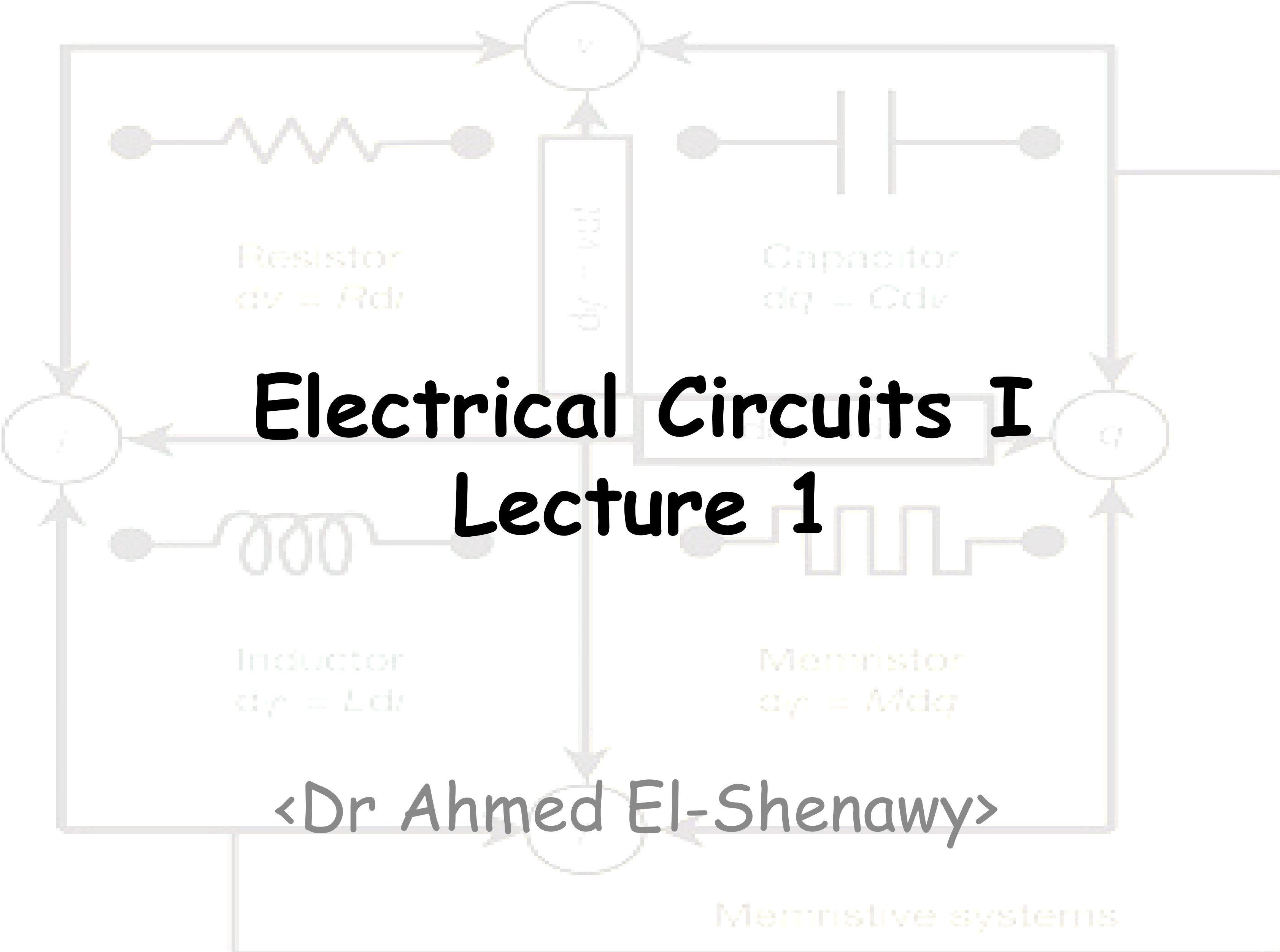

Electrical Circuits I
Lecture 1

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Course Contents

- Basic dc circuit elements, series and parallel Networks
- Ohm's law and Kirchoff's laws
- Nodal Analysis
- Mesh Analysis
- Source Transformation Method
- Superposition Theory
- Thevenin's Theorem and Norton Theorem
- Maximum Power Transfer
- Alternating current Fundamentals and AC generation
- RMS value, average value, form factor and crisp factor
- Phasor concept
- Relation between voltage and current in resistor, capacitor and inductor
- Response of RL and RC circuits
- Sinusoidal response of RLC circuit
- Series Resonance

