CHAPTERS 27 AND 28 NOTES

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Contents

27 Magnetic Field and Magnetic Forces

But the *fundamental* nature of magnetism is the interaction of moving electric charges. Unlike electric forces, which act on electric charges whether they are moving or not, magnetic forces act only on *moving charges.*

27.1 Magnetism.

Remark. The earth itself is a magnet. Its north geographic pole is close to a magnetic south pole, which is why the north pole of a compass needle points north. The earth's magnetic axis is not quite parallel to its geographic axis (the axis of ro- tation), so a compass reading deviates somewhat from geographic north. This deviation, which varies with location, is called *magnetic declination or magnetic variation.*

Remark. While isolated positive and negative charges exist, there is no experimental evidence that one isolated magnetic pole exists; poles always appear in pairs. If a bar magnet is broken in two, each broken end becomes a pole

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27.2 Magnetic Field.

Definition 1. Summary of Electric interactions:

(1) A distribution of electric charge creates an electric field $\vec{E}$ in the surrounding space.
(2) The electric field exerts a force $\vec{F} = q\vec{E}$ on any other charge q that is present in the field.

Definition 2. Summary of Magnetic interactions:

(1) A moving charge or a current creates a **magnetic field (B)** in the surrounding space (in addition to its *electric* field).
(2) The magnetic field exerts a force $\vec{F}$ on any other moving charge or current that is present in the field.

Magnetic Field strength can be found by the equation

$$B = \frac{\mu_0 I}{2\pi r}$$

where μ_0 is the permitivity of free space($4\pi \cdot 10^{-7}\ T \cdot m/A$) and r is the seperation.

Remark. Like electric field, magnetic field is a vector field–that is, a vector quantity associated with each point in space. We will use the symbol $\vec{B}$ for magnetic field.

27.2.1 Magnetic Forces on Moving Charges.

Definition 3. Key Characteristics of Magnetic Force on Moving Charges:

(1) Force Magnitude is proportional to the magnitude of the charge.
(2) The magnitude of the force is also propor- tional to the magnitude, or "strength," of the field.
(3) The magnetic force depends on the particle's velocity.
(4) The magnetic force $\vec{F}$ does not have the same direction as the magnetic field $\vec{B}$ but instead is always perpendicular to both $\vec{B}$ and the velocity $\vec{v}$.

The Magnetic force can be found by the equation

$$F = |q|v \times B = |q|vBsin\phi$$

where ϕ is the angle between the direction of velocity and direction of the magnetic field and the magnitude is measured in teslas ($1T = 1N/A \cdot m$) or in Gauss(1G = 10^{-4}T)

Remark. The magnetic field of the earth is 10^{-4}T 1 Gauss.

Remark. When a charged particle moves through a region of space where both electric and magnetic fields are present, *both fields exert forces on the particle*. The total force $\vec{F}$ is the vector sum of the electric and magnetic forces:

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

27.3 Magnetic Field Lines and Magnetic Flux.

Definition 4. Magnetic Field Lines: Just like an electric field, a magnetic field can be represented through field lines. The more lines there are in a given area the stronger the field , and they never intersect. Magnetic Field Lines are not lines of force, just direction.

Definition 5. Magnetic Flux(Φ_B): A measurement of the total magnetic field which passes through a given area. The total magnetic flux through the surface is the sum of the contributions from the individual area elements. Can be found using the following equation:

$$\Phi_B = \int Bcos\phi dA = \int \vec{B} \cdot d\vec{A}$$

Magnetic Flux is scalar and its units are Weber(1 Wb = 1 $T \cdot m^2$ = 1 $N \cdot m/A$)

27.4 Motion of Charged Particles in a Magnetic Field.

Remark. Motion of a charged particle under the action of a magnetic field alone is always motion with constant speed.

Remark. When velocity and magnetic field are perpendicular, the particle exhibits circular motion. This relation is shown by

$$F = |q|vb = m\frac{v^2}{R}$$

whose radius can be found by

$$R = \frac{mv}{|q|B}$$

and whose angular speed can be found by

$$\omega = \frac{v}{r} = \frac{|q|B}{m}$$