



# World Robot Olympiad 2017

Advanced Robotics Category

Building Directions



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## Tetracubes

### Cut List and Materials

Description	Quantity	Size
Laminated plywood 24 mm	1	1220 mm x 1220 mm
Contact Cement or other glue suitable for wood	1	

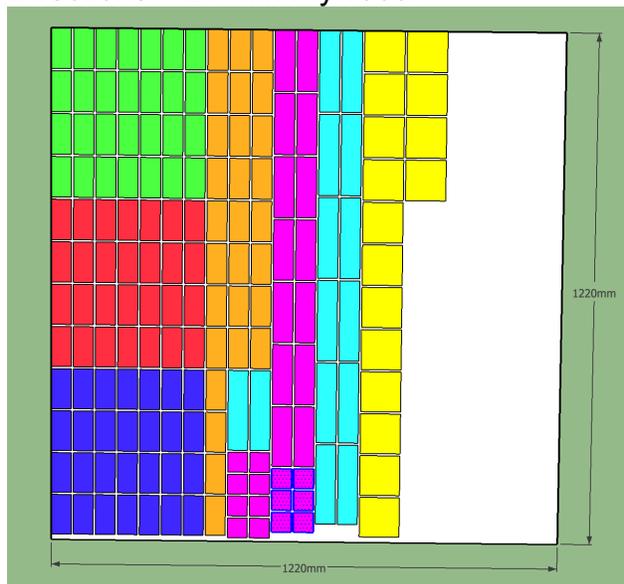
### Materials:

Tetracubes may be made of solid wood or wood products such as laminate plywood or fiberboard. This can primarily be based on availability, cost, and tools. Each piece is made of four cubes. The exterior dimensions of the cube are 48 mm ± 1 mm. The weight of one piece (four cubes) is between 200 and 230 grams. If you can source 24 mm plywood, one half of a sheet is enough material to make a complete set. Soft and/or lightweight wood is fine. The robots should not easily damage the tetracubes.

### Construction:

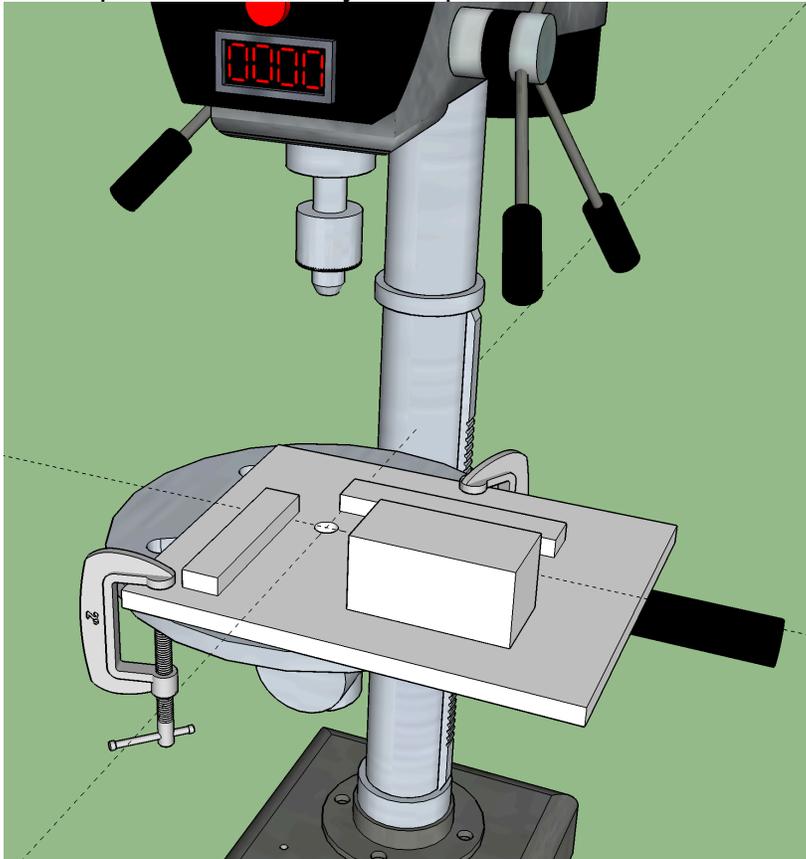
The seven tetracubes are actually just five distinct shapes with the S and J being flipped to become the Z and L. You may choose to create these shapes exactly to shape, but you may prefer to cut smaller rectangles as shown below and glue them together to make the shapes.