Introduction

- ➢Electrical systems pervade our lives; they are found in home, school, workplaces, factories, and transportation vehicles-everywhere.
- ➢A circuit model is used to connect our visualization to our analysis of a physical system.
- ➢ The challenge is to develop models that will predict the physical behaviour of real components accurately and result in mathematical equations that can be solved.

Basic Electrical Quantities

Basic quantities: current, voltage and power.

Electric current:

Electric current in a wire is defined as the net amount of charge that passes through the wire per unit time , and is measured in amperes (A).

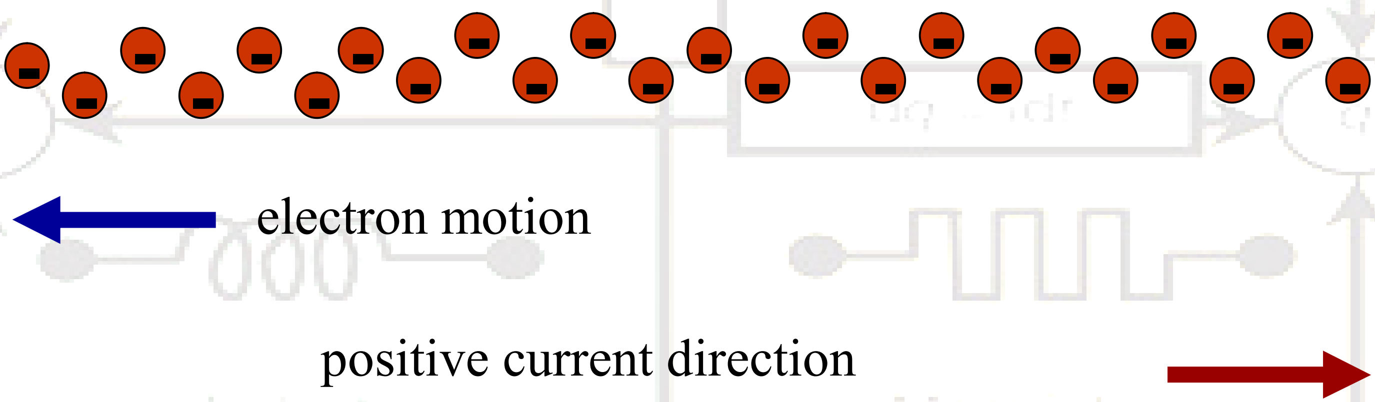
$$i = \frac{dq}{dt}$$

where

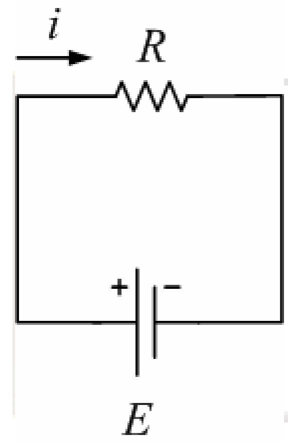
i = current in amperes
q = charge in coulombs
t = time in sec.

- 1 Ampere = 1 Coulomb per second (C/s)
- Current in circuits physically realized by movement of electrons.
- Direction of current must be specified by an arrow.

- By convention, current direction defined as flow of positive charge.
- Note that positive charge is not flowing physically.
- Electrons have negative charge.
- They move in the opposite direction of current.



