The Complete Homemade Juggling Beanbag Guide

30-Panel Isovertex Rhombic Triacontahedron Chapter

Small file size version (150dpi images)

By Joshua Clifton
Contact me on Reddit under Joshuacliftojm
or at juggle@joshuaclifton.com

Published 8/18/2022

Last edited 9/17/2024

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.

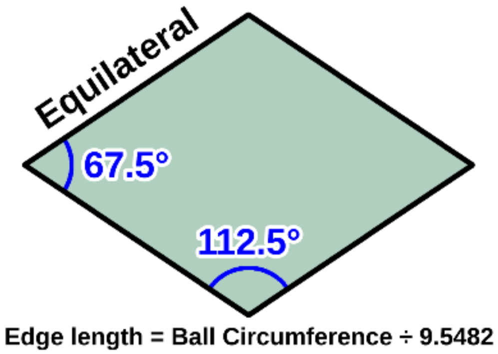
If this guide is useful to you, please **consider donating at my website** linked on the left. I am not monetizing the guide, and I am in need of income.

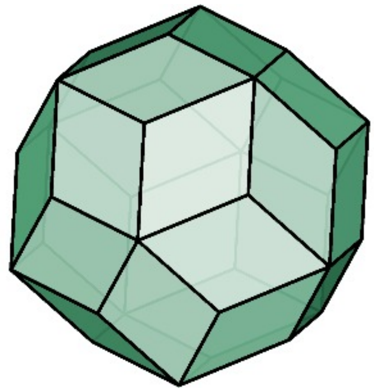
My website also provides blank **color arrangement diagrams** for experimenting with new arrangements in an image editor.

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.

30-PANEL ISOVERTEX RHOMBIC TRIACONTAHEDRON INSTRUCTIONS





“Tet Net” arrangement

My design testing fabric ball

Chapter Index

Design Notes

I was inspired to add this design to my guide in May, 2022 by the lovely footbag shown on the left by Hane Dane Craft (edit: the website where I found them, hanedanefootbags.com, no longer exists, but many of Petersen's footbags are displayed on his [Facebook page]). The Rhombic Triacontahedron is a beautiful shape composed entirely of rhombi (diamonds) meeting at twenty 3-way vertices and twelve 5-way vertices (each vertex type is illustrated on the right).

This design is very versatile in the color arrangements it supports, and is simpler and easier to make than the 26 or 32-panel designs because it has only one panel shape and one edge length, and because its structure allows for a very simple assembly method. I much prefer making this design to those.

The only (minor) drawback is that 5-way vertices can be a bit crowded and difficult to work with when using a thick and fluffy fabric like felt. The corduroy was fine.

I designed my own rhombus that produces a much better sphere than the normal one by forming 3-way and 5-way polyhedral vertices that have equal sums of angles (see the "How I Developed This Design" section for more information), for which I coined the term "isovertex". It does not fit together into a polyhedron without bending, though, so my polyhedron illustrations are not accurate representations of the shape that my pattern produces, but are true rhombic triacontahedra.

I do also provide patterns and sizing calculations for the normal rhombus at the end of the chapter. That rhombus has the interesting property of the ratio of the long diagonal to the short being equal to the Golden Ratio.

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 or Protractor, 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 Pattern

Back to Chapter Index

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, pre-calculated pattern measurements, and instructions for drawing the pattern yourself. Click the hyperlinks or look to the Chapter Index to locate those sections. At the end of the chapter there are ready-to-print patterns for normal rhombus (the one for the true rhombic triacontahedron).

Color Arrangements

Back to Chapter Index

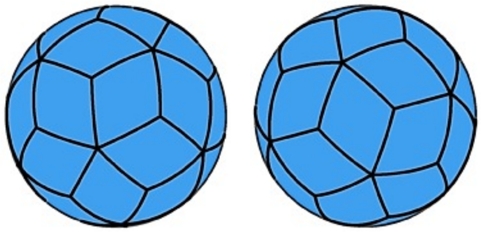
Following are color arrangement ideas, grouped by the number of colors they use. I copied #22, #24, #25, #36, and #38 from footbags by Hane Dane Craft[3] The rest (except for the Patchwork Ball) are mine, or are derived from those ideas. I am rather proud of my Tet Net arrangement. I made my corduroy beanbag with that arrangement and it's a great look.

To help me figure out the arrangements and create my diagrams, I stuck colored thumbtacks into an all-white 30-panel beanbag 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 the bags.

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

3 The original website, hanedanefootbags.com, no longer exists, but many of Allan Petersen's footbags are displayed at https://www.facebook.com/profile.php?id=100054375258284.

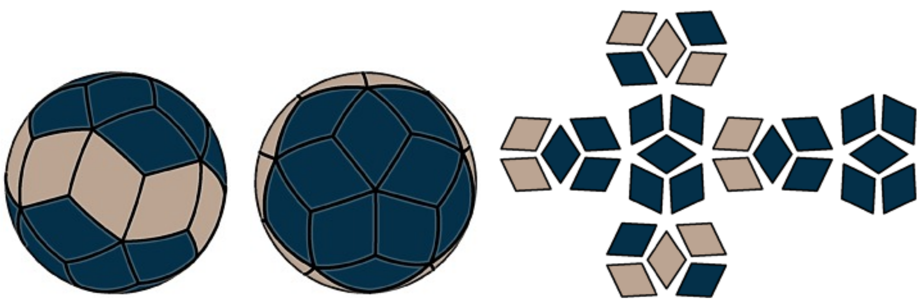
1 color



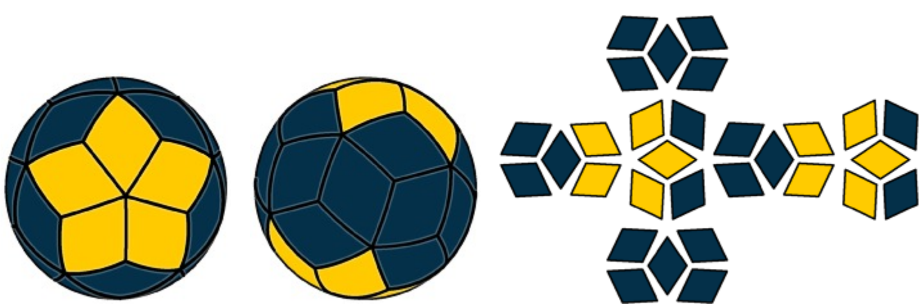
#1: I list this because this design, more than any of the others in my opinion, has an intriguing and mesmerizing seam structure that is fun to gaze at without the distraction of a color pattern. Depending on how you look at it you can see the five-pointed flowers or three-section hexagons, some of which are adjacent to each other and some of which overlap. The three-panel shapes also look like isometric projections of cubes.

2 colors

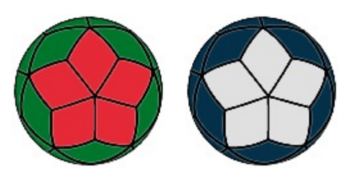
Back to Chapter Index

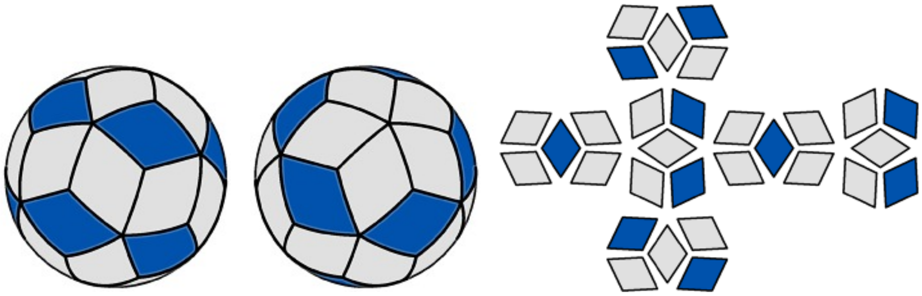


#2: Belt. A wavy ring of 10 panels around the middle between two caps of a second color.

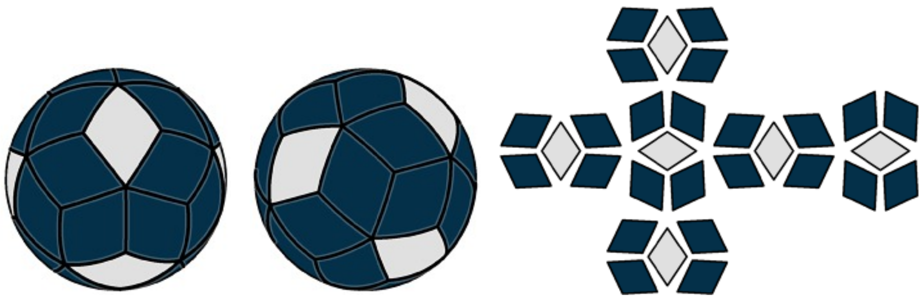


#3: Flower Ball. A five-pointed flower shape on opposite sides of the ball, with a contrasting color on the remaining 20 panels. This arrangement would make a good Christmas ornament with poinsettia or start-in-a-night-sky colors.

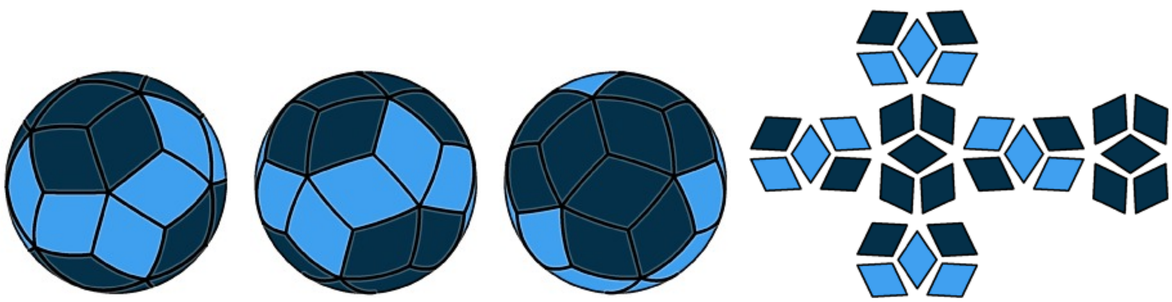




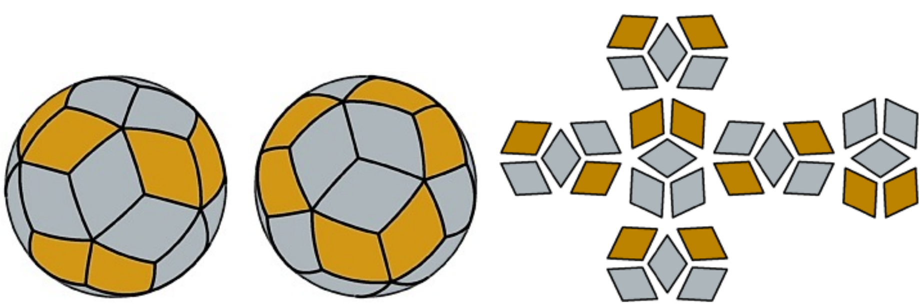
#4: Belt and Flowers. A combination of the above two arrangements. A belt around the middle with the five-pointed “flower” in each cap assigned the same color as the belt, creating checkered rings between the belt and flowers.



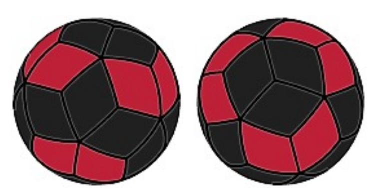
#5: Gems. The center panel of each five-panel patch (each corresponding to a face of a cube) is a contrasting color to the other panels, resulting in six diamonds equally spaced around the ball, each with the same orientation as the one opposite it.

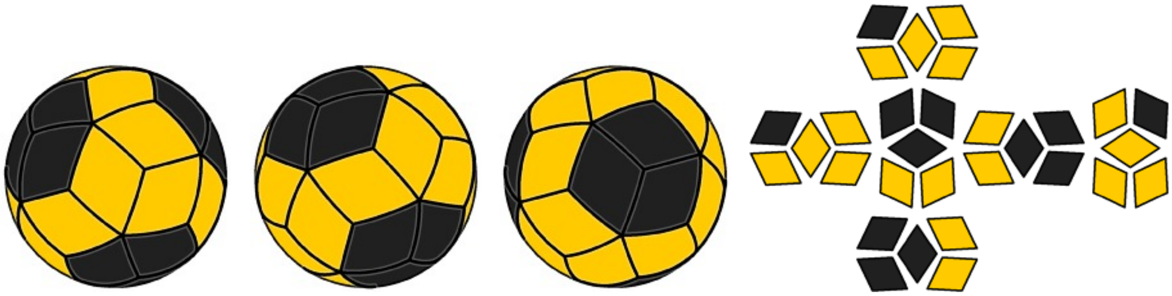


#6: Crown of Thorns. A wreath-like ring around the ball with six panels oriented horizontally and six oriented vertically, three pointing upward and three pointing downward. The remaining panels form a three-lobe patch above and below the crown. On the right is a sharper contrast variation that I also like.

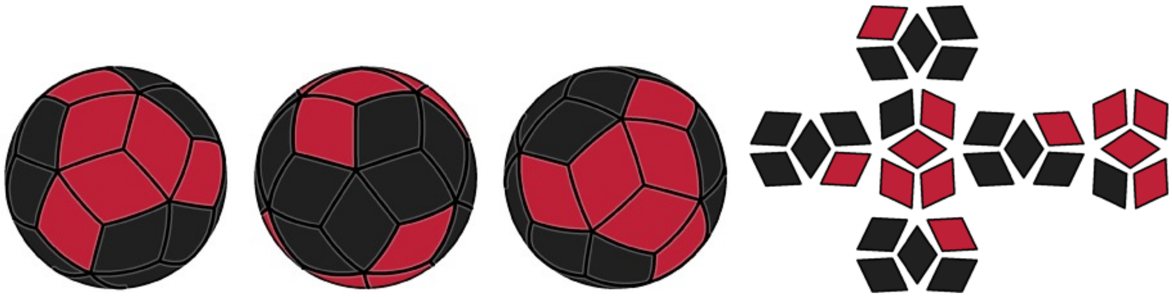


#7: Chevron Rings. Related to the Crown of Thorns arrangement. The three central panels of each tri-lobe shape above and below the crown are assigned the color of the crown, leaving behind two opposing rings of chevron shapes. On the right is a bolder version.





