

## Introduction to Electronic Circuit for Instrumentation

- Fundamental quantities
  - Length
  - Mass
  - Time
  - Charge and electric current
  - Heat and temperature
  - Light and luminous intensity
  - Matter (atom, ion and molecule)

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**Table 1.3 Standard prefixes**

Prefix	Symbol	Power
atto	a	$10^{-18}$
femto	f	$10^{-15}$
pico	p	$10^{-12}$
nano	n	$10^{-9}$
micro	$\mu$	$10^{-6}$
milli	m	$10^{-3}$
centi	c	$10^{-2}$
deci	d	$10^{-1}$
deka	da	10
kilo	k	$10^3$
mega	M	$10^6$
giga	G	$10^9$
tera	T	$10^{12}$

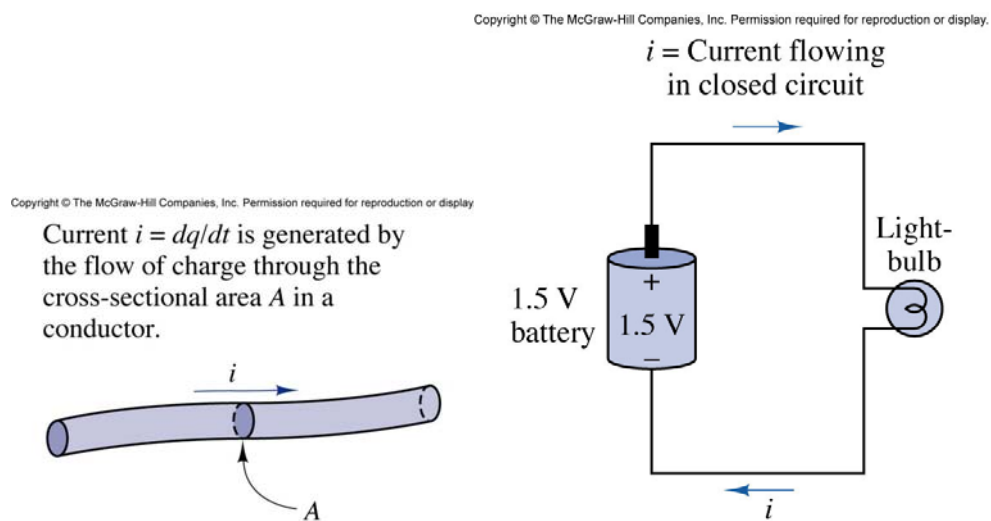
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**Table 1.2 SI units**

Quantity	Unit	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd

- Fields of study in science
  - Mathematics
  - Physics (mechanics and electromagnetics)
  - Chemistry
  - Biology
- How about engineering?
- Materials

- Electrical properties
    - Conductor
    - Semiconductor
    - Insulator and dielectrics
  - Magnetic properties
    - Diamagnetism
    - Paramagnetism
    - Ferromagnetism
    - Ferrimagnetism
    - Antiferromagnetism
  - Electrolyte
  - Gas
  - Cell and biological tissue
- Basics of electromagnetism
    - Space and time
    - Charge, mass, force and field
    - Work and potential
    - Voltage, current, power and energy
    - Voltage reference (signal ground, chassis ground and earth ground)
    - Statics and dynamics
    - Maxwell's equations



- How to sense or perceive?

- Human (sensor, sensory nerve and central nervous system)
    - See
    - Hear
    - Touch
    - Smell
    - Taste
  - Machine
- 
- How to actuate or affect?
    - Human (central nervous system, motor nerve and muscle)
    - Machine
- 
- Basic tools of machine sensation (signal, noise, interference and information)
    - Function of time, DC and AC
    - Signal waveform
      - Unit step
      - Pulse
      - Sinusoid
      - Exponential
    - Voltage signal with respect to signal ground
      - Grounded signal and isolated (or floating) signal
      - Unipolar signal and bipolar signal
      - Single-ended signal and differential signal
      - Differential-mode signal and common-mode signal
      - Balanced signal and unbalanced signal
    - Signal amplitude (peak, peak-to-peak, average and rms), period and frequency
    - Fourier series and transform
    - Random noise (probability, PDF, mean, standard deviation and variance)
    - Signal-to-noise ratio (SNR)
    - Numbers
      - Natural number and 0
      - Integer
      - Rational number
      - Irrational number
      - Real number
      - Imaginary number

- Complex number
- Analog and digital
  - Decimal and binary number
  - Sampling
  - Quantization
  - ADC and DAC
- Basics of instrumentation (machine sensation or perception)
  - General structure of instrumentation
    - Measurand
    - Sensor or transducer
    - Signal conditioning and processing (analog and digital)
    - Output
  - System model
    - Input and output
    - Gain or transfer function
    - Linearity and nonlinearity
    - Transient response and steady-state response
    - Time-domain representation and frequency-domain representation
  - Analysis
    - DC analysis
    - Transient analysis
    - Sinusoidal analysis or AC analysis
    - Frequency response
  - Design or problem solving
    - Problem statement
    - Identification of goal
    - Information collection (literature survey and summary)
    - Idea generation and planning
    - Details of solution (equation, implementation, experiment, and so on)
    - Validation
- Electric circuit
  - Source
    - Voltage source
    - Current source

- Dependent source
- Passive two-terminal electric component
  - Resistor
  - Capacitor
  - Inductor
- Load
  - Light bulb and LED
  - Speaker
  - Heater
  - Motor
  - ADC and digital devices
- Electronic circuit
  - Semiconductor device
    - Diode
    - Transistor
    - Operational amplifier
    - Switch and multiplexer
    - Analog ICs for nonlinear functions
  - Amplifier
  - Active filter
  - Nonlinear analog signal processing
  - Signal generation
  - ADC and DAC
- Digital circuit
  - Gate
  - Counter and register
  - Memory
  - PLD
  - Microprocessor
  - ADC and DAC
- Digital signal processing
  - Microprocessor or computer
  - Programming language

- Firmware, embedded software and software
- DSP implementation using C language function
  
- Examples of bioinstrumentation
  - Thermometer
  - Electrocardiogram (ECG)
  - Noninvasive blood pressure