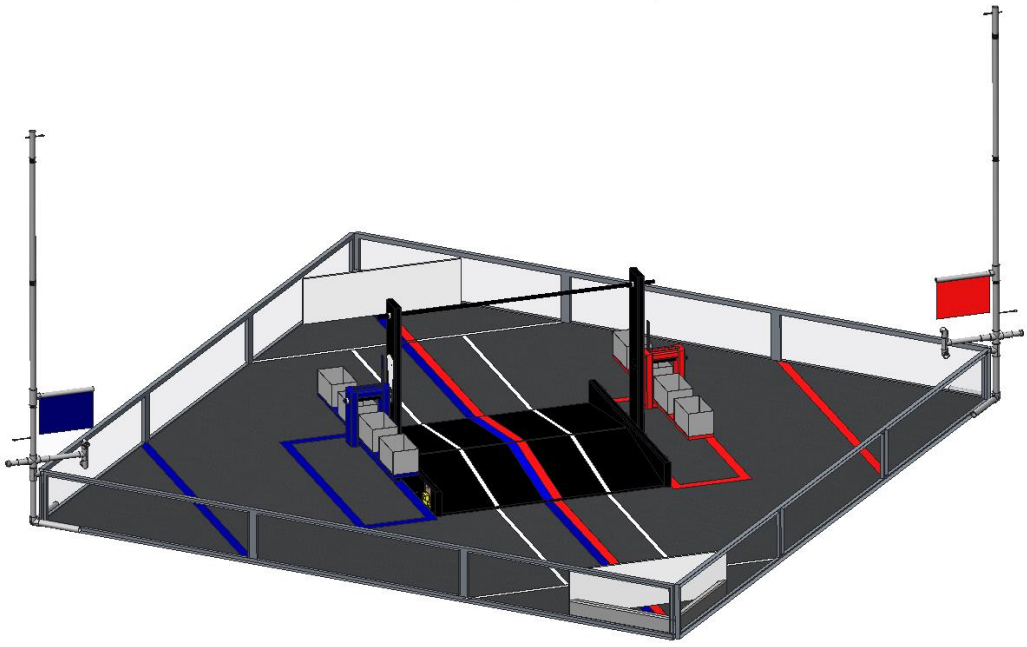
FIRST® Tech Challenge

# FTC BLOCK PARTY!

## 2013 - 2014 PLAYING FIELD BUILD GUIDE



Rev 1.21 – September 5, 2013

# *Read through all the instructions before you begin to build!*

This *Guide* is intended as instructions for building the Field Elements for the 2013-2014 FTC Game. Field electronics and Playing Field set-up are described in separate documents.

| **Revision History** | | |
|---|---|---|
| **Rev** | **Date** | **Description** |
| 1.00 | August 5, 2013 | Initial Release |
| 1.10 | August 29, 2013 | Revisions and corrections. Significant changes include the following:<br>• Changed critical dimensions with updated and corrected values<br>• Changing part (H16) from 5/16” bit to 3/8” bit<br>• Adding instructions for building a hanger for newer style HiTechnic IR beacon<br>• Changing instructions to move the positions of the mount screws for the IR beacon hangers (to accommodate the newer style beacon)<br>• Changing how to secure the baskets to the balance arms (to improve durability)<br>• Adding text to alert partners of potential size differences in the cross fitting (P4), which will affect the length of the flag lift shaft length (P12)<br>• Adding a cut guide for the 1x6 piece of lumber<br>• Miscellaneous corrections to text and images |
| 1.20 | September 5, 2013 | Corrections<br>• Corrected a diagram in the Critical Dimensions section. The critical dimension of the height of the balance arm board above the Soft Tile floor is 10.5” when measured from the *top* of the board to the top of the floor.<br>• Additional miscellaneous corrections. |
| 1.21 | September 5, 2013 | Made several minor changes to make this document consistent with the game manual and with other documents for this season. |

# Contents

# 1 *Bill of Materials* (BOM)

This section lists the components needed to build a Field. A detailed *Bill Of Materials* (BOM), which also lists where to purchase these items, is available in Microsoft Excel and Adobe Acrobat formats.

## 1.1 Playing Field

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| F1 | FTC Field perimeter | | | | 1 | 1 |
| F2 | 5/8" gray soft tiles | | | | 36 | 36 |
| F3 | IR beacon (Use 2 masters) | 2 | | | 0 | 2 |
| F4 | Yellow 2" game cubes | | | | 100 | 100[1] |

## 1.2 Hardware

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| H1 | 1/2” x 10” Steel Threaded Pipe (1.27 cm x 25.4 cm) | 2 | | | | 2 |
| H2 | 1/2” x 60” Steel Threaded Pipe (1.27 cm x 152.4 cm) | 1 | | | | 1 |
| H3 | 1/2” Pipe Floor Flange<br><br>The pipe flange serves as the cantilever base for the rounded steel pipe that supports the weight of a balance arm.<br><br>If you are having problems sourcing the pipe flange and/or the steel pipe, then a replacement cantilever solution, which has a rounded bearing surface for the balance arm, should be able to support the weight | 2 | | | | 2 |

[1] Note that a minimum of 100 cubes are required to run the Game. Event organizers, however, should have additional cubes on hand to act as spares.

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| | of the balance arm and allow it to swing/pivot freely without binding.<br><br>Critical dimensions for the placement of the cantilever arm are provided later on in the build guide. | | | | | |
| H4 | 10-32 x 3/4" Machine screws | 8 | | | | 8 |
| H5 | 10-32 x 2" Machine screws | 22 | | | | 22 |
| H6 | 10-32 hex drive threaded insert | 30 | | | | 30 |
| H7 | 1" ID shaft collars | 6 | | | | 6 |
| H8 | 1/4-20 x 4" eyebolt | | 4 | | | 4 |
| H9 | 1/4-20 hex nut | | 6 | | | 6 |
| H10 | #8 x 1.5" wood screws | 18 | | 12 | | 30 |
| H11 | #10 x 3" wood screws | 16 | | | | 16 |
| H12 | 6-9/16" finish corner brace | 2 | | | | 2 |
| H13 | 13/64" drill bit | 1 | | | | 1 |
| H14 | 1/4" drill bit | 1 | | | | 1 |
| H15 | 9/32" drill bit | 1 | | | | 1 |
| H16 | 3/8" drill bit | 1 | | | | 1 |
| H17 | 1" flat drill bit | 1 | | | | 1 |
| H18 | 1/4" x 1-1/4" fender washer | As needed to balance arms | | | | As needed to balance arms |
| H19 | 3/32" drill bit | 1 | | | | 1 |
| H20 | Metric 5mm hex key | 1 | | | | 1 |
| H21 | #6 x 5/8" wood screw | 16 | | | | 16 |
| H22 | #6 flat washer | 16 | | | | 16 |

## 1.3 Wood

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| W1 | 2x4 lumber: cut to 48" length (121.9 cm) (note actual cross section is 1.5" x 3.5" or 3.81 cm x 8.89 cm) | 3 | | | | 3 |
| W2 | 2x6l: cut to 48" length (121.9 cm) (note actual cross section is 1.5" x 5.5" or 3.81 cm x 13.97 cm) | 2 | | | | 2 |
| W3 | 2x6 lumber: cut to 38" Length (96.52 cm) (note actual cross section is 1.5" x 5.5" or 3.81 cm x 13.97 cm) | 2 | | | | 2 |
| W4 | 1x6 lumber: cut to 48" length (121.9 cm) (note actual cross section is 0.75" x 5.5" or 1.91 cm x 13.97 cm) | 2 | | | | 2 |
| W5 | 2x4 lumber: cut to 5.5" length (13.97 cm) (note actual cross section is 1.5" x 3.5" or 3.81 cm x 8.89 cm) | 4 | | | | 4 |
| W6 | 2x4 lumber: cut to 12" length (30.48 cm) (note actual cross section is 1.5" x 3.5" or 3.81 cm x 8.89 cm) | 4 | | | | 4 |
| W7 | 1/2 in. x 2 ft. x 4 ft. Sandeply hardwood plywood handy panel (actual dimensions are 0.472" x 23.875" x | 2 | | | | 2 |

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| | 47.875" or 1.2 cm x 60.64 cm x 121.60 cm) | | | | | |
| W8 | 1/2 in. x 10" x 34" (1.2 cm x 25.4 cm x 86.36 cm) plywood panel. | | | 2 | | 2 |
| W9 | 2x4 lumber: cut to 24" length (60.96 cm)<br>(note actual cross section is 1.5" x 3.5" or 3.81 cm x 8.89 cm) | | | 4 | | 4 |
| W10 | Wood craft door hanger (For IR beacon).[2] | 2 | | | | 2 |

## 1.4 PVC Pipe and Fittings

The table below lists the required quantities and types of PVC pipe and fittings that are needed to build one Playing Field. Approximately 18 feet of 3/4" diameter PVC pipe and 5 feet of 1/2" diameter PVC pipe are needed for one Playing Field. **All PVC is Schedule 40.**

A Note about PVC pipe lengths - The lengths of the PVC pipes were designed for the existing FTC Field perimeter wall designs (used in the 2012-2103 Ring It Up Season and earlier). For more recently designed Fields, the actual cut lengths of the various PVC pipes might be slightly different than the values listed in this *Build Guide*. Changes might be needed to accommodate the slightly different geometry of any newly introduced Field perimeter designs.

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| P1 | 1" x 1"x 1/2" schedule 40 PVC Slip x Slip x Slip Reducing tee | | 2 | | | 2 |
| P2 | 1/2" PVC schedule 40 fitting: 90° Elbow (Slip x Slip) | | 4 | | | 4 |
| P3 | 1/2" PVC schedule 40 fitting: T-Joint (Slip x Slip x Slip) | | 2 | | | 2 |
| P4 | 3/4" PVC schedule 40 fitting: Cross joint (Slip x Slip x Slip x Slip) | | 2 | | | 2 |

[2] Note: If you are unable to obtain these pre-made hangers, you may use a small piece of 1/4" (0.64 cm) thick wood to make them. Directions are included in this guide. Approximate size of wood is 3 1/2" x 9 1/2" x 1/4" (8.9 cm x 24.13 cm x 0.64 cm).

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| P5 | 3/4" PVC schedule 40 fitting: T-Joint (Slip x Slip x Slip) | | 2 | | | 2 |
| P6 | 3/4" PVC schedule 40 fitting: 3-Way joint (Side Outlet Elbow, Slip x Slip x Slip) | | 2 | | | 2 |
| P7 | 1/2" PVC schedule 40 fitting: Coupling (Slip x Slip) | | 4 | | | 4 |
| P8 | 1/2" PVC schedule 40 fitting: End Cap (slip) | | 2 | | | 2 |
| P9 | 1/2" PVC schedule 40 Pipe: 8" (20.32 cm) | | 2 | | | 2 |
| P10 | 1/2" PVC schedule 40 Pipe: 1.5" (3.81 cm) | | 4 | | | 4 |
| P11 | 1/2" PVC schedule 40 Pipe: 3" (7.62 cm) | | 2 | | | 2 |
| P12[3] | 1/2" PVC schedule 40 Pipe: 4.25" (10.8 cm) (assumes a 2-5/8" width for cross joint fitting (P4)) | | 2 | | | 2 |
| P13 | 1/2" PVC schedule 40 Pipe: 11.75" (29.85 cm) | | 2 | | | 2 |
| P14 | 3/4" PVC schedule 40 Pipe: 10" (25.4 cm) | | 4 | | | 4 |
| P15 | 3/4" PVC schedule 40 Pipe: 9.5" (24.13 cm) | | 2 | | | 2 |
| P16 | 3/4" PVC schedule 40 Pipe: 1.75" (4.45 cm) | | 2 | | | 2 |
| P17 | 3/4" PVC schedule 40 Pipe: 72" (182.88 cm) | | 2 | | | 2 |
| P18 | 3/4" PVC schedule 40 Pipe: 1.625" (4.13 cm) | | 2 | | | 2 |

[3] Part (P12) is the shaft for the lift crank. The shaft should be long enough to span the width of the cross joint fitting (P4). The cross joint fitting (P4) that was used to build the Field prototypes has a width of 2-5/8" (6.67cm). This translates to a pipe length of 4.25" (10.8cm). Some Partners have reported using cross joint fittings (P4) of width 3-1/4" (8.26cm). This wider fitting would require a pipe length of 5" (12.7cm). Measure your cross joint fitting (P4) prior to cutting this piece.

## 1.5 Gaffer's Tape

The table below lists the gaffer's tape required for the Playing Field and Alliance stations. The number of rolls of gaffer's tape, depends on the number of times a Field is set up.

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| T1 | 1" White gaffer's tape (2.54 cm wide) | As needed | | | As needed | As needed |
| T2 | 2" Red gaffer's tape (5.08 cm wide) | As needed | | | As needed | As needed |
| T3 | 2" Electric blue gaffer's tape (5.08 cm wide) | As needed | | | As needed | As needed |

## 1.6 Miscellaneous

These additional items are required for constructing the Field.

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| M1 | PVC cement | As needed | | | | As needed |
| M2 | Black paint | As needed | | | | As needed |
| M3 | Red paint | As needed | | | | As needed |
| M4 | Blue paint | 1 quart | | | | 1 quart |
| M5 | White paint | | | 1 quart | | 1 quart |
| M6 | Primer and sealer | As needed | As needed | Assemblies | | 1 gallon |
| M7 | Sterilite 1695 Mini Crate (dimensions 9" L x 7 7/8" W x 6 1/8" H or 22.9cm L x 20.0cm W x 15.6cm H).<br><br>NOTE: If you are unable to source the Sterilite 1695 Mini Crate locally, and you need to find or build a suitable replacement, it is important that the overall length of the container be equal to or slightly less than the length of the Sterilite container (9" or 22.9 cm). The other dimensions should be very close to the 1695's dimensions, but it is critical that the length is the same or slightly smaller size.<br><br>Also note that ideally the container should be translucent so the teams and referees can see how many blocks are in a box. However, if the translucent color of the Sterilite MiniCrate is unavailable, an alternate color (such as red, blue, or a neutral color like black or yellow) could be substituted. | 8 | | | | 8 |
| M8 | White 8 1/2" x 11" (21.59 cm x 27.94 cm) card Stock | | 2 | | | 2 |
| M9 | White poster board (enough for two 8 1/2" x | | As needed | | | As needed |

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| | 11" or 21.59 cm x 27.94 cm pieces) | | | | | |
| M10 | Adhesive Velcro (3/4" or 1.90cm width) | As needed | | | | As needed |
| M11 | 8" cable ties | | | | As needed | As needed |
| M12 | 9V alkaline batteries | See note | | | | See note |
| M13 | Tape measure | | | | 1 | 1 |
| M14 | 1/4" staples (T50 style) | As needed | | | | As needed |
| M15 | Sharpie (Magnum) | | 1 | | | 1 |
| M16 | Vinyl letters to indicate location of IR beacon. | As needed | | | | |
| M17 | 8.5" x 11" (21.59 cm x 27.94 cm) Adhesive Paper. | | 2 | 2 | | 4 |
| M18 | Four sided die (optional). | | | | 1 | 1 |
| M19 | Synthetic twine | | At least 23' or 7m | | | At least 23' or 7m |
| M20 | Adhesive Velcro (2" or 5.08cm width) | Around 80" (or 2.03m) | | | | Around 80" (or 2.03m) |

## 1.7 Optional PVC Cleaning Supplies

The items that are listed in these sections can be used to clean the lettering and dirt off of the PVC pipe and fittings. The sanding sponges listed below can also be used to preparing the wooden components for painting and priming.

| Item | Description | Center Balance Assembly | Flag Lift Assemblies | Corner Barrier Assemblies | Field | Total |
|---|---|---|---|---|---|---|
| CL1 | 3M medium-grit sanding sponge | | As Needed | | | As Needed |
| CL2 | 3M fine-grit sanding sponge | | As Needed | | | As Needed |

## 1.8 Tools

Gather the following tools before beginning construction:

- Wood saw (hand saw, circular saw, electric miter saw, or table saw)
- Electric drill
- Drill Bits: 3/32", 13/64", 1/4", 9/32", and 3/8"
- 1" Flat drill bit (spade bit) or 1" hole saw
- Paint brush (optional paint pad or roller)
- Paint tray (optional)

- Utility knife
- PVC pipe cutter or hack saw
- Rubber mallet (to tap PVC pieces together while assembling)
- Scissors
- Phillips and flat head screwdrivers
- M5 (5mm) hex driver (for installing threaded inserts)
- 5/32" hex driver (for tightening set screws on shaft collars)
- Staple gun (T50 style staples)
- Straight edge/ruler (2 ft. or longer)
- Tape measure
- Pencil
- Safety glasses
- Work gloves
- Dust mask
- Matches or lighter (to melt tips of synthetic twine)

# 2 Cut Guide

This section details how to cut standard length pieces of lumber and PVC pipe to get the lengths needed for the build.

## 2.1 Special Note Regarding Cut Length for Part W5

Note that the *Bill of Materials* lists the length of part W5 as 5.5". Part W5 is used to construct the frame for the balance arms (see section 0 ). Before cutting the length of 2x4 boards for W5, measure the width of your 1x6 board (W4) and verify that it is 5.5" or less in width. If board W4 is greater than 5.5" in width, increase the length of board W5 accordingly. For example, if board W4 is actually 5.625" in width, increase the length of part W5 (for all quantities of W5) to 5.625" to accommodate the slightly wider board.

## 2.2 Cut Guide for 2x4 Lumber

This year's build requires several pieces that are cut from a 2x4 piece of lumber. Note that the actual dimensions of the 2x4 cross section are 1.5" x 3.5" (or 3.81cm x 8.89cm). This section details how to cut ***three*** 12' (3.66m) pieces of lumber into the parts needed for the build. When measuring for the cuts to the lumber, do not forget to account for the kerf of the saw blade.

### 2.2.1 Board #1

Board #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W1 | 48” (1.22m) | 1 |
| W5 | 5.5” (13.97cm) | 4 |
| W6 | 12” (30.48cm) | 4 |
| W9[*] | 24” (60.96cm) | 1 |

### 2.2.2 Board #2

Board #2 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W1 | 48” (1.22m) | 2 |
| W9* | 24” (60.96cm) | 1 |

### 2.2.3 Board #3

Board #3 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W9* | 24” (60.96cm) | 2 |

## 2.3 Alternate Cut Guide for 2x4 Lumber

This year’s build requires several pieces that are cut from a 2x4 piece of lumber. Note that the actual dimensions of the 2x4 cross section are 1.5” x 3.5” (or 3.81cm x 8.89cm). This section details how to cut ***four*** 8’ (3.66m) pieces of lumber into the parts needed for the build. When measuring for the cuts to the lumber, do not forget to account for the kerf of the saw blade.

### 2.3.1 Board #1

Board #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W1 | 48” (1.22m) | 1 |
| W5 | 5.5” (13.97cm) | 4 |
| W9* | 24” (60.96cm) | 1 |

### 2.3.2 Board #2

Board #2 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W1 | 48” (1.22m) | 1 |
| W6 | 12” (30.48cm) | 3 |

[*] Note that the ends of part W9 will ultimately be cut at 45 degree angles to form the legs of the corner barrier.

### 2.3.3 Board #3

Board #3 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W9* | 24" (60.96cm) | 3 |

### 2.3.4 Board #4

Board #4 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W1 | 48" (1.22m) | 1 |
| W6 | 12" (30.48cm) | 1 |

## 2.4 Cut Guide for 2x6 Lumber

This year's build requires several pieces that are cut from a 2x6 piece of lumber. Note that the actual dimensions of the 2x6 cross section are 1.5" x 5.5" (or 3.81cm x 13.97cm). This section details how to cut ***two*** 8' (2.44m) pieces of lumber into the parts needed for the build. When measuring for the cuts to the lumber, do not forget to account for the kerf of the saw blade.

### 2.4.1 Board #1

Board #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W2 | 48" (1.22m) | 1 |
| W3 | 38" (0.97m) | 1 |

### 2.4.2 Board #2

Board #2 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W2 | 48" (1.22m) | 1 |
| W3 | 38" (0.97m) | 1 |

## 2.5 Cut Guide for 1x6 Lumber

This year's build requires several pieces that are cut from a 1x6 piece of lumber. Note that the actual dimensions of the 1x6 cross section are 0.75" x 5.5" (or 1.91cm x 13.97cm).

If you have a 12' (3.66m) long board, cut two 48" (1.22m) long boards for the Field and do not forget to account for the kerf of the saw blade when measuring for the cuts.

If you have an 8' (2.44m) long board, cut the board into two equally sized pieces. Each piece will be slightly undersized, due to the kerf of the blade (typically about 0.125" or 0.3175cm, which translates to each piece being about 1/16" or 0.15875cm short). Having each piece slightly less than 48" is acceptable since the board length is not a critical dimension.

### 2.5.1 Board #1

Board #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| W4 | 48” (1.22m) | 2 |

## 2.6 Cut Guide for 1/2" Schedule 40 PVC Pipe

The corner flag lift assemblies require several lengths of 1/2" PVC pipe. This section details how to cut ***one*** 10’ (3.05m) pipe into the required lengths.

### 2.6.1 A Special Note about Fitting Width and Pipe Lengths

The prototype Fields for this season’s Game were built using cross joint fittings (P4) that measured 2-5/8” (6.67cm) in width. Based on this width of (P4) the length of the Flag lift shaft (P12) should be 4.25” (10.8cm) long. Some Partners have reported using cross joint fittings (P4) that are bigger than the ones used for the prototypes. These larger cross joint fittings (P4) have a width of 3-1/4” (8.26cm). These larger cross joint fittings (P4) require a longer Flag shaft (P12). The longer flag shaft (P12) should be 5” (12.7cm) long to accommodate the wider fitting.

### 2.6.2 Pipe #1

**IMPORTANT NOTE:** You should measure the width of your cross joint fittings (P4) prior to cutting your PVC pipe. If your fitting is 2-5/8” wide, then you can cut the Flag lift shaft (P12) to 4.25” (10.8cm) long. If your fitting is wider, you will need to adjust the shaft length accordingly. Also, if you need to modify the length of your Flag lift shaft (P12), you should verify that the critical dimensions for the Flag lift crank that are specified in section 4.5.2 (on page 63) are satisfied to within a 1” tolerance.