- In general, current can be an arbitrary function of time.
  Constant current is called direct current (DC).
  Current that can be represented as a sinusoidal function of time (or in some contexts a sum of sinusoids) is called alternating current (AC).



Voltage

Voltage is the energy absorbed or expended as a unit charge moves from one point to the other.

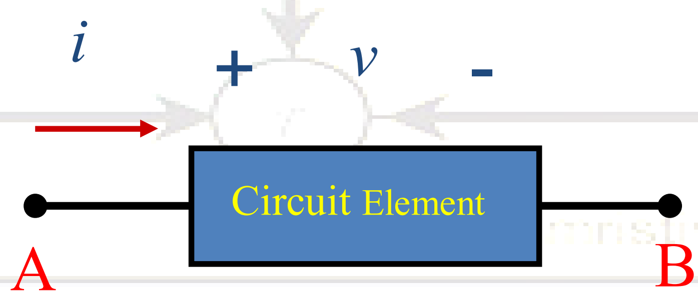
- Analogous to pressure in hydraulic system.
- Sometimes called potential difference.
- Can be created by a separation of charge.
- Is a measure of the potential between two points.
- Voltage pushes charge in one direction.

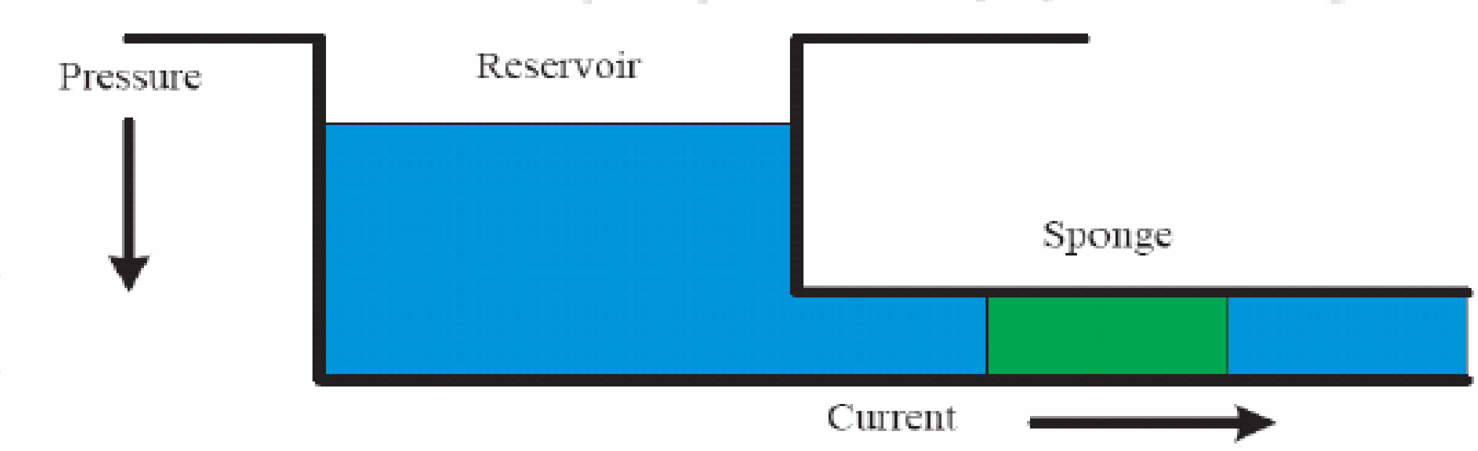
➢We use polarity (+ and – on batteries) to indicates which direction the charge is being pushed

➢Voltage is the energy required to move a unit charge through an element, measured in volts (V)

$$v = \frac{d\omega}{dq}$$

where v = voltage in volts
ω = energy in Joules
q = charge in coulombs





Voltage ~ Pressure

Electric Current ~ Water Current

Sponge ~ Resistance

Electrical Power

Time rate of expending or absorbing energy and is measured by Watts.

