Electrodynamics

Warm-Up questions

Chapter 8.1

i. The electroscope is one of the first instrument used to measure a electrical quantity: charges. Different models exist, but we are interested in the one drawn below.

Two thin gold sheets are parallel to each other in a glass bottle. They are fixed to a metallic rod, which is ended by a metallic plate outside the bottle. The goal of the bottle is to protect the gold sheet from draught (among other).

To take the measure, we place the object to measure close to the plate.

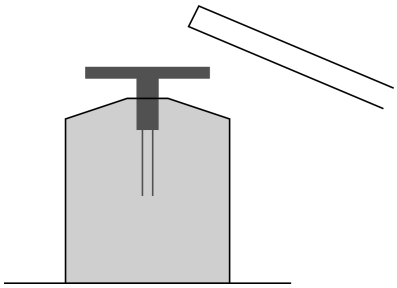

Figure 1: Electroscope

a) What happens when one put a positively charged object close to the device? Describe the kind of charges, which appear at each place.

b) With this instrument can we determine the sign of the charges?

c) And can we determine the amount of charge?

Chapter 8.2

ii.

a) Calculate the charge on a sphere of radius r made of conducting material. Assume that the sphere is at a potential U.

b) A positive charges q sits at $(0, 0, 1)$. Calculate the charge to be placed at $(0, 0, 3)$ such that the origin is at zero potential.

c) Let the x, y-plane as well as the x, z-plane be perfect conductors. Let the charge per area on the x, y-plane be $1\,\mathrm{C} \cdot \mathrm{m}^{-2}$ and the charge per area on the x, z-plane be $-2\,\mathrm{C} \cdot \mathrm{m}^{-2}$. Draw the equipotential lines.

d) Show that the electrical field of the form

$$\vec{E}(x, y, z) = \begin{pmatrix} y \\ -x \\ 0 \end{pmatrix}$$

cannot arise in electrostatics.

e) *(More difficult)* Two identical spheres of radius R are at a distance d from each other. After charging one of the spheres with 4 C and the other one with 2 C, we connect them with a wire. Calculate the energy dissipated through the wire in the process reaching equilibrium. Assume that $R << d$.

Chapter 8.3

iii.

a) Assume we have a uniform B-field in z-direction. Calculate the difference in the radius of the trajectory of a $^{14}C^{+}$ particle and $^{13}C^{+}$ particle assuming the same initial velocity of $1000\,\mathrm{m\cdot s^{-1}}$, along the x-axis.

b) Consider a homogeneous B-field in the z-direction. Start with an electron somewhere in the $z = d$-plane. The initial velocity is $(0, v_0, 1)$. Calculate the length of the trajectory until the electron hits the $z = 0$-plane.

Chapter 9.2

iv. Calculate the equivalent resistor and the current, which goes out of the battery.

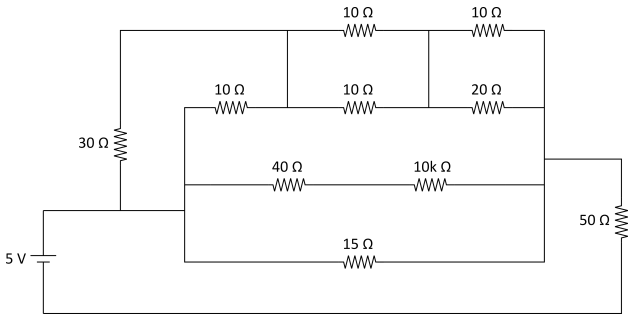

Figure 2:

Chapter 9.5

v. In the circuit below, the current that flows through the 30 Ω resistor is 2.0 A. What is the value of the resistor R_1?

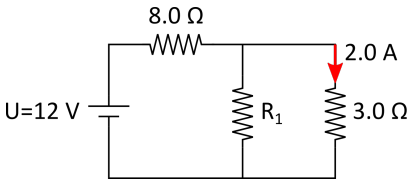

Figure 3:

vi. Given the circuit below, determine...

a) The current flowing through each resistor.

b) The voltage of the battery on the left.

c) The power deliver to the circuit by the battery on the right.

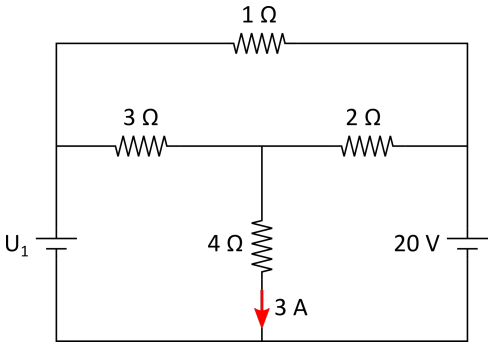

Figure 4: