The Complete Homemade Juggling Beanbag Guide

14-Panel Spherical Cuboctahedron & Trunc Octahedron Chapter

Small file size version (150dpi images)

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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.

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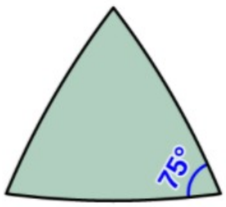
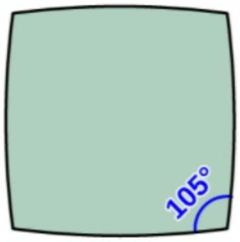
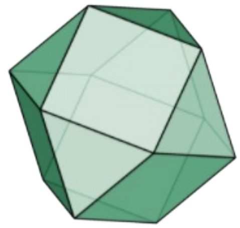
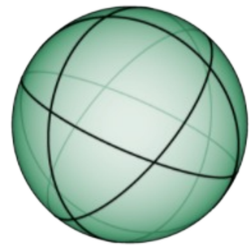
1 Icon from https://freesvg.org/vector-illustration-of-external-link-icon

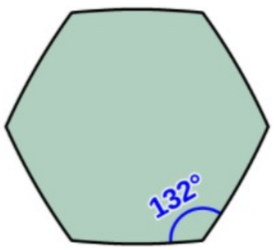
2 **If the linked PDF does not open at the specified location**, keep it open, switch to the previous PDF's tab, and click the link again. **Cross-document links may not work in mobile PDF readers.** In that case you must open the document yourself and find the linked topic.

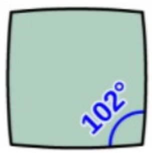
14-PANEL SPHERICAL CUBOCTAHEDRON AND TRUNCATED OCTAHEDRON INSTRUCTIONS

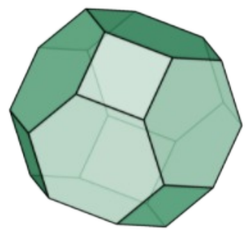
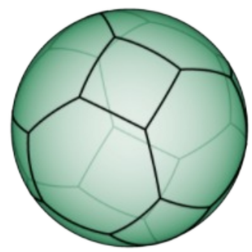




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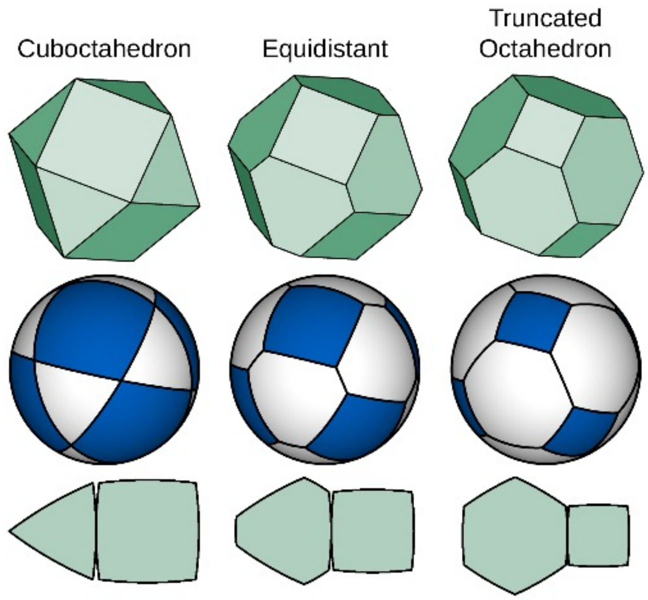
Design Notes



These two designs are the Archimedean shapes on either side of my original, Equidistant Cuboctahedron design in a truncation progression. As shown on the right, the triangles of the cuboctahedron can be truncated to form my Equidistant hexagons, and can be further truncated to form equilateral (regular) hexagons, which further shrinks the squares. Going the other way, the hexagons can be edge-truncated to form the other two face shapes. All three designs are related to the octahedron (and the cube), and therefore have octahedral symmetry, allowing them to **support checkered color arrangements**.

The Cuboctahedron and Truncated Octahedron each has a distinctive appearance, and the Cuboctahedron's triangles support color arrangements that the hexagons of the other two do not. However, because the Equidistant design's two panel shapes are the same distance from the center, and are more nearly the same size, it has a somewhat more uniform roundness when using stiff, non-stretch fabrics. The truncated octahedron is the least uniformly round, with large hexes that are relatively flat, and small squares that bulge outward a bit relative to the hexes. (This is just a perfectionist's nit-pick, though.)

I did not put nearly as much effort into refining these two designs as I did for all my others. I was too burned out in general and lacked the drive to perform all the experimentation. The panel curvatures are quite good, but there may be room for improvement. I described my design process in the "How I Developed These Designs" section.

Supplies

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- **For the templates**
  - Cardboard or Template Plastic, Scissors or X-Acto Knife, Glue Stick or Double-Sided Adhesive Tape (to attach the pattern to the template material). **For drawing the pattern by hand:** Paper, Protractor, Compass (for the circular panel shapes), 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 for both ball designs. (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, tables of pre-calculated pattern measurements, and instructions for drawing both the Cuboctahedron patterns (triangles and squares) and Truncated Octahedron patterns (hexagons and squares). Click the hyperlinks or look to the Chapter Index to locate those sections.

Color Arrangements – Cuboctahedron (Triangles & Squares)

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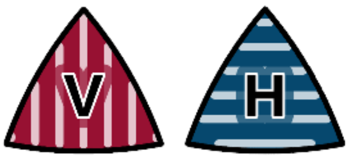
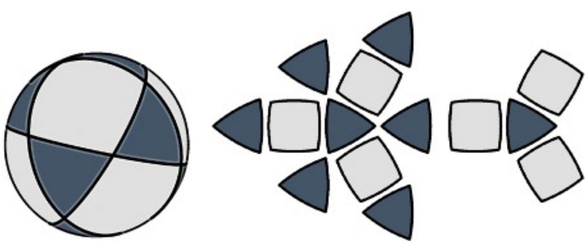
Following is a collection of color arrangement ideas for the cuboctahedron, grouped by the number of colors they contain. Color arrangements for the Truncated Octahedron are in the next section.



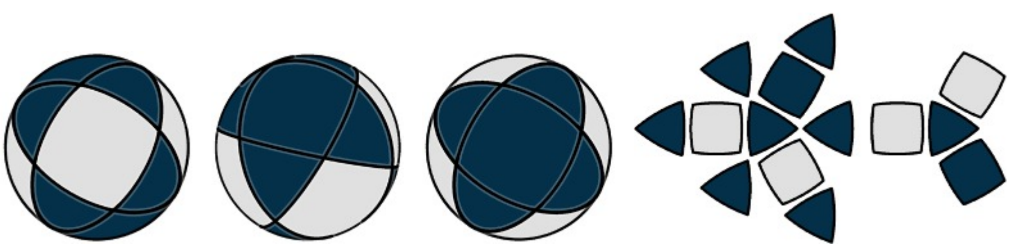
The **V** and **H** labels (on diagrams having triangles not all of the same color) indicate how to orient each triangle pattern relative to woven fabric's grain or corduroy cords. This will make the grainline conform to my recommended layout in the "Making the Panels" section, which calls for half of the triangles to be oriented one way and the other half the other so that the direction of stretch is balanced on the ball. **For the unlabeled arrangements, just make four triangles of each orientation.**

A great method of playing with color arrangements is to make a single-color bag and then stick colored thumbtacks into the panels. Having that for reference will also help you keep track of what you are doing as you assemble a bag. **I also provide printable blank color arrangement diagrams** for the ball views and the assembly layout after the printable patterns. Look at the chapter index to locate them.

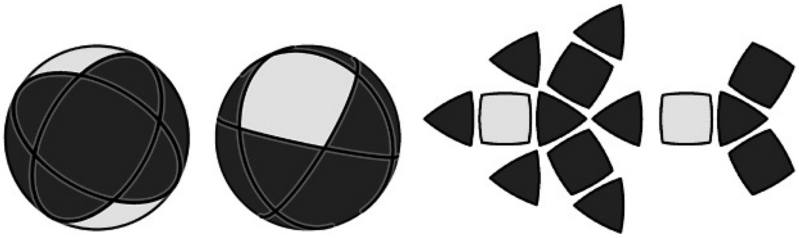
2 colors



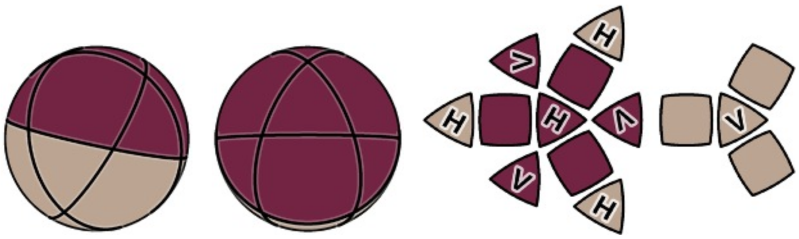
#1: Checker Ball. The squares one color and the triangles another, contrasting color.



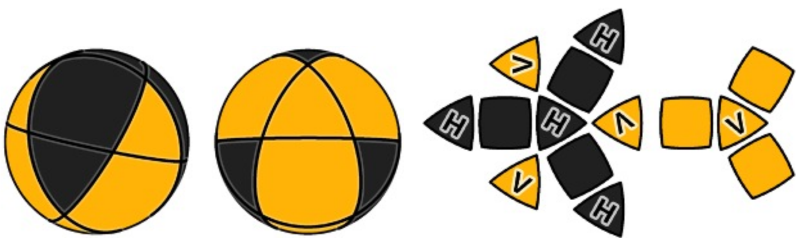
#2: Diamond Ring. A ring of four diamonds/squares of color A around the middle surrounded by a contrasting color B on the two "caps" above and below this ring. Each cap is composed of a square surrounded by four triangles.



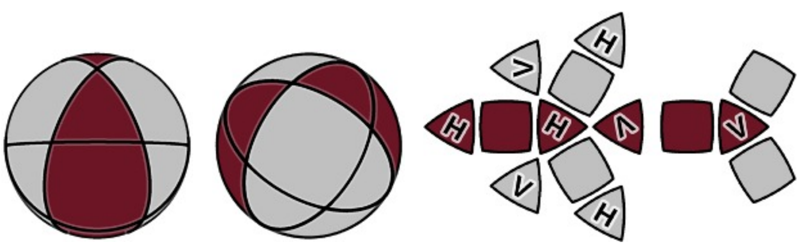
#3: Billiard Ball/Belt. Color A on two opposite square panels surrounded by color B on the remaining 12 panels.



#4: Hemispheres. Each triangle-centric hemisphere a different color.

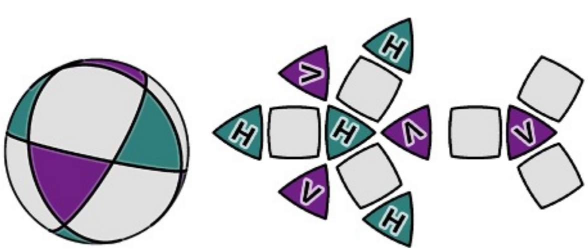


#5: Fanged Hemispheres. Each color on opposing trefoil shapes composed of a triangle with a square and triangle on each of its edges.

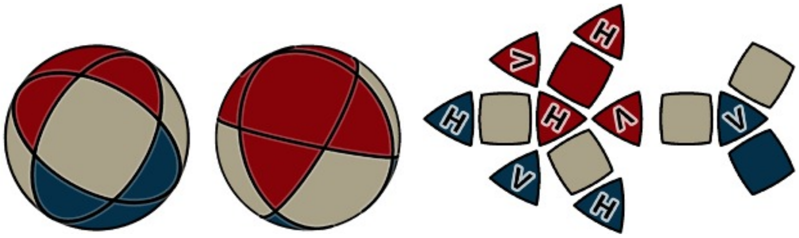


#6: Orange Peel Ball. Color A on two opposing, parallel stripes composed of a square with a triangle on two opposite edges, and color B on two wider stripes composed of two squares and two triangles.

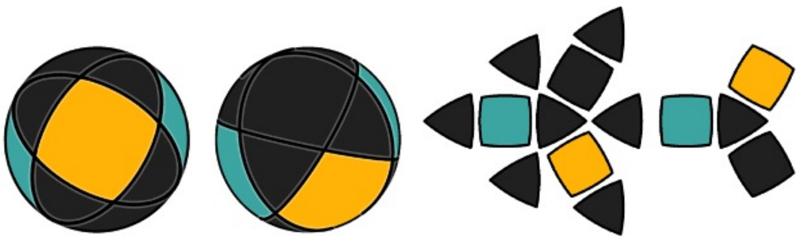
3 colors



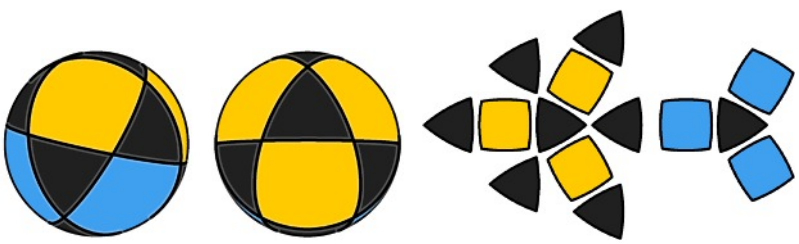
#7: Checker Ball (3-color variation). The squares are color A and the triangles alternate between colors B and C so that no panel shares an edge with another of the same color.



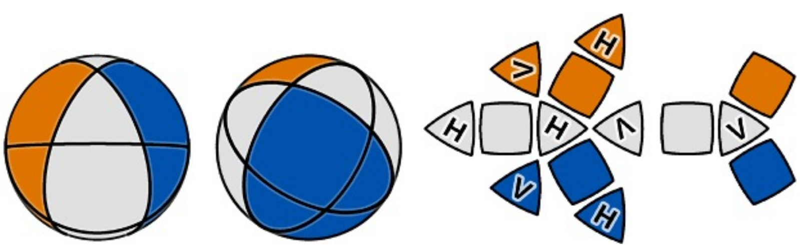
#8: Diamond Ring with Dual Caps. Based on the 2-color Diamond Ring arrangement, this has the same ring of four diamonds/squares of color A around the middle, but each five-panel "cap" above and below the ring is a unique color. The caps are composed of a square surrounded by four triangles.



#9: Bi-Color Diamond Ring. Same as the 2-color Diamond Ring arrangement, but the ring has two alternating colors. Each color is opposite its match.

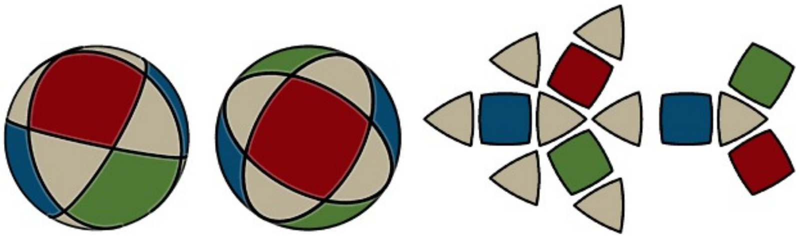


#10: Checkered Hemispheres. Similar to the Checker Ball arrangement, but the three squares on one hemisphere are a different color from the squares on the other. The triangles are all the same color.

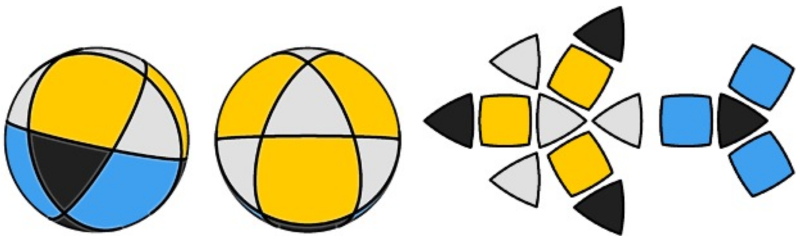


#11: Orange Peel Ball (3-color variation). Same as the 2-color Orange Peel Ball arrangement, but the two wide stripes are each a unique color. The wide stripes are composed of two squares and two triangles and the narrow stripes are composed of a square with a triangle on two opposite edges.

4 colors

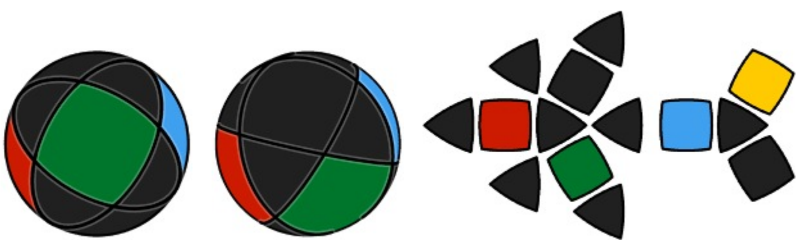


#12: Checker ball (4-color variation). Color A on the triangle panels and colors, B, C, and D each on a pair of opposite square faces.

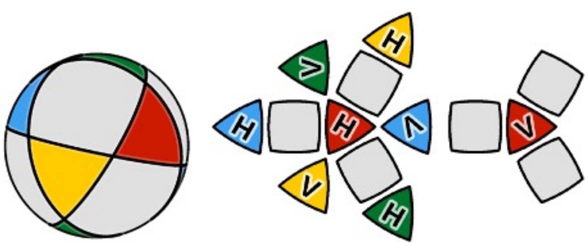


#13: Bi-Color Hemispheres. Each hemisphere has two unique colors – one on the squares and the other on the triangles.

5 colors

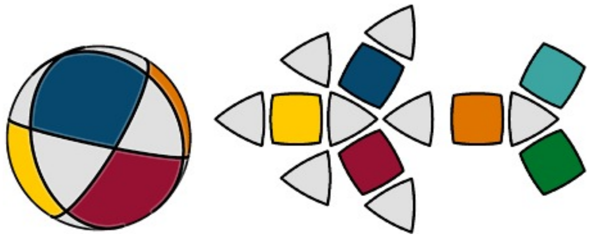


#14: Quad-Color Diamond Ring. Same as the 2-color Diamond Ring arrangement, but each of the diamonds/squares of the ring is a unique color.

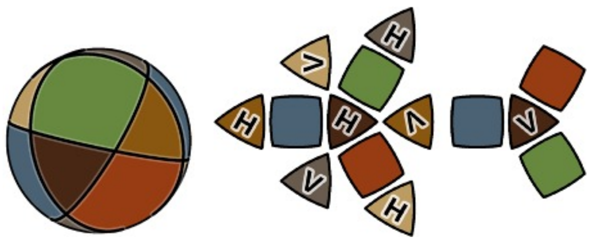


#15: Checker Ball (5-color variation). Similar to the 3-color Checker Ball arrangement, but the triangles are in four colors, each color opposite its match.

7 colors



#16: Checker ball (7-color variation). The triangles all one color and each square a unique color.



#17: Patchwork ball. Each color on a pair of opposite panels of the same shape.

Color Arrangements – Truncated Octahedron (Hexes & Squares)

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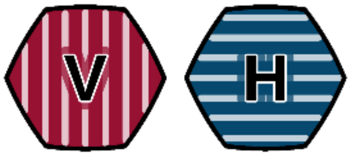
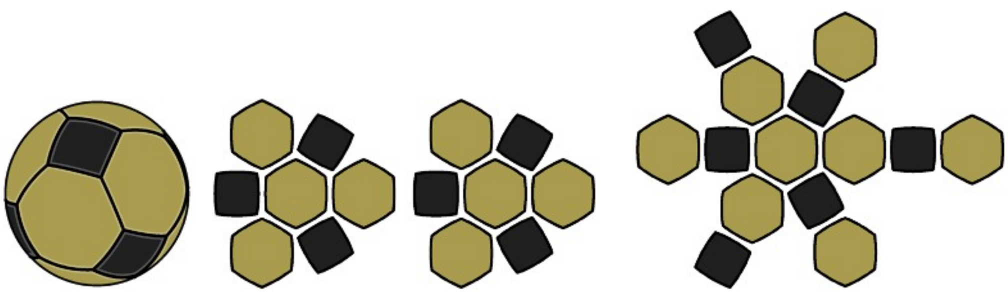
Following is a collection of color arrangement ideas for the truncated octahedron, grouped by the number of colors they contain. I include **two different assembly layout diagrams** for each arrangement: the one for my **dual-hemisphere assembly method** (assemble two separate hemispheres and then sew them together around the equator) and a more **general purpose layout** in case you don't care for my method.



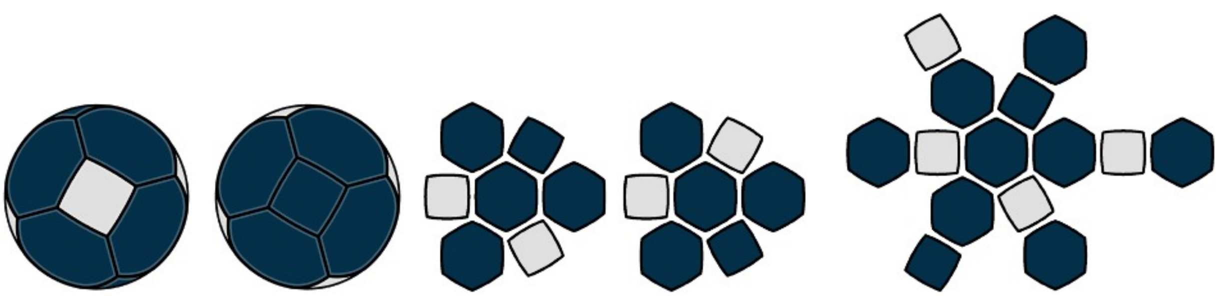
The **V** and **H** labels (on diagrams having hexes not all of the same color) indicate how to orient each hex pattern relative to woven fabric's grain or corduroy cords. This will make the grainline conform to my recommended layout in the "Making the Panels" section, which calls for half of the hexes to be oriented one way and the other half the other so that the direction of stretch is balanced on the ball. **For the unlabeled arrangements, just make four hexes of each orientation.**

A great method of playing with color arrangements is to make a single-color bag and then stick colored thumbtacks into the panels. Having that for reference will also help you keep track of what you are doing as you assemble a bag. **I also provide printable blank color arrangement diagrams** for the ball views and the assembly layout after the printable patterns. Look at the chapter index to locate them.

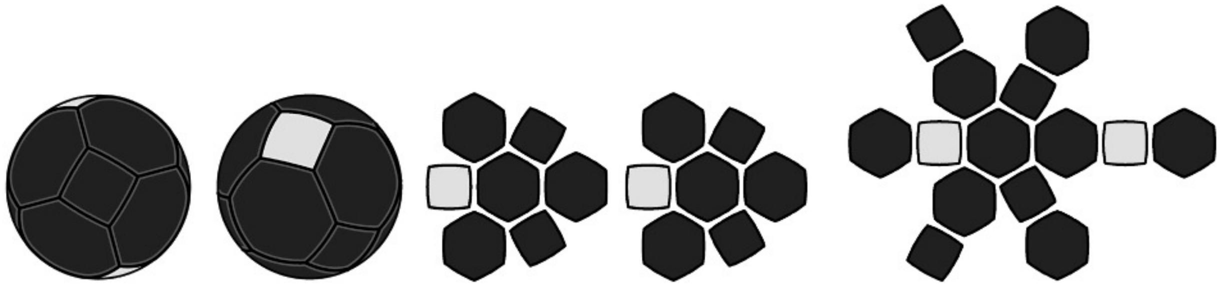
2 colors



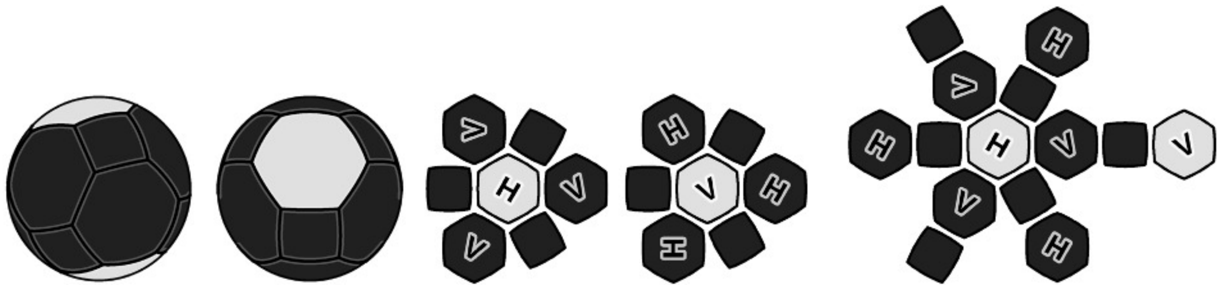
#1: Soccer Ball. The squares one color and the hexagons another, contrasting color.



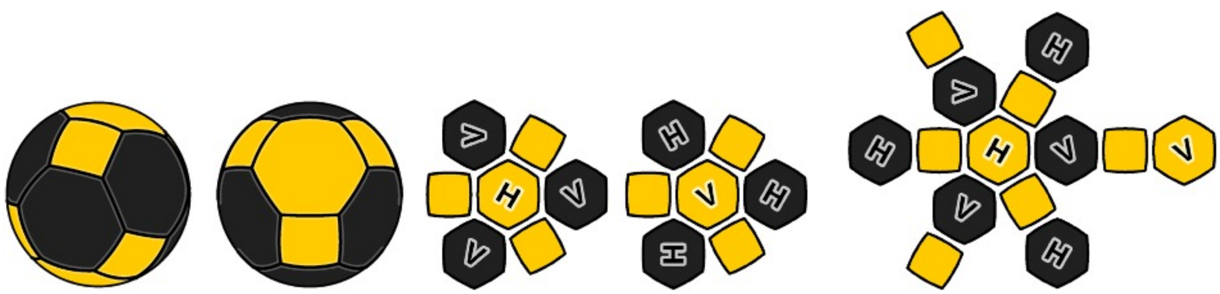
#2: Diamond Ring. A ring of four diamonds/squares of color A around the middle surrounded by a contrasting color B on the two "caps" above and below this ring. Each cap is composed of a square surrounded by four hexes.



#3a: Square-centric Billiard Ball/Belt. Color A on two opposite square panels surrounded by color B on the remaining 12 panels.

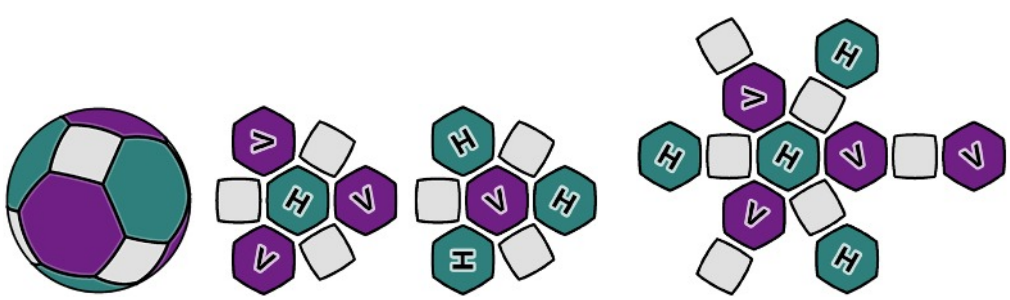


#3b: Hex-centric Billiard Ball/Belt. Color A on two opposite hex panels surrounded by color B on the remaining 12 panels. Alternatively, you can assign a third color to the squares for a checkered/soccer ball appearance as shown on the right. My corduroy ball pictured under the chapter header uses this variation (The bottom hex is actually a fourth color, but that is hard to see).

