**Implementation of Quilt Fabric Estimator**

**Intro**

In this project, I have designed an estimator to calculate the amount of yardage of fabrics you would need to purchase in order to produce a desired quilt (or portions of a quilt), based on number, size and shape of rectangular or triangular pieces in "blocks" (the typical unit of construction) of a quilt. For example, here is a diagram of a quilt block: <https://www.pinterest.com.mx/pin/543880092498520547/>. If the "finished size" of the block in the diagram is 12 inches, most of the pieces that make up the block are either 2-inch finished squares, or 2" finished "half-square triangles" (HSTs). If you know you will have, say, 64 of these blocks in your quilt, you can figure out how many of each piece in each color you will need to complete the entire quilt.

**Motivation**

Many kinds of electronic quilting software packages are available on the market. Here is a very popular one for $240: <https://electricquilt.com/online-shop/electric-quilt-8/>. (These pricey packages allow you to *design* your quilts, as well as providing fabric calculators.) This student has found FREE websites that offer some fabric calculation. Here is one: <https://app.prequilt.com/fabric-calculator>. You will notice that the only triangle calculation offered is for the HST, which severely curtails the app's usefulness.

When you cut quilt fabric, you must add 1/4" "seam allowance" to all sides of what you want want your pieces to be when they are combined into a quilt. For example, if you need squares that have a "finished size" of 2 inches, you simply cut out 2 1/2-inch squares. 42" of usable width of fabric on a bolt, and it's pretty easy to stand in JoAnn fabric and do the mental math as to how much yardage you'd need ("gee, I can get 16 x 2 1/2-inch squares from a 2 1/2-inch wide strip of fabric; I need 160 squares, so I need 10 x 2 1/2-inch strips, which is 25 inches, which is just less than 3/4 yards of fabric, so I'll buy 7/8 yd to be safe--boom").

Not so with triangles. Even HSTs that finish at 2x2 on the short edges need to be cut as 2 7/8" squares first, because of the additional allowance at the diagonal middle, and the "pointy corners." Forget 30-60-90, equilateral or scalene triangles.

**The problem is that fabric is expensive.** Therefore, you want to purchase enough fabric to complete your project, with maybe an extra 1/8 or 1/4 yard in case of mistakes, but you CANNOT have even a 1/4" too little, because you will be unable to complete your project, and then possibly unable to purchase more of the same fabric. So you need a ball-park estimator. This estimator would be useful not only for the projects you have designed from scratch, but also to recalculate fabric requirements given in purchased patterns or directions in quilt books. As a quilter, I have made lots of patterns that have included mistakes in their fabric requirements. Most call for far too much fabric--one pattern I made cost me nearly double what I would have spent if I had figured out the requirements myself. I've also made at least two in which they underestimated fabrics (fortunately, the fabrics came out of my "stash" and I had more than enough on hand).

**About the Design**

To develop my estimator, I determined 6 main kinds of shapes about which I would want to be able to input information into a system, and for which I would want to get yardage estimation out. These shapes are:

* HST (half-square triangle)
* QST (quarter-square triangle)
* RightTriangle (a right triangle whose short sides are not the same)
* Square
* Rectangle
* ScaleneTriangle (a triangle whose three sides are unequal, but this will work for any triangle without a right angle, or, in other words, that you cannot "pair up" into a rectangle or square with another).

(In the design of my estimator, I used trigonometry to calculate the augmented lengths of the sides of triangles. Most of the trig I used came from the dusty circular files in my mind, placed there back in high school. Reminders of how SSS and ASA are implemented came from the following sources:

* <https://www.dummies.com/education/math/trigonometry/use-the-law-of-cosines-with-sss/>
* <https://www.mathsisfun.com/algebra/trig-solving-asa-triangles.html>)

To build the software for the estimator, I used two Design Patterns: the **Builder Pattern** and the **Template Pattern**. (A very helpful treatise on the Builder Pattern came to me from <https://www.geeksforgeeks.org/builder-design-pattern/>). The Builder Pattern turned out to be perfect for this project. I had to not only estimate the fabric, but also give brief cutting directions, so that whomever uses the estimator would have equally-critical information on how the fabric was intended to be cut. I literally needed to BUILD a set of directions step-by-step. In this program, then, the client uses the Builder interface (PieceBuilder) to polymorphically instantiate a concrete Builder (HstBuilder, QstBuilder, RightTriangleBuilder, RectangleBuilder, SquareBuilder, or ScaleneTriangleBuilder). It then instantiates a QuiltMaker (Director) object, to which it passes the Builder object. The QuiltMaker is then periodically called to set its own fields to prepare for the big bang, when all the fields are set and ready; then the QuiltMaker's buyFabric method is called by the client to launch the construction of the Fabric object.

