Reese Ch. 20

(Sects. 8-11 = pp. 918-930)

- Gauss's Law for Magnetic Fields
- Magnetic Poles and Current Loops
- Ampere's Law
- Displacement Current
  and the Ampere-Maxwell Law

Gauss's Law for Magnetic Fields

- Electric field lines emanate from positive charges and terminate on negative charges. Gauss's law for electric field describes this in a precise way:

$$\boxed{\int_{\substack{closed\\surface}} \vec{E}\cdot d\vec{S} = \frac{Q_{net\ enclosed}}{\varepsilon_o}}$$

- No confirmed observation has ever shown magnetic field lines to emanate or terminate:

$$\boxed{\int_{\substack{closed\\surface}} \vec{B}\cdot d\vec{S} = 0}$$

Magnetic Poles and Current Loops

- The basic magnetic field structure is evidently dipolar (NOT "monopolar").
- Unlike the electric dipole field (which is created by equal and opposite electric charges), the **magnetic dipole field is produced by a loop of electric current.**
- The current loop can be microscopic and permanent (the unpaired electron spins in magnetic materials) or macroscopic and driven (the current driven through the coils of an air-core electromagnet).

Ampere's Law

- The Biot-Savart Law (Reese Section 20.6) gives a basic rule for calculating the "static" magnetic field due to any configuration of steady electric currents.
- Ampere's Law, which can be derived from the Biot-Savart Law, relates the line-integral of a static magnetic field **B** around any closed path to the net electric current flowing through the (open) surface spanned by the path:

$$\boxed{\oint_{\substack{closed\\path}} \vec{B}\cdot d\vec{r} = \mu_o I_{net}}$$

- If the currents are not steady, then Ampere's Law must be replaced by a more general law . . .

The Ampere-Maxwell Law

$$\oint_{\substack{closed\\path}} \vec{B}\cdot d\vec{r} = \mu_o(I_{total}) = \mu_o\left(I_{conduction} + I_{dipslacement}\right)$$

- Here the <u>displacement current</u> is ε_o times the rate of change of electric–field flux through the open surface spanning the closed path: $$I_{displacement} = \varepsilon_o \frac{d\Phi_{electric}}{dt}$$
- The electric-field flux is defined by $$\Phi_{electric} \equiv \int_{\substack{open\\surface}} \vec{E}\cdot d\vec{S}$$