The Complete Homemade Juggling Beanbag Guide

26-Panel Rhombicuboctahedron Chapter

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This is part of a multi-document guide. Hyperlinks with the icon[1] open other guide documents[2], if they are saved to the same folder (**CTRL+Click** opens them in a new tab).

Visit my website to download those, and check back occasionally for revisions and corrections:

www.joshuaclifton.com/juggle

Compare the Last Edited date above on the right with the one on the web page to see if I have submitted changes.

Please contact me with your thoughts! Feedback on this project would be helpful and encouraging. You may also request custom patterns or other help with your project.

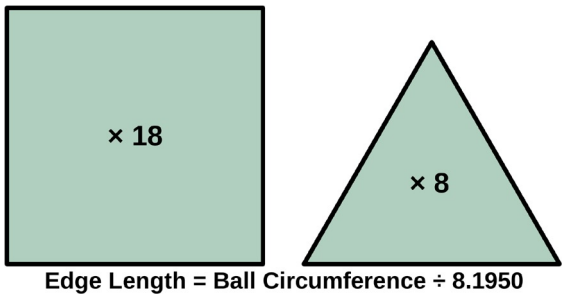
If this guide is useful to you, please **consider donating at my website** linked on the left. I am not monetizing the guide, and I am in need of income.

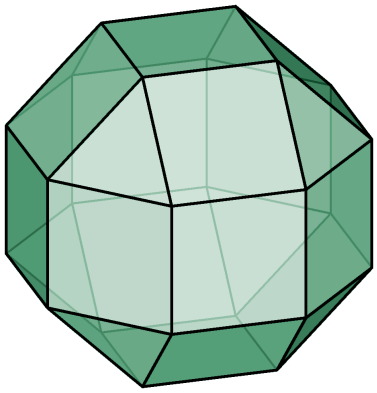
My website also provides blank **color arrangement diagrams** for experimenting with new arrangements in an image editor.

1 Icon from https://freesvg.org/vector-illustration-of-external-link-icon

2 **If the linked PDF does not open at the specified location**, keep it open, switch to the previous PDF's tab, and click the link again. **Cross-document links may not work in mobile PDF readers.** In that case you must open the document yourself and find the linked topic.

26-PANEL RHOMBICUBOCTAHEDRON INSTRUCTIONS





The second image is my Photoshop-altered version showing the colors I wish I could have used. The right two photos are of my second beanbag, for which I used my 3-color "Orthogonal Stripes/Baseball Curve" arrangement.

Chapter Index

Design Notes

This design allows for **very striking checkered color arrangements**, as well as many other, unique and beautiful arrangements. It supports **more versatility in color arrangements** than the previous designs (if you don't count the fact that the 24-panel design supports all arrangements of the 4-panel Orange Peel Ball, Cube, and Octahedron). My collection of arrangements for this design is much larger than for any of those. This is a fairly **complicated panel structure to assemble** compared to the 24 and 30-panel designs, though.

I developed this design in May, 2021, five months after publishing this guide, and it is my first new design in over seven years. The rhombicuboctahedron is the dual polyhedron of the 24-face deltoidal icositetrahedron (instructions and patterns for that design are in my 24-panel chapter). It is **composed of 18 squares and 8 equilateral triangles**.

Supplies

- **For the templates**
  - Cardboard or Template Plastic, X-Acto Knife or Scissors, Glue Stick or Adhesive Tape (to attach the pattern to the template material). **For drawing the pattern by hand:** Paper, Compass, metric Ruler, fine-point Pencil.
- **For the beanbag**
  - Fabric, Needle and durable Thread, Scissors, Fabric Marker or soft Pencil, beanbag Filler, Funnel.
- **For your information**
  - Unless you are experienced with this sort of thing, I recommend that you browse through the **General Information and Techniques** chapter (in the ***01 – Homemade Juggling Beanbag Guide – Index & Supplementary Chapters*** document) before starting. You may find some tips there that will improve your experience and your beanbags.

Printing and Drawing the Patterns

Later in this chapter I provide ready-to-print patterns. (When printing them, be sure to tell the Print Dialog to print only the page(s) you want so you don't print the entire document.) After those are sizing formulas and instructions for drawing the patterns yourself, including pre-calculated pattern measurements. Click the hyperlinks or look to the Chapter Index to locate those sections.

Color Arrangements

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Following is a collection of color arrangement ideas, grouped by the number of colors they contain. The assembly layout diagrams show both my dual-hemisphere assembly method and a square-centric ring by ring method in case you prefer that. I took arrangements 4, 5, 10, 12a, 13, 16, and 26 from the 26-panel footbags at HaneDaneFootbags.com (edit: that site no longer exists, but many of Petersen's footbags are displayed on his Facebook page). The rest are my own, or are variations of those.

To help me figure out the arrangements and create the diagrams, I stuck colored thumbtacks into an all-white 26-panel bag I made using my design-testing fabric. I recommend this as a way to design new arrangements or to use as a reference to aid you in correctly assembling your color arrangements.

I also provide printable blank color arrangement diagrams for the ball views and the assembly layouts after the printable patterns. You can use those to experiment with color arrangements without having to make a beanbag. Look to the Chapter Index to locate them.

2 colors

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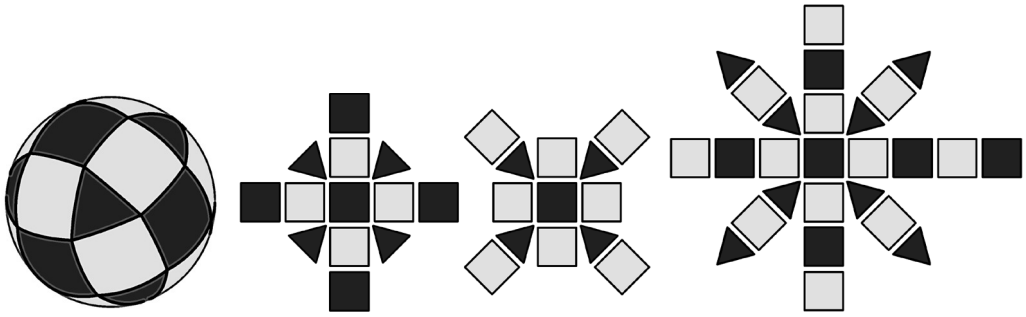
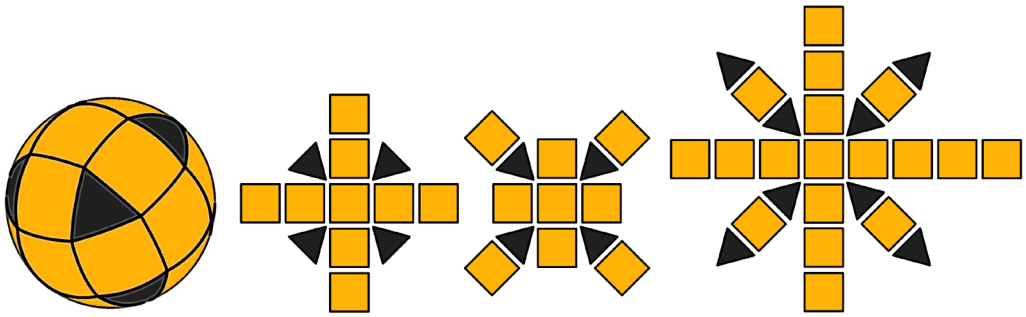
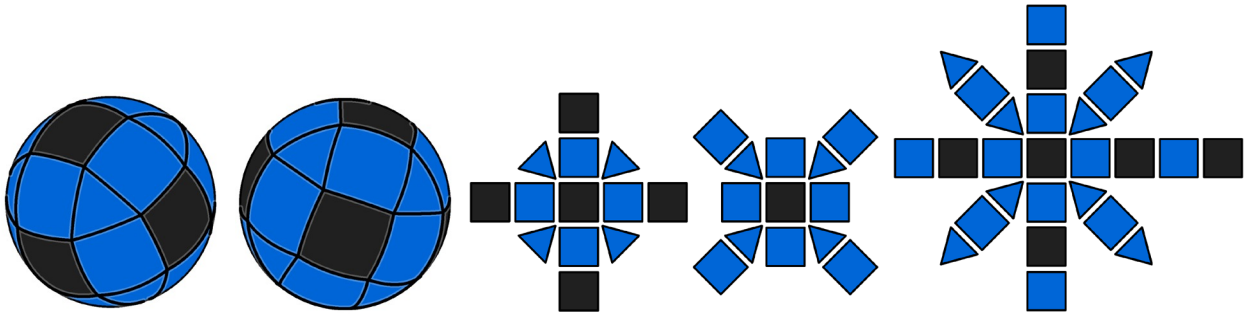


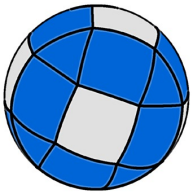
#1: Checker Ball. Two contrasting colors form a checker pattern. All triangles are the same color, and the 6 squares at their corners (those corresponding to the faces of a cube) are the same color as the triangles. The remaining 12 squares (at the triangles' edges) are a contrasting color.

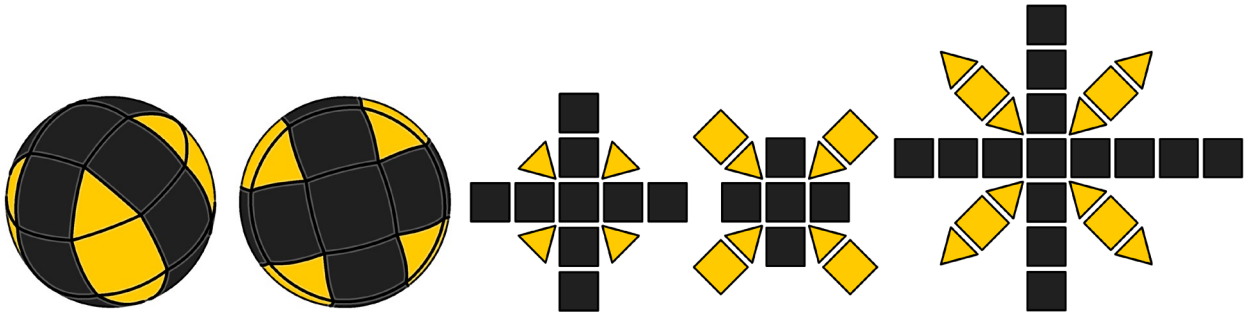


#2: Orthogonal Rings/Cube Corners. Color A on all 18 squares and color B on the 8 triangles.

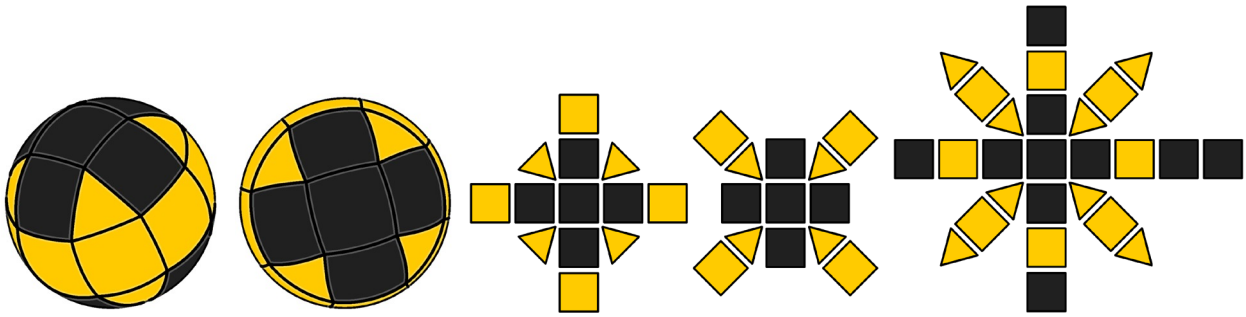


#3: Cube Faces. Color A on the 6 squares corresponding to the faces of a cube (at the corners of the triangles). Color B on the remaining 12 squares and 8 triangles. The ball illustration on the right shows the opposite contrast, which emphasizes the cube edge framework around the 6 squares.

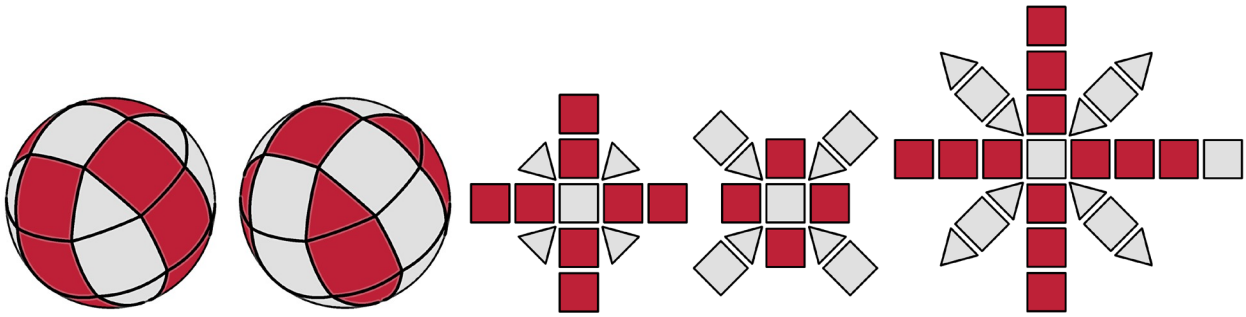




#4: Spikes. Color A on four parallel spikes, each consisting of a pair of triangles and the square between them. Color B on the remaining 14 squares.

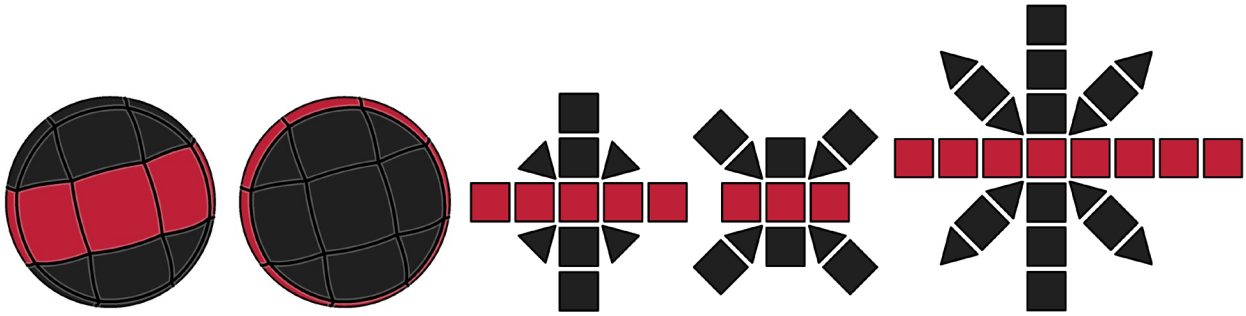


#5: Fence. Same as the above arrangement but the spike color is also assigned to the squares between the middles of the spikes. This forms a continuous ring around the ball with four posts around it, or, if you prefer, two opposing cross-shaped patches. There are 8 squares and 8 triangles of the fence color, and 10 squares of the other color.

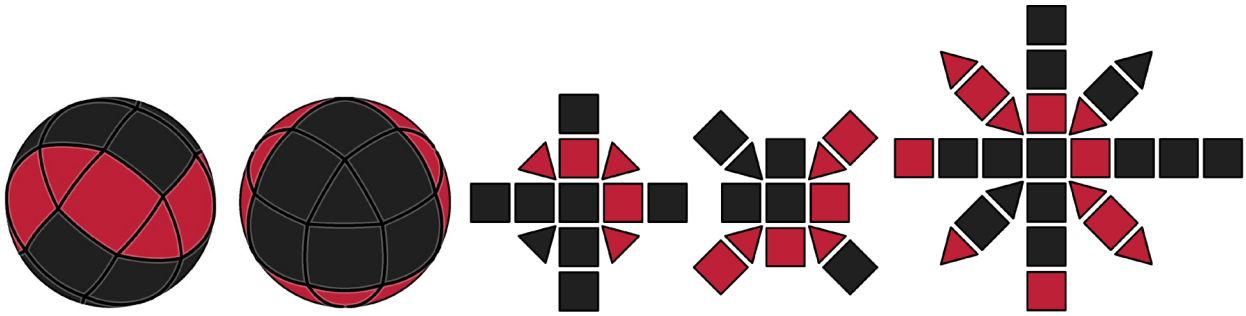


#6: Two-Color Stripey Ball. Same as the Spikes arrangement, but the square at each pole is the same color as the spikes, emphasizing the three-square stripes between the spikes. There are 12

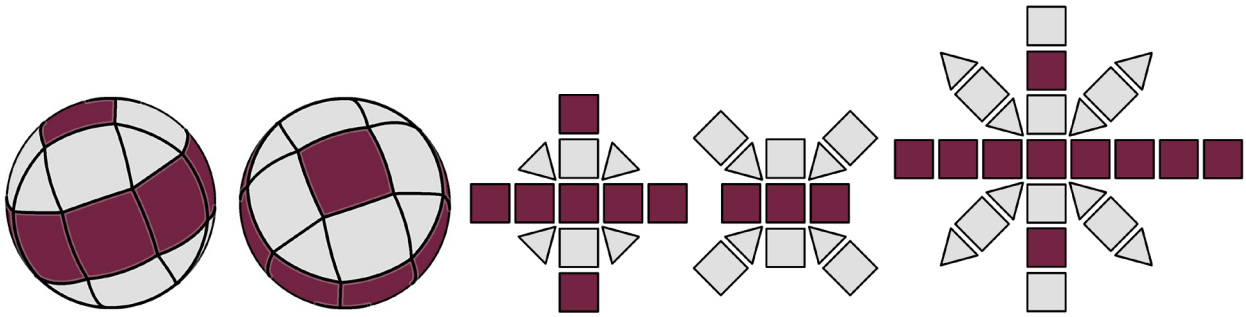
squares of the stripe color and 6 squares and 8 triangles of the background color. The second ball illustration shows how the colors look when swapped. The assembly diagrams are for the first.



#7: Belt. A simple ring of 8 squares around the ball. A second color is on the remaining 8 triangles and 10 squares.

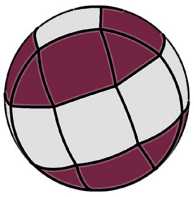


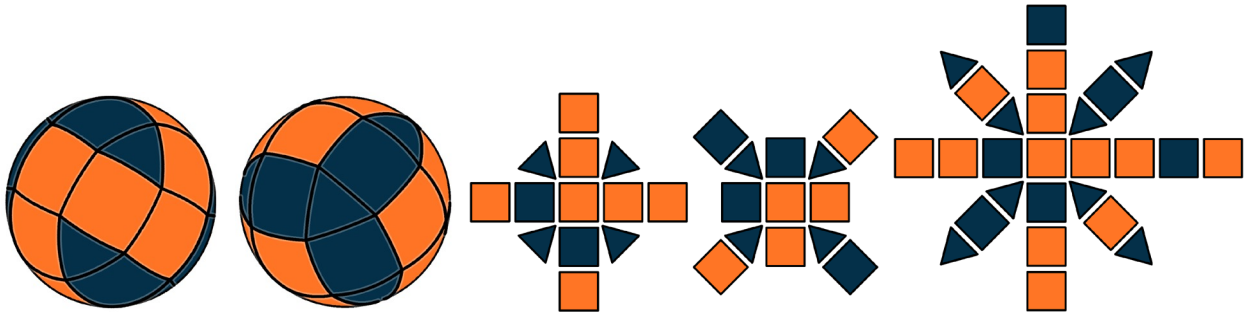
#8: Undulating Belt. Color A on a wave pattern around the ball consisting 6 squares alternating with 6 triangles. Color B is on two triangular patches consisting of a triangle surrounded by 6 squares.



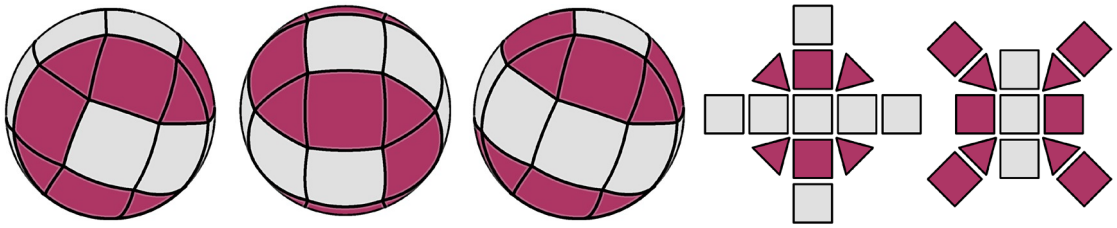
#9: Alternating Rings. Related to the belt arrangement but the belt color is also assigned to the two squares at the poles. The second color now forms rings of alternating squares and triangles around each pole.

If you are using a dark/vivid color and a light/neutral color as my illustrations show, you can emphasize either the equator and poles, or the two rings between them. The illustration on the right shows what my colors look like when swapped.

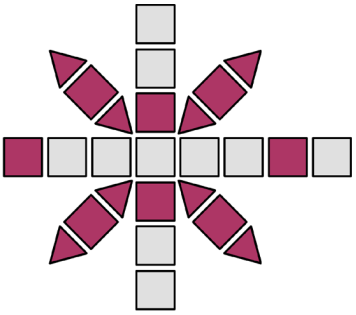


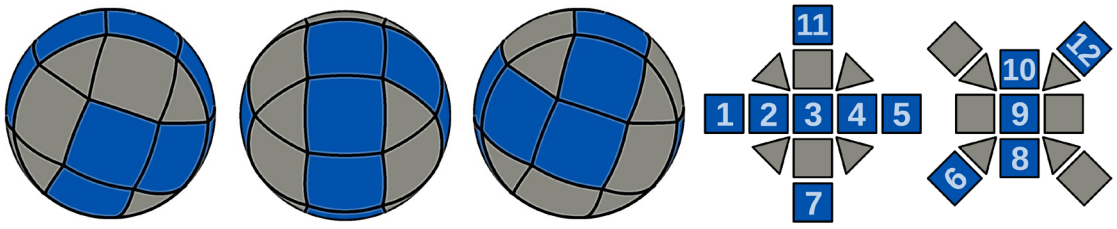


#10: Zig-Zag/Opposing Trefoils. Color A on a zig-zagging line of 12 squares, color B on an opposing pair of three-pointed patches consisting of a triangle with a square and a triangle on each of its edges.

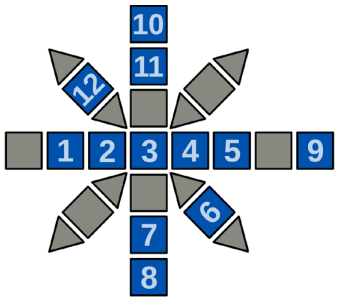


#11: Orthogonal Stripes/Baseball Curve. This is an arrangement I invented based on the next two. One color is on two 5-square stripes that are opposite and perpendicular to each other, and the other color is on a circuit around the ball shaped like the seam of a baseball (or a serpentine curve, if you follow it linearly). That path consists of 8 squares alternating with 8 triangles.

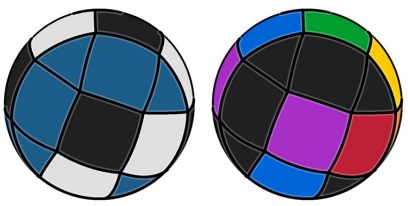




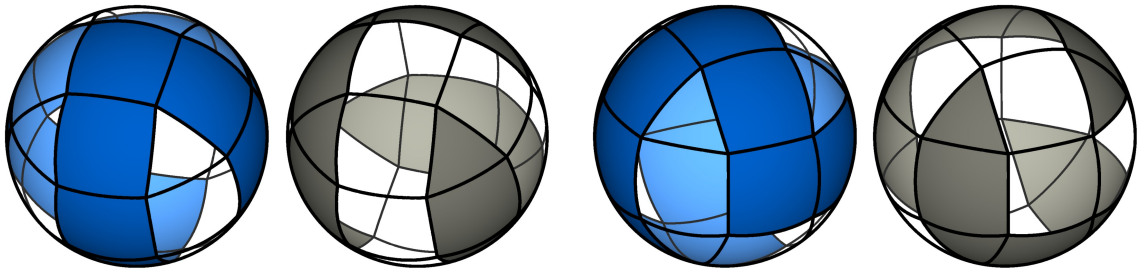
#12a: Meandering Circuit. One color (blue in my example) follows a wandering circuit around the ball composed of 12 squares. The other color (gray) fills the two remaining S-shaped spaces, each consisting of 3 squares alternating with 4 triangles, with triangles at both ends. Below are transparent views I made to help illustrate the turnings of the paths. (This version was from HaneDaneFootbags.com. The next arrangement is a variation of this that I accidentally created when trying to figure this one out from a photo.)



Because the meandering circuit (the blue path) has 12 squares, it can have a repeating sequence of 2, 3, 4, or 6 colors. The numbers on the diagrams will help you sequence the colors. On the right are examples.

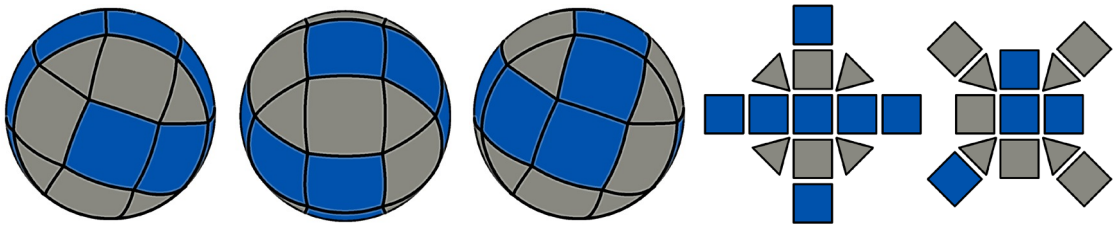


Note that this is a chiral arrangement (its mirror image is not the same). Laying the panels out as shown above with the fronts facing up will yield the arrangement shown in the illustrations while laying them out with the backs facing up will flip the arrangement to its mirror image.

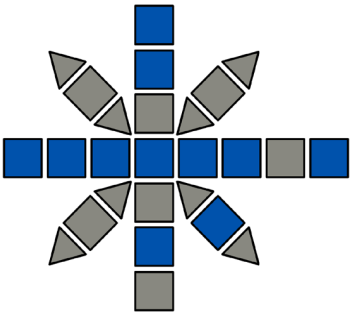


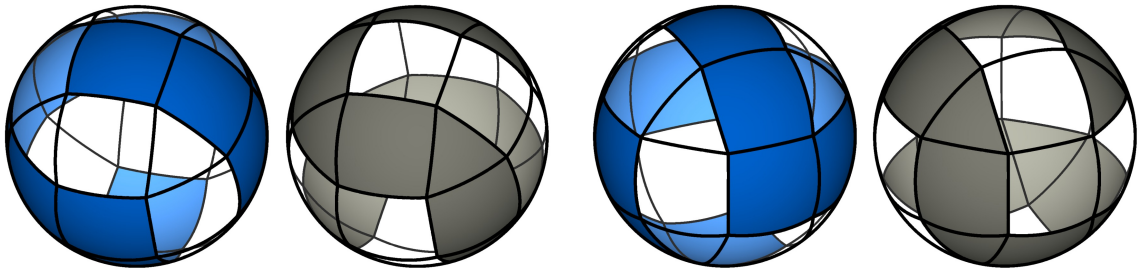
View 1: Blue circuit | View 1: Gray paths | View 2: Blue circuit | View 2: Gray paths

Meandering Circuit transparent views



#12b: Perplexing Paths. Two colors follow twisting paths that intertwine with each other intriguingly from one side of the ball to the other. In this variation of the previous arrangement, the blue path consists of only 11 squares and does not complete a circuit but has two ends. The other color now forms a single path, still composed of alternating squares (7) and triangles (8) with a triangle at both ends. The ball illustrations show the same perspectives as the Meandering Circuit illustrations so you can compare them. This variation is also chiral (its mirror image is not the same). Laying the panels out as shown above with the fronts facing up will yield the arrangement shown in the illustrations while laying them out with the backs facing up will flip the arrangement to its mirror image.





View 1: Blue path | View 1: Gray path | View 2: Blue path | View 2: Gray path

Perplexing Paths transparent views

3 colors

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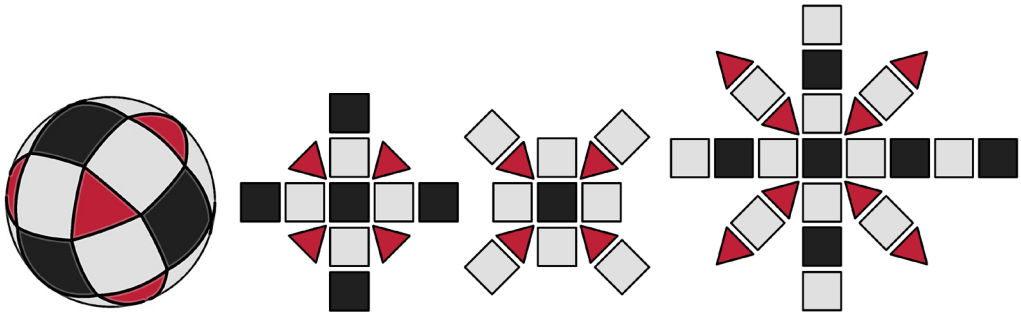
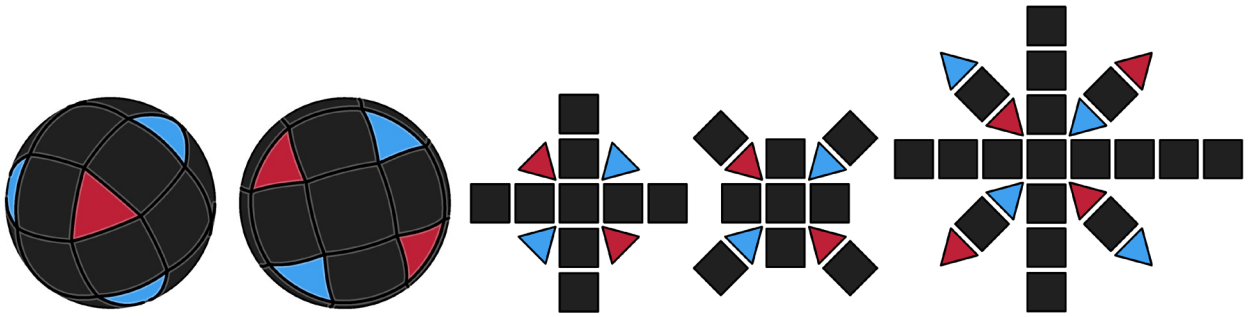
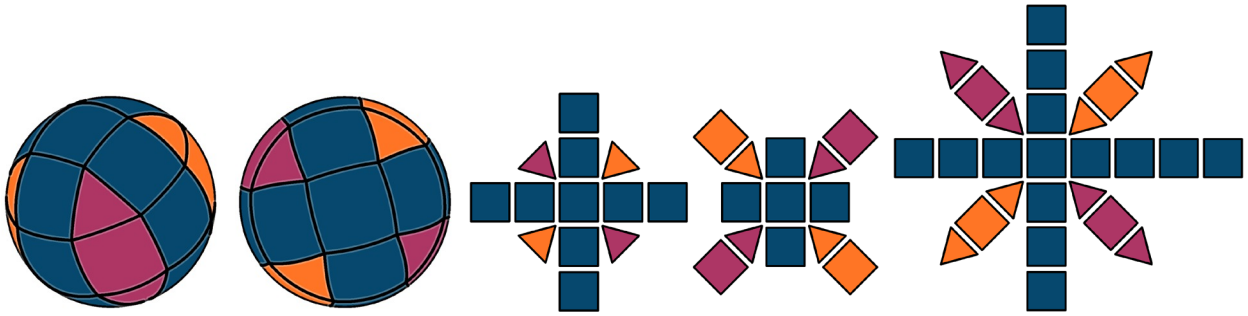


#13: Three-Color Checker Ball. Color A on the triangles, a contrasting color B on the 12 squares that share an edge with them, and color C on the remaining 6 squares, forming a checker pattern. I used this arrangement for one of my corduroy balls. Photos of it are beneath the chapter header.

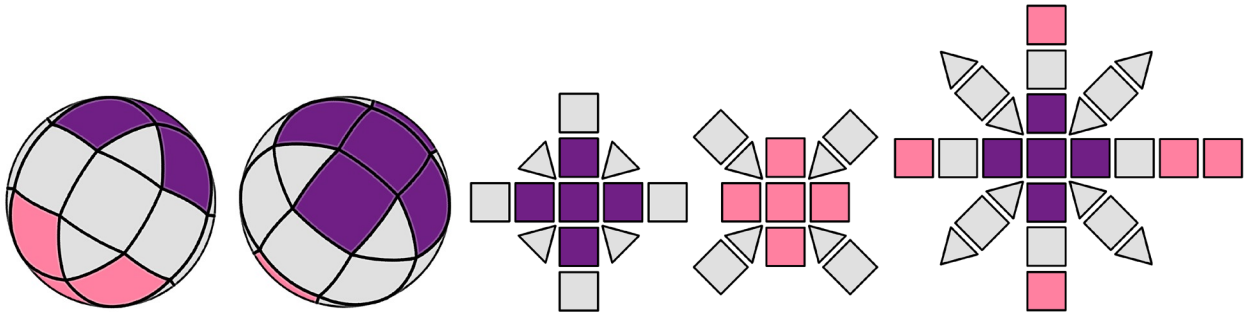
Swapping the black and white squares, putting the blacks at the triangles' edges and the whites at their corners, yields a cube framework arrangement.



