Al-Rasheed University College
Medical Instrumentation Tech. Eng.

Measurements & Medical Transducers

2nd Stage
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Lecture 3

System of Units of Measurements

2.1 Introduction

- The physical quantities الكميات الفيزيائية must be defined both in **<u>kind</u>** and **<u>value</u>**. The measure of kind of physical quantity is called “the unit”.

- For example, when we say (100 meters), we know that the **meter is the unit** of length and that the **value of length is one hundred.** The physical quantity, length, is therefore defined by the unit, meter. Without the unit, the number (100) has no physical meaning.

- In science and engineering, two kinds of units are used:
  - fundamental.
  - derived.

2.2 Fundamental and Derived Units

- **Fundamental units** are units that are independently selected and are not dependent on any other units. They are also called ”**base units**”. The most famous examples of fundamental units are the units meter for length (**m**), kilogram for mass (**kg**), and second for time (**s**).

- Table (1) shows the seven basic SI unit quantity and units of measurement, with their unit symbol:

Table (1):

Quantity	*Unit*	*Symbol*
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electrical current	Ampere	A
Thermodynamic temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	**Mole**	**mol**

➢ **Derived units** are the units that can be expressed mainly in terms of fundamental units.

- **For example**, the unit of area of some rectangle (m^2) and it is derived from

Area = length ∗ width

The length and width the equation above are measured in meters. Therefore, the unit for area is resulting from (**m ∗m = m^2**).

- The volume can be calculated as;

volume = length ∗width ∗height

The unit for volume can be derived as;

m ∗m ∗m = m^3

- As another example, the **density** can be calculated as;

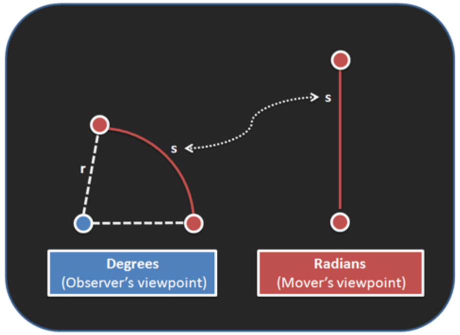
$$density = \frac{mass}{volume} \qquad \frac{kg}{m^3}$$

- The derived units may take special names such as the names of the famous scientists. i.e., Newton is the measure of force which equals to **Kg m/s²** while it is commonly referred as **N (the first letter of the scientist rule).** Some of the derived units are listed in Table (3).

Table (3): Examples of some physical quantities with their corresponding symbols.

No.	Quantity	Unit	Symbol
1	Area	Sequare meter	m^2
2	Volume	Cubic meter	m^3
3	Velocity	Meter per second	m/s
4	Acceleration	Meter per square second	m/s^2
5	Angular velocity	Radian per second	Rad/sec
6	Angular acceleration	Radian per square second	Rad/sec^2
7	Densityالكثافة	Kilogram per cubic meter	Kg/m^3
8	Mass flow rate (liquids)	Kilogram per second	Kg/s
9	Volum flow rate	Cubic meter per second	m^3/s
10	Forceالقوة	Newton	N
11	Pressure الضغط	Newton per square meter	N/m^2
12	Torque عزم الدوران	Newton meter	Nm

Degrees vs. Radians



No.	Quantity	Unit	Symbol
12	Momentum الزخم	Kilogram meter per second	Kg m/s
13	Work, Energy	Joule	J
14	Power	Watt	W
15	Voltage	Volt	V
16	Electric charge	Coulumb	C
17	Electric Field strength	Volt per meter	V/m
18	Electric resistance	Ohm	Ω
19	Electric capacitance	Farad	F
20	Electric inductance	Henry	H
21	Electric conductance	Seimens	S
22	Resistivity	Ohm meter	Ωm
23	Permittivity	Farad per meter	F/m

2.3 Multiples and Submultiples of units

➢ The units in actual use are divided into submultiples for the purpose of measuring quantities smaller than the unit itself.

➢ Table(3) lists the decimal multiples and submultiples of units.

$$10^{+n} \rightarrow \textbf{multiples}$$

$$10^{-n} \rightarrow \textbf{submultiples}$$

10^n	Prefixe	Example	10^n	Prefixe	Example
10^{18}	exa- (E)	exajoule, EJ	10^{-1}	deci- (d)	decibel, dB
10^{15}	peta- (P)	petasecond, Ps	10^{-2}	centi- (c)	centimeter, cm
10^{12}	tera- (T)	terahertz, THz	10^{-3}	milli- (m)	millimeter, mm
10^{9}	giga- (G)	gigavolt, GV	10^{-6}	micro- (µ)	microgram, µg
10^{6}	miga- (M)	megawatt, MW	10^{-9}	nano- (n)	nanometer, nm
10^{3}	kilo- (K)	kilogram, kg	10^{-12}	pico- (p)	picofarad, pF
10^{2}	hecto- (H)	(rarely used)	10^{-15}	femto- (f)	femtometer, fm
10^{1}	deca- (Da)	(rarely used)	10^{-18}	atto- (atto)	attocoulomb, aC

- Table (4) lists some of common conversion factors for **English** into **SI** units.

Table (4) English units into SI conversions

No.	Quantity	English unit	Symbol	SI unit
1	Length	Foot	Ft	0.3048 m
		Yard	Yd	0.9144 m
		Inch	In	25.4 mm
		Mile	Mi	1.609 km
		Nautical mile	N mi	1.852 km
2	Mass	Pound	Lb	0.4539237 kg
		Ounce	Oz	28.35 g
		Slug	Slug	14.6 kg
3	Force	poundal	Pdl	0.138255 N
4	Power	Horse power	Hp	745.7 w
5	Work, energy	Foot-poundal	Ft-pdl	0.0421401 J
6	Temperature	Fahrenheit	F	$C = \frac{5}{q}(F - 32)\ C^{\circ}$ $K = \frac{5}{q}(F + 459.67)k^{\circ}$

Example (1) : The floor area of an office building is 5000 m^2 calculate the floor area in ft^2

Solution

1 ft = 0.3048 m

$$\therefore A = 5000\ m^2 \times \left(\frac{1\ ft}{0.3048\ m}\right)^2 = 53819.552\ ft^2$$

Example (2): The velocity of light in free space is expressed as 3 X 10^8 m/s. Give the velocity of light in (i) km/hr (ii) ft/s

Solution

(i) $1\ \text{km} = 1000\ \text{m} \rightarrow \text{m} = \frac{1}{1000}\ \text{km}$

$1\ \text{hr} = 3600\ \text{s} \rightarrow \text{s} = \frac{1}{3600}\ \text{hr}$

$\therefore C = 3 \text{ X } 10^8 \frac{m}{s}$

$= 3 \text{ X } 10^8 \frac{3600\ km}{1000\ hr} = 10.8 \text{ X } 10^8\ \text{km/hr}$

(ii) $1\ \text{ft} = 0.3048\ \text{m} \rightarrow \text{m} = \frac{1}{0.3048}\ \text{ft}$

$\therefore C = 3 \text{ X } 10^8 \frac{m}{s}$

$= 3 \text{ X } 10^8 \frac{\frac{1}{0.3048} ft}{s} = 9.8425\ \text{ft/s}$

Quiz