MOMATH

NATIONAL MUSEUM OF MATHEMATICS

THE 2013 ROSENTHAL PRIZE

for Innovation in Math Teaching

Geometry Lesson Plan
Mathematics and Fashion Design

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Grade

7

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Overview

In this lesson, students will apply their knowledge of circumference and area of a circle to solve problems in fashion design. More specifically, they will use annuli (flat ring-shaped objects) and sections of annuli to create circle skirts found in daily life, such as in women's skirts, tree skirts, skirted tables, lampshades, Hawaiian feather capes, shawls, etc. In the process, students will need to find the radius of a circle indirectly and devise a tool or a method to determine the radius for a variety of circle sizes. Students will compare the advantages and disadvantages of different tools or methods developed by other students and discuss their accuracy. Finally, they will create their tool and convince others to buy it. There are many existing resources that address the topic of circle skirts; however, the main goal of this lesson is to organize and unify those resources to inspire students to apply the Common Core Mathematics Practice Standards and to provide the motivation for learning specific content knowledge.

Prerequisite Knowledge

- ★ Understand different parts of a circle (definition of a circle, radius, diameter, and circumference).
- ★ Know how to construct a circle with a compass.
- ★ Know the formulas for the circumference and area of a circle, as well as the perimeter and area of both a rectangle and a triangle.
- ★ Know how to measure length.
- ★ Understand standard units of measurement.
- ★ Know how to solve a one-step equation.

Common Core Practice Standards

- ★ CCSS.Math.Content.7.G.B.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

- ★ CCSS.Math.Content.7.G.A.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

- ★ CCSS.Math.Content.7.G.A.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.

Common Core State Standards

- ★ Students will make sense of the problems and persevere in solving them.
- ★ Students will model a real-life situation using mathematics.
- ★ Students will choose appropriate tools strategically.

Lesson Goals

- To use mathematical concepts, in particular circumference and area of a circle, to solve real-life problems.
- To communicate understanding of mathematical concepts to others.

Materials

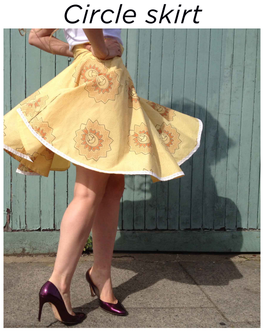
- Circle skirt patterns or any clothing patterns as examples.
- Tape measures, rulers, compasses, scissors.
- Tape to assemble the pieces.
- Optional materials:
    - Large paper rolls to make patterns and fabric remnants to make skirts.
    - Examples of actual women's skirts, tree skirts, skirted tables, lampshades, Hawaiian feather capes, shawls, etc.
- In case there is a need to develop intuition for the formula for circumference of a circle, bring circular objects of different sizes such as paper plates, coins, cans, cups, etc.

Lesson Activities

There are two activities, each 50-60 minutes in length.

Activity 1: 50-60 minutes

Circle skirts were very popular in the 1950s. Their classic flaring silhouette is an iconic image of fashion from that era. The skirt is constructed from a circular piece of fabric, with a cutout in the center for the waist. Circle skirt design can also be used for other purposes such as tree skirts, table skirts, shawls, etc. Recently, circle skirts have experienced a comeback as a fashion trend.

Circle skirt	*Tree skirt*	*Hawaiian feather cape*	*Lampshade*
			

Present the following situation to students. (See Activity 1 – Student Handout #1.)
If possible, obtain and display sample objects.

Mrs. Johnson is making a circle skirt for her 12-year-old niece. Visualize the fabric pieces that should be cut and sewn to make this skirt. Draw the pattern pieces. What measurements do you think she needs to get? Label the pattern pieces with the necessary measurements.

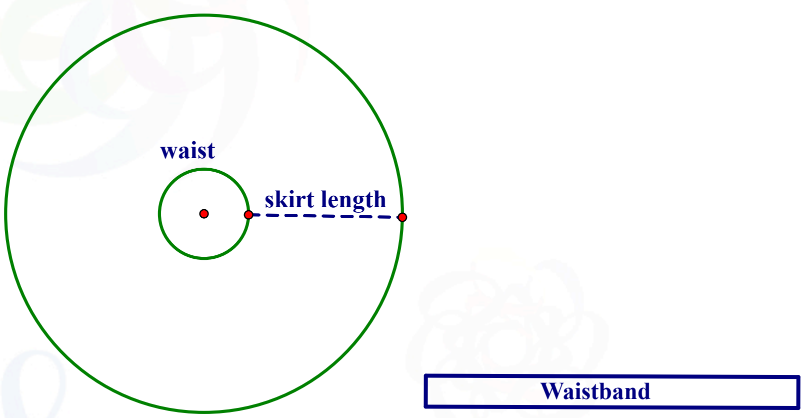
Teaching the Lesson

Have one student read the problem out loud. Ask one or more students to describe the problem in their own words. Ask students if they need clarification. If available, show students a sample sewing pattern that dressmakers often use; however, do not show the pattern pieces for the circle skirt.

Have students think about the problem and explore the solution individually for a few minutes. Have them share the pattern drawings in pairs or in small groups for a few more minutes. At this point, students may already have come up with several different patterns. Ask them to explain how their pattern matches the desired style and how it would fit on a person's body. If some students come up with a pattern that does not work, suggest that they cut out the pattern and try to form the skirt.

The most basic pattern for a circle skirt is very simple. It consists of an annulus (a donut-hole shape comprised of two concentric circles) and a rectangular waistband, as shown below. Guide the students to reach a conclusion using concentric circles for the pattern. Ask them to focus on this design and label the necessary measurements based on the problem below. (See Activity 1 – Student Handout #2.)

Given that a person's waist measures 25 inches and the desired skirt length is 18 inches, label the diagram with appropriate measurements. How do you construct the pieces on fabric? Consider the math concepts that must be applied in this situation. (Figures are not drawn to scale.)

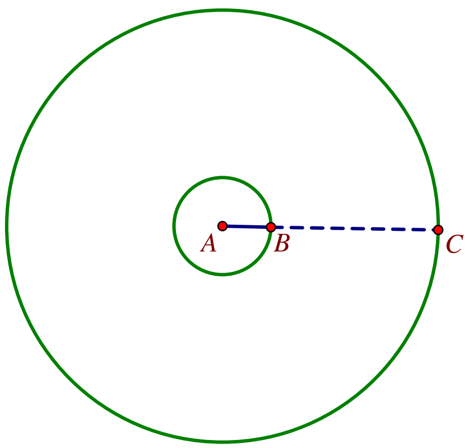


Mathematical ideas that should be included in the discussion:

* What measurements are necessary?
* What tools are necessary to construct the pattern on fabric?
* How do you determine the radius of the inner circle using the circumference (waist measure)?
* How do you determine the radius of the outer circle using the radius of the inner circle and the desired skirt length?
* How accurate do clothing designers need to be in their measurement and calculation?