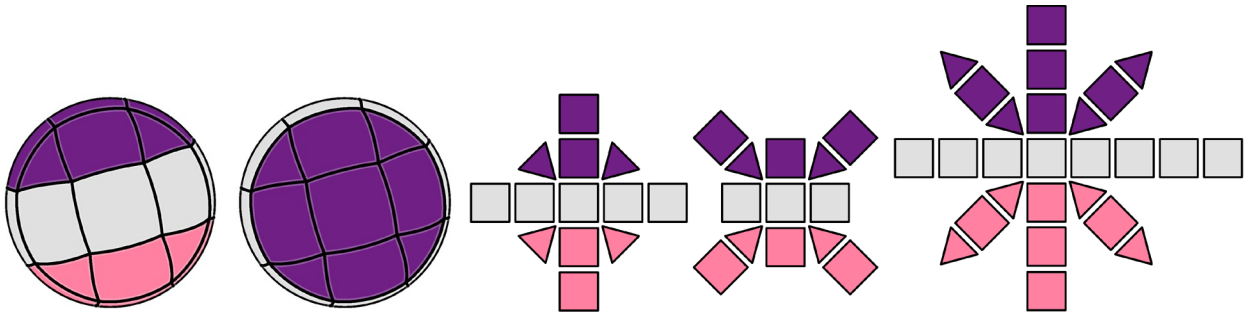
#14: Alternating Triangles. The squares are all one color and the triangles alternate between two contrasting colors. There are 4 triangles of each color.



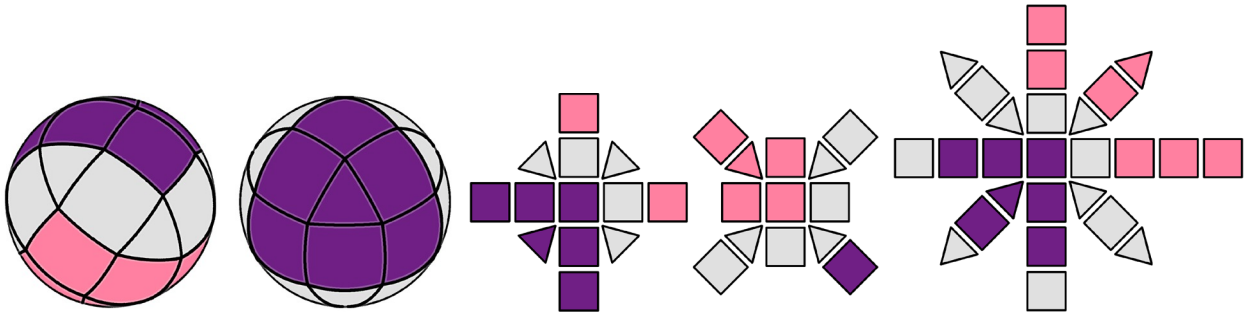
#15: Spikes (3-color variation). Same as the 2-color Spikes arrangement, but colors A and B are each on a pair of opposing spikes. Color C is on the remaining 14 squares.



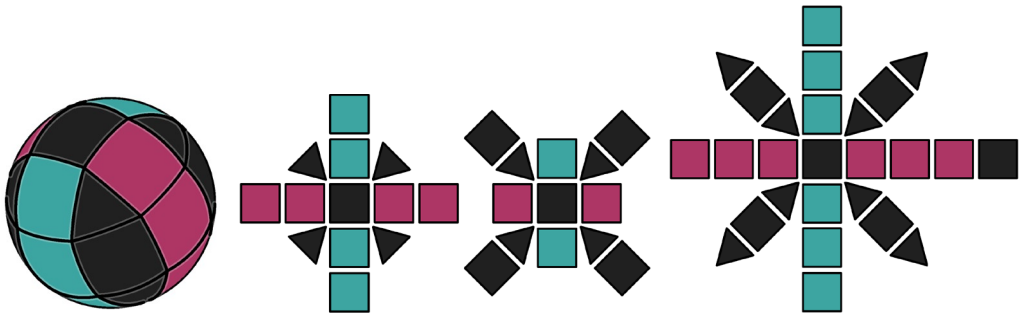
#16: Fence with Dual Caps. Same as the 2-color Fence arrangement, but each cross-shaped patch above and below the fence is a different color.



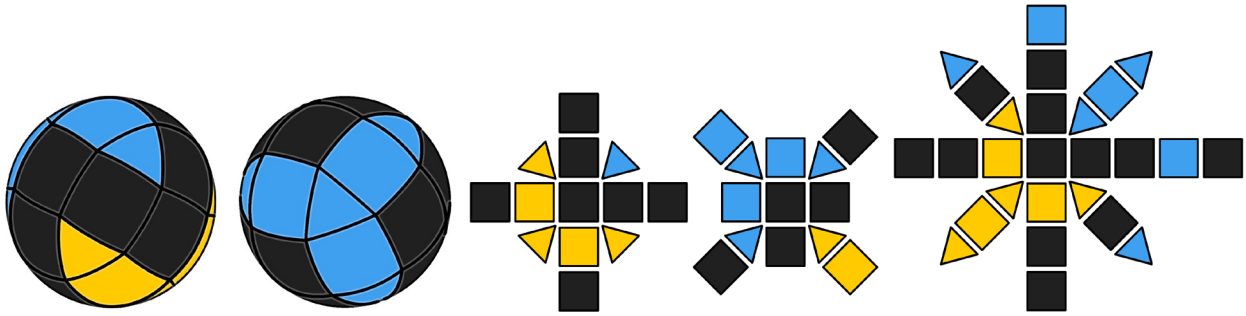
#17: Belt with Dual Caps. Same as the 2-color Belt arrangement but each circular patch above and below the belt is a different color. There are 8 squares of the belt color, and 5 squares and 4 triangles of each cap color.



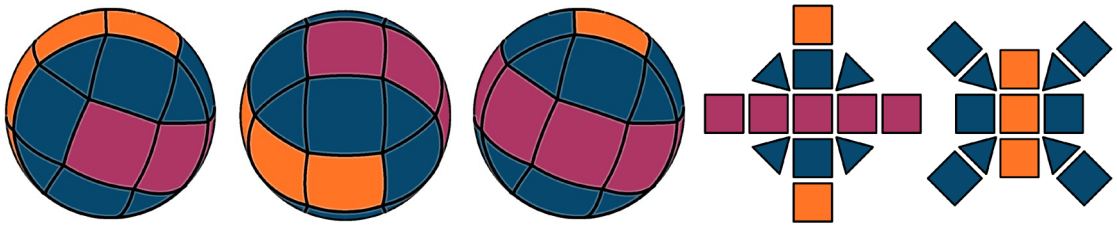
#18: Undulating Belt with Dual Caps. Same as the 2-color Undulating Belt arrangement but each triangular patch above and below the belt is a different color. There are 6 squares and 6 triangles of the belt color, and 6 squares and 1 triangle of each cap color.



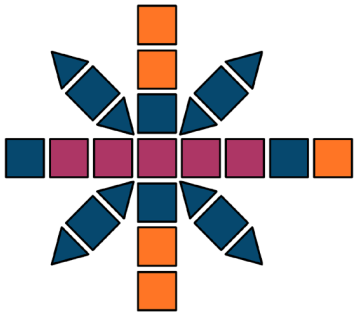
#19: Three-Color Stripey Ball. Related to the Spikes arrangement and a variation of the Two-Color Stripey Ball. In this variation two alternating colors are used for the three-square stripes and a third color is used for the spikes between them and for the square at each pole.

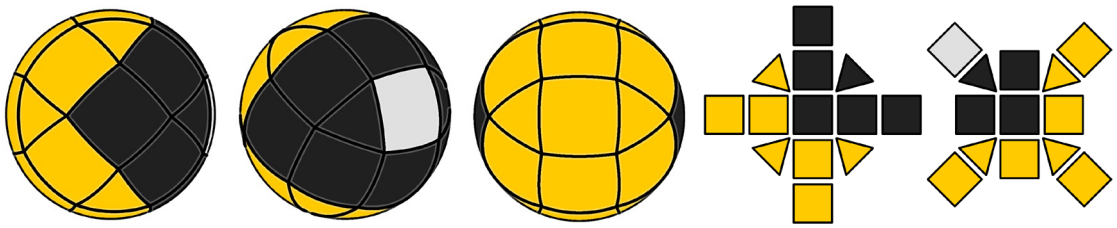


#20: Zig-Zag/Opposing Trefoils (3-color variation). Same as the 2-color Zig-Zag arrangement but each trefoil patch above and below the zig-zag is a unique color. The zig-zag is composed of 12 squares and each trefoil patch is a triangle with a square and a triangle on each of its edges.

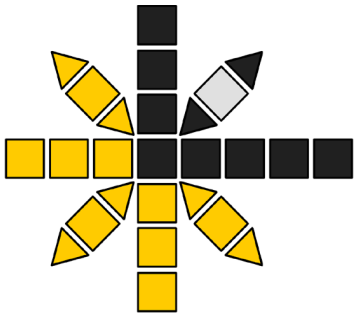


#21: Orthogonal Stripes/Baseball Curve (3-color variation). One color forms a circuit around the ball shaped like the seam of a baseball (or a serpentine curve, if you follow it linearly). In this variation of the 2-color arrangement, each opposing perpendicular 5-square stripe within the baseball curve is a unique color. There are 8 squares of the baseball curve color in addition to 8 triangles. I used this arrangement for one of my corduroy balls. Photos of it are beneath the chapter header.





#22: Pac-Man Eating a Dot. Here's an amusing arrangement that stuck out to me this morning from the seams of my experimental beanbag. The shape isn't quite right (Pac-Man is a bit scrawny), but it's close. There are 9 yellow squares, 6 yellow triangles, 8 black squares, 2 black triangles, and one white square.



4 colors

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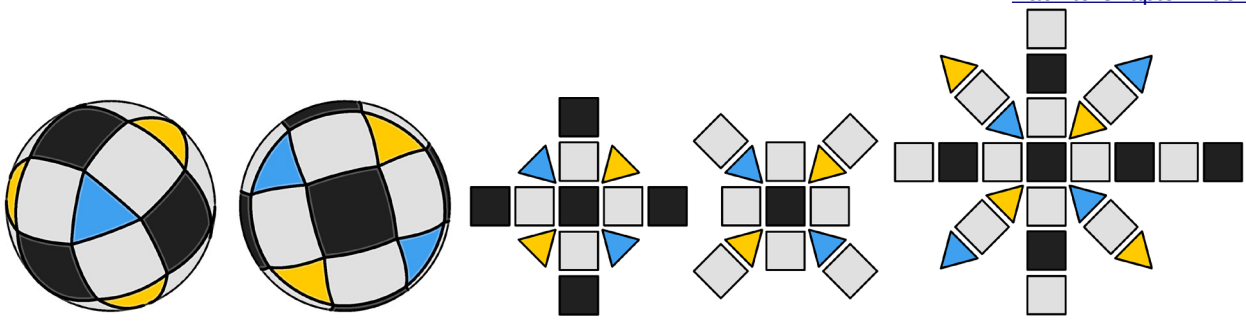
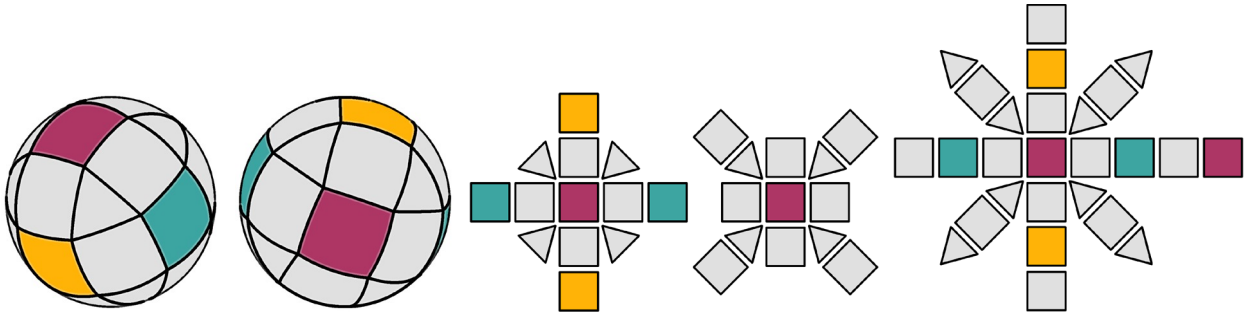


#23: Alternating Triangles with Checkered Squares. A combination of the Three Color Checker Ball and the Alternating Triangles arrangements. In this arrangement both the squares and the triangles alternate between two colors. There are 4 triangles of each color, 12 squares of the color at the triangles' edges, and 6 squares of the color at their corners.

Swapping the black and white squares, putting the blacks at the triangles' edges and the whites at their corners, yields a cube framework arrangement.



#24: Cube Faces (4-color variation). Same as the 2-color Cube Faces arrangement in which the squares at the triangles' corners are assigned a color that contrasts with the rest of the panels, but in this variation the squares are in three colors, each on a pair of opposite squares. The background color is on the remaining 12 squares and 8 triangles.

5 colors

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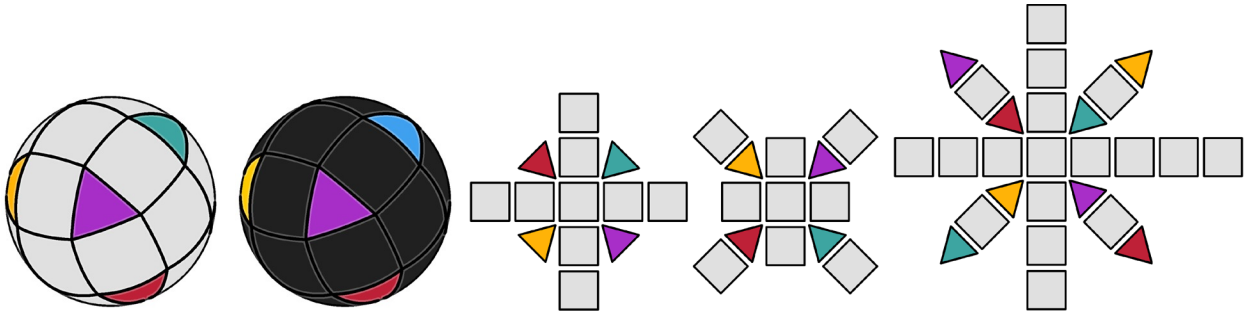
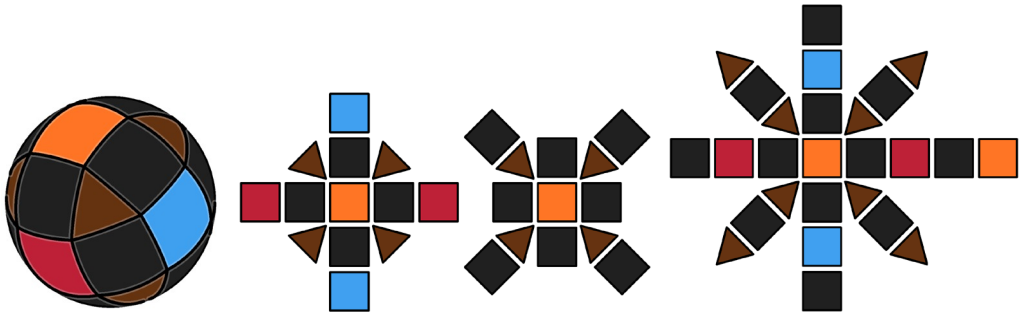
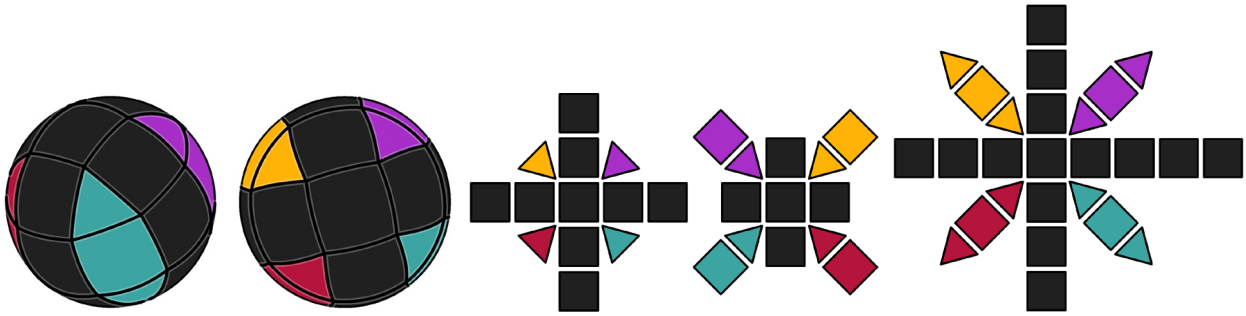


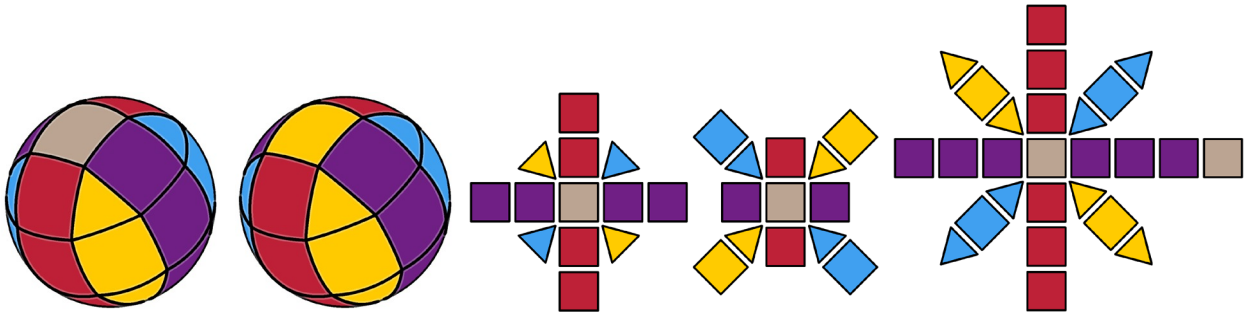
#25: Quad-Color Triangles. The triangles are assigned four colors, each on a pair of opposite triangles. The squares are all a single, contrasting color.



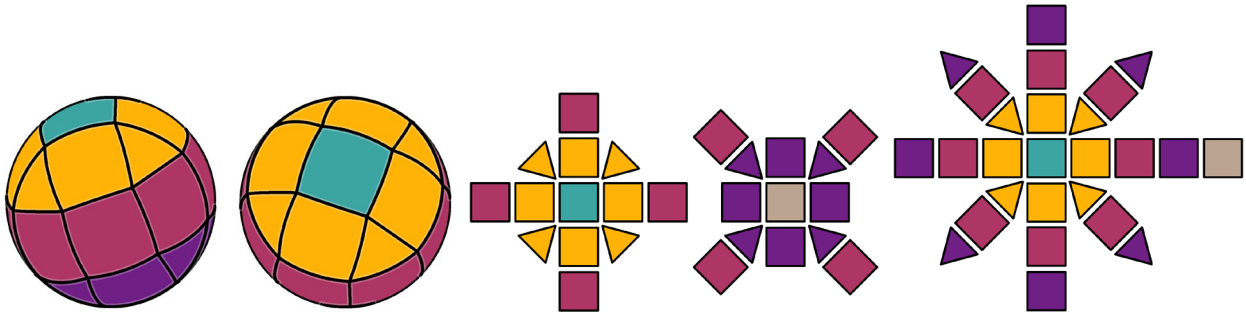
#26: 4-Color Cube Faces with Checkered Edges. The six squares at the triangles' corners, those corresponding to the faces of a cube, follow the 4-color Cube Faces arrangement in which each opposing pair is a unique, bold color. The remaining squares (those at the triangles' edges) are a single background color, and the triangles are another single background color, forming neutral checkered outlines around the bold squares.



#27: Spikes (5-color variation). Same as the 2-color Spikes arrangement but each spike is a unique color. The background color fills 14 squares.



#28: Five-Color (or Four-Color) Stripey Ball. Each of four main colors is on two opposing three-panel patches forming rings around the ball that intersect at two square-panel poles. Those two squares can either be assigned a neutral fifth color as the first ball illustration shows, or one of the colors used for the triangle-tipped stripes as shown in the second ball illustration, in which case only four colors are needed. (Note that using one of the three-square stripe colors for the poles would create a complete ring around the ball, which would interfere with the aesthetic.)



#29: Concentric Rings. One square of color A surrounded by a ring of color B composed of 4 squares alternating with 4 triangles. A ring of 8 squares of color C around the middle, and then a ring of color D (squares and triangles again), and finally a square of color E.

6 colors

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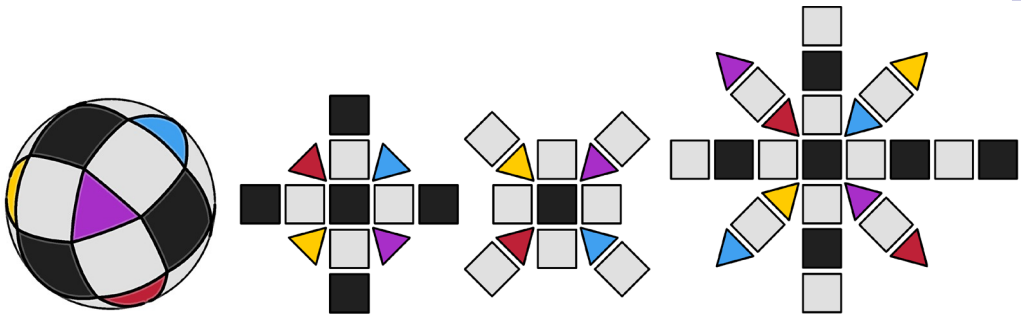

#30: Six-Color Checker Ball. A combination of the Three Color Checker Ball and the Quad-Color Triangles arrangements. The squares alternate between two colors and the triangles are assigned four colors, each on a pair of opposite triangles. There are 12 squares of the color at the triangles' edges and 6 squares of the color at their corners. A photo of my corduroy ball using this arrangement (Photoshop-edited to include more colors) is beneath the chapter header.

Swapping the black and white squares, putting the blacks at the triangles' edges and the whites at their corners, yields a cube framework arrangement.

Cutting Out the Templates

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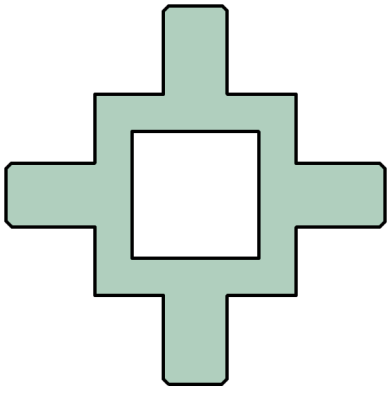
Because this design has so many panels, **I recommend making combo type templates as shown on the right**, or at least the stencil (interior) type (if you don't use cutting templates). The combo type includes the stitching template on the inside and the cutting template on the outside (actually just the corners of it because the tabs interrupt it). **Interior tracing is much faster and easier than exterior**, and for the cutting patterns you really only need the corners. My Ready-to-Print patterns are the combo type, but can be used to make any other type of template. An X-Acto knife and steel ruler work best for cutting out the interiors.



If you use a thick marker to trace the patterns, **remember to stitch on the *outside* of stencil type patterns, where the edges of the template were (inside the lines for exterior templates)**, so you don't change the size of the ball. If the marker soaks through the fabric you're using, however, you will need to stitch inside the patterns to **hide the lines within the seams**. In that case, cut out the templates' interiors slightly outside the lines, shifting the edges outward by the width of the marker lines. Then the edges of the patterns they produce will be correctly positioned for stitching inside them. For combo templates, shift the outer edges by the same amount to maintain the same seam allowance.

I recommend keeping the inner part that you cut out of stencil or combo templates for use in drawing the front stitching patterns. Step 2 of the Assembly instructions explains why.

Making the Panels

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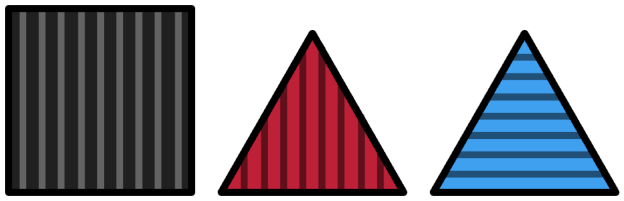
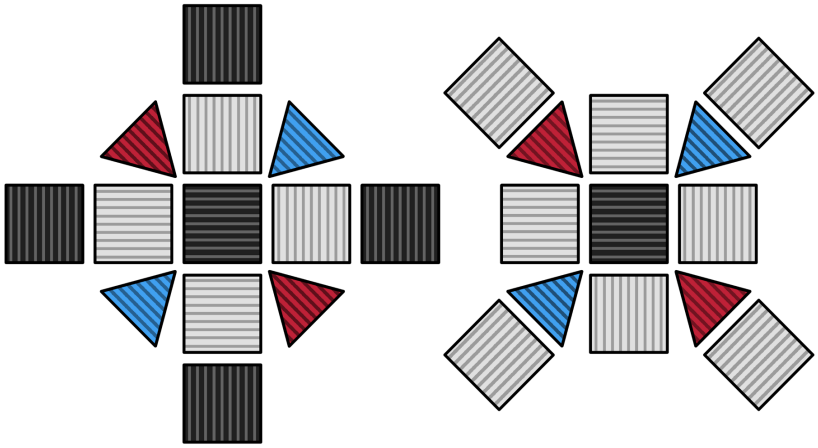
Note that if you are using separate stitching and cutting templates and they are not translucent, you must be careful which pattern, cutting or stitching, you trace first so that the **second template doesn't hide the lines of the first** and prevent you from aligning the two. **Do not necessarily use them in the sequence below**.

1. You will need **18 squares and 8 triangles**, and **you will be tracing the patterns onto the back of the fabric (the side that will be inside the bag)**. If you use cutting templates, first trace those. If you are using the combo type like the one illustrated above, trace the inside and outside of them and skip Step 2.

   If you are using something like **corduroy, denim, or a striped fabric, or any woven fabric**, I recommend orienting the **squares parallel to the lengthwise/straight grain (or cords)** of the fabric, and the **triangles half in a vertical orientation and half in a horizontal** (though the triangles' orientation is not as important because they are few and small).

   You can then arrange the lines of the fabric as shown in the panel layout on the right, so that on the ball the lines of the squares that correspond to the faces of a cube (the black ones) are oriented the same way as I recommend on the cube (each square is surrounded by squares with perpendicular orientations), the lines of the other squares (the whites) alternate around each circumference, and the triangles are also balanced, alternating between orientations around each black panel. This will **produce a balanced look, and it will balance woven fabric's direction of stretch** so the ball is not lopsided or otherwise non-spherical.

2. If you are using separate stitching and cutting templates, use the smaller, stitching templates to trace the stitching patterns within each cutting pattern, being sure to center them well (centering them allows you to align the patterns more easily as you sew, but is not otherwise important).
3. Cut out the panels.

Assembly

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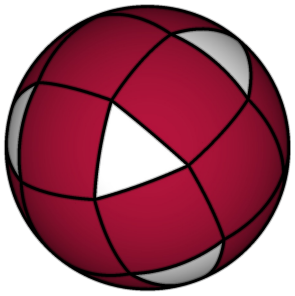
Following is my own method of assembling the panels. **The next page has illustrations, and written instructions follow after those.** Like my 12, 14, and 32-panel designs, this is a **two-hemisphere method**, but in this design **the hemispheres are not the same**. Still, it fulfills the purpose of making the assembly simple and easy to follow, and the intended color arrangement easy to maintain. It also requires no overlapping of stitching and as few as two threads.

The method consists of forming two separate hemispheres composed of 9 squares and 4 triangles, and then sewing the hemispheres together around the equator following a path like the crenels of a castle wall. Up to three pairs of seams are left open (marked by dashed lines in the illustrations) so the bag can be turned out through them.

If you prefer simply to add panels to a central square until you end at the opposite square, you can use that layout type from my color arrangement diagrams instead of the one in Illustration A. Then, after following the stitching paths in Illustrations B and C, use a similar path to continue adding panels. The remaining illustrations and some of my written instructions will not apply.

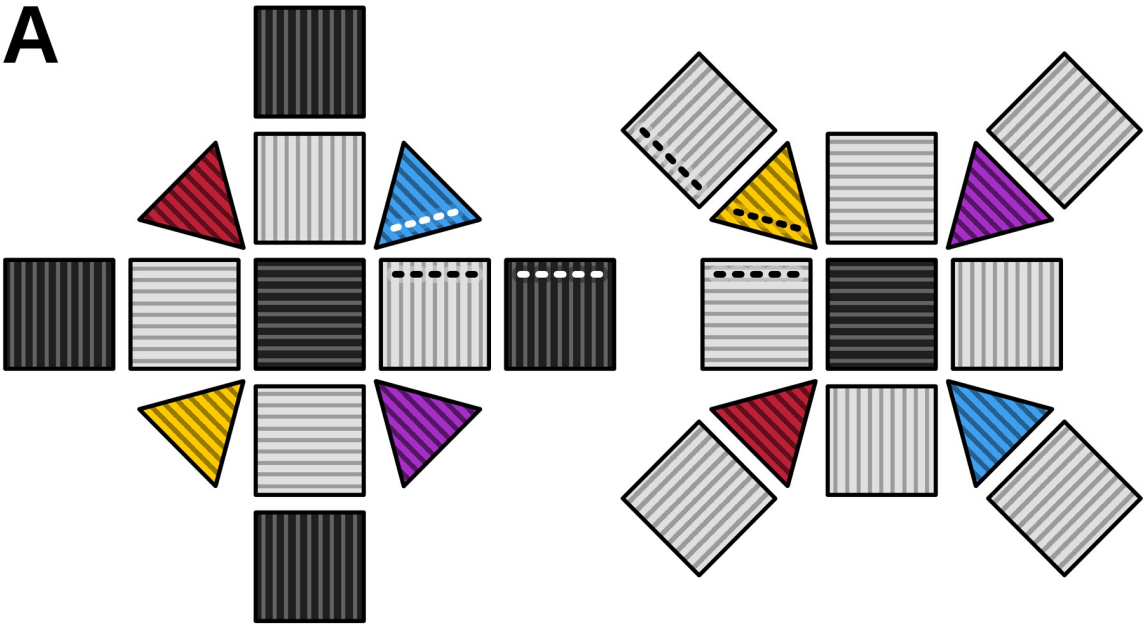
Helpful Hints: While assembling the bag, remember the following points.



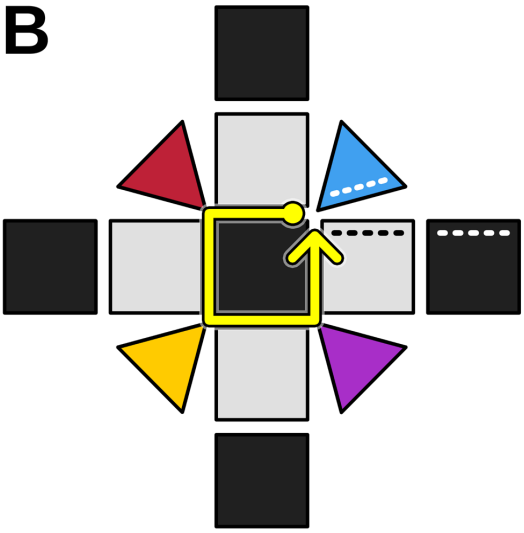
- Every intersection will have four panel corners. Three will be squares and one will be a triangle.
- Six squares (those at the corners of triangles) will join only to other squares. The remaining twelve will join to two squares and two triangles, each shape opposite its match.

The assembly illustrations are on the next page, and the written instructions begin on the page after that.

A



B

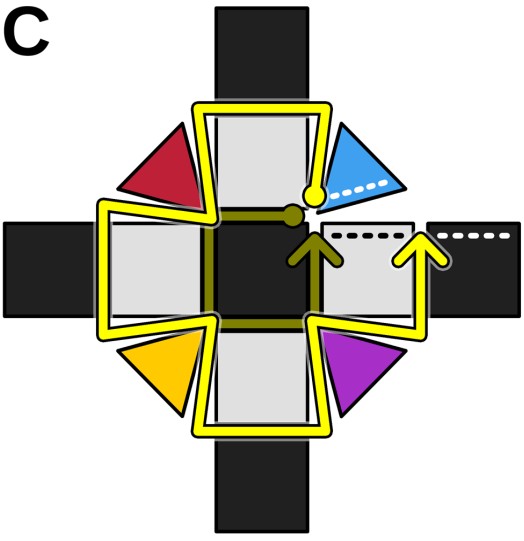


The hatching lines in Illustration A are a guide for balancing corduroy cords or woven fabric's grainline.

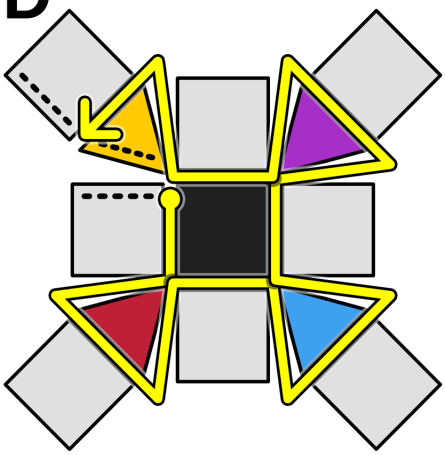
The dashed lines indicate where to draw front stitching lines to aid in sewing those final seams from the outside.

Left-handed diagrams are provided after the written instructions.

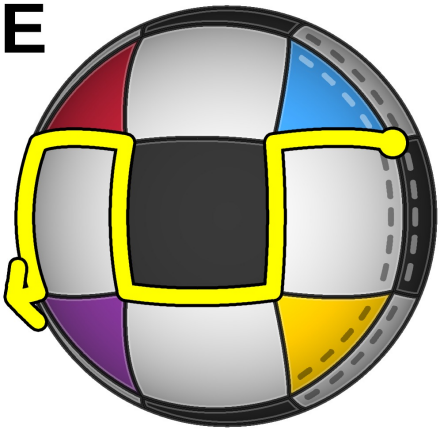
C



D



E



Note that the ball is inside out at this point, so the front stitching patterns (the dashed lines) will not actually be visible. I show them just for positional reference.

1. ***Illustration A:*** **Lay the panels out as shown** (I prefer to place them front face up, though placing them with their backs up will create a mirror-image version of chiral arrangements) and **arrange them according to your color pattern**. The **hatching lines serve as a guide** if you are using a woven fabric, or something like corduroy or a striped fabric and want to **orient the lengthwise/straight grain of the fabric** as I prefer to, both for **aesthetics and for a balanced fabric stretch**. Further explanation of this is in the "Making the Panels" section.

2. Use the stitching template to **draw stitching lines on the *fronts*** of the six panel edges shown with dashed lines in Illustration A. (**If you are left-handed**, try using the diagram at the end of these instructions, which I think will feel more natural for you.) My stitching pathway leaves these edges partially unsewn so the bag can be turned out between them. They will then be **sewn from the outside following the front stitching lines**. (If you use a thin fabric and don't need such a large opening, just skip marking a pair or two of panels and add those seams to your stitching path.) Be sure to align the template as well as possible with the stitching patterns on the backs.

   If you want to **hide the stitching lines within the seams**, sketch them a millimeter or two nearer to the panel edges and stitch slightly inside them (toward the middle of the panels). **If you use a Stencil or Combo type template,** use the inner portion that you cut out of the template to draw these patterns, since the main template will cover the area near the edge.

   I have found it helpful to **add marks along the front stitching lines for each stitch** so that I can more easily keep the exterior stitches even with each other and not get a skewed seam. I space the stitch marks ⅛″ (3mm) apart. If you **make these marks on your template first**, you can more easily transfer them onto these and future panels.

3. ***Illustration B:*** **For the left hemisphere**, start with the center square and the one above it and sew them together with their **front faces together** starting at the beginning of the arrow in the illustration (starting here allows the thread to be continued into the next path). **This step will attach four squares to the central square**. (If you follow the left-handed diagram below, you will be starting with the center square and the one below it.)

4. ***Illustration C:*** When you reach the starting point, begin the next stitching path which **attaches the triangles between the squares, and an additional square to the outer edge of each of the first squares**. If you do not need the left-most seam marked with dashed lines to be left open to turn the bag out through, you may continue into that seam at the end.

   When you add the fourth corner to each intersection, I recommend following the suggestions in the **General Information and Techniques** chapter under "Stitching Techniques", subheading "Closing seam intersections tightly". **4-way and above intersections take a little extra care if you want them tightly closed and elegant-looking**. In short, **stitch each panel tip to the one diagonally opposite it (the thread will form an X across the intersection)and cinch them together**.

5. ***Illustration D:*** **For the right hemisphere**, start at the spot indicated and follow the path around, **attaching all the panels in one circuit around the central square**. If you do not need the right-most seam marked with dashed lines to be left open to turn the bag out through, you may continue into that seam at the end.

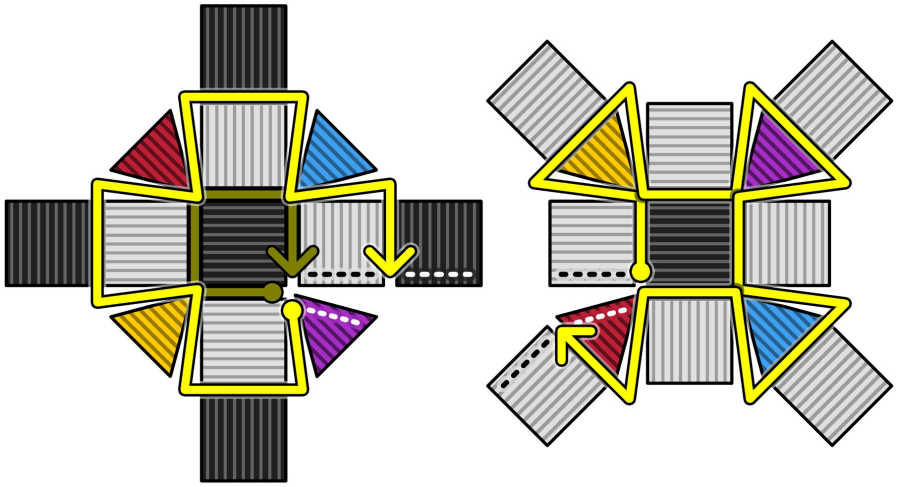
6. ***Illustration E:*** **Join the two hemispheres** at one of the seams adjacent to the seams with the front stitching lines. **Be sure to align the seams correctly** so as to form your intended color pattern and to make the front stitching lines on each half meet each other. Starting at that point, sew the two hemispheres together around the entire ball, **following a square-wave path around** the outer squares of each hemisphere, until you reach the other side of the front stitching lines. Joining the first couple of equatorial edges is **easier if you flip the hemispheres right side** out so the front faces of the panels are exposed and can be placed together. Again, as you reach each intersection, **I recommend using my technique of closing the intersections tightly** so as to produce a more elegant ball.

7. **Sew a few starter stitches** at one end of the final seams to make it easier to continue from the outside. If you don't need the entire opening to turn the bag out, continue to sew as much as you don't need. To **reduce the number of stitches you need to make from the outside**, you can make extra stitches and then loosen them to allow the panels to spread enough to turn the bag out. Then you can pull them tight again from the outside. If you want to do this, or if you want to be able to loosen the last several stitches enough to push a funnel between them, **your final thread will need several inches of extra length**.

8. **Turn the bag right side out through the opening**. A good method for this is to use the back end of a pen or other slender tool to push the fabric through the opening from the opposite side and then either invert the bag around the tool, or remove the tool and work the bag through with your fingers. **Be gentle so as not to pop any stitches**.

9. **Pull out the last stitch so that the thread is on the outside** where you can get to it. Continue sewing the opening closed following the front stitching lines. For help, see the "Stitching Techniques" section of the **General Information and Techniques** chapter under "Backstitch from the exterior Approaches". Fill the bag at some point during this final sewing with a funnel. I find it helpful to **put some filler in first to prevent the bag from collapsing** while I sew, and to hold the seam allowances in place and give me something to push the needle against.

   You can sew the entire opening closed before fully filling the bag, which prevents the filler from spilling back out while you sew. Just loosen the last several stitches enough to push the funnel between them, or at least to push some filler in with your fingers. Then re-tighten the stitches (see "Tips on finishing the bag").



Left-handed diagram

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Ready-to-Print Patterns

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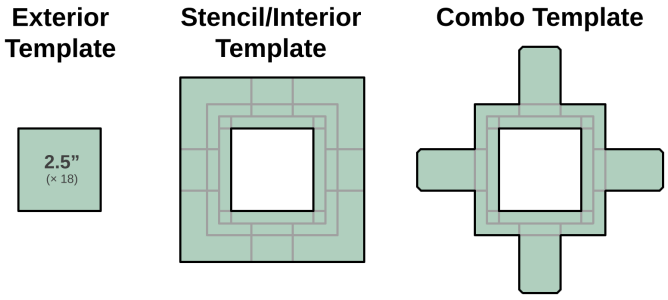
The pattern pages are 8.27"×11" (210mm×279mm) to fit both "Letter" and "A4" sizes. ***Make sure the print is not being scaled to fit the printer margins*** *(select Default/None scaling/Actual size/Ignore printer margins). To verify correct sizing,* ***compare the centimeter grid to a ruler*** *and adjust the next print if necessary. (Note that PDF viewers and printers can both contribute to slight size inaccuracy.)*

On the following pages are patterns for beanbag diameters from 2″ – 3″ in ¼″ increments, and 7″ patterns for scaling to larger sizes. The patterns are reduced by 3.75% from the mathematical calculation to account for the inflation in size I observed in my corduroy bag. **If you use a dense/stiff or completely non-stretch fabric, I recommend enlarging the pattern to about 104% to get the intended ball size.**

To make the templates, I recommend cutting out the portions of the paper with the patterns you want and gluing or taping them to your template material, and then cutting along the patterns.

The patterns are Combo patterns. They have the **stitching patterns on the inside (filled with gray)** and the **cutting patterns on the outside**, with **4mm, 6mm, and 8mm allowances** so you can choose the amount that works best for your fabric and preference (the lighter, 6mm pattern is a hair under ¼″). They also include **tabs to help you hold the templates down**.

The examples on the right show the **three ways you can cut out the templates**. If you want separate stitching and cutting templates, you will need to print the patterns twice.



To produce other pattern sizes or correct an incorrectly sized beanbag, adjust the size scaling in the print dialog. For example, to reduce my 2.5″ pattern to the 2.3″ size recommended by the Juggling Store for small hands and numbers juggling, divide 2.3 by 2.5, multiply the result by 100, and that is your scale (92% in this case). If your beanbag ends up not being the expected size, see the **General Information and Techniques** chapter under "Adjusting/Scaling a Pattern to Produce an Accurate Ball Size" for help with correcting it.

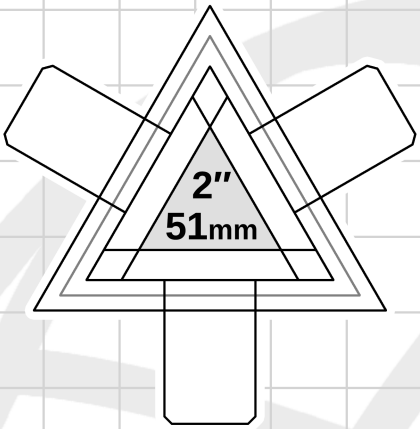
The table below provides the scaling for the ⅛″ increments between my ¼″ sizes. The centimeter grid can be used to verify correct scaling.

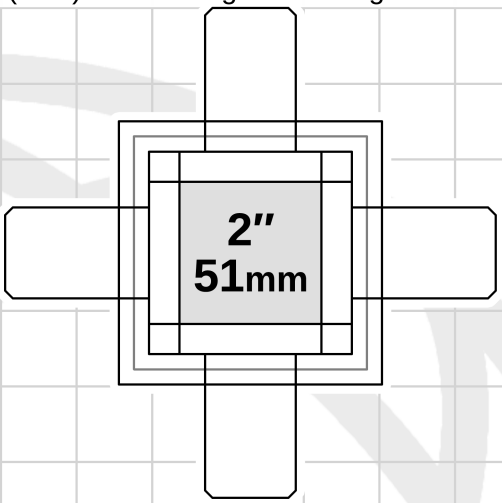
Target Diameter	Print this pattern size	At this scale
1¾″ (44.5mm)	2″	87.5%
1⅞″ (47.6mm)	2″	93.8%
2⅛″ (54.0mm)	2¼″	94.4%
2⅜″ (60.3mm)	2½″	95%
2⅝″ (66.7mm)	2¾″	95.4%
2⅞″ (73.0mm)	3″	95.8%

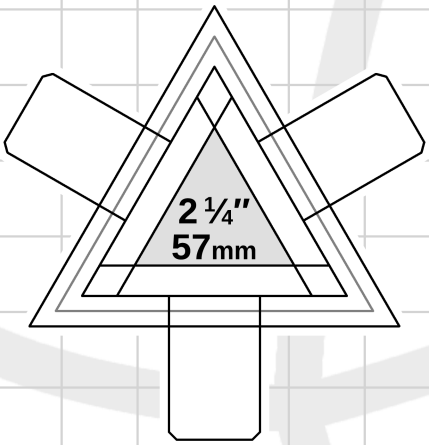
Rhombicuboctahedron (26 Panels)

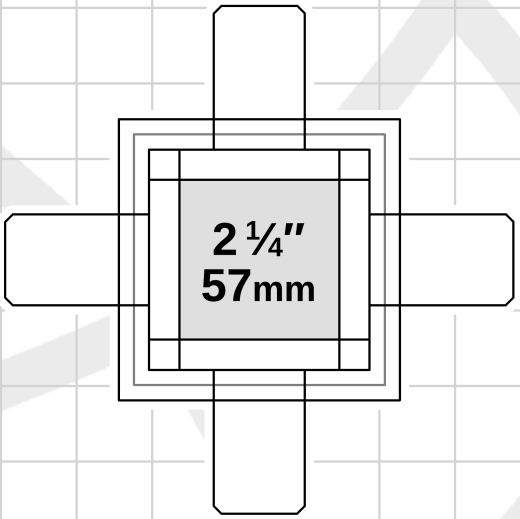
Uses 8 triangles, 18 squares

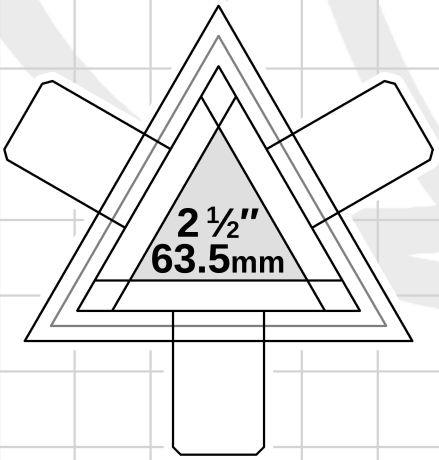
Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (1⁄2″) or 25% larger than target diameter.

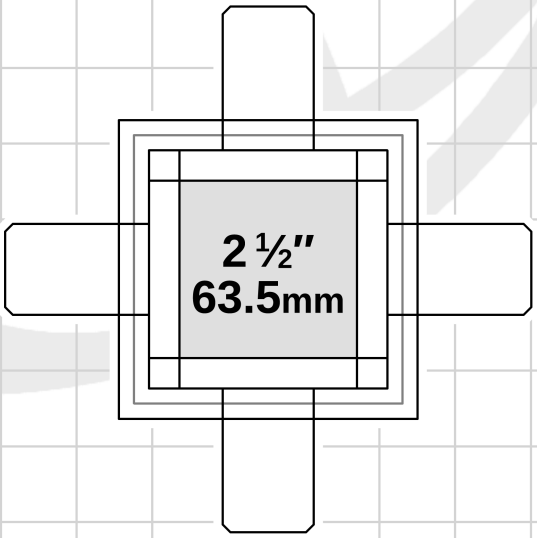












Rhombicuboctahedron (26 Panels)

Uses 8 triangles, 18 squares

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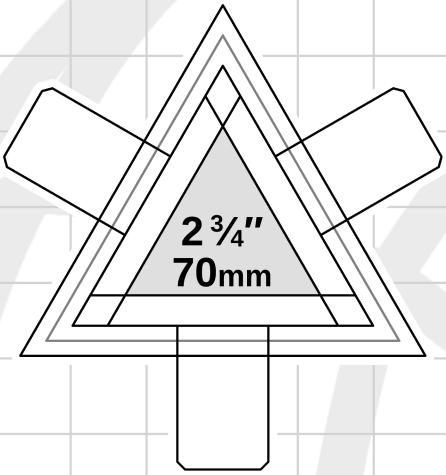
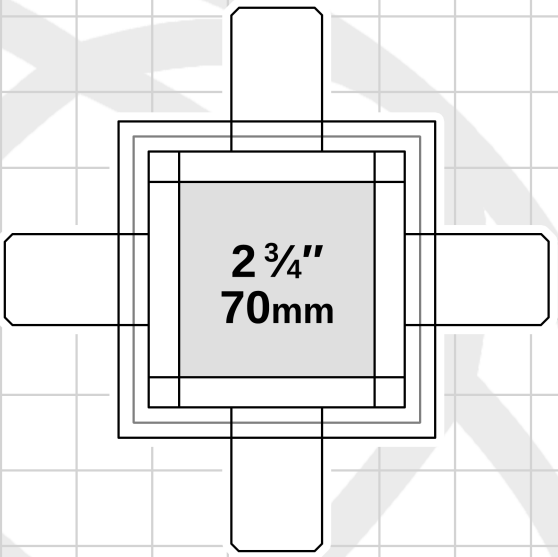
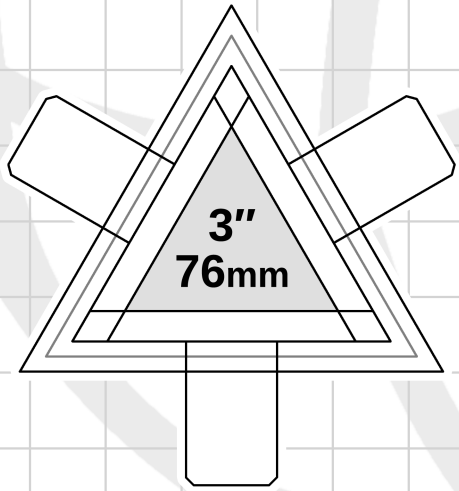
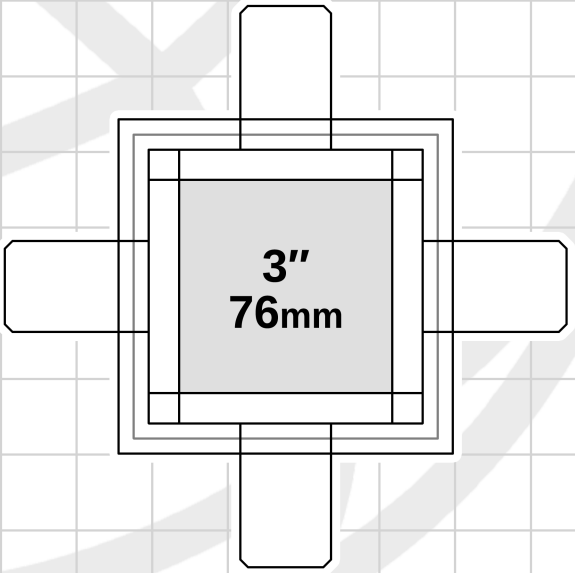
For footbags with gathered seams, try two sizes (1⁄2″) or 25% larger than target diameter.







