SNS COLLEGE OF TECHNOLOGY

(An Autonomous Institution)

Coimbatore-35

DEPARTMENT OF BIOMEDICAL ENGINEERING

23BMT203 - BIOMEDICAL TRANSDUCERS AND SENSORS

UNIT I - Fundamental of Measurement

II Year/ IV Sem

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ASP / BME / SNSCT

BIOMEDICAL TRANSDUCERS AND SENSORS

- ✓ Signals and Noise in the Measurement
- ✓ Characteristics of the Measurement System (Static & Dynamic),
- ✓ Determination of Absolute Quantity
- ✓ Standards, Calibration,
- ✓ Accuracy and Error
- ✓ Units of Measurement Quantities.
- ✓ Physiological parameter and its measurement constraints.

Units of Measurement Quantities

- Quantitative measurements are represented numerically with units for easy comparison.
- Using different units for the same quantity can create inconvenience, even if conversion is possible.
- Independently defined units for related quantities may introduce numerical factors in equations, such as when converting mechanical work to heat.
- To avoid such issues, a coherent system of units defines units systematically, eliminating conversion factors.
- While systems like CGS and MKS existed, the International System of Units (SI) is now the recommended standard.

Units of Measurement Quantities

The International System of Units

- Base Units and Derived Units
- Dimension of a Quantity
- Recommendations for the Use of SI Units and Symbols

Non-SI Units

Units of Measurement Quantities

The International System of Units

- **The International System of Units (SI) was established by the International Organization for Standardization (ISO) as a coherent system of units for physical quantities.**
- **SI standards define quantities, units, symbols, and writing rules, as documented in ISO 1000 (1992) and ISO 31 (Parts 0–13, 1992).**

Units of Measurement Quantities

Base Units and Derived Units

- **The SI system is built on seven base quantities with their corresponding base units: meter (length), kilogram (mass), second (time), ampere (electric current), kelvin (temperature), mole (amount of substance), and candela (luminous intensity).**

SI Base Units

Base Quantity	SI Base Unit Name	SI Base Unit Symbol
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

Units of Measurement Quantities

Derived Units

- **Derived quantities are expressed in terms of base quantities (e.g., velocity as length divided by time), and their units, derived units, are combinations of base units (e.g., meter per second for velocity).**
- **Some derived quantities have special names and symbols in SI, such as radian and steradian, which are dimensionless supplementary units. For example, moment of force is typically expressed as N · m instead of kg m^2/s^2.**

Units of Measurement Quantities

SI-Derived Units with Special Names

Derived Quantity	SI-Derived Unit: Special Name	Symbol	Expressed in Terms of SI Base Units and SI-Derived Units
plane angle	radian	rad	1 rad = 1 m/m = 1
solid angle	steradian	sr	1 sr = 1 m^2/m^2 = 1
frequency	hertz	Hz	1 Hz = 1/s
force	newton	N	1 N = 1 kg m/s^2
pressure, stress	pascal	Pa	1 Pa = 1 N/m^2
energy, work quantity of heat	joule	J	1 J = 1 N · m
power, radiant flux	watt	W	1 W = 1 J/s
electric charge, quantity of electricity	coulomb	C	1 C = 1 A s
electric potential, potential difference, tension, electromotive force	volt	V	1 V = 1 W/A
capacitance	farad	F	1 F = 1 C/V
electric resistance	ohm	Ω	1 Ω = 1 V/A
electric conductance	siemens	S	1 S = 1/Ω
magnetic flux	weber	Wb	1 Wb = 1 V s
magnetic flux density	tesla	T	1 T = 1 Wb/m^2
inductance	henry	H	1 H = 1 Wb/A
Celsius temperature	degree Celsius	°C	1°C = 1 K (in temperature difference)
luminous flux	lumen	lm	1 lm = 1 cd sr
illuminance	lux	lx	1 lx = a 1 m/m^2
activity (of a radio nuclide)	becquerel[a]	Bq	1 Bq = 1/s
absorbed dose, specific energy imparted, kerma, absorbed dose index	gray[a]	Gy	1 Gy = 1 J/kg
dose equivalent, dose equivalent index	sievert[a]	Sv	1 Sv = 1 J/kg

Units of Measurement Quantities

The dimensions of the seven base units, which are length, mass, time, electric current, thermodynamic temperature, amount of substance, and luminous intensity, are conventionally denoted by L, M, T, I, Θ, N, and J, respectively

Some Examples of Quantities, Units, and Their Dimension

Quantity	Unit	Dimension
velocity	m/s	LT^{-1}
force	kg m/s^2 or N	LMT^{-2}
energy	kg m^2/s^2 or J	L^2MT^{-2}
electric potential	kg $m^2/(s^2$ A) or V	$L^2MT^{-3}I^{-1}$
heat capacity	kg $m^2/(s^2$ K) or J/K	$L^2MT^{-2}\Theta^{-1}$
molar concentration	mol/m^3	$L^{-3}N$
illuminance	cd sr/m^2 or lx	$L^{-2}J$

SI Prefixes

	Prefix	
Factor	Name	Symbol
10^{24}	yotta	Y
10^{21}	zetta	Z
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{2}	hecto	h
10	deca	da
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a
10^{-21}	zepto	z
10^{-24}	yocto	y

Units of Measurement Quantities

Non-SI U nits

- **Recognized Non-SI Units:** The International Committee for Weights and Measures (ISO) recognizes certain non-SI units for continued use due to their practical importance.
- These include units for time (minute, hour, day), plane angle (degree, minute, second), volume (liter), mass (tonne, unified atomic mass unit), and energy (electron volt).
- **Traditional Units and Dual Reporting:** Many fields, like medicine, still use traditional non-SI units (e.g., mmHg, cal).
- While SI conversions are important, it's often more practical to provide values in both SI and the traditional unit (e.g., 16 kPa (120 mmHg)) or simply the SI unit with the traditional equivalent in parentheses as an approximation.