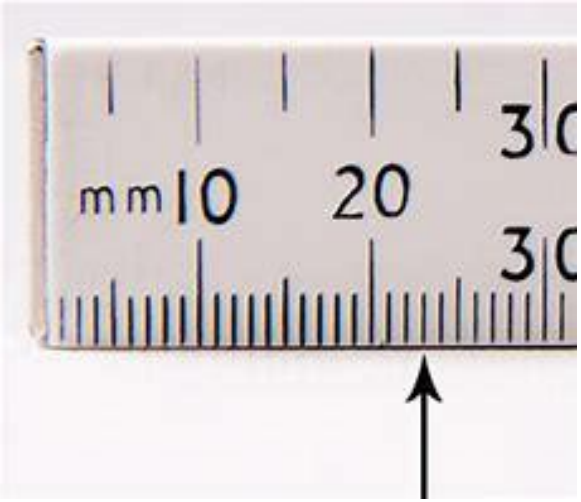
[5.5] Estimating Experimental Uncertainty

Review

Experimental Uncertainty

- **Experimental uncertainty** - the **<u>estimated</u>** amount by which a measurement might be in error.



- The uncertainty goes **between the number and the unit**.

- Eg. 23.00 ± 0.01 mm

Review
Range

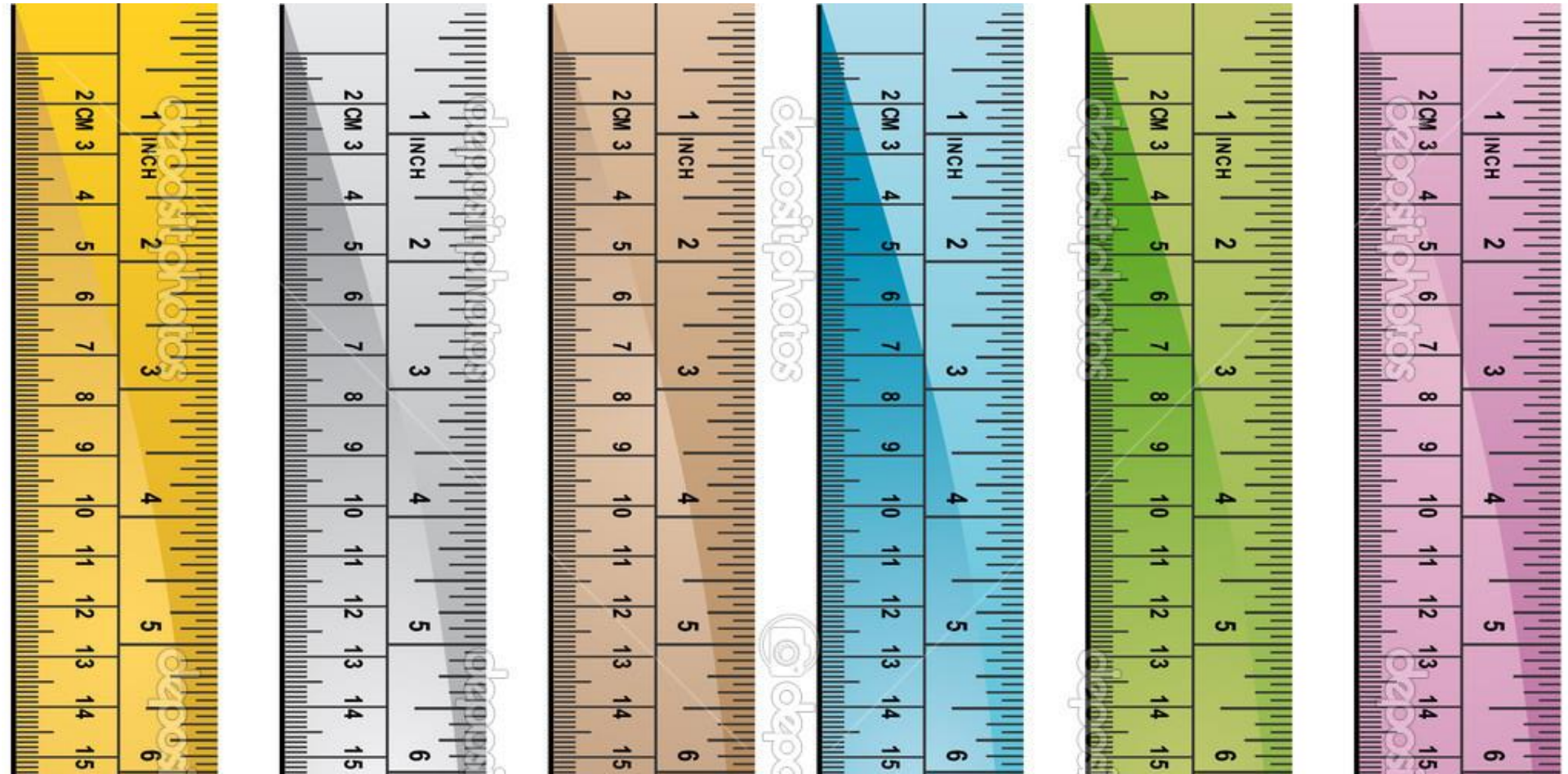
- **Range -** A range includes the set of possible values in a measurement.