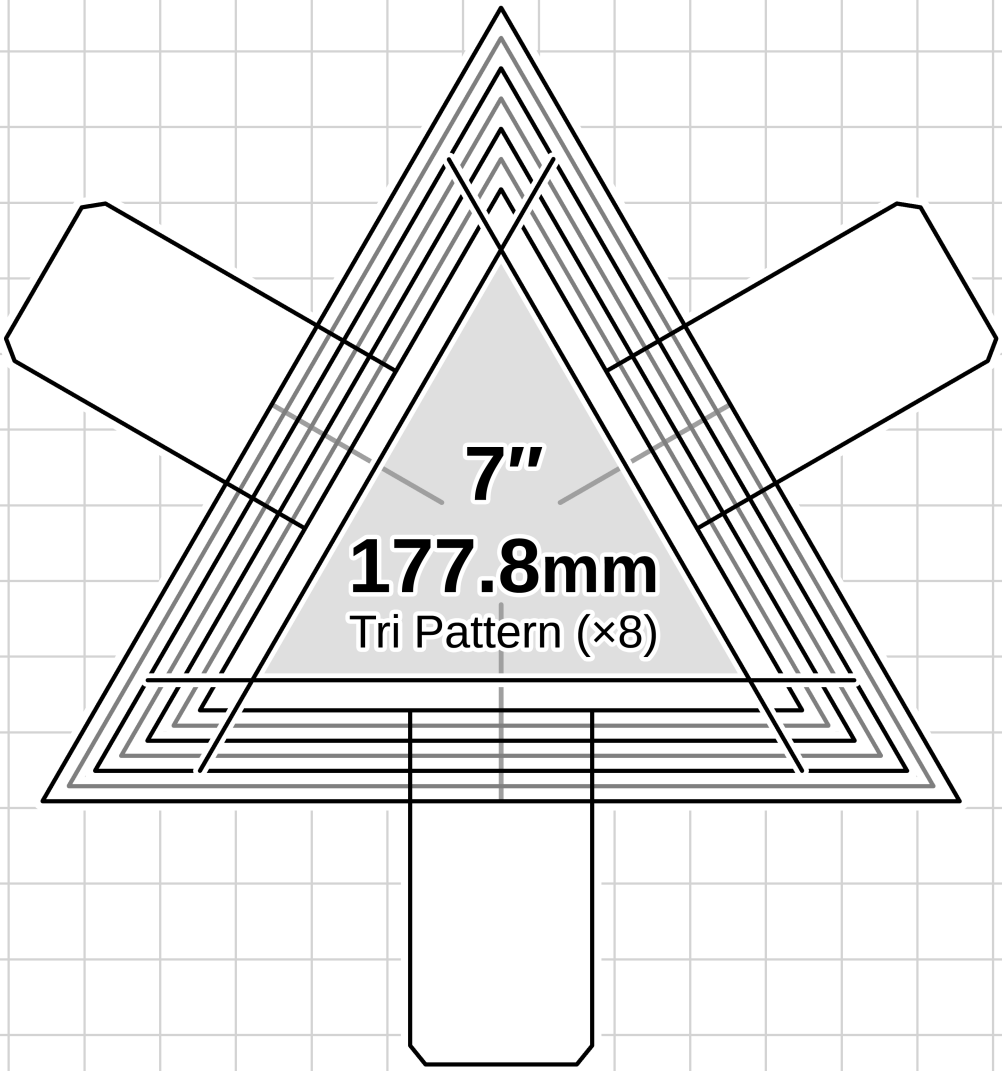


Rhombicuboctahedron (26 Panels)

Uses 8 triangles, 18 squares

Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (1⁄2″) or 25% larger than target diameter.

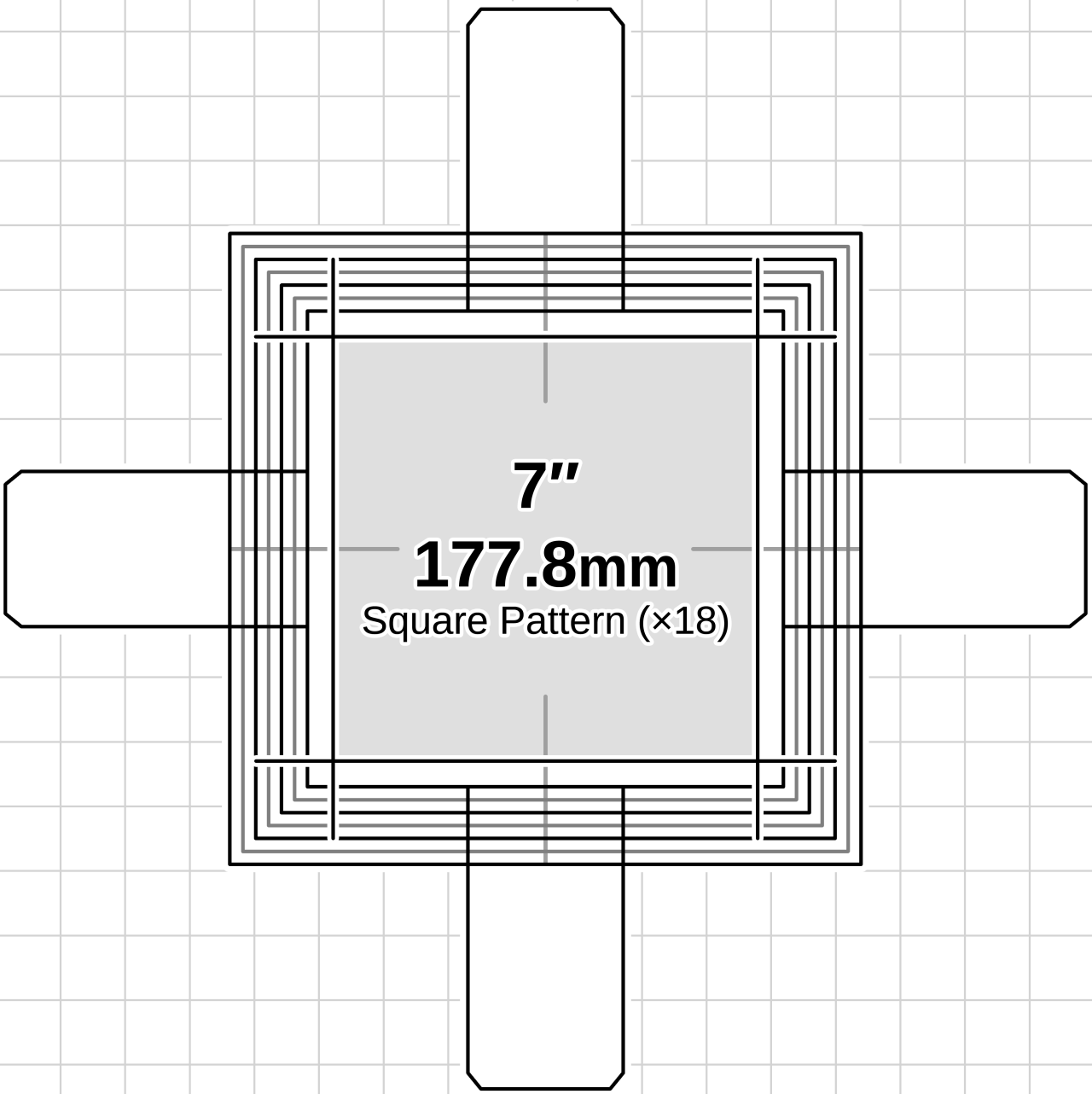
Extra large and versatile patterns for scaling to larger sizes in the Print Dialog (the square is on the next page). Print each pattern twice if you want both a stitching template and a cutting template (or cut out combo templates). The inner patterns (filled with gray) are the stitching patterns. Each dark pattern outside of those marks a 4mm seam allowance interval (at 100% scaling). Use those or the lighter, half-intervals between them to cut out the amount of allowance you want for the cutting templates.



Rhombicuboctahedron (26 Panels)

Uses 8 triangles, 18 squares

Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (1⁄2″) or 25% larger than target diameter.



Blank Color Arrangement Diagrams

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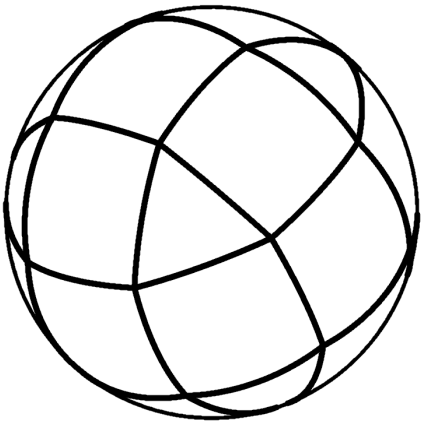
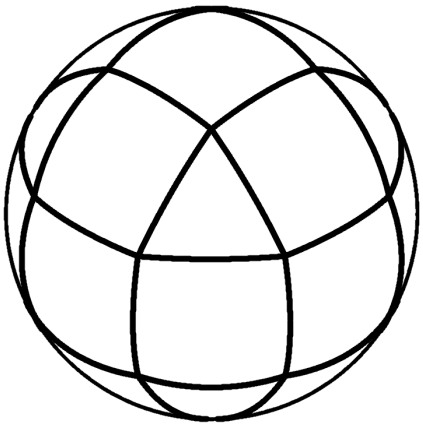
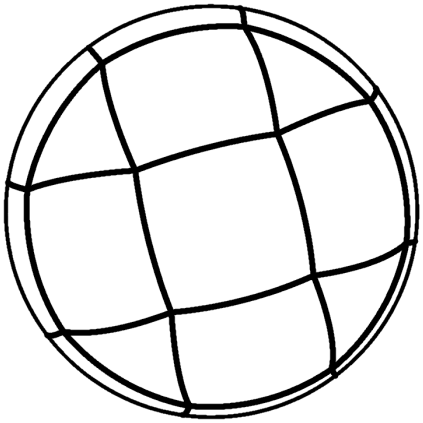
Following are the ball and assembly layout diagrams I used for my color arrangement illustrations. You can use these to experiment with your own arrangements. I also offer PNG format diagrams for download on my website that you can use in an image editor. If they are unavailable, you can capture a screenshot of these pages or export the images and then color them in an image editor. Or you can just print them and color them by hand.