In between the Builder interface and the concrete Builders, I placed an abstract class: Piecing Assistant. This abstract class, together with the concrete Builder classes, provides a Template Pattern for the Builders, as five of the ten methods for each builder are exactly the same (and are therefore "moved up" as concrete methods into the abstract class), and the other five have hooks from the abstract class into the concrete classes. Thus, the Template Pattern is excellent for code reduction and reuse. Also, the abstract class contains several fields necessary to all the concrete classes. The job of a concrete Builder, then, is to instantiate and build a Fabric object. This object, which uses the FabricPlan interface, mainly just contains getters, setters and a toString method. The Fabric object also stores a minCut double value, which it uses after the client is done obtaining user input, to add together and display all cuts of the SAME fabric for each of the DIFFERENT Fabric objects created during the information-collection phase.

In addition to the Builder Pattern and Template Method, I also used the **Factory Method** *in the client class* to easily instantiate the particular concrete Builder class. (**Iterators** were also used in for-loops in the client class, but these iterators were supplied by Java.)

**Adding New Concrete Builder Classes:**

It did not occur to me until I finished the coding and am now writing this README that I forgot all about diamond (parallelogram) shapes--I sure have made plenty of quilts with diamonds in them!! Because I will most certainly USE my estimator, I will definitely add diamonds as another PieceBuilder concrete class. The only thing I have to change will be to write the class (a copy-paste-edit from another concrete Builder), make sure it extends Piecing Assistant, and update my drivers (QuiltClient will just need its queryFirstSide and pieceFactory methods, and the display of choices, updated). Simple!!

I almost never use fabric pieces that have curved edges; but if I did decide to add a CircleBuilder, the circle's *diameter* would be exactly the same, functionally, as the side of a square. I would use an **Adapter Pattern** that would call the SquareBuilder.

**How it Works:**

If you run the UI Driver (QuiltClient), this is the basic logic:

* define ArrayList fabricList (of Fabric objects)
* define ArrayList fabricNames (fabric names correspond to Strings in Fabric objects)
* while true:
  + if not 1st time though loop:
    - ask to estimate another?, or quit (BREAK)
  + display menu of shape choices:
    - Half-Square Triangle
    - Quarter-Square Triangle
    - Other Right Triangle (Half-Rectangle)
    - Scalene Triangle (no right angle)
    - Square
    - Rectangle
  + <user enters int; choice validated>
    - Factory Method returns corresponding Builder Object
    - QuiltMaker instantiated
  + if fabricNames not empty
    - iterate through fabricNames; display previously-used fabricNames
  + ask user to enter a new or previously-used fabricName?
  + <user enters String; choice validated>
  + QuiltMaker begins setting its fields with input or calculated values
  + ask user how many of the pieces/block?
  + <user enters int; choice validated>
  + ask user how many blocks/quilt?
  + <user enters int; choice validated>
  + ask user for the length of a side?
  + <user enters double; choice validated>
  + if Builder instanceof RightTriangle, ScaleneTriangle or Rectangle
    - ask user for length of 2nd side?
    - <user enters double; choice validated>
  + if Builder instance of Scalene Trianlge
    - ask user for length of 3rd side?
    - <user enters double; choice validated>
  + add unique fabricName to fabricNames
  + (QuiltMaker has finished setting all of its own fields)
  + BOOM: **QuiltMaker calls Builder's methods IN THE PROPER ORDER to produce Fabric object**
  + add Fabric object to fabricList
* end while
* display: "Here are your completed estimates:"
* iterate through each fabricName
  + iterate through fabricList, matching fabricName
    - add all minCutInches for this fabricName
    - **print out Fabric object's toString method**
  + end for (fabricList)
  + **print Grand Total of inches/yardage for this fabricName** -end for (fabricName)

**Terms:**

* HST: Half-Square Triangle (hypotenuse of each triangle gets cut on the bias of the fabric)
* QST: Quarter-Square Triangle (hypotenuse of each triangle gets cut on the grain of the fabric)
* WOF: Width of Fabric (generally 42 inches)
* seam allowance: (nearly universally understood to be 1/4")

