1-4 Units of Measurement

QUANTITY	UNIT	STANDARD
Length	Foot	The king's foot
Mass	Kilogram	Kg prototype
Mass	a.m.u.	1/12th of a carbon-12 atom
Something that has magnitude, size or amount		Objects or natural phenomena that are of constant value, easy to preserve and reproduce

Common SI Units Table

Common SI Units		
Length 	**meter (m)** kilometer (km) decimeter (dm) centimeter (cm) millimeter (mm) micrometer (μm) nanometer (nm)	 1 km = 1,000 m 1 dm = 0.1 m 1 cm = 0.01 m 1 mm = 0.001 m 1 μm = 0.000 001 m 1 nm = 0.000 000 001 m
Volume 	**cubic meter (m^3)** cubic centimeter (cm^3) liter (L) milliliter (mL)	 1 cm^3 = 0.000 001 m^3 1 L = 1 dm^3 = 0.001 m^3 1 mL = 0.001 L = 1 cm^3
Mass 	**kilogram (kg)** gram (g) milligram (mg)	 1 g = 0.001 kg 1 mg = 0.000 001 kg
Temperature 	**Kelvin (K)** Celcius (°C)	 0°C = 273 K 100°C = 373 K

p. 20

SI Measurements

- Le Systeme’ International d’Unites

Quantity	Quantity symbol	Unit name	Unit abbreviation	Defined standard
Length	l	meter	m	the length of the path traveled by light in a vacuum during a time interval of 1/299 792 458 of a second
Mass	m	kilogram http://viewpure.com/ZMByI4s-D-Y	kg	the unit of mass equal to the mass of the international prototype of the kilogram
Time	t	second	s	the duration of 9 192 631 770 periods of the radiation corresponding to the transition between the two hyperfine levels of the ground state of the cesium-133 atom
Temperature	T	kelvin	K	the fraction 1/273.16 of the thermodynamic temperature of the triple point of water
Amount of substance	n	mole	mol	the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12
Electric current	I	ampere	A	the constant current which, if maintained in two straight parallel conductors of infinite length, of negligible circular cross section, and placed 1 meter apart in vacuum, would produce between these conductors a force equal to 2×10^{-7} newton per meter of length
Luminous intensity	I_v	candela	cd	the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540×10^{12} hertz and that has a radiant intensity in that direction of 1/683 watt per steradian

