PHY-112
Principles of Physics-II
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Spring-24 | Class-17

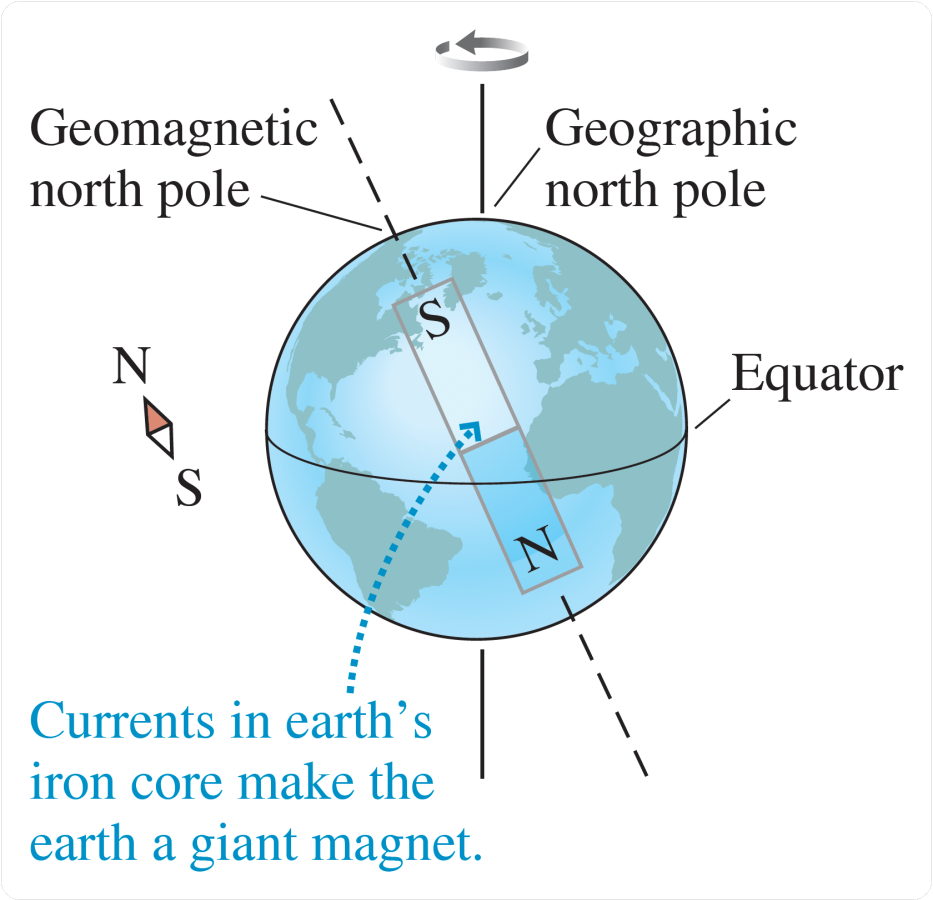
Enter Magnetic Fields

What is magnetism?