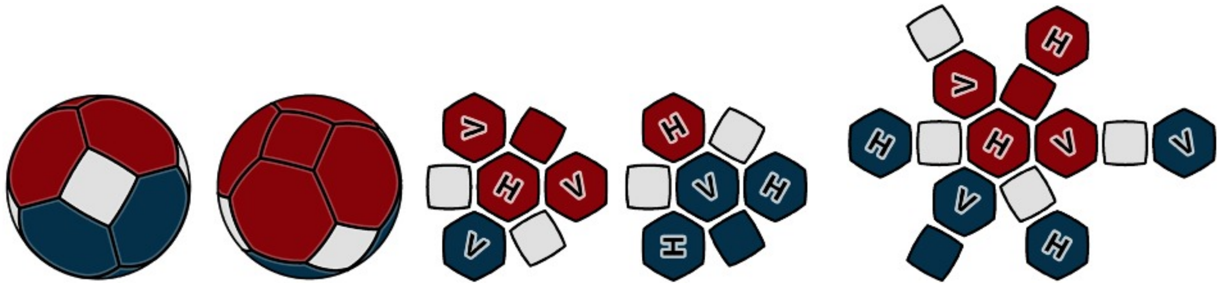


#4: Gears. Color A on two opposite "gear" shapes composed of a hex surrounded by three squares. Color B on the six hexes around the middle between the gears.

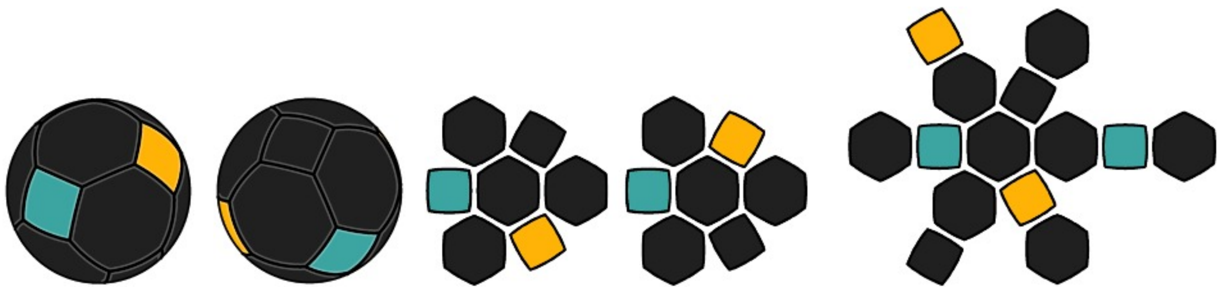
3 colors



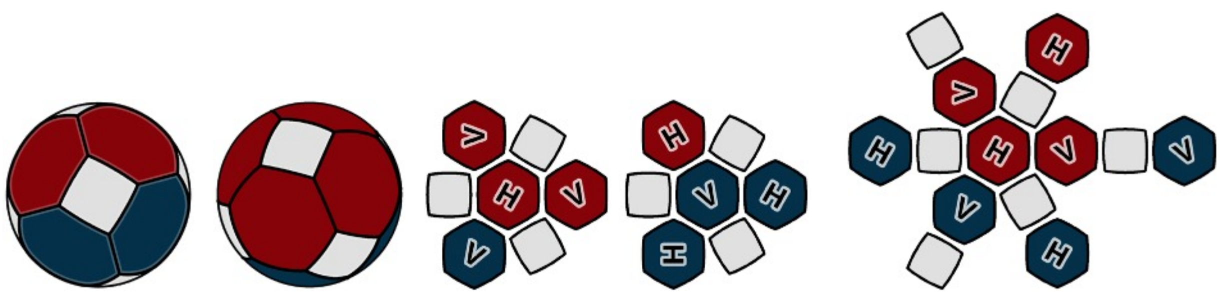
#5: Checker Ball. The squares are color A and the hexagons alternate between colors B and C so that no panel has a neighbor of the same color.



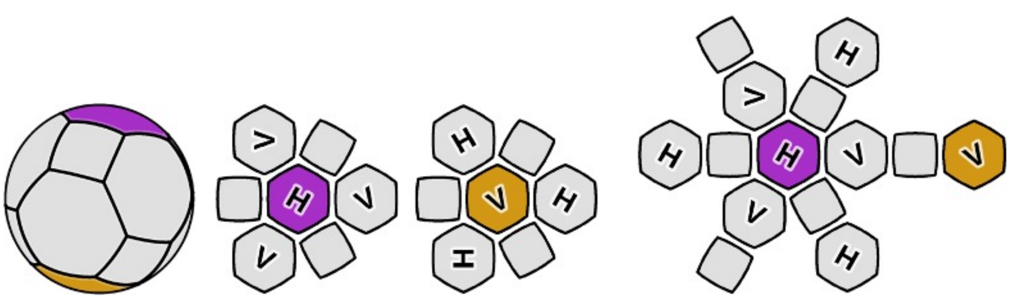
#6: Diamond Ring with Dual Caps. Based on the 2-color Diamond Ring arrangement, this has the same ring of four diamonds/squares of color A around the middle, but each five-panel "cap" above and below the ring is a unique color. The caps are composed of a square surrounded by four hexagons.



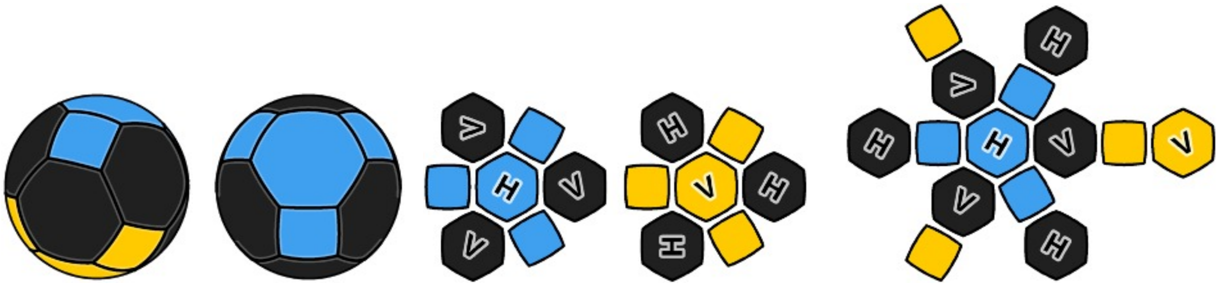
#7: Bi-Color Diamond Ring. Same as the 2-color Diamond Ring arrangement, but the ring has two alternating colors. Each color is opposite its match.



#8: Hemispheres with Stars. Similar to the Diamond Ring with Dual Caps arrangement, but all the squares are now the same color, forming uniformly distributed "stars".

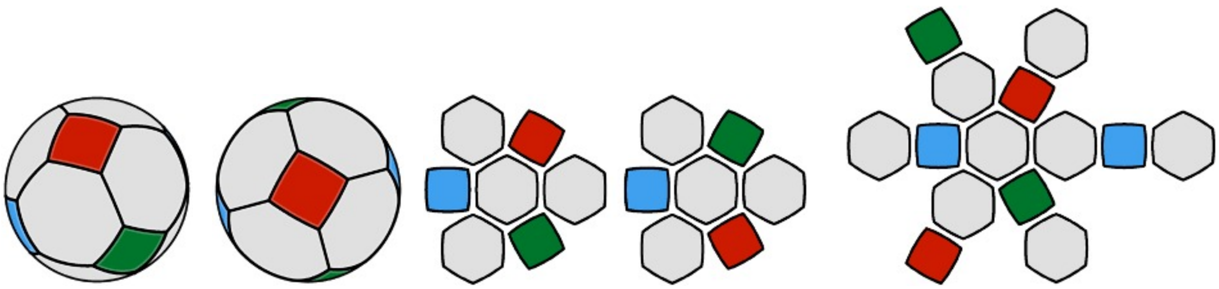


#9: Bi-Polar. Same as the Billiard Ball arrangement, but each polar hex is a unique color. All the squares and the six hexes around the middle are all the same color. Alternatively, you can assign a fourth color to the squares for a checkered/soccer ball appearance as shown on the right. My corduroy ball pictured under the chapter header uses this variation.



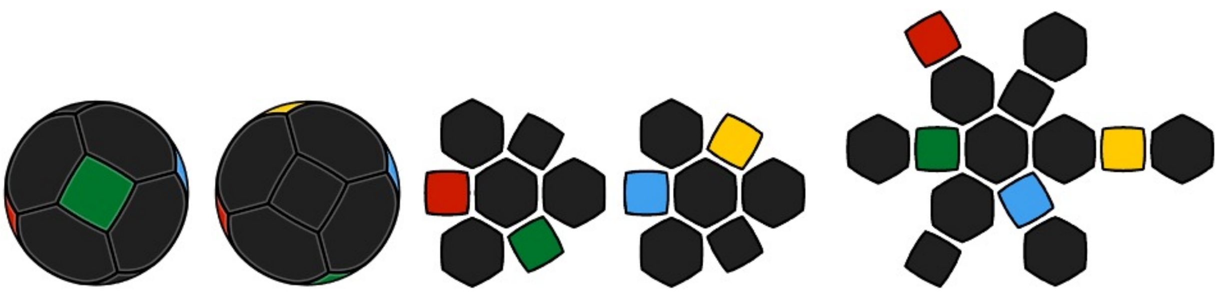
#10: Dual Gears. Same as the 2-color Gears arrangement, but each gear is a unique color.

4 colors

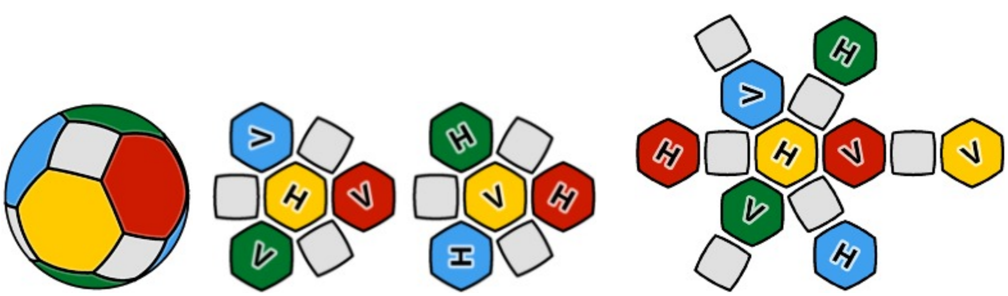


#11: Soccer ball (4-color variation). Color A on the hex panels and colors, B, C, and D each on a pair of opposite square faces. This results in color A framing each of the other colors.

5 colors

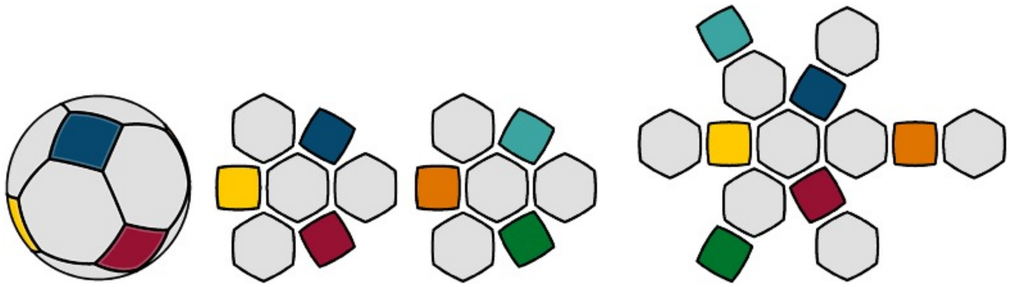


#12: Quad-Color Diamond Ring. Same as the 2-color Diamond Ring arrangement, but each of the diamonds/squares of the ring is a unique color.



#13: Checker Ball (5-color variation). Similar to the 3-color Checker Ball arrangement, but the hexagons are in four colors, each color opposite its match.

7 colors



#14: Soccer ball (7-color variation). The hexagons all one color and each square a unique color.

Cutting Out the Templates

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To make exterior type templates, simply use scissors to cut along the patterns. If you want to make stencil (interior) types, you will need to use an X-Acto knife. If you lack the skill to cut curves with a knife, you can convert the curves into three or more straight cuts that approximate the curve. The Truncated Octahedron makes a perfectly good ball with straight-edged panels, so for that you can skip the curves altogether and cut out straight-edged templates, which are easier.

If you use a thick marker to trace the patterns, remember to **stitch on the side of the pattern lines where the edges of the template were** (inside the lines for exterior templates, outside the lines for stencil or combo), 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, when using stencil or combo templates, 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.

Continued on the next page

Making the Panels

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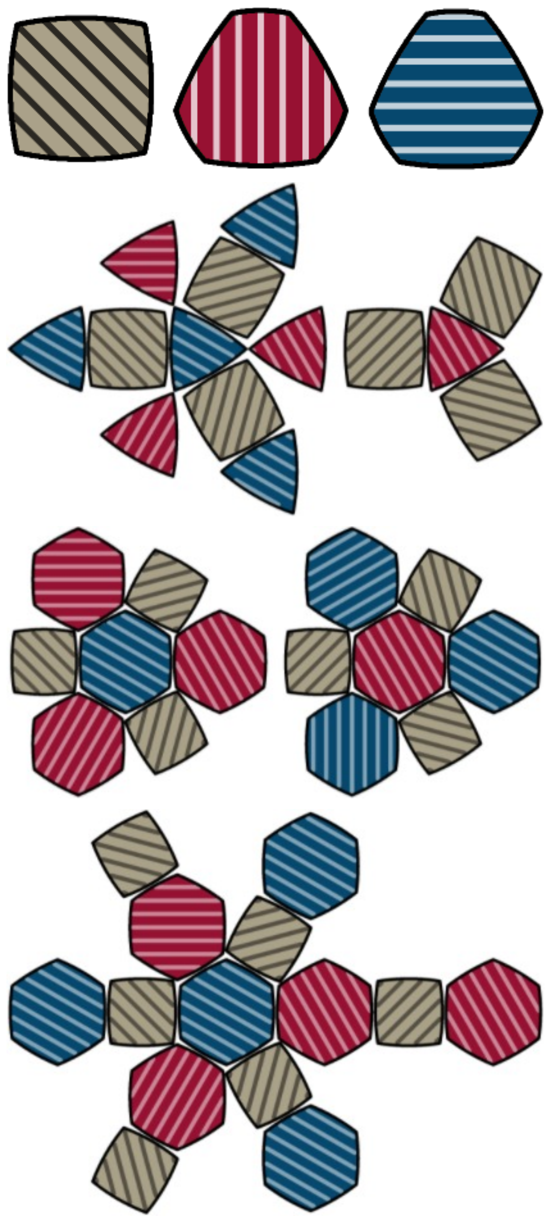
Depending on the type of template you're using (exterior or interior) and whether it is translucent or not, you must be careful which pattern, cutting or stitching, you trace first so that the **second template doesn't hide the lines of the first** and prevent you from aligning the two. **Do not necessarily use them in the sequence below**. Note that the top illustration is reused from my Equidistant Cuboctahedron design, which uses triangular hexes, and is a stand-in for both the triangles and the hexes.

1. You will need **6 squares and 8 hexes/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 something like **corduroy, denim, or a striped fabric, or other woven fabric**, I recommend orienting the **squares diagonally** to the lengthwise/straight grain (or cords) of the fabric, and the **hexes/triangles half in a vertical orientation and half in a horizontal** as shown on the right.

   You can then arrange the lines of the fabric as shown in the panel layouts, so that on the ball the lines of the squares/diamonds are oriented the same way as I recommend on the cube (each square is surrounded by squares with perpendicular orientations), and the lines of the hexes are arranged as I recommend on the octahedron, with no adjacent panels having matching orientations. This will **produce a balanced look, and it will balance the fabric's direction of stretch** so the ball is not lopsided or otherwise non-spherical.



2. 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 – Cuboctahedron (Triangles & Squares)

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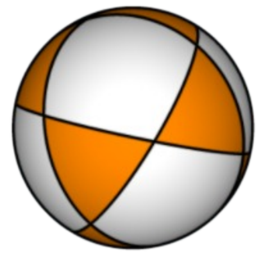
I assemble this design by forming two separate hemispherical pieces (one larger than the other) and then sewing them together. This gets all the panels joined to each other as soon as possible, and in a simple and clear manner, which reduces the risk of losing track of the arrangement during assembly. It is also optimized for using the fewest threads, for less time spent tying knots and starting new threads (it can be done with as few as three threads).

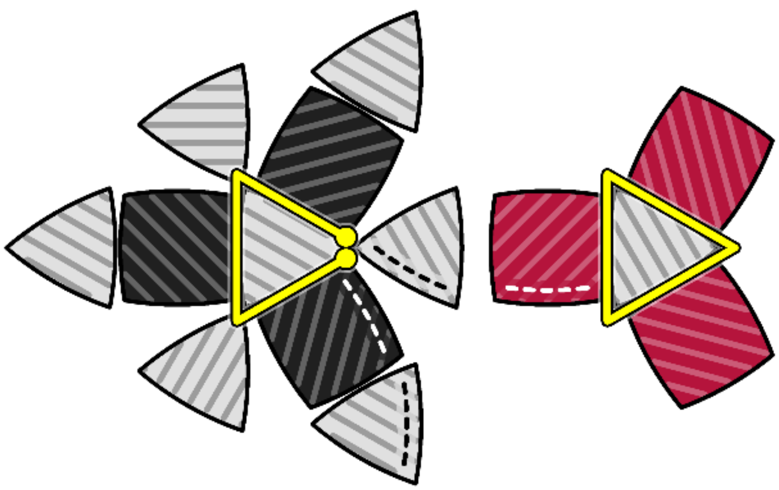
With so many panels and seams, **it is easy to make a mistake** and join the panels incorrectly. It may be helpful to make a cardboard model with colored panels or labels to use as a reference. A card stock like index cards or file folders works well for this. Just make straight-edged templates (rather than circular), cut a few layers at a time to produce the panels faster, and tape them together.

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

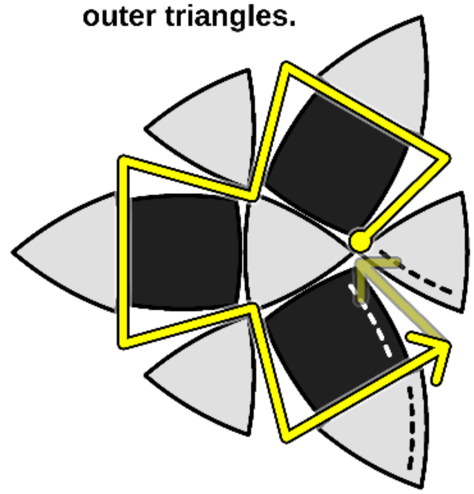


- Every intersection will have four panel corners. Two will be triangles and two will be squares. Each shape is opposite its match.
- No panel will join to another of the same shape. Squares have triangles on each of their edges, and triangles have squares on each edge.

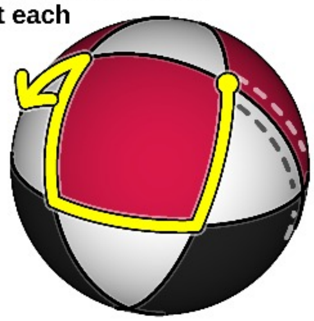
A **Sew around the central triangle of each section, attaching the three squares to its sides.** In the left section, start at the dots and sew in either direction.



B **In the left section, continue around each square to attach all six outer triangles.**



C **After assembling both sections, fit them together so that the front patterns meet each other and sew around the three squares of the right section, starting at the front patterns.**



Note that in illustration C the ball is still inside out and so the front stitching patterns (the dashed lines) won't actually be visible. I show them just for positional reference.

1. ***Illustration A:*** **Lay the panels out as shown** and **arrange them according to your color pattern**. My illustrations assume the fronts face up, but it doesn't matter (except for chiral color arrangements, which none of mine are). The **hatching lines in Illustration A 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 four outer panel edges shown with dashed lines to form two seams in a row around the equator. My stitching pathway leaves these two seams 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 left-most pair of edges.) 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 A (stitching):*** **Start with a central triangle panel on either hemisphere and sew a square panel to each of its sides.** For the larger hemisphere, I recommend beginning at the corner between the panels with the front stitching patterns (proceed in either direction) so that you can continue the thread for the next step (if you intend to continue the thread, make sure it is long enough). **Sew the panels with their front faces together** so the bag will be inside out.

   Do the same for the other hemisphere.

4. ***Illustration B:*** When you have attached all three panels **on the larger hemisphere, continue into the path in Illustration B that attaches the six triangles to the squares**. If you do not need both open seams at the end to turn the bag out through, you may sew the last seam shown with a faded arrow that closes one of them, ending at the starting corner of the central triangle. Tie off the thread and trim it when you're finished, unless you want to continue it for the next step.

5. ***Illustration C:*** **Place the two hemispheres together** carefully so as to form your intended color pattern and to make the front stitching lines on each half meet each other. **Aligning the panel edges correctly can be somewhat confusing**. Refer to the Helpful Hints if you are confused. 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.

   Sew around the ball starting on one side of the front patterns and ending at the other. You will be zig-zagging around the outer triangles of the larger hemisphere and the outer squares of the smaller hemisphere, attaching them to each other.

6. Begin closing the final seams with the front patterns marked on them. (If the hub thread from the smaller hemisphere is long enough and ends at the right corner, it can be used for this.) **Sewing a few starter stitches** makes it easier to continue from the outside. Sew as much of the final opening as you don't need for turning the bag right side out. **First, though, I recommend that you tie the thread at, or a short distance before, the front pattern seams** (leaving enough of an opening to allow the panels to spread and the bag to be turned out) so it does not loosen behind that point when you turn the bag out.

   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. At this point, **consider ironing the seam allowances flat**; see the **General Information and Techniques** chapter under "Better Seams by Ironing".

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").

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Assembly – Truncated Octahedron (Hexagons & Squares)

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Illustrated instructions are on the next page and written instructions begin on the page after that.

I assemble this design by forming two separate hemispheres and then sewing them together. This gets all the panels joined to each other as soon as possible, and in a simple and clear manner, which reduces the risk of losing track of the arrangement during assembly. **If you prefer simply to attach all panels to a central hex**, use that layout type from my color arrangements section instead of the one in Illustration A. You can then start with the stitching path I use for the first hemisphere (Illustrations A & B, or A_{ALT}), and continue from there to attach the rest of the panels. The remaining illustrations and some of the written instructions will not apply.

For the dual-hemisphere method I describe **two different approaches to sewing the hemispheres**: one that uses as few as 6 threads, and an alternative method based on my 32-panel assembly method that uses few as 3 threads. **The alternative method is much simpler at the cost of more duplicate stitching. I prefer that one.**

For the **first method**, the stitching for each hemisphere begins at the intersection indicated by the spot in the center of the arrows in Illustration A (on the next page) and proceeds around the “hub” seams and then out the “spoke” seam. Additional threads are used for the remaining spoke seams on one hemisphere (the first is shown in Illustration B). I join the hemispheres together by using the spoke threads from one to continue up into the “equator”, and then into the spoke seam of the other hemisphere. Up to three equatorial seams will be sewn from the outside (indicated by the dashed lines).

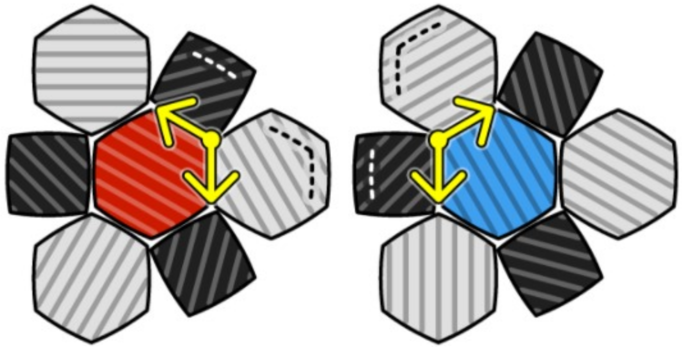
In the **alternative method** (Illustrations A_{ALT} and B_{ALT}) you sew out and back at each spoke seam as you proceed around the hubs. This results in complete hemispheres which are much simpler and easier to join together because you have only the equator to sew around, not the spoke seams as well. The duplicate stitches can be extra long (at least if you are using the backstitch), and so are not terribly tedious.

With so many panels and seams, **it is easy to make a mistake** and misalign the panels or join four corners together instead of three. It may be helpful to make a cardboard model with colored panels or labels to use as a reference. A card stock like index cards or file folders works well for this. Just make straight-edged templates (rather than circular), cut a few layers at a time to produce the panels faster, and tape them together.

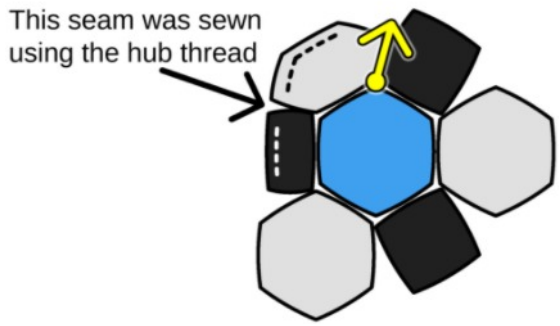
Helpful Hints: While assembling the bag, remember the following points.

- Every intersection will have three panel corners. Two will be hexes and one will be a square.
- No square will join to another square.

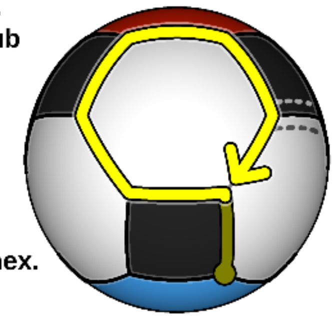
A **Sew around each hub panel starting between the panels with the front stitching patterns, then out the spoke seam.**



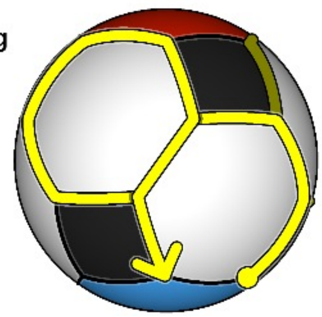
B **Sew a spoke seam adjacent to the front pattern.**



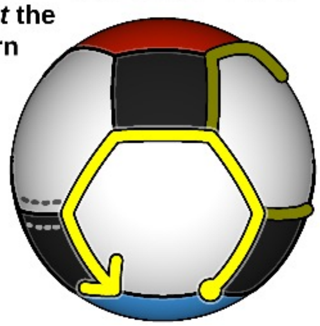
C **Continue into the equator seams, joining the hemispheres, then up the spoke seam. Cross the hub edge of the hex at the top (double-stitching it) and then continue around the hex.**



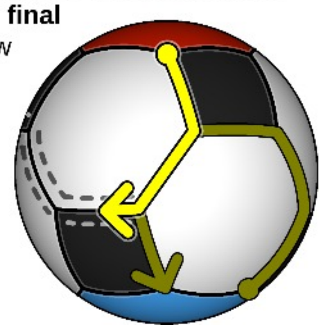
D **The next spoke thread follows a figure eight around two hexes, double-stitching three seams.**



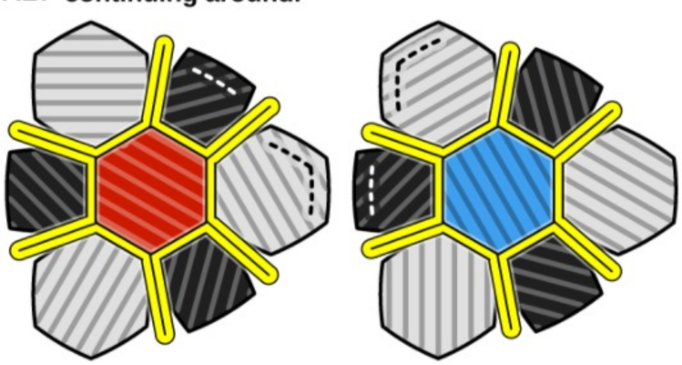
E **Sew around the final hex panel that has two unsewn spoke seams (the hex *without* the front pattern on it).** Do not yet enter the seams with the front stitching patterns.



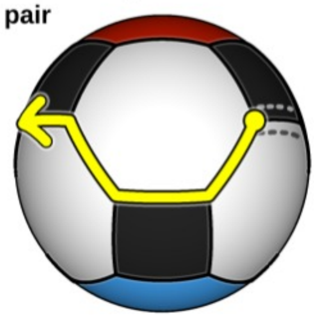
F **Sew the final spoke seam on the other hemisphere and then begin sewing the final seams.** Sew as much as you don't need to turn the bag out through.



A ALT **Alternatively, sew around the hub panels, but at each spoke seam, sew out and back before continuing around.**



B ALT **After sewing both hubs and all spoke seams, place the hemispheres together at a pair of edges adjacent to the front stitching patterns and sew around the equator. Skip C – F.**



Note that in the ball illustrations the ball is still inside out and so the front stitching patterns (the dashed lines) won't actually be visible. I show them just for positional reference.

1. ***Illustration A:* Lay the panels out as shown** and **arrange them according to your color pattern**. My illustrations assume the fronts face up, but it doesn't matter (except for chiral color arrangements, which none of mine are). The **hatching lines in Illustration A 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 outer panel edges shown with dashed lines to form three seams in a row around the equator. My stitching pathway leaves these three seams 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 upper pair or two of edges.) 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 $\frac{1}{8}$″ (3mm) apart. If you **make these marks on your template first**, you can more easily transfer them onto these and future panels.

3. ***Illustration A (stitching):* Start with a central hex panel and sew a panel to each of its sides** beginning at the corner between the panels with the front stitching patterns and proceeding in either direction. **Sew the panels with their front faces together** so the bag will be inside out.

   Illustration A_{ALT}:* Alternatively, sew out and back at each spoke seam**, joining the outer panels to each other. The duplicate stitches can be up to twice as long if you're using the backstitch and are careful how tightly you pull them (if you pucker the fabric, wiggle it straight again). **If you take that route, you will be skipping to Step 11** (after completing the other hemisphere), beginning at the second paragraph labeled "Illustrations F and B_{ALT}***". Just join the two completed hemispheres, starting at one end of the front stitching patterns and sewing around to the other end (see the "Crossing seam intersections…" topic in the **General Information and Techniques** chapter for advice). Then follow the relevant instructions in Step 11.

   When you finish the two hemispheres in the alternative method, be sure to **join the hemispheres so as to form your intended color pattern** and to make the front stitching lines on each half meet each other. 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.

4. ***Continuing Illustration A:*** When you have attached all six panels and the thread has **reached the starting point again**, **sew the adjacent sides of the two outer panels together**, connecting the two segments of the front stitching lines, and then tie off the thread and trim it. You are done with this hemisphere for now. The spoke seams (the adjacent edges of the outer panels) will be sewn with threads that continue from the other hemisphere.

5. **Construct the other hemisphere in the same way.**

6. ***Illustration B:*** On either hemisphere, **sew a spoke seam** that is adjacent to the one that is already sewn, starting at the center panel and sewing outward. If you orient the panels as they are in the illustrations, your path can match mine. But if you don't, just modify the path as needed, using mine as a general guide. Either way, the next step continues this thread, so leave it hanging.

7. ***Illustration C:*** **Continue the thread into the other hemisphere** by sewing across a hex-square seam and a hex-hex seam, which will join the two hemispheres, and then up the spoke seam of the other hemisphere. **Be sure to select the correct panel from the other hemisphere** to join so as to form your intended color pattern and to make the front stitching lines on each half meet each other. **Aligning the panel edges correctly can be somewhat confusing**. Refer to the Helpful Hints if you are confused. 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.

8. If your panels are oriented as mine are, you can continue across the hub seam of the hex on the second hemisphere, double-stitching it, and continue around the hex, closing the spoke seam on the second hemisphere that is adjacent to the front patterns. (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 do bunch up the fabric, just wiggle it straight again.) Tie and trim this thread.

9. ***Illustration D:*** Start a thread at the hub end of the next spoke seam on the first hemisphere (the one on the right in my illustrations), sew up the spoke seam, then along five equatorial seams, and then up the second hemisphere's spoke seam. Continue around the hex in the opposite direction (double-stitching the hub seam), down the spoke seam, across the hex-hex equatorial seam you just stitched, and then down the spoke seam adjacent to the one you started with, forming most of a figure eight around the two hex panels. Tie the thread and trim it.

10. ***Illustration E:*** Sew around the final hex panel that has two unsewn spoke seams, closing the last equatorial seams not having the front patterns marked on them.

11. ***Illustration F:*** Sew the final spoke seam on the other hemisphere and continue across the hex-hex equatorial seam, restitching it.

    Illustrations F and B_{ALT}***:*** Then proceed into the final equatorial seams with the front patterns marked on them. **Sewing a few starter stitches** makes it easier to continue from the outside. Sew as much of the final opening as you don't need for turning the bag right side out. **First, though, I recommend that you tie the thread at, or a short distance before, the front pattern seams** (leaving enough of an opening to allow the panels to spread and the bag to be turned out) so it does not loosen behind that point when you turn the bag out.

    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**.

12. At this point, **consider ironing the seam allowances flat**; see the **General Information and Techniques** chapter under "Better Seams by Ironing".

13. **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**.

14. **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").

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Ready-to-Print Patterns

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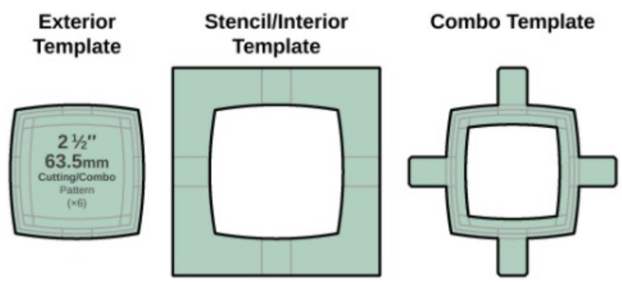
The pattern pages are 8.27″×11″ (210mm×279mm) to fit both "Letter" and "A4" sizes. ***Make sure the print is not being scaled to fit the printer margins*** *(select Default/None scaling/Actual size/Ignore printer margins). To verify correct sizing,* ***compare the centimeter grid to a ruler*** *and adjust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

The **Cuboctahedron patterns** (triangles and squares) begin on the next page. Those are followed by the **Truncated Octahedron Patterns** (hexes and squares). The patterns are for beanbag diameters from 2″ – 3″ in ¼″ increments, and there are 7″ patterns for scaling to larger sizes. The Cuboctahedron patterns are reduced by 5.87% and the Truncated Octahedron by 4.66% from the mathematical calculations to account for the inflation in size I observed in my corduroy bags. **If you use a dense/stiff or completely non-stretch fabric, I recommend enlarging the pattern to about 105% 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 cutting patterns have 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″), and they include **tabs for the optional combo type template** (stitching pattern on the inside, cutting pattern on the outside, with the tabs to help you hold it down).



The examples on the right show the **three ways you can cut out the Cutting/Combo templates** (using the 8mm allowance). Remember that the cutting patterns have slightly different proportions from the stitching patterns (they are parallel, not proportional), so you should not use them as stitching patterns. **You can cut out the Truncated Octahedron patterns as straight-edged templates and still get a perfectly good sphere, but it will be about 2% smaller.**

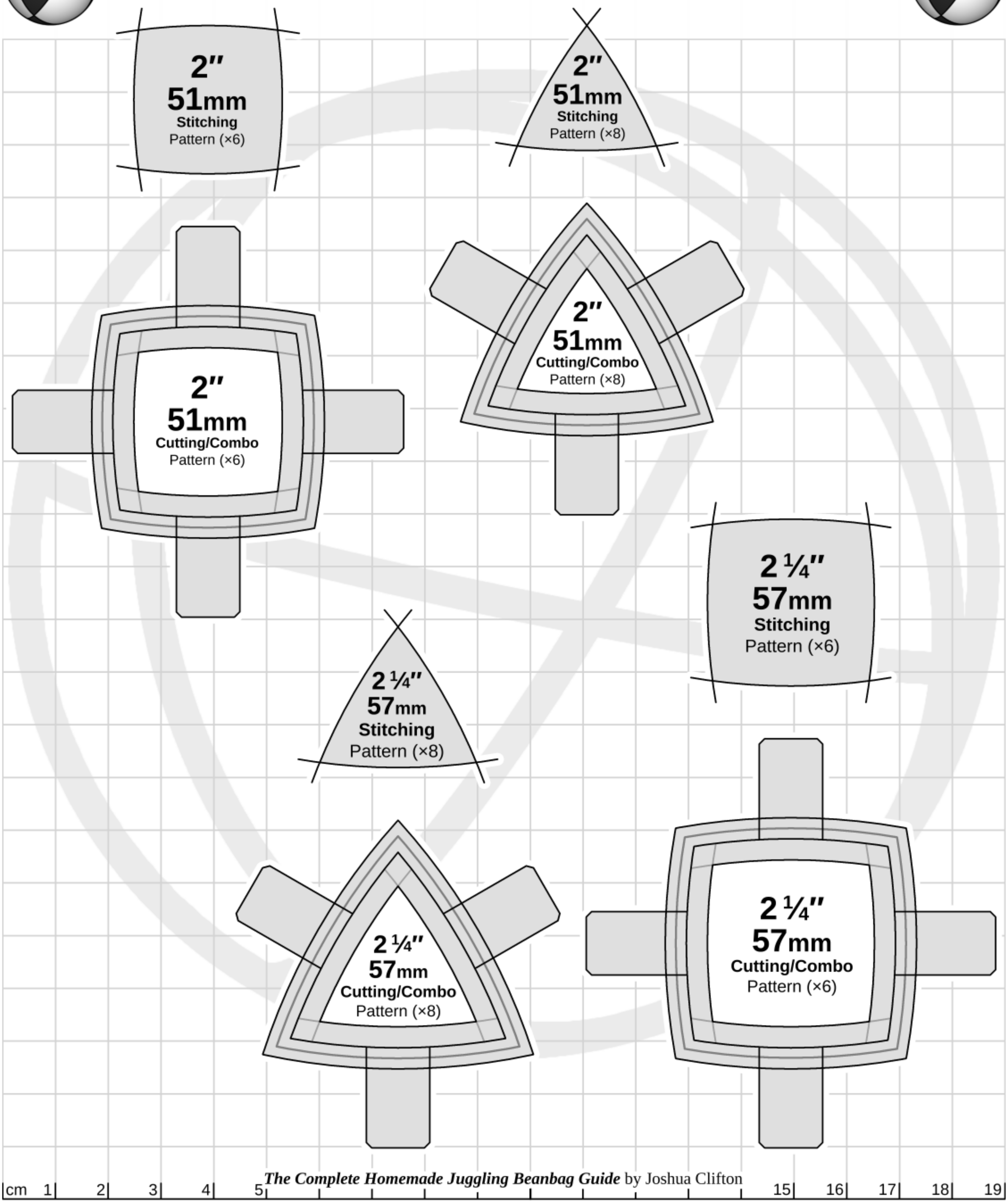
To produce other pattern sizes or correct an incorrectly sized beanbag, adjust the size scaling in the print dialog. For example, to reduce my 2.5″ patterns to the 2.3″ size recommended by the Juggling Store for small hands and numbers juggling, divide 2.3 by 2.5, multiply the result by 100, and that 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%

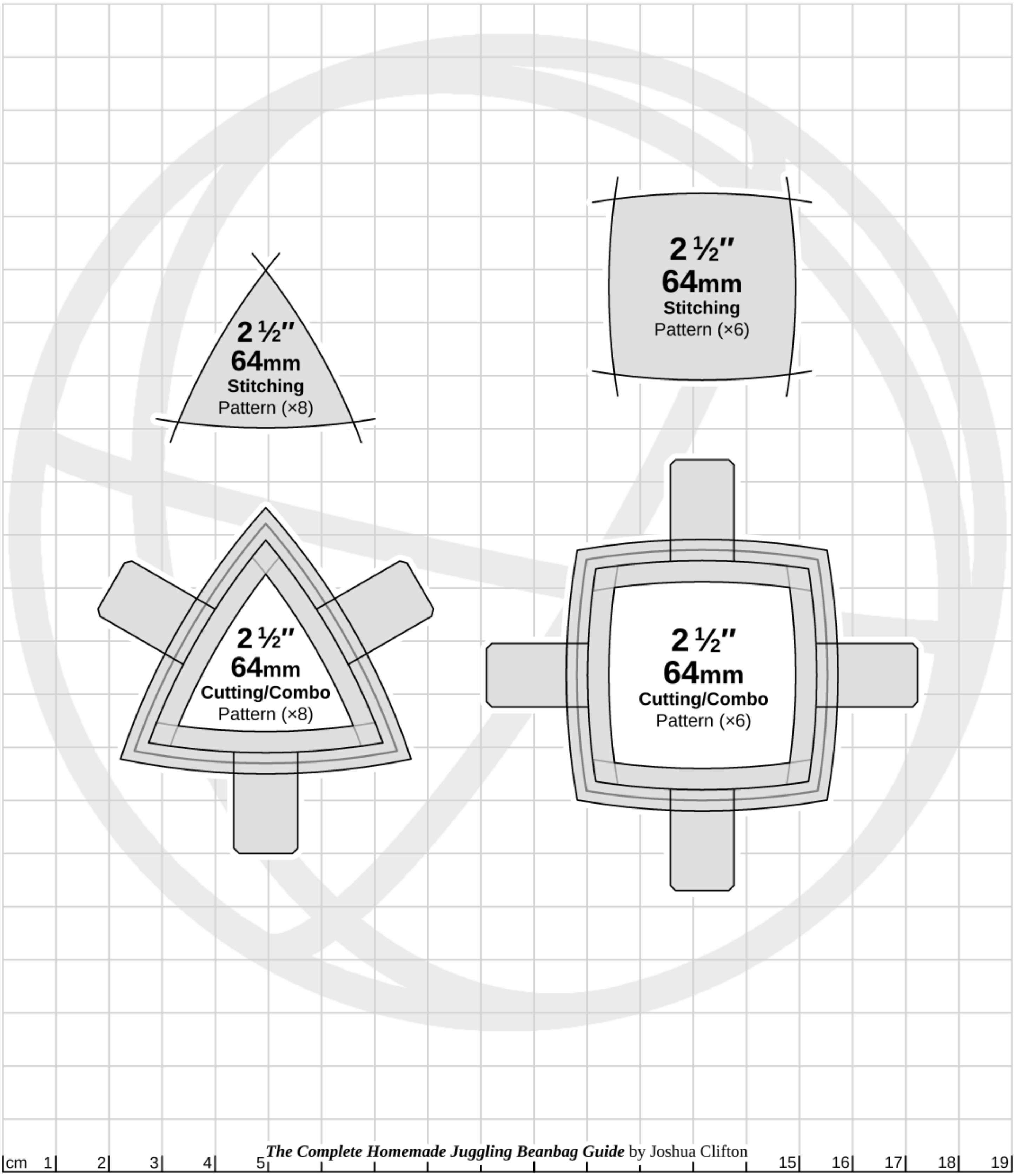
Cuboctahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



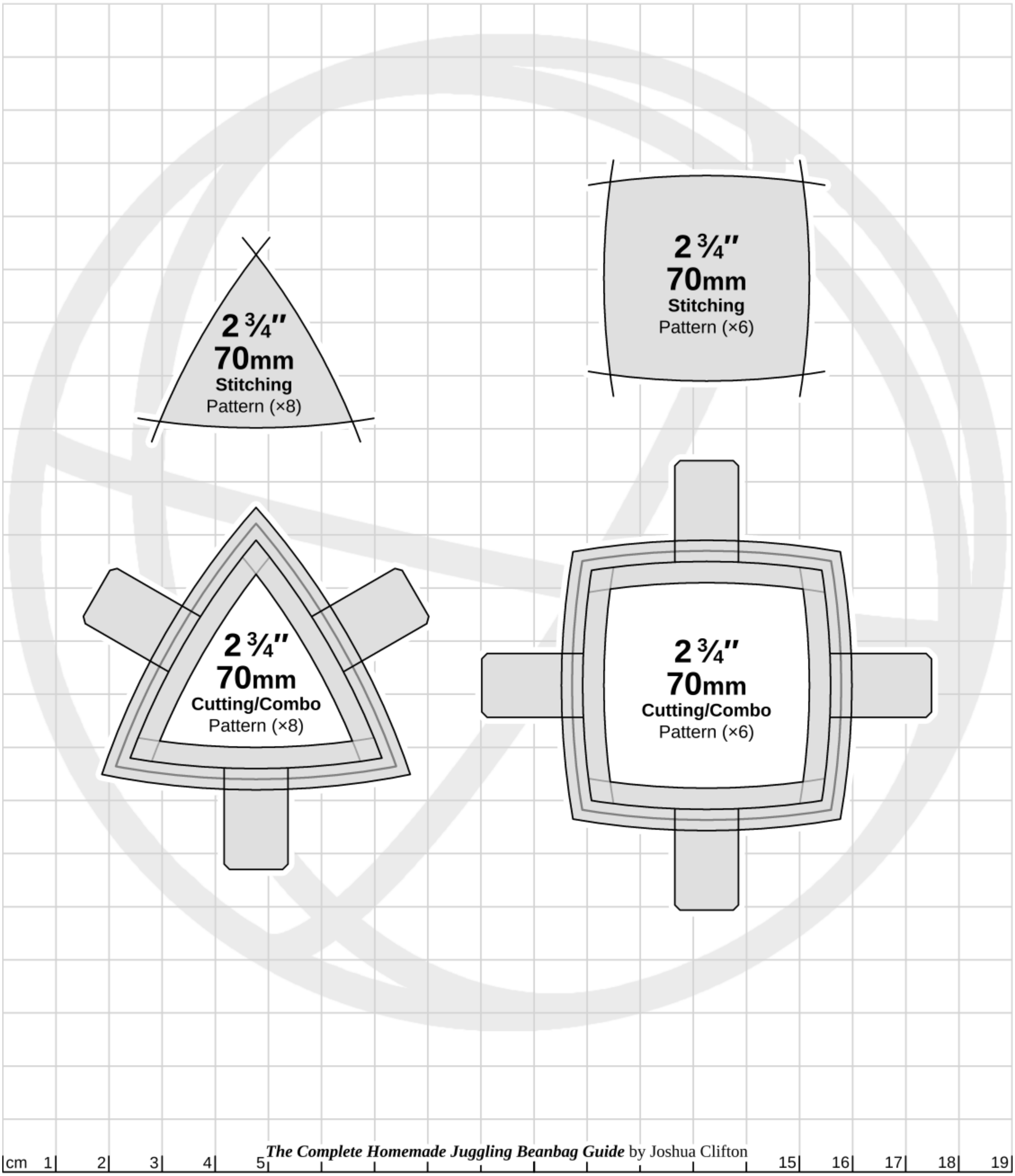
Cuboctahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



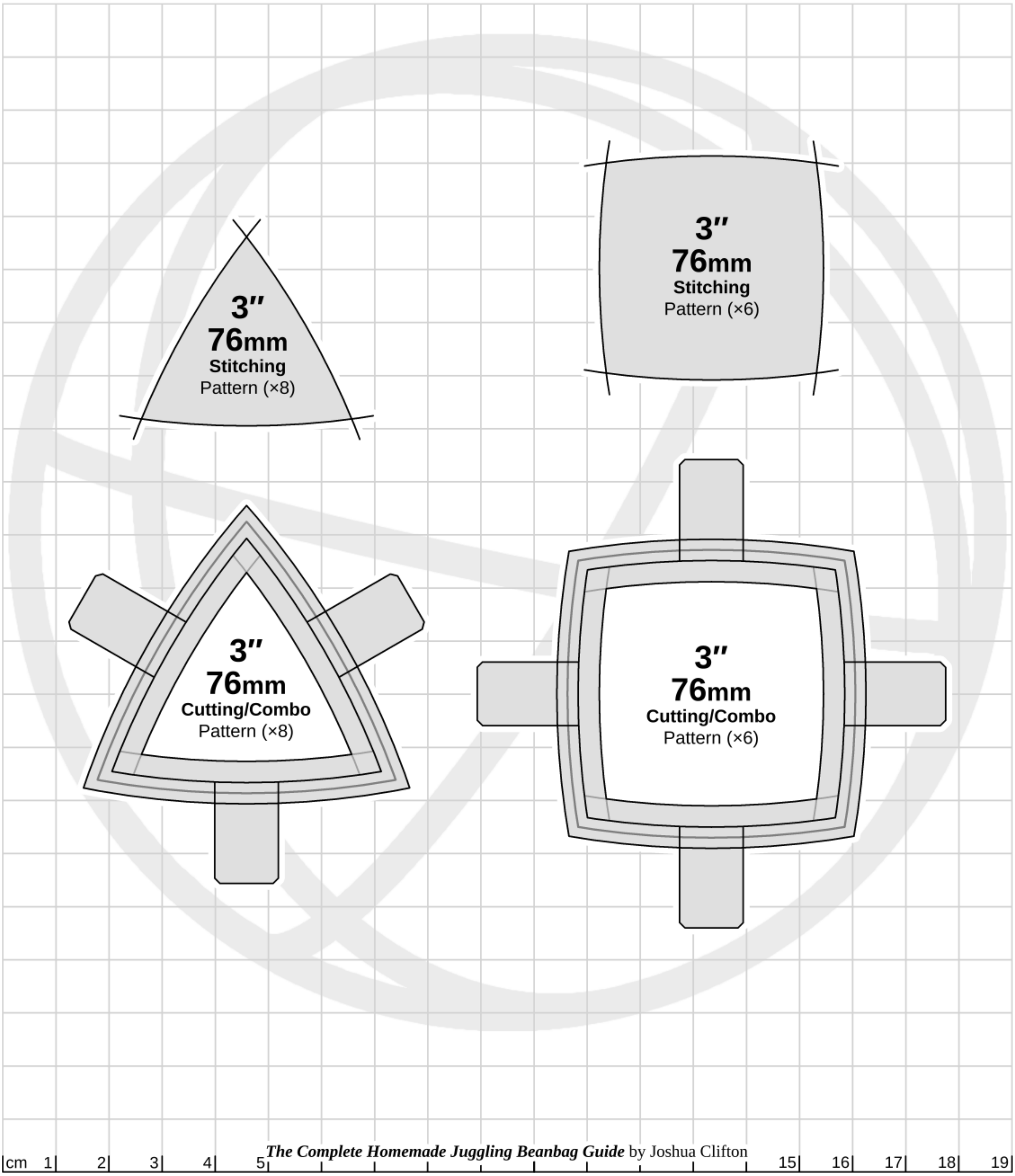
Cuboctahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



Cuboctahedron (14 panels)

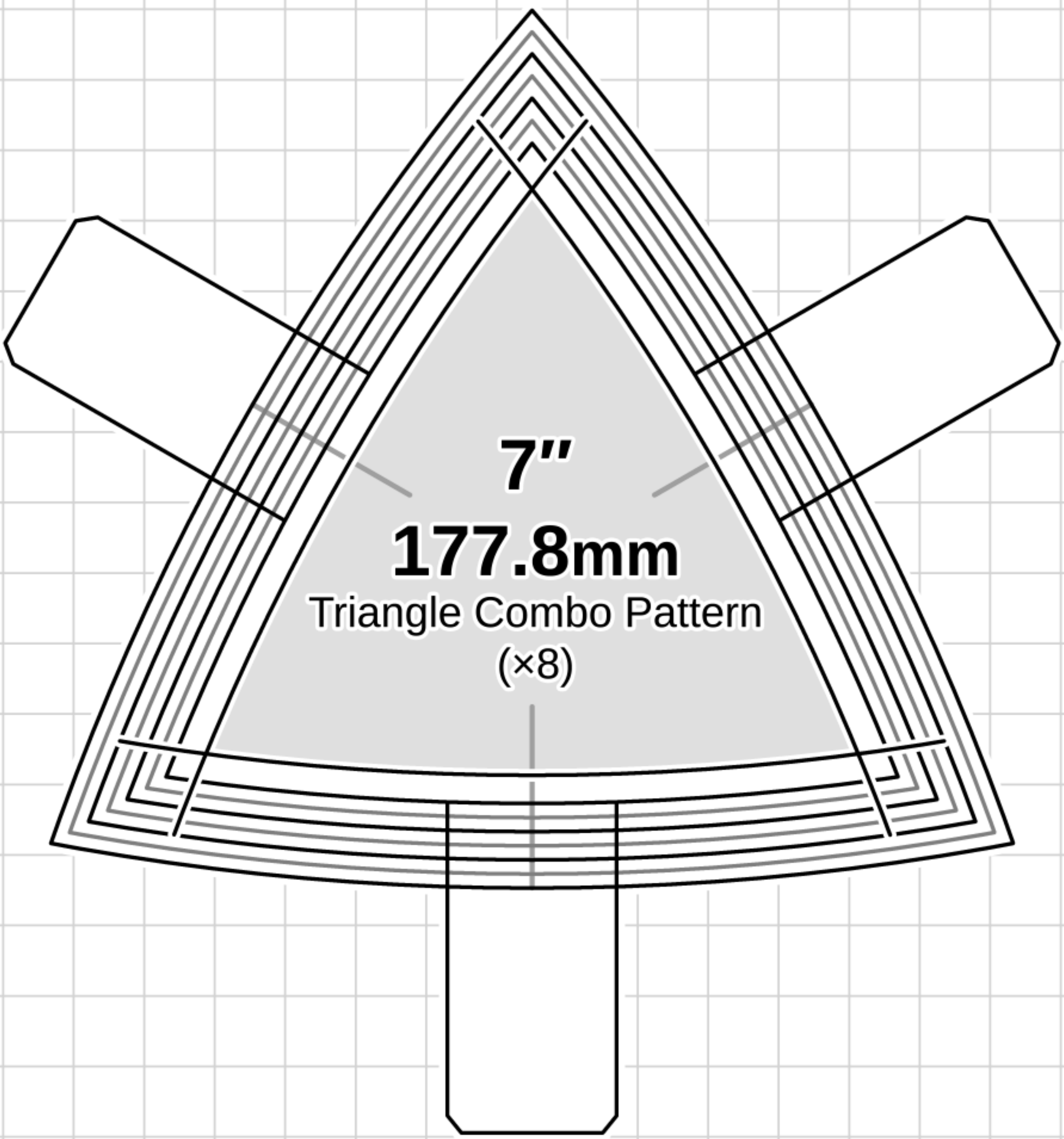
(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



Cuboctahedron (14 panels)

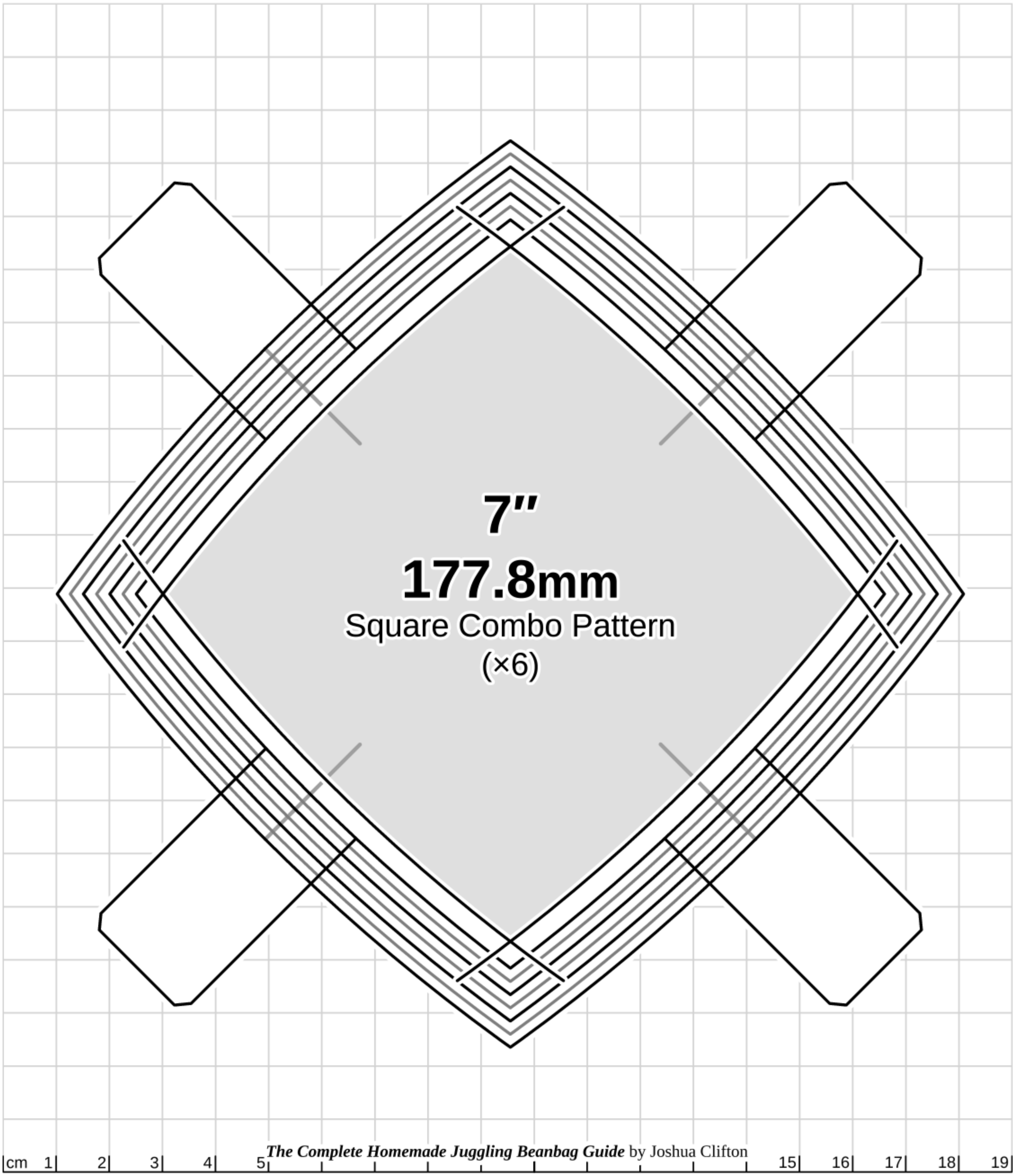
(Pattern sizes are adjusted for corduroy and do not account for gathered seams)

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.



