Institutt for fysikk, NTNU
TFY4155/FY1003: Elektrisitet og magnetisme
Spring 2005

Summary, week 2 (January 12)

Quantization of charge

[FGT 21.2; YF 21.1; TM 21.1; AF 21.7; LHL 19.1; DJG "Advertisement"]

Electric charge q always appears in integers of the *elementary charge* e:

$$q = ne \qquad n = 0, \pm 1, \pm 2, ...$$

Matter is made of atoms, consisting of a positively charged nucleus and negatively charged electrons. The nucleus consists of a number of protons and neutrons. A neutral atom with atomic number Z has Z protons in the nucleus and Z electrons around the nucleus. A proton has charge $+e$, an electron has charge $-e$, whereas the neutron has zero charge.

Conservation law for charge

[FGT 21.2; YF 21.1; TM 21.1; AF 21.8; LHL 19.1; DJG "Advertisement"]

The net charge is always conserved in a closed system.

Coulomb's law

[FGT 21.3; YF 21.3; TM 21.3; AF 21.3; LHL 19.3; DJG 2.1.2]

$$\boldsymbol{F} = \frac{qq'}{4\pi\varepsilon_0 r^2}\hat{r}$$

= electrostatic force between two point charges q and q' separated by a distance r. With $\hat{r}$ directed *from* q *towards* q', $\boldsymbol{F}$ represents the force *on* q'. The charges q and q' may be positive or negative. Two positive charges repel each other, two negative charges repel each other, whereas one positive and one negative charge attract each other.

SI unit for electric charge:
[FGT 21.3; YF 21.3; TM 21.1; AF 21.4; LHL 19.1; DJG "Advertisement"]

$[q]$ = C (coulomb)
The elementary charge: $e = 1.6 \cdot 10^{-19}$ C

The permittivity of vacuum: $\varepsilon_0 = 8.85 \cdot 10^{-12}$ C^2/Nm^2 ($1/4\pi\varepsilon_0 \simeq 9 \cdot 10^9$ Nm^2/C^2)

The superposition principle
[FGT 21.4; YF 21.3; TM 21.3; AF 21.5; LHL 19.3; DJG 2.1.1]

$$\boldsymbol{F}_i = \sum_{j=1}^{n} \boldsymbol{F}_{ij} = \frac{1}{4\pi\varepsilon_0} \sum_{j=1}^{n} \frac{q_j q_i}{r_{ij}^2} \hat{r}_{ij}$$

= electrostatic force on charge q_i from charges q_j $(j = 1, 2, \ldots n)$ separated by distances r_{ij}.