Directions – 24 mm Plywood:



The colors indicate the cube they will be used to construct. They will not be painted until after assembly.

1. Cut 14 plywood strips 48 mm wide and 1220 mm long.
2. Cut 2 plywood strip 96 mm wide and 1220 long.
3. Cut the strips into the appropriate rectangles as shown above.
4. Apply contact cement or other glue according to directions and combine rectangles so that they are 48 mm thick. Clamp if necessary and allow to dry enough that you can continue.
5. If necessary, remove excess glue, and edges, etc.
6. Drill 15 mm holes in the center of the primary cube face. A jig, as shown below will help with consistency and speed.



7. The guide fences can be set 24 mm away from the center of the drill bit. Press the corner of the block into the jig corner, drill, rotate, drill. The light blue and purple blocks will need the jig adjusted to drill holes in the interior cube (back fence is 24 mm away, side fence is 72 mm).
8. Combine rectangles to build the L, J, S, Z, and T shapes. Glue, clamp, and allow to dry.
9. Refer to rules document for paint colors.

**Tip:**

You may want to consider swapping steps 3 and 4 – gluing the long strips together before cutting the rectangles.

**Alternatives:**

Alternative tetracubes were prototyped using an automated router. This is a reasonable approach if you have access to one. The CAD/CAM file that controlled the router specified that the holes were machined while the pieces were cut out. The internal corners need to be notched so that they will stack with the exterior corners of other tetracubes.

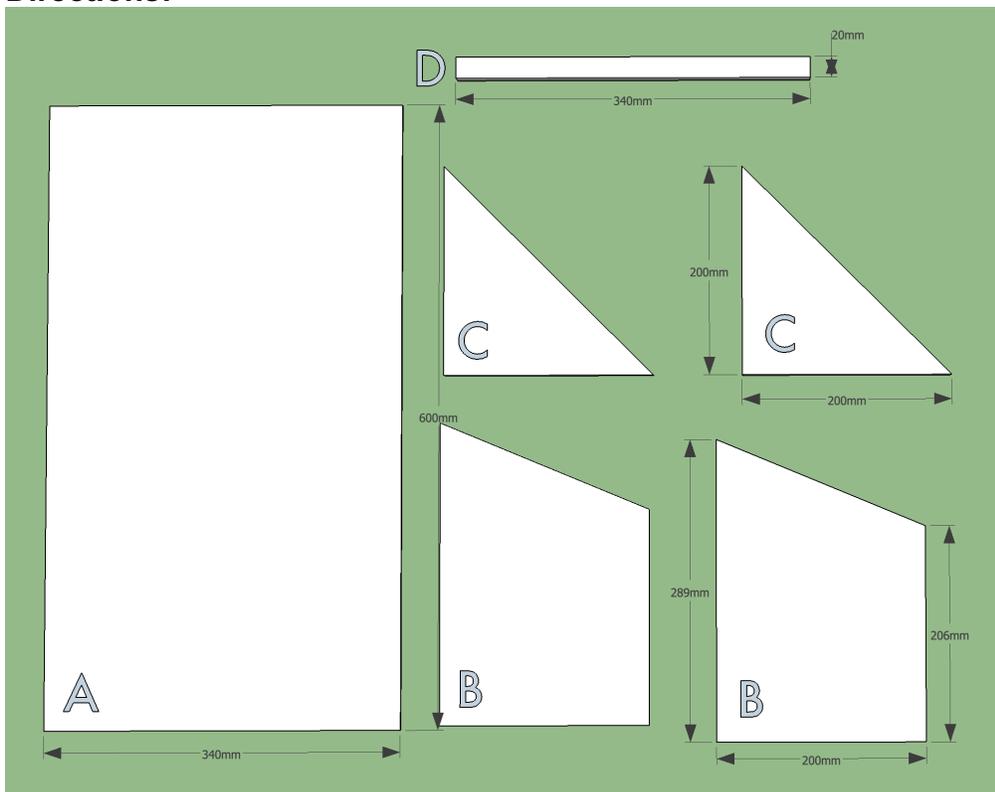
Alternative tetracubes were prototyped using a laser cutter and 3 mm HDF (high density fiberboard). This is a reasonable approach if you have access to one. The holes were cut at the same time and sizes were very accurate. There are many layers to glue together, and you may find it useful to insert waxed dowels to keep the pieces aligned while all of the pieces are glued.

