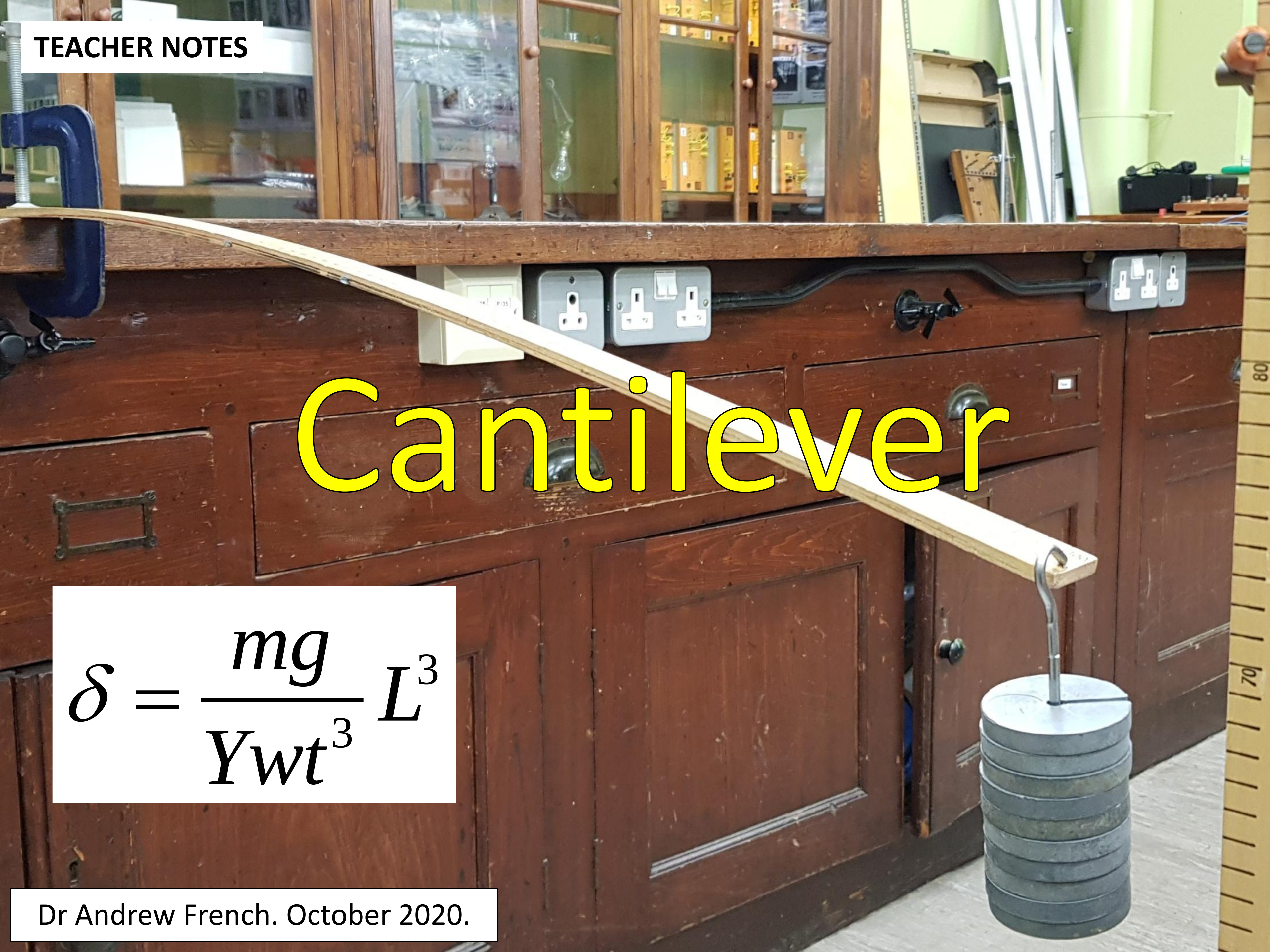


TEACHER NOTES

Cantilever