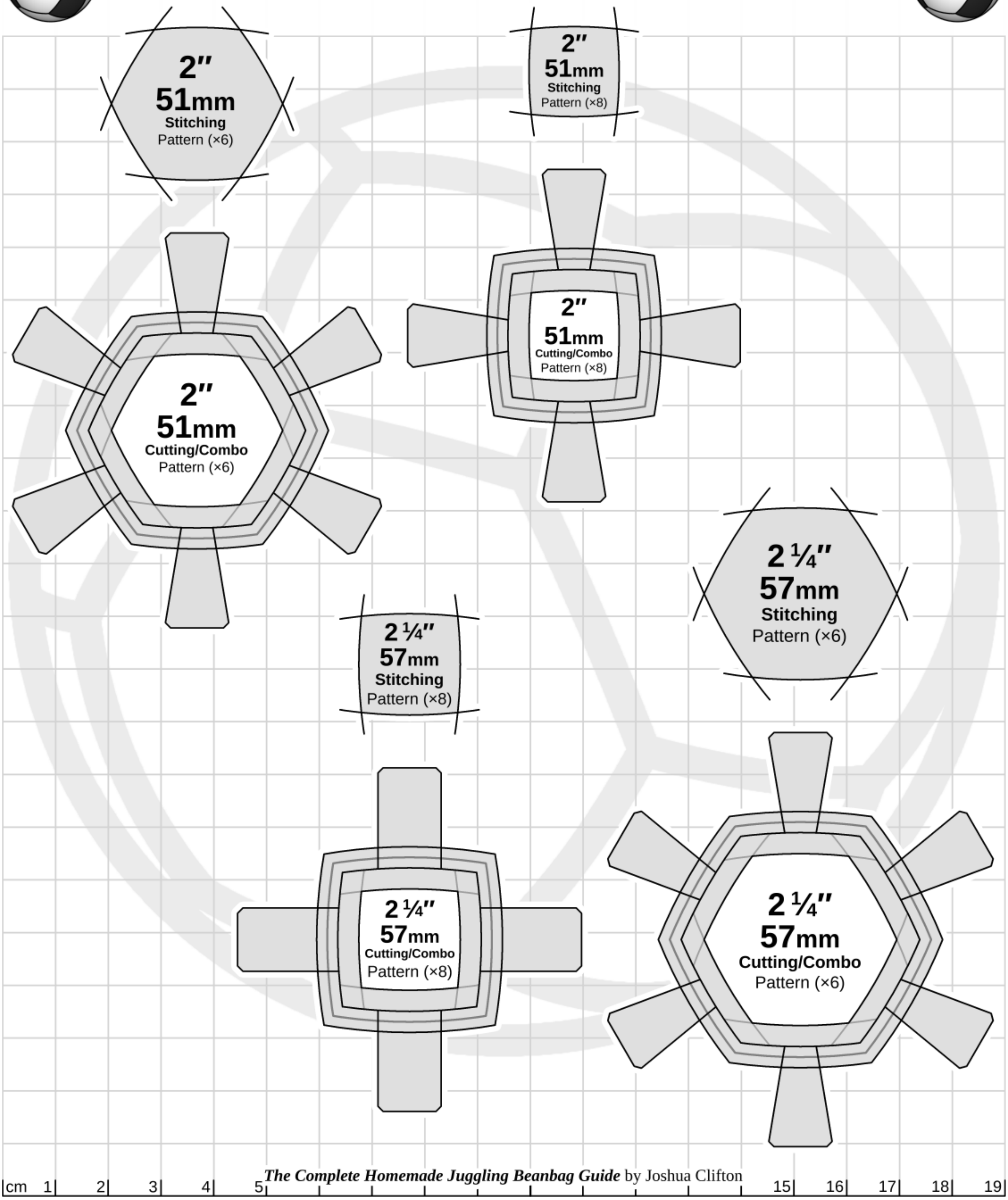
Cuboctahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



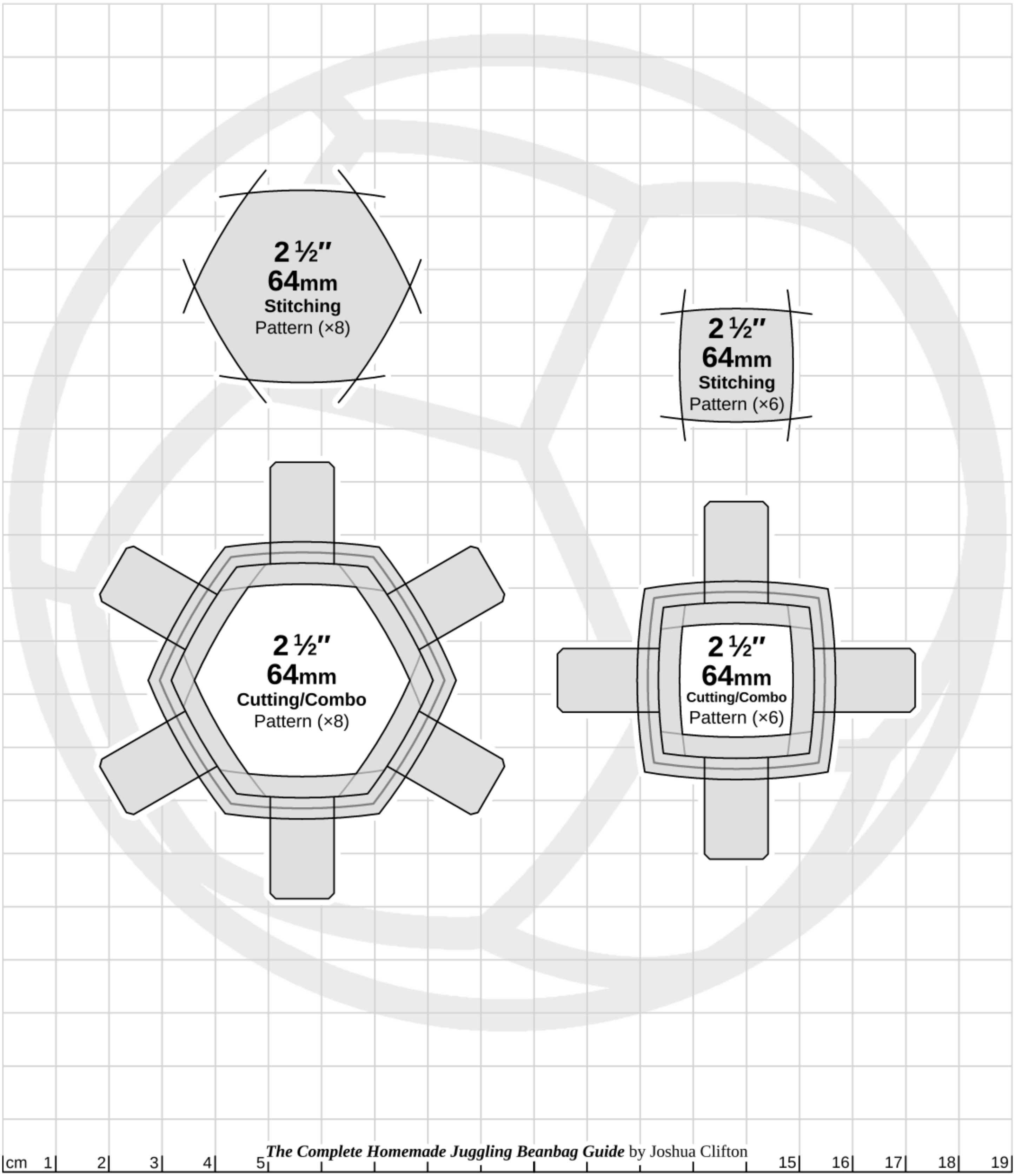
Truncated Octahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



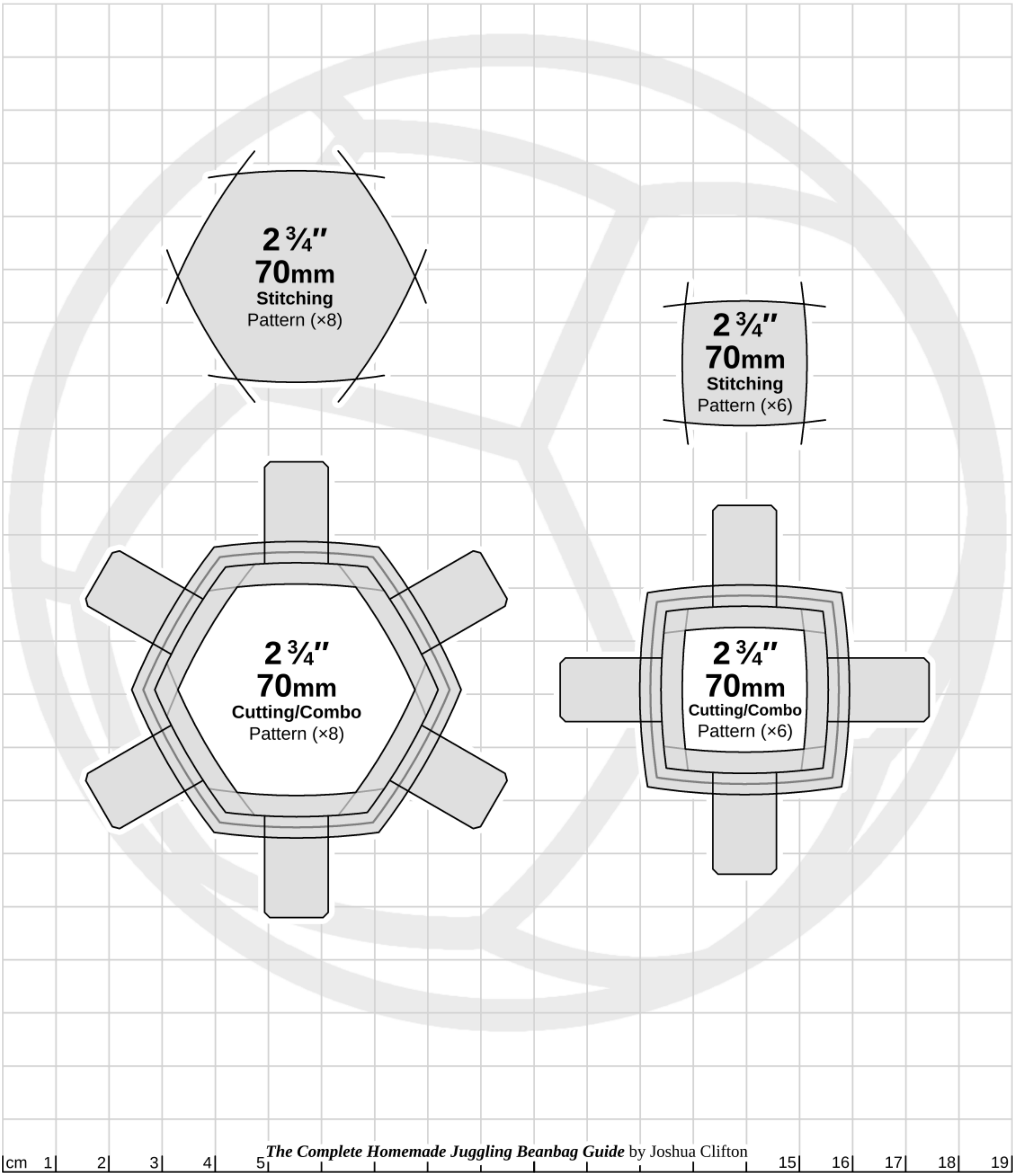
Truncated Octahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



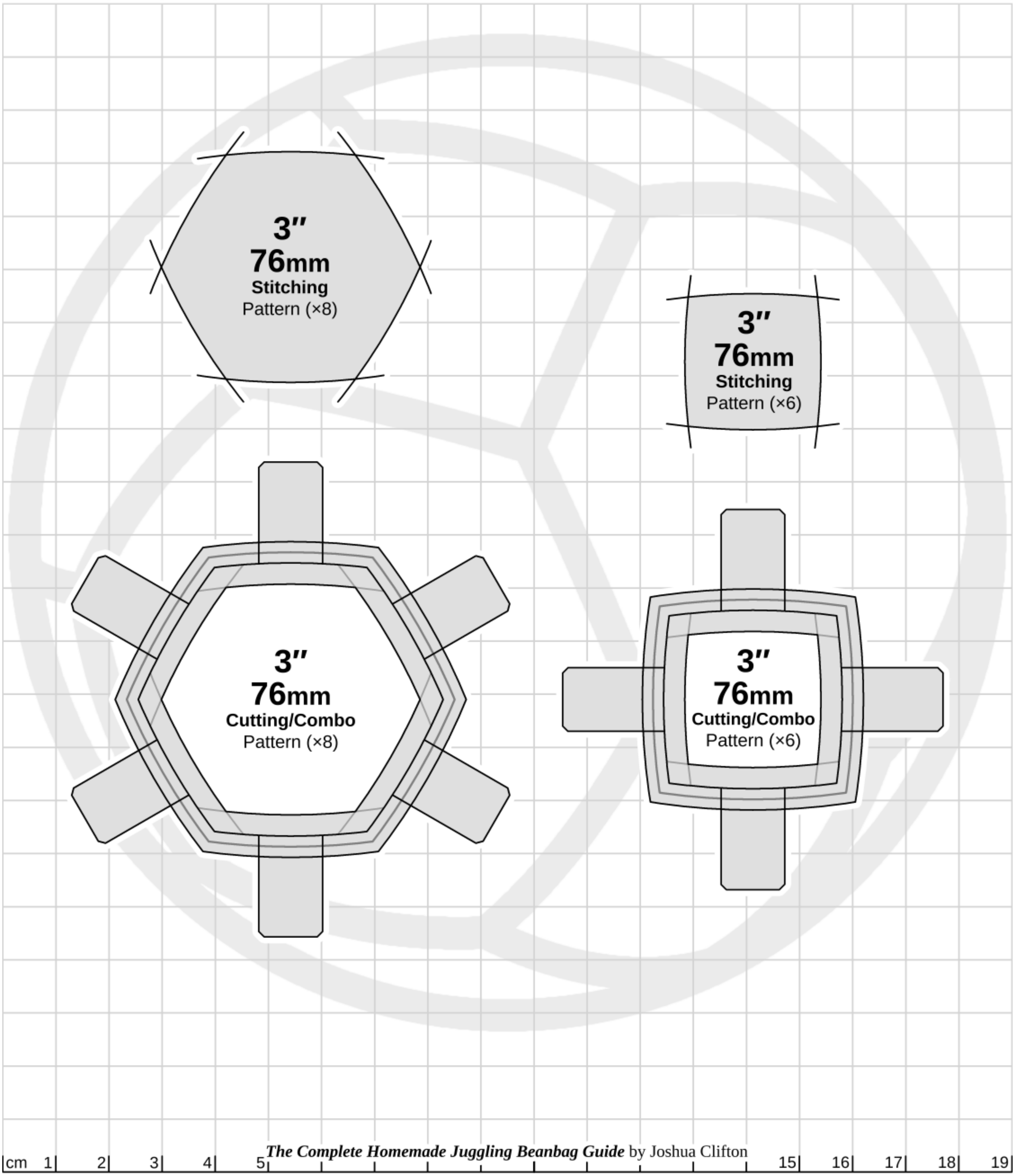
Truncated Octahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



Truncated Octahedron (14 panels)

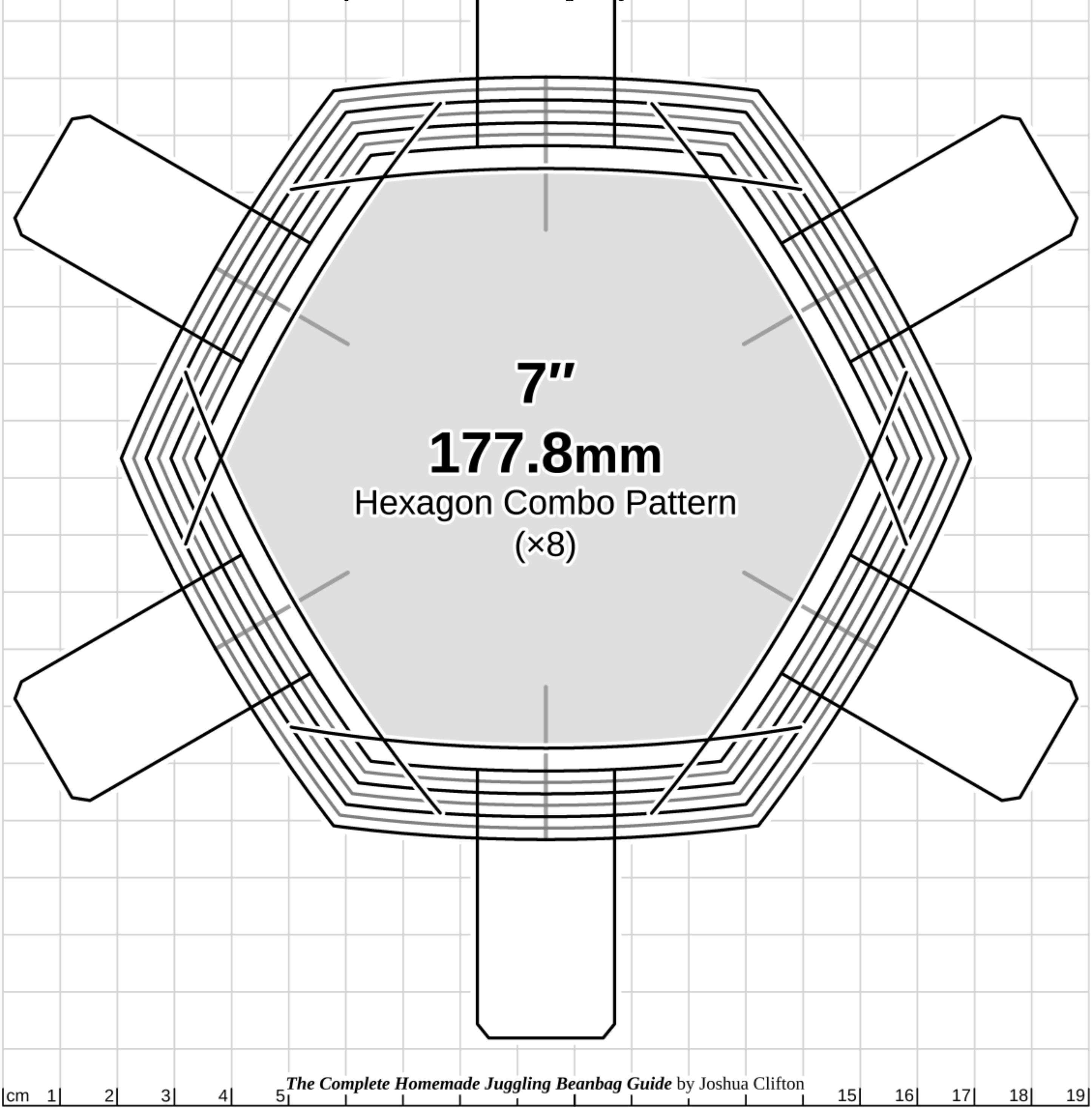
(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



Truncated Octahedron (14 panels)

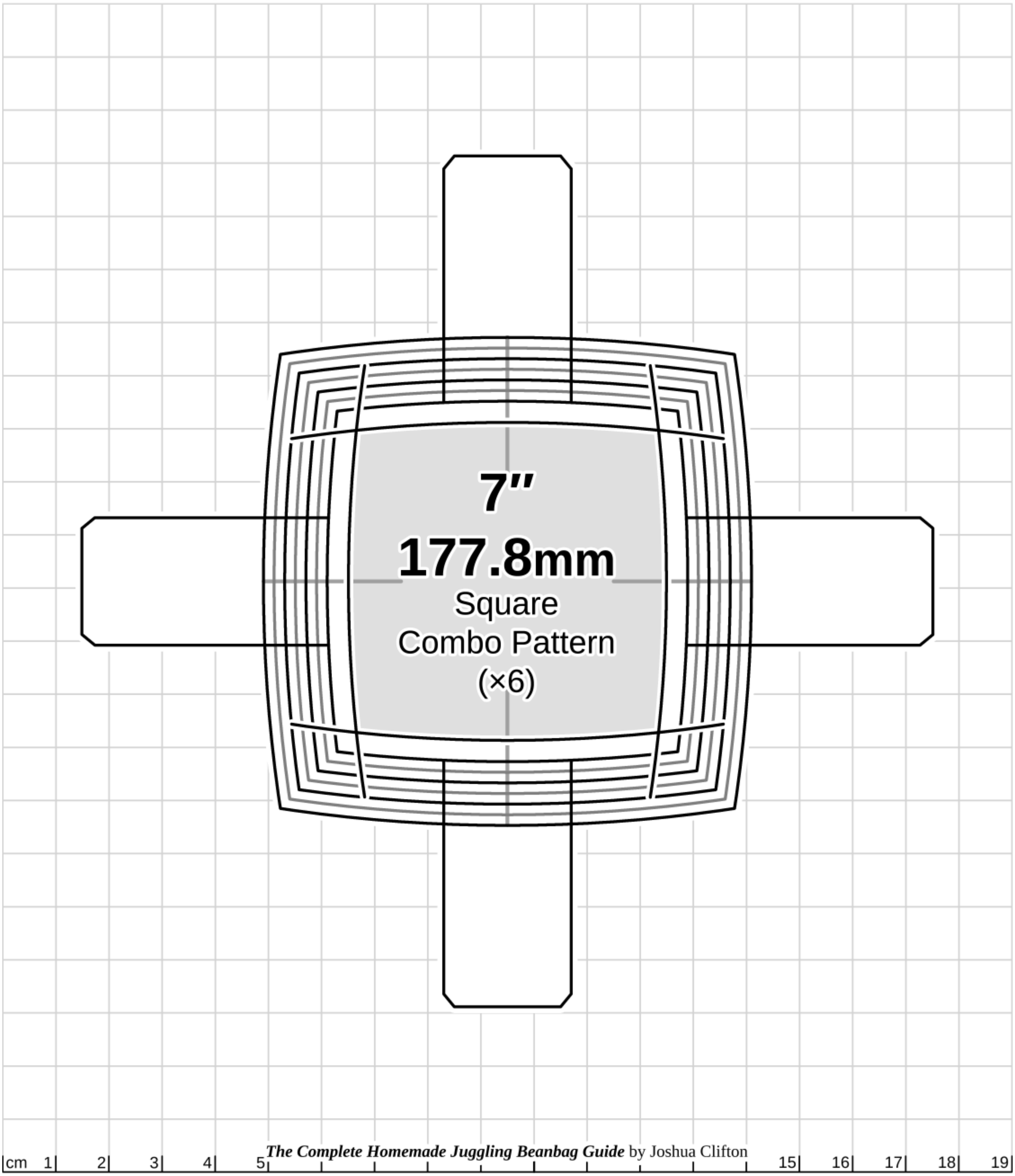
(Pattern sizes are adjusted for corduroy and do not account for gathered seams)

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.