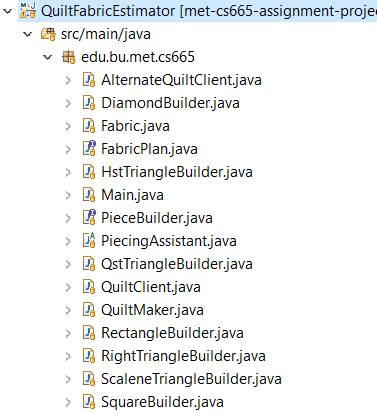
**Assumptions and Limitations:**

* The UI graphic is console-based only at this time, but could be expanded one day.
* The output at the end does not currently get written to a file, but it could easily be, to print out and take to the store. It is also nearly as easy, however, to cut and paste the console output to a Word document and then take THAT to the store.
* The program will limit the length of a side of a piece to 40-inches. This is somewhat arbitrary, but if a long, skinny triangle is laid across the WOF, more than 2" could be consumed by the "pointy angles." This is so unlikely to happen that this programming quilter chose for now not to worry about it.
* The WOF is not alterable at this time, but could easily be by adding an additional user query. The WOF could then be Fabric-object-specific by only changing the PiecingAssistant abstract class, which would change the *calculations* based on the WOF variable. On the other hand, if you wanted to log the specific WOF in the Fabric object by building in a field for it, you would have to change the PieceBuilder interface as well as the PiecingAssistant class, the FabricPlan interface as well as the Fabric class, and the Quiltmaker class, as well.
* No diamonds (parallelograms) yet--but they are coming!

**Additional credits:**

* For help with Scanner usage and exception-handling: <https://stackoverflow.com/questions/24414299/java-scanner-exception-handling>

**Listing of the files in my QuiltFabric Estimator (you will notice that I added DiamondBuilder--the week after I handed in my final project!):**



**Sample output run of the Quilt Fabric Estimator in Eclipse:**

Welcome to the Quilt Fabric Estimator.

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 1

Enter a new or previously-used name for this fabric: white

How many of these pieces per block (positive integer)? 8

How many blocks in your quilt (positive integer)? 64

Finished measurement of short side (a double): 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 1

Here are previously-used fabric names, for reference:

white

Enter a new or previously-used name for this fabric: blue

How many of these pieces per block (positive integer)? 8

How many blocks in your quilt (positive integer)? 64

Finished measurement of short side (a double): 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 5

Here are previously-used fabric names, for reference:

white

blue

Enter a new or previously-used name for this fabric: blue

How many of these pieces per block (positive integer)? 8

How many blocks in your quilt (positive integer)? 64

Finished measurement of side (a double): 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 6

Here are previously-used fabric names, for reference:

white

blue

Enter a new or previously-used name for this fabric: white

How many of these pieces per block (positive integer)? 4

How many blocks in your quilt (positive integer)? 64

Finished measurement of one side (a double)

(The first side you enter will be cut along WOF): 4

Finished measurements of second side: 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 2

Here are previously-used fabric names, for reference:

white

blue

Enter a new or previously-used name for this fabric: blue

How many of these pieces per block (positive integer)? 4

How many blocks in your quilt (positive integer)? 64

Finished measurement of hypotenuse (a double): 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 1

Here are previously-used fabric names, for reference:

white

blue

Enter a new or previously-used name for this fabric: grey

How many of these pieces per block (positive integer)? 8

How many blocks in your quilt (positive integer)? 64

Finished measurement of short side (a double): 2

All set on that piece. Would you like to estimate another (y or n)? y

Which piece shape would you like to estimate?

1: Half-Square Triangle

2: Quarter-Square Triangle

3: Other Right Triangle (halved-rectangle)

4: Scalene Triangle (no right angle)

5: Square

6: Rectangle

7: Diamond

Enter a number 1 - 7: 5

Here are previously-used fabric names, for reference:

white

blue

grey

Enter a new or previously-used name for this fabric: teal

How many of these pieces per block (positive integer)? 1

How many blocks in your quilt (positive integer)? 64

Finished measurement of side (a double): 4

All set on that piece. Would you like to estimate another (y or n)? n

Here are your completed estimations:

For white, for 2-inch finished HSTs:

You need a total of 512 triangles. This means you will need to cut 256 squares.

Cut WOF strips 2 7/8-inches wide.

Cut each strip into 14: 2 7/8-inch squares.

Cut each square in half diagonally.

