Electricity

IB Physics Content Guide

Big Ideas

- Electricity consists of charged particles moving in a continuous circuit
- Voltage, Current, and Resistance are related to each other though Ohm's Law
- The resistance of a wire is affected by its thickness, length, and material resistivity
- The total current flowing into a junction must equal the total current flowing out of that same junction
- The voltage dropped around a continuous loop traced in a circuit add up to the voltage provided
- Resistors can be combined in different ways to produce different results
- It is possible that the act of taking a measurement will change the value being measured

1 – Electrical Properties

I can describe the properties of Voltage, Current, Resistance, and Power			
I can quantify current through a representation of charge of numbers of electrons			
I can relate energy and voltage conceptually and mathematically			
I can mathematically relate the electrical properties and solve for an unknown			

2 – Circuits

I can describe the direction of conventional current compared to the movement of charges			
I can identify component combinations as parallel or series			
I can describe how current flows through parallel and series resistors			
I can describe the set up to measure current and voltage in a circuit			

3 – Calculating Resistance

I can describe the property of resistivity and how it and the wire dimensions affect resistance			
I can calculate the equivalent resistance for combinations of resistors in series and parallel			
I can step through the calculation of equivalent resistance for a complex combination			

4 – Circuit Analysis

I can use Kirchhoff's First Law to determine an unknown current at a junction			
I can calculate voltage, current, and resistance for every component in a series or parallel circuit			
I can compare the properties for simple series and parallel circuits			

5 – Potential Dividers

I can identify the different circuit diagram symbols for different types of resistors			
I can describe how environmental changes can affect the resistance of LDRs and Thermistors			
I can describe how changing resistor values can affect the voltage drop in a potential divider circuit			
I can design a potential divider circuit to perform a certain task			

6 – Non-Ideal Meters

I can connect a meter to measure current or voltage			
I can describe the conditions required for an ideal ammeter or voltmeter			
I can calculate for a situation when the meter isn't ideal			

7 – Batteries

I can describe the difference between primary and secondary cells			
I can define the electromotive force and describe how it is different than terminal voltage			
I can solve for a circuit that includes a battery with internal resistance			

Defining Current and Voltage

	Variable Symbol	Description	Unit
$I = \frac{\Delta q}{\Delta t}$	I	Current	Amperes [A]
	Δq	Change in Charge	Coulombs [C]
	Δt	Change in Time	Seconds [s]

Charge of 1 Electron	1.6×10^{-19} C

# of Electrons per Coulomb	6.25×10^{18} e^-

Potential difference is defined as the work done (energy transferred) when one unit of positive charge moves between two points along the path of the current

	Variable Symbol	Description	Unit
$V = \frac{W}{q}$	V	Potential Difference (voltage)	Volts [V]
	W	Work	Joules [J]
	q	Charge	Coulombs [C]

Electrical Properties

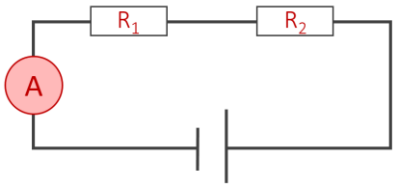
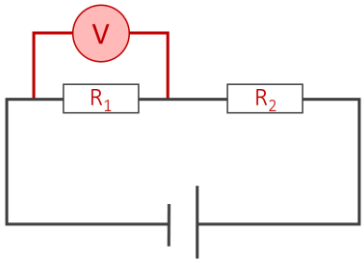
Property	What is it?	Symbol	Unit
Voltage	Potential Difference	V	Volts [V]
Current	The rate at which charges move through a wire	I	Amperes [A]
Resistance	How hard it is for a current to flow through a conductor	R	Ohms [Ω]
Power	Energy dissipated per second	P	Watts [W]

Power Formula	Ohm's Law		
$P = IV = I^2R = \frac{V^2}{R}$	$V = I \times R$	$I = \frac{V}{R}$	$R = \frac{V}{I}$

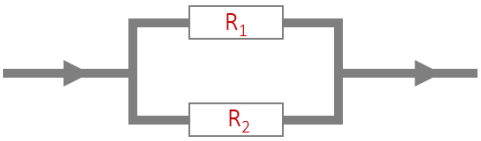
Resistivity

	Variable Symbol	Description	Unit
$\rho = \frac{RA}{L}$ $A_{circle} = \pi r^2$	ρ	Resistivity	Ohm Meters [Ω m]
	R	Resistance	Ohms [Ω]
	A	Cross Sectional Area	Square meters [m^2]
	L	Length	Meters [m]

Measuring Circuits

	Ammeter	Voltmeter
Ideal Resistance	R = 0 Ω	R = ∞ Ω
How is it connected to the component being measured?	Ammeters must be connected in **series**	Voltmeters must be connected in **parallel**
Drawing of meter measuring R_1		

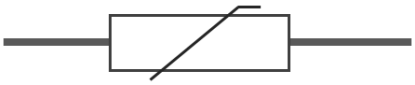
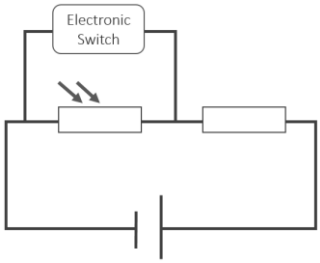
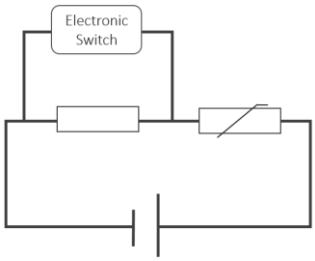
Equivalent Resistance

	Drawing with R_1 and R_2	Equation
Series		$R_{total} = R_1 + R_2 + \cdots$
Parallel		$\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Circuit Analysis

	Series Circuits	Parallel Circuits
Current	Same for all resistors $I = I_1 = I_2 = \ldots$	Splits over all resistors $I = I_1 + I_2 + \ldots$
Voltage	Splits over all resistors $V = V_1 + V_2 + \ldots$	Same for all resistors $V = V_1 = V_2 = \ldots$

Voltage Dividers

	Light-Dependent Resistor		Thermistor	
Symbol				
Relationship	Light	Increases	Heat	Increases
	Resistance	Decreases	Resistance	Decreases
Circuit	Switch turns on in the dark: 		Switch turns on in a fire: 	

Batteries

Primary Cells	Secondary Cells
Cannot be recharged	*Can be recharged by passing a current through the battery in the opposite direction as it would normally travel*

$\varepsilon = I(R + r)$

Variable Symbol	Description	Unit
ε	Electromotive Force (e.m.f)	Volts [V]
I	Current	Amps [A]
R	Circuit Resistance	Ohms [Ω]
r	Internal Resistance	Ohms [Ω]