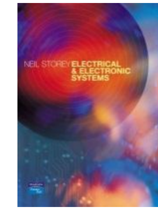
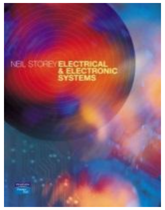
Basic Electric Circuits & Components



Chapter 2

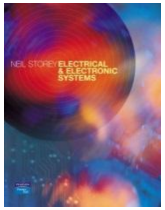
- Introduction
- SI Units and Common Prefixes
- Electrical Circuits
- Direct Currents and Alternating Currents
- Resistors, Capacitors and Inductors
- Ohm’s and Kirchhoff’s Laws
- Power Dissipation in Resistors
- Resistors in Series and Parallel
- Resistive Potential Dividers
- Sinusoidal Quantities
- Circuit Symbols



Introduction

- This lecture outlines the basics of **Electrical Circuits**
- For most students much of this will be familiar
  - this lecture can be seen as a revision session for this material
- If there are any topics that you are unsure of (or that are new to you) you should get to grips with this material *before* the next lecture
  - the following lectures will assume a basic understanding of these topics
- We will return to look at several of these topics in more detail in later lectures

SI Units



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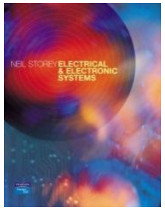
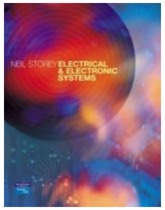
Quantity	Quantity symbol	Unit	Unit symbol
Capacitance	C	Farad	F
Charge	Q	Coulomb	C
Current	I	Ampere	A
Electromotive force	E	Volt	V
Frequency	f	Hertz	Hz
Inductance (self)	L	Henry	H
Period	T	Second	s
Potential difference	V	Volt	V
Power	P	Watt	W
Resistance	R	Ohm	Ω
Temperature	T	Kelvin	K
Time	t	Second	s



Common Prefixes

Prefix	Name	Meaning (multiply by)
T	tera	10^{12}
G	giga	10^{9}
M	mega	10^{6}
k	kilo	10^{3}
m	milli	10^{-3}
μ	micro	10^{-6}
n	nano	10^{-9}
p	pico	10^{-12}



Electrical Circuits

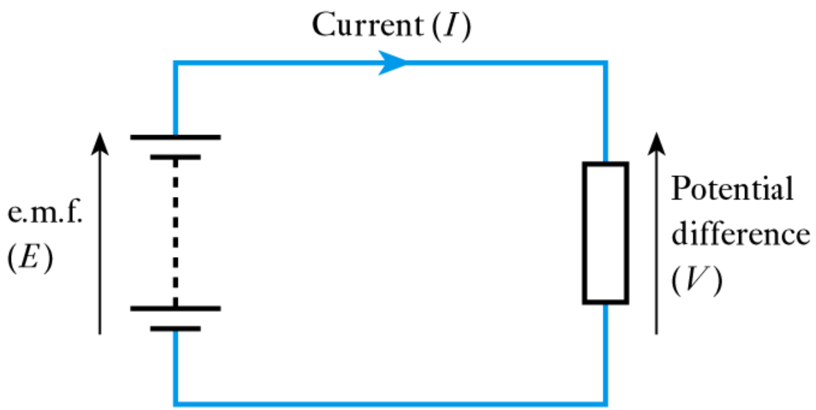
- **Electric charge**
  - an amount of electrical energy
  - can be positive or negative
- **Electric current**
  - a flow of electrical charge, often a flow of electrons
  - conventional current is in the opposite direction to a flow of electrons
- **Current flow in a circuit**
  - a sustained current needs a complete circuit
  - also requires a stimulus to cause the charge to flow

