BFF1303: ELECTRICAL / ELECTRONICS ENGINEERING

Introduction

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Introduction

BFF1303 ELECTRICAL/ELECTRONICS ENGINEERING

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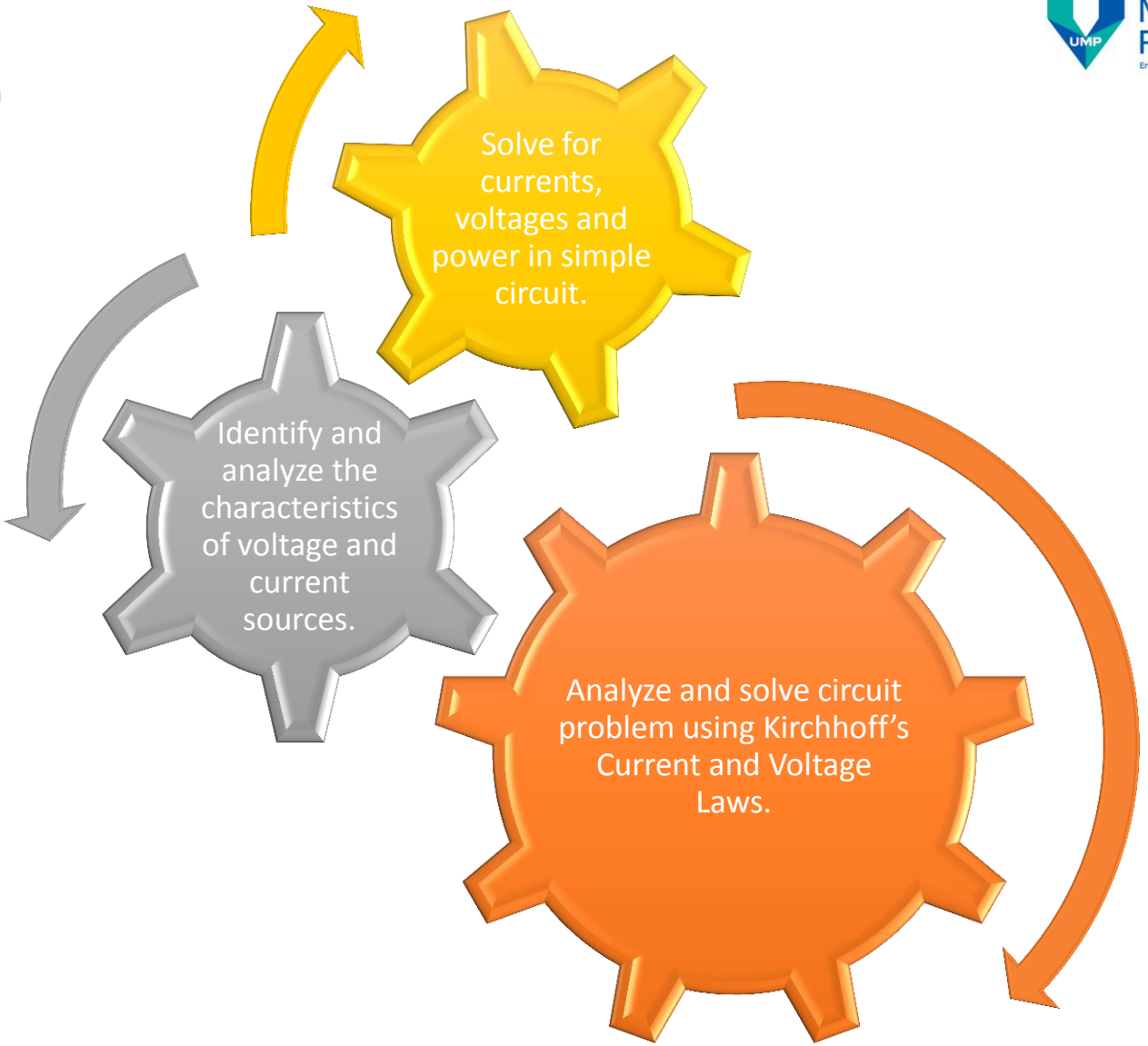
Contents:

- Ohm' Law
- Electrical Circuits
- Systems of Units
- Charge and Current
- Voltage
- Switch
- Power and Energy
- Circuit Elements
- Nodes, Branches and Loops
- Basic Connection

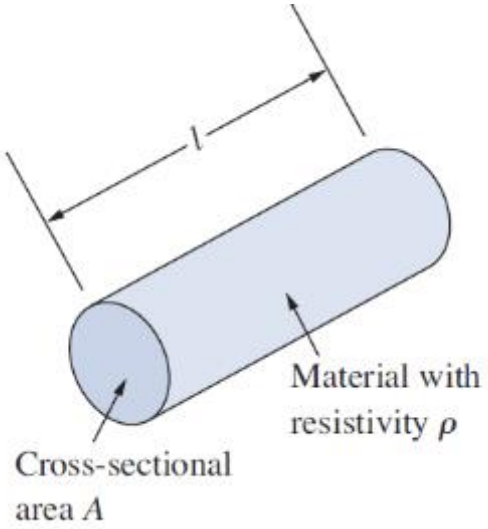
Outcomes


Solve for currents, voltages and power in simple circuit.
Identify and analyze the characteristics of voltage and current sources.
Analyze and solve circuit problem using Kirchhoff's Current and Voltage Laws.

Ohm's Law

- Most material have a characteristic behavior of **resisting** the flow of electric charge.
- The physical property to resist current known as **resistance** and is represented by the symbol R .
- The resistance of any material with a uniform cross-sectional area A depends on A and its length l

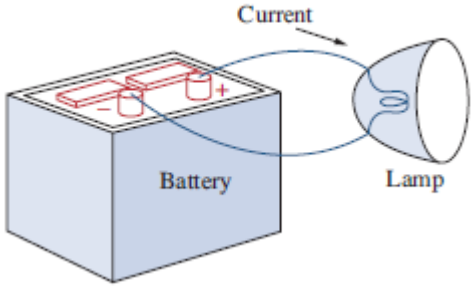
$$R = p\frac{l}{A}$$

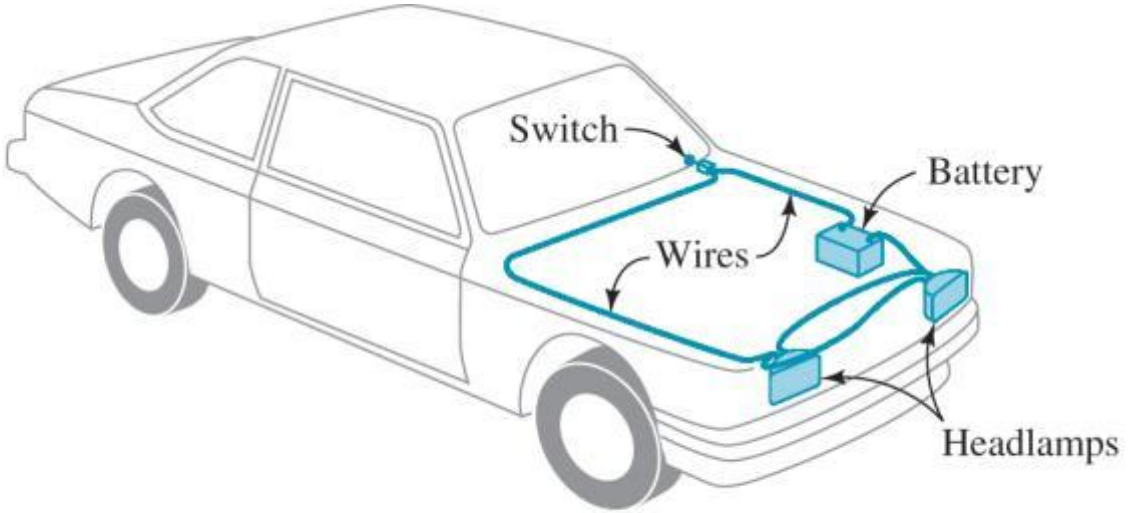


Electrical Circuits

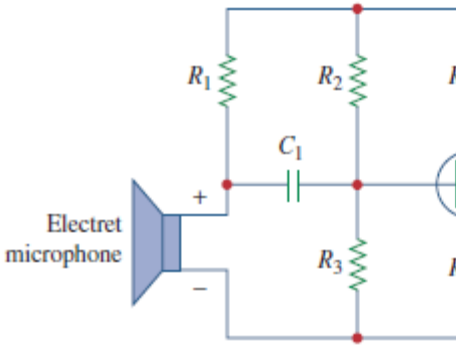
- An interconnection of electrical elements.
- Consists of various type of elements connected in closed path by conductors.
- The circuits elements consists of: resistance, inductance, capacitance and voltage sources.
- Charge flow easily through conductors
- Conductors correspond to connecting wire in physical circuits.

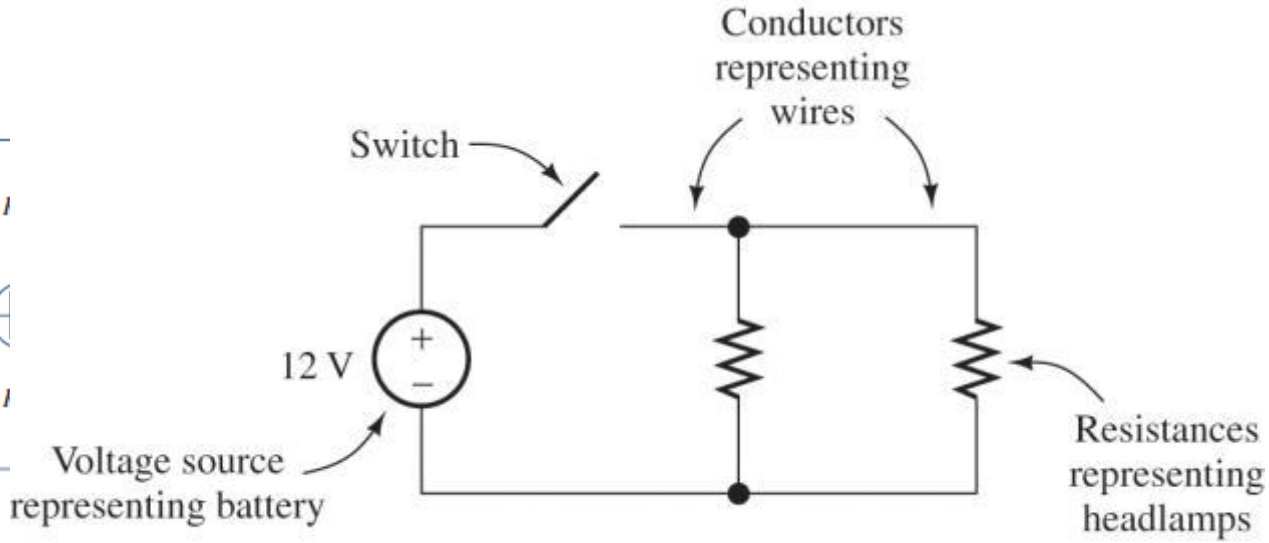
Electrical Circuits





(a) Physical configuration





(b) Circuit diagram

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SI Fundamental Units

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

Systems of Units

Quantity	Unit	Symbol
Current	Ampere	A
Charge	Coulomb	C
Voltage	Volt	V
Resistance	Ohm	Ω
Power	Watt	W

Charge and Current

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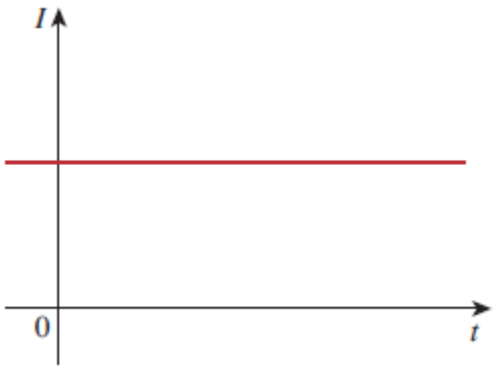
- **Charge** is an electrical property of the atomic particles of which matter consists, measured in **coulombs (C)**.

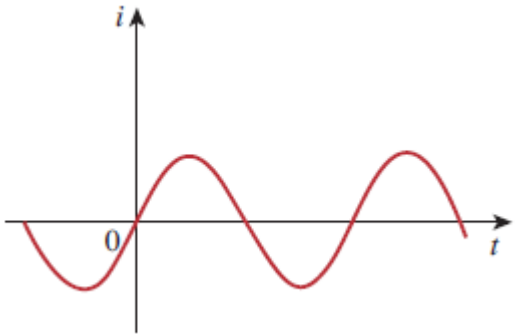
- The charge *e* on an electron is **negative** and equal in magnitude to 1.602×10^{-19} C.

- The *law of conservation of charge* states that charge can neither be **created** nor **destroyed**, **only transferred**. Thus the algebraic sum of the electric charges in a system does not change.

- **Electric Current** is the time rate of change of charge, measured in amperes (A).
  - 1 ampere = 1 coulomb/second

- Generally, there are 2 types of current
  - **direct current (dc)** – a current that remains constant with time. Symbol, *I*
  - **alternating current (ac)** – a current that varies sinusoidal with time. Symbol, *i*

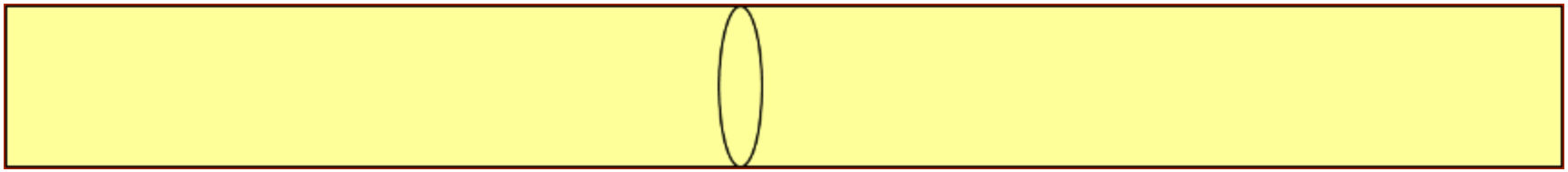




Charge and Current

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

$$Q = \int_{t_o}^{t} i \; dt$$



Example #1

The total charge entering a terminal is given by

$$q(t) = 5t \sin 4\pi t$$

Calculate the current at $t = 0.5s$

Solution

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

$$= \frac{d}{dt}(5t \sin 4\pi t)$$

$$= (5\sin 4\pi t + 20\pi t \cos 4\pi t)$$

$$i = 5\sin 2\pi + 10\pi \cos 2\pi$$

$$i = 31.42\,\text{mA}$$

Example #2

Determine the total charge entering a terminal between $t = 1\text{s}$ and $t = 2\text{s}$ if the current passing the terminal is

$$i = \left(3t^2 - t\right)\text{A}$$

Solution

$$Q = \int_{t=1}^{2} i\,dt = \int_{1}^{2} \left(3t^2 - t\right) dt$$

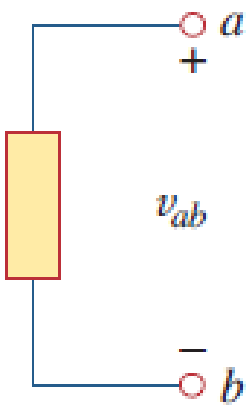
$$= \left(t^3 - \frac{t^2}{2} \right)\Bigg|_1^2 = (8-2) - \left(1 - \frac{1}{2}\right)$$

$$= 5.5\text{C}$$

Voltage

- **Voltage** (or **potential difference**) – the energy required to move a unit charge through an element, measured in **volts (V)**.
- To move an electron in a conductor in a particular direction requires some work or energy transfer.
- This work is performed by an external **electromotive force (emf)** – i.e. batterry
- This emf also known as **potential difference** or **voltage**.
- Voltage is a **measurement of potential** between **two points**.

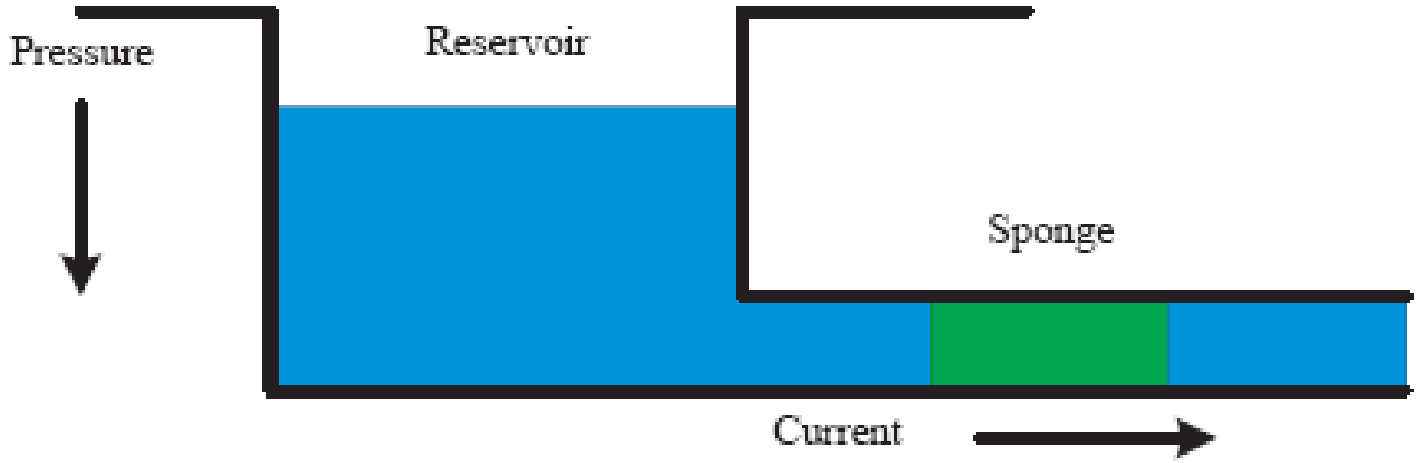
Voltage



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

- Voltage v_{ab} the energy (or work) needed to move a unit charge from a to b.
  - 1 volt = 1 joule/coulomb = 1 newton-meter/coulomb
- Plus (+) and minus (-) signs – voltage polarity or direction of charges being pushed.
- 2 type of voltages
  - dc voltage, (V) – a constant voltage with time. i.e. battery.
  - ac voltage, (v) – a voltage that varies sinusoidally with time. i.e. electric generator