Sample Solution:

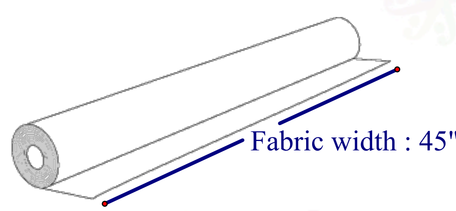
* The waist size, 25 inches, is the circumference of the inner circle. This is also the length of the waistband. The width of the waistband can vary, but it is typically about 1-2 inches.
* To draw the concentric circles accurately, the radii of the concentric circles need to be determined. The radius of the inner circle is $\frac{25}{2\pi} \approx 3.98 \approx 4$ inches. Adding the desired skirt length, 18 inches, the radius of the outer circle is approximately 22 inches.



waist circumference: 25"
inner radius: AB ≈ 4"
skirt length: BC = 18"
outer radius: AC ≈ 22"

Present the next part to students. (See Activity 1 – Student Handout #3.)

There are three common widths for bolts of fabric: 36" (inches), 44" or 45" and 54". Most apparel fabrics will be 44" or 45" wide (and folded in half on the bolt). Suppose that you bought fabric with a 45" width, what is the minimum length of fabric that you would need to buy? How would you fold, draw, cut, and assemble the fabric pieces to form the skirt? Consider the most efficient way to accomplish this task.



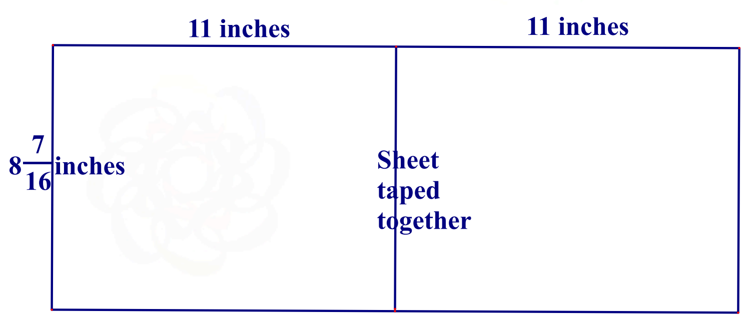
Mathematical ideas that should be included in the discussion:

* What measurements and tools are necessary?
* How do you fold the fabric and position or construct the pattern on the fabric efficiently?
* Given the width of the fabric, what is the minimum length of fabric needed to make the skirt?
* How do you determine the area of a rectangular waistband and the area of the donut hole? What does the area of each shape represent in this situation?
* How much fabric is wasted?
* Should you consider any seam allowance and adjustments in the measurements to be able to fit the skirt on the person's body comfortably? The teacher may decide to ignore seam allowance at this stage to simplify the situation.

A note about seam allowance: Seam allowance needs to be added to both the waistline seam and side seams if the donut shape is formed from different pieces. For the waistline, dressmakers typically subtract about ½ inch from the final radius measurement. For the side seams, they may add ½ inch for each raw edge to be seamed to the initial waistline circumference measurement.

Assign students to small groups. If possible, give each group large pieces of paper with 45" width to construct their own patterns. They may use one of the group members as a fashion model and use the measurements of this student instead of the given measures in the previous task.

If large paper is not available, as an alternative, teachers may provide students with regular-sized paper, 8.5"x 11", to make a scale model of the skirt. If each inch of the skirt is scaled by a factor of 3/16 inch, fabric with a 45" width will be $135/16 = 8\ 7/16$ inches. The width of the paper, 8.5", can be cut off by $1/16$ inch (or left alone as $8\ 1/2$ inches since it is very close) to simulate the width of the fabric. Several pieces of paper can be taped together to simulate the fabric length if necessary. The radius of the outer circle for the skirt pattern is scaled to $22 \times 3/16 = 4\ 1/8$ inches and the diameter is $8\ 1/4$ inches. There should be enough length to position half of the circle so that a diameter is aligned with the width of the fabric.



For the circle skirt pattern:

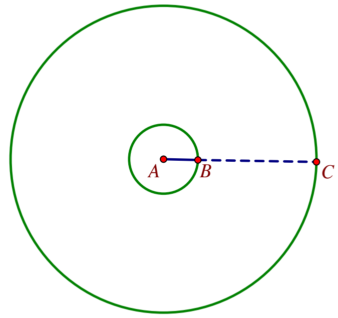
Scaled down measurements in inches:

waist circumference: $25\cdot\left(\frac{3}{16}\right) = 4\frac{11}{16}$

inner radius: $AB \approx 4\cdot\left(\frac{3}{16}\right) = \frac{3}{4}$

skirt length: $BC = 18\cdot\left(\frac{3}{16}\right) = 3\frac{3}{8}$

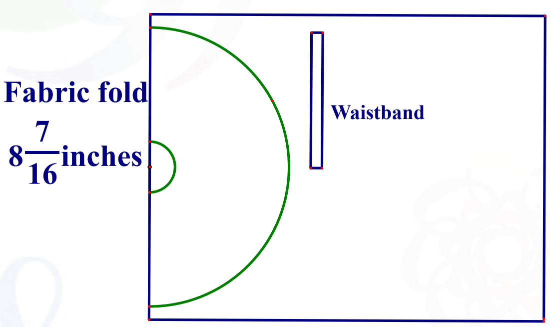
outer radius: $AC \approx 22\cdot\left(\frac{3}{16}\right) = 4\frac{1}{8}$



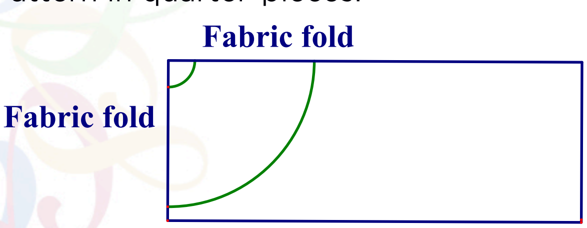
$$25\cdot\left(\frac{3}{16}\right) = 4\frac{11}{16}\text{ in.}$$

Students can construct the annulus pattern in half or quarter pieces to be “sewn” together later.
To save time, the teacher may provide pre-cut circles with radius $4\frac{1}{8}$ inches for this part of the activity.

To construct the pattern in half-pieces, fold the fabric parallel to the width into two layers. Use enough area to get a full circle when unfolded. On actual fabric, the width of the waistband may be doubled for double-facing and hem or to hold an elastic waistband in place if desired when sewn together with the skirt.



Pattern in quarter-pieces:



Students discuss their methods in groups and later share group's findings with the whole class.
The teacher moves around to each group to observe student interactions and facilitate discussions.

Have each group present pattern pieces and how they constructed their patterns to the whole class.

If possible, give each group a piece of fabric to apply their patterns and make the skirt. Instead of sewing, they may use tape or staples to assemble the pieces. For fun, each group could decorate their skirt. As an option, you can have a fashion show at the end of the lesson or unit.

Assessment / Exit Slip:

1. Describe the math concepts that you applied in this lesson.
2. Complete the statement: *I am still confused about...*

Activity 2: 50-60 minutes

At the beginning of this activity, have students review the previous tasks. Have one or more students summarize the important concepts to the whole class. Address any questions or concerns from the student comments on exit slips.

Suppose that a dressmaker does not know how to find the radius of a circle given the waist measurement (circumference). Design a measuring tool or a method that will help any dressmaker determine the radius of the inner circle for the circle skirt. The tool should be easy for anyone to use and flexible enough to accommodate various common skirt sizes. Explain how to use your tool and any mathematical calculations and reasoning used in designing your tool. Prepare a brief presentation to convince others to buy your tool. (See Activity 2 – Student Handout #1.)

The mathematical concepts in this activity are similar to the previous activity. The focus is on communication and creativity. Have students work individually for a few minutes, then have them return to their small groups to discuss and complete the task. Each group should submit a product along with an explanation of how to use their product and any mathematical reasoning used to design their tool. They should also prepare a brief presentation to convince the audience to buy their tool. If technology is available, students may make a video showing how to use their tool or method. Encourage students to think of multiple representations of the same concept. The teacher can decide how long the presentation should be depending on the amount of time available. The group presentations may also need to be done on a separate day. At the end, the students can also vote on the best tool.

Questions for students to think about:

* What does it mean to find the radius of the circle? How does it relate to the diameter? To the circumference? To the area?
* What mathematical understanding is needed to find the radius when one can't measure it directly?
* Can your tool accommodate different skirt sizes?
* Do you need to bring in any outside information to accomplish this task?
* Describe what your tool measures and how to use your tool. Explain in detail so that a person who does not know much math can understand how to use your tool.
* Discuss the accuracy of your tool.

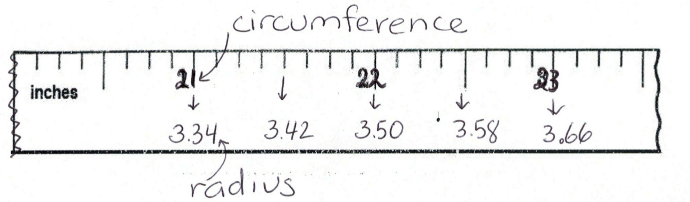
Possible Student Responses

Student Response #1:

Using the formula for the circumference of a circle, $C = 2\pi r$, the radius, r, can be determined by taking the circumference (waist measure) and dividing it by 2π (approximately 6.28). Students may create a step-by-step instruction sheet explaining how to apply the formula to draw the circle skirt pattern on fabric.

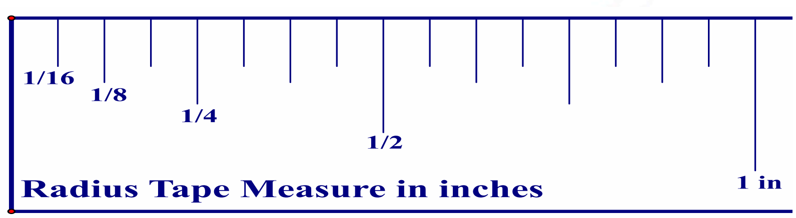
Student Response #2:

Students may create a special tape measure with the radius predetermined and preprinted so that when one wraps it around the waist, he/she can read off the radius measure from the tape measure. For example, if the waist size is 22 inches, when wrapped around the waist, the tape measure would say 22 inches on one edge and the corresponding radius ~3.5 inches on the other edge. See sample figure below.



However, the radius measurements in decimal shown in the modified tape measure above are inconvenient. Since the common tape measure is marked to 1/16 of an inch, the teacher should suggest that students convert the decimal values into increments of 1/16. For example, 3.34 should be converted to approximately $3\frac{5}{16}$.

A better alternative would be to give students a roll of flagging tape or blank adding-machine tape and have them determine the unit of measure for the radius and mark the radius tape measure on their own. They can approximate 2π to be about $6\frac{1}{4}$ inches, use a ruler to measure this length, and mark on the edge of the blank roll to be a radius of 1 inch. From there, they can create the half mark, quarter mark, and so on. This way, they can predetermine the radius increments on their measuring tool in desired fractional marks. See sample figure below.



Note: One inch in radius corresponds to a circumference of 2π ($\approx$ 6.28) inches. This drawing is made very close to actual size. If printed, make sure that printer scale is set to 100%.

Detailed directions for creating a radius tape measure are provided in the student handout **"Creating Your Own Radius Tape Measure"**.

Many tool companies have already designed and produced similar tapes that measure diameters. As part of the assessment for this activity, teachers may compare the students' tools alongside one of the pre-built tape measures to see how accurate they are. Alternately, teachers can print a diameter tape template at the following website by Greg Tarrant: http://www.blocklayer.com/Diameter-Tape.aspx.

Student Response #3:

Some students may make a chart with various waist measures and the corresponding radius measure so that a dressmaker could use the chart to look up the desired length. If students are proficient in creating a spreadsheet, then they may utilize available computers to generate the chart.