$$p = \frac{d\omega}{dt}$$

$$p = \left(\frac{d\omega}{dq}\right)\left(\frac{dq}{dt}\right) = vi$$

where
p = power in watts
ω = energy in Joules
t = time in seconds
q = charge in coulombs
i = current in apperes
v = voltage in volts

By convention

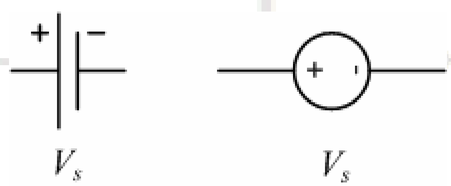
- Circuit elements that absorb power have a positive value of p.
- Circuit elements that produce power have a negative value of p.

Elements of electrical circuits

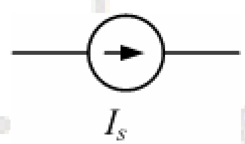
Active elements

Active elements are the elements that can generate energy or power, such as voltage and current sources.

➢Ideally, a voltage source produces V_s volts regardless of the current absorbed or produced by the connected device.



➢ Ideally, a current source produces I_s amps regardless of the current in the connected device.

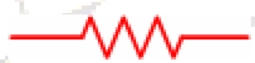


➢In a particular circuit, there can be active elements that absorb power – for example, a battery being charged.

Passive elements

passive elements are the elements that can not generate energy, such as resistors, capacitors and inductors.

resistors

- The ability of a material to resist (impede, obstruct) the flow charge is called its resistivity. It is represented by the letter R.
- A resistor is a circuit element that dissipates electrical energy (usually as heat)
- Real-world devices that are modeled by resistors: incandescent light bulbs, heating elements, long wires
- Resistance is measured in Ohms (Ω)
- Resistor is indicated by the symbol 

➢Resistance of a wire depends on some factors like as length (L), cross-sectional area (A) and resistivity of material (ρ).

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

Where ρ resistivity in Ω.m

L length in m

A cross-section area in m^2

➢The conductance (G) of a pure resistor is the reciprocal of its resistance. The unit of conductance is the siemens (S) or mho (℧).

$$G = \frac{1}{R}$$

Ohm’s Law

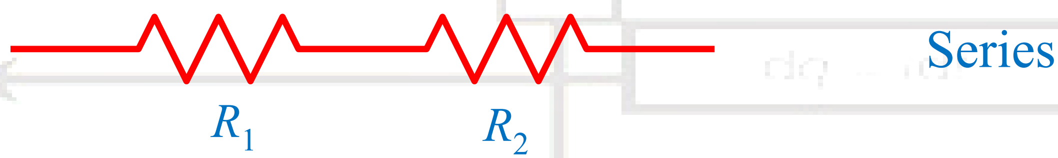
Ohm's law states that the current through a conductor between two points is directly proportional to the potential difference or voltage across the two points, and inversely proportional to the resistance between them.

- The mathematical equation that describes this relationship is:

$$i = \frac{v}{R}$$

where v is the potential difference measured across the resistance in units of volts; i is the current through the resistance in units of amperes and R is the resistance of the conductor in units of ohms.

