CIVL2201 Structural Mechanics: Semester 1, 2002

Appendix - Notes on Error Analysis

An error analysis should be carried out on all experimental work to give an indication of the accuracy of the experimental procedure. There will be an error in **every** measurement made in the lab.

Errors can be expressed into ways:
An **absolute error** is an error with physical units.
A **relative error** is an error expressed as a fraction of the value measured.

The error is the difference between the result of the measurement and the true value of whatever was being measured. This error may arise from the quality of the tools, the ability of the operator to use them properly, and the inability to control what is being measured. Since the lab experiments normally require the comparison of theory with practice, one must estimate the size of the errors. An approximate rule of thumb is that the error in a reading is at least ±1 of the smallest division on the device. For example, a rule with divisions at 1 mm spacings has been used to measure a distance, s, of 112 mm. Using the rule of thumb above, the absolute error εs = ±1 mm, and the relative error is 1/112 = 0.0089, or 0.89%.

When calculating using values with errors, the errors are propagated into the calculated result. In strict terms, for a function of many variables $z = F(x_1, x_2, x_3, \ldots x_n)$, then the error in z, εz, is given by:

$$\varepsilon z = \sqrt{(\varepsilon x_1)^2\left(\frac{\partial F}{\partial x_1}\right)^2 + (\varepsilon x_2)^2\left(\frac{\partial F}{\partial x_2}\right)^2 + (\varepsilon x_3)^2\left(\frac{\partial F}{\partial x_3}\right)^2 + \ldots + (\varepsilon x_n)^2\left(\frac{\partial F}{\partial x_n}\right)^2}$$

However, there are some simple rules for error propagation.

Rule 1: The **absolute** error on adding or subtracting values, $z = x + y$, or $z = x - y$

$$\varepsilon z = \sqrt{(\varepsilon x)^2 + (\varepsilon y)^2}$$

Rule 2: The **Relative** error in multiplying or dividing values, $z = xy$, or $z = x/y$

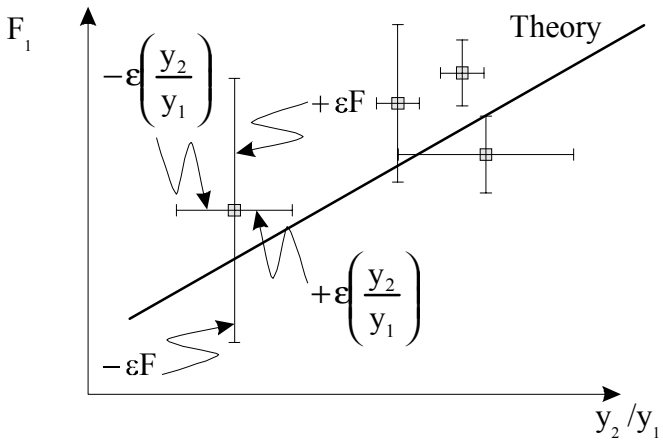
$$\frac{\varepsilon z}{z} = \sqrt{\left(\frac{\varepsilon x}{x}\right)^2 + \left(\frac{\varepsilon y}{y}\right)^2}$$

Rule 3: The **relative** error is raising a value to a power $z = x^n$

$$\frac{\varepsilon z}{z} = n\frac{\varepsilon x}{x}$$

Rules 1 and 2 depend on the assumption that the errors on x and y have nothing to do with one another and may cancel each other out partially. This is clearly not true for Rule 3, which is why Rule 3 can not be derived from Rule 2.

Once you have calculated your errors, they should be incorporated into your graphical representation of your results in **absolute** terms.
As illustrated the experimental points are distinct symbols. The error bars extend a distance ±ε and are different lengths depending on the measured values.



Adapted from Fluids 1 handout by Graeme Wood