Truncated Octahedron (14 panels)

(Pattern sizes are adjusted for corduroy and do not account for gathered seams)



Blank Color Arrangement Diagrams

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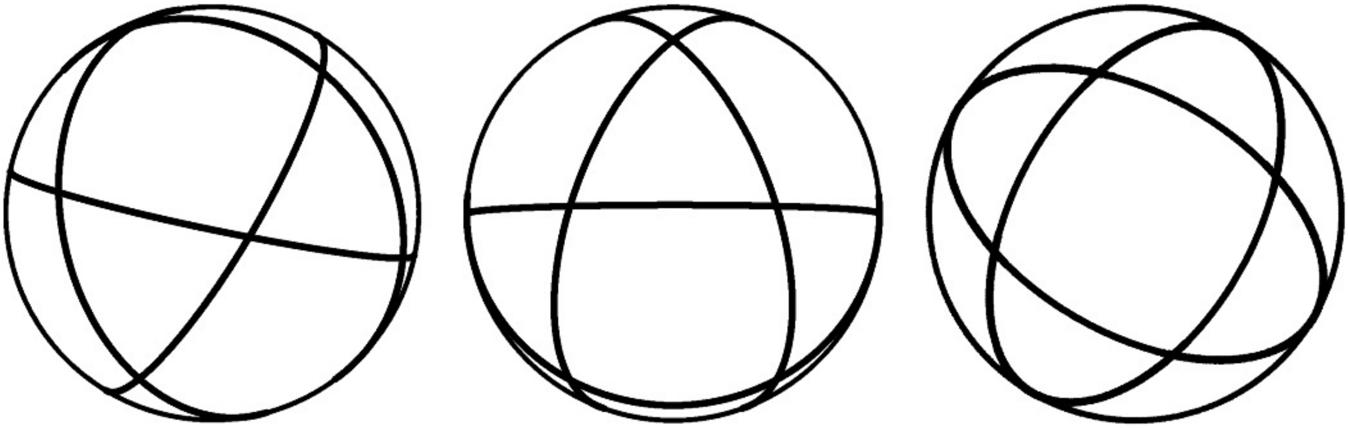
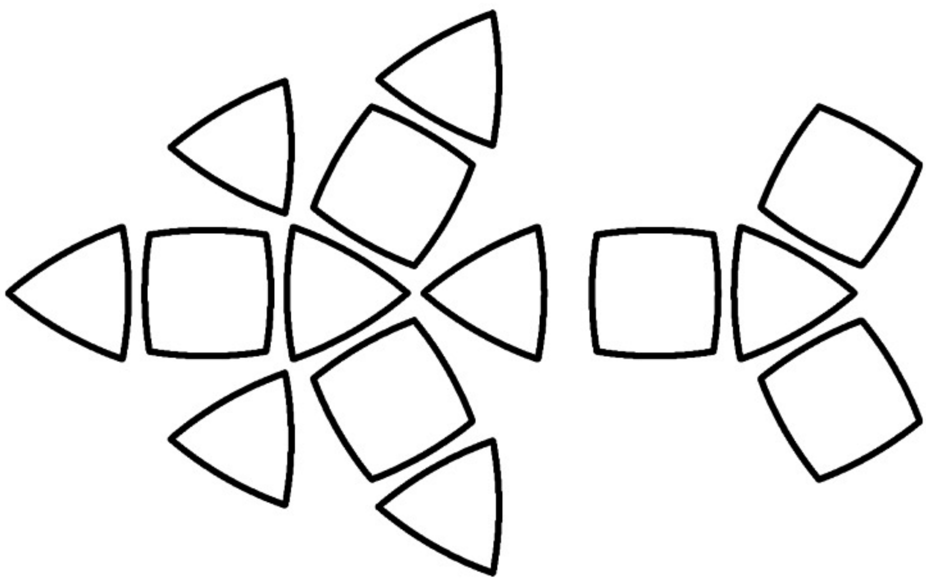
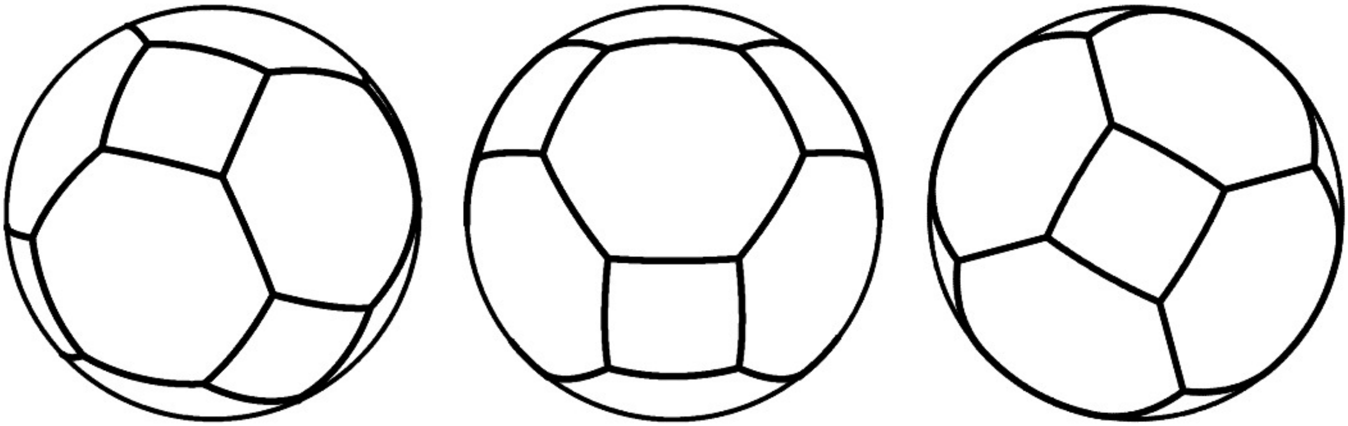
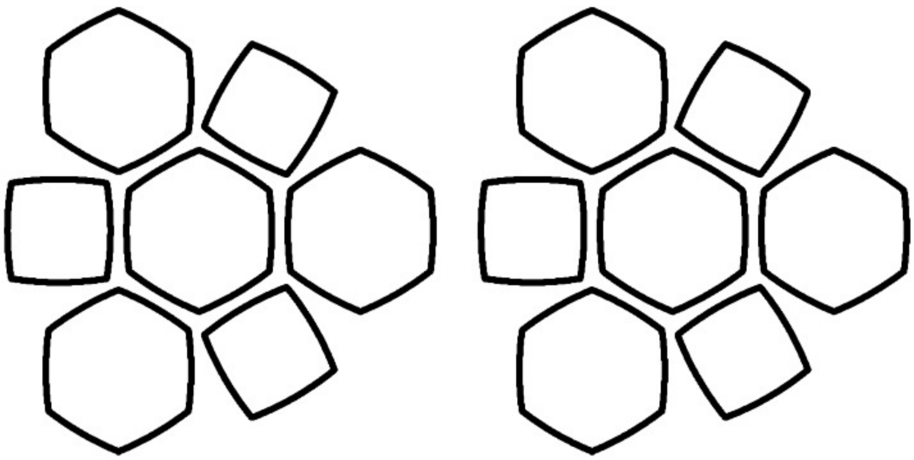
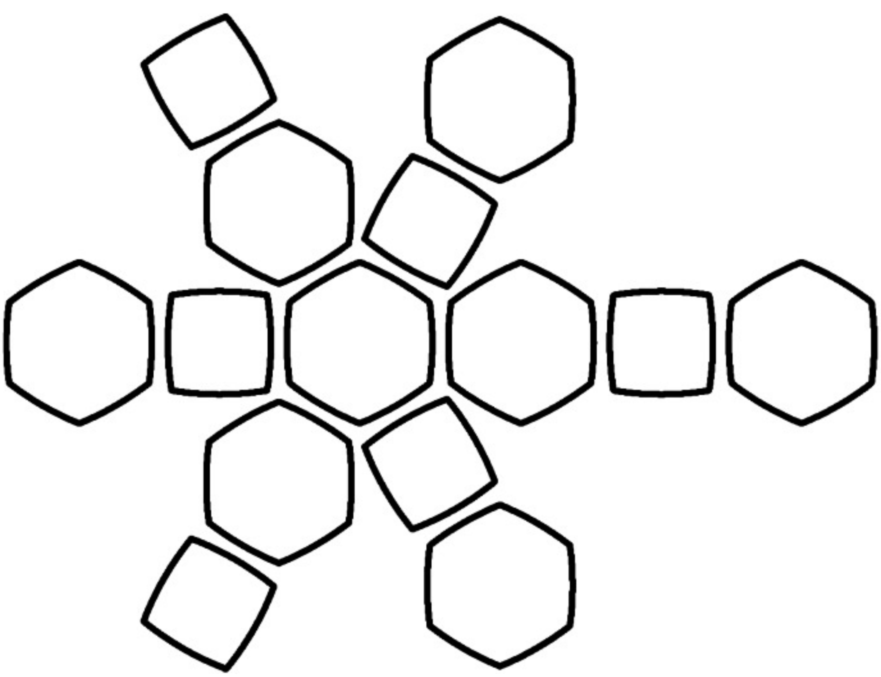
These are the ball and assembly layout diagrams I used for my color arrangement illustrations (the truncated octahedron is on the next page). You can use these to experiment with your own arrangements. I also offer PNG format diagrams for download on my website that you can use in an image editor. If they are unavailable, you can capture a screenshot of this page or export the image and then color it in an image editor. Or you can just print it and color it by hand.











Sizing Formulas for Drawing the Cuboctahedron Patterns

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The drawing instructions that follow include, for each panel shape, a table of pre-calculated panel framework and arc measurements for all ⅛″ diameter increments from 1 ¾″ – 3″. If you do not need to create a custom size, skip to those. The "Mathematics" section has explanations of all the formulas and ratios, and expresses their values in higher precision. I provide printable measuring tapes at the end of the **General Information and Techniques** chapter in case you care to measure your beanbags.

Design summary

The panel shapes for the cuboctahedron are a circular triangle and a circular square. They are drawn using guide polygons, the corners of which are the circle centers for the arcs that form the panel shapes. To draw the guide polygons and arcs to produce a desired bag size, you need the relationship between them and the resulting bag circumference. I provide the formulas that define those relationships below, and they are fully explained and illustrated in the "Mathematics" section of this chapter.

Adjusting for the influence of fabric attributes on beanbag size

The bag I made with thick corduroy was **3.62 – 8.12%** 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 **5.87%**. This makes my adjustment factor **1.0587**, almost exactly that of the Equidistant Cuboctahedron.

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 which is fairly thin, stiff, tightly-woven, and non-stretch, was -1.07 – +2.85% of the mathematical prediction for an average of 0.89% larger, but that was just for analyzing the shape characteristics of the bag.

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. Folding thin or flexible fabric doesn't consume as much of its size, and so the bag will be close to the mathematical prediction, unless it is stretchy. Corduroy folds and compresses easily and has a bit of stretch, resulting in a significant increase in size when filled.

Sizing formulas

Below are the formulas to calculate the pattern construction elements (*Diameter* and *Circumference* refer to your target ball size). 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

- **Guide Triangle Circumradius = *Diameter* × 1.9331 ÷ 1.0587**
  = *Circumference* × 0.6153 ÷ 1.0587

- **Guide Triangle Side Length = *Diameter* × 3.3482 ÷ 1.0587**
  = *Circumference* × 1.0658 ÷ 1.0587
- **Arc Radius = *Guide Tri Circumradius* × 1.0916**
  = *Guide Tri Side Length* × 0.6302
- For double-checking: **Pattern Height = *Guide Tri Circumradius* × 0.2561**
  = *Guide Tri Side Length* × 0.1479

Square Panel

- **Circle Center Distance (Guide Square Diagonal) = *Diameter* × 3.6333 ÷ 1.0587**
  = *Circumference* × 1.1565 ÷ 1.0587
- **Guide Arc Radius (Guide Square Side) = *Diagonal* ÷ $\sqrt{2}$ ≈ *Diagonal* × 0.7071**
- **Pattern Arc Radius = [same as Triangle Panel's Arc Radius]**
- For double-checking: **Panel Width = *Guide Square Diagonal* × 0.1615**

How to Draw the Cuboctahedron Patterns – Triangle

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Following the pattern measurement table are manual and SketchUp directions for drawing the circular triangle panel shape. The illustration numbers correspond to the steps of the manual directions. 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.

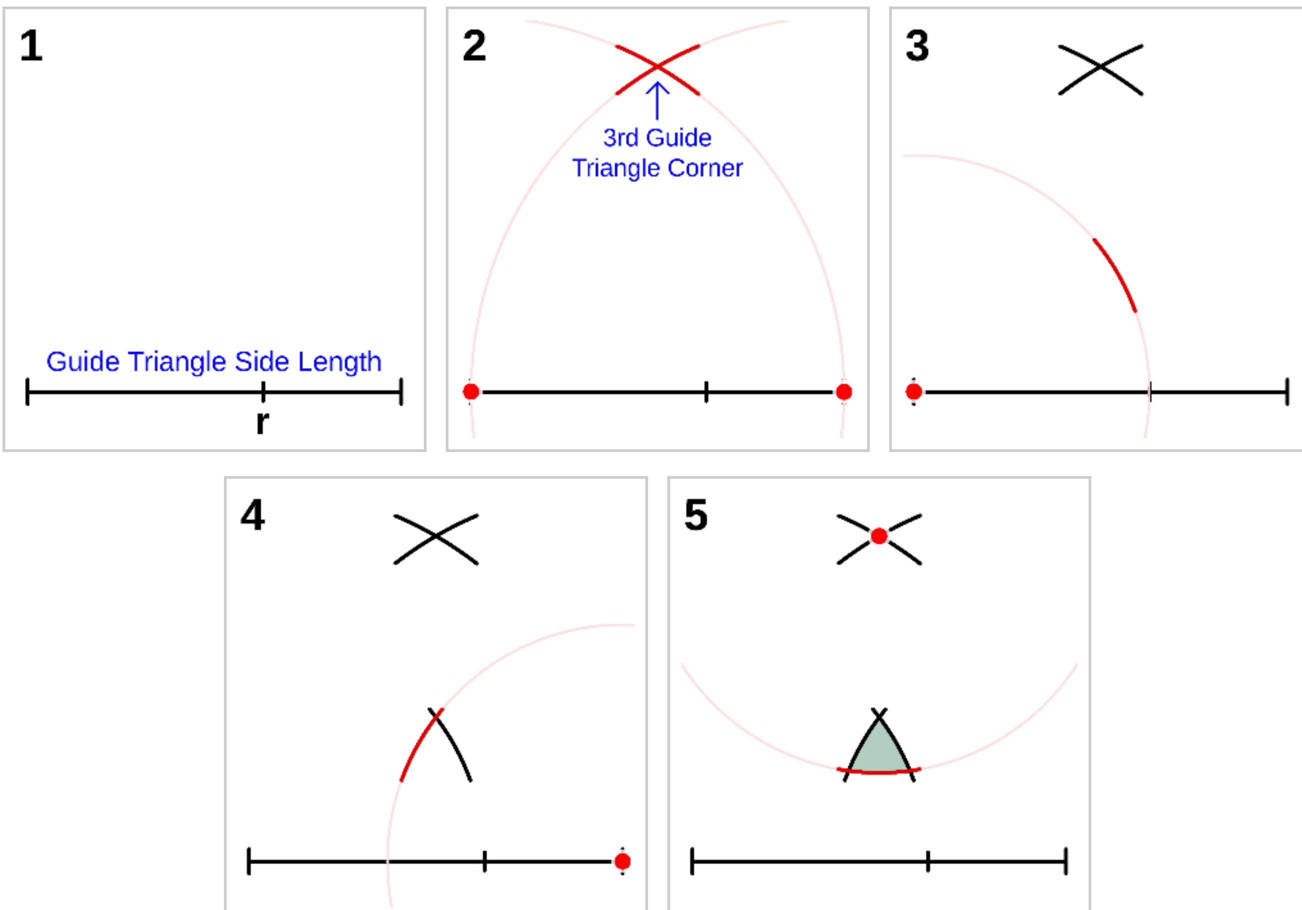
Cuboctahedron's Triangle pattern measurement table

The table below has stitching pattern measurements for each ⅛″ diameter increment from 1¾″ to 3″. The values in the **Adjusted** columns account for my **1.0587** 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 in the previous section.

To draw the cutting pattern, use the same guide triangle but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm) and center the new arcs at the same points. The cutting pattern will be larger than, but parallel to, the stitching pattern. Alternatively, you could just draw a simpler, straight-edged pattern around the circular one since the curves are so shallow.

Finished Diameter	**Guide Triangle Side Length** (mm)		**Guide Triangle Circumradius** (mm)		**Arc Radius** (mm)		**Pattern Height** (mm) (for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	148.825	**140.574**	85.924	**81.160**	93.795	**88.595**	22.007	**20.787**
1⅞″ (47.6mm)	159.456	**150.615**	92.062	**86.957**	100.495	**94.923**	23.579	**22.272**
2″ (50.8mm)	170.086	**160.656**	98.199	**92.755**	107.194	**101.251**	25.151	**23.757**
2⅛″ (54.0mm)	180.717	**170.697**	104.337	**98.552**	113.894	**107.579**	26.723	**25.242**
2¼″ (57.2mm)	191.347	**180.738**	110.474	**104.349**	120.594	**113.907**	28.295	**26.726**

Finished Diameter	**Guide Triangle Side Length** (mm)		**Guide Triangle Circumradius** (mm)		**Arc Radius** (mm)		**Pattern Height** (mm) (for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
2⅜″ (60.3mm)	201.977	**190.779**	116.612	**110.146**	127.293	**120.236**	29.867	**28.211**
2½″ (63.5mm)	212.608	**200.820**	122.749	**115.943**	133.993	**126.564**	31.439	**29.696**
2⅝″ (66.7mm)	223.238	**210.861**	128.887	**121.740**	140.693	**132.892**	33.011	**31.181**
2¾″ (69.9mm)	233.868	**220.902**	135.024	**127.538**	147.392	**139.220**	34.583	**32.666**
2⅞″ (73.0mm)	244.499	**230.942**	141.161	**133.335**	154.092	**145.548**	36.155	**34.150**
3″ (76.2mm)	255.129	**240.983**	147.299	**139.132**	160.792	**151.877**	37.727	**35.635**



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

Manual directions for the Cuboctahedron's Triangle

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

1. Draw a horizontal line the length of **Guide Triangle Side Length** and mark each end of it. This is the base of an imaginary equilateral guide triangle. Mark another point (labeled *r* in Illustration 1) the distance of **Arc Radius** from one end of the line which will be used to extend the compass to the correct radius.

2. Before using that radius measurement, set the compass radius to the length of the line, position it at each end of the line, and draw a small arc above the center to form an X that marks the third corner of the Guide Triangle.

3. Now use the **Arc Radius** mark (the point labeled *r* in Illustration 1) to reduce the compass radius to that radius and draw an arc above the line as shown in Illustration 3.
4. Keeping the compass radius unchanged, place the compass on the other end of the line and draw another arc like the previous one.
5. Place the compass on the intersection of the first two arcs (the 3rd Guide Triangle Corner) and draw a third arc that joins the previous two arcs and completes the panel shape. The circular triangle's height (corner to middle of opposite arc) should equal the specified **Pattern Height**.
6. To draw a cutting pattern, draw everything the same but increase the Arc Radius by the desired seam allowance (I use 8mm) and then draw the last three arcs from the same three points using that new radius. Or just draw a straight-edged triangle around the circular one since the curves are so shallow.

SketchUp directions for the Cuboctahedron's 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 = **Guide Triangle Circumradius**, which will result in a triangle with sides of length **Guide Triangle Side Length**.
2. Draw circles with the specified **Arc Radius** centered on the three corners of the guide triangle. The intersection of the circles forms the circular triangle panel shape whose height (corner to middle of opposite arc) should equal the specified **Pattern Height**.
3. To draw a cutting pattern, draw the same guide triangle but increase the circle radii by the desired seam allowance (I use 8mm).

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How to Draw the Cuboctahedron Patterns – Square

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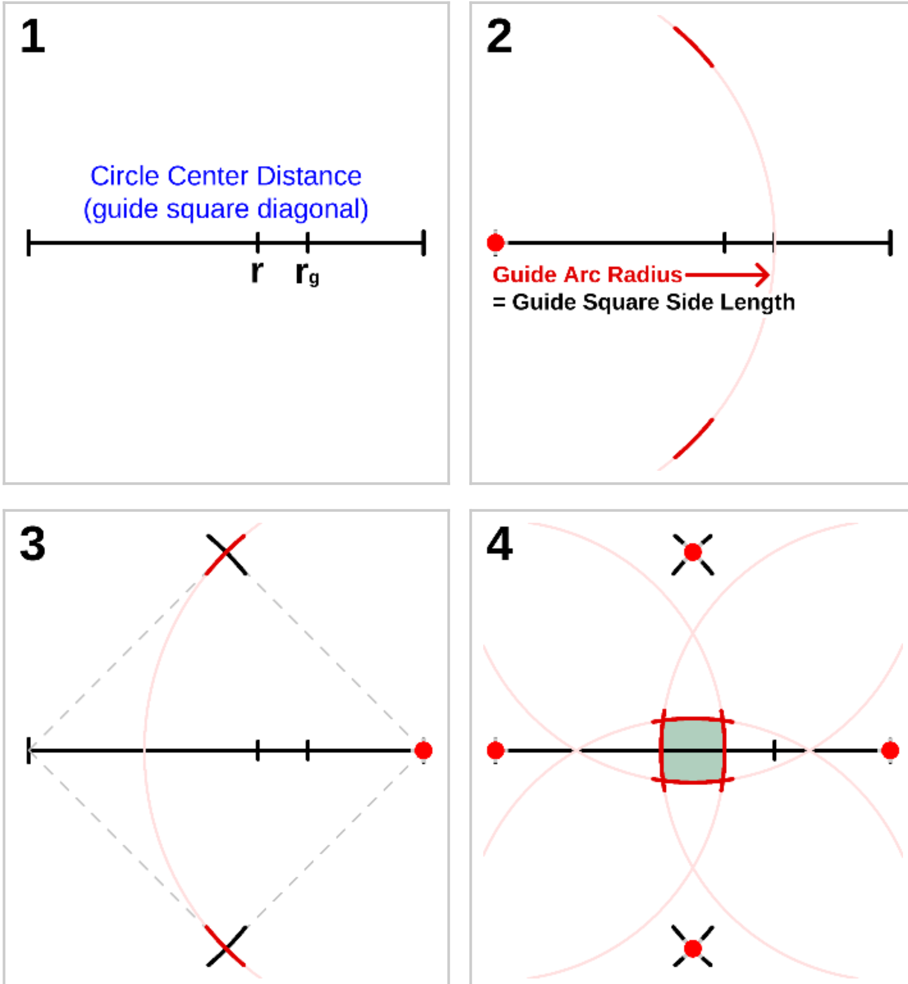
Following the pattern measurement table are manual and SketchUp directions for drawing the circular square panel shape. The illustration numbers correspond to the step numbers in the written directions. To conserve your template material, I recommend that you draw the pattern on paper and then glue or tape the pattern to your template material before cutting it out.

Cuboctahedron's 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 my **1.0587** 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.

To draw the cutting pattern, use the same guide square, but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm) and center the new arcs at the same points. The cutting pattern will be larger than, but parallel to, the stitching pattern. Alternatively, you could just draw a simpler, straight-edged pattern around the circular one since the curves are so shallow.

Finished Diameter	**Circle Center Distance** (guide square diagonal) (mm)		**Guide Arc Radius** (guide square side length) (mm)		**Pattern Arc Radius** (mm)		**Pattern Width** (mm) (for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	161.500	**152.546**	114.198	**107.866**	93.795	**88.595**	26.090	**24.644**
1⅞″ (47.6mm)	173.036	**163.442**	122.355	**115.571**	100.495	**94.923**	27.954	**26.404**
2″ (50.8mm)	184.571	**174.338**	130.512	**123.275**	107.194	**101.251**	29.817	**28.164**
2⅛″ (54.0mm)	196.107	**185.234**	138.669	**130.980**	113.894	**107.579**	31.681	**29.925**
2¼″ (57.2mm)	207.643	**196.130**	146.826	**138.685**	120.594	**113.907**	33.545	**31.685**
2⅜″ (60.3mm)	219.179	**207.026**	154.983	**146.390**	127.293	**120.236**	35.408	**33.445**
2½″ (63.5mm)	230.714	**217.922**	163.140	**154.094**	133.993	**126.564**	37.272	**35.205**
2⅝″ (66.7mm)	242.250	**228.818**	171.297	**161.799**	140.693	**132.892**	39.135	**36.966**
2¾″ (69.9mm)	253.786	**239.714**	179.454	**169.504**	147.392	**139.220**	40.999	**38.726**
2⅞″ (73.0mm)	265.321	**250.611**	187.611	**177.208**	154.092	**145.548**	42.863	**40.486**
3″ (76.2mm)	276.857	**261.507**	195.768	**184.913**	160.792	**151.877**	44.726	**42.246**



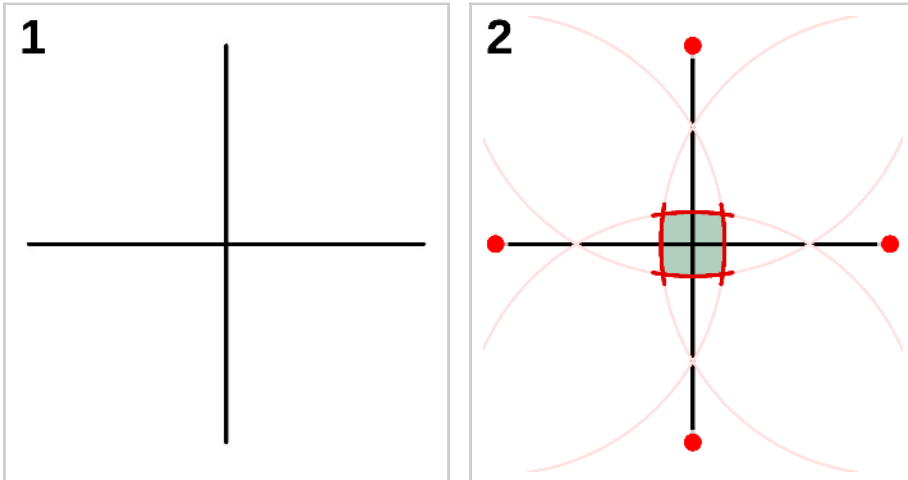
Illustrations for the manual directions. The numbers correspond to the step numbers.

Manual directions for the Cuboctahedron's Square

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

1. Draw a horizontal line of length **Circle Center Distance** and mark each end of it. Also mark two points along it: r, which is the distance of **Pattern Arc Radius** from one end, and r_g, which is the distance of **Guide Arc Radius** from the same end. You will use these marks to extend the compass to the correct radii.
2. Extend the compass to the **Guide Arc Radius** mark (r_g), and from that endpoint of the line draw partial arcs above and below the middle of the line.
3. Place the compass on the opposite endpoint and draw two more arcs to produce two X-shaped intersections. Those are two of the Guide Square's corners. The other two are the endpoints of the first line. The four corners are the compass points to use in forming the panel shape.
4. Extend the compass to the **Pattern Arc Radius** mark (r) and draw four arcs, two centered at the endpoints of the line, and two centered at the arc intersections you made in the previous step. This forms the circular square, whose width and height should equal **Pattern Width**. Any error you make will be compounded several times in the juggling bag, so be as precise as you can.

5. To draw a cutting pattern, increase the Pattern Arc Radius by the desired seam allowance (I use 8mm) and then draw the four new arcs centered at the same four points. Or just draw a straight-edged square around the circular one since the curves are so shallow.



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

SketchUp directions for the Cuboctahedron's Square

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

1. Draw two perpendicular lines of length **Circle Center Distance** and center them on each other.
2. Draw circles of radius **Pattern Arc Radius** centered on all four ends of the lines. The intersection of the four circles forms the circular square. Its width and height should equal **Pattern Width**.
3. To draw a cutting pattern, draw the same two lines but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm).

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Sizing Formulas for Drawing the Trunc Octahedron Patterns

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The drawing instructions that follow include, for each panel shape, a table of pre-calculated panel framework and arc measurements for all ⅛″ diameter increments from 1 ¾″ – 3″. If you do not need to create a custom size, skip to those. The "Mathematics" section has explanations of all the formulas and ratios, and expresses their values in higher precision. I provide printable measuring tapes at the end of the **General Information and Techniques** chapter in case you care to measure your beanbags.

Design summary

The panel shapes for the truncated octahedron are a circular hexagon and a circular square. They are drawn using guide polygons, the corners of which are the circle centers for the arcs that form the panel shapes. To draw the guide polygons and arcs to produce a desired bag size, you need the relationship between them and the resulting bag circumference. I provide the formulas that define those relationships below, and they are fully explained and illustrated in the "Mathematics" section of this chapter.

I also provide measurements and instructions for drawing straight-edged patterns, since they work almost equally well for this design.

Adjusting for the influence of fabric attributes on beanbag size

The bag I made with thick corduroy was **2.68 – 6.64%** 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 **4.66%**. This makes my adjustment factor **1.0466**.

