Buffon's Needles

Participants:

Ages 12 and up. Knowledge of probability and integration is desirable.

Preparations:

A number of sticks and a "board" are required. The sticks can be needles, toothpicks, matches, popsicle sticks, wooden skewers or other types of small sticks that have all the same length. The board can be done with a big piece of paper (wrapping paper, for instance) or drawn on the floor with chalk.

Activity:

The activity consists of finding an approximation of the number pi using probability.

1. Draw a set of parallel lines on the board. The distance between them must be exactly twice the length of the needle.
2. Toss the sticks in the air so they fall over the board.
3. Count the number of sticks that are crossing one of the parallel lines.
4. Divide the number of sticks thrown by the number of sticks that crossed lines. The result should approximate pi.

The activity coordinator will explain the activity. The participants will perform the experiment by themselves in small groups.

Alternatives:

- What happens when you have a different separation between parallel lines?
- Try to use different shapes of sticks and board. For instance a stick on a checkerboard or throwing equilateral triangles on a triangular grid.

Create and Share!
Record a video of the event, record your own explanation, create new geometric probability challenges. Share your creations using the hashtags **#idm314needle** and **#idm314**.

Mathematical background and resources:

This activity is based on "Buffon's needle problem", named after french mathematician Georges-Louis Leclerc, Comte de Buffon, who first published it in the 18th century.

The probability for one needle to cross a line is 1/pi. We can estimate the probability of an event by repeating an experiment many times, and dividing the number of success cases by the total number of cases. In this case, the "success" is to cross a line, and that gives us our approximation.

Why does the number pi appear in the probability? A needle that falls perfectly parallel to the lines in the board would have an almost 0 probability of crossing a line, while one that falls perfectly perpendicular would have a probability of 0.5 of crossing a line (the maximum). The probability is related to the angle of rotation of the needle, and all possible angles describe a full circle. For a detailed and longer explanation you can search for "Buffon's needle problem".

One explanation can be given using integration, and just an intuitive idea of probability (see ref. 2, method 1). If the students have a more formal training in probability, it can be explained using density functions (see ref. 1) or mathematical expectation (ref. 2, method 2).

References:
1. https://www.youtube.com/watch?v=sJVivjuMfWA
2. https://www.youtube.com/watch?v=szUH1rzwbAw
3. https://en.wikipedia.org/wiki/Buffon%27s_needle_problem