- Expressed as:

Lowest value - Highest value

- Eg. **25.10 cm - 25.25 cm**

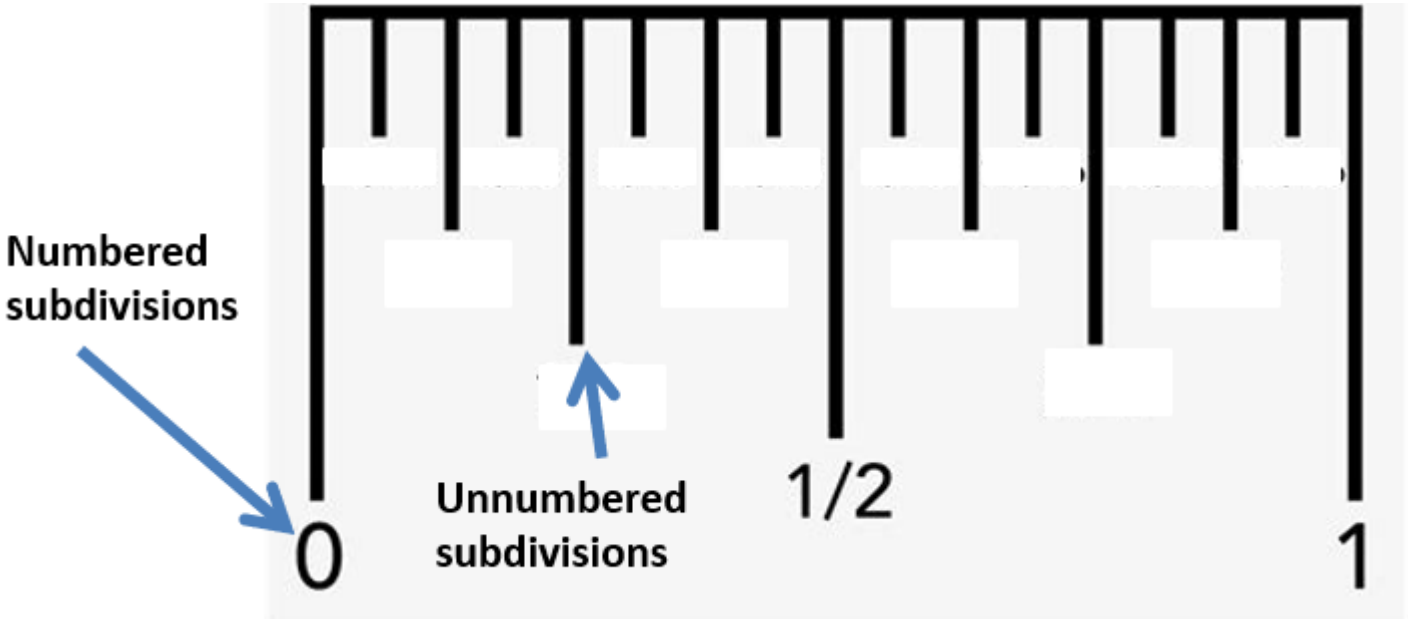
Estimating the Experimental Uncertainty from A Scale



1/10 of Method

- To calculate the experimental uncertainty we will use the following equation:

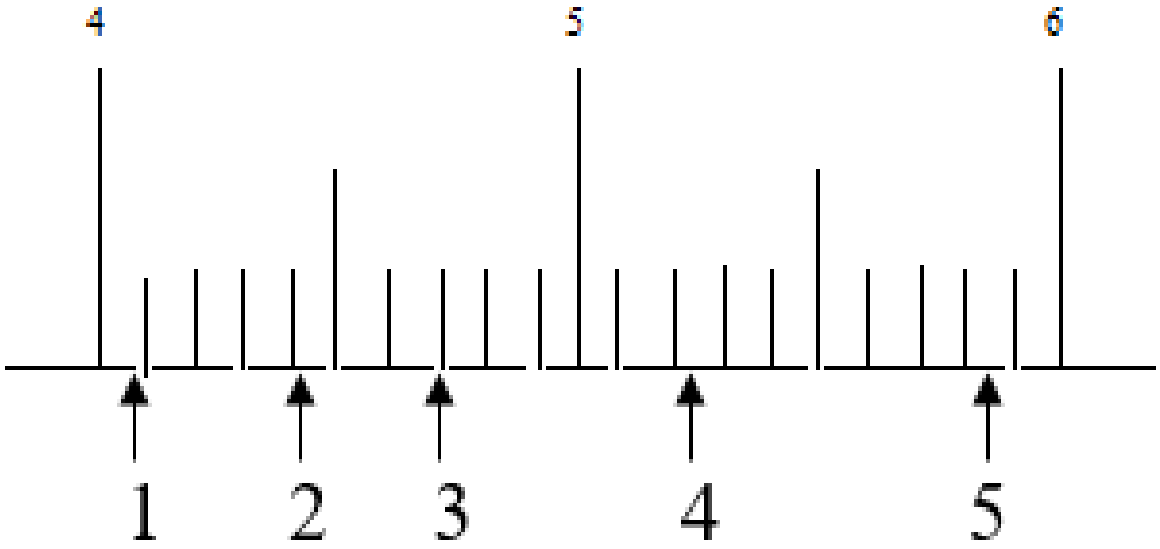
$$\text{Experimental Uncertainty} = \frac{1}{10} \times \text{the smallest unnumbered subdivision}$$



1/10 of Method

Experimental Uncertainty = $\frac{1}{10}$ × **the smallest unnumbered subdivision**

- **Example:** Using the scale. Estimate the experimental uncertainty
- **EU = _____**



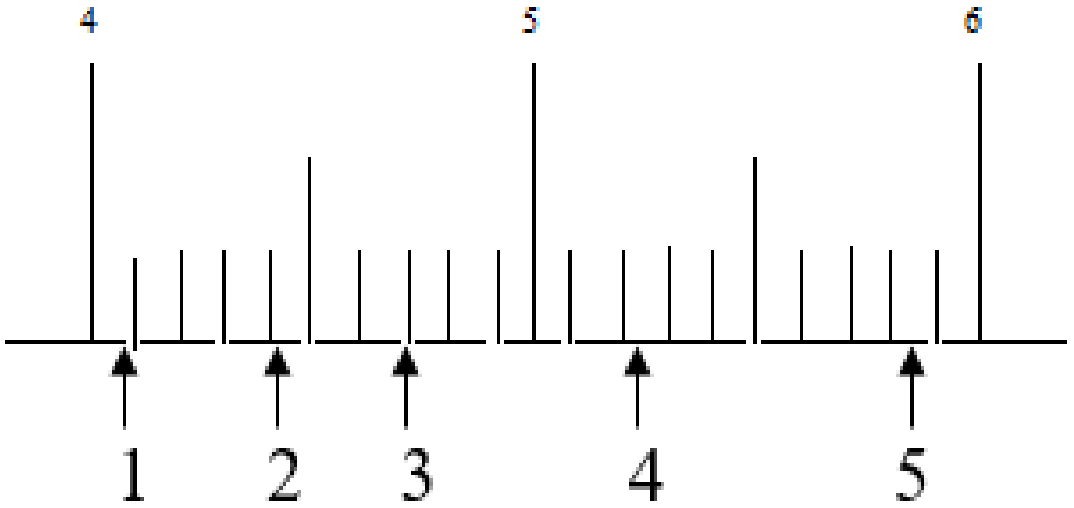
1/10 of Method

Experimental Uncertainty = $\frac{1}{10}$ × **the smallest unnumbered subdivision**

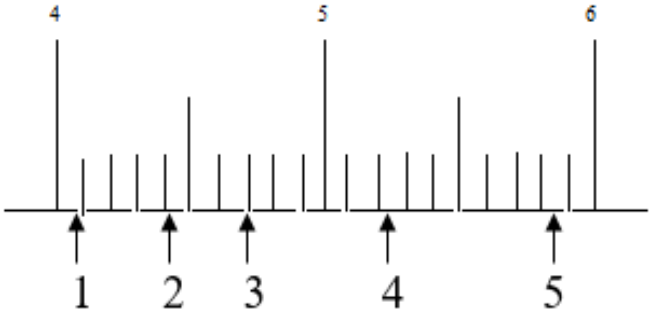
- **Example:** Using the scale. Estimate the experimental uncertainty

- **EU** = $\frac{1}{10} \times 0.1$ **cm**

- **EU** = 0.01 **cm**



Practice #2



Ex. 2) **Using the numbers on the scale:**

a) Determine the measurement and write them with the experimental uncertainty

b) Write the range of the measurement

1) a) _____ b) _____

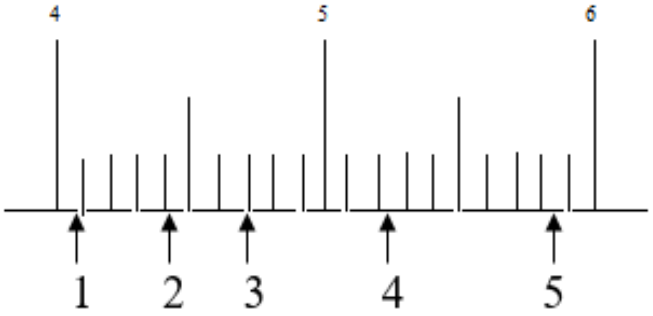
2) a) _____ b) _____

3) a) _____ b) _____

4) a) _____ b) _____

5) a) _____ b) _____

Practice #2



Ex. 2) **Using the numbers on the scale:**

a) Determine the measurement and write them with the experimental uncertainty

b) Write the range of the measurement

1) a) ___**4.08 ± 0.01 cm**_____ b) ____4.07 cm – 4.09 cm__

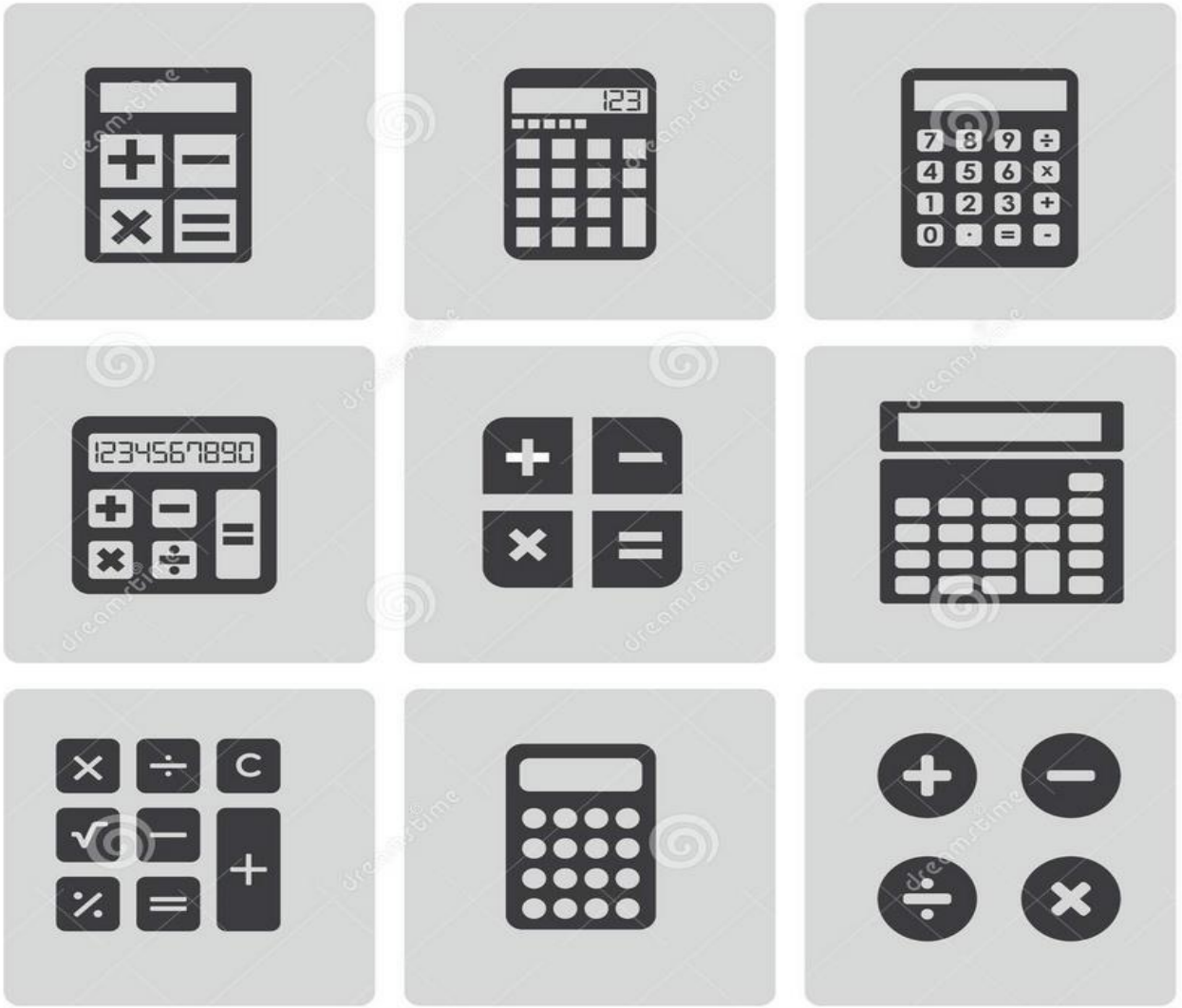
2) a) ___**4.42 ± 0.01 cm**____ b) ____4.41 cm – 4.43 cm__