p. 18

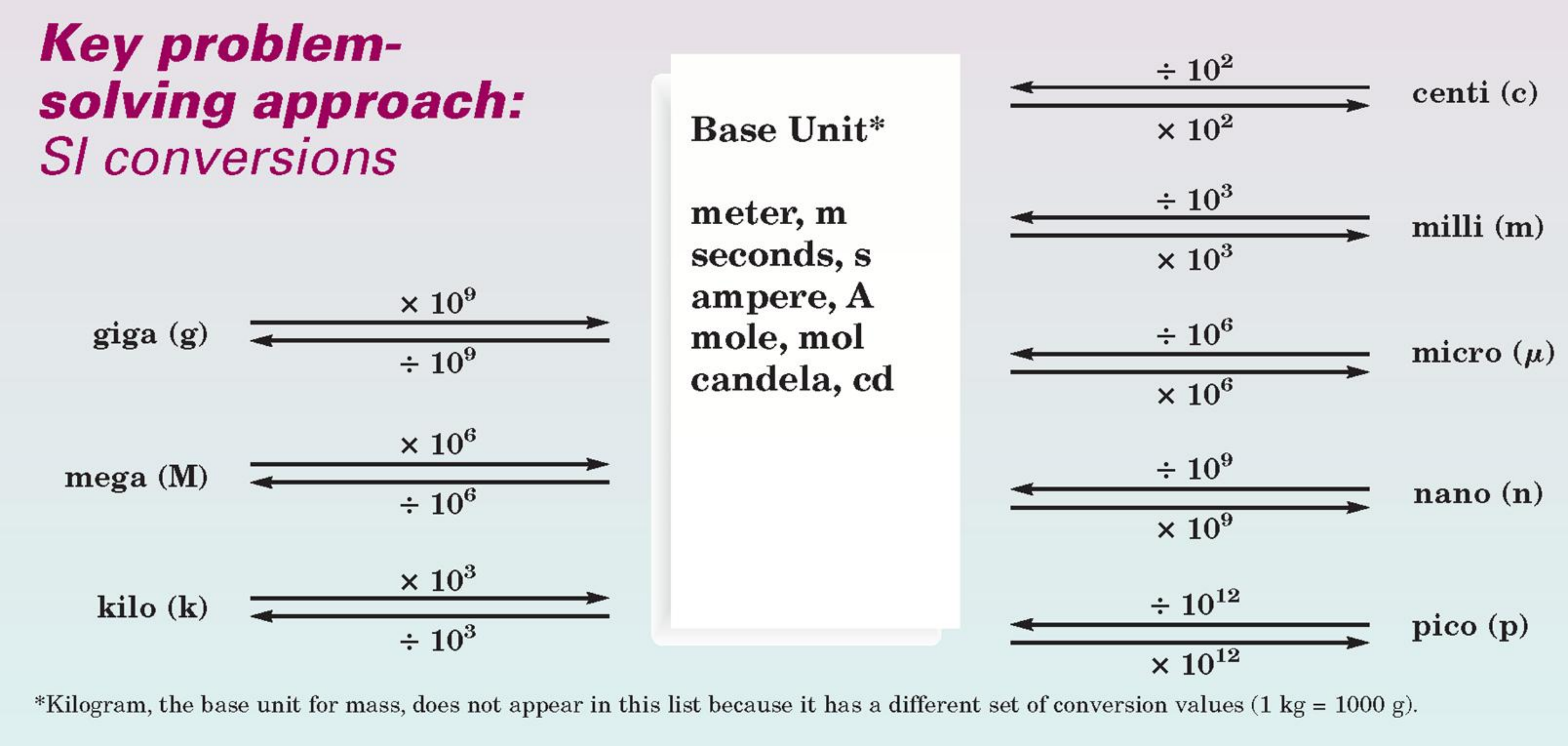
SI Base Units

Comparing Mass and Weight

- Mass is the measure of the amount of matter in an object.
  - Unit = kg
- Weight is the measure of the gravitational pull on matter
  - Unit = N (newtons)
  - Dependant on gravity

giga	G	1 Gm = 1 x 10^9 m
mega	M	1 Mm = 1 x 10^6 m
kilo	k	1 km = 1000 m
hecto	h	1 hm = 100 m
deka	D or da	1 Dm = 10 m
		1 m = 1 meter
deci	d	1 dm = 0.1 m
centi	c	1 cm = 0.01m
milli	m	1 mm = 0.001m
micro	µ	1 µm = 1 x 10^{-6} m
nano	n	1 nm = 1 x 10^{-9} m

SI Conversions Image



p. 40*

Derived SI Units

- Derived Units – a combination of SI units
- Example 1 $kg/m \cdot sec^2$ = 1 pascal (Pa)
- Volume – the amount of space occupied by an object
  - L x W x H = 1m x 1m x 1m = $1m^3$
  - 1dm x 1dm x 1dm = $1dm^3$ = 1 liter
  - 1cm x 1cm x 1cm = $1cm^3$ = 1 mL

Derived Units Table

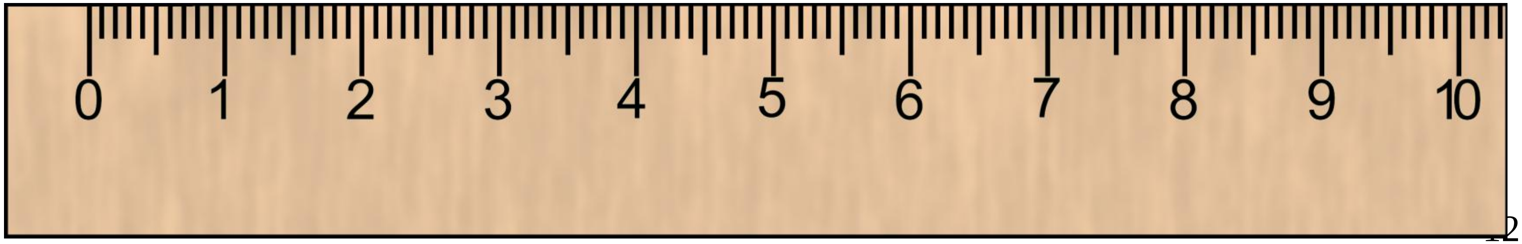
Quantity	Quantity symbol	Unit	Unit abbreviation	Derivation
Area	A	square meter	m^2	length × width
Volume	V	cubic meter	m^3	length × width × height
Density	D	kilograms per cubic meter	$\frac{kg}{m^3}$	$\frac{\text{mass}}{\text{volume}}$
Molar mass	M	kilograms per mole	$\frac{kg}{mol}$	$\frac{\text{mass}}{\text{amount of substance}}$
Molar volume	V_m	cubic meters per mole	$\frac{m^3}{mol}$	$\frac{\text{volume}}{\text{amount of substance}}$
Energy	E	joule	J	force × length

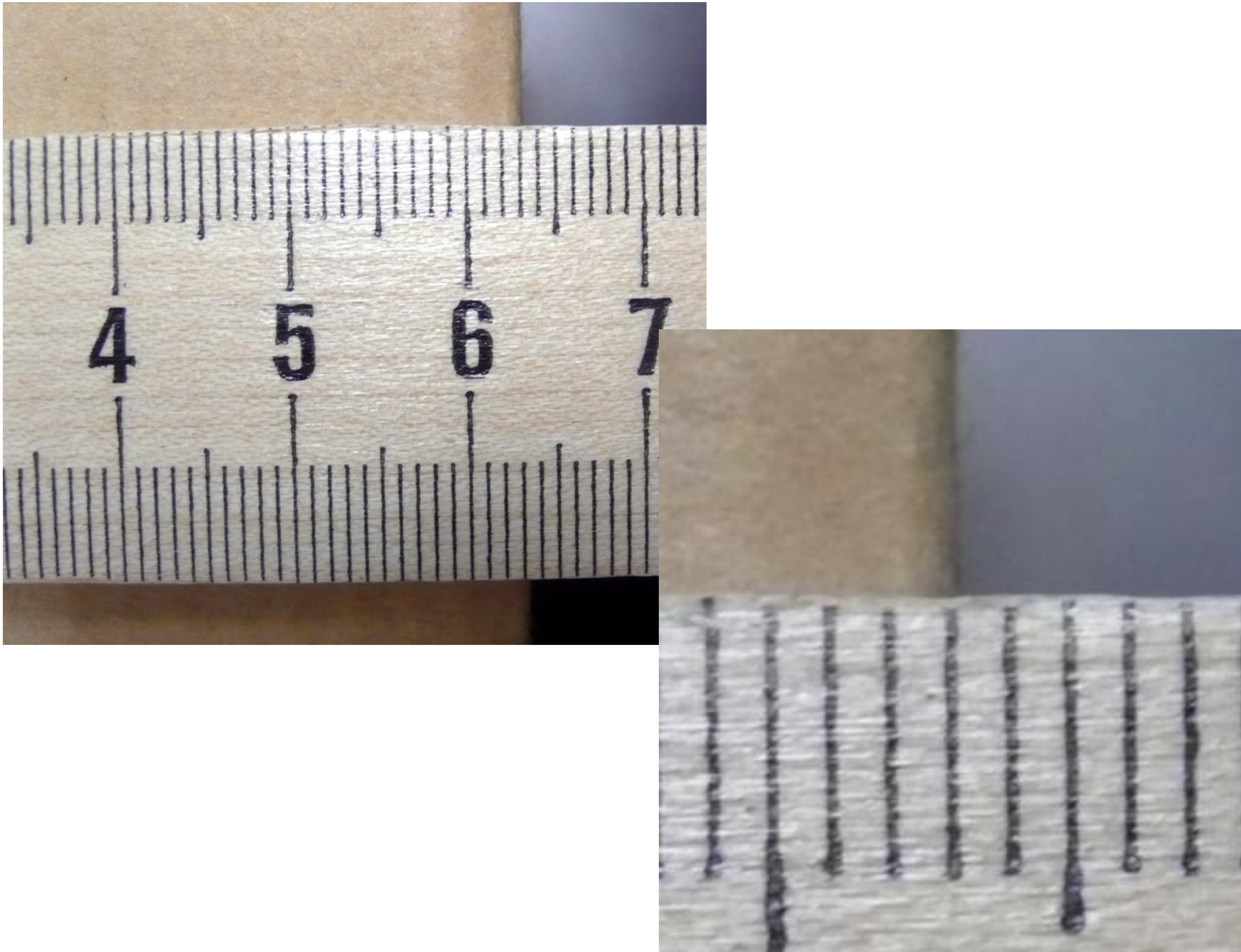
p. 36

1.5 Uncertainty in measurement

- Measurements are always uncertain because measuring instruments are never flawless and some estimation is always required