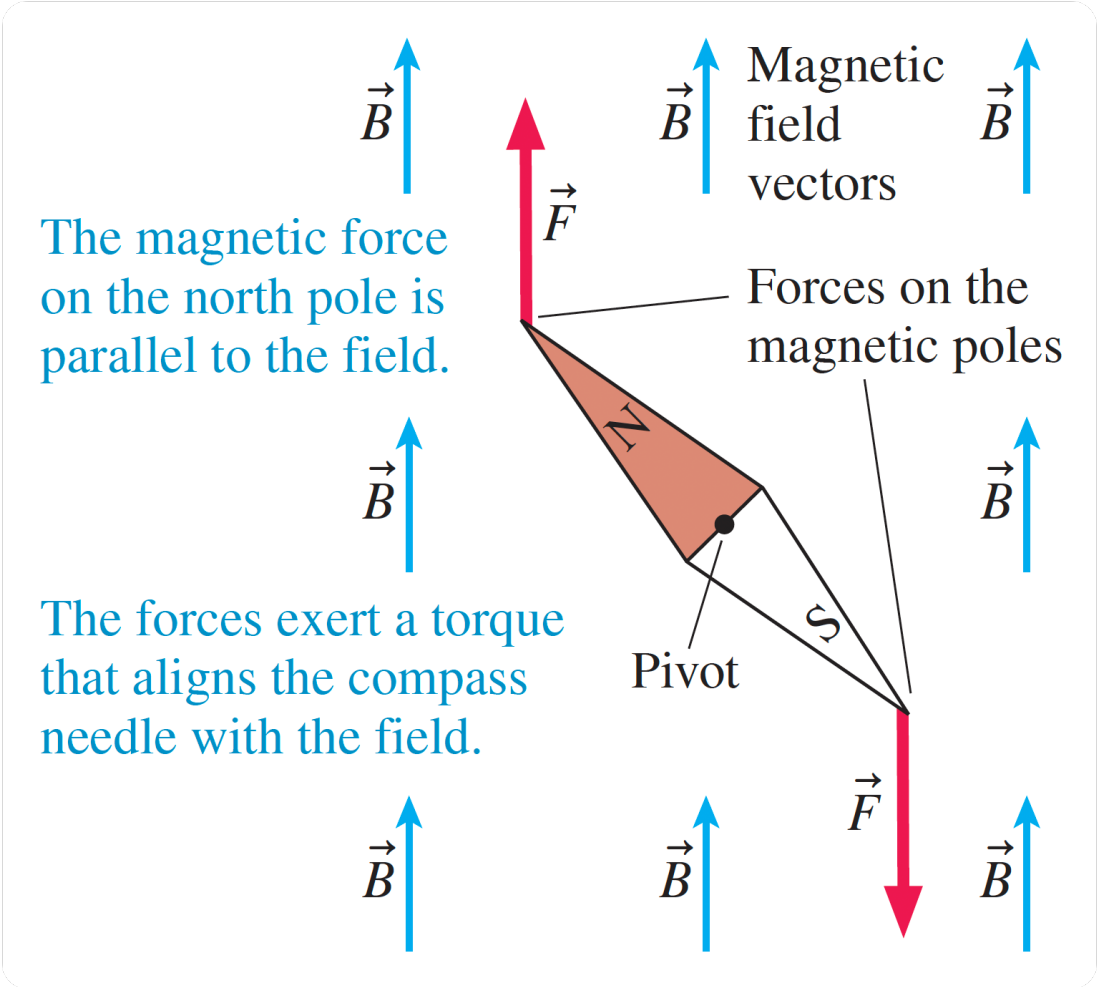
Magnetism is an interaction between moving charges. One creates it, another experiences it. But both need to be ***moving***.

- A Magnetic field $\vec{B}$ is created by a moving charge
- Magnetic interactions are understood in terms of Magnetic poles: North and South
- Magnetic forces, similar to Electric forces, are due to the action of Magnetic fields
- Magnetic poles **never occur in isolation**. All magnets are **dipoles**, with two poles.
- Practical Magnetic fields are created by electric currents—collections of moving charges.