3) a) ___**4.69 ± 0.01 cm**_____ b) ____4.68 cm – 4.70 cm___

4) a) ___**5.23 ± 0.01 cm**____ b) ____5.22 cm – 5.24 cm___

5) a) ___**5.84 ± 0.01 cm**_____ b) ____5.83 cm – 5.85 cm___

Calculations with Uncertainties



Calculations with Uncertainties

Addition (+) and Subtraction (-)

- When performing additions and subtractions we simply need to add together the absolute uncertainties.

- **Rules:**

$$(A \pm a) + (B \pm b) = (A + B) \pm (a + b)$$

$$(A \pm a) - (B \pm b) = (A - B) \pm (a + b)$$

Calculations with Uncertainties

Addition (+) and Subtraction (-)

- **Example**:

Add the values **1.2** ± 0.1, **12.01** ± 0.01, **7.21** ± 0.01

Step 1: 1.2 + 12.01 + 7.21 = **20.4**2 (*3 sig fig*)

Step 2: 0.1 + 0.01 + 0.01 = 0.**1**2 (*1 sig fig*)

Answer: **20.4** ± 0.**1**

Calculations with Uncertainties

Addition (+) and Subtraction (-)

- **Practice:** Find the measurement and the experimental uncertainty in each set of measurement values. Use the correct significant figures!

a) (186 ± 2 cm) + (147 ± 3 cm) = _____

b) (143 ± 1 mL) + (144 ± 4 mL) + (141 ± 2 mL) = _____

c) (186 ± 2 cm) − (147 ± 3 cm) = _____

d) (11.0 ± 0.1 cm) − (12.2 ± 0.4 cm) − (11.8 ± 0.2 cm) = _____

Calculations with Uncertainties

Addition (+) and Subtraction (-)

- **Practice:** Find the measurement and the experimental uncertainty in each set of measurement values. Use the correct significant figures!

a) (186 ± 2 cm) + (147 ± 3 cm) = 333 ± 5 cm

b) (143 ± 1 mL) + (144 ± 4 mL) + (141 ± 2 mL) = 428 ± 7 mL

c) (186 ± 2 cm) − (147 ± 3 cm) = 39 ± 5 mL

d) (41.0 ± 0.1 cm) − (12.2 ± 0.4 cm) − (11.8 ± 0.2 cm) = 17.0 ± 0.7cm

Calculations with Uncertainties

Multiplication (×) and Division (÷)

- When performing multiplications and divisions, or, dealing with powers, we simply add together the **percentage** (%) uncertainties.