# Ramp

## Cut List and Materials

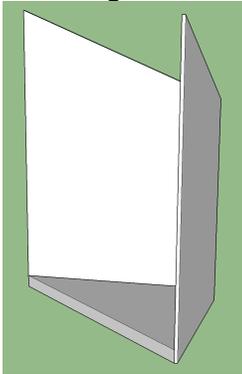
Description	Quantity	Size
<b>A</b> Dry-erase whiteboard sheet – 3 mm thick	1	340 mm x 600 mm
<b>B</b> Laminated plywood – 3 mm thick. (may use remaining whiteboard material) 112.5 degree angle	2	200 mm x 289 mm
<b>C</b> Laminated plywood – 12 mm (for top and bottom support) 45 degree angle	2	197 mm x 197 mm triangle
<b>D</b> Laminated plywood – 12 mm (for attaching top sheet)	1	340 mm x 20 mm
Wood Screws	14	#8 x 18 mm
Black Dry Erase marker	1	

## Directions:

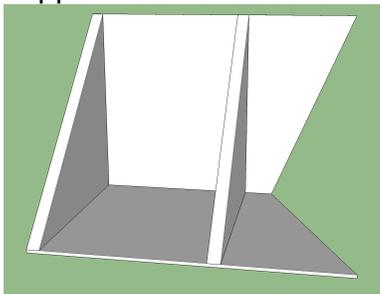


1. Cut dry-erase sheet to size. **A**
2. Cut plywood side supports to size. Place a mark at 206 mm, connect to nearest corner and cut to remove the small triangle. **B**
3. Cut 12 mm plywood square, mark diagonal, and cut into two triangles. **C**
4. Cut 12 mm plywood strip 340 mm x 20 mm. **D**

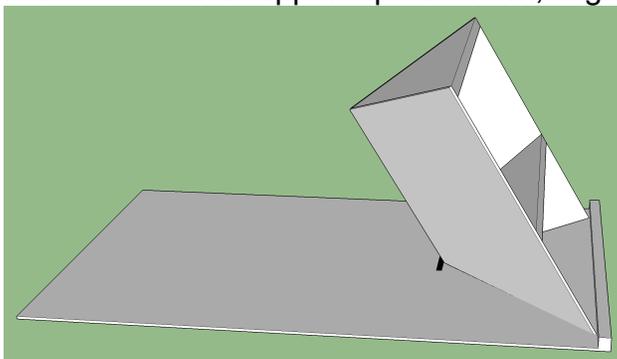
5. Arrange one plywood triangle and place side supports vertically (match short sides). It may be useful to tape or clamp the pieces together while drilling and fastening.



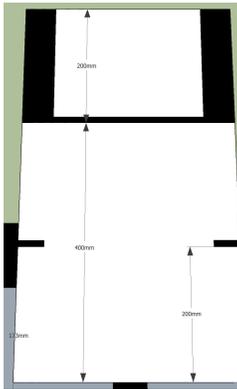
6. Drill pilot holes for screws and fasten each side with 3 wood screws.
7. Lay on side. Use a square to create a perpendicular line ~150 mm from bottom support. Center second triangular support on the line.



8. Drill holes and fasten with 3 wood screws per side.
9. Place support upright on floor and position dry-erase sheet so that edge is 200 mm from floor. Mark sheet at each corner of triangular support.
10. Place sheet and support upside down, aligning corners with marks.



11. Place the 20 mm x 340 mm strip against the support triangles. You may wish to trim the strip if the overhang is too great. Clamp the strip to the top sheet, turn over and drill pilot holes through the top into the strip. Be sure to place holes within 50mm of the front edge.
12. To assemble the ramp, place the support sitting vertically on the floor. Place a weight on the lower brace. Place the top and slide it so the strip rests on the support corners.



13. Use the dry-erase marker to mark the upper third of the ramp as the Release Area and mark where the ramp should overlap with the field border. (You wish to use black tape to more permanently mark the edges. Do not use tape for the thin horizontal lines as this may interfere with the movement of tetracubes.)

