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# Constructing a Square Indian Fire Altar Activity

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## Constructing a Square Ancient Indian Fire Altar Activity

In this activity, we will model constructing a square fire altar with a method similar to one used by people in ancient India. The fire altars, which were made of bricks, had various shapes. Instructions for building the altars were in Vedic texts called *Śulba-sūtras*. We will follow instructions for constructing a square *gārhapatya* fire altar from the *Baudhāyana-śulba-sūtra*, which was written during the Middle Vedic period, about 800-500 BC.

The quote which follows is taken from the translation of the *Baudhāyana-śulba-sūtra* by Sen and Bag. [Sen & Bag, p. 85]

7.4 According to tradition, the *gārhapatya* fire has the measure of 1 *vdāyāma*.

7.5 It is a square by one tradition...

7.6 The square is to be divided into 7 parts and then into 3 parts transversely. In the second layer, bricks are to be placed towards north.

7.7 To place square bricks, bricks of sides one-sixth, one-fourth and one-third of 1 *vdāyāma* are made. Of them, ... bricks of the first type and ... of the second are placed in the first layer; ... of the third type and ... of the first are placed in the second layer.

One *vdāyāma* is about 5.5 feet. We will use paper squares to model a *gārhapatya* fire altar to scale using the method in Stanza 7.7. First we need to decide on the dimensions of our square altar. Since we need square “bricks” of side-lengths of one-sixth, one-fourth, and one-third of the altar side-length, let us choose a convenient side-length.

1. The least common multiple of 6, 4, and 3 is \_\_\_\_\_.

We will make our square fire altar with this many inches as the side-length. We can now use this to determine the side-length of our square “bricks”.

2. The side-length of a “brick” of the first type is  $1/6$  the altar side-length or \_\_\_\_\_ inches.

3. The side-length of a “brick” of the second type is  $1/4$  the altar side-length or \_\_\_\_\_ inches.

4. The side-length of a “brick” of the third type is  $1/3$  the altar side-length or \_\_\_\_\_ inches.

Next, we need to decide how many bricks we need of each type. (The answer is actually given in the *Baudhāyana-śulba-sūtra*, but we are going to figure it out for ourselves.) Earlier in the instructions in Stanza 7.6, another method is given for constructing a square *gārhapatya* fire altar which uses 21 rectangular bricks. So, we will also use 21 bricks per layer, but square bricks not rectangular. According to Stanza 7.7, we want to make two layers of 21 square bricks each; the first layer using bricks of the first and second type and the second layer with bricks of the third and first type. For the first layer, let  $a$  be the number of bricks of the first type and  $b$  the number of bricks of the second type.

5. Write an equation in  $a$  and  $b$  to represent the requirement that the total number of bricks in the first layer is 21.

Another requirement is that when our bricks are positioned in a square the area of the bricks will add up to the total area of our altar. Let us write an equation for this requirement in a general way so that it doesn't depend on our units. So, we will use 1 square unit for the total area of our altar. Recall each brick of type one is  $1/6$  the altar side length. So, the area of one brick of type one is  $(1/6)^2$  or  $1/36$  the area of the altar. Also, recall that  $a$  is the number of bricks of the first type. Thus, the area to be covered by the bricks of type one in the first layer will be  $a$  times  $1/36$  or  $a/36$ .

6. What is the area that will be covered by bricks of type 2 in the first layer?

7. Write an equation in  $a$  and  $b$  to represent the requirement that the area covered by the bricks is equal to the area of 1 whole altar, namely 1 square unit.

8. To find the total number of bricks of type 1 and type 2, solve the system of equations formed by the equations you came up with in questions 5 and 7.

9. Repeat the process above to determine how many bricks of type 3 and type 1 are needed to complete the second layer with 21 total bricks. Let  $c$  be the number of square bricks of type 3 in the second layer and  $d$  the number of type 1.

Now we are ready to make our “bricks” by cutting squares out of paper. In questions 2 through 4, we decided on the side-lengths of the squares, and in questions 7 and 9, we determined how many of each type we need. Cut out the appropriate number of squares of each type.

Looking back at the translation of the original text, there are not instructions for how to arrange the squares in each layer into a larger square fire altar.

10. Using the “bricks” you have cut out for layer one, find a way to arrange them in a square and draw a sketch below. Is this the only way? Is there a way that you think is most likely to have been used?

11. Using the “bricks” you have cut out for layer two, find a way to arrange them in a square and draw a sketch below. Is this the only way? Is there a way that you think is most likely to have been used?

## Teacher Notes

### Materials for each student or group of students (if working in groups)

- 3 sheets of 8.5 by 11 inch paper for cutting out “bricks”
- Scissors

### Skills Required

- Writing algebraic equations.
- Solving a linear system of two equations in two unknowns.

### Solutions

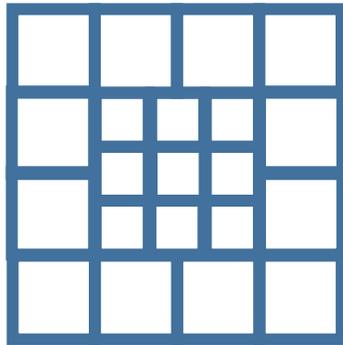
1. 12      2. 2      3. 3      4. 4      5.  $a + b = 21$

6.  $b/16$       7.  $\frac{a}{36} + \frac{b}{16} = 1$  or  $4a + 9b = 144$

8.  $a = 9, b = 12$

9. Solve the linear system  $\begin{cases} c + d = 21 \\ \frac{c}{9} + \frac{d}{36} = 1 \end{cases}$  or  $\begin{cases} c + d = 21 \\ 4c + d = 36 \end{cases}$ . The solution is  $c = 5, d = 16$ .

10. One solution is



11. One solution is