Voltage



Pressure = Voltage

Water current = Electric current

Sponge porosity = Resistance

Switches

- Control the current in circuits.
- When ideal switch is open, the current through it is zero the voltage across is determine by the remainder of the circuit.
- When ideal switch is closed, the voltage across it is zero, and the current through it determined by the remainder of the circuit.

Power and Energy

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- Time rate of **supplying** or **absorbing energy**, measured in **watts (W)** or **joules per second (J/s)**.

$$p = \frac{dw}{dt} = \frac{dw}{dq}\frac{dq}{dt} = vi \qquad p = vi$$

- Positive power – power is **absorb** by the element

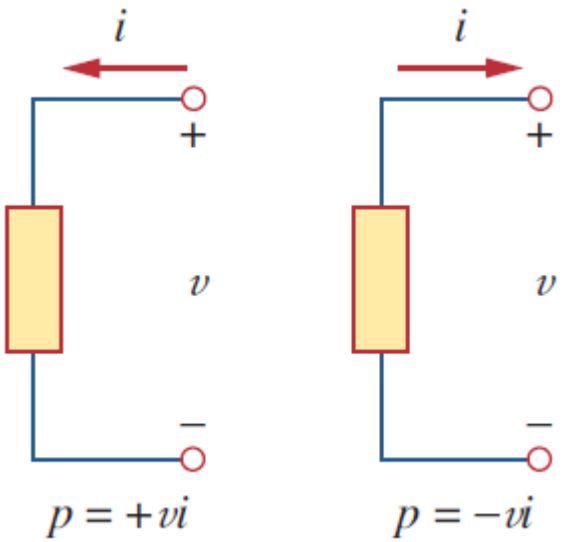
$$p = +vi$$

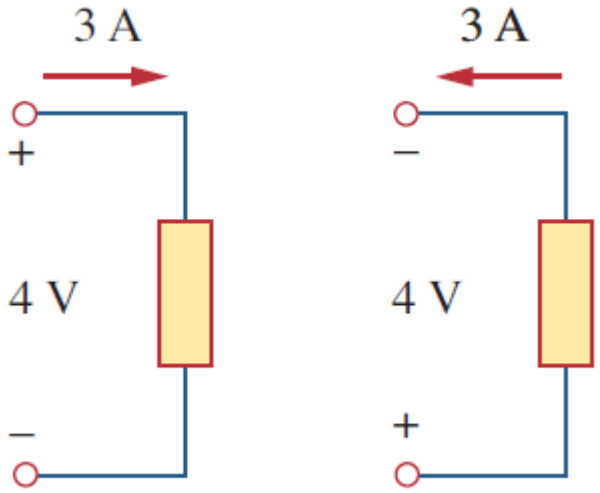
- Negative power – power is **supplied** by the element

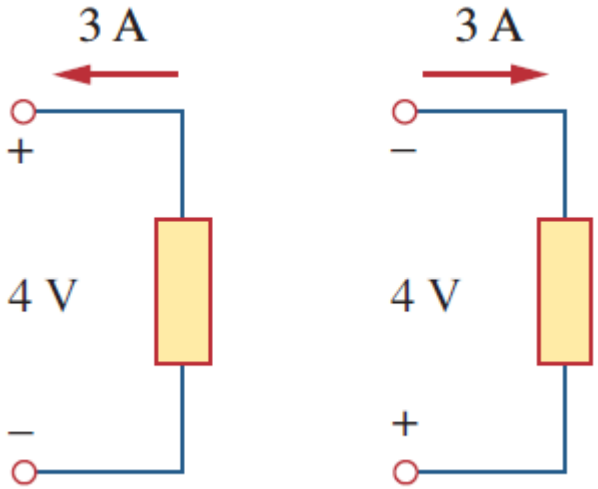
$$p = -vi$$

- How to identify positive and negative power? Based on the **direction of current flow and voltage polarity**.

Power and Energy







Note: focus on the direction of current entering an element. If enter at:

- +ve terminal – power absorbed
- -ve terminal – power supplied

Law of conservation of energy – the algebraic sum of power in a circuit, at any instant of time, must be zero.

$$\sum p = 0$$

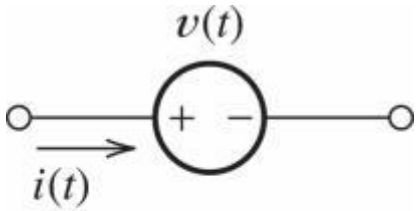
- The total power supplied to the circuit must equal to the total power absorbed.