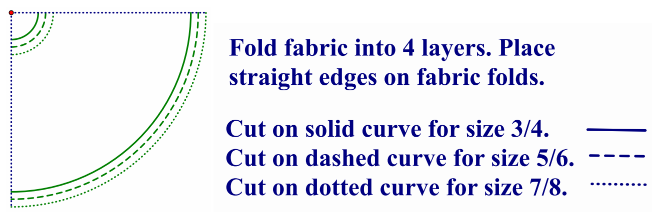
Common dress size for juniors	Waist (inches)	Radius for inner circle (inches)
3/4	22	$3.50 \approx 3\frac{1}{2}$
5/6	23	$3.66 \approx 3\frac{11}{16}$
7/8	24	$3.82 \approx 3\frac{13}{16}$
9/10	25	$3.98 \approx 4$
11/12	26	$4.14 \approx 4\frac{1}{8}$
13/14	27	$4.30 \approx 4\frac{5}{16}$
15/16	28	$4.46 \approx 4\frac{1}{2}$
17/18	29.5	$4.70 \approx 4\frac{11}{16}$
19/20	31	$4.93 \approx 4\frac{15}{16}$

Note: The above size chart is taken from Simplicity, a popular pattern design company. Size charts may vary by company and clothing style.

A paper pattern in sewing and fashion design is the paper or cardboard template from which the parts of a garment are traced onto fabric before cutting out and assembling.

Student Response #4:

Students can design a life-sized paper pattern that any dressmaker can buy to make the skirt. The pattern can accommodate different dress sizes. Students should include instructions on how to apply and position the pattern onto fabric. They should consider the different common sizes that rolls of fabric usually come in. Common student work samples include a template with ¼ of a circle drawn with three selected sizes.



Common Student Missteps/Difficulties

* Students do not know the formulas for circumference and area of circles. Teachers should spend some extra time to establish or develop intuition for these formulas, especially the idea that the ratio between the circumference and the diameter (or radius) of a circle is constant and how the value of π (pi) was estimated through time.

  The following lesson from an NCTM Illumination math activity is especially helpful to explore or demonstrate the relationship between the radius or diameter and the circumference and area of a circle.
  Illumination Activity: http://illuminations.nctm.org/ActivityDetail.aspx?ID=116

* Students do not understand the difference between perimeter and area for a closed two-dimensional shape.
* Students do not know how to measure length and the relationship between different measures of length in the metric system (meters, centimeters, …) and English system (inches, feet, yard, etc.).
* Students do not know how to solve simple equations, especially with unfamiliar symbols like π.
* Students are unfamiliar with sewing techniques that may cause them to make the wrong assumptions or apply inappropriate calculations.

Teacher Expectations

In this lesson, the teacher should expect to develop and convey a deeper understanding of the relationship between radius, diameter, circumference, and area of a circle and how to apply these concepts in a real-life setting. The teacher needs to involve and empower the students to collaborate and communicate mathematical understanding to their peers and to be motivated and engaged in the creative process.

Lesson Notes and Suggestions

The same concepts in this lesson can be applied to other designs, such as tree skirts, table skirts, capes, shawls, lampshade covers, etc. In addition, students can create skirts for smaller objects such as dolls.

Repeated Reasoning – Additional Exercises and Extension

The following questions may be assigned as homework or exit slip. **(See student handout below.)**

1. Given that a person's waist size is 30 inches, their desired skirt length is 20 inches, and the width of their waistband is to be 2 inches, determine the following quantities.
   a) Radii of the inner and outer circles for the skirt pattern, without seam allowance.
   b) Area of the donut shape and area of the waistband, without seam allowance or double-facing for the waistband.
   c) Seam allowance needs to be added to both the waistline seam and side seams if the donut shape is formed from different pieces. For the waistline, dressmakers typically subtract about ½ inch from the final radius measurement for the inner circle. For the side seams, they may add ½ inch for each raw edge to be seamed to the initial waistline circumference measurement. Suppose that you bought fabric with 36" width, what is the minimum length of fabric that you would need to buy? Consider how the pattern will be folded and positioned on fabric.

Solution:

a) Radius of inner circle: $\frac{30}{2\pi} \approx 4.77 \approx 4\frac{3}{4}$ inches

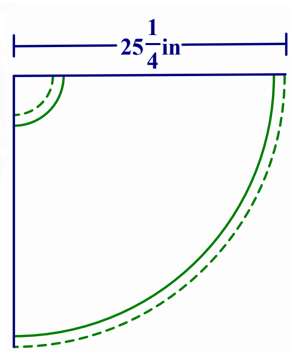
Add the skirt length to get the radius of the outer circle: $4\frac{3}{4} + 20 = 24\frac{3}{4}$ inches

b) Area of the donut shape = Area of the outer circle – Area of the inner circle

$= \left(24\frac{3}{4}\right)^2 \times \pi - \left(4\frac{3}{4}\right)^2 \times \pi = 590\pi \approx 1854\ \text{in}^2$

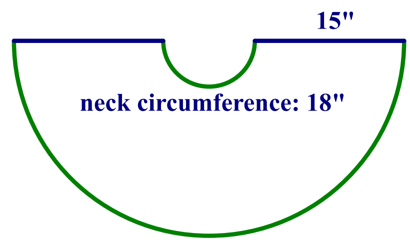
Area of the waistband = $(30 \times 2) = 60\ \text{in}^2$

c) Since the radius of the outer circle is $24\frac{3}{4}$ inches, adding ½ inch for the seam line would result in a radius length of $25\frac{1}{4}$ inches. Either two half-circle pieces or four quarter-circle pieces need to be cut. The minimum total length of fabric for the donut shape would be $25\frac{1}{4} \times 4 = 101$ inches ≈ 8.5 feet. The waistband can be cut from the leftover part of the fabric after the circle pattern is cut, since the width of the fabric is 36 inches.



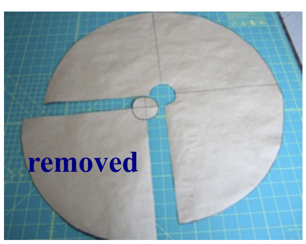
Circle Skirt Variations

2. Kimo would like to make a Hawaiian feather cape like the one shown below using a half-circle. When the straight edges are aligned together, the neckline has a circumference of 18 inches and a cape length of 15 inches. Discuss all adjustments that Kimo needs to make to approximate the radius of each half-circle in the pattern, without seam allowance.



Solution:
$\frac{1}{2}\text{Circumference} = \frac{1}{2}(2\pi r) = \pi r$ = 18, so radius of the inner half-circle is $\frac{18}{\pi} \approx 5.73 \approx 5\frac{3}{4}$ inches.
Adding the desired cape length, 15", the radius of the outer half-circle is $20\frac{3}{4}$ inches.

