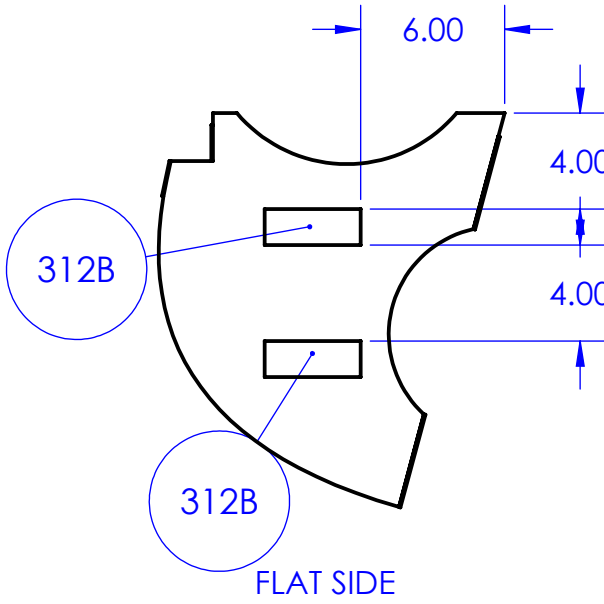
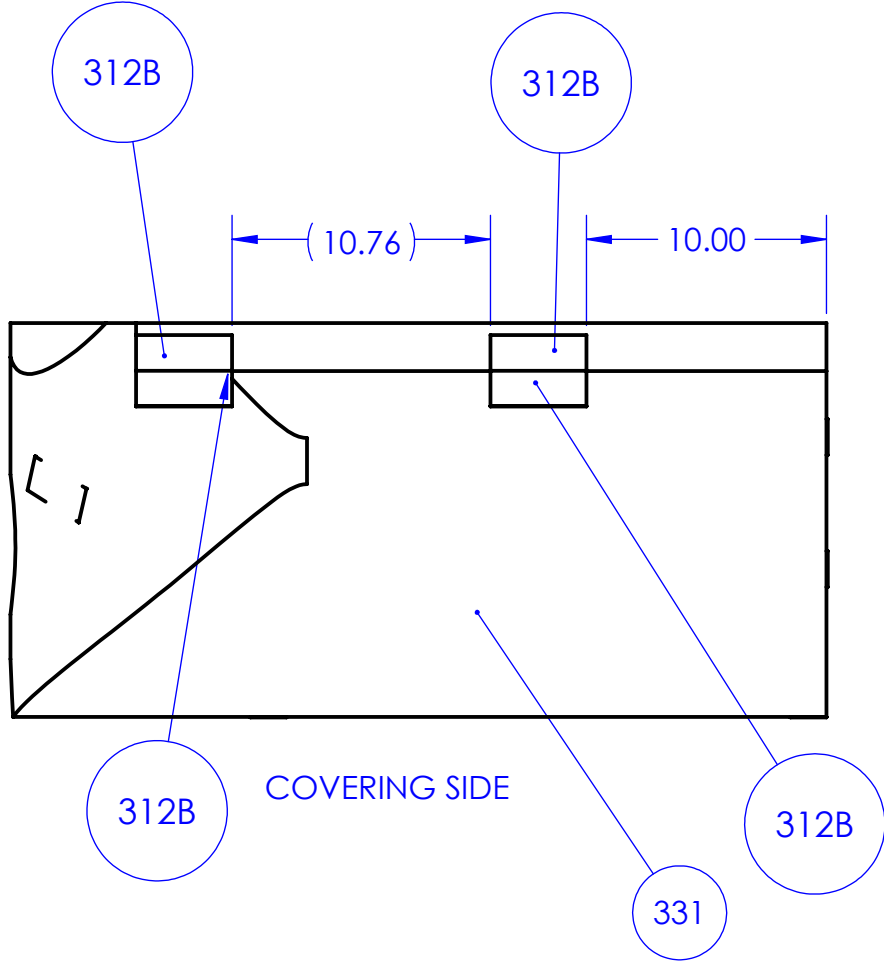
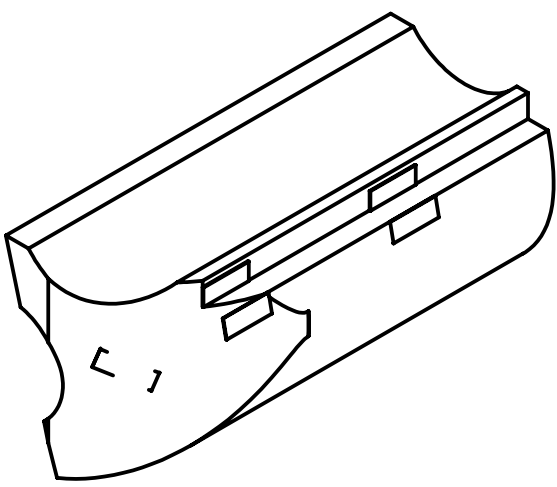
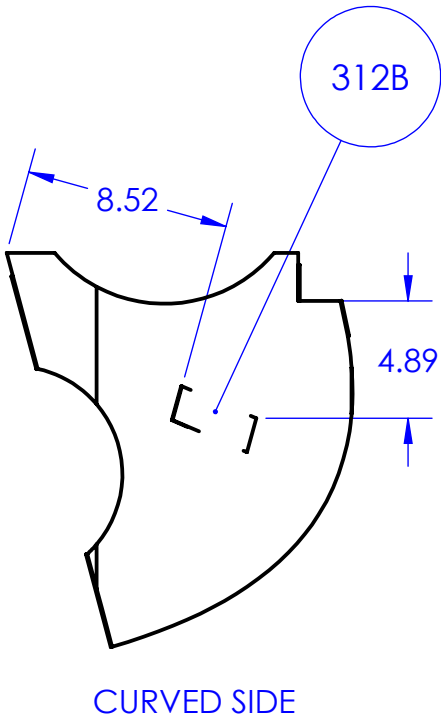


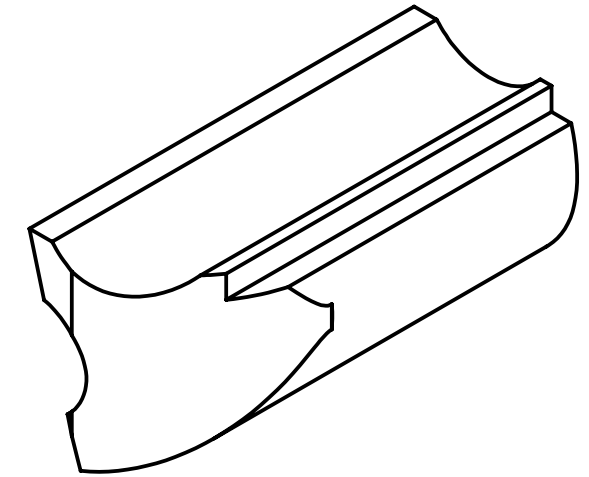
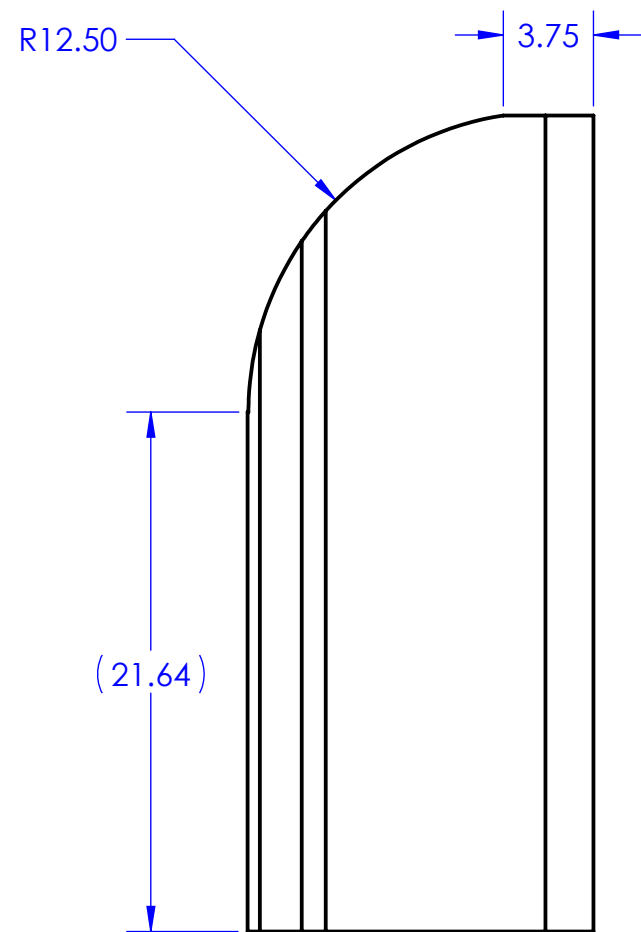
COVERING SIDE

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09 Dwg. #: 320	Assignment: CDR Nxt Asb: NONE	Title: BACK BUMPER LEFT Date: 2/9/17 Scale: 1:8	Drwn. By: TARGET PRACTICE Chkd. By: ME STAFF
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- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. WRAP OVERHANGING VELCRO

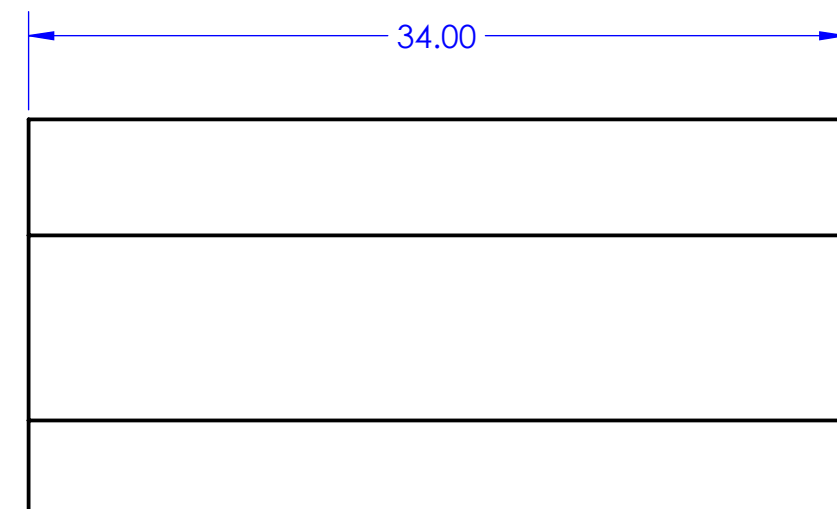
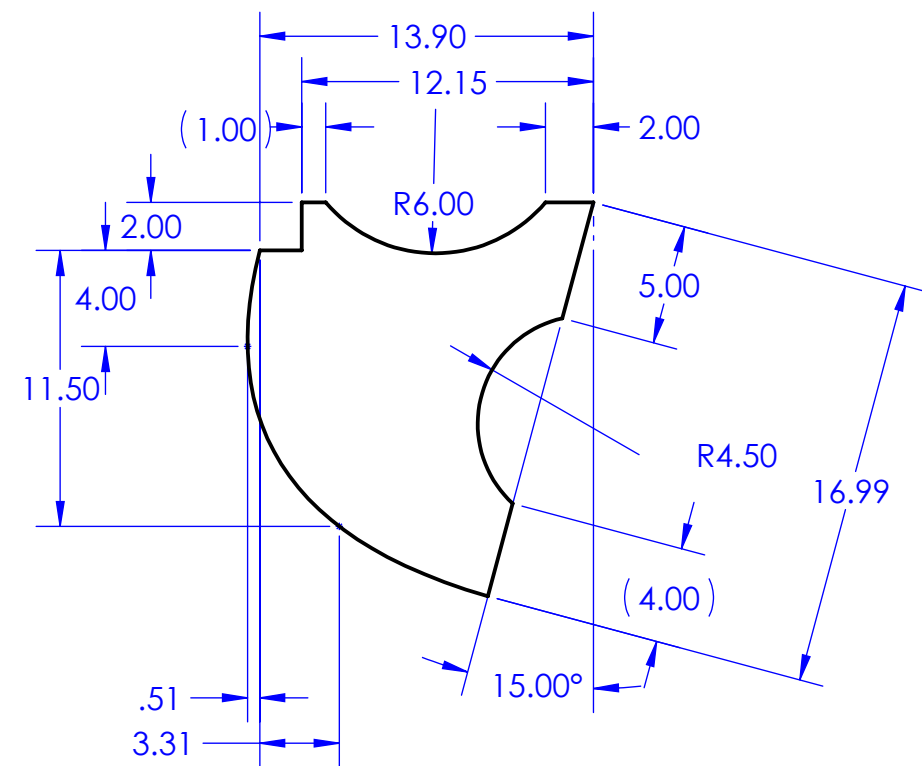
PART NO.	PART NAME	QTY.
331	RIGHT BACK BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	4
312B	BUMPER VELCRO LOOPS	7





NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
3. STOCK EXPANDED POLYSTYRENE FOAM BLOCK
4. CUTS AND CUT ANGLES ARE SHOWN

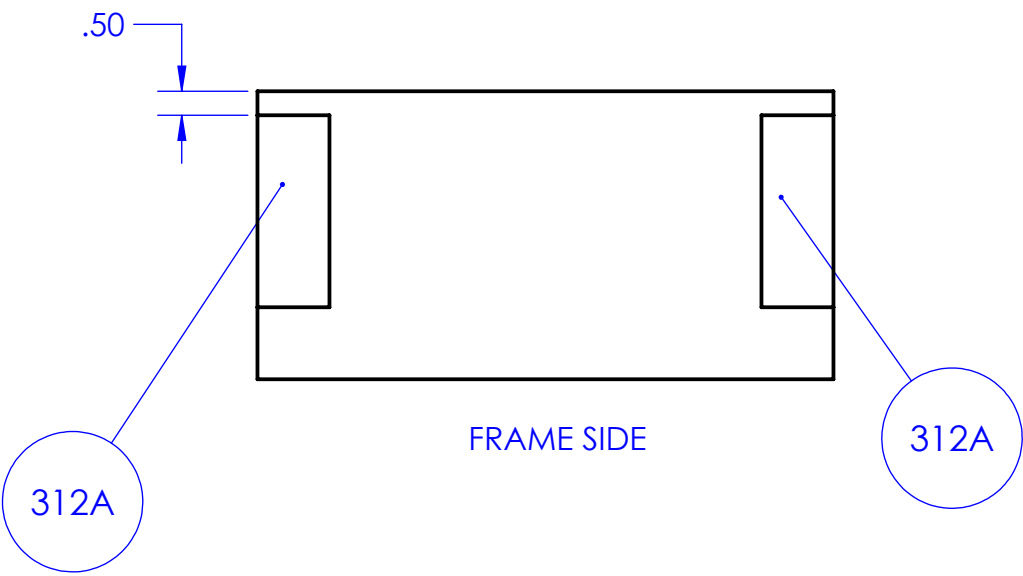
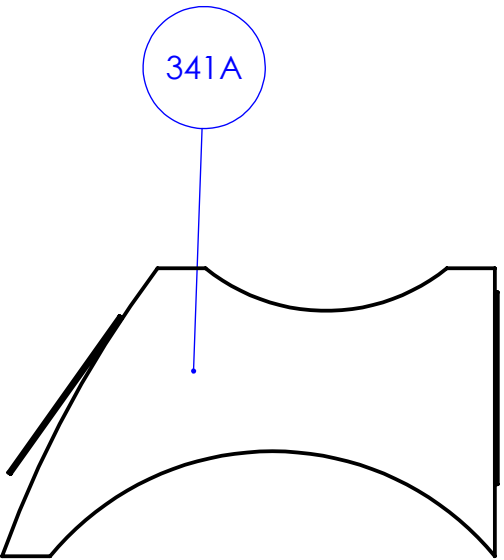
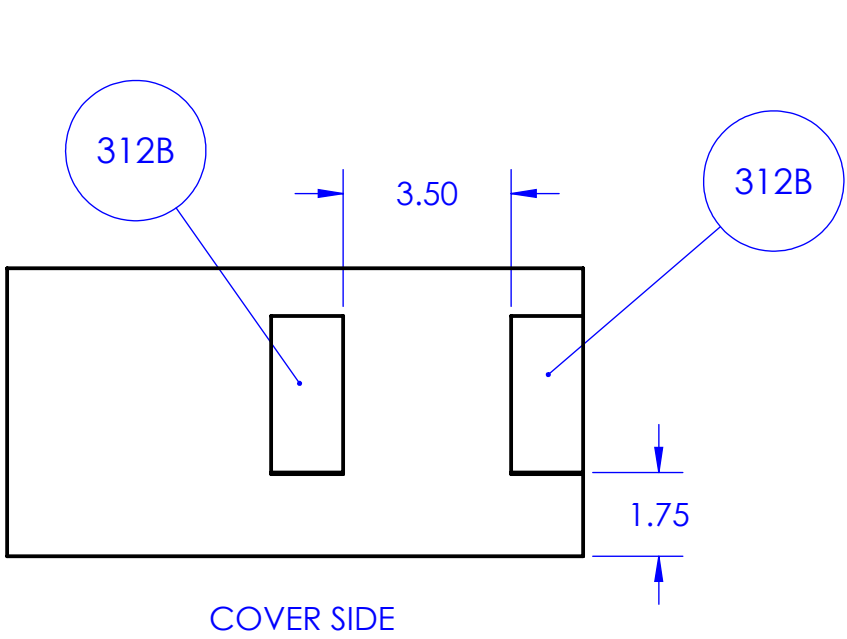
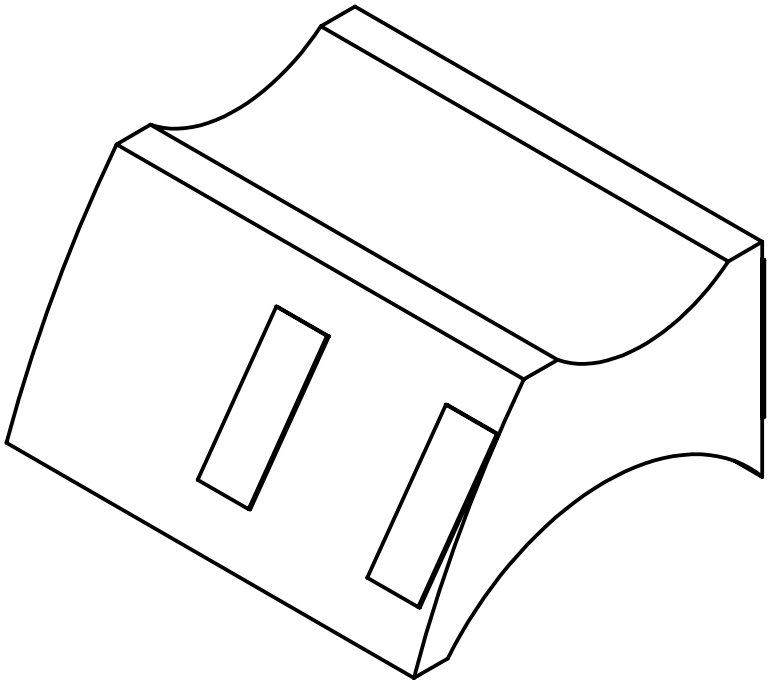


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: RIGHT BACK BUMPER BLOCK		Drwn. By: TARGET PRACTICE
	Dwg. #: 331	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

NOTE:

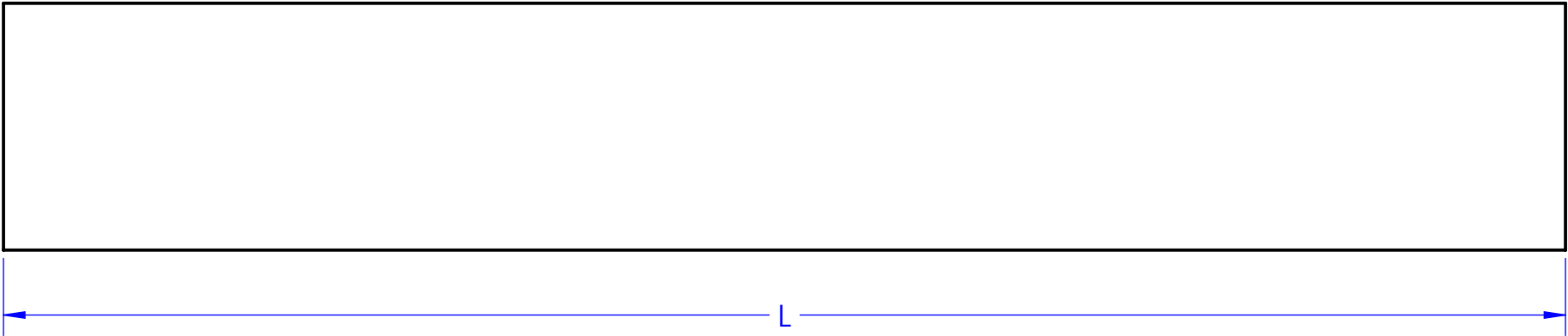
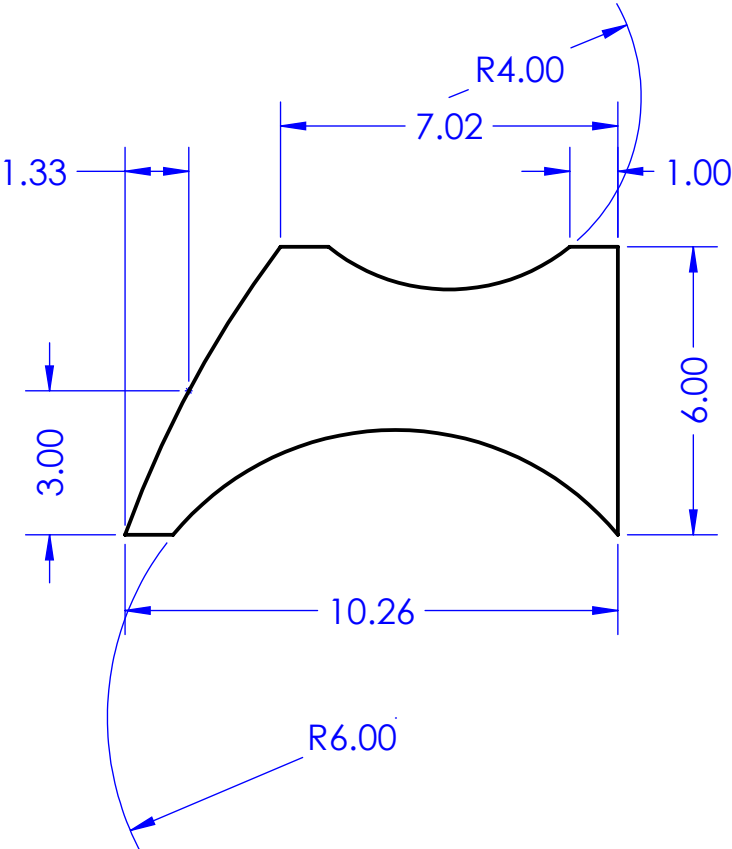
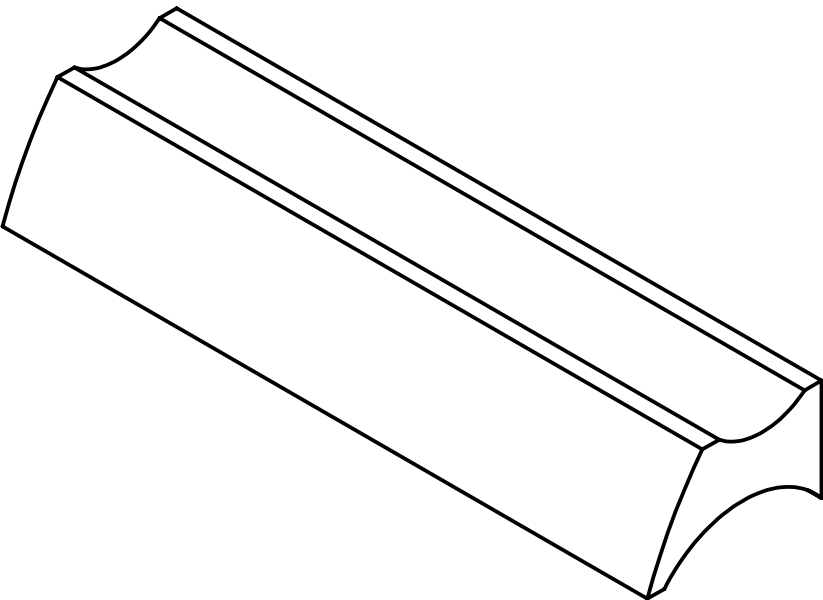
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
3. WRAP OVERHANGING VELCRO

PART NO.	PART NAME	QTY.
341A	SIDE FRONT BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	2
312B	BUMPER VELCRO LOOPS	2



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SIDE FRONT BUMPER RIGHT		Drwn. By: TARGET PRACTICE
	Dwg. #: 340	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK EXPANDED POLYSTYRENE FOAM BLOCK
 - 4. CUTS AND CUT ANGLES ARE SHOWN

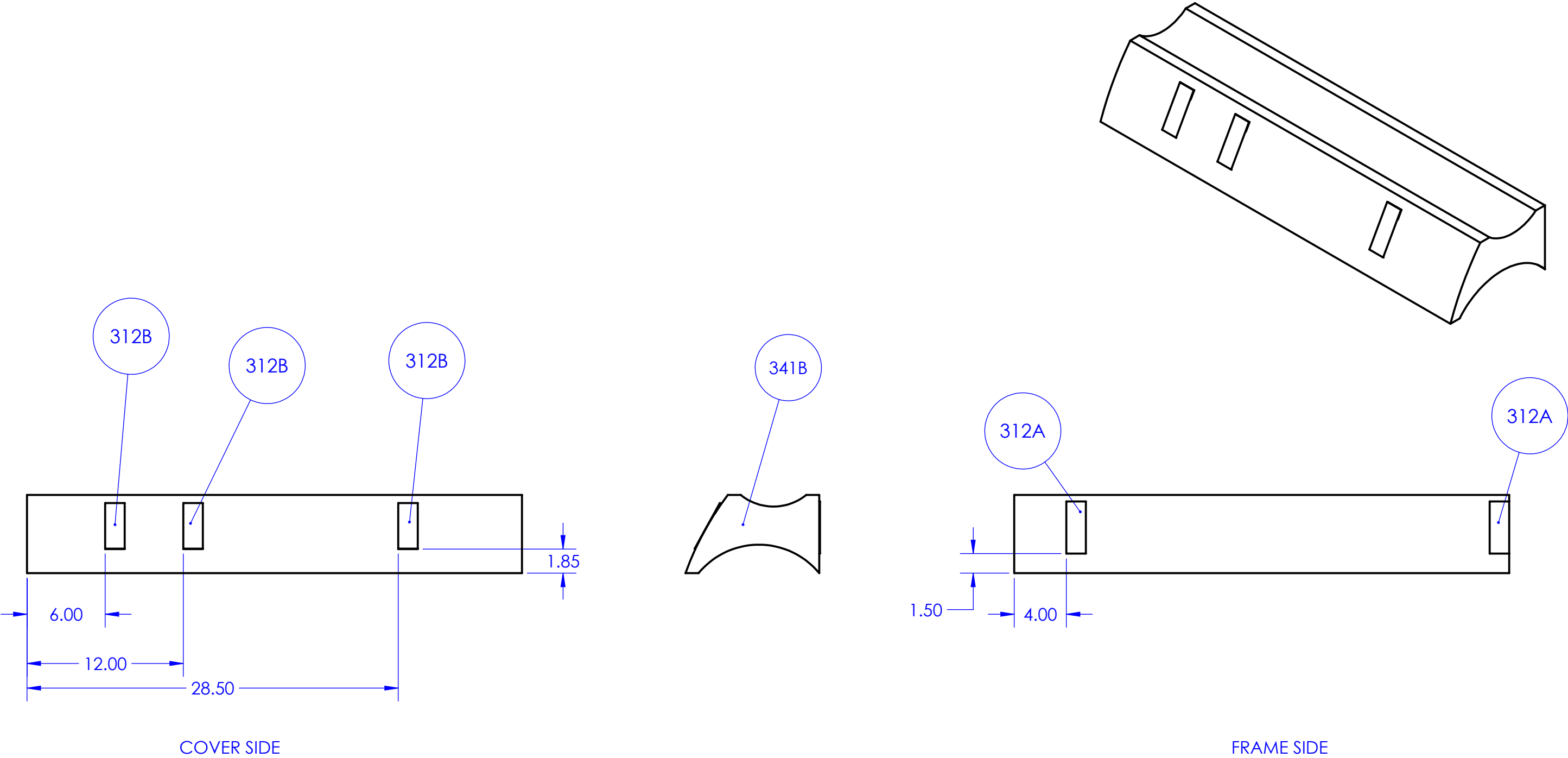


PART NAME	Part Number	Length, L [in]
SIDE FRONT BUMPER FOAM BLOCK	341 A	12.00
SIDE BACK BUMPER FOAM BLOCK	341 B	38.00

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SIDE BUMPER FOAM BLOCK		Drwn. By: TARGET PRACTICE
	Dwg. #: 341	Nxt Asb: NONE	Date: 2/9/2017	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. WRAP OVERHANGING VELCRO

PART NO.	PART NAME	QTY.
341B	SIDE BACK BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	2
312B	BUMPER VELCRO LOOPS	3

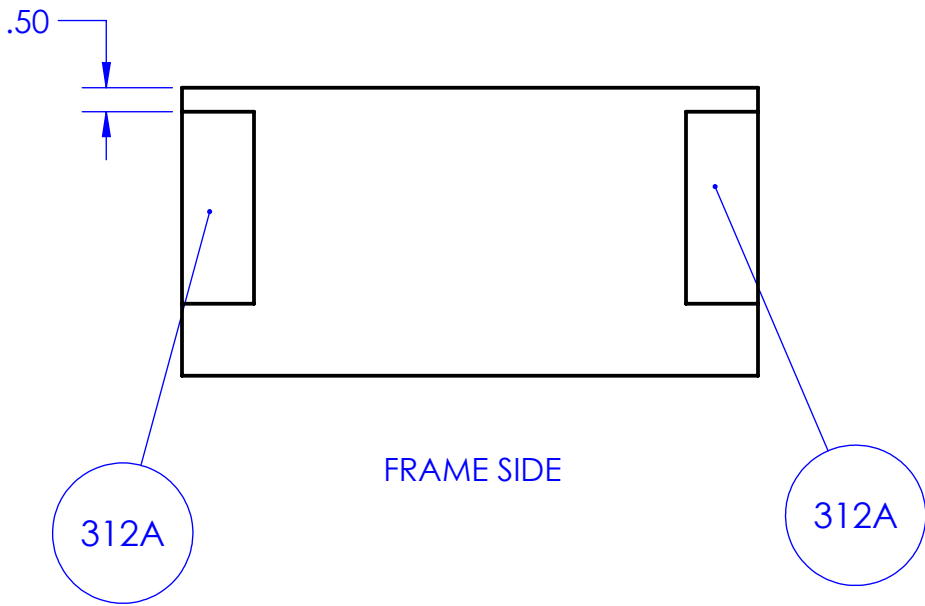
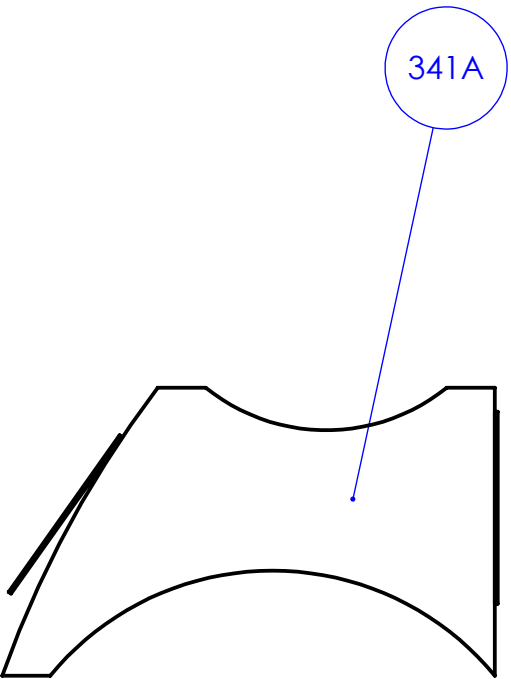
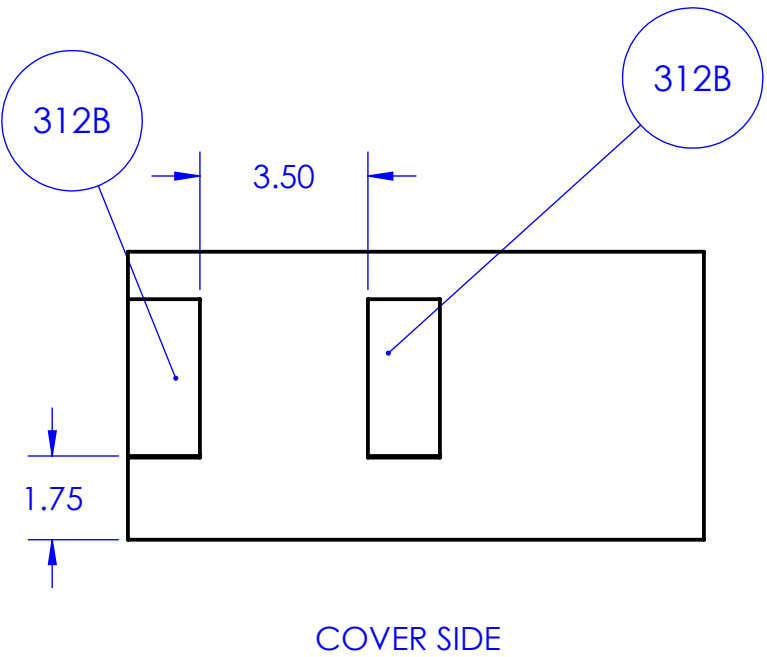
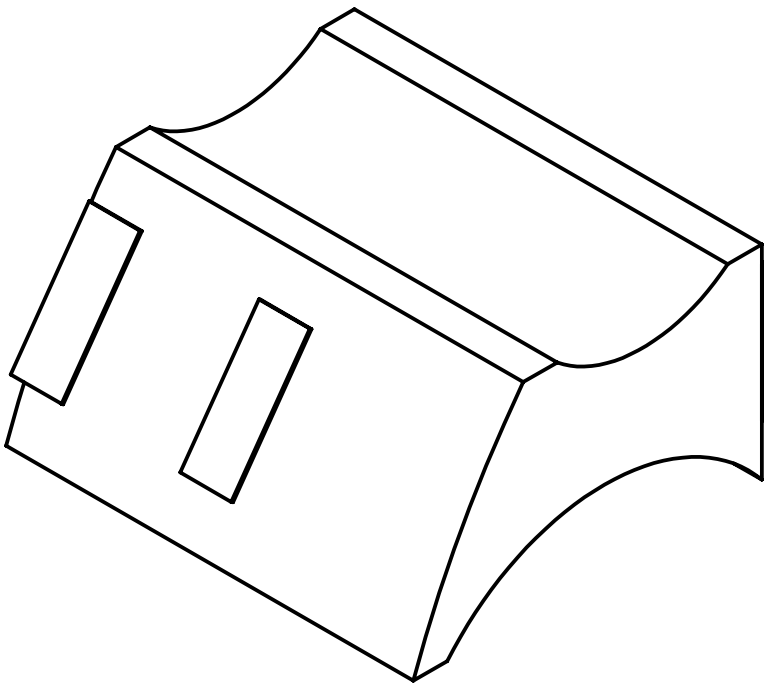


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SIDE BACK BUMPER RIGHT		Drwn. By: TARGET PRACTICE
	Dwg. #: 350	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
3. WRAP OVERHANGING VELCRO

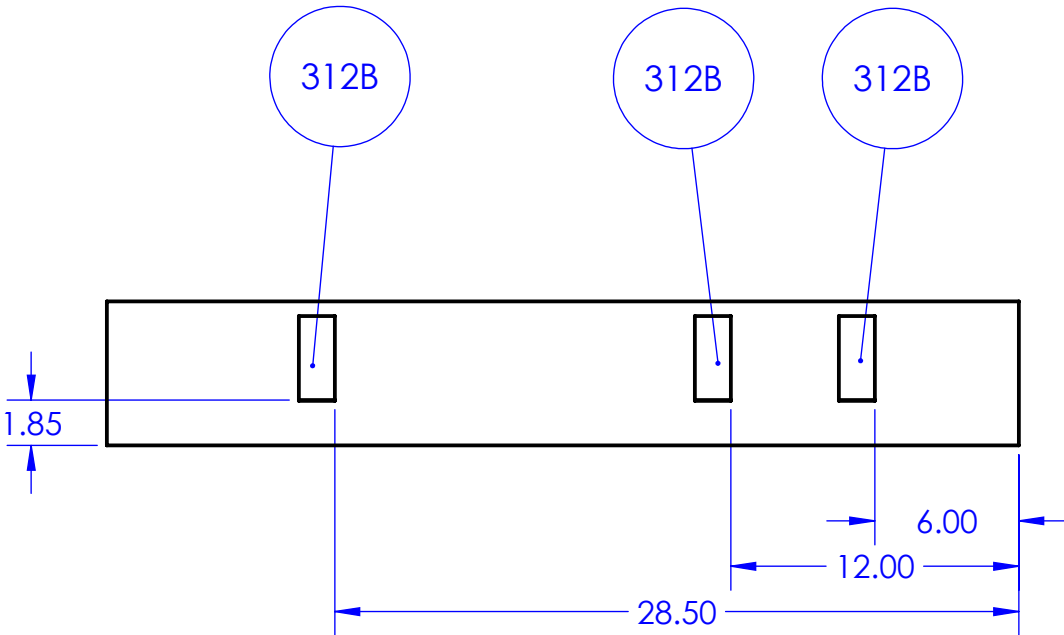
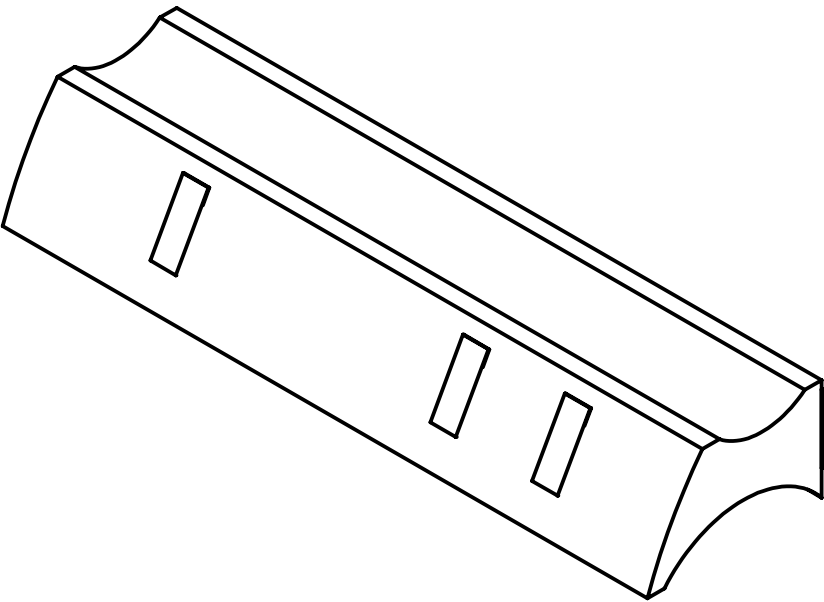
PART NO.	PART NAME	QTY.
341A	SIDE FRONT BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	2
312B	BUMPER VELCRO LOOPS	2



