Medical Physics Class
Units and Physical Quantities

By

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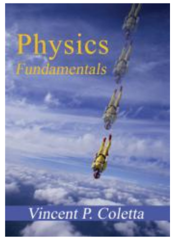


Reference: Physics Fundamentals
by Vincent P. Coletta
Loyola Marymount University, Los Angeles, CA

Learning Goals

Looking forward at …

- Use of Units
- Fundamental Quantities
- Base and Derived Units
- Powers of Ten
- Conversion of Units
- Consistency of Units
- Significant Figures

Use of Units

- The unit is a standard measurement used to express the numerical value of any physical quantity.
- It provides a reference that allows people to compare and communicate measurements consistently.
  - Distance or length may be expressed in units such as meters, feet, miles, or kilometers.
  - Time may be expressed in units of seconds, hours, days, or years.
  - Speed may be expressed in units of miles per hour, kilometers per hour, meters per second,

and so on.

Fundamental Quantities

- Fundamental quantities are the basic physical quantities that do not depend on other quantities. They form the foundation for measuring all other physical quantities.
  - ✓ They are independent and cannot be expressed using other quantities.
  - ✓ All other physical quantities are derived from these fundamental ones.

Fundamental Quantities

The Seven Fundamental Quantities in SI System

Physical Quantity	Definition	Base Unit	Symbol
Length	Measurement of distance	Meter	m
Mass	Amount of matter in an object	Kilogram	kg
Time	Duration of events	Second	s
Electric Current	Flow of electric charge	Ampere	A
Temperature	Measure of thermal energy	Kelvin	K
Amount of Substance	Number of particles in a substance	Mole	mol
Luminous Intensity	Brightness of light	Candela	cd

Base and Derived Units

- base units are the units used to express fundamental quantities.
  - meters, feet, seconds, and hours are all base units, since they are used to measure the two fundamental quantities length and time.
- derived units are the units used to express all other quantities are called.
  - miles per hour and meters per second are examples of derived units.
- Base units are further characterized as being either primary or secondary.
  - For each fundamental quantity, one base unit is designated the primary unit and all other units for that quantity are secondary.
  - For measuring time, the second is the primary base unit, and minutes, hours, days, and so on are all secondary base units.

Powers of Ten (Scientific notation)

- Powers of ten are used to express very large or very small numbers efficiently.
- Units that are powers-of-ten multiples of other units are often convenient to use, and so we use certain prefixes to denote those multiples. For example,

1. centi- means a factor of 10^{-2}, $\longrightarrow$ 1 centimeter (cm) 10^{-2} m
2. milli- means a factor of 10^{-3}, $\longrightarrow$ 1 millimeter (mm) 10^{-3} m
3. kilo- means a factor of 10^{3}, $\longrightarrow$ 1 kilometer (km) 10^{3}m.

Scientific notation helps simplify calculations and improve readability.

Will see more common powers of ten units during this course.

Conversion of Units

- Unit conversion is the process of changing a quantity from one unit to another.

- Step-by-step example:
  1. Identify the given unit and the required unit.
  2. Use the correct conversion factor.
  3. Multiply or divide as necessary.

- Example: Convert 5 kg to grams:

$$1 \text{ kg} = 1000\text{g}$$

$$5 \text{ kg} \times 1000 \text{ g/kg} = 5000\text{g}$$

Conversion of Units

- It is often necessary to convert units from one system to another.
- For example, you may need to convert a distance given in miles to units of meters.

  - To do this, you can use the conversion factor

    $1\ mile\ = 1609\ meters.$

- you may need to convert a time given in days to units of seconds.

$$1day = 1day\left(\frac{24\ hour}{1day}\right)\left(\frac{60\ mintue}{1\ hour}\right)\left(\frac{60\ second}{1\ minute}\right) = 86400\ second$$

Consistency of Units

- When performing calculations, **units should be carried along** just like numerical values. Treating units as algebraic quantities helps ensure accuracy and prevents mistakes.
- **Why Is This Important?**
  - ✓ Helps **identify errors** in calculations.
  - ✓ Ensures **logical and meaningful results**.
  - ✓ Allows for **easier unit conversions** when necessary.

Consistency of Units

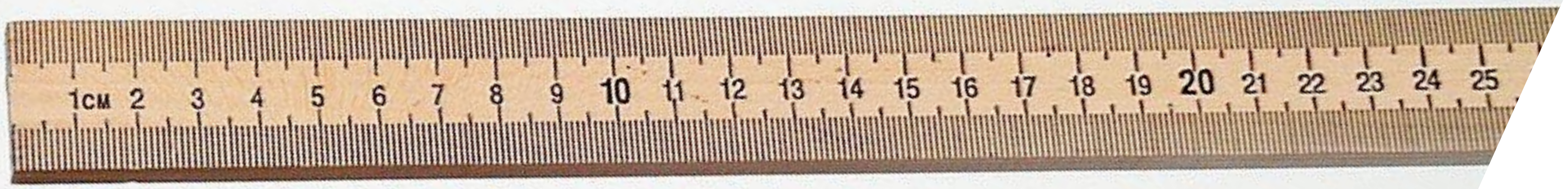
- **How to Apply Unit Consistency in Calculations**
  - ✓Write down the given values with their units.
  - ✓Use conversion factors when needed.
  - ✓Perform the calculation while keeping track of units.
  - ✓Cancel out units algebraically to ensure the final result has the correct unit.

Significant Figures

- Significant figures (sig figs) are the **digits in a number that contribute to its precision**. They help in maintaining accuracy when performing calculations in science and medicine.
- there is always some level of uncertainty due to the limitations of the measuring instrument or human estimation.

Significant Figures

- Example: Measuring the length of an object with a meter stick that has millimeter markings. measurements may be accurate to the nearest millimeter.
- If you measure 18.5cm, the uncertainty might be ± 0.1cm. This means the actual length is somewhere between 18.4 cm and 18.6 cm.



Significant Figures

- All non-zero digits are significant;

  1, 2, 3, 4, 5, 6, 7, 8, and 9;
- Zeros between non-zero digits are significant,

  like 705 and 80008;
- Leading zeros are never significant,

  like in 0.03 or 0068;
- Trailing zeros are significant ONLY if a decimal place is present;

  - **380 → 2 significant figures** (3 and 8).
  - **38.00 → 4 significant figures** (3, 8, and two zeros).

Significant Figures

- When two or more numbers are multiplied or divided, the final answer should be given to a number of significant figures equal to the smallest number of significant figures in any of the numbers used in the calculation.

$$15.025 \times 20.1 = 302$$

$$\frac{1.35}{0.241} = 5.60$$

Significant Figures

- when you add or subtract, the number of decimal places retained in the answer should equal the smallest number of decimal places in any of the quantities you add or subtract.

- $12.25 + \ 0.6 + \ \ 44 = 57$

Homework

1. How many significant figures are in the following number: 3005?
2. How many significant figures are in the following number: 0.0043?
3. Find the sum of the following distances: 4.65 m, 31.5 cm, 52.7 m?
4. Find the sum of the following masses: 21.6 kg, 230 kg, 55 g?
5. A doctor prescribes 0.00520 g of a drug. How many significant figures does this value have?
6. A scientist records a chemical volume as 5.080 L. How many significant figures?
7. A doctor prescribes 0.50 g of a medication to a patient. The available medication comes in a solution with a concentration of 250.0 mg/mL. How many milliliters (mL) of the solution should the nurse administer?
8. Multiply: $(2.50 \times 10^2) \times (4.0 \times 10^3)$ and give the answer with the correct sig figs.
9. Divide: $6.321 \div 2.1$ and give the answer with the correct sig figs.
10. Add: $4.321 + 0.02 + 10.1$, using correct sig figs.
11. Subtract: $89.320 - 0.4$ with the correct number of sig figs.
12. A nurse administers 0.050 g of a drug. If the syringe has markings down to 0.001 g, how many sig figs should be reported in the final dosage?

The End

Do not forget to do your homework ………