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Exercises and Complements for the Introduction to Physics II  
for Students  
of Biology, Pharmacy and Geoscience

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Sheet 2 / 02.03.2022

**Solutions**

**Exercise 5.**

The electrical field of a conducting sphere is:

$$E = \frac{Q}{4\pi\epsilon_0 r^2}$$
$$Q = E \cdot 4\pi\epsilon_0 r^2$$

Thus, the total charge of planet Earth ( $r = 6371$  km) is obtained by :

$$Q = -130 \text{ V/m} \cdot 4\pi\epsilon_0 \cdot (6371 \text{ km})^2 = -5.87 \cdot 10^5 \text{ C}$$

**Exercise 6.**

(a) The total charge is given by the product of the linear charge density and the length:

$$q = \lambda l = 17.5 \text{ nC}$$

(b) The electric field of a line charge at  $x_0$  is given by<sup>1</sup>:

$$E_{x_0} = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{x_0(x_0 - l)}$$

At  $x_0 = 6$  m we get:

$$E_{6\text{m}} = 8.988 \cdot 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2} \cdot \frac{17.5 \text{ C}}{6 \text{ m} \cdot (6 \text{ m} - 5 \text{ m})} = 26 \frac{\text{N}}{\text{C}}$$

At  $x_0 = 9$  m we get:

$$E_{9\text{m}} = 8.988 \cdot 10^9 \frac{\text{N} \cdot \text{m}^2}{\text{C}^2} \cdot \frac{17.5 \text{ C}}{9 \text{ m} \cdot (9 \text{ m} - 5 \text{ m})} = 4.4 \frac{\text{N}}{\text{C}}$$

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<sup>1</sup>The derivation of the following equation is not relevant for the exam but can be reviewed on page 4 of this pdf-document:  
<https://www.plus.ac.at/wp-content/uploads/2021/02/513448.pdf>

**Exercise 7.**

(a) Potential of a point charge:

$$U_P(r) = \frac{1}{4\pi\epsilon_0} \frac{q_P}{r} = 14.38 \text{ V}$$

(b) An electron volt corresponds to the energy gained by an elementary electric charge when it passes through a voltage of 1 V.

$$1 \text{ eV} = 1.6 \cdot 10^{-19} \text{ C} \cdot 1 \text{ V} = 1.6 \cdot 10^{-19} \text{ J}$$

Electrostatic energy:

$$W = q_E U_P(r = 1 \cdot 10^{-10} \text{ m}) = -14.38 \text{ eV} = -2.3 \cdot 10^{-18} \text{ J}$$

(c) Proton and electron in hydrogen:

$$U_P(r = 5.3 \cdot 10^{-11} \text{ m}) = 27.13 \text{ V}$$

$$W = q_E U_P(r = 5.3 \cdot 10^{-11} \text{ m}) = -27.13 \text{ eV} = -4.3 \cdot 10^{-18} \text{ J}$$

**Exercise 8.**

(a) The following applies:

$$E = \frac{F}{Q} = \frac{m_e \cdot a}{e} = 11.3 \cdot 10^3 \frac{\text{V}}{\text{m}}$$

(b) Because it is a uniformly accelerated motion, the following holds:

$$t = \frac{v}{a} = 1 \text{ ns}$$