Electrical Circuits

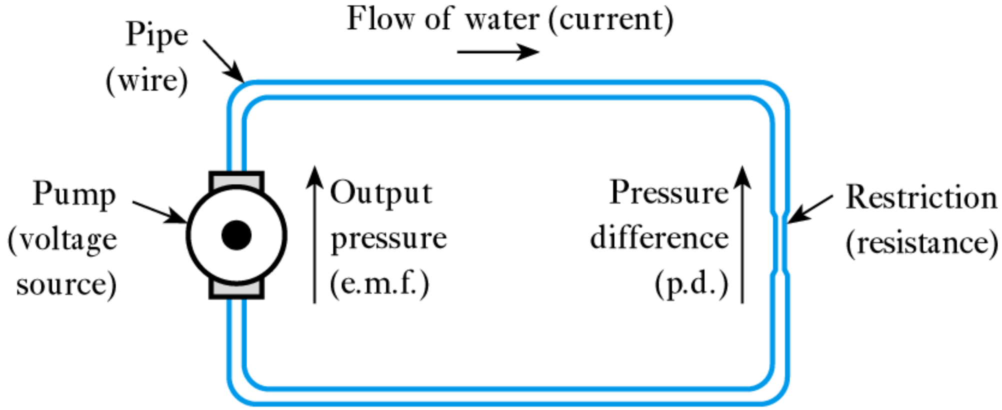
- **Electromotive force** and **potential difference**
  - the stimulus that causes a current to flow is an **e.m.f.**
  - this represents the energy introduced into the circuit by a battery or generator
  - this results in an electric potential at each point in the circuit
  - between any two points in the circuit there may exist a **potential difference**
  - both e.m.f. and potential difference are measured in volts

