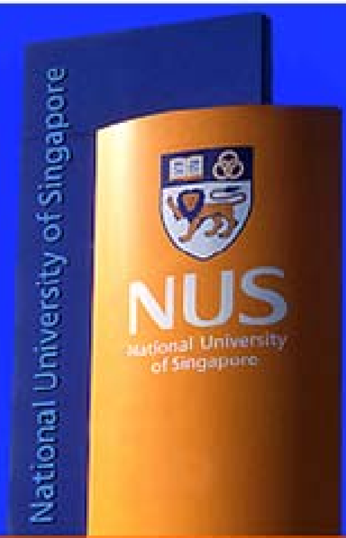

Singapore's Global University

CG1108
Electrical Engineering

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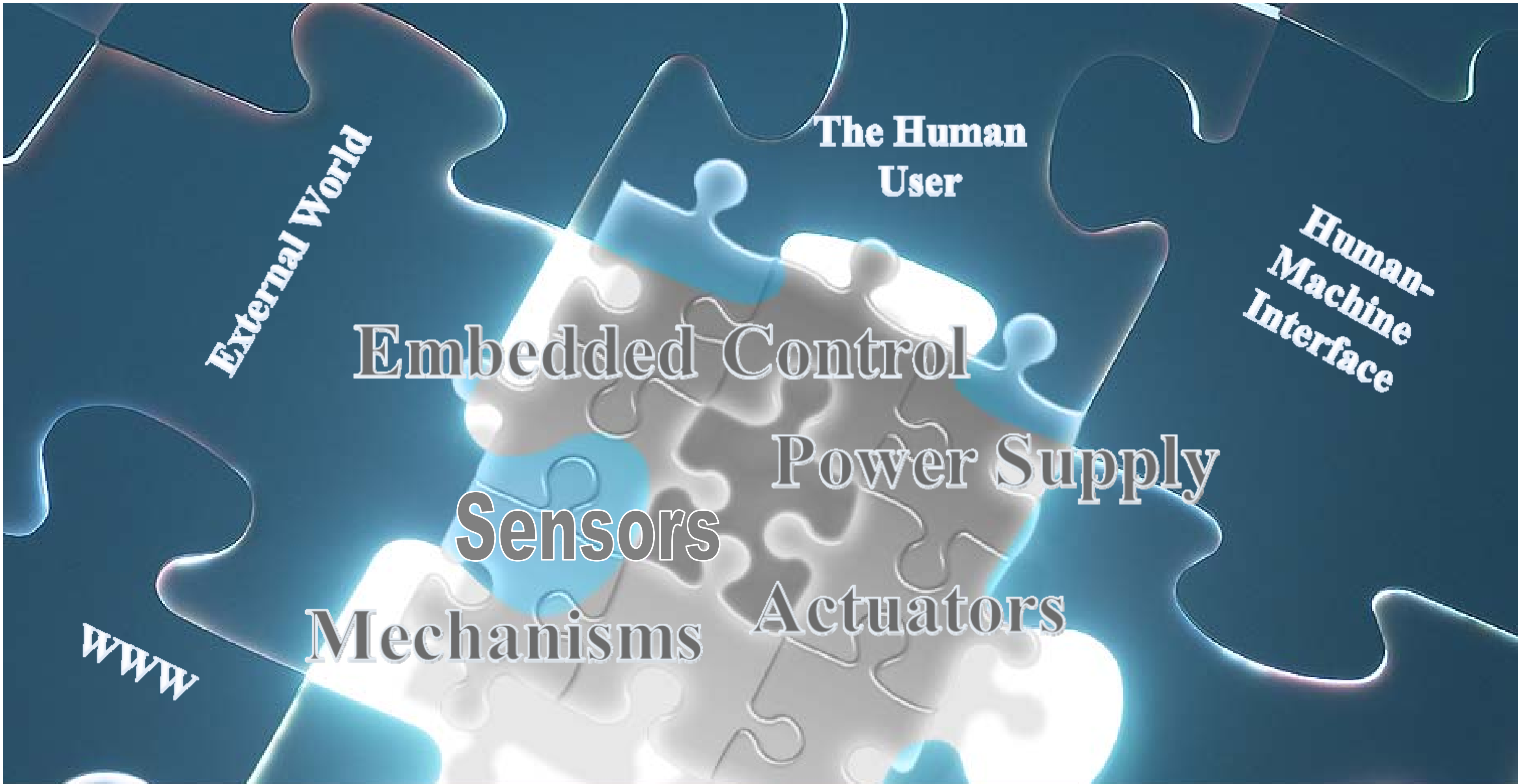


Two main objectives of Electrical Engineering

1. To gather, store, process, transport and present ***information***
2. To distribute, store and convert ***energy*** between various forms

- Allan Hambley (Electrical Engineering 4/e)

8 Major Areas of *EE*

- Communication Systems
- Computer Systems
- Control Systems
- Electromagnetics
- Electronics
- Photonics
- Power Systems
- Signal Processing

- Allan Hambley (Electrical Engineering 4/e)

CG1108 Module Overview

- Module prepared for computer engineering students
- To teach basic circuit principles in electrical engineering
  - DC and AC circuit analysis techniques and applications
  - Mini-projects carried out by students in groups
- In this course students also learn about the importance of resourcefulness, teamwork, integrity and communications.

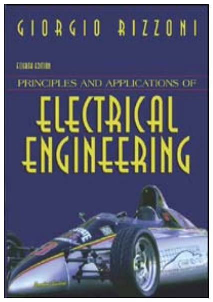
Lecture Outline

- Module outline
- Assessment
- Online tools
- CG1108 Design Challenge
- Topic 1: Fundamental Concepts, Definitions
- Topic 2: Kirchhoff’s Laws, i.e. KCL, KVL

Assessments

ASSESSMENT	PERCENTAGE
Lab and Lab Test	20%
Mid-term Test	10%
Project	30%
Final Exam	40%
Total	**100%**

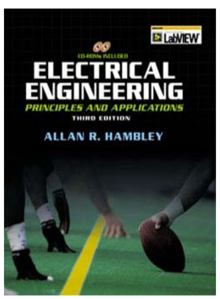
Text & Readings



Reference

Electrical Engineering: Principles and Applications

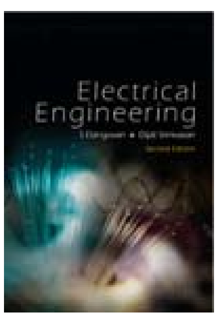
Allan R. Hamley, 3rd edition, 2004



Supplementary

Principles and Applications of Electrical Engineering

Giorgio Rizzoni, 4th edition, 2003



Electrical Engineering

S. Elangovan & Dipti Srinivasan, 2nd edition, 2006

7

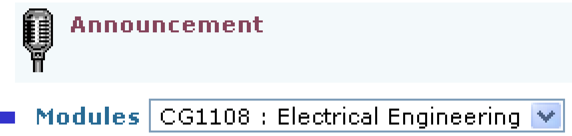
Powerful learning platform

- Annoucement
- Forum
- Workbin

Other useful tools

- Resource banks, Communities and groups, Profile, Chat room, etc

Announcement



Please check announcements regularly

- Important information
- Project submission

Urgent announcement may sent via SMS

- Please update your contact via IVLE profile

Workbin

CG1108
Workbin : Electrical Engineering

To view files, click on the folders.

- Root
  - Lecture Notes (0)
  - Assignments (0)
  - Softwares (0)
  - Student Submission (0)

Download module materials

Search: Search Cancel

Edit	Del				Folder & File Name
					OrCAD105_Demo.zip.001
					OrCAD105_Demo.zip.002
					OrCAD105_Demo.zip.003
					OrCAD105_Demo.zip.004
					OrCAD105_Demo.zip.005
					OrCAD105_Demo.zip.006
					OrCAD105_Demo.zip.007
					OrCAD105_Demo.zip.008

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Folder Expiry Date & Time :	28-Jun-2010 09:44 AM		
Folder Status :	Students can view all files (includes files submitted by other students)		

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Edit	Del			Folder & File Name	Size	Owner	Date

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Homepage

Welcome to use CG1108 homepage

http://my.ece.nus.edu.sg/CG1108/index.htm

To check latest information

Log in using NUSNET account

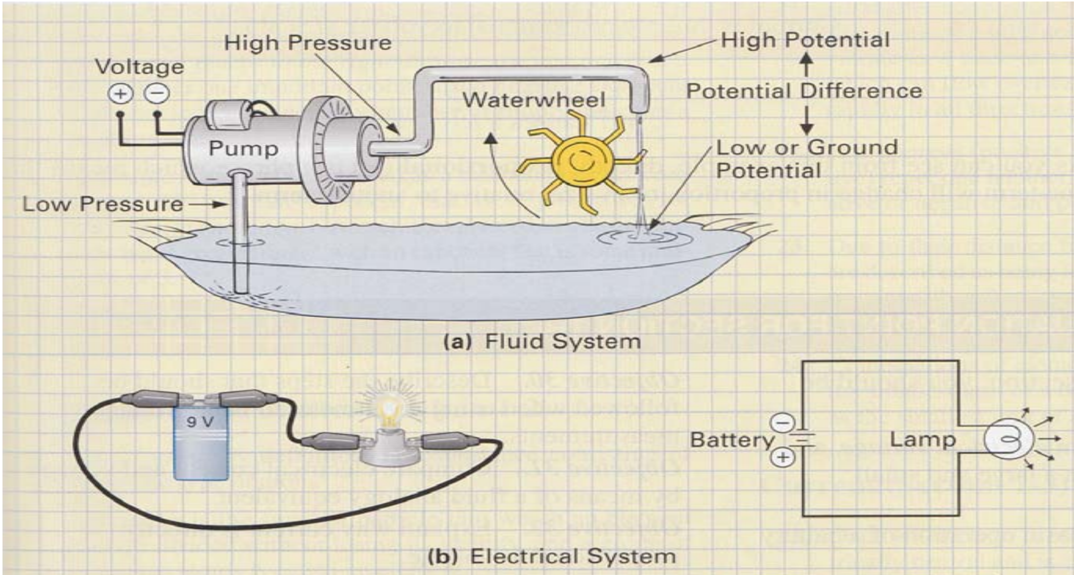
Required NUS intranet or VPN connection

Learning Objectives

1. Be familiar with some electrical quantities like charge (electron), voltage, current and power.
2. Learn about ideal voltage and current source.
3. Apply the passive sign convention.
4. Learn about resistance, resistor and Ohm’s law.
5. Calculate the power dissipated by a resistor.