Pipe #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| P9 | 8” (20.32cm) | 2 |
| P10 | 1.5” (3.81cm) | 4 |
| P11 | 3” (7.62cm) | 2 |
| P12[4] | 4.25” (10.8cm) (assumes a 2-5/8” width for cross joint fitting (P4)) | 2 |
| P13 | 11.75” (29.85cm) | 2 |

[4] Part (P12) is the shaft for the lift crank. The shaft should be long enough to span the width of the cross joint fitting (P4). The cross joint fitting (P4) that was used to build the Field prototypes has a width of 2-5/8” (6.67cm). This translates to a pipe length of 4.25” (10.8cm). Some Partners have reported using cross joint fittings (P4) of width 3-1/4” (8.26cm). This wider fitting would require a pipe length of 5” (12.7cm). Measure your cross joint fitting (P4) prior to cutting this piece.

## 2.7 Cut Guide for 3/4" Schedule 40 PVC Pipe

The corner Flag lift assemblies require several lengths of 3/4" PVC pipe. This section details how to cut ***two*** 10' (3.05m) pipe into the required lengths.

### 2.7.1 Pipe #1

Pipe #1 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| P14 | 10" (25.4cm) | 2 |
| P15 | 9.5" (24.13cm) | 1 |
| P16 | 1.75" (4.45cm) | 1 |
| P17 | 72" (182.88cm) | 1 |
| P18 | 1.625" (4.13cm) | 1 |

### 2.7.2 Pipe #2

Pipe #2 should be cut into the following sizes:

| Part # | Length | Quantity |
|---|---|---|
| P14 | 10" (25.4cm) | 2 |
| P15 | 9.5" (24.13cm) | 1 |
| P16 | 1.75" (4.45cm) | 1 |
| P17 | 72" (182.88cm) | 1 |
| P18 | 1.625" (4.13cm) | 1 |

# 3 Building Instructions

The Playing Field can be built using simple hand and power tools. A drill press and table saw may speed-up construction, but are not required. Familiarize yourself with the build instructions before starting construction of a Playing Field.

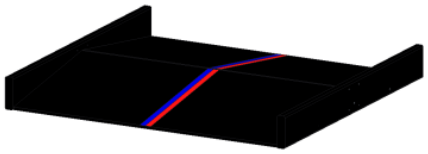
## 3.1 Center Field Element

The center Field Element consists of a ramp base, pull-up bar, and balance arms.

### 3.1.1 Special Note Regarding the Use of Threaded Inserts

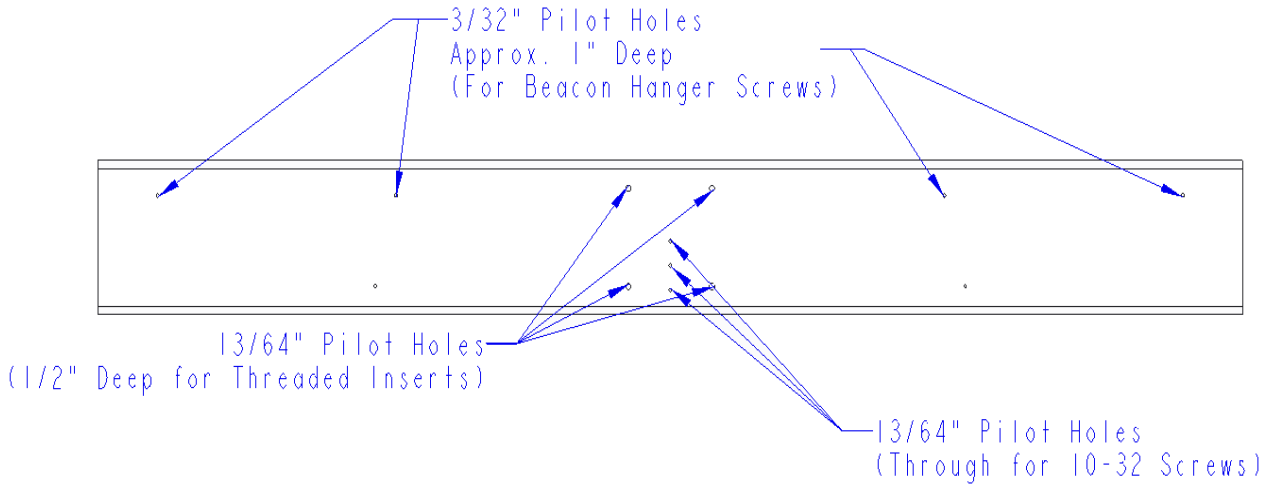
The center Field Element is constructed using threaded inserts and machine screws. This is done to make it easier to disassemble the Element for transport. When fully assembled, the center Field Element does not fit easily through a standard door and it might not fit in a typical passenger vehicle. The use of the threaded inserts and machine screws allow for easy disassembly/reassembly of the structure.

### 3.1.2 Ramp Base

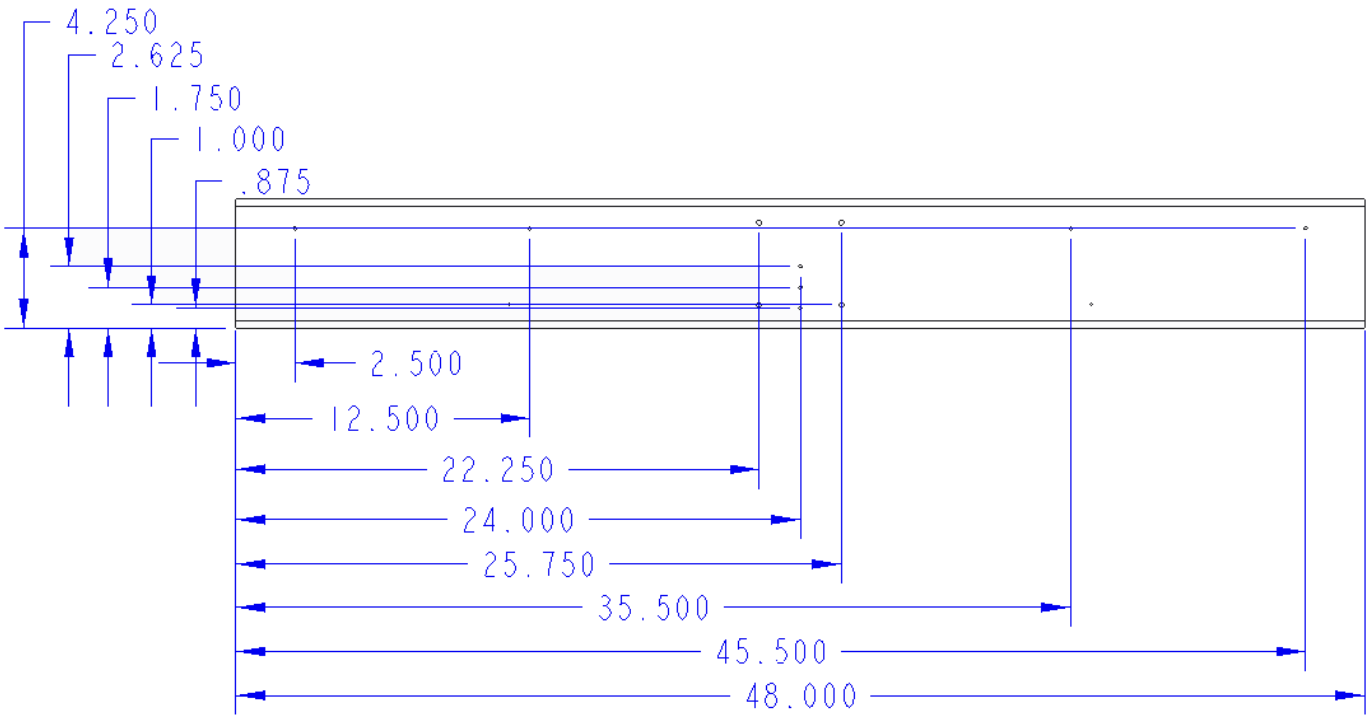


| Parts Required for the Ramp Base | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| W1 | 3 | 2x4 beam (cut to 48" length[5]) |
| W2 | 2 | 2x6 beam (cut to 48" length) |
| H5 | 14 | 10-32 x 2" machine screw |
| H6 | 14 | Hex drive-threaded 10-32 insert |
| H10 | 8 | 1.5" #8 wood screws |
| M10 | AR | ¾" adhesive Velcro |
| W7 | 2 | 24x48x1/2" plywood panel |
| M14 | A/R | ¼" staples |
| T1 | A/R | 1" white gaffer'sgaffer's Tape |
| T2 | A/R | 2" red gaffer's tape |
| T3 | A/R | 2" electric blue gaffer's tape |

Diagrams showing the location of pilot holes for the 2x6x48" sidewalls (W2) are pictured below:

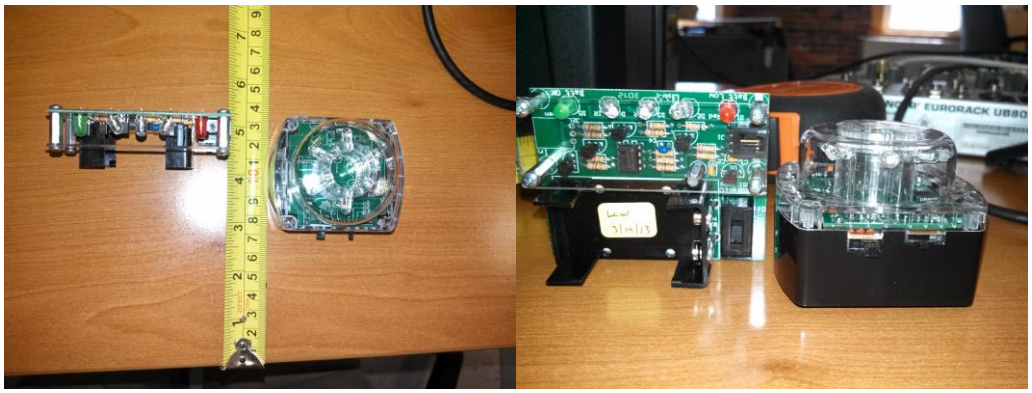



[5] Note that the crossbeams must be long enough to allow for clearance so that the 2x4 plywood panels (W7) can be installed as the ramp surfaces.




### 3.1.2.1 Important Note Regarding a Change in Position of IR Beacon Screw Mounts

HiTechnic is introducing a brand new IR beacon for the 2013-2014 season. This new beacon (model # HBK2100) is substantially thicker than the old beacon (model #FTCBCN). Unfortunately, the new beacon was unavailable at the time of first release for this *Build Guide*. As a result, **the layout for the holes that was specified for the IR beacon mounts in version 1.0 of this document is no longer valid.** The layout of the holes had to change in order to accommodate the wider form of the new beacon. The new hole pattern makes sure that the balance arm and baskets have enough clearance so they are unlikely to strike the beacon during a match.

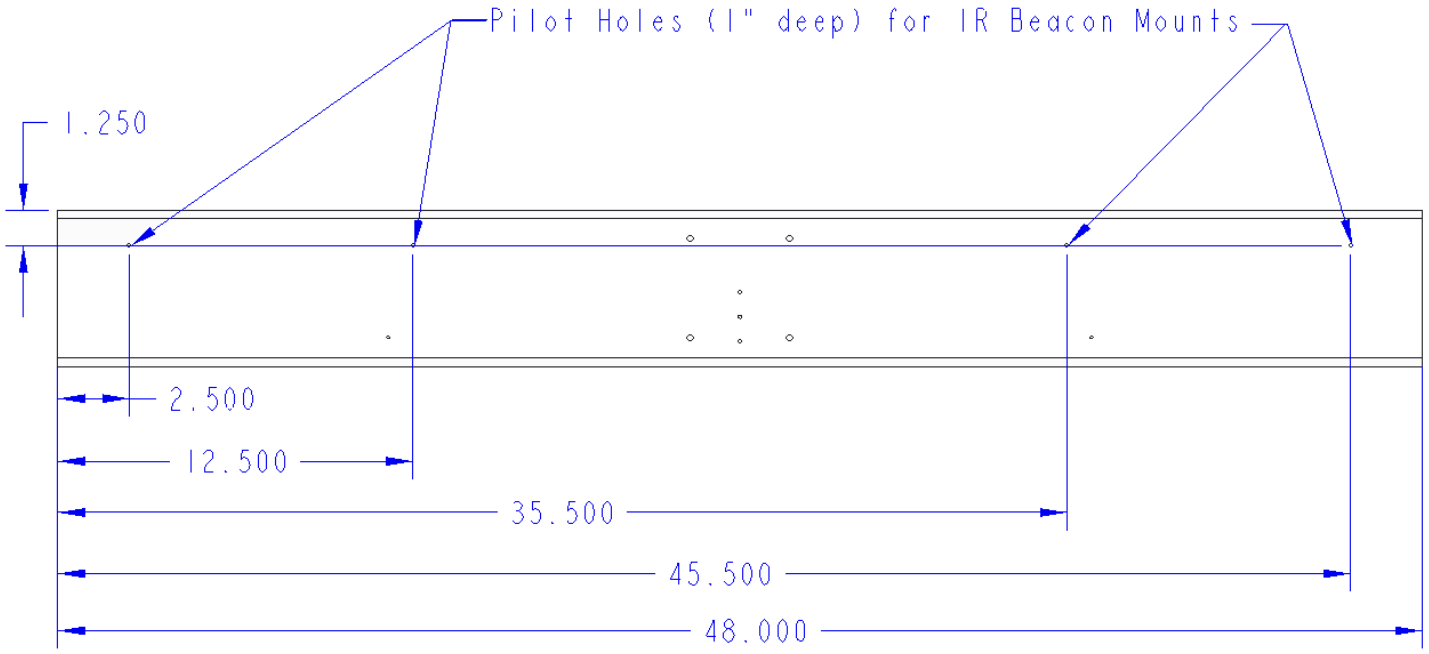


If you have already built your Field using version 1.0 of the *Build Guide*, please use the dimensioned drawings shown in the diagrams above to move your beacon hanger screw mounts**.** If you have not yet built your Field, please make sure you use the most current layout to place your IR beacon hanger screws in the correct spots along the sidewalls. Do not use the layout of the IR beacon screw mount holes in version 1.0 of this guide. It is no longer valid.

**Step 1 – Installing IR Beacon Mounts**

Mounts need to be installed for the infrared beacon on the sidewalls. These mounts consist of 1.5” #8 wood screws (H10) that are screwed partially into the sidewall. They are located underneath the center of where the baskets will be on the balance arm. They are all 1.25” from the top of the sidewall.

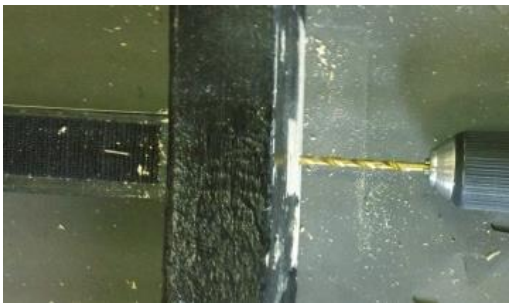
1. Drill a 3/32” (H19) pilot hole 2.5” in from each end of the sidewall (W2), roughly 1” deep.
2. Drill two more pilot holes of the same size, but 12.5” in from both ends.
3. Insert a #8 1.5” wood screw (H10) into all four pilot holes so that there is still a 3/4” of the screw sticking out of the sidewall.
4. Repeat on the other sidewall (W2).



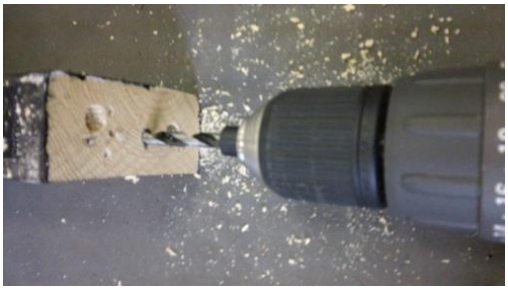

**Step 2 – Installing the Center Crossbeam**

Use machine screws and threaded inserts to fasten sidewalls to crossbeams.

1. Measure 23.25” in from the edge of one of the 2x6x48” sidewalls (W2) and mark with a line.
2. Place a 2x4x48” crossbeam (W1) on the ground, skinny (1.5”) side up, and line up its 3.5” edge up with the mark just made in such a way that the W1 board it is centered on the sidewall. Clamps can be used to hold it in place for the drilling of the pilot holes, but are not necessary.
3. Use a 13/64” bit (H13) to drill three holes through the 2x6x48” sidewall, all of them 24” from each end, into the 2x4x48” crossbeam (W1). They should be spaced 0.875” vertically. The location of these holes can be better seen in the diagrams above.
4. Use 1/4” bit (H14) to expand the pilot holes roughly ½” deep into the 2x4 crossbeam to make clearance holes for the threaded inserts.
5. Use M5 (5mm) hex driver to drive the threaded inserts into the ends of the crossbeam.
6. Secure the sidewalls to the beam using three 2” 10-32 machine screws (H5).
7. Repeat steps 1-6 on the other side of the crossbeam.



Step 2-3: Drill three 13/64” pilot holes through the sidewall into the crossbeam. 24” from the edges of the sidewall, 0.875” apart and off the ground.

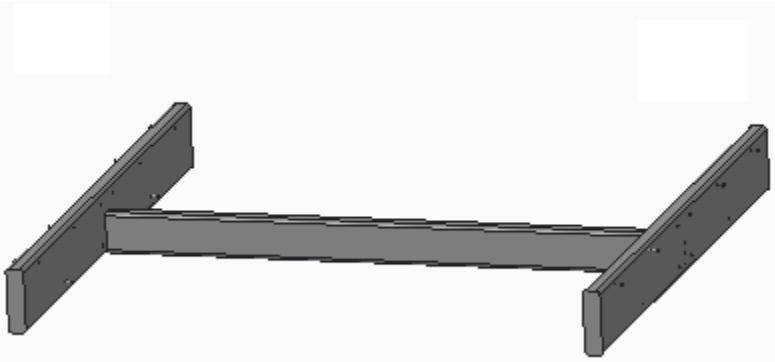


Step 2-4: Re-drill the pilot holes in the crossbeam using a ¼” drill bit, approximately ½” deep. This makes room for the threaded inserts.

Step 2-5: Drive threaded inserts into sidewall using M5 hex driver.

Step 2-6: Attach the sidewall to the crossbeam using three 2” 10-32 machine screws.

The center assembly frame should now look like the image shown below.

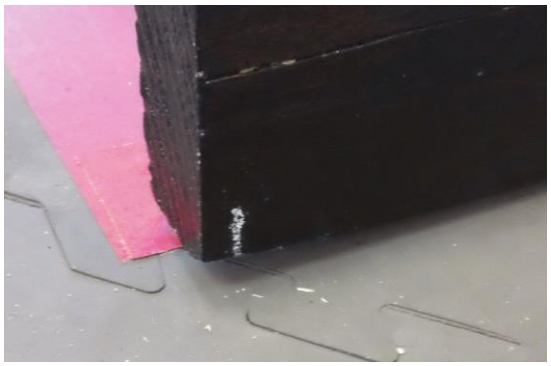


**Step 3 – Attaching Outer Crossbeams**

Draw lines from the center crossbeam (W1) to the bottom of the sidewall (W2) to help mark the location of the outer crossbeams (W1). The crossbeams will be secured to the center assembly using machine screws and threaded inserts.

1. Make a mark at the bottom of all the sidewalls (W2), 0.375” in from their outer edges.
2. Place a straight edge so that it runs from the mark from step 3-1 to the top of the middle crossbeam (W1). Trace a line along the bottom of the straight edge and repeat this on the other three sides.
3. Take a 48” 2x4 crossbeam (W1) and align the top 3.5” side edges of the cross beam with the alignment marks just drawn on the sidewalls. The outer and bottom edge of this crossbeam should be resting on the ground. Trace the outline of the crossbeam (W1) onto the sidewall (W2). Do this on both ends of the crossbeam. **Note:** It will help to hold the crossbeam in place with a clamp or by placing an object under the higher side of the beam.
4. Remove the outer crossbeam and using a 13/64” bit (H13), drill two evenly spaced pilot holes within the traced outline of the crossbeam (W1), through the sidewall (W2). Again, do this on both sides.

5. Replace the crossbeam within the traced lines and using the 13/64” drill bit (H13), re-drill through the sidewall, from the outside this time, into the crossbeam about 2”. The drill bit should go through the holes made in step 4. Repeat for both sides of the crossbeam.
6. Remove the crossbeam and widen the four pilot holes in the crossbeam using a ¼” drill bit (H14). This will make space for the threaded inserts. Make sure the center of the ¼” drill bit (H14) matches the center of the 13/64” pilot holes and drill straight into the crossbeam. Otherwise it will be difficult for the machine screws to catch the thread of the inserts.
7. Insert the threaded inserts (H6) into the crossbeam using the M5 hex drive.
8. Replace the crossbeam between the two sidewalls and line up the threaded inserts with the pilot holes on the sidewall. Fasten it in place using four 2” 10-32 machine screws (H5) driven through the pilot holes in the sidewalls and into the threaded inserts.
9. Repeat steps 2-9 for the other outer crossbeam.
10. For ease of assembly and disassembly, mark the crossbeams and sidewalls so they can be put in the correct place again.

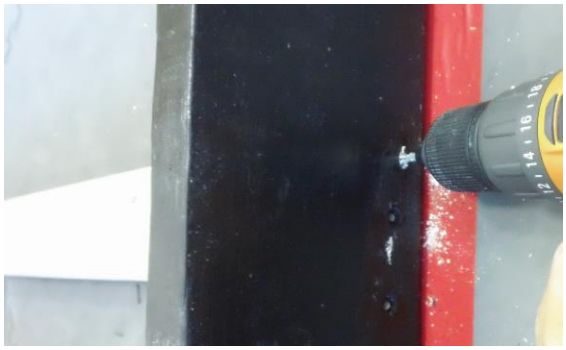


Step 3-1: Make a mark 0.375” in from the outer edge of the sidewall.

Step 3-2: Trace a line on the sidewall for guidance from the top of the center crossbeam, to the bottom edge of the sidewall, stopping at the mark 0.375” in from the outer edge.

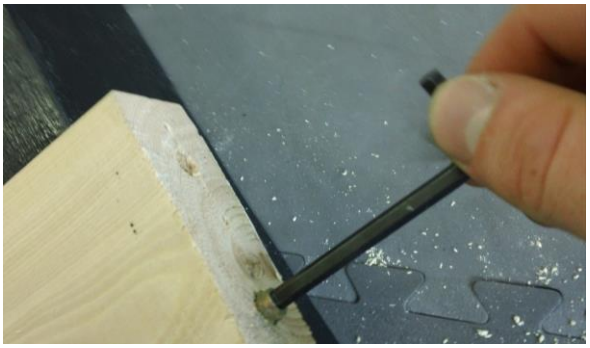
Step 3-3: Place a crossbeam so that its top edge is flush to the line and an outer corner rests on the ground as shown in the illustrtation above. Hold it in place and trace its outline.

Step 3-4: Drill two evenly spaced pilot holes through the crossbeam, within the confines from the traced 2x4 using a 13/64” drill bit.



Step 3-5: Place the outer crossbeam (W1) back within the confines drawn in step 3. From the outside, drill through the pilot holes from step 4, into the crossbeam (W1), roughly 2" deep.

Step 3-6: Make space for the threaded inserts by widening the 13/64" pilot holes already in the crossbeam. Center a ¼" drill bit on the holes and drill about ½" into the crossbeam (W1).



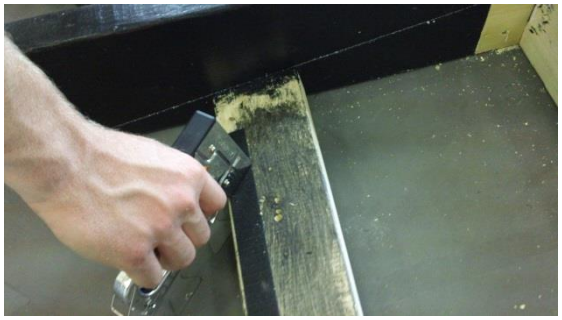
Step 3-7: Use a hex driver to install the two threaded inserts.

Step 3-8: Replace the crossbeam in the correct position and use two 2" 10-32 machine screws to secure the crossbeams to the sidewalls.

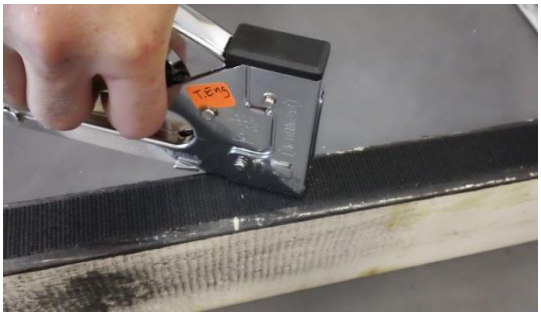
**Step 4 – Put Adhesive-Backed Velcro on the Top Surfaces of Crossbeams**

Velcro will be installed onto the tops of the crossbeams and on the bottom of the ramps to keep the ramps from moving during a Match. Note that this Guide demonstrates placing the Velcro strips onto unpainted wooden surfaces. However, in practice, these wooden surfaces should be primed and painted ***before*** applying the Velcro strips. This will help prevent moisture from warping the wood.

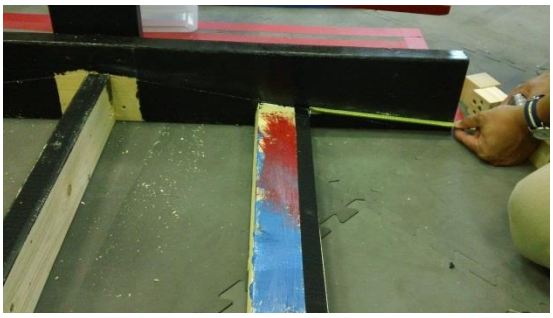
1. Place 3 strips of the hook side adhesive-backed Velcro (M10) along the tops of the three cross beams. Use staples to better secure the strips to the crossbeams.
2. Measure the distance from the edge of the sidewall to the Velcro strip on one of the outer crossbeams.
3. Take one of the 2'x4' panels (W7) and place one strip of Velcro (loop side) along the edge of the board running lengthwise. This strip will mate up with the VELCRO strip (hook side) that was installed on the top of the center crossbeam.
4. Measure and mark from the other edge of the 2'x4' panel (W7) an amount equal to the distance that was measured in step 4-2.
5. Place a Velcro strip (loop side) along the mark.
6. Verify that the positions of the Velcro strips match.
7. Secure the strips to the bottom side of the ramp with staples.
8. Repeat sub-steps 2 through 7 for the other 2'x4' panel (W7).
9. Place the completed boards onto the center ramp assembly so that they overlap the center crossbeam equally. The boards form the surfaces of the ramp for the assembly.



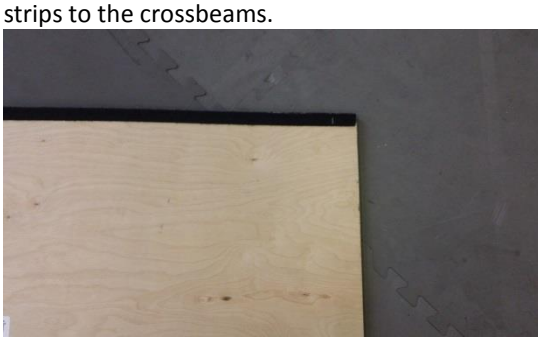
Step 4-1: Place hook side Velcro strips onto the top sides of the crossbeams.



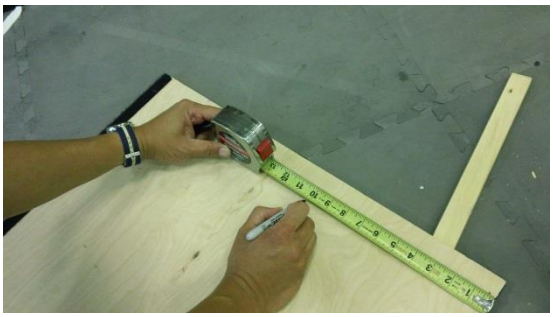
Step 4-1: Use staples to better secure the strips to the crossbeams.



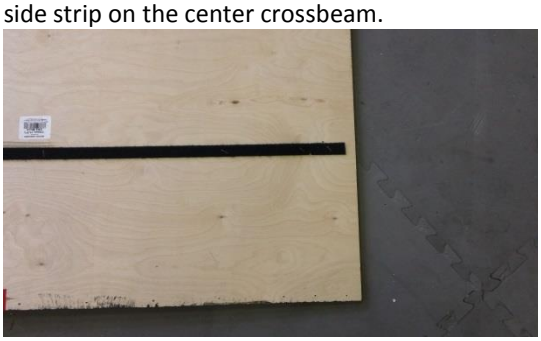
Step 4-2: Measure the distance from the edge of the sidewall to the Velcro strip on one of the outer crossbeams.



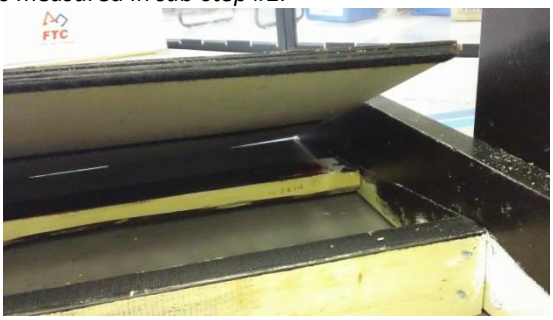
Step 4-3: Place a strip of Velcro (loop side) along the edge of one of the 2'x4' panels (W7). This strip will match up with the hook side strip on the center crossbeam.



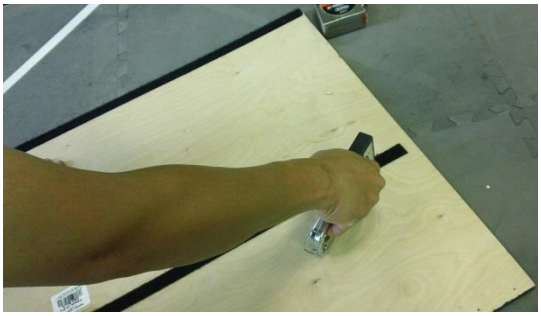
Step 4-4: Measure and mark from the other edge of the 2'x4' panel (W7) an amount equal to the distance that was measured in *sub-step #2.*



Step 4-5: Place a Velcro strip (loop side) along the mark.

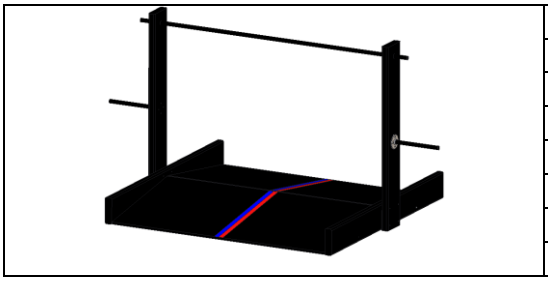


Step 4-6: Verify that the positions of the Velcro strips match.



Step 4-7: Secure the Velcro strips with staples, and then repeat the process for the other 2'x4' board (W7).

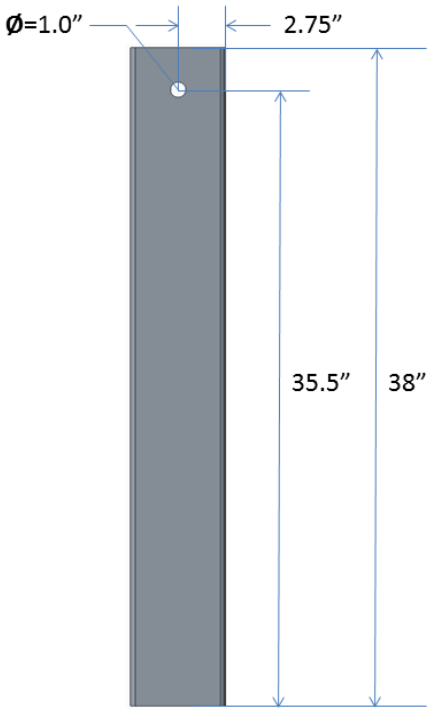
### 3.1.3 Installing Vertical Arms, Pull-Up Bar, and Cantilever Support Tubes



| Parts Required for the Pull-Up Bar | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| W3 | 2 | 2x6 beam (cut to 38” length) |
| H1 | 2 | 1/2” x 10” steel-threaded pipe |
| H2 | 1 | 1/2” x 60” steel-threaded pipe |
| H3 | 2 | ½” pipe floor flange |
| H4 | 8 | 10-32 x ¾” machine screw |
| H5 | 8 | 10-32 x 2” machine screw |

**Step 1 - Drill Holes for Pull-Up Bar:**

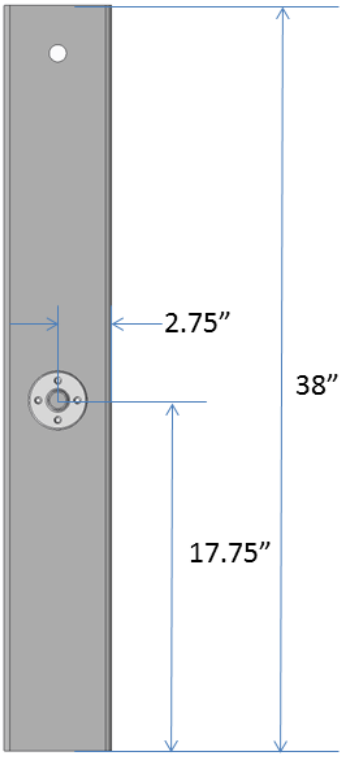
1. Lay out one of the vertical arms (W3) on the work area.
2. Mark the location for the clearance hole for the pull-up bar.
   2.1. Hole should be in the middle of the width of the beam that makes the vertical arm.
   2.2. Hole should be 35.5” from one of the ends of the beam.
   2.3. Note that the placement of the holes for the pull-up bar on both vertical arms is critical so that the holes will align properly and the pull-up bar will slide freely through the clearance holes.
3. Use a 1” spade bit (H17) to drill a hole through the face of the vertical arm.
4. Repeat steps 1 through 3 for the second vertical arm.



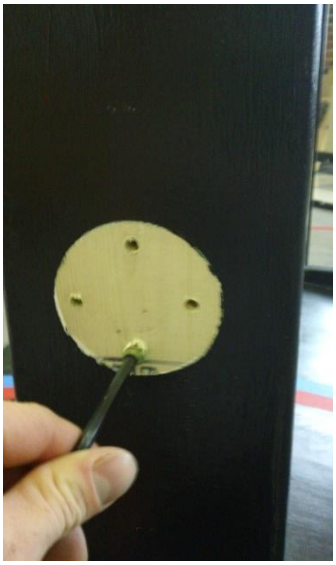
**Step 2 – Mount Pipe Flange for Cantilever Bars:**

1. Position a pipe flange (H3) so that its center is 17.75” inches from the bottom of the vertical arm and in the middle of the width of the beam (i.e., its center is 2.75” from edge).
2. Mark the locations of the mounting holes for the flange.
3. Using a ¼” bit (H14), drill clearance holes (3/4” deep) for the threaded inserts.
4. Install the threaded inserts (H6) into the clearance holes using an M5 hex driver so they are flush with the surface of the board.
5. Attach the pipe flange to the vertical arm using ¾” 10-32 machine screws (H4).
6. Repeat steps 1 through 5 for the other vertical arm.

Note: Dimensions are not to scale in diagram.




Drill four ¼” clearance holes for the threaded inserts at the marks made in sub-step 2.



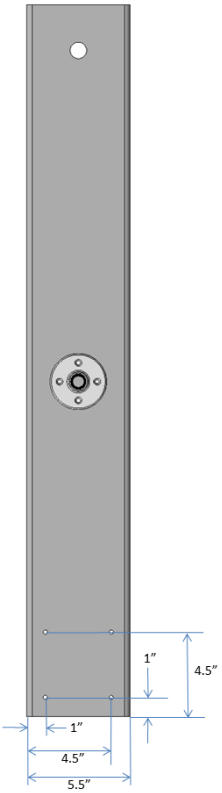
Install the threaded inserts into the ¼” holes.

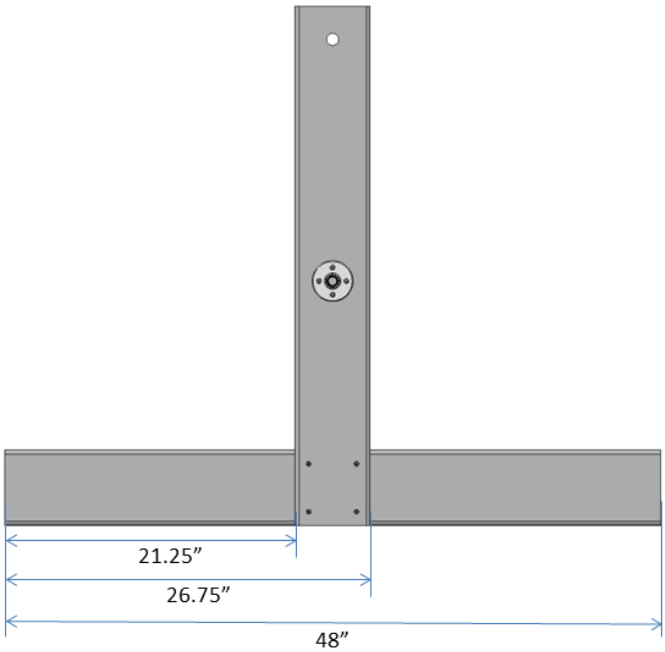
Fasten the flange to the vertical arm using four 3/8” 10-32 machine screws.

**Step 3 – Installing the Vertical Arms to Ramp Base:**

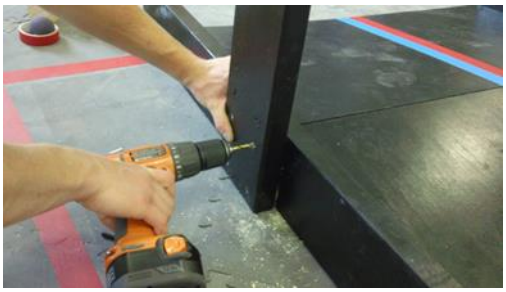
1. Layout the holes at the base of the 2x6x38” vertical arm (W3) per the dimensioned drawing (see right).
2. Mark a vertical line 21.25” in from the edge of the sidewall and place a vertical arm along this line so that it is centered on the sidewall and flat against the ground. Clamp or otherwise hold the vertical arm in place for the drilling of the pilot holes.
3. Drill 13/64” (H13) pilot holes 2” deep at each mark, through the vertical arm and into the sidewall
4. Remove vertical arm and re-drill the clearance holes in the sidewall using a 1/4” bit (1/2” deep) (H14).
5. Drive the threaded inserts (H6) into the sidewall using an M5 hex driver.
6. Attach the vertical arm to the sidewall using 2” 10-32 machine screws (H5).
7. Repeat steps 1 through 6 for the other vertical arm.

Layout holes at base of vertical arm.



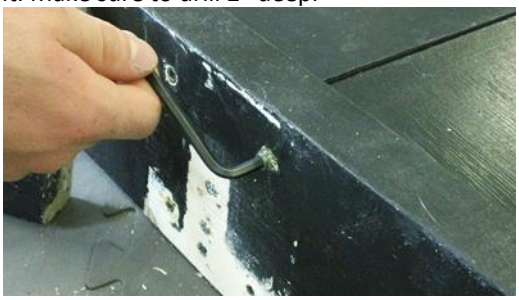




Align vertical arm to sidewall. Clamp the two pieces together to maintain alignment.



Step 3-3: Drill a pilot hole at each mark on the vertical arm using 13/64” bit. Make sure to drill 2” deep.

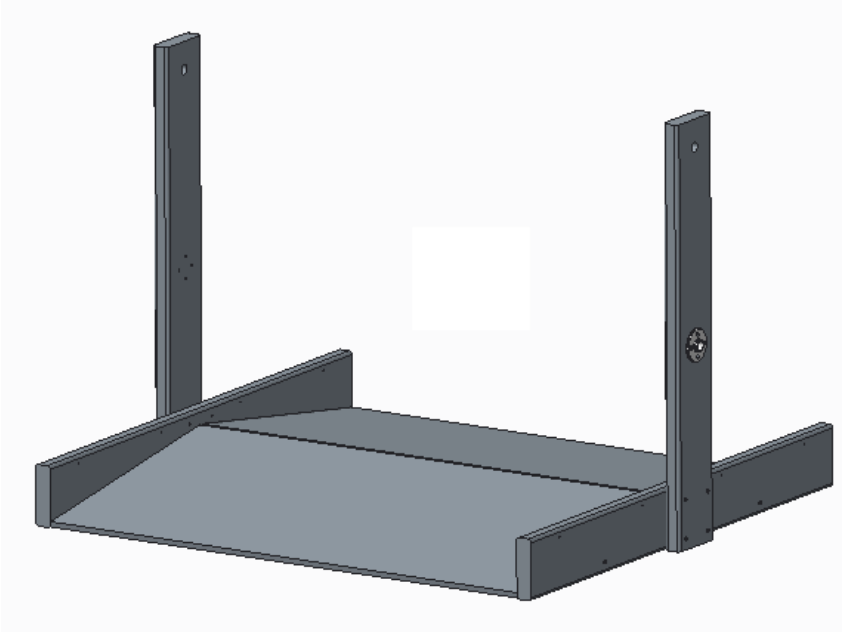
Step 3-4: Re-drill clearance holes for threaded inserts using 1/4” bit (1/2” deep).



Step 3-5: Drive threaded inserts into sidewall using M5 hex driver.

Step 3-6: Attach vertical arm using 2” 10-32 machine screws.

Once complete, the assembly should resemble the image below.

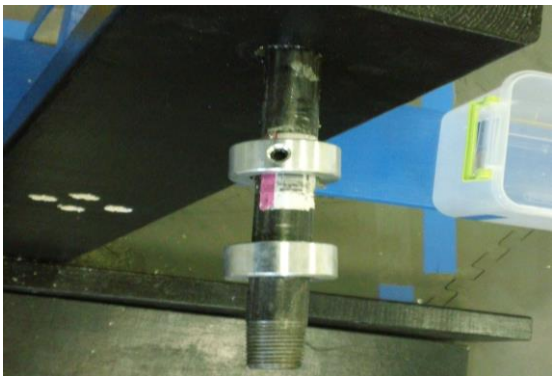


**Step 4 – Installing the Pull-Up Bar and Cantilever Tube**

1. Slide the 60” Pull-Up bar (H2) through one of the 1” holes that are near the tops of both vertical arms.

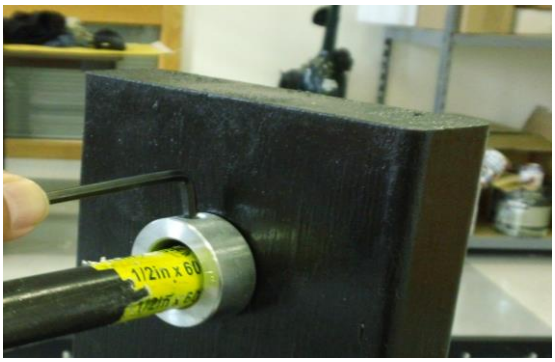
2. Before putting the bar through the other 1” hole, slide 2 collars (H7) onto the bar, but do not tighten.
3. Insert the bar through the hole in the other vertical arm. Adjust the pipe so that it is positioned evenly across both arms. There should be approximately 3” (7.62cm) of the bar sticking out beyond each vertical arm.
4. Take the remaining 2 collars (H7) and place one on each end of the pull up bar.
5. Slide the outer collars so that they sit flush against the vertical arms. Tighten their set screws using a 5/32” Hex Driver (H20) to secure their position. The outer collars should sit about 51” apart in order to ensure that the arms stay vertical.
6. Slide the inner collars so that they sit flush against the vertical arms. Tighten their set screws using a 5/32” Hex Driver (H20) to secure their position.

7. To install the balance arm cantilever tubes, screw the 10” long threaded steel pipes (H1) into the pipe flanges mounted on the vertical arms.



Slide two collars onto the 60” tube, without tightening their set screws, before the tube goes through the second 1” hole.