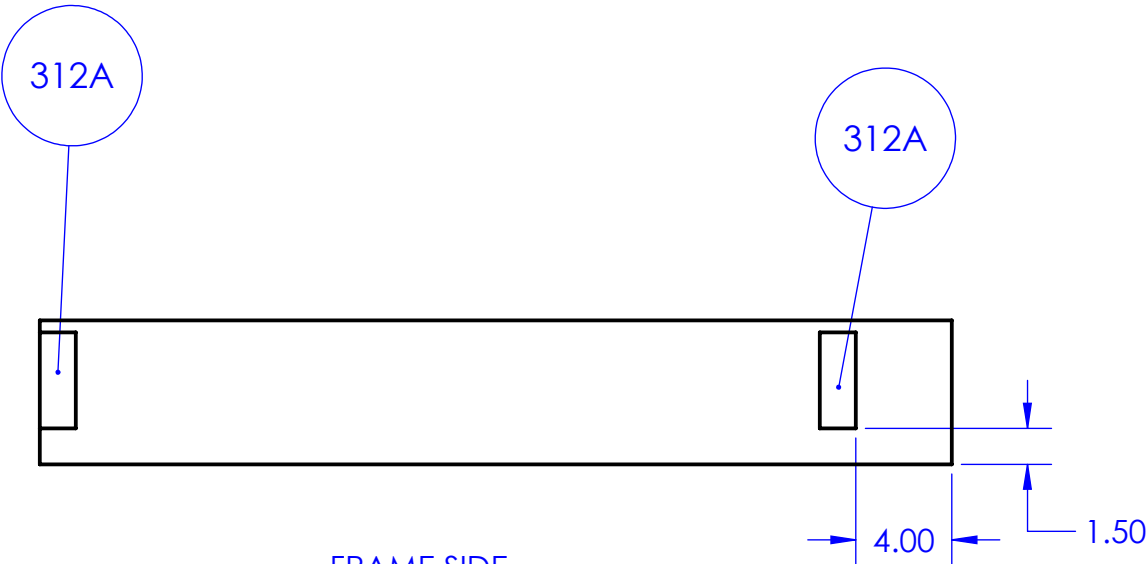
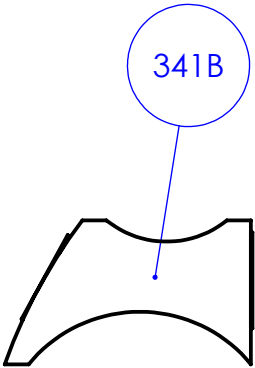
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SIDE FRONT BUMPER LEFT		Drwn. By: TARGET PRACTICE
	Dwg. #: 360	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. WRAP OVERHANGING VELCRO

PART NO.	PART NAME	QTY.
341B	SIDE BACK BUMPER FOAM BLOCK	1
312A	BUMPER VELCRO HOOKS	2
312B	BUMPER VELCRO LOOPS	3

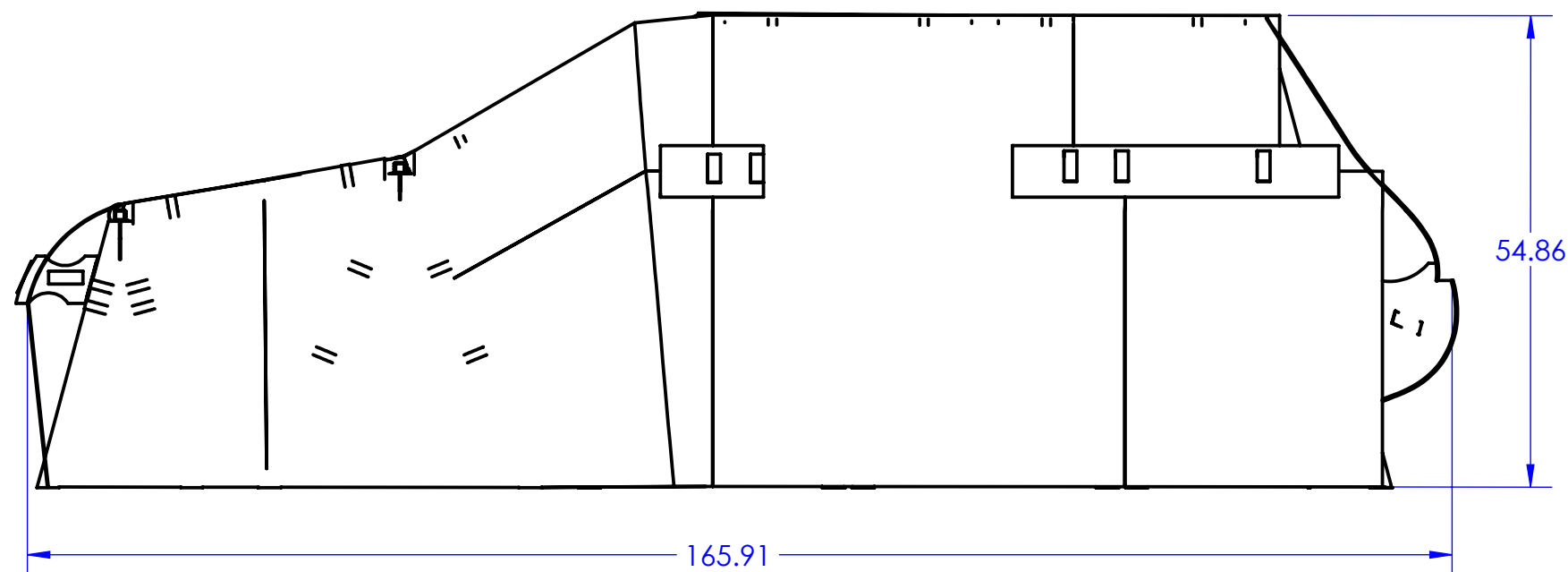
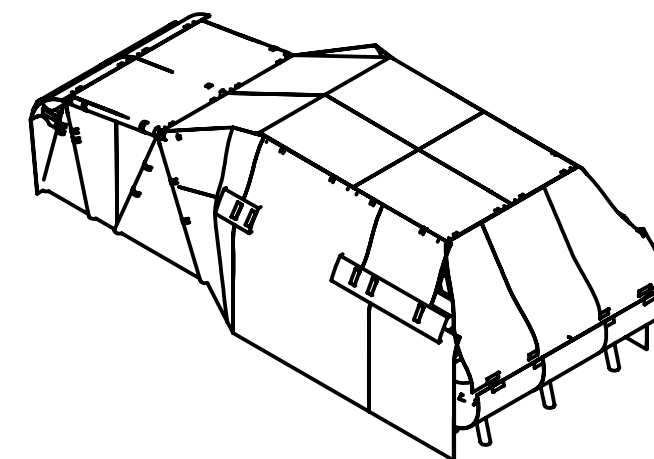
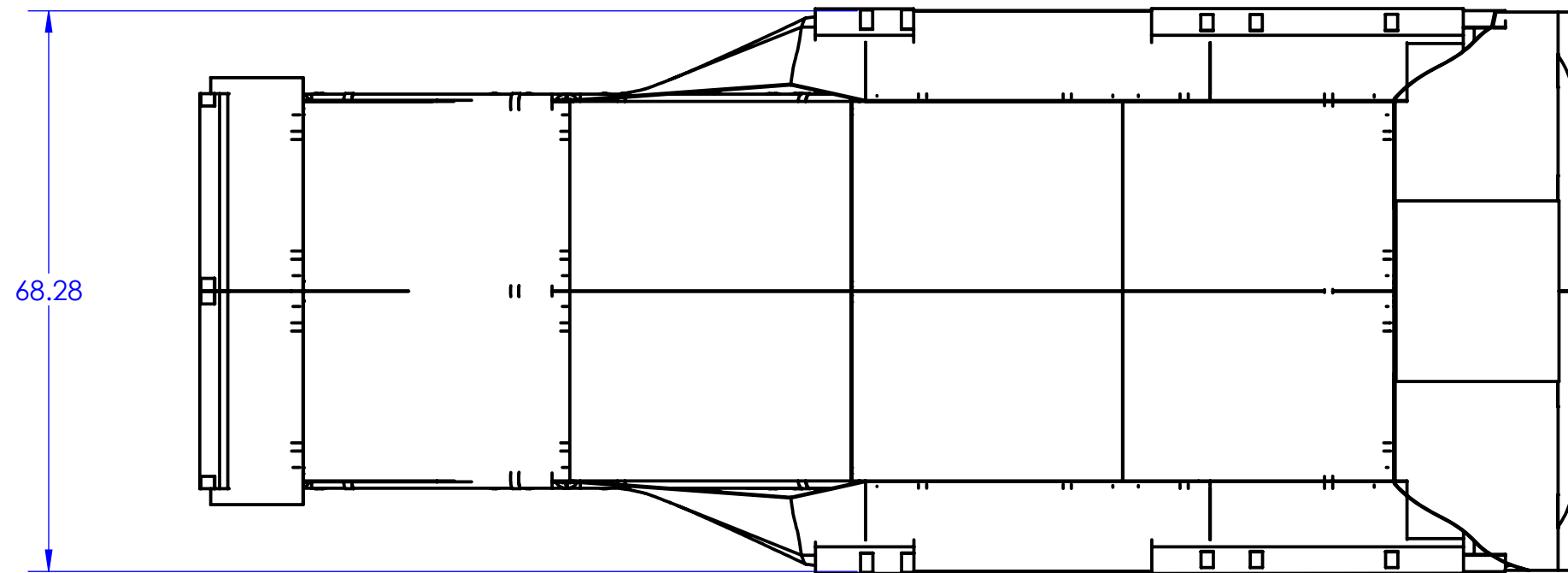


COVER SIDE



FRAME SIDE

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: SIDE BACK BUMPER LEFT		Drwn. By: TARGET PRACTICE
	Dwg. #: 370	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

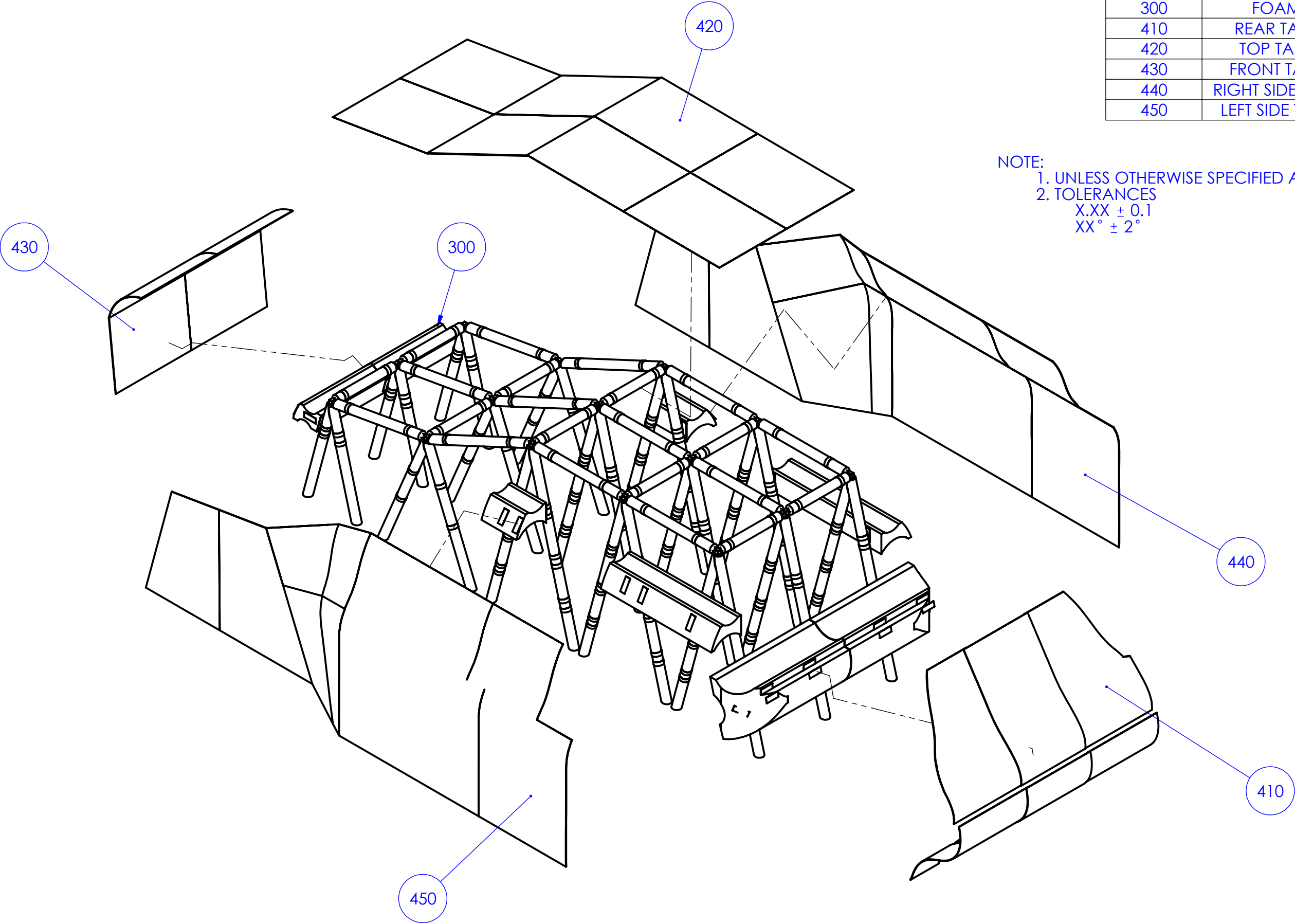


- NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
 3. COVERING ATTACHES AS THE OUTERMOST COMPONENTS

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: TARP ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 400	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:20	Chkd. By: ME STAFF

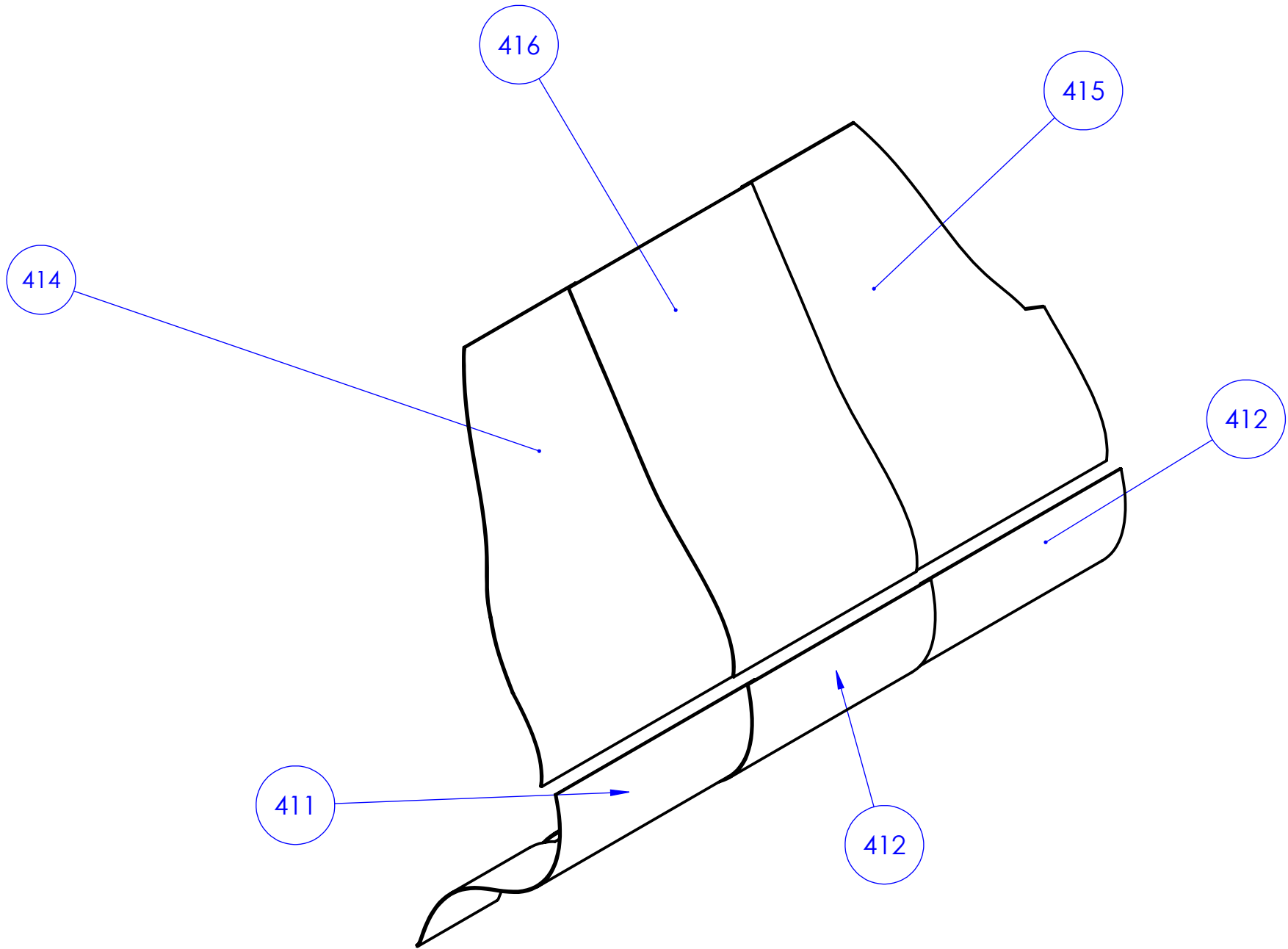
PART NO.	PART NAME	QUANTITY
300	FOAM ASSEMBLY	1
410	REAR TARP ASSEMBLY	1
420	TOP TARP ASSEMBLY	1
430	FRONT TARP ASSEMBLY	1
440	RIGHT SIDE TARP ASSEMBLY	1
450	LEFT SIDE TARP ASSEMBLY	1

NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°



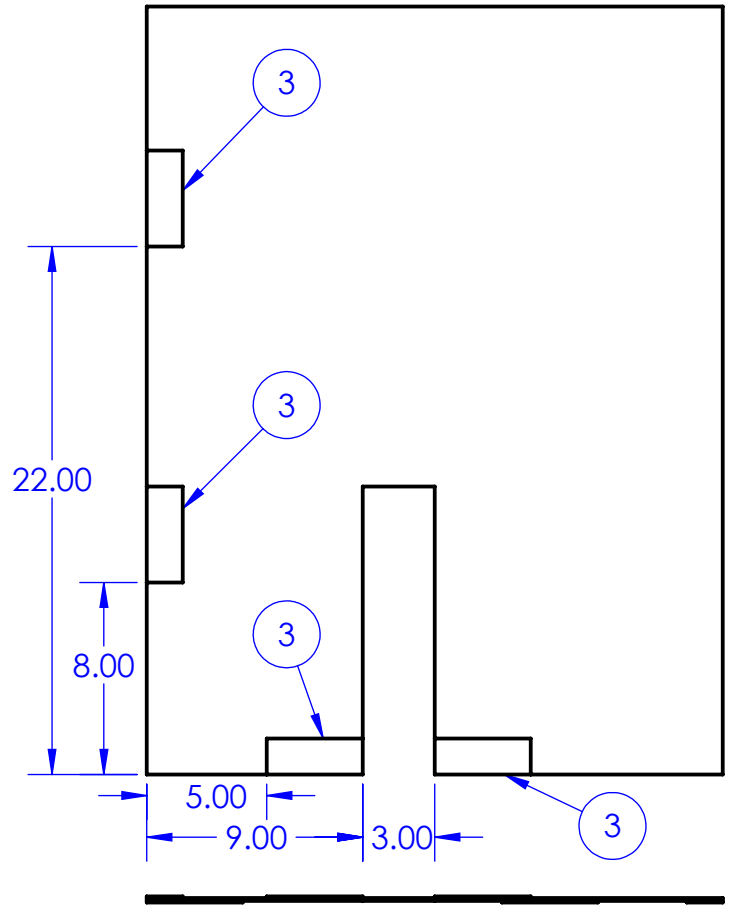
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: EXPLODED TARP ASSEMBLY		Drwn. By: TARGET PRACTICE	
	Dwg. #: 401	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:24	Chkd. By: ME STAFF	

PART NO.	PART NAME	QUANTITY
411	LEFT B1 ASSEMBLY	1
412	RIGHT B1 ASSEMBLY	1
413	B2 ASSEMBLY	1
414	LEFT B3 ASSEMBLY	1
415	RIGHT B3 ASSEMBLY	1
416	B4 ASSEMBLY	1

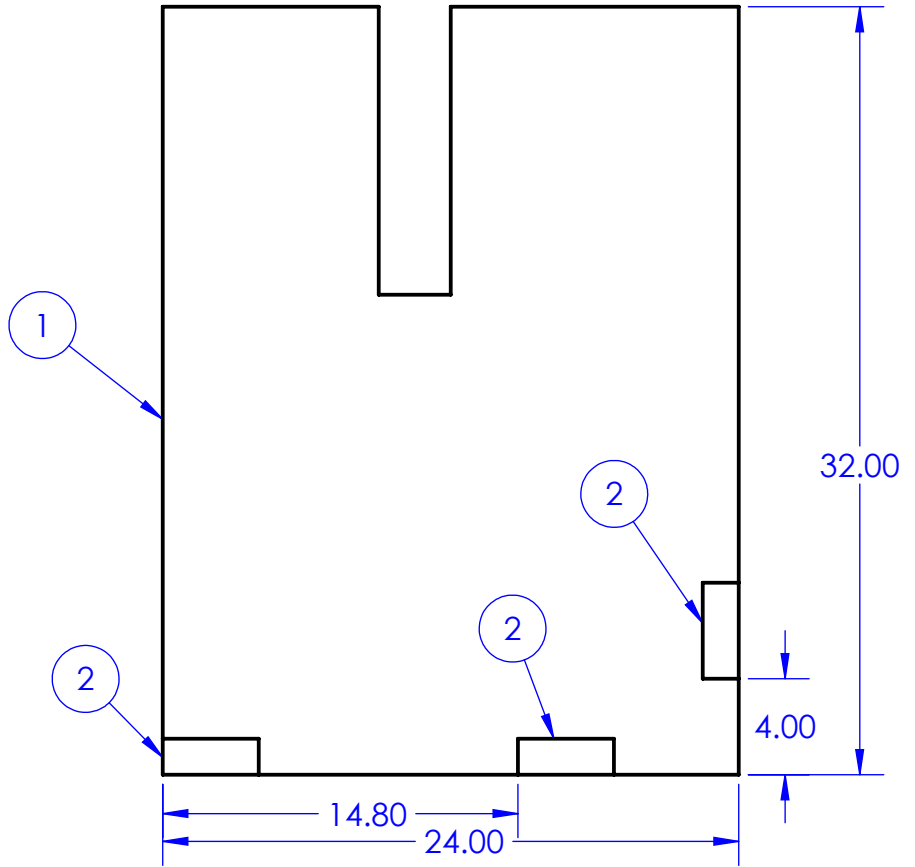


NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. COVERING OVERLAPS ADJACENT PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: REAR TARP ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 410	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF

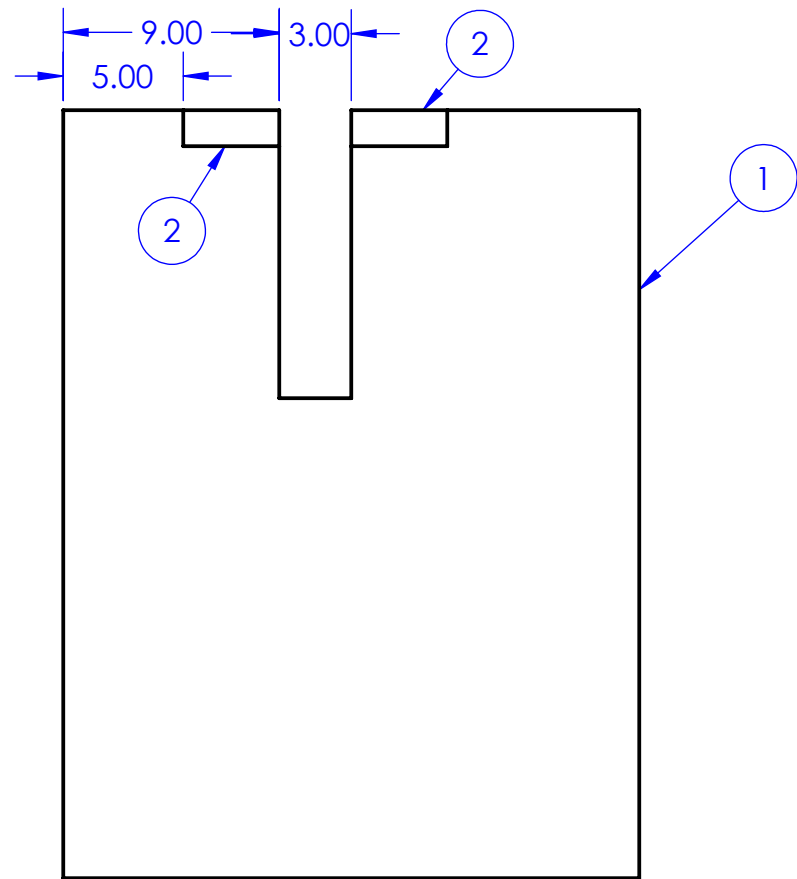
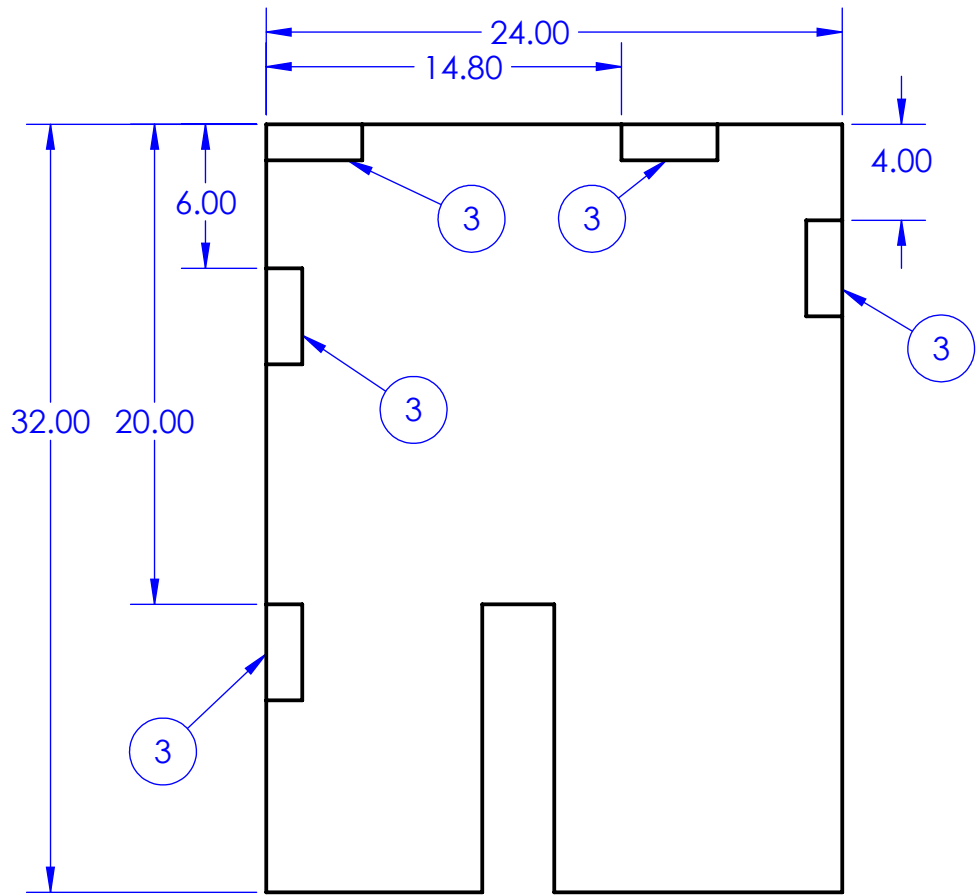


BALLOON	PART NO.	PART NAME	QTY.
1	461	B1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	3
3	312B	BUMPER VELCRO LOOPS	4



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left B1 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 411	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

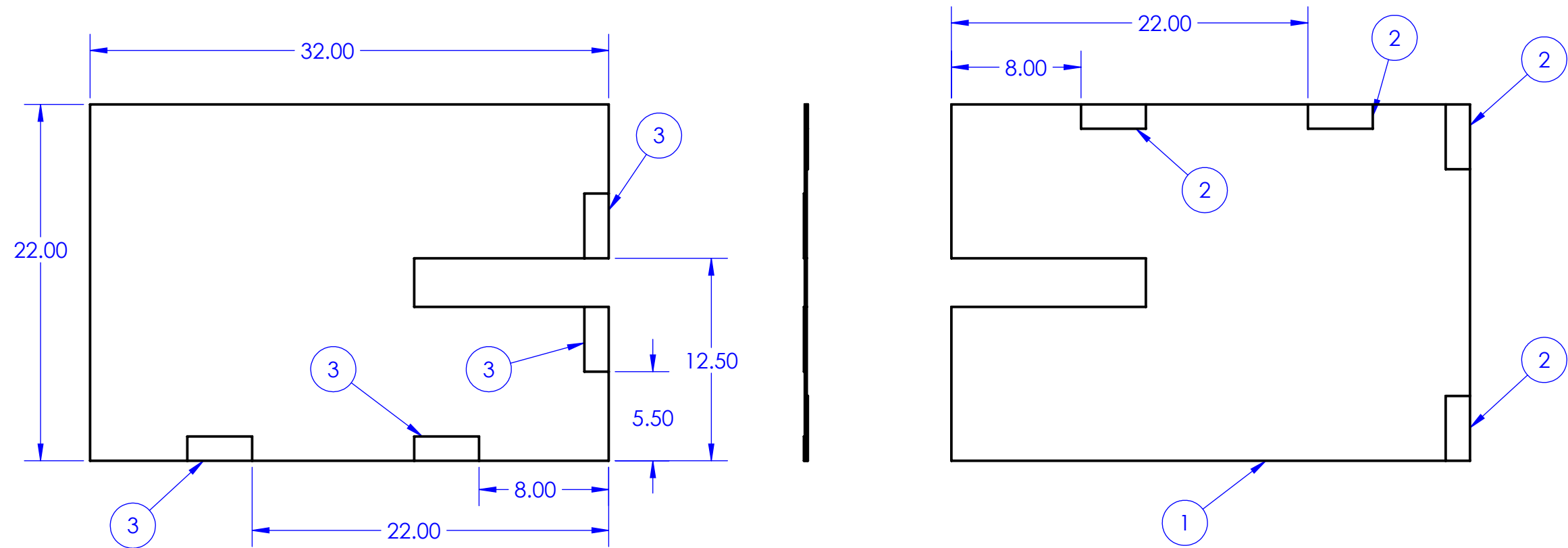


BALLOON	PART NO.	PART NAME	QTY.
1	461	B1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	2
3	312B	BUMPER VELCRO LOOPS	5

NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

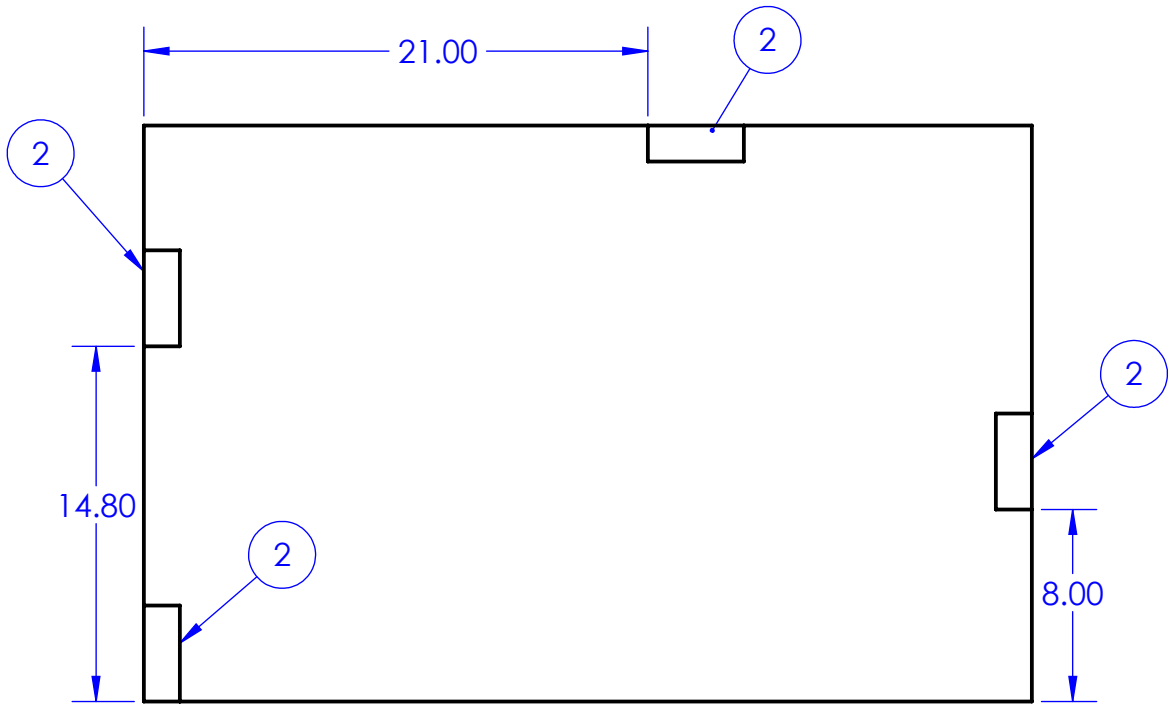
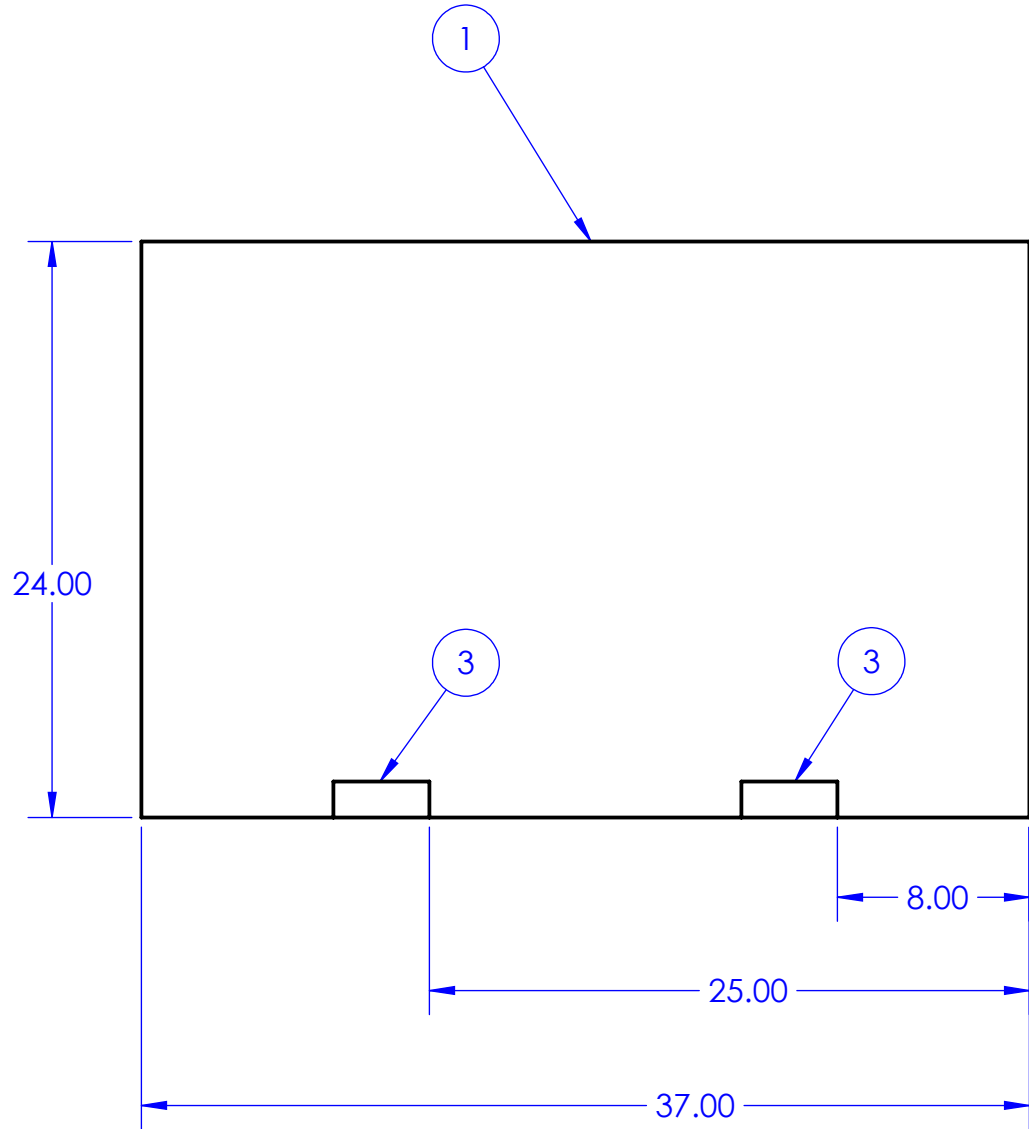
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right B1 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 412	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

BALLOON	PART NO.	PART NAME	QTY.
1	462	B2 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	4



