



ZEN AND THE ART OF FIELD CONSTRUCTION

A MANUAL OF CONSTRUCTION TIPS AND TECHNIQUES FOR BUILDING THE 2009 FTC PLAYING FIELD.

This manual should be used in conjunction with the detailed field drawings.

hot!
shot

Document Revision History

Rev	Date	Changes	Initials
3	09/10/09	Added Table of Contents, and revision history.	LAR
4	09/11/09	Section 7.2.3 & 7.2.4: Changed illustration and text to show placement of beacon from 8" from center post TO 6" inches from inside edge of polycarbonate. Section 7.1.5 Added note on beacon connection.	LAR

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1. OVERVIEW

The Game Design Committee (GDC) realizes that while the field drawings show the field elements and dimensions, actually constructing the field can be a challenge. The purpose of this document is to help clarify the design intent of the field elements and to share some construction tips, tricks, and techniques.

First of all, don't panic. While there appears to be quite a few elements most are duplicates so once you have mastered the first one the rest are easy. You can even mass produce many of the elements and then just assemble them. The GDC has designed this field using readily available parts that should be available at any Home Depot or Lowe's across the country. All the parts can be made using simple hand tools, you do not have to be a master carpenter or machinist to construct this field. The GDC has listened to the input from the Affiliate Partners (AP) and this year's field has been designed to disassemble into small, easily carried and stored elements.

Where possible we have identified parts by their SKU and UPC number to make it easy for you to find the correct part. However, we have found that not all parts are carried by all stores so where possible we have identified where you can make substitutions without affecting the play of the game. In general, if the substitution does not affect how the robot interacts with the field element then you can feel comfortable with the substitution. If you have any questions feel free to contact FIRST or the GDC for clarification.

Remember, Rule G12 is your friend. This rule stipulates that field tolerances can vary by as much as +/- 1" which gives you a lot of leeway during construction. Teams must design their robots to accommodate this level of variation in the field, if they don't it is their problem not yours. While you should try to construct the field as close as possible to the official drawings there is always going to be slight variability (+/- 1/8" is probably normal) in parts, assemblies, etc. The key dimensions and parts that are critical to the game are noted in the following sections.

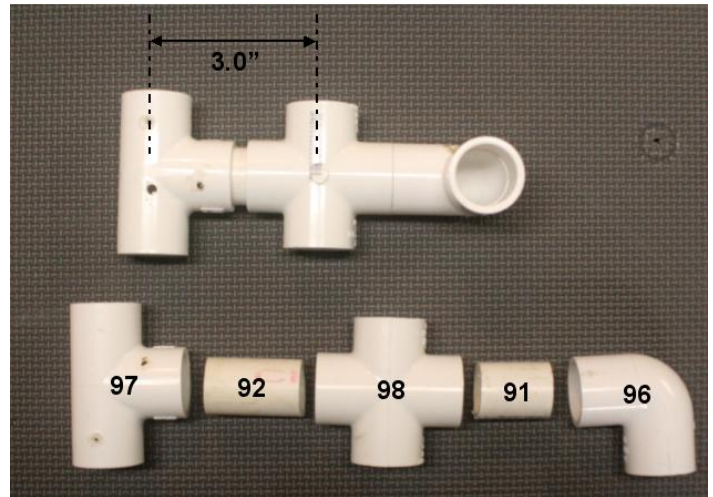
Many of the field elements are made from PVC pipe and fittings. This is a cheap and readily available material but we have found that fittings purchased in different stores even within a chain can vary in size. So it is always a good idea to dry fit the parts first and adjust the lengths until everything fits properly. It is worth investing in a good PVC cutter. It is faster and makes cleaner cuts than a saw.

2. BALL CHUTES

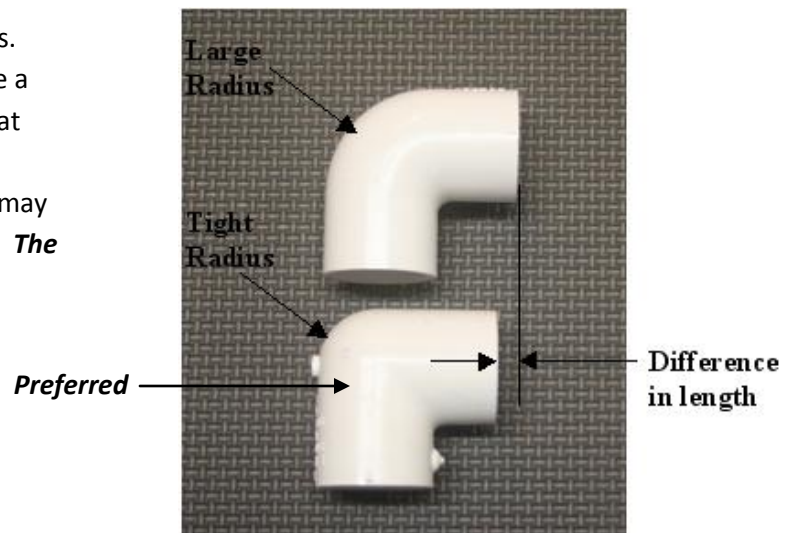
There are four (4) ball chutes per field: two (2) red and two (2) blue. Each ball chute is made of three (3) sub assemblies: the Chute Support, the Trigger, and the Ball Tube. All parts are made from readily available (and cheap!) PVC tubing.

2.1. BALL CHUTE SUPPORT:

2.1.1. A critical dimension is the spacing of the two pipes, parts # 94. These pipes must fit into the two mating holes in the Corner Base and therefore must be 3" apart, center to center. The spacing of these pipes is controlled by the length of pipe #92. Remember to dry fit the tee #97, cross #98, and pipe #92 together and measure the center to center distance. Adjust the length of #92 until the pipes are 3" apart, center to center.

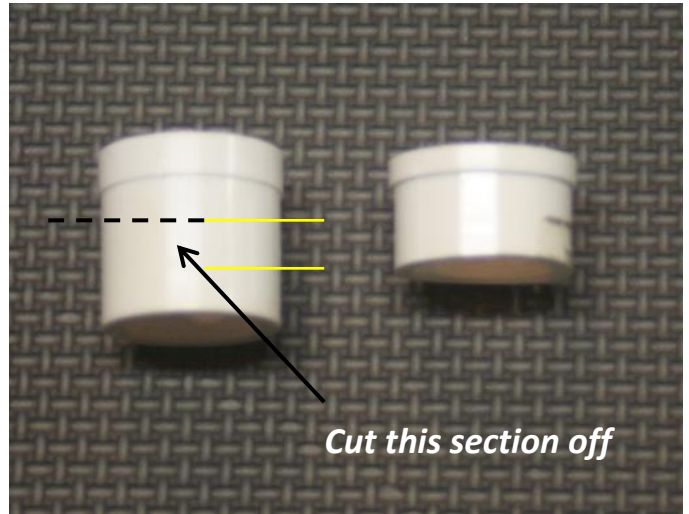


2.1.2. We have found two distinct types of elbows. The ones typically sold at Home Depot have a tighter corner radius while the ones found at True Value have a larger radius. The large radius bend tees tend to be larger in size and may make it difficult to maintain the 3" spacing. **The tight radius is preferred.**



2.1.3. The length of pipes # 94 controls the height of the trigger assembly and thus affects where the robots will interact with the trigger. Try to keep the height of the upper bushing at the specified dimension

2.1.4. Bushings #99 must be modified. The bottom 1/4" is cut off to allow the 1/2" pipe to pass completely through. The exact length of the modified bushing is not important so long as the pipe can pass through. We have found that due to production tolerances these bushings may fit too tightly on the trigger pipe # 82. A fix for this will be addressed in the section on building the trigger. Trimming up to 1/2" off the bushing short will help to minimize the contact area and let the trigger move freely.



2.1.5 When you cement the parts together start with 97, 92, and 98. Make sure they remain square to each other and are at the proper center to center spacing. As you glue on parts 91 and 96 make sure 96 is horizontal. If this tee is angled down or up this can cause the trigger to open or close on it's own due to gravity. When you attach part 97 with the bushings, make sure it is vertical (same orientation as part 98)



2.1.6. While the red and blue Ball Chutes share the same number and type of parts, they are mirror images of each other. Be sure to make two of each



2.1.7. The Bonus Ball holder.



2.2. TRIGGER

2.2.1. This is the one field element that teams will interact with the most. Robots are expected to push and pull on the trigger so it should be assembled carefully and glued so that it holds together. ***We suggest making a spare of each type just in case of breakage***



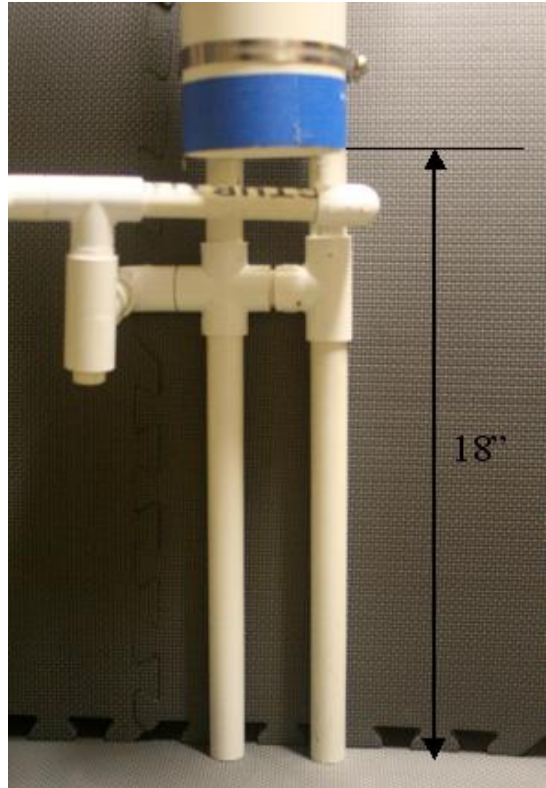
2.2.2. Teams are only allowed to interact with the trigger at the taped regions and the elbow in between. Use the same 2" gaffer's tape that you use to outline the drivers and start boxes.

2.2.3. While the red and blue Triggers share the same number and type of parts, they are mirror images of each other. Be sure to make two of each

2.2.4. We have found that the fit between the 4" pipe, # 82 and the bushings, # 99 can vary from a nice slip fit to very, very tight. You should dry fit these parts prior to assembly and try to find pipes that fit loosely. If this does not work you will have to sand the pipe until you get a nice fit that allows the trigger to turn smoothly with just a light push. A little lubricant like WD-40, grease or even petroleum jelly (Vaseline™) will help.

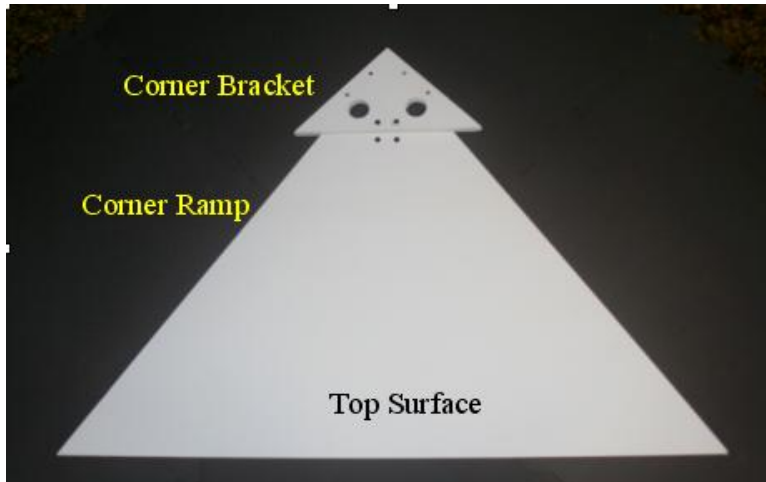
2.3. BALL TUBE

- 2.3.1. The overall length of the tube is not critical, providing it holds the required fifteen (15) balls
- 2.3.2. Use the same 2" wide gaffer's tape that you use to outline the drivers and start boxes to create a stripe at the top and bottom of the tube. You can add additional stripes if you wish or add sponsor logos to the tubes, just be sure teams can clearly determine if this is a red or blue tube.
- 2.3.3. When the tube is assembled onto the ball chute the critical dimension is the height of the bottom of the tube above the bottom of the Ball Chute pipes.



3.1 CORNER RAMPS

3.1.1. The Corner Bracket and the Corner Ramp are connected via a hinge. This hinge provides no functionality during the game (teams are not expected to lift the ramp). The primary purpose of the hinge is to allow the parts to fold flat for storage and transport. Therefore almost any small hinge will work providing it does not substantially alter the final assembly dimensions.

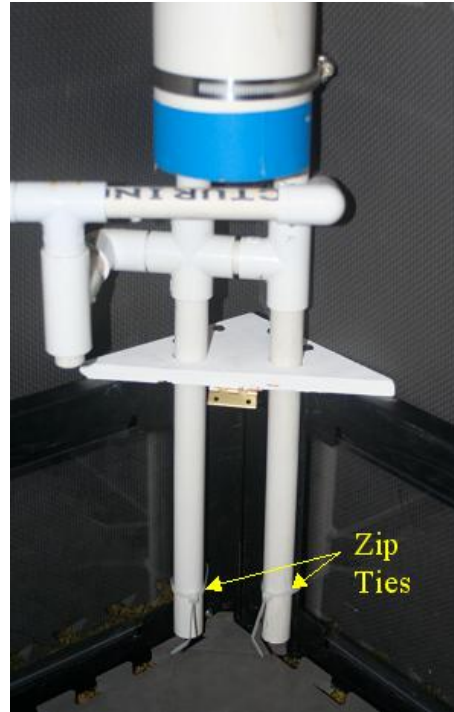


- 3.1.2. All plywood parts should be painted flat white. It is recommended that the parts be painted on all sides to prevent warping, particularly in hot, humid climates like Florida
- 3.1.3 .A little careful planning allows for eight (8) Ramps to be made from a single 4' x 8' sheet of plywood. We have found it easiest to rip the sheet lengthwise 17" wide then lay out four (4) ramps. The sides can be easily cut with a hand held circular saw.
- 3.1.4. The drawings call for 1/4" thick plywood for the ramps but many stores may only carry 5/32" plywood. This is fine, the ramps are primarily there to scatter the balls and thickness will have no affect on performance.

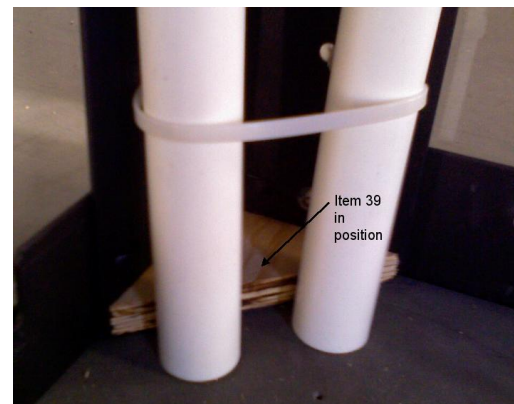
3.2. CORNER BRACKET

3.2.1. The Corner Brackets replace the metal corner brackets that are typically used to secure the field perimeter. There are two types of FTC fields, the original IFI manufactured fields and the newer fields. The Corner Bracket drawing includes holes for both types of fields but you may want to check to see which field you have before you start drilling any holes.

3.2.2. The critical dimension is the center to center distance between the two 1.125" dia. holes. These holes must be 3" apart to allow the Ball Chute Support to pass through. The holes must also be located such that the Ball Chute Support pipes end up adjacent to the field perimeter since the pipes are zip tied to the walls to keep the Chute from moving. The zip ties can be placed into whatever holes are available. The photo shows the ties being threaded through the window opening and the end of the metal frame



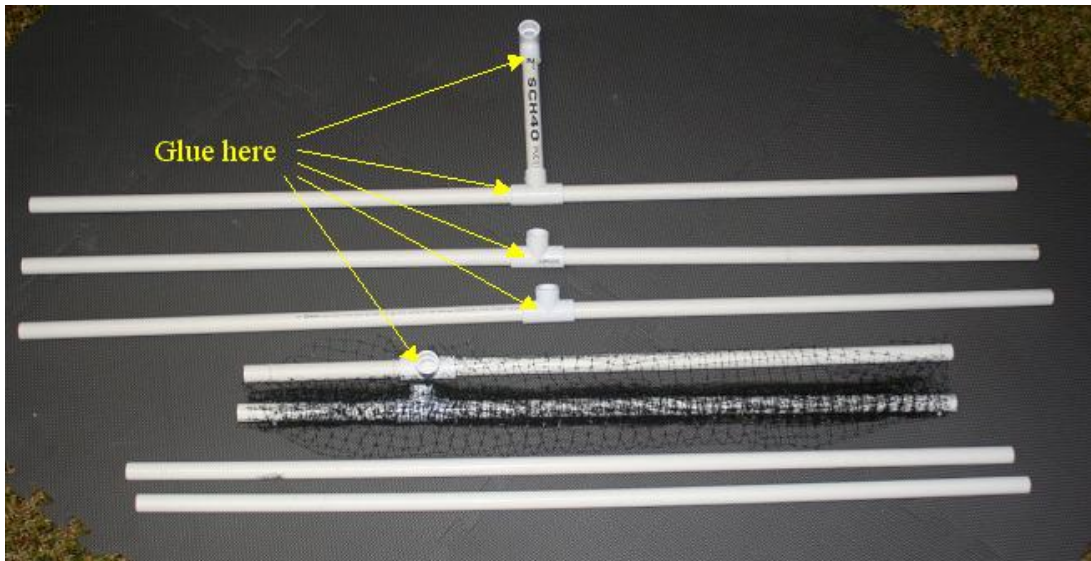
3.2.3. Block # 39 is used to push the ball chute supports away from the field thus angling the chutes and letting the balls fall properly. Place the block into position before zip tying the support



3. BACKSTOP

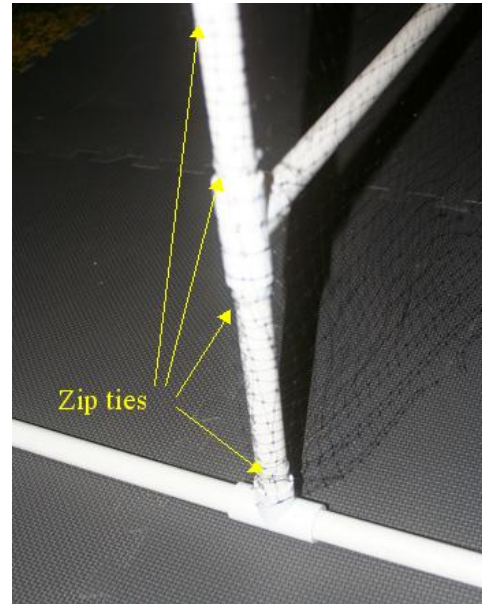
4.1 FRAME

- 4.1.1. The frame is made from 1/2" PVC pipe and fittings. The structure is self supporting without the need to cement the individual parts together. This also allows the frame to come apart easily for transport and storage. If you find that the joints are a little loose you can glue together certain key parts (see photo below) that will still allow the frame to fold up.



4.2. NET

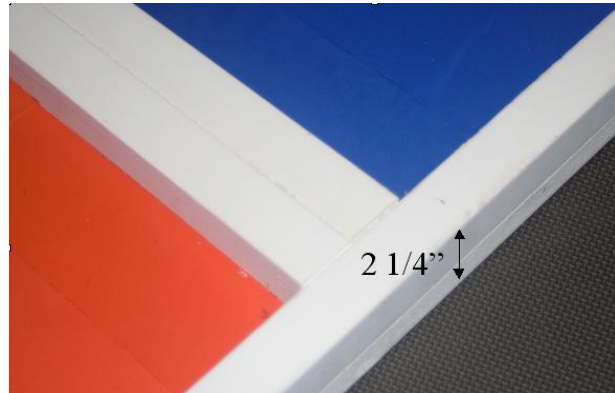
4.2.1 The sole purpose of the netting is to prevent balls from flying into the audience, it is not intended to be used by teams to ricochet balls into the outside goals, though it will certainly be used that way (see Rule 2.3: Definition of Off Field Goal). This means that the netting does not have to achieve a certain level of tautness and so long as the balls don't pass through almost any kind of net is acceptable. The BOM calls for Bird Blocker netting but if you cannot find this you may substitute as needed. Remember you want the audience to see through the net so window screening is probably not a good choice here. Use zip ties to attach the net to the two outer uprights and as needed.



