EEE 3352

Electromechanics & Electrical Machines

Lecture 1: Introductory concepts

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1. Introductory concepts

1. Physical quantities, dimensions and units
2. Scalars, vectors, phasors
3. Basic laws:
   - Faraday's
   - Ampere's
   - Newton's 2nd
   - Conservation of mass, energy, mag. & elec. flux

1.1 Physical quantities, dimensions and units

-physical quantities in **electrical engineering** cover what happens in:

- conductors & insulators: electric
- magnetic & non mag materials: magnetic

Electrics

- mechanical engineering
- thermodynamics

Mechanics

Some of physical quantities

Mechanical	[symbol]
Length	[l or x]
Force	[F]
Momentum	[Γ]
Acceleration	[a]
Torque	[T]
Angular speed	[ω]
Mass	[m]

Electrical	[Symbol]
Voltage	[v, V]
Resistance	[R]
Capacitance	[C]
Inductance	[L]
Electric charge	[q, Q]
Current density	[J]
Magnetic flux	[ϕ]

Dimensions and Units

- used to describe physical quantities:

Dimension:

- characteristic of a physical quantity

Unit:

- how the physical quantity is to be measured in terms of standard quantities

- traditionally, 3 reference dimensions in mechanics:
    - length
    - mass
    - time

- 2 more dimensions for
    - electricity and magnetism (e.g. current)
    - thermodynamics (e.g. temperature)

- a number of independent base units
  - need to be chosen
  - carefully defined

\- the actual number being the same as that of the independent dimensions

- SI (International system) - adopted internationally
    - 7 base units
    - 2 supplementary units

SI quantities & units

	Quantity	Unit Name	Unit
Base	Time	second	s
	Length	metre	m
	Mass	kilogram	kg
	Electric current	Ampere	A
	Thermodynamic temperature	Kelvin	K
	Luminous intensity	candela	cd
	Amount of substance	mole	mol
Supp	Plane Angle	radian	rad
	Solid angle	steradian	sr

Units

- definition of units are precise
- in EEE 3352 you need only remember for electric current

  see extract from

  “IET Units and Symbols for Electrical and Electronic Engineering”

- units of all physical quantities can be expressed in terms of the base and supplementary units
- in practice, it is better to define derived units in cases where

1. the quantity is used frequently
   - eg Hz derived from s^{-1} for frequency
2. the units are lengthy
   - eg N for kgm/s^2
3. a new physical concept is introduced
   - eg V for $kgm^2s^{-3}A^{-1}$

- the numerical values of many quantities may be many orders of magnitude away from unity (bigger or smaller)
- it may be convenient to either use power of 10 or to use decimal prefixes with the unit

Base 10 and their prefixes

quantity	name	symbol
10^{18}	exa	E
10^{15}	peta	P
10^{12}	tera	T
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k

quantity	name	symbol
10^{2}	hecto	h
10^{1}	deca	da
10^{-1}	deci	d
10^{-2}	centi	c

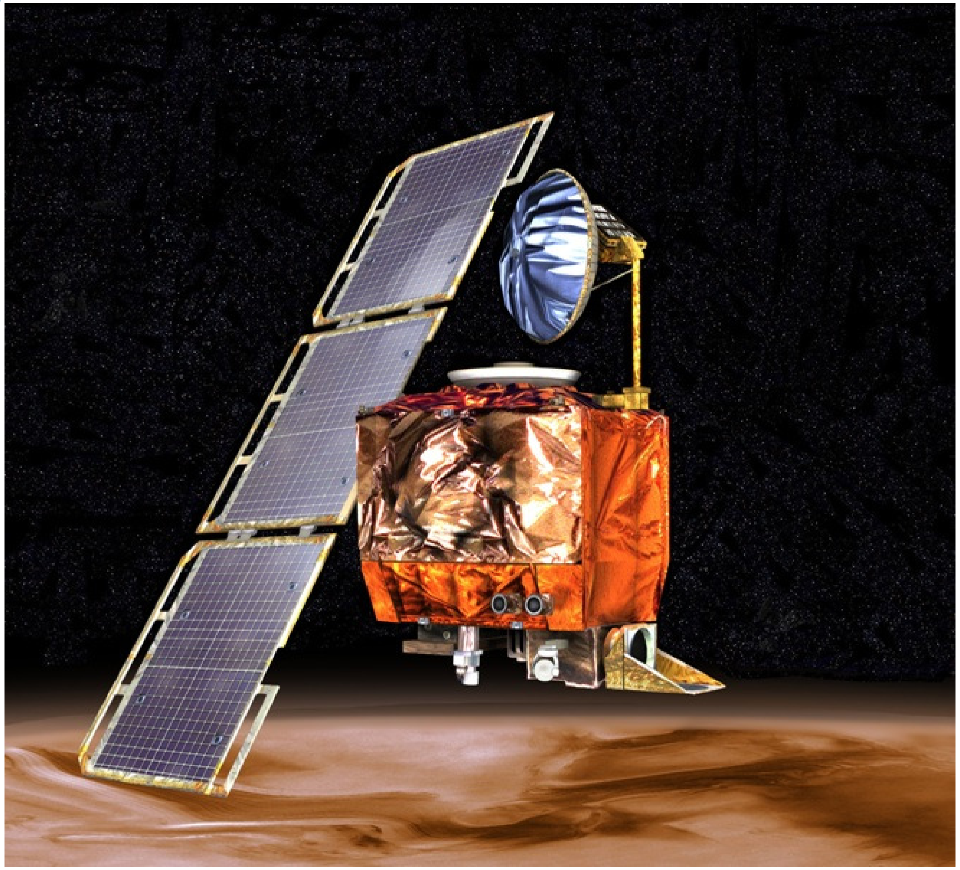
quantity	name	sym
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

Relationships

- equations are a compact and effective way of stating relationships between various quantities
- equations may arise in 4 different ways:

1. a statement of a basic law, tested and accepted e.g. Faraday's law, $v = N\dfrac{d\phi}{dt}$
2. a definition of a new quantity or concept e.g. electric current density, $J = \dfrac{di}{dA}$
3. description of material property e.g. permeability, $\mu = \dfrac{B}{H}$
4. derivation from other equations, using mathematical processes

Importance of dimensions & units



- NASA's Mars Climate Orbiter 1999
- $ 125 million
- NASA (metric); Lockheed Martin (imperial)

- "Metric mishap caused loss of NASA orbiter"
  - http://edition.cnn.com/TECH/space/9909/30/mars.metric.02/
- "Mars Probe Lost Due to Simple Math Error"
  - https://www.latimes.com/archives/la-xpm-1999-oct-01-mn-17288-story.html

1.2 Scalars, Vectors and Phasors

Scalar

- has
  - magnitude only
  - is specified by a single numerical value together with its unit
- eg., mass

Vector

- has a magnitude and direction ;
- needs 2 values to specify it, if it is confined to a plane, or
- needs 3 three values, if in general space;
- quoted values depend on system: i.e
  - x,y (z) for Cartesian or;
  - r,θ (ω) for polar representation

Phasor

- is a technique for describing any sinusoidally varying quantity;
- in general $y=y_m(\cos\omega t+\phi)$ means the projection of a phasor
  - of magnitude or peak value, y_m ;
  - rotating at angular speed ω onto a fixed reference unit;
  - angle ϕ from reference;
  - at time t will give the instantaneous value of y

1.3 Basic Laws

Maxwell's Equations

	general	particular
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Faraday's Law	$\nabla \times E = -\dfrac{\partial B}{\partial t}$ →	$v = N\dfrac{d\phi}{dt}$
Ampere's Law	$\nabla \times H = \dfrac{\partial D}{\partial t} + J$ →	$Hl = NI$

Newton’s 2nd Law

rectilinear

$$\sum F = m\frac{d^2x}{dt^2} = ma$$

rotational

$$\sum T = J\frac{d^2\theta}{dt^2} = J\alpha$$

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$$\sum F = m\frac{d^2x}{dt^2} = ma = 0$$

$$\sum T = J\frac{d^2\theta}{dt^2} = J\alpha = 0$$

Law of conservation of energy

Law of conservation of mass

Maxwell's Equations

Gauss's Laws:

- Conservation of electric charge $\nabla \bullet D = \rho$
- Conservation of magnetic flux $\nabla \bullet B = 0$

-End of Lecture 1-