

## Lilavathi's Cup

### Objectives and Standards

CCSS.MATH.CONTENT.HSA.CED.A: Create equations that describe numbers or relationships

### Background Information:

Baskara II lived in southwestern India during the 12<sup>th</sup> century CE. He was an astronomer, mathematician, and teacher. Baskara wrote an influential book of mathematical verse titled Lilavathi, also the name of his beloved daughter. Over 200 years later, a writer engaged in translating the book into Persian offers this intriguing legend concerning the book's title.

Baskara cast a horoscope for his daughter to determine her marital prospects. The horoscope yielded the sad news that Lilavathi would be denied a happy marriage and children unless she married during a particular hour of a certain day. Baskara calculated the favorable hour and constructed a curious clock to indicate its arrival on the scheduled wedding day. A small cup was placed afloat in a larger vessel of water. The cup had a small hole in the bottom. Water leaked into the cup at a rate calculated to sink the cup at the appointed hour. Despite cautions not to interfere with the clock, Lilavathi could not contain her intellectual curiosity. She leaned over to check its progress and, unnoticed, a pearl from her wedding attire dropped into the cup, stoppering the hole. Thus, the cup did not sink as calculated and the wedding was cancelled forever. To console his heartbroken daughter, Baskara wrote for her the book that bears her name.

The Lilavathi is a textbook on arithmetic and algebra, dealing mostly with problem solving techniques including the Method of Supposition (an advanced form of what students today would call "guess and check"). As with most scholarly writings from this culture, the Lilavathi is presented as poetry. The 279 verses are said to be artistically delightful and are often humorous. Many of the verses are sample problems posed from the author to his beloved daughter, Lilavathi herself. Addressing her as "Oh! You intelligent girl, Lilavathi" and "O! Auspicious girl with lovable eyes of a fawn", Baskara's affections are clear and touching. One example problem:



*From a swarm of bees, a number equal to the square root of half the total number of bees flew out of the lotus flowers. Soon after,  $\frac{8}{9}$  of the total swarm went to the same place. A male bee enticed by the fragrance of the lotus flew into it. But when it was inside, the night fell, the lotus closed, and the bee was caught inside. To its buzz, its consort responded anxiously from outside. O my beloved! How many bees are in the swarm?*

Today, we would express this symbolically as an equation, and solve for  $x$ . Rather than  $x$ , Baskara might have used "ya" an abbreviation of *yavat tavat* (unknown quantity). In Indian mathematics of this period, multiple unknown variables might be referenced as flavors or colors.

**Problem:** Consider the clock composed of a leaky cup floating in a larger vessel of water. How might Baskara have constructed the cup so that it sinks after a specified amount of time?

1. List some variables that might affect the length of time required for the cup to sink.
2. Circle the variables that would be easy to measure and change in an experiment.
3. Select one variable to study in an experiment.
4. Consider the list of materials available for an experiment:
  - 1 large, transparent cup, filled about half-way with water
  - 1 small paper “Dixie” cup, to float inside the larger cup
  - 6 large metal washers to add weight to the small paper cup
  - 1 round toothpick for puncturing the bottom of the small paper cup
  - 1 stopwatch to measure time
  - 1 computer with Excel or other software capable of graphing and curve fitting
5. Design and conduct an experiment to determine the relationship between the chosen variable and the time it takes the cup to sink.
6. Express the relationship graphically and as an equation (using Excel, Desmos, or some other graphing software). Identify what type of curve best fits the data.

**Challenge #1:** Express the relationship in a few lines of poetic verse, as Baskara and Lilavathi might have done.

**Challenge #2:** Using your experimental results, calculate the necessary requirements to make a cup that will sink after exactly two minutes. Test it!

Know, oh brilliant young student, that success will surely mean you are to marry someone with a stellar intellect, stunning good looks, a burgeoning bank account, and a virtuous heart. Perhaps it shall be the brother or sister of your lab partner!



Story of Baskara II and Lilavathi from: Joseph, G. (2011). *The Crest of the Peacock: Non-European Roots of Mathematics (Third Edition)*. Princeton; Oxford: Princeton University Press. doi:10.2307/j.ctt7sdsb