Physics 105

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Chapter -1-

(Introduction, Measurement, Estimating)

❖ Section (1.5): Units, Standards, and the SI System

- ***Measurement:***
  - The measurement of any *quantity* is made relative to particular standard **or** unit and this unit must be specified by *numerical value* of the quantity.
  - So to ***express*** the result of measurement we need a *value* and *unit*
    - ✓ ***Example 1:*** specify the value and unit
    - ✓ ***Solution :***

Value ⟶ **2m** ⟵ Unit

- ***Units:***
  - The base quantities:
    - ✓ Length: Meter (**m**)
    - ✓ Mass: Kilogram (**kg**)
    - ✓ Time: Second **(s)**

★ ***Question 1:*** Why Length (L), Mass (M), Time (T) are called base quantities?

☑ ***Solution:*** because the *major quantities* and *extensions* contain (L , M , T) like:

- ✓ Velocity (m/s) ⟶ L/T
- ✓ Acceleration (m/s^2) ⟶ L/T^2
- ✓ Density (kg/m^3) ⟶ M/L^3

★ ***Question 2:*** show the following **quantity** which has amount can be express by terms of the base quantity L, M ,T

Momentum (p = m*v)   Force (F = m*a)

☑ ***Solution:***

p = m*v (m ⟶ mass / v ⟶ velocity)
So p = kg * m/s
So p = M *L / T #

Momentum

F = m*a (m ⟶ mass / a ⟶ acceleration)
The unit of force is Newton (N)
So N = 1kg *1m/1s^2
So N =M*L/T^2 #

Force

- Before this name (base quantities)was called the *(MKS)system* and sometime people use *(cgs)system*
  - ✓ ***(MKS) system:***
    - M: Meter
    - K: Kilogram
    - S: Second
  - ✓ ***(cgs) system***
    - c: centimeter
    - g: gram
    - s: second

- It is easy to convert from **MKS** ⟶ **cgs** ,by using this transfer:
  - ✓ 1 meter ⟶ 100 Centimeter
  - ✓ 1 Kilogram ⟶ 1000 Gram

- So the all scientist decided to make *a universal system* of unit called SI unit it is mean Système International (French for International System).
- In the SI unit there are 7 base unit:

Quantity	**Unit**
Length	Meter **(m)**
Time	Second **(s)**
Mass	Kilogram **(kg)**
Electric current	Ampere **(A)**
Temperature	Kelvin **(K)**
Amount of substance	Mole **(mol)**
Luminous intensity	Candela **(cd)**

❖ Section (1.6): Converting units

- To convert between units, we need *a conversation factor*
  - Like: 1in =2.54cm
- So, we can do this ⟶ $1=2.54\frac{cm}{in}$ in this way the conversion factor can be expressed.
  - ✓ ***Example 1:*** How much 3in in cm ?
  - ✓ ***Solution:***

$$1 = 2.54\frac{cm}{in} \quad \textbf{So} \quad 3\cancel{in} * 2.54\frac{cm}{\cancel{in}} = 7.62cm$$

  - ✓ ***Example 2:*** A car is moving at 20m/s express the speed by km/h.
  - ✓ ***Solution:***

$$1\ km = 1000\ m$$

$$1\ h = 60\ min = 60*60s = 3600s$$

$$\textbf{So,}\quad 20\ m/s = 3600\cancel{s} * 20\frac{\cancel{m}}{\cancel{s}} * \frac{1}{1000\ \cancel{m}} = 72\ km/h$$

  - ✓ ***Example 3:*** The area of a plate is $32cm^2$ express the area in unit of m^2.
  - ✓ ***Solution:***

$$1\ m = 100cm$$

$$1m^2 = 10000cm^2 \longrightarrow 1 = \frac{1}{10000}\frac{m^2}{cm^2}$$

$$32cm^2 \longrightarrow 32\cancel{cm^2} * \frac{1}{10000}\frac{m^2}{\cancel{cm^2}} = 0.0032\ m^2$$

★ ***Question 3***: The speed of a car is 100 Km/h express the speed in terms of m/s.
- ☑ ***Solution:*** (27.8m/s)

★ ***Question 4***: The volume of 1.84 in^3 express the volume in m^3.
- ☑ ***Solution:*** ($3.02*10^{-5}m^3$)

- ***Metric (SI) Prefixes:*** that's mean are always considered to be part of the unit the larger and smaller units are defined in *multiples of 10* from the standard unit.

