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

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			

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			

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			

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			

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			

Force Fields

Shelving Guide

Forces between objects

Coulomb's Law

	Variable Symbol	Unit
Electrostatic Force	F	N
Object 1 Charge	q_1	C
Object 2 Charge	q_2	C
Separation Distance	r	M
Coulomb Constant	k	$N\ m^2\ C^{-2}$
Permittivity of Free Space	ε_0	$C^2\ N^{-1}\ m^{-2}$

Data Booklet Equations:

$$F = k\frac{q_1 q_2}{r^2}$$

$$k = \frac{1}{4\pi\varepsilon_0}$$

$k = 8.99 \times 10^9\ N\ m^2\ C^{-2}$
$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2\ N^{-1}\ m^{-2}$

Universal Law of Gravitation

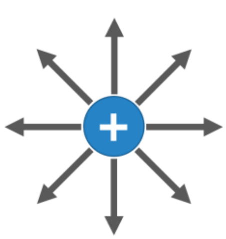
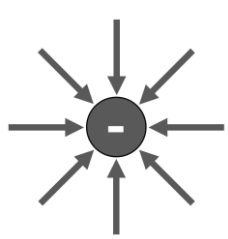
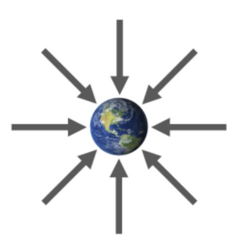
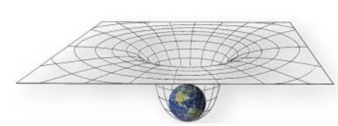
	Variable Symbol	Unit
Gravitational Force	F	N
Object 1 Mass	M	kg
Object 2 Mass	m	kg
Separation Distance	r	m
Gravitational Constant	G	$N\ m^2\ kg^{-2}$

Data Booklet Equation:

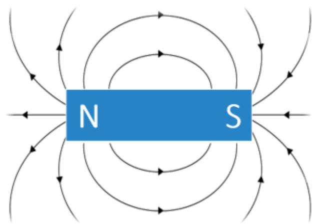
$$F = G\frac{m_1 m_2}{r^2}$$

$G = 6.67\ N\ m^2\ kg^{-2}$

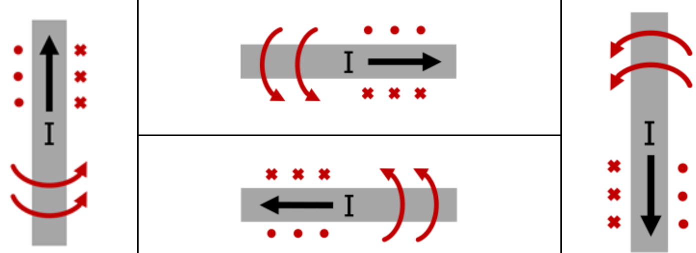
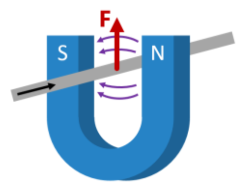
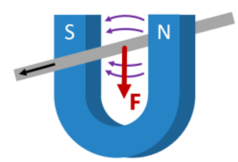
Force Fields

<table>
<tr><th colspan="3">Electric Field</th><th colspan="3">Gravitational Field</th></tr>
<tr><td colspan="2"></td><td></td><td colspan="2"></td><td></td></tr>
<tr><td>Symbol</td><td>E</td><td rowspan="2">Data Booklet Equation:
$E = \frac{F}{q}$</td><td>Symbol</td><td>g</td><td rowspan="2">Data Booklet Equation:
$g = \frac{F}{m}$ $g = G\frac{M}{r^2}$</td></tr>
<tr><td>Units</td><td>$F\ C^{-1}$</td><td>Units</td><td>$F\ kg^{-1}$</td></tr>
</table>

Magnetic Fields

Right Hand Rule

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
Magnetic Force	F	N
Magnetic Field Strength	B	T
Current	I	A
Wire Length	L	m
Angle to Field	θ	°
Particle Charge	q	C
Particle Velocity	v	$m\ s^{-1}$

Data Booklet Equations:

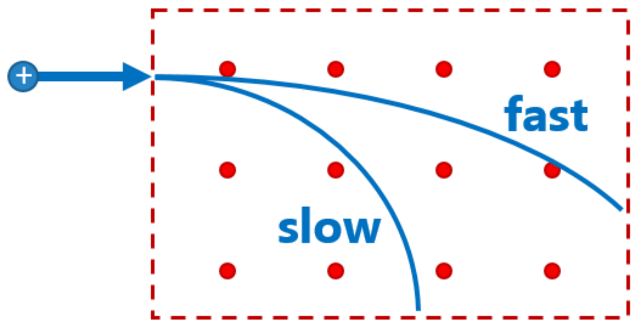
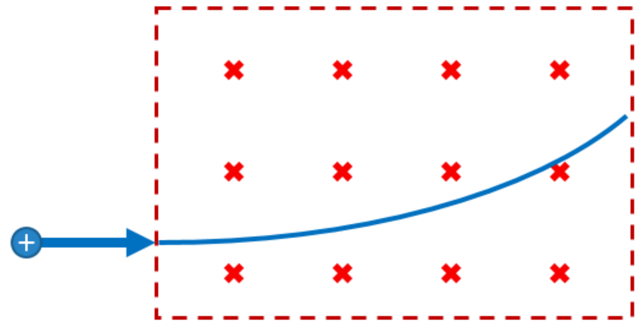
Wire:

$$F = BIL \sin\theta$$

Particle:

$$F = qvB \sin\theta$$

Charged Particles Moving through a Magnetic Field

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