Calculations with Uncertainties

Multiplication (×) and Division (÷)

Example:

Multiply the values: 1.2 ± 0.1, 12.01 ± 0.01

Step 1: 1.2 x 12.01 =**14** **(***2sigfig***)**

Step 2: (0.1 / 1.2) x 100 = **8**.33 % (*1sig fig*)

Step 3: (0.01 / 12.01) X 100 = 0.0**8**3% (*1sig fig*)

Step 4: 8.33 + 0.083 = **8**.413 % (*1sig fig*)

Answer: 14 ± 8 % OR **14 ± 1**

Calculations with Uncertainties

Multiplication (×) and Division (÷)

- **Practice:** Find the measurement and the experimental uncertainty in each set of measurement values. Use the correct significant figures!

a) $(14.01 \pm 0.01\ \text{mL}) \times (1.6 \pm 0.1\ \text{mL}) =$ _____

b) $(13.04 \pm 0.02\ \text{cm}) \div (1.2 \pm 0.1\ \text{cm}) =$ _____

Calculations with Uncertainties

Multiplication (×) and Division (÷)

a) (14.01 ± 0.01 mL) × (1.6 ± 0.1 mL) = _____

Step 1: 14.01 x 1.6 = **22**.416 **(***2sigfig***)**

Step 2: (0.01 / 14.01) x 100 = 0.0**7**14 % (*1sig fig*)

Step 3: (0.1 / 1.6) X 100 = **6**.25% (*1sig fig*)

Step 4: 6.25% + 0.0**7**14 % = **6**.3214 % (*1sig fig*)

Answer: 22 ± **6** % mL

Calculations with Uncertainties

Multiplication (×) and Division (÷)

b) (13.04 ± 0.02 cm) ÷ (1.2 ± 0.1 cm) = _____

Step 1: 13.04 ÷ 1.2 = **10**.867 (*2sigfig*)

Step 2: (0.02 / 13.04) x 100 = 0.**1**533 % (*1sig fig*)

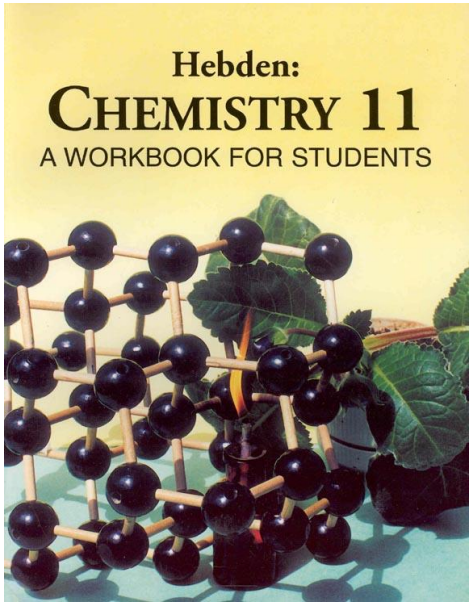
Step 3: (0.1 / 1.2) X 100 = **8**.333% (*1sig fig*)

Step 4: 0.**1**533 % + **8**.333 % = **8**.48 % (*1sig fig*)

Answer: 11 ± 8 % cm

HOMEWORK

Complete the following questions provided as well as:



<u>Textbook</u>: pg. 35 - 36 - #51-52

<u>Textbook:</u> Determine the uncertainty for each measurement for questions:
pg. 32-34 - #48 abc, 49ab and 50abc

HOMEWORK

Complete the following questions provided as well as:

Textbook: pg. 35 - 36 - #51-52

Textbook: Determine the uncertainty for each measurement for questions:

pg. 32-34 - #48 abc, 49ab and 50abc

1. Multiply: (5.0 m ± 4.0%) x (3.0 s ± 3.3%) = _____

2. Divide: (5.0 m ± 4.0%) ÷ (3.0 s ± 3.3%) = _____

3. Add: (6.5 ±0.5) m + (3.3 ±0.1) m = _____

4. Subtract: (6.5 ±0.5) m -(3.3 ±0.1) m = _____

HOMEWORK

Complete the following questions provided as well as:

Textbook: pg. 35 - 36 - #51-52

Textbook: Determine the uncertainty for each measurement for questions:

pg. 32-34 - #48 abc, 49ab and 50abc

1. Multiply: (5.0 m ± 4.0%) x (3.0 s ± 3.3%) = <u>(15.0 m•s ± 7.3%)</u>

2. Divide: (5.0 m ± 4.0%) ÷ (3.0 s ± 3.3%) = <u>(1.7 m/s ± 7.3%)</u>

3. Add: (6.5 ±0.5) m + (3.3 ±0.1) m = <u>(9.8 ±0.6) m</u>

4. Subtract: (6.5 ±0.5) m -(3.3 ±0.1) m = <u>(3.2 ±0.6) m</u>