Fluid Flow Analogy

SOURCE:
Cook, 6e



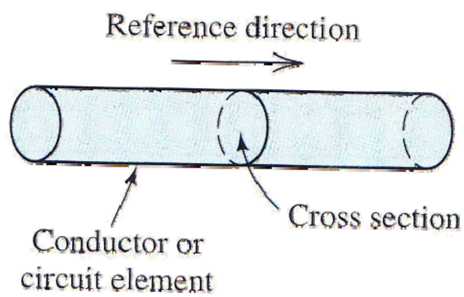
Fluid System	***Electrical System***
Pump	Battery
Water	Charge
Frictionless pipes	Conductors (wires)
Flow rate of the fluid	Electrical current
Valves	Switches
Restriction of flow	Electrical resistance

- Current is a measure of the flow of charge *through* the cross section of a circuit element.
- Voltage is measured *across* the ends of a circuit element or *between* any other two points in a circuit.

Electrical Current

Hambley, 4e

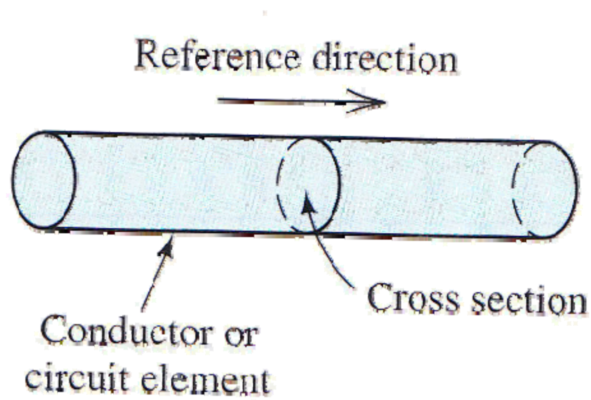
- Electrical current is the time rate of flow of electrical charge through a conductor or circuit element.
- The units are amperes (A), which are equivalent to coulombs per second (C/s).
- The charge on an electron is -1.602×10^{-19} C.
- Conceptually, to find the current for a given circuit element, we first select a cross section of the circuit element roughly perpendicular to the flow of current.



- Then, we select a reference direction along the direction of flow. Thus, the reference direction points from one side of the cross section to the other.

Electrical Current

Hambley, 4e



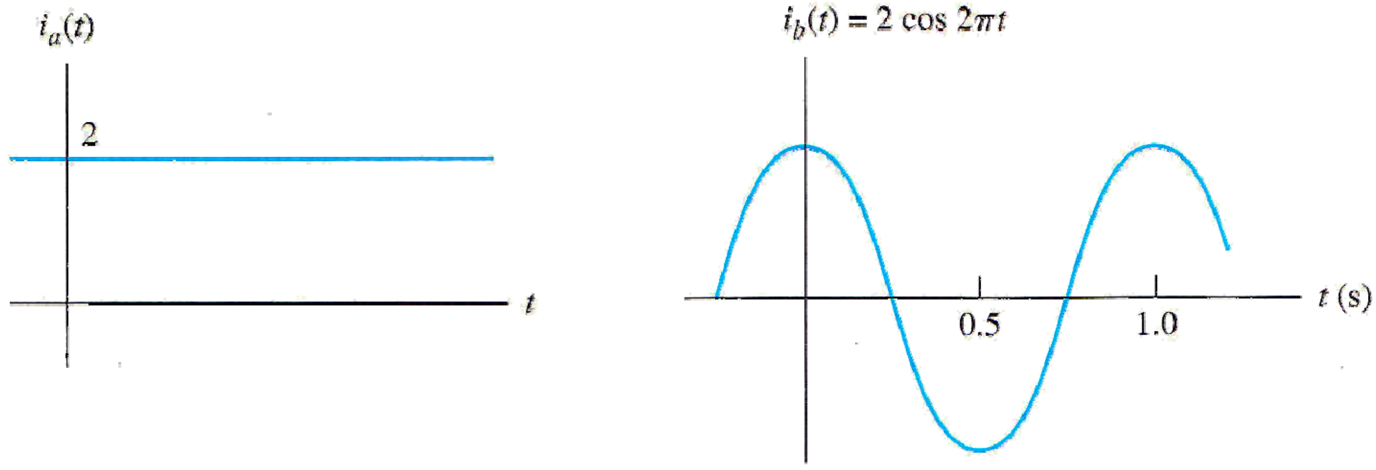
- We obtain a record of the net charge as a function of time denoted as q(t).
- The electrical current flowing through the element in the reference direction is given by:

$$i(t) = \frac{dq(t)}{dt}$$

- A constant current of one ampere means that one coulomb of charge passes through the cross section each second.

Direct Current and Alternating Current

Hambley, 4e



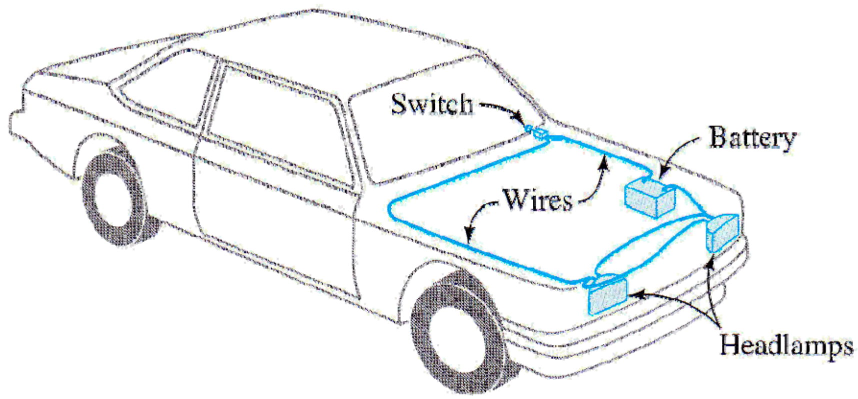
(a) Dc current

(b) Ac current

- When a current is constant with time, we say that we have direct current, abbreviated as dc.
- A current that varies with time, reversing direction periodically, is called alternating current, abbreviated as ac.

Voltages

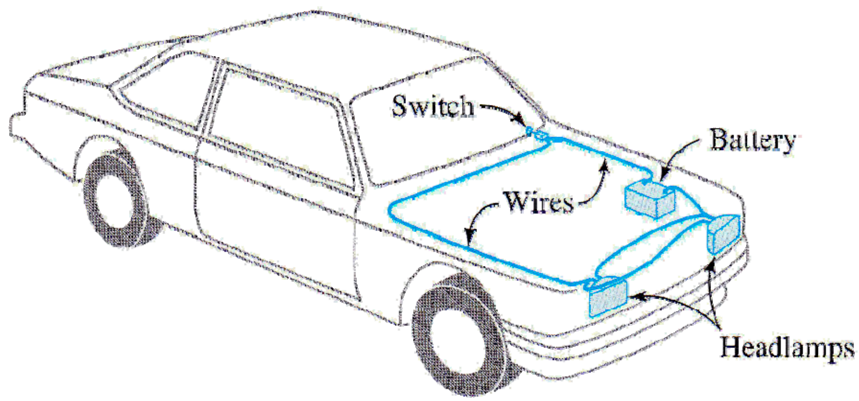
Hambley, 4e



- When charge moves through circuit elements, energy can be transferred.
- The **voltage** associated with a circuit element is the energy transferred per unit of charge that flows through the element.
- The units of voltage are volts (V), which are equivalent to joules per coulomb (J/Q).

Voltages

Hambley, 4e



- The voltage across its terminals is (nominally) 12 V. This means that 12 J are transferred to or from the battery for each coulomb that flows through it.
- When charge flows in one direction, energy is supplied by the battery, appearing elsewhere in the circuit as heat or light or perhaps as mechanical energy at the starter motor.
- If charge moves through the battery in the opposite direction, energy is absorbed by the battery, where it appears as stored chemical energy.

Power

Voltage = Energy per unit charge

Current = Charge per unit time

Voltage x Current = Energy per unit time

Power = Voltage x Current

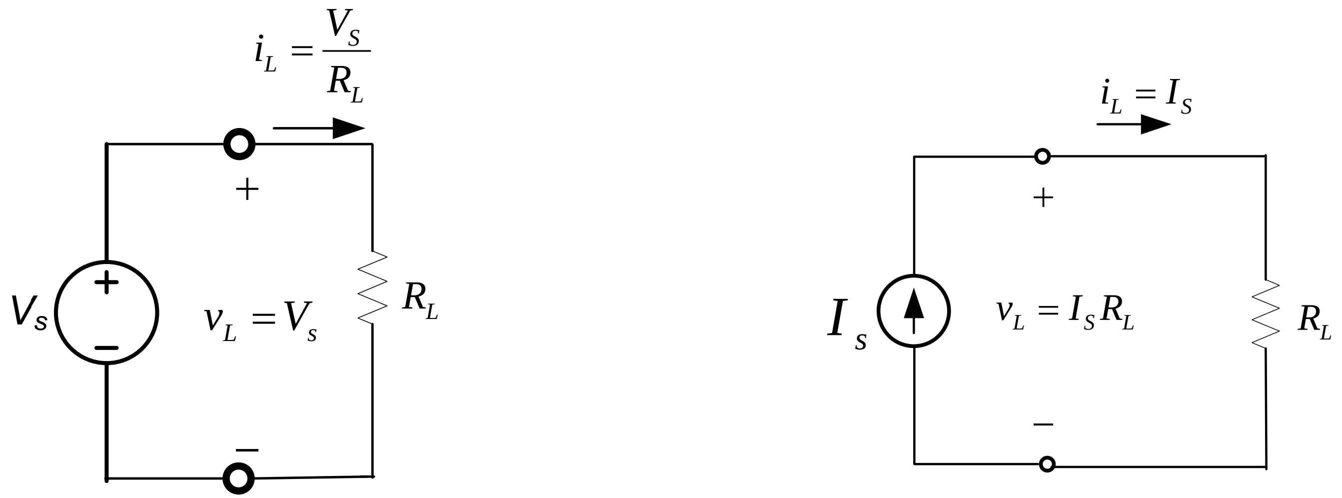
Sources

- Various sources of electrical energy
  - Batteries
  - Electric Generators
  - Fuel Cells
  - Solar panels

- All electrical sources have voltage and current at their output, which is a measure of the power output.

- Sources are classified as either voltage source or current source.

