8 | 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
- Many applications use a potential divider circuit design to produce a result when certain conditions are met
- The voltage that a battery can supply is related to its internal resistance

Content Objectives

8.1 – Electrical Current

p. 208-213, 217-218

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			
I can use Kirchhoff's First Law to analyze the current flowing in an out of a junction			

8.2 – Ohm's Law and Resistance

p. 219-225

I can use Kirchhoff's Second Law to analyze the current flowing in an out of a junction			
I can qualitatively describe voltage, current, and resistance			
I can mathematically relate voltage, current, and resistance using Ohm's Law			
I can describe the difference between ohmic and non-ohmic resistors			
I can identify groups of resistors as being connected in series of parallel			
I can calculate the equivalent resistance for resistors connected in series			
I can calculate the equivalent resistance for resistors connected in parallel			
I can quantitatively describe how adding resistors changes the equivalent resistance			

8.3 – Circuits

p. 226-231

I can calculate the equivalent resistance for resistors in a combination circuit with series AND parallel			
I can describe how voltage is divided across resistors in series			
I can describe how current is divided across parallel branches in a circuit			
I can use a circuit diagram to calculate V, I, and R for resistors in simple series or parallel circuits			
I can use a circuit diagram to calculate V, I, and R for resistors in a combination circuit			

8.4 – Measuring Circuits and Resistivity

📖 p. 226-231

I can explain how a voltmeter or ammeter must be connected in a circuit			
I can identify the resistance required for an ideal voltmeter or ammeter			
I can predict the reading on a meter when given its internal resistance			
I can calculate a meter's internal resistance from a meter reading and circuit diagram			
I can calculate the electrical power of a component when given voltage, current, or resistance			
I can qualitatively describe the factors that affect a wire's resistance			
I can define the resistivity of a meter with proper units			
I can calculate for an unknown variable in the resistivity formula			

8.5 – Voltage Dividers and Batteries

📖 p. 232-241

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 experienced			
I can design a potential divider circuit to perform a certain task			
I can compare the differences between primary and secondary cells			
I can describe the mechanics required to recharge a battery			
I can define the electromotive force and describe how is it is different than the battery's voltage			
I can solve for a circuit that includes a battery with internal resistance			
I can describe how a battery's voltage changes over time			

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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:

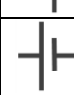
$$A = \pi r^2$$

Electrical Properties

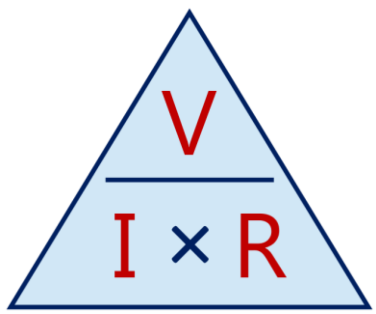
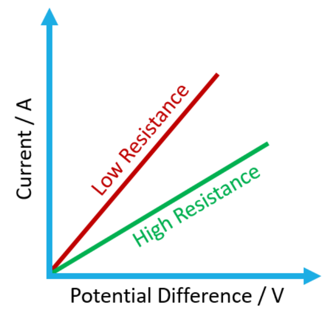
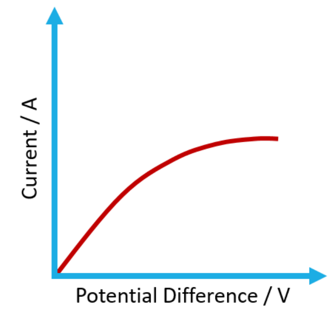
Property	What is it?	Symbol	Unit
Voltage	Potential Difference	V	Volts [V]
Current	The rate at which charges move through a wire	I	Amperes [A]
Resistance	How hard it is for a current to flow through a conductor	R	Ohms [Ω]

Kirchhoff's Laws

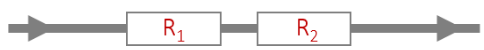
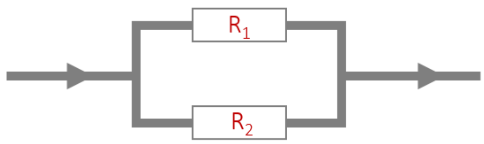
$\Sigma I = 0$ (junction)			
The total current coming into a junction must equal the total current leaving the same junction			
Entering Junction	→	●	Positive
Exiting Junction	●	→	Negative

$\Sigma V = 0$ (loop)			
The sum of the voltages (potential differences) provided must equal the voltages dissipated across components			
Across resistors			Always Negative
Negative to Positive	→		Positive
Positive to Negative	→		Negative

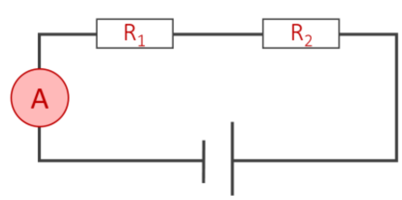
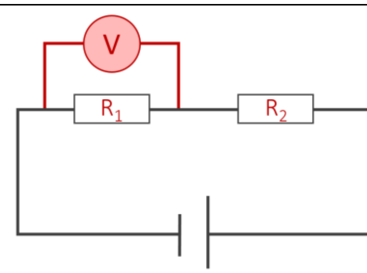
Ohm's Law

		Ohmic Resistor	Non-Ohmic Resistor
	$V = I \times R$ $I = \frac{V}{R}$ $R = \frac{V}{I}$		

Equivalent Resistance

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

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		

Resistivity

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

Data Booklet Equation:

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

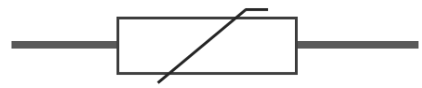
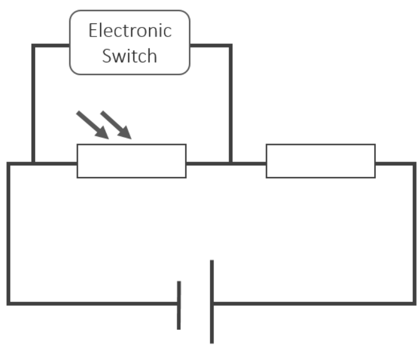
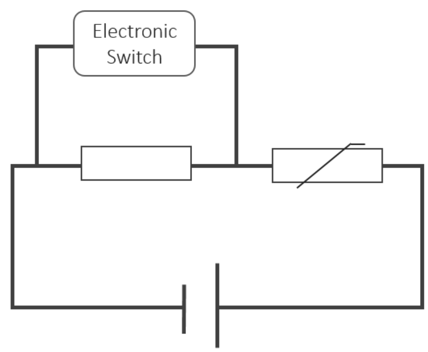
Cross Sectional Area:

$$A = \pi r^2$$

Power

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

Voltage Dividers

	Light-Dependent Resistor	Thermistor
Symbol		
Relationship	Light: Increases Resistance: Decreases	Heat: Increases 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:

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