- **Energy** is the capacity to do work, measured in joules (J).

$$w = \int_{t_0}^{t} p \, dt = \int_{t_0}^{t} vi \, dt$$

Example #3

Find an expression for the power for the voltage source



$v(t) = 12 \text{ V}$

$i(t) = 2e^{-t} \text{ A}$

Compute the energy for the interval from $t_1 = 0$ to $t_2 = \infty$

Solution

$$p(t) = v(t)i(t)$$
$$= 12 \times 2e^{-t}$$
$$= 24e^{-t} \text{ W}$$

$$w = \int_0^\infty p(t)\, dt$$
$$= \int_0^\infty 24e^{-t} dt$$
$$= \left[-24e^{-t} \right]_0^\infty = 24 \text{ J}$$

Circuit Elements

- **Element** – basic building block of a circuit or electrical components of an electrical circuit.
- **Electric circuit** – an interconnection of electrical elements.
- **Circuit analysis** – process of determining voltages across (or the currents through) the elements of the circuit.
- 2 types of electrical circuits:
  - Active elements
  - Passive elements

Circuit Elements

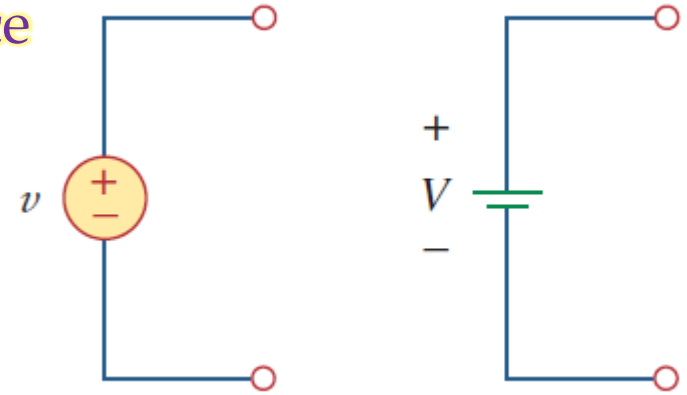
- Active elements:- capable of generating electrical energy i.e. voltage source & current source.
- Passive elements :- not capable of generating electrical energy i.e. resistor, capacitor and inductors.
- Voltage and current source deliver power to the electrical circuit.
- 2 kinds of source
  - Independent source
  - Dependent source

Ideal Independent Source

- An active elements that provides a specified voltage or current that is completely independent of other circuit elements.

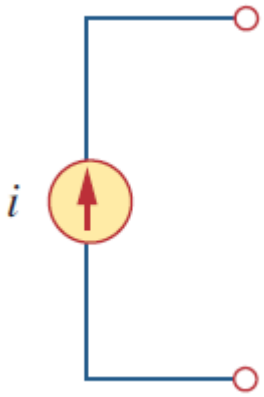
i. Ideal Independent Voltage Source

- Ideal independent voltage source delivers to the circuit **whatever current is necessary to maintain its terminal voltage**.



ii. Ideal Independent Current Source

- Ideal independent current source delivers to the circuit **whatever voltage is necessary to maintain the designated current**.

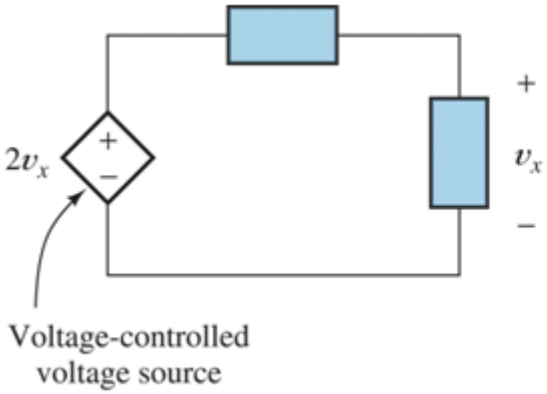


Ideal Dependent @ Controlled Source

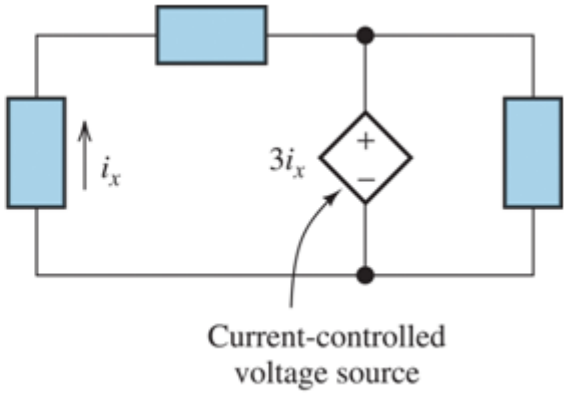
- An active elements in which the source quantity is controlled by another voltage or current

- 4 types of dependent source
  - Voltage-Controlled Voltage Source (VCVS)
  - Current-Controlled Voltage Source (CCVS)
  - Voltage-Controlled Current Source (VCCS)
  - Current-Controlled Current Source (CCCS)