Voltage Source or Current Source

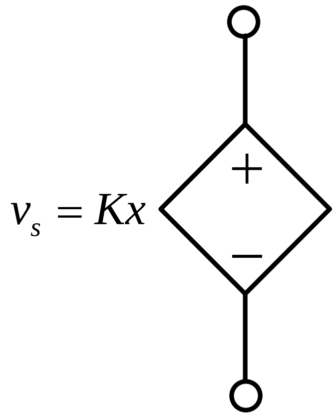


- An ideal voltage source maintains the voltage across its terminals irrespective of the current flowing through it.

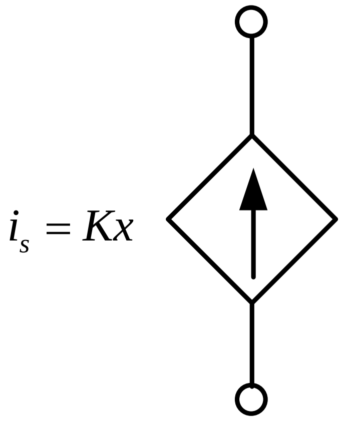
- An ideal independent current source forces a specified current to flow through itself, irrespective of the voltage across it.

Dependent source

- If the characteristic output of the source is dependent on any other variable (current or voltage) in another part of the circuit, then it is known as dependent source
- Otherwise, it's known as independent source



Dependent voltage source



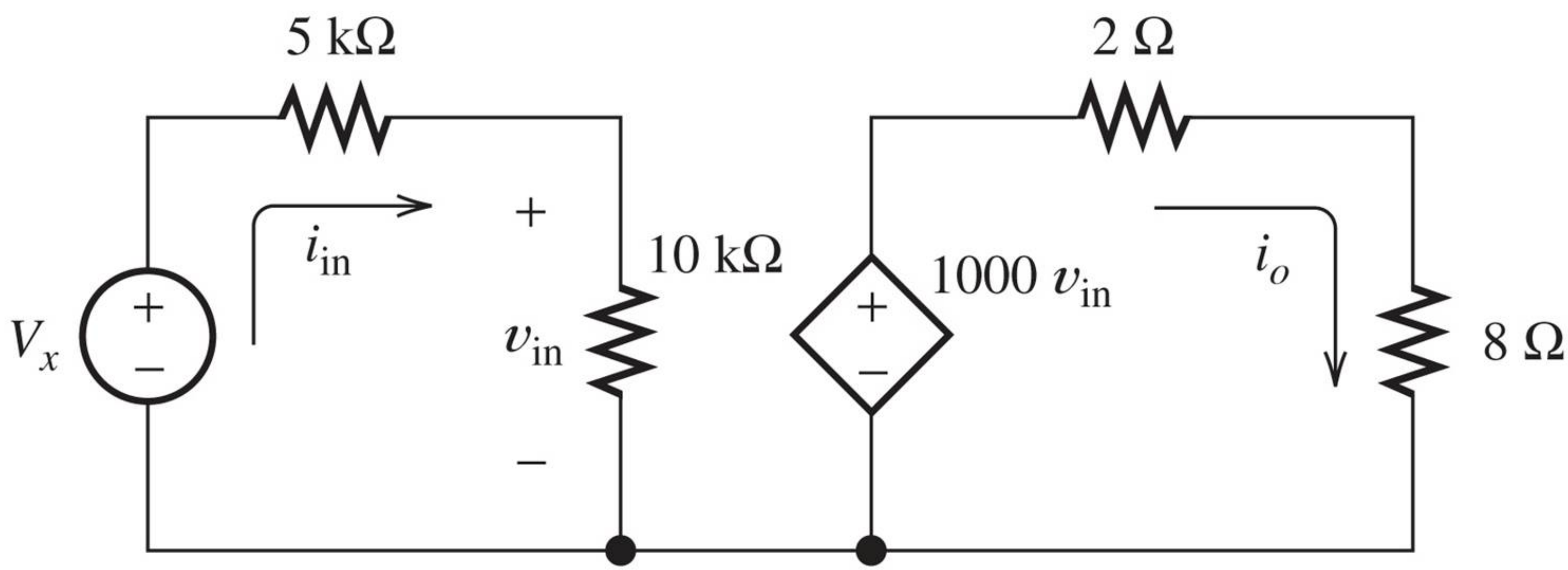
Dependent current source

Different types of dependent source

- Voltage controlled voltage source
- Current controlled voltage source
- Voltage controlled current source
- Current controlled current source

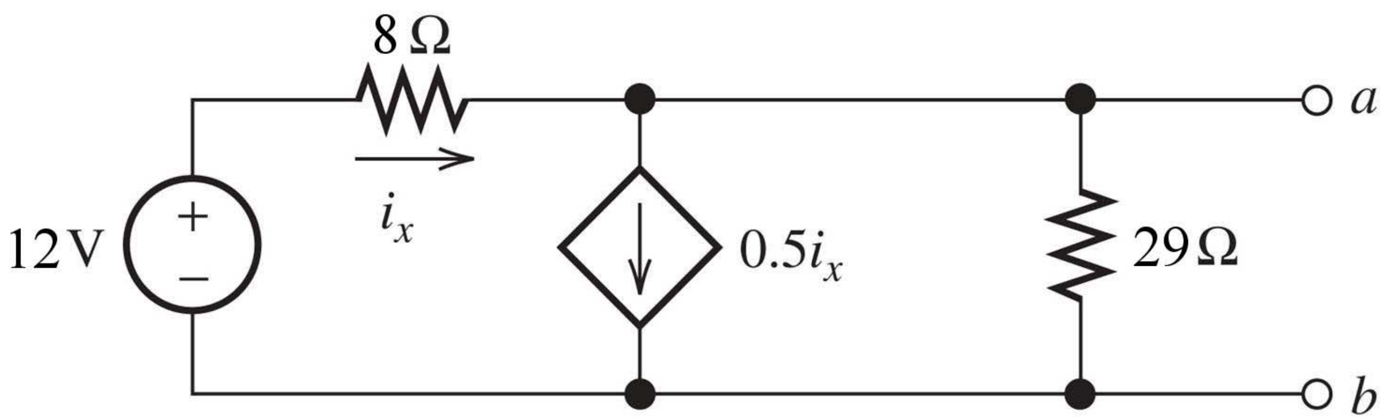
Example 1: Voltage controlled voltage source

The circuit in the Figures is the electrical model for an electronic megaphone, in which the 8 Ω resistance models a loudspeaker, the source V_x and the 5 kΩ resistance represent a microphone, and the remaining elements model an amplifier. Given that the power delivered to the 8 Ω resistance is 8 W, determine the current circulating in the right-hand loop of the circuit. Also, determine the value of the microphone voltage V_x.



Example 2: Voltage controlled current source

Find the Thévenin and Norton equivalent circuits for the circuit below:



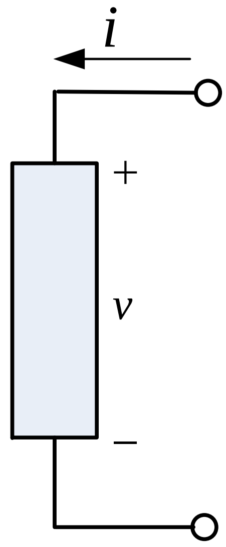
Power and Sign Convention

- Power generation
  - When charge moves from negative voltage polarity to positive polarity, it gains energy
- Power dissipation
  - When charge moves from positive voltage polarity to negative polarity

Passive sign convention

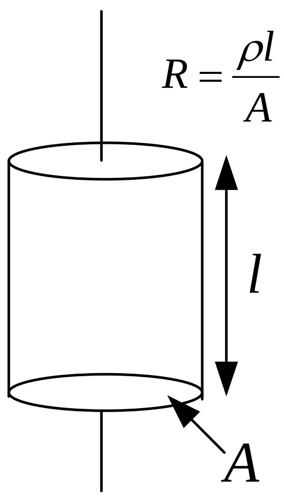
- Reference direction (positive current direction) for current is to enter into the positive voltage terminal of the element

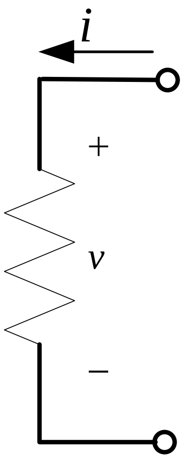
- i-v characteristics for various circuit elements will follow this sign convention

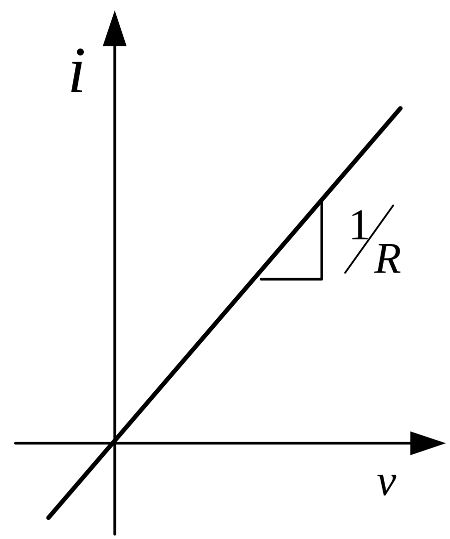


Resistance and Ohm's Law

- When current flows through a metal wire or other circuit elements, it encounters some resistance.
- This resistance related to the material and size of the element.





