**PROBLEM:**

Estimate the number of Skittles candies that will fit into a box measuring 9” x 8” x 7”

**ASSUMPTIONS (For all three methods):**

* All skittles have the same volume
* 5 squares on graph paper is equal to 1”

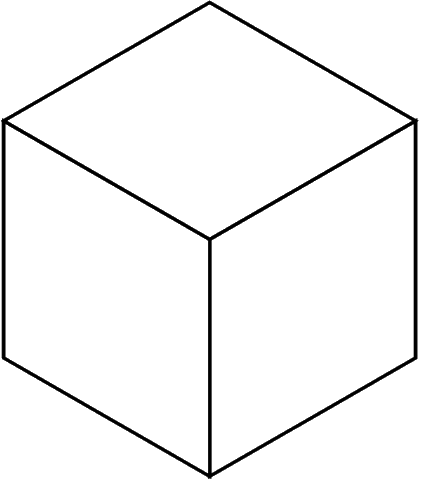
**FIRST METHOD (MEASURED):**

**ADDITIONAL ASSUMPTIONS:**

-A small scale test box accurately scales up to reflect the larger problem box.

**PROCEDURE (For first method):**

* create a 2” x 2” x 2” box using graph paper; as 5ive blocks is one inch, the length of each side is 10 squares. Have two people hold the sides of the box flat (prevent bulging of paper) while a third person fills the box with skittles. Continually place a flat piece of paper over the top of the box to ensure skittles aren’t piling higher than the rims of the box. Once finished, dump skittles out and count.

**COLLECTED DATA (For first method):**

* # of skittles fit inside a 2” x 2” x 2” box = 112 skittles

2” x 2” x 2”

\*Not to scale

**SOLUTION (For first method):**

* Volume of problem box → [9” x 8” x 7”] = 504
* Amount of 2” x 2” x 2” boxes inside a 504box → 504/ [2” x 2” x 2”] = 63
* Skittles in the problem box → (63) (112 skittles) 7,100 skittles

**REFLECTIONS ON ANSWER 1:**

While this answer is close (absolutely within an order of magnitude), the reality of the situation is that because a larger portion of the the skittles will be touching the walls compared to skittles touching other skittles, meaning that the skittle density will be artificially low. Still, this answer gives a reasonable starting point, and serves as a useful estimate, even if its fundamental assumption is flawed.

**SECOND METHOD (NON-MEASURED):**

**ADDITIONAL ASSUMPTIONS:**

* Skittles act like rectangular boxes, and do not interlock or settle into the empty space left by other Skittles.

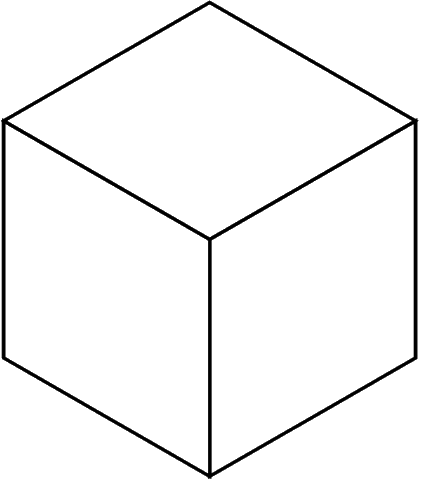
**PROCEDURE:**

* Using the graph paper to estimate the length, width, and height of the candy, estimate the volume of one skittle, treating it like a rectangle.
* Divide the total volume of the problem box by the volume of one ideal rectangular Skittle.

**COLLECTED DATA (for the second method)**

* Length of a skittle 0.5 in

Box w/ “dimensions” of Skittle

* Width of a skittle 0.5 in

0.5” x 0.5” x 0.25”

* Height of a skittle 0.25 in
* Approximate volume of a skittle 0.0625

**SOLUTION (for the second method)**

* Volume of problem box → [9” x 8” x 7”] = 504
* Volume of a skittle 0.0625
* Number of skittles in problem box = [Volume of Problem Box] / [Volume of a Skittle] = 504/ 0.0625 8,100 skittles.

**REFLECTIONS ON ANSWER 2:**

Whereas estimate one is an underestimate, this is very likely an overestimate, as it assumes that the skittles arrange themselves in a perfectly ordered, efficient pattern when they are in the box. While this is theoretically possible if every skittle is carefully placed individually, it is simply not the reality of what happens when skittles are simply poured into the box. In this real life case, skittles lie with all manner of orientations, with some fitting together more efficiently than the rectangular box model presented in this method’s assumptions, but many more fitting together less efficiently, meaning that a realistic box filled with skittles is, on average, much less space efficient than the model presented here, and as a result holds less skittles.

Also, the assumption is made that all skittles are the same size. Clearly, this is not the case, and while that may affect the volume calculation slightly in this method, as it means not every “box skittle” is exactly the same size, the difference this makes in the total skittle count is very small (likely well below 100.)

**THIRD METHOD (VERIFICATION):**

**ASSUMPTIONS:**

* If we average out the number of skittles per cubic inch from several boxes of different dimensions, we will get a much more accurate idea of the number of skittles per unit of volume

**METHOD:**

* Collect an assortment of small boxes and determine their dimensions.
* For each box, have two people hold the sides, preventing bulging, and fill it with skittles. Use a separate piece of paper or lid to ensure that no skittles are overflowing.
* For each box, dump out the skittles in the box and count.
* Use this number and the volume to determine the number of skittles per cubic inch in each box.
* Calculate an average skittle density (in skittles/) by taking the arithmetic mean of the skittle densities for each box.
* Use this average to determine the number of skittles that would fit in the problem box.

**COLLECTED DATA:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Box Dimensions** | ” x ” x ” | ” x ” x ” | ” x ” x ” |
| **Box Volume ()** | 16.2559 | 10.4502 | 28.3203 |
| **Number of Skittles** | 241 | 149 | 436 |
| **Skittles per (**skittles/**)** | 14.8254 | 14.2581 | 15.3953 |

**SOLUTION:**

Average Skittle density == 14.8263 skittles/

Volume of problem box → [9” x 8” x 7”] = 504

Number of Skittles in problem box = 504 \* 14.8263 skittles/= 7,472 skittles

**REFLECTIONS ON ANSWER**

This answer (7,472 skittles) falls between the estimates we got from methods one and two, which makes sense. In estimate one, we underestimate, because skittle density decreases when the box surface area to box volume ratio increases; this is because skittles fill the space less efficiently when they are bumping up against walls instead of interlocking with other skittles. In estimate two, we overestimate, because the assumption that the skittles stack perfectly is simply unrealistic. Skittles stack almost stochastically, so they fill each box in such a way that more empty space is present than in the estimate two assumption. Of the three, then, this third answer is the most reasonable.

That is not to say, though, that it is perfect. The data demonstrates that as the volume of the box increases, the skittle density increases, so by using smaller test boxes, even though we are taking an average, we are still like under the actual value. Unfortunately, the logical extension of this is that the only true way to verify the answer is to build the project box and get the actual number, but procuring almost 10,000 skittles is more or less unfeasible, so this average density method is the nearest form of verification we have.

It may perhaps be better, as a larger box seems to provide a more correct density, to use only the density from the large test box, giving an answer of 504 \* 15.3953 skittles/= 7,759 skittles, but this is only a difference of 287 skittles from our other answer, or a difference of about 3.8%. In other words, the difference between the two is more or less negligible, so our verification stands, even if it very well could be made more accurate with ever larger test boxes.

In fact, as a whole, these results are not too badly spread out. Even the largest gap - that which is between estimates one and two, is only 14%, which, while it would be unacceptably large for anything outside of an estimate, is not terribly unreasonable here. Indeed, it is safe to say the true answer, if we were to build the problem box and fill it, would lie between about 7,500 and 8,000 skittles - a very small band of values.