**Tips:**

When cutting the dry-erase material, it may be useful to place painter’s tape over the line and the saw will cut both material and tape. Then remove tape fragments. Some saws will leave a smoother edge on the bottom of the material than the top.

## Border and Scoring Frame

### Cut List and Materials – Border

Description	Quantity	Size
Framing lumber (40 mm – 50 mm) x (70 mm – 100 mm)	4	2360 mm (actually 2300 + width of lumber)
Framing or Decking Screws	14	#9 x 80 mm

### Cut List and Materials – Scoring Frame

Description	Quantity	Size
<b>A</b> Framing lumber –50 mm	2	833 mm x 60 mm
<b>A</b> Framing lumber –50 mm	1	400 mm x 60 mm
<b>A</b> Framing lumber – 88 mm	1	400 mm x 60 mm
<b>A</b> Framing lumber – 12 mm	1	954 mm x 75 mm
<b>B</b> Laminated plywood – 3 mm	1	480 mm x 825 mm
<b>B</b> Laminated plywood – 12 mm	1	540 mm x 500 mm
Framing or Decking Screws	13	#9 x 80 mm
Wood Screws	14	#8 x 18 mm

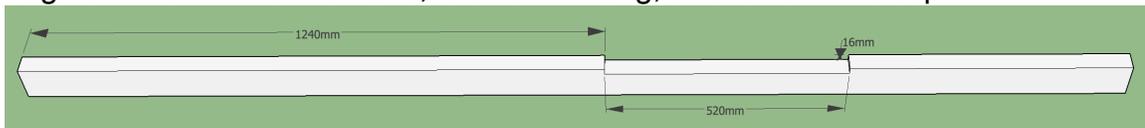
### Tip:

You may want to paint all pieces and allow it to dry before assembly. All pieces are black except for the 3 mm plywood, which is white.

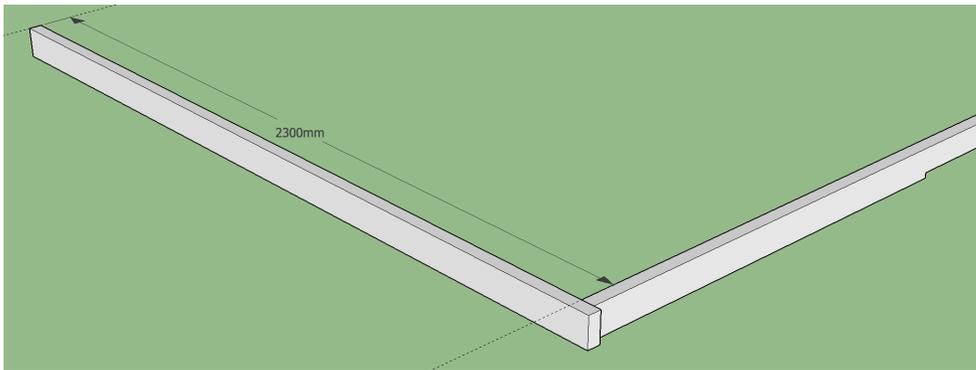
### Directions – Border:



- Cut framing lumber to length.
- The border piece the contains the Scoring frame needs a notch removed. It begins 1240 mm from on end, is 520 mm long, and is 16 mm deep.

