IGN Code-Foo Challenge

Trevor Boone

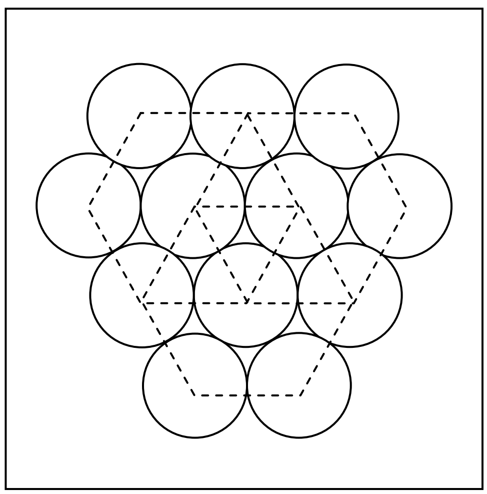
Question 1 - How many pennies could you put on the Golden Gate Bridge without any of them overlapping? Please write out each step in your thought process.

1. Find Dimensions of The Golden Gate Bridge
    a. Google Search for “Golden Gate Bridge Dimensions”
    b. First result is website: http://www.goldengatebridge.org/research/factsGGBDesign.php
    c. Most Relevant Dimensions from the website are:
        i. Total length of Bridge including approaches from abutment to abutment: 1.7 miles = 8,981 ft = 2,737 m
        ii. Length of suspension span including main span and side spans: 1.2 miles = 6,450 ft = 1,966 m
        iii. Width of Bridge: 90 ft = 27 m
        iv. Width of roadway between curbs: 62 ft = 19 m
        v. Width of sidewalk: 10 ft = 3 m
    d. Since the suspension span is the part that’s really the “bridge” I’ll use 6450 feet for the length.
2. In order to see whether the ~8 ft difference between the width of the roadway + 2*the width of the sidewalk and the total bridge width given above is some kind of structure pennies couldn’t fit on, I look to find a picture of the bridge.
    a. Google Image Search for “Golden Gate Bridge”
    b. Image found (cropped):

    c. From the image it looks like the bridge is widest at the main towers, but the width of the sidewalk and road, which appears to make up the area that could be covered by pennies, stays about the same width. The extra 8 feet might also be the total width of the barriers between the sidewalk and the street and the edges of the bridge. So I’ll use (the width of the roadway + 2*the width of the sidewalk) = 82 feet for the width.

d. For the purposes of this challenge, I will consider the bridge to be one long rectangle. This ignores the effect of the main towers, lampposts, etc., all of which would slightly affect the area on which pennies may be placed, but the flat sidewalk and street surfaces make up the vast majority of the bridge surface, so the error introduced by this simplification is probably no more than 2%.

3. Find Dimensions of a Penny
   a. Google Search for "Penny Dimensions," Found a few yahoo answers pages with conflicting numbers.
   b. Tried search for "U.S. Penny," and found website for United States mint, which gives coin specifications (http://www.usmint.gov/about_the_mint/?action=coin_specifications). According to the U. S. Mint, the penny has a diameter of 0.750 inches and a thickness of 1.55 mm (which Google says is equal to 0.061023622 inches.)
4. Evaluate tightest arrangement of pennies when laid flat
   a. Pennies (or any other circular object, for that matter) can be packed the most tightly in a hexagonal formation as shown below:



   b. This means that the pennies may be represented by an arrangement of alternating isosceles triangles with sides equal to penny diameter (0.75 inches), in which each vertex represents the center of a penny.
5. Find out how many flat pennies will fit in the area of the bridge
   a. To figure out how many pennies would fit on the bridge, I first figure out how to express the number of pennies as a function of rows and columns of an arrangement of isosceles traingles as shown in the figure below:

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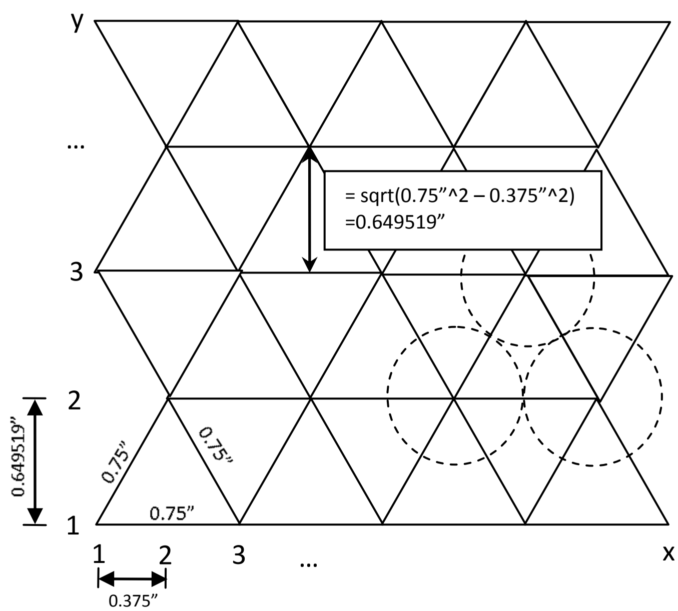

b. From looking at the figure, I figure that the number of vertices (i.e., pennies) can be expressed in terms of x and y by the following:

Number of Pennies = [x / 2 (rounded up)] * [y / 2 (rounded up)] +

[x / 2 (rounded down)] * [y / 2 (rounded down)]

c. To determine x and y, the arrangement may be made in one of two orientations: one with x parallel to the bridge length, and one with x parallel to the bridge width. I'll evaluate both and determine which will fit more pennies.

   i. x parallel to bridge width:

      x = [bridge width (82 feet = 984 in) – 0.75 in (to represent the half a penny outside of the triangle arrangement on each side)] / 0.375 in (rounded down) = 2622

      y = [bridge length (6450 feet = 77400 in) – 0.75 in (to represent the half a penny outside of the triangle arrangement on each side)] / 0.649519 in (rounded down) = 119163

      Number of Pennies = [1311] * [59582] + [1311] * [59581] = 154911693 pennies

   ii. x parallel to bridge length:

      x = [bridge length (6450 feet = 77400 in) – 0.75 in (to represent the half a penny outside of the triangle arrangement on each side)] / 0.375 in (rounded down) = 206398

y = [bridge width (82 feet = 984 in) – 0.75 in (to represent the half a penny outside of the triangle arrangement on each side)] / 0.649519 in (rounded down) = 1513

Number of Pennies = [103199] * [757] + [103199] * [756] = 156140087 pennies

iii. With x parallel to the bridge length, we can fit 1228394 more pennies on the bridge, giving us a final answer of **156140087 pennies**.

6. Find out how many pennies on their side will fit in the area of the bridge
    a. It also occurs to me that one could cover the bridge with pennies lying on their side without them overlapping as well. While from a practical standpoint it would be a lot harder to place pennies on the bridge on their side, you would be able to fit quite a bit more pennies that way.
    b. The number of pennies that could fit on the bridge on their side can be expressed as a number of "stacks" (x), each containing the same number of pennies (y). The number of pennies that would fit on the bridge in this arrangement is simply x*y. Like the arrangement of isosceles triangles, the stacks can be placed in two directions: one with stacks running parallel to the length of the bridge and one with stacks running parallel to the width of the bridge.
        i. Stacks parallel to bridge length:

        x = bridge width (82 feet = 984 in) / penny diameter (0.75 in) (rounded down) = 1312 stacks

        y = bridge length (6450 feet = 77400 in) / penny thickness (0.061023622 in) (rounded down) = 1268361 pennies/stack

        Number of Pennies = 1312 stacks * 1268361 pennies/stack = 1664128992

        ii. Stacks parallel to bridge width:

        x = bridge length (6450 feet = 77400 in) / penny diameter (0.75 in) (rounded down) = 103200 stacks

        y = bridge width (82 feet = 984 in) / penny thickness (0.061023622 in) (rounded down) = 16124 pennies/stack

        Number of Pennies = x stacks * y pennies/stack = 1663996800

        iii. With the stacks parallel to the length of the bridge, 132192 more pennies will fit, so when the pennies are placed on their side, up to **1664128992 pennies** will fit on the bridge, or about ten and a half times as many pennies as will fit lying flat.