Using Measuring Instruments

This practical session is to help you think about the limits to the precision of some commonly used measuring instruments.

1. Using a Ruler

Measure the dimensions of a sheet of A4 paper, using a ruler marked in mm.

Results

Width (w) = _____ mm ± _____ mm = _____ mm ± _____%

Length (ℓ) = _____ mm ± _____ mm = _____ mm ± _____%

We are therefore saying that the dimensions are in the following ranges

_____ mm < w < _____ mm

_____ mm < ℓ < _____ mm

Now use the minimum and maximum values of w and ℓ to calculate the minimum and maximum values of the surface area of a sheet of A4 paper

_____ mm^2 < area < _____ mm^2

so we have (indirectly) measured the area to be

area = _____ mm^2 ± _____ mm^2

which could be expressed as

area = _____ mm^2 ± _____%

Notice that the indeterminacy (uncertainty) in the area is a greater <u>percentage</u> of the result than the indeterminacies in the original measurements of w and ℓ.

If you have done your calculations correctly, you should find that

% indeterminacy in area = % indeterminacy in w + % indeterminacy in ℓ

2. Using a Voltmeter

Take a battery and measure its voltage using a) the 30 V calibration and b) the 7·5 V calibration.

Results

a) Scale reading = _____ ± ____ so, voltage = _____V ± _____V

This means that we have found

_____ V **<** voltage of battery **<** _____ V

b) Scale reading = _____ ± ____ so, voltage = _____ V ± _____ V

This means that we now have a smaller range of possible voltages

_____ V **<** voltage of battery **<** _____ V

Conclusion

_____

_____

Reading Analogue Voltmeters

There is a choice of six different calibrations on the voltmeters.
The number written under each red terminal tells you the *maximum* voltage which can be measured when using that terminal.

For example, using the 30 V red terminal, you can measure voltages between zero and 30 V. In other words, the highest number on the scale (150) represents 30 V. So, to convert scale reading to voltages, simply divide by 5 (150/30).

Similarly, if you are using the 7·5 V calibration, divide the scale readings by 20 (150/7·5).

N.B. Use the mirror near the scale to help you find the correct position from which to view the scale.

c) Try using a number of different voltmeters to measure the voltage of the *same* battery .

Voltmeter	Scale Reading	Voltage /V
	±	±
	±	±
	±	±
	±	±
	±	±

These results suggest that the voltmeters used are reliable/unreliable.

3. Using Vernier Callipers

a) Use a Vernier calliper to measure the thickness of a sheet of paper.

Thickness of one sheet of paper = _____ mm ± _____ mm

which corresponds to a % uncertainty of about _____ %

b) Now use the same Vernier calliper to find the average thickness of a sheet of paper with much greater precision.

Total thickness of _____ sheets of paper = _____ mm ± ____ mm

Therefore, we can say that the average thickness of one sheet of paper is _____ mm ± _____ mm which corresponds to a % uncertainty of about _____ %.

c) Measure the diameter of a cylindrical object at 5 different places.

Results

1 _____ mm ± _____ mm

2 _____ mm ± _____ mm

3 _____ mm ± _____ mm

4 _____ mm ± _____ mm

5 _____ mm ± _____ mm

average diameter _____ mm ± _____ mm

maximum reading _____ mm ± _____ mm

minimum reading _____ mm ± _____ mm

Our measurements suggest that the manufacturers have produced cylinders with a diameter given by

average diameter ±½(maximum reading - minimum reading), which gives

_____ mm ± _____ mm

or, as a percentage

_____ mm ± _____ %

Manufacturers often describe this percentage figure as the “tolerance” of the manufacturing process.