

## **Absolute Uncertainty**

**If you only have one reading, or all repeat readings are the same, the absolute uncertainty is  $\pm$  smallest increment**

width of stick measured with ruler (precision 1mm): 25mm, 25mm, 25mm

$$\text{width} = 25 \pm 1 \text{ mm}$$

**If the repeat readings are different, the absolute uncertainty is  $\pm$  (range / 2)**

width of a stick measured with vernier caliper (precision 0.1mm): 25.1mm, 25.6mm, 25.3mm

$$\text{width} = 25.3 \pm 0.25 \text{ mm}$$

**If two measurements are added or subtracted, the absolute uncertainties are added.**

mass of rocket before launch =  $420 \pm 0.5 \text{ g}$

mass of rocket after launch =  $106 \pm 0.5 \text{ g}$

$$\text{mass lost} = 420 - 106 = 314 \pm 1 \text{ g}$$

## **Percentage Uncertainty**

**Multiplying or dividing by a constant number does not change the percentage uncertainty.**

$$\text{radius} = 5\text{mm} \pm 10\%$$

$$\text{diameter} = \text{radius} \times 2 = 10\text{mm} \pm 10\%$$

**Unit conversions do not change percentage uncertainty.**

$$\text{diameter} = 10\text{mm} \pm 10\%$$

$$\text{diameter} = 1\text{cm} \pm 10\%$$

$$\text{diameter} = 0.01\text{m} \pm 10\%$$

**When multiplying or dividing two measured quantities, the percentage uncertainties are added.**

$$\text{width} = 25\text{mm} \pm 10\%$$

$$\text{length} = 50\text{mm} \pm 5\%$$

$$\text{area} = 25\text{mm} \times 50\text{mm} = 1250\text{mm}^2 \pm 15\%$$

**Raising a measurement to the power n multiplies the percentage uncertainty by n.**

$$\text{radius} = 5\text{mm} \pm 10\%$$

$$\text{area} = 3.14 \times \text{radius}^2$$

$$\text{area} = 79\text{mm}^2 \pm 20\%$$

## Putting Into Practice

Mass on balance - 1g precision:

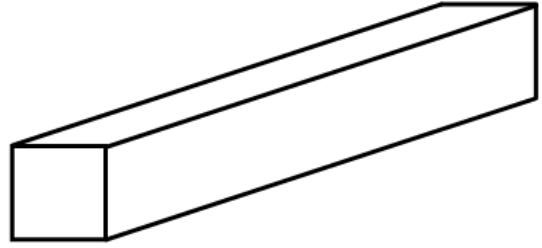
471g

Length with ruler - 1mm precision:

300mm, 300mm, 300mm

Width with vernier caliper - 0.1mm precision:

14.9mm, 14.6mm, 14.5mm, 14.4mm



1. Calculate the absolute and percentage uncertainty in the mass measurement.
  
  
  
  
  
  
  
  
  
  
2. Calculate the average length and its absolute and percentage uncertainty.
  
  
  
  
  
  
  
  
  
  
3. Calculate the average width and its absolute and percentage uncertainty.
  
  
  
  
  
  
  
  
  
  
4. Calculate the cross sectional area of the square face and its percentage uncertainty.
  
  
  
  
  
  
  
  
  
  
5. The formula for the density of the rod is:  $\text{density} = \text{mass} / (\text{area} \times \text{length})$   
What will be the percentage error in the calculated density? (No need to actually calculate the density.)