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| **Force Fields** | IB Physics Content Guide |

# Big Ideas

* Opposite charges/poles attract while like charges/poles repel
* The force between charged particles demonstrates the same relationship as the force between bodies with mass
* A force field describes the force at a location per unit mass, charge, or current
* A current flowing through a conductor produces a magnetic field
* The relative directions of current, magnetic field, and electromagnetic force can be found using the right-hand rules

# Content Objectives

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| 1 – Static Electricity |  |
| I can explain how objects can become charged |  |  |  |
| I can qualitatively describe the reactions between charged particles |  |  |  |
| I can describe the process of grounding a charged object |  |  |  |

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| 2 – Electrostatic and Gravitational Force |  |
| I can use Coulomb’s Law to relate electrostatic force to particle charge and separation distance |  |  |  |
| I can use the Law of Gravitation to relate gravitation force to object mass and separation distance |  |  |  |
| I can determine the units of Coulomb’s Constant and the Gravitation Constant using unit analysis |  |  |  |
| I can describe how the sign of the calculated electrostatic force indicates attraction or repulsion |  |  |  |
| I can compare and contrast electrostatic and gravitation forces |  |  |  |
| I can discuss the impact of permittivity on Coulomb’s Constant |  |  |  |

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| 3 – Force Fields |  |
| I can calculate force between objects with a net charge or mass |  |  |  |
| I can draw the vector force field for electric and gravitational fields |  |  |  |
| I can describe the role of a test charge or test mass in representing force fields |  |  |  |
| I can describe how the magnitude of a force changes with distance from an object |  |  |  |
| I can calculate field strength with proper units around a single object |  |  |  |
| I can calculate the net field strength based on two or more objects |  |  |  |
| I can determine the location where the net field strength is zero |  |  |  |

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| 4 – Magnetism and Right Hand Rule |  |
| I can describe the pole conditions required for magnetic attraction and repulsion |  |  |  |
| I can explain what happens when a dipole magnet is cut into pieces |  |  |  |
| I can describe the role of magnetic domains in magnetizing and de-magnetizing a material |  |  |  |
| I can draw in magnetic field lines around a magnet with a north and south pole |  |  |  |
| I can describe the layout of the Earth’s magnetic poles |  |  |  |
| I can use the right-hand rule to draw in a magnetic field around a current carrying wire |  |  |  |
| I can use the right-hand rule to predict the current direction through a wire with a surrounding field |  |  |  |
| I can indicate a vector that is pointing into or out of the page |  |  |  |
| I can describe some applications of electromagnets in use today |  |  |  |
| I can describe the design factors that affect the strength of an electromagnet |  |  |  |

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| 5 – Electromagnetic Force |  |
| I can use the right-hand rule to predict the force direction on a charge moving through a field |  |  |  |
| I can use the right-hand rule to predict the force direction on a current carrying wire placed a field |  |  |  |
| I can describe the general functions of electric motors and generators |  |  |  |
| I can calculate the magnetic field strength and force on a wire or moving charged particle |  |  |  |
| I can predict the trajectory of a charged particle moving through a magnetic field at different speeds |  |  |  |

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| **Force Fields** | Shelving Guide |

# Forces between objects

## Coulomb’s Law

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Electrostatic Force | F | N |  | $$F=k\frac{q\_{1}q\_{2}}{r^{2}}$$ |
| Object 1 Charge | q1 | C |  |
| Object 2 Charge | q2 | C |  | $$k=\frac{1}{4πε\_{0}}$$ |
| Separation Distance | r | M |  |
| Coulomb Constant | k | N m2 C-2 |  | k = 8.99 × 109 N m2 C-2 |
| Permittivity of Free Space | ε0 | C2 N-1 m-2 |  | ε0 = 8.85 × 10-12 C2 N-1 m-2 |

## Universal Law of Gravitation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equation:* |
| Gravitational Force | F | N |  | $$F=G\frac{m\_{1}m\_{2}}{r^{2}}$$ |
| Object 1 Mass | M | kg |  |
| Object 2 Mass | m | kg |  |  |
| Separation Distance | r | m |  |
| Gravitational Constant | G | N m2 kg-2 |  | G = 6.67 N m2 kg-2 |

# Force Fields

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| --- | --- |
| Electric Field | Gravitational Field |
|  |  |  |  |
| Symbol | E | *Data Booklet Equation:*$E=\frac{F}{q}$  | Symbol | g | *Data Booklet Equation:*$g=\frac{F}{m}$ $g=G\frac{M}{r^{2}}$  |
| Units | F C-1 | Units | F kg-1 |

## Magnetic Fields

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## Right Hand Rule

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| Right Hand Rule #1 | Right Hand Rule #2 |
| Magnetic field around a current carrying wire | Electromagnetic force direction on a wire or moving particle  |
| Thumb | Current | Thumb | Current |
| Fingers | Magnetic Field | Fingers | Magnetic Field |
|  |  |  | Palm | Force |
|  |  |
|  |

## Electromagnetic Force

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Variable Symbol | Unit |  | *Data Booklet Equations:* |
| Magnetic Force | F | N |  |  |
| Magnetic Field Strength | B | T |  | Wire: |
| Current | I | A |  | $$F=BIL\sin(θ)$$ |
| Wire Length | L | m |  |  |
| Angle to Field | θ | ° |  | Particle: |
| Particle Charge | q | C |  | $$F=qvB\sin(θ)$$ |
| Particle Velocity | v | m s-1 |  |  |

## Charged Particles Moving through a Magnetic Field

|  |  |  |
| --- | --- | --- |
|  | Magnetic Field | Out of Screen | Magnetic Field | Into Screen |
| Positive Particle |  |  |
| Negative Particle |  |  |