Measurements

Purpose

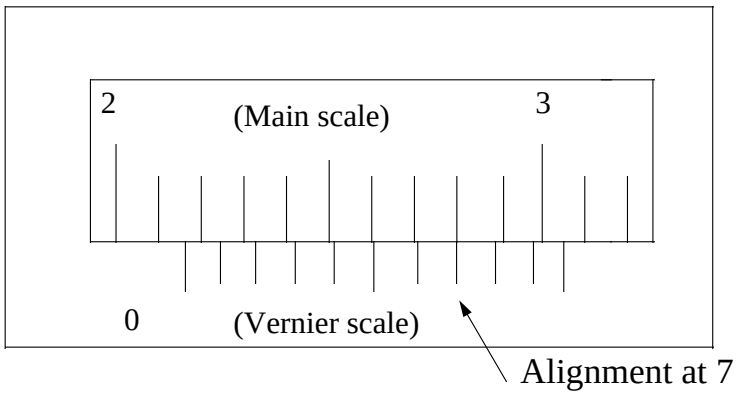
To learn the proper use of a meterstick, vernier caliper, micrometer, and laboratory balance and to learn how to use the correct number of significant figures in data and results.

Equipment

Meterstick, 2-meterstick, vernier caliper, micrometer, laboratory balance, ruler, metal cylinder.

Discussion

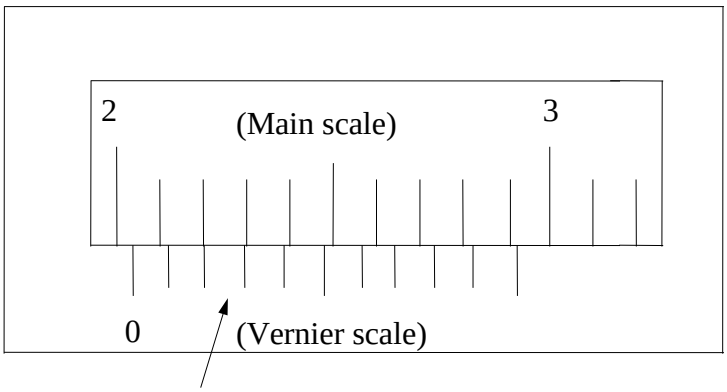
The number of significant figures in a measurement depends on the measuring device and its precision. When an object is measured in a same manner, a vernier caliper has a greater precision than a meterstick and a micrometer has a greater precision than a vernier caliper. A measurement reading should have one more significant figure than the smallest subdivision marked on the scale.



2.1 cm + 0.070 cm = 2.170 cm

(main scale at vernier 0 mark) (vernier scale)

Vernier Caliper. Example of reading: The main scale gives a reading to 1/10 of cm at the 0 mark on the vernier scale. The next digit (the second decimal place in cm) is made on the vernier scale where the marks line up. If a mark on the vernier scale is aligned with a mark on the main scale as in the first example, the mark on the vernier scale gives the next digit and the estimated figure is 0.

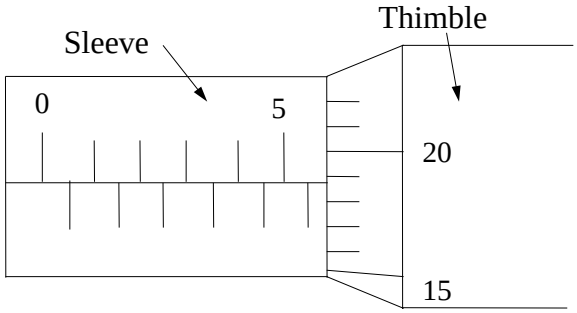


No alignment. Phase change for 2 and 3 marks.

2.0 cm + 0.025 cm = 2.025 cm

(main scale at vernier 0 mark) (vernier scale)

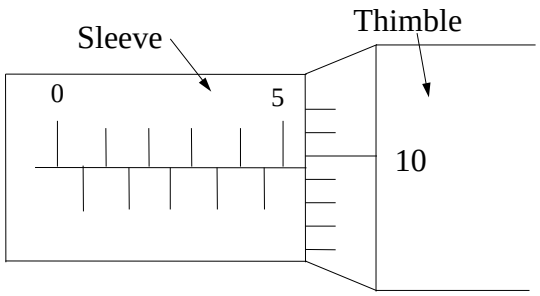
Example 2: If no marks are aligned, there is a phase change between marks. In this example, there is a phase change for 2 and 3 marks, so the reading on the vernier scale is 0.025 cm where the last digit is estimated to be 5 whenever there is no alignment.