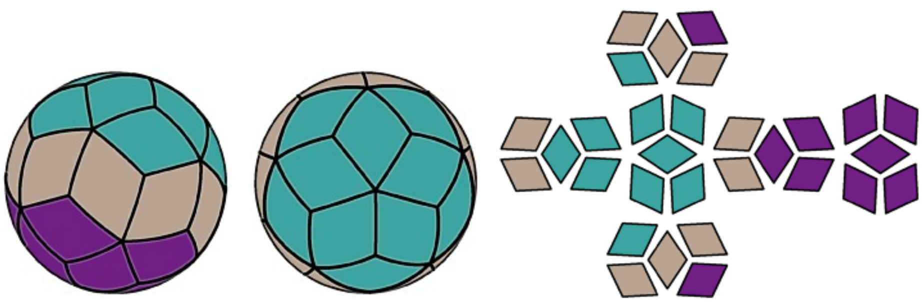
#8: Tet Net. One color on a network of 18 panels roughly corresponding to the edges of a tetrahedron, with a three-panel patch where each tetrahedral vertex would be. The other color on the remaining panels forming four, isolated, 3-panel patches equally spaced around the ball, corresponding to the faces of a tetrahedron. I am proud of this arrangement, and the corduroy ball I made looks great!



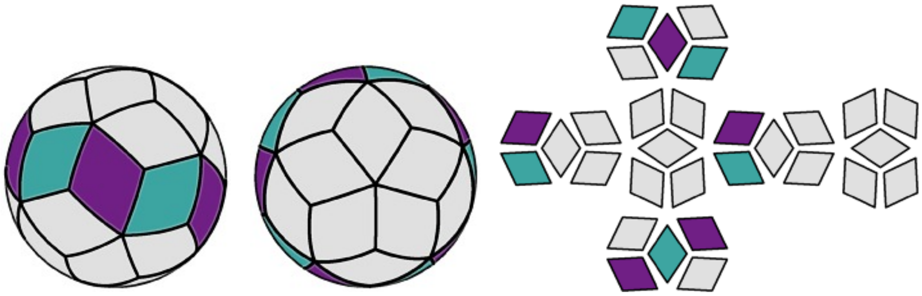
#9: Shredder. A pair of three-toothed saw blade shapes, each opposite the other. The blades are mirror images of each other. When rotated on the blades' axis, the teeth point in the same direction (middle illustration), but when facing each one, the teeth of one will point clockwise and the other counter-clockwise as shown by the first and third illustrations.

3 colors

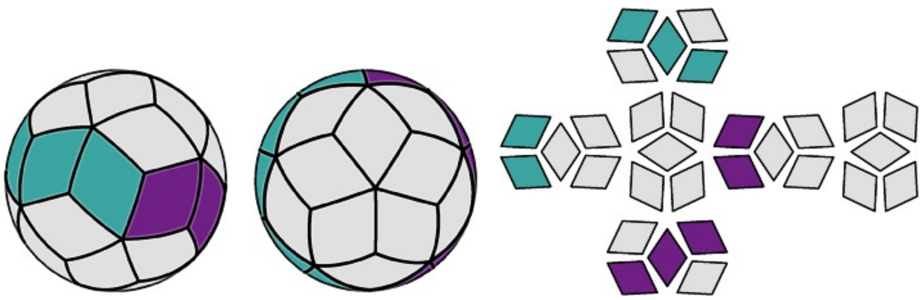
Back to Chapter Index



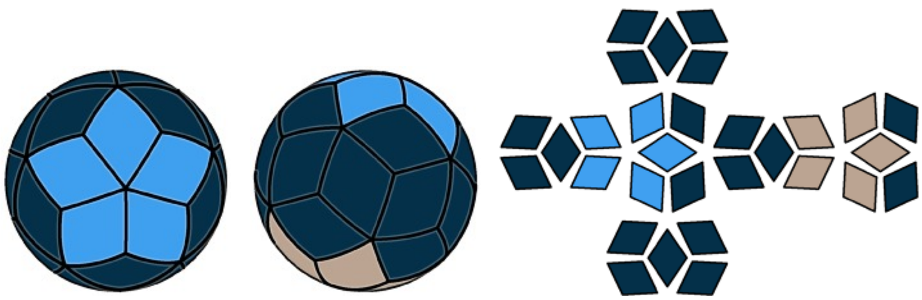
#10: Belt with Dual Caps. Same as the 2-color Belt arrangement but each cap above and below the belt is a unique color.



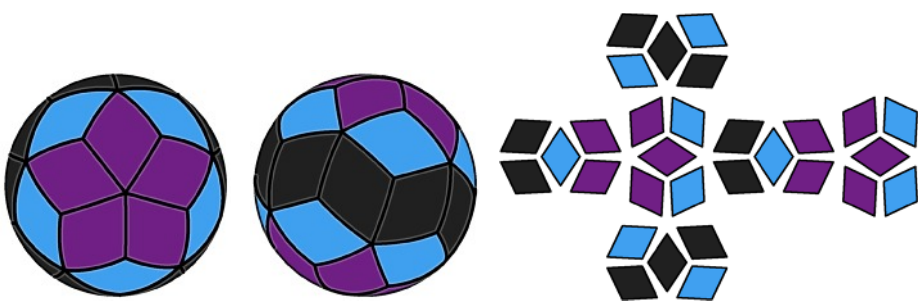
#11a: Bi-Color Belt Type A. Same as the 2-color Belt arrangement, but the belt consists of two alternating colors (5 panels of each color).



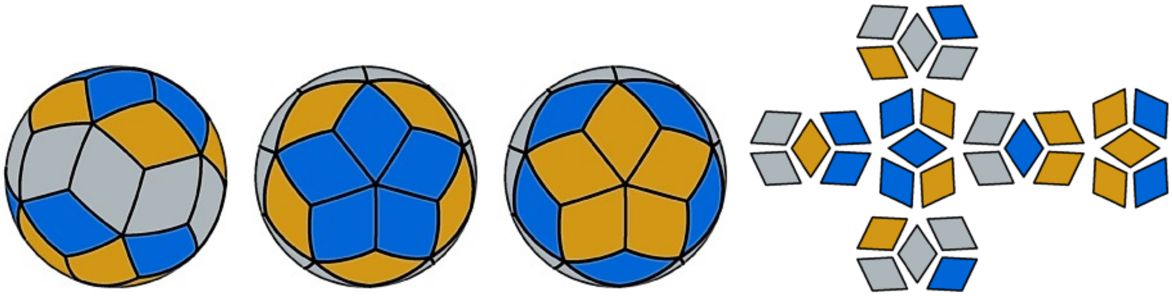
#11b: Bi-Color Belt Type B. In this variation of the above arrangement, each belt color is on five consecutive panels, forming a half-and-half belt.



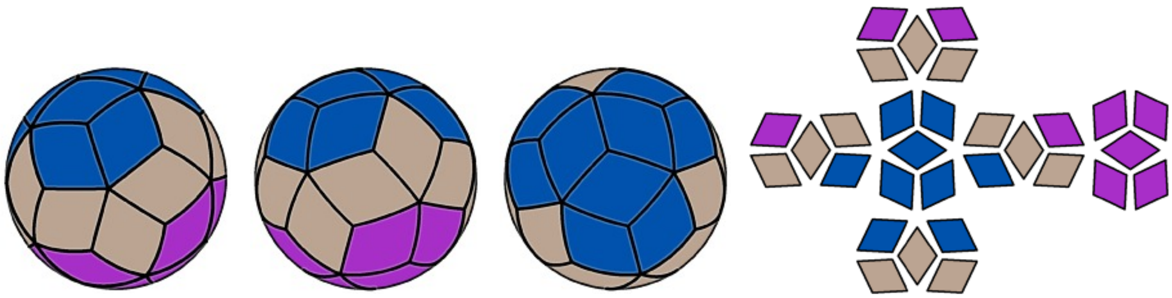
#12: Dual Flowers. Same as the 2-color Flower Ball arrangement, but each flower is a unique color.



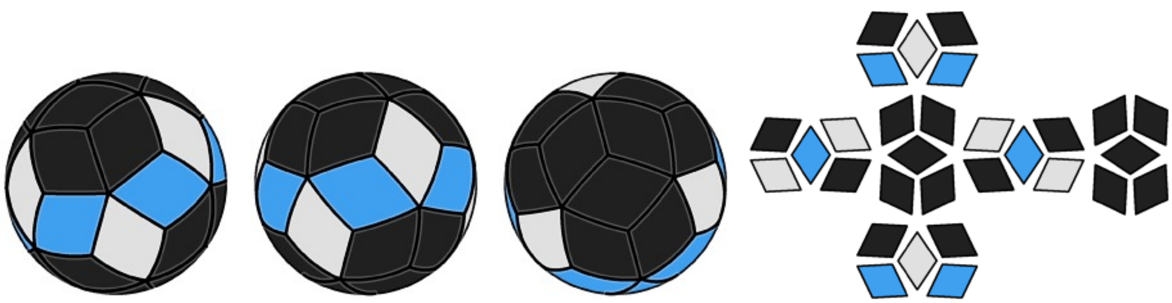
#13a: Flowers with Leaves. Similar to the Flower arrangements, but the five panels surrounding each flower are assigned a third color.



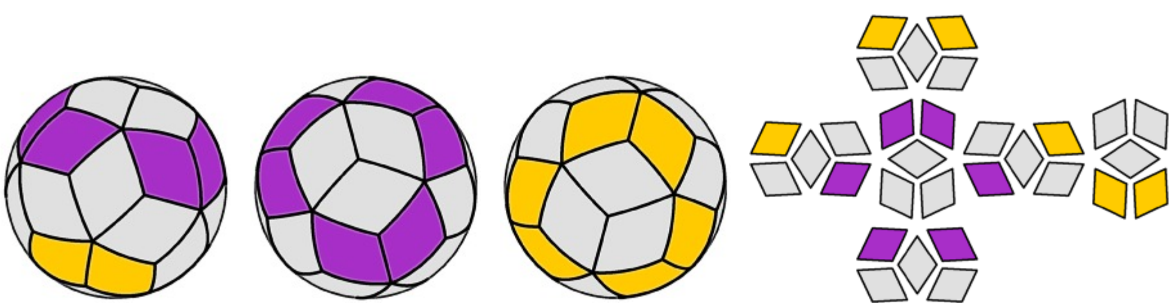
#13b: Reverse Flowers with Leaves. Same as the Flowers with Leaves arrangement, but the colors of the flowers and leaves are reversed on the other side of the ball, creating alternating colors from one flower to the other.



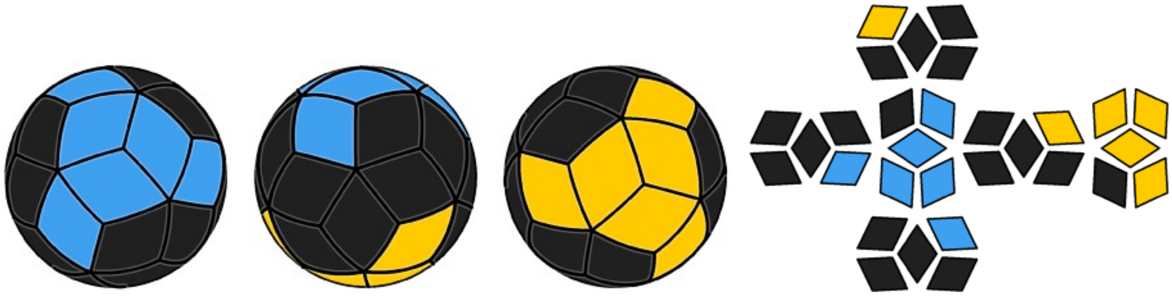
#14: Crown of Thorns with Dual Caps. Same as the 2-color Crown of Thorns, but each three-lobe patch is a unique color.



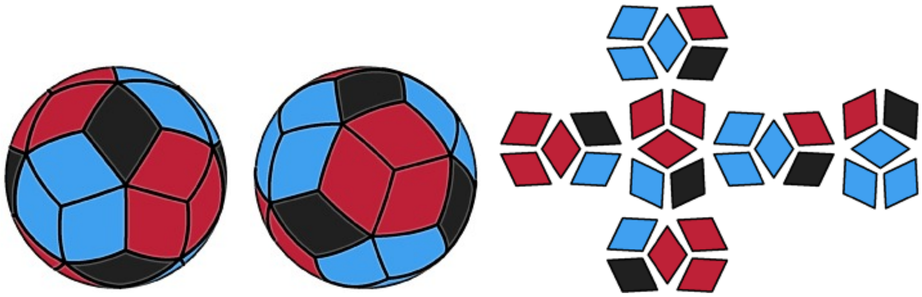
#15: Bi-Color Crown of Thorns. Same as the 2-color Crown of Thorns, but the six vertical panels are assigned a different color from the six horizontals.



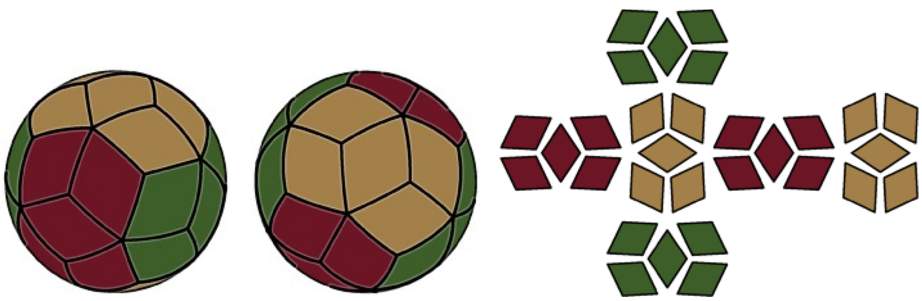
#16: Dual Chevron Rings. Related to the Crown of Thorns with Dual Caps arrangement. The three central panels of each tri-lobe shape above and below the crown are assigned the color of the crown, leaving behind two opposing rings of chevron shapes, each ring a unique color.



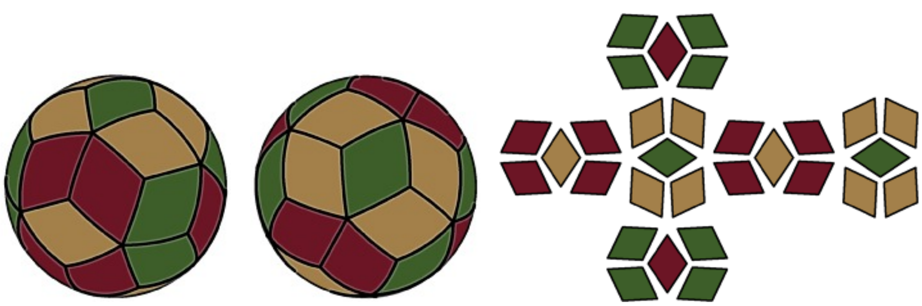
#17: Dual Shredder. Same as the 2-color Shredder arrangement except that each blade is a different color.



#18: Octa-Patch. Eight 3-panel patches arranged like the faces of an octahedron, and alternating between two colors. The six panels between the patches (corresponding to the octahedron's vertices or the faces of a cube) are a third color.



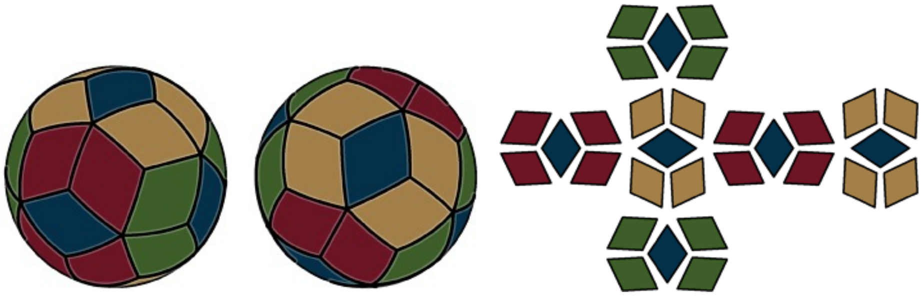
#19: Cube/Volleyball. Each of the three colors is on a pair of opposite 5-panel patches, forming an approximate cube or volleyball appearance. To enhance the volleyball appearance when using a fabric with stripes or cords, follow the second pattern orientation in the Making the Panels section.



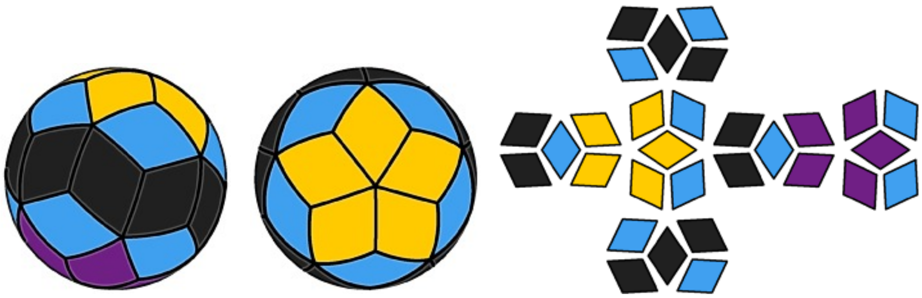
#20: Cube with Exchanged Centers. Same as the Cube arrangement, but the center panel of each 5-panel patch is assigned the color of the pair of patches connecting to the convex edges so that the center panels are isolated from the other panels of the same color.

4 colors

Back to Chapter Index

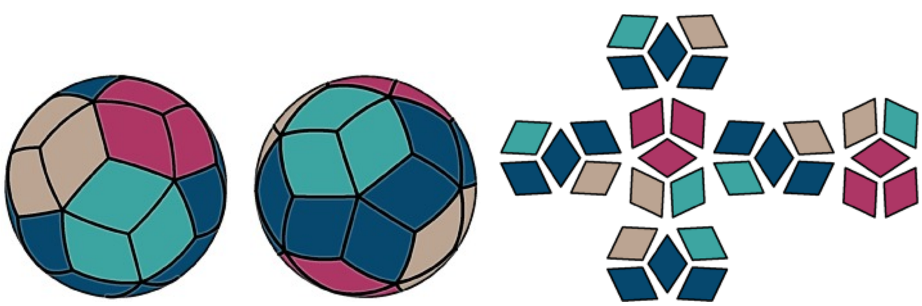


#21: Cube with Gems. Same as the 3-color Cube arrangement but the center panel of each 5-panel patch is assigned a fourth color, forming a gem in each cube face.

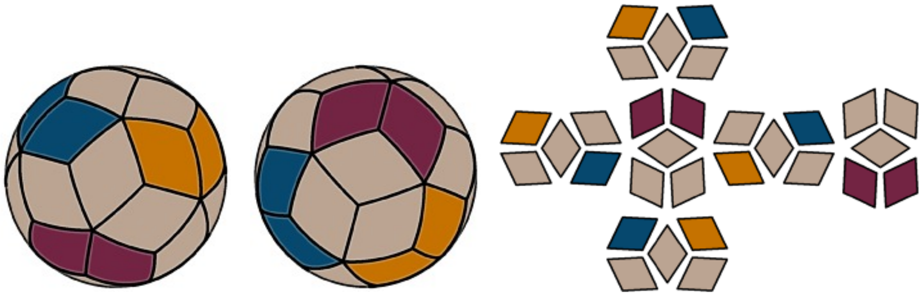


#22: Dual Flowers with Leaves. Same as the 3-color Flowers with Leaves arrangement, but each flower is a different color.

#23: Tri-Color Gems. Same as the 2-color Gems arrangement, but each of the three pairs of opposing gems is a unique color.



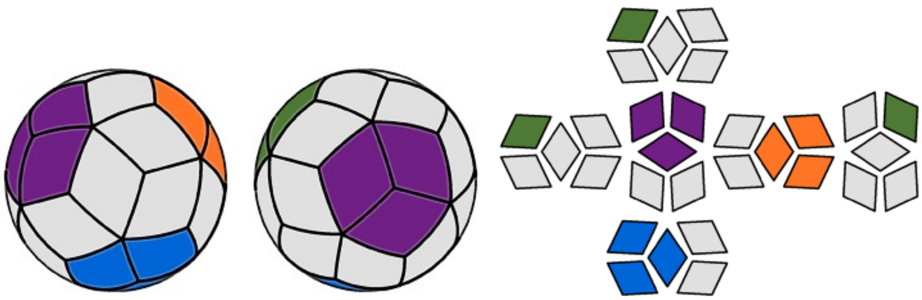
#24: Tri-Leaf. Two triplets of 3-panel patches on opposite sides of the ball, each patch, or "leaf", a different color, with a matching patch directly opposite it. The sequence of leaf colors is the reverse of the one on the other side of the ball. (That is, if the sequence is defined in a clockwise direction on one side, it will be in a counter-clockwise direction on the other side.)



#25: Chevrons. Related to the Tri-Leaf arrangement, this can be produced by changing the three central panels of each tri-leaf formation to the background color, leaving only the leaves' three outer edges colored. These produce two opposing rings of chevrons. Each chevron color is opposite its match. The sequence of chevron colors is the reverse of the one on the other side of the ball. (That is, if the sequence is defined in a clockwise direction on one side, it will be in a counter-clockwise direction on the other side.)

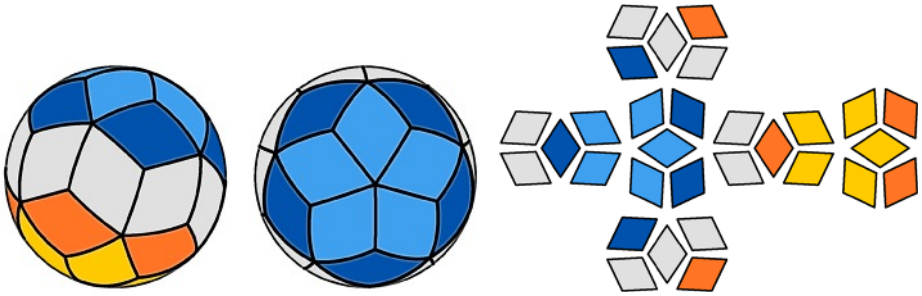
5 colors

Back to Chapter Index

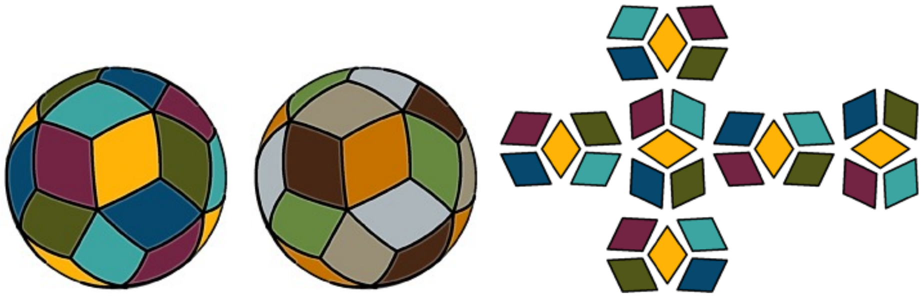


#26: Tetra-Patch (or Tet Net, 5-color variation). Same as the 2-color Tet Net arrangement, but each of the four 3-panel patches is a unique color. The patches correspond to the faces of a tetrahedron and are surrounded by an 18-panel network roughly corresponding to the edges and vertices of the tetrahedron.

#27: Octa-Patch (five-color variation). Same as the 3-color Octa-Patch arrangement, but the 3-panel patches are now in four colors, each color on opposite sides of the ball so that no patch touches its match and all colors are visible at any angle.



#28: Dual Flowers with Leaves (five-color variation). Same as the 4-color Dual Flowers with Leaves arrangement, but each flower and leaves design uses a unique pair of colors.

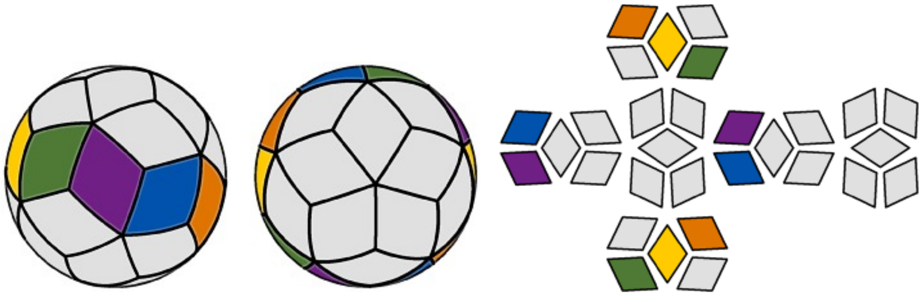


#29: Patchwork Ball. (I created both a bold version and an earthtone version.) Each color on six panels corresponding to the faces of a cube, meaning that each color is positioned so that it is on three pairs of opposite panels, evenly spaced around the surface of the ball. If you look at the 4-color Cube with Gems arrangement, you will see how three pairs of five-panel patches are arranged as the faces of a cube, with the center panel of each patch assigned a fourth color. The Patchwork arrangement puts all five colors on each patch, and if you think of each color as the center of its own five-panel patch, it would be positioned as the "gem" panels are, or as the orange panels are in my assembly layout diagram above.

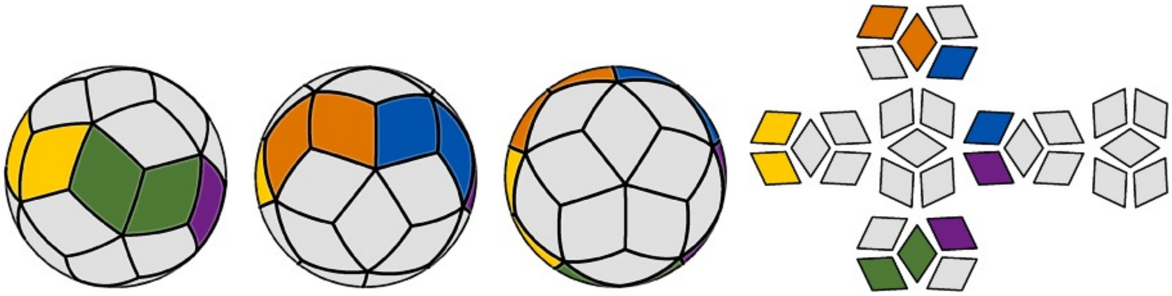
On the right is an actual cloth ball that uses an elegant version of this same arrangement (referred to as "tumbling blocks"). It was this that gave me the idea for this arrangement. (Photo from an article titled "Pieced Balls" at www.personal.psu.edu/axd2/quilt/qlt36.html.)

6 colors

Back to Chapter Index

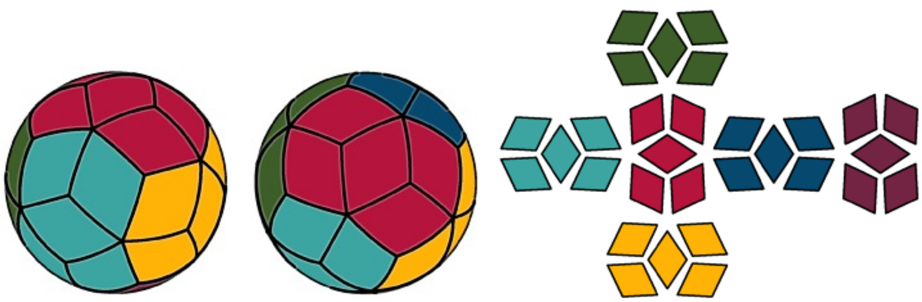


#30a: Penta-Color Belt Type A. Same as the 2-color Belt arrangement, but the belt consists of a sequence of five colors that repeats once. Each color is opposite its match.

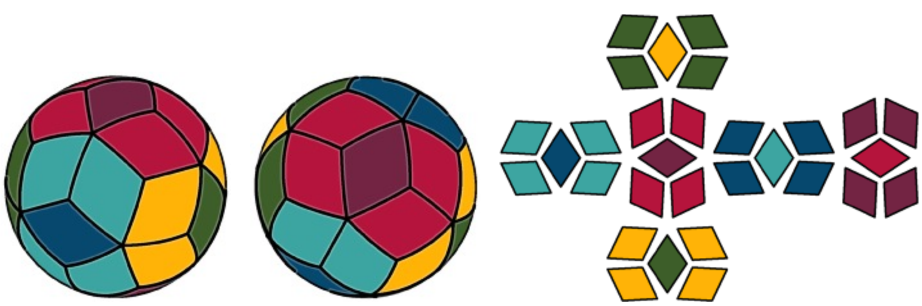


#30b: Penta-Color Belt Type B. In this variation of the above arrangement, each belt color is on a pair of adjacent panels (the sequence does not repeat in this case).

#31: Rainbow Flowers. Same as the 2-color Flower Ball arrangement, but each flower is composed of a sequence of five colors. The sequence on each flower is the reverse of the other so that each color is opposite its match. (That is, if the sequence is defined in a clockwise direction on one side, it will be in a counter-clockwise direction on the other side.)



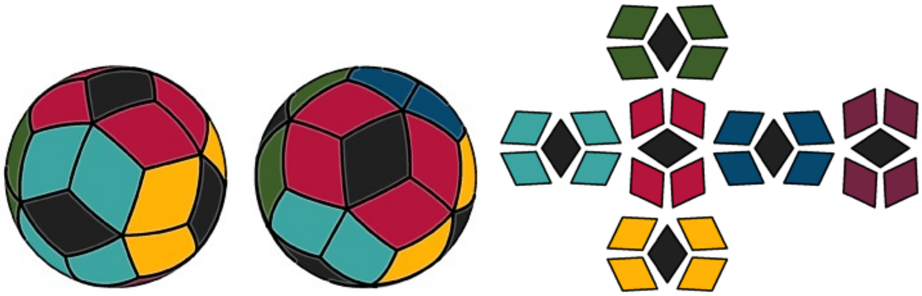
#32: Cube/Volleyball (six-color variation). Same as the 3-color Cube/Volleyball arrangement, but each 5-panel patch is a unique color.



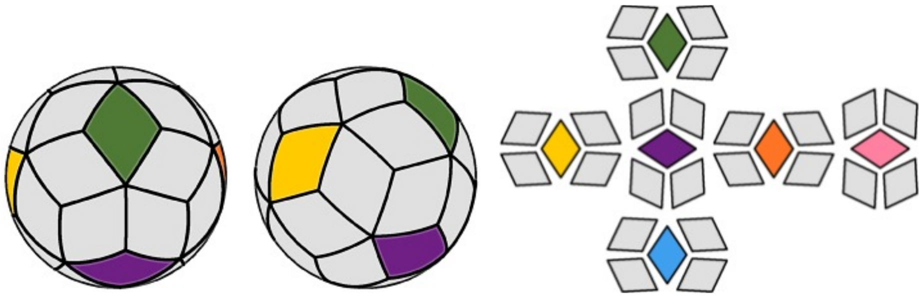
#33: Cube with Exchanged Centers (six-color variation). Same as the 3-color Cube with Exchanged Centers arrangement, but each 5-panel patch is a unique color, and the center panel is assigned the color of the opposite patch (you could also assign it the color of a patch connecting to one of the convex edges as in the 3-color version).

7 colors

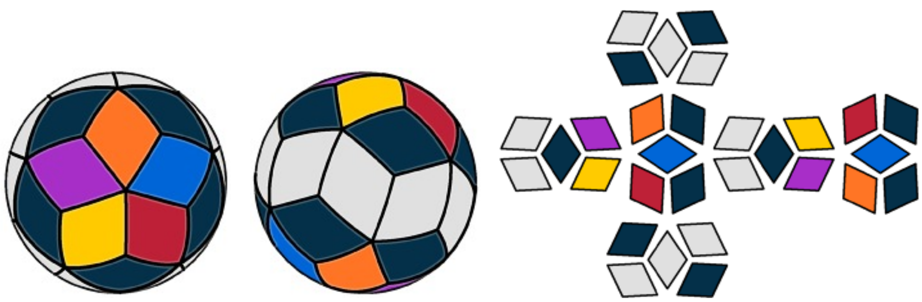
Back to Chapter Index



#34: Cube with Gems (seven-color variation). Same as the 4-color Cube with Gems arrangement, but each 5-panel patch is a unique color, with a seventh color in the center of each patch.

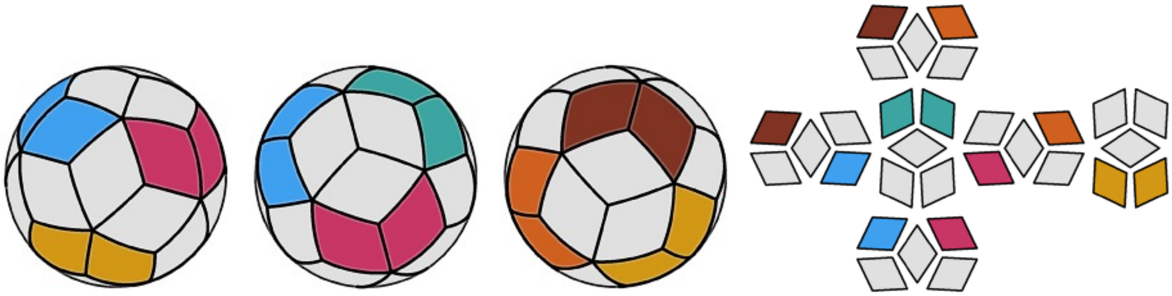


#35: Hexa-Color Gems. Same as the 2-color Gems arrangement but each gem is a unique color.



#36: Rainbow Flowers with Leaves. Same as the 3-color Flower with Leaves arrangement, but each flower is a sequence of five colors. The sequence of colors on each flower is the reverse of the other so that each color is opposite its match. (That is, if the sequence is defined in a clockwise direction on one side, it will be in a counter-clockwise direction on the other side.)

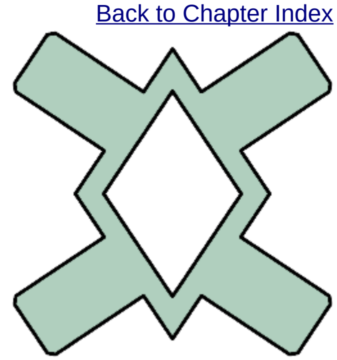
#37: Dual Tri-Leaf. Same as the 4-color Tri-Leaf arrangement, but each triplet of "leaves" (three-panel patches) has a unique trio of colors.



#38: Chevrons (7-color variation). Related to the Dual Tri-Leaf arrangement, this can be produced by changing the three central panels of each tri-leaf formation to the background color, leaving only the leaves' three outer edges colored. These produce two opposing rings of chevrons. Each chevron is a unique color.

Cutting Out the Templates

Back to Chapter Index



Because this design has so many panels, **I recommend making a combo type template as shown on the right,** or at least a stencil (interior) type (if you don't use a cutting template). 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 pattern 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 are the best tools 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 template's interior slightly outside the lines, shifting the edges outward by the width of the marker lines. Then the edges of the pattern it produces 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

Back to Chapter Index

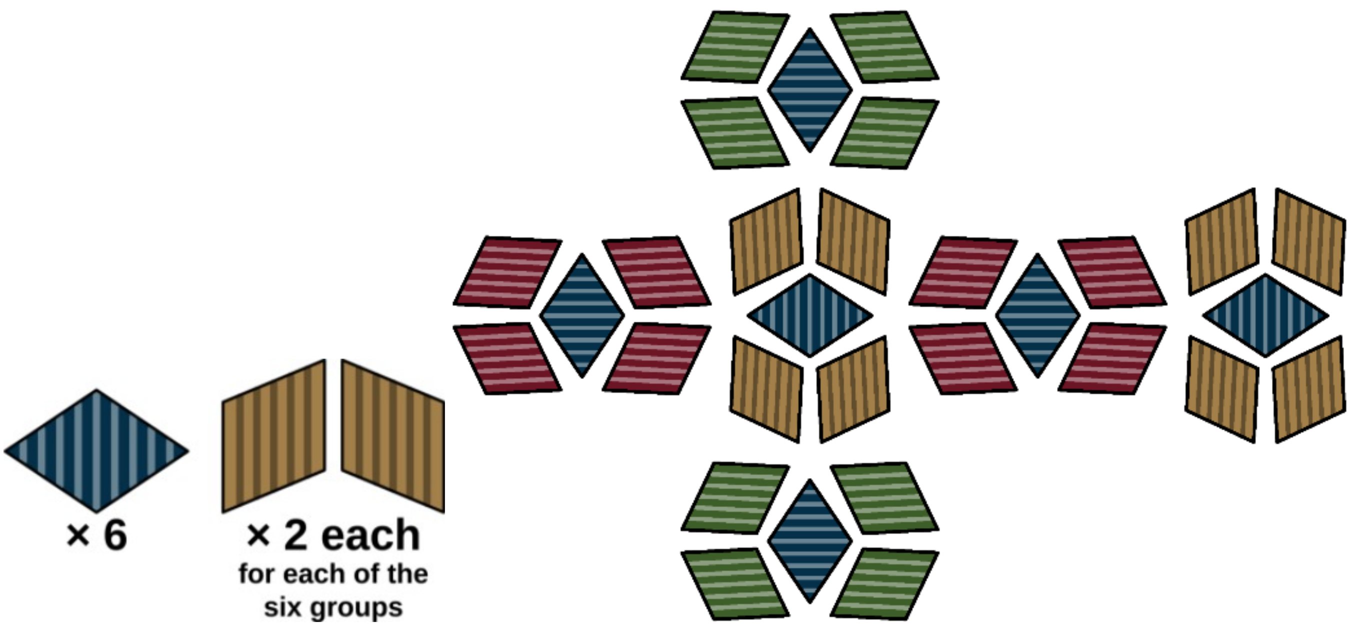
Note that if you are using a separate stitching and cutting template and they are not translucent, you must be careful which pattern, cutting or stitching, you trace first so that the **second template doesn't hide the lines of the first** and prevent you from aligning the two. **Do not necessarily use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

1. You will need 30 panels, and **you will be tracing the patterns onto the back of the fabric (the side that will be inside the bag)**. If you use a cutting template, first trace that. If you are using a combo type like the one illustrated above, trace the inside and outside of it and skip Step 2.

   If you are using something like **corduroy, denim, or a striped fabric, or other woven fabric**, **There are two good options for orienting the panels to the lines or grain of the fabric.**

   a. You can **orient all the panels in the same way, with the lines or grain of the fabric running from corner to corner for a uniform pattern on the ball** (I orient the grainline along the long diagonal). For a fabric lacking stripes or cords, you might as well do this as it is simpler, and option b will not produce much visual effect.

   b. You can **orient the panels as shown below to produce a volleyball-style pattern on the ball.** This would work well with color arrangements resembling a cube, such as my "Cube with Gems" shown on the right. The center panel of each five-panel group (the blue ones in the illustrations) has the cords oriented across the short diagonal, and the four panels surrounding it have the cords oriented parallel to a pair of edges (half of these must be a mirror image of the other half). **This results in all cords/stripes on each group being parallel**, and the six groups are oriented as the three-panel patches are on a volleyball[4][5].

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

3. Cut out the panels.

4 Thanks to Uri Yurman for this idea.

5 Volleyball image source: https://www.pngitem.com/middle/TowJo_volleyball-png-transparent-png/.

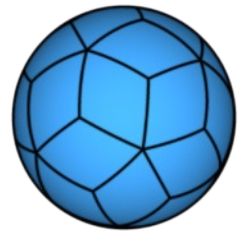
Assembly

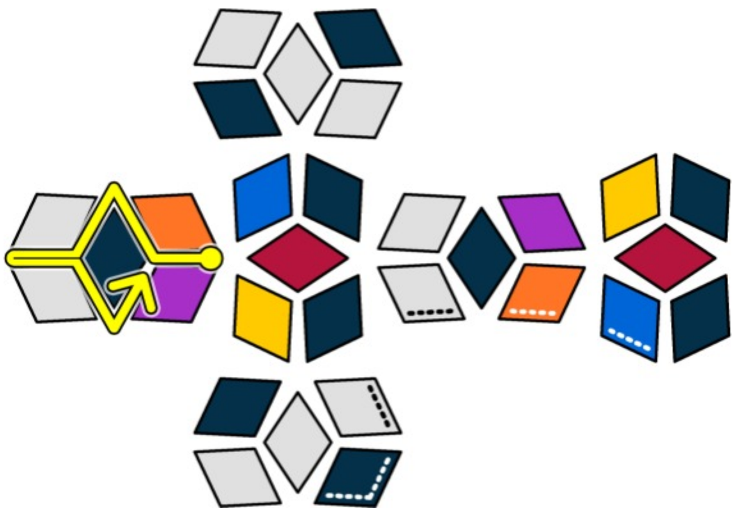
Back to Chapter Index

Following is a method of assembling the panels I developed. I have made several balls using this method and it really **makes this structure simple and easy to assemble. The method has two stages.** Stage 1 is to form six five-panel patches. Stage 2 is to assemble the patches into a ball as you would a cube, following the numbered stitching pathways in the second diagram.

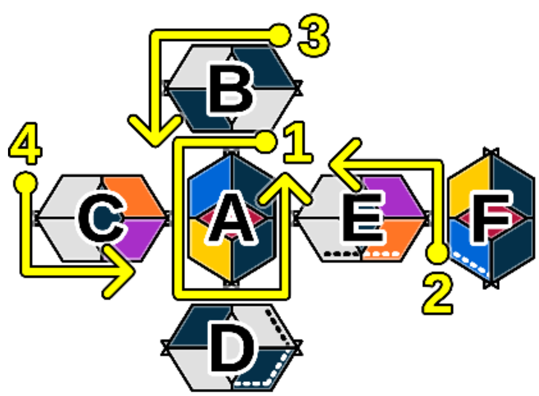
I am right-handed and so the diagrams are oriented for stitching toward the left. In case you are left-handed or prefer the opposite orientation, **I included left-handed diagrams below the instructions.** To convert this layout to the left-handed one, simply rotate your layout of panels 180° before drawing the front patterns.

Helpful Hints: Remember that when placing panels together to sew them, or when any pair of panels are folded together along their joined seam, they should match up corner to corner, edge to edge. Each type of corner, acute and obtuse, will join only to others of its type. The sharp corners point into 5-way vertices and the blunt corners point into 3-way vertices.





Stage 1: Arrange the panels, draw the front stitching patterns, and sew each group of five panels into a patch.



