

Error in Measurements

PES 115 Prelab Questions

Lab Station:

All prelab questions are due **before** the beginning of every lab class.
No late work will be accepted!

** Disclaimer: This pre-lab is *not* to be copied, in whole or in part, unless a proper reference is made as to the source. (It is strongly recommended that you use this document *only* to generate ideas, or as a reference to explain complex physics necessary for completion of your work.) Copying of the contents of this web site and turning in the material as “original material” is *plagiarism* and will result in serious consequences as determined by your instructor. These consequences may include a failing grade for the particular pre-lab or a failing grade for the entire semester, at the discretion of your instructor. **

1. What is the uncertainty in a measurement made with a meter stick (1 mm resolution)?

The uncertainty in a measurement made with a meter stick with 1 mm resolution would be half of the smallest division of the instrument:

$$\frac{1}{2} \text{ smallest division} = \frac{1}{2}(1\text{mm}) = 0.5\text{mm}$$

$$\delta(\text{length}) = \pm 0.5\text{mm}$$

2. A mass is measured to be 35.6 grams on an electronic balance. What is the uncertainty in this measurement?

The uncertainty in a measurement made with an electronic balance would (AGAIN) be one-half of the smallest division of the instrument.

As a thought experiment, if the mass being measure was just a **little bit** lighter, what would the scale read?

35.5g ... Right!

If the mass being measure was just a **little bit** heavier, what would the scale read?

35.7g ... Right again! (See, you guys are so smart!)

Hence the smallest division of the instrument is 0.1 grams! Half the smallest division is:

$$\frac{1}{2} \text{ smallest division} = \frac{1}{2}(0.1 g) = 0.05 g$$

$$\delta(\text{mass}) = \pm 0.05 g$$

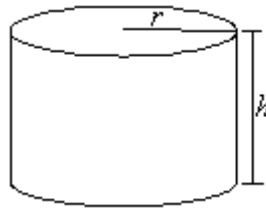
3. Calculate the uncertainty for the volume of the following cylinder:

$$\text{Radius} = 21.4 \pm 0.02 \text{ cm}$$

$$\text{Height} = 1.2 \pm 0.01 \text{ cm}$$

$$\text{Hint: } r^2 = r \cdot r$$

First, let's define a few of the necessary equations and known variables we need:



Known Variables:

$$|h| = 1.2 \text{ cm} \quad |\delta h| = 0.01 \text{ cm} \quad |r| = 21.4 \text{ cm} \quad |\delta r| = 0.02 \text{ cm}$$

We can calculate the volume of the cylinder by using the following: r h

$$\tau_{\text{CYLINDER}} = \pi r^2 h$$

$$\tau_{\text{CYLINDER}} = (3.14)(21.4 \text{ cm})^2(1.2 \text{ cm}) = 1725.6 \text{ cm}^3$$

The uncertainty of the volume is given by:

$$\delta \tau_{\text{CYLINDER}} = |\tau| \pi \left(\frac{\delta r}{|r|} + \frac{\delta r}{|r|} + \frac{\delta h}{|h|} \right)$$

$$\delta\tau_{\text{CYLINDER}} = |\tau| \pi \left(2 \left(\frac{\delta r}{|r|} \right) + \frac{\delta h}{|h|} \right)$$

$$\delta\tau_{\text{CYLINDER}} = |1725.6 \text{ cm}^3| (3.14) \left(2 \left(\frac{0.02 \text{ cm}}{|21.4 \text{ cm}|} \right) + \frac{0.01 \text{ cm}}{|1.2 \text{ cm}|} \right)$$

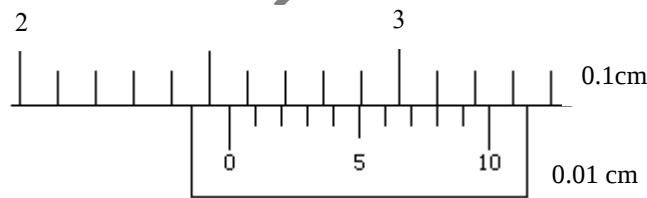
$$\delta\tau_{\text{CYLINDER}} = |1725.6 \text{ cm}^3| (3.14) (2 (0.00093457) + 0.008333) = (1725.6 \text{ cm}^3) (3.14) (0.01020216)$$

$$\delta\tau_{\text{CYLINDER}} = \pm 55.28 \text{ cm}^3$$

We could actually go one step further and determine the complete volume and uncertainty of the cylinder:

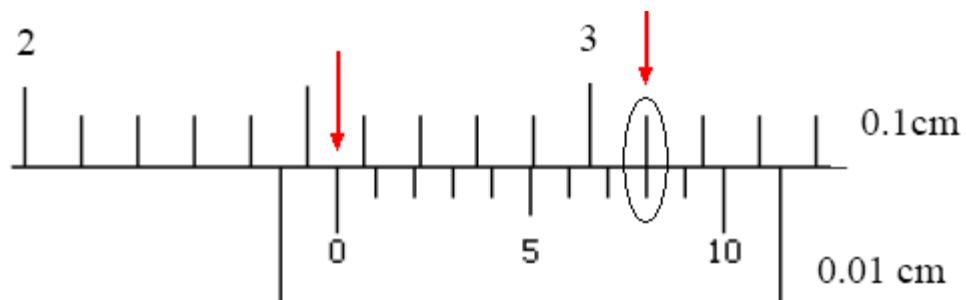
$$\tau_{\text{CYLINDER}} = 1725.6 \pm 55.28 \text{ cm}^3$$

4. What is the length reading from the following vernier caliper?



First, we have to determine the number of whole centimeters. This is the value of the top scale (rounded down) where the 0 mark (of the bottom scale) lands. In this case, the 0 mark falls right after the 2.5 cm mark. In fact, it falls right between the 2.5 cm and the 2.6 cm mark, so like we said earlier; we round down to 2.5 cm. So, this is our 1's and 10th's of centimeters measurement. Next, we have to find where one of the bottom scale lines matches up exactly with one of the top scale lines. On the bottom scale, the 0-line appears to be right between the 2.5 and 2.6 cm mark – this doesn't LINE UP. The 1-line on the bottom scale appears to be slightly to the right – so this doesn't LINE UP either. The 2-line is slightly to the left of the 2.7 cm mark – doesn't LINE UP ... 3-line is out in 'Lala land'. 4-line is slightly to the right again, 5-line slightly to the left (but this is pretty close to lining up). 6-line ... nope, 7-line ... nope ... but wait: 8th line! FINALLY!

This occurs at 0.08 cm (the 8th line).



Thus, the length reading from the micrometer is: **2.58 cm**. However, to be completely correct, we must include the uncertainty of the measurement. This is half of the smallest division of the instrument – in this case **0.005 cm**.

$$\text{length} = 2.58 \pm 0.005 \text{ cm}$$