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

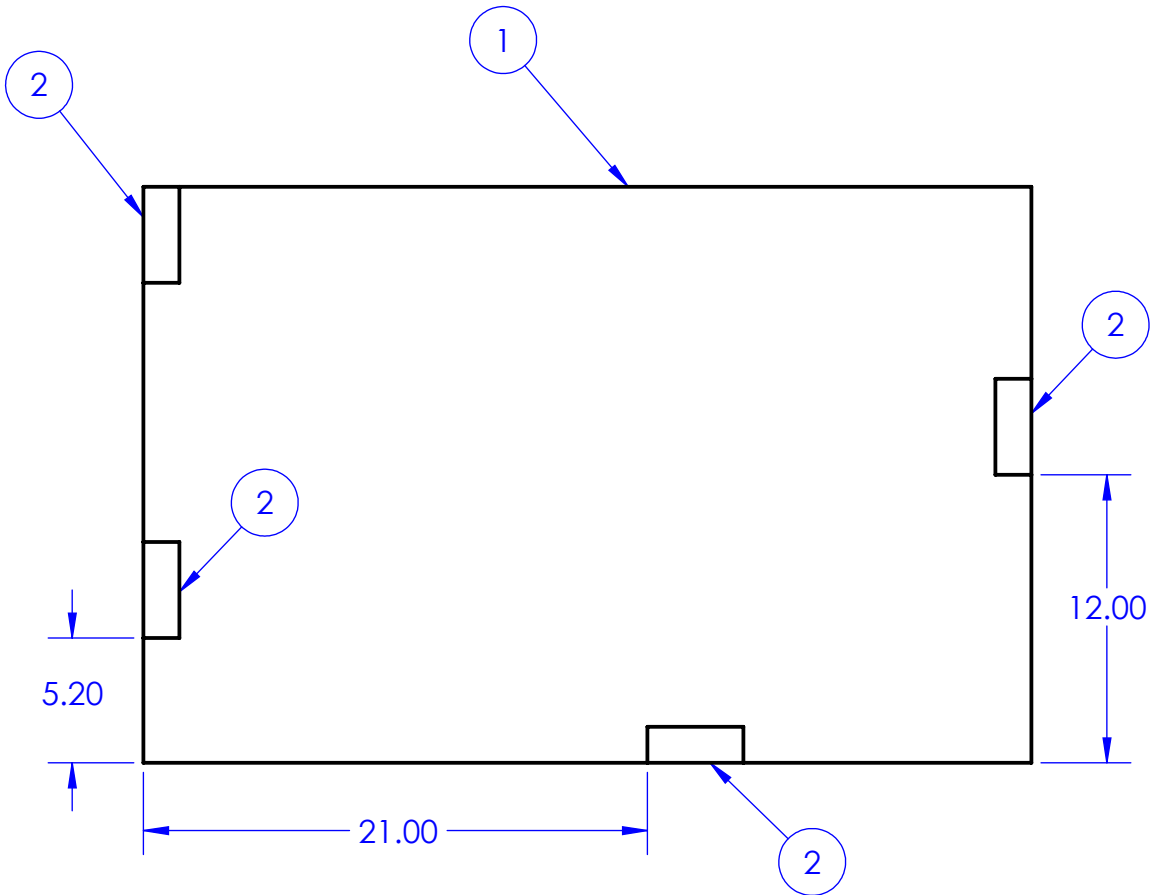
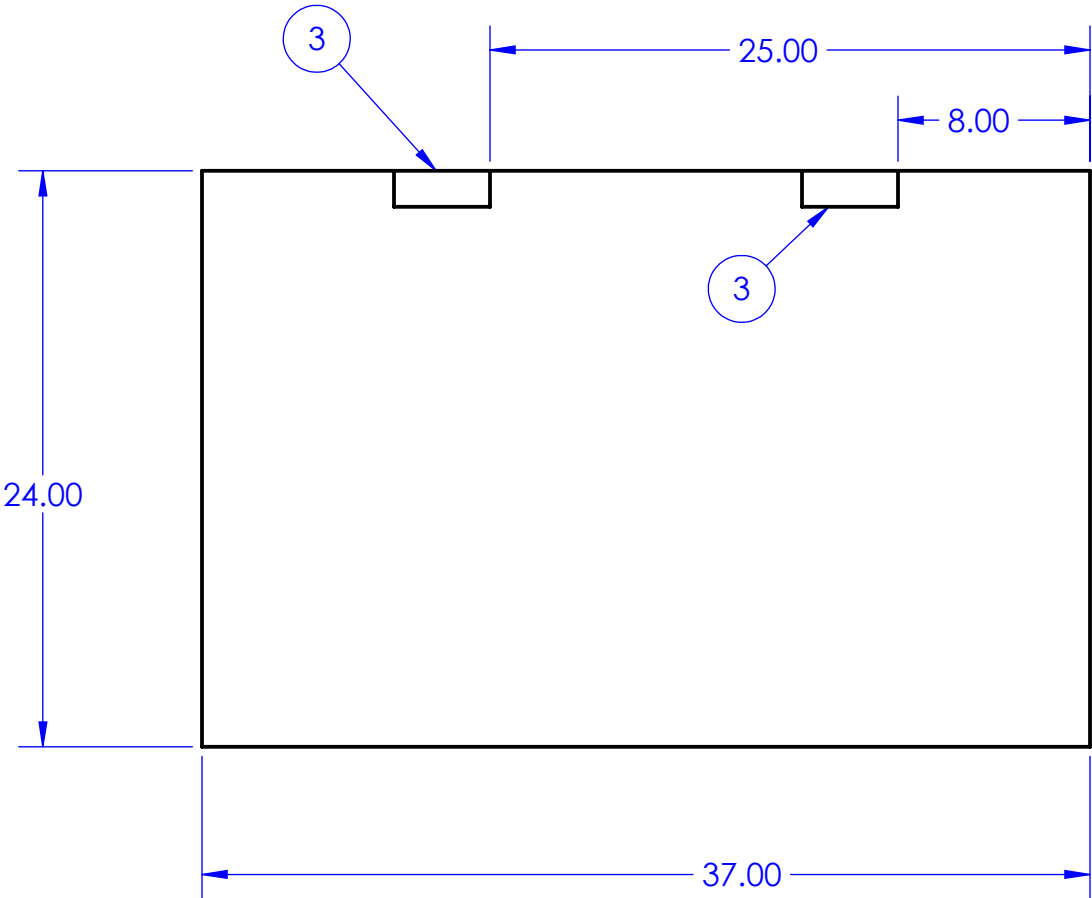
BALLOON	PART NO.	PART NAME	QTY.
1	463	B3 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left B3 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 414	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

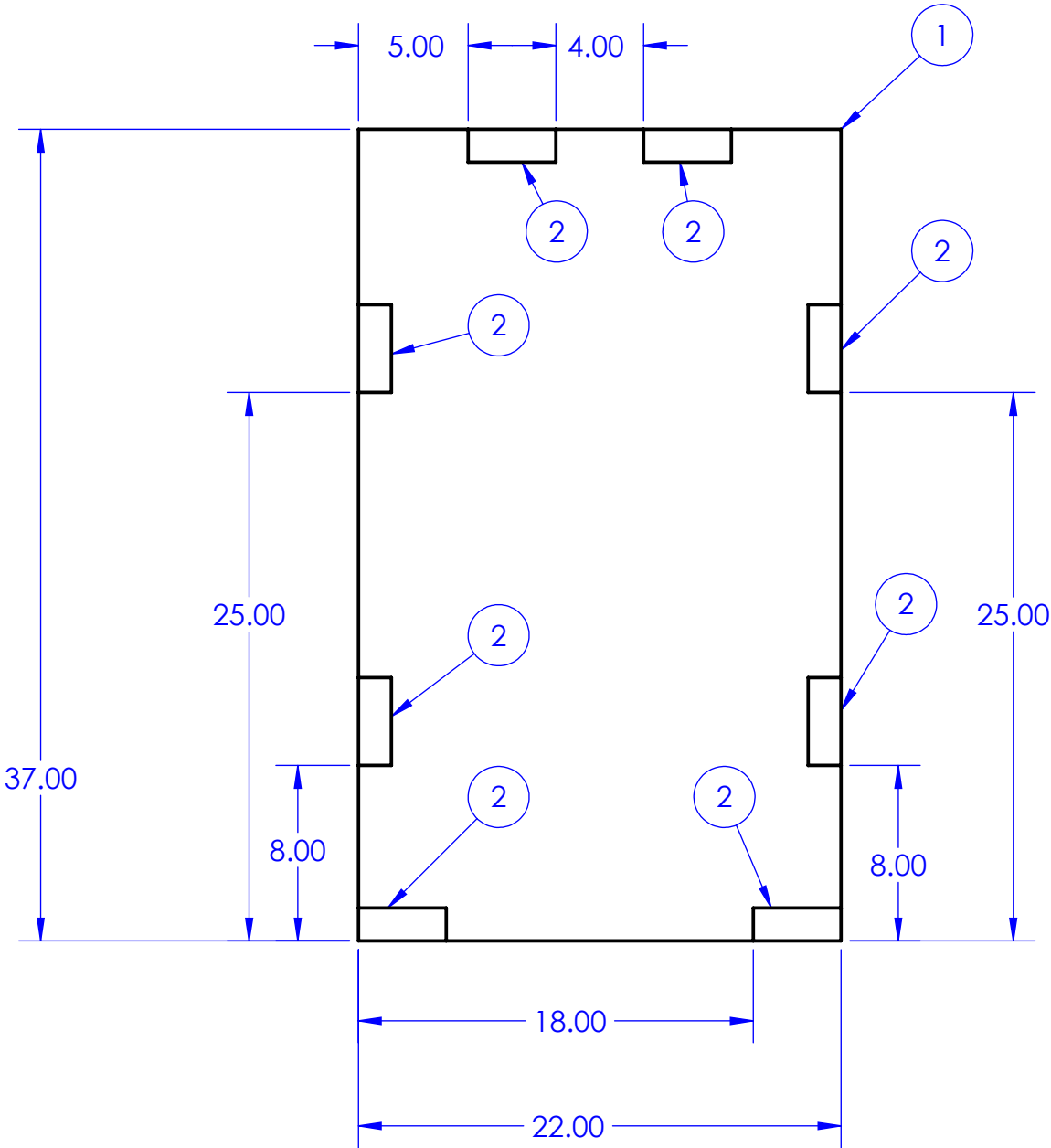
BALLOON	PART NO.	PART NAME	QTY.
1	463	B3 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right B3 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 415	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

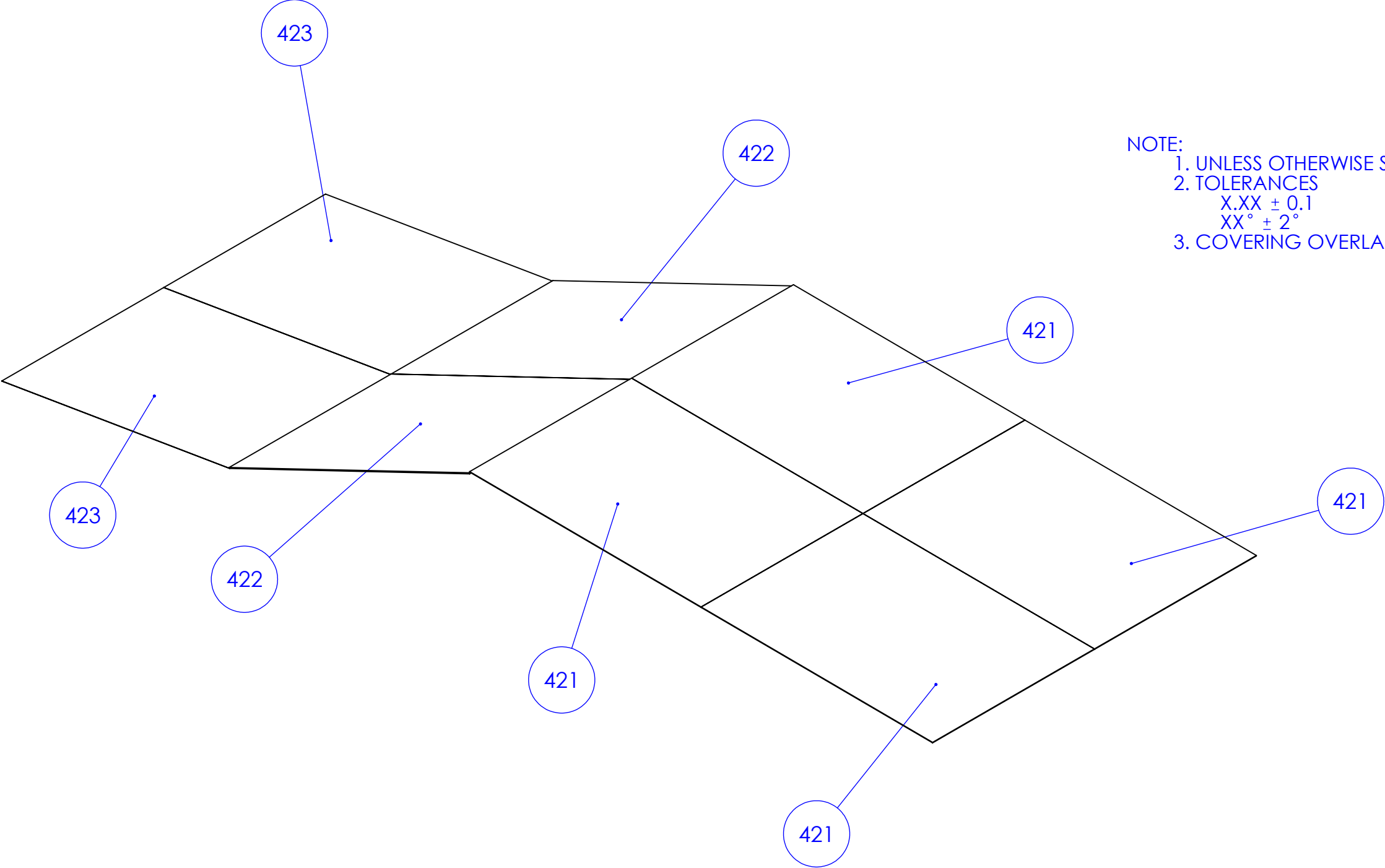
BALLOON	PART NO.	PART NAME	QTY.
1	464	B4 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	8
3	312B	BUMPER VELCRO LOOPS	0



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering	Lab Section: 09	Assignment CDR	Title: B4 Assembly	Drwn. By: TARGET PRACTICE
AEBS TEST TARGET TEAM	Dwg. #: 416	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1
				Chkd. By: ME STAFF

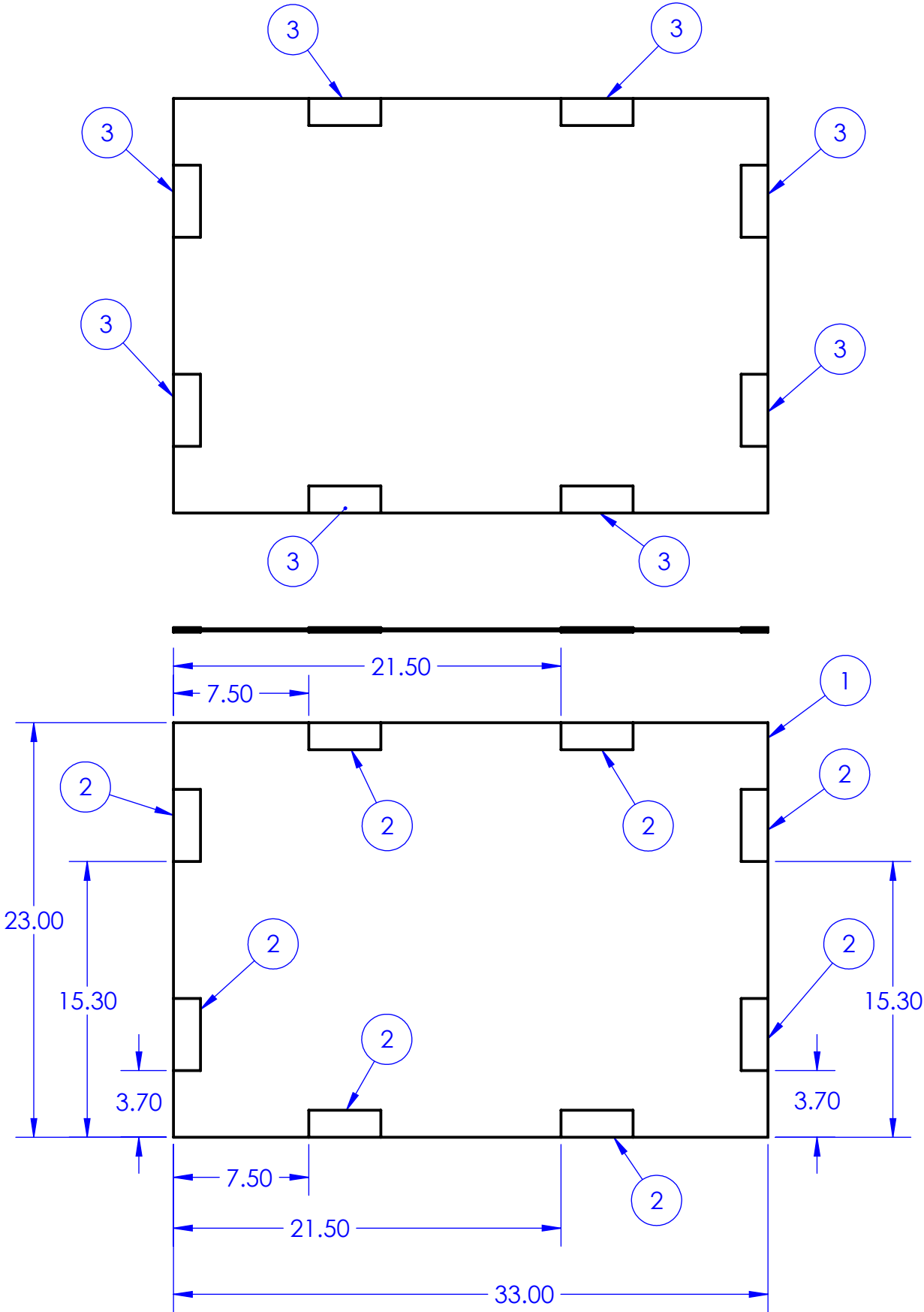
PART NO.	PART NAME	QUANTITY
421	T1 ASSEMBLY	4
422	T2 ASSEMBLY	2
423	T3 ASSEMBLY	2



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. COVERING OVERLAPS ADJACENT PIECES

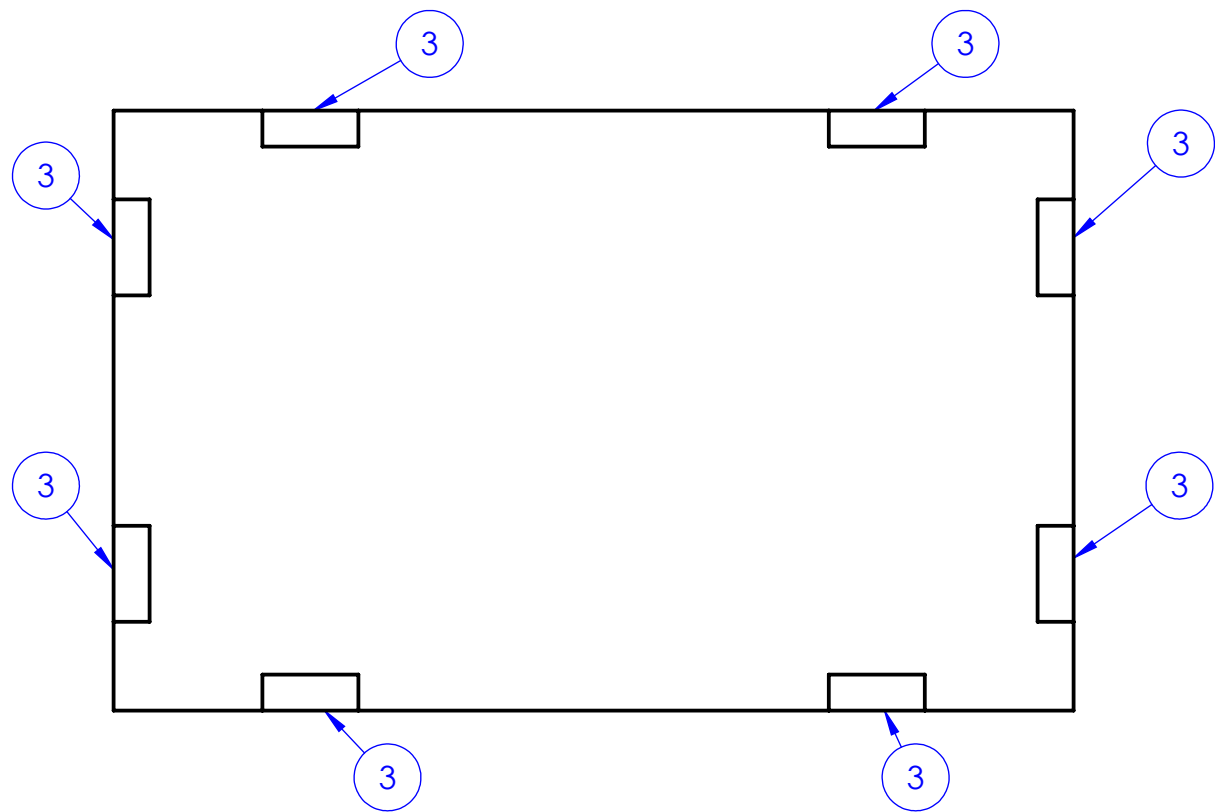
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: TOP TARP ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 420	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF

BALLOON	PART NO.	PART NAME	QTY.
1	471	T1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	8
3	312B	BUMPER VELCRO LOOPS	8

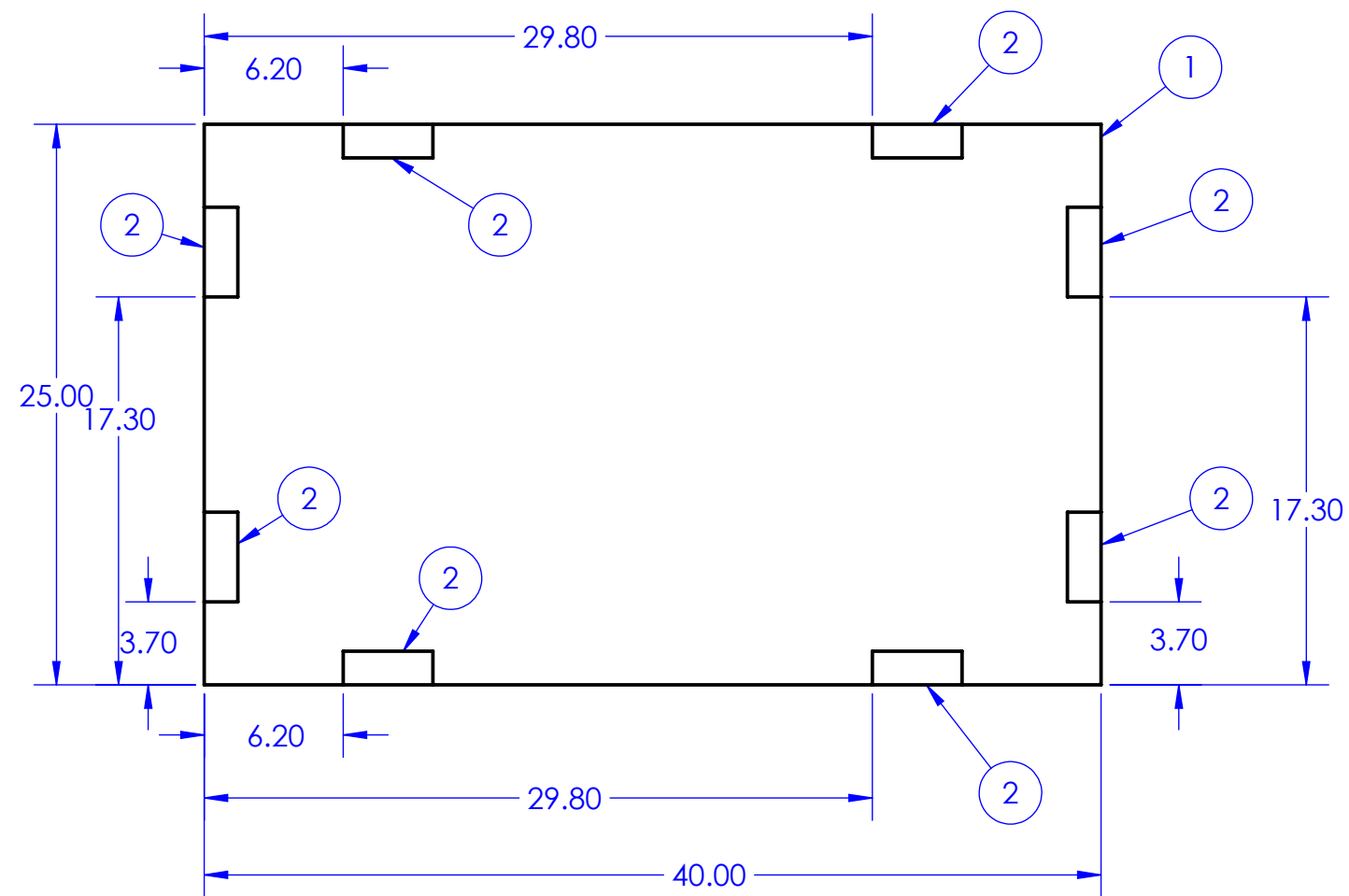


NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. LOCATIONS FOR BOTH THE VELCRO HOOKS AND LOOPS
 ARE THE SAME

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: T1 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 421	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

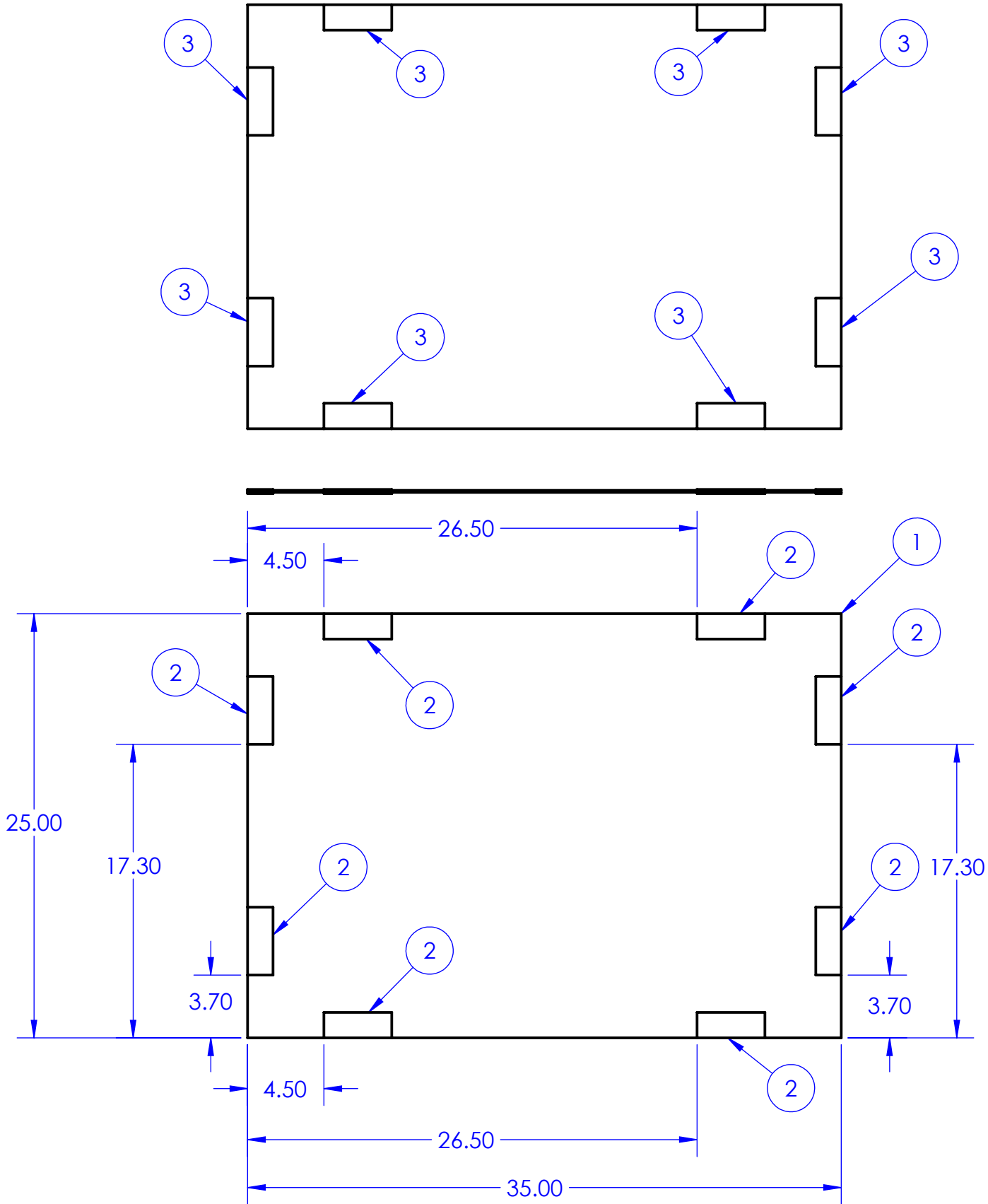


BALLOON	PART NO.	PART NAME	QTY.
1	472	T2 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	8
3	312B	BUMPER VELCRO LOOPS	8



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. LOCATIONS FOR BOTH THE VELCRO HOOKS AND LOOPS
 ARE THE SAME

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: T2 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 422	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

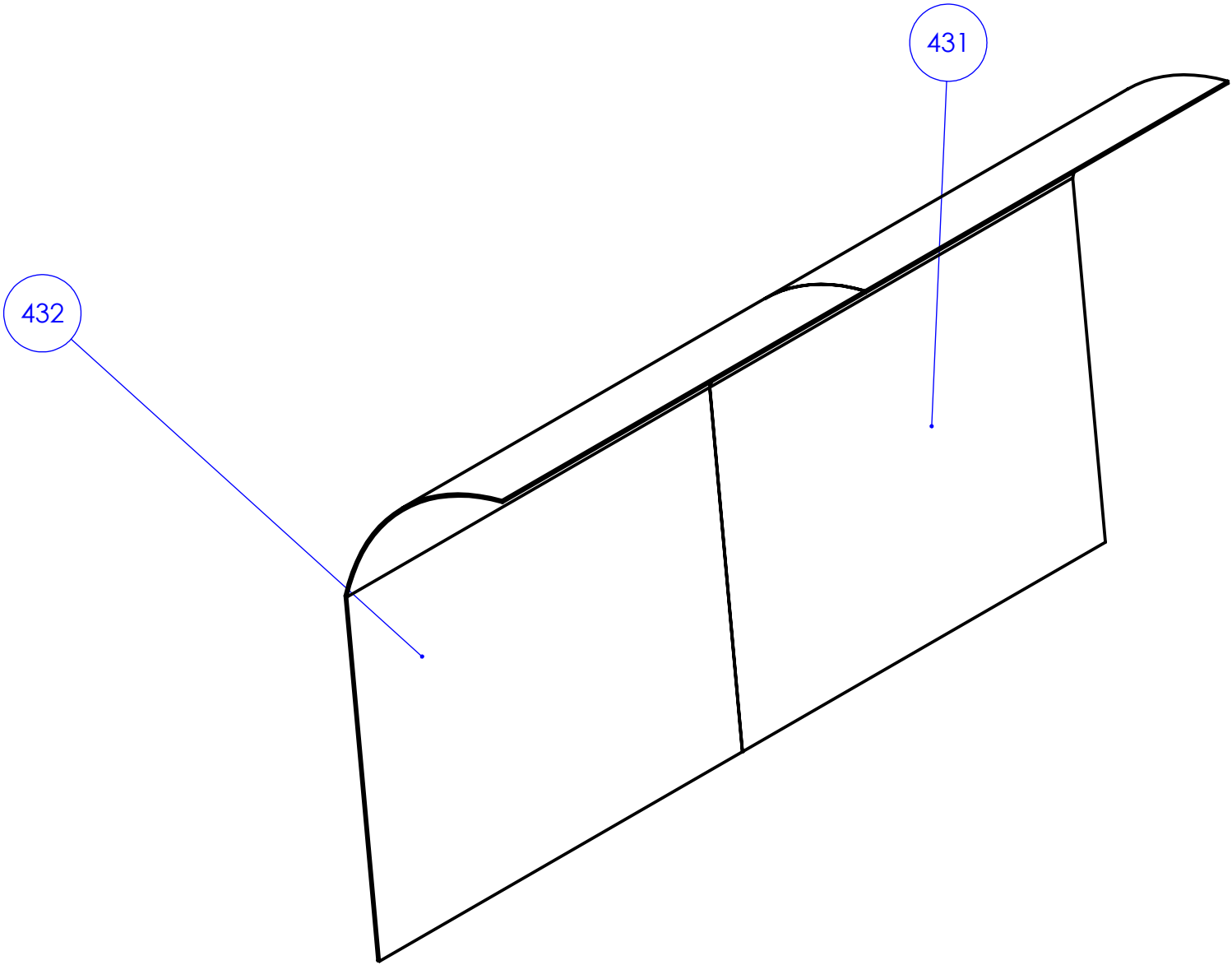


BALLOON	PART NO.	PART NAME	QTY.
1	473	T3 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	8
3	312B	BUMPER VELCRO LOOPS	8

NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. LOCATIONS FOR BOTH THE VELCRO HOOKS AND LOOPS
 ARE THE SAME

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: T3 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 423	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

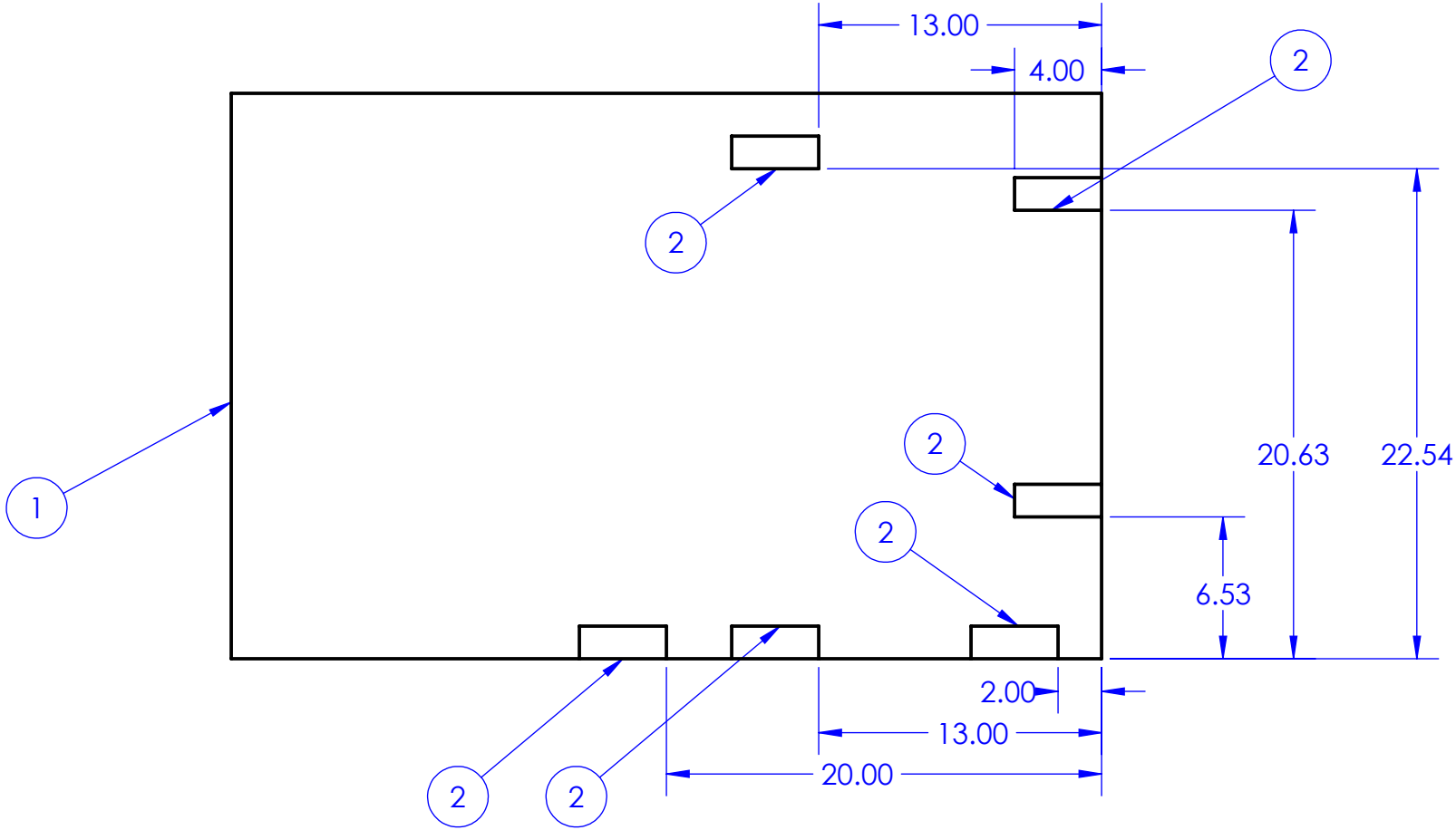
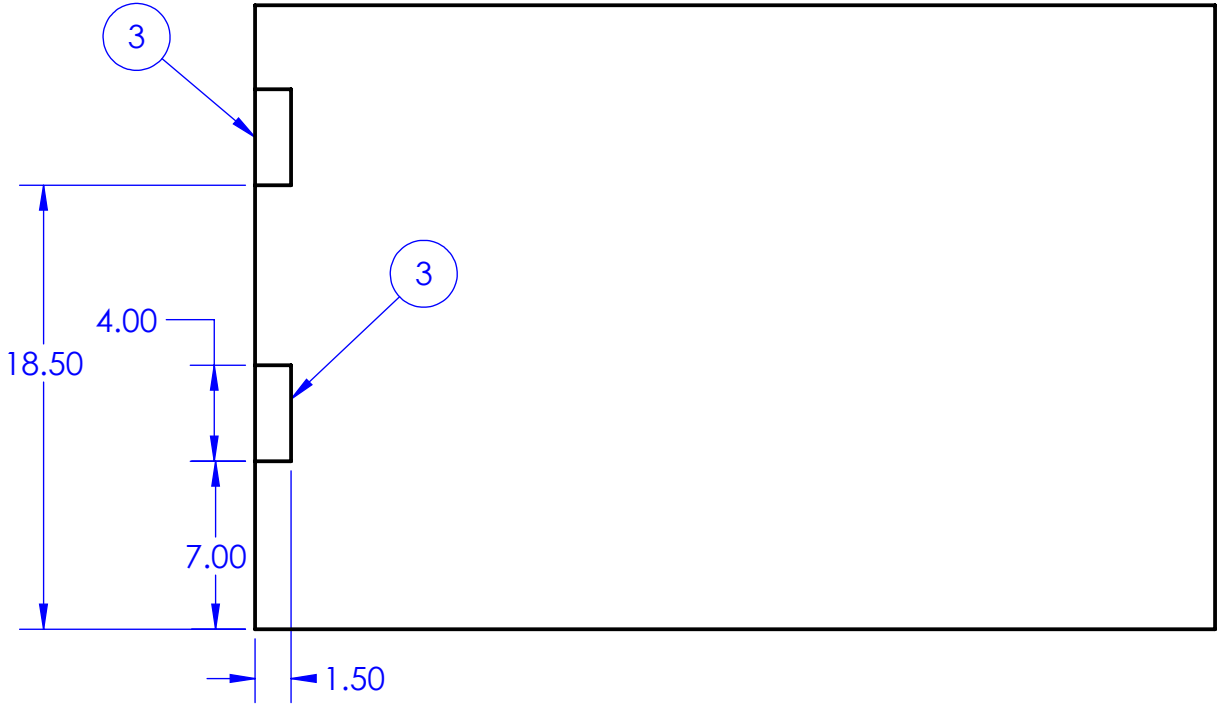
PART NO.	PART NAME	QUANTITY
431	LEFT F1 ASSEMBLY	1
432	RIGHT F1 ASSEMBLY	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. COVERING OVERLAPS ON SIDE

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: FRONT TARP ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 430	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