Electrical Circuits

- A simple circuit

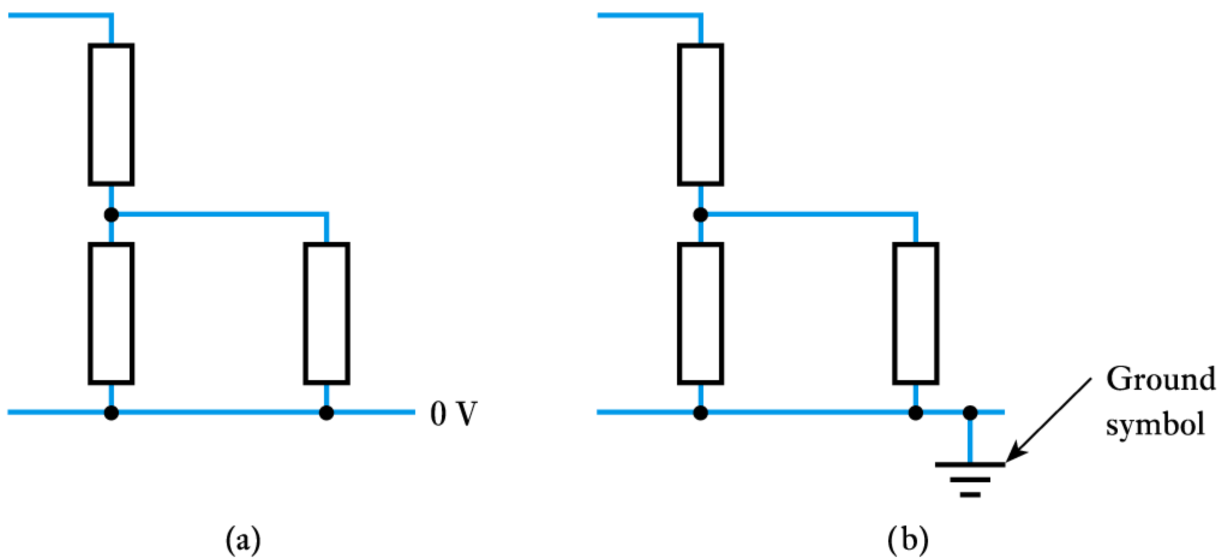


- A water-based analogy



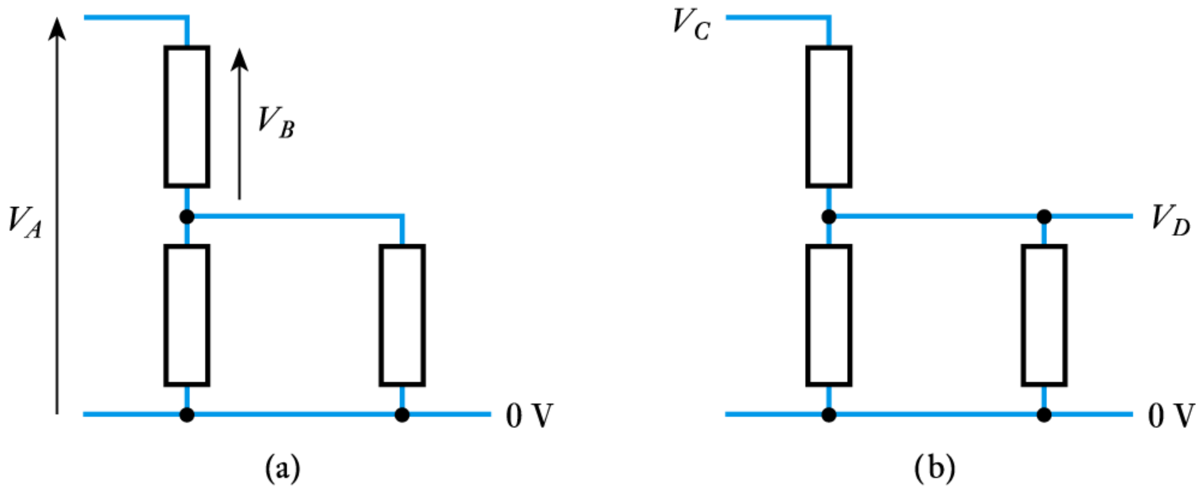
Electrical Circuits

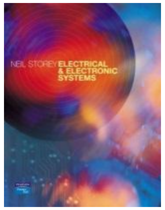
- **Voltage reference points**
  - all potentials within a circuit must be measured with respect to some other point
  - we often measure voltages with respect to a zero volt reference called the **ground** or **earth**



Electrical Circuits

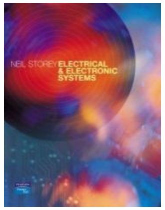
- **Representing voltages in circuit diagrams**
  - conventions vary around the world
  - we normally use an arrow, which is taken to represent the voltage on the head with respect to the tail
  - labels represent voltages with respect to earth





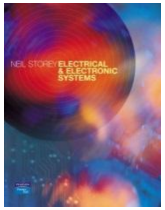
Direct Current and Alternating Current

- Currents in electrical circuits may be constant or may vary with time
- When currents vary with time they may be **unidirectional** or **alternating**
- When the current flowing in a conductor always flows in the same direction this is **direct current** (**DC**)
- When the direction of the current periodically changes this is **alternating current** (**AC**)



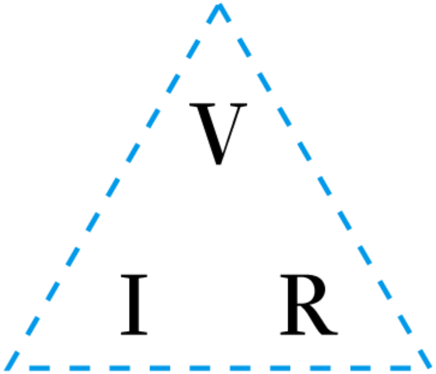
Resistors, Capacitors and Inductors

- **Resistors** provide resistance
  - they oppose the flow of electricity
  - measured in Ohms (Ω)
- **Capacitors** provide capacitance
  - they store energy in an electric field
  - measured in Farads (F)
- **Inductors** provide inductance
  - they store energy in a magnetic field
  - measured in Henry (H)
- We will look at each component in later lectures



Ohm's Law

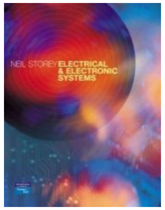
- *The current flowing in a conductor is directly proportional to the applied voltage V and inversely proportional to its resistance R*