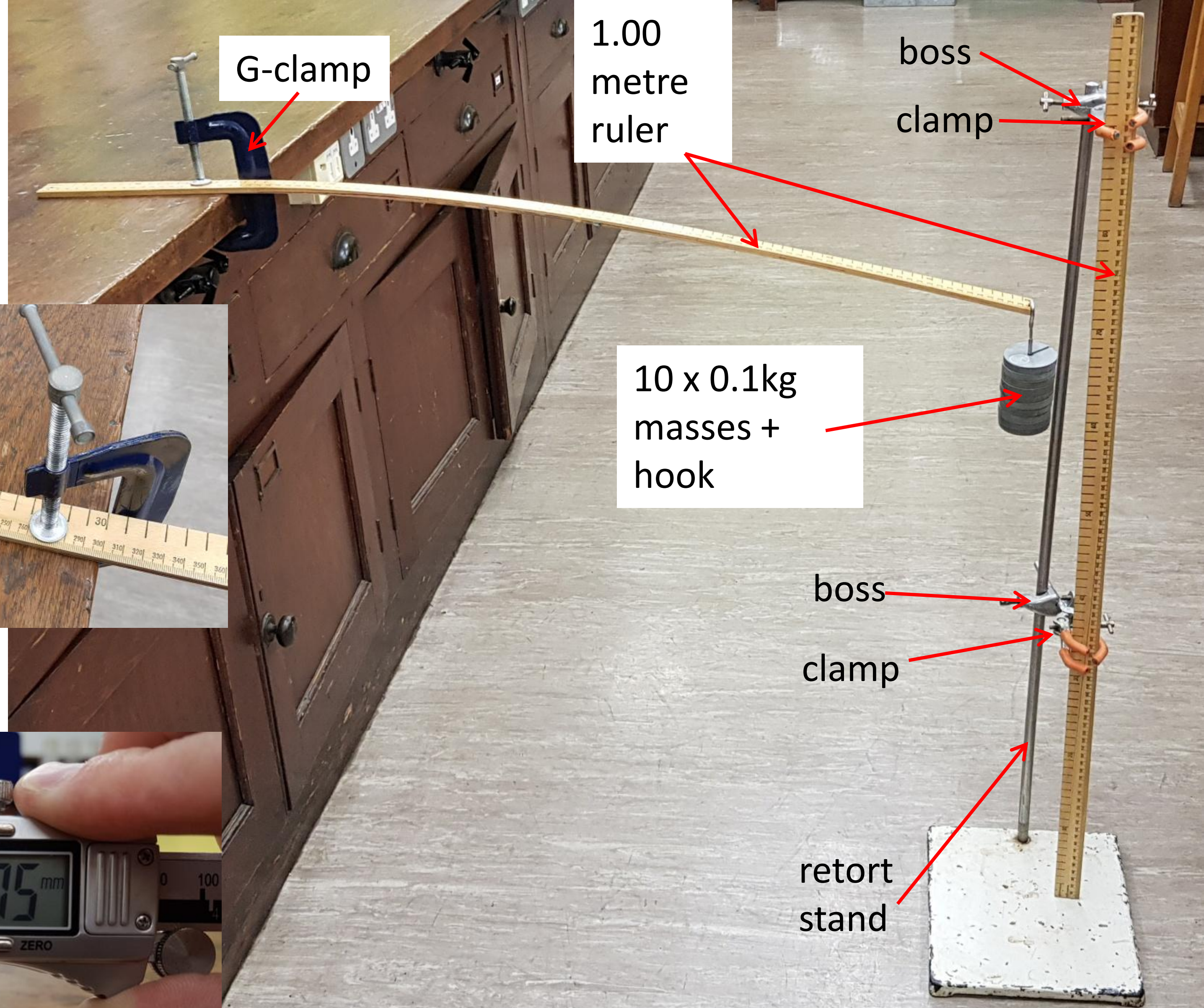
$$\delta = \frac{mg}{Ywt^3} L^3$$

Dr Andrew French. October 2020.