3. For a Halloween costume party, Carol decides to make a witch cape using two layers of fabric, with each layer consisting of three-quarters of an annulus (donut shape). When the straight edges are aligned together, the neckline has a circumference of 21 inches. The desired cape length is 10 inches.

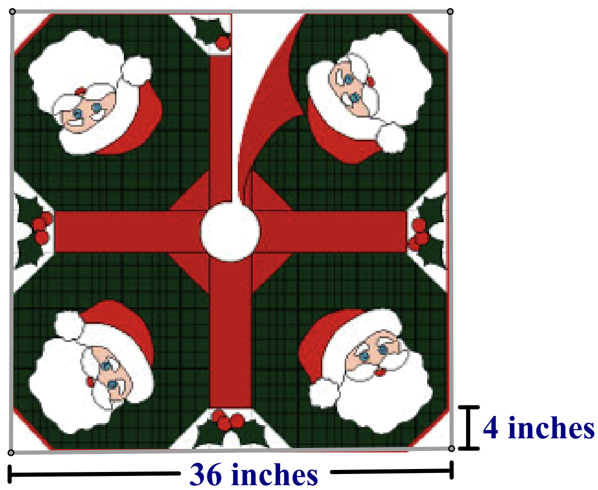


a) Discuss all of the adjustments that Carol needs to make in order to approximate the radii of the three-quarter circle pattern, ignoring seam allowance.
b) Approximate the total area of each layer of fabric in this pattern.

Solution:

a) $\frac{3}{4}\text{Circumference}=21$ inches, so Circumference = $\frac{21\times4}{3}$ = 28 inches.
Radius of the inner three-quarter circle is $\frac{28}{2\pi} \approx 4.5$ inches.
Adding the desired cape length, the radius of the outer circle is 14.5 inches.
b) Total area: $\frac{3}{4}$ of the area of the annulus = $\frac{3}{4}\pi[(14.5^2) - (4.5^2)] = 142.5\pi \approx 448$ in^2.

4. Mrs. Wills is making a skirt for her holiday tree. From a square piece of fabric with side length 36 inches, she cuts a circular hole in the middle to fit the tree base and a right isosceles triangle at each of the four corners. The tree base has a circumference of 20 inches. The length of a leg of each triangle cutout is 4 inches. Determine the amount of fabric, in square inches, that would be discarded and the remaining area for the tree skirt.

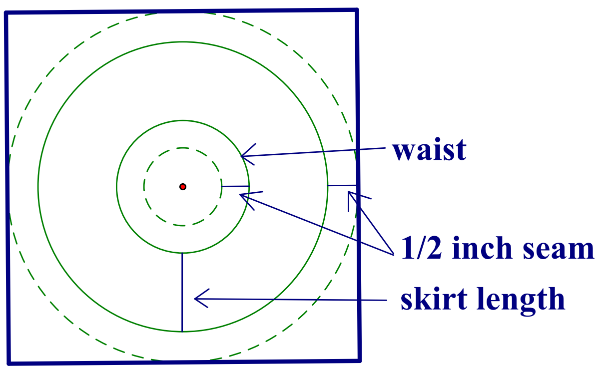


Solution:

Radius of the circular hole = $\frac{20}{2\pi} = \frac{10}{\pi}$ inches. Area = $\left(\frac{10}{\pi}\right)^2 \pi = \frac{100}{\pi} \approx 32$ in^2.
The four triangular cutouts form 2 squares with side length 4 inches.
Total area of the 4 triangles = 32 in^2.
Total area of fabric discarded = Area of hole + area of 4 triangles in^2.
Remaining area for the tree skirt $\approx 36^2 - 64 = 1232$ in^2.

5. A variation of the circle skirt consists of two or more layers of fabric where each layer is a donut hole shape with a different skirt length. Kimberly is making a circle skirt for her doll with two layers. The waist size of the doll is 6 inches. The skirt length for the bottom layer is 4 inches and for the top layer 3 inches. The pattern for each layer will be cut from a square piece of fabric. Kimberly would like to use ½ inch seam allowance for the hem. Determine the minimum length of the side of each fabric square.

Pattern for each layer



Cut on dashed circle.
Sew on solid circle.

Solution:

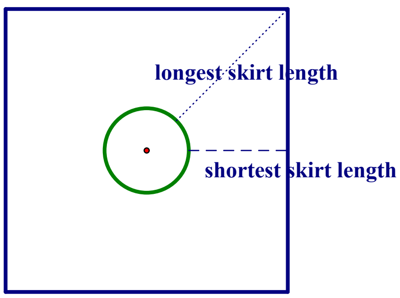
To determine the minimum side length of each square, we need to determine the diameter of the outer circle.

Radius of the circle at the waist is $\frac{6}{2\pi} \approx 1$ inch.

Radius of the outermost (dashed circle) for the bottom layer = radius of the circle at the waist + skirt length + ½ inch seam = 1 + 4 + ½ = 5.5 inches. Its diameter, which is also the side length of the square, is 5.5 x 2 = 11 inches.

Radius of the top layer with 3 inch skirt length and ½ inch seam is 4.5 inches. Its diameter, which is also the side length of the square, is 9 inches.

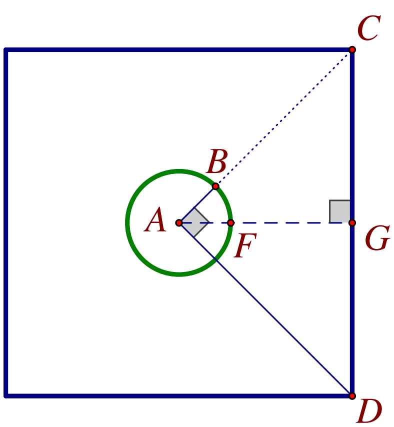
6. Another variation of the double-layer skirts consists of two or more layers of fabric where each layer is cut into a square and a circular hole. Mrs. Howard is making this skirt with two layers for her daughter. Her daughter's waist measures 22 inches. The length of the skirt varies depending on the position of the point on an edge of the square.



a) If Mrs. Howard wants the shortest skirt length to be 10 inches, what is the side length of the square for each layer, without seam allowance?

b) If Mrs. Howard wants the longest skirt length to be 12 inches, what is the side length of the square for each layer, without seam allowance?