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 which is fairly thin, stiff, tightly-woven, and non-stretch, was -0.75 – +2.56% of the mathematical prediction for an average of 0.91% larger, but that was just for analyzing the shape characteristics of the bag. **The spherical design was 1.75% larger than the straight-edged ball.**

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. Folding thin or flexible fabric doesn't consume as much of its size, and so the bag will be close to the mathematical prediction, unless it is stretchy. Corduroy folds and compresses easily and has a bit of stretch, resulting in a significant increase in size when filled.

Sizing formulas

Below are the formulas to calculate the pattern construction elements (*Diameter* and *Circumference* refer to your target ball size). 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.**

Hex Panel

- **Guide Hex Corner Width = *Diameter* × 2.6056 ÷ 1.0466**
  = *Circumference* × 0.8294 ÷ 1.0466
- **Guide Hex Circumradius/Side Length = *Diameter* × 1.3028 ÷ 1.0466**
  = *Circumference* × 0.4147 ÷ 1.0466
- **Arc Radius = *Guide Hex Corner Width* × 0.6146**
  = *Guide Hex Circumradius/Side Length* × 1.2293
- For double-checking: **Pattern Height = *Guide Hex Corner Width* × 0.2293**
  = *Guide Hex Circumradius/Side Length* × 0.4586

Square Panel

- **Circle Center Distance (Guide Square Diagonal) = *Diameter* × 2.8507 ÷ 1.0466**
  = *Circumference* × 0.9074 ÷ 1.0466
- **Guide Arc Radius (Guide Square Side) = *Diagonal* ÷ $\sqrt{2}$ ≈ *Diagonal* × 0.7071**
- **Pattern Arc Radius = [same as Triangle Panel's Arc Radius]**
- For double-checking: **Panel Width = *Guide Square Diagonal* × 0.1236**

Straight-Edged Hex Panel

- **Hex Corner Width = *Diameter* × 0.6851 ÷ 1.0466**
  = *Circumference* × 0.2181 ÷ 1.0466
- **Hex Circumradius/Side Length = *Diameter* × 0.3426 ÷ 1.0466**
  = *Circumference* × 0.1090 ÷ 1.0466
- For double-checking: **Hex Height = *Hex Corner Width* × 0.8660**
  = *Hex Circumradius/Side Length* × 1.7321

Straight-Edged Square Panel

- **Square Diagonal = *Diameter* × 0.4844 ÷ 1.0466**
  = *Circumference* × 0.1542 ÷ 1.0466
- **Square Side = [same as Hex Circumradius/Side Length]**

How to Draw the Trunc Octahedron Patterns – Circular Hexagon

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Following the pattern measurement table are manual and SketchUp directions for drawing the hex panel shape. 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.

Trunc Octahedron's Hexagon 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 **1.0466** estimated 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 in the previous section.

To draw the cutting pattern, use the same guide hex, but increase the Arc Radius by the desired seam allowance (I use 8mm) and center the new arcs at the same points. The cutting pattern will be larger than, but parallel to, the stitching pattern. Alternatively, you could just draw a simpler, straight-edged pattern around the circular one since the curves are so shallow.

Finished Diameter	**Guide Hex Corner Width** (mm)		**Guide Hex Circumradius/Side Length** (mm)		**Arc Radius** (mm)		**Pattern Height** (mm)(for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	115.819	**110.663**	57.910	**55.331**	71.188	**68.019**	26.557	**25.375**
1⅞″ (47.6mm)	124.092	**118.567**	62.046	**59.283**	76.273	**72.877**	28.454	**27.187**
2″ (50.8mm)	132.365	**126.471**	66.183	**63.236**	81.358	**77.735**	30.351	**28.999**
2⅛″ (54.0mm)	140.638	**134.376**	70.319	**67.188**	86.443	**82.594**	32.248	**30.812**
2¼″ (57.2mm)	148.911	**142.280**	74.455	**71.140**	91.528	**87.452**	34.145	**32.624**
2⅜″ (60.3mm)	157.183	**150.185**	78.592	**75.092**	96.613	**92.311**	36.042	**34.437**
2½″ (63.5mm)	165.456	**158.089**	82.728	**79.045**	101.697	**97.169**	37.939	**36.249**
2⅝″ (66.7mm)	173.729	**165.994**	86.865	**82.997**	106.782	**102.028**	39.836	**38.062**
2¾″ (69.9mm)	182.002	**173.898**	91.001	**86.949**	111.867	**106.886**	41.732	**39.874**
2⅞″ (73.0mm)	190.275	**181.803**	95.137	**90.901**	116.952	**111.745**	43.629	**41.687**
3″ (76.2mm)	198.548	**189.707**	99.274	**94.854**	122.037	**116.603**	45.526	**43.499**

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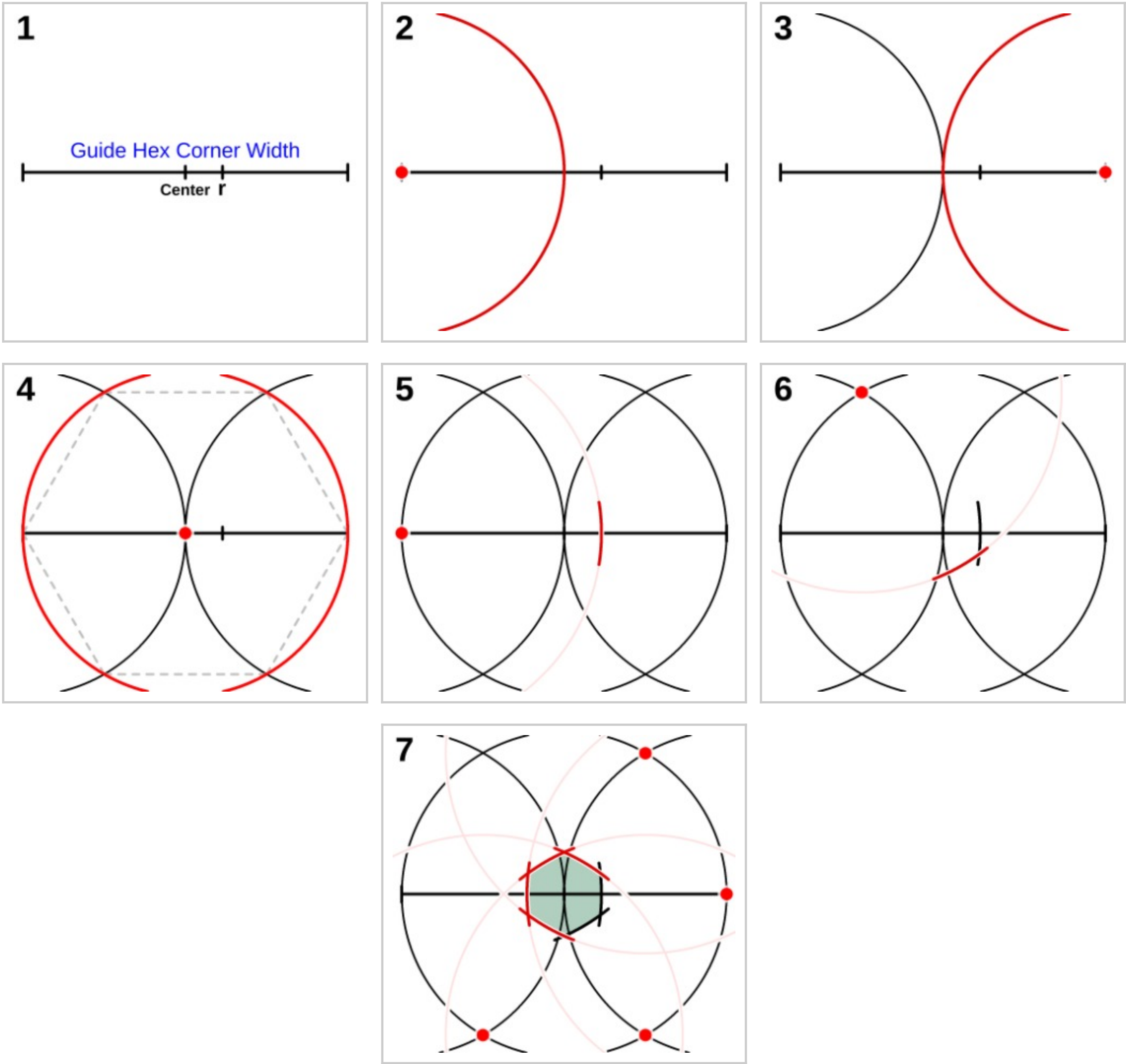


Illustrations for the manual directions. The numbers correspond to the step numbers.

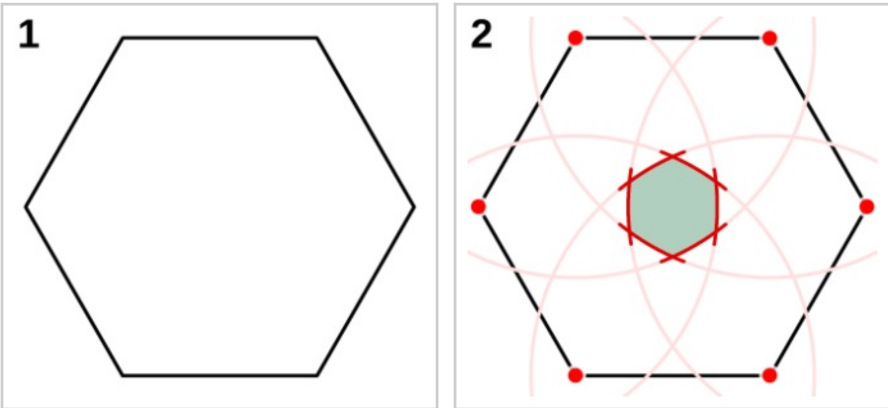
Manual directions for the Trunc Octahedron's Hex

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

1. Draw a horizontal line of length **Guide Hex Corner Width** and mark each end of it. Also mark two points along it: a center mark (**Guide Hex Circumradius/Side Length** distant from each end), and *r*, which is the distance of **Arc Radius** from the end. You will use these marks to extend the compass to the correct radii.
2. Place the compass on one end of the line, extend it to the center mark, and draw half a circle centered on the line.
3. Place the compass on the opposite endpoint and draw another half circle centered on the line.
4. Place the compass on the center point of the line and draw a full circle, which should meet both ends of the line. The points where this circle intersects the other two circles and the two

endpoints of the first line form the corners of the Guide Hexagon as shown by the dashed lines. Those points are the centers for the circles that form the pattern shape.

5. Extend the compass to the **Arc Radius** mark (*r*) and, from an endpoint of the line, draw a short arc through the line as shown in Illustration 5.
6. Keeping the compass radius the same, place the compass on one of the intersections of the circles and draw another arc as shown in Illustration 6.
7. Center the compass on the remaining circle intersections and on the other endpoint of the line and draw four more arcs (six total). The intersection of the six arcs forms the circular hexagon. Its height, arc to opposite arc, should equal **Pattern Height**. Any error you make will be compounded several times in the juggling bag, so be as precise as you can.
8. To draw a cutting pattern, increase the Arc Radius by the desired seam allowance (I use 8mm) and then draw the six new arcs centered at the same six points (the guide hex remains the same size). Or just draw a straight-edged hexagon around the circular one since the curves are so shallow.



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

SketchUp directions for the Trunc Octahedron's Hex

(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 6 sides and draw a hexagon with circumradius = **Guide Hex Circumradius/Side Length**.
2. Draw circles of radius **Arc Radius** centered on all six corners of the hexagon. The intersection of the six circles forms the circular hex panel shape. Its height, arc to opposite arc, should equal **Pattern Height**.
3. To draw a cutting pattern, draw everything the same but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm).

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How to Draw the Trunc Octahedron Patterns – Circular Square

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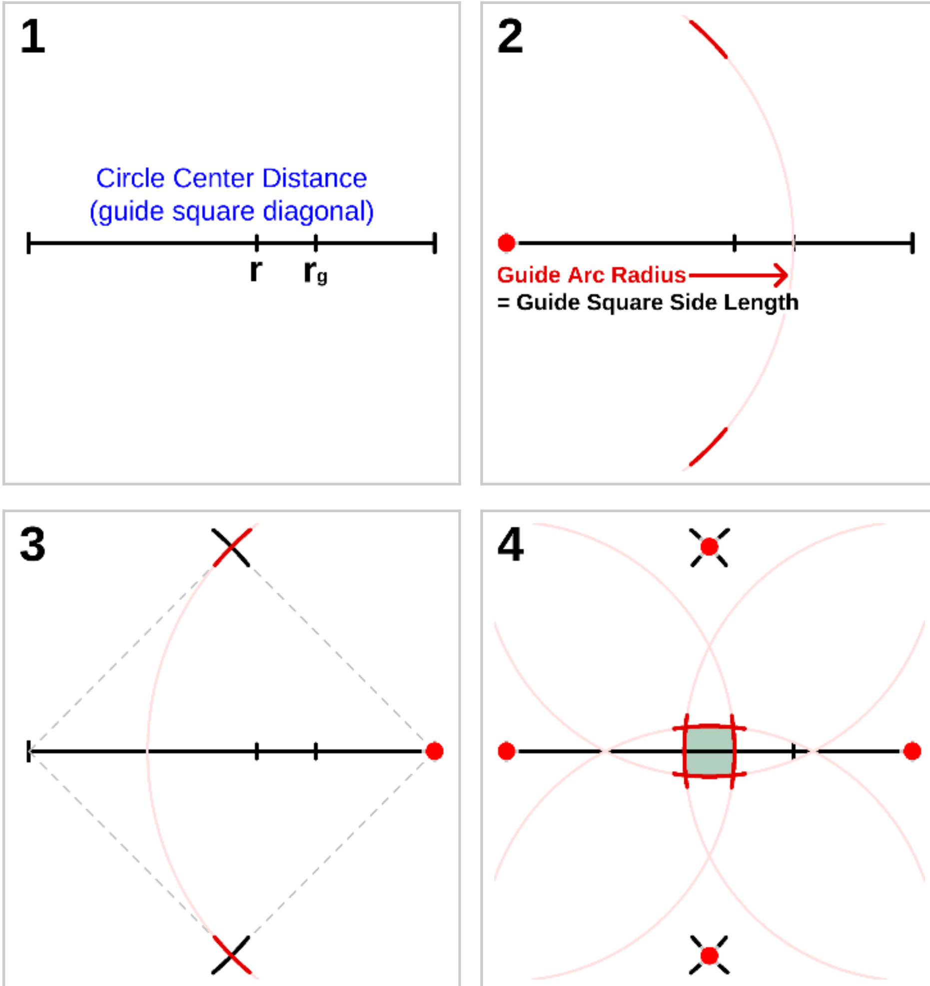
Following the pattern measurement table are manual and SketchUp directions for drawing the square panel shape. To conserve your template material, I recommend that you draw the pattern on paper and then glue or tape the pattern to your template material before cutting it out.

Truncated Octahedron 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 **1.0466** estimated 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.

To draw the cutting pattern, use the same guide square, but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm) and center the new arcs at the same points. The cutting pattern will be larger than, but parallel to, the stitching pattern. Alternatively, you could just draw a simpler, straight-edged pattern around the circular one since the curves are so shallow.

Finished Diameter	**Circle Center Distance** (guide square diagonal) (mm)		**Guide Arc Radius** (guide square side length) (mm)		**Pattern Arc Radius** (mm)		**Pattern Width** (mm) (for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	126.714	**121.072**	89.600	**85.611**	71.188	**68.019**	15.662	**14.965**
1⅞″ (47.6mm)	135.765	**129.720**	96.000	**91.726**	76.273	**72.877**	16.781	**16.034**
2″ (50.8mm)	144.816	**138.368**	102.400	**97.841**	81.358	**77.735**	17.900	**17.103**
2⅛″ (54.0mm)	153.867	**147.016**	108.800	**103.956**	86.443	**82.594**	19.019	**18.172**
2¼″ (57.2mm)	162.918	**155.664**	115.200	**110.071**	91.528	**87.452**	20.137	**19.241**
2⅜″ (60.3mm)	171.969	**164.312**	121.601	**116.186**	96.613	**92.311**	21.256	**20.310**
2½″ (63.5mm)	181.020	**172.960**	128.001	**122.301**	101.697	**97.169**	22.375	**21.379**
2⅝″ (66.7mm)	190.071	**181.608**	134.401	**128.416**	106.782	**102.028**	23.494	**22.447**
2¾″ (69.9mm)	199.122	**190.256**	140.801	**134.531**	111.867	**106.886**	24.612	**23.516**
2⅞″ (73.0mm)	208.173	**198.904**	147.201	**140.646**	116.952	**111.745**	25.731	**24.585**
3″ (76.2mm)	217.224	**207.552**	153.601	**146.762**	122.037	**116.603**	26.850	**25.654**



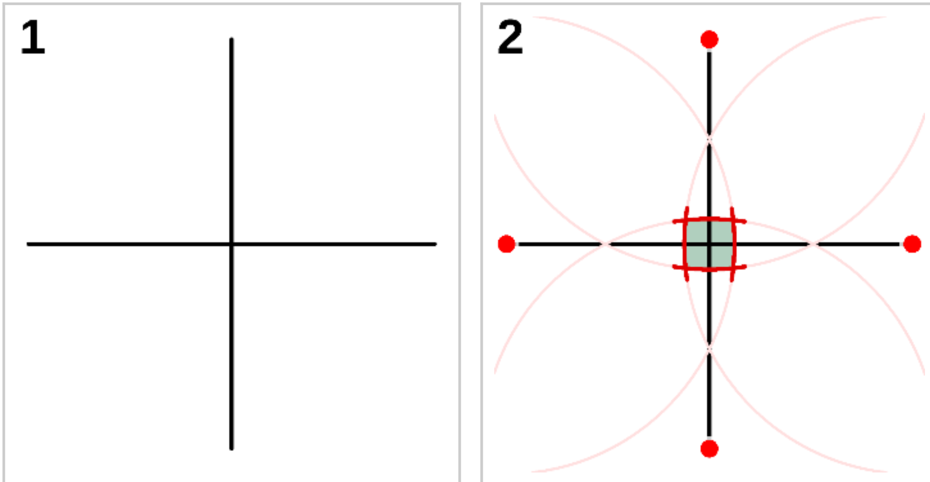
Illustrations for the manual directions. The numbers correspond to the step numbers.

Manual directions for the Trunc Octahedron's Square

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

1. Draw a horizontal line of length **Circle Center Distance** and mark each end of it. Also mark two points along it: r, which is the distance of **Pattern Arc Radius** from one end, and r_g, which is the distance of **Guide Arc Radius** from the same end. You will use these marks to extend the compass to the correct radii.
2. Place the compass on that end of the line, extend it to the **Guide Arc Radius** mark (r_g), and draw partial arcs above and below the middle of the line.
3. Place the compass on the opposite endpoint and draw two more arcs to produce two X-shaped intersections. Those are two of the Guide Square's corners. The other two are the endpoints of the first line. The four corners are the compass points to use in forming the panel shape.
4. Extend the compass to the **Pattern Arc Radius** mark (r) and draw four arcs, two centered at the endpoints of the line, and two centered at the arc intersections you made in the previous step. This forms the circular square, whose width and height should equal **Pattern Width**. Any error you make will be compounded several times in the juggling bag, so be as precise as you can.

5. To draw a cutting pattern, increase the Pattern Arc Radius by the desired seam allowance (I use 8mm) and then draw the four new arcs centered at the same four points. Or just draw a straight-edged square around the circular one since the curves are so shallow.



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

SketchUp directions for the Trunc Octahedron's Square

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

1. Draw two perpendicular lines of length **Circle Center Distance** and center them on each other.
2. Draw circles of radius **Pattern Arc Radius** centered on all four ends of the lines. The intersection of the four circles forms the circular square. Its width and height should equal **Pattern Width**.
3. To draw a cutting pattern, draw the same two lines but increase the Pattern Arc Radius by the desired seam allowance (I use 8mm).

How to Draw the Trunc Octahedron Patterns – Straight-Edged Hexagon

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Following the pattern measurement table are manual and SketchUp directions for drawing the straight-edged hex panel shape. 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.

Trunc Octahedron's Hexagon 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 **1.0466** estimated 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 Hex Corner Width by the allowance × 4(tan 30°) ≈ 2.3094, or the circumradius/side length by allowance × 2(tan 30°) ≈ 1.1547. (I use 8mm allowances.)

Finished Diameter	**Hex Corner Width** (mm)		**Hex Circumradius/Side Length** (mm)		**Hex Height** (mm)(for double-checking)	
	Base	**Adjusted**	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	30.453	**29.097**	15.227	**14.549**	26.373	**25.199**
1⅞″ (47.6mm)	32.628	**31.175**	16.314	**15.588**	28.257	**26.999**
2″ (50.8mm)	34.803	**33.254**	17.402	**16.627**	30.141	**28.799**
2⅛″ (54.0mm)	36.979	**35.332**	18.489	**17.666**	32.024	**30.599**
2¼″ (57.2mm)	39.154	**37.411**	19.577	**18.705**	33.908	**32.399**
2⅜″ (60.3mm)	41.329	**39.489**	20.665	**19.744**	35.792	**34.198**
2½″ (63.5mm)	43.504	**41.567**	21.752	**20.784**	37.676	**35.998**
2⅝″ (66.7mm)	45.680	**43.646**	22.840	**21.823**	39.560	**37.798**
2¾″ (69.9mm)	47.855	**45.724**	23.927	**22.862**	41.443	**39.598**
2⅞″ (73.0mm)	50.030	**47.802**	25.015	**23.901**	43.327	**41.398**
3″ (76.2mm)	52.205	**49.881**	26.103	**24.940**	45.211	**43.198**

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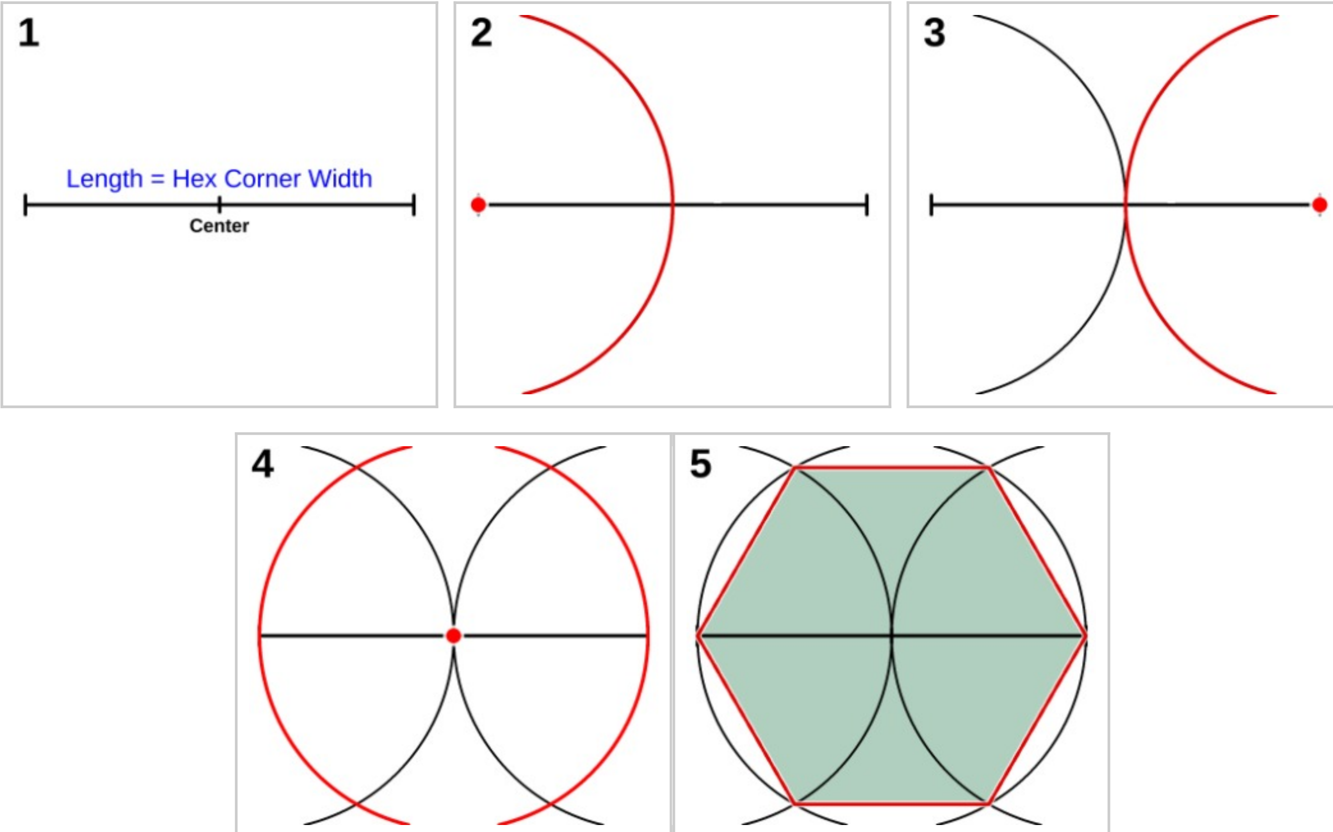

Illustrations for the manual directions. The numbers correspond to the step numbers.

Manual directions for the Trunc Octahedron's Hex

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

1. Draw a horizontal line of length **Hex Corner Width** and mark each end of it. Also mark a point in the exact center of the line (**Hex Circumradius/Side Length** distant from each end).
2. Place the compass on one end of the line, extend it to the center mark, and draw half a circle centered on the line.
3. Place the compass on the opposite endpoint and draw another half circle centered on the line.
4. Place the compass on the center point of the line and draw a full circle, which should meet both ends of the line. The points where this circle intersects the other two circles, and the two endpoints of the first line form the corners of the hexagon.
5. Join the six intersections with straight lines to complete the hexagon. Its height, side to side, should equal **Hex Height**. Any error you make will be compounded several times in the juggling bag, so be as precise as you can.
6. To draw the cutting pattern, increase the Hex Corner Width by the allowance $\times\ 4(\tan 30°)$ or $4/\sqrt{3}$ ≈ 2.3094. (I use 8mm allowances.)

SketchUp directions for the Trunc Octahedron's Hex

(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 6 sides and draw a hexagon with circumradius = **Hex Circumradius/Side Length**.
2. To draw the cutting pattern, increase the circumradius/side length by the allowance × $2(\tan 30°)$ or $2/\sqrt{3}$ ≈ 1.1547. (I use 8mm allowances.)