Your WOF strips will be cut like this:

\_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ ^

| /| /| /| /| |

| / | / | / | / | 2 7/8-inches ... etc. for 42 inches.

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You will need a total of 19 of these strips.

Minimum cut of this fabric for these pieces is 54.625 inches.

Please buy a minimum of 1 5/8 yards, and consider extra in case of cutting mishaps.

For white, for 4-inch x 2-inch finished rectangles:

You need a total of 256 rectangles.

Cut WOF strips 2 1/2-inches wide.

Cut each strip into 9: 4 1/2-inch rectangles.

Your WOF strips will be cut like this:

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| | | | | 2 1/2-inches ... etc. for 42 inches.

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You will need a total of 29 of these strips.

Minimum cut of this fabric for these pieces is 72.5 inches.

Please buy a minimum of 2 1/8 yards, and consider extra in case of cutting mishaps.

TOTAL INCHES YOU WILL NEED FOR FABRIC white: 127.125

TOTAL YARDS = 3 5/8 yards

(PLEASE ADD EXTRA in case of cutting mishaps.)

For blue, for 2-inch finished HSTs:

You need a total of 512 triangles. This means you will need to cut 256 squares.

Cut WOF strips 2 7/8-inches wide.

Cut each strip into 14: 2 7/8-inch squares.

Cut each square in half diagonally.

Your WOF strips will be cut like this:

\_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ \_\_\_\_\_ ^

| /| /| /| /| |

| / | / | / | / | 2 7/8-inches ... etc. for 42 inches.

|/ |/ |/ |/ | |

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You will need a total of 19 of these strips.

Minimum cut of this fabric for these pieces is 54.625 inches.

Please buy a minimum of 1 5/8 yards, and consider extra in case of cutting mishaps.

For blue, for 2-inch finished squares:

You need a total of 512 squares.

Cut WOF strips 2 1/2-inches wide.

Cut each strip into 16: 2 1/2-inch squares.

Your WOF strips will be cut like this:

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| | | | | 2 1/2-inches ... etc. for 42 inches.

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You will need a total of 32 of these strips.

Minimum cut of this fabric for these pieces is 80.0 inches.

Please buy a minimum of 2 1/4 yards, and consider extra in case of cutting mishaps.

For blue, for 2-inch finished QSTs:

You need a total of 256 triangles. This means you will need to cut 64 squares.

Cut WOF strips 3 1/4-inches wide.

Cut each strip into 12: 3 1/4-inch squares.

Cut each square in half diagonally, TWICE.

Your WOF strips will be cut like this:

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| X | X | X | X | 3 1/4-inches ... etc. for 42 inches.

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You will need a total of 6 of these strips.

Minimum cut of this fabric for these pieces is 19.5 inches.

Please buy a minimum of 5/8 yards, and consider extra in case of cutting mishaps.

TOTAL INCHES YOU WILL NEED FOR FABRIC blue: 154.125

TOTAL YARDS = 4 3/8 yards

(PLEASE ADD EXTRA in case of cutting mishaps.)

For grey, for 2-inch finished HSTs:

You need a total of 512 triangles. This means you will need to cut 256 squares.

Cut WOF strips 2 7/8-inches wide.

Cut each strip into 14: 2 7/8-inch squares.

Cut each square in half diagonally.

Your WOF strips will be cut like this:

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| /| /| /| /| |

| / | / | / | / | 2 7/8-inches ... etc. for 42 inches.

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You will need a total of 19 of these strips.

Minimum cut of this fabric for these pieces is 54.625 inches.

Please buy a minimum of 1 5/8 yards, and consider extra in case of cutting mishaps.

TOTAL INCHES YOU WILL NEED FOR FABRIC grey: 54.625

TOTAL YARDS = 1 5/8 yards

(PLEASE ADD EXTRA in case of cutting mishaps.)

For teal, for 4-inch finished squares:

You need a total of 64 squares.

Cut WOF strips 4 1/2-inches wide.

Cut each strip into 9: 4 1/2-inch squares.

Your WOF strips will be cut like this:

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| | | | | 4 1/2-inches ... etc. for 42 inches.

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You will need a total of 8 of these strips.

Minimum cut of this fabric for these pieces is 36.0 inches.

Please buy a minimum of 1 yards, and consider extra in case of cutting mishaps.

TOTAL INCHES YOU WILL NEED FOR FABRIC teal: 36.0

TOTAL YARDS = 1 yards

(PLEASE ADD EXTRA in case of cutting mishaps.)