EE-0001
PEEE Refresher Course

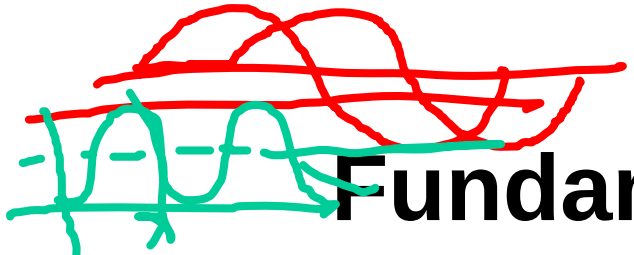
Week 1: Engineering Fundamentals

Engineering Fundamentals

- Bentley Chapters 1 & 2
- Camara Chapters 1, 2, & 3
- Electrical Quantities
  - Energy (work), power, charge, current
  - Electrostatic pressure, resistance
- Circuit Elements
  - Resistor, Inductor, Capacitor
- Circuit Equations
  - Series, Parallel, Wye-Delta Conversions
  - Norton Equivalent
  - Thevenin Equivalent
  - Kirchhoff's Laws
  - Loop and Node equations
- Complex Algebra
- Transients & Resonance
- R, C, RC, RLC

Fundamental Electrical Units

Quantity	Units	Symbol	Formula	Equivalent Units
energy (work)	joule	W	$W = \int P dt$	watt-second
power	watt	P	$P = \frac{dW}{dt}$	volt-ampere or joule/second
charge	coulomb	Q	$Q = CV$	ampere-second
current	ampere	I	$I = \frac{V}{R}$	coulomb/second
electrostatic pressure	volt	V	$V = IR$	joule/coulomb
resistance	ohm	R	$R = \frac{V}{I}$	volt/ampere



Voltage

- Energy gained or lost when a charge is moved from one point to another.
- Potential difference

$$V_{ab} = \frac{W}{Q} \left[\frac{\text{joule}}{\text{coulomb}}\right]$$

$$= \frac{dw}{dq}$$

- EMF

$$E = \frac{dw}{dq} = \frac{P}{I} = V$$

E = energy given up or generated

V = potential difference between two terminals

Power

- Time rate of doing work
  - BTU/second
  - Joule/second
  - watts *
  - horsepower

$$P = VI \quad [\text{watts}]$$

$V = \text{voltage}$

$I = \text{current}$

$$P_{avg} = \frac{1}{t}\int_0^t vi\,dt \quad [\text{watts}]$$

Energy (work)

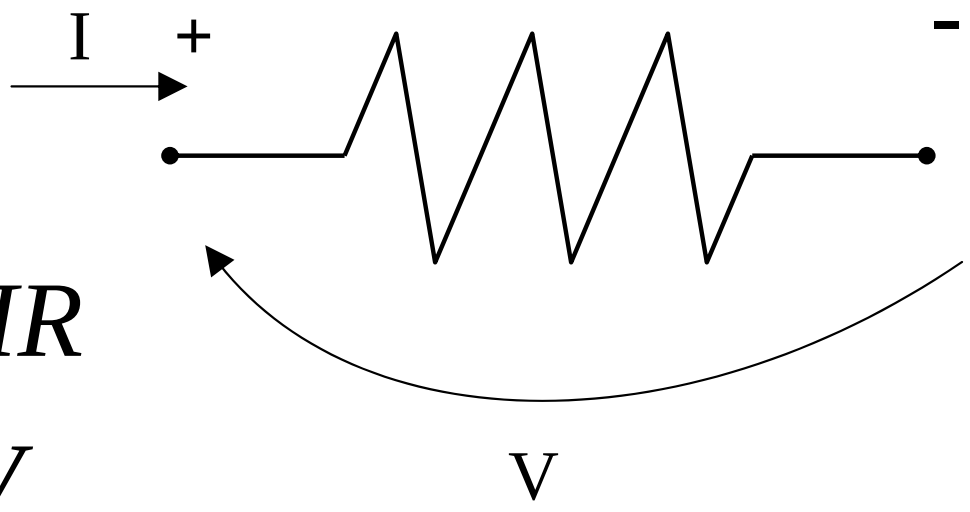
$$W = \int_{t_1}^{t_2} P\,dt \quad [\text{watt - sec}]$$

