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 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 must equal 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
- The resistance of a wire is affected by its thickness, length, and material resistivity

Content Objectives

1 – Electrical Current

I can quantify charge in terms of Coulombs			
I can calculate the charge of a certain # of electrons and the # of electrons for a given charge			
I can describe current in terms of amps and coulombs per second			
I can describe the subatomic properties of a conductor to allow charge to flow			
I can the electron drift speed for a given current and wire			

2 – Electrical Properties

I can describe the properties of Voltage, Current, Resistance, and Power			
I can use Ohm's Law to mathematically relate these electrical properties and solve for an unknown			

3 – 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			

4 – 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 the equivalent resistance for a complex combination			

5 – Voltage Dividers and Batteries

I can use Kirchhoff's First Law to determine an unknown current at a junction			
I can use Kirchhoff's Second 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 and contrast the properties for simple series and parallel circuits			

6 – 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			

7 – Voltage Dividers and Batteries

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			

8 – Batteries

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

Electricity

Shelving Guide

Charge

Symbol	q	Unit	Coulombs [C]
Charge of 1 Electron			1.6×10^{-19} C
# of Electrons per Coulomb			6.25×10^{18} e^-

Current

Symbol	I	Unit	Amperes [A]
Unit in terms of Coulombs			$A = \frac{C}{s}$

Drift Speed

	Variable Symbol	Unit
Current	I	A
# of Electrons per m^3	n	---
Cross Sectional Area	A	M^2
Drift Speed	v	m s^{-1}
Charge	q	C

Data Booklet Equation:

$$I = nAvq$$

Cross Sectional Area:

$$A = \pi r^2$$

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]

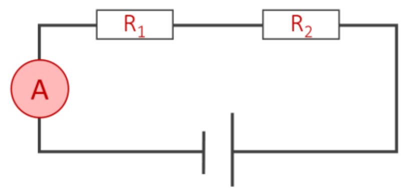
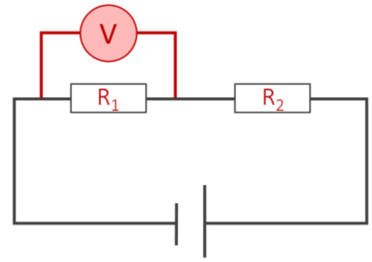
Power

In terms of V and I	In terms of I and R	In terms of V and R
$P = V \times I$	$P = I^2R$	$P = \frac{V^2}{R}$

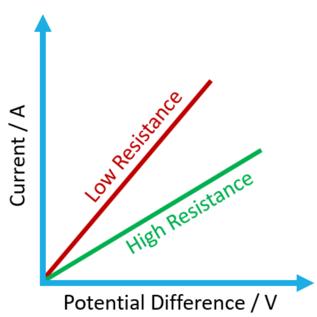
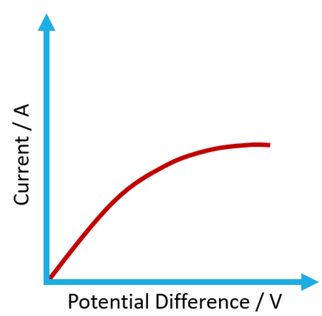
Ohm's Law

$V = I \times R$	$I = \frac{V}{R}$	$R = \frac{V}{I}$

Measuring Circuits

	Ammeter	Voltmeter
Ideal Resistance	$R = 0\ \Omega$	$R = \infty\ \Omega$
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		

Resistivity

	Variable Symbol	Unit
Resistivity	ρ	Ω m
Resistance	R	Ω
Cross Sectional Area	A	m^2
Length	L	m
Ohmic Resistor 	Non-Ohmic Resistor 	

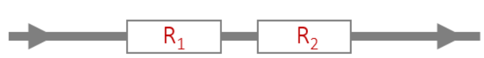
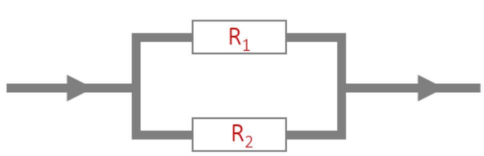
Data Booklet Equation:

$$\rho = \frac{RA}{L}$$

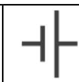
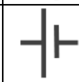
Cross Sectional Area:

$$A = \pi r^2$$

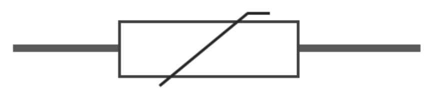
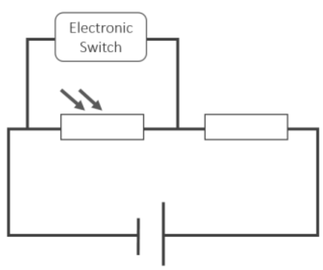
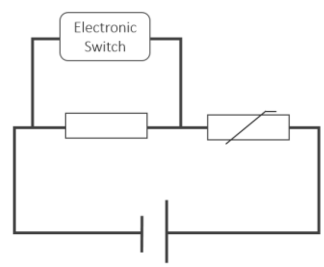
Equivalent Resistance

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

Kirchhoff's Laws

$\Sigma I = 0 \ (junction)$				$\Sigma V = 0 \ (loop)$			
The total current coming into a junction must equal the total current leaving the same junction				The sum of the voltages (potential differences) provided must equal the voltages dissipated across components			
				Across resistors			Always Negative
Entering Junction	→	•	Positive	Negative to Positive	→		Positive
Exiting Junction	•	→	Negative	Positive to Negative	→		Negative

Voltage Dividers

	Light-Dependent Resistor		Thermistor	
Symbol				
Relationship	Light	Increases	Light	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*

	Variable Symbol	Unit
Electromotive Force (e.m.f)	ε	V
Current	I	A
Circuit Resistance	R	Ω
Internal Resistance	r	Ω

Data Booklet Equation:

$$\varepsilon = I(R + r)$$