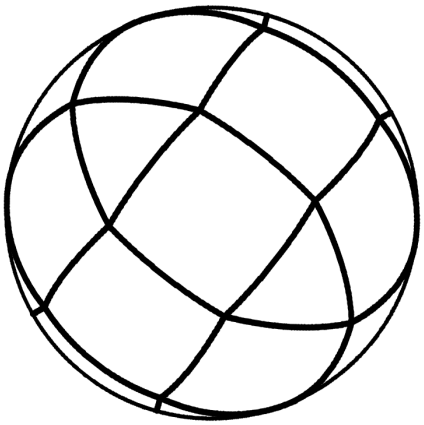
standard view



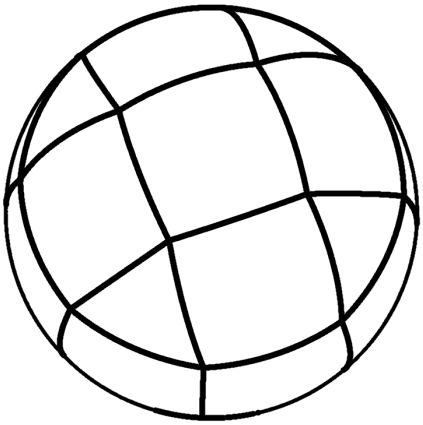
triangle view



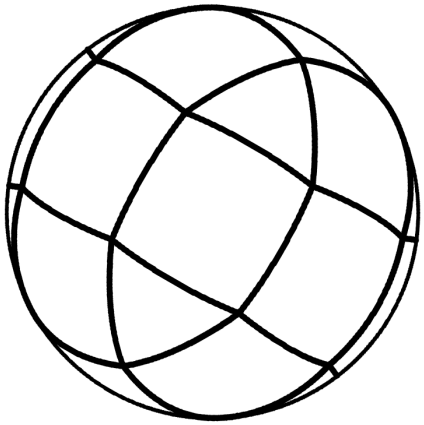
belt view



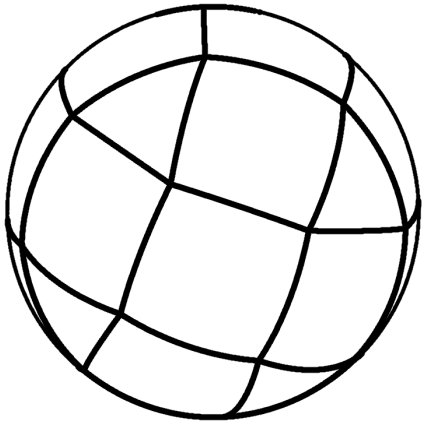
undulating belt view



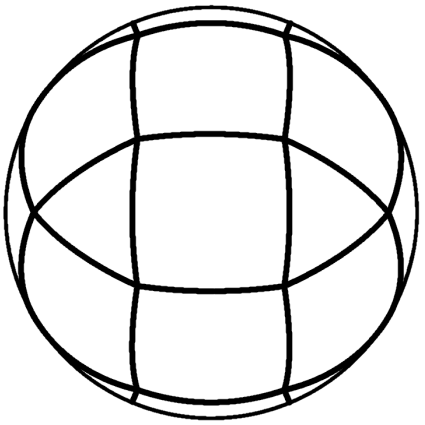
rings polar view



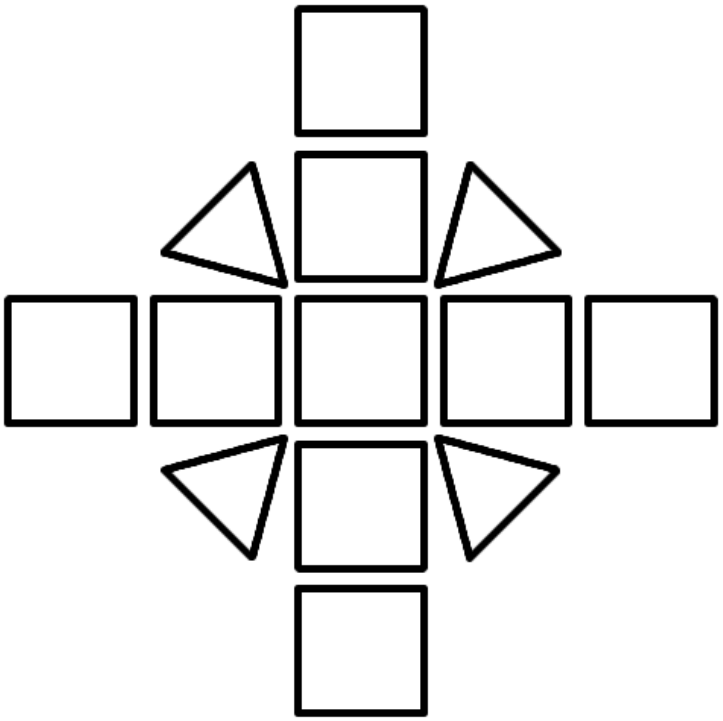
fencepost view

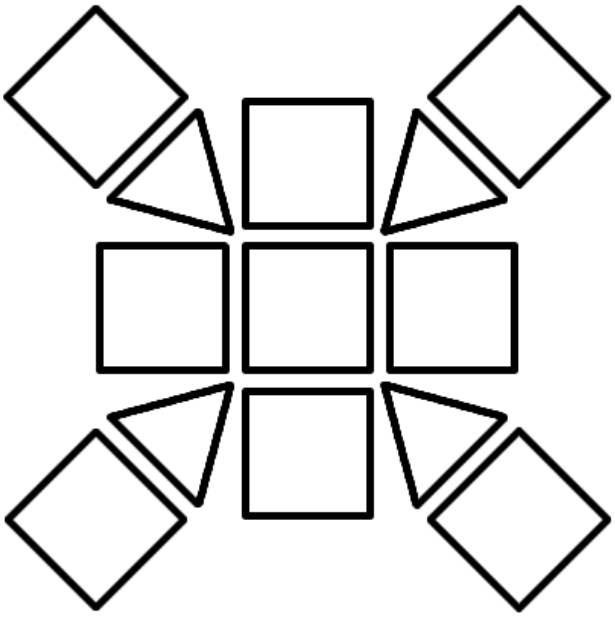


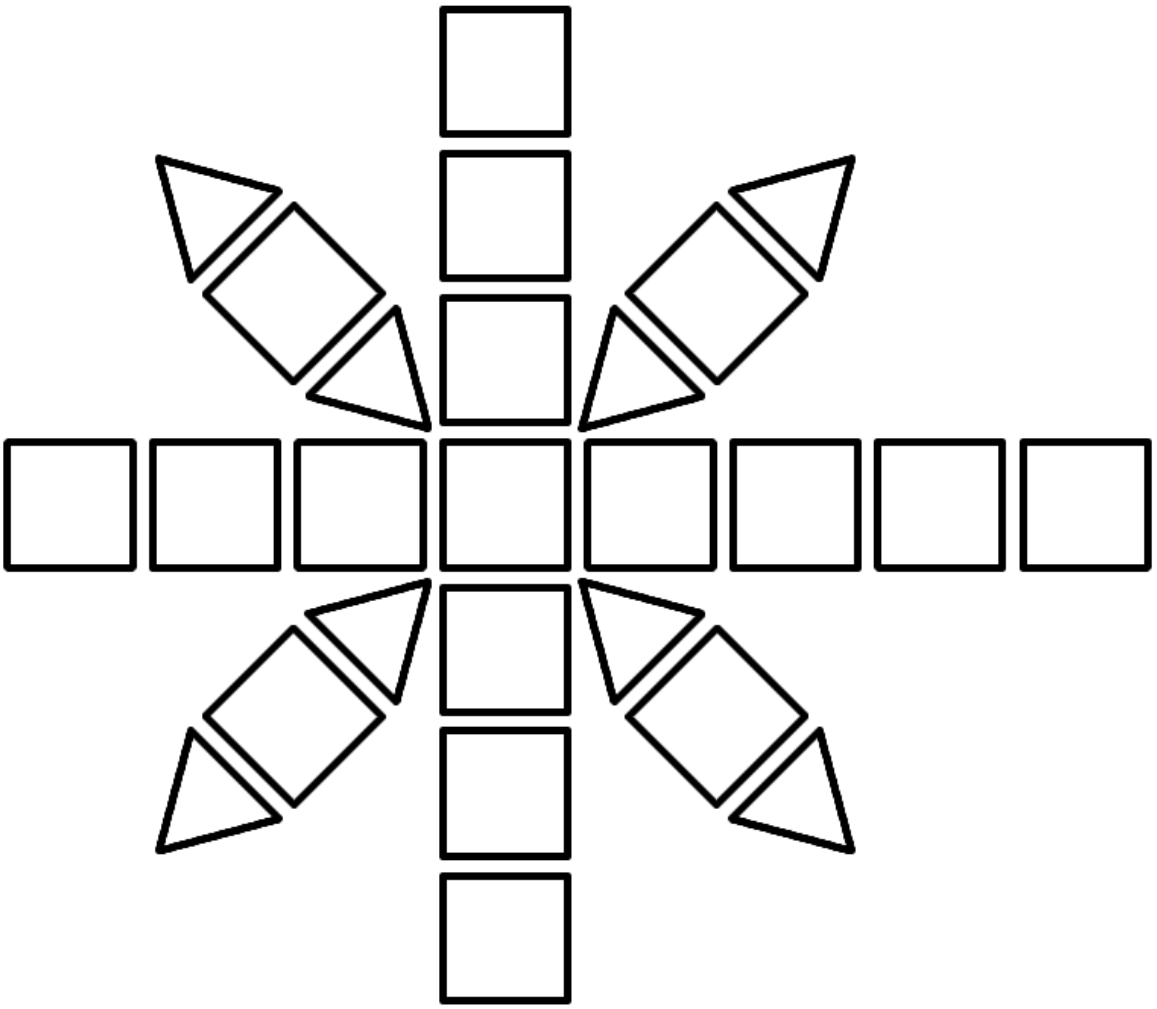
meandering circuit view 1 & 3



meandering circuit view 2







Sizing Formulas for Drawing the Patterns

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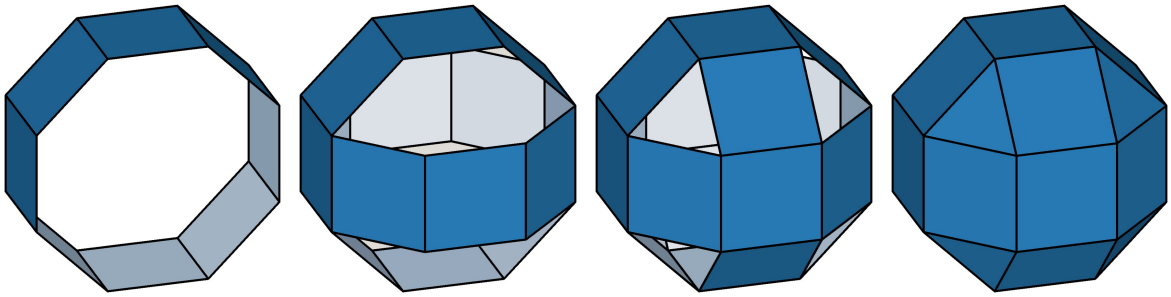
The next section has a table of pre-calculated pattern measurements for all ⅛″ diameter increments from 1¾″ – 3″. Following that are the drawing instructions. If you do not need to create a custom size, skip to that. I provide printable measuring tapes at the end of the **General Information and Techniques** chapter in case you care to measure your beanbags. The "Mathematics" section has explanations of all the formulas and ratios, and expresses their values in higher precision.

Design summary

The rhombicuboctahedron's faces are squares and equilateral triangles, and the edge lengths are slightly under ⅛ of the target ball circumference (the Mathematics section explains this). The polyhedron can be conceptualized as three rings of eight squares, each at right angles to the others, with triangles filling in the eight corners between them.



Adjusting for the influence of fabric attributes on beanbag size

The bag I made with thick corduroy was 1.510 – 5.995% larger than the mathematical prediction depending on whether I filled it loosely or over-filled it. The moderately filled size was 2.638% larger. I target halfway between the min and max inflations when sizing my patterns, which is **3.753%**. This makes my adjustment factor **1.0375**.

I use the adjustment factor to adjust the pattern size to produce a more accurate finished size when using my fabric and stitching techniques. If you gather the seams, use a different fabric, or do anything else that changes the size of the bag, you may need to figure out your own adjustment factor. For help, see the **General Information and Techniques** chapter under "Adjusting/Scaling a Pattern to Produce an Accurate Ball Size".

The bag I made with my design testing fabric (fairly thin, stiff, tightly-woven, non-stretch), moderately tightly filled, had a negative inflation of -0.15% (slightly smaller). So if you are using a fabric like this, I recommend that you use the Base value in the measurement tables rather than the Adjusted value. Based on my experience with using denim for my 24-panel design, I expect it will behave the same way as my design testing fabric. So if you use a thick, firm denim or similar fabric, use the Base sizing values for that, as well.

As I understand it, the bag size is affected by fabric attributes as follows. The folding of the fabric at the seams will cause thick, firm fabrics to significantly shrink the bag size unless the fabric has some stretch. Folding thin fabric doesn't consume as much of its size, but my design testing fabric, though fairly thin, has no stretch at all, and so ended up producing about the same size bag as the denim, which

stretches a little. Corduroy is a softer, more loosely woven fabric than denim and flexes and compresses more easily, and so not as much of the panels' size is consumed by the folding. My denim and design testing fabric bags have very prominent seams while my corduroy bags have much more subtle seams.

Sizing formulas

Below are the formulas to calculate the pattern construction elements (*Diameter* and *Circumference* refer to your target ball size, π = 3.1416). The value in orange is the adjustment factor. **Don't forget to multiply the final result by 25.4 if you need to convert inches to millimeters.**

Triangle Panel

- **Triangle Side Length = *Diameter* × *π* ÷ 8.1950 ÷ 1.0375 ≈ *Diameter* × 0.3834 ÷ 1.0375**
  = *Circumference* ÷ 8.1950 ÷ 1.0375
- **Triangle Circumradius = *Diameter* × 0.2213 ÷ 1.0375**
  = *Circumference* × 0.0705 ÷ 1.0375

Square Panel

- **Square Side Length = [same as Triangle Side Length above]**
- **Square Diagonal** (for drawing by hand) **= *Side Length* × $\sqrt{2}$ ≈ *Side Length* × 1.4142**

How to Draw the Triangle

Back to Chapter Index

Following the pattern measurement table are manual and SketchUp directions for drawing the triangle. To conserve your template material, I recommend that you draw the pattern on paper and then glue or tape the pattern to your template material before cutting it out.

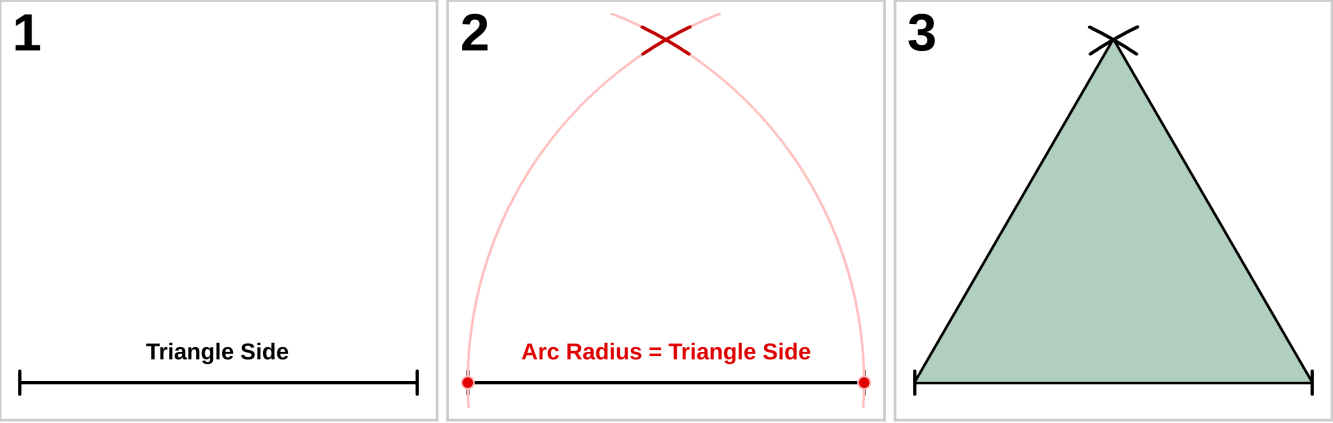
Triangle pattern measurement table

The table below has stitching pattern measurements for each ⅛″ diameter increment from 1¾″ to 3″. The values in the **Adjusted** columns account for the 1.0375 adjustment factor. The adjusted values decrease the **Base** pattern size so that you will get a more accurate finished size when using corduroy or something similar (a soft, flexible, moderately thick fabric). If you are using a firm denim or a thin, but non-stretch fabric, use the Base value instead. I attempt to explain why in the "Adjusting for the influence of fabric attributes on beanbag size" topic earlier in this chapter.

To draw the cutting pattern, increase the Triangle Side Length by the desired allowance × 3.4641, or increase the Triangle Circumradius by the allowance × 2.

Finished Diameter	**Triangle Side Length** (mm)		**Triangle Circumradius** (mm)	
	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	17.040	**16.424**	9.838	**9.483**
1⅞″ (47.6mm)	18.257	**17.597**	10.541	**10.160**
2″ (50.8mm)	19.474	**18.770**	11.244	**10.837**
2⅛″ (54.0mm)	20.692	**19.944**	11.946	**11.514**

Finished Diameter	Triangle Side Length (mm)		Triangle Circumradius (mm)	
	Base	Adjusted	Base	Adjusted
2¼″ (57.2mm)	21.909	**21.117**	12.649	**12.192**
2⅜″ (60.3mm)	23.126	**22.290**	13.352	**12.869**
2½″ (63.5mm)	24.343	**23.463**	14.054	**13.546**
2⅝″ (66.7mm)	25.560	**24.636**	14.757	**14.224**
2¾″ (69.9mm)	26.777	**25.809**	15.460	**14.901**
2⅞″ (73.0mm)	27.994	**26.983**	16.163	**15.578**
3″ (76.2mm)	29.212	**28.156**	16.865	**16.256**



Illustrations for the manual directions. The numbers correspond to the step numbers.

Manual directions for the Triangle

(The terms in bold refer to columns in the pattern measurement table above.)

1. Draw a horizontal line the length of **Triangle Side Length** and mark each end of it.
2. Place a compass on one end of the line, extend it to the other end, and draw a small arc above the center of the line. Draw the same arc from the other end of the line. The resulting X-shaped intersection marks the third corner of the triangle.
3. Draw lines from each end of the first line to the X, forming an equilateral triangle.
4. To draw a cutting pattern, multiply the desired allowance by 3.4641 and add that to the **Triangle Side Length**. Or, just draw the cutting pattern around the stitching pattern, using its edges as guides.

SketchUp directions for the Triangle

(The terms in bold refer to columns in the pattern measurement table above.)

1. Use the polygon tool (in the Shapes tool drop-down, or in Draw menu -> Shapes) set to 3 sides and draw a triangle with circumradius = **Triangle Circumradius**, which will result in a triangle with sides of length **Triangle Side Length**.

2. To draw a cutting pattern, multiply the desired allowance by 2 and add that to the **Triangle Circumradius** (or by 3.4641 and add that to the **Triangle Side Length**). Or, just draw the cutting pattern around the stitching pattern, using its edges as guides.

The instructions for the square are on the next page

How to Draw the Square

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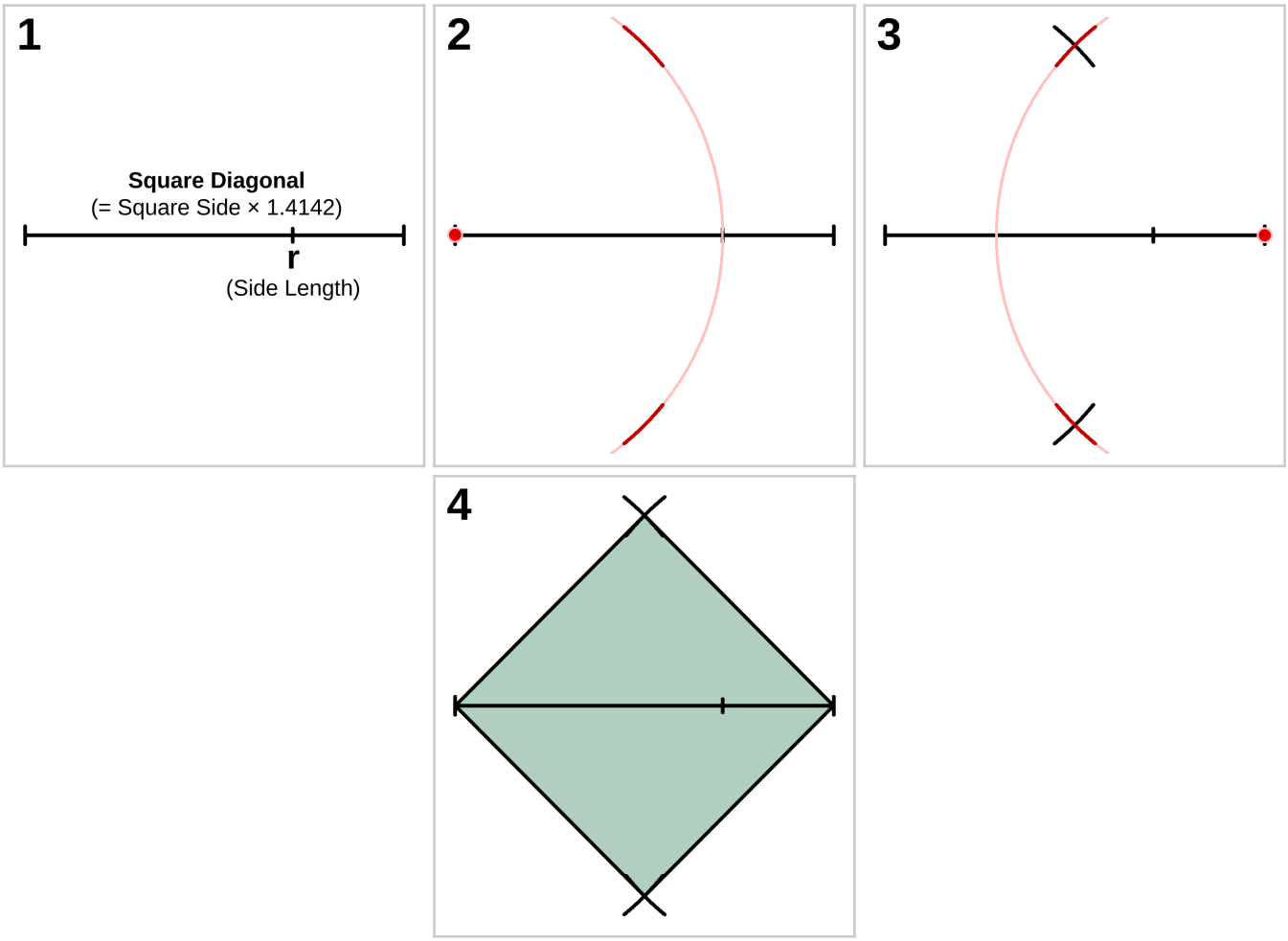
Following the pattern measurement table are manual and SketchUp directions for drawing the square. To conserve your template material, I recommend that you draw the pattern on paper and then glue or tape the pattern to your template material before cutting it out.

Square pattern measurement table

The table below has stitching pattern measurements for each ⅛″ diameter increment from 1¾″ to 3″. The values in the **Adjusted** columns account for the 1.0375 adjustment factor. The adjusted values decrease the **Base** pattern size so that you will get a more accurate finished size when using corduroy or something similar (a soft, flexible, moderately thick fabric). If you are using a firm denim or a thin, but non-stretch fabric, use the Base value instead. I attempt to explain why in the "Adjusting for the influence of fabric attributes" topic.

To draw the cutting pattern, increase the Square Diagonal by the desired allowance × 2.8284, and increase the Square Side Length by the allowance × 2.