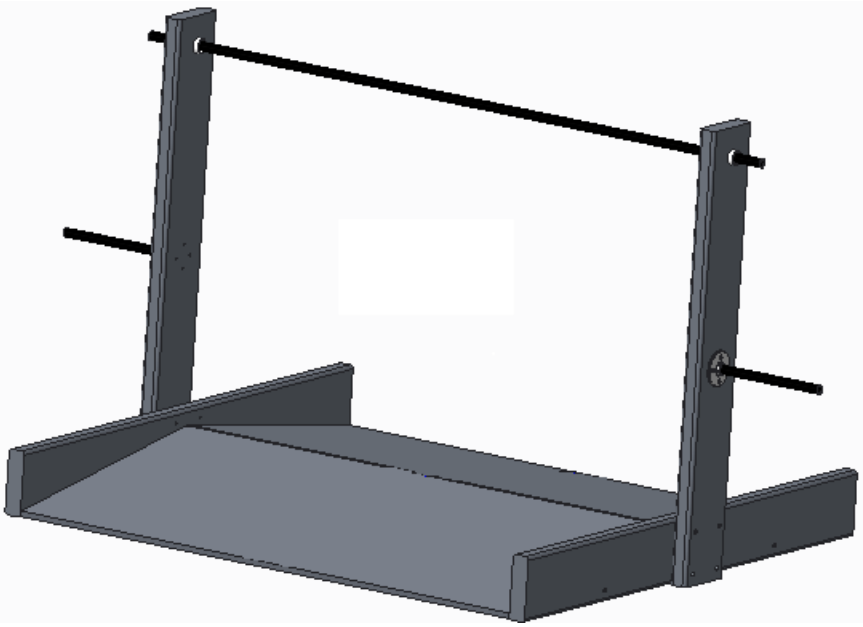
Align the pipe so it sticks roughly 3” out from the vertical arm and place a collar flush against the outside of each vertical arm. Tighten the set screw to secure the collar in place.



Flush the inside collars against each vertical arm and tighten their set screws with a 5/32” hex driver (H20) to secure their positions.

Screw the two 10” balance arm support tubes into the pipe flanges located on the vertical 2x6’s.

Once finished, the center assembly should look like this:

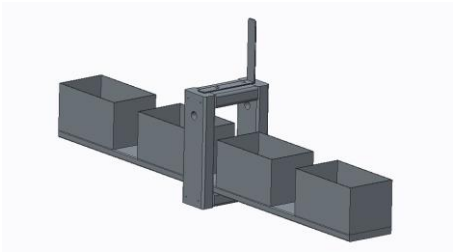


### 3.1.3.1 Safety Note Concerning Steel Pipes

The exposed ends of the steel pipes (H1) and (H2) pose a potential hazard to Referees, Team members, and other participants on the Field. Typically, the steel pipes are sold with plastic caps, which are used as thread protectors. After your Field has been assembled, it is recommended that you cover the exposed ends of the steel pipes (H1) and (H2) with these plastic caps to provide a modest amount of protection for participants who are working near the center structure. If you do not have any plastic caps available, it is recommended that after assembling the center structure you cover the exposed tips of the steel pipes (H1) and (H2) with white (or some other highly visible color) gaffer's tape (T1). When you cover the cantilever pipes (H1) make sure that the tape does not affect the motion of the balance arms.

### 3.1.4 – Building the Two Cantilever/Balance Arms

**Completed Balance Arm**

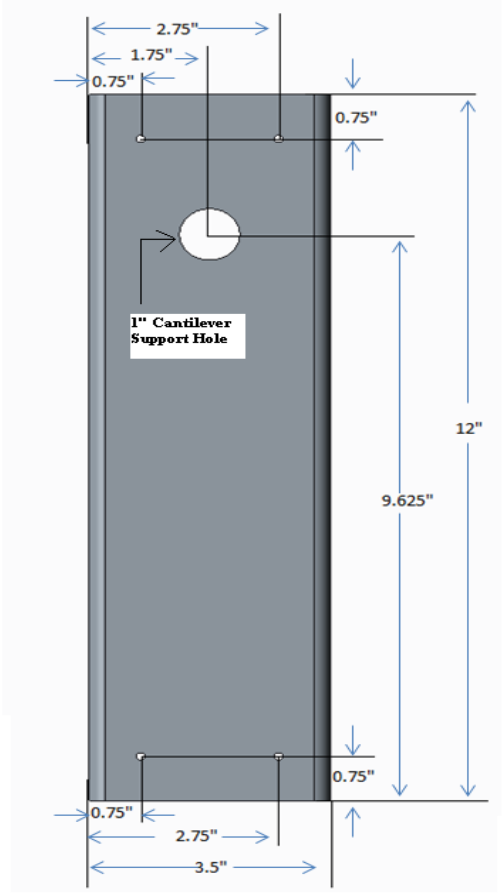


| Parts Required for Balance Arm Construction | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| W4 | 2 | 1x6x48" |
| W5 | 4 | 2x4x5.5" |
| W6 | 4 | 2x4x12" |
| H10 | 10 | #8 x 1.5" wood screw |
| H11 | 16 | #10 x3" wood screw |
| H12 | 2 | Finish corner brace |
| H18 | A/R | Fender washer |

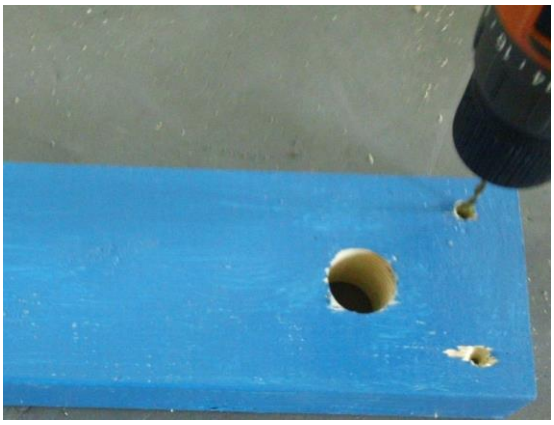
**Step 1 – Build Balance Arm Frame**

1. Draw the center point of the 1” cantilever support holes on all four of the 12” 2x4s (W6) so they match the picture to the right (Figure1).
2. Using a 1” spade drill bit (H17), drill through all the 2x4s at the marked location. **Note**: For well-balanced cantilevers, it is paramount that the holes are straight and accurately placed in accordance with Figure 1.
3. Mark the location of the four pilot holes located at the corners of the 2x4x12” boards (W6) as seen in Figure 1 and drill at each mark with a 3/32” drill bit (H19), all the way through the wood (H19). Repeat for all four 2x4x12” boards.
4. Flush a 2x4x5.5” piece of wood (W5) to the <u>bottom</u> and sides of the 2x4x12” and fasten using 3” wood screws (H11) so that they go through the pilot holes and into the 2x4x5.5” board.
5. Flip the resulting assembly over and lay another 2x4x12” board (W6) on top, making sure its bottom edges match up with the 2x4x5.5” board (W5).
6. Fasten the top 2x4x12” piece (W6) to the 2x4x5.5” (W5) piece of wood using 3” wood screws (H11), as in step 4.
7. Repeat steps 4-6 to begin making the second balance arm.

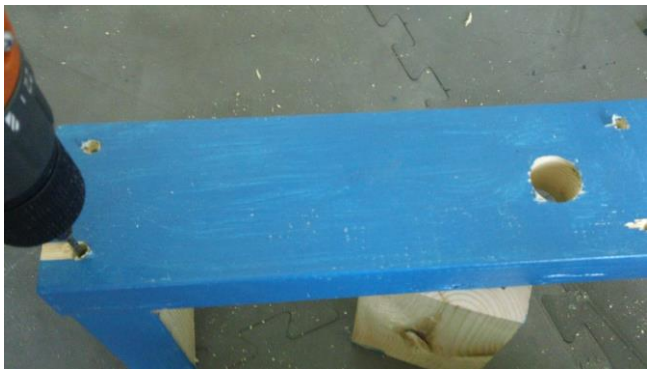
**Figure 1: 2x4x12” Board**



Step 1-2: Drilling the 1” cantilever support hole. One line is 9.625” from the bottom and the other is 1.75” from the sides. The hole was started at their intersection.



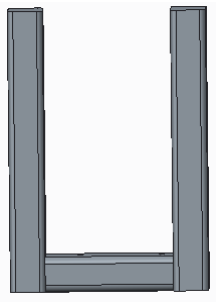
Step 1-3: Drilling the 3/32” pilot holes (H19) into the 2x4x12” board.



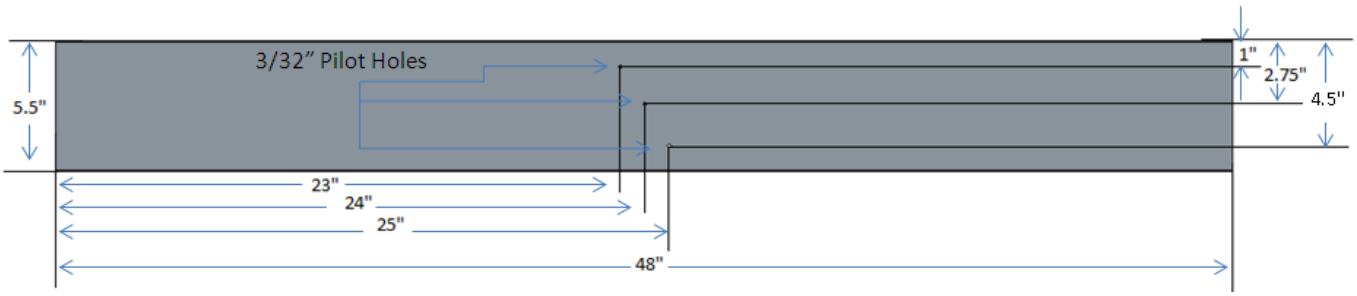
Step 1-4: Fastening the bottom 2x4x5.5” board to the 2x4x12” board using 3” wood screws.

Step 1-6: Fastening the other 2x4x12” board to the bottom 2x4x5.5” board.

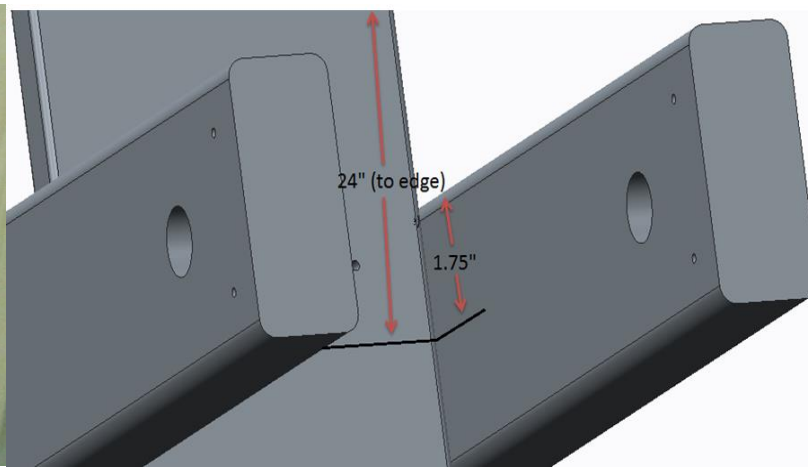
The assembly should now represent the figure to the right, and it is time to add the 1x6x48” board, as well as the top 2x4x5.5” piece.



8. Drill three 3/32” pilot holes (H19) into the 1x6x48” board (W4) at the locations shown in the illustration below.
9. To center the 1x6x48” board, draw a straight line across the center of the 1x6 board (W4), which should be approximately 24”from either edge. The center of the 2x4x12” boards (W6) are then marked as well, 1.75” in from the sides. This is illustrated in a picture below.
10. Once all three lines are touching as shown below, 1.5” wood screws can be driven through the 1x6’s three pilot holes, into the 2x4x5.5” board below it.
11. With the 1x6 secure, the other 2x4x5.5” piece of wood (W5) can be secured to the assembly. Flush the 2x4x5.5” board to the top of the 2x4x12” board and drive 3” wood screws (H11) through the pilot holes, into the 2x4x5.5” board.
12. Repeat steps 8-11 on the other cantilever assembly.

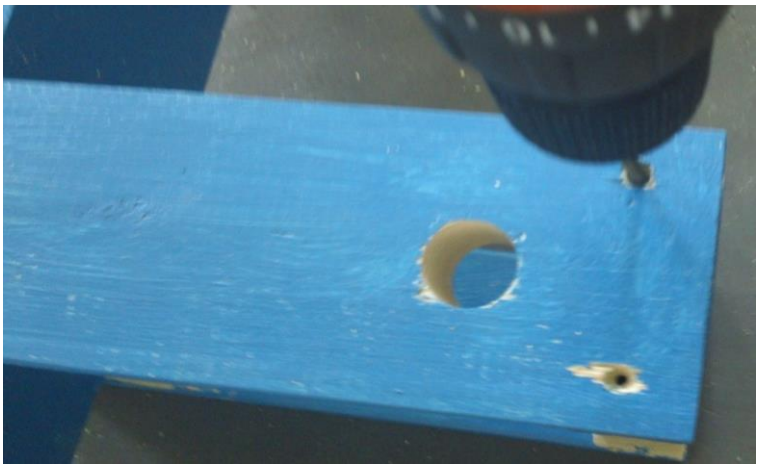



Step 1-8: Drilling the 3/32"pilot holes into the 1x6 (W4), according to the dimensions shown in Figure 2.



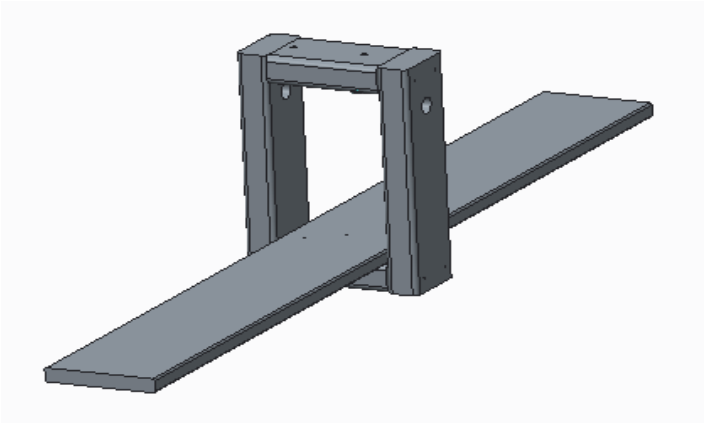

Step 1-9: Centering the 1x6 (W4) onto the assembly by matcing up the lines on drawn W4 to the lines on W6.

Step 1-10: Fastening the 1x6x48" board (W4) to the 2x4x5.5" board (W5) using 1.5" wood screws.



Step 1-11: Fastening the 2x4x5.5" board (W5) to the top of the 2x4x12" boards, after the boards have been made flush to one another.

The Balance Arms should resemble the picture to the right after step 1-11 has been completed.

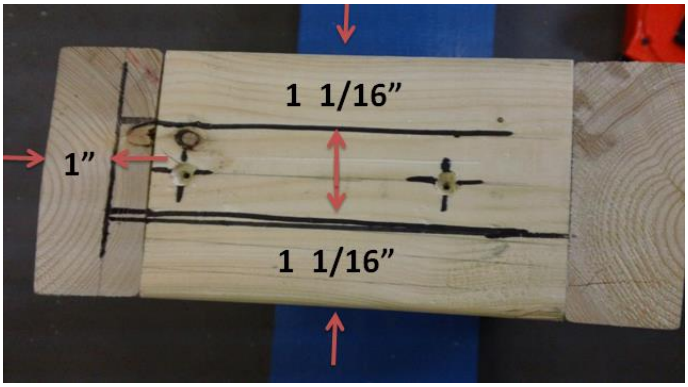


**Step 3 – Install the Corner Brace**

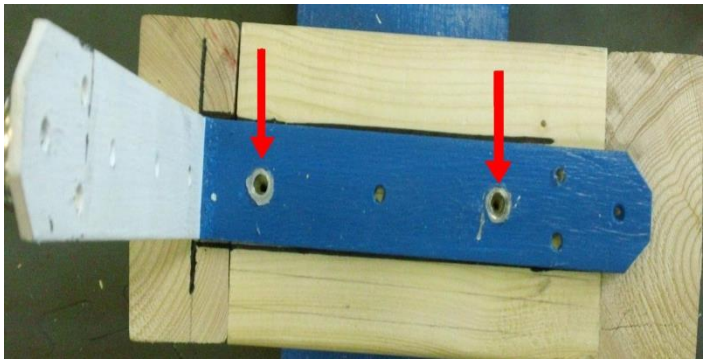
It is now time to attach the corner braces (H12). Since proper alignment is important special care is taken to center the bracket on the top of the assembly. **Important:** If the corner brace does not sit level on the top of the balance arm, it is necessary to level it by putting paper or wood shavings under the side of the bracket that needs to be raised.

13. Measure 1” in from the edge of a 2x4x12” board (W6) and make a line. Then measure and mark two lines 1 and 1/16” in from the outsides of the 2x4x5.5” board (W5); as shown in the top left picture below. Note that it is permitted to move the corner brace (H12) closer to the edge of the 2x4x12” board (W6). If desired, instead of measuring 1” from the edge of board (W6), the brace can be installed so that it is at the edge of (W6). These build instructions provide a 1” gap to allow for the future addition of an electronic mechanism that can be used to indicate (with colored LED’s) whether or not an arm is in balance. If you do not intend on using such a mechanism, then you should move the corner brace (H12) to the edge of board (W6) in order to make it easier for the referees and teams to determine if an arm is in balance or not.
14. Align the Corner Brace (H12) so that it follows all the lines just drawn, as pictured top right below. Once aligned, mark the centers of the two holes indicated by the red arrows.
15. Remove the Corner Brace and drill two 3/32” pilot holes on the marks just drawn. The marks and pilot holes can be seen in the top left picture.
16. Place two 1.5” inch screws (H10) through the past indicated holes and fasten the bracket to the assembly.
17. Repeat steps 1-4 for the other side’s balance arm.

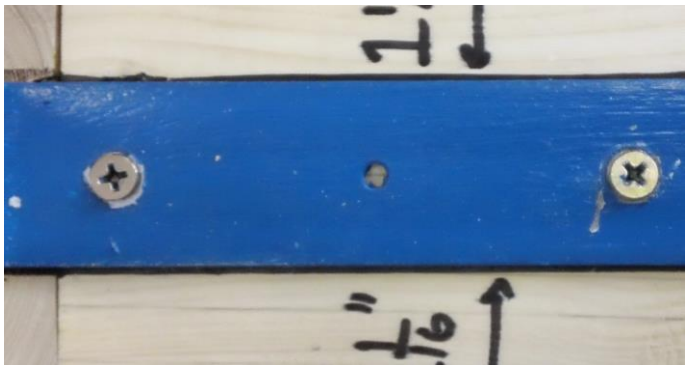
Don’t forget to shim the corner brace level with the 2x4x5.5” it is attached to!




Step 1- 13: The lines used for centering the bracket with the pilot holes.



Step 1-14: Aligning the bracket and red arrows indicating the placement of the 3/32” pilot holes.



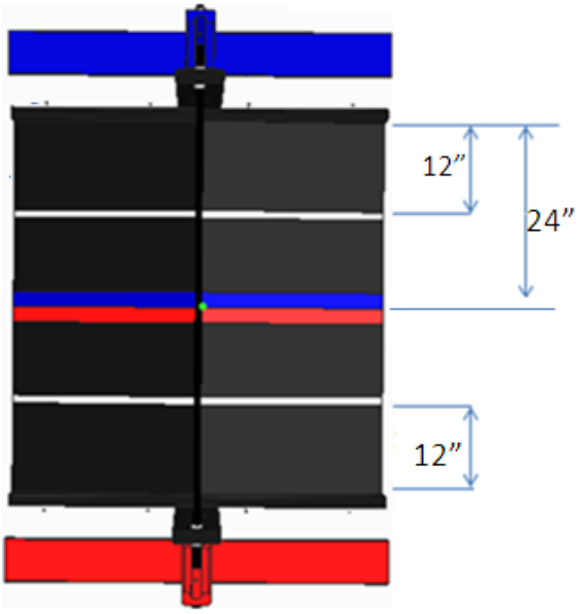
Step 1-16: 1.5” wood screws are used to fasten the bracket to the rest of the assembly. These may need to be loosened to allow space for wood shavings or paper to shim the corner brace level with the 2x4x5.5” board and then retightened to check level. Repeat until level.

### 3.1.5 Painting and Taping the Center Assembly and Balance Arms

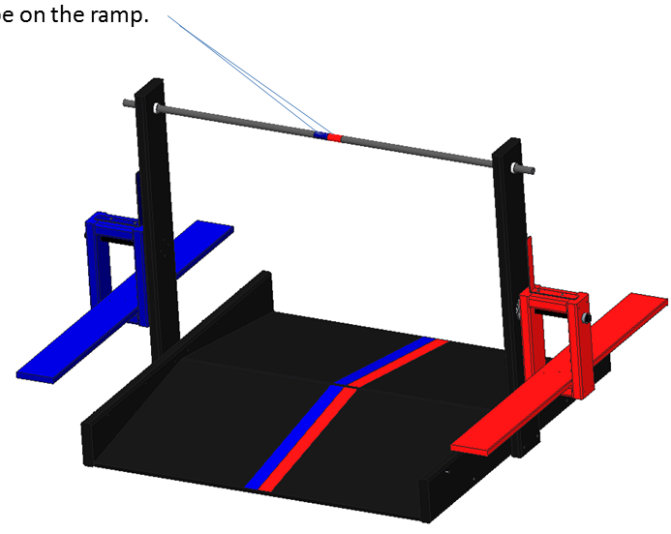
| Items Needed to Paint and Tape the Center Assembly and Balance Arms | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| T1 | A/R | 1” White gaffer’s tape |
| T2 | A/R | 2” Red gaffer’s tape |
| T3 | A/R | 2” Blue gaffer’s tape |
| M2 | A/R | Black paint |
| M3 | A/R | Red paint |
| M4 | A/R | Blue paint |
| M6 | A/R | Primer and sealer |

With the center assembly complete and the balance arms complete except for the installation of the baskets, it is time to paint the pieces. It is recommended to sand any rough edges and prime all surfaces before applying colored paint. **Note**: The red, blue, and white lines in the illustrations below are tape, not paint. Follow the pictures below for correct painting:

1. The touching edges of the red (T2) and blue (T3) tape at the center of the ramps should be 24” from the edges of the ramp and the center of the white tape (T1) should be 12” from the edge of the ramp. The diagram below illustrates correct placement.
2. Also, a 2” blue band of tape should be placed around the pull-up bar directly over the 2” blue tape on the ramp, and a 2” red band of tape should be placed around the pull-up bar, directly over the 2” red tape on the ramp.
3. When painting the balance arms, do not paint the inside surfaces of the holes that come in contact with the cantilever pipes (H1). Keep these surfaces clean and unpainted to minimize the friction on the bearing surfaces of the balance arms.