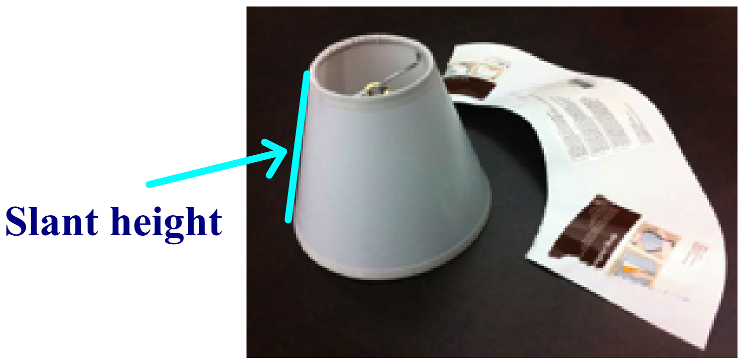
Solution:



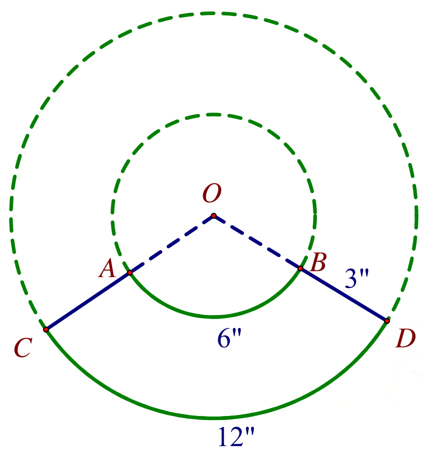
a) Shortest skirt length FG: 10 inches
Radius AF: $\frac{22}{2\pi} = \frac{11}{\pi} \approx 3.5$ inches
AG = AF + FG 3.5 + 10 = 13.5 inches
Side length of square 13.5 x 2 = 27 inches

b) Longest skirt length BC: 12 inches
AC = AB + BC $\approx$ 3.5 + 12 = 15.5 inches
Using the Pythagorean Theorem for right triangle CAD:
CD $\approx \sqrt{15.5^2 + 15.5^2} = 15.5\sqrt{2} \approx$ 22 inches

7. Ray found an old lampshade. He would like to make a new cover for it by cutting and pasting a section of an annulus (donut-hole shape). The circumference of the top circle of the lampshade is 6 inches, and the bottom circle is twice as long. The slant height of the lampshade is 3 inches. Determine the fraction of the annulus that he must use to create the lampshade cover.



Solution:



The circumferences of the circles on the lampshade correspond to the arclengths of the section of the annulus. The similarity ratio (scale factor) for the radii of two circles is the same as the similarity ratio of the circumferences, or in this case the similarity of the ratio of the arclengths 3:6 or 1:2. The radius of the inner circle, OB, is 3”, and the radius of the outer circle, OD, is 6”.
The circumference of the inner circle of the annulus is 6π inches. The ratio of the arclength AB to its circumference is $\frac{6}{6\pi} = \frac{1}{\pi} \approx \frac{1}{3}$.

Accommodations for Students with Disabilities and ELA Students

For students with special needs and ELA students, visual teaching aids will be especially helpful. Encourage group members to communicate their understanding and clarify or rephrase their responses to one another. Teachers can also break down the tasks into smaller steps and provide specific examples with concrete measures.

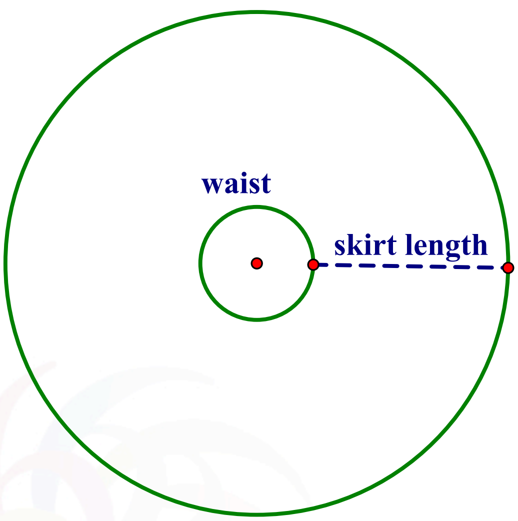
MOMATH
MUSEUM OF MATHEMATICS

Activity 1 - Student Handout #1

Mrs. Johnson is making a circle skirt for her 12-year-old niece. Visualize the fabric pieces that should be cut and sewn to make this skirt. Draw the pattern pieces. What measurements do you think she needs to get? Label the pattern pieces with the necessary measurements.

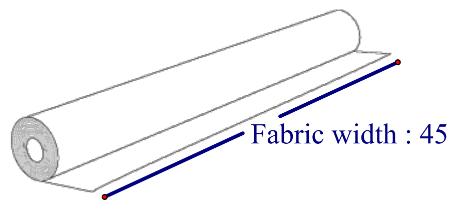
Activity 1 - Student Handout #2

Given that a person's waist measures 25 inches and the desired skirt length is 18 inches, label the diagram with appropriate measurements. How do you construct the pieces on fabric? Consider the math concepts that must be applied in this situation. (Figures are not drawn to scale.)



Activity 1 - Student Handout #3

There are three common widths for bolts of fabric: 36" (inches), 44" or 45" and 54". Most apparel fabrics will be 44" or 45" wide (and folded in half on the bolt). Suppose that you bought fabric with a 45" width, what is the minimum length of fabric that you would need to buy? How would you fold, draw, cut, and assemble the fabric pieces to form the skirt? Consider the most efficient way to accomplish this task.



Assessment / Exit Slip

1. Describe the math concepts that you applied in this lesson.
2. Complete the statement: *I am still confused about...*

MUSEUM OF MATHEMATICS

Activity 2 - Student Handout #1

Suppose that a dressmaker does not know how to find the radius of a circle given the waist measurement (circumference). Design a measuring tool or a method that will help any dressmaker determine the radius of the inner circle for the circle skirt. The tool should be easy for anyone to use and flexible enough to accommodate various common skirt sizes. Explain how to use your tool and any mathematical calculations and reasoning used in designing your tool. Prepare a brief presentation to convince others to buy your tool.

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Creating Your Own Radius Tape Measure

In this activity, your goal is to create a special tape measure with the radius predetermined so that when it is wrapped around a circle, you can read off the radius measure from the tape directly.
Materials needed:

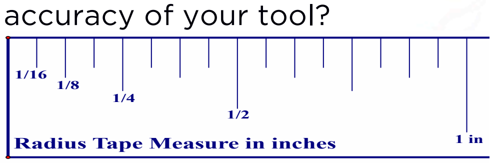
- Blank flagging tape, adding machine tape, or strips of blank paper taped together.
- Ruler marked in inches or centimeters.