- Example: A ruler

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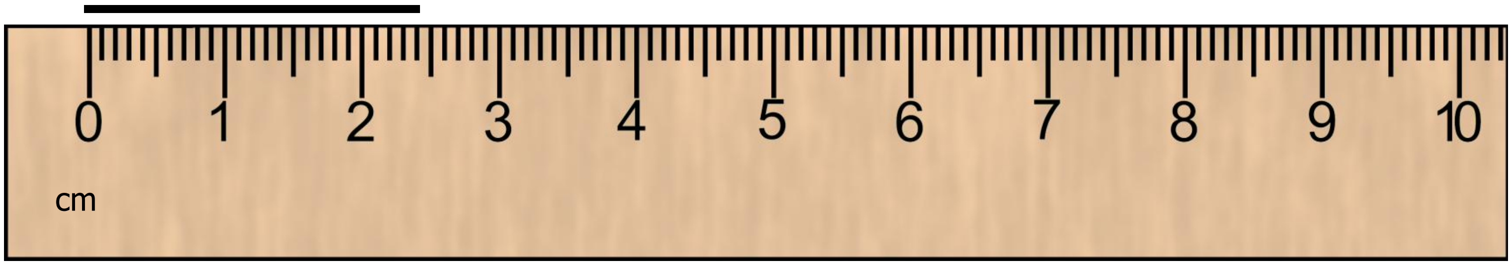
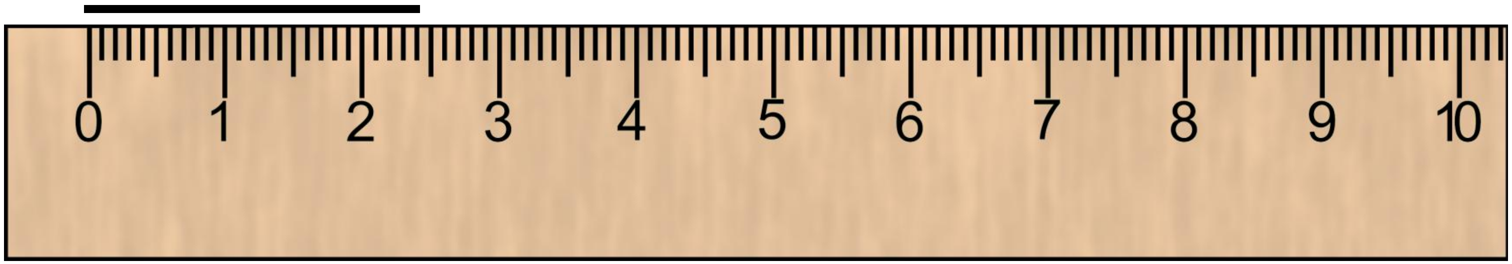
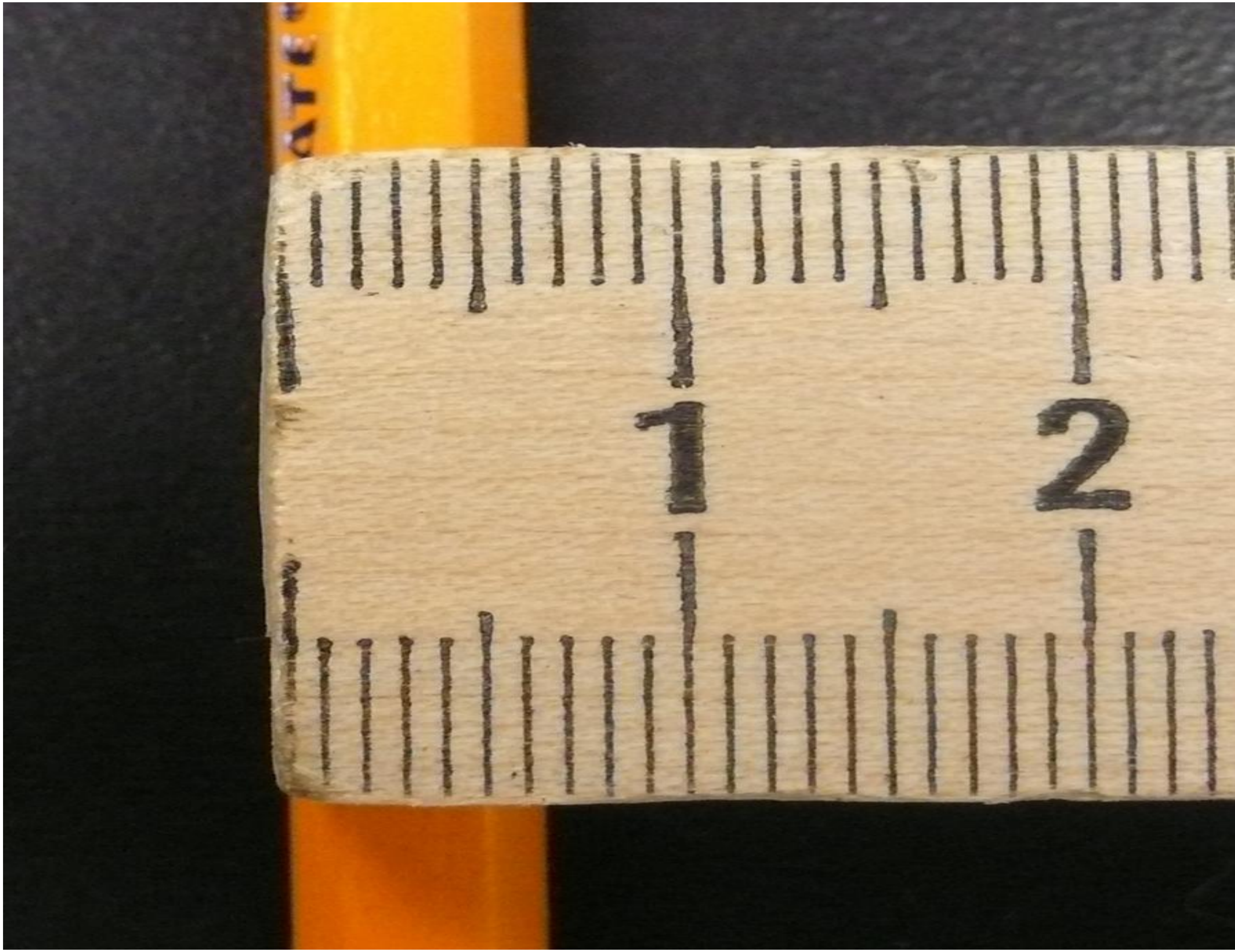


- When using any measuring instrument measure to the lowest calibrated unit on the instrument, then estimate the next decimal place.
- What units are on this ruler?
- What is the lowest calibrated (marked) unit?
- If measuring in the units given on the ruler, how many decimal places should your measurement have?