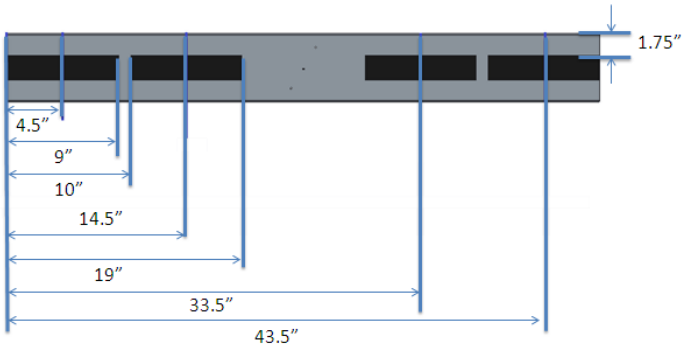

Place 2” blue and 2” red bands of tape around the pull-up bar, directly over the corresponding pieces of tape on the ramp.

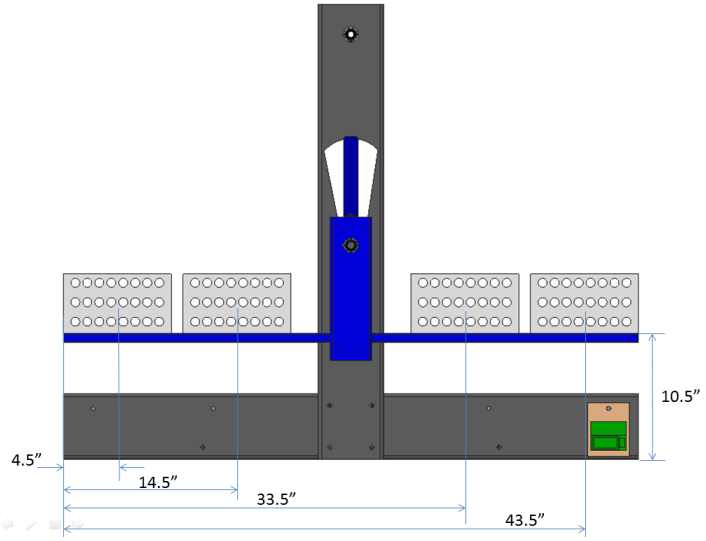


### 3.1.6 Attaching the Baskets

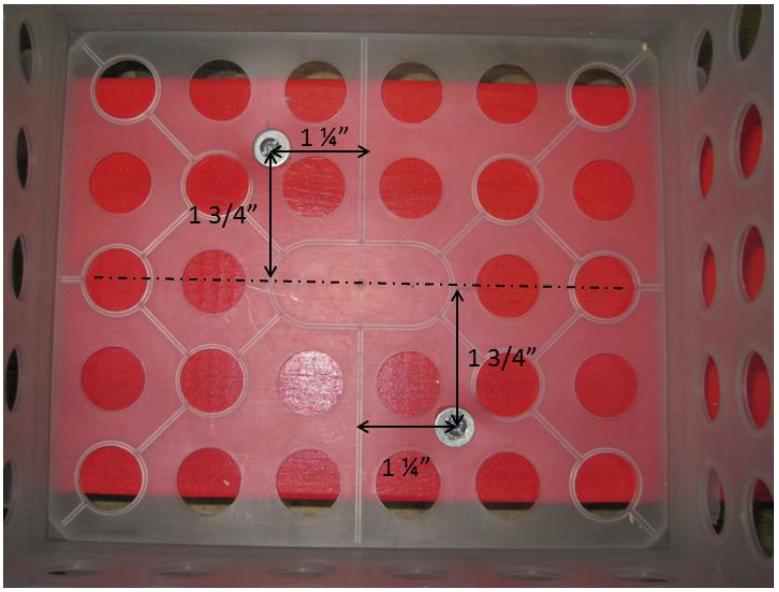
With the balance arm's frame now complete, the baskets for the cubes can be attached to the balance arm.[6]

| Items Needed for Attaching the Baskets | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| M7 | 8 | Sterilite Mini Crates |
| M20 | A/R | 2" Adhesive Velcro |
| M14 | A/R | Staples |




1. Cut out eight 9" strips of both sides of Velcro (M20).
2. Peel off the backing of the hard (hook side) Velcro and place it on the bottoms of the baskets, so that it runs parallel to the long end's edges. It should be 2 ¾" from the edge. Repeat for all baskets.
3. Peel off the backing of the 9" pieces of the soft (loop side) of the Velcro and place them onto both of the 1x6x48" (W4) boards according to the diagram above and to the left. Use staples (M14) to keep the Velcro in place on the board.
4. Place the baskets on the 1x6 board so that the centers of the basket line up with the critical dimensions shown in the image above and to the right.
5. With the Velcro adhesive holding the baskets in place, use a 3/32" drill bit (H19) to pre-drill a pair of holes through the bottom of the basket and about 1/2" deep into the 1x6 board. Use the dimensions in the figure below and to the right[7] to place the holes on the bottom of each basket.
6. Use two #6 x 5/8" wood screws (H21) and two #6 flat washers (H22) to further secure the basket to the board. Do this for each basket on the arm.
7. With all baskets on the balance arm, slide the arm onto the 10" tube (H1). Tighten a collar (H7) onto the tube so it is close to the balance arm, but not touching.




[6] The original version of the *Build Guide* only used Velcro to secure the baskets to the board. Revision 1.1 added two screws and flat washers per basket to fasten the baskets more securely to the board.

[7] Note that the Velcro strips on the board and bucket are not shown in the image.

8. Visibly check to see if the balance arm is level. If not, place washers (H18) onto the bottom of the 1x6 (W4) on its higher side until the arm is level. This procedure is explained in detail in the next section.
9. Repeat steps 4-7 for the other balance arm.

### 3.1.7 Leveling the Balance Arms

A balance arm should be level before it is used for a Match. A balance arm is considered level when its indicator (H12) points straight up when the baskets are empty. Use a spirit level/bubble level to verify that the indicator (H12) is level. If your balance arms are not level after completion, whether it's due to discrepancies in the wood density or inaccuracies in construction, it might be necessary to level the arms by adding weight to the arms.

If an arm is unbalanced, you can add steel washers (H18) to the lighter side (the side that sits higher when arm is at rest) to make the arm level. Use 2" (5.08cm) gaffer's tape to secure the washers to the bottom side of the board. Adjust the quantity and position of the washers along the bottom of the board to make the arm level when the baskets are empty.

Make sure the washers are flush with the bottom of the board and securely fastened so they will not come loose during a Match. When the arm is balanced, both ends of the balance arm will be at the same height above the floor.

Level the arm by attaching washers to the bottom of the 1x6 board using tape. Vary the number and placement of the washers to achieve the proper balance.

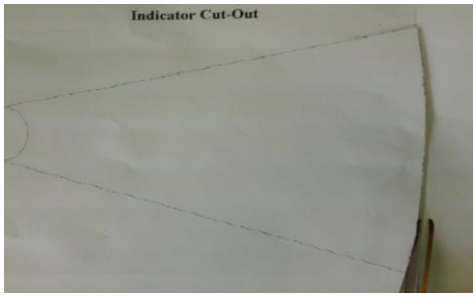
### 3.1.8 Setting Up the Balance Indicators

A white poster board cutout will work as a background to the balance indicators (H12). The cutout needs to be trimmed so that the indictors will be "in balance" (i.e., within the boundaries of the cutout) when there is a difference of two blocks (F4) in the outermost position of the outer baskets. The cutout should also be trimmed so the indicators will be out of balance (i.e., out of the boundaries of the cutout) when there is a difference of three blocks in the outermost position of the outer baskets.

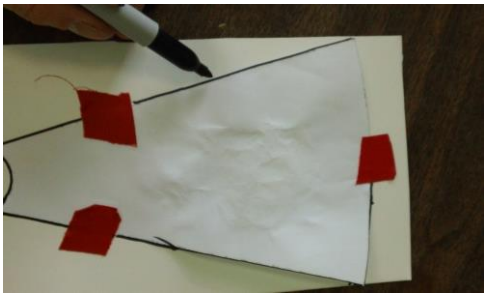
| Items Needed to Set Up the Indicators | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| M9 | A/R | White poster board |
| M10 | A/R | Adhesive Velcro |

1. Print out the indicator cut-out (see page 37) and trim with scissors or utility knife.
2. Fasten the indicator cut-out to a piece of white poster board (M9) with tape or other means and trace its outline onto the paperboard. Cut along the outline to create a rough copy of the indicator background.
3. Attach Velcro hooks to the poster board indicator and loops to the vertical 2x6x38" board (W3), a few inches above the pipe flange (not much Velcro is necessary). Place the indicator onto the vertical 2x6 board so that the top of the indicator lines up with the top of the corner brace and it is centered on the 2x6.

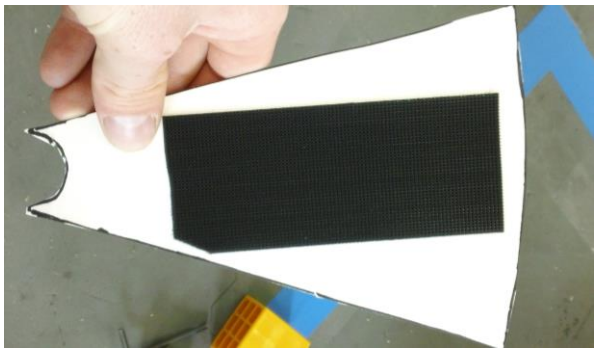
4. To calibrate the indicator to the balance arm, place two cubes into the outside of one of the outer baskets. Let the balance settle, and then mark with a line where the corner brace is relative to the indicator. This will serve as the outer limits of the indicator.
5. Repeat step 4, but with two blocks in the outside of the other outer basket.
6. Cut along the lines just drawn on the indicator using scissors or a utility knife.
7. Place the indicator back on the 2x6 and verify that it still indicates the outer limits of the corner brace by placing two blocks into the outside of the outer baskets again. Adjust the poster board background if necessary.
8. Repeats steps 1-7 for the center assembly's indicator on the other side.



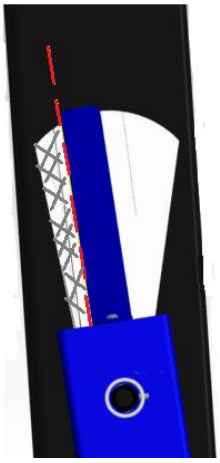

Step 1: Cut out the indicator background along the lines.



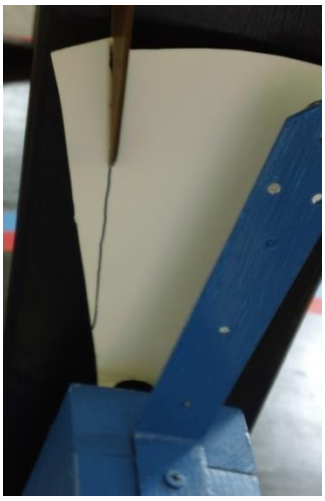
Step 2: Secure the cut indicator cut-out to a piece of poster board and trace it onto the poster board.



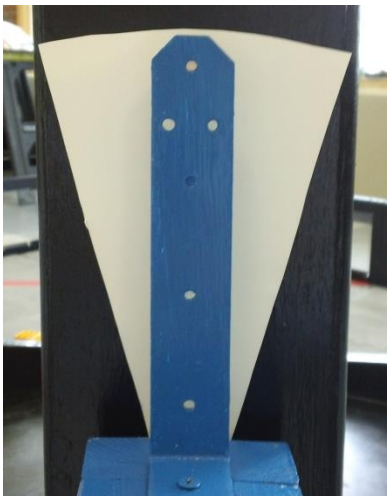
Step 3: Place a strip of Velcro hooks on the indicator background (there is more pictured than necessary) and a strip of Velcro on the 2x6x38" board a few inches above the pipe flange.



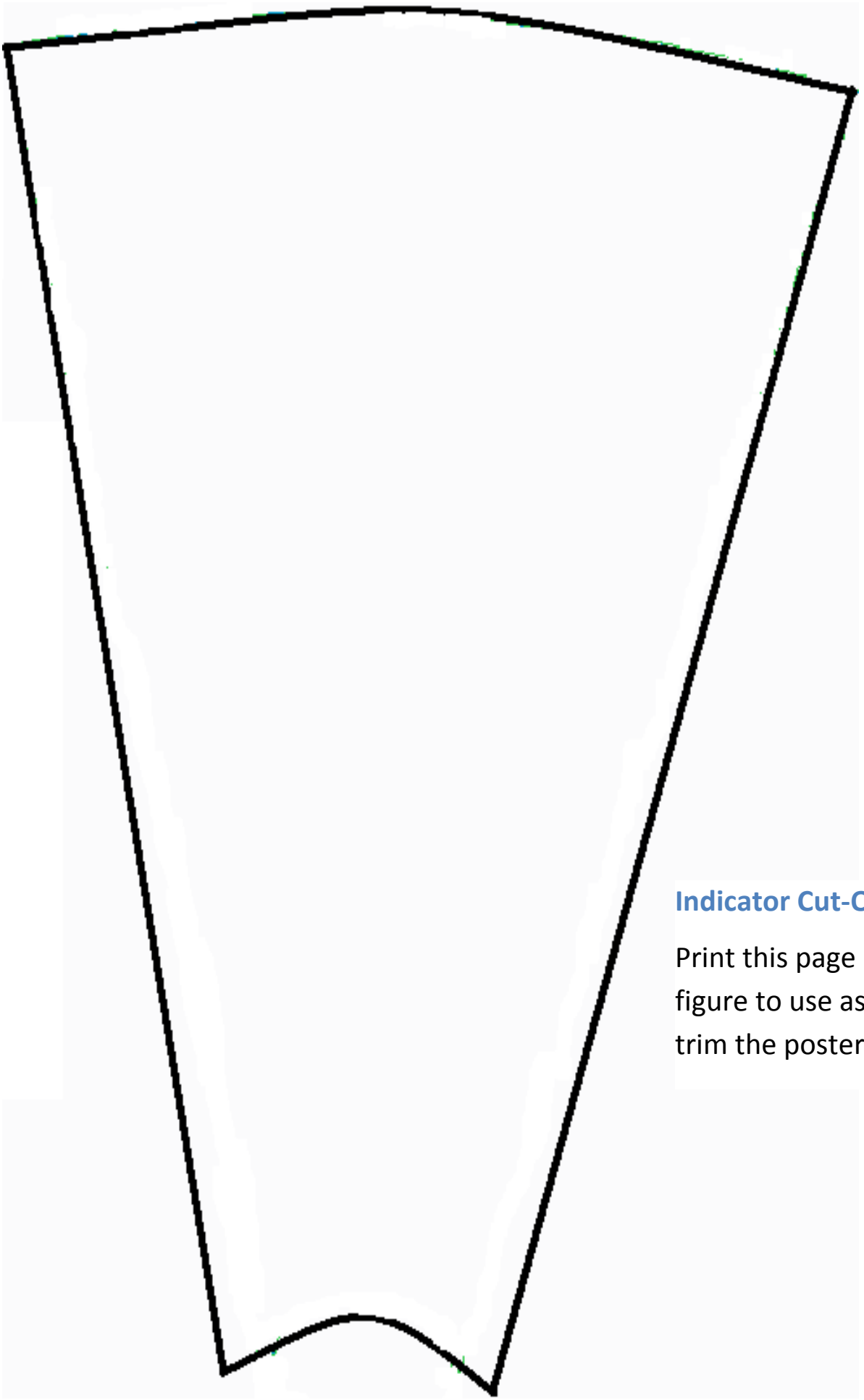
Steps 4-5: Use the edge of the corner brace to determine where to mark the outer limit of the balance when two blocks are placed in one of the outer baskets. Mark this along the poster board so it can be cut later.



Step 6: Trim along the line made in sub-step #4.



The finished poster board indicator background.



## Indicator Cut-Out

Print this page and cut out the figure to use as a template to trim the poster board.

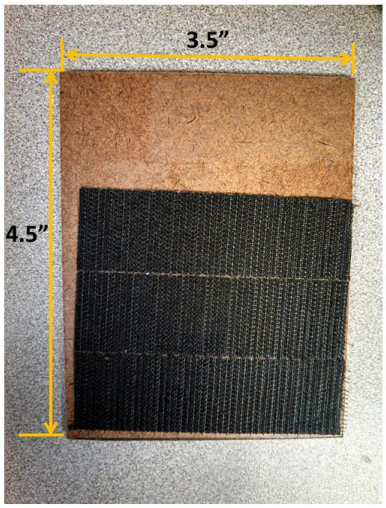
### 3.1.9 Building the IR Beacon Mount[8]

The IR beacon is mounted on a thin plywood hanger for placement under the crates. The mount will be hung from the wood screws installed in Step 1 of section 3.1.2 on page 16. Velcro is used to fasten the beacon to the mount so that the beacon can be moved so that its LED's sit at the critical dimension of 2.75" (6.96cm) above the ground. The overall dimensions of the beacon mount are less important. The critical dimensions are the placement of the beacon mount screws along the sidewall (see Step 1 of section 3.1.2 on page 16) and the height of the LED's above the ground (2.75" or 6.96cm).

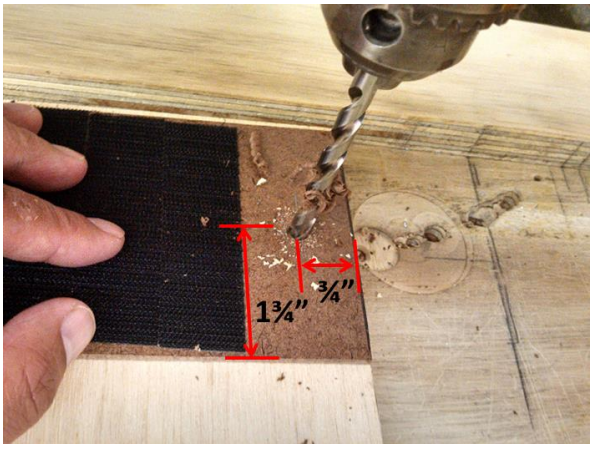
1. Cut the thin plywood so it is 4.5" (11.43cm) tall using a utility knife.
2. Cut the wood again so that it is 3.5" (8.89cm) wide.
3. Place three 3" (7.62cm) strips of hook side, 3/4" (1.91cm) adhesive Velcro near the bottom of the wood.
4. Drill 3/8" hole 3/4" (1.91cm) from the top of the wood and 1.75" (4.45cm) from the sides.
5. Place three 3" (7.62cm) long strips of loop side, 3/4" (1.91cm) adhesive Velcro onto the back of the beacon. Note that the manufacturer of the IR beacon specifies that the entire backside of the beacon should be covered with Velcro so that this side is electrically insulated. This requires three strips of Velcro.
6. Place the beacon so it is centered on the wood (1/4" or 0.64cm from each side) and so that its LEDs sit approximately 1.5" below the hanger hole. The position of the beacon should be adjusted before Competition so that its LEDs sit 2.75" (6.96cm) off of the ground.

[8] Note that this *Build Guide* includes instructions for mounting the older style HiTechnic IR Beacon (HiTechnic Item # FTCBCN). HiTechnic will be introducing a new style of IR beacon for the 2013-2014 season. The dimensions of the new style beacon were not available at the time of original publication of this *Build Guide*. The dimensions became available for release 1.10 of this *guide*.

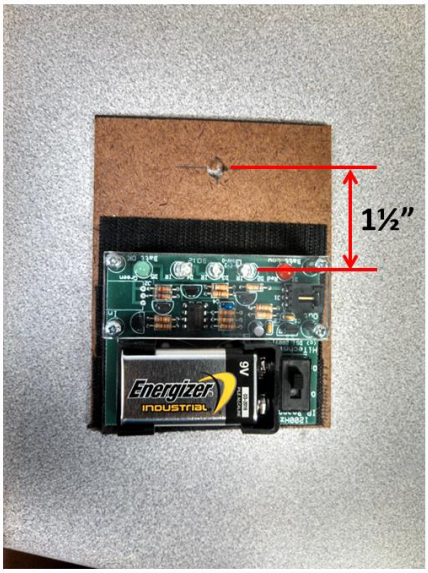
Trim the hanger board to 4.5” in length. Placing a straight edge against the cut line will help ensure a straight cut.




Trim the board so that it is 3.5” wide. Cover the bottom portion of the hanger with three strips of hook-side Velcro.




Drill a 3/8” hole (H16) 3/4” from the top of the board and 1.75” in from each edge.




After placing loop-side adhesive Velcro onto the IR beacon, mount it on the hanger so that it is centered from the sides and so that its LEDs sit approximately 1.5” below the hanger hole. Placing the beacon at this position should put the LEDs 2.75” above the Soft Tile floor. Check the height of the LEDs above the floor and if required, adjust the IR beacon’s position accordingly.

