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## Chapter 8: *Magnetism*

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### 8.1 Domain Theory of Magnetism

#### **Definition:**

Magnetism is primarily caused by the motion of charged particles like electrons around the nucleus in atoms and the movement of charges in wires (electric current). In the late 20th century, the Domain Theory of magnetism was developed to explain how certain materials become magnetic.

#### **Notes:**

- Each electron in an atom produces a small magnetic field, resulting in tiny "atomic magnets."
- When electrons align in the same direction, their magnetic effects combine, creating a net magnetic field.
- In unmagnetized materials, the atomic magnetic fields are randomly oriented, but in magnetized materials, the fields are aligned.
- Groups of atoms with aligned magnetic fields form a "domain," which can consist of approximately  $10^2$  atoms.

#### **Diagram:**

- **Before magnetization:** Random domain alignment.
  - **After magnetization:** Domains aligned in the same direction.
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#### 8.1.1 Force Between Magnetic Poles

##### **Notes:**

- Magnetic poles always exist in pairs: north (N) and south (S).
- **Like poles repel, while unlike poles attract.**
- The force between magnetic poles can be calculated using the formula:

$$F = \frac{\mu_0 m_1 m_2}{4\pi r^2}$$

Where:

$F$  = force between poles,

$m_1, m_2$  = magnetic pole strengths,

$r$  = distance between poles,  
 $\mu_0$  = permeability of free space.

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## 8.2 Magnetic Field

### **Definition:**

The magnetic field is the region of space around a magnet where it can exert force on other magnetic materials or poles.

### **Notes:**

- Magnetic field lines are used to represent the direction of the magnetic field.
  - Field lines originate from the N-pole and terminate at the S-pole.
  - Inside the magnet, field lines run from the S-pole to the N-pole.
  - The **intensity of the magnetic field (B)** at any point is measured in tesla (T).
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### 8.2.1 Magnetic Field of a Bar Magnet

#### **Notes:**

- A bar magnet behaves as a dipole with distinct N and S poles.
  - The magnetic field of a bar magnet can be visualized using compass needles or iron fillings.
  - The field lines are directed from the N-pole to the S-pole, forming a closed-loop pattern.
  - The magnetic field inside the magnet runs from the S-pole to the N-pole.
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### 8.2.2 Direction of Magnetic Field at a Point

#### **Notes:**

- To determine the direction of the magnetic field at a given point, place a test magnet (N-pole) at that point.
- The direction of the force on the test magnet gives the direction of the magnetic field.
- The strength of the magnetic field can be measured by the force acting on the test magnet.

### 8.2.3 Relative Strength of Magnetic Field

**Notes:**

- The strength of the magnetic field is stronger where the field lines are closer together and weaker where they are farther apart.
  - **Like poles:** The field is weaker between them.
  - **Unlike poles:** The field is stronger between them.
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### 8.2.4 Magnetic Shielding

**Definition:**

Magnetic shielding is the phenomenon in which a material or arrangement of materials shields an area from external magnetic fields.

**Notes:**

- Magnetic shielding is important in devices where external magnetic fields can cause malfunction.
  - Materials used for shielding include **iron, nickel, and cobalt**.
  - Magnetic shields are usually rounded because magnetic field lines cannot easily turn at right angles.
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### 8.3 Induced Magnetism

**Definition:**

Induced magnetism is the phenomenon where a non-magnetic material becomes magnetized when exposed to an external magnetic field.

**Notes:**

- A material becomes magnetized when placed inside a magnetic field, and this effect can be temporary or permanent.
- Common methods of inducing magnetism:
  - a. **Stroking Method:** Rubbing one pole of a magnet along a metal bar.
  - b. **Hammering Method:** Placing a bar inside a magnetic field and gently hammering it to align domains.

- c. **Heating Method:** Heat can demagnetize materials, though it can also induce magnetism in some cases.
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### 8.3.1 Temporary and Permanent Magnets

**Notes:**

- **Temporary Magnets** (Electromagnets): These magnets lose their magnetism when the external current is turned off.
  - **Permanent Magnets:** These magnets retain their magnetism even in the absence of an external magnetic field.
  - Examples of permanent magnets include **iron ore, nickel, and cobalt.**
  - Electromagnets are used in **motors, door locks, and MRI machines.**
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### 8.3.2 Uses of Permanent Magnets and Electromagnets

**Notes:**

- Permanent magnets are used where a continuous supply of electric energy is not available.
  - Electromagnets are used where the magnetic field needs to be adjusted, like in **electric motors, generators, and MRI machines.**
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### 8.4 Types of Magnetic Materials

**Notes:**

Magnetic materials are classified based on their response to external magnetic fields:

1. **Diamagnetic Materials:**
  - Slightly repelled by a magnetic field.
  - Examples: **copper, gold, water.**
2. **Paramagnetic Materials:**
  - Weakly attracted to a magnetic field.
  - Examples: **aluminum, lithium.**
3. **Ferromagnetic Materials:**

- Strongly attracted to magnetic fields and retain magnetization.
- Examples: **iron, cobalt, nickel.**

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## 8.5 Earth's Magnetic Field

### Notes:

- The Earth behaves like a giant magnet with a magnetic field generated by currents in molten iron in the core (Dynamo Effect).
- **Auroras** occur when solar particles interact with Earth's magnetic field.
- The Earth's **geographical poles** and **magnetic poles** are not the same; the magnetic poles are tilted by  $11.3^\circ$  from the geographical poles.

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### All Formulae (Collected at End)

#### 1. Force Between Magnetic Poles

$$F = \frac{\mu_0 m_1 m_2}{4\pi r^2}$$

#### 2. Magnetic Field of a Solenoid

$$B = \mu_0 nI$$

#### 3. Magnetic Field of a Wire

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

#### 4. Force on a Current-Carrying Wire in a Magnetic Field

$$F = BIL\sin\theta$$

#### 5. Magnetic Field due to a Bar Magnet (Dipole Model)

$$B = \frac{\mu_0 m}{4\pi r^3} (2\cos\theta)$$