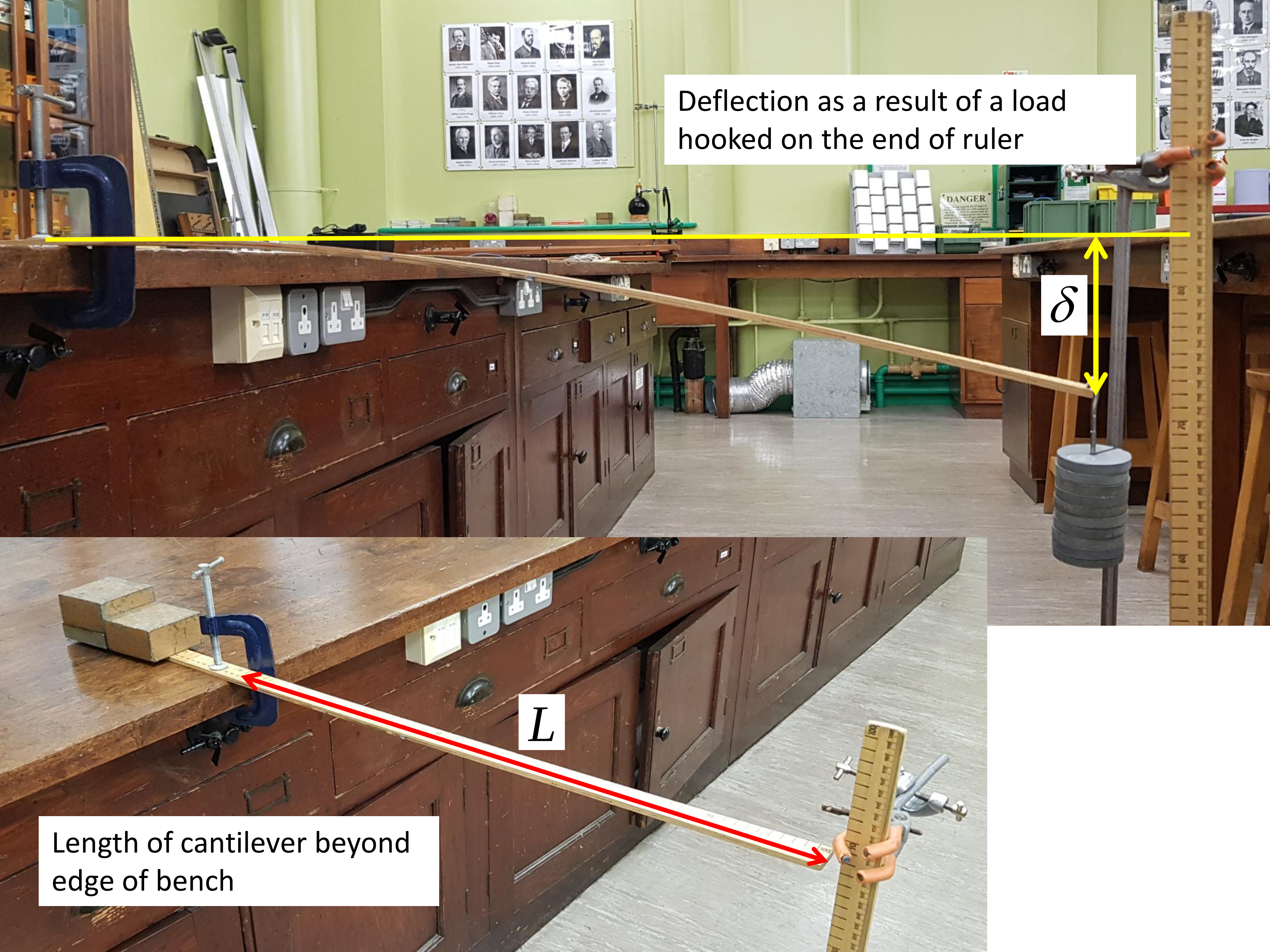
Equipment

1kg counter-weights

Digital calliper



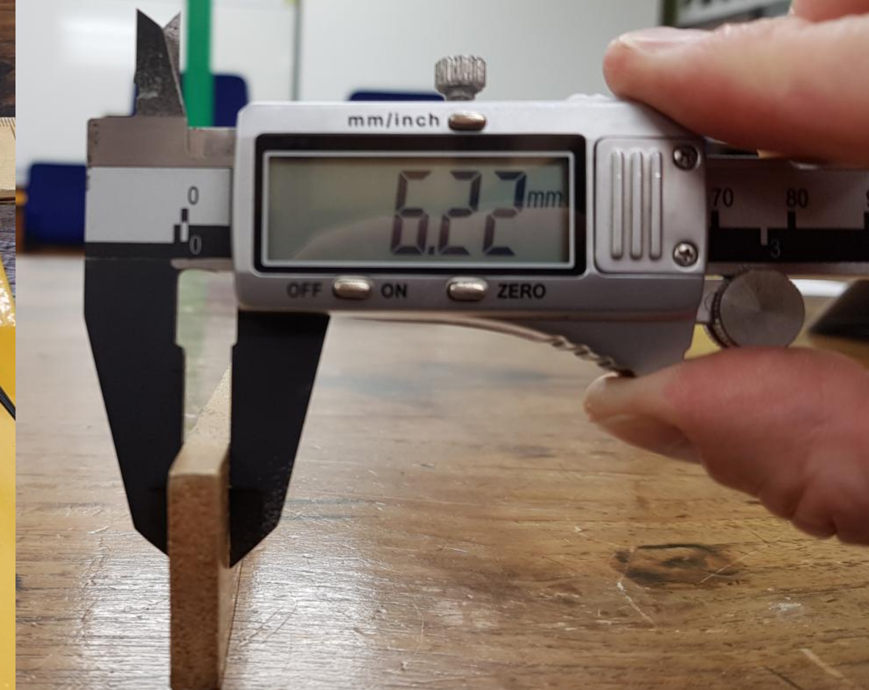
Also: Straight edge (e.g. 30cm ruler) to help with measuring ruler deflection.
Laptop + Excel for recording and plotting graphs *as measurements are taken*.


Deflection as a result of a load hooked on the end of ruler
δ
DANGER
L
Length of cantilever beyond edge of bench

• Make deflection measurements by squatting down such that the deflected beam is at eye level. Then use a 30cm ruler (or any other short straight edge) to find the height of the bottom of the deflected ruler, in mm.

• Record unloaded *and* loaded ruler heights, as the unloaded ruler may not be perfectly straight.

Note the ruler should be better aligned than in this photograph!



Ruler measurements:

$$M = 114g$$

$$l = 1{,}000\text{mm}$$

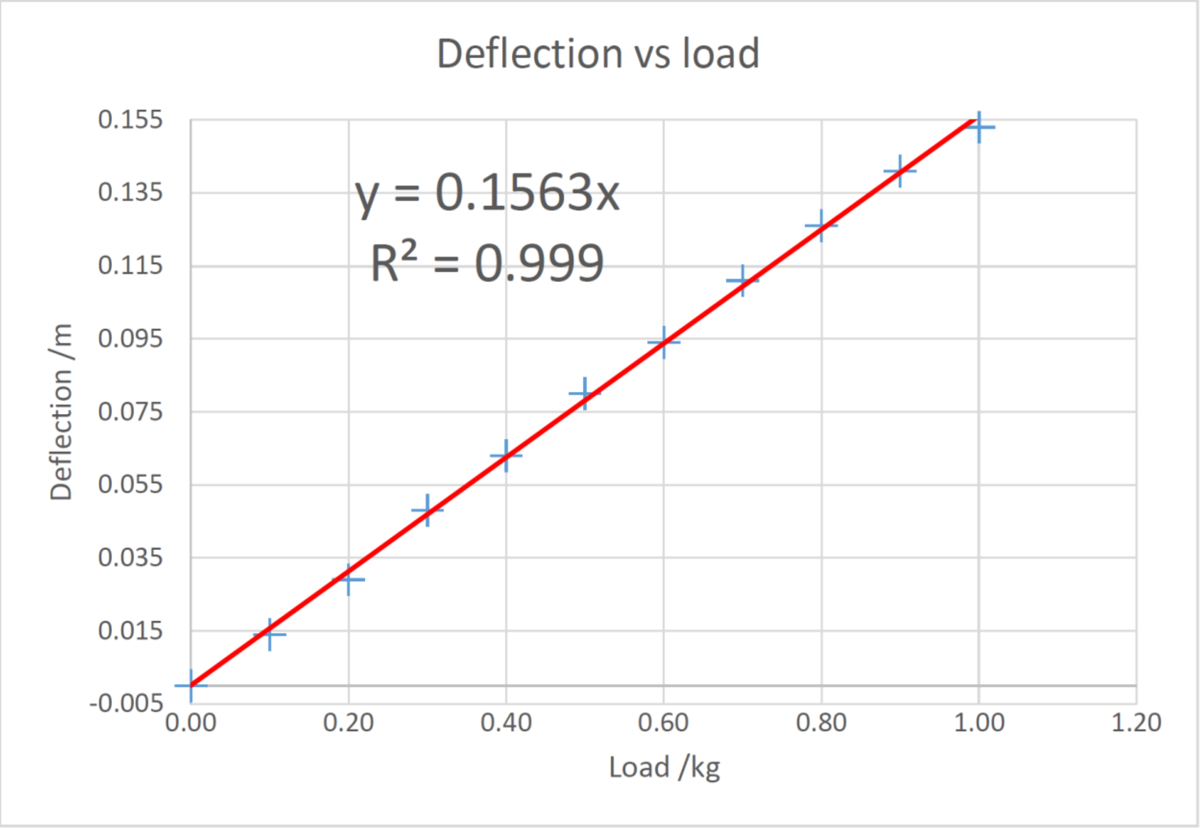
$$w = 27.75\text{mm}$$

$$t = 6.22\text{mm}$$

EXPERIMENT #1: L = 0.800m, load m varies from 0.1 to 1.0 kg

Fixed extension (L=0.800m), variable load

h /mm	deflection /m	load /kg
871	0.000	0.00
857	0.014	0.10
842	0.029	0.20
823	0.048	0.30
808	0.063	0.40
791	0.080	0.50
777	0.094	0.60
760	0.111	0.70
745	0.126	0.80
730	0.141	0.90
718	0.153	1.00