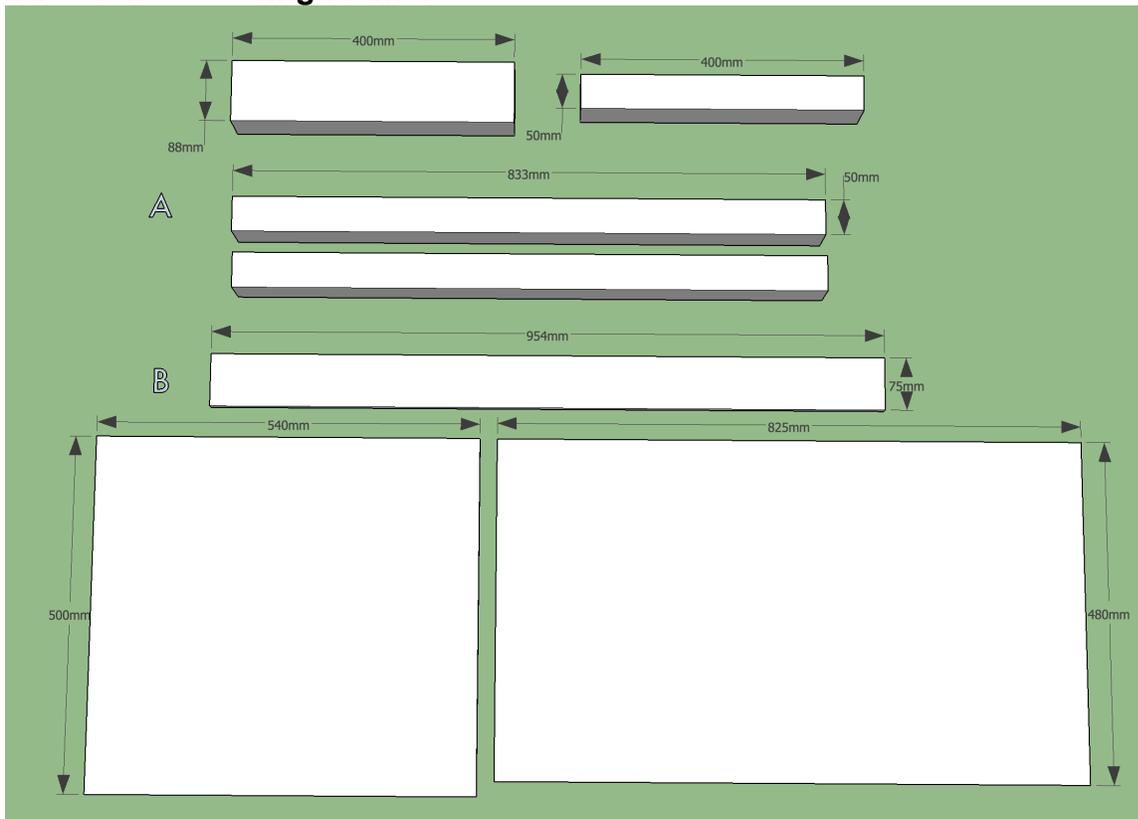


- Flip the notched border piece so that the notch faces the floor. Place another border piece against the long portion of the notch piece to create a flush corner. (Be sure to notice that the notch is ~1240 mm from the inner joint and the edge of the other border frame is 2300 mm from the inner joint.)



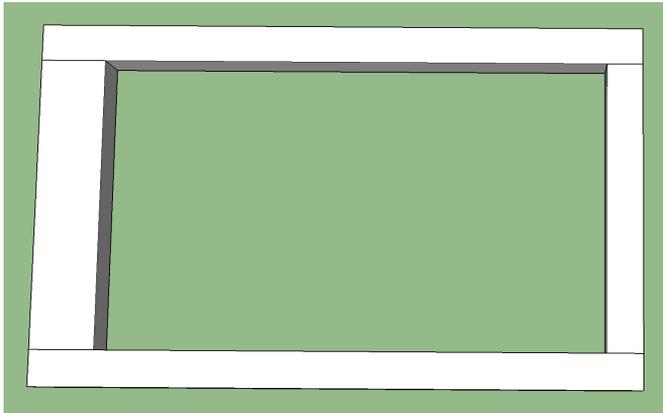
17. Drill pilot holes and attach the border pieces with 2 screws.
18. Continue overlapping the border frames in a clockwise direction, measuring 2300 mm from the inner edge to the end of the border piece, drilling pilot holes and attaching with 2 screws.
19. Once all four border frames are connected, measure both diagonals. It may be necessary to use clamps or weights to improve the square
20. If easy disassembly and storage is important, you may want to consider hanger bolts and wing nuts to attach the corners.

