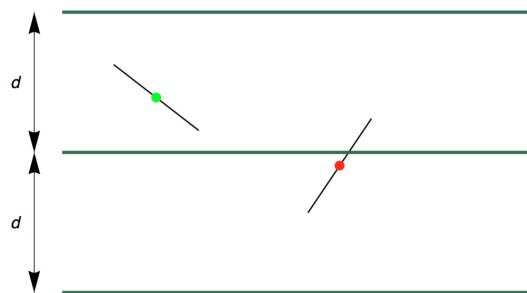


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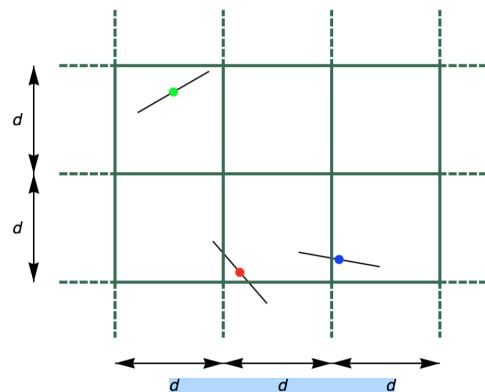
This project is due on Oct 03. You can turn in any part of the problems for partial credit. You are allowed to use any available resource<sup>1</sup> for this project, but your solution and code must be your own and reflect your own understanding of the problem.

1. (10 points) A plane has parallel lines on it at equal distances  $d$  from each other. A needle of length  $l$  ( $l < d$ ) is thrown at random on the plane. Figure 1 shows a single grid with two needles of length  $l$  representing two possible outcomes. What is the probability that the needle will lie across a line?
  - (a) Write a program in Julia or Matlab to approximate the probability using 1000 needles.
  - (b) Compute the probability using mathematical techniques that you have learned<sup>2</sup>. Reduce your answer to its simplest form.
  - (c) Use the previous questions to run an approximation for  $\pi$ .



**Figure 1.** Buffon's needles on a single grid.

2. (15 points) In the double-grid experiment, also called the Laplace extension of Buffon's problem, a plane is covered with two sets of parallel lines where one set is orthogonal to the other. Figure 2 shows a double-grid plane and three needles of length  $l$  crossing zero, one and two lines. What is the probability that the needle will lie across zero, one or two lines?
  - (a) Write a program in Julia or Matlab to approximate the probabilities using 1000 needles.
  - (b) Compute the probabilities.

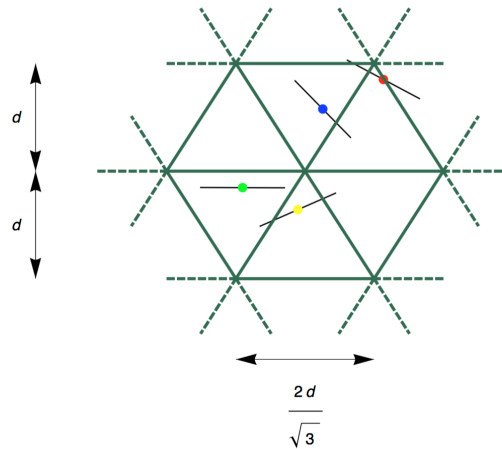


**Figure 2.** Buffon's needles on a double grid.

<sup>1</sup>books, articles, friends, Google, etc. Note I'm not included in this list, because I don't know answers to most of the questions.

<sup>2</sup>in or outside of this class

3. (15 points) In the triple-grid experiment, a plane is covered with equilateral triangles of altitude  $d$  and hence of side  $\frac{2d}{\sqrt{3}}$ . Figure 3 shows a triple-grid plane and four needles of length  $l$  crossing zero, one, two and three lines. What is the probability that the needle will lie across zero, one, two or three lines?
- Write a program in Julia or Matlab to approximate the probabilities using 1000 needles.
  - Compute the probabilities.



**Figure 3.** Buffon's needles on a triple grid.