Al-Rasheed University College
Medical Instrumentation Tech. Eng.

Measurements & medical Transducers

2^{nd} Stage
Lecturer: Dr. Najim Abdallah

Lecture Three

System of Units of Measurements

3.1 Introduction

- The physical quantities must be defined both in kind and value. 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.

3.2 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 six basic S.I 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

- 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

$$\text{Area} = \text{length} * \text{width}$$

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

- The volume can be calculated as;

$$\text{volume} = \text{length} * \text{width} * \text{height}$$

The unit for volume can be derived as;

$$m * m * m = \boldsymbol{m^3}$$

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

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

- The derived units may take special names such as the names of the famous scientists. Some of the derived units are listed in table (3) ;

Table (3) The derived units

No.	Quantity	Unit	Symbol
1-	Area	Square 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-	Density	Kilogram per cubic meter	Kg/m^3
8-	Mass flow rate	Kilogram per second	Kg/s
9-	Volume flow rate	Cubic per second	m^3/s
10-	Force	Newton	N
11-	Pressure	Newton per square meter	n/m^2
12-	Torque	Newton-meter	n.m
13-	Moment of inertia	Kilogram-square meter	$Kg.m^2$
14-	Momentum	Kilogram-meter per second	Kg.m/s
15-	Work, energy	Joule	J
16-	Power	Watt	W

3.3 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.

No.	Prefix	Power of 10	Symbol
1-	Exa	10^{18}	E
2-	Peta	10^{15}	P
3-	Tera	10^{12}	T
4-	Giga	10^{9}	G
5-	Mega	10^{6}	M
6-	Kilo	10^{3}	K
7-	Hecto	10^{2}	H
8-	Deca	10	Da
9-	Deci	10^{-1}	D
10-	Centi	10^{-2}	C
11-	Milli	10^{-3}	m
12-	Micro	10^{-6}	μ
13-	Nano	10^{-9-}	n
14-	Pico	10^{-12}	P
15-	Femto	10^{-15}	F
16-	Atto	10^{-18}	a

- 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 .

Sol:

1 ft = 0.3048 m → $\frac{1\text{ft}}{0.3048} = 1\text{m}$

$A = 5000 \times (\frac{1\text{ft}}{0.3048})^2 = 53819.552\ ft^2$

Example (2): The velocity of light in free space is expressed as 3 X $\mathbf{10^8}$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) $1 \text{ ft} = 0.3048 \text{ m} \rightarrow \text{m} = \frac{1}{0.3048} \text{ ft}$

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

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

H.W

If the density of water is given as 62.5 lb/ft^3, calculate the density of water in:

(i) lb/in^3 (Ans. D = 0.0362 lb/in^3)

(ii) g/cm^3 (Ans. 1 g/cm^3)