Directions for making a radius tape using inches:

- The circumference, C, of a circle is determined by the formula $C = 2\pi r$, where r is the radius.
- A circle with radius 1 inch has a circumference of $2\pi(1) = 2\pi$ inches. For convenience, we will round 6.28 to 6.25 or $6\frac{1}{4}$.
- Measure and cut a strip of paper (or flagging tape) of length $6\frac{1}{4}$ inches. This will be a radius of 1 inch on the radius tape.

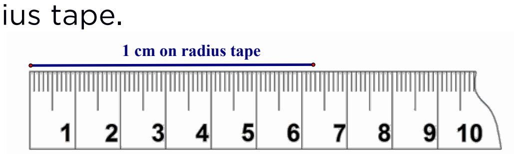
Not actual size.

- Divide and mark this length in halves, fourths, eighths and sixteenths. You may do this by folding the paper.
- Carefully transfer the marks on the roll of blank tape repeatedly for desired length of radius.
- How do you check the accuracy of your tool?



Directions for making a radius tape using centimeters:

- The circumference, C, of a circle is determined by the formula $C = 2\pi r$, where r is the radius.
- A circle with radius 1 cm has a circumference of $2\pi(1) = 2\pi \approx 6.28$ cm. For convenience, we will round 6.28 to 6.3.
- Measure and cut a strip of paper (or flagging tape) of length 6.3 cm. This will be a radius of 1 cm on the radius tape.



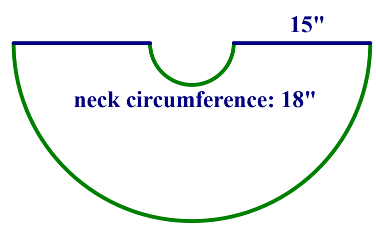
- Divide and mark this length in tenths. (Use $\approx$ 0.6 cm or 6 mm for each tenth.)
- Transfer the marks on the roll of blank tape repeatedly for desired length of radius.

Student Handout
Repeated Reasoning – Additional Exercises and Extension

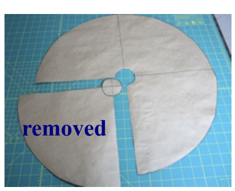
1. Given that a person's waist size is 30 inches, their desired skirt length is 20 inches, and the width of their desired waistband is 2 inches, determine the following quantities.
   a) Radii of the inner and outer circles for the skirt pattern, without seam allowance.
   b) Area of the donut shape and area of the waistband, without seam allowance or double-facing for the waistband.
   c) Seam allowance needs to be added to both the waistline seam and side seams if the donut shape is formed from different pieces. For the waistline, dressmakers typically subtract about ½ inch from the final radius measurement for the inner circle. For the side seams, they may add ½ inch for each raw edge to be seamed to the initial waistline circumference measurement. Suppose that you bought fabric with 36" width, what is the minimum length of fabric that you would need to buy? Consider how the pattern will be folded and positioned on fabric.

2. Kimo would like to make a Hawaiian feather cape like the one shown below using a half-circle. When the straight edges are aligned together, the neckline has a circumference of 18 inches and a cape length of 15 inches. Discuss all adjustments he needs to make to approximate the radius of each half-circle in the pattern, without seam allowance.





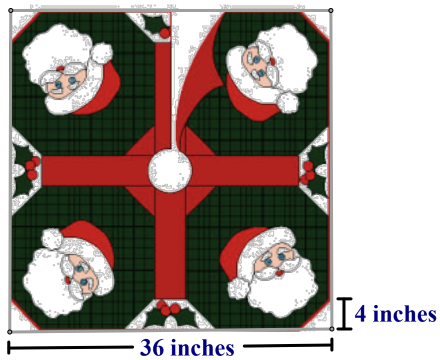
3. For a Halloween costume party, Carol decides to make a witch cape using two layers of fabric, with each layer consisting of three-quarters of an annulus (donut shape). When the straight edges are aligned together, the neckline has a circumference of 21 inches and the desired cape length is 10 inches.



   a) Discuss all adjustments she needs to make to approximate the radii of the three-quarter circle pattern, ignoring seam allowance.

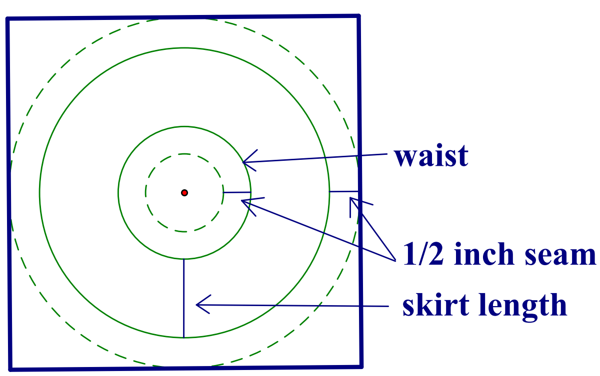
   b) Approximate the total area of each layer of fabric in this pattern.

4. Mrs. Wills is making a skirt for her holiday tree. From a square piece of fabric with side length 36 inches, she cuts a circular hole in the middle to fit the tree base and a right isosceles triangle at each of the four corners. The tree base has a circumference of 20 inches. The length of a leg of each triangle cut out is 4 inches. Determine the amount of fabric, in square inches, that would be discarded and the remaining area for the tree skirt.



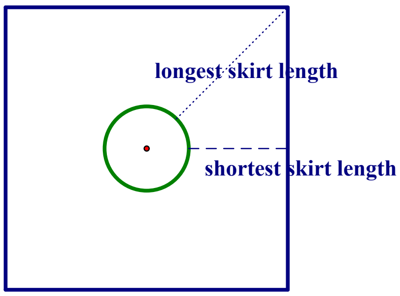
5. A variation of the circle skirts consists of two or more layers of fabric where each layer is a donut hole shape with a different skirt length. Kimberly is making a circle skirt for her doll with two layers. The waist size of the doll is 6 inches. The skirt length for the bottom layer is 4 inches and for the top layer 3 inches. The pattern for each layer will be cut from a square piece of fabric. Kimberly would like to use ½ inch seam allowance for the hem. Determine the minimum length of the side of each fabric square.