- The dark numbered lines represent centimeters
  - the thin lines are 0.1 cm or millimeters
- When reading the ruler you would read the centimeters, then the tenth of the cm (mm) then estimate the last number
  - Example 2.45cm
  - Written as 2.45 +/-0.05cm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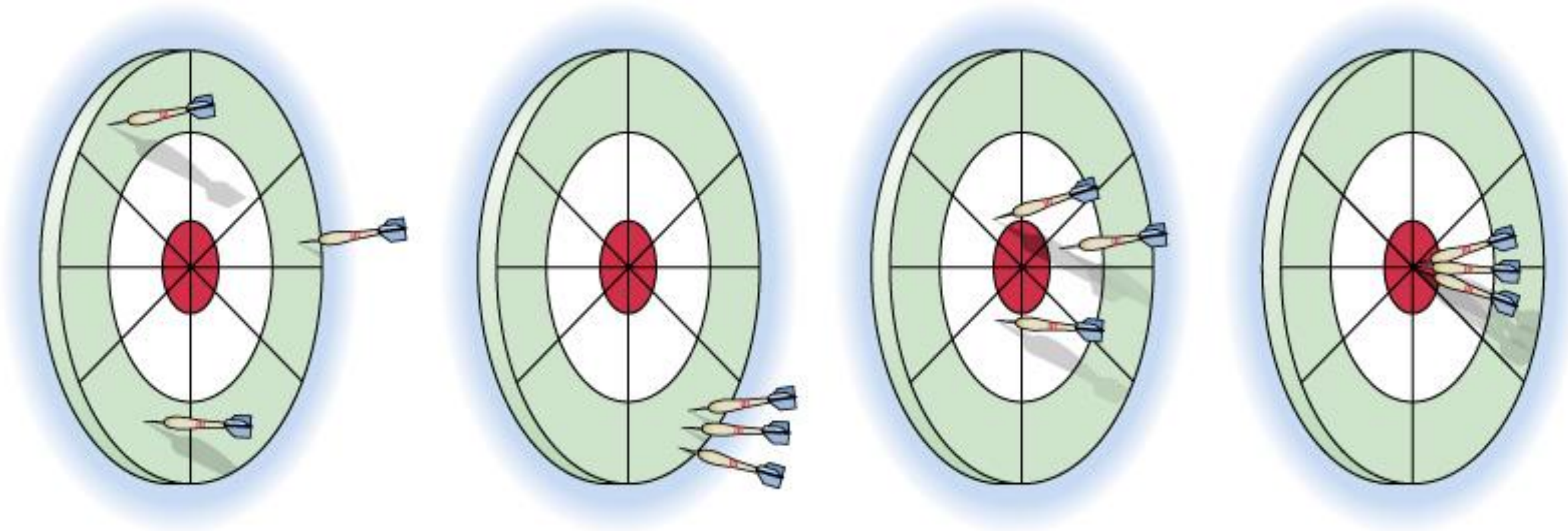
Reliability

- Two ways to check you numbers
  - repeat the measurement
  - test against a standard
- Precision- how close the repeated measurements are to each other
- Accuracy-how close the measurements are to a standard or accepted value