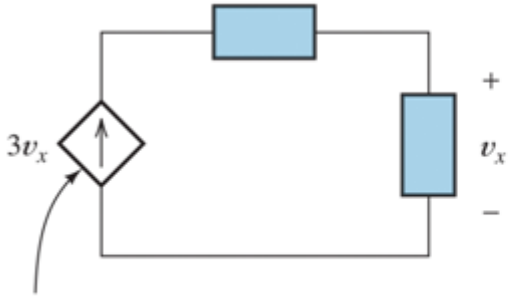
Circuit Elements



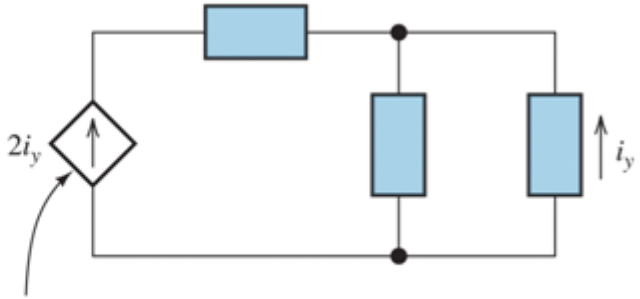
Voltage-controlled voltage source



Current-controlled voltage source

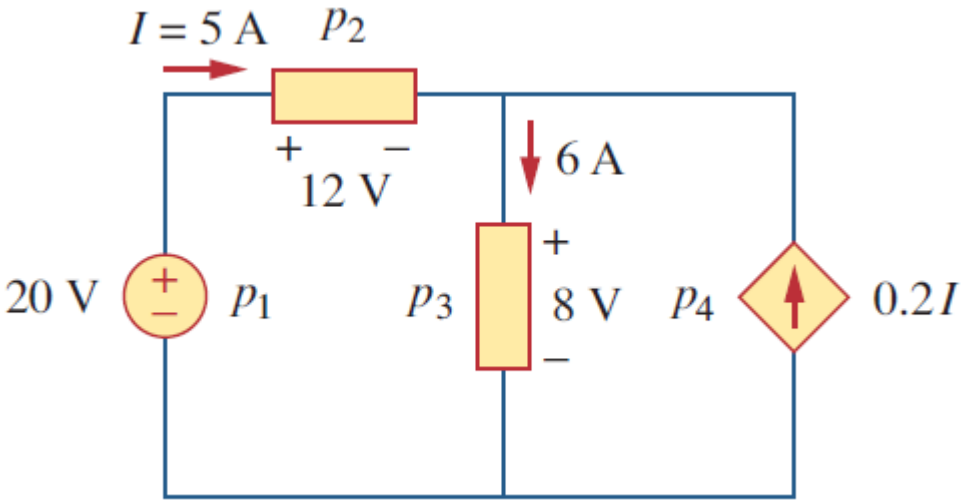


Voltage-controlled current source



Current-controlled current source

Example #4



Calculate the power supplied or absorbed by each element in figure above

Example #4

Solution

$$p_1 = (20)(5) = 100\,\text{W}$$

Since the current leaves the positive terminal thus, $p_1 = -100\,\text{W}$

$$p_2 = (12)(5) = 60\,\text{W}$$ The current enters the positive terminal

$$p_3 = (8)(6) = 48\,\text{W}$$ The current enters the positive terminal

Since the current leaves the positive terminal thus, $p_4 = -8\,\text{W}$

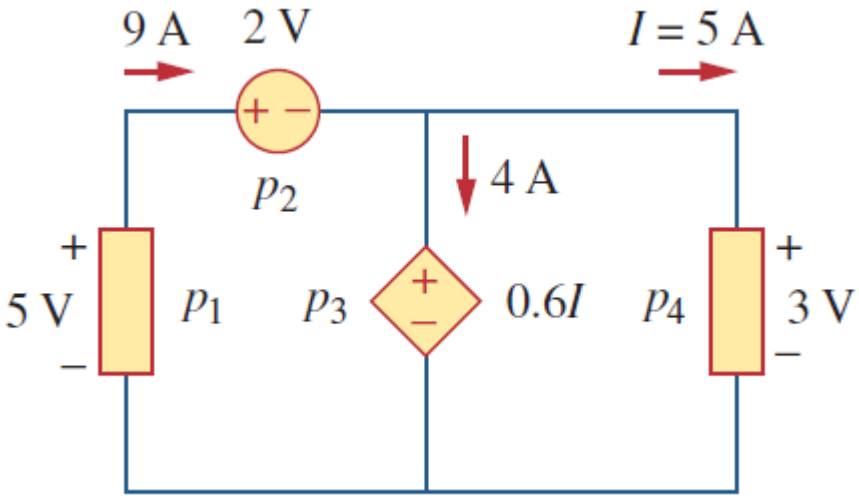
$$p_4 = (8)(0.2I) = (8)(1) = 8\,\text{W}$$

Algebraic sum of power in the circuit

$$p_1 + p_2 + p_3 + p_4$$

$$-100 + 60 + 48 - 8 = 0\,\text{W}$$

Example #5



Calculate the power supplied or absorbed by each element in figure above

Example #5

Solution

$$p_1 = (5)(9) = 45\,\text{W}$$

Since the current leaves the positive terminal thus, $p_1 = -45\,\text{W}$

$$p_2 = (9)(2) = 18\,\text{W}$$ The current enters the positive terminal

$$p_3 = (4)(0.6I) = (4)(3) = 12\,\text{W}$$

The current enters the positive terminal

$$p_4 = (3)(5) = 15\,\text{W}$$ The current enters the positive terminal

Algebraic sum of power in the circuit

$$p_1 + p_2 + p_3 + p_4$$

$$-45 + 18 + 12 + 15 = 0\,\text{W}$$

Branch

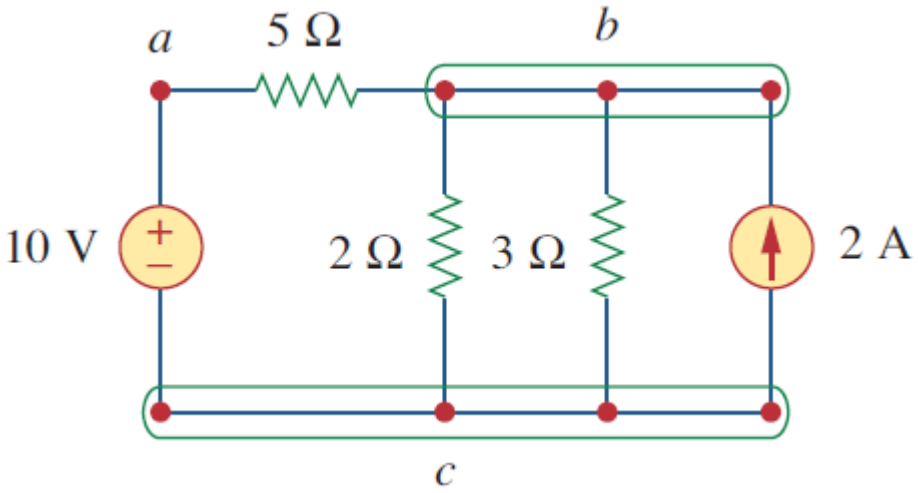
Represents a single 2-terminal elements such as voltage source or a resistor.

Node

A point of connection between 2 or more branches.
If a short circuit (a connecting wire) connects between 2 nodes, this 2 nodes constitute a single node.

Loop

A closed path formed by starting at a node, passing through a set of nodes and returning to the starting node without passing through any node more than once.