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How to Draw the Trunc Octahedron Patterns – Straight-Edged Square

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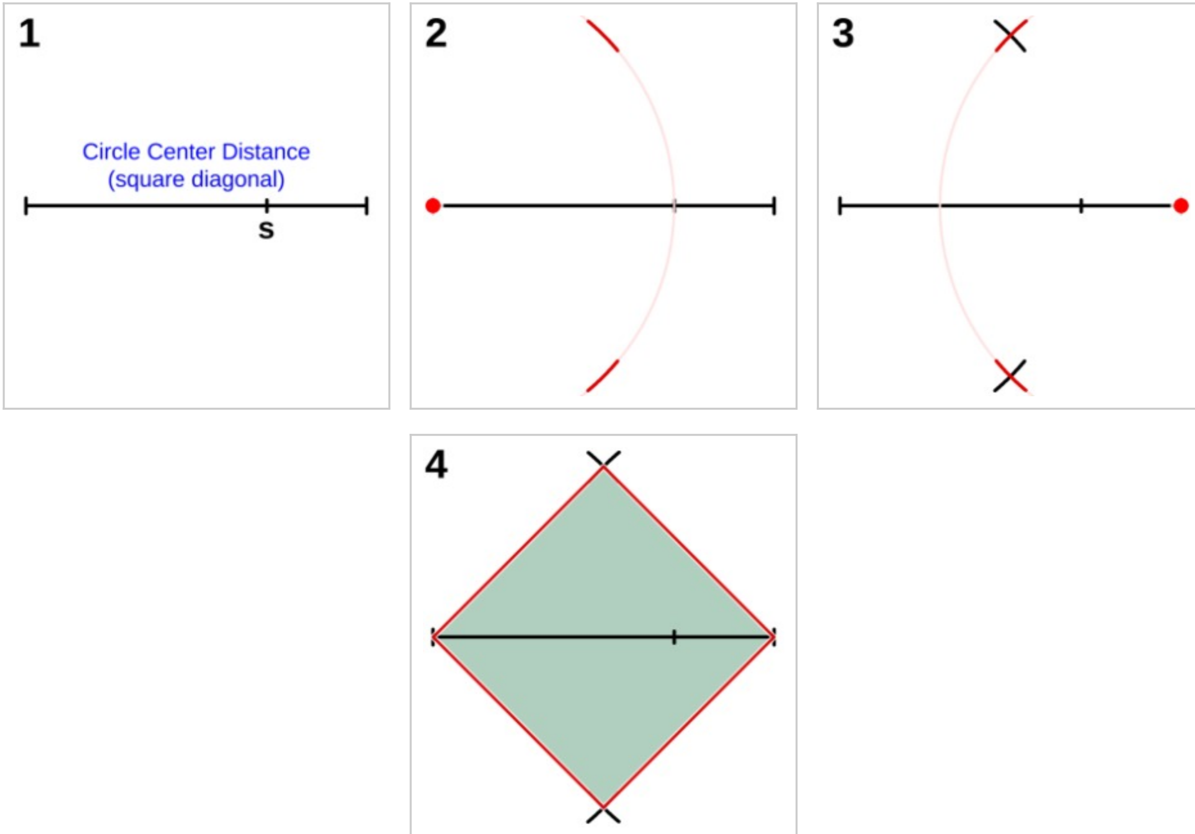
Following the pattern measurement table are manual and SketchUp directions for drawing the straight-edged square panel shape. To conserve your template material, I recommend that you draw the pattern on paper and then glue or tape the pattern to your template material before cutting it out.

Truncated Octahedron 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 **1.0466** estimated 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.

To draw the cutting pattern, increase the side length by the allowance × 2, or the diagonal by allowance × $2\sqrt{2}$ ≈ 2.8284. (I use 8mm allowances.)

Finished Diameter	**Diagonal** (mm)		**Side Length** (mm)	
	Base	**Adjusted**	Base	**Adjusted**
1¾″ (44.5mm)	30.453	**29.097**	15.227	**14.549**
1⅞″ (47.6mm)	32.628	**31.175**	16.314	**15.588**
2″ (50.8mm)	34.803	**33.254**	17.402	**16.627**
2⅛″ (54.0mm)	36.979	**35.332**	18.489	**17.666**
2¼″ (57.2mm)	39.154	**37.411**	19.577	**18.705**
2⅜″ (60.3mm)	41.329	**39.489**	20.665	**19.744**
2½″ (63.5mm)	43.504	**41.567**	21.752	**20.784**
2⅝″ (66.7mm)	45.680	**43.646**	22.840	**21.823**
2¾″ (69.9mm)	47.855	**45.724**	23.927	**22.862**
2⅞″ (73.0mm)	50.030	**47.802**	25.015	**23.901**
3″ (76.2mm)	52.205	**49.881**	26.103	**24.940**



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

Manual directions for the Trunc Octahedron's Square

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

1. Draw a horizontal line of length **Diagonal** and mark each end of it. Also mark a point along it, *s*, which is the distance of **Side Length** from one end.
2. Place a compass on that end of the line, extend it to the **Side Length** mark, and draw partial arcs above and below the middle of the line.
3. Place the compass on the opposite endpoint and draw two more arcs to produce two X-shaped intersections. Those are two of the square's corners. The other two are the endpoints of the first line.
4. Join the four corners with straight lines to form the square.
5. To draw the cutting pattern, increase the side length by the allowance × 2, or the diagonal by allowance × $2\sqrt{2} \approx 2.8284$ (I use 8mm allowances.)

SketchUp directions for the Trunc Octahedron's Square

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

1. Simply draw a square with sides equal to **Side Length**.
2. To draw the cutting pattern, increase the side length by the allowance × 2, or the circumradius by allowance × $\sqrt{2} \approx 1.4142$. (I use 8mm allowances.)

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

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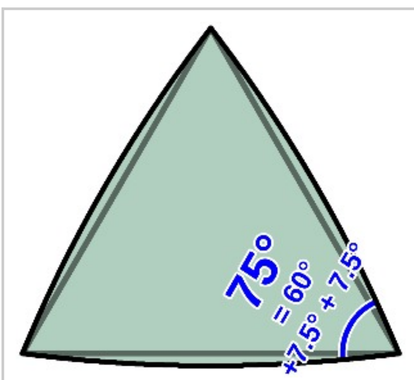
This section describes the math involved in drawing patterns to produce specified beanbag sizes, and creating the pattern sizing formulas. *(The numbers in tiny, right-justified typeface are my computer calculator's unrounded values which I display rounded to six places for brevity.)*

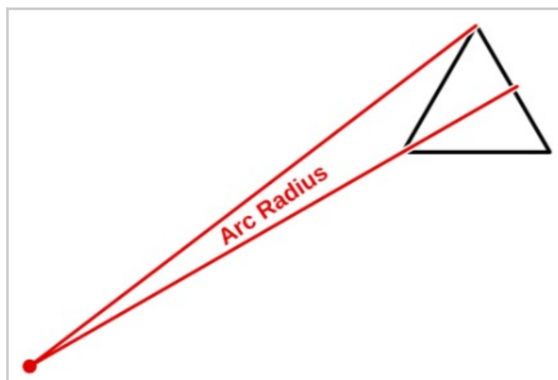
The normal cuboctahedron has two triangles and two squares meeting at each vertex for a sum of 300°. This produces an angular ball. My circular patterns use an edge arc that adds 15° to the corners (7.5° on either side of the corners) so that the sum of the four corners is 360° and the vertex is no longer pointed. Rounding the edges and widening the corner angles transforms the polyhedron into a fair approximation of a sphere.

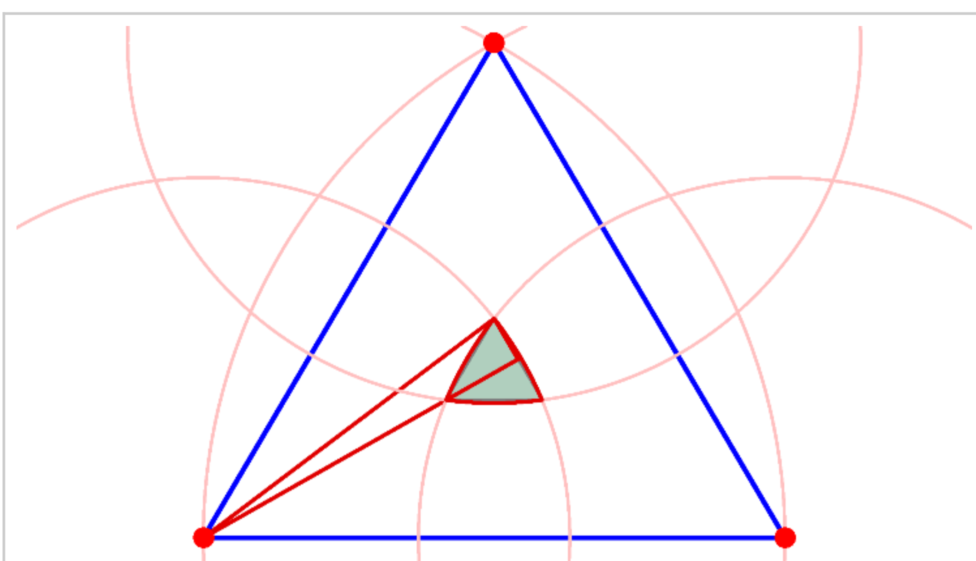
Using my edge arc radius formula from Chapter 5, I can calculate the radius needed to produce that arc, which is the first step toward calculating the guide triangle and square whose corners are the circle centers for the arcs that form the panel shapes.

Arc Radius $= \dfrac{0.5\,s}{\sin 7.5°} \approx \dfrac{0.5\,s}{0.130526} \approx$ **3.830649*s*** (*s* = length of the inner polygons' sides) 3.8306487877701943345454814326507

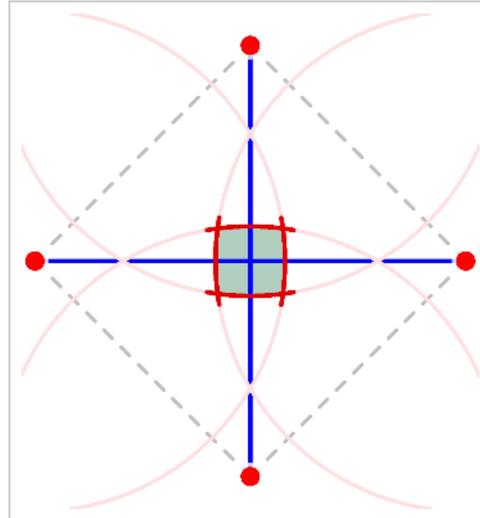
Then I can calculate the distance between circle centers and produce the guide polygons. The guide triangle is shown in blue the third illustration. The guide square is shown on the next page.







The Guide Square (shown in dashed gray lines) is not drawn directly, but instead its diagonal is calculated and then two perpendicular lines the length of its diagonal are drawn. The endpoints of those lines are the locations of the circle centers for the arcs that form the circular square pattern.

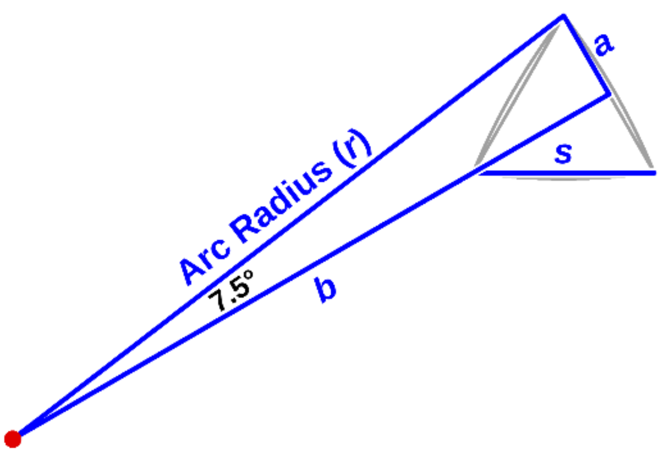


Calculating the guide polygon

For the formulas in this section, I will define the following variables:

d = diagonal of the square
g = sagitta (height of apex of the arc over the base polygon's edge)
h_{ct} = height of the circular triangle pattern
w_{cs} = width/height of circular square pattern
r = radius of the circles that form the patterns' edge arcs
r_{gs} = circumradius (half the diagonal) of the guide square
r_{gt} = circumradius (center to corner) of the guide triangle
s = side length of the base polygon
s_{gs} = side length of the guide square
s_{gt} = side length of the guide triangle

Calculating the distance between the inner polygon's center and the circle centers (yielding the guide polygon's circumradius), involves solving a right triangle as shown below. The hypotenuse is the arc radius, side a is half of the inner polygon's side, and I need to solve for side b, which extends from the circle center to the polygon's opposite side. After that, I can subtract the apothem (center to edge) of the polygon to get the portion of b that is the guide polygon's circumradius. Read the "Curved-Edge Faces" section of Chapter 5 for a full explanation of this process.



$r \approx 3.830649s$ (calculated earlier) 3.8306487877701943345454814326507

$a = 0.5s$

$$b = \frac{a}{\tan 7.5°} \text{ or } \sqrt{r^2 - a^2} \;\blacktriangleright$$

$$b = \frac{0.5\,s}{\tan 7.5°} \text{ or } \sqrt{(3.830649\,s)^2 - (0.5\,s)^2}$$

$$\approx 3.797877s$$

3.7978770563625752202632095702106

Triangle Apothem = $\frac{\sqrt{3}}{6}s \approx 0.288675s$ 0.28867513459481288225457439025098

Guide Triangle Circumradius ≈ $3.797877s - 0.288675s$ **≈ 3.509202*s*** 3.5092019217677623380086351799596

Guide Triangle Side Length (Circle Center Distance) ≈ $\sqrt{3}(3.509202s)$ **≈ 6.078116s** 6.0781160225201089158286214651731

Because the circular square panel's sides/arcs match those of the triangle, its side b (the distance between its circle center and the farther side of the square) is the same length. In this case, to get the guide square's circumradius (center to corner, half the diagonal), I must subtract half of the base square's width, which is $0.5s$. Then I can double that to get the guide square's diagonal, which is what I use to position the circles rather than drawing the actual guide square.

Guide Square Circumradius (half of diagonal) ≈ $3.797877s - 0.5s$ **≈ 3.297877*s*** 3.2978770563625752202632095702106

Guide Square Diagonal (circle center distance) ≈ $2(3.297877s)$ **≈ 6.595754*s*** 6.5957541127251504405264191404212

To draw the guide square's corners by hand, I need its side length.

Guide Square Side Length ≈ $\frac{6.595754s}{\sqrt{2}}$ **≈ 4.663902*s*** 4.6639024601470138670269327409635

Calculating the ball circumference

Calculating the circumference of the ball requires knowing the heights of the patterns. That requires calculating the sagitta, or height of the arc's apex over the polygon edge.

Sagitta, g = $r - \frac{0.5s}{\tan 7.5°} \approx 3.830649s - 3.797877s$ **≈ 0.032772*s*** 0.0327717314076191142822718624401

Then I add that to the unit triangle's height to get the circular triangle's height, and add it twice to the square's height/width/side length to get the circular square's height/width:

Height of Circular Triangle, h_{ct} = $\frac{\sqrt{3}}{2}s + 0.032772s$ **≈ 0.898797*s*** 0.89879713519205776104599503319304

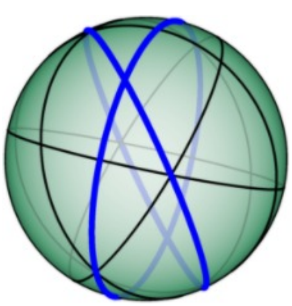
Height/Width of Circular Square, w_{cs} ≈ $s + 2(0.032772s)$ **≈ 1.065543s** 1.0655434628152382285645437248802

I will also need the diagonal of the circular square (which is the same as that of the normal square):

Diagonal of Circular Square, *d* = $\sqrt{2}s$ **≈ 1.414214*s*** 1.4142135623730950488016887242097

Expressing the ball circumference in terms of the base polygon side length

There are three ways to measure the circumference of the cuboctahedron, but I will ignore the edge arc circumference so as to be consistent with the other 14-panel designs:



Circumference A = $4h_{ct} + 2w_{cs}$
Circumference B = $4d$

Using the values I calculated previously,

Circumference A ≈ $4(0.898797s) + 2(1.065543s) \approx 5.726275s$ 5.7262754663987075013130675825326
Circumference B ≈ $4(1.414214s) \approx 5.656854s$ 5.6568542494923801952067548968388

Circumference A is greater than B by 1.23%. I will calculate the weighted average with A weighted twice since it occurs 6 times on the polyhedron and B occurs 3 times:

Weighted Average Circumference ≈ 5.703135*s* 5.7031350607632650659442966873013

Last step: Expressing the guide polygons in terms of the ball size

In order to draw a guide triangle or square to produce a desired ball size, I need to express the guide polygons and arc radius in terms of the ball size. To calculate those in terms of the ball Circumference, C, I divide the expressions I calculated earlier by the circumference expression above. For the Diameter, D, I multiply the circumference expressions by π.

Arc Radius, $r \approx \frac{3.830649}{5.703135}C \approx \mathbf{0.671674}C$ 0.67167421899658270893026523495956

$\approx \mathbf{2.110127}D$ 2.1101267920053261832960200114633

Circumradius of Guide Triangle, $r_{gt} \approx \frac{3.509202}{5.703135}C \approx \mathbf{0.615311}C$ 0.61531103233212171593555159946834

$\approx \mathbf{1.933057}D$ 1.9330566188473453251058362624112

Side Length of Guide Triangle, $s_{gt} \approx \frac{6.078116}{5.703135}C \approx \mathbf{1.065750}C$ 1.0657499704568909848590733339449

$\approx \mathbf{3.348152}D$ 3.3481522777509078977224352890364

Circumradius of Guide Square, $r_{gs} \approx \frac{3.297877}{5.703135}C \approx \mathbf{0.578257}C$ 0.57825687472342833638673974044111

$\approx \mathbf{1.816648}D$ 1.8166475495189158633710120050981

Side Length of Guide Square, $s_{gs} \approx \frac{4.663902}{5.703135}C \approx \mathbf{0.817779}C$ 0.81777871476935212934807491594746

$\approx \mathbf{2.569128}D$ 2.5691276025814995956594523625394

Cutting pattern adjustment

To make a cutting pattern, simply increase the arc radius by the desired seam allowance. The guide polygons remain the same.

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Mathematics Behind the Relationship Between the Pattern Parameters and the Ball Size – Truncated Octahedron

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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.)*

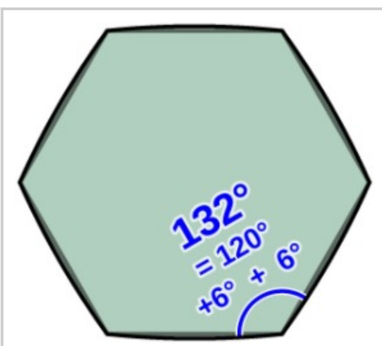
The normal truncated octahedron has two hexagons and one square meeting at each vertex for a sum of 330°. Unlike the cuboctahedron, this produces quite a round ball without modification. As I understand it, there are two reasons for this. The angle sum is 10% greater than that of the cuboctahedron, making the vertices less pointed, and the edges are only about 59% as long, requiring less distortion to conform to a spherical shape. My circular patterns use an edge arc that adds 12° to the corners (6° on either side of the corners) making the angle sum of the three corners 366°. This further flattens the vertices and gives the edges a curved shape, resulting in a slightly rounder ball.

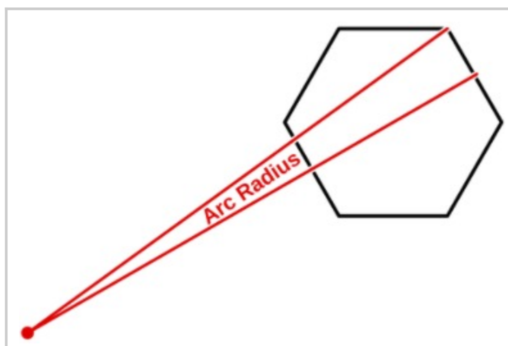
Using my edge arc radius formula from Chapter 5, I can calculate the radius needed to produce that arc, which is the first step toward calculating the guide hexagon and square whose corners are the circle centers for the arcs that form the panel shapes:

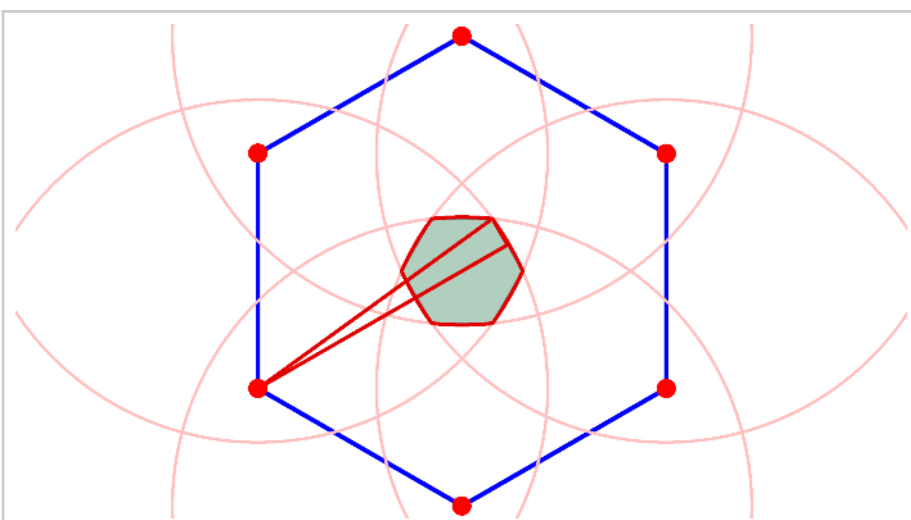
$$\textbf{Arc Radius} = \frac{0.5s}{\sin 6°} \approx \frac{0.5s}{0.104528} \approx \mathbf{4.783386}\boldsymbol{s} \quad (s = \text{length of the inner polygons' sides})$$

4.78338611675281306686138886397097

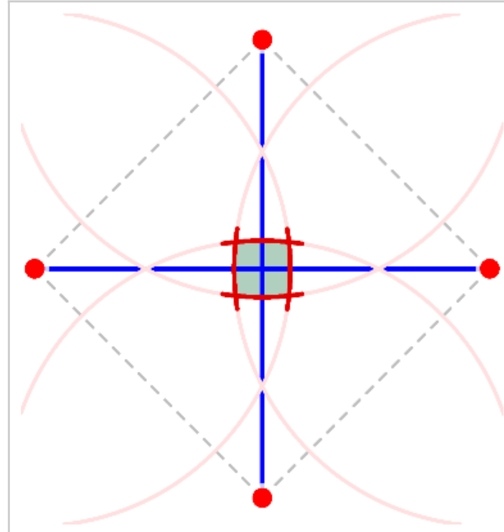
Then I can calculate the distance between circle centers and produce the guide polygons. The guide hexagon is shown in blue the third illustration. The guide square is shown on the next page.







The Guide Square (shown in dashed gray lines) is not drawn directly, but instead its diagonal is calculated and then two perpendicular lines the length of its diagonal are drawn. The endpoints of those lines are the locations of the circle centers for the arcs that form the circular square pattern.

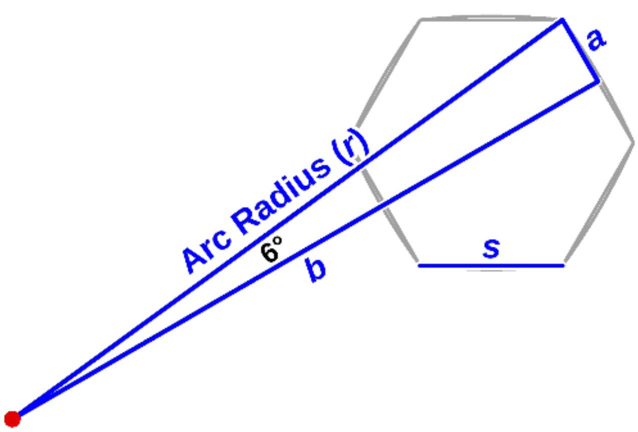


Calculating the guide polygon

For the formulas in this section, I will define the following variables:

d = diagonal of the square
g = sagitta (height of apex of the arc over the base polygon's edge)
h_{ch} = height of the circular hexagon pattern
w_{cs} = width/height of circular square pattern
L_a = length of edge arcs
r = radius of the circles that form the patterns' edge arcs
r_{gh} = circumradius (center to corner) of the guide hexagon
r_{gs} = circumradius (half the diagonal) of the guide square
s = side length of the base polygons
s_{gh} = side length of the guide hexagon
s_{gs} = side length of the guide square

Calculating the distance between the inner polygon's center and the circle centers (yielding the guide polygon's circumradius), involves solving a right triangle as shown below. The hypotenuse is the arc radius, side a is half of the inner polygon's side, and I need to solve for side b, which extends from the circle center to the polygon's opposite side. After that, I can subtract the apothem (center to edge) of the polygon to get the portion of b that is the guide polygon's circumradius. Read the "Curved-Edge Faces" section of Chapter 5 for a full explanation of this process.



$r \approx 4.783386s$ (calculated earlier) 4.7833861167528130668613886397097

$a = 0.5s$

$b = \dfrac{a}{\tan 6°}$ or $\sqrt{r^2 - a^2}$ ►

$b = \dfrac{0.5s}{\tan 6°}$ or $\sqrt{(4.783386\,s)^2 - (0.5\,s)^2}$

$\approx 4.757182s$ 4.7571822271112924648419857274729

Hexagon Apothem = $\cos 30°s \approx 0.866025s$ 0.8660254037844386467637231707529 4

Guide Hexagon Circumradius & Side Length ≈ $4.757182s - 0.866025s$ **≈ 3.891157*s*** 3.8911568233268538180782625567 2

(A regular hexagon has the convenient property of the circumscribing radius being equal to the side length.)

Because the circular square panel's sides/arcs match those of the hex, its side *b* (the distance between its circle center and the farther side of the square) is the same length. In this case, to get the guide square's circumradius (center to corner, half the diagonal), I must subtract half of the base square's width, which is $0.5s$. Then I can double that to get the guide square's diagonal, which is what I use to position the circles rather than drawing the actual guide square.

Guide Square Circumradius (half of diagonal) ≈ $4.757182s - 0.5s$ **≈ 4.257182*s*** 4.2571822271112924648419857274729

Guide Square Diagonal (circle center distance) ≈ $2(4.257182s)$ **≈ 8.514364*s*** 8.5143644542225849296839714549458

To draw the guide square's corners by hand, I need its side length.

Guide Square Side Length ≈ $\frac{8.514364\,s}{\sqrt{2}}$ **≈ 6.020565*s*** 6.0205648430744874979097139546959

Calculating the ball circumference

Calculating the circumference of the ball requires knowing the heights of the patterns and the length of the edge arcs. To calculate the height of the patterns, I need the sagitta, or height of the arc's apex over the polygon edge.

Sagitta, g = $r - \frac{0.5\,s}{\tan 6°} \approx 4.783386s - 4.757182s$ **≈ 0.026204*s*** 0.0262038896415206020194029122368

Then I add twice that to the unit hexagon's height to get the circular hexagon's height, and to the square's height to get the circular square's height/width:

Height of Circular Hexagon, h_{ch} ≈ $2(\cos 30°)s + 2(0.026204s)$ **≈ 1.784459*s*** 1.78445858685191849756625216597 95

Height/Width of Circular Square, w_{cs} ≈ $s + 2(0.026204s)$ **≈ 1.052408*s*** 1.0524077792830412040388058244736

I will also need the diagonal of the circular square (which is the same as that of the normal square):

Diagonal of Circular Square, *d* = $\sqrt{2}s$ **≈ 1.414214*s*** 1.4142135623730950488016887242097

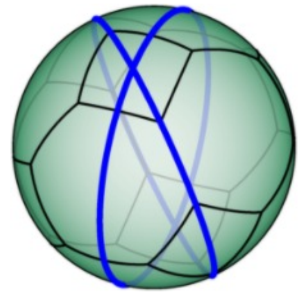
Now I will calculate the length of the edge arcs. The arc length formula is

Arc Length, $L_a = \frac{\theta° r \pi}{180}$ (where θ is 12), so

Arc Length, $L_a \approx \frac{12°(4.783386\,s)(3.141593)}{180} \approx 1.001830s$ 1.0018300455782697691034017280526

Expressing the ball circumference in terms of the base polygon side length

There are two ways to measure the circumference of the truncated octahedron:



Circumference A = $4h_{ch} + 2w_{cs}$
Circumference B = $4d + 4L_a$

Using the values I calculated previously,

Circumference A ≈ $4(1.784459s) + 2(1.052408s) \approx 9.242650s$ 9.2426499059737563983426203128652
Circumference B ≈ $4(1.414214s) + 4(1.001830) \approx 9.664174s$ 9.6641744318054592716203618090492

Circumference B is greater than A by 4.56%. I will calculate the weighted average with A weighted twice since it occurs 6 times on the polyhedron and B occurs 3 times:

Weighted Average Circumference ≈ 9.383158*s* 9.3831580812509906894352008115932

For the straight-edged ball, the value is 9.171087*s* 9.1710869033477995144754418762953

Last step: Expressing the guide polygons in terms of the ball size

In order to draw a guide hexagon or square to produce a desired ball size, I need to express the guide polygons and arc radius in terms of the ball size. To calculate those in terms of the ball Circumference, C, I divide the expressions I calculated earlier by the circumference expression above. For the Diameter, D, I multiply the circumference expressions by π.