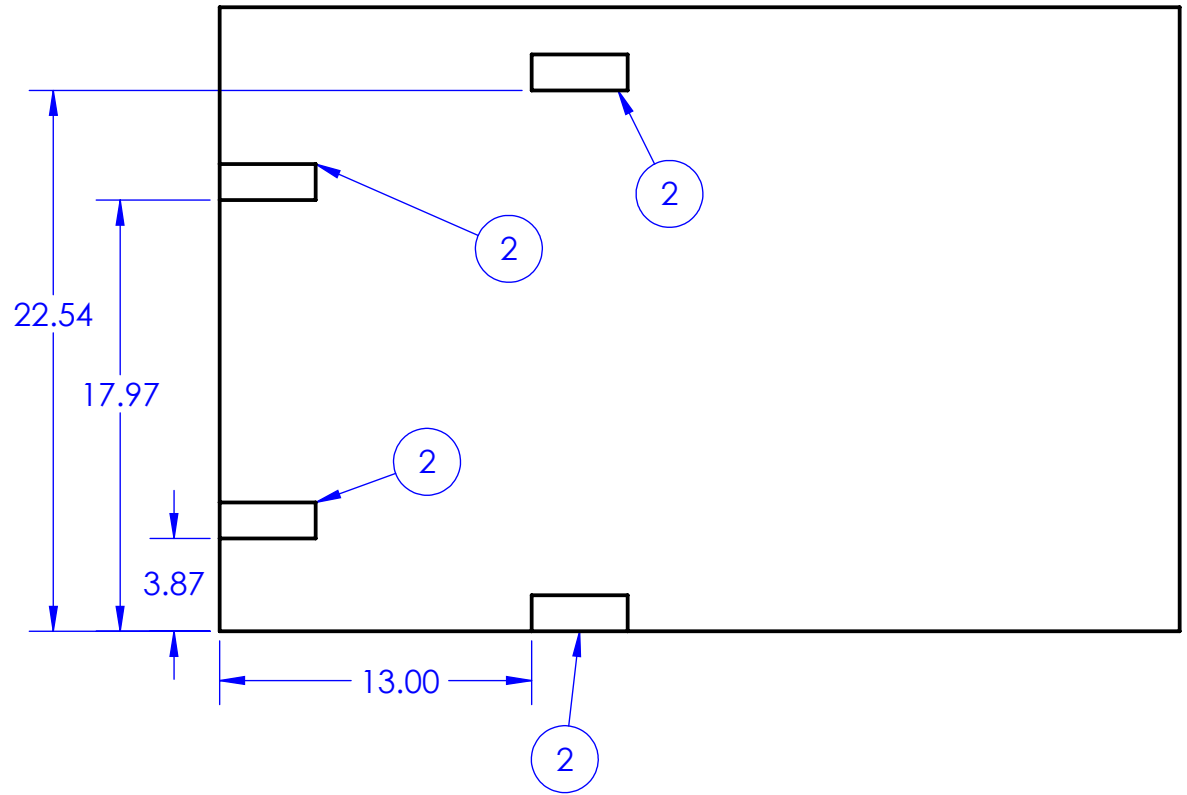
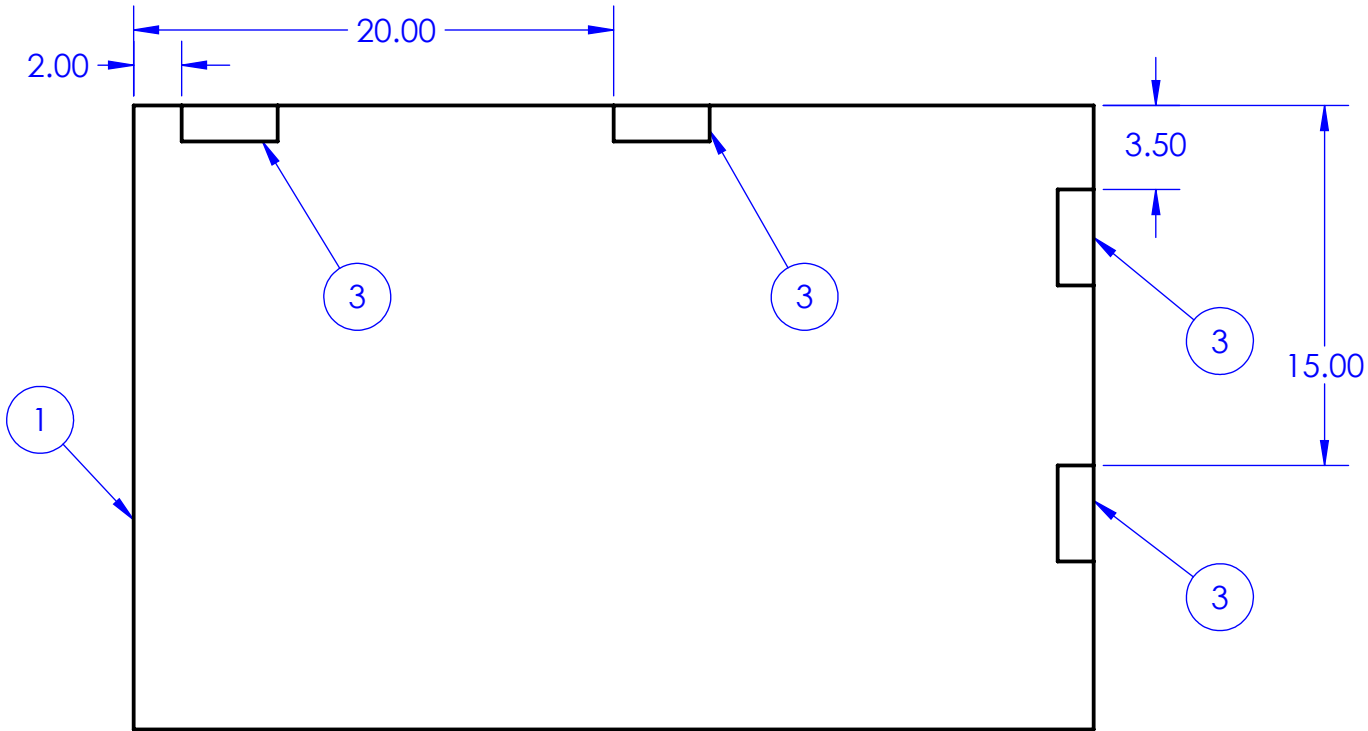
BALLOON	PART NO.	PART NAME	QTY.
1	481	F1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	6
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: LEFT F1 Assembly		Drwn. By:
	Dwg. #: 431	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

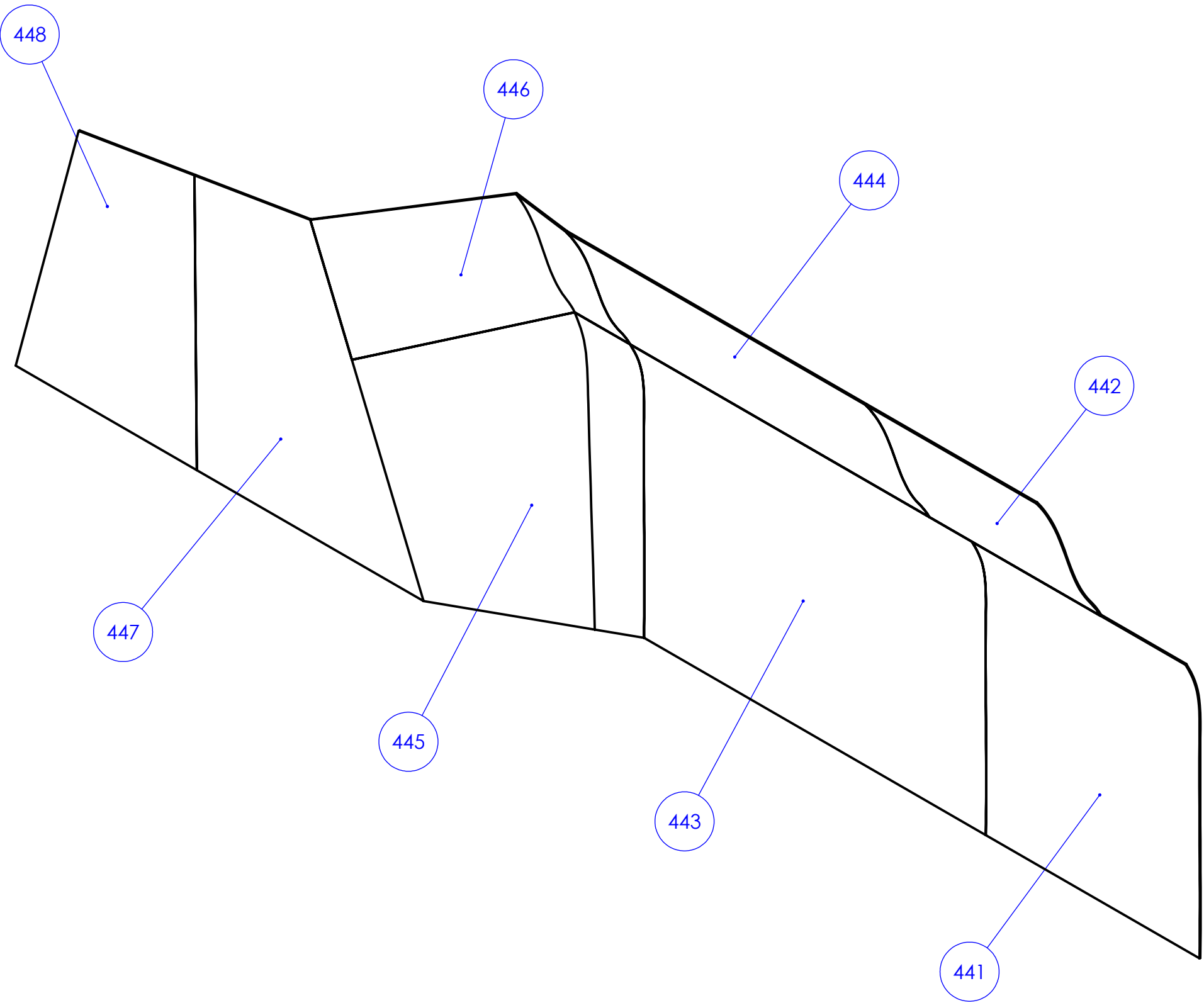
BALLOON	PART NO.	PART NAME	QTY.
1	481	F1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	4



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right F1 Assembly		Drwn. By:
	Dwg. #: 432	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

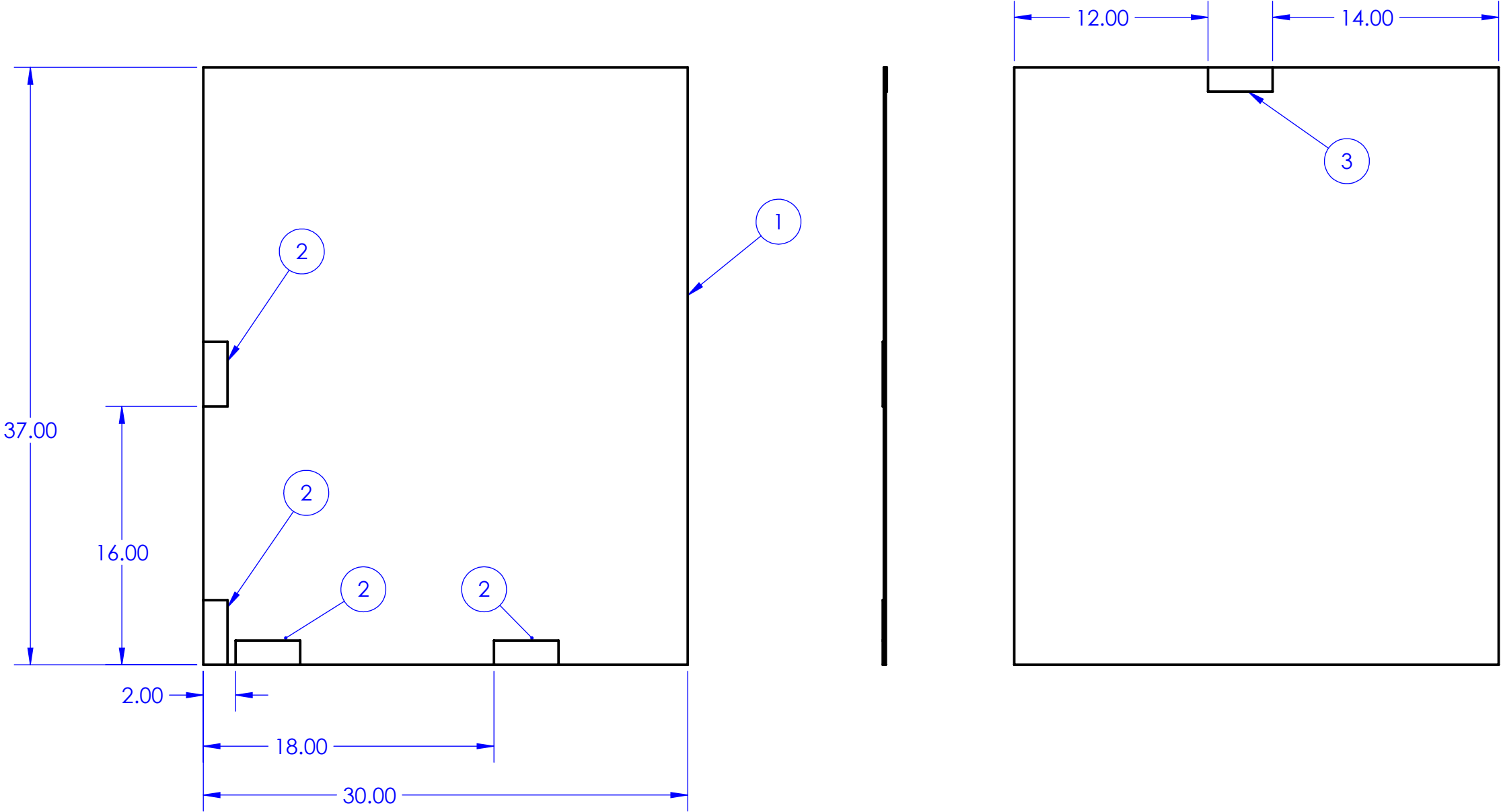
PART NO.	PART NAME	QUANTITY
441	RIGHT S1 ASSEMBLY	1
442	RIGHT S2 ASSEMBLY	1
443	RIGHT S3 ASSEMBLY	1
444	RIGHT S4 ASSEMBLY	1
445	RIGHT S5 ASSEMBLY	1
446	RIGHT S6 ASSEMBLY	1
447	RIGHT S7 ASSEMBLY	1
448	RIGHT S8 ASSEMBLY	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. COVERING OVERLAPS ADJACENT PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: RIGHT SIDE TARP ASSEMBLY		Drwn. By: TARGET PRACTICE	
	Dwg. #: 440	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF	

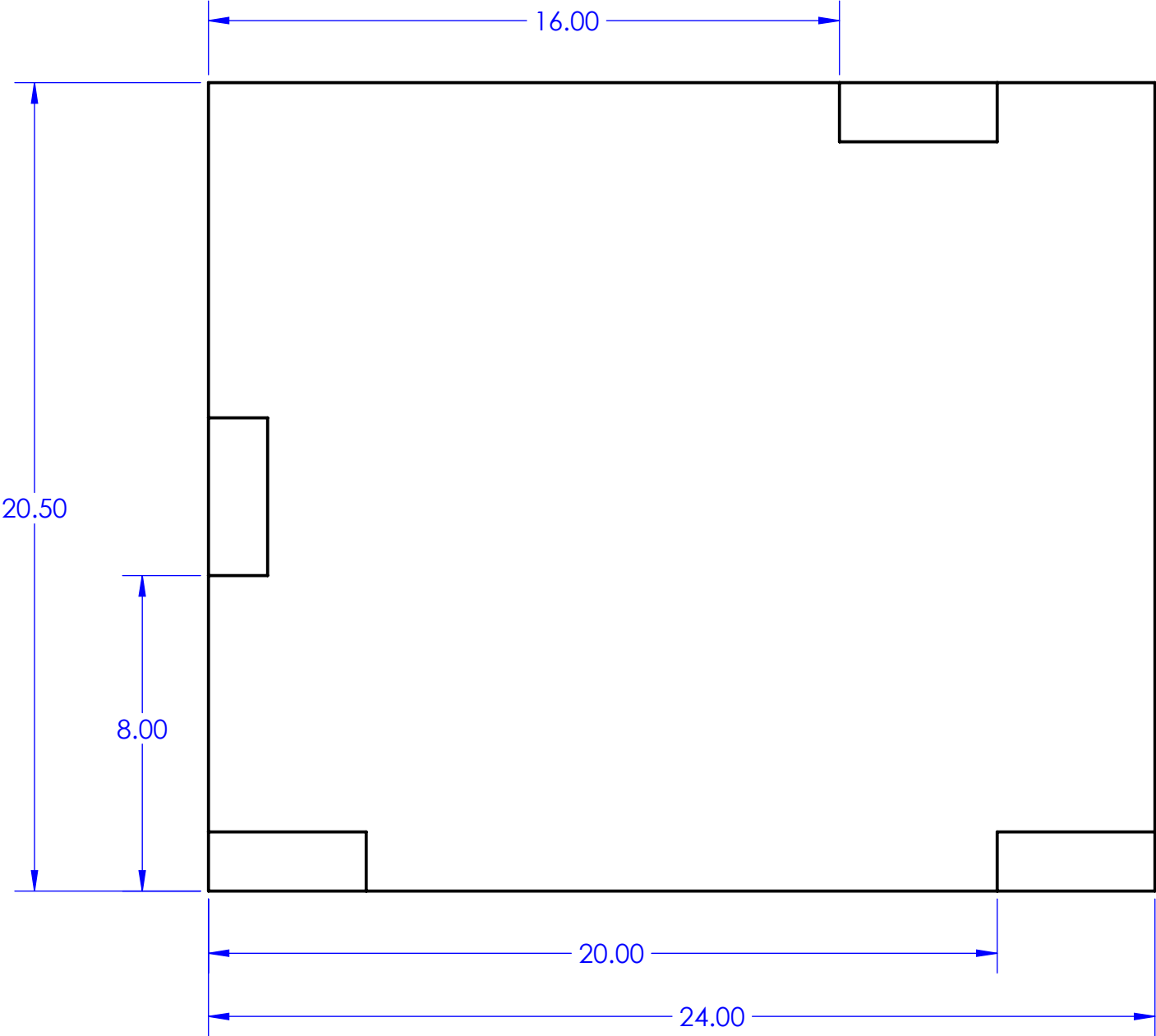
BALLOON	PART NO.	PART NAME	QTY.
1	491	S1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S1 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 441	Nxt Asb: NONE	Date: 2/7/2017	Scale: 1:8	Chkd. By: ME STAFF

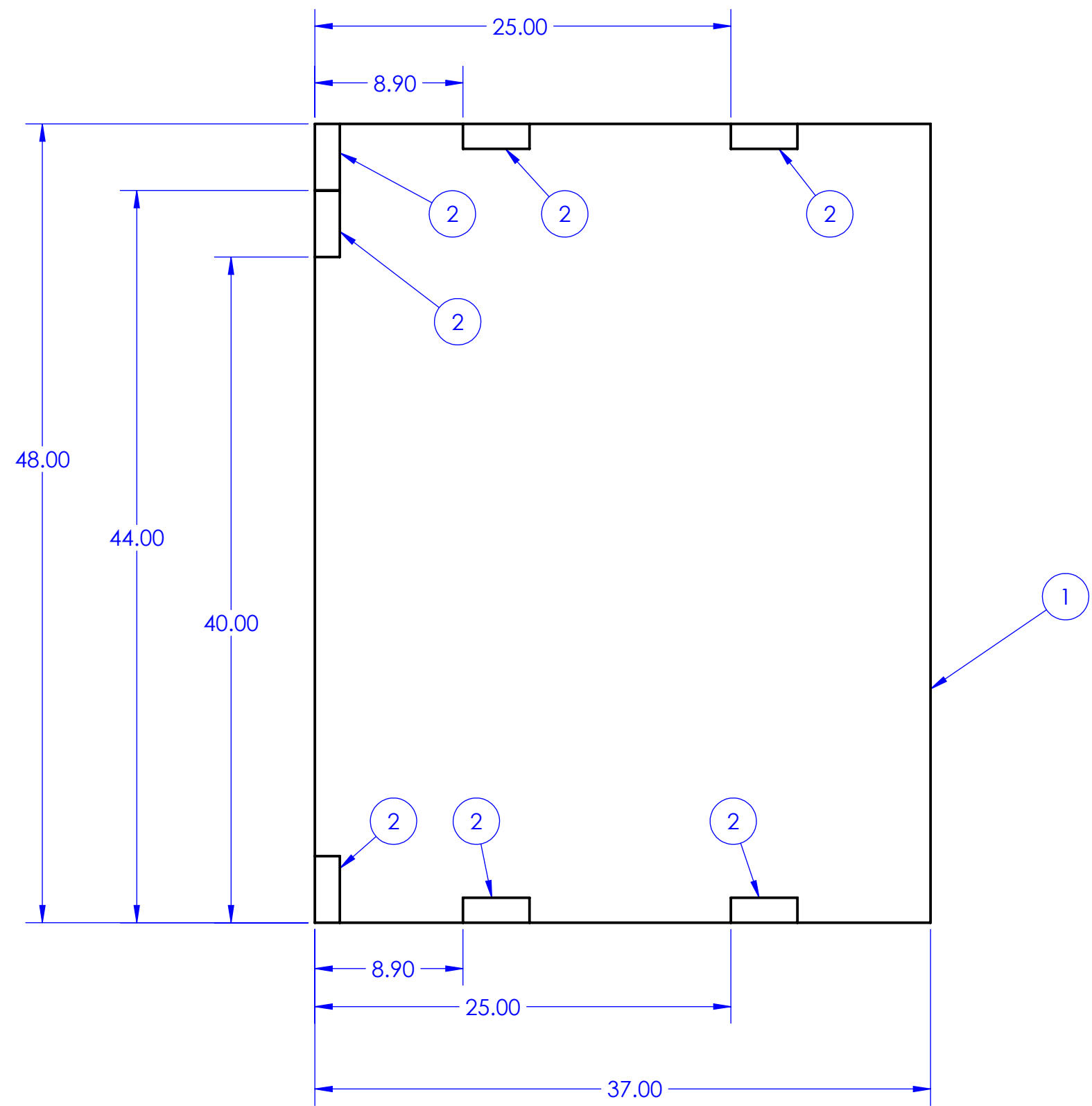
BALLOON	PART NO.	PART NAME	QTY.
1	492	S2 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	0



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S2 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 442	Nxt Asb: NONE	Date: 2/7/2017	Scale: 1:4	Chkd. By: ME STAFF

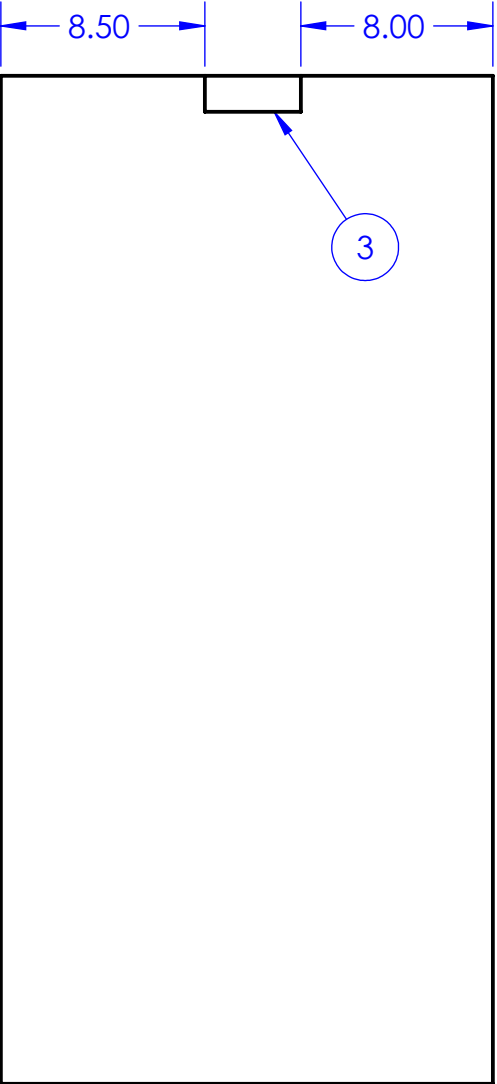
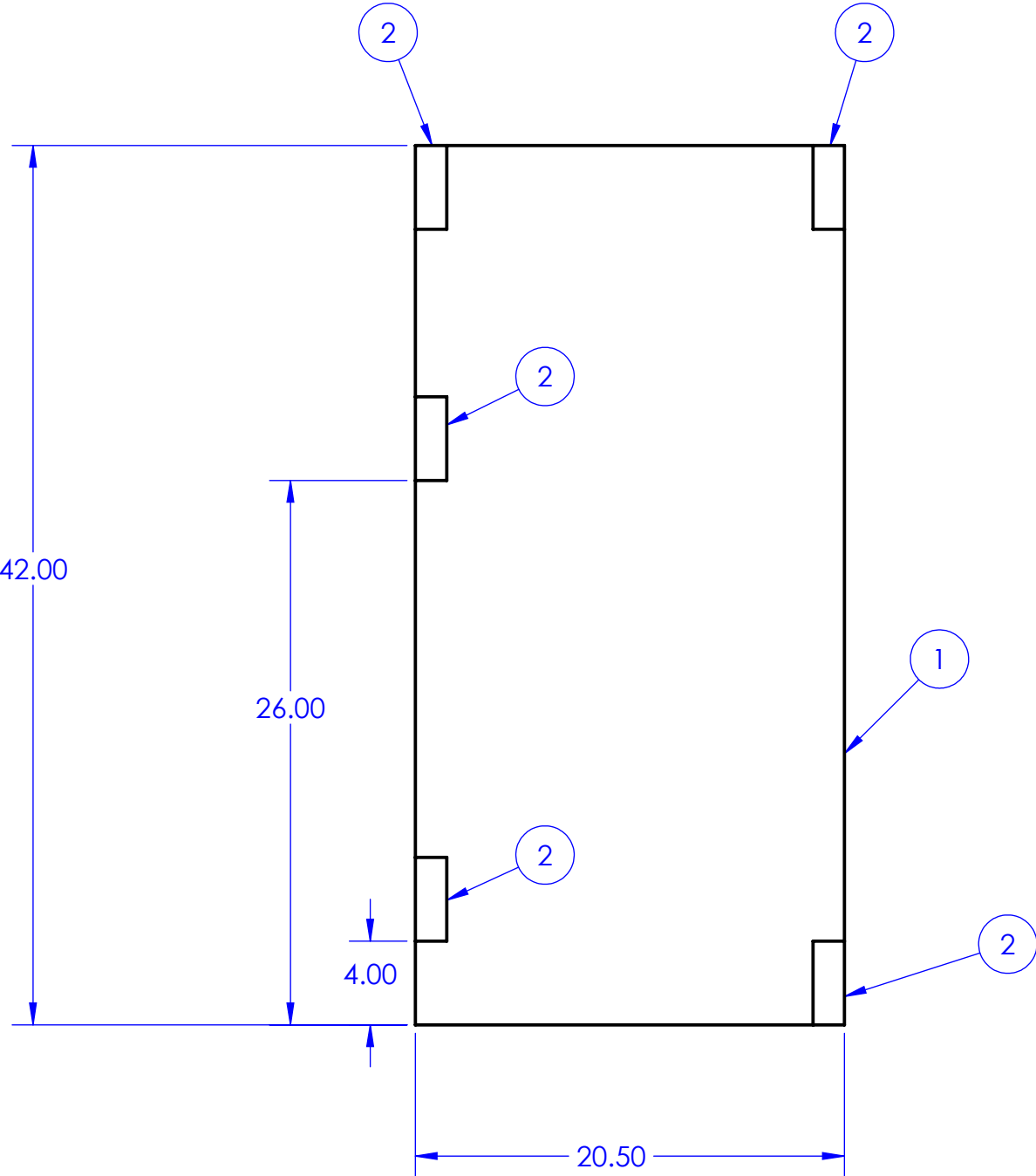
BALLOON	PART NO.	PART NAME	QTY.
1	493	S3 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	7
3	312B	BUMPER VELCRO LOOPS	0



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S3 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 443	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

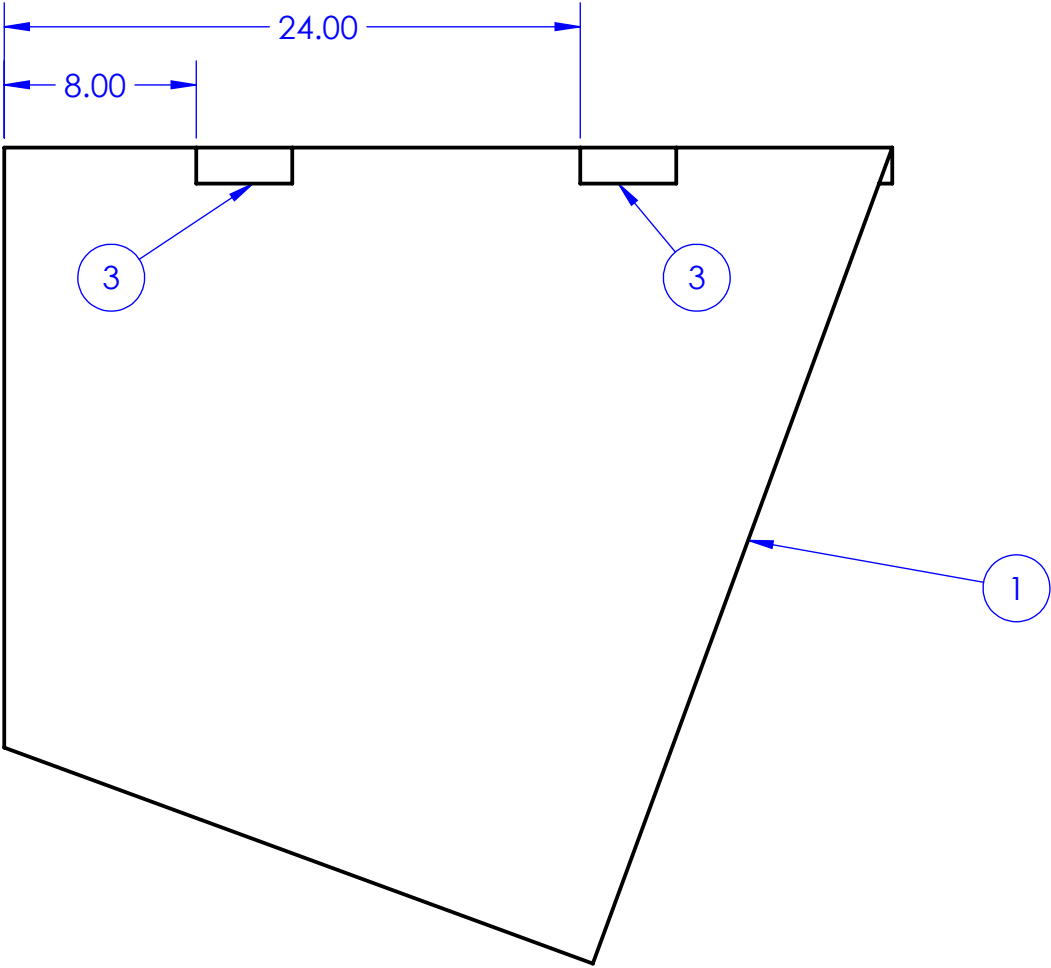
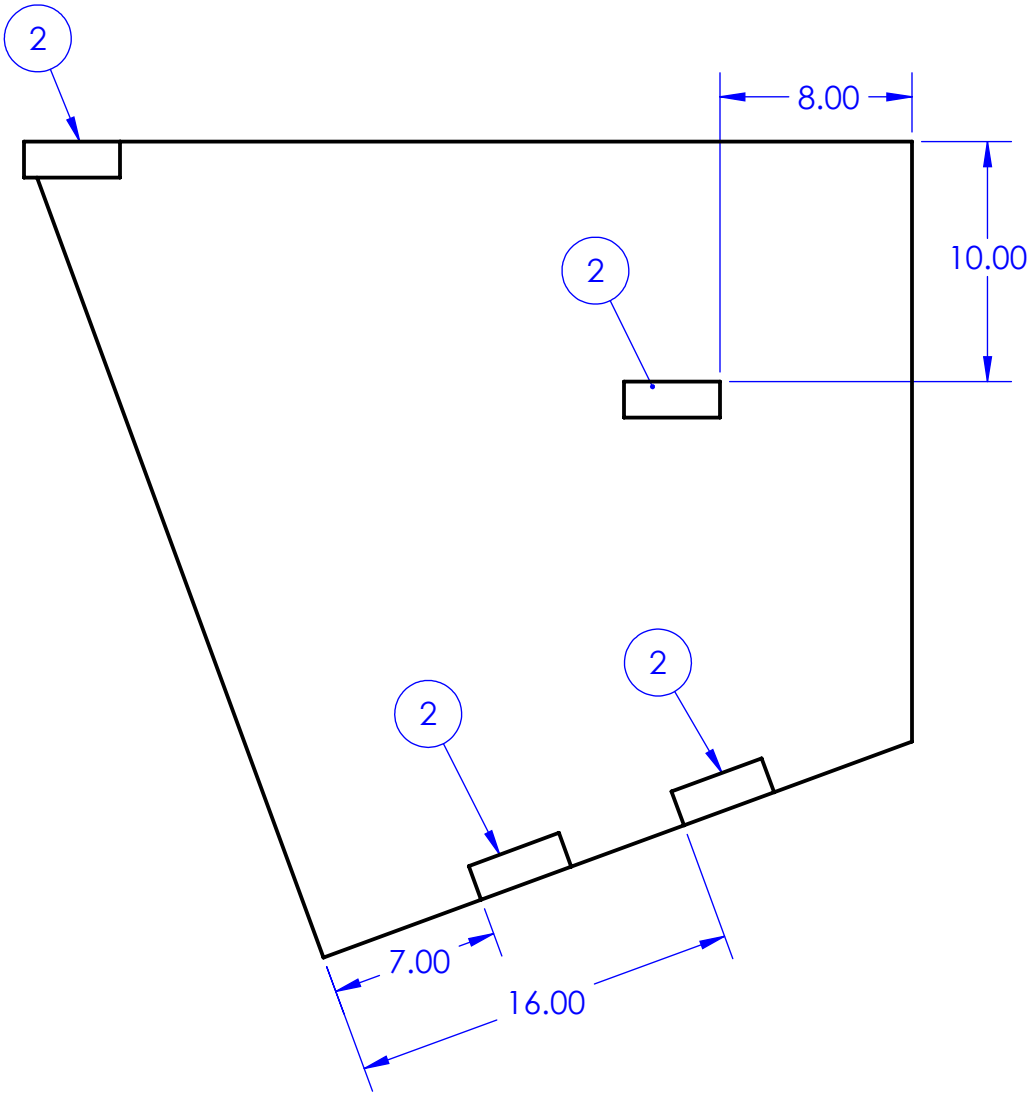
BALLOON	PART NO.	PART NAME	QTY.
1	494	S4 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	5
3	312B	BUMPER VELCRO LOOPS	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

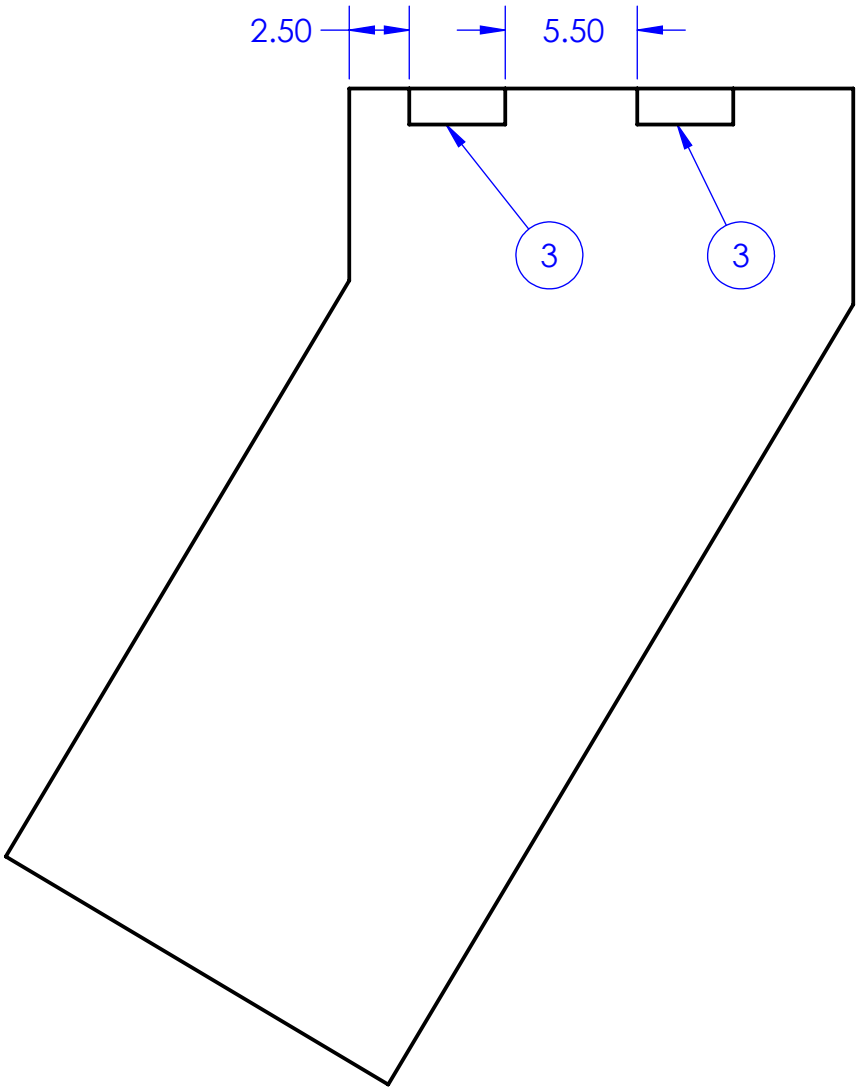
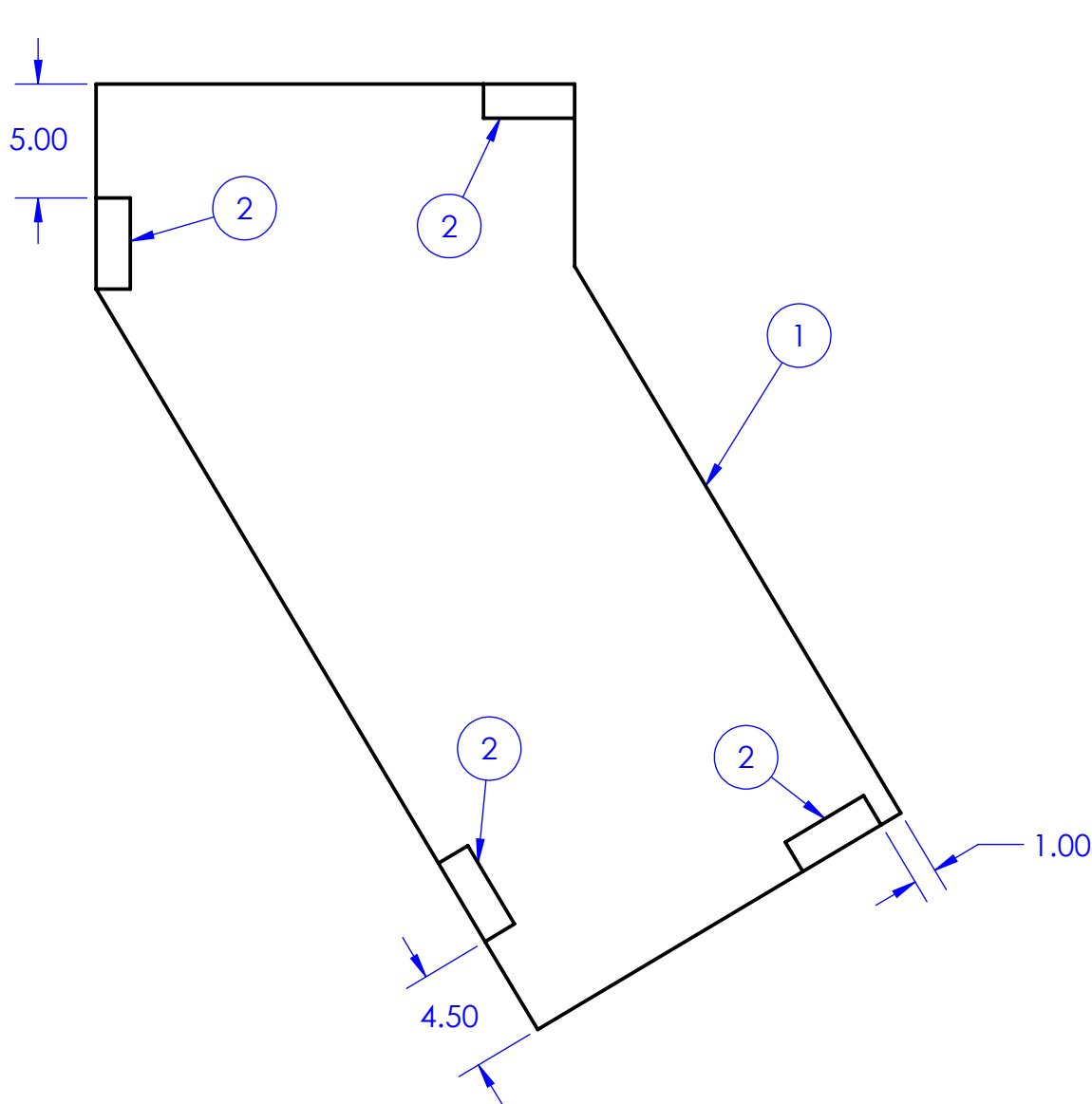
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S4 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 444	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

