The Number of Nestle Smarties in a Ping-Pong-Ball-Contaminated Mason Jar Encountered in the PHYS 2300 Lab

Anneya Golob

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Abstract

The number of Nestle Smarties contained in a standard 500 mL Mason jar which also held 3 ping pong balls suitable for international competition was sought in the PHYS 2300 laboratory. Since it is against laboratory rules to bring food or drink into the laboratory at any time, this quantity was found by [**CONCISE EXPLANATION OF PROCEDURE**]. The number of Nestle Smarties contained in the jar was found to be $n_{\text{Smarties}} \pm \sigma_{n_{\text{Smarties}}}$ [**IN AGREEMENT OR NOT?**] with the true value of 193 Smarties.

1 Theory/Introduction

Nestle Smarties are a sugar-coated chocolate candy available in Canada and numerous other countries. They are generally oblate spheroids with a minor axis of approximately 5 mm and a major axis of approximately 12 mm, although individual candies with a wide range of defects have been observed (Golob, 2016).

During the first session of the PHYS 2300 lab, a contest to accurately determine the number of Nestle Smarties, n_{Smarties}, in a Mason jar which also contained 3 ping pong balls was held. To aid in the determination of the unknown quantity, a Fun Size box of Nestle Smarties was provided (although - since food and drink are prohibited in the lab - it proved to be of little use) in addition to an empty Mason jar and tools to measure masses and distances...

The number of Nestle Smarties in a ping-pong-ball-contaminated Mason jar can be expressed as

$$n_{\text{Smarties}} = \frac{m_{system} - m_{Mason\,jar} - 3m_{ping\,pong\,Ball}}{m_{Smartie}} \tag{1}$$

where $m_{Mason\,jar}$ is the mass of an empty Mason jar, $m_{ping\,pong\,ball}$ is the mass of a standard ping pong ball, $m_{Smartie}$ is the mean mass of an individual Smartie candy, and m_{system} is the mass of the filled jar presented in the lab.

2 Apparatus & Procedure

To determine the number of Nestle Smarties in the Mason jar, all variables in Equation 1 needed to be measured and recorded with reasonable uncertainties. The mass of the filled jar, m_{system}, and the mass of an empty jar, $m_{Mason\,jar}$, were determined using a mechanical mass balance. The mass of a competition grade ping pong ball and the mass of an individual Nestle Smartie were determined by ... [WHAT DID YOU DO?]

3 Data & Analysis

The results of the measurements and queries[?] described in Section 2 are described in Table 1. Uncertainties in the measured quantities were estimated by ... [INCLUDE ANY REASONING THAT WENT INTO YOUR CHOICE OF UNCERTAINTIES]. The values in Table

Quantity	Value	Uncertainty
m_{system}	# g	$\sigma_{m_{system}}$ g
$m_{ping\,pong\,ball}$		
$m_{Mason\,jar}$		
$m_{Smartie}$		

Table 1: Measured values of quantities required to determine the number of Nestle Smarties in a ping-pong-ball-contaminated Mason jar.

1 were used in Equation 1 to determine the unknown number of Nestle Smarties in the Mason jar.

4 Results & Discussion

The number of Nestle Smarties in the Mason jar was found to be $X \pm Y$ Smarties as demonstrated in Appendix B. The uncertainty in this measurement was dominated by the uncertainty in the mass of [WHAT?] because [WHY?]. The true value of $n_{Smarties}$ was found to be 193, in [AGREEMENT/DISAGREEMENT?] with the estimated value. The analysis performed in this lab was time-sensitive and limited by our inability to legally isolate Nestle Smarties candies for individual inspection because of laboratory regulations as outlined in the course syllabus. Ideally, it would have been possible to [STUFF, THINGS].

5 Conclusions

The number of Nestle Smarties contained in a ping-pong-ball-contaminated Mason jar was determined during a 1 hour period in the PHYS 2300 lab, where food and drink are prohibited. In light of the limitations of the scenario, the number was determined by [VERY CONCISE EXPLANATION] and found to be $\# \pm \#$, in [AGREEMENT/DISAGREEMENT] with the true value of 193 Smarties. The accuracy and precision of the measurement were hampered by [CIRCUMSTANCES]. To improve on the estimate of $n_{Smarties}$, ... [WHAT YOU WOULD HAVE DONE TO DETERMINE THE NUMBER OF SMARTIES IN THE JAR GIVEN

UNLIMITED TIME AND MONEY].

References

Golob, A. 2016, The Mass of a Smartie

Appendices

A Derivation of Uncertainty in $n_{Smarties}$

Assuming Gaussian uncertainties, the uncertainty in Equation 1 can be derived as follows:

$\sigma_{n_{Smarties}} = \sqrt{\left(\frac{\partial n_{Smarties}}{\partial m_{system}}\right)^2 \sigma_{m^2_{system}} + \left(\frac{\partial n_{Smarties}}{\partial m_{Mason\,jar}}\right)^2 \sigma^2_{m_{Mason\,jar}} + \left(\frac{\partial n_{Smarties}}{\partial m_{ping\,pong\,ball}}\right)^2 \sigma^2_{ping\,pong\,ball} + \left(\frac{\partial n_{Smarties}}{\partial m_{Smartie}}\right.}$

Partial derivatives with respect to each measured can be expressed as

$\frac{\partial n_{Smarties}}{\partial m_{system}} =$ ... ,

$\frac{\partial n_{Smarties}}{\partial Mason\,jar} =$ ...,

$\frac{\partial n_{Smarties}}{\partial_{ping\,pong\,ball}} =$..., and

$\frac{\partial n_{Smarties}}{\partial Smartie_{system}} =$... .

Substituting the partial derivatives into the uncertainty equation gives

$$\sigma_{n_{Smarties}} = \sqrt{(...)^2 \sigma_{m^2_{system}} + (...)^2 \sigma^2_{m_{Mason\,jar}} + (...)^2 \sigma^2_{ping\,pong\,ball} + (...)^2 \sigma^2_{Smartie}}. \qquad (2)$$

B Sample Calculations

The number of Nestle Smarties in the Mason jar was calculated by substituting the values in Table 1 into Equation 1 as follows:

$n_{\text{Smarties}} = \frac{X-Y-Z}{W}$

$n_{\text{Smarties}} = \#.$

The uncertainty associated with the number of Nestle Smarties in the Mason jar was calculated by substituting the values in Table 1 into Equation 2 as follows:

$$\sigma_{n_{Smarties}} = \sqrt{(...)^2 \sigma_{m^2_{system}} + (...)^2 \sigma^2_{m_{Mason\,jar}} + (...)^2 \sigma^2_{ping\,pong\,ball} + (...)^2 \sigma^2_{Smartie}}$$

$$\sigma_{n_{Smarties}} = \#.$$