$$V = IR$$

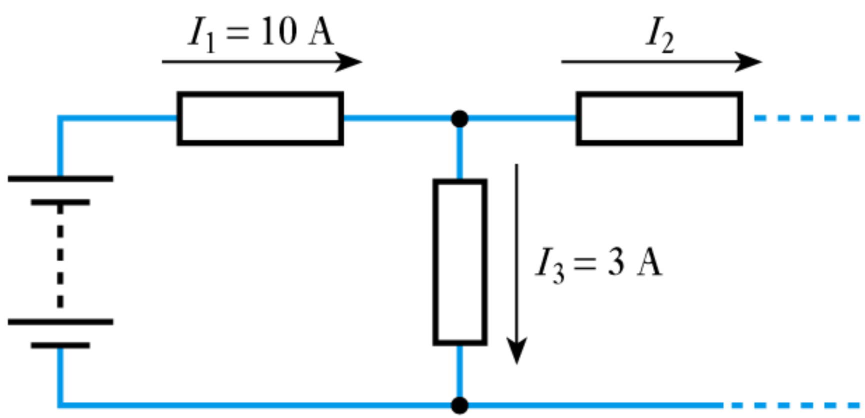
$$I = V/R$$

$$R = V/I$$



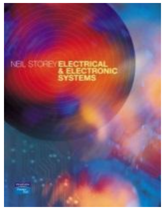
Kirchhoff’s Current Law

- *At any instant the algebraic sum of the currents flowing into any junction in a circuit is zero*
- For example



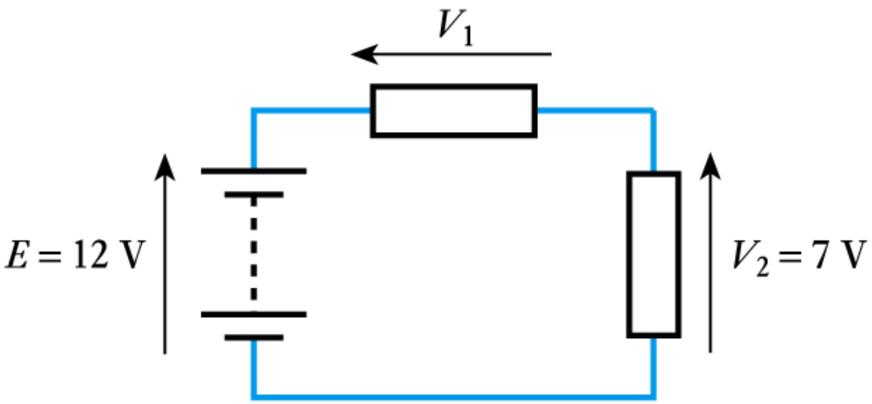
$$I_1 - I_2 - I_3 = 0$$

$$\begin{aligned} I_2 &= I_1 - I_3 \\ &= 10 - 3 \\ &= 7\text{ A} \end{aligned}$$



Kirchhoff's Voltage Law

- *At any instant the algebraic sum of the voltages around any loop in a circuit is zero*
- For example

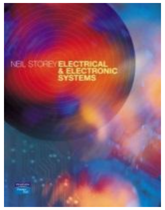


$$E - V_1 - V_2 = 0$$

$$V_1 = E - V_2$$

$$= 12 - 7$$

$$= 5\text{ V}$$



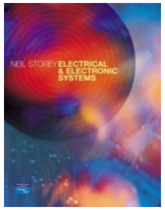
Power Dissipation in Resistors

- The instantaneous power dissipation *P* of a resistor is given by the product of the voltage across it and the current passing through it. Combining this result with Ohm's law gives:

$$P = VI$$

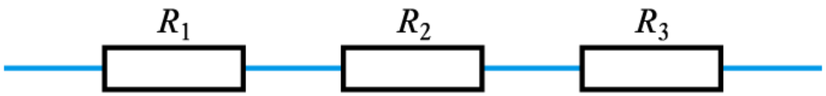
$$P = I^2R$$

$$P = V^2/R$$



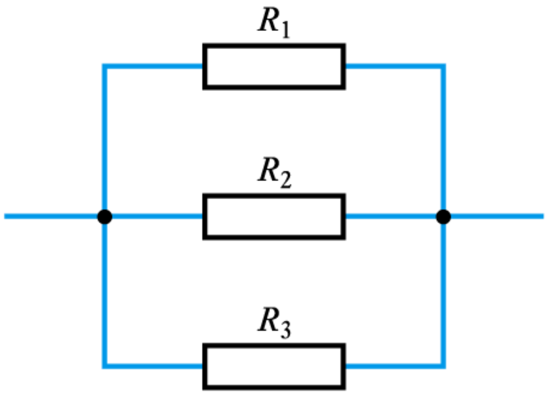
Resistors in Series and Parallel

- Series

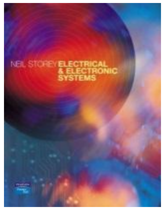


$$R = R_1 + R_2 + R_3$$

- Parallel

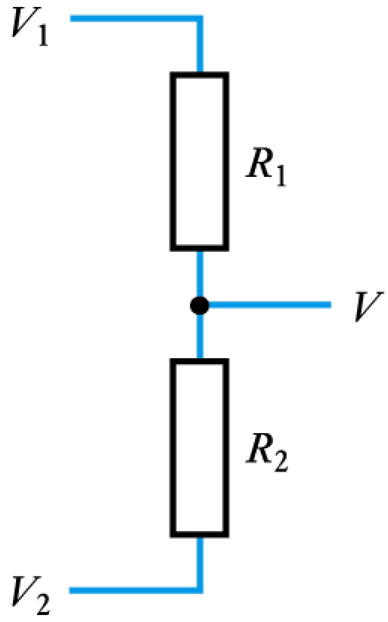


$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$



Resistive Potential Dividers

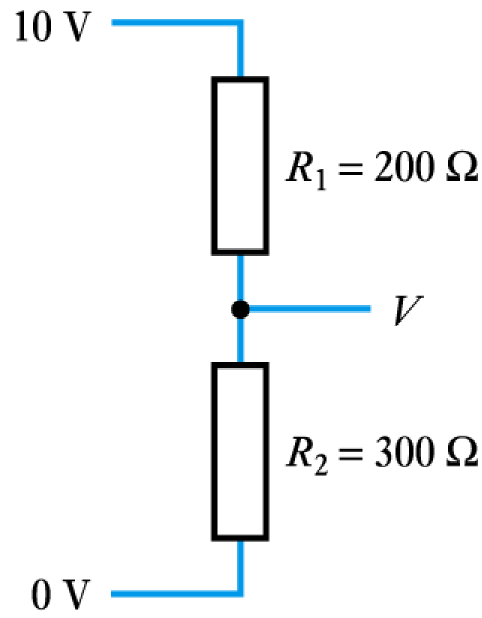
- General case



$$V = V_2 + (V_1 - V_2)\frac{R_2}{R_1 + R_2}$$

Resistive Potential Dividers

- Example



$$V = V_2 + (V_1 - V_2)\frac{R_2}{R_1 + R_2}$$

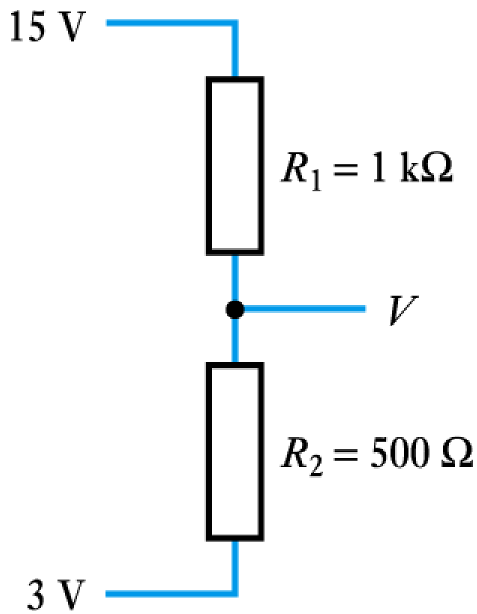