5. CENTER GOAL

5.1. CENTER GOAL BASE

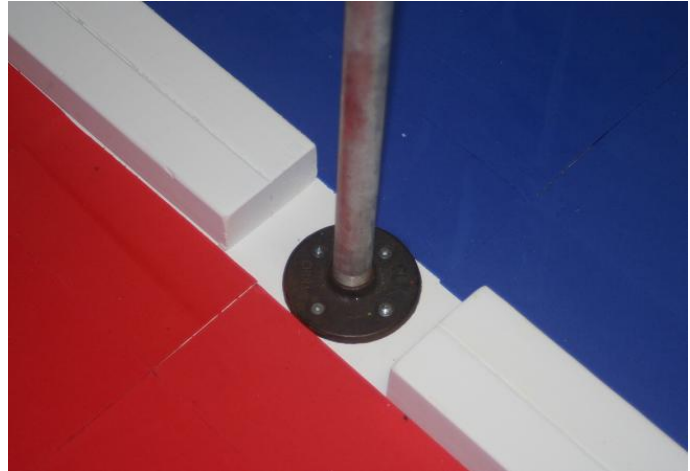
5.1.1. The base is made of 3/4" plywood with walls made using 2x2 nominal lumber. This lumber actually measures 1 1/2" x 1/1/2" which means the top of the wall should be 2 1/4" above the tile floor. The walls are attached to the plywood using wood screws screwed in from the bottom. We recommend at least five (5) screws per side to provide sufficient strength during transport.



5.1.2. The pipe flange is screwed into the plywood with flat head wood screws. The 36" long iron pipe is hand screwed into the flange. Do not over tighten the pipe since you will have to remove it later for storage and transport. Besides, the overall height of the pipe is not important since the wooden dowel inside actually controls the center goal height. The easiest way to get the height of the dowel correct is to first push it into the pipe. Then place the center goal on the dowel and measure the distance from the tile floor to the bottom edge of the 9" hole in the goal face. Subtract 30" from your measurement and this is the amount you need to cut off the dowel. For instance if the measured height of the goal face is 34", subtracting 30" means you should cut 4" off the dowel to have the goal face at the proper height.

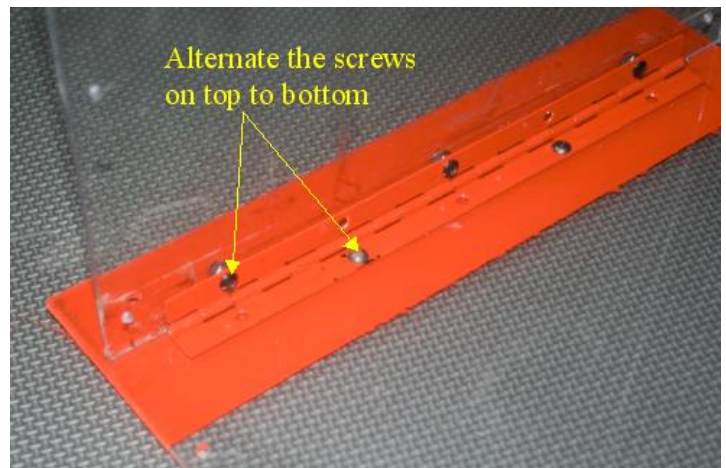


5.1.3. The thin red and blue foam pads are cut to size and glued onto the plywood with spray on adhesive. These foam pads come in different sizes depending on where they are purchased so just cut and piece them until you fill the required space.



5.2. CENTER GOAL

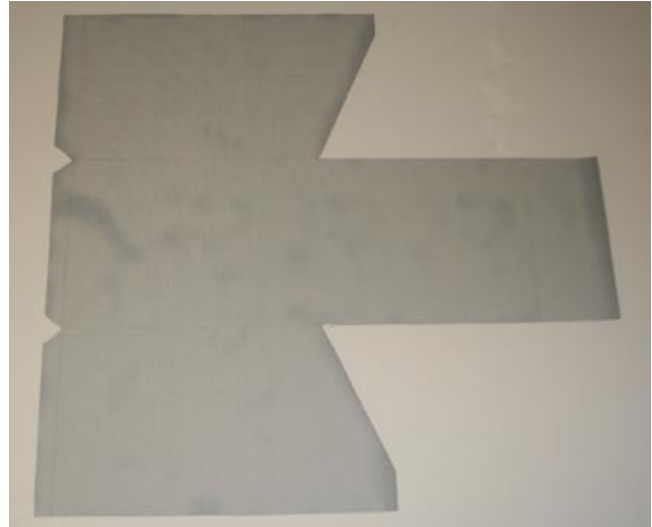
5.2.1 To make the goal fold flatter for storage you can alternate the screws holding the hinge in place. This prevents the heads of the screws from interfering with each other.



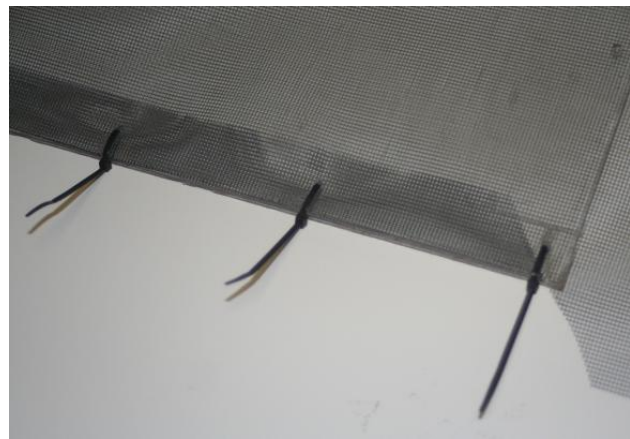
5.3. GOAL NETS

The goal nets look complicated but the process to construct them is made up of a series of simple steps.

