Chapter 2

System of Units of Measurements

Important Terms

- **Dimension** –

Used to define physical characteristics of a quantity. E.g.: Length, volume, velocity, heat etc.

- **Unit** –

Is a standard or reference by which a dimension can be expressed **numerically**.

- **SI Unit** – The International System of units
  - Example:
  - meter, kilogram, second, ampere, Kelvin, Mole, Candela, Radian, Steradian.

Introduction

Many approximate unites were used such as:

- Number of days to ride a hoarse over a distance
- Hands
- Bucket or Barrel

- With the advances of technology SI system was adopted.
  - – SI Electrical Units
  - – SI Mechanical Units
  - – SI Temperature scales

1. Fundamental Units

No.	Physical Quantity (symbol)	Unit Name, symbol	Dimension Symbol
1	Length (l)	Meter, m	L
2	Mass (m)	Kilogram, kg	M
3	Time (t)	Second, s	T
4	Electric current (I)	Ampere, A	I
5	Temperature (θ or T)	Kelvin, K	θ
6	Amount of substance (n)	Mole, mol	N
7	Luminous intensity (Φ)	Candela, cd	J

2. Other Unit Systems

- 1. **English systems**

  Example: (foot for length, pound for mass)

  -Used in medieval England.

Ex: 1 in = 0.02540 m,

$10.76 \text{ foot}^2 = 1 m^2$,

1 psi = 6897Pa, 1 pound = 0.454kg.

- 2. **CGS systems** (using the centimeter, gram, and seconds as fundamental mechanical units which were employed for scientific purposes).

3. Secondary Units

- The **product/multiple/derivative** of fundamental units are known as secondary units.

- For example:
  - *Multiple* : Area(m^2), Volume (m^3)
  - *Product* : speed (ms^{-1}) , Charge (As)
  - *Derived* units :Newton(N), Joule (J), Power (W), Frequency (Hz).

3. Secondary Units

Example: Derived Units

Quantity	*Unit*	*Symbol*	*Dimensions*
Charge	Coulomb	C	IT
Capacitance	Farad	F	$M^{-1}L^{-2}T^{4}I^{2}$
Inductance	Henry	H	$ML^{2}T^{-2}I^{-2}$
Potential	Volt	V	$ML^{2}T^{-3}I^{-1}$
Resistance	Ohm	Hz Ω	$ML^{2}T^{-3}I^{-2}$
Energy	Joule	J	$ML^{2}T^{-2}$
Force	Newton	N	MLT^{-2}
Frequency	Hertz	f	$1/T$
Power	Watt	W	$ML^{2}T^{-3}$
Pressure	Pascal	Pa	$ML^{-1}T^{-2}$

Metric Prefixes

Metric Prefixes: Are letter symbols for multiples and submultiples of 10

TABLE 1-1 Scientific Notation and Metric Prefixes

Value	Scientific notation	Prefix	Symbol
1 000 000 000 000	10^{12}	tera	T
1 000 000 000	10^{9}	**giga**	**G**
1 000 000	10^{6}	**mega**	**M**
1000	10^{3}	**kilo**	**K**
100	10^{2}	hecto	h
10	10	deka	da
0.1	10^{-1}	deci	d
0.01	10^{-2}	centi	c
0.001	10^{-3}	**milli**	**m**
0.000 001	10^{-6}	**micro**	**μ**
0.000 000 001	10^{-9}	**nano**	**n**
0.000 000 000 001	10^{-12}	**pico**	**p**

SI Units, Symbols & Dimensions

TABLE 1-2 SI Units, Symbols, and Dimensions

Quantity	Symbol	Unit	Unit symbol	Dimensions
Length	l	meter	m	$[L]$
Mass	m	kilogram	kg	$[M]$
Time	t	second	s	$[T]$
Area	A	square meter	m^2	$[L^2]$
Volume	V	cubic meter	m^3	$[L^3]$
Velocity	v	meter per second	m/s	$[LT^{-1}]$
Acceleration	a	meter per sec per sec	m/s^2	$[LT^{-2}]$
Force	F	newton	N	$[MLT^{-2}]$
Pressure	p	newton per square meter	N/m^2	$[ML^{-1}T^{-2}]$
Work	W	joule	J	$[ML^2T^{-2}]$
Power	P	watt	W	$[ML^2T^{-3}]$

Dimension Analysis

- It is necessary for every equation to be **balanced** dimensionally.

- Dimension of physical quantity:

  [force] = [mass X acceleration] $= MLT^{-2}$

  Unit for force = N = $kgms^{-2}$

Example:

- The unit of voltage is volt (V). Express the dimension of voltage using only **base units.**

- <u>**Solution**</u>

  From definition: electric potential V is expressed either **Joules per coulomb** or in **volts.**

  Then:

  Volts = joules / coulomb

  $V = FL/Q = MLT^{-2} \times L / IT$

  $= ML^{2}T^{-3}I^{-1}$

- Answer: V= <u>$kgm^{2}s^{-3}A^{-1}$</u>

Exercise:

- Attempted by students –
- Prove the dimensions of all the quantities listed in slide 9.
- (*Hint: Start by knowing the definitions, i.e. how the quantities are obtained).*

- Example: Charge = Current x time

  Q = <u>IT</u>

  In base units: <u>As</u>