Example



(a) Low accuracy
Low precision

(b) Low accuracy
High precision

(c) High accuracy
Low precision

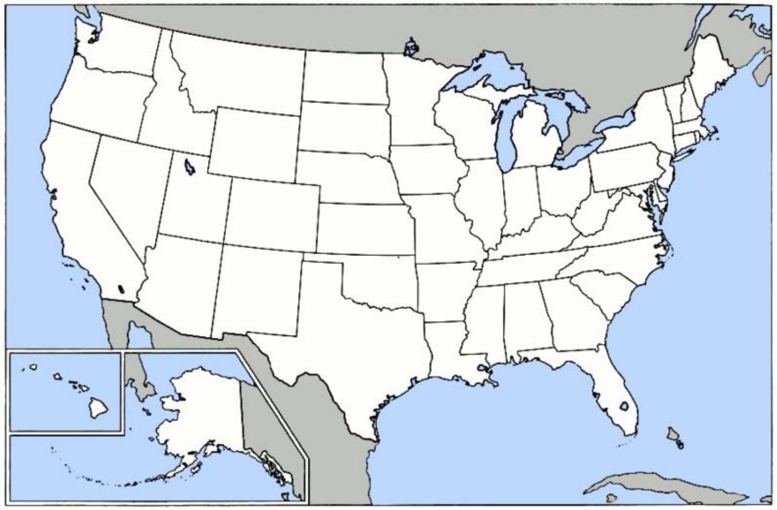
(d) High accuracy
High precision

Sample Problem

- Sara calculates the density of water to be 0.88g/ml, 0.87g/ml and 0.88g/ml on three trials
- Is she precise ?
  - Yes, all close together
- Is she accurate?
  - No, accepted value is 1 g/ml

1-6 Working with Numbers

- Significant Digits (sig fig's) - certain digits and the estimated digit of a measurement.
- Rules of Sig Fig's (Atlantic-Pacific Rule)



P of pacific stands for decimal point **present**

- If a decimal point is present you start on the left side of the number, like the pacific ocean is on the left side of America. Read through the number until you hit a non zero number. This begins the significant numbers.

Examples

- 34.067g
  - 5 sig figs
- 0.0007458ml
  - 4 sig figs
- 0.009070g
  - 4 sig figs

A of Atlantic stands for decimal point **absent**

- If the decimal point is absent you begin counting all non-zero digits from the right or Atlantic side of the number.

Examples

- 2030cm
  - 3 sig figs
- 2007dm
  - 4 sig figs
- 19,000,000,000g
  - 2 sig figs

Practice Problems

- 0.0026701m
  - 5 sig figs
- 19.0550kg
  - 6 sig figs
- 3500V
  - 2 sig figs
- 1,809,000L
  - 4 sig figs

Sig Fig's in Calculations

- Exact numbers or conversions do not count as sig figs
- In multiplication or division the answer can only have as many sig figs as the number with the least amount of sig figs.

Example: Volume = length x width x height

- Find the volume an object 10.876m x 1.34m x 13.22m
- on your calculator you will get a number like 192.6661648
- The correct answer would be 193m^3
  - 1.34m only has 3 sig figs

- In addition or subtraction the largest uncertainty determines the number of sig figs

Example

- Add 34.50g + 3.2345g + 671.1g + 25.345g = 734.1795g
- The largest uncertainty is 0.1 therefore the answer could have one digit after the decimal.   The correct answer would be 734.2g after rounding up

Practice Problems

- 6.15m x 4.026m = 24.8m^2
- 12.7km / 3.0 = 4.2km
- 150ml + 76.9ml + 209ml + 0.036ml = 440ml
- (35.6L + 2.4L) / 4.803 = 7.91L
- 2.542m x (16.408m - 3.88m) = 31.85m^2

Scientific Notation

- Example 19,000,000ml
  – You can only have two sig fig's
  – 1.9×10^7
- Example 0.0004569g
  – 4 sig figs
  – 4.569×10^{-4}g

Sample Problems

- 32,700
  - 3.27×10^4
- 1,024,000
  - 1.024×10^6
- 0.0047100
  - 4.7100×10^{-3}
- 0.000000003901
  - 3.901×10^{-9}

Percent Error

- $\% \text{ Error} = \frac{(\text{measured} - \text{accepted})}{\text{accepted}} \times 100$

Sample Problem

- A class calculated the density of water calculated the density of water. Many students reported values other than the accepted value of 1g/ml or 1g/cm^3
- Lets say you calculated the density of water to be .9g/ml
- % Error = $\frac{0.9 - 1}{1}$ x 100 = -10% error

Using Ratios

- Density is a ratio of mass to volume

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

1) Calculate the density of a material that has a mass of 52.4 g and a volume of 13.5 cm^3.

Example

1) A student finds a rock on the way to school. In the laboratory he determines that the volume of the rock is 22.7 mL, and the mass is 39.9 g. What is the density of the rock?

The mass of a toy spoon is 7.5 grams, and its volume is 3.2 ml. What is the density of the toy spoon?