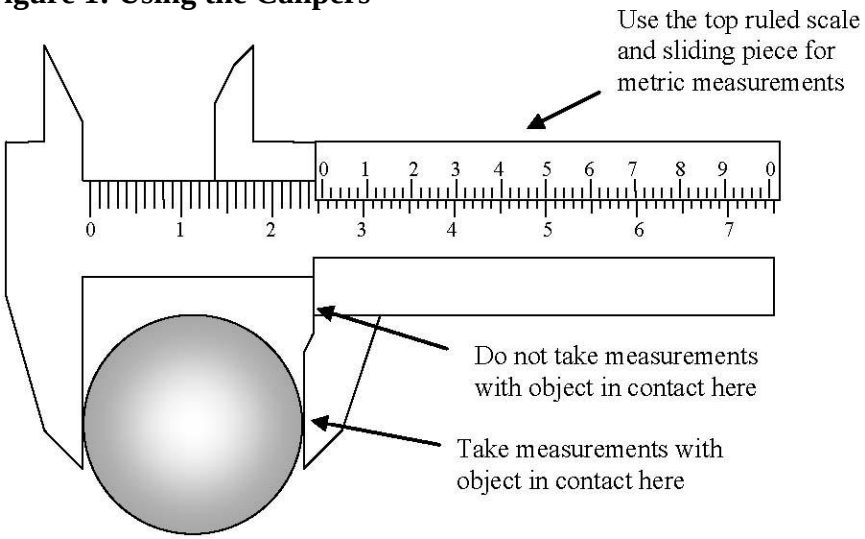
Using the Calipers:

You will now use your calipers to measure the diameter of piece of chalk. Take your calipers and slide the moving part back and forth until is loosely touches both sides of your piece of chalk, across the diameter (see the figure below). You want to make sure that the calipers touch both sides of the chalk, but don't squeeze tightly. Since we want to take measurements in mm, not inches, look only at the top ruled markings on the calipers and the top sliding piece. The reading is taken from the line below the zero on the top sliding piece. Notice that in the figure below, the zero line is between 25 and 26 mm. This means the diameter is a little larger than 25 mm. How do we find the next digit? Take a look at all the lines on the sliding piece. Which line lines up best with any of the lines directly below it? In the figure, it seems that the 4 line is just a tiny bit forward of the line below it and the 6 line is clearly behind the line below it. The 5 looks to line up really well, so this means the next digit is a 5, actually, a 5.0 or the reading is 25.50 mm. If you had decided that the next vertical line is even better, it would have been 25.52 The calipers have an uncertainty of 0.02 mm, and our reading is then 25.50 mm ± 0.02 mm. In terms of cm that would be 2.550 or 2.552 cm with an absolute uncertainty of 0.002 cm.

Figure 1: Using the Calipers



You can log on to the following site to practice the reading of such Vernier calipers:
http://www.phy.ntnu.edu.tw/ntnujava/index.php?topic=52

Your answer should be:

Chalk Diameter: 2.550 cm ± 0.002cm.

If you call the chalk diameter x, then the **absolute error** would be called Δx. You would write your answer as follows: $x = 2.550cm \pm 0.002cm$ or
x=25.50 mm ± 0.02 mm
Every single time you write down a piece of data, be sure to also write down the units.
Is your measurement x in cm or mm? Write the unit down next to your value. You always record the value measured with the highest possible precision. This means that you write 2.550 cm, and not 2.55 cm.

What about the units of the **absolute uncertainty** Δx?
Also write its unit down next to your absolute uncertainty Δx=0.002cm. The absolute error is the same for every measurement taken with the same instrument.
The **relative uncertainty** is the ratio between the **absolute uncertainty** Δx and the value x itself. Being a ratio between numbers of the same units, the relative uncertainty is **dimensionless**:

relative uncertainty: $\frac{\Delta x}{x} = \frac{0.002}{2.550} = 0.0008 = 0.08\%$

The relative uncertainty is a number which is always smaller than 1. Therefore, we can express the relative uncertainty in % by multiplying the ratio by 100. Also, note that we write the relative uncertainty with one significant figure only. This is because the numerator, the absolute uncertainty, has only one significant figure. We are applying the rule that in any quotient or product of values, the value with the smallest number of significant figures determines the number of significant figures of your final answer.