$$= 10\frac{R_2}{R_1 + R_2}$$

$$= 10\frac{300}{200 + 300}$$

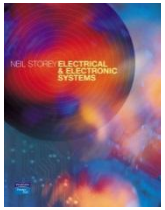
$$= 6\text{V}$$

Resistive Potential Dividers

- Example

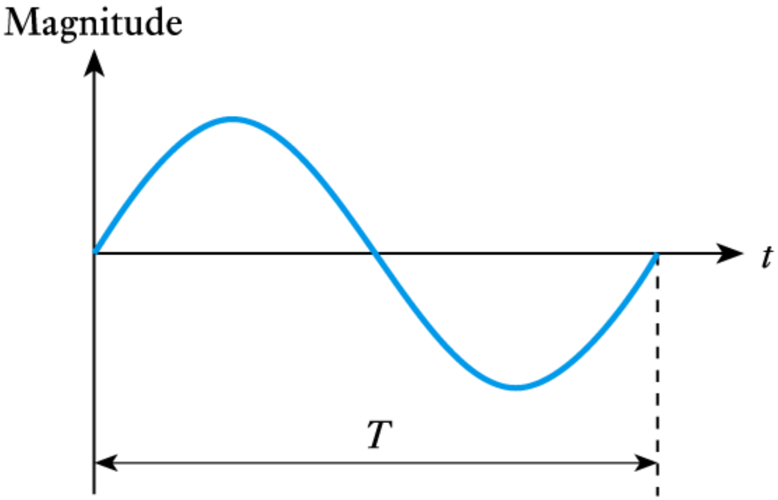


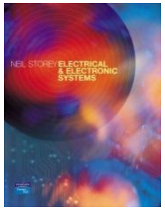
$$
\begin{aligned}
V &= V_2 + (V_1 - V_2)\frac{R_2}{R_1 + R_2} \\
&= 3 + 12\frac{500}{1000 + 500} \\
&= 3 + 4 \\
&= 7\text{V}
\end{aligned}
$$



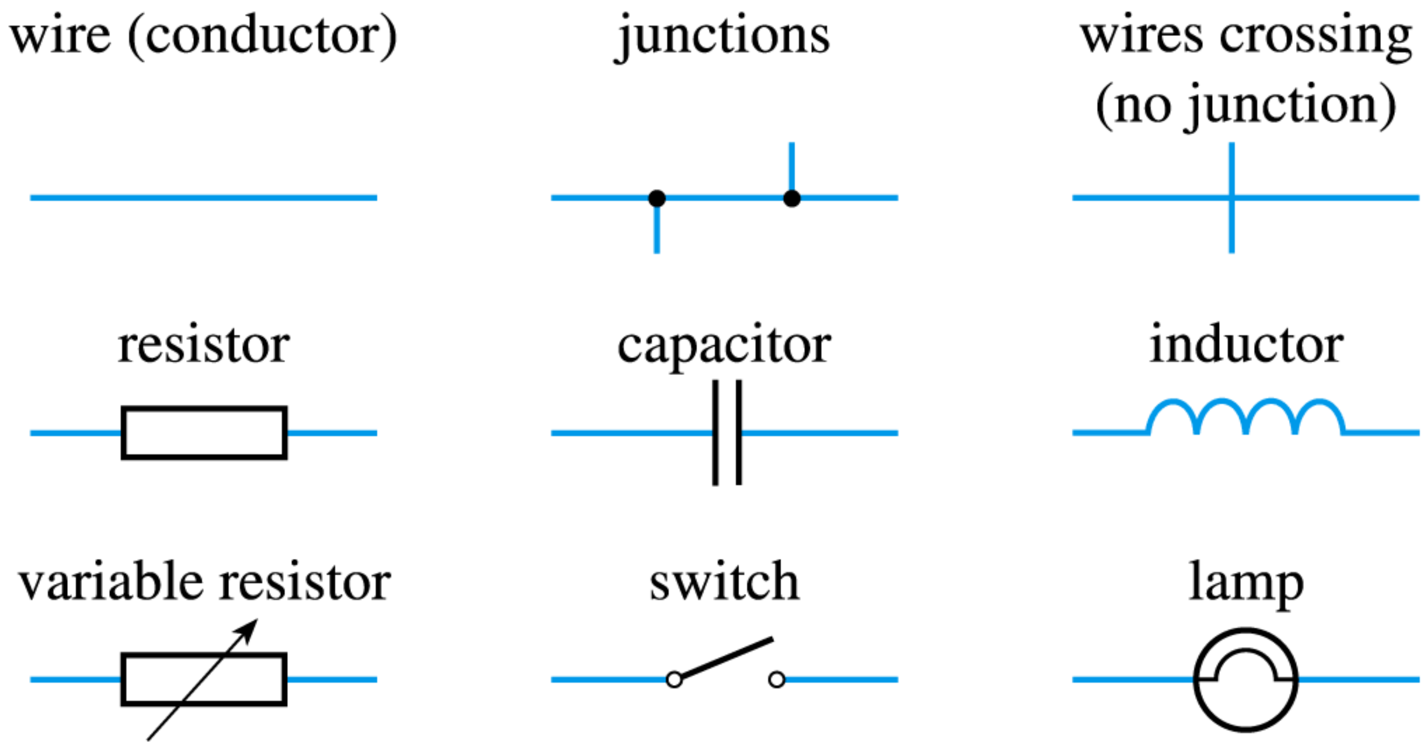
Sinusoidal Quantities

- Length of time between corresponding points in successive cycles is the **period *T***
- Number of cycles per second is the **frequency *f***
- **$f = 1/T$**

