KARLSRUHE INSTITUTE OF TECHNOLOGY - INTERNATIONAL DEPARTMENT GMBH

Pre-Semester 2010 - Physics Course - Extra Tutorial

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Sheet 10
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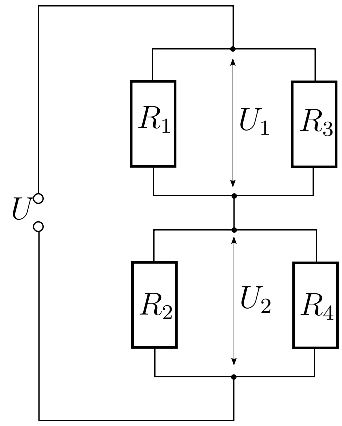
1. Resistors



In the figure above it is $R_1 = 10\,\Omega$, $R_2 = 20\,\Omega$, $R_3 = 50\,\Omega$, $R_4 = 100\,\Omega$ and $U = 24\,\mathrm{V}$.

(a) Compute the total resistance of the circuit.

(b) What is the current I which flows through the voltage source? And what is the power P which is dissipated in the circuit?

(c) Compute the voltages U_1 and U_2!

(d) What are, hence, the currents I_j which flow through the single resistors R_j?

2. Capacitances

(a) A parallel plate capacitor with plate area A and distance d is filled with a dielectric material having relative permittivity ϵ_r. What is its capacitance C? In the case that a voltage U is applied across it, what is the charge Q on (each of) its plates?

(b) Consider a *series connection* of 2 capacitors with capacitances $C_1 = 6C_0$ and $C_2 = 3C_0$ (C_0 is just some constant). What is the total capacitance?

(c) Now, consider the same 2 capacitors as in the previous exercise (2b). What is the total capacitance if they are connected *in parallel*?

3. Copper Wire

A wire of copper (with specific resistance $\rho_s = 16.78 \cdot 10^{-9}\,\Omega\mathrm{m}$) has a cross section of $A = 1\,\mathrm{mm}^2$ and a length of $\ell = 10\,\mathrm{m}$. If the voltage $U = 50\,\mathrm{V}$ is applied across it, what current I flows through it and what electric power P is dissipated in it?

4. Point Mass

Throughout this exercise we consider a point with mass m which moves in the (2-dimensional) $x-y$-plane. Give for each of the following situations, its coordinates $x(t)$, $y(t)$ and velocities $v_x(t)$, $v_y(t)$ as a function of time t. (It may be helpful and a good exercise to write down first the *initial conditions*)

(a) The point *starts at rest* in $x = y = 0$. It is accelerated by a constant force F_x which acts in x-direction.

(b) Gravity is acting in the negative y-direction. The point starts at an "height" $y = h$ ($x = 0$). It has an initial velocity v_{x0} in x-direction.