BALLOON	PART NO.	PART NAME	QTY.
1	495	S5 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

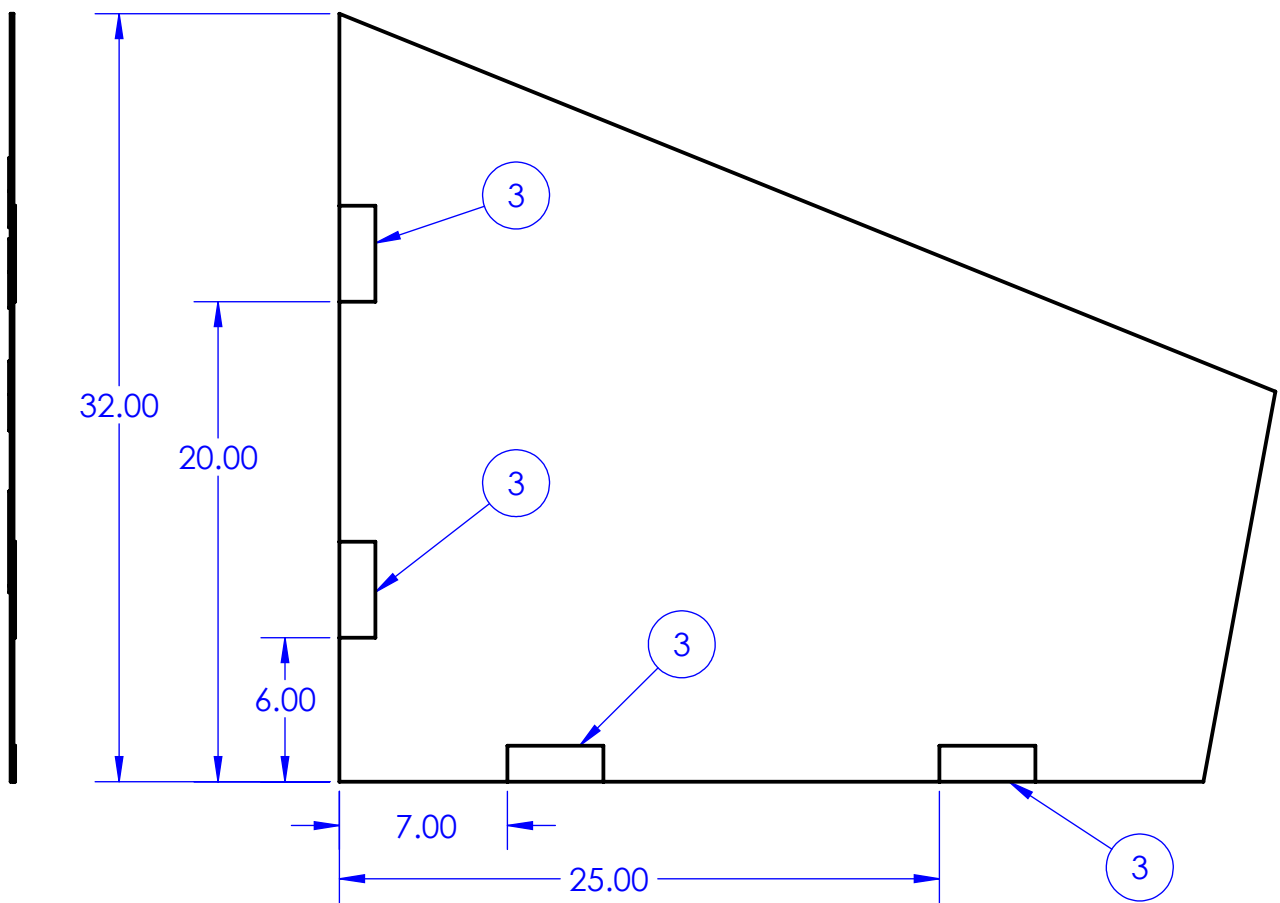
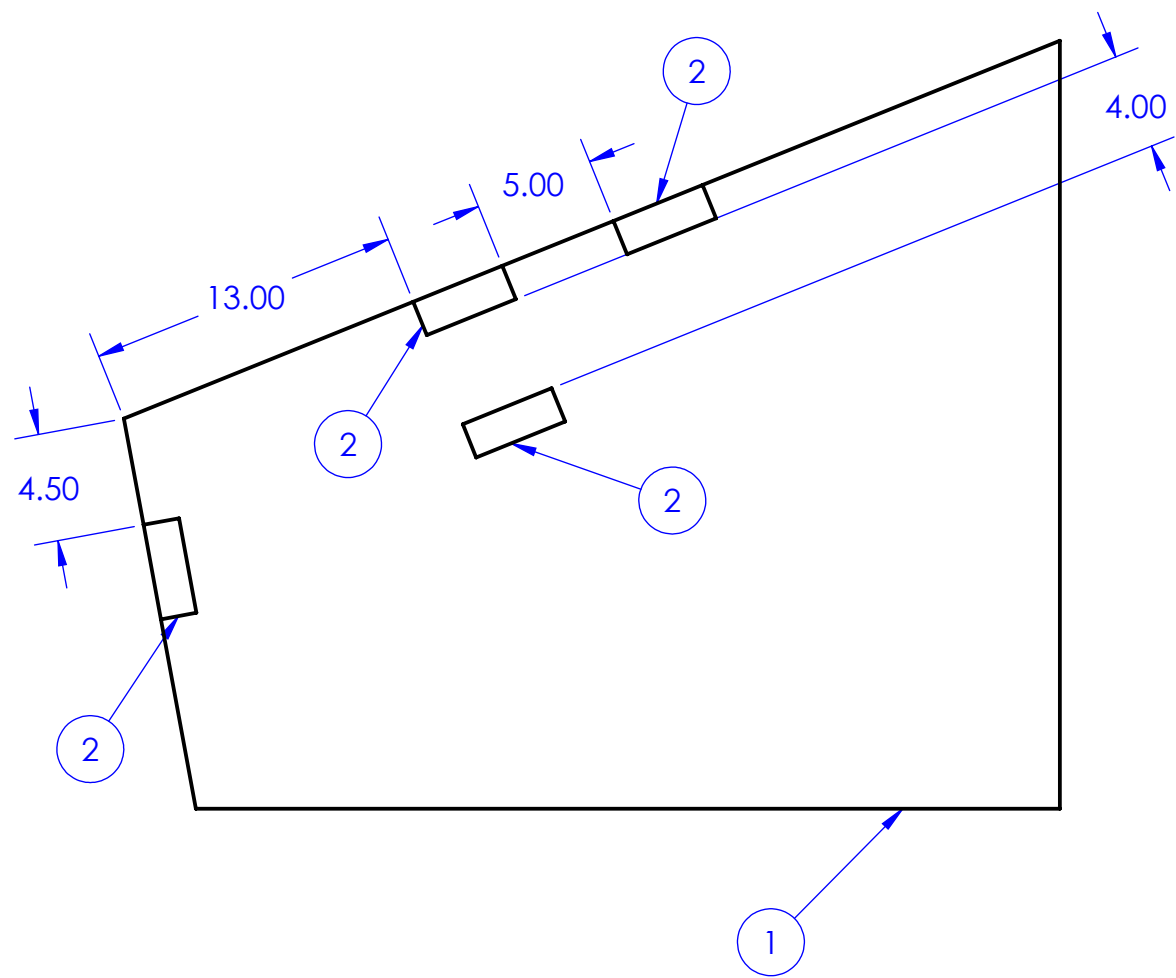
BALLOON	PART NO.	PART NAME	QTY.
1	496	S6 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S6 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 446	Nxt Asb: NONE	Date: 2/7/2017	Scale: 1:8	Chkd. By: ME STAFF

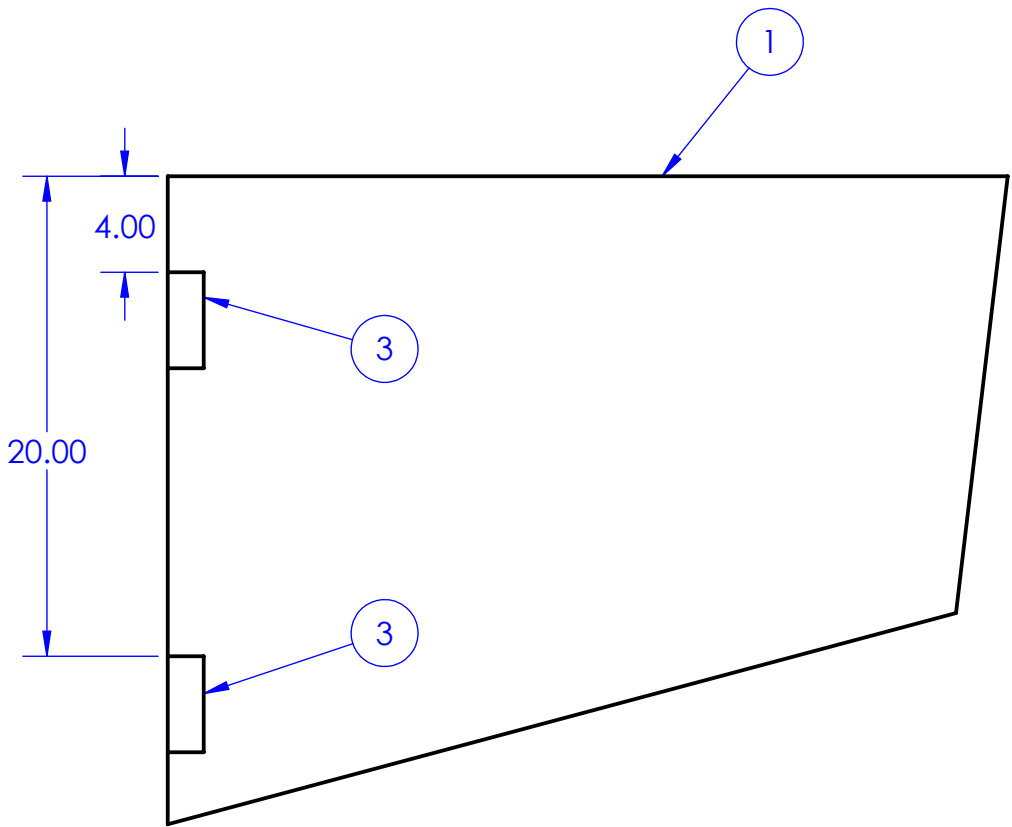
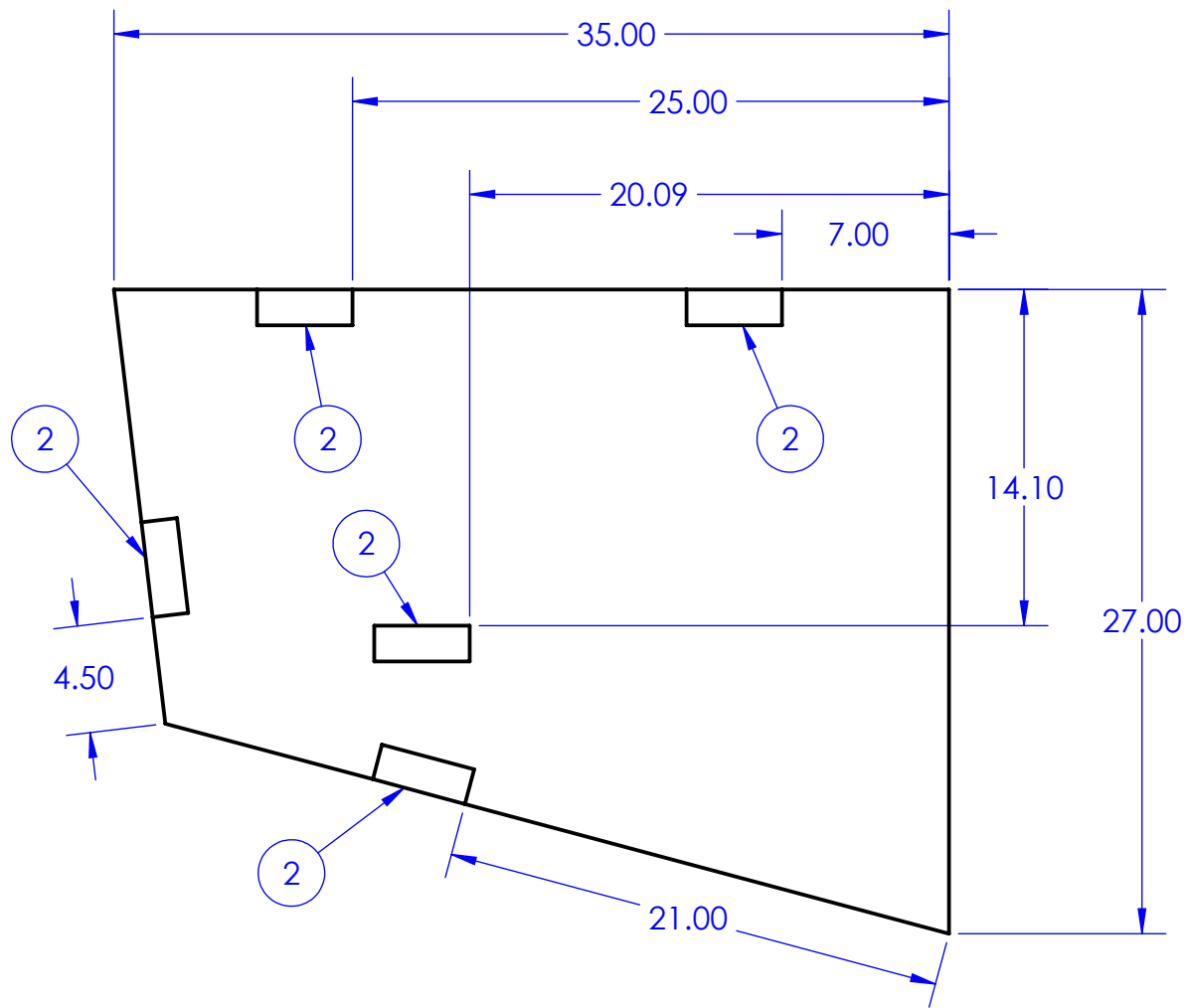
BALLOON	PART NO.	PART NAME	QTY.
1	497	S7 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	4



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S7 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 447	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

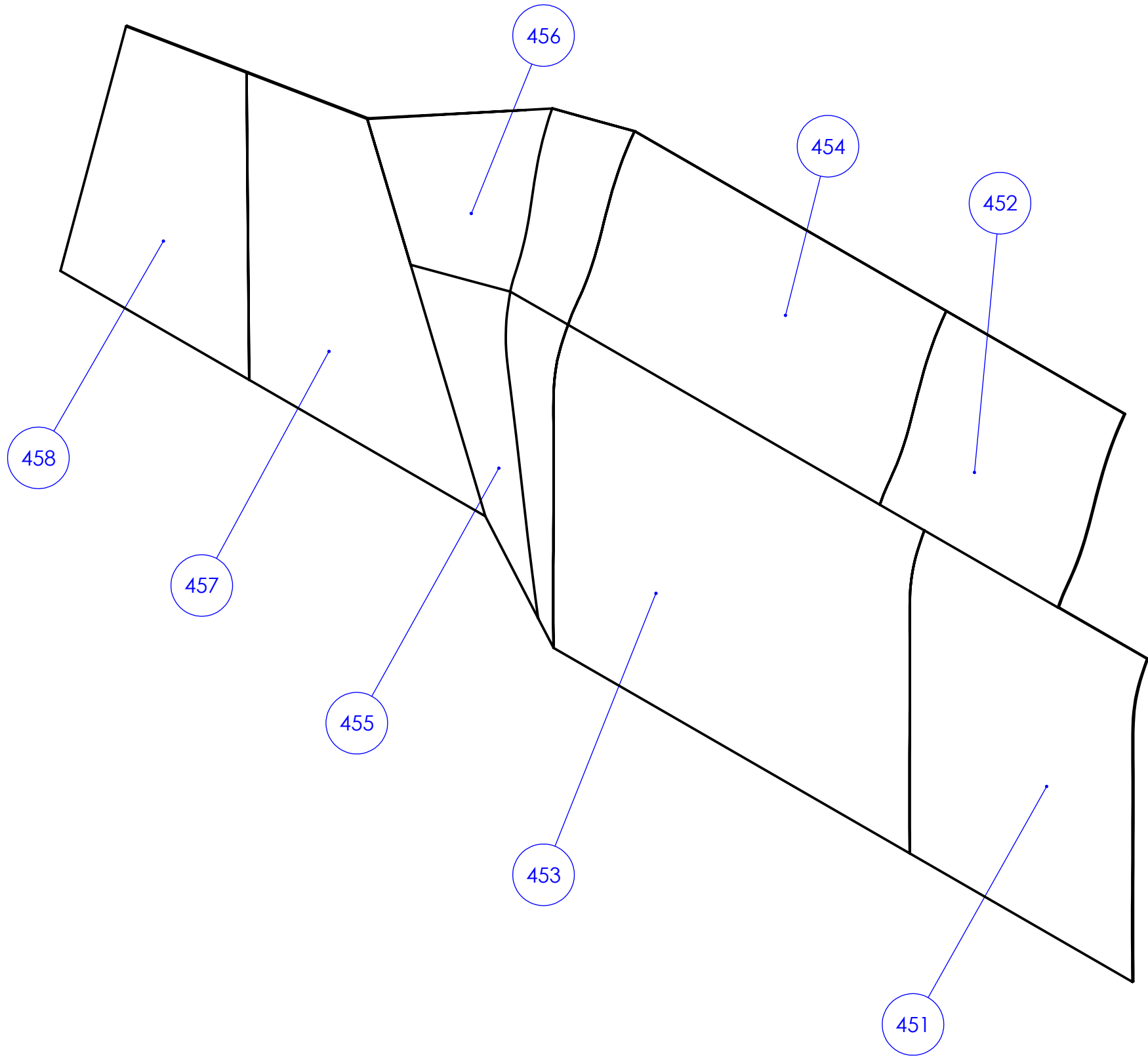
BALLOON	PART NO.	PART NAME	QTY.
1	498	S8 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	5
3	312B	BUMPER VELCRO LOOPS	3



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S8 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 448	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

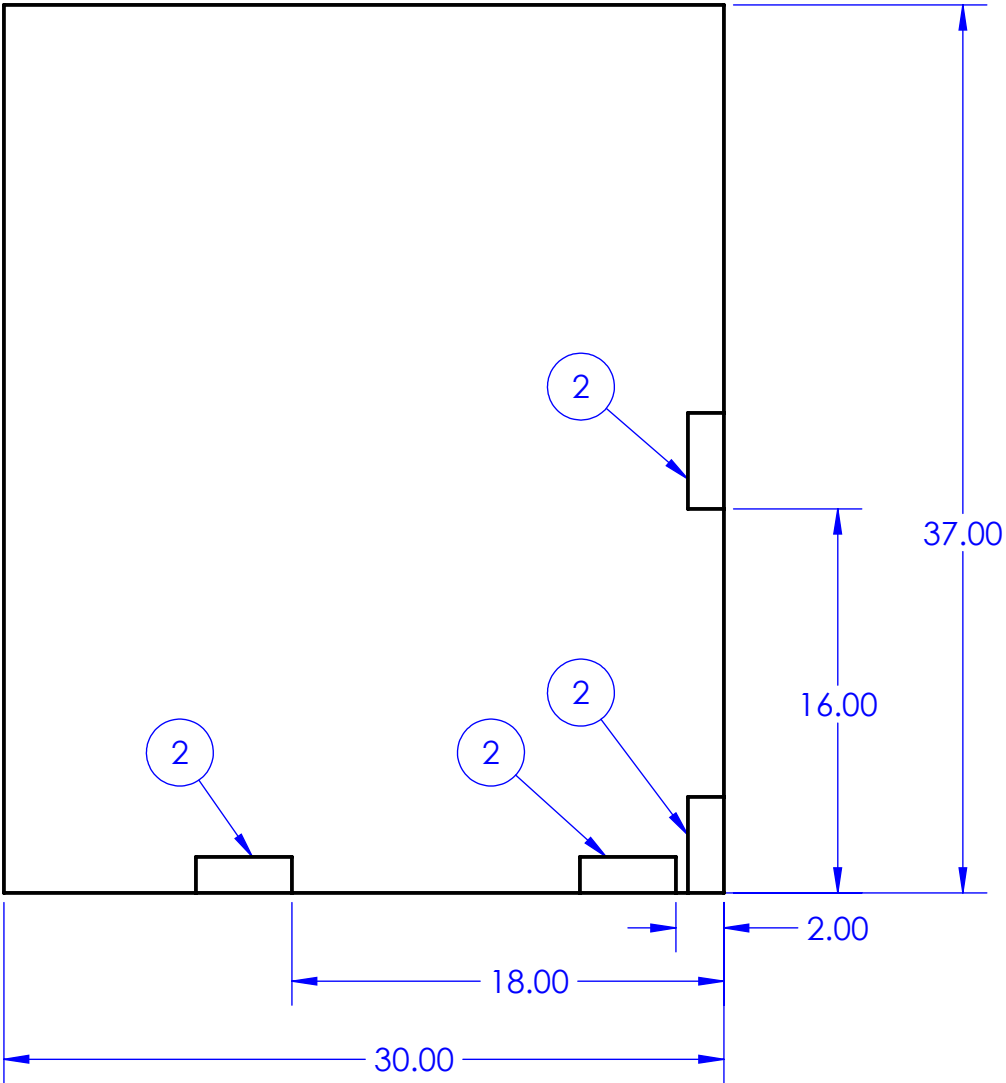
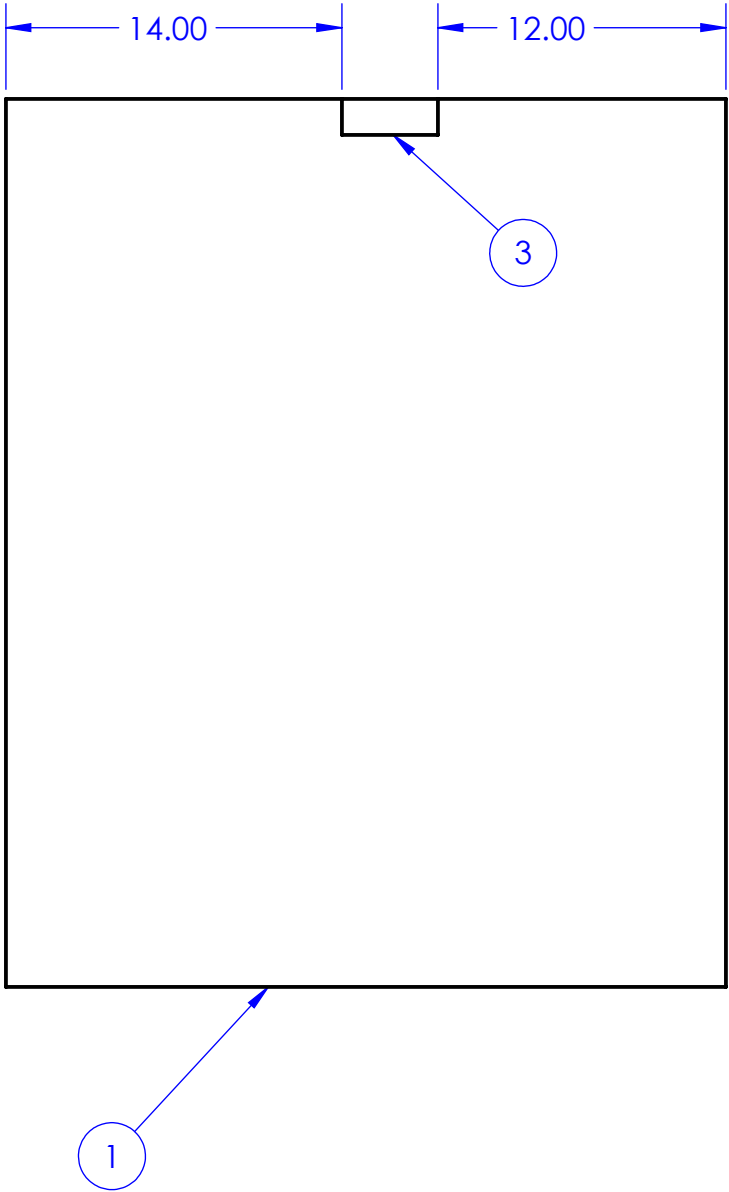
PART NO.	PART NAME	QUANTITY
451	LEFT S1 ASSEMBLY	1
452	LEFT S2 ASSEMBLY	1
453	LEFT S3 ASSEMBLY	1
454	LEFT S4 ASSEMBLY	1
455	LEFT S5 ASSEMBLY	1
456	LEFT S6 ASSEMBLY	1
457	LEFT S7 ASSEMBLY	1
458	LEFT S8 ASSEMBLY	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°
3. COVERING OVERLAPS ADJACENT PIECES

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: LEFT SIDE TARP ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 450	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF

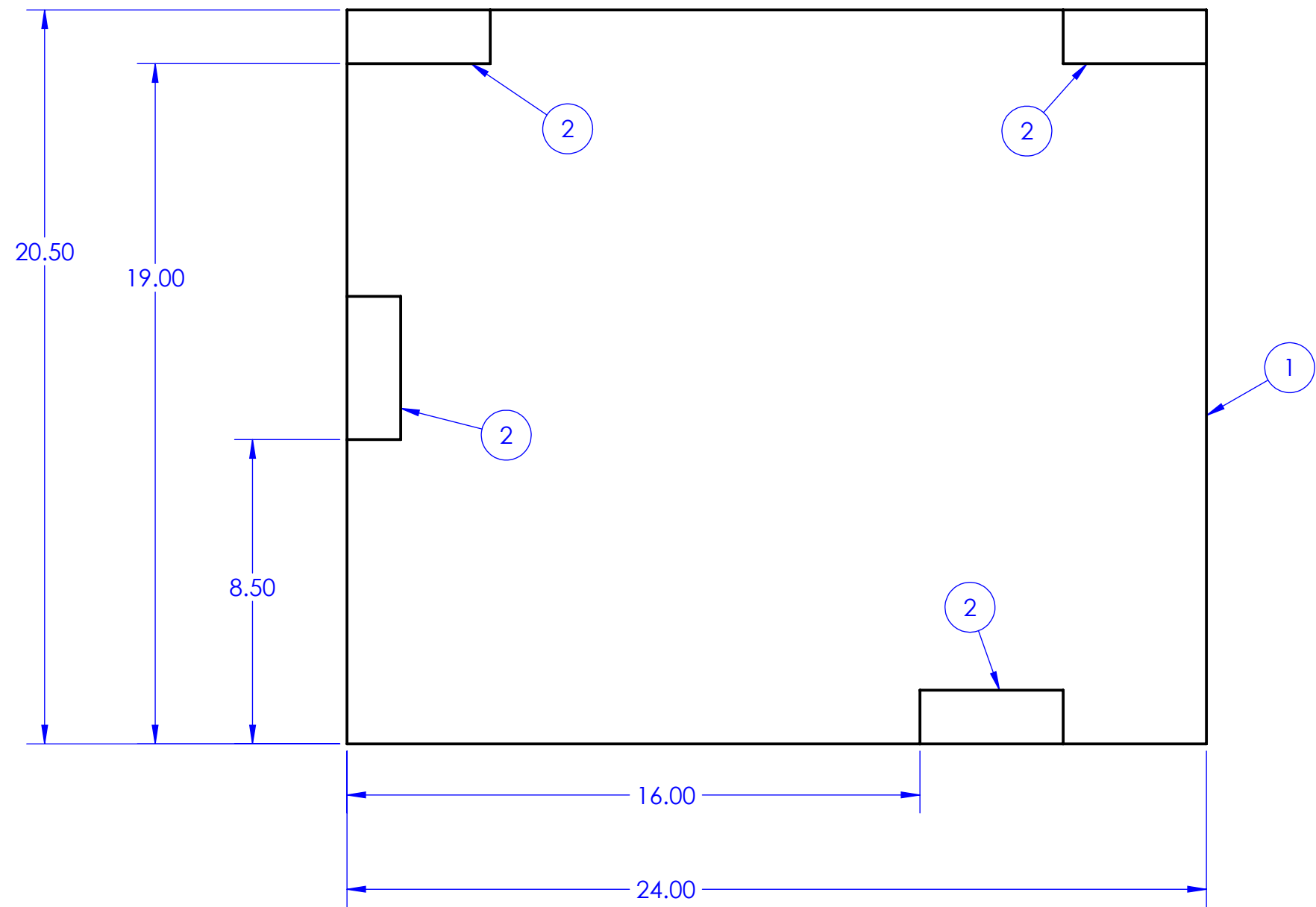
BALLOON	PART NO.	PART NAME	QTY.
1	491	S1 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	1



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left S1 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 451	Nxt Asb: NONE	Date: 2/7/2017	Scale: 1:8	Chkd. By: ME STAFF

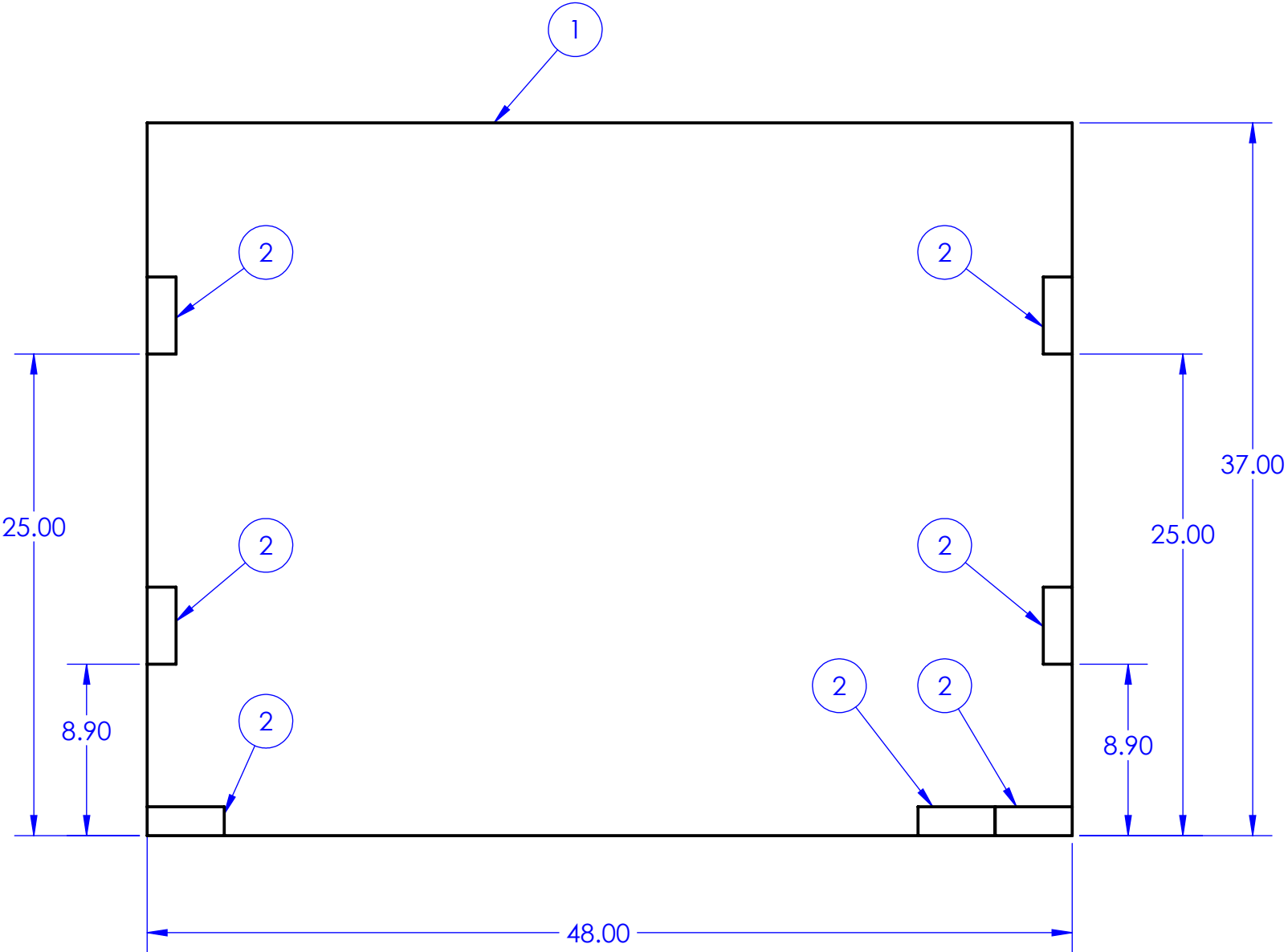
BALLOON	PART NO.	PART NAME	QTY.
1	492	S2 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	0



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left S2 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 452	Nxt Asb: NONE	Date: 2/7/2017	Scale: 1:4	Chkd. By: ME STAFF

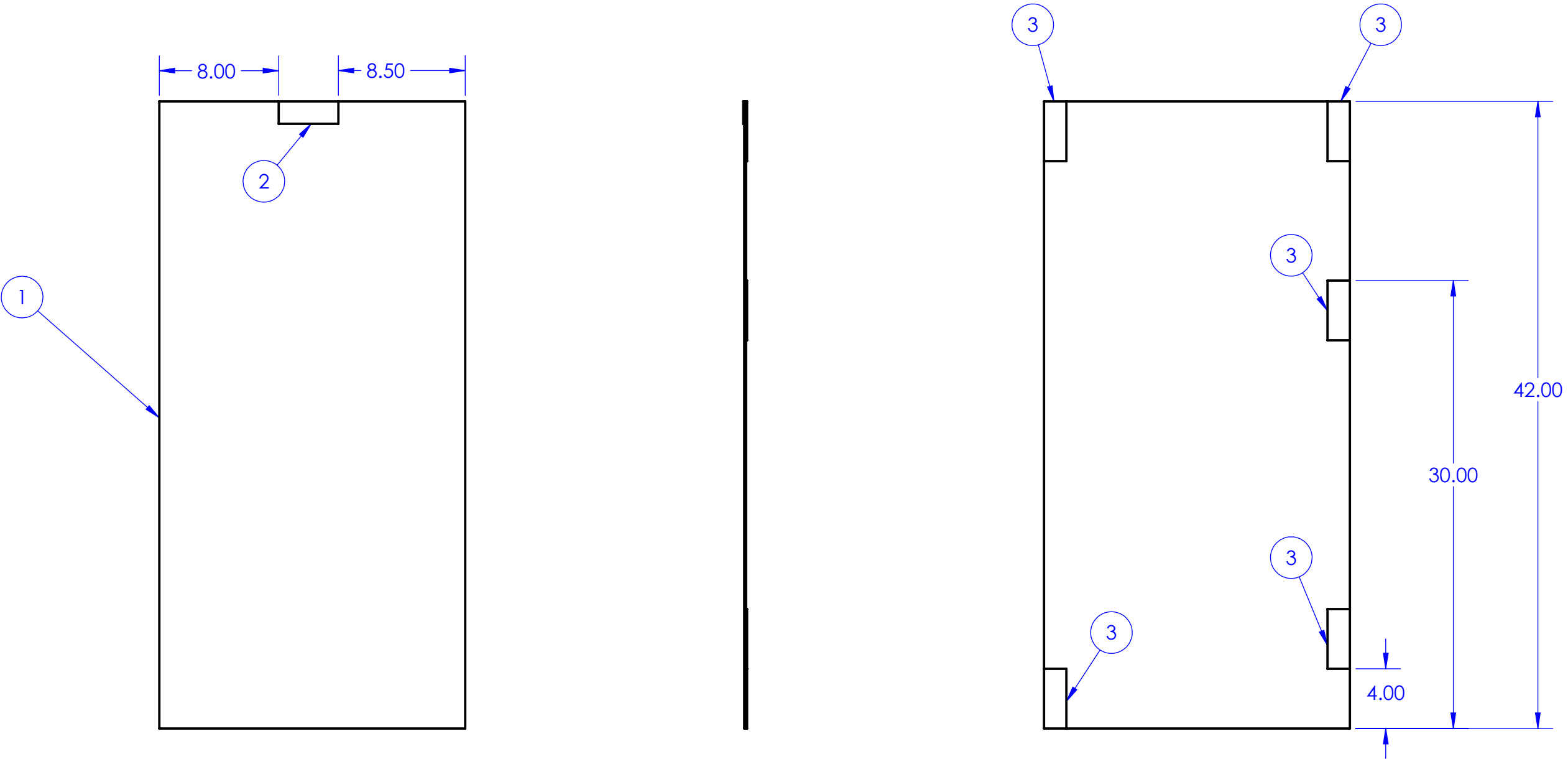
BALLOON	PART NO.	PART NAME	QTY.
1	493	S3 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	7
3	312B	BUMPER VELCRO LOOPS	0



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left S3 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 453	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