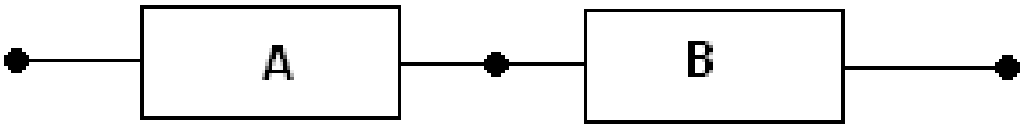


Basic Connection

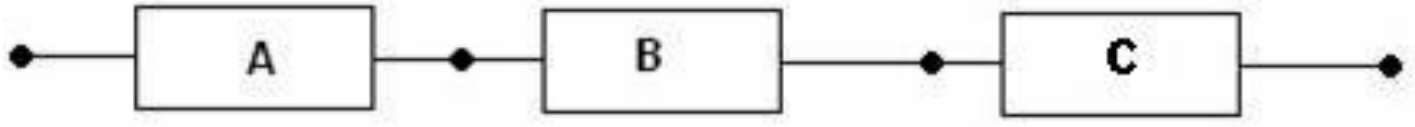
- 2 types of connections:
  - Series
  - Parallel

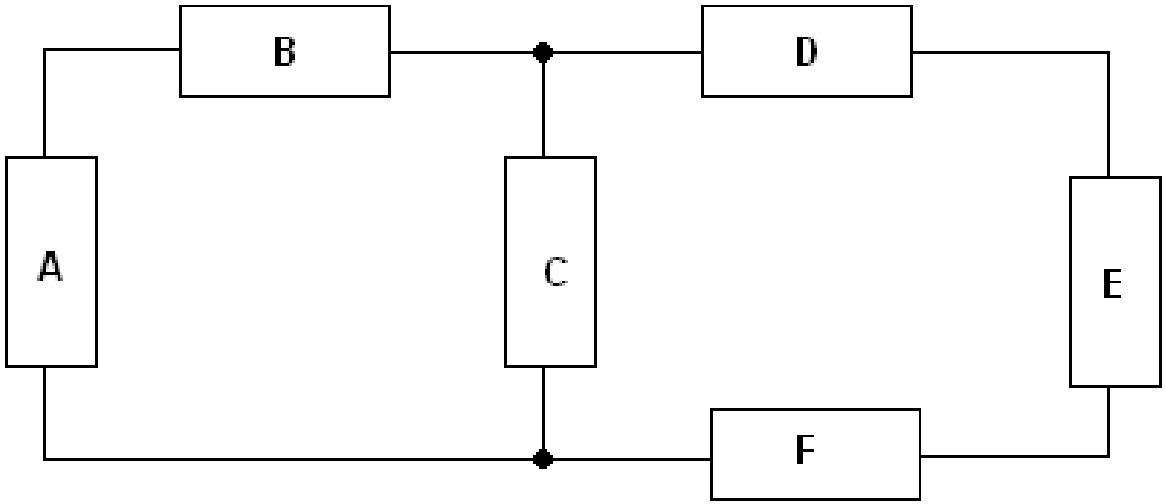
- When **Series** connection – **2 elements** are joint at a **node** and no other element is connected to that node.

- Elements in series carry the **same current**.



Basic Connection





The series connection are:

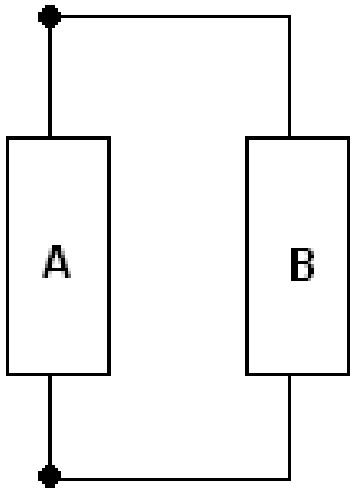
- A & B
- D, E & F

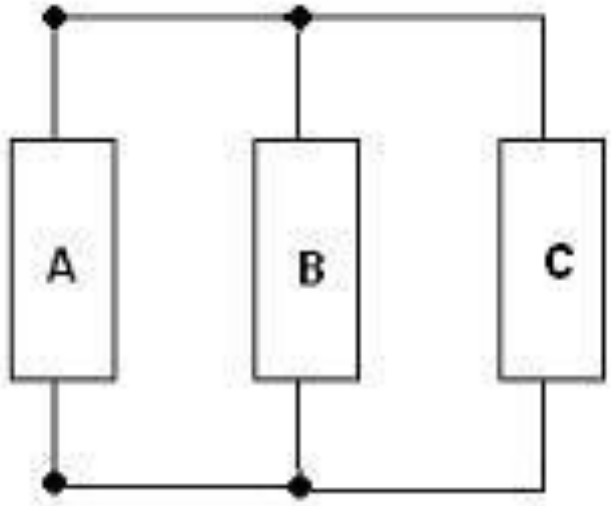
6 branches.
5 nodes.
2 loops.