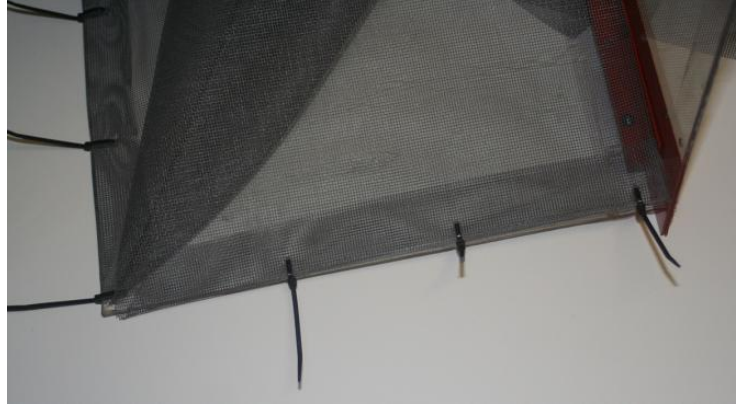
5.3.1. First cut the netting to size. The BOM calls out for fiberglass netting. This typically comes in either black or gray. We have found that the gray allows for the balls to be seen easier by the audience.



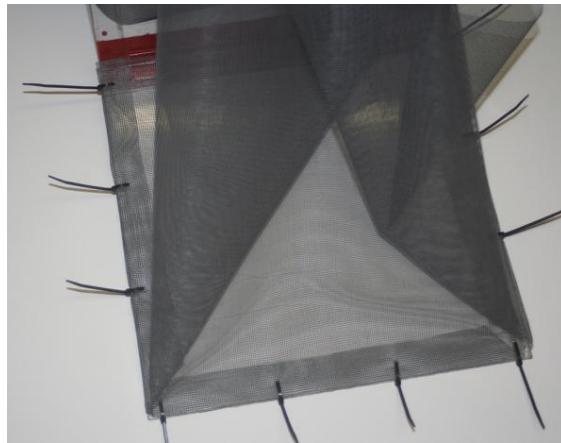
5.3.2. Attach the center section of the net to the base using zip ties. Fold the 1 inch flap under and then zip tie with the net on top of the base.



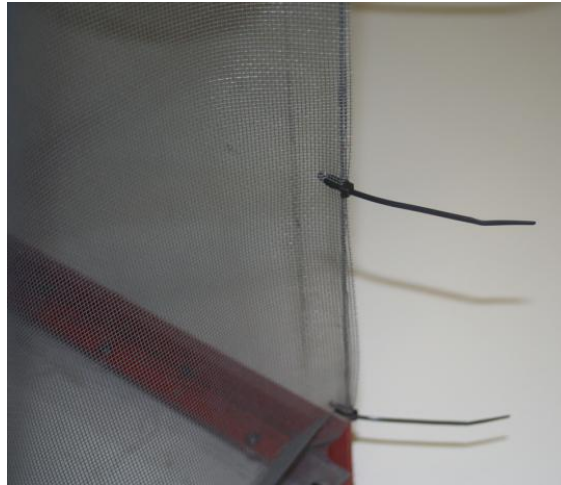
5.3.3. Now fold under the flap on the right side and zip tie this to the base. Try to keep the netting taut



5.3.4. Repeat this for the left side of the net.

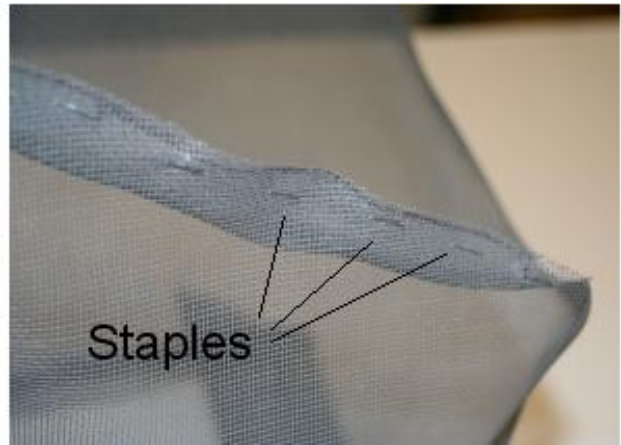
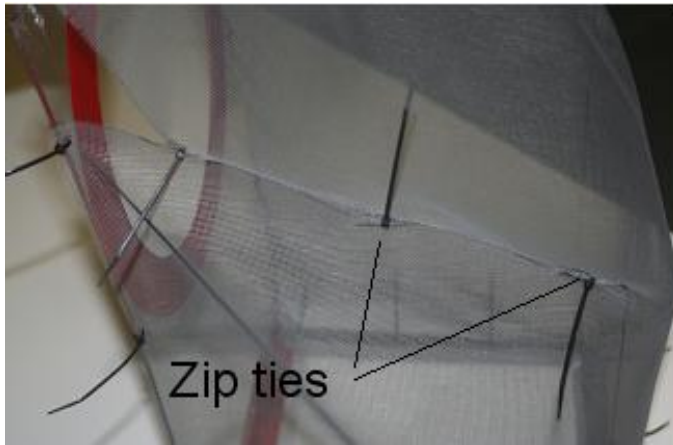


