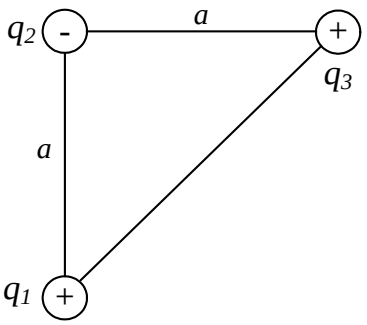
UNIVERSIDADE da MADEIRA

Electromagnetism

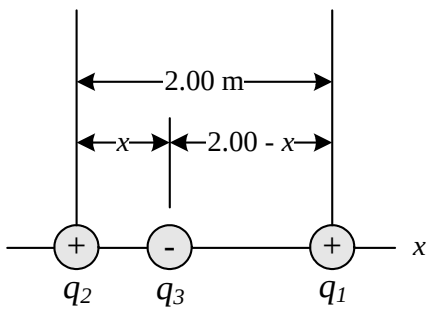
Series of problems 1

1. The electron and proton of the hydrogen atom are separated (on average) by 5.3×10^{-11} m. Find the magnitudes of the electrical and gravitational forces between the two particles.

2. Consider three point charges located at the corners of a right-angled triangle as shown in the figure, where $q_1 = q_3 = 5.0\,\mu$C, $q_2 = -2.0\,\mu$C, and $a = 0.10$ m. Find the resulting force exerted on q_3.



3. Three point charges are on the x axis as shown in the figure. The positive charge $q_1 = 15.0\,\mu$C is at $x = 2.00$ m, the positive charge $q_2 = 6.00\,\mu$C is at the origin, and the resulting force acting on q_3 is zero. What is the x coordinate of q_3?



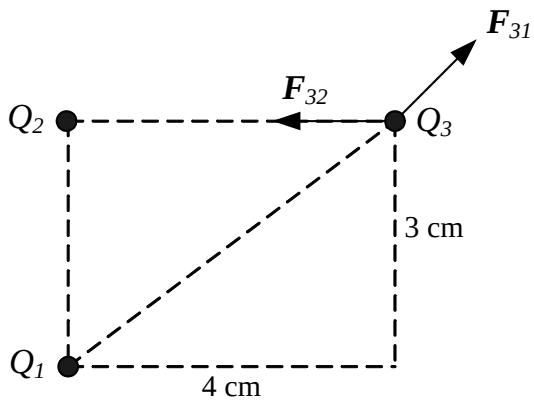
4. Find the force acting on the charge Q_1 (20×10^{-6} C), due to another charge Q_2 (-300×10^{-6} C) where the charges Q_1 and Q_2 are in positions $(0, 1, 2)$ m and $(2, 0, 0)$ m, respectively.

5. Two point charges, $Q_1 = 50 \times 10^{-6}$ C and $Q_2 = 10 \times 10^{-6}$ C, are located at positions $(-1, 1, -3)$ m and $(3, 1, 0)$ m, respectively. Find the force acting on Q_1.

6. Find the force acting on a charge of 100×10^{-6} C at position $(0, 0, 3)$ m if four equal charges of 20×10^{-6} C are on the axes x and y at ± 4 m from the origin.

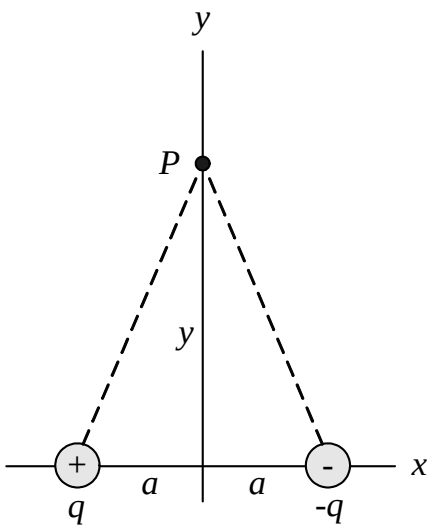
7. A point charge $Q_1 = 300 \times 10^{-6}$ C, located at position $(1, -1, -3)$ m, feels a force $\mathbf{F}_1 = 8\mathbf{a}_x - 8\mathbf{a}_y + 4\mathbf{a}_z$ due to another point charge Q_2 located at position $(3, -3, -2)$ m. Determine Q_2.

8. Three point charges are located at the corners of a rectangle in free space, as illustrated in the figure. The charges are: $Q_1 = +3 \times 10^{-6}$ C, $Q_2 = -2 \times 10^{-6}$ C, $Q_3 = +5 \times 10^{-6}$ C. Find $\mathbf{F}_3$, the force acting on Q_3.

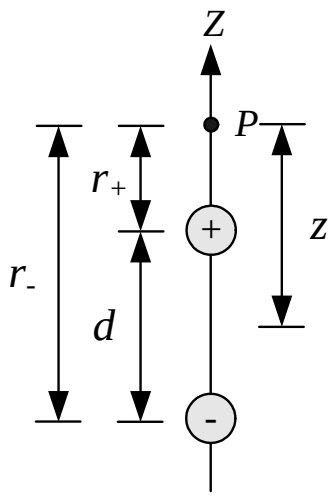


9. A charge $q_1 = 7.0\,\mu$C is located at the origin and a second charge $q_2 = -5.0\,\mu$C is located on the x axis, 0.30 m from the origin. Find the electric field at point P with coordinates $(0; 0.40)$ m.

10. An electric dipole is defined as a positive charge q and a negative charge $-q$ separated by a distance $2a$. For the dipole illustrated in the following figure, find the dipole-induced electric field $\mathbf{E}$ at point P located on the y axis for a distance from the origin $y \gg a$.



11. The figure shows two charged particles of magnitude q but with but with opposite signs, separated by a distance d; an electric dipole. Find the electric field due to the electric dipole at point P which is at a distance z from the midpoint of the dipole and the axis that passes through the particles, which is called the dipole axis.



Solutions:

1) $F_e = 8.2 \times 10^{-8}\,\mathrm{N}; F_g = 3.6 \times 10^{-47}\,\mathrm{N}$; 2) $\mathbf{F}_3 = (-1.1; 7.9)$ N; 3) $x = 0.77\,\mathrm{m}$; 4) $\mathbf{F}_{12} = (4.0; -2.0; -4.0)$ N; 5) $\mathbf{F}_{12} = (-0.14; 0; -0.11)$ N; 6) $\mathbf{F} = (0; 0; 1.7)$ N; 7) $Q_2 = -40\,\mu\mathrm{C}$; 8) $\mathbf{F}_3 = (-13; 32)$ N; 9) $\mathbf{E}_P = (1.1; 2.5)\times 10^5\,\mathrm{N\,C^{-1}}$; 10) $\mathbf{E}_P = \frac{1}{4\pi\varepsilon_0}\frac{2q}{y^3}(a, 0)$; 11) $\mathbf{E}_P = \frac{1}{4\pi\varepsilon_0} q \left(\frac{1}{\left(z-\frac{d}{2}\right)^2} - \frac{1}{\left(z+\frac{d}{2}\right)^2} \right) \mathbf{u}_z$.