Finished Diameter	**Square Diagonal** (mm)		**Square Side Length** (mm)	
	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	24.098	**23.227**	17.040	**16.424**
1⅞″ (47.6mm)	25.820	**24.886**	18.257	**17.597**
2″ (50.8mm)	27.541	**26.545**	19.474	**18.770**
2⅛″ (54.0mm)	29.262	**28.205**	20.692	**19.944**
2¼″ (57.2mm)	30.984	**29.864**	21.909	**21.117**
2⅜″ (60.3mm)	32.705	**31.523**	23.126	**22.290**
2½″ (63.5mm)	34.426	**33.182**	24.343	**23.463**
2⅝″ (66.7mm)	36.147	**34.841**	25.560	**24.636**
2¾″ (69.9mm)	37.869	**36.500**	26.777	**25.809**
2⅞″ (73.0mm)	39.590	**38.159**	27.994	**26.983**
3″ (76.2mm)	41.311	**39.818**	29.212	**28.156**



Illustrations for the manual directions. The numbers correspond to the step numbers.

Manual directions for the Square

(The terms in bold refer to columns in the pattern measurement table above.)

1. Draw a horizontal line the length of **Square Diagonal** and mark each end of it. Mark another point located the distance of **Square Side Length** from the left end of the line (labeled *r* in Illustration 1).
2. Place a compass on the left end of the line, extend it to point *r*, and draw a short arc above and below the center of the line as shown in Illustration 2.
3. Place the compass on the other end of the line and draw the same two arcs, forming two X-shaped intersections as shown in Illustration 3. These form the other two corners of the square.
4. Draw lines connecting each line endpoint to each arc intersection, forming the square panel as shown in Illustration 4. Measure its sides and make sure they are equal. Any error you make will be compounded many times in the juggling bag, so be as precise as you can.
5. To draw a cutting pattern, multiply the desired allowance by 2.8284 and add that to the **Square Diagonal** (the first line you drew), and multiply it by 2 and add that to the **Square Side Length** (the distance of point *r*). Or, just draw the cutting pattern around the stitching pattern.

SketchUp directions for the Square

(The terms in bold refer to columns in the pattern measurement table above.)

1. Draw a square with sides of length **Square Side Length**. SketchUp snaps lines to perpendiculars, so drawing a square is easy and does not require the Protractor tool. (You could also use the Polygon tool set to 4 sides and draw a square with circumradius equal to one half of **Square Diagonal**).
2. To draw a cutting pattern, multiply the desired allowance by 2 and add that to the **Square Side Length**. Or, just draw the cutting pattern around the stitching pattern, using its edges as guides.

Mathematics Behind the Relationship Between the Pattern Parameters and the Ball Size

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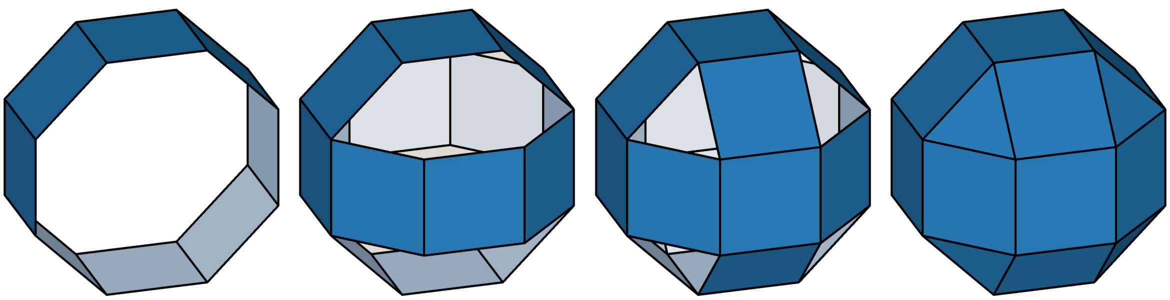
This section describes the math involved in drawing patterns to produce specified beanbag sizes, and creating the pattern sizing formulas. *(The numbers in tiny, right-justified typeface are my computer calculator's unrounded values which I display rounded to six places for brevity.)*

This design is refreshingly simple compared to most of the other designs in this guide. The faces are squares and equilateral triangles, they do not need curved edges, and calculating the relationship between the panel size and the ball circumference is simple.

The polyhedron can be conceptualized as three rings of eight squares, each at right angles to the others, with triangles filling in the eight corners between them. The circumference around the squares is a little smaller than the circumference around the triangles, so rather than simply defining the edge length as ⅛ of the circumference, I calculated a weighted average of the two measurements for more accuracy.



The circumference around the squares is 8(*Edge Length*). The circumference around the triangles is

4(*Triangle Height*) + 2(*Square Diagonal*) + 2(*Edge Length*) = 8.292529(*Edge Length*) 8.2925287398839446846582701314311

Circumference	Relative Proportion	Frequency
8(*Edge Length*)	1	3
4(*Tri Ht*) + 2(*Sq Diag*) + 2(*Edge Len*)	1.036566 1.0365660924854930855822837664289	6
Weighted Average	**1.024377** 1.0243773949903287237215225109526	

Based on the weighted average, the circumference is *Edge Length* × **8.195019**. 8.1950191599226297897721800876207

So I will define the side length of my panels as

$$\textbf{Side Length, } s = \frac{\textit{Circumference}}{8.195019} = \frac{\textit{Diameter} \times \pi}{8.195019} \approx \textit{Diameter} \times 0.383354$$ 0.38335391196564980468246798779767

To draw the triangle using a defined circumradius rather than a defined edge length, use the circumradius formula:

$$\textbf{Equilateral Triangle's Circumradius (center to corner)} = \frac{1}{\sqrt{3}} s \approx 0.577350s$$

Cutting pattern calculations

To draw the cutting pattern for the triangle directly (rather than using the stitching pattern as a guide), and make it perfect, trigonometry is needed. To create seam allowance a, the triangle's apothem (distance from center to edge, or inscribed radius) needs to be increased by a, effectively shifting the edges outward by a. The formula for the apothem of an equilateral triangle with side length s is

$$\text{Triangle Apothem} = \frac{\sqrt{3}}{6}s \approx 0.288675s$$

Multiplying the reciprocal of that value by the allowance (or dividing the allowance by that value) will yield the amount by which to increase the triangle's side length. And since the triangle's circumradius is twice its apothem, the circumradius will increase by $2a$.

Triangle Side Length Increase = $\frac{6}{\sqrt{3}}a \approx 3.464102a$

Triangle Circumradius Increase = $2a$

For the square, the side length will increase by $2a$, and the circumradius will increase by $\sqrt{2}\,a$, making the diagonal increase $2\sqrt{2}\,a$. (The diagonal is used for drawing the square by hand.)

Square Side Length Increase = $2a$

Square Diagonal Increase = $2\sqrt{2}\,a \approx 2.828427a$ 2.828427124746190076033774484194

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How I Developed This Design

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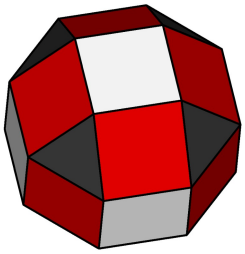
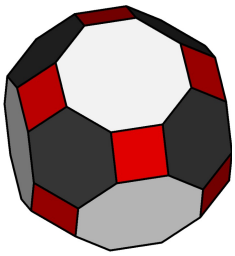
Initial interest

I developed this design in May, 2021, five months after publishing the Second Edition guide. It is the first new design I have added in over seven years (the last was the baseball in January, 2014). I had been making frequent edits to this guide since publishing it, and I occasionally made a major change or addition, but for the most part I had run out of ideas for the continuance of my hobby, and I was bored.

Then, on May 3rd, I was browsing through my Lineup of Footbag Panel Structures and I became interested in the 26-panel design (shown below). This footbag design typically uses three different shapes: semiregular hexagons (black), semiregular octagons (white), and squares (red). I had always assumed that the design was based on the Rhombicuboctahedron, but while writing this chapter I discovered the Truncated Cuboctahedron (hexagons, octagons, and squares), which could also have been the basis. In either case it is modified from the original polyhedron. The black and white panels are either triangles and squares with truncated corners, or edge-truncated hexagons and octagons.



Rhombi-cuboctahedron



Truncated Cuboctahedron

Note that the name “Truncated Cuboctahedron” is misleading as an actual truncated cuboctahedron has rectangles instead of squares, and the hexagons and octagons cannot both be equilateral, as I discovered when I tried to form this solid from a cuboctahedron. I had to invent my own complicated process for drawing it. But I only drew this and the steps of rectifying a cuboctahedron (farther on in this section) out of boredom. They are unnecessary illustrations, but they gave me many hours of enjoyable work.

The footbag pictured is the “Alpha” by Flying Clipper from http://www.flyingclipper.com/home/fly/page_272_99/alpha_footbag.html

For some reason this design had never appealed to me before. Now it did, and as I researched it I regained the old excitement. I did not care for the look of the truncated triangle/octagon design, though.

Out of curiosity, and to see if I liked the un-truncated, Rhombicuboctahedral design, I searched online to see if anyone had made a true Rhombicuboctahedral beanbag. I found only one manufacturer that does: Allan Petersen of Hane Dane Craft. Below are photos of his 26-panel footbags.

26-panel footbags by Allan Petersen of Hane Dane Craft (source website, hanedanefootbags.com, no longer exists).

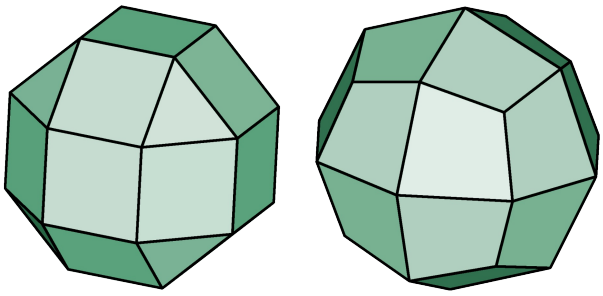
Some of my color arrangements were taken from those photos. I highly recommend browsing the Hane Dane Footbags website (edit: HanedaneFootbags.com no longer exists, but many of Petersen's footbags are displayed on his Facebook page). Petersen makes some beautiful footbag designs I haven't seen elsewhere, and he has a gallery of unique footbags he has made. I added my favorites to my Lineup of Footbag Panel Structures in Chapter 4. The following excerpt from the "Hane Dane Story" reminds me of myself:

> "As an artist and woodworker, he's always had an affinity for geometrical shapes and especially the geometric construction of spheres, whether using fabric or wood."

Photo from https://www.facebook.com/452373822180321/photos/a.452380642179639/690989614985406/.

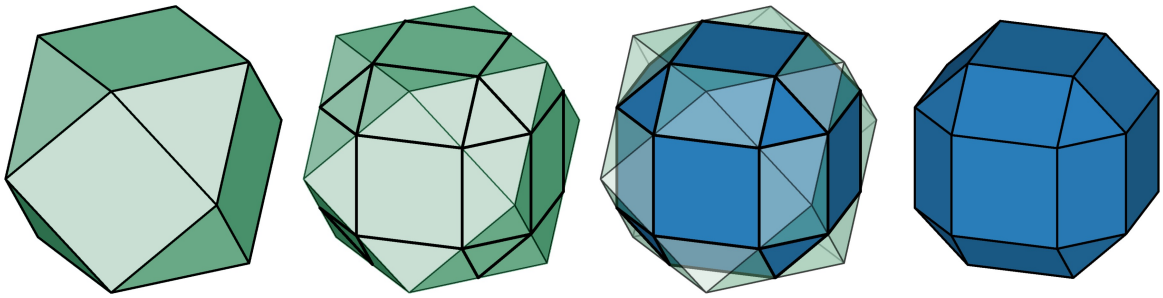
About the Rhombicuboctahedron

The Rhombicuboctahedron is an Archimedean solid and is the dual of the 24-face Deltoidal Icositetrahedron (I have an instructional chapter on that structure), meaning that where this solid has a face, the other has a vertex aligned with its center. The triangular faces correspond to the three-way vertices and the square faces correspond to the four-way vertices. The two solids are shown below, oriented so as to display their relationship to each other.



The Rhombicuboctahedron (left) and Deltoidal Icositetrahedron (right) are duals of each other.

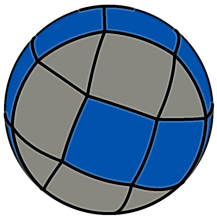
This shape is similar to a rectified (fully truncated) cuboctahedron, but rectifying a cuboctahedron forms rectangular faces at each vertex in addition to square and triangular faces at each of the cuboctahedron's faces as shown below.



Rectification (truncation to the center of each edge) of a cuboctahedron

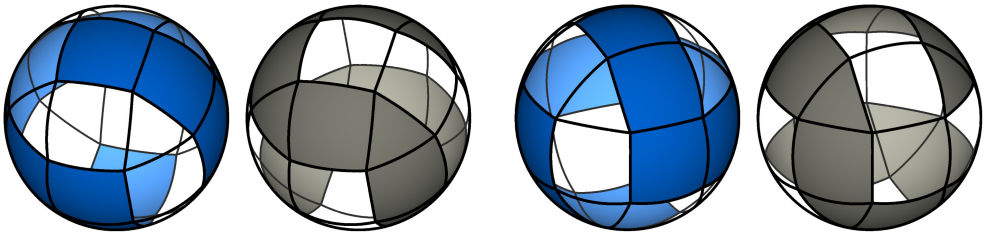
Meandering Circuit color arrangement mistake

I made a mistake when I created the diagrams for the Meandering Circuit color arrangement. The arrangement was based on the photo on the right from HaneDaneFootbags.com (I added the labels). My original, erroneous version was what is now version b, shown in the diagram to the right of the photo. Somehow, during the process of studying the photo, extrapolating what was on the reverse side, reproducing the arrangement with thumbtacks on my all-white beanbag, and drawing the illustrations, I omitted panel A from the blue path and added panel B. When extrapolated to the rest of the ball, this changed the blue path from a complete circuit to one with two ends on opposite sides of the ball, and merged the two S-shaped gray paths into a single path.



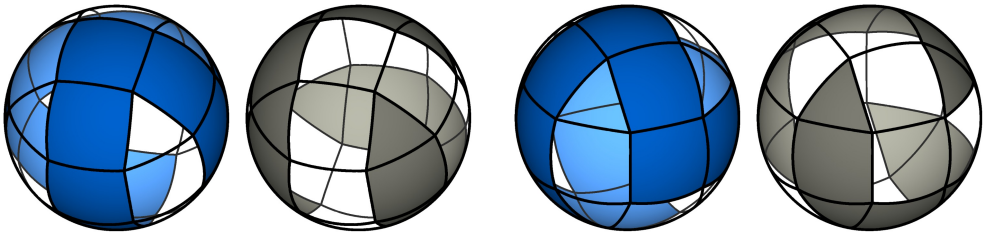
It was not until a few weeks later (but still before I had published this chapter) that I happened to be looking at the photo and realized my mistake. But my mistake had created a good arrangement – like a dual intertwining maze. So I kept it, but created new illustrations for the corrected version. Below are the transparent views I made of the two arrangements. View 1 is rolled back away from our perspective in relation to the perspectives above.

Incorrect
(double-ended blue path and single gray path)



View 1: Blue path | View 1: Gray path | View 2: Blue path | View 2: Gray path

Correct
(continuous blue path and two S-shaped gray paths)



View 1: Blue circuit | View 1: Gray paths | View 2: Blue circuit | View 2: Gray paths

I derived the Orthogonal Stripes/Baseball Curve arrangement from those two arrangements, and I prefer it to those two. I made my second corduroy ball using my 3-color variation of that arrangement.

Capturing and editing the photos

I improved the technique I developed for the previous designs of capturing high dynamic range photos of the beanbags. Because the different colors of panels reflect differing amounts of light, it is not possible in some cases to capture a single image that properly exposes all panels. My black, white, and red beanbag has both extremes of albedo as well as the red in the middle. So for my photos I used three different exposures and extracted panels from each photo to produce the final image. Appendix III shows my method.

Conclusion

This design turned out to be a very simple and easy one, which I was glad of because I have been too tired and depressed to do the kind of intensive design, trial-and-error, and mathematics work I did for the other designs. The color arrangements section grew much more than I ever expected. That part is easy and fun, though.

In all, this chapter took 48 days to create; I am submitting it today, June 19th. I was out of town for about three weeks of that, though, during which I had no access to my sewing supplies, so that delayed me (I was able to make a lot of edits to the chapter and create some illustrations during that time, though). I needed to make a second corduroy beanbag to get the adjustment factor for my ready-to-print patterns and pattern measurement tables. My first bag (the black, white, and red one) had a much higher than expected adjustment factor (3.881% – 9.614%), which I think was due to the white and red panels being made with store-bought corduroy that had a looser weave than my other colors which I got from slacks, and to the white corduroy being thicker than the others. The size may also have been influenced by my use of stencil-type templates which I had adjusted for stitching inside the lines. I made the second bag using exterior templates as I had for all but the 32-panel design. I wanted the sizing to be consistent with my other designs. My second bag had an inflated size much nearer to the other designs, with an inflation factor of 1.510% – 5.995%.

I enjoyed creating this chapter and I am very pleased with my illustrations and beanbag photos. It gave me a month and a half of fun distraction and satisfaction, and I will probably be tweaking it, and my new Appendix III, for quite a while.

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