5.3.5. Zip tie the right side of the net to the goal face.



5.3.6. Repeat this for the left side

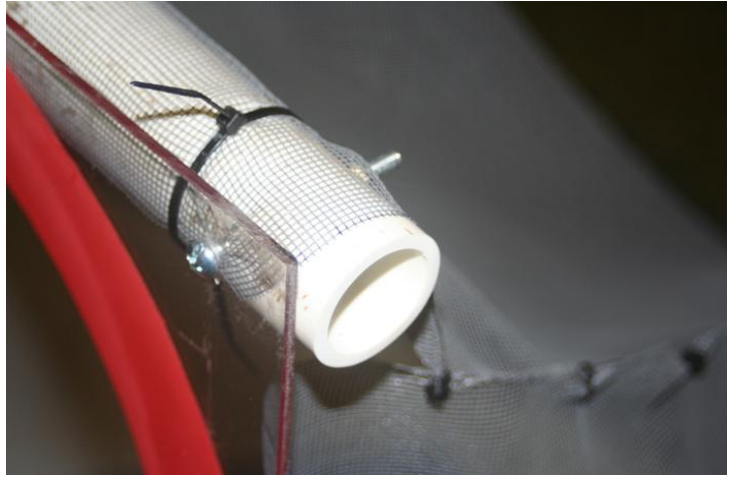
5.3.7. Use zip ties to hold the top of the sides together to create an enclosure. Use a minimum of 3 zip ties but 5 will make for a cleaner look. You can also use an ordinary paper stapler to connect the sides to the top



5.3.8 For a cleaner look, and to minimize the chance of robots accidentally entangling the net, you can sew the sides together using a heavy string or fishing line. This takes a little more time than the zip ties or staples, but it looks so much better



5.3.9. To complete the enclosure, tuck the center section between the goal front and the pipe. You will have to punch a hole in the net to allow the screws to pass through. Tighten the screws to hold the net in place. To zip tie the net to the pipe you should use doubled 4" long zip ties rather than a single longer one. The longer zip ties are wider and may tear the net if you try to force them through.



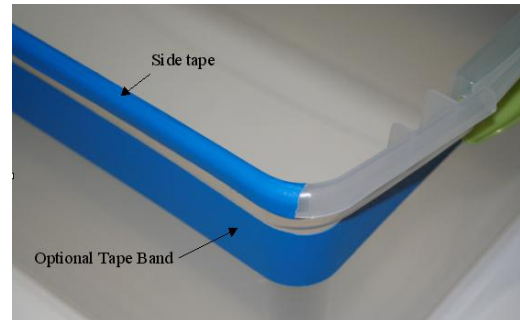
5.3.10. The finished net should look like this.



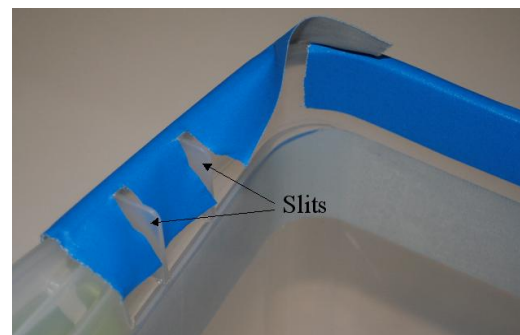
6. OUTSIDE GOALS

6.1. BINS

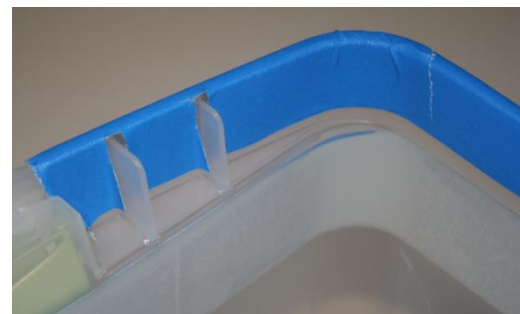
6.1.1. Applying the tape to the rim of the bins can be tricky. Here is one way to accomplish a neat, clean appearance. First apply tape to the straight sides of the bin, allowing the tape to extend just a small amount around the curve.



6.1.2. Apply a short section of tape from the handle to the side tape along the outside of the rim. Cut slits in the tape where the ribs are on the inside of the bin.



6.1.3. Press the tape down on the inside making sure not to wrinkle the tape on the inside of the curve.



6.1.4. To make the bin more visible to the audience you can apply an optional band of tape just below the handle.



7. IR BEACONS

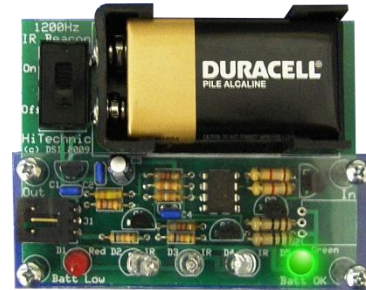
Each playing field will be equipped with a matched pair of IR Beacon. The base and the satellite beacons both operate on a single 9 volt battery that will deliver a consistent 1200Hz IR signal for approximately 4 hours, indicated by a bright green LED. When the red LED is lit, it is time to change the battery. Please follow the safe handling procedure outlined in the information supplied with the beacon.