### 3.1.10 Alternate IR Beacon Mount

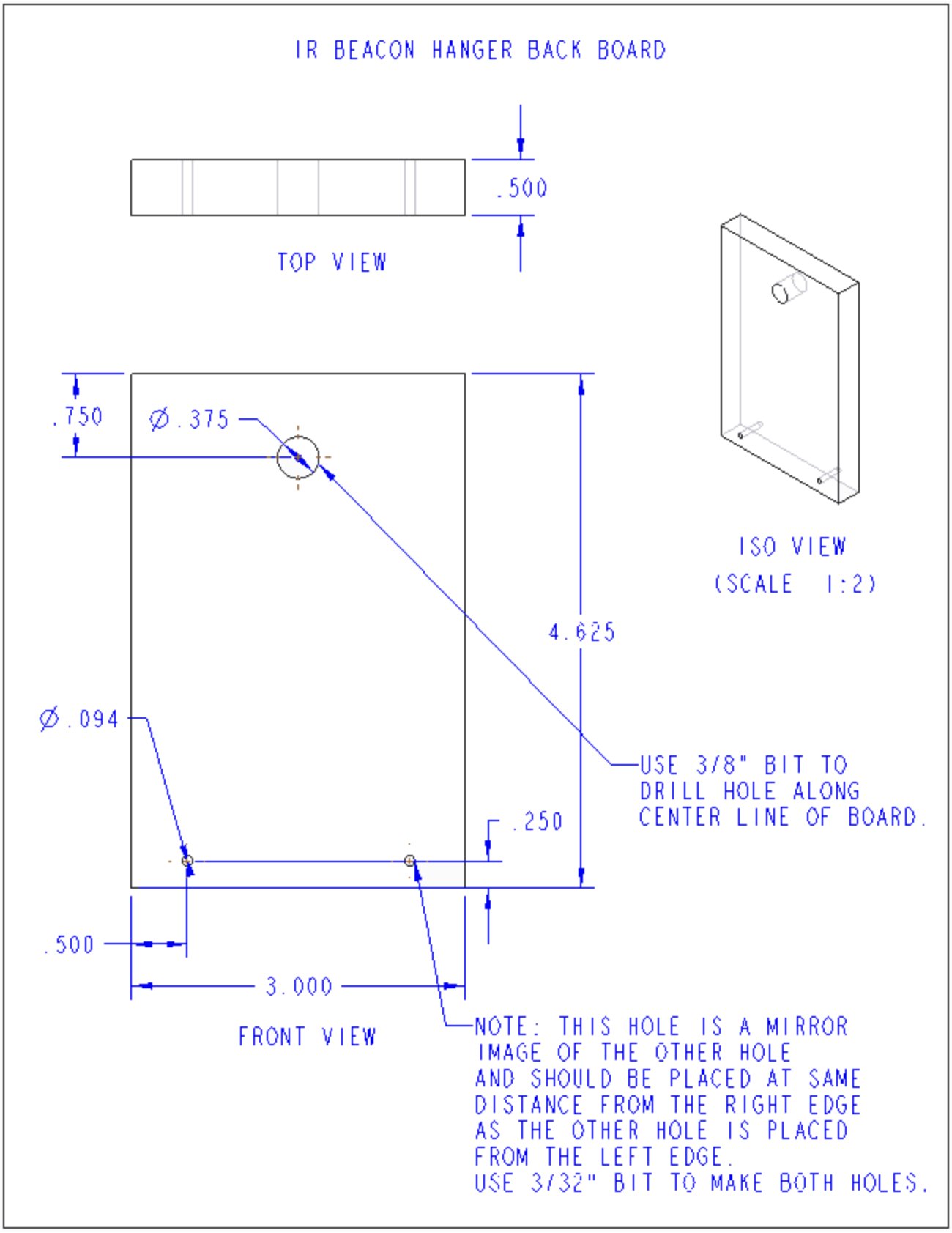
For the 2013-2014 HiTechnic is introducing a new style of IR beacon. This new beacon (model # HBK2100) is different in form than the older style beacon. This new beacon requires a different style of hanger. This section provides instructions for building an IR beacon hanger to be used with model # HBK2100. This alternate beacon hanger will be hung from the wood screws installed in Step 1 of section 3.1.2 on page 16. Note however, that because of the thickness of the plywood used for the alternate hanger, the screws described in Step 1 of section 3.1.2 on page 16 should be backed out slightly so that 3/4" of the screw (instead of 1/2" as it was originally specified in version 1.00 of this document) sticks out of the side wall.

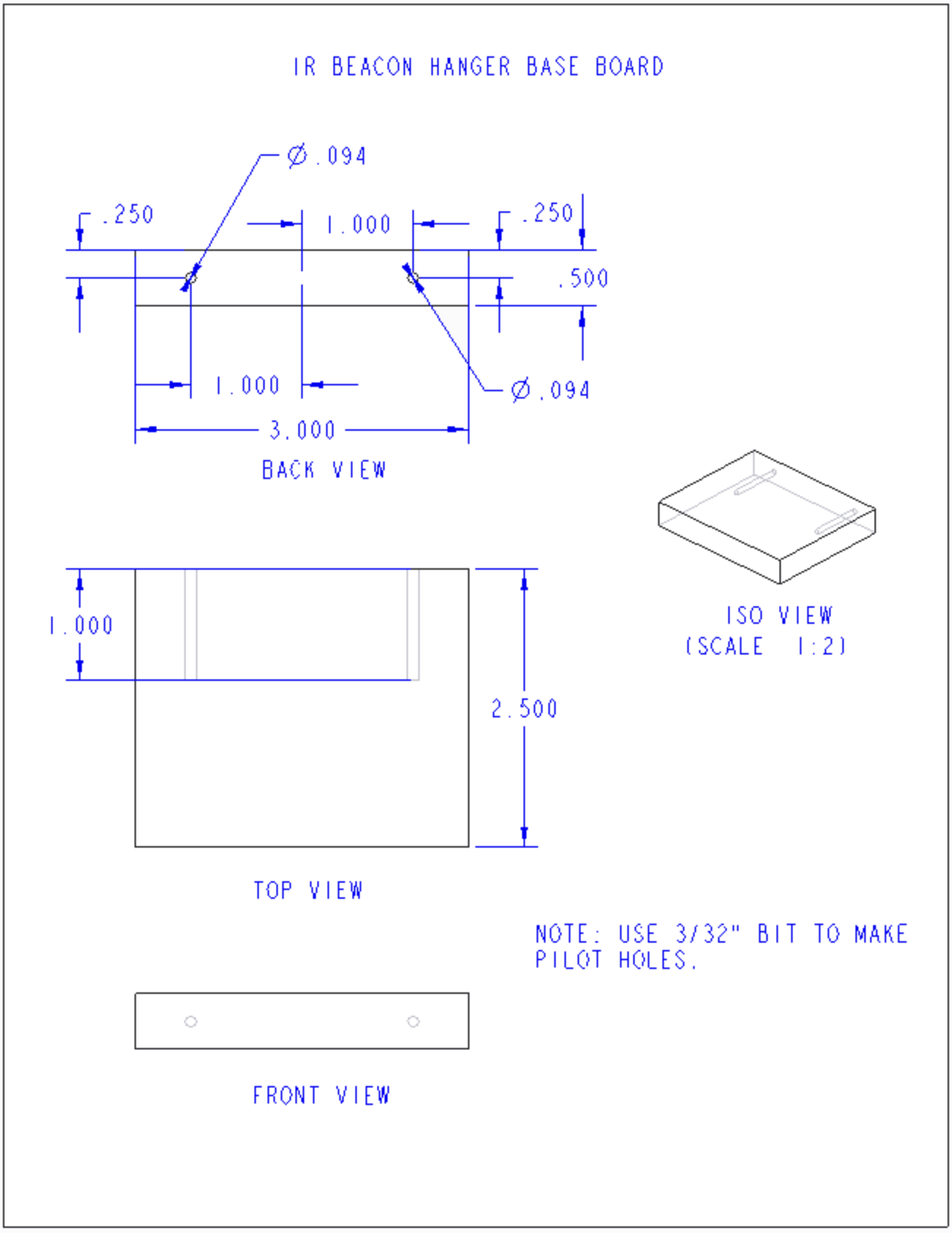
Note that you should use the same style of beacon per Field. Do not mix an older style beacon with a newer style beacon on the same Field. Either use all newer style beacons (HBK2100) or all older style beacons (FTCBCN) on a single Field.

You will need two beacon hangers per Field. The beacon hanger is constructed from two pieces of plywood. It has a back board (W11) and a base (W12). Use the extra plywood that was used to create piece (W8) to create the pieces needed for the IR beacon hanger.

The two pieces are held together by two #8 x 1.5” wood screws (H10). The IR beacon is secured to the base using Velcro fastener (M10).

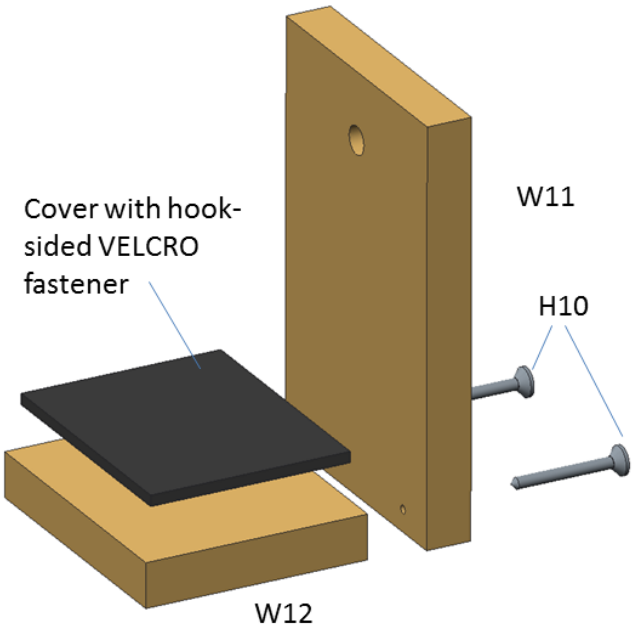
| **Items Needed to Build Hanger (2x)** | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| W11 | 2 | 1/2" x4.625” x 3” plywood |
| W12 | 2 | 1/2" x2.5” x 3” plywood |
| H10 | 4 | #8 x 1.5” Wood screws |
| M10 | A/R | Adhesive Velcro (3/4” wide) |
| M2 | A/R | Black paint (optional) |
| M6 | A/R | Primer and sealer (optional) |

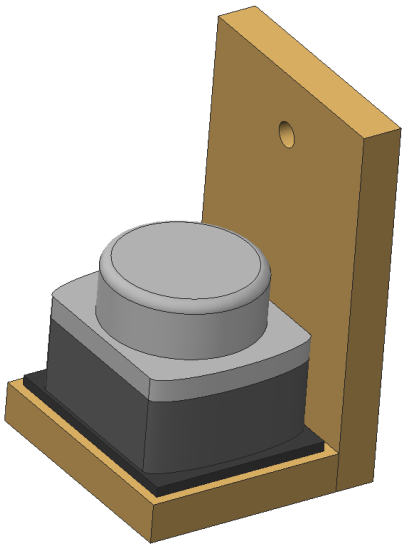

IR BEACON HANGER BACK BOARD
.500
TOP VIEW
ISO VIEW
(SCALE 1:2)
.750
Ø.375
4.625
Ø.094
USE 3/8" BIT TO
DRILL HOLE ALONG
CENTER LINE OF BOARD.
.250
.500
3.000
FRONT VIEW
NOTE: THIS HOLE IS A MIRROR
IMAGE OF THE OTHER HOLE
AND SHOULD BE PLACED AT SAME
DISTANCE FROM THE RIGHT EDGE
AS THE OTHER HOLE IS PLACED
FROM THE LEFT EDGE.
USE 3/32" BIT TO MAKE BOTH HOLES.

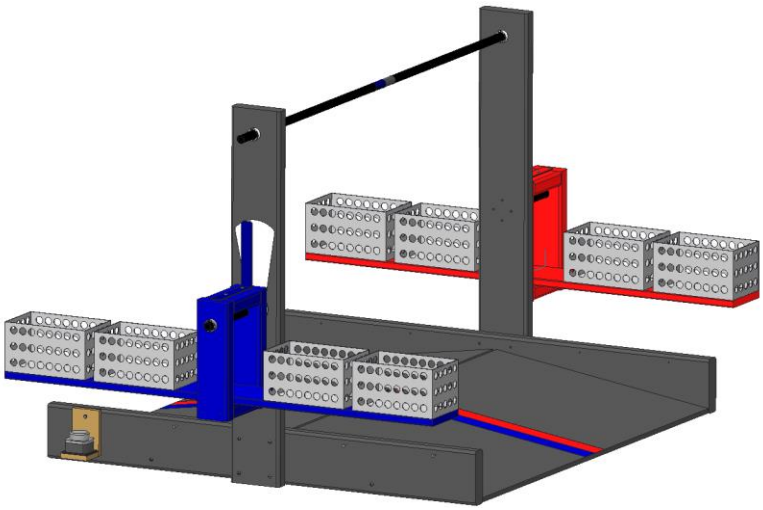



To construct the beacon hanger,

1. Use the two diagrams on the previous two pages to cut and drill the back board and base from 1/2" thick plywood.
2. Fasten the backboard to the base using two #8 x 1.5” wood screws.
3. Place hook-sided Velcro to the base.
4. Place loop-sided Velcro to the bottom of the IR beacon.
5. Secure the beacon to the base.
6. Repeat these steps (1-5) to build the second hanger.
7. Prime and paint the wooden hangers if desired.



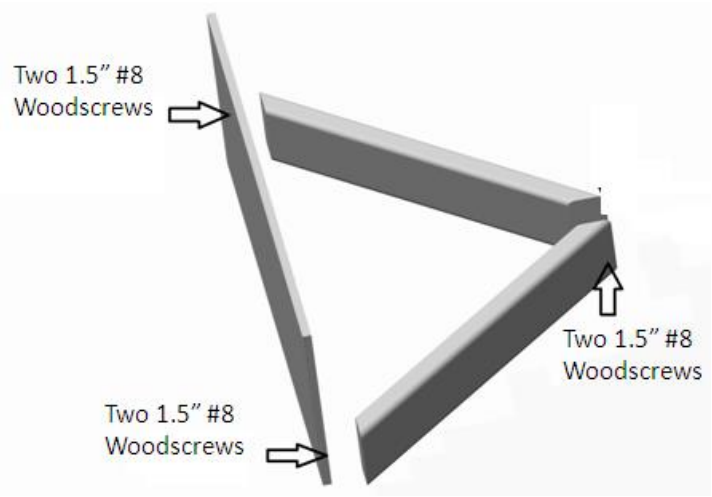


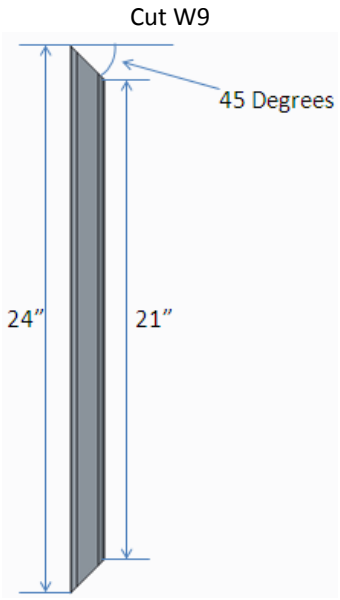
 

## 3.2 Building the Corner Barriers

The corner barriers require four cuts to be made on the two 24” 2x4’s (W9 boards). The cuts are made at 45 degree angles, reducing one side of the W9 boards to 21”. The result can be seen in the diagram to the below and to the right:

| Items Needed to Build Backstop | | |
|---|---|---|
| **Item** | **Quantity** | **Description** |
| W8 | 2 | ½x10x34” plywood |
| W9 | 4 | 2x4x24/21” lumber |
| H10 | 12 | #8 x 1.5” wood screws |
| M5 | A/R | White paint |
| M6 | A/R | Primer and sealer |
| M17 | 2 | White adhesive paper (8.5” x 11”) |




1. With the two W9 boards cut, lay them out according to the diagram above and to the left.
2. Secure the two W9 boards to one another using two 1.5” woodscrews (H10). **Note:** Before inserting the woodscrews, drill two 3/32” pilot holes about 1” into one of the W9 boards at an angle so the screws won’t poke out through the other side of the second piece of wood (also W9).
3. Place the W8 piece of plywood on the ground and against the two W9 pieces of wood. Secure the plywood to the 2x4’s using four 1.5” screws.
4. Paint the backstop white. It is recommended to sand rough edges and prime the surfaces before applying the white paint.
5. Repeat steps 1-4 to build the other corner barrier.
6. Print out the logos on page 47 onto white adhesive paper (M17), center them horizontally and vertically on the plywood, and stick the logos onto the faces of the corner barriers (after the paint has dried).

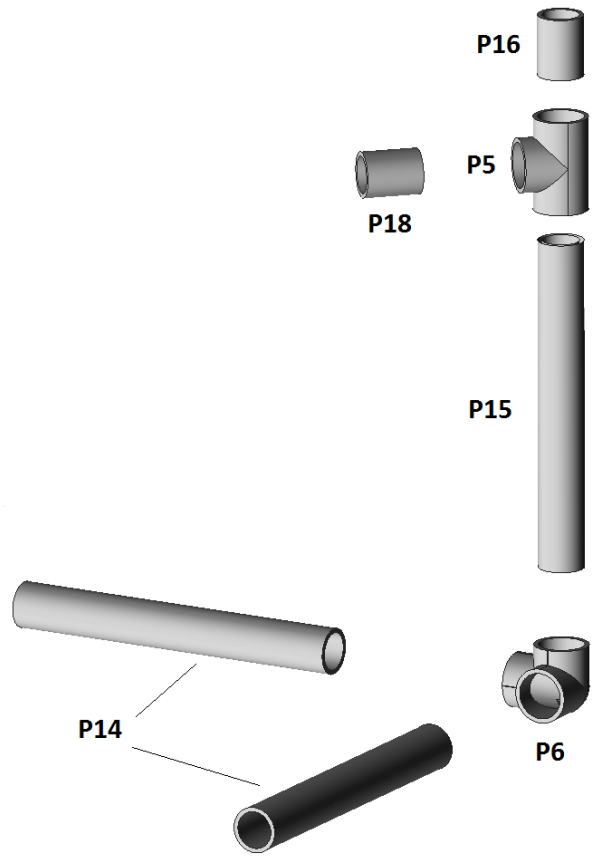
## 3.3 Corner Flag Poles

The corner Flag poles are constructed from PVC pipe and fittings, and are held together with PVC cement. Make sure the pieces are clean and dry prior to cementing them together. Note that most PVC cement sets very quickly so cement each joint individually as you build the structures. Also, a rubber mallet can be useful when assembling the pieces to tap them together quickly before the cement sets.

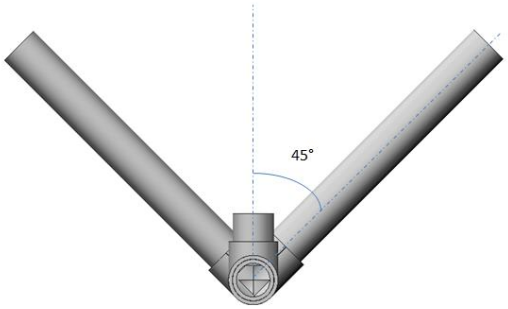
You will need to build a total of two (2) complete corner Flag poles for a Field.

### 3.3.1 Flag Base

Assemble and individually cement the pieces together in the manner shown in the exploded diagram below.



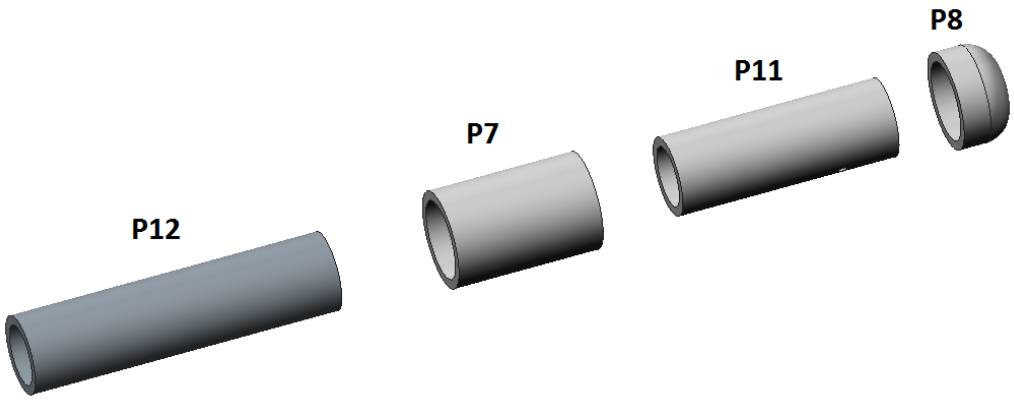

**Important Note:** The tee joint shown in the figure to the left (part P5) should be aligned so that the short pipe that sticks out of the joint (P18) points at a 45 degree angle to the legs of the structure (P14) when looking straight down from the top at the flag base (see figure below).



### 3.3.2 Flag Lift Shaft Assembly

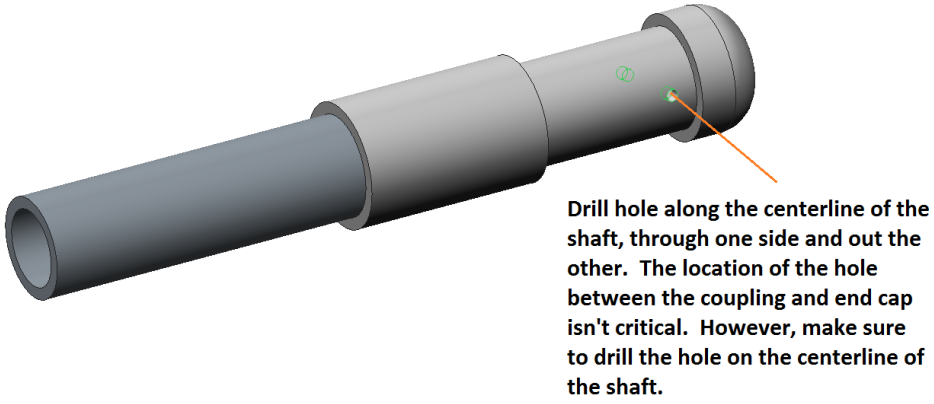
**Step1**

Assemble and individually cement the pieces together in the manner shown in the exploded diagram below.