Stage 2: Sew the patches together like a cube, following the numbered stitching pathways.

1. ***Stage 1:*** **Lay the panels out as shown above** (I prefer to place them front face up) and **arrange them according to your color pattern**.

2. Use the stitching template to **draw stitching lines on the *fronts*** of the six panel edges shown with dashed lines in the diagrams. 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 or flexible fabric and don't need such a large opening, just skip marking the outer-most pair or two of panels.) 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. **Sew each group of five panels together** as shown by the yellow arrow on the left-most group. Place two panels **front faces together**, sew along the edge from the acute corner to the obtuse corner. Then add the middle panel and the subsequent panels. The stitching path requires double-stitching the opposite seam from the one you started with so you can continue around the middle panel.

   If you are using the backstitch, you can make the duplicate stitches up to twice as long without causing the fabric to ripple as long as you're careful how tightly you pull them (if you pucker the fabric, wiggle it straight again). Tie off the thread and trim it after each patch. Place each finished patch in the original position among the others.

4. ***Stage 2:*** Now **assemble the six patches as you would a cube** design, following the numbered pathways in the second illustration (left-handed stitching pathways are diagrammed below). Place patches A and B **front faces together** and sew them together toward C, then add C and sew it to A.

   When you reach the midpoint of each patch's edge, which are the 5-way vertices, and have to **cross the perpendicular seams**, I recommend referring to the "Stitching Techniques" section of the **General Information and Techniques** chapter and using the second method I describe in the "Closing seam intersections tightly" topic. **In short, make two stitches diagonally across the intersection to form an X, and plan it so the thread ends up in a position from which you can continue sewing the patches together.** The 5-way vertices can open up a bit and look a little sloppy if they are not cinched shut well. This method will make them look perfect, and will pass the thread through the intersection to the other side at the same time.

5. **Continue adding patches in alphabetical order** as in the previous step and sewing them according to the pathways depicted in the diagram. Keep in mind that you can sew the first two paths with one very long thread by reversing the direction of path #2. **Sew the patches front faces together** so the bag will be inside out. At the end you should have an inside-out bag with up to three adjacent, parallel seams open, and these should have stitching lines on the fronts.

   The 5-way vertex on the final seams (the ones with the front stitching lines) can be difficult to close tidily from outside the bag. It will be a little easier to sew the final seams if you can start at the inside corner of A-D-E, closing that one first from inside the bag, and then turn the bag out and continue your stitching after the 5-way vertex from outside the bag. But that will mean you end in the middle of the D-F seam, leaving the second half of the patches' seam unsewn. So I recommend that as you sew path #4, after completing the C-F seam, you stitch into the D-F seam just to the middle to close that seam, then backtrack to continue path #4 into the C-D seam.

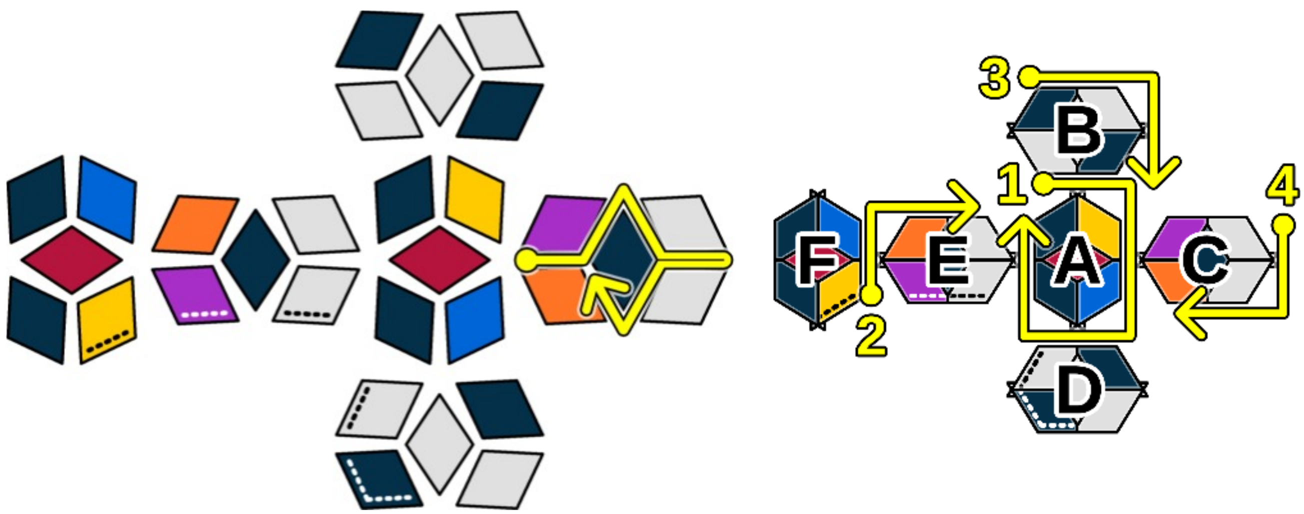
6. Start a new thread and **sew a few starter stitches** at one end of the final seams to make it easier to continue from the outside. If you don't need the entire opening to turn the bag out, continue to sew as much as you don't need. To **reduce the number of stitches you need to make from the outside**, 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**.

7. **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**.

8. **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 diagrams. To convert my assembly layouts to this one, simply rotate the layout of panels 180° and then draw the front stitching patterns in the lower-left quadrant instead of the lower-right.

Back to Chapter Index

Ready-to-Print Patterns for the Isovertex Rhombus

Back to Chapter Index

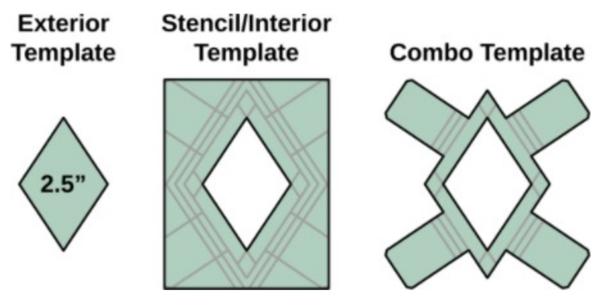
The pattern pages are 8.27″×11″ (210mm×279mm) to fit both “Letter” and “A4” sizes. ***Make sure the print is not being scaled to fit the printer margins*** *(select Default/None scaling/Actual size/Ignore printer margins). To verify correct sizing,* ***compare the centimeter grid to a ruler*** *and adjust 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 my isovertex rhombus which produces a better sphere than the normal rhombus. (The patterns for the normal rhombus shape are at the end of the chapter.) The patterns are for beanbag diameters from 2″ – 3″ in ¼″ increments, and there is a 7″ pattern for scaling to larger sizes. The patterns are reduced by 2.71% 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 103% to get the intended ball size.**

To make the template, I recommend cutting out the portion of the paper with the pattern you want and gluing or taping it to your template material, and then cutting along the pattern.

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.

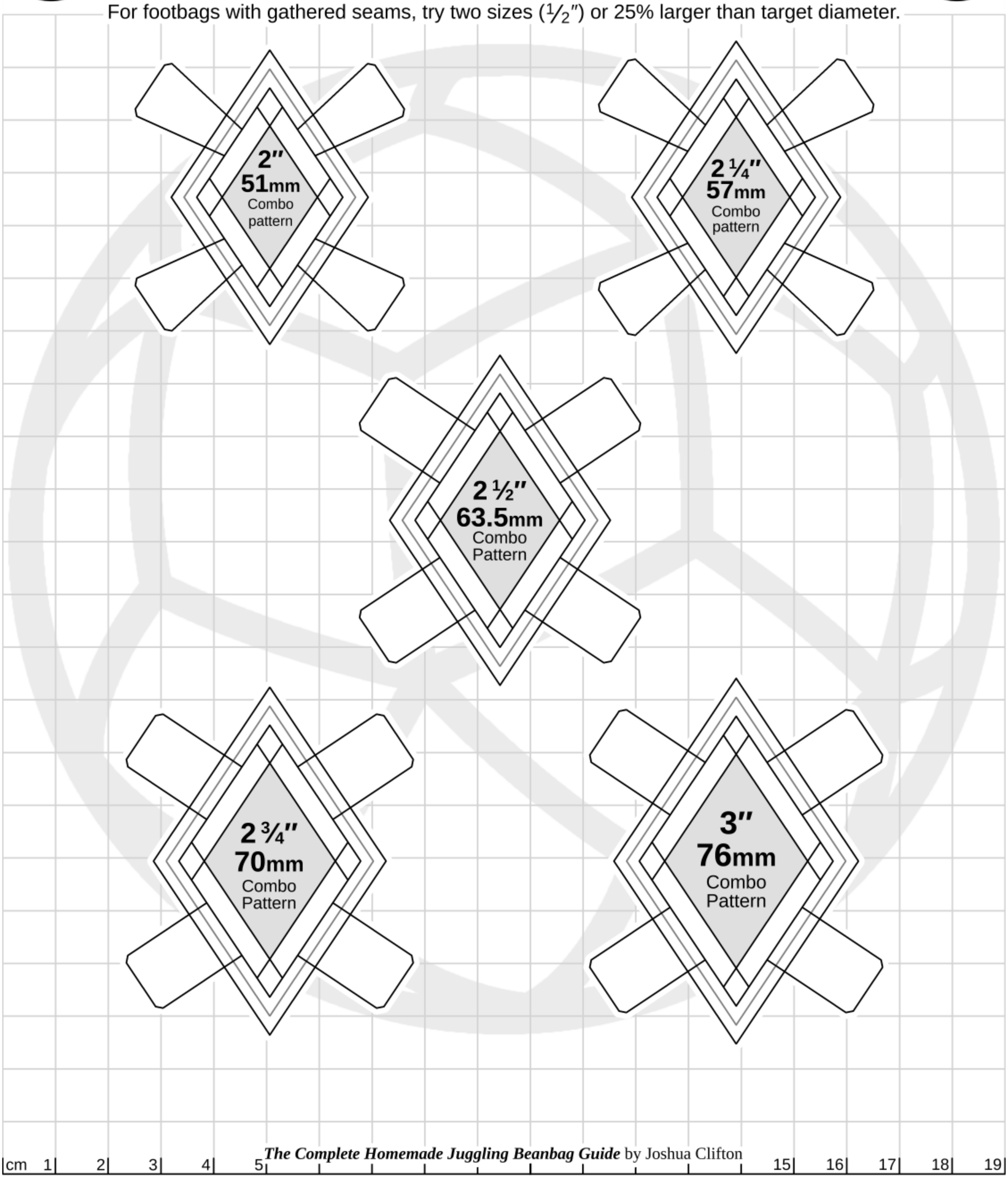
The table below provides the scaling for the ⅛″ increments between my ¼″ sizes. The centimeter grid can be used to verify correct scaling.

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%

Rhombic Triacontahedron (30 panels)

Isovertex rhombus *(produces a better cloth sphere)*

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.

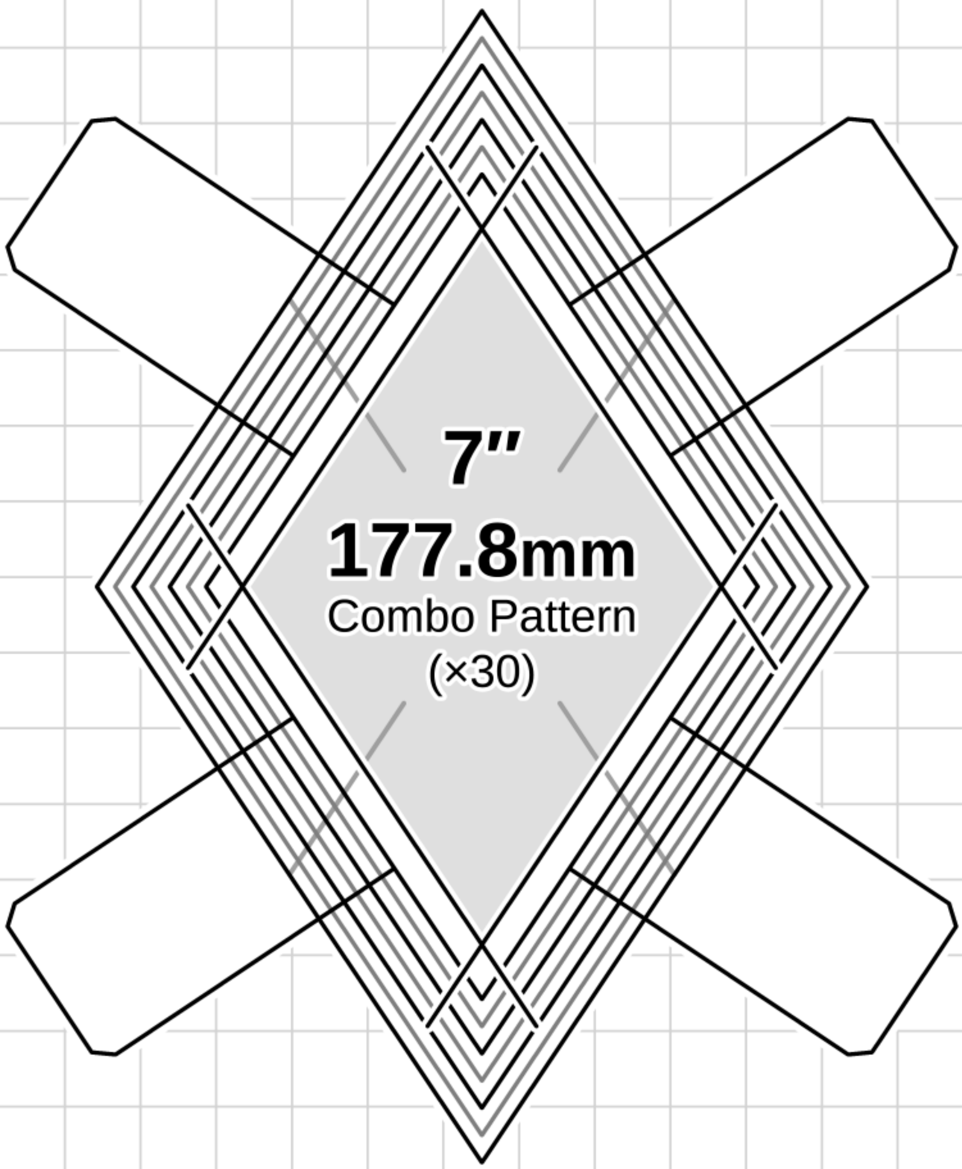


Rhombic Triacontahedron (30 panels)

Isovertex rhombus *(produces a better cloth sphere)*

Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (½″) or 25% larger than target diameter.