7.1. BATTERY HANDLING

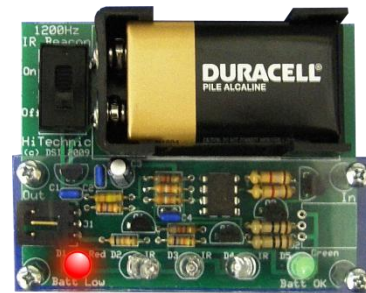
7.1.1. The 9V battery will supply a consistent IR signal for approximately **4 hours**. The green led indicates the battery is good.

IMPORTANT:

The power switch **must be** in the **OFF** position before installing the battery.



7.1.2. When the red led is lit, it is time to change the battery. **Be sure to turn the power switch to OFF before changing the battery.**

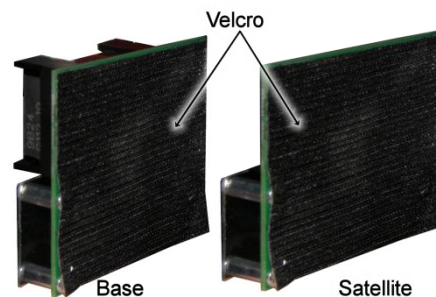


7.2. MOUNTING BEACONS

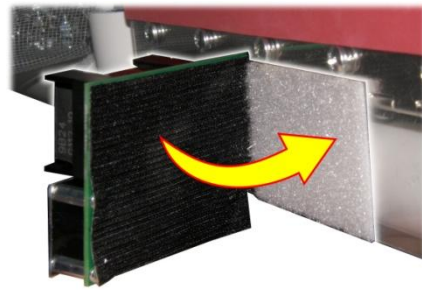
7.2.1. Cut and apply a piece of mounting Velcro to the back of both the beacon base and the satellite boards.

IMPORTANT:

To prevent damage to the boards never place an unprotected board onto any metal surface once the battery is installed.



7.2.2. Apply the other part of the Velcro to the polycarbonate under each goal such that the beacon is positioned as described in sections 7.2.3 and 7.2.4.

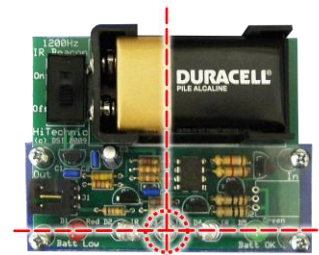


7.2.3 Mount the base beacon under the red goal, and position it so the center emitter is 6" from the inside edge of the polycarbonate, and 14" below the bottom of the goal opening.

Note: For consistency it is recommended that each field be set up with the Base IR Emitter (beacon) mounted on the RED side.

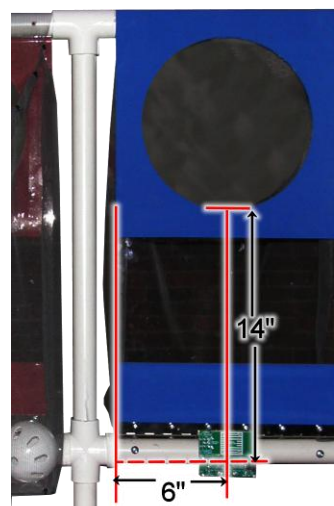


Base IR Emitter

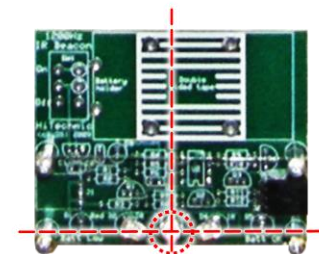


Measure on center IR emitter

7.2.4 Mount the satellite beacon under the blue goal, and position it so the center emitter is 6" from the inside edge of the polycarbonate, and 14" below the bottom of the goal opening.



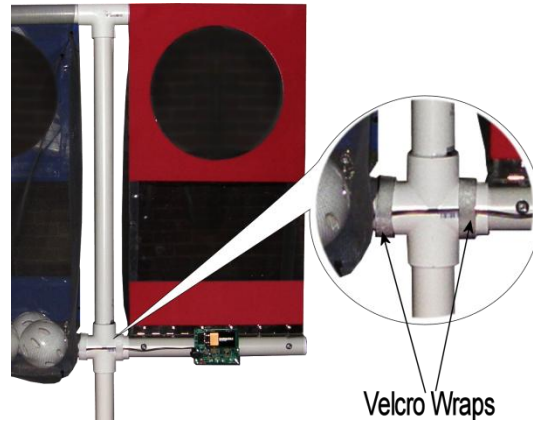
Satellite IR Emitter



Measure on center IR emitter

7.1.5 Dress the connector wire neatly using Velcro wraps on either side of the T-joint as shown.

Note: The connector may be plugged into either board. Orientation is not significant.



YOU'RE DONE!

That's it, you've now completed your field and you're ready to play!

Special thanks go out to Joe Perrotto, the FIRST Tech Challenge Delaware Affiliate Partner for composing this Zen Guide. Joe Perrotto, Mannie Lowe (Georgia Affiliate Partner), Michael Coleman (Florida Affiliate Partner) and Mark Edelman (Northern California Affiliate Partner) all collaborated to develop the game, field drawings, bill of materials, and the game itself. Paul Roush of the Washington State FTC Group made countless updates to the drawings, at all hours of the day and night, to get this done as well. Without their hard work, creativity, and commitment to inspiring kids through FIRST, HotShot! and the supporting documentation would not have been possible.