

## - Units in calculations

- Units are treated just like pure numbers

Area $=4$ in $\times 6$ in $=(4 \times 6)($ in $\times$ in $)=24$ in $^{2}$

- Systems of units (metric, English, SI, ...)
- Equalities between units

$$
1 \mathrm{in}=2.54 \mathrm{~cm} \quad 1 \mathrm{mi}=1.609 \mathrm{~km}
$$

- Conversion factors - ratios between two equal or equivalent units (derived from equalities)

$$
\frac{1 \mathrm{in}}{2.54 \mathrm{~cm}}=1 \quad \text { or } \quad \frac{2.54 \mathrm{~cm}}{1 \mathrm{in}}=1
$$

### 1.3 The Unit Conversion Method

- Units of measurement
- Measurements - quantitative observations
- Units - standards used to compare
measurements (yard $\rightarrow$ standard for comparison of length measurements)
- A measured quantity is reported as a number and a unit
(Measured quantity) $=$ number $\times$ unit
5.5 seconds $=5.5 \times 1 \mathrm{~s}$
- Unit conversions (old unit $\rightarrow$ new unit)
- Quantity remains the same; units change

$$
\text { new unit }=\text { old unit } \times(\text { conv } . \text { factor })
$$

conv.factor $=\frac{\text { new unit }}{\text { old unit }}$

$$
\text { new unit }=\text { old unit } \times \frac{\text { new unit }}{\stackrel{\text { old unit }}{ }}
$$

- The old units cancel



### 1.4 Measurement in Scientific Study

- Systems of units (metric, English, SI, ...)
- The International System of units (SI)
- Based on the metric system
- SI base units


## Table 1.2 SI Base Units

| Physical Quantity (Dimension) | Unit Name | Unit Abbreviation |
| :--- | :--- | :---: |
| Mass | kilogram | kg |
| Length | meter | m |
| Time | second | s |
| Temperature | kelvin | K |
| Electric current | ampere | A |
| Amount of substance | mole | mol |
| Luminous intensity | candela | cd |

## Example:

- The gas mileage of a car is $\mathbf{3 5} \mathbf{~ m i} / \mathbf{g a l}$. How many km can the car travel on a full 10 gal tank of gas?
$1 \mathrm{mi}=1.609 \mathrm{~km}$
$10 g a l \times \frac{35 m i}{1 g a l}=350 \mathrm{mi}$

$$
350 \mathrm{mi} \times \frac{1.609 \mathrm{~km}}{1 m i}=563 \mathrm{~km}
$$

- Prefixes used with SI units (denote powers of 10)
- Used to express very small or very large quantities

Table 1.3 Common Decimal Prefixes Used with SI Units

|  |  | Meaning |  |  |
| :--- | :---: | :---: | :--- | :--- |
| Prefix* $^{*}$ | Prefix <br> Symbol | Number | Word | Multiple ${ }^{+}$ |
| tera | T | $1,000,000,000,000$ | trillion | $10^{12}$ |
| giga | G | $1,000,000,000$ | billion | $10^{9}$ |
| mega | M | $1,000,000$ | million | $10^{6}$ |
| kilo | k | 1,000 | thousand | $10^{3}$ |
| hecto | h | 100 | hundred | $10^{2}$ |
| deka | da | 10 | ten | $10^{1}$ |
| - | - | 1 | one | $10^{0}$ |
| deci | d | 0.1 | tenth | $10^{-1}$ |
| centi | c | 0.01 | hundredth | $10^{-2}$ |
| milli | m | 0.001 | thousandth | $10^{-3}$ |
| micro | $\mu$ | 0.000001 | millionth | $10^{-6}$ |
| nano | n | 0.000000001 | billionth | $10^{-9}$ |
| pico | p | 0.000000000001 | trillionth | $10^{-12}$ |
| femto | f | 0.000000000000001 | quadrillionth | $10^{-15}$ |

## - Examples:

$1 \mathrm{~mm}=10^{-3} \times(1 \mathrm{~m})=10^{-3} \mathrm{~m}$
$1 \mathrm{MW}=10^{6} \times(1 \mathrm{~W})=10^{6} \mathrm{~W}$
$1 \mu \mathrm{~s}=10^{-6} \times(1 \mathrm{~s})=10^{-6} \mathrm{~s}$
$1 \mathrm{ng}=10^{-9} \times(1 \mathrm{~g})=10^{-9} \mathrm{~g}$

- Mass and weight
- Mass is constant (depends on the amount of matter)
- Weight can vary with the strength of the gravitational field
- Mechanical balances actually measure mass


## Example:

A jet engine consumes $\mathbf{1 . 1} \mathbf{~ g a l}$ of fuel per second. How many liters of fuel does the engine need in order to operate for $\mathbf{1 . 5}$ hours? $1 \mathrm{gal}=3.785 \mathrm{~L} \quad 1 \mathrm{~h}=60 \mathrm{~min}=3600 \mathrm{~s}$

## Plan:

$1.1 \mathrm{gal} / \mathrm{s} \rightarrow$ ? L/s
1.5 Hours $\rightarrow$ ? minutes $\rightarrow$ ? seconds

Seconds $\times \mathrm{L} / \mathrm{s} \rightarrow$ ? L

## Example (cont.):

$1.1 \frac{\mathrm{gal}}{\mathrm{s}} \times\left(\frac{3.785 \mathrm{~L}}{1 \text { gal }}\right)=4.2 \frac{\mathrm{~L}}{\mathrm{~s}}$
$1.5 h \times\left(\frac{60 \text { minn }}{1 / h}\right) \times\left(\frac{60 s}{1 \text { mín }}\right)=5400 s$
$5400 s^{\prime} \times\left(\frac{4.2 L}{1 s^{\prime}}\right)=22000 L$

