

Chapter 14: D.C. Circuits

- Practical Circuits
- Series and parallel arrangements
- Potential divider
- Balanced potentials

- a. Recall and use appropriate circuit symbols as set out in SI Units, Signs, Symbols and Abbreviations (ASE, 1981) and Signs, Symbols and Systematics (ASE, 1995).
- b. Draw and interpret circuit diagrams containing sources, switches, resistors, ammeters, voltmeters, and/or any other type of component referred to in the syllabus.

Symbol	Meaning	Symbol	Meaning
	Cell/ Battery		Thermistor
	Power Supply		Diode
	Switch		Potential Divider
	Ammeter		Earth
	Voltmeter		Aerial/ Antenna
	Galvanometer		Capacitor
	Filament Lamp		Inductor
	Resistor		Wires crossing with no connection
	Variable Resistor		Wires crossing with connection
	Light-Dependent Resistor		Loudspeaker

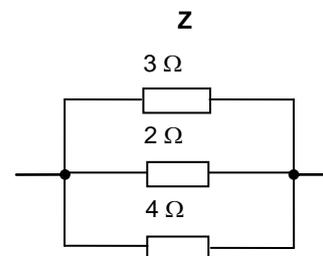
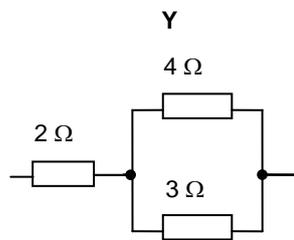
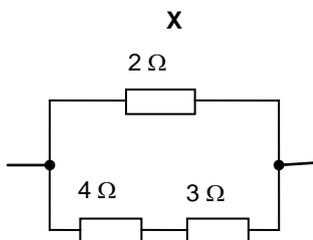
- c. Solve problems using the formula for the combined resistance of two or more resistors in series.
- d. Solve problems using the formula for the combined resistance of two or more resistors in parallel.

Resistors in Series: $R = R_1 + R_2 + \dots$

Resistors in Parallel: $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

EXAMPLE 14CD1

Three resistors of resistance $2\ \Omega$, $3\ \Omega$ and $4\ \Omega$ respectively are used to make the combinations X, Y and Z shown in the diagrams. List the combinations in order of increasing resistance.



Resistance for X = $(\frac{1}{2} + \frac{1}{4+3})^{-1} = 1.56\ \Omega$

Resistance for Y = $2 + (\frac{1}{4} + \frac{1}{3})^{-1} = 3.71\ \Omega$

$$\text{Resistance for } Z = \left(\frac{1}{3} + \frac{1}{2} + \frac{1}{4}\right)^{-1} = 0.923 \Omega$$

Therefore, the combination of resistors in order of increasing resistance is Z X Y.

e. Solve problems involving series and parallel circuits for one source of e.m.f.

EXAMPLE 14E1

E.g. 4 Referring to the circuit drawn, determine the value of I_1 , I and R , the combined resistance in the circuit.

$E = I_1 (160) = I_2 (4000) = I_3 (32000)$ $I_1 = \frac{2}{160} = 0.0125 \text{ A}$ $I_2 = \frac{2}{4000} = 5 \times 10^{-4} \text{ A}$ $I_3 = \frac{2}{32000} = 6.25 \times 10^{-5} \text{ A}$ <p>Since $I = I_1 + I_2 + I_3$, $I = 13.1 \text{ mA}$</p> <p>Applying Ohm's Law, $R = \frac{2}{13.1 \times 10^{-3}} = 153 \Omega$</p>	
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EXAMPLE 14E2

A battery with an EMF of 20 V and an internal resistance of 2.0 Ω is connected to resistors R_1 and R_2 as shown in the diagram. A total current of 4.0 A is supplied by the battery and R_2 has a resistance of 12 Ω . Calculate the resistance of R_1 and the power supplied to each circuit component.

$E - I r = I_2 R_2$ $20 - 4 (2) = I_2 (12)$ $I_2 = 1 \text{ A}$ <p>Therefore, $I_1 = 4 - 1 = 3 \text{ A}$</p> $E - I r = I_1 R_1$ $12 = 3 R_1$ <p>Therefore, $R_1 = 4$</p> <p>Power supplied to $R_1 = (I_1)^2 R_1 = 36 \text{ W}$</p> <p>Power supplied to $R_2 = (I_2)^2 R_2 = 12 \text{ W}$</p>	
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f. Show an understanding of the use of a potential divider circuit as a source of variable p.d.