where P = watts

- or -

$$W = Pt \qquad \text{if power is constant}$$

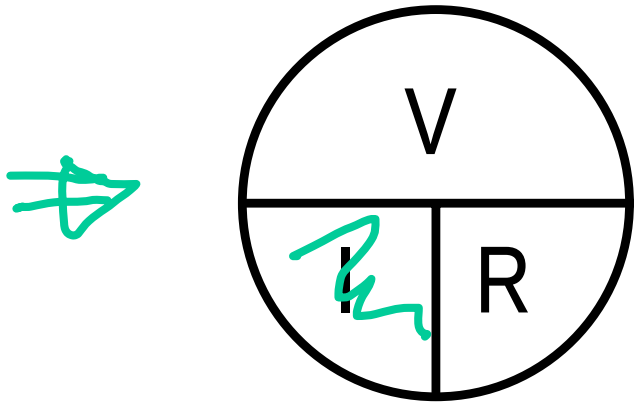
Ohm's Law



$$V = IR$$

$$I = \frac{V}{R}$$

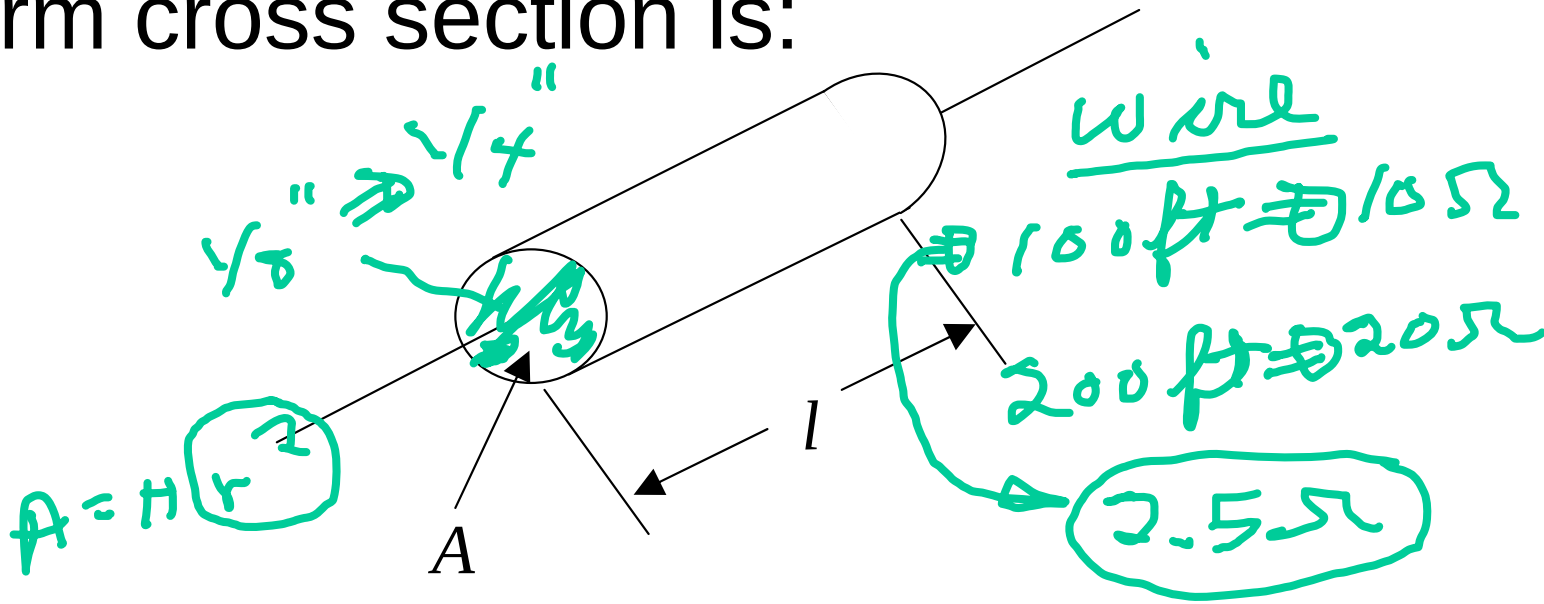
$$R = \frac{V}{I}$$



Resistance

The resistance of a section of conductor of uniform cross section is:

$$R = \frac{\rho l}{A}$$



where

A=cross-sectional area (square meters or circular mils)

l = length (meters or feet)

R = resistance (ohms)

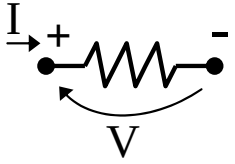
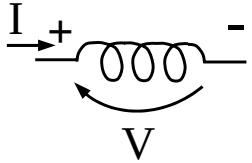
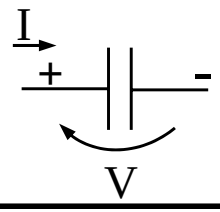
ρ = resistivity of material (ohm-meters) = 1/conductivity

Resistivity for Typical Conductive Materials

Material	Resistivity, ohm-meters	Resistivity, ohm-circular mills per foot
aluminum	2.6×10^{-8}	17
copper	1.7×10^{-8}	10
cast iron	9.7×10^{-8}	58
lead	22×10^{-8}	132
silver	1.6×10^{-8}	9.9
steel	$(11\text{-}90) \times 10^{-8}$	66-540
tin	11×10^{-8}	69
nichrome	100×10^{-8}	602

Note: The area of a circle one mill (0.001 inch) in diameter is one circular mil; the area of any circle in circular mils equals the square of its diameter in mils.

Circuit Element Characteristics

Element	Schematic Symbol	Current Through	Voltage Drop	Power Dissipation	Stored Energy	Units
resistor		$I = \frac{V}{R}$	$V = IR$	$\frac{V^2}{R}$ or I^2R	zero	ohm Ω, KΩ, MΩ
inductor		$I = \frac{\phi}{L}$ $= \frac{1}{L}\int V\,dt$	$V = L\frac{dI}{dt}$	zero	$W = \frac{1}{2}LI^2$	henry h, mh, μh
capacitor		$I = C\frac{dV}{dt}$	$V = \frac{1}{C}\int I\,dt$	zero	$W = \frac{1}{2}CV^2$	farad f, μf, pf

Metric Prefixes

Multiplier	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	**pico**	**p**
10^{-9}	**nano**	**n**
10^{-6}	**micro**	**μ**
10^{-3}	**milli**	**m**
10^{-2}	centi	c
10^{-1}	deci	d
$10^{0} = 1$	----	----
10^{1}	deka	da
10^{2}	hecto	h
10^{3}	**kilo**	**k**
10^{6}	**mega**	**M**
10^{9}	**giga**	**G**
10^{12}	**tera**	**T**
10^{15}	peta	P
10^{18}	exa	E

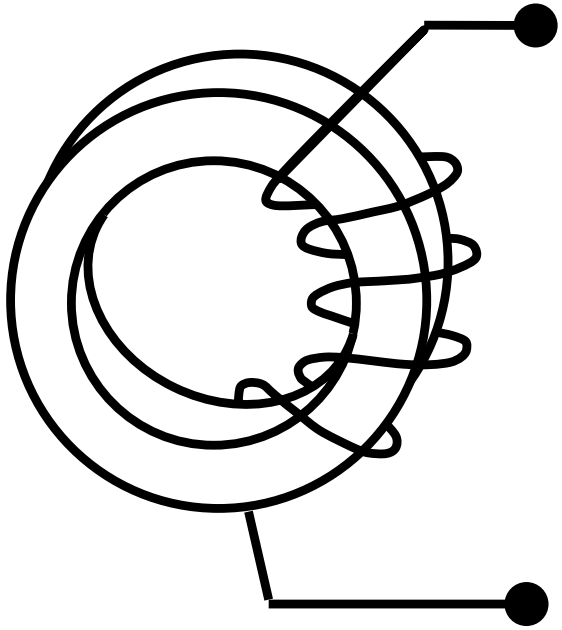
Note the use of lower case letters for multipliers less than one and the use of upper case letters for multipliers greater than 10^6.

Inconsistent usage on "kilo".

Commonly used multipliers shown in **bold**.

Inductance

The inductance of a coil is:



$$L \propto KN^2$$

where

N = number of turns

L = inductance in henries

K = a constant dependent upon geometry and material