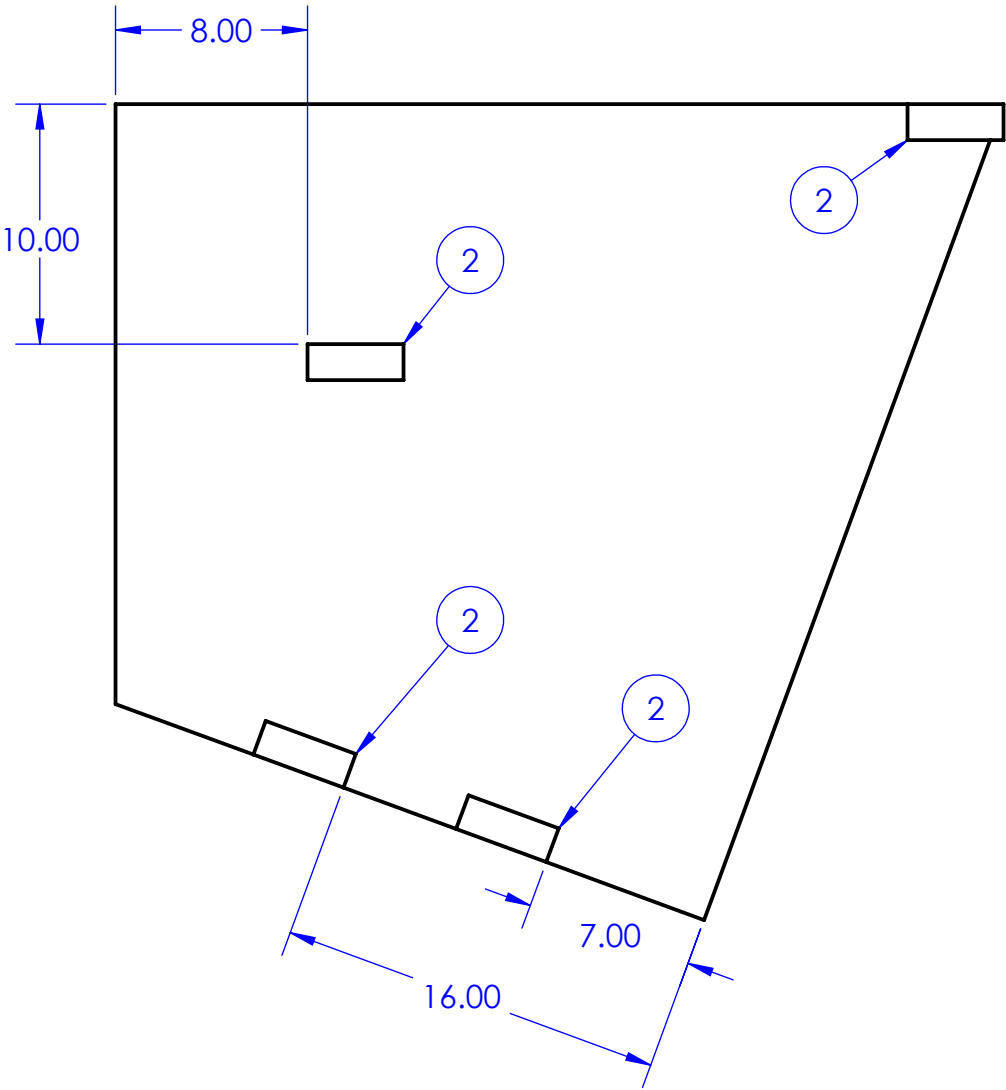
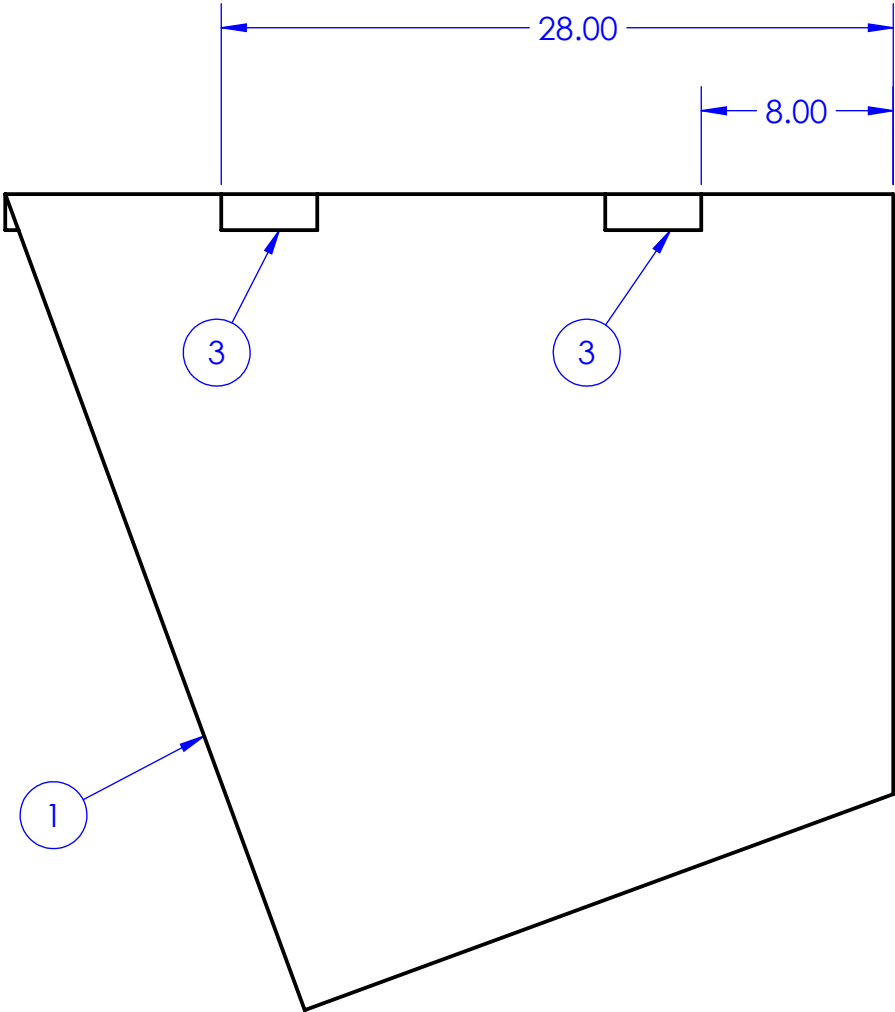
BALLOON	PART NO.	PART NAME	QTY.
1	494	S4 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	1
3	312B	BUMPER VELCRO LOOPS	5



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Right S4 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 444	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

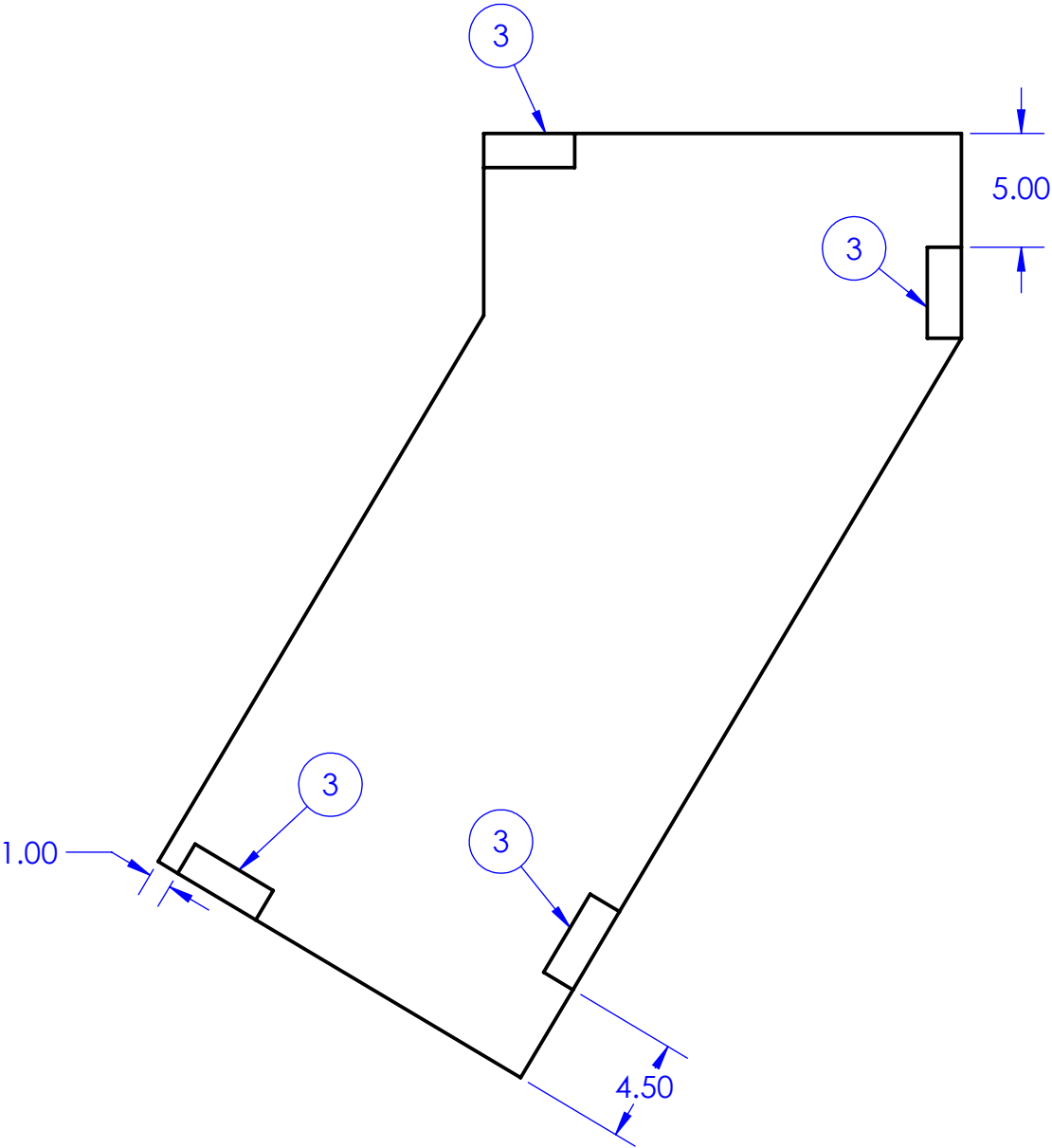
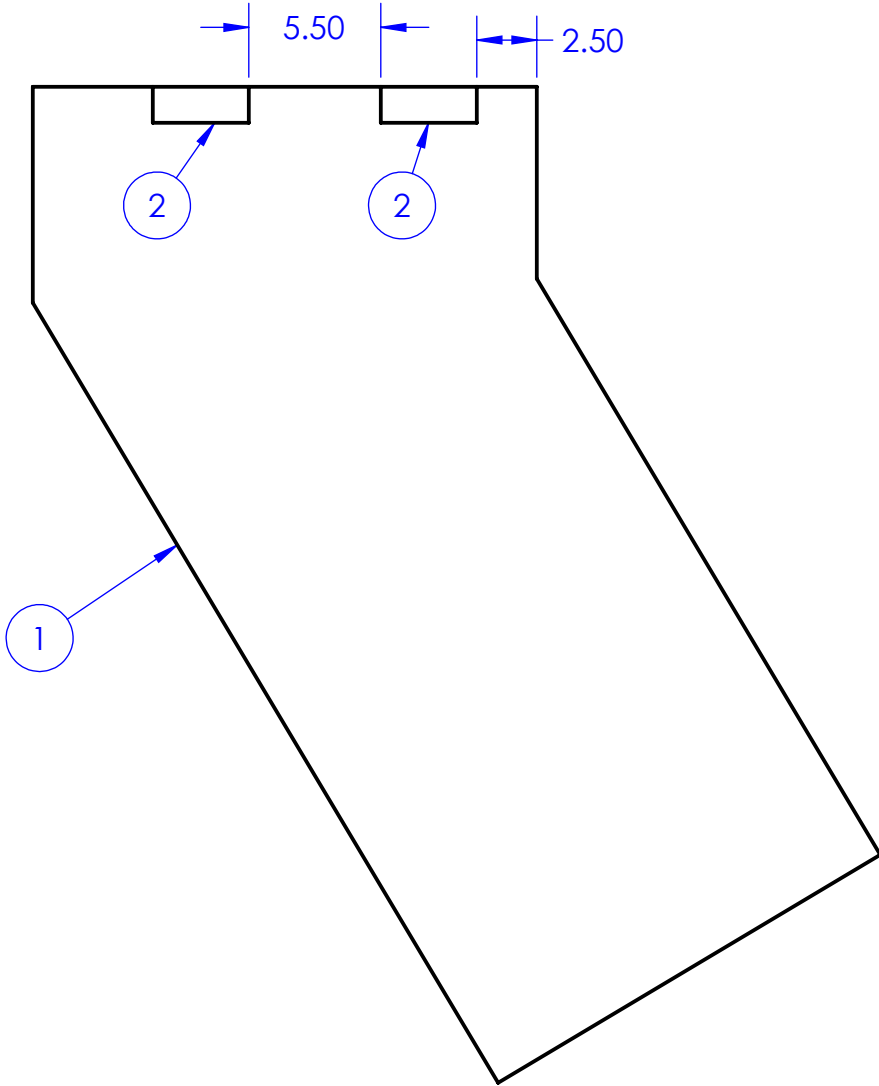
BALLOON	PART NO.	PART NAME	QTY.
1	495	S5 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	2



NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left S5 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 455	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

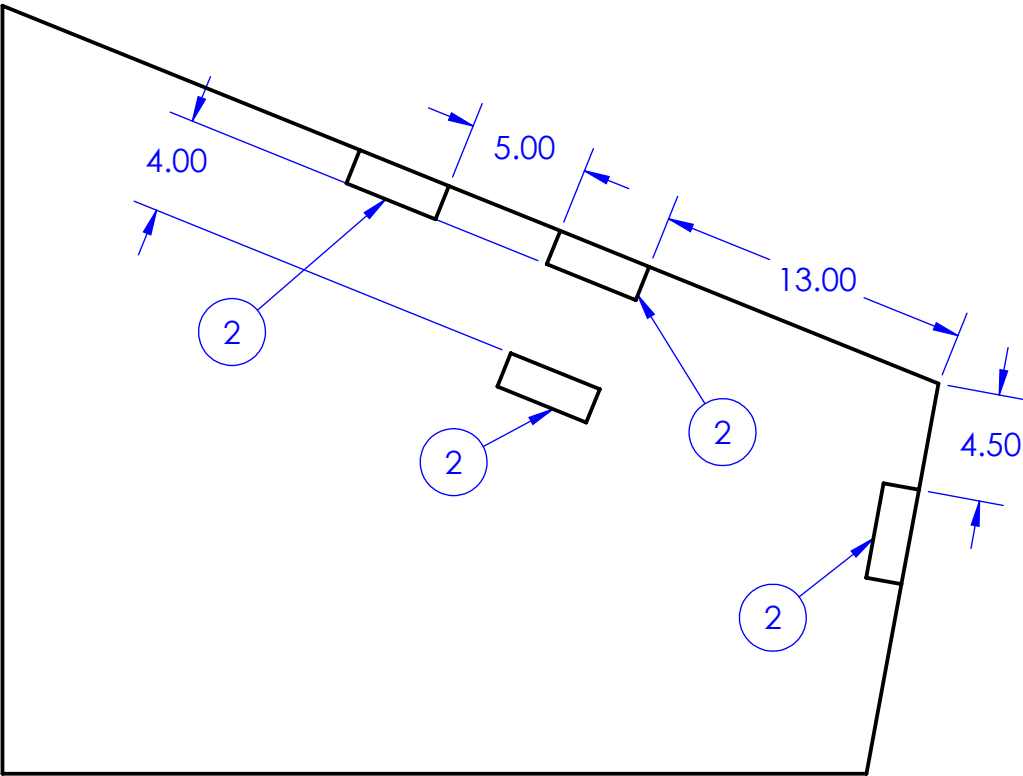
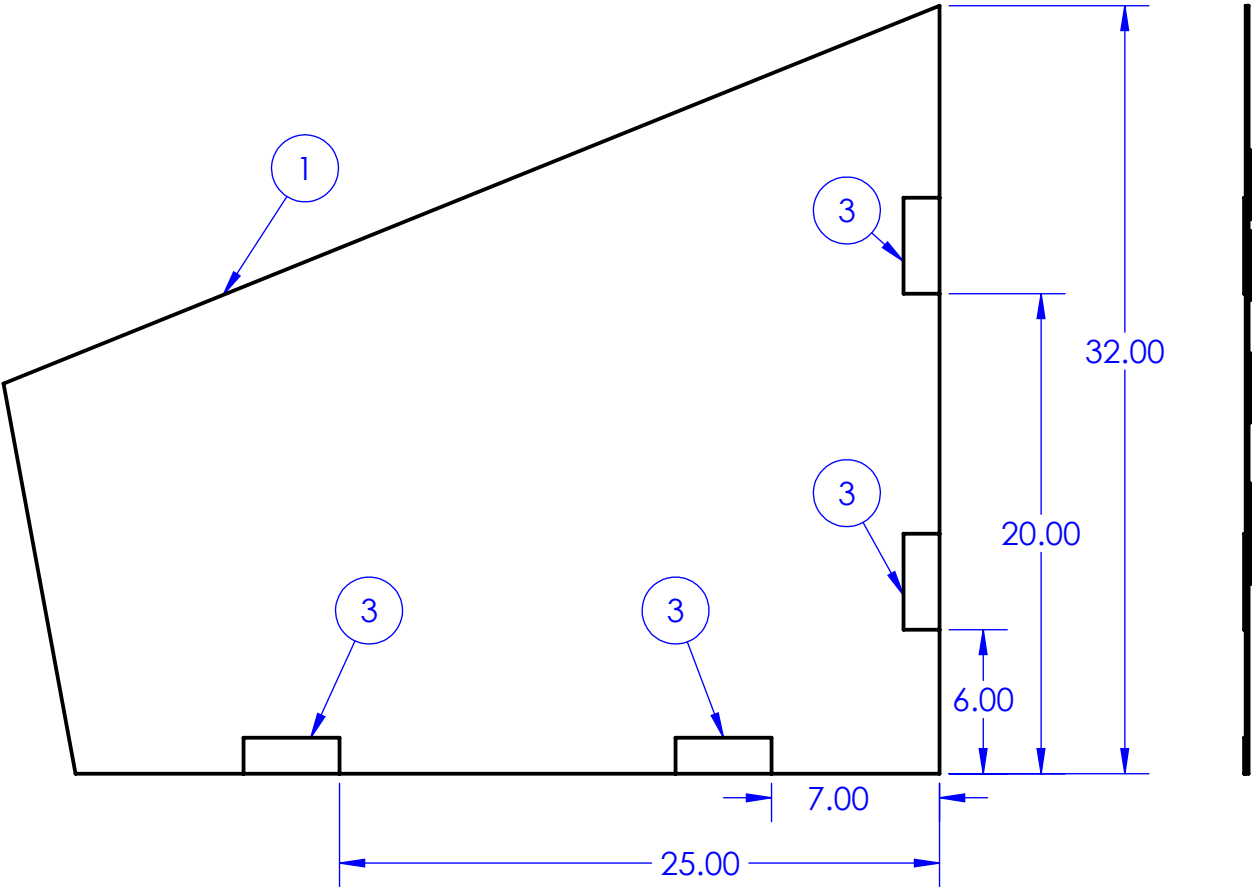
BALLOON	PART NO.	PART NAME	QTY.
1	496	S6 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	2
3	312B	BUMPER VELCRO LOOPS	4



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX° ± 2°

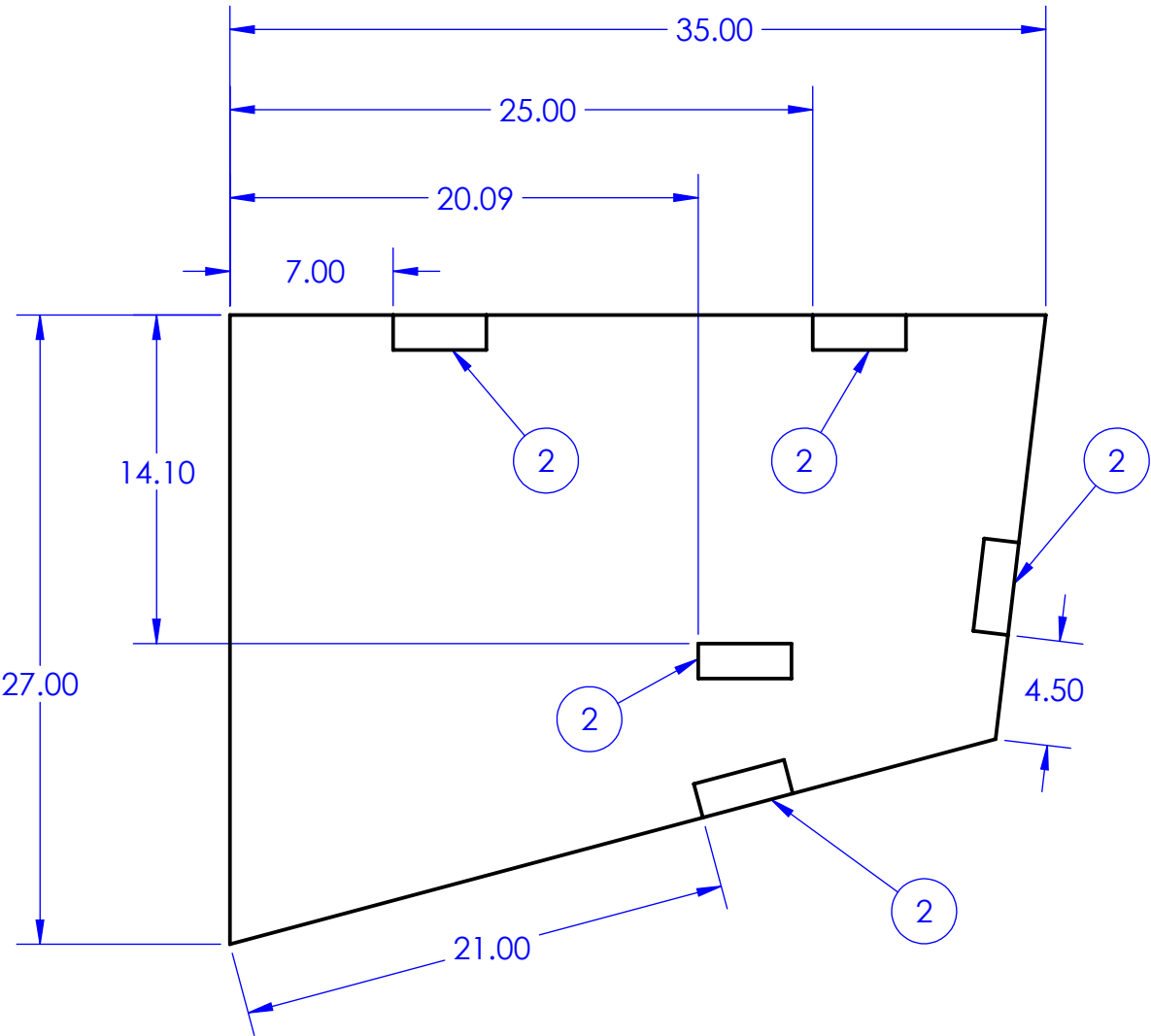
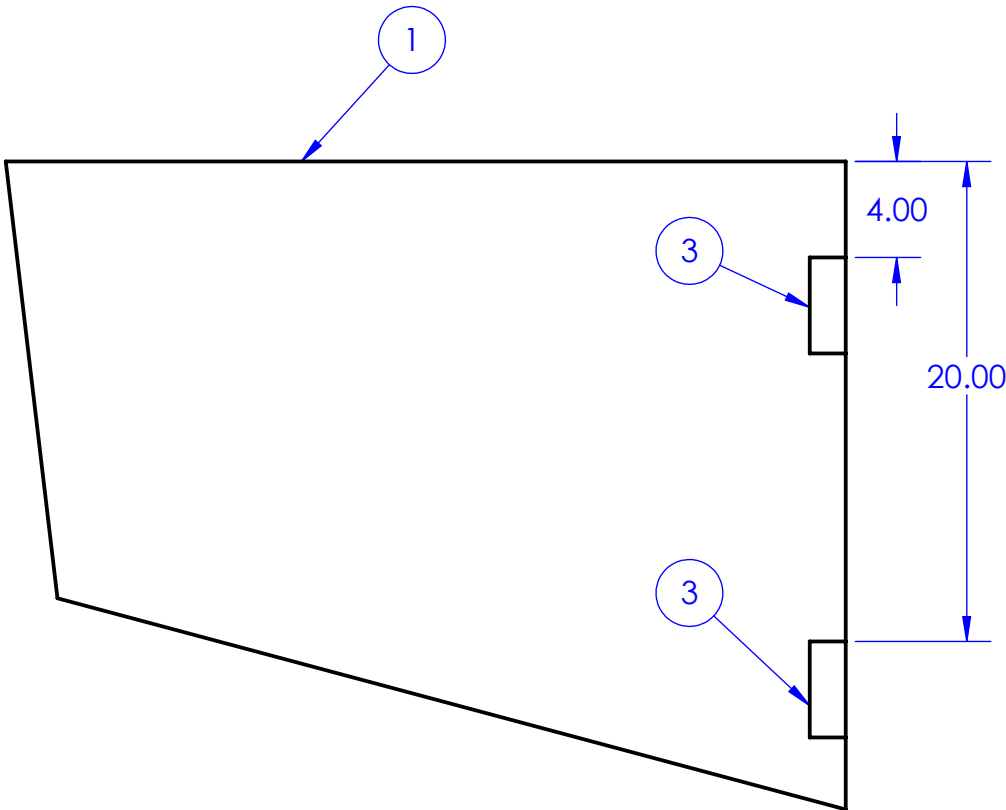
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment CDR	Title: Left S6 Assembly		Drwn. By: TARGET PRACTICE
	Dwg. #: 456	Nxt Asb: NONE	Date: 2/7/2017	Scale: 8:1	Chkd. By: ME STAFF

BALLOON	PART NO.	PART NAME	QTY.
1	497	S7 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	4
3	312B	BUMPER VELCRO LOOPS	4



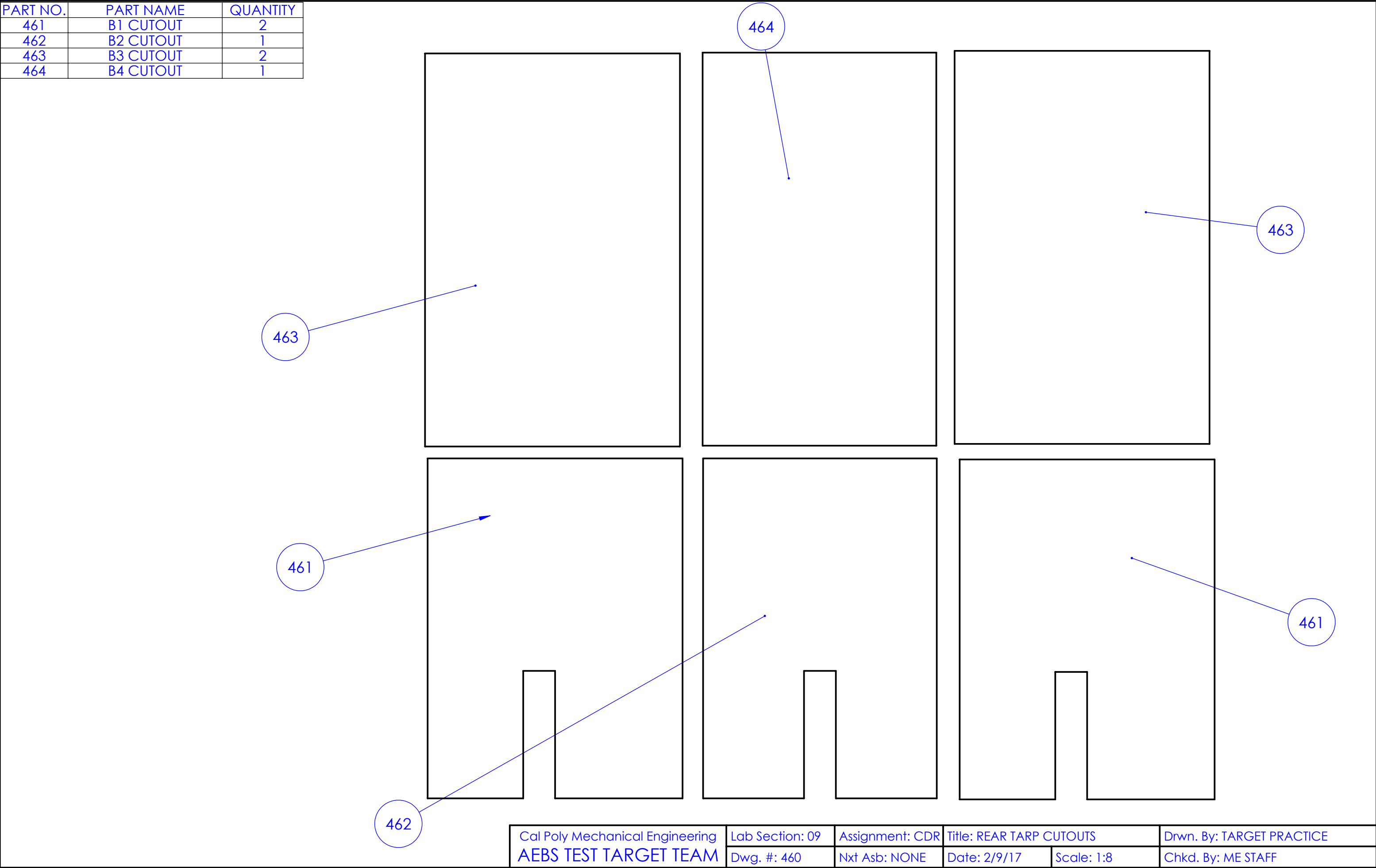
NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

BALLOON	PART NO.	PART NAME	QTY.
1	498	S8 CUTOUT	1
2	312A	BUMPER VELCRO HOOKS	5
3	312B	BUMPER VELCRO LOOPS	3

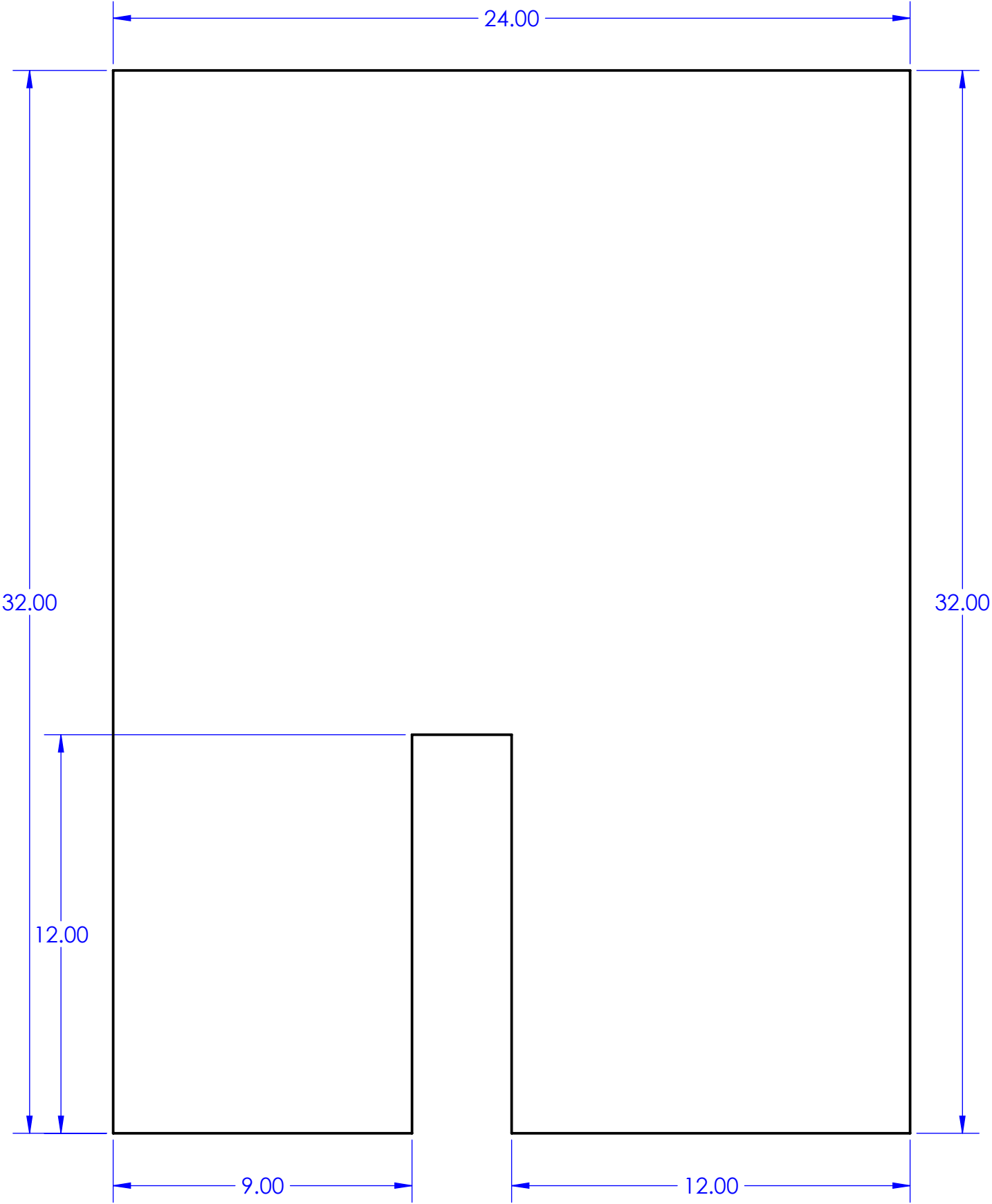


NOTE:
 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 2. TOLERANCES
 X.XX ± 0.1
 XX° ± 2°

PART NO.	PART NAME	QUANTITY
461	B1 CUTOUT	2
462	B2 CUTOUT	1
463	B3 CUTOUT	2
464	B4 CUTOUT	1

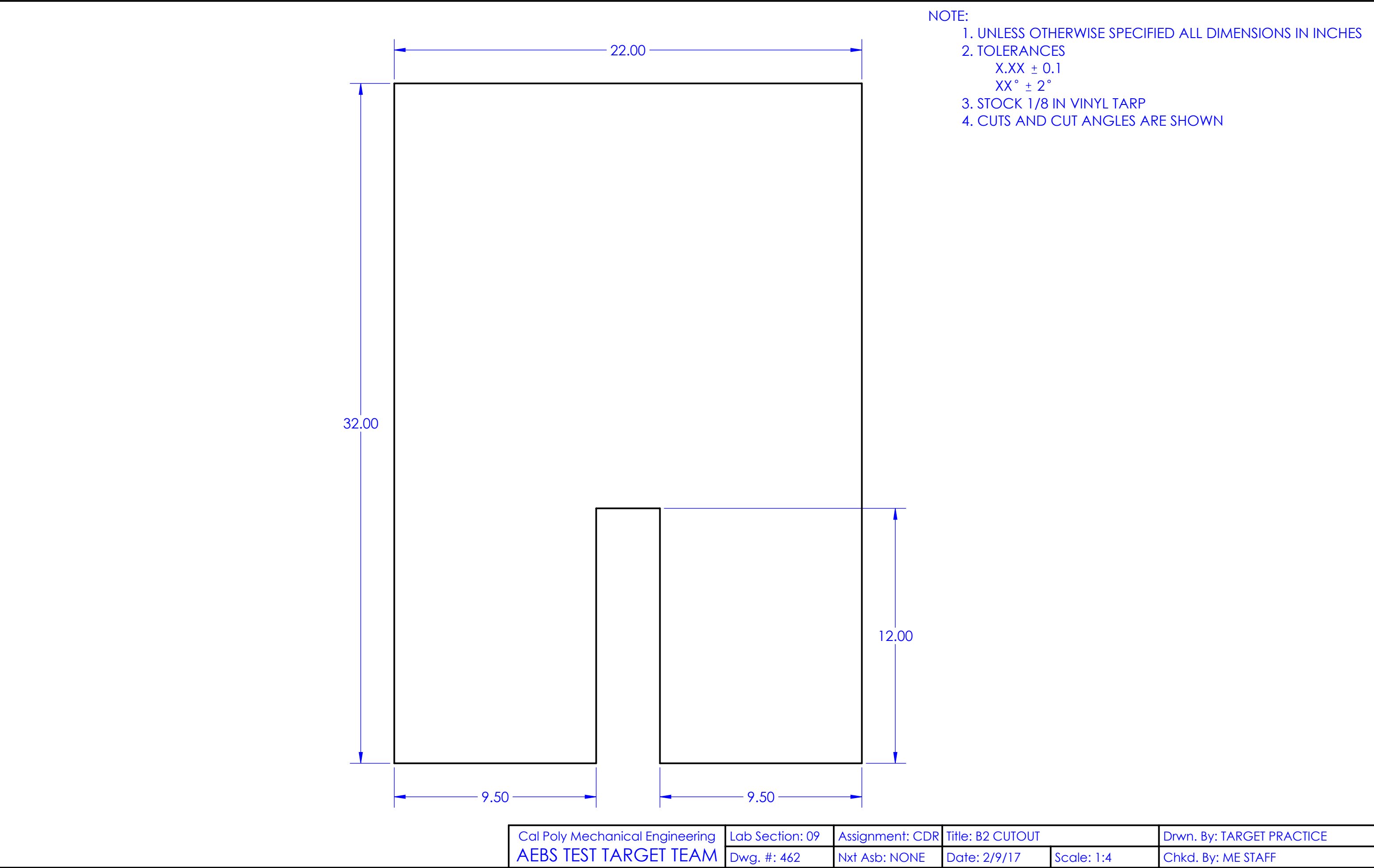


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: REAR TARP CUTOUTS		Drwn. By: TARGET PRACTICE
	Dwg. #: 460	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF



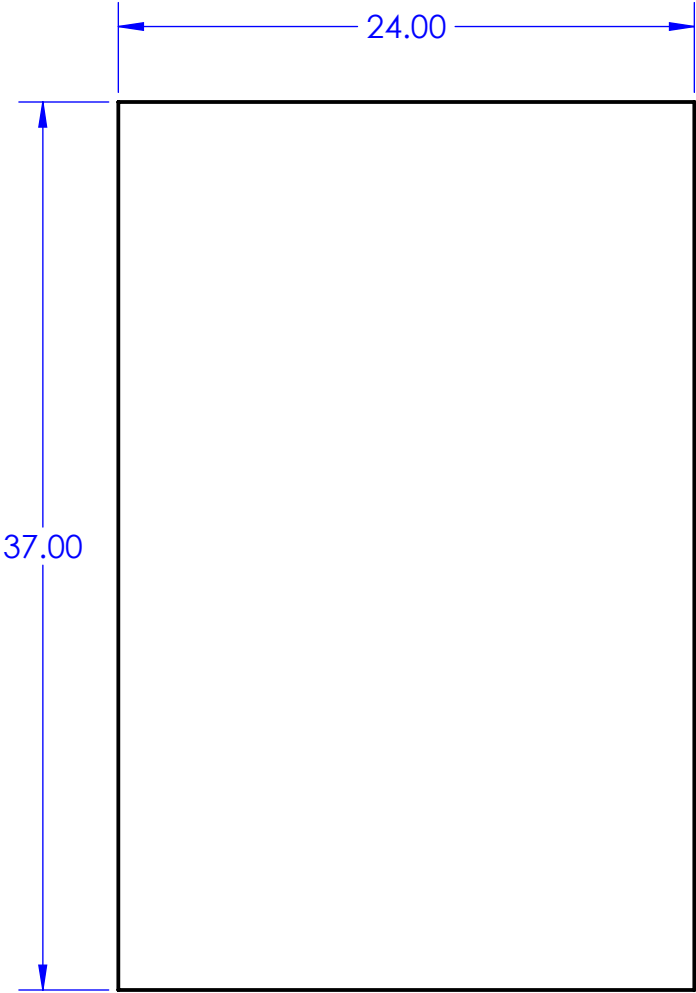
- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B1 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 461	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



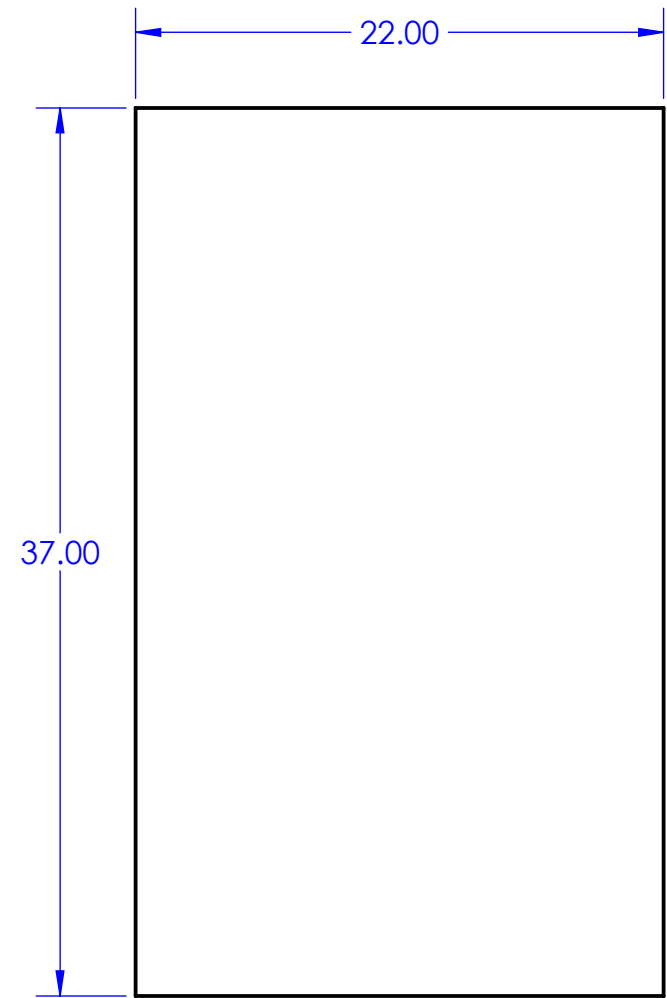
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B2 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 462	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