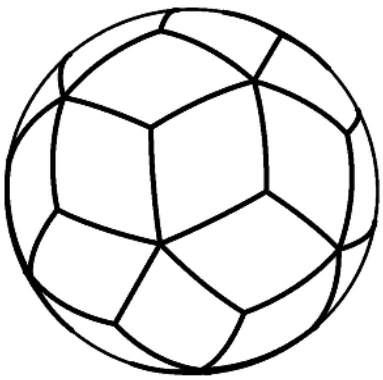
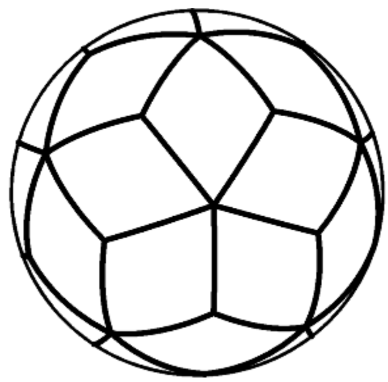
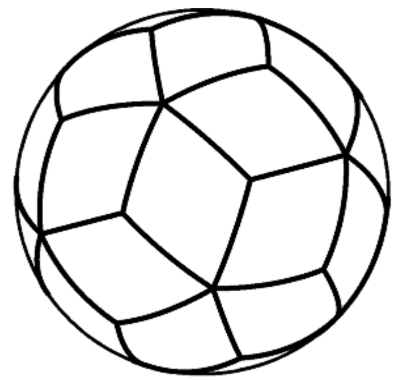
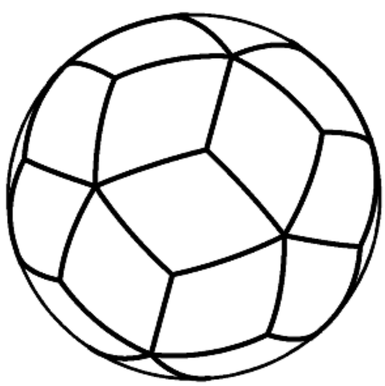
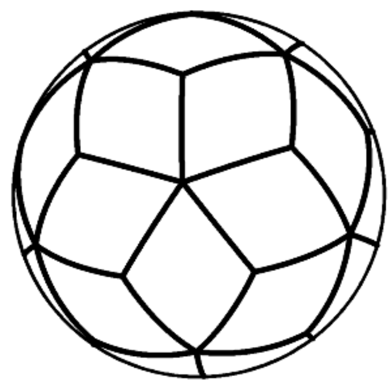
Extra large and versatile pattern for scaling to larger sizes in the Print Dialog. Print twice if you want both a stitching template and a cutting template (or cut out a combo template). The inner pattern (filled with gray) is the stitching pattern. Each dark pattern outside of that marks a 4mm seam 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 template.

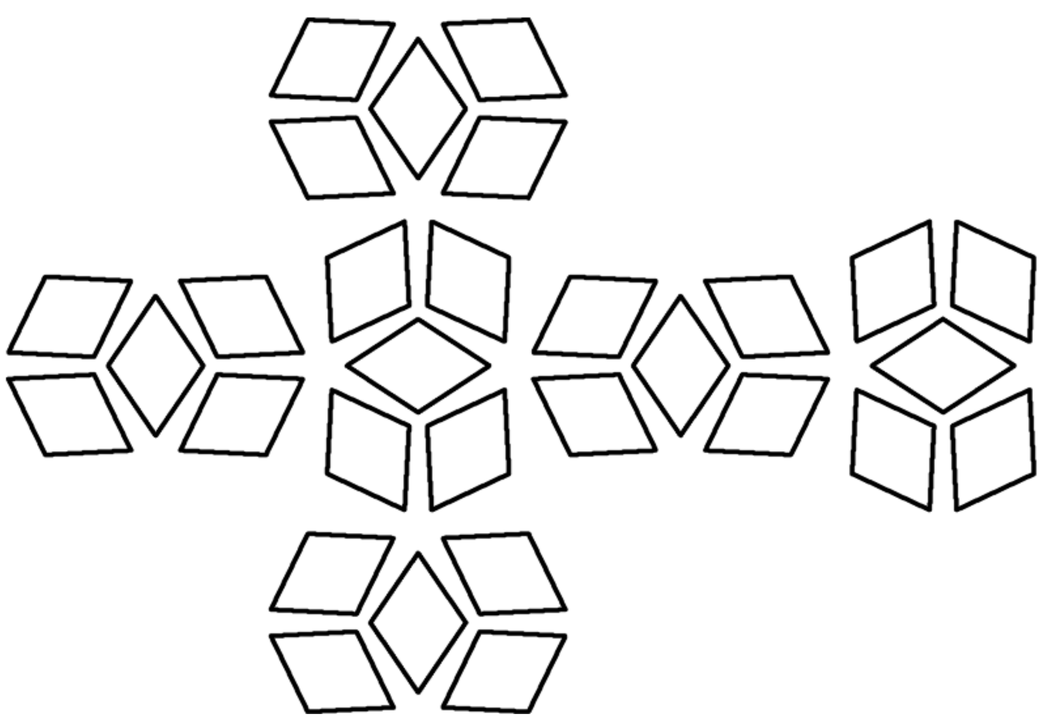


Blank Color Arrangement Diagrams

Back to Chapter Index

These are some of the ball diagrams and the assembly layout diagram 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.



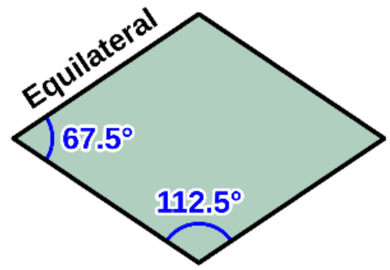
Sizing Formulas for Drawing the Pattern

Back to Chapter Index

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 expresses their values in higher precision.

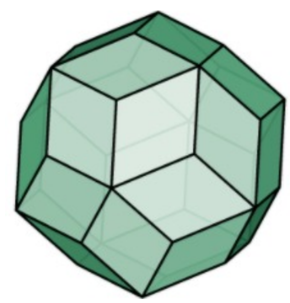
Design summary

On the right is the generic definition of the panel shape. To calculate the pattern size, all that is needed is to calculate the side length, which is equal to the target circumference of the ball divided by 9.5482. All edges are equal.



Edge length = Ball Circumference ÷ 9.5482

Adjusting for the influence of fabric attributes on beanbag size



The bag I made with thick corduroy was 0.773 – 4.655% larger than the mathematical prediction depending on whether I filled it loosely or over-filled it. I target halfway between the min and max inflations when sizing my patterns, which is 2.71%. This makes my adjustment factor **1.0271**.

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), had an average inflation of 0.368% (0.126% when moderately tightly filled). Only slightly larger than the mathematically predicted size. 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 like denim to significantly shrink the bag size unless the fabric has some stretch (denim stretches a little). Folding thin fabric doesn't consume as much of its size, and my design testing fabric is both thin and has no significant stretch, and so ended up almost the exact predicted size, much as denim did in the 24-panel bag. 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, and it stretches about like denim, and so it ends up larger.

Sizing formulas (Isovertex rhombus)

Below are the formulas to calculate the pattern dimensions (*Diameter* and *Circumference* refer to your target ball size, π = 3.1416). The value in orange is the adjustment factor. These calculations are for my isovertex rhombus. If you want to make a ball or cardboard model of the true rhombic triacontahedron, refer to the formulas in the Mathematics section. **Don't forget to multiply the final result by 25.4 if you need to convert inches to millimeters.**

- **Side Length = *Diameter* × *π* ÷ 9.5482 ÷ 1.0271 (≈ *Diameter* × 0.3290 ÷ 1.0271)**
  = *Circumference* ÷ 9.5482 ÷ 1.0271
- **Acute Angle = 67.5°**
- **Obtuse angle = 112.5°**
- **Long Diagonal = *Side Length* × 1.6629**
- For double-checking: **Short Diagonal = *Side Length* × 1.1111**

Table of Pre-Calculated Pattern Measurements

Back to Chapter Index

The table below has stitching pattern measurements for each ⅛″ diameter increment from 1¾″ to 3″. The values in the **Adjusted** columns account for my 1.0271 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 above.

To draw the cutting pattern, increase the Side Length by the desired allowance × 2.1648, increase the Long Diagonal by the allowance × 3.5999, and the Short Diagonal by the allowance × 2.4054. The angles remain the same.

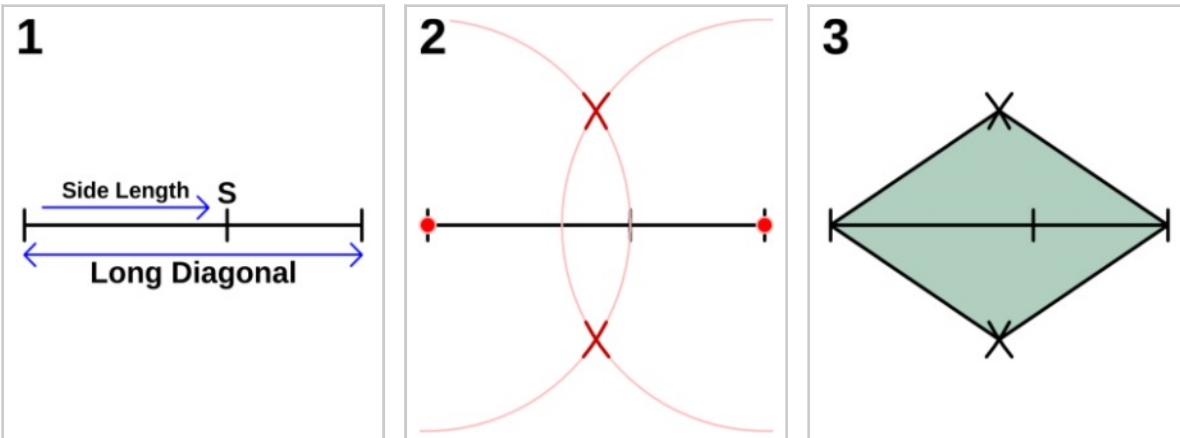
Finished Diameter	**Side Length** (mm)		**Long Diagonal** (mm)		**Short Diagonal** (mm) (for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	14.625	**14.239**	24.321	**23.679**	16.251	**15.822**
1⅞″ (47.6mm)	15.670	**15.256**	26.058	**25.370**	17.411	**16.952**
2″ (50.8mm)	16.715	**16.274**	27.795	**27.062**	18.572	**18.082**
2⅛″ (54.0mm)	17.759	**17.291**	29.532	**28.753**	19.733	**19.212**
2¼″ (57.2mm)	18.804	**18.308**	31.270	**30.445**	20.894	**20.342**
2⅜″ (60.3mm)	19.848	**19.325**	33.007	**32.136**	22.054	**21.473**
2½″ (63.5mm)	20.893	**20.342**	34.744	**33.827**	23.215	**22.603**
2⅝″ (66.7mm)	21.938	**21.359**	36.481	**35.519**	24.376	**23.733**
2¾″ (69.9mm)	22.982	**22.376**	38.218	**37.210**	25.537	**24.863**
2⅞″ (73.0mm)	24.027	**23.393**	39.956	**38.901**	26.698	**25.993**
3″ (76.2mm)	25.072	**24.410**	41.693	**40.593**	27.858	**27.123**

How to Draw the Panel Shape

Back to Chapter Index

The panel shape is a rhombus quadrilateral or diamond. I have provided two methods of drawing it. For hand drawing, I recommend using the compass method which involves drawing a line for the rhombus' long diagonal, and using a compass to draw intersecting arcs that mark the locations of the other two corners. For drawing on a computer, it is simpler to use a protractor tool and measure the angles.

There is a separate set of illustrations for each method. Their numbers correspond to the step numbers. 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.



Manual directions (Compass method)

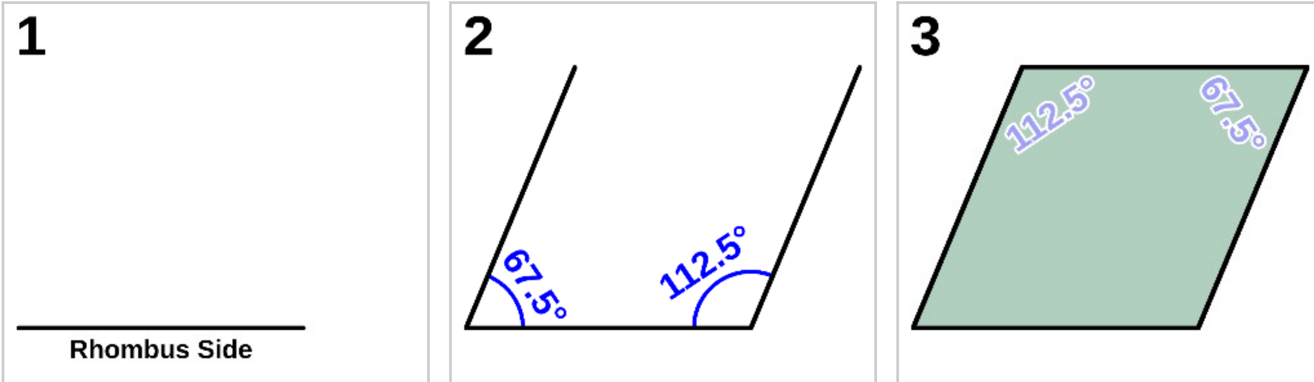
(The terms in bold refer to columns in the pattern measurement table above.

1. Draw a horizontal line the length of **Long Diagonal** and mark each end of it. Then mark a point on it the distance of **Side Length** from one end (labeled S).

2. Place a compass on the end of the line and extend it to point S (so that its radius is equal to **Side Length**) and draw a small arc above and below the line. Position the compass on the other end of the line and draw the same two arcs to form two X-shaped intersections.

3. Draw lines connecting each end of the first line to both of the arc intersections, forming the rhombus shape. To ensure you drew the shape correctly, measure the sides and make sure they are equal, and match the Side Length from the measurement table, and measure the diagonals and compare them to the table values. Any error you make will be compounded many times in the juggling bag, so be as precise as you can.