Geomagnet and Compasses



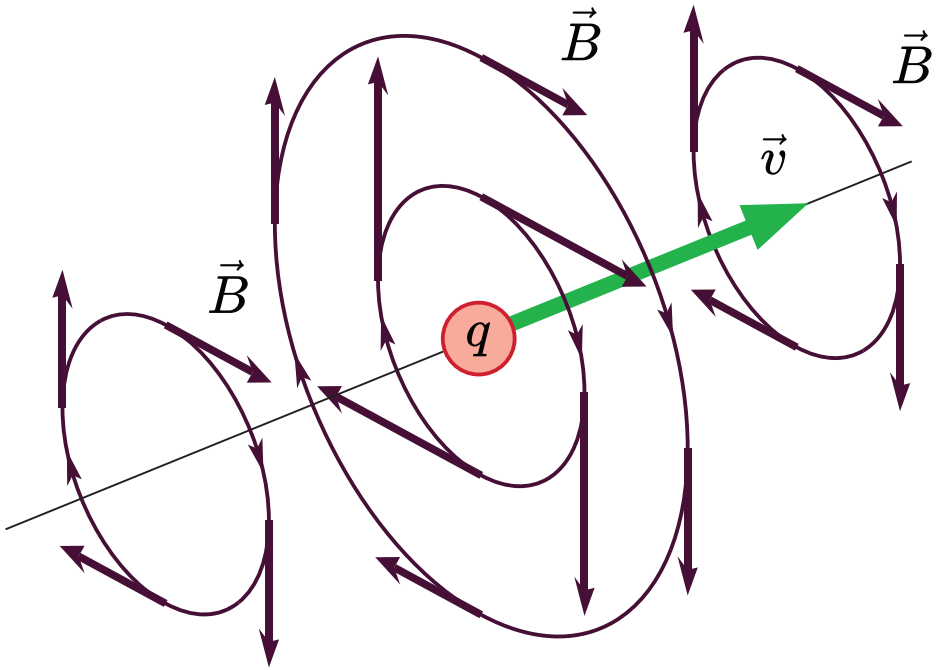
Geomagnet and Compasses



Two Kinds of Magnetism?

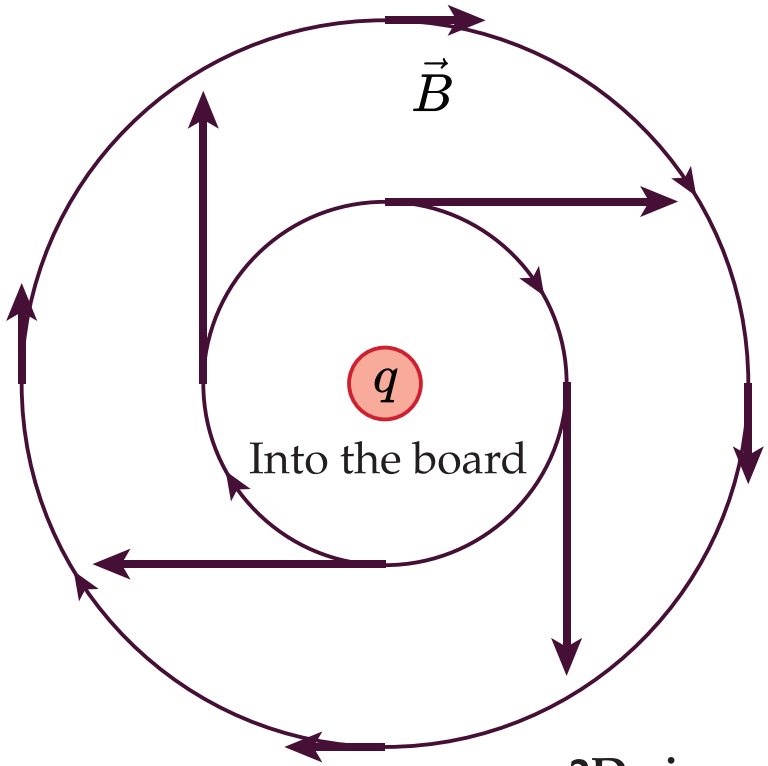
One of the major goals for our study of magnetism is to see that these two quite different ways of producing Magnetic effects are really just two different aspects of a **single** Magnetic force. We would be omitting *permanent* magnets out of our story because they are boring!

$\vec{B}$-field lines are circular for Single *moving* Point Charges



Line of motion

3D view



2D view

You must not FORGET!!!

A moving charge has both a $\vec{B}$-field and an $\vec{E}$-field. What you know about electric fields has not changed. **All charges create electric fields, but only moving charges create Magnetic fields.**

Remember Gauss's Law?

Gauss's Law for Electric Fields

Gauss's Law for $\vec{E}$-fields:

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{\text{enclosed}}}{\varepsilon_0}. \qquad \text{(Integral Form)}$$

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho_{\text{enclosed}}}{\epsilon_0}. \qquad \text{(Differential Form)}$$

This is Maxwell's 1st equation. It establishes the fact that Electric monopoles or charges ***can*** exist in isolation.

Gauss's Law for Magnetic Fields

Gauss's Law for $\vec{B}$-fields:

$$\oint \vec{B} \cdot d\vec{a} = 0. \qquad \text{(Integral Form)}$$

$$\vec{\nabla} \cdot \vec{B} = 0. \qquad \text{(Differential Form)}$$

This is Maxwell's 2nd equation. It establishes the fact that Magnetic monopoles or charges ***cannot*** exist in isolation. It always comes in dipoles.