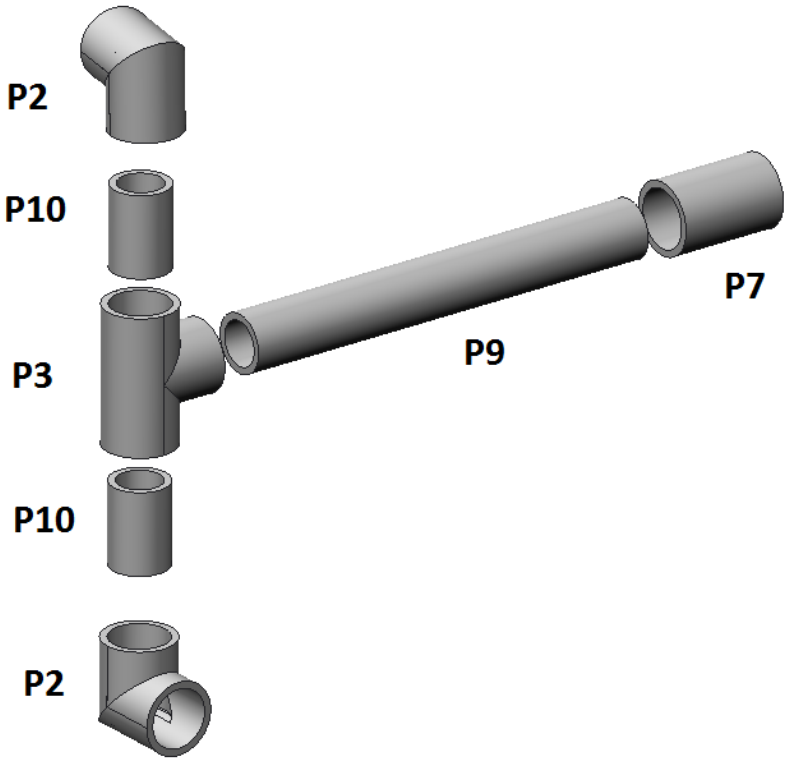

**Step 2**

After the cement has had several minutes to dry, use a 13/64" drill bit (H13) to drill a hole along the center line of part (P11), in between the couple (P7) and the end cap (P8). The hole should be drilled through both sides of the pipe and go straight through the middle of the pipe. If a drill press is not available, holding the pipe in place with a vise will help ensure a straight and centered hole (see figure below).



### 3.3.3 Flag Lift Crank Assembly

Assemble and individually cement the pieces together in the manner shown in the exploded diagram below.

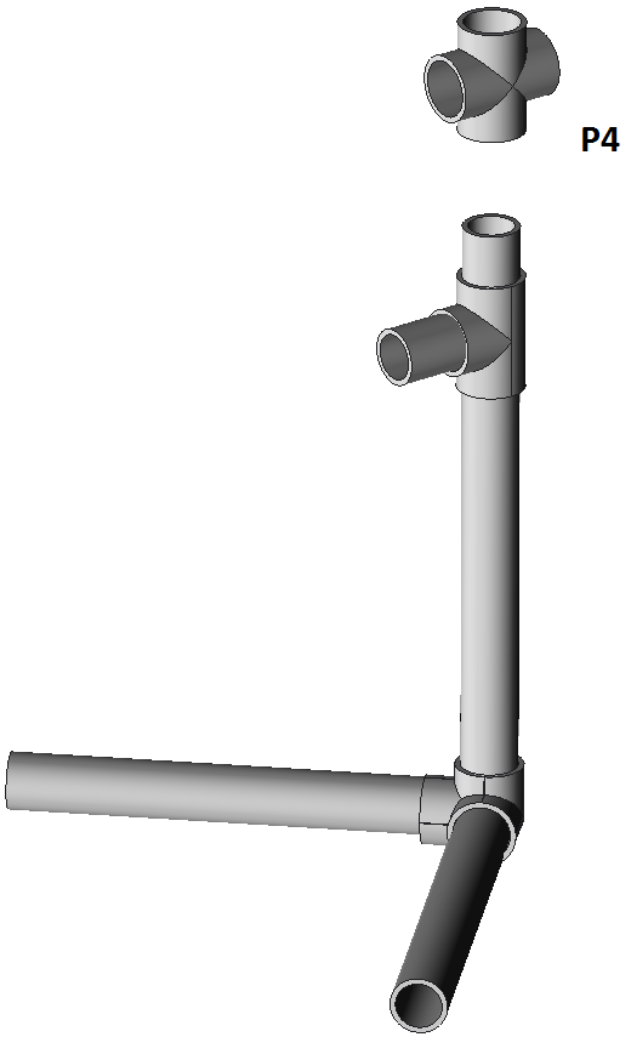


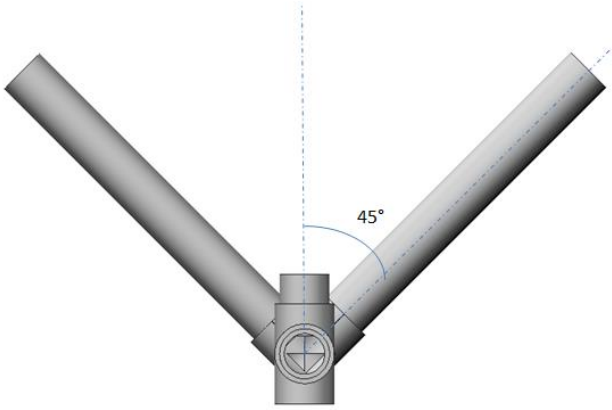
### 3.3.4 Flag Lower Assembly

**Step 1**

Assemble and cement the "cross" joint to the Flag base (see exploded figure below). Make sure the interior of the cross joint is clean and clear of PVC cement drips or globs. The interior needs to remain clean and smooth so that the Flag lift axle will be able to turn freely within the fitting.




**Important Note:** The cross joint shown in the figure to the left (part P4) should be aligned so that its horizontal axis makes a 45 degree angle to the legs of the structure when looking straight down from the top at the flag base (see figure below).



**Step 2**

**Important Note:** For this step do not use any PVC cement to connect the parts. The Flag lift shaft assembly will be connected to the Flag lift crank assembly through a friction fit only. PVC cement should ***not*** be used to join the two assemblies. The purpose of the friction fit is to act as an over-torque protection mechanism. In the event that a Robot inadvertently over-torques the lift crank when the Flag is its endmost position, the crank should break free from the friction connection and spin around the shaft without damaging the Flag or lift mechanism.

Slide the Flag lift shaft assembly through the cross fitting. Connect the lift crank to the lift shaft with friction only (no cement). Push or tap the ends of the two assemblies to mate them together. The fit should be secure, but the shaft should still spin freely in the cross fitting when the crank is turned. There should be enough play in fit to allow the shaft to turn without binding on the cross fitting.

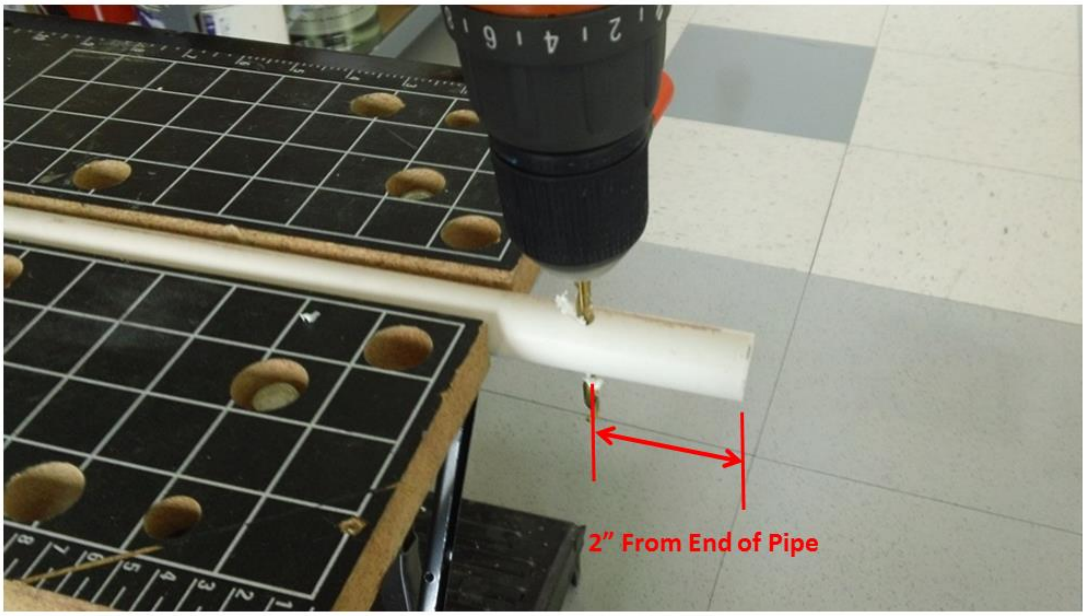
Slide lift shaft assembly through cross fitting and then slip the lift crank assembly onto the shaft assembly. **Do not use any cement for this step.**

With the two pieces connected (without any cement) the shaft should be able to spin freely in the cross fitting when the crank is turned.

### 3.3.5 Flag Assembly

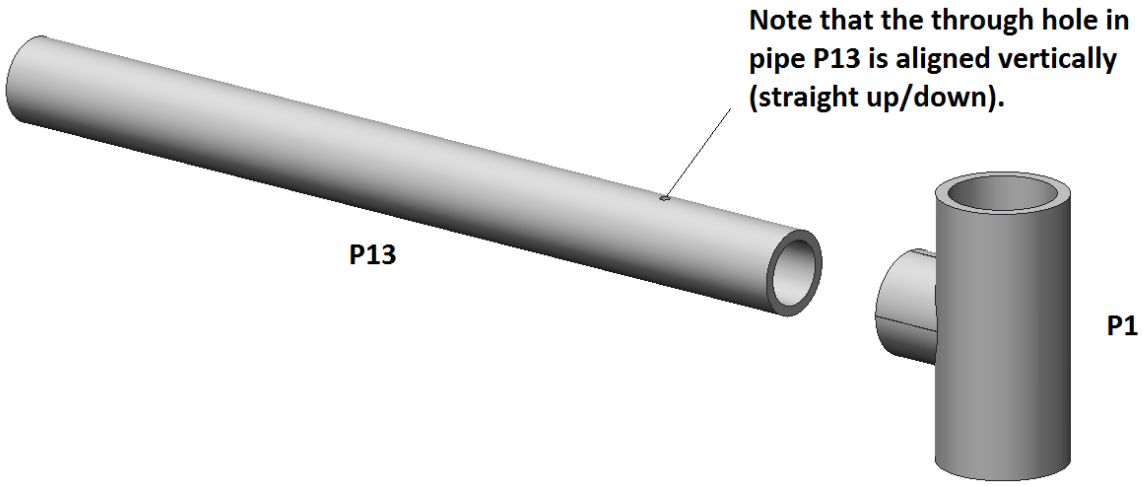
**Step 1**

Use the 13/64" bit (H13) to drill a hole along the center line of pipe (P13). The hole should be placed along the centerline, 2" (5.08cm) away from one end of the pipe. Also, the hole should be drilled through both sides of the pipe.



**Step 2**

Assemble and individually cement the pieces together in the manner shown in the exploded diagram below. Note that the through hole in pipe (P13) should be aligned vertically (pointing straight up/down).




**Step 3**

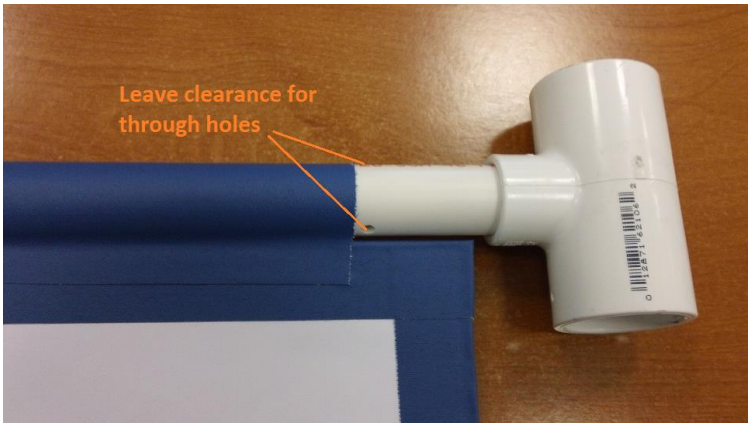
Print out the logo on page 52 onto 8.5” x 11” (21.59cm x 27.94cm) card stock. Print the logo on both sides of the stock so that the logo will be legible on both sides when held in a landscape orientation.

**Step 4**

Use 2” gaffer’s tape (red for the Red Alliance Flag, blue for the Blue Alliance Flag) to tape around the edges of the printed logo. Tape the edges on both sides of the paper to create a colored border for the Alliance Flag. Note that by making the border wide enough, the gaffer’s tape can be used to cover the additional text that appears at the bottom of page 53.


**Step 5**

Use 2” gaffer’s tape to secure the paper flag to the Flag arm (P13). Make sure to leave clearance by the through hole to allow a piece of twine to be threaded through the hole.



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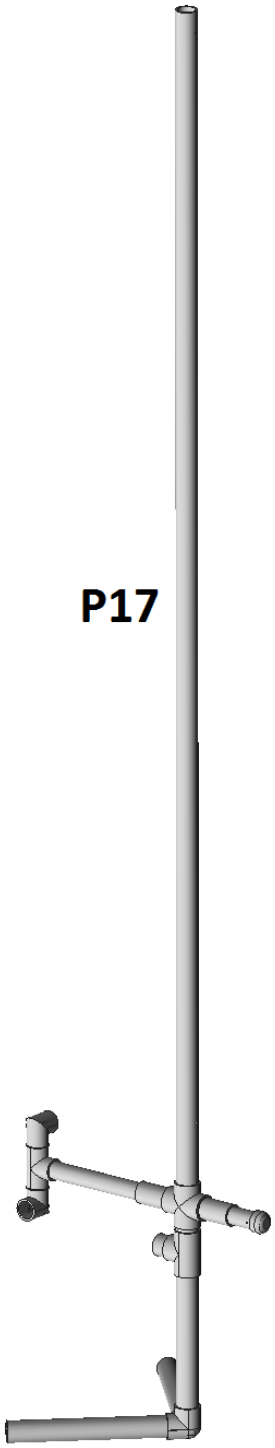
### 3.3.6 Flag Pole

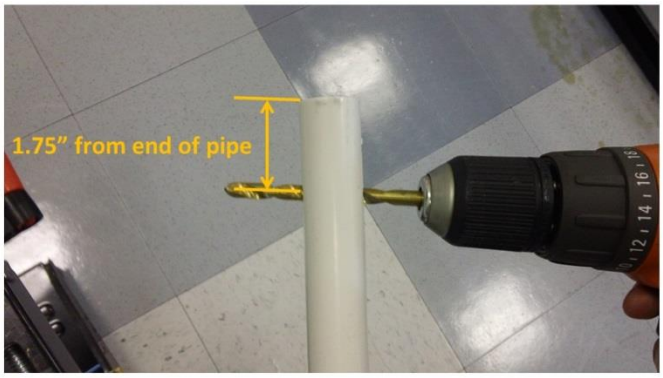
**Step 1**

Assemble and cement the Flag pole (P17) into the lower Flag assembly (see figure below).

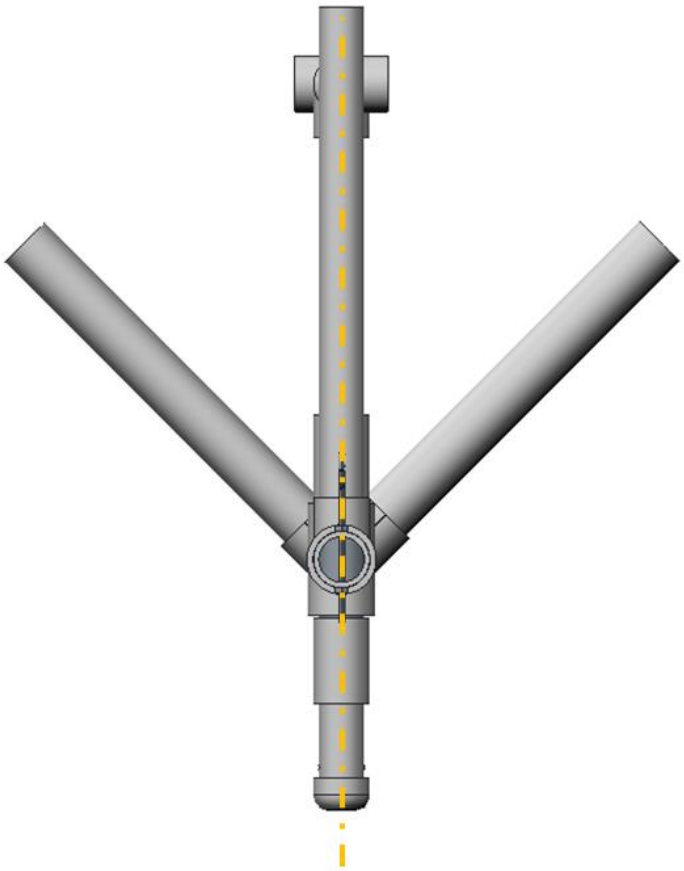


**Step 2**

Drill a clearance hole through the center line of the top end of the Flag pole using a 9/32” bit (H15). The hole should be drilled 1.75” from the end of the pipe.




The hole should be aligned so that when the eye bolt is installed in the through holes, the main axis of the bolt will point in the same direction as the shaft of the Flag lift crank (see figure below).

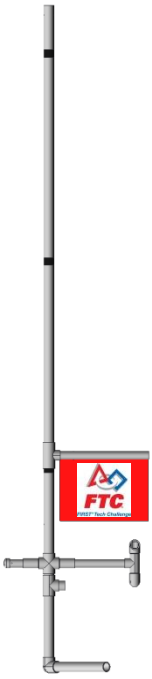


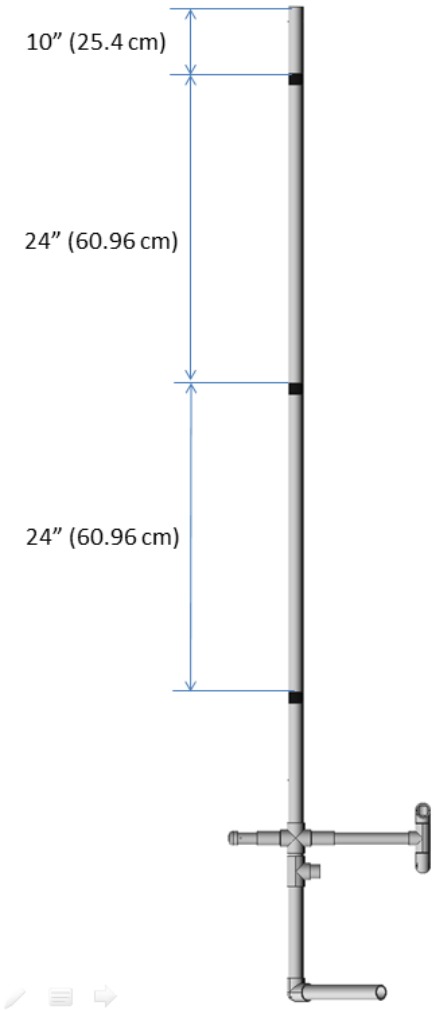
**Step 3**

Use a black permanent marker to make 1” tall rings around the Flag pole with the spacing as shown in the figure to the right.

**Step 4**

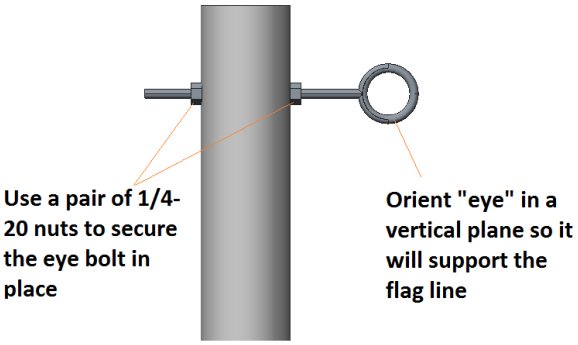
Slide the Flag over the pole.





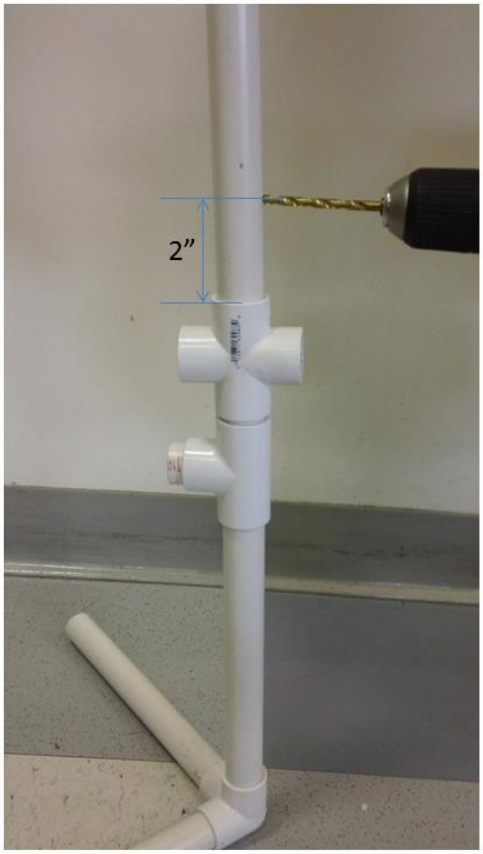

**Step 5**

Install a 4” eyebolt (H8) in the clearance hole. Use the 1/4-20 nuts (H9), one on each side of the pipe) to hold the bolt in position. The “eye” of the bolt should be on the same side as the Flag lift crank. Rotate the “eye” so that it is oriented in a vertical plane. The center of the “eye” should be about 1.5” (3.81cm) from the surface of the pipe.




**Step 6**

Using a 13/64” bit (H13), drill a hole on the backside of the Flag pole. Drill only through one side of the PVC pipe. This hole will be used as a pilot hole for an eyebolt that will be used as a line guide for the Flag lift (see figure below - note that the lift crank was removed in the image for clarity). The hole should be oriented so that when the eyebolt is screwed into the pipe, it will point in the same direction as the back side of the lift crank.




**Step 7**

With the 1/4-20 hex nut (H9) installed on the eyebolt, install the eyebolt (H8) into the pilot hole of the Flag pole. The eyebolt should grab onto the PVC material as you turn the bolt to seat it into the pipe. Use the 1/4-20 nut as a limit stop when installing the eyebolt. Orient the “eye” of the bolt so that it is in a horizontal plane (see diagram below). The center of the “eye” should be about 3” (7.62cm) from the surface of the vertical pipe.