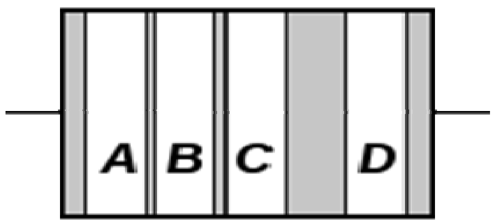


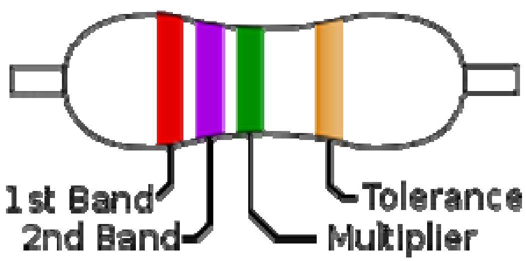
Ohm's law $v = iR$

Resistivity of common materials at room temperature

Material	Resistivity (Ohm-meter)
Aluminum	2.733×10^{-8}
Copper	1.725×10^{-8}
Gold	2.271×10^{-8}
Iron	9.98×10^{-8}
Nickel	7.20×10^{-8}
Platinum	10.8×10^{-8}
Carbon	3.5×10^{-8}

Resistor Color Code Reading





Resistance = AB x 10^C

Color	Significant figures	Multiplier	Tolerance
Black	0	$\times 10^0$	–
Brown	1	$\times 10^1$	±1%
Red	2	$\times 10^2$	±2%
Orange	3	$\times 10^3$	–
Yellow	4	$\times 10^4$	–
Green	5	$\times 10^5$	±0.5%
Blue	6	$\times 10^6$	±0.25%
Violet	7	$\times 10^7$	±0.1%
Gray	8	$\times 10^8$	±0.05%
White	9	$\times 10^9$	–
Gold	–	$\times 10^{-1}$	±5%
Silver	–	$\times 10^{-2}$	±10%
None	–	–	±20%

Mnemonics

- *Better Build Roof Over Your Garage Before Vehicle Gets Wet*
- *Better Be Right Or Your Great Big Venture Goes West*
- *Bye Bye Rosie, Off You Go, Bristol Via Great Western*
- *Bad Beer Rots Our Young Guts But Vodka Goes Well*
- *Bill Brown Realized Only Yesterday Good Boys Value Good Work*

Power in resistors

- Power is the product of voltage and current.

$$p = vi$$

$$v = iR$$

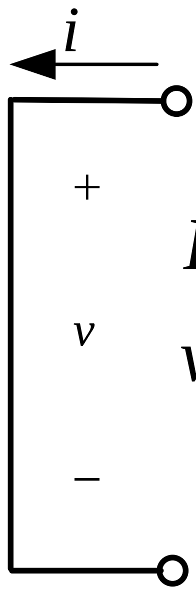
$$p = i^2 R$$

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

$$p = \frac{v^2}{R}$$

- Thus, power in a resistor is always positive

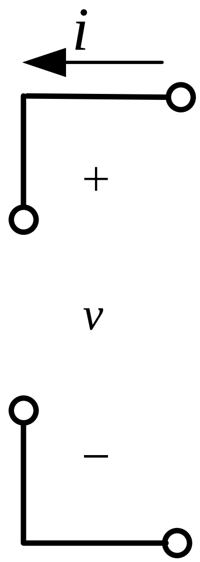
Short Circuit and Open Circuit



$$R = 0$$

$$v = 0 \text{ for any } i$$

Short Circuit



$$R = \infty$$

$$i = 0 \text{ for any } v$$

Open Circuit

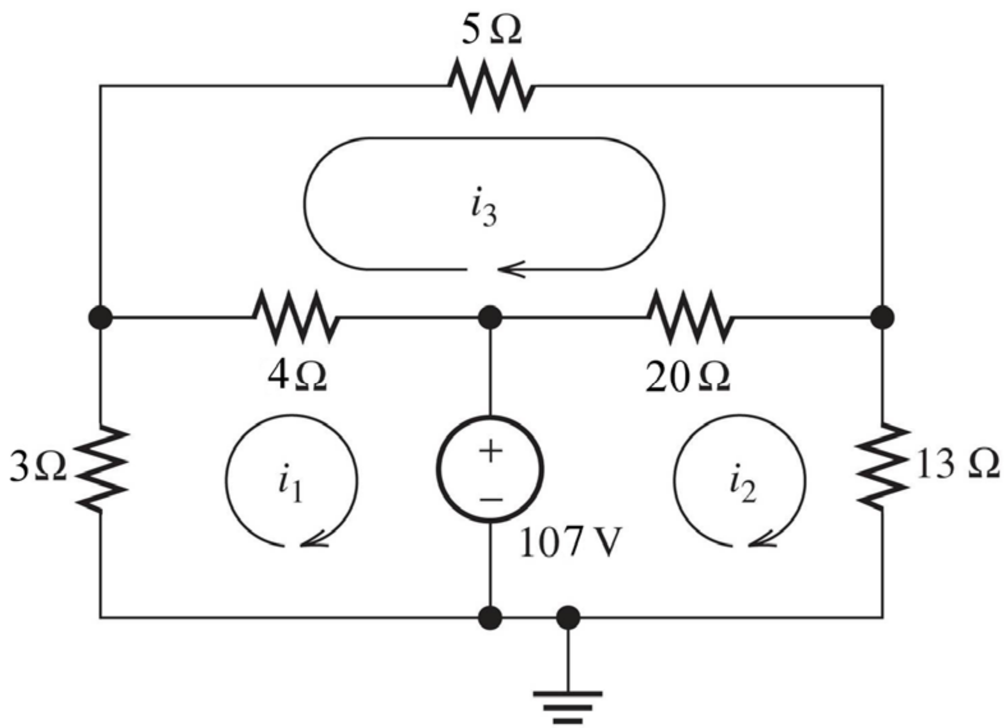
Topic 2

Learning objectives:

1. Identify the principal elements of electric circuits: nodes, loops, meshes, branches,
2. Apply Kirchhoff's laws to simple electric circuits and derive the basic circuit equations.
3. Apply the voltage and current divider laws
4. Analyze simple series, parallel circuits.
5. Understand the rules for connecting electric measuring instruments to electric circuits.

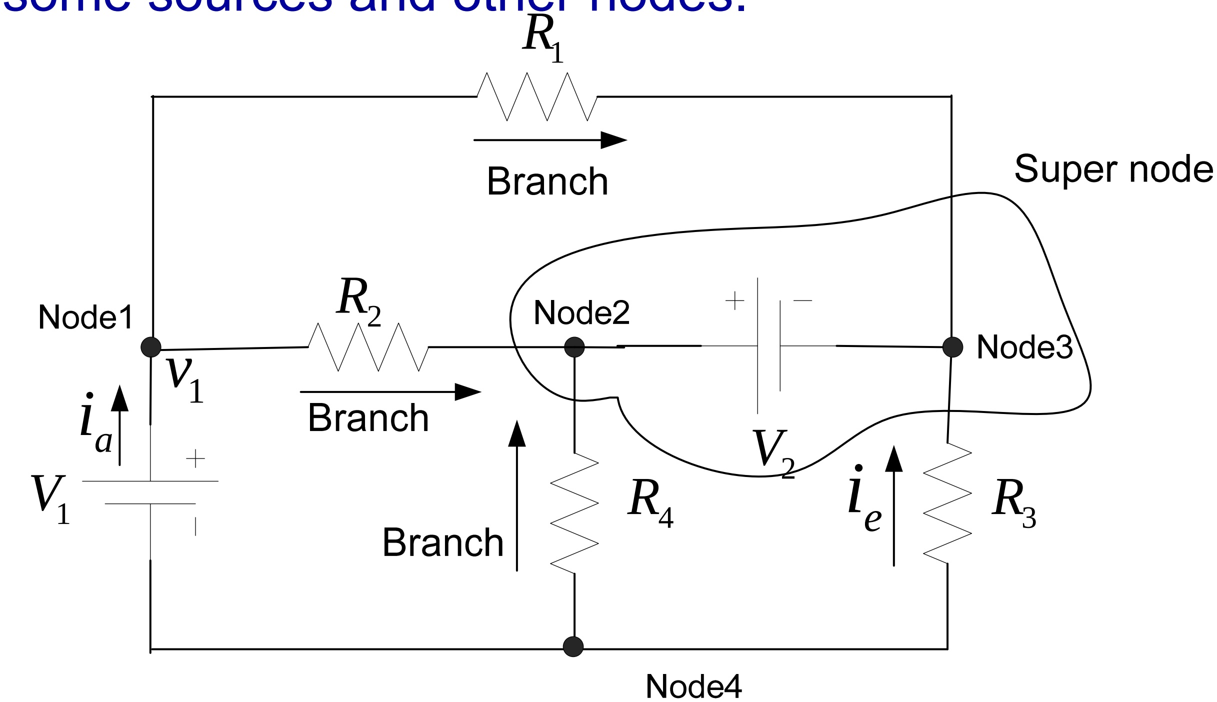
Network/circuit Analysis

- Finding the voltage and/or current at different parts of the circuit is known as circuit analysis



Node, branch, supernode defined

- A node in an electrical circuit is a point at which two or more elements are joined together.
- Any portion of the circuit with two terminals connected is known as a branch.
- A super node is a closed surface enclosing part of a circuit. It may contain some sources and other nodes.

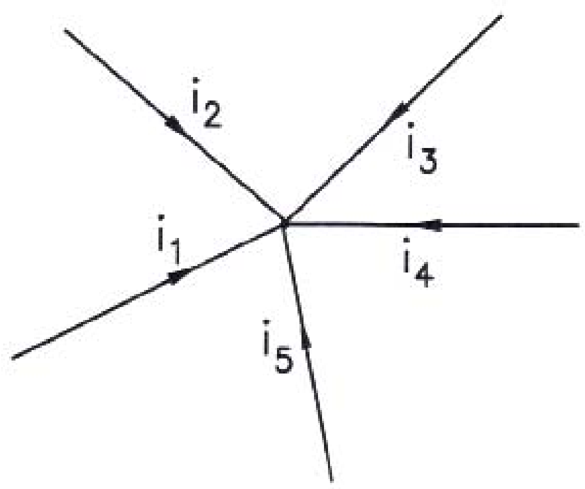


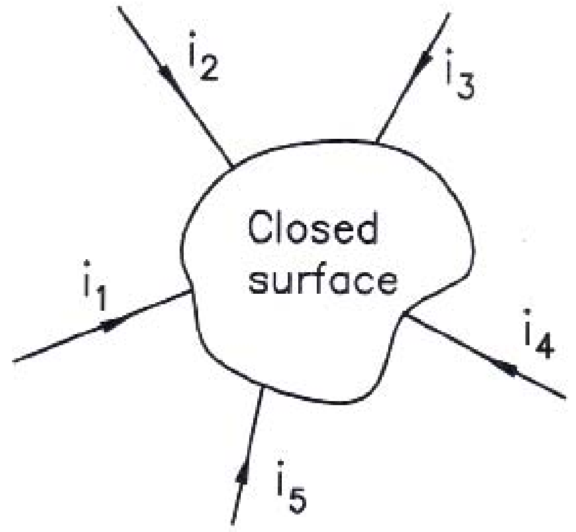
Kirchoff's Current Law (KCL)