4. To draw a cutting pattern, multiply the desired allowance by 3.5999 and add that to the **Long Diagonal**, and multiply it by 2.1648 and add that to the **Side Length** length. Or, just draw it around the stitching pattern.



SketchUp directions (Protractor method)

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

1. Draw a line the length of **Side Length**. (If you are drawing this by hand, I recommend marking the ends of each line you draw and then extending it on both ends to aid in accurately aligning a protractor to it.)
2. Use the Protractor tool to measure a 67.5° angle on one end of the line and a 112.5° angle on the other. Draw lines the length of **Side Length** from each end of the first line at the marked angles.
3. Draw the final side connecting the ends of the two previous sides. To ensure you drew the rhombus correctly, make sure the final side matches the length of the other three, and you can measure the diagonals and compare them to the ones in the measurement table. Any error you make will be compounded many times in the juggling bag, so be as precise as you can.
4. To draw a cutting pattern, multiply the desired allowance by 2.1648 and add that to the **Side Length**. Or, just draw the cutting pattern around the stitching pattern, using its edges as guides.

Back to Chapter Index

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

Back to Chapter Index

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.) Note that the polyhedron's faces do not quite match my rhombus shape because my custom rhombus does not actually form a closed polyhedron. The polyhedron shown is the true rhombic triacontahedron.*

Isovertex rhombus calculations (for producing uniform vertices)

There are two ways to calculate the isovertex rhombus angles. I originally used the algebraic method, but I later discovered the weighted average method.

Calculating the Isovertex Rhombus Angles – Algebraic Method

I will define ***a* to be the acute angle** and ***b* to be the other angle**. I will create two equations defining the necessary properties of the angles, perform a substitution, and solve.

$\mathbf{a + b = 180°}$ (property of a rhombus)
$\mathbf{3b = 5a}$ ► $b = \frac{5}{3}a$ (definition of an isovertex rhombus forming 3-way and 5-way vertices)

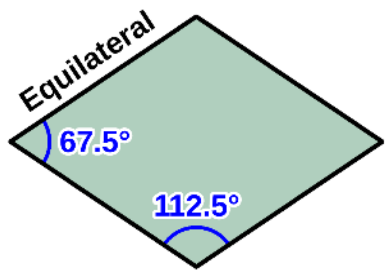
Substitution into the first equation: $a + \frac{5}{3}a = 180°$

Solve: $\frac{8}{3}a = 180°$ ► $a = \frac{3(180°)}{8}$ ► $\mathbf{a = 67.5°}$

So $b = 180° - 67.5° = \mathbf{112.5°}$

So the rhombus' angles are:

Acute Angles = **67.5°**
Obtuse Angles = **112.5°**



Calculating the Isovertex Rhombus Angles – Weighted Average Method

The two vertex sums on the polyhedron are

5-way vertex sum ≈ 317.174744° (5 × 63.434949°) 317.17474411461005324213903139774
3-way vertex sum ≈ 349.695154° (3 × 116.565051°) 349.69515353123396805471658116135

To calculate the count of each vertex type on the polyhedron, take the count of each type of corner on the face (2a and 2b), multiply each by the number of faces (60 each), and divide each by the number meeting at the corresponding vertex type (60a/5 and 60b/3). There are 12 5-way and 20 3-way vertices. So

$$\textbf{Weighted average} \approx \frac{317.174744°(12)+349.695154°(20)}{32} = \mathbf{337.5°}$$

Then simply divide that by 5 to get the acute angle and by 3 to get the obtuse angle.

$$\textbf{Acute angle} = \frac{337.5°}{5} = \mathbf{67.5°} \qquad \textbf{Obtuse angle} = \frac{337.5°}{3} = \mathbf{112.5°}$$

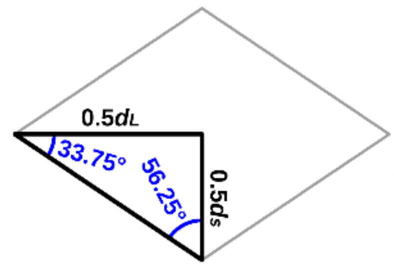
Calculating the polygon circumference in terms of the rhombus' side length

To produce a ball of a desired size, I need to know the relationship between the rhombus side length and the size of the ball it will produce. To do that, I will first calculate the rhombus' diagonals in terms of its side length, since the diagonals are part of the circumference measurement, and then I will express the circumference entirely in terms of the side length.

I will define the following variables to calculate the circumference:

s = side length
d_L = long diagonal
d_s = short diagonal

The diagonals can be calculated in terms of the side length by creating a right triangle that bisects both of the rhombus' angles and applying the trig functions to it:

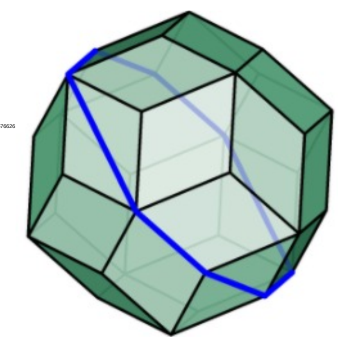


$$\mathbf{d_L} = 2(\sin 56.25°)s = 2(\cos 33.75°)s \approx \mathbf{1.662939s}$$

$$\mathbf{d_s} = 2(\sin 33.75°)s = 2(\cos 56.25°)s \approx \mathbf{1.111140s}$$

1.11114046603920444948556616278971

The circumference is composed of two long diagonals, two short diagonals, and four sides:



$$\textbf{Circumference} = 2d_L + 2d_s + 4s \approx \mathbf{9.548159s}$$

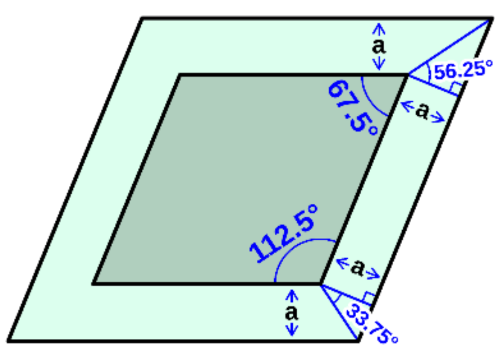
9.54815938128858984728647676626

Solving for the side length:

$$s \approx \frac{\textit{Circumference}}{9.548159} \approx \textit{Circumference}(0.104732)$$

Cutting pattern calculations

To draw the cutting pattern directly (rather than using the stitching pattern as a guide), and make it perfect, more trigonometry is needed. In the diagram and formulas below, a is the seam allowance.



$$\textbf{Side Length Increase} = (\tan 56.25° + \tan 33.75°)a \approx \mathbf{2.164784a}$$

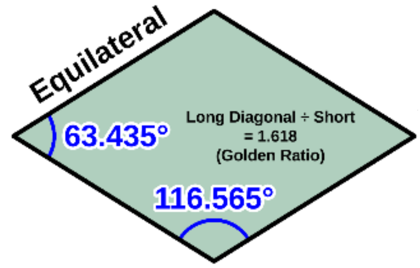
$$\textbf{Long Diagonal Increase} = 2\frac{1}{\cos 56.25°}a \approx \mathbf{3.599905a}$$

3.5999048925456628185540381637676

$$\textbf{Short Diagonal Increase} = 2\frac{1}{\cos 33.75°}a \approx \mathbf{2.405380a}$$

2.4053795477401811221748872956369

Normal rhombus calculations



On the right is the generic definition of the normal rhombus panel shape. In this rhombus, the ratio of the long diagonal to the short is equal to the golden ratio.

The rhombus' angles are:

Acute Angles = arctan2 ≈ **63.434949°**
Obtuse Angles = 180° – arctan2 ≈ **116.565051°**

116.56505117707798935157219372045

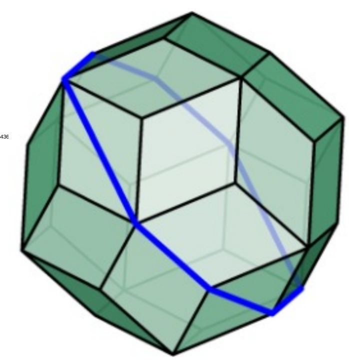
I will define the following variables to calculate the circumference:

s = side length
d_L = long diagonal
d_s = short diagonal

The diagonals can be calculated in terms of the side length by creating a right triangle that bisects both of the rhombus' angles (see the illustration on the previous page) and applying the trig functions to it:

$\boldsymbol{d_L} \approx 2(\sin 58.282526°)s \approx 2(\cos 31.717474°)s \approx \mathbf{1.701302}\boldsymbol{s}$ 1.701301616704079864363080994126

$\boldsymbol{d_s} \approx 2(\sin 31.717474°)s \approx 2(\cos 58.282526°)s \approx \mathbf{1.051462}\boldsymbol{s}$ 1.0514622242382672120513381696958



The circumference is composed of two long diagonals, two short diagonals, and four sides:

Circumference = $2d_L + 2d_s + 4s \approx \mathbf{9.505528}\boldsymbol{s}$ 9.5055276818846941528288383276436

Cutting pattern calculations

I have not illustrated this for the normal rhombus, but the illustration for the modified one will make this easier to understand.

Side Length Increase ≈ $(\tan 58.282526° + \tan 31.717474°)a \approx \mathbf{2.236068}\boldsymbol{a}$ 2.2360679774997896964091736687312

Long Diagonal Increase ≈ $2\dfrac{1}{\cos 58.282526°}a \approx \mathbf{3.804226}\boldsymbol{a}$ 3.8042260651806142884657573335174

Short Diagonal Increase ≈ $2\dfrac{1}{\cos 31.717474°}a \approx \mathbf{2.351141}\boldsymbol{a}$ 2.3511410091698925166748238185563

Back to Chapter Index

How I Developed This Design

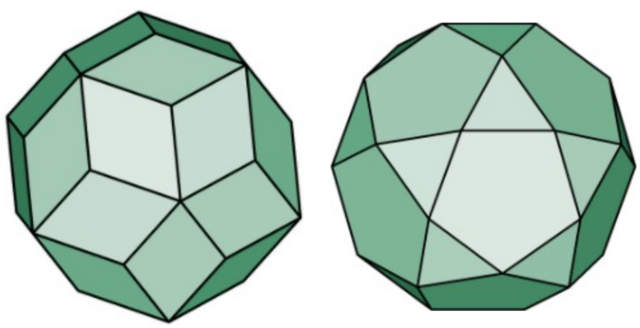
Back to Chapter Index

Footbags by Hane Dane Craft. Photos from: https://www.facebook.com/profile.php?id=100054375258284

Discovering and developing the design

During my research for the 26-panel Rhombicuboctahedron chapter in May, 2021, **I discovered Allan Petersen of Hane Dane Craft**. His original website, hanedanefootbags.com, was taken down about a year after I discovered it, but sometime during the next year I found a **Facebook page where Petersen had posted photos of many of his footbags** (URL under the photos). There I found the strikingly lovely footbags shown above. **I liked them so much that I decided to add this panel structure to my guide.**

The rhombic triacontahedron is a Catalan solid and is the dual of the 32-face icosidodecahedron. Where the icosidodecahedron has a face, this solid has a vertex. The 3-way vertices correspond to the icosidodecahedron’s twenty triangles and the 5-way vertices correspond to its twelve pentagons. Its face shape, called a rhombus or diamond, has the interesting property of the ratio of the long diagonal to the short being equal to the Golden Ratio.



The Rhombic Triacontahedron (left) and the Icosidodecahedron (right) are duals of each other.

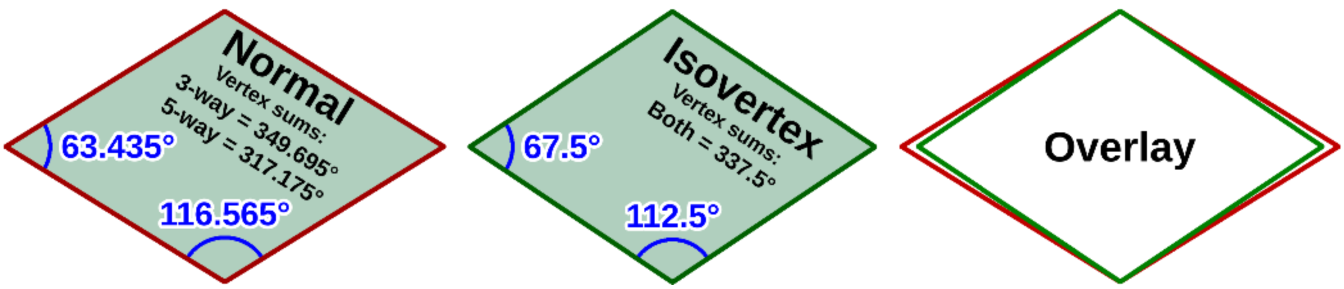
I began working on the design on May 19, 2022 and finished this chapter on August 1 (I also finished most of the Third Edition guide changes during that time). For the first few weeks I was somewhat apathetic about this design and about adding it to my guide. My depression has been bad and so my emotional engagement with any project tends to be low. But it was still enjoyable and I worked on it at a leisurely pace.

I began by making a 2.5″ beanbag with my design testing fabric. **While it made a decent ball, the 5-way vertices protruded outward noticeably, and the panels had slight tension ripples** running parallel to the short diagonal, as if the 5-way vertices were being pulled inward, compressing the panels from acute corner to acute corner, and the 3-way vertices were being pushed outward, putting tension on the panels in the perpendicular direction (as might be anticipated when this shape is inflated into a sphere). I made a larger, 3″ ball, and it was the same. I attempted to show these defects in the photos below.

