NOTES: Accuracy, Precision and Uncertainty

Date: Feb. 14

In everyday life, people often use the words "accurate" and "precise" to mean the same thing. In mathematics and the trades, however, they have different meanings.

Accuracy

Accuracy refers to the exactness of a measurement.

To be accurate, a measured value must be as close to the real value as possible.

If you have measured something accurately, someone should be able to repeat the same measurement and get the same value.

Precision and Uncertainty

Like accuracy, precision is related to exactness. It is determined by the limitations of the measuring instrument.

Because of the limited precision of a measuring device, there is always some uncertainty when taking measurements. It is often necessary to record this.

- **Precision** is the smallest unit of measurement on the measuring device being used.
- Unless otherwise stated, **uncertainty** is given as ± half of the precision of the measuring device.

uncertainty: ± 0.5 m

precision: 1 mm

~~precision~~: (0.1 cm)

uncertainty: ± 0.05 mm

precision: 0.1 mm

more precise tool

less uncertainty

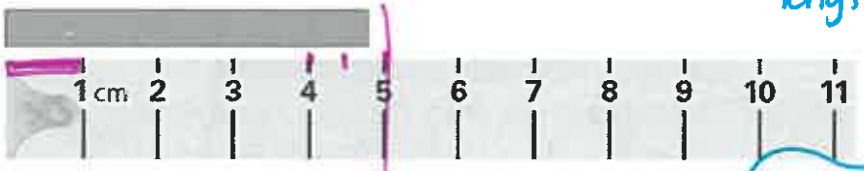
Examples

Determine the length of each object, including uncertainty.

precision:

1 cm

Smallest division on ruler



length is between 4.5 and 5.5 cm

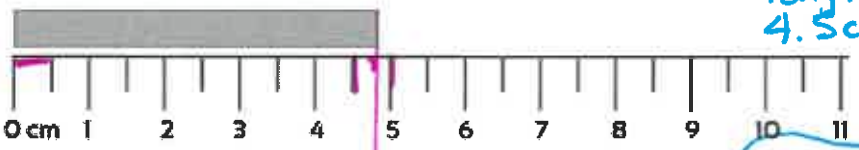
length: 5 cm ± 0.5 cm

uncertainty (half of precision)

read length to nearest 0.5 cm.

precision:

0.5 cm



length is between 4.5 cm and 5 cm.

length: 4.75 cm ± 0.25 cm

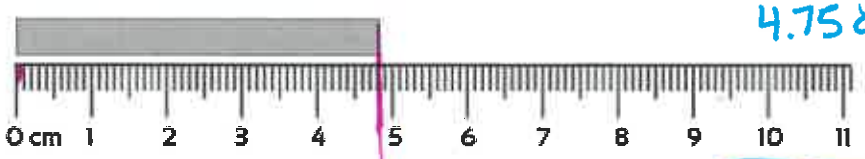
read length to nearest 0.25 cm

precision:

1 mm

OR

0.1 cm



length is between 4.75 cm and 4.85 cm

length: 4.8 cm ± 0.05 cm

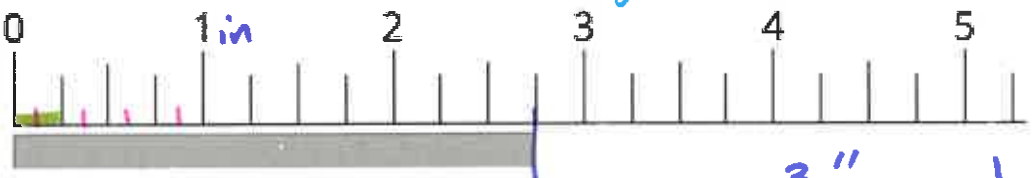
read length to nearest 0.05 cm

OR

48 mm ± 0.5 mm

(between 47.5 mm and 48.5 mm)

precision: $\frac{1}{4}''$



length is between $2\frac{5}{8}''$ and $2\frac{7}{8}''$

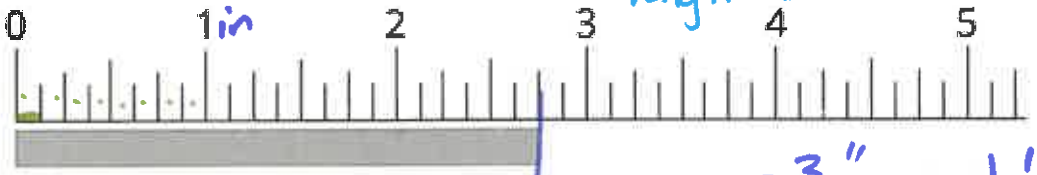
$2\frac{3}{4}'' - \frac{1}{8} = 2\frac{6}{8} - \frac{1}{8} = 2\frac{5}{8}''$ (×2)