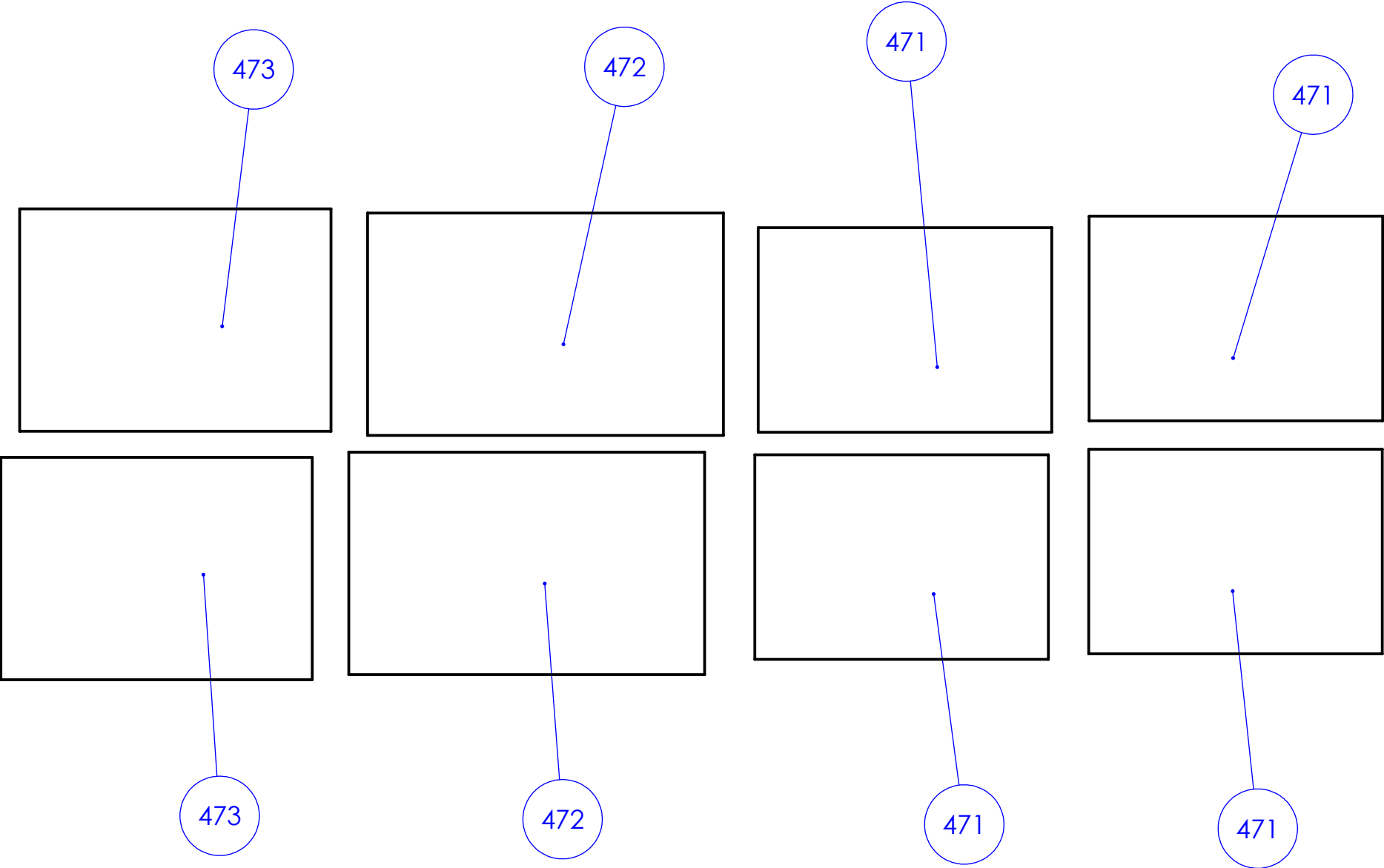
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B3 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 463	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: B4 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 464	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:8	Chkd. By: ME STAFF

PART NO.	PART NAME	QUANTITY
471	T1 CUTOUT	4
472	T2 CUTOUT	2
473	T3 CUTOUT	2



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: TOP TARP CUTOUTS		Drwn. By: TARGET PRACTICE
	Dwg. #: 470	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:16	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: T1 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 471	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN

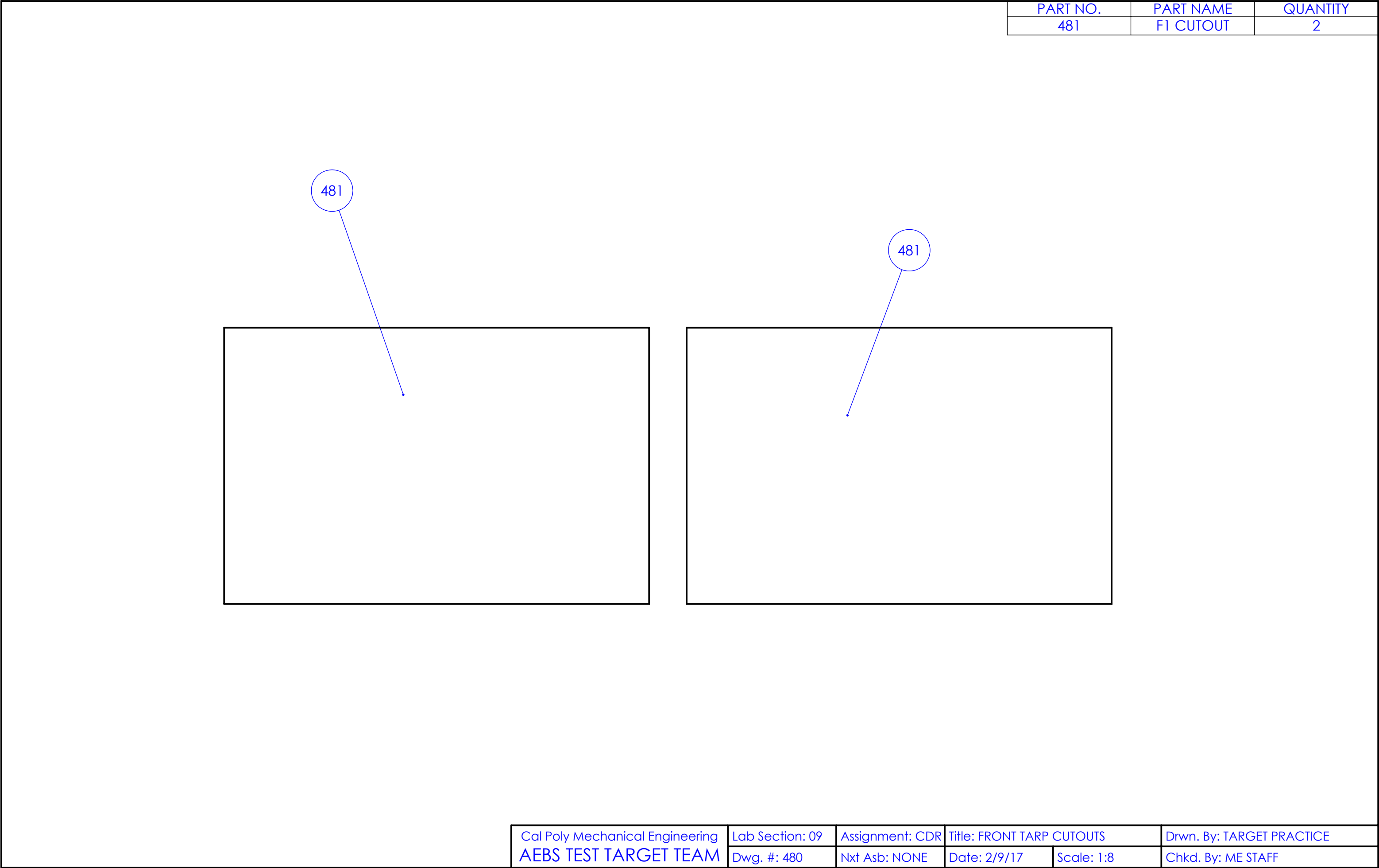


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: T2 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 472	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

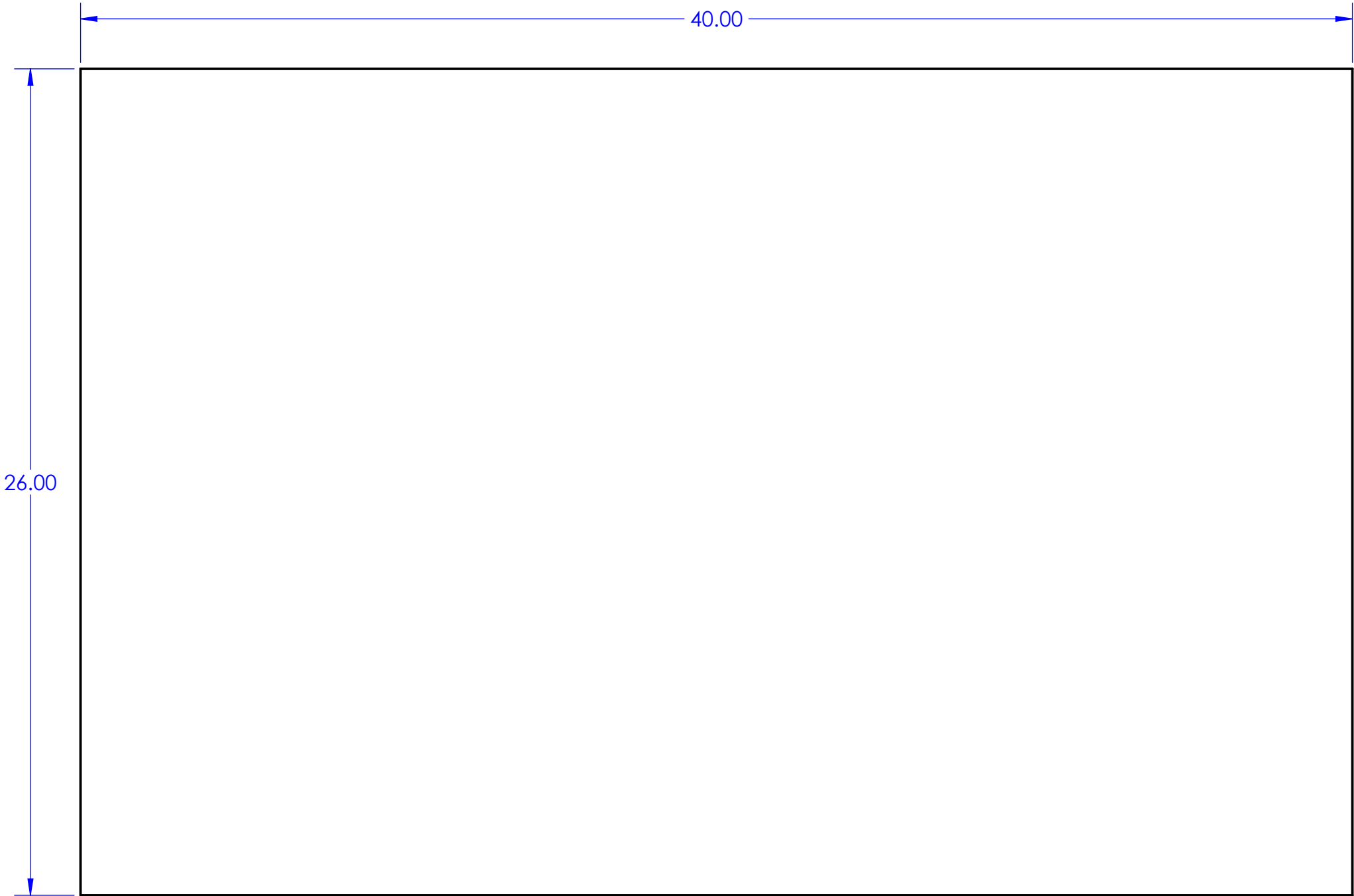
- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: T3 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 473	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

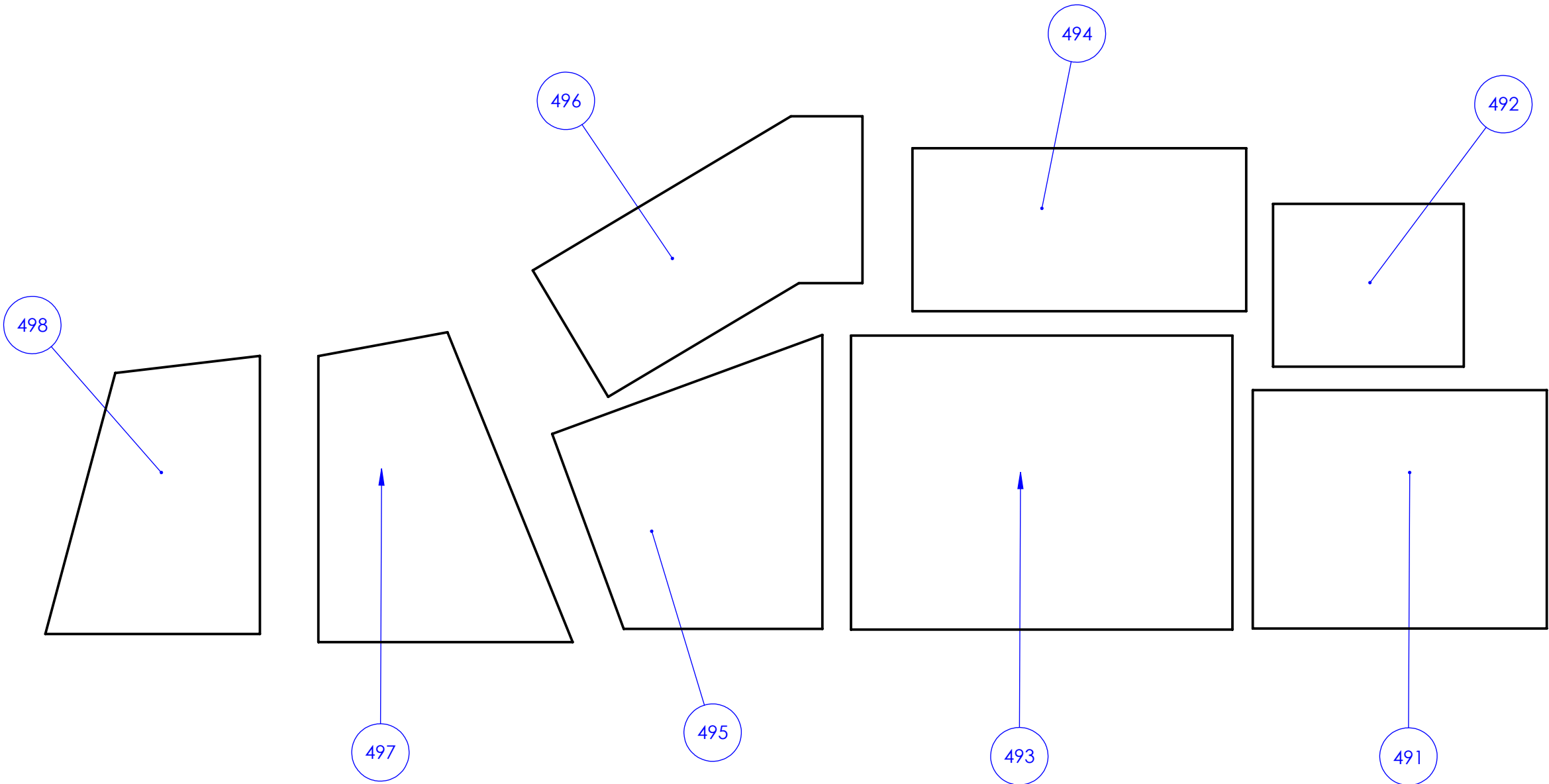


- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: F1 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 481	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

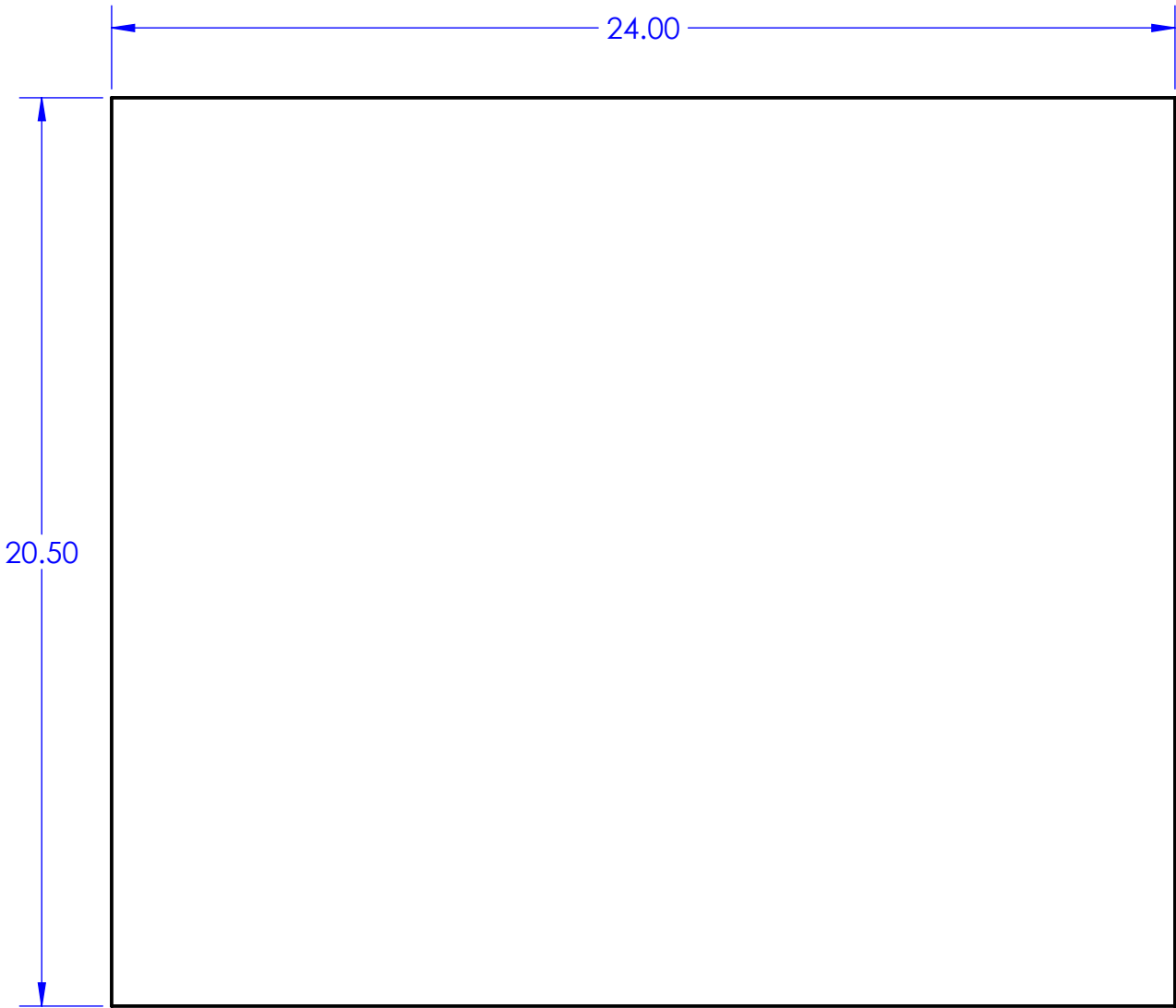
PART NO.	PART NAME	QUANTITY
491	S1 CUTOUT	1
492	S2 CUTOUT	1
493	S3 CUTOUT	1
494	S4 CUTOUT	1
495	S5 CUTOUT	1
496	S6 CUTOUT	1
497	S7 CUTOUT	1
498	S8 CUTOUT	1



- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S1 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 491	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
 - X.XX ± 0.1
 - XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S2 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 492	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF



- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN

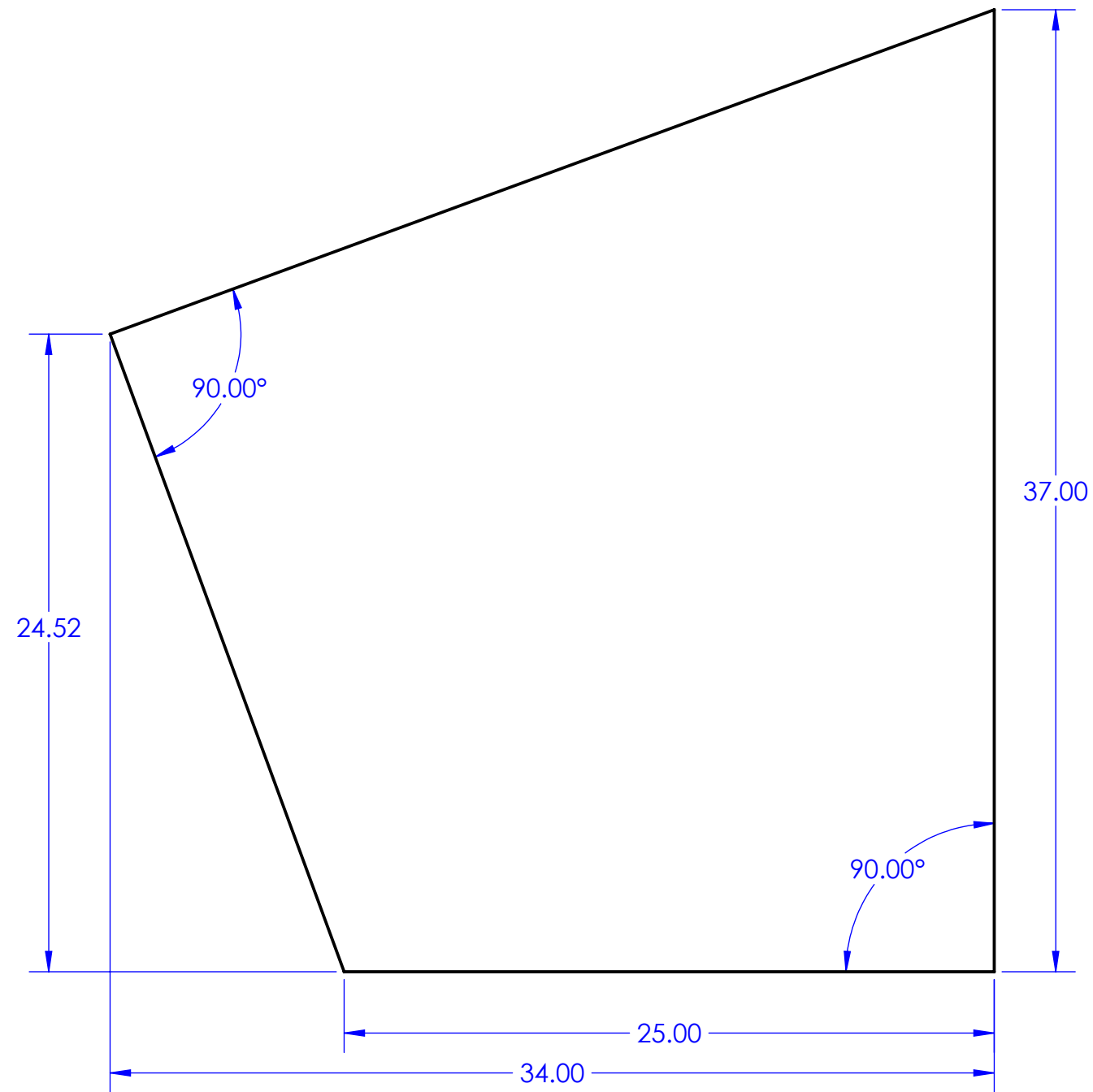
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S3 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 493	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:6	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



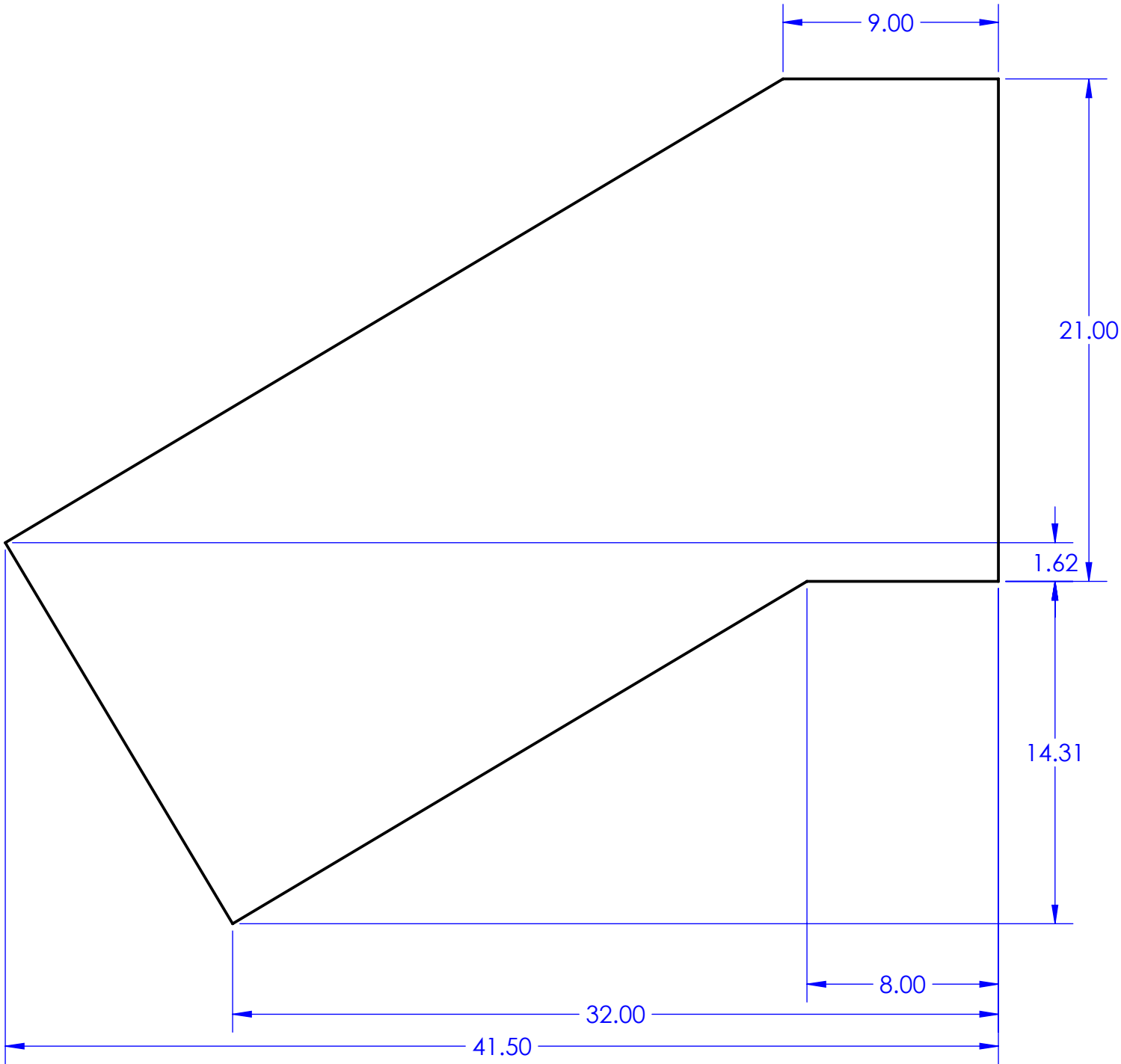
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S4 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 494	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:4	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



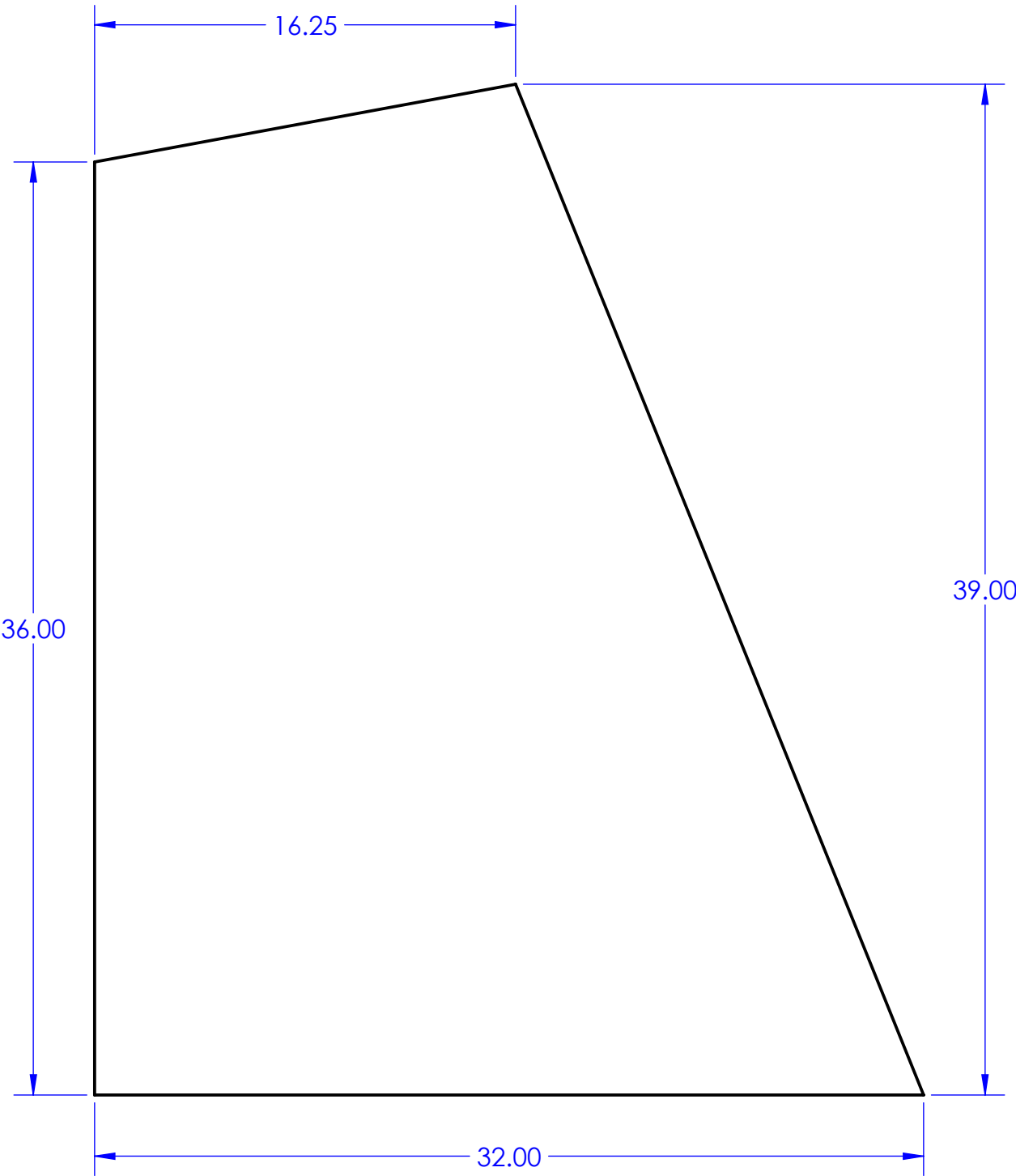
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S5 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 495	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:6	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



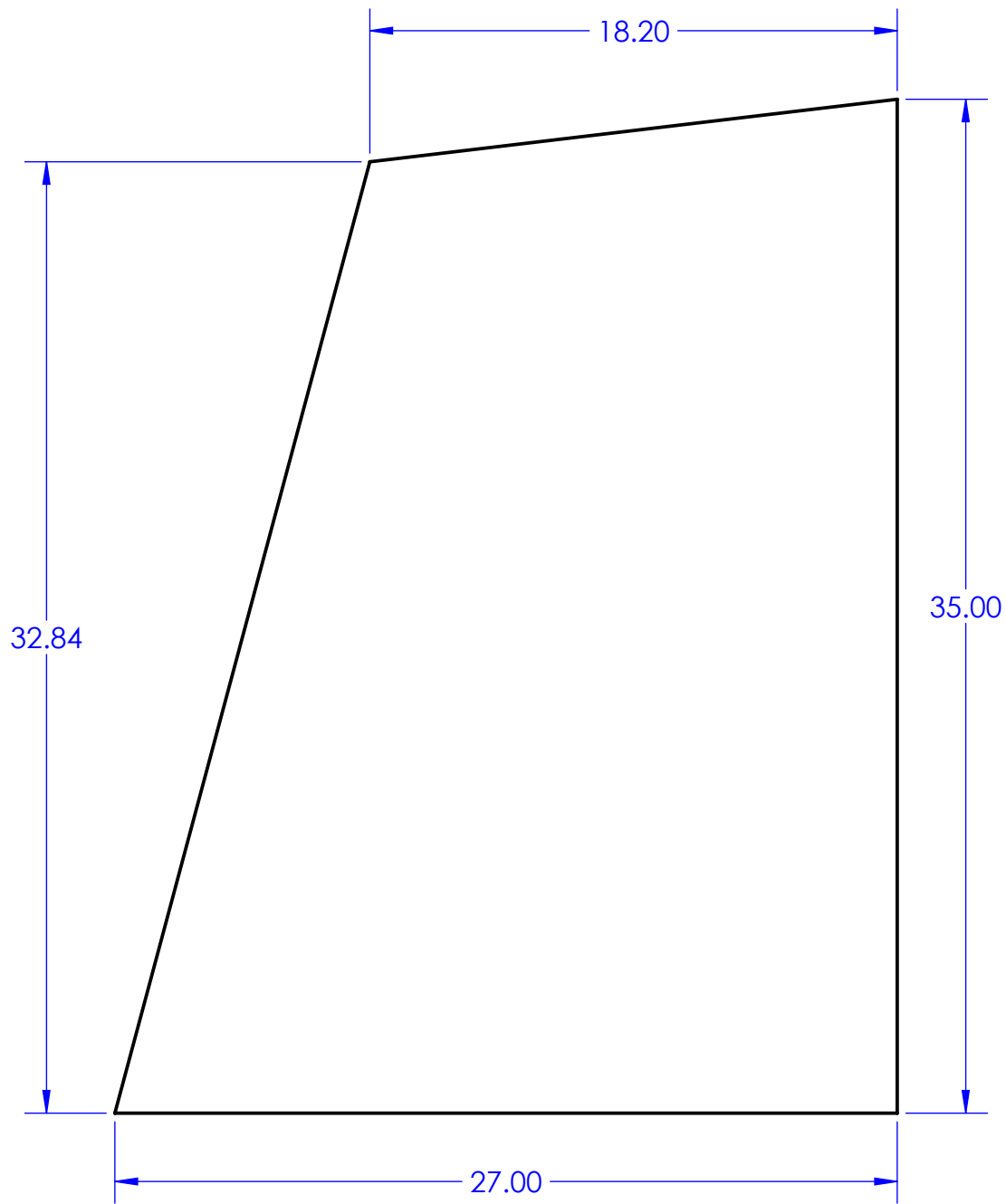
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S6 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 496	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:6	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



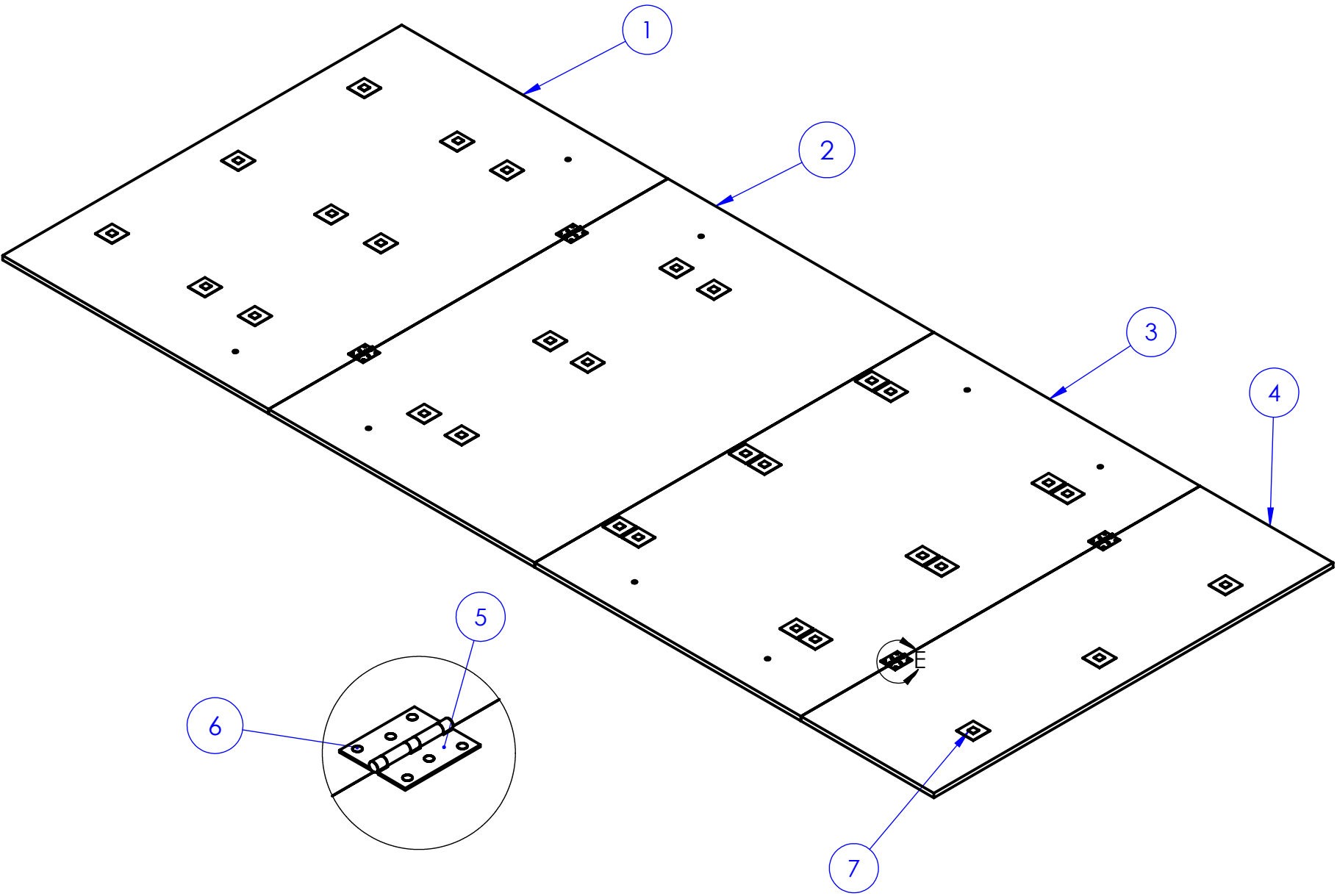
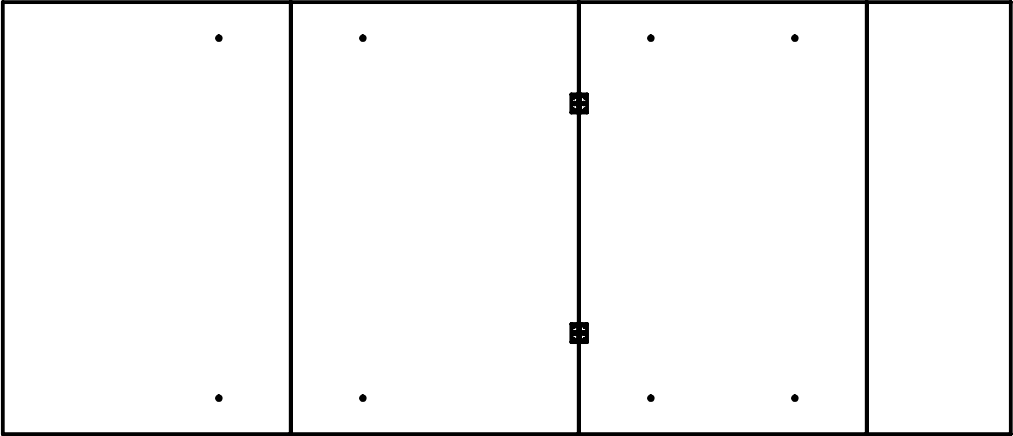
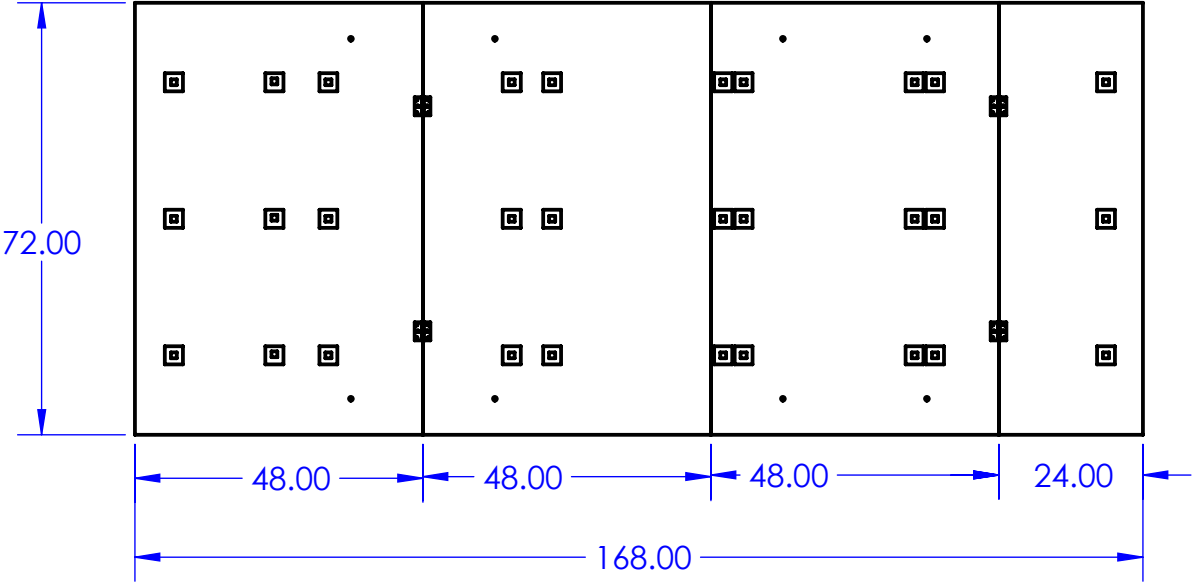
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S7 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 497	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:6	Chkd. By: ME STAFF

- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 1/8 IN VINYL TARP
 - 4. CUTS AND CUT ANGLES ARE SHOWN



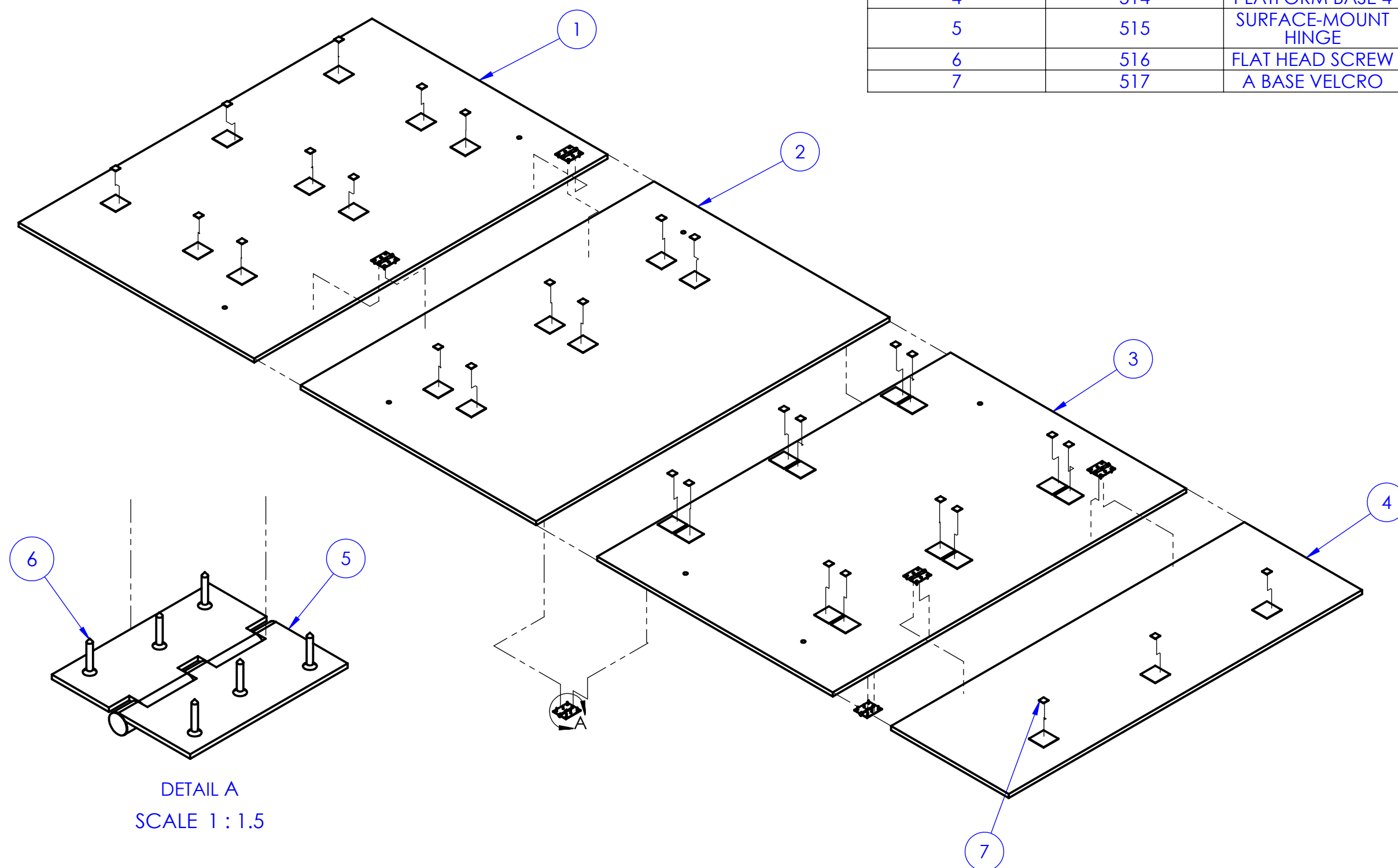
Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: S8 CUTOUT		Drwn. By: TARGET PRACTICE
	Dwg. #: 498	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:6	Chkd. By: ME STAFF

BALLOON	PART NO.	PART NAME	QTY.
1	511	PLATFORM BASE 1	1
2	512	PLATFORM BASE 2	1
3	513	PLATFORM BASE 3	1
4	514	PLATFORM BASE 4	1
5	515	SURFACE-MOUNT HINGE	6
6	516	FLAT HEAD SCREW	36
7	517	A BASE VELCRO	30



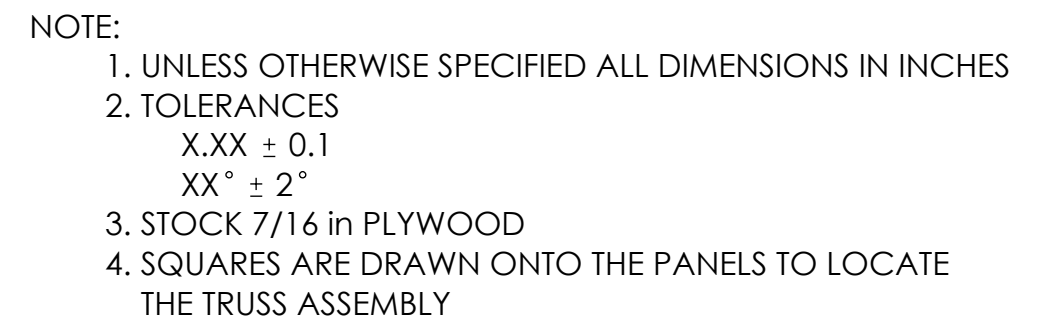
DETAIL E
SCALE 1 : 4

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: BASE ASSEMBLY		Drwn. By: TARGET PRACTICE
	Dwg. #: 500	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:32	Chkd. By: ME STAFF

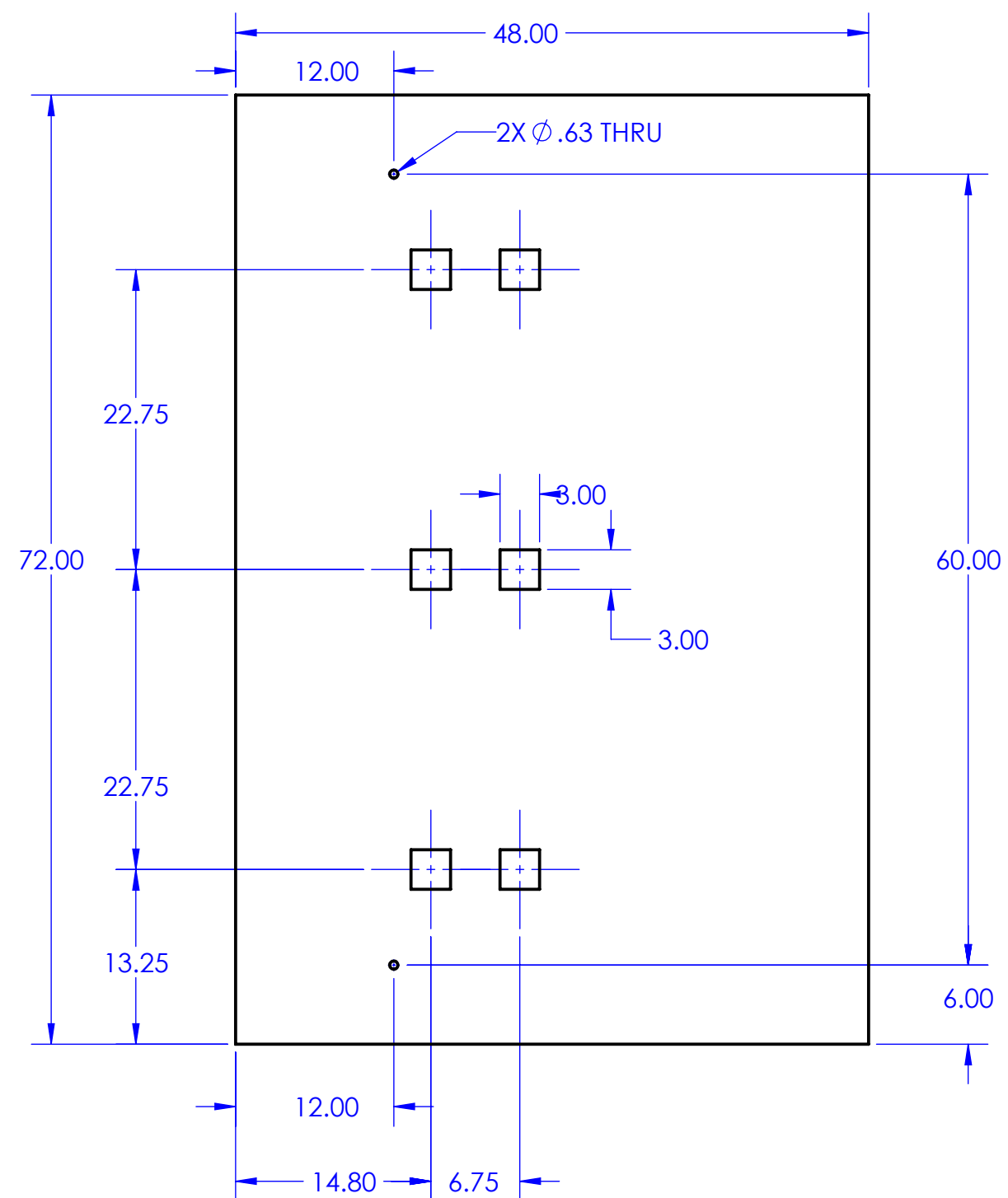


BALLOON	PART NO.	PART NAME	QTY.
1	511	PLATFORM BASE 1	1
2	512	PLATFORM BASE 2	1
3	513	PLATFORM BASE 3	1
4	514	PLATFORM BASE 4	1
5	515	SURFACE-MOUNT HINGE	6
6	516	FLAT HEAD SCREW	36
7	517	A BASE VELCRO	30

DETAIL A
SCALE 1 : 1.5

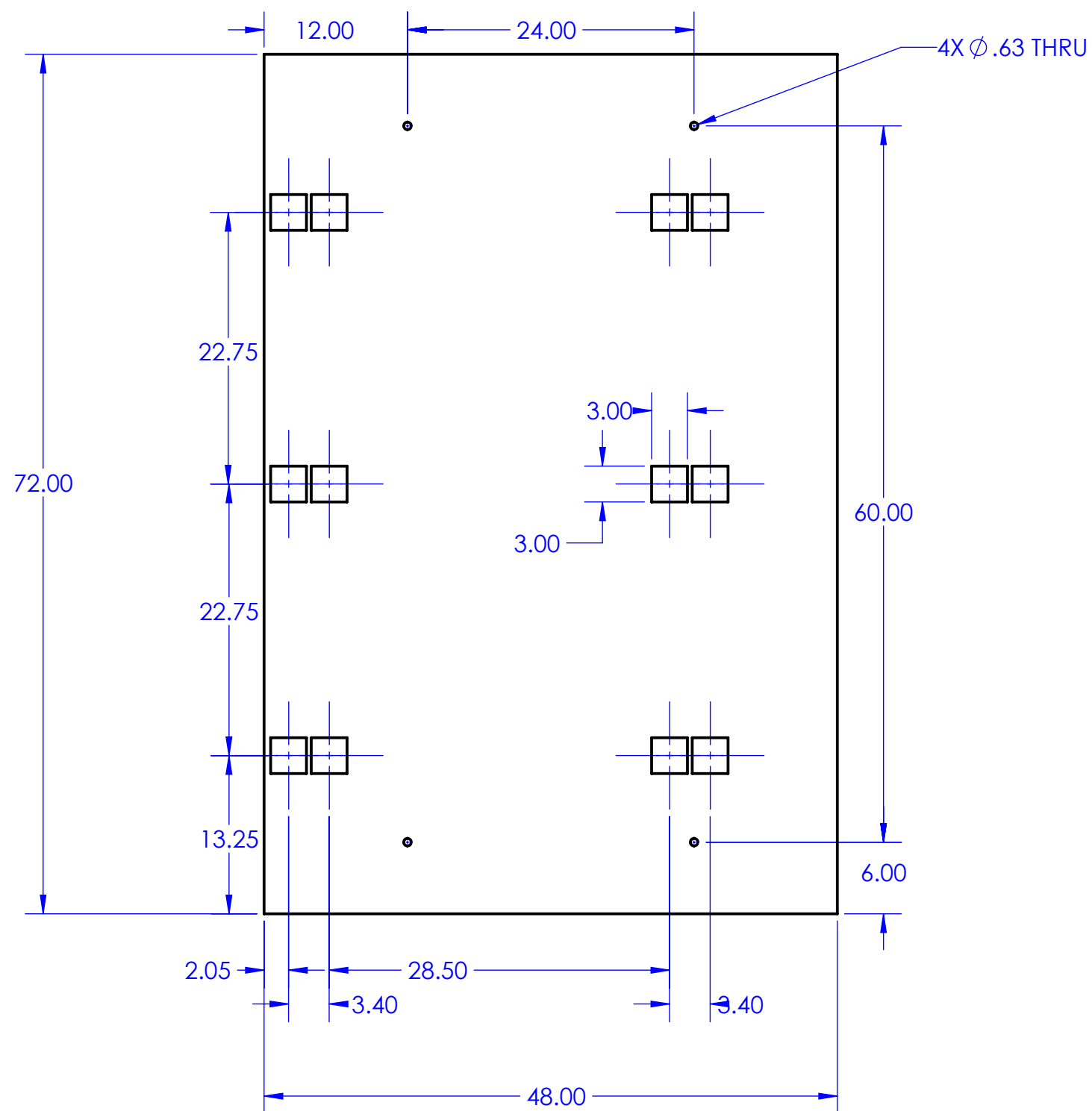


Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: PLATFORM BASE 1		Drwn. By: TARGET PRACTICE
	Dwg. #: 511	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF



NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
3. STOCK 7/16 in PLYWOOD
4. SQUARES ARE DRAWN ONTO THE PANELS TO LOCATE THE TRUSS ASSEMBLY

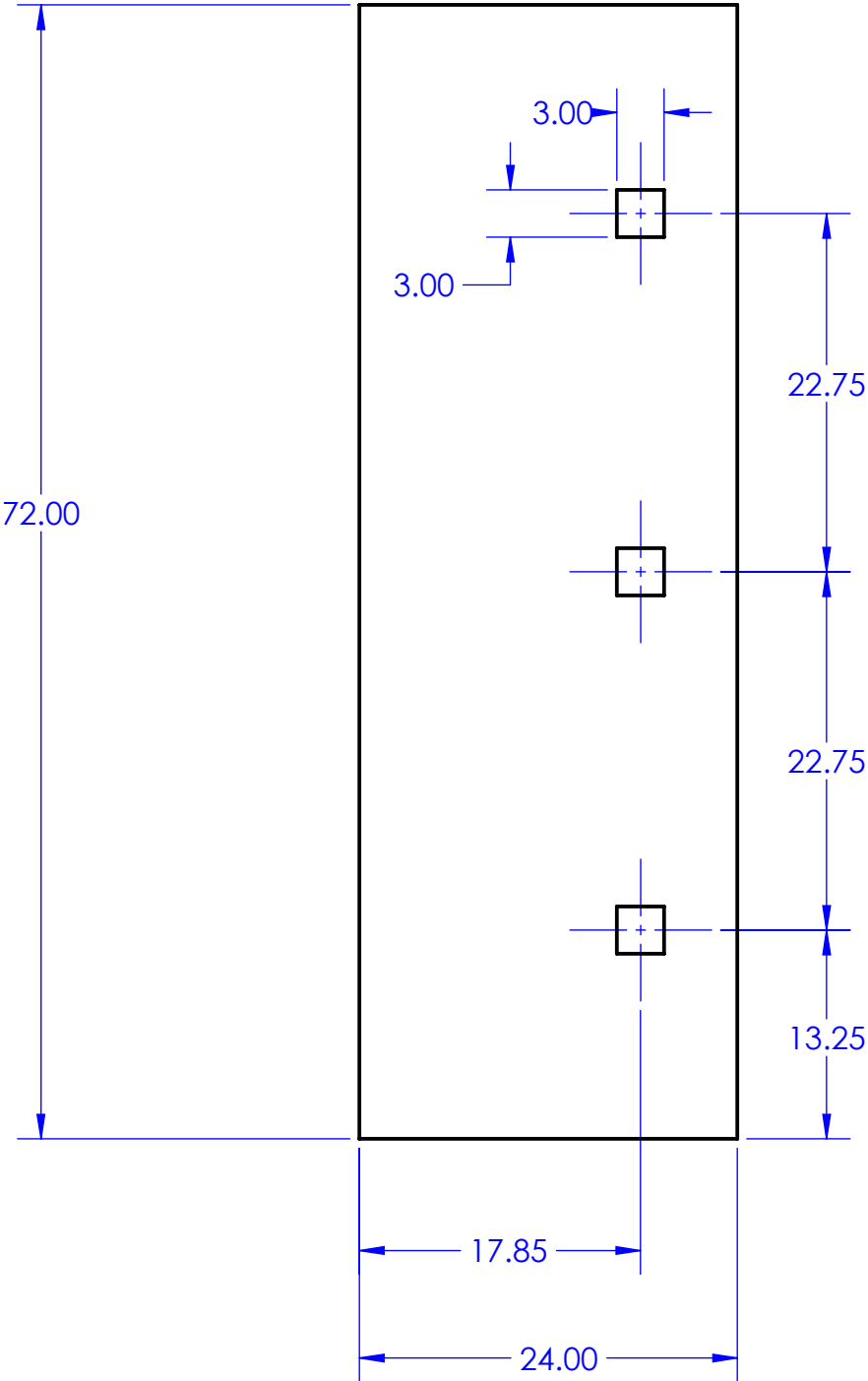


NOTE:

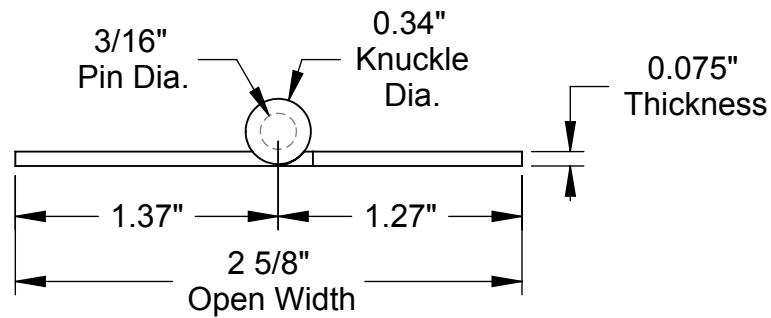
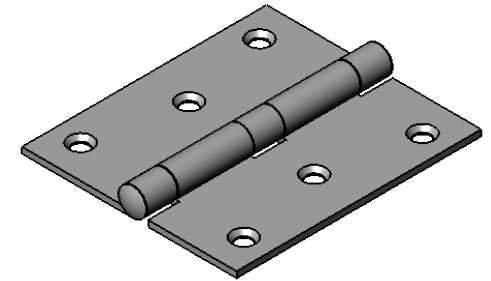
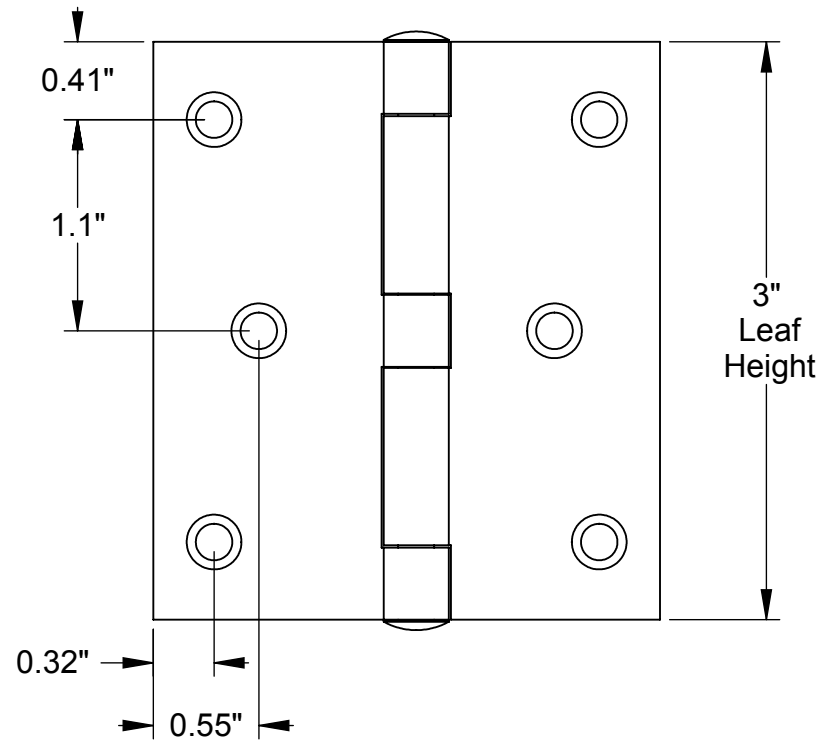
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX° \pm 2°
3. STOCK 7/16 in PLYWOOD
4. SQUARES ARE DRAWN ONTO THE PANELS TO LOCATE THE TRUSS ASSEMBLY

Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09 Dwg. #: 513	Assignment: CDR Nxt Asb: NONE	Title: PLATFORM BASE 3 Date: 2/9/17	Scale: 1:12	Drwn. By: TARGET PRACTICE Chkd. By: ME STAFF
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- NOTE:
- 1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
 - 2. TOLERANCES
X.XX ± 0.1
XX° ± 2°
 - 3. STOCK 7/16 in PLYWOOD
 - 4. SQUARES ARE DRAWN ONTO THE PANELS TO LOCATE THE TRUSS ASSEMBLY



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: PLATFORM BASE 4		Drwn. By:TARGET PRACTICE
	Dwg. #: 514	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:12	Chkd. By: ME STAFF



Hinge uses #10 flat head screws.

McMASTER-CARR CAD

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Information in this drawing is provided for reference only.

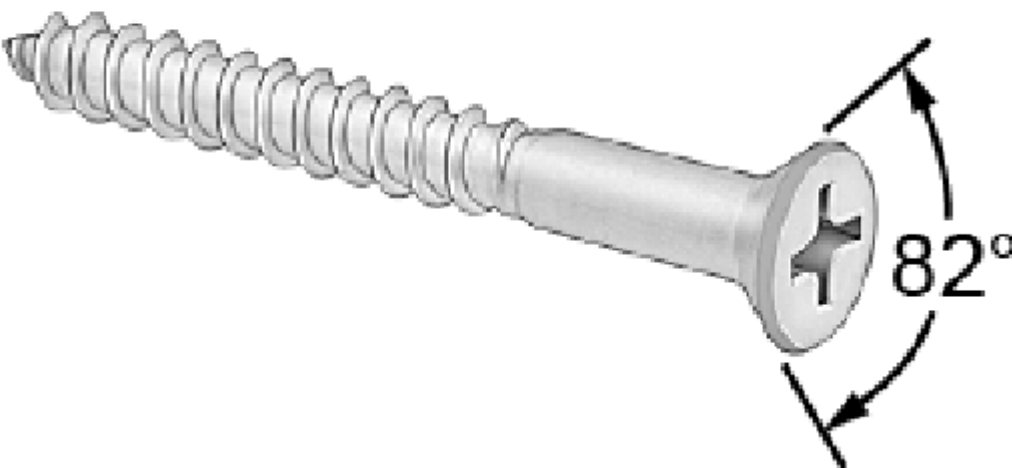
PART
NUMBER

515

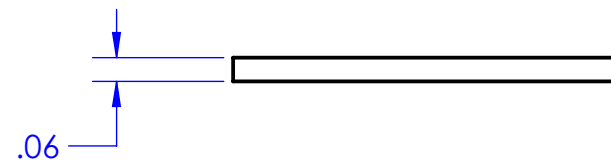
Surface-Mount
Hinge

Phillips Flat Head Screws for Wood

18-8 Stainless Steel, Number 10 Size, 5/8" Long

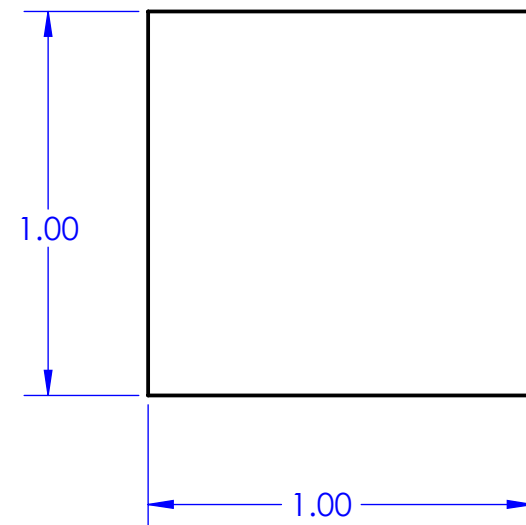


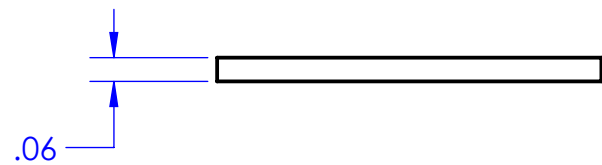
Material	18-8 Stainless Steel
Screw Size	No. 10
Screw Size Decimal	0.190"
Equivalent	
Length	5/8"
Head	
Diameter	0.385"
Height	0.116"
Drive Size	No. 2
Drive Style	Phillips
Softwood Drill Bit Size	3/32"
Softwood Drill Bit Size Decimal Equivalent	0.094"
Hardwood Drill Bit Size	7/64"
Hardwood Drill Bit Size Decimal Equivalent	0.109"
Approximate Threads per Inch	13
Thread Direction	Right Hand
Threading	Fully Threaded
Tapping Method	Thread Forming
Head Type	Flat
Flat Head Profile	Standard
Countersink Angle	82°
Tip Type	Pointed
Shank Cross Section	Round
System of Measurement	Inch
For Use In	Wood
RoHS	Compliant



NOTE:

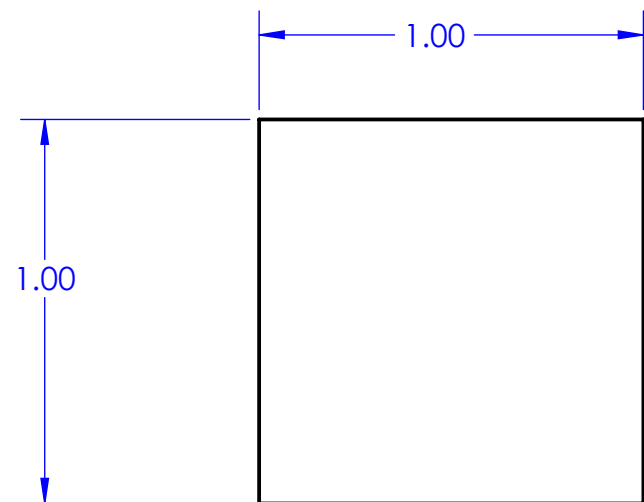
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX.X° \pm 2.0°
3. FEMALE VECRO (LOOP)

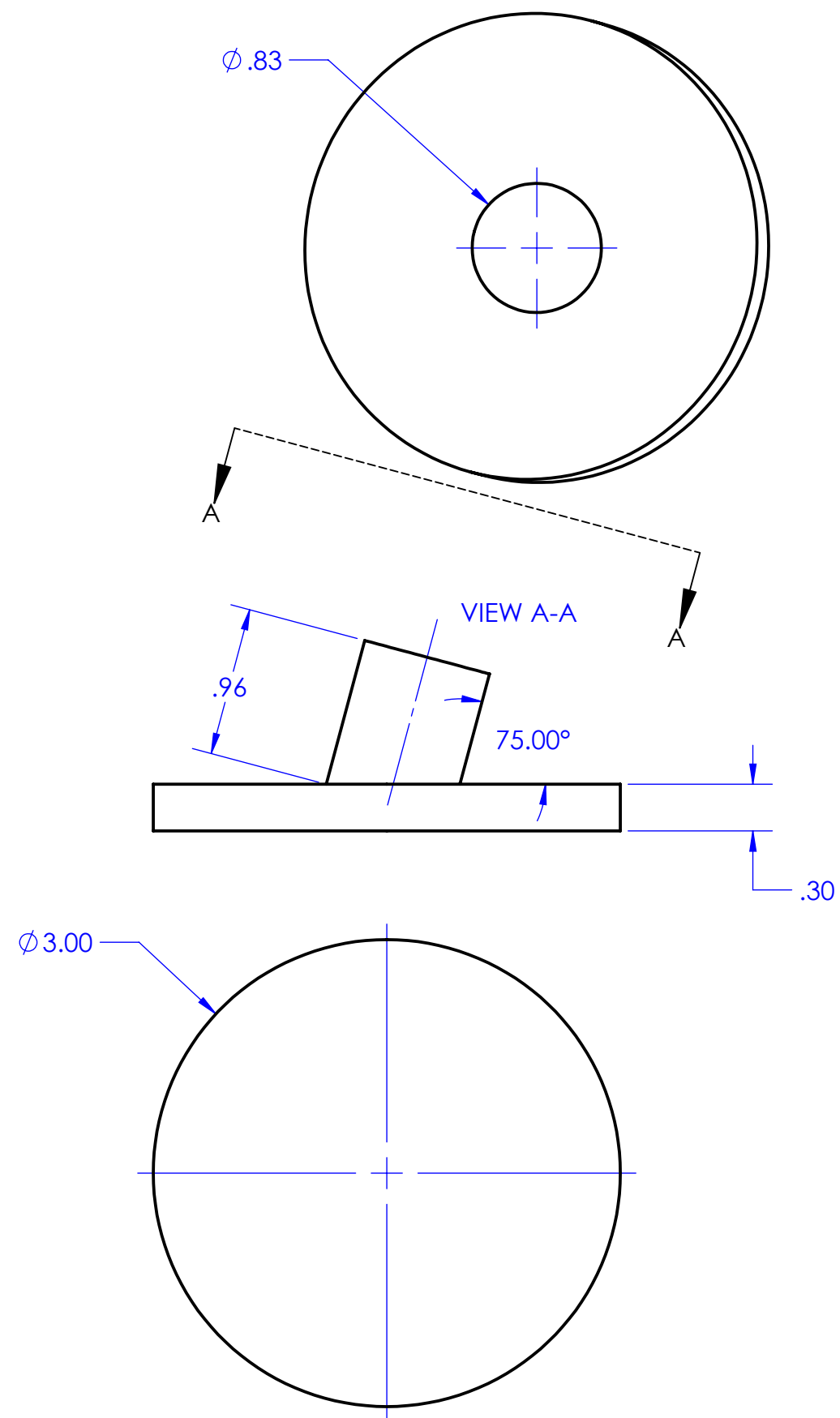




NOTE:

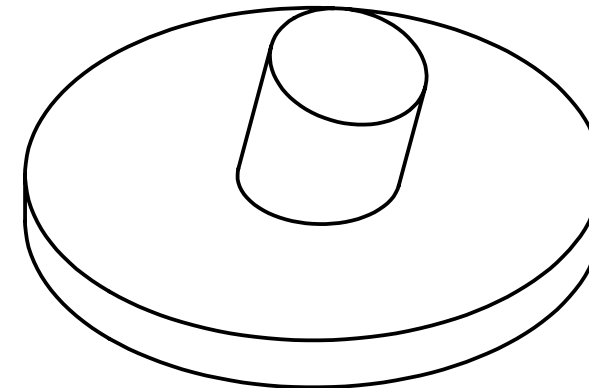
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX \pm 0.1
XX.X° \pm 2.0°
3. MALE VECRO (HOOK)



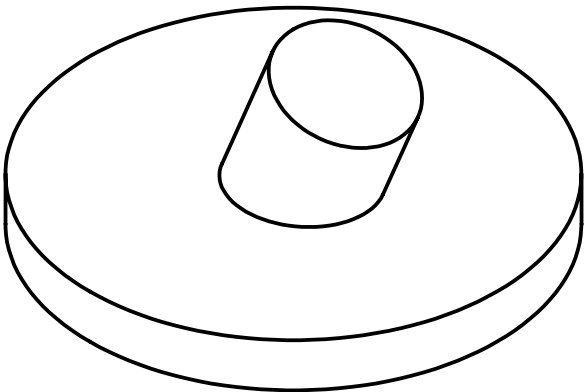
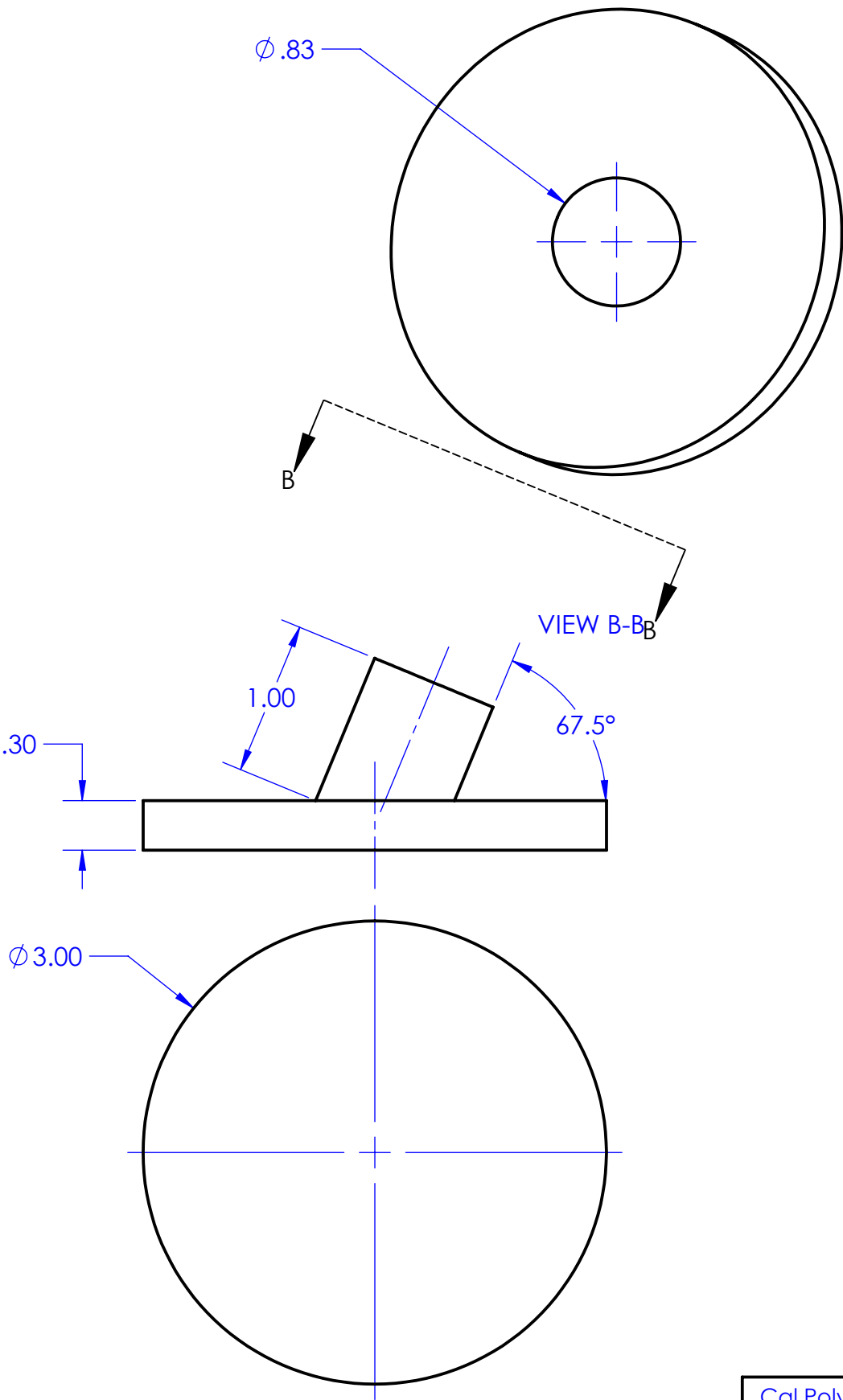


NOTE:

1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
 $X.XX \pm 0.1$
 $XX^\circ \pm 2^\circ$
3. STOCK 7/16 in PLYWOOD



NOTE:
1. UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS IN INCHES
2. TOLERANCES
X.XX ± 0.1
XX.X° ± 2.0°



Cal Poly Mechanical Engineering AEBS TEST TARGET TEAM	Lab Section: 09	Assignment: CDR	Title: V plug 65.5 deg		Drwn. By:TARGET PRACTICE
	Dwg. #: 522	Nxt Asb: NONE	Date: 2/9/17	Scale: 1:1	Chkd. By: ME STAFF