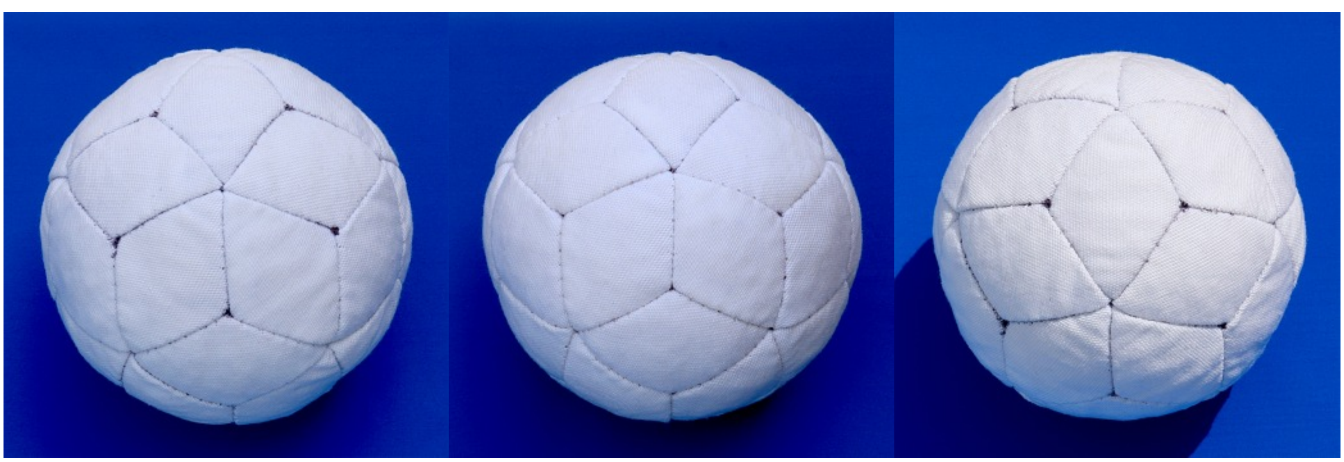
I was willing to live with this at first, but then I decided to try to do what I did for the 24-panel Deltoidal Icositetrahedron and create a custom version of the solid that had more uniform vertices. **The normal shape has 3 × 116.565° = 349.695° vertices and 5 × 63.435° = 317.175° vertices. The 5-way vertices are significantly sharper and farther from the center.**

Using algebra, I calculated that a rhombus with 67.5° and 112.5° angles would create perfectly uniform vertices of 337.5° (which I later discovered is the weighted average of the two vertex sums)**.** When I tried to build a 3D solid out of this face shape in SketchUp, however, I found that it does not fit together. I made a card stock version and while the vertices looked wonderfully uniform, the panels had to bend a bit to fit together. I could not figure out a way to build a modified rhombic triacontahedron around a simpler shape as I did with the 24-panel design, so I had no way to design an improved version with faces that did fit together.

But **I decided to try making a beanbag out of the modified rhombus anyway. To my great delight, it turned out perfect!** The tension seemed to be perfectly balanced with no tension ripples on the panels, and the ball was perfectly spherical with no vertex prominence at all! At that point I began to feel excited about this project. I decided to use the modified rhombus in my guide, but provide patterns for the normal one, as well. I coined the term **"isovertex"** to describe the uniform nature of the vertices produced by my rhombus. The difference between the normal rhombus and my slightly fatter, blunter one is almost imperceptible on the cloth balls.



Rhombus comparison



Left: Protruding 5-way vertices (top vertex displays this best) produced by the normal rhombus. **Middle:** Uniform roundness resulting from the isovertex modification. **Right:** Tension ripples on the normal rhombus beanbag (shown best around the foremost vertex). Most of the panels had these ripples, but they are difficult to capture with the camera. I need the right angular light to make them cast shadows.

Figuring out how to draw the rhombic triacontahedron

I could find no information on how to draw the rhombic triacontahedron, but Wikipedia did provide the dimensions and angles of the rhombus, as well as the dihedral angle of the solid's faces (144°). With that information I was able to clumsily and imprecisely construct the solid in SketchUp by fitting the faces together at that dihedral angle. It was very difficult. My 3D model is mathematically imperfect due to rounding the angles to three decimal places, but the imprecision is insignificant.

Then I needed to draw the spherical version for my title page balls and for the color arrangement diagrams. That presented a new challenge because the method I had always used before (described in Appendix II under “Method 1”), did not seem to work for this shape. When I drew a circle at one of the solid’s edges to create the edge arc, it did not intersect both ends of the edge, or of any edge. It took a few days to figure out why and to be able to articulate it in writing.

In the mean time I invented a new method that worked for this type of solid and added instructions for it in Appendix II. Then, as I tried to figure out exactly why Method 1 did not work so I could explain the problem, I realized that it would actually work, but the implementation of it would need to be different. So I added a note about that in the Method 1 section.

The reason my original method didn’t work as it did for the other solids is that it assumes that all vertices are the same distance from the center of the solid, and they are not in this shape. The same is true of the deltoidal icositetrahedron, but I had drawn that (in 2013) by merely combined a spherical cube and a spherical octahedron.

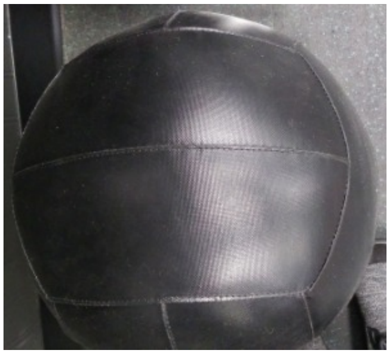
During the days I spent working on the Method 2 illustrations, I discovered that the edge framework I was drawing closely resembled the Brilliant.org logo. So I made a small project out of trying to duplicate their logo. I added a section about that at the end of Appendix II.

Because my modified rhombus does not fit into a closed solid, I could not correctly depict it in my 3D models, and so my illustrations of the polyhedral solid are actually the true rhombic triacontahedron.

Volley Bag derivation

Volley Bag photo from http://www.jugglingstore.com/volley-bag-737.html

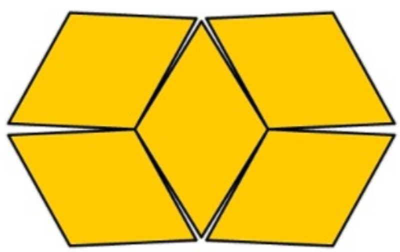
Many years ago I discovered a design called the Volley Bag and showcased it in Chapter 4: “Other Juggling Bag and Footbag Designs”. This design is similar to a volleyball, but with twelve panels instead of eighteen. I wanted to make a ball with this panel structure, but I did not know how to design the panel shape. This year (2022) I found an exercise ball in a gym that had a very similar panel structure and it renewed my interest.



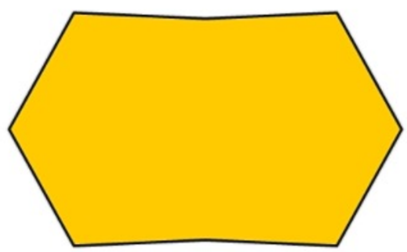
When I first discovered the Volley Bag, I tried deriving the panel shape from a joined pair of pentagons from a dodecahedron by converting the angles into curves and dividing the result down the middle (the dodecahedron has six pairs of pentagons that are positioned similarly to the pairs of panels of the Volley Bag). Then, years later, I theorized that the panel shape could be derived from the circular squares of the spherical cube design by dividing them in half and modifying the curves.

Now I see that they might more easily be derived from the rhombic triacontahedron. The assembly method I developed involves grouping the panels into six groups of five, which are then assembled like the faces of a cube. After learning to see this panel structure this way, I happened to realize that this patch of five rhombi is very similar in shape and relative position to the pairs of panels on the Volley Bag, and it is more nearly that shape than the other two options. I depict below how the panel structures of the cube, dodecahedron, and rhombic triacontahedron bear a correspondence to the Volley Bag structure, and how the patches of rhombi could be morphed into its panel shape. I may eventually experiment with this. Right now I do not know how to design the edge arcs so they form an optimal ball. I just drew rough approximations for the illustrations.

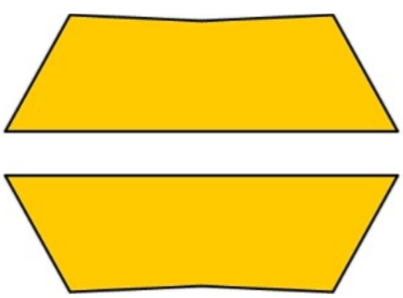
These three panel structures could be used to derive the Volley Bag structure.



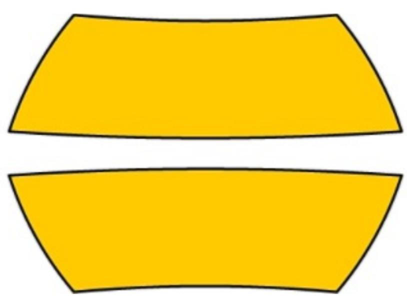
Five rhombi from the rhombic triacontahedron.



Merged into a single shape.



Divided into two.



The straight edges converted into arcs.

Back to Chapter Index

Ready-to-Print Patterns for the Normal Rhombus

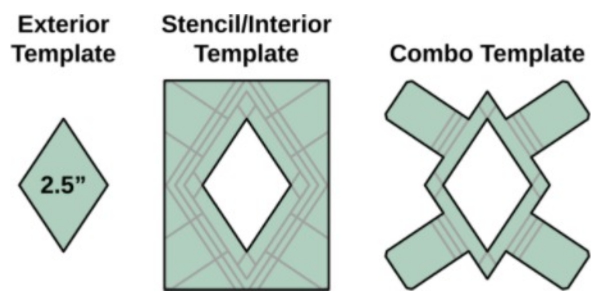
Back to Chapter Index

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 the normal rhombus that produces a true rhombic triacontahedron, but not as good a cloth sphere. The patterns are for beanbag diameters from 2″ – 3″ in ¼″ increments, and there is a 7″ pattern for scaling to larger sizes. The patterns are sized using my inflation-corrected sizing so as hopefully to produce accurate finished sizes (they are reduced by 2.71% from the mathematical calculation to account for the inflation in size I observed in my corduroy bag).

To make the template, I recommend cutting out the portion of the paper with the pattern you want and taping it to your template material, and then cutting along the pattern.

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.

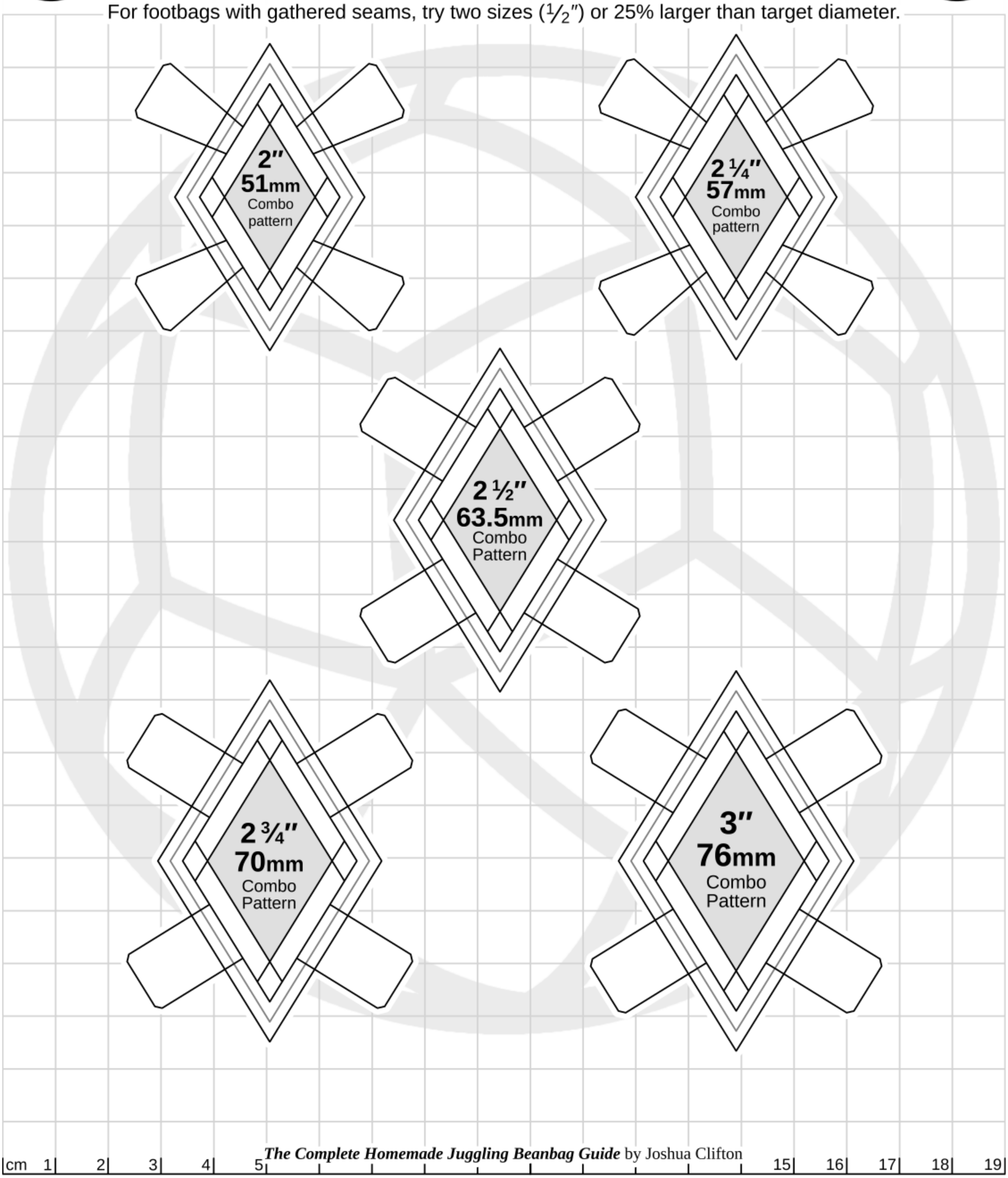
The table below provides the scaling for the ⅛″ increments between my ¼″ sizes. The centimeter grid can be used to verify correct scaling.

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%

Rhombic Triacontahedron (30 panels)

Normal, Catalan solid rhombus

Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (½″) or 25% larger than target diameter.



Rhombic Triacontahedron (30 panels)

Normal, Catalan solid rhombus

Pattern sizes are adjusted for corduroy and do not account for gathered seams.
For footbags with gathered seams, try two sizes (½″) or 25% larger than target diameter.

Extra large and versatile pattern for scaling to larger sizes in the Print Dialog. Print twice if you want both a stitching template and a cutting template (or cut out a combo template). The inner pattern (filled with gray) is the stitching pattern. Each dark pattern outside of that 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 template.