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| **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

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| 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  |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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  |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| 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 |  |  |  |

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| **Electricity** | Shelving Guide |
| Charge |  | Current |
| Symbol | q | Unit | Coulombs [C] | Symbol | I | Unit | Amperes [A] |
| Charge of 1 Electron | 1.6 × 10-19 C | Unit in terms of Coulombs | $$A=\frac{C}{s}$$ |
| # of Electrons per Coulomb | 6.25 × 1018 e- |

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| --- | --- | --- | --- | --- |
| Drift Speed | Variable Symbol | Unit |  | *Data Booklet Equation:* |
| Current | I | A |  | $$I=nAvq$$ |
| # of Electrons per m3 | n | --- |  |
| Cross Sectional Area | A | M2 |  |  |
| Drift Speed | v | m s-1 |  | Cross Sectional Area:$$A=πr^{2}$$ |
| Charge | q | C |  |

## Electrical Properties

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| --- | --- | --- | --- |
| 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 toflow through a conductor | R | Ohms [Ω] |

## Power

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

## Ohm’s Law

|  |  |  |
| --- | --- | --- |
| $$V=I × R$$ | $$I=\frac{V}{R}$$ | $$R=\frac{V}{I}$$ |
| 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 R1 |  |  |

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| Resistivity | Variable Symbol | Unit |  | *Data Booklet Equation:* |
| Resistivity | ρ | Ω m |  | $$ρ=\frac{RA}{L}$$ |
| Resistance | R | Ω |  |
| Cross Sectional Area | A | m2 |  | Cross Sectional Area:$$A=πr^{2}$$ |
| Length | L | m |  |
| Ohmic Resistor | Non-Ohmic Resistor |
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## Equivalent Resistance

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|  | Drawing with R1 and R2 | Equation |
| Series |  | $$R\_{total}=R\_{1}+R\_{2}+…$$ |
| Parallel |  | $$\frac{1}{R\_{total}}=\frac{1}{R\_{1}}+\frac{1}{R\_{2}}+…$$ |

## Kirchhoff’s Laws

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| $$ΣI=0  (junction)$$ | $$ΣV=0  (loop)$$ |
| 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

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|  | 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

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| 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* |

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|  | Variable Symbol | Unit |  | *Data Booklet Equation:* |
| Electromotive Force (e.m.f) | ε | V |  | $$ε=I(R+r)$$ |
| Current | I | A |  |
| Circuit Resistance | R | Ω |  |  |
| Internal Resistance | r | Ω |  |  |