**Directions – Scoring Frame:**



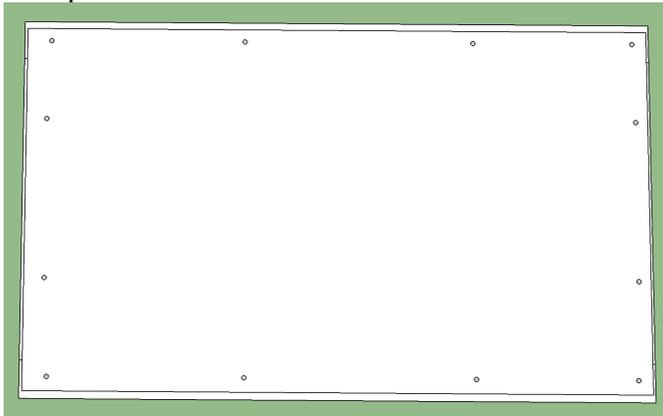
10. Cut the edge pieces for the frame to size. You may need to glue together several pieces for thickness. **A**
11. Cut the laminate pieces to size. **B**

12. Place all **A** pieces as shown below. Drill pilot holes and attach with the long screws.

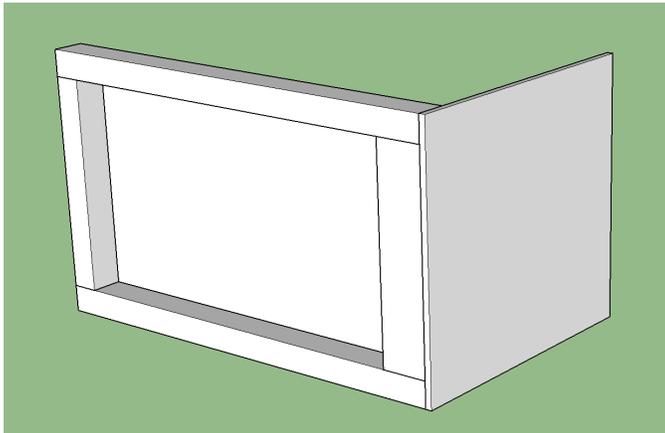


If you have access to a table saw, set the blade to a 5 degree tilt and trim the thick edge.

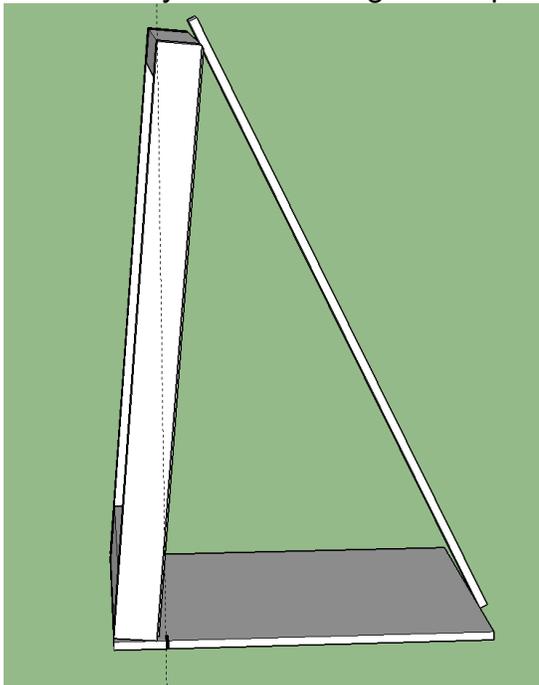
13. Place the 3 mm plywood backing over back of the frame. If needed, clamp the long diagonal to push it into a rectangle. If you have cut the 5 degree angle, make sure to verify that the plywood is attached to the back (smaller) face of the frame.
14. Drill pilot holes and use the shorter screws to attach backing to the frame.



15. Rotate the frame and place upright on a long side. Place the 12 mm plywood at the thick end of the frame. Drill pilot holes and use 3 long screws to attach. If you did not trim the frame, leave the screws about 5 mm loose to help set the angle in the next step.



16. Place the frame upright. Use the remaining long board to brace the frame and set the angle. You may want to hold it in place and estimate angled lines to help join the brace to the frame. Drill pilot holes and attach with short screws on bottom and long screws on top.
17. The official frame will have a 5 degree tilt to help pieces stay in the frame. This results in a 74mm setback. Measure from the front edge and place a mark at 74 mm. The dotted line shows a vertical line square to the base. If you have a plumb bob, that is one way to make this measurement. Placing the form in a doorway is another way to make a align the top corner and the mark.



18. You may wish to insert shims (thin wooden wedges) into the gap and tighten the screws holding the base plywood to the frame.