Arc Radius, r ≈ $\frac{4.783386}{9.383158}C \approx \mathbf{0.509784}\boldsymbol{C}$ 0.50978424058641434806424894795598

$\approx \mathbf{1.601534}\boldsymbol{D}$ 1.6015344251421310256651099098234

Circumradius & Side Length of Guide Hex, $r_{gt} \approx \frac{3.891157}{9.383158}C \approx \mathbf{0.414696}\boldsymbol{C}$ 0.41469586141812854936968869975597

$\approx \mathbf{1.302805}\boldsymbol{D}$ 1.3028054717052836267922154054 42

Circumradius of Guide Square, $r_{gs} \approx \frac{4.257182}{9.383158}C \approx \mathbf{0.453705}\boldsymbol{C}$ 0.45370462591031101994122067173066

$\approx \mathbf{1.425355}\boldsymbol{D}$ 1.4253551196595384578133998313397

Side Length of Guide Square, $s_{gs} \approx \frac{6.020565}{9.383158}C \approx \mathbf{0.641635}\boldsymbol{C}$ 0.64163523527377338958448613319022

$\approx \mathbf{2.015757}\boldsymbol{D}$ 2.0157565414204450476293872788105

Cutting pattern adjustment

To make a cutting pattern, simply increase the arc radius by the desired seam allowance. The guide polygons remain the same.

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How I Developed These Designs

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”Juggling Thingies” - Cuboctahedral juggling bags made by John Nord. Left photo from Uri Yurman’s Facebook profile. Right photo from a Reddit post by KrazyPete. The attractiveness of the photo on the left helped inspire me to create a cuboctahedron pattern.

Background Note: *Read the "Curved-Edge Faces" section of Chapter 5 for a full explanation of why the sum of corner angles forming a polyhedral vertex is important, and why I made the choices I did. In short, a sum of 360° will result in a perfectly flat vertex that neither forms a point nor puckers inward (flat at the vertex itself, but roughly spherical around it due to the curved edges). That is optimal when trying to form a smoothly spherical ball. This is achieved by rounding the edges of the panels, which both widens the corners and gives the finished seams a curved shape around the ball.*

Introduction

I added these two designs for completeness, and because I was bored. Their inclusion in my collection did not feel very important, though the cuboctahedron had nagged at me occasionally over the years to add it. But I am glad for the inspiration this project gave me to improve my other documents (mainly Chapter 5 of the root document), and the motivation it gave me to proof-read the mathematics sections of my other chapters again. Those sections have had the fewest proof-reading passes due to my burned out brain not being able to effectively process them. I found and corrected quite a few (mostly minor) errors, and made some improvements. Adding new chapters always shakes up the documents in my mind and helps me to see errors or potential for improvements that I was blind to before, and revives my interest in this hobby and motivation to make improvements.

I expanded and improved Chapter 5, adding an introduction, a section on choosing a design testing fabric, and a section on the Equidistant transformation. I also reworked the Curved-Edge Faces section to use the example of designing a 96° corner for the triangle panel (the angle I actually used for the octahedron) instead of the 90°. I had wanted to do that for a long time. The reason I had used the 90° example was that I had already created the illustrations for that demonstration in 2015, thinking it was to be the solution to the curvature problem in the octahedron pattern. It was rather foolish of me to create illustrations for an unproved theory, but I have to follow my motivation, and that was what I was motivated to do at the time. Until now I lacked the motivation to create all new illustrations.

Anyway, I mainly wanted to create cuboctahedron patterns, but I decided to create the truncated octahedron patterns as well since it is closely related. In a small way, I was inspired to add the cuboctahedron to my guide by the left image above, which I found on Uri Yurman's Facebook page about a year ago while corresponding with him concerning the rhombic dodecahedron design. I found the second image while researching the source of the first. The cuboctahedron can be quite attractive, though I didn't think so when I last saw John Nord's Juggling Thingies in around 2013 while designing the Equidistant Cuboctahedron.

Also, Marylis Ramos' cuboctahedron patterns are bizarrely wrong for producing a smoothly spherical ball. I will discuss this at the end of this section (she does not provide truncated octahedron patterns). So hobbyists cannot use her patterns if they want this design. I wanted to provide proper patterns for them.

I mean no offense, Marylis. You did excellent work designing your octahedron and 4-panel orange peel ball patterns, and your overall document presentation, and obviously knew what you were doing. I am grateful to you for the part you played in my hobby. But I cannot see how the extreme edge arcs of your cuboctahedron patterns, and especially of your icosahedron and truncated tetrahedron patterns, can possibly produce a good ball, or how the panels they produce could even fit together, and so I'm guessing you lacked sufficient time or motivation by that point in your project to complete your calculations and testing. And I acknowledge that you did say your pattern booklets were a work in progress.

By the way, looking back at your original post on jugglingdb.com (now available only via the Internet Archive), I noticed in your background story where you said, "I soon became obsessed with how to generate a perfectly spherical shape using fabric." Yeah, LOL, me too! It's an odd thing to be fascinated by, isn't it?

I have copied Ramos' post at the end of this chapter in case it disappears from the internet.

Design Process

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I began working on these designs at the end of April, 2023, ten years to the month after creating my first 14-panel design, the Equidistant Cuboctahedron (though, at that time, and until seven years later in 2020, it did not have curved panel edges). I spent almost seven months on these due to being too burned out for long periods to continue. I was also very unsure what curvature to use, especially for the cuboctahedron, which is the shape I worked on first.

I began with arcs that added 18° to each of the cuboctahedron's panel corners for a vertex sum of 372°. This was too steep and the area around the vertices was too flat and the seams bulged out a little too far in their middles. Then I made one that added 15° for a 360° vertex sum. This is the lowest that will still produce a non-pointed vertex. The vertices on the ball looked good (being flat only at the vertices themselves but properly spherical around them), but the seam curvature, though acceptable, still looked a little too bulged (too little for most people to notice or care, mind you – I am obsessive in my attention to detail and excellence).

This confused me because all my other designs needed at least a 360° vertex sum to form a good ball, and most needed a higher sum. I may need to revise my theory about this. Perhaps the apex height is of greater importance than the corner angle. The cuboctahedron has long edges for its panel count, and so the arc apex is higher over the edge than on designs with the same arc-tangent angle but shorter edges.

I did not feel up to designing a Bézier curve that lowered the curve apex while maintaining the same steepness at the ends, and for a few months I was unsure what to do, and I was too depressed for more experimentation.

I also made a truncated octahedron ball and I began by adding 12° to each corner for a 366° vertex sum. This is what my dodecahedron design needed and I guessed this design, having short edges like that one, would need about the same (by my calculations the truncated octahedron's edges are 89% the length of the dodecahedron's for the same polyhedron circumference). The resulting ball's hex-square seams looked too bulged while the hex-hex seams looked too straight, and the squares protruded farther than the hexes. I then made a ball with straight edges (producing vertex sums of 330°) and that looked almost identical. So, again, I was unsure how to proceed.

The way the small squares of the truncated octahedron protruded from the sphere relative to the large hexes, and also produced more bulged seams against the hexes than the hexes did against other hexes, suggest to me that the seam shape is partly dependent upon the relative distance from the center of two adjoining panels. If one of the panels is farther from the center, as the squares are, it may pull the seams outward, too. I had not encountered this before because all my other designs have panels that are equally distant from the center, or nearly so. This means that the cuboctahedron's seams, which are all triangle-square seams, may be slightly too bulged due to the triangles being farther from the center of the solid, and not to an over-steep panel curvature. There are still aspects of designing polyhedral balls I do not understand.

When it became clear that I was not going to find the motivation to perform the theorizing and experimentation needed to refine these designs to the degree I had done for my past designs, I decided that the balls I had made were sufficiently good to use as my official patterns. These panel designs are very good and only a perfectionist could find fault with them, and maybe not even a perfectionist.

My work sped up after I started making color arrangement diagrams and began drawing the assembly and pattern-drawing diagrams. At the end, after making the two corduroy balls for the photos and pattern adjustment factors, I made a 360° cuboctahedral ball with felt, just to make sure the design worked for a light, moderately stretchy fabric. It turned out excellently.

In total I made 5 cuboctahedral balls (the 372° and 360° spherical balls and a straight-edged, polyhedral ball to see how that would turn out, all with the design testing fabric, and the corduroy and felt 360° balls) and 3 truncated octahedral balls (the 366° and straight-edged design testing balls, and the corduroy ball). The straight-edged cuboctahedral ball was pretty angular. Juggleable, but with significantly sharp, protruding vertices and nearly straight seams, as expected.

Discussion of Marylis Ramos' Cuboctahedron Patterns

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Marylis Ramos' cuboctahedron patterns, which can be found in one of her two PDF pattern compilations titled "Sewing Patterns for Jugglers – Polyhedra Series"[3], have extremely steeper arcs. I have long known that they must be way too steep, but I never made a ball with her patterns or figured out what arc she had used. (Her Icosahedron and Truncated Tetrahedron patterns are even worse. Oddly, however, her Cube and Dodecahedron patterns have curves that are a little too shallow.)

3 If unavailable at that URL, try the copy on my own web server: Sewing Patterns for Jugglers - Polyhedra Series.

With the help of my edge-arc radius formula and SketchUp, I was able in three tries to create a pattern curve that matched hers. Its arc tangents increase the corner angles by 46°, producing vertex sums of 484°. Even Ramos' spherical cube pattern uses only +25° corners for a vertex total of 345° (which is too low for that design; my +36° corners work better). I do not know why she designed these patterns like this. The patterns for the square panel are compared in the illustration on the next page.

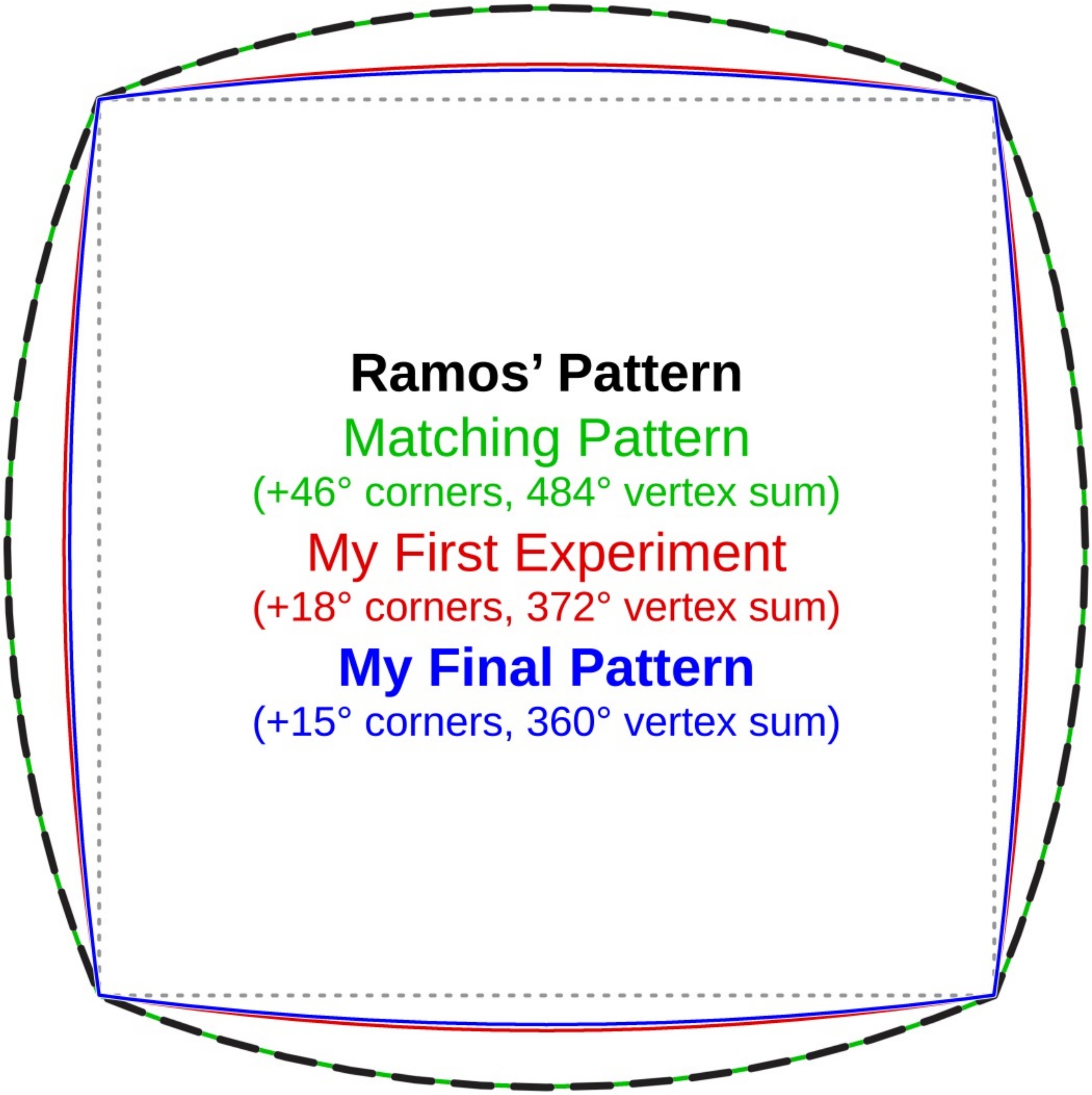
Though I have not made a ball with Ramos' patterns, I know from my experience with other designs, and from my 372° ball, that her patterns would cause the ball's vertices to pull inward so drastically that they would form inverted corners, and the seams to bulge out so sharply that they would form prominent protrusions, resulting in a ball shaped like a blunt 24-pointed star (each edge/seam forming one of the points). I made a cube years ago with panel edges much too steeply curved (I don't remember what tangent angle I used) and they produced a 12-pointed star shape that reminded me of a Star Bit from Nintendo's Super Mario Galaxy video game (it was blunter than a Star Bit, though).

I show Ramos' Truncated Tetrahedron and Icosahedron patterns after the Cuboctahedron pattern comparison, and figured out what arcs she used for them. They produce vertex sums of 534° and 530°, respectively, and the Truncated Tetrahedron's hex pattern has such steep arcs that they form concave corners at 198°!

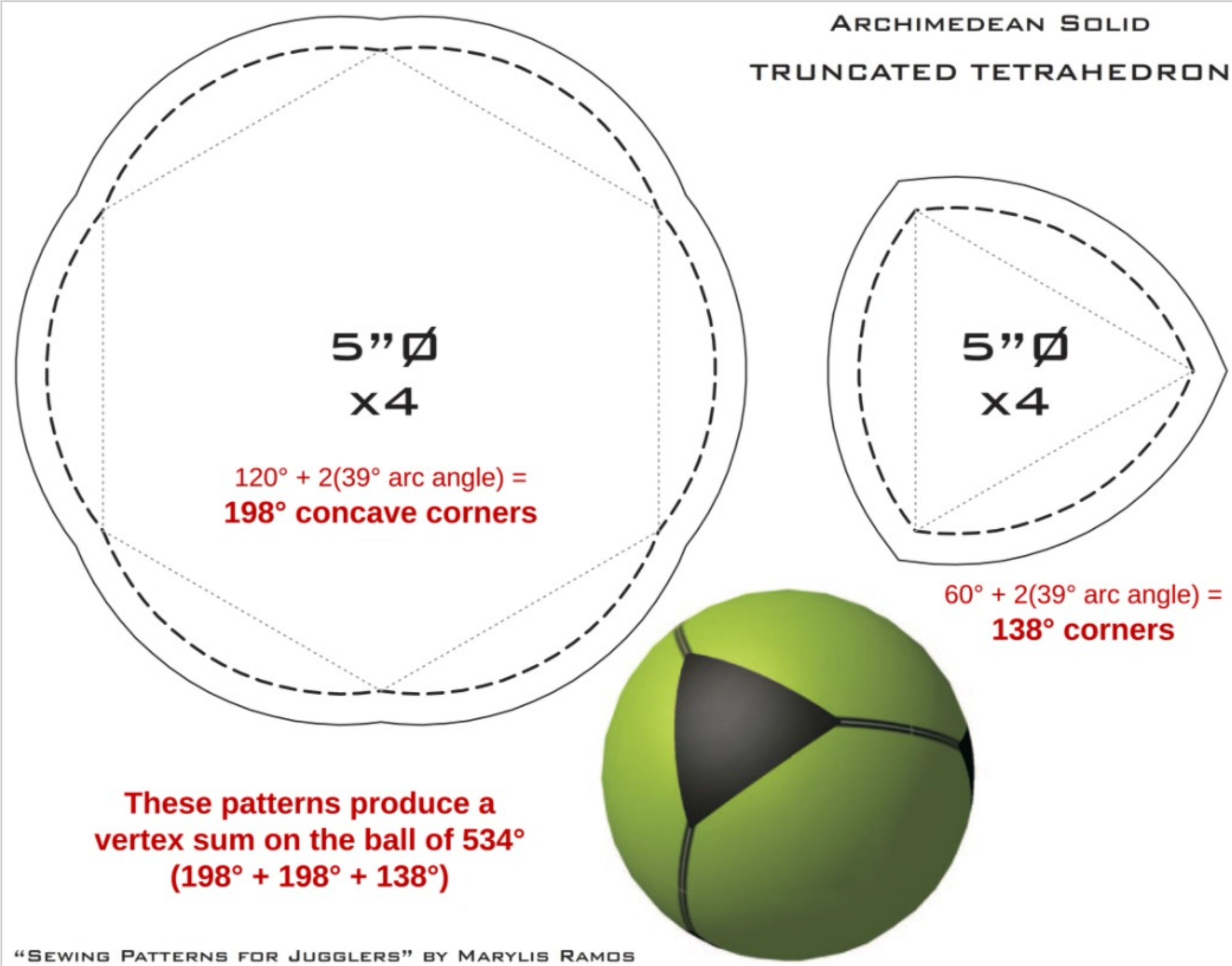
Vertex sums greater than the mathematically correct 360° often work better, when using circular arcs rather than Bézier curves, due to the need for higher apexes to produce the right seam curvature on the ball, but only moderately so. The highest I have used was for my tetrahedron pattern, which has a vertex sum of 386°. My cube has a vertex sum of 378°, and my octahedron (without the Bézier curve modification) has a sum of 384°. The rest of my designs are lower than those.

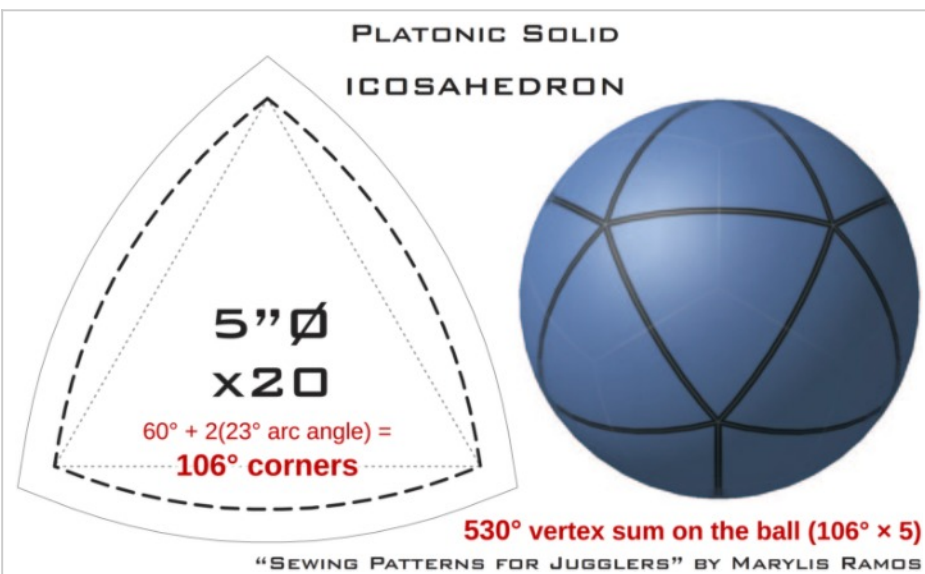
My original octahedron pattern in my First Edition Guide had 106.259° panel corners for a vertex sum of 425.036°, and that pattern's arc was so over-steep that a Reddit contributor advised against using it[4]. That is what motivated me to redesign my patterns and create the Second Edition Guide. I reduced that pattern's corners to 96° (384° sum), which matches Ramos' apex heights, and I later gave it a Bézier curve modification to correct the corner angle to 90°. (That original angle, rounded down, just happens to match Ramos' icosahedron triangle pattern at 106°, I just noticed. But while the octahedron has four panel corners meeting at each vertex, the icosahedron has five, and so its panels ought to have narrower corners.)

4 https://www.reddit.com/r/juggling/comments/2l4pwe/making_your_own_beanbags_some_advice_and_creative/. See 2nd comment, by ds300.



My Cuboctahedron square patterns in red and blue compared to Marylis Ramos' pattern in dashed black. The green pattern behind Ramos' is the matching pattern I used to determine the arc radius she used.





Patterns and ball illustrations by Marylis Ramos (cleaned up, rearranged, captions added, and not at original scale). Original PDF available at https://jugglingedge.com/pdf/jugglingballtemplates2.pdf, and on my own web server.

These patterns have edge arcs that are even more bizarrely over-steep than those of the Cuboctahedron. The Truncated Tetrahedron’s patterns have +78° corners (39° tangent-chord angles) for a vertex sum of 534°. The hex pattern’s corners are actually concave at 198°! The Icosahedron’s pattern has +46° corners (23° tangent-chord angles) for a vertex sum of 530°. These patterns would produce panels that would not even fit together.

“Sewing Patterns for Juggling” (jugglingdb.com article by Marylis Ramos)

Article source: http://web.archive.org/web/20100717034026/http://www.jugglingdb.com:80/compendium/skills/equipment/making/balls/sewingpatterns.html

Marylis Ramos – 4th February, 2004

By Marylis Ramos

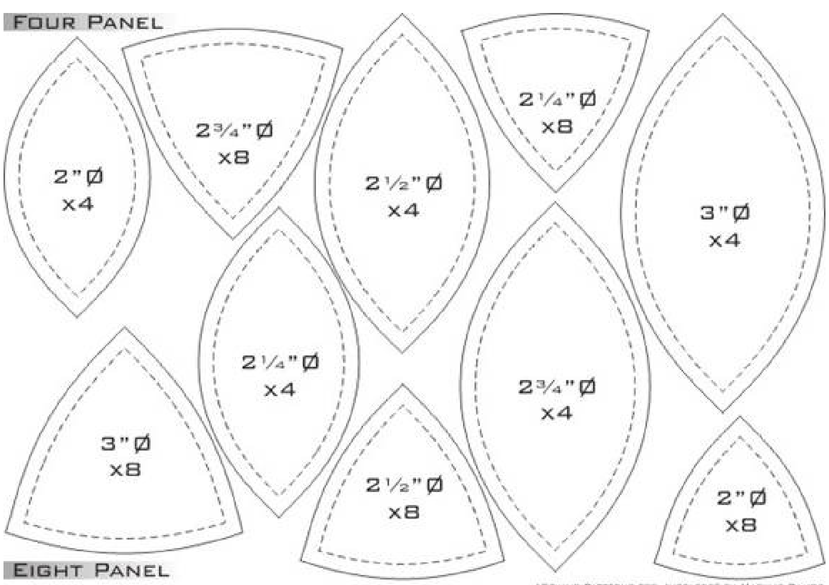
This booklet is a collection of experimental juggling ball sewing patterns that were generated using a combination of Kaleidotile (http://www.geometrygames.org/KaleidoTile/index.html), Plate-n’-Sheet (a demo of which can be found on http://www.rlcad.com.au/), AutoCAD, and of course, Dave Barnes’ famous Barnesy Bags how-to. Feel free to try out these patterns and make your own set of juggling balls!

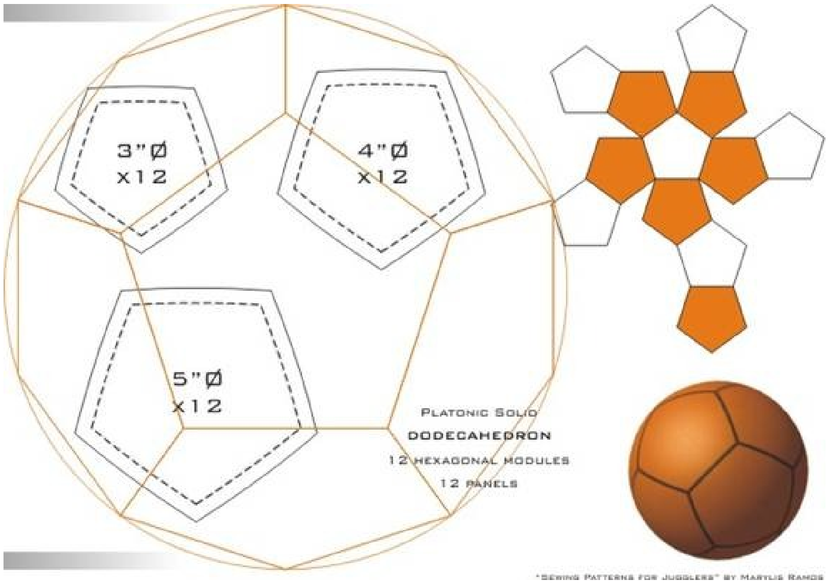
My interested in this project began with an attempt to sew 14 sand-filled suedette 100g beanbags. They are now finished, and feel very nice but I am never ever making them again =P. They have since been christened ‘Sandays’ – Peter Bone has tried them out but thought they were a bit too heavy for 11 =). I soon became obsessed with how to generate a perfectly spherical shape using fabric. I’ve tried the patterns for the 4-panels and the cube (Fergie bags = juggler object lust), and they work well. It may take a few tries to get it right though, so don’t be discouraged if your creations don’t quite look ball-like, or if the seams burst…you’ll get the hang of it very quickly. Be sure to check out the Barnesy Bags how-to (http://www.jugglingdb.com/compendium/skills/equipment/making/balls/barnesybags.html) for tips on sewing and fabric selection!

This small selection includes patterns for 3, 4, 5, 6 and 8 panel beanbags based on a lemon-shaped template; 6, 8, 10, 12 and 16 panel patterns based on a triangular-shaped template, and various polyhedral patterns: the tetrahedron, cube, dodecahedron, icosahedron, truncated tetrahedron, and cuboctahedron. Each pattern is labelled according to the approximate diameter of the finished ball, along with the number of panels you have to cut out to finish one ball. Each pattern is available in at least 2 different sizes.

This booklet is a work-in-progress, so please don’t hesitate to send me any comments or suggestions that you may have. Happy Sewing!

Some sample images:





***Here are the files to download:*[5]**

***Sewing Patterns for Juggling Part I.pdf* (1004k)**

***Sewing Patterns for Juggling Part II.pdf* (1.3M)**

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5 Also available on my web server: Sewing Patterns for Juggling Part I.pdf (orange peel series), Sewing Patterns for Juggling Part II.pdf (polyhedral series)