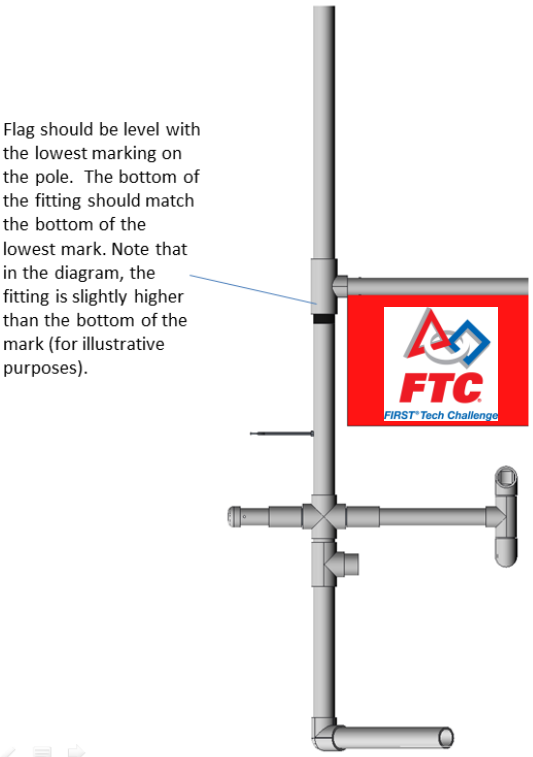
### 3.3.7 Threading the Flag Pole

Nylon twine (M19) will be used to lift the Flag pole when the crank is turned. The line will be threaded from the Flag assembly, up and over the top eyelet, and then down through the bottom eyelet to the Flag lift shaft. When a Robot turns the crank, the twine will wrap around the shaft and the Flag assembly will rise.

You will want to use a piece of twine that is long enough to allow the Flag to be lowered so that the Flag assembly rests at the level of the lowest band on the Flag pole. This is the starting position of the Flag at the beginning of each Match. A string of length approximately 11.25' (3.43m) should be about long enough to thread the Flag pole. You will have to trim the line to get the exact length needed.

Note that after you cut the nylon twine, you can melt the tips of the twine using a match or lighter to prevent it from becoming frayed. This will also make it easier to thread the line.

To melt the tip of the twine, hold the tip close to (but not touching) the flame from a match or lighter. Be careful not to burn yourself with the flame. Also note that the metal surfaces of the lighter will get hot with use. Let the synthetic material melt slightly. Extinguish flame and allow the material to cool.



**Step 1**

Thread one end of the line through the hole drilled on the Flag base. Secure the end of the line with a double knot.

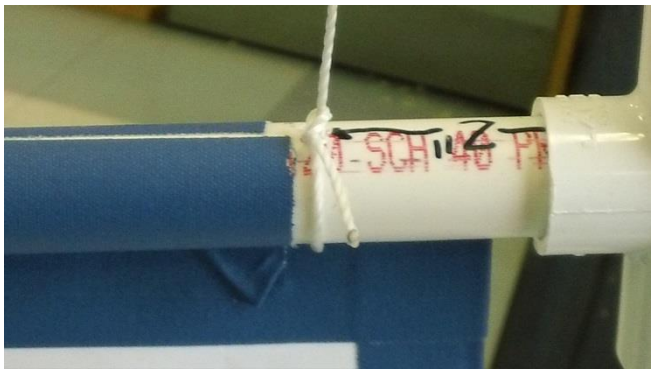
**Step 2**

Thread line through the top eye bolt and feed it down towards the line shaft

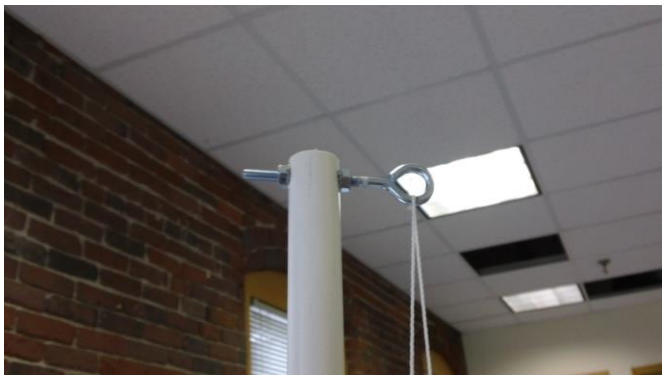
**Step 3**

Thread line through bottom eyelet and through the hole drilled in the lift shat. Tie off end of the line with a double knot so it will not slip off of the lift shaft.

Once the line has been properly threaded, a turn of the crank in either direction should cause the line to wrap around the shaft, raising the Flag.

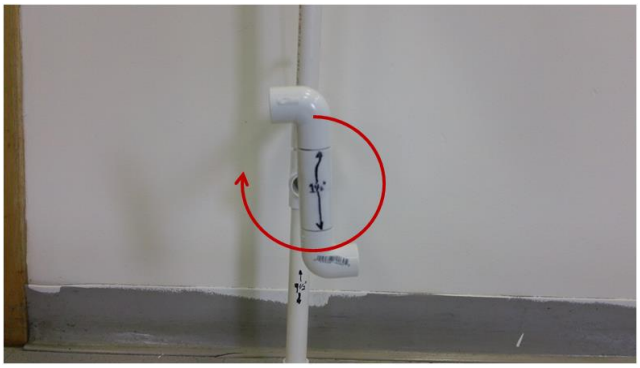


Thread one end of line through hole. Secure line with knot.



Thread line through the top eye bolt and feed it down towards the lift shaft.

Thread line through bottom eyelet and hole drilled in shaft. Secure with double knot.



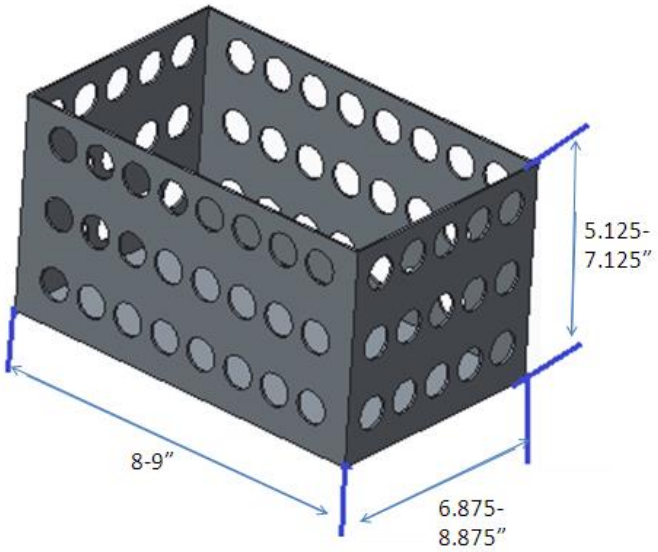
Once the Flag pole has been threaded, turning the crank should cause the line to wrap around the shaft and raise the Flag.

# 4 Critical Dimensions

Note that Field construction may vary from venue to venue. This section provides critical dimensions for the components of this year's Game. Note that the allowable variation in critical dimensions is +/- 1" (2.54 cm).

## 4.1 Box Dimensions

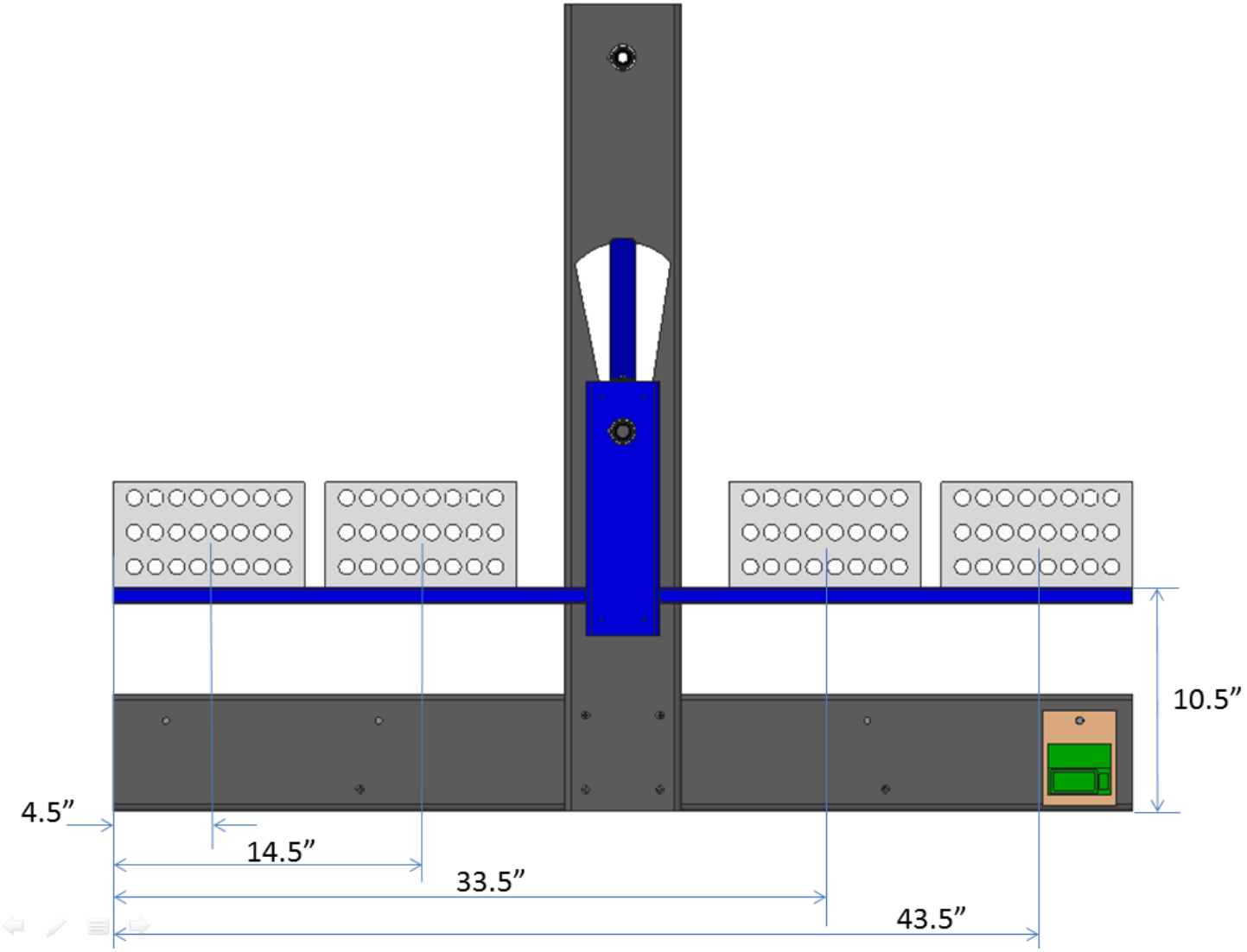
The box that is specified in the *Bill of Materials* (M7) has the dimensions of 9" x 7-7/8" x 6-1/8" (22.9cm x 20.0cm x 15.6cm). If this particular box (Sterilite Mini Crate) is unavailable, a substitute box should have a length of 9" (22.9cm) or smaller, with a recommended minimum length of 8" (20.32cm). The width of a substitute box should be within the range of 6.875" to 8.875" (17.46cm to 22.54cm). The height of a substitute box should be within the range of 5.125" to 7.125" (13.02cm to 18.1cm).



## 4.2 Balance Arm Dimensions

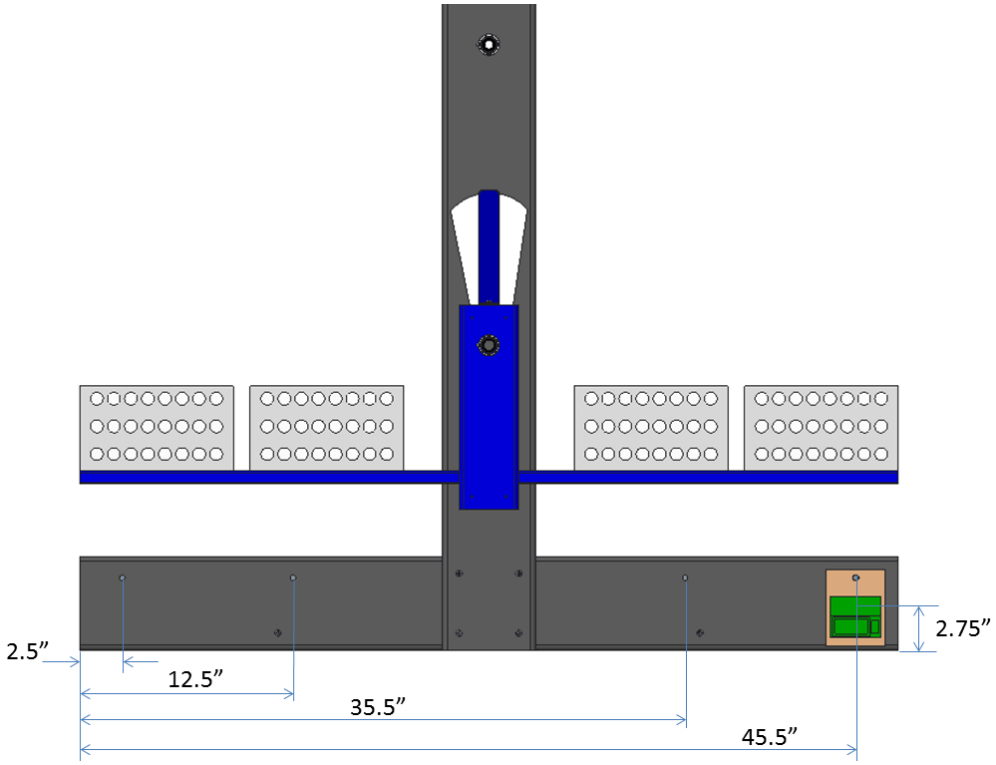
The critical dimensions for the balance arms are listed in the figure below.

Note that when verifying the critical dimensions of the unloaded balance arm, you should first use a spirit level to verify that the balance indicator (H12) is level (i.e., points straight up). Once you have verified that the indicator (H12) is level, you should measure the height of the ends of the balance arm board (W4) to verify that it is 10.5" (26.7cm) above the floor on each end of the balance arm (with an allowed variation of +/- 1" or 2.54cm).



## 4.3 IR Beacon Mount Dimensions

The IR beacons are hung from wood screws that are installed along the sidewall of the center ramp structure. The critical dimensions for a sidewall are depicted in the image below (IR LEDs should sit 2.75” above Soft Tile floor),



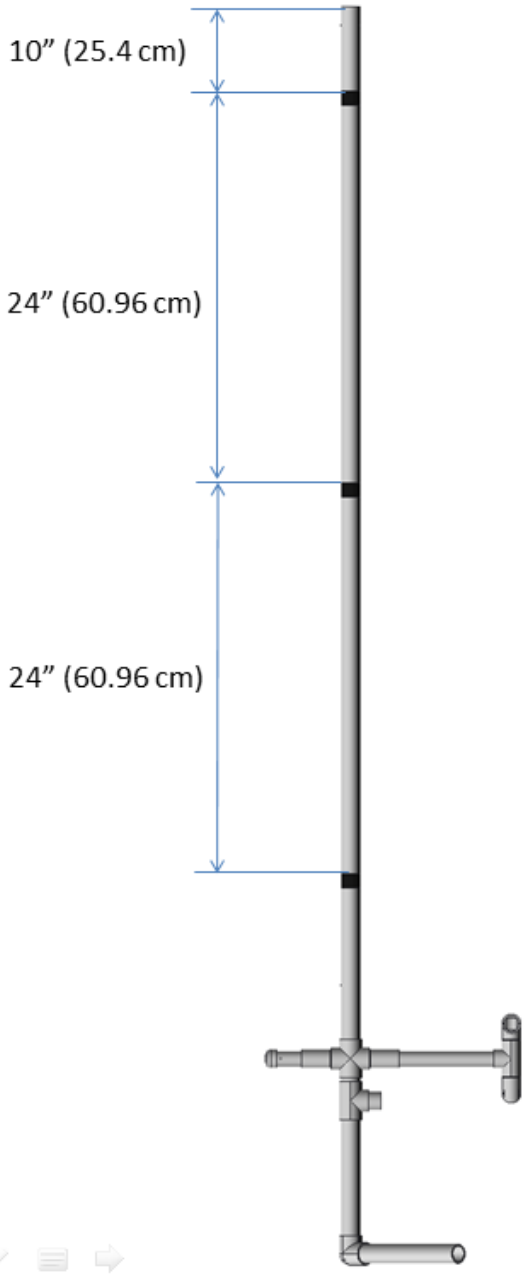

## 4.4 Pull-Up Bar Dimension

The height of the pull-up bar from the top of the ramp is shown in the following diagram. The critical dimension, as measured from the centerline of the pull-up bar, is 31.25” (79.38cm) above the peak of the ramp.

## 4.5 Flag Pole Dimensions

### 4.5.1 Critical Dimensions for Pole Markings

There are three 1” (2.54cm) wide bands around the Flag pole of each corner Flag assembly. The bottom-most band indicates the start position of the Flag. The middle band indicates the first level of bonus. The top band indicates the second (i.e., highest) level of bonus. The critical dimensions of the bands are listed below.

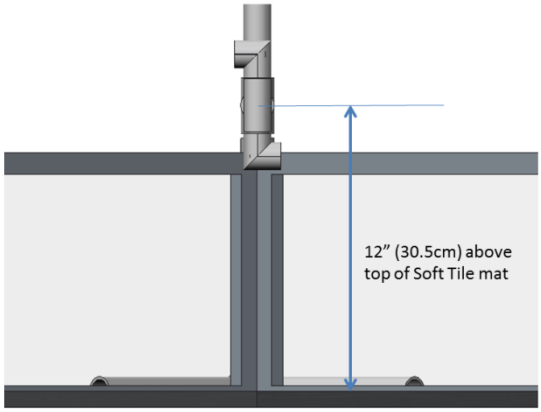


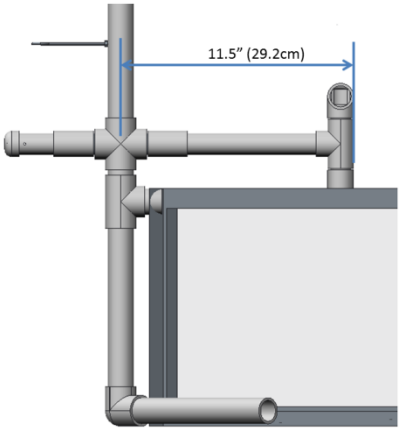
### 4.5.2 Critical Dimensions for Lift Crank

The center of the lift crank should sit 12” (30.5cm) above the top surface of the Soft Tiles (F2) of the perimeter interior. The face of the lift crank should extend about 11.5” (29.2cm) from the center of the Flag pole.

Note that the illustration below and to the right shows the lift crank parallel to the floor. When you build your actual Flag lift assembly, the crank will droop slightly (i.e., the shaft crank will point at a slight angle downwards from horizontal) due to the oversized fit of the cross joint. This is normal for the Flag lift assembly.

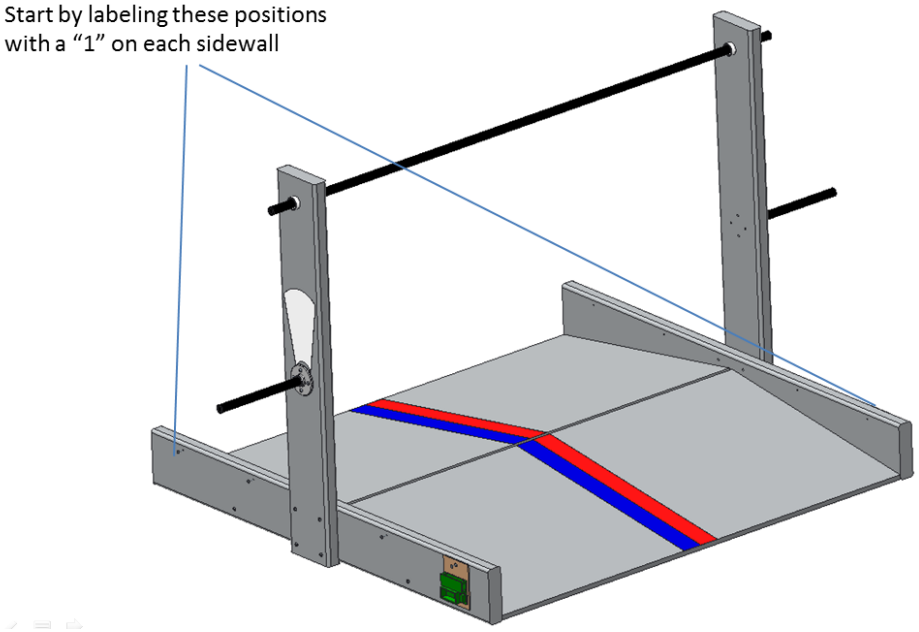
The critical dimension of the height of the lift crank above the Soft Tile floor includes this drooping effect (i.e., the crank rests closer to the floor due to the oversized cross joint).



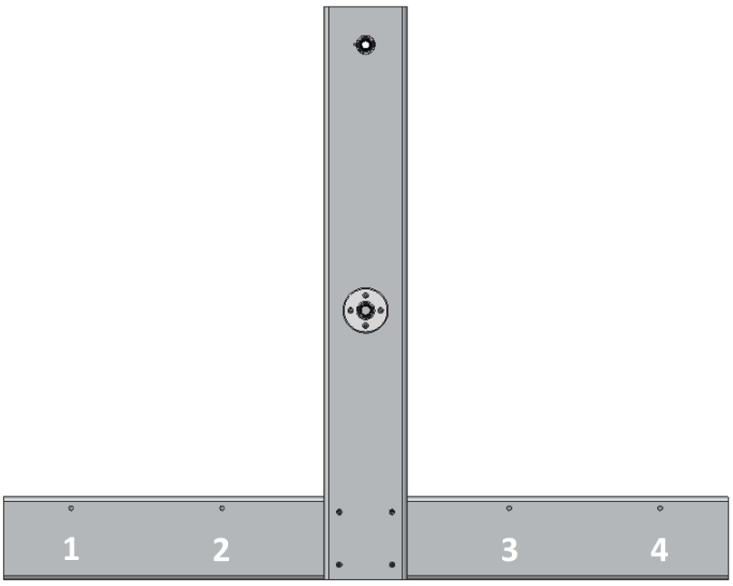
# 5 Labeling

The IR beacon mounting screws should be labeled using vinyl numerals (M16). The positions should be labeled “1”, “2”, “3” and “4” on the outer sidewalls. When facing the outer sidewall, the numbering should begin with “1” on the left hand side of each outer sidewall.



When facing the Blue Alliance side of the center ramp structure, the “1” position will be on the left hand side of the sidewall.

**Blue Alliance Sidewall**




When facing the Red Alliance side of the center ramp structure, the “1” position will also be on the left hand side of the sidewall.

**Red Alliance Sidewall**