

Summary, week 15 (April 12 and 13)

**Magnetic force on electric current**

[FGT 28.4; YF 27.6; TM 26.1; AF 24.9; LHL 23.2; DJG 5.1.3]

Straight conductor, length  $L$ , current  $I$ :

$$\mathbf{F} = I\mathbf{L} \times \mathbf{B}$$

In general: Conducting wire with length  $L$ , current  $I$ , arbitrary shape on conductor:

$$\mathbf{F} = \int_L d\mathbf{F} = I \int_L d\mathbf{l} \times \mathbf{B}$$

**Magnetic force between parallel current-carrying wires**

[FGT 29.1; YF 28.4; TM 27.2; AF 24.14; LHL 23.5]

Force pr unit length between parallel wires with current  $I_1$  and  $I_2$ , respectively:

$$f = \frac{\mu_0 I_1 I_2}{2\pi r}$$

where  $r$  is the distance between the wires.

Same direction for the currents  $\Rightarrow$  attraction

Opposite direction for the currents  $\Rightarrow$  repulsion

**Ampere's law**

[FGT 29.1, 29.3; YF 28.6, 28.7; TM 27.4; AF 26.2; LHL 23.6; DJG 5.3]

$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{in}}$$

for closed integration curve enclosing stationary current  $I_{\text{in}}$ . Is valid for *arbitrary* closed curve and *arbitrary* current  $I$ .

Sign on the current according to the right hand rule.

Ampere's law is *useful* when we have a suitable symmetry in the problem, so that the integral on the left hand side becomes easily solvable.

Magnetic field from infinitely long solenoid that is tightly wound:

Inside the solenoid:

$$B = \mu_0 n I$$

with  $I$  = current in wire and  $n$  = number of turns pr unit length. I.e., uniform magnetic field inside long solenoid.

Outside the solenoid,  $B = 0$ .

Next week: Gauss' law for the magnetic field. Summary, electrostatics and magnetostatics: Maxwell's equations. Different types of magnetism: Paramagnetism, diamagnetism, ferromagnetism.