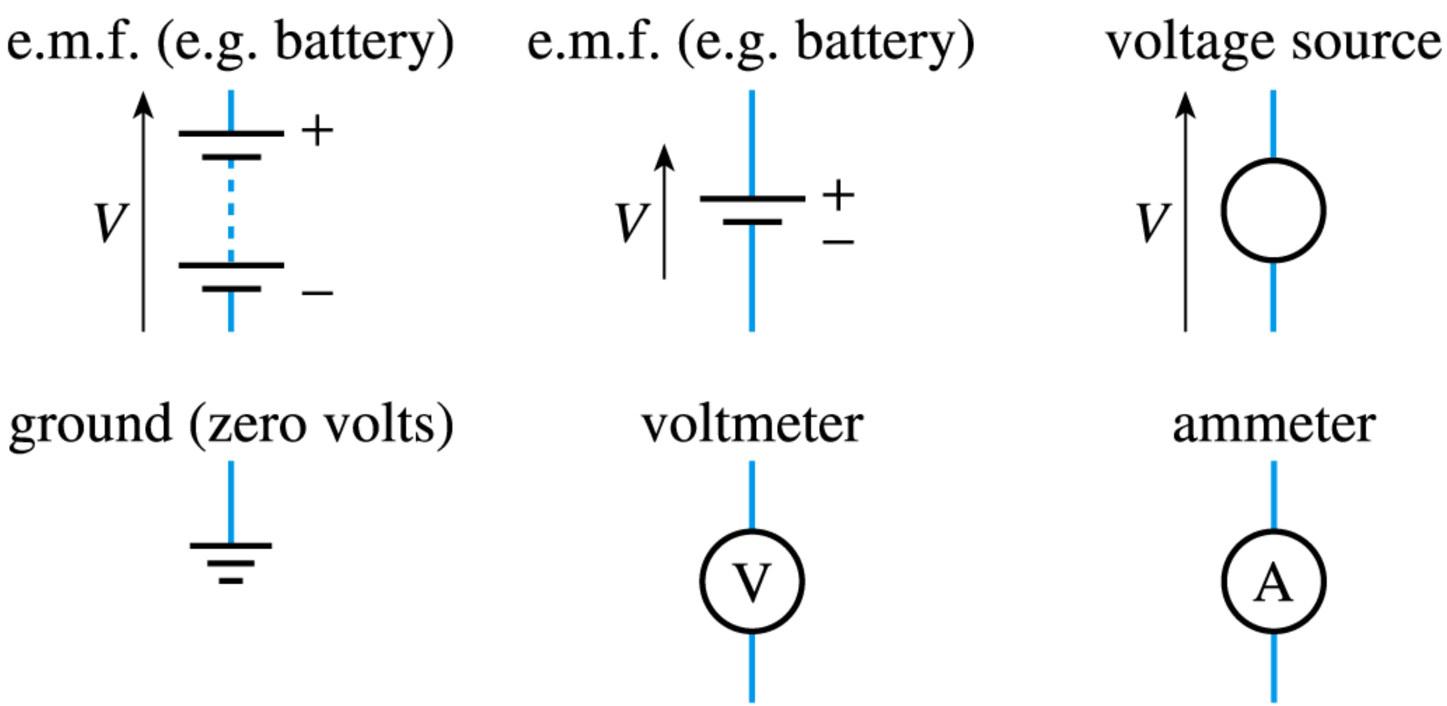




Circuit Symbols



Circuit Symbols



Key Points

- Understanding the next few lectures of this course relies on understanding the various topics covered in this session
- A clear understanding of the concepts of voltage and current is essential
- Ohm’s Law and Kirchhoff’s Laws are used extensively in later lectures
- Experience shows that students have most problems with potential dividers – a topic that is used widely in the next few lectures
- You are advised to make sure you are happy with this material now