Basic Connection

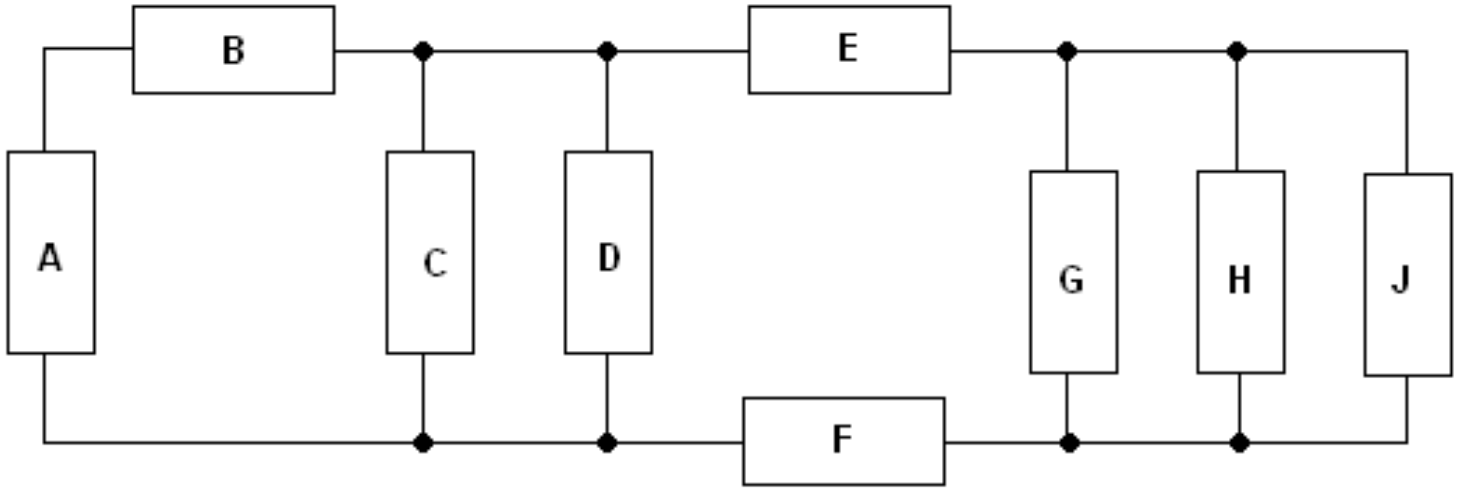
- **Parallel** connection – elements that are connected to the **same pair of terminals.**

- Elements in parallel have the **same voltage** across them.





Basic Connection



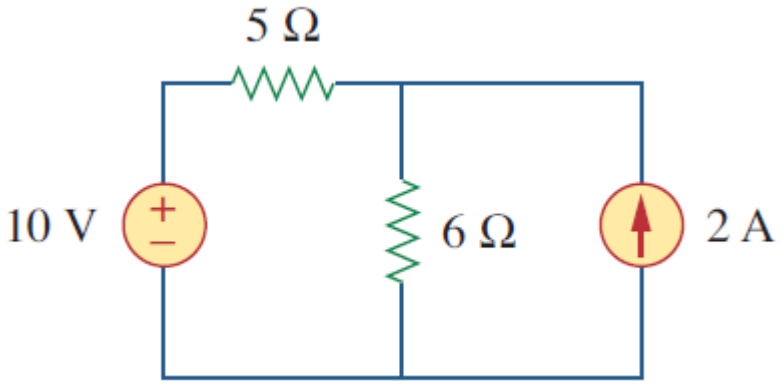
Parallel connections:

- C &D
- G, H & J

Series connection – A & B

9 branches.
5 nodes.
5 loops.

Example #6



Determine the number of branches and nodes. Identify which elements are in series and parallel.

Example #6

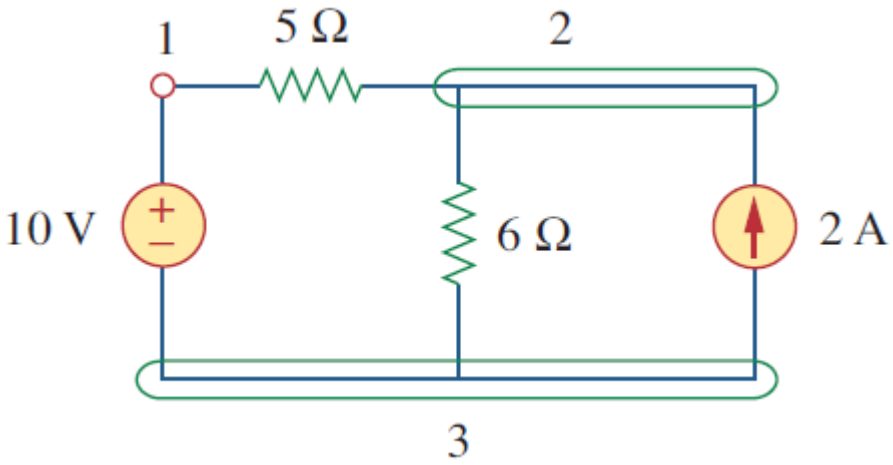
Solution

Since there are 4 elements, the circuit has 4 branches: 10 V, 5 Ω, 6 Ω and 2 A.

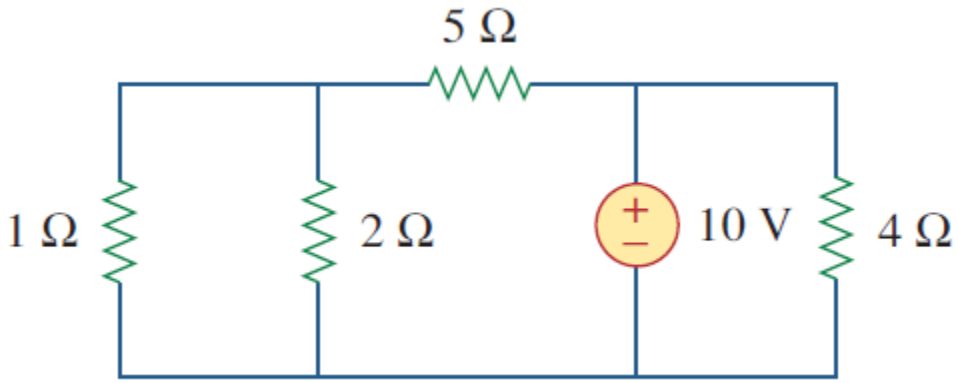
Has 3 nodes.

Series connection: 5 Ω resistor with 10 V voltage source.

Parallel connection: 6 Ω resistor with 2 A current source.



Example #7



Determine the number of branches and nodes. Identify which elements are in series and parallel.

Example #7

Solution

Since there are 5 elements, the circuit has 5 branches:
10 V, 5 Ω, 4 Ω , 2 Ω and 1 Ω .

Has 3 nodes.

Parallel connection: 1 Ω resistor with 2 Ω resistor.
4 Ω resistor with 10 V source.