- the net current entering a node is zero

  Or

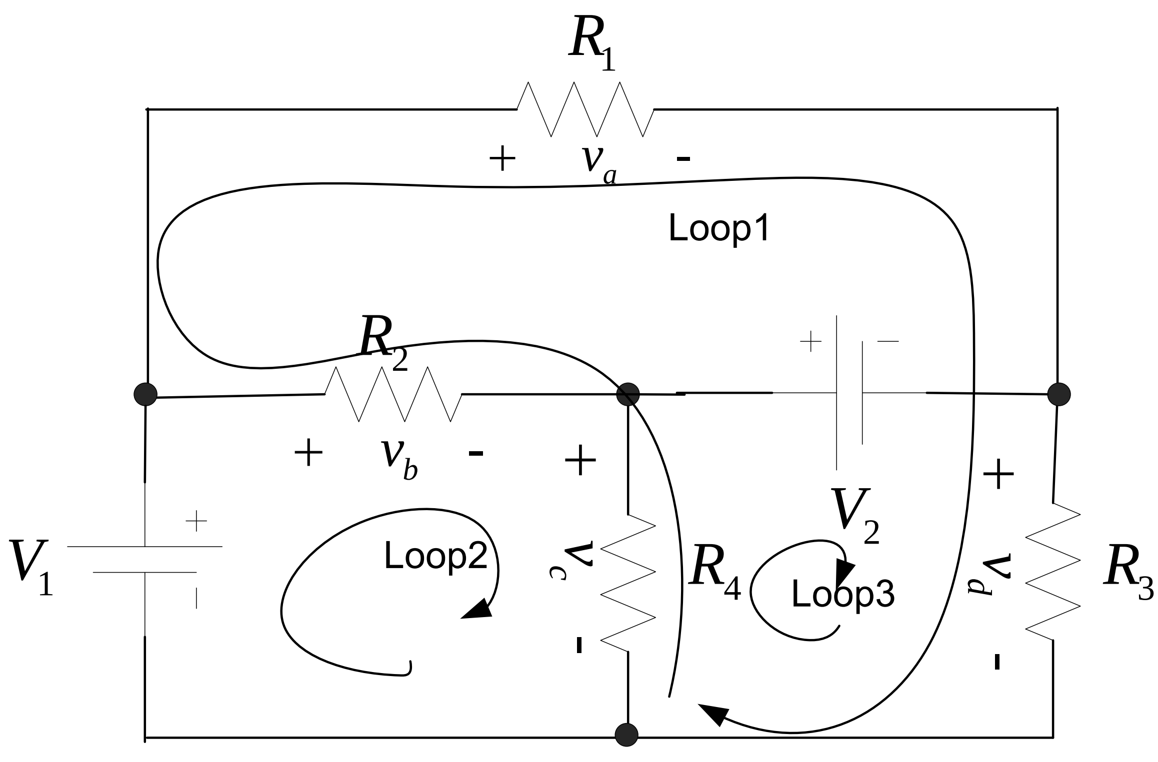
- the net current leaving a node is equal to zero





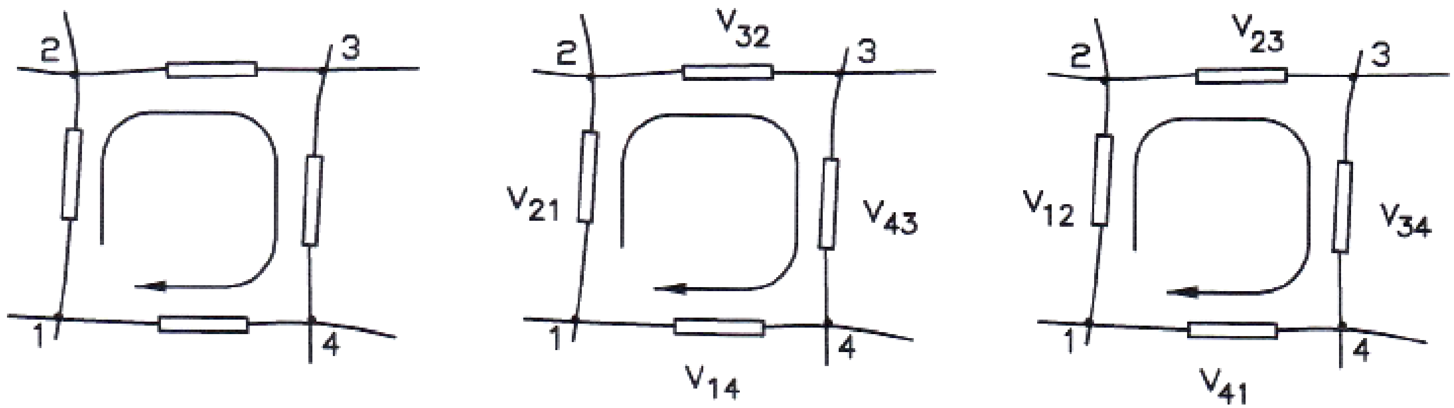
Mesh, Loop

- A mesh is a closed path in the circuit.
- A loop is also a closed path in the circuit.
- A mesh is a loop that does not contain other loops.



Kirchoff's Voltage Law (KVL)

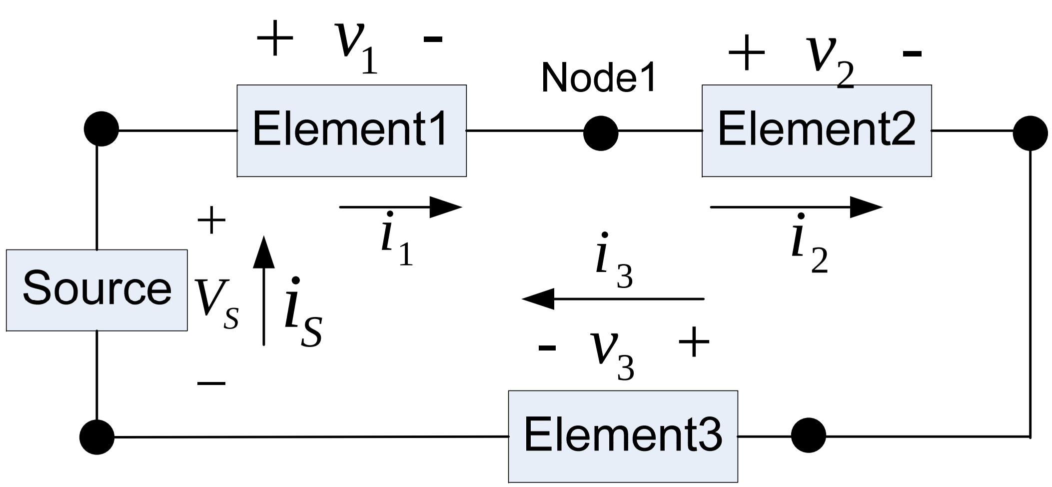
- The sum of voltage rise (or voltage fall) around a loop (closed path) is equal to zero.
- Voltage rises when we go from negative polarity to positive polarity.
- Voltage falls when we go from positive polarity to negative polarity.



(a) Closed circuit. (b) Potential rise across elements. (c) Potential drop across elements.

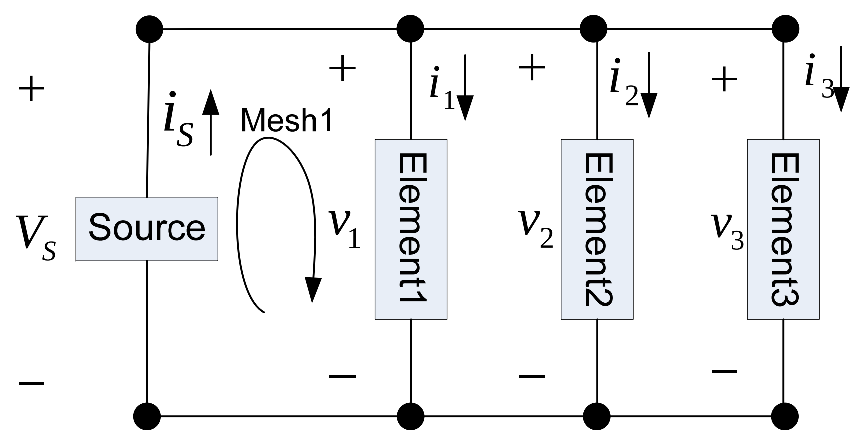
Series Circuit

- When elements are connected end to end they carry the same current.
- Apply KCL at any node to find the current.

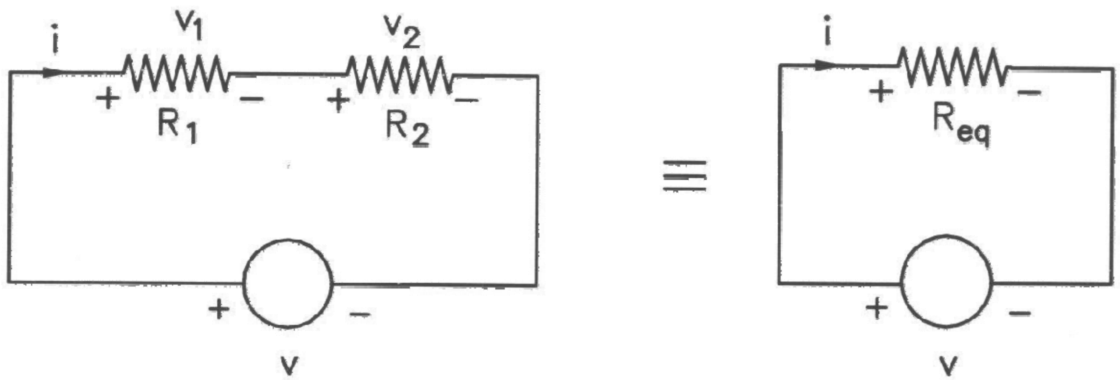


Parallel Circuit

- If both ends of one elements are connected to the corresponding ends of the other element, we call it a parallel circuit.
- Voltages across the elements are identical (KVL)



Series Connection of Resistors



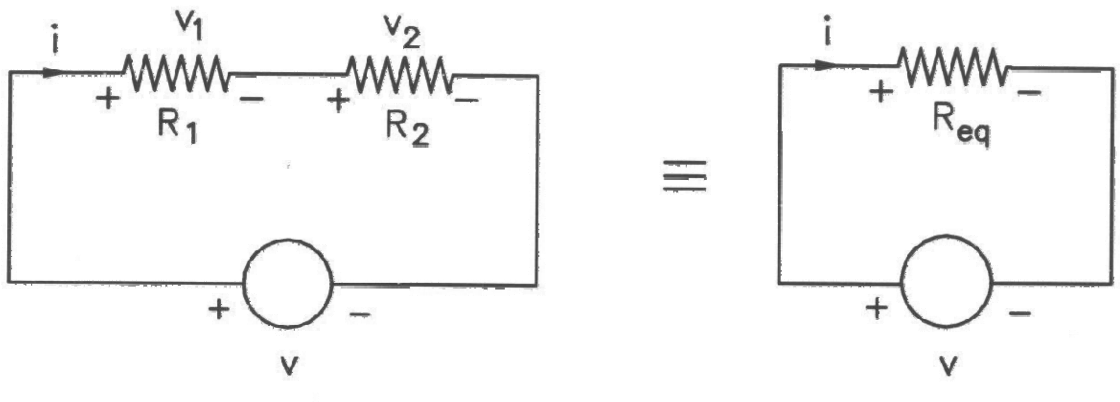
- Two resistors R_1, and R_2 are connected in series. The current flow through these two resistors is the same i.

$$\begin{aligned} v_1 &= i\,R_1 \\ v_2 &= i\,R_2 \\ v &= v_1 + v_2 = i\,R_1 + i\,R_2 \\ &= i\,(R_1 + R_2) = i\,R_{eq} \end{aligned}$$

- R_{eq} of two resistors connected in series is obtained as follows.