5.5 mm + 0.188 mm = 5.688 mm

(Sleeve) (Thimble)

Micrometer. Example of reading on micrometer: The reading on the sleeve is in mm and the reading on the thimble is in 1/100 of mm or 0.01 mm. The last digit is estimated.



5.0 mm + 0.096 mm = 5.096 mm

(Sleeve) (Thimble)

Procedure

1. Use a meterstick to measure the length, width, and thickness of your lab table. Readings should be made to 0.1mm (or 0.01cm or 0.0001m). Record the data along with the precision. Make each measurement five times at different locations on the lab table.

2. Find the average of the length, width, and thickness of the lab table and compute the volume of the tabletop in m^3 and cm^3. Use the proper number of significant figures in your answer and attach the appropriate units. Show your calculations with units.

3. Determine the thickness of a single sheet of your physics textbook in four ways.
   1) Measure the thickness of 1000 pages of the book (excluding the cover) and divide by the number of sheets (one half the pages = 500 sheets) of paper. Measure with a meterstick three times and obtain an average value. Record its precision.
   2) Repeat 1) with a vernier caliper.
   3) Measure the thickness of a single sheet using a micrometer. Record its precision.
   4) Measure the thickness of 100 pages of the book with the micrometer.

4. Measure the diameter of a cylinder using a micrometer. Make your measurements three times. Calculate the average value.

5. Roll the cylinder on a piece of paper beginning and ending at the same point on the circumference. Roll the cylinder as many times as possible without exceeding the maximum distance the vernier caliper can measure. Make your measurements three times and calculate the average.

6. Use the average values of the diameter and the circumference of the cylinder to calculate the value of π.

7. Measure the length of the cylinder using the vernier caliper three times and calculate the average.

8. Measure the mass of the cylinder.

DATA: EXPERIMENT #1 - MEASUREMENTS

TABLE 1.

		Length ( )	Width ( )	Thickness ( )
Lab Table w/ meterstick	1			
	2			
	3			
	4			
	5			
Average				
Precision of the instrument				
Volume		m^3		cm^3

Calculations:

TABLE 2.

		Thickness
Textbook w/ meter stick	1	
	2	
	3	
Average		
Precision		
Total # of sheets		
Average of single sheet		
2. Textbook w/ vernier caliper	1	
	2	
	3	
Average		
Precision		
Total # of sheets		
Average of single sheet		
3. Textbook w/ micrometer Single sheet		
4. Textbook w/ micrometer	1	
	2	
	3	
Average		
Precision		
Total # of sheets		
Average of single sheet		

Calculations:

TABLE 3.

	Trial	Diameter ( )	Circumference ( )	Length ( )
Cylinder	1			
	2			
	3			
Average				
Precision				
Calculated Value of π				
Material of cylinder			Mass =	

Calculations:

Analysis

(Read the section on Laboratory Report in Introduction for format of the report.)

1. List the four values of the thickness per sheet obtained by the four different ways.

2. Which measurement resulted in the greater number of significant figures in determining the (average) thickness of a single sheet of your physics textbook by the methods used? Does your data agree with your prediction?

3. Calculate the percent error of the value of π. Use the appropriate number of significant figures of $\pi = 3.14159265...$ as the accepted value.

4. Calculate the density of the cylinder. The density ρ of a substance is the mass per unit volume, i.e. $\rho = m/V$. Express the results in both g/cm^3 and kg/m^3.

5. Calculate the % error of the density of the cylinder (Use the correct number of significant figures). The accepted values of the densities of some materials are given below.

Table 1.1 Density of some materials

Substance	Density (g/cm3)	Density (kg/m3)
Aluminum	2.7	2.7×10^3
Brass	8.4	8.4×10^3
Copper	8.9	8.9×10^3
Iron or steel	7.88	7.88×10^3
Lead	11.3	11.3×10^3
Nickel	8.8	8.8×10^3
Zinc	7.1	7.1×10^3

6. Calculate the standard error α to your length of the table top measurement.