Pattern for each layer



Cut on dashed circle.
Sew on solid circle.

6. Another variation of the double-layer skirt consists of two or more layers of fabric where each layer is cut into a square and a circular hole. Mrs. Howard is making this skirt with two layers for her daughter. Her daughter's waist measures 22 inches. The length of the skirt varies depending on the position of the point on an edge of the square.



a) If Mrs. Howard wants the shortest skirt length to be 10 inches, what is the side length of the square for each layer, without seam allowance?

b) If Mrs. Howard wants the longest skirt length to be 12 inches, what is the side length of the square for each layer, without seam allowance?

7. Ray found an old lampshade. He would like to make a new cover for it by cutting and pasting a section of an annulus (donut hole shape). The circumference of the top circle of the lampshade is 6 inches, and the bottom circle is twice as long. The slant height of the lampshade is 3 inches. Determine the fraction of the annulus that he must use to create the lampshade cover.

References

Ashley. *Double Layer Square Circle Skirt*. N.d. Photograph. *Make It & Love It*. 5 Nov. 2012. Web. 28 Nov. 2013. <http://www.makeit-loveit.com/2012/11/the-double-layer-square-circle-skirt.html>.

Ashwell, Liz. *New Life for Old Lamp*. N.d. Photograph. *New Life for Old Lamp*. Pacific Fabrics & Craft, 5 Jan. 2012. Web. 27 Nov. 2013. <http://www.pacificfabrics.com/blog/?page=22>.

Carrie, McGhie. *Fabric*. N.d. Photograph. Reno, NV. *Going Batty! The Gathering Place for Quilting & Sewing*. Going Batty! Web. 29 Nov. 2013. <http://goingbatty.com>.

"Circle Skirt Maths – Explained!" *By Hand London*. By Hand London, 6 Sept. 2012. Web. 30 July 2013. <http://byhandlondon.com/2012/09/06/circle-skirt-maths-explained>.

"Circle Tool." *Circle Tool*. N.p., n.d. Web. 5 Sept. 2013. <http://illuminations.nctm.org/ActivityDetail.aspx?ID=116>.

"Common Core State Standards Initiative." *Common Core State Standards Initiative*. N.p., n.d. Web. 20 July 2013. <http://www.corestandards.org/Math/Content/7/G/A/2>.

Dampier, Robert. *Portrait of Princess Nahiennaena of Hawaii*. 1825. Honolulu Museum of Art, Honolulu. *Wikipedia, the Free Encyclopedia*. Wikipedia, 27 Mar. 2009. Web. 28 Nov. 2013. <http://en.wikipedia.org/wiki/File:Robert_Dampier_(1800–1874),_Nahiennaena_(1825).jpg>.

Full Circle Skirt. N.d. Photograph. *By Hand London*. By Hand London, 31 May 2013. Web. 31 July 2013. <http://byhandlondon.com/topics/diy/>.

Hawaiian Feather Cape. N.d. Photograph. University of Pennsylvania Museum of Archaeology and Anthropology. *Penn Museum Blog*. University of Pennsylvania, 27 Nov. 2012. Web. 26 Nov. 2013. <http://www.penn.museum/blog/collection/125th-anniversary-object-of-the-day/feather-cape-object-of-the-day-46/attachment/screen-shot-2012-11-27-at-9-57-20-am/>.

Ho Ho Ho Tree Skirt. N.d. Photograph. *McCall's Quilting*. Creative Crafts Group. Web. 28 Nov. 2013. <http://www.mccallsquilting.com/patterns/details.html?idx=7209>.

Johnson, Liz. *Citrus Holiday: Simply Quilted Patchwork Tree Skirt*. N.d. Photograph. *Sew4Home*. Sew4Home, 31 Aug. 2013. Web. 26 Nov. 2013. <http://www.sew4home.com/projects/fabric-art-accents/citrus-holiday-simply-quilted-patchwork-tree-skirt>.

"Measurement Charts for Sewing." *Simplicity Creative Group*. N.p., n.d. Web. 28 Nov. 2013. <http://www.simplicity.com/t-sewing-measurement-charts.aspx>.

Metric Ruler. Digital image. *Craftsmanspace*. Craftsmanspace, n.d. Web. 29 Nov. 2013. <http://www.craftsmanspace.com/knowledge/reading-a-metric-rule.html>.*Protection Fabrics*. Digital image. *Conservation Technology*. Conservation Technology, n.d. Web. 29 Nov. 2013. <http://www.conservationtechnology.com/pond_liner_fabrics.html>.

Ruler with an Inch Scale. Digital image. *Woodrow*. Woodrow Engineering Company, 2013. Web. 29 Nov. 2013. <http://www.woodrow.net/bm1268a-12-brass-maple-ruler-with-an-inch-scale/>.

Silva, Laura. *Fabric Covered Lampshade*. 2011. Photograph. Northern Arizona. *Laura's Crafty Life*. 10 Mar. 2011. Web. 28 Nov. 2013. <http://www.laurascraftylife.com/2011/03/fabric-covered-lampshade.html>.

Sonia. *Hawaiian Feather Cape*. 2011. Photograph. Bishop Museum, Honolulu. *Comocean Sets Sail*. Blogger, 24 Aug. 2011. Web. 28 Nov. 2013. <http://comocean-on-the-ocean.blogspot.com/2011_08_01_archive.html>.

Stealy, Carol. *Witch Cape*. 2011. Photograph. *Fun Threads Designs*. Fun Threads Designs, 25 Oct. 2011. Web. 28 Nov. 2013. <http://funthreads.blogspot.com/2011/10/tuesday-tutorial-5.html>.

Tarrant, Greg. "Printable Diameter Tape Templates. Wrap around Pipe to Measure Diameter." *Printable Diameter Tape Templates. Wrap around Pipe to Measure Diameter*. N.p., n.d. Web. 27 Nov. 2013. <http://www.blocklayer.com/Diameter-Tape.aspx>.

Willard, Dana. *Double Layer Skirt*. N.d. Photograph. *Made*. Web. 28 Nov. 2013. <http://www.danamadeit.com/2012/07/more-and-more-circle-skirts-and-the-double-layer.html>.

Woods, Lynn. "How to Sew a Half Circle Skirt." 2 *Half Circle Skirt*. Kalico Fabric, 2011. Web. 30 July 2013. <http://www.kalicofabric.com/half-circle-skirt.html>.