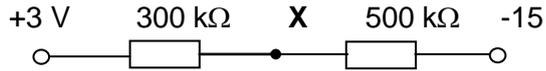
For **potential divider** with 2 resistors in series,

$$\text{Potential drop across } R_1, V_1 = \frac{R_1}{R_1 + R_2} \times \text{PD across } R_1 \text{ \& } R_2$$

$$\text{Potential drop across } R_2, V_2 = \frac{R_2}{R_1 + R_2} \times \text{PD across } R_1 \text{ \& } R_2$$

EXAMPLE 14F1

Two resistors, of resistance 300 k Ω and 500 k Ω respectively, form a potential divider with outer junctions maintained at potentials of +3 V and -15 V.



Determine the potential at the junction X between the resistors.

$$\text{The potential difference across the } 300 \text{ k}\Omega \text{ resistor} = \frac{300}{300 + 500} [3 - (-15)] = 6.75 \text{ V}$$

$$\begin{aligned} \text{The potential at X} &= 3 - 6.75 \\ &= -3.75 \text{ V} \end{aligned}$$

g. Explain the use of thermistors and light-dependent resistors in potential dividers to provide a potential difference which is dependent on temperature and illumination respectively.

USAGE OF A THERMISTOR

A thermistor is a resistor whose resistance varies greatly with temperature. Its resistance decreases with increasing temperature. It can be used in potential divider circuits to monitor and control temperatures.

EXAMPLE 14G1

In the figure below, the thermistor has a resistance of 800 Ω when hot, and a resistance of 5000 Ω when cold. Determine the potential at W when the temperature is hot.

<p>When thermistor is hot, potential difference across it</p> $= \frac{800}{800 + 1700} \times (7 - 2)$ $= 1.6 \text{ V}$ <p>The potential at W = 2 + 1.6 V = 3.6 V</p>	
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USAGE OF A LIGHT-DEPENDENT RESISTOR

An LDR is a resistor whose resistance varies with the intensity of light falling on it. Its resistance decreases with increasing light intensity. It can be used in a potential divider circuit to monitor light intensity.

EXAMPLE 14G2

In the figure below, the resistance of the LDR is 6.0 MΩ in the dark but then drops to 2.0 kΩ in the light. Determine the potential at point P when the LDR is in the light.

<p>In the light the potential difference across the LDR</p> $= \frac{2k}{3k + 2k} \times (18 - 3)$ $= 6 \text{ V}$ <p>The potential at P = 18 - 6 = 12 V</p>	
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h. Recall and solve problems using the principle of the potentiometer as a means of comparing potential differences.

The potential difference along the wire is proportional to the length of the wire. The sliding contact will move along wire AB until it finds a point along the wire such that the galvanometer shows a zero reading.

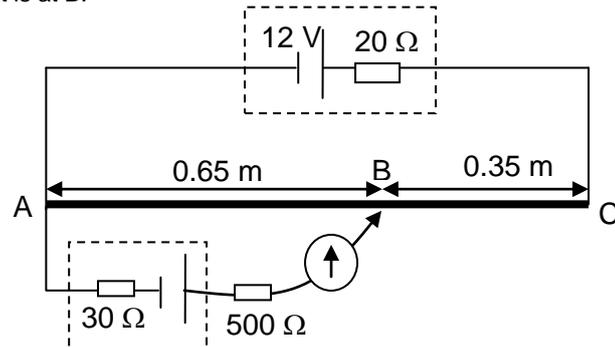
When the galvanometer shows a zero reading, the current through the galvanometer (and the device that is being tested) is zero and the potentiometer is said to be “balanced”.

If the cell has negligible internal resistance, and if the potentiometer is balanced,

$$\text{EMF / PD of the unknown source, } V = \frac{L_1}{L_1 + L_2} \times E$$

EXAMPLE 14H1

In the circuit shown, the potentiometer wire has a resistance of 60 Ω. Determine the EMF of the unknown cell if the balanced point is at B.



Resistance of wire AB

$$= \frac{0.65}{0.65 + 0.35} \times 60 = 39 \Omega$$

EMF of the test cell

$$= \frac{39}{60 + 20} \times 12 = 5.85 \text{ V}$$