$2\frac{3}{4}'' + \frac{1}{8} = 2\frac{6}{8} + \frac{1}{8} = 2\frac{7}{8}''$ (×2)

length: $2\frac{3}{4}'' \pm \frac{1}{8}''$

$\frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$

precision: $\frac{1}{8}''$

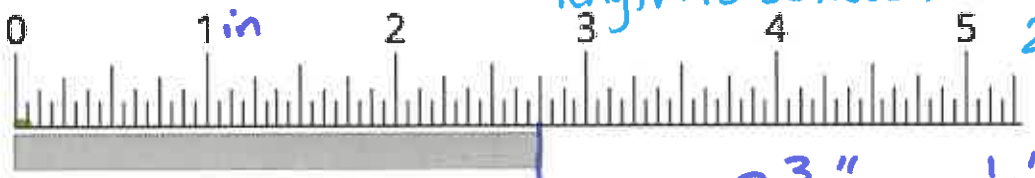


length is between $2\frac{11}{16}''$ and $2\frac{13}{16}''$

length: $2\frac{3}{4}'' \pm \frac{1}{16}''$

$\frac{1}{2} \times \frac{1}{8} = \frac{1}{16}''$

precision: $\frac{1}{16}''$



length is between $2\frac{23}{32}''$ and $2\frac{25}{32}''$

length: $2\frac{3}{4}'' \pm \frac{1}{32}''$

$\frac{1}{2} \times \frac{1}{16} = \frac{1}{32}''$

State the precision and uncertainty of the following:

a. The outside temperature was recorded as 12°C using the thermometer shown.

11.5°C and 12.5°C (somewhere between)

precision 1°C

uncertainty ± 0.5°C

b. An odometer records distance travelled to the nearest kilometer. The odometer reading on Jim's car is 42 325 km.

precision 1km

uncertainty ± 0.5km

c. The digital scale shown was used to determine a patient's weight.

129.3

precision 0.1 lb

uncertainty ± 0.05 lb

Combining Measurements with Uncertainty

When adding or subtracting measurements that have uncertainty, we need to ADD the uncertainties.

$$\begin{array}{r} 32.5\text{ cm} \pm 0.5\text{ cm} \\ +\ 41.0\text{ cm} \pm 0.5\text{ cm} \\ \hline 73.5\text{ cm} \pm 1\text{ cm} \end{array} \qquad \begin{array}{r} 72.5\text{ cm} \pm 0.5\text{ cm} \\ -\ 31.0\text{ cm} \pm 0.5\text{ cm} \\ \hline 41.5\text{ cm} \pm 1\text{ cm} \end{array}$$

Example

Marcie is a carpenter. She is installing sheets of plywood as subflooring on a balcony. She has measured two of the sheets to be 2.25 m and 1.30 m long, using a tape measure marked in centimetres. (precision) uncertainty = ±0.5cm.

a) Write the lengths of each sheet of plywood in the form: *measured value* ± *measurement uncertainty*.

Sheet 1: 2.25m ± 0.5cm
225cm ± 0.5cm.

m → cm ×100

Sheet 2: 1.30m ± 0.5cm
130cm ± 0.5cm

b) What is the total length, including uncertainty, of the two sheets if they are placed end to end?

$$\begin{array}{r} 225\text{ cm} \pm 0.5\text{cm} \\ +\ 130\text{ cm} \pm 0.5\text{cm} \\ \hline 355\text{ cm} \pm 1\text{ cm} \end{array}$$

between 354cm and 356cm long.

c) Marcie needs to shorten the 2.25-m piece of plywood. She cuts a 30-cm section from the end. What is the new length of this sheet, including uncertainty?

$$\begin{array}{r} 225\text{ cm} \pm 0.5\text{cm} \\ -\ 30\text{ cm} \pm 0.5\text{cm} \\ \hline 195\text{ cm} \pm 1\text{ cm} \end{array}$$

between 194 cm and 196 cm long.