Prefix	Symbol	Value
Tera	T	10^{12}
Giga	G	10^{9}
Mega	M	10^{6}
Kilo	K	10^{3}
Centi	C	10^{-2}
Milli	M	10^{-3}
Micro	µ	10^{-6}
Nano	n	10^{-9}
Pico	p	10^{-12}

✓ ***Example:*** express the value of this by using prefixes.
- $5 * 10^{-6}$m
- $20 * 10^{6}$kg

✓ ***Solution:***
- $5 * 10^{-6}$ m ⟶ 5µm
- $20 * 10^{6}$ kg ⟶ 20 Mkg

❖ Section (1.8): Dimensions and Dimensional Analysis

- ***Dimensions:*** are length, width and height.

➢ We remember the base quantity (Length, Mass and Time).

➢ For example, Dimension of **v** = $\frac{displacment}{time} = \frac{L}{T}$ the **v** unit $\frac{m}{s}, \frac{cm}{s}, \frac{km}{h}$

✓ ***Example 1:*** What are the dimensions of force?

✓ ***Solution:***

F = ma

F = m$\frac{v}{T}$ = m$\frac{L}{T^2}$

➢ We can determine if relationship is incorrect by using technique called *dimensional analysis.*

✓ ***Example 2:*** Is the relation $v_f = v_i + at^2$ **incorrect?**

✓ ***Solution:***

$$v = \frac{L}{T} \quad , a = \frac{V}{T} = \frac{L}{T^2}$$

$$\textbf{So } \left[\frac{L}{T}\right] =^? \left[\frac{L}{T}\right] + \left[\frac{L}{\cancel{T^2}}\right][\cancel{T^2}]$$

$$\left[\frac{L}{T}\right] =^? \left[\frac{L}{T}\right] + [L] \ \#$$

- The first term is the *same dimension* but the second term is *different dimension*.
- **So** the relation is **incorrect**

★ ***Question 5:*** Is the relation $v_f = v_i + at$ **incorrect?**

☑ ***Solution:*** (it is ***correct***)

★ ***Question 6:*** For a simple pendulum the period of oscillation is $T = 2\pi\sqrt{\frac{l}{g}}$ Is the relation dimensionally, correct?

☑ ***Solution:*** (it is ***correct***)

Problems

17. A typical atom has a diameter of about1.0 * 10^{-10} m

(a) What is this in inches?

(b) Approximately how many atoms are along a 1.0-cm line, assuming they just touch?

☑ ***Solution (a):***

- ✓ Convert the diameter of an atom to inches
- ✓ The diameter of a typical atom is 1.0×10^{-10} m.
- ✓ To convert meters to inches, we use the conversion factor 1m=39.37inches
- ✓ **So,** Diameter in inches $=1.0\times10^{-10}$ m × 39.37 inches/m
- ✓ Calculating this: Diameter in inches = 3.937×10^{-9} inches

☑ ***Solution (b):***

- ✓ Number of atoms along a 1.0-cm line
- ✓ Given that 1.0 cm = 0.01 m, we need to find how many atoms fit along this length.
- ✓ Since the atoms are lined up side by side, the number of atoms can be found by dividing the total length by the diameter of one atom.
- ✓ ***Number of atoms*** $= \frac{0.01\,m}{1.0\times10^{-10}\,m}$
- ✓ Calculating this: Number of atoms = 1.0×10^{8}

21. American football uses a field that is 100.0 yd long, whereas a soccer field is 100.0 m long. Which field is longer, and by how much (give yards, meters, and percent)?

☑ ***Solution:***

- ✓ To determine which field is longer and by how much, we need to convert the lengths of both fields to the same units.
- ✓ Let's convert the soccer field's length from meters to yards and then compare the two fields.
- ✓ Convert 100.0 meters to yards (The conversion factor between meters and yards is):

1 m=1.09361 yards

- ✓ **So,** the length of the soccer field in yards is: 100.0 m×1.09361 yards/m = 109.361 yards
- ✓ The Length of the football field is 100.0 yards and the Length of the soccer field is 109.361 yards
- ✓ **So, *<u>the soccer field is longer</u>***
- ✓ The difference in yards=109.361 yards−100.0 yards = 9.361 yards
- ✓ To <u>convert</u> the difference back to meters: 9.361 yards×0.9144 m/yard = 8.556 m
- ✓ The percentage difference is calculated relative to the length of the football field:

$$\text{Percentage difference} = \left(\frac{9.361\text{ yards}}{100.0\text{ yards}}\right) \times 100\% = 9.361\%$$

33. I agree to hire you for 30 days. You can decide between two methods of payment: either

(1) \$1000 a day

(2) Or, one penny on the first day, two pennies on the second day and continue to double your daily pay each day up to day 30

Use quick estimation to make your decision, and justify it.

☑ ***Solution:***

✓ Let's compare the two payment methods to determine which one is better by estimating the total amount you would receive with each option.

✓ Payment Method 1: \$1000 a day for 30 days with this method, you receive a fixed amount of \$1000 each day for 30 days

$$\text{Total Payment} = 1000\ \text{dollars/day} \times 30\ \text{days} = 30{,}000\ \text{dollars}$$

✓ Payment Method 2: Starting with one penny and doubling each day for 30 days

✓ With this method, you start with one penny (0.01 dollars) on the first day, and the amount doubles each subsequent day.

✓ The amount you receive on day n is given by: Payment on day n = $0.01 \times 2^{(n-1)}$ dollars

✓ The total amount over 30 days is the sum of a geometric series.

✓ Total Payment = 0.01 dollars × ($2^0+2^1+2^2+\ldots+2^{29}$)

✓ Total Payment = $0.01 \times (2^{30}-1)$ dollars

✓ Calculating 2^{30}:

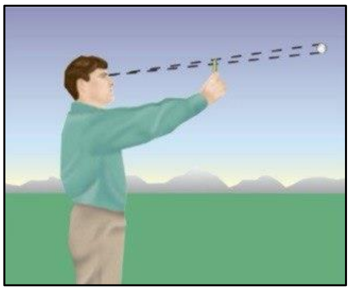
$2^{30} = 1{,}073{,}741{,}824$

✓ **So,** the total amount is:

$$\text{Total Payment} = 0.01 \times (1{,}073{,}741{,}824 - 1) = 10{,}737{,}418.23\ \text{dollars.}$$

✓ Payment Method 2 (starting with one penny and doubling each day) is far superior, yielding around \$10.7 million, compared to just \$30,000 with Payment Method 1.

48. Hold a pencil in front of your eye at a position where its blunt end just blocks out the Moon (Fig.). Make appropriate measurements to estimate the diameter of the Moon, given that the Earth–Moon distance is $3.8 * 10^5$ km.



☑ ***Solution:***

✓ To estimate the diameter of the Moon using a pencil and the Earth-Moon distance, we can use the concept of similar triangles. Here's how:

✓ When you hold the pencil such that its blunt end just blocks the Moon from your view, you are essentially creating two similar triangles:

✓ ***Triangle 1****:* Formed by your eye, the blunt end of the pencil, and the point where the pencil just covers the Moon.

✓ ***Triangle 2****:* Formed by your eye, the Earth, and the Moon.

- Let d be the diameter of the blunt end of the pencil
- Let L be the distance from your eye to the pencil
- Let D be the diameter of the Moon
- Let 3.8×10^5 km be the distance from the Earth

✓ Since the triangles are similar, the ratio of corresponding sides of the triangles will be equal:

$$\frac{d}{L} = \frac{D}{3.8 \times 10^5 km}$$

✓ From this, we can solve for the diameter of the Moon (D):

$$D = \frac{d \times 3.8 \times 10^5 km}{L}$$

✓ Calculating this:

$$D = \frac{0.006 \times 3.8 \times 10^5}{0.5} = 4.56 \times 10^3 km = 4560 km$$

13. Express the following using the prefixes of Table:

a) $1*10^6$volts
b) $2*10^{-6}$ meters
c) $6*10^3$days
d) $18*10^2$ bucks
e) $7*10^{-7}$ seconds

☑ ***Solution:***

a) 1×10^6volts = 1 MV (megavolt)

b) 2×10^{-6}meters = 2 μm (micrometers)

c) 6×10^3days = 6 kdays (kilo-days)

d) 18×10^2 bucks = 18 hbucks (hecto-bucks)

e) 7×10^{-7} seconds = 0.7 μs (microseconds)

12. Write the following as full (decimal) numbers without prefixes on the units:

a) 286.6 mm
b) 85 μm
c) 760 mg
d) 62.1 ps
e) 22.5 nm
f) 2.50 gigavolts

☑ ***Solution:***

a) 286.6 mm = 0.2866 m

b) 85 μm = 0.000085 m

c) 760 mg = 0.760 g

d) 62.1 ps = 0.0000000000621 s

e) 22.5 nm = 0.0000000225 m

f) 2.50 gigavolts = 2,500,000,000 V

14. One hectare is defined as 1* 10^4 m^2 , one acer is 4.356 * 104 ft^2 .
How many acres are in one hectare?

☑ ***Solution:***

✓ We know:

1 hectare = 1×10^4 m^2

1 m = 3.28084 feet

1 acre = 4.356×10^4 ft^2

✓ **So,** to convert square meters to square feet:

1 m^2 = $(3.28084 \text{ ft})^2$ = 10.7639 ft^2

✓ Now, calculate how many acres are in one hectare:

$$\text{Acres in one hectare} = \frac{107639 ft^2}{4.356 \times 10^4 ft^2/acre}$$

✓ Acres in one hectare ≈ 2.471 acres

15. The Sun, on average, is 93 million miles from Earth. How many meters is this? Express (a) using powers of 10, and (b) using a metric prefix (km).

☑ ***Solution:***

✓ We know the following conversion factors:

1 mile = 1.60934 kilometers (km)

1 kilometer = 1,000 meters (m)

✓ Convert 93 million <u>miles to kilometers:</u>

93,000,000 miles× 1.60934 km/mile = 149,668,620 km

✓ Convert <u>kilometers to meters:</u>

149,668,620 km×1,000 m/km = 1.4966862×10^{11} m

✓ The distance in kilometers is: 149,668,620 km ≈ 1.4967×10^8 km

Questions:

1. **One of world's largest cut diamonds is the first star of Africa (mounted in the British Royal Scepter and kept in the Tower of London) its volume 1.84 cubic inches. What is its volume in cubic centimeters? in cubic meters?**

   ☑ ***Solution:***

   $30.2cm^{3}$ / $3.02*10^{-5}m^{3}$

2. **The density of mercury is 13.5 g/cm^3 . What is this value in kilograms per cubic meter?**

   ☑ ***Solution:***

   1.35×10^{4} kg/m^3

3. **Starting with definition 1 in = 2.54 cm , find the number of**
   (a) kilometers in 1.60 mile
   (b) feet in 1.9km

   ☑ ***Solution:***

   (a) 2.57 km

   (b) $6.23 * 10^{3}$ ft

4. **The most powerful engine available for the classic 1963 Chevrolet Corvette Sting Ray developed 360 horsepower and had a displacement of 327 cubic inches. Express this displacement in liters (L) by using only the conversions 1 L = 1000 cm^3 and 1 in. = 2.54 cm.**

   ☑ ***Solution:***

   5.36L

5. **A square field measuring 100.0 m by 100.0 m has an area of 1.00 hectare. An acre has an area of 43,600 f. If a lot has an area of 17.0 acres, what is its area in hectares?**

   ☑ ***Solution:***

   4.86 hectares

6. **How many years older will you be 1.10 billion seconds from now? (Assume a 365-day year.)**

   ☑ ***Solution:***

   34.9 y

7. **How many nanoseconds does it take light to travel 5.50 ft in vacuum ?(This result is a useful quantity to remember)**

   ☑ ***Solution:***

   5.59 ns