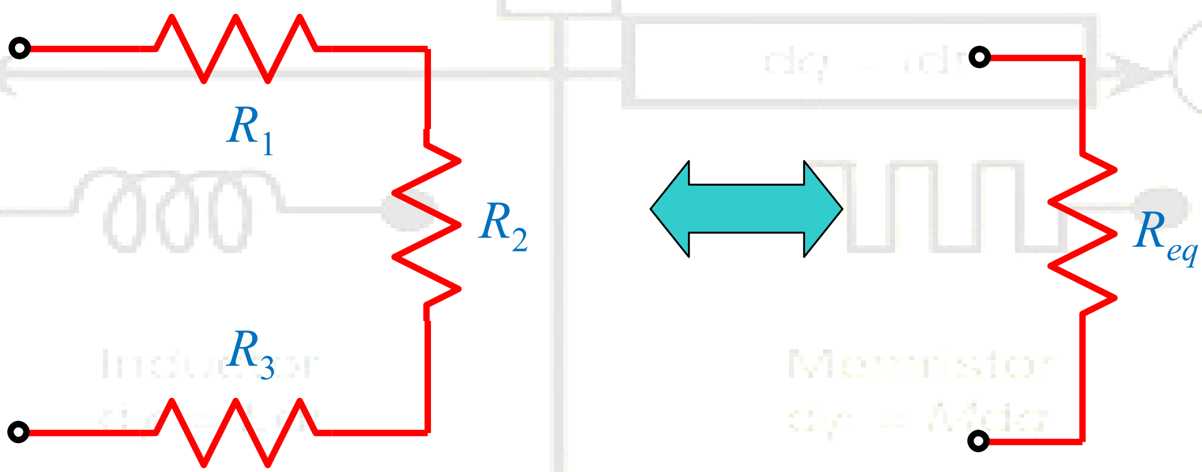
Two elements are in series if the current that flows through one must also flow through the other.



➢ If we wish to replace the two series resistors with a single equivalent resistor whose voltage-current relationship is the same, the *equivalent* resistor has a value given by

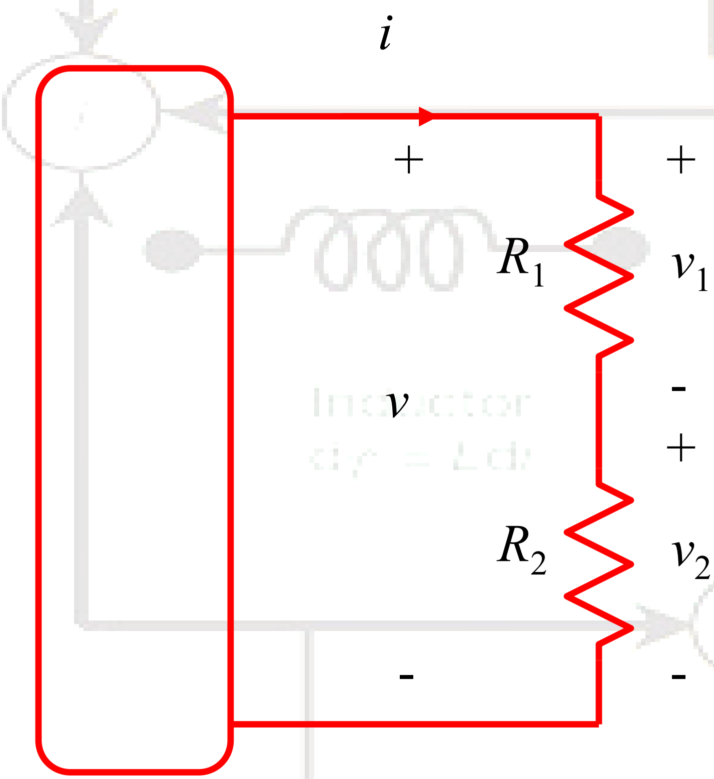
$$R_{eq} = R_1 + R_2$$

- For N resistors in series, the equivalent resistor has a value given by:



$$R_{eq} = R_1 + R_2 + R_3 + \Lambda + R_N$$

- Consider two resistors in series with a voltage v across them:



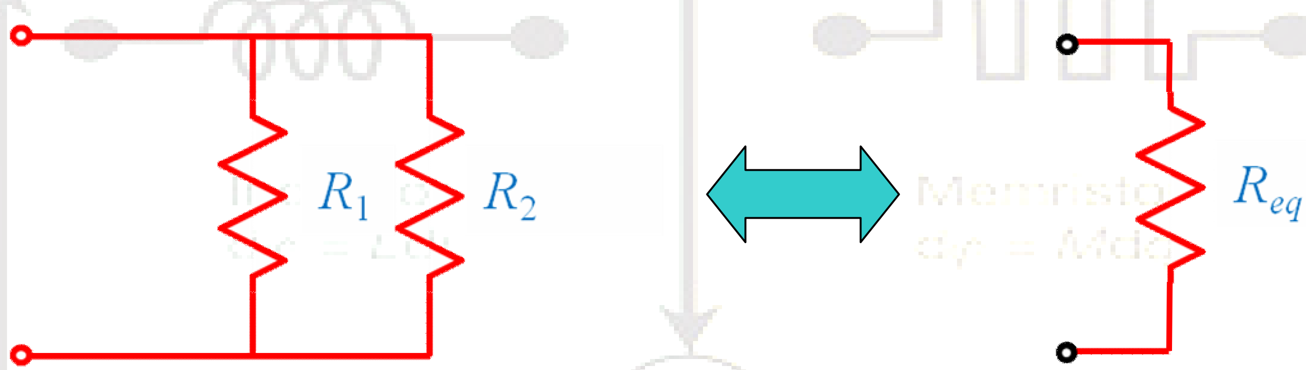
Voltage division:

$$v_1 = v\frac{R_1}{R_1 + R_2}$$

$$v_2 = v\frac{R_2}{R_1 + R_2}$$

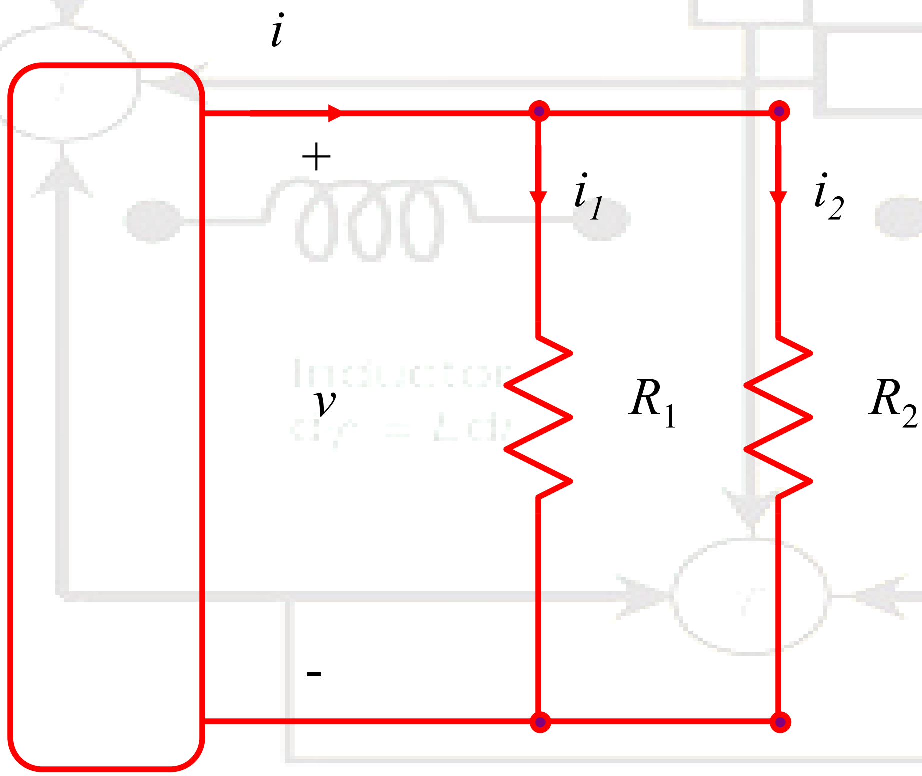
Resistors in Parallel

- When the terminals of two or more circuit elements are connected to the same two nodes, the circuit elements are said to be in parallel.
- If we wish to replace the two parallel resistors with a single equivalent resistor whose voltage-current relationship is the same, the *equivalent* resistor has a value given by



$$R_{eq} = \frac{R_1 R_2}{R_1 + R_2}$$

- Consider two resistors in parallel with a voltage v across them:



Current division:

$$i_1 = i\frac{R_2}{R_1 + R_2}$$

$$i_2 = i\frac{R_1}{R_1 + R_2}$$