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

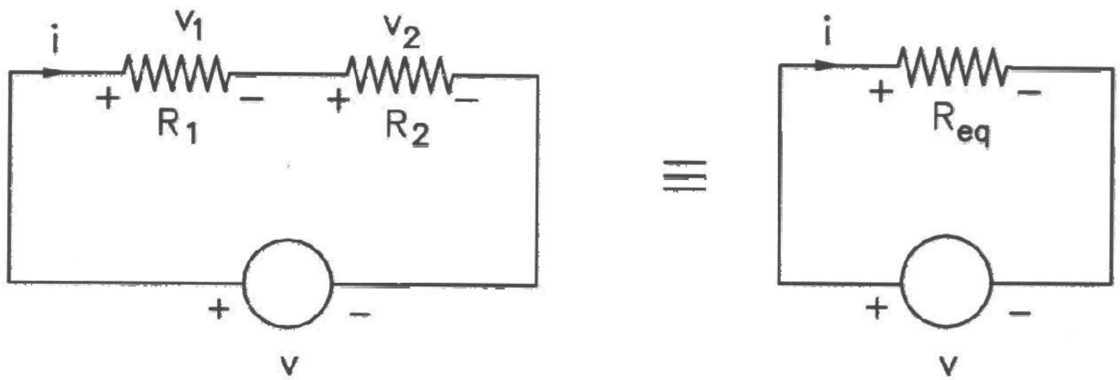
Series Connection of Resistors



- If *n* resistors are connected in series, the equivalent resistance will be:

$$R_{eq} = R_1 + R_2 + \ldots + R_n$$

Voltage Division Method



- Find the voltages across the resistors R_1, and R_2 of the circuit above

$$\begin{aligned} v_1 &= i\,R_1 \\ v_2 &= i\,R_2 \\ v &= v_1 + v_2 = i\,R_1 + i\,R_2 \\ &= i\,(R_1 + R_2) = i\,R_{eq} \end{aligned} \quad \Longrightarrow \quad i = \frac{v}{R_1 + R_2}$$

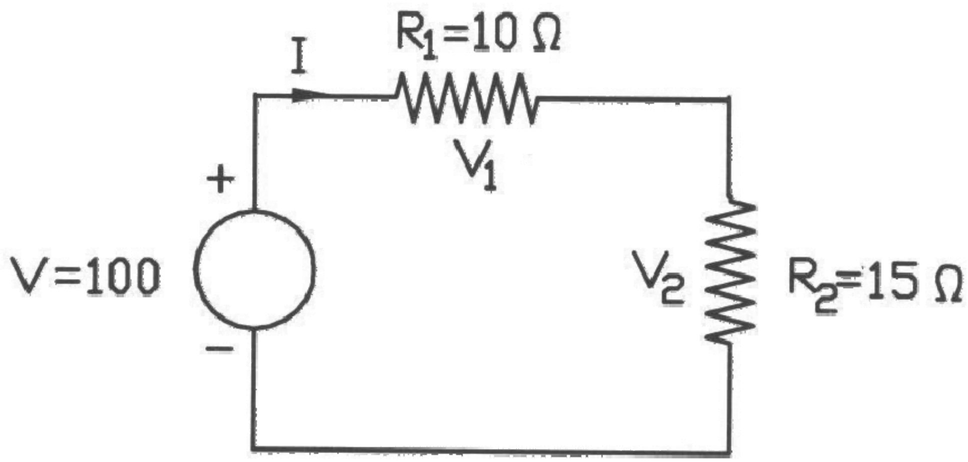
- Substituting for *i* in the equations above, we get:

$$\begin{aligned} v_1 &= i\,R_1 = \frac{R_1}{R_1 + R_2}\,v \\ v_2 &= i\,R_2 = \frac{R_2}{R_1 + R_2}\,v \end{aligned}$$

The applied voltage *v* is divided between these two resistors in proportion to their resistances. This is known as the **Voltage Division Method.**

Series Connection of Resistors - Example

- Determine the current flow and voltages across the resistors.

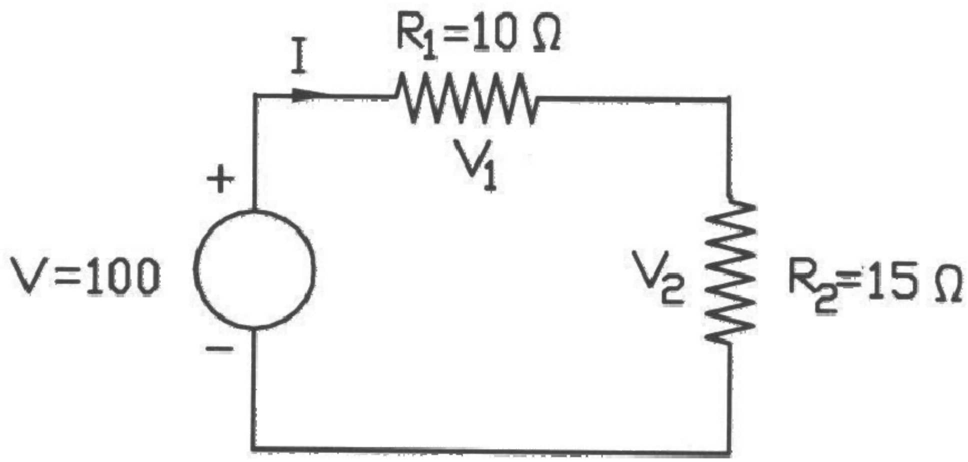


- The two resistors are connected in series:

$$
\begin{aligned}
R_{eq} &= 10 + 15 = 25\Omega \\
I &= \frac{V}{R_{eq}} = \frac{100}{25} = 4 \ \text{A} \\
V_1 &= R_1 \times I = 10 \times 4 = 40 \ \text{V} \\
V_2 &= R_2 \times I = 15 \times 4 = 60 \ \text{V}
\end{aligned}
$$

Series Connection of Resistors - Example

- Determine the current flow and voltages across the resistors.

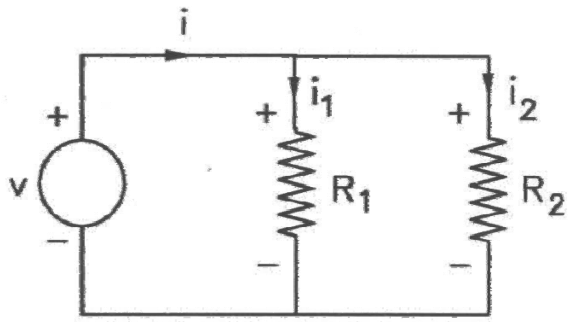


- Using voltage division method, V_1, and V_2 may be obtained as:

$$V_1 = \frac{R_1}{R_1 + R_2} \times V = \frac{10}{25} \times 100 = 40 \text{ V}$$

$$V_2 = \frac{R_2}{R_1 + R_2} \times V = \frac{15}{25} \times 100 = 60 \text{ V}$$

Parallel Connection of Resistors



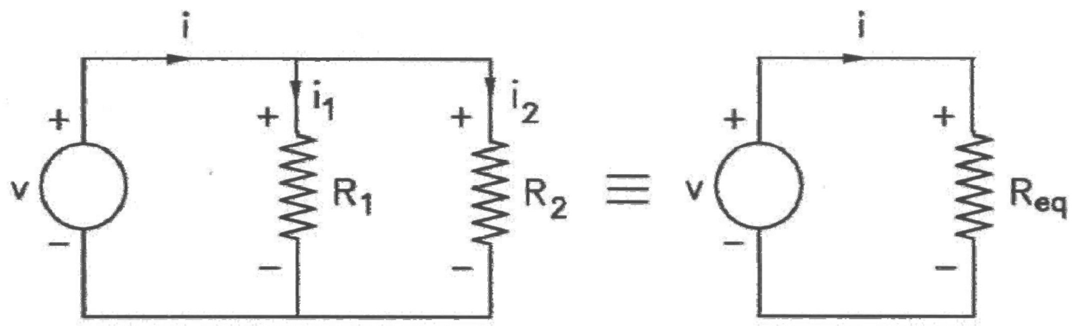
$$i_1 = \frac{v}{R_1}$$

$$i_2 = \frac{v}{R_2}$$

- Two resistors R_1, and R_2 are connected in parallel. The voltage applied across these two resistors is the same *v*.

$$\begin{aligned} i &= i_1 + i_2 = \frac{v}{R_1} + \frac{v}{R_2} \\ &= \left(\frac{1}{R_1} + \frac{1}{R_2}\right) v \\ &= \frac{v}{R_{eq}} \end{aligned}$$

Parallel Connection of Resistors



- R_{eq} of two resistors connected in parallel is obtained as follows:

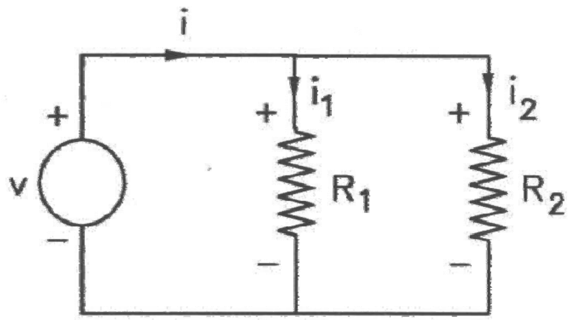
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{R_1 + R_2}{R_1 R_2}$$

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

- If n resistors are connected in parallel, the equivalent resistance will be given by:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}$$