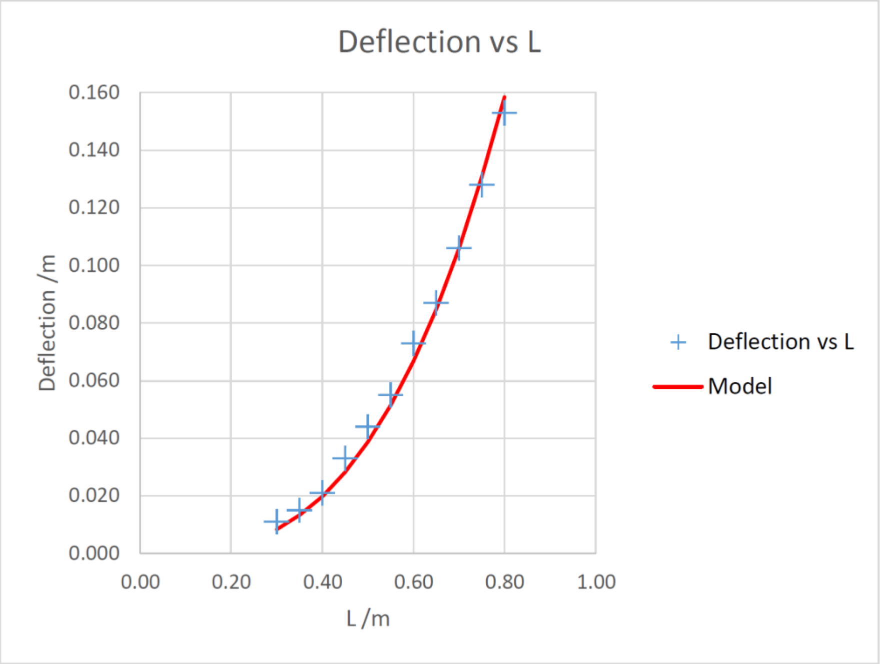


Deflection appears to be *proportional* to load: $$\delta \propto m$$

EXPERIMENT #2: fixed load of m = 1.00kg, L varies from 0.300m to 0.800m.

Fixed load (1.00kg), variable L

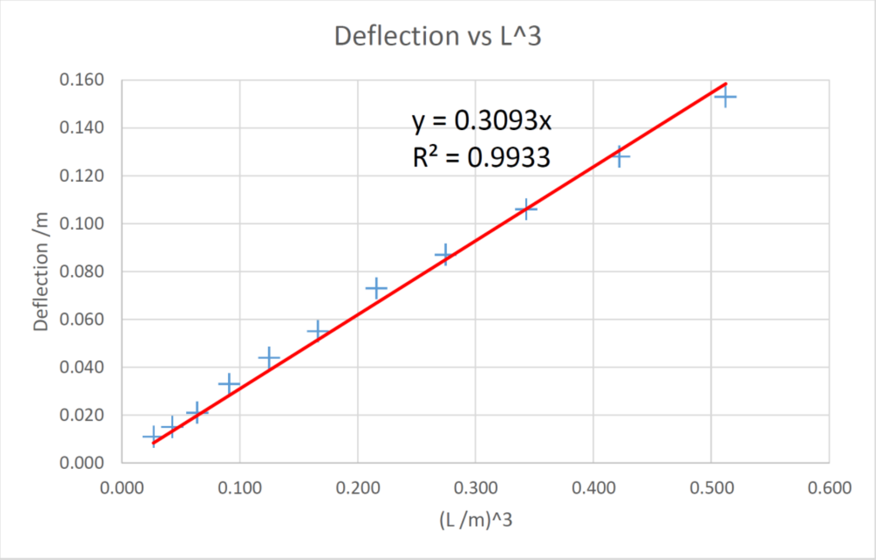
h /mm no load	h /mm load	deflection /m	L /m	L^3	model deflection /m
870	717	0.153	0.80	0.512	0.158
868	740	0.128	0.75	0.422	0.130
868	762	0.106	0.70	0.343	0.106
865	778	0.087	0.65	0.275	0.085
867	794	0.073	0.60	0.216	0.067
860	805	0.055	0.55	0.166	0.051
859	815	0.044	0.50	0.125	0.039
858	825	0.033	0.45	0.091	0.028
853	832	0.021	0.40	0.064	0.020
853	838	0.015	0.35	0.043	0.013
849	838	0.011	0.30	0.027	0.008



Model* is:

$$\delta = \frac{mg}{Ywt^3} L^3$$

Young's modulus



* Woan. *Cambridge Handbook of Physics Formulas* pp82

$$\delta = \frac{mg}{3Y \times \frac{1}{3} wt^3} L^3 \qquad \delta = 0.3093 L^3 \qquad \Rightarrow 0.3093 = \frac{mg}{Ywt^3} \qquad \Rightarrow Y = \frac{mg}{0.3093 wt^3}$$

$$\Rightarrow Y = \frac{1.00 \times 9.81}{0.3093 \times 27.75 \times 10^{-3} \times \left(6.22 \times 10^{-3}\right)^3} = 4.80 \times 10^9 \text{ Pa}$$

$$\Rightarrow Y = 4.90 \text{GPa}$$

Young's modulus of structural timber is between 3GPa and 10GPa, so our result seems reasonable.

Reference