Parallel Connection of Resistors



- Let us determine the currents i_1, and i_2 in the resistors R_1, and R_2

$$i = i_1 + i_2 = \frac{v}{R_1} + \frac{v}{R_2}$$

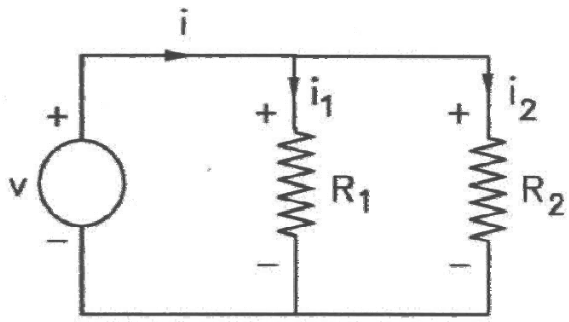
$$= \left(\frac{1}{R_1} + \frac{1}{R_2}\right) v$$

$$= \frac{v}{R_{eq}} \quad \Longrightarrow \quad v = R_{eq}\, i = \frac{R_1 R_2}{R_1 + R_2}\, i$$

- Substituting for v in $i_1 = \frac{v}{R_1}$ we get: $i_1 = \frac{v}{R_1} = \frac{1}{R_1} \times \frac{R_1 R_2}{R_1 + R_2}\, i = \frac{R_2}{R_1 + R_2}\, i$

$i_2 = \frac{v}{R_2}$ $\qquad i_2 = \frac{v}{R_2} = \frac{1}{R_2} \times \frac{R_1 R_2}{R_1 + R_2}\, i = \frac{R_1}{R_1 + R_2}\, i$

Current Division Method



- Let us determine the currents i_1, and i_2 in the resistors R_1, and R_2

$$i_1 = \frac{v}{R_1} = \frac{1}{R_1} \times \frac{R_1 R_2}{R_1 + R_2} i = \frac{R_2}{R_1 + R_2} i$$

$$i_2 = \frac{v}{R_2} = \frac{1}{R_2} \times \frac{R_1 R_2}{R_1 + R_2} i = \frac{R_1}{R_1 + R_2} i$$

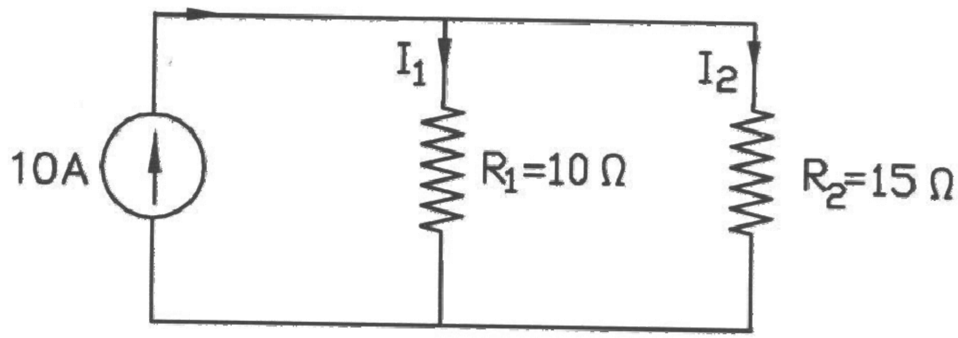
The current divides in inverse proportion of the resistance. This is known as the **Current Division Method.**

- The ratio of the currents in the two parallel paths is:

$$\frac{i_1}{i_2} = \frac{R_2}{R_1}$$

Parallel Connection of Resistors - Example

- Determine the current through the resistors:

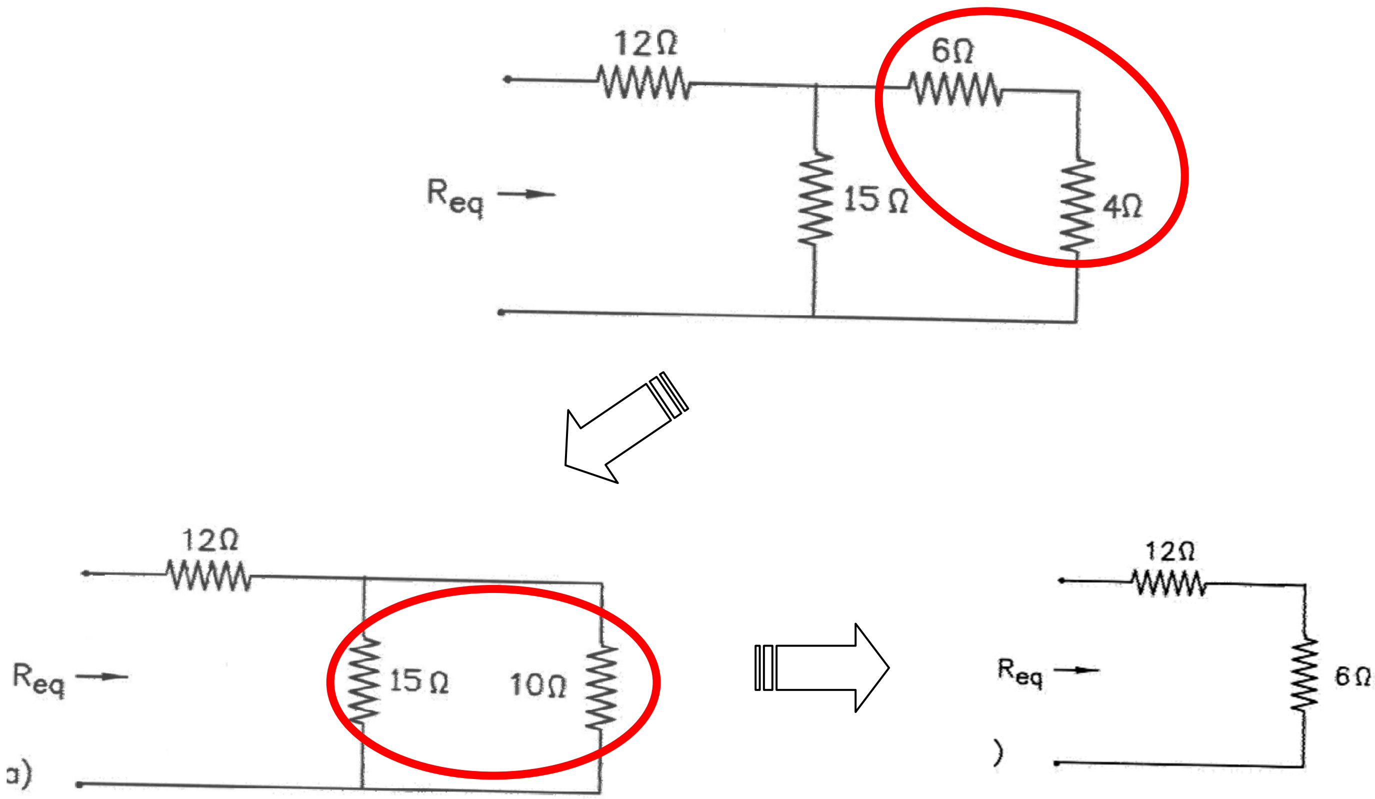


$$
\begin{aligned}
R_{eq} &= \frac{10 \times 15}{10 + 15} = 6\Omega \\
V &= R_{eq} \times I = 6 \times 10 = 60 \text{ V} \\
I_1 &= \frac{V}{R_1} = \frac{60}{10} = 6 \text{ A} \\
I_2 &= \frac{V}{R_2} = \frac{60}{15} = 4 \text{ A}
\end{aligned}
$$

$$
\begin{aligned}
I_1 &= \frac{R_2}{R_1 + R_2} \times I = \frac{15}{25} \times 10 = 6 \text{ A} \\
I_2 &= \frac{R_1}{R_1 + R_2} \times I = \frac{10}{25} \times 10 = 4 \text{ A}
\end{aligned}
$$

Circuits with Series-Parallel Paths – Example 1

- Find the equivalent resistance:

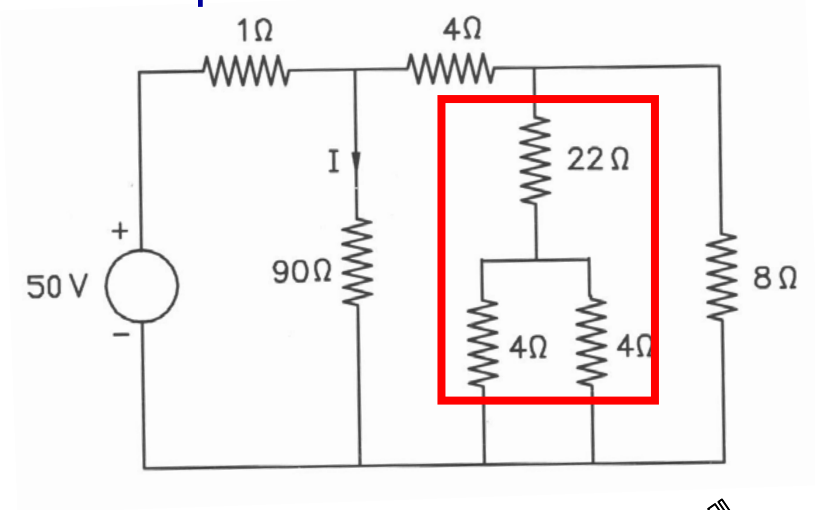


$$\boxed{R_{parallel} = \frac{15 \times 10}{15 + 10} = 6 \ \ \Omega}$$

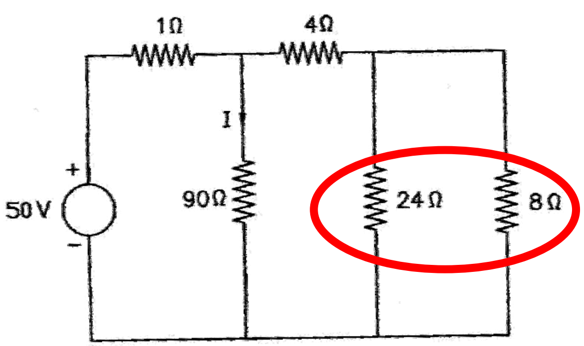
$$\boxed{R_{eq} = 12 + 6 = 18 \ \ \Omega}$$

Circuits with Series-Parallel Paths – Example 2

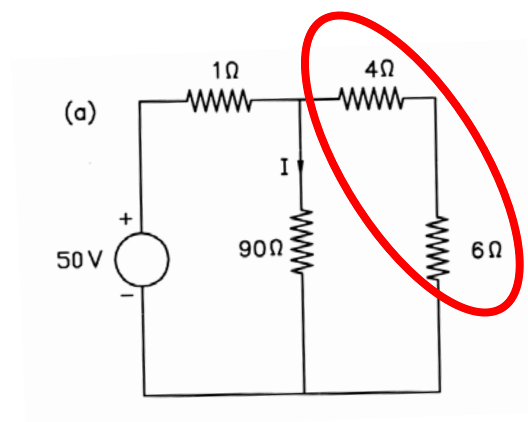
Find the equivalent resistance seen by the source and the current I:



$$\boxed{(4||4) + 22 = 24 \ \ \Omega}$$



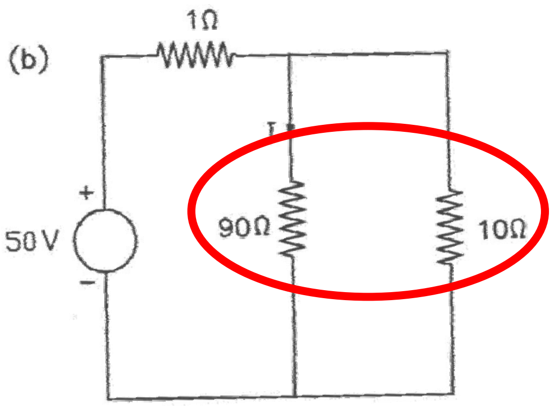
$$\boxed{24||8 = \frac{24 \times 8}{32} = 6 \ \ \Omega}$$



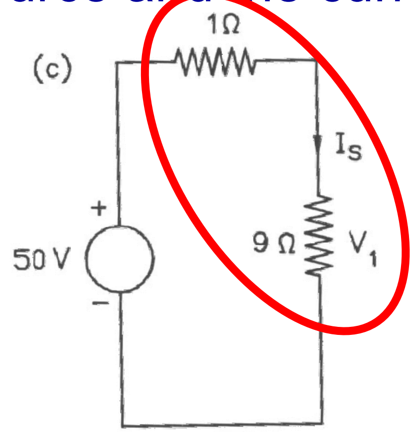
$$\boxed{4 + 6 = 10 \ \ \Omega}$$

Circuits with Series-Parallel Paths – Example 2

Find the equivalent resistance seen by the source and the current I:



$$\boxed{10 \| 90 = 9 \ \ \Omega}$$



$$\boxed{I_s = \frac{50}{10} = 5 \ \ \mathrm{A}}$$

The voltage drop across the 9 Ω resistance is:

$$\boxed{V_1 = 9 \times 5 = 45 \ \ \mathrm{V}}$$

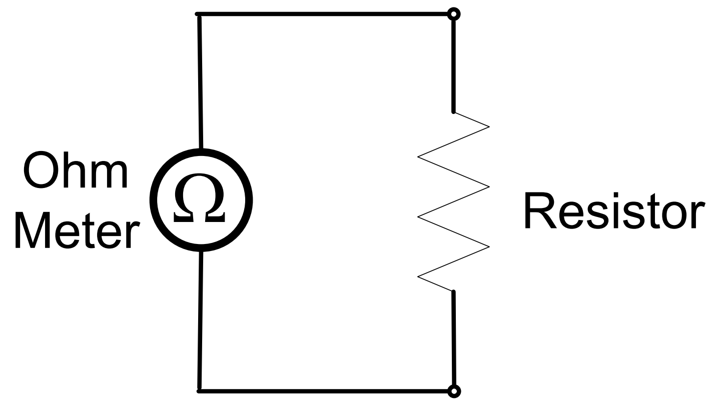
The voltage V, across the 9 Ω resistor is the same as the voltage across the parallel combination of 90 Ω and 10 Ω resistances. The required current I is:

$$\boxed{I = \frac{V_1}{90} = \frac{45}{90} = 0.5 \ \ \mathrm{A}}$$

Measuring Devices

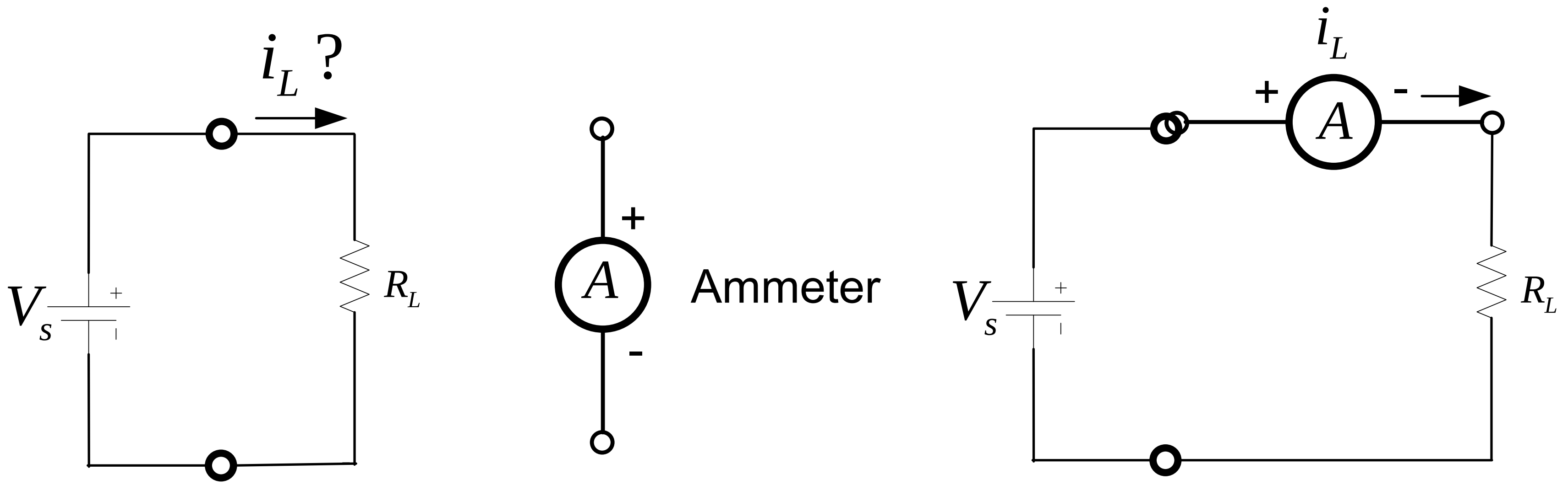
- Ohm meter – for resistance measurement
- Ammeter – for current measurement
- Voltmeter – for voltage measurement
- Wattmeter – for power measurement

Ohmmeter



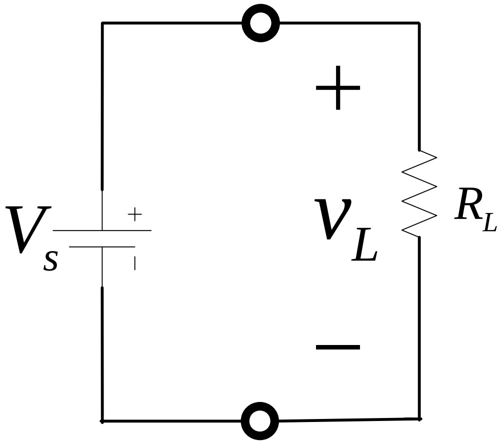
- The element should be removed from the circuit when resistance is measured (at least one end of the element should be removed from the circuit and the circuit should be de-energised).

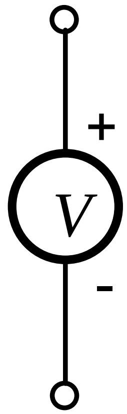
Ammeter

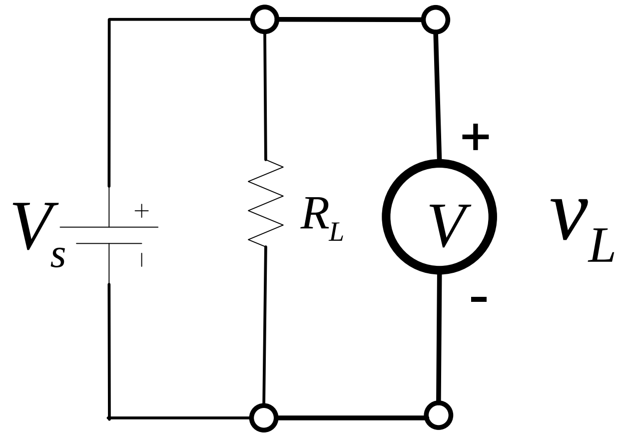


- The ammeter is connected in series with the element so that the same current passes through both the ammeter
- Ideal ammeter has zero resistance

Voltmeter

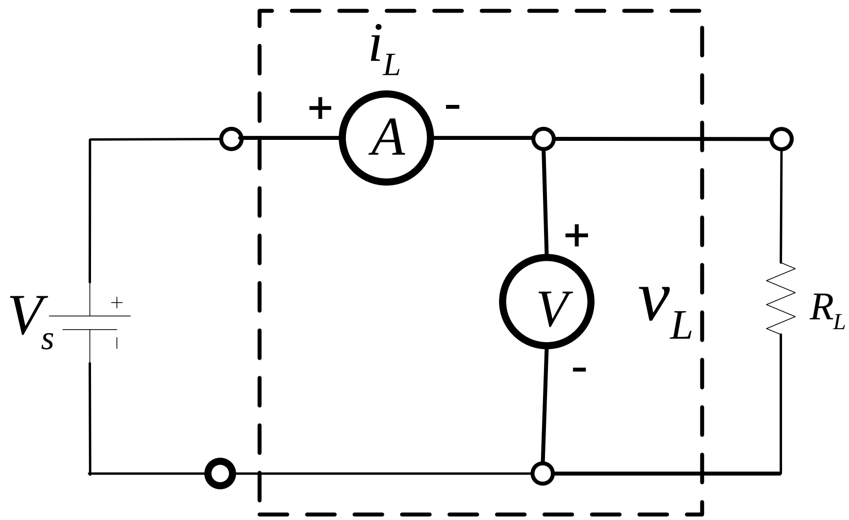






- Voltmeter is connected in parallel to the two points
- An ideal voltmeter has infinite resistance

Wattmeter



Internal connection
of Wattmeter

- Measurement of power requires both voltage across and current through the element.

CG1108 Lab

Address:

– DSA lab is at level 4 of block E4A (i.e E4A-04).

- You must bring along the printout of the lab sheet which has to be submitted at the end of the lab.
- The lab briefing will start 10 min after the start of the lab session

Lab Safety


No smoking
No drinking
No eating


Slippers or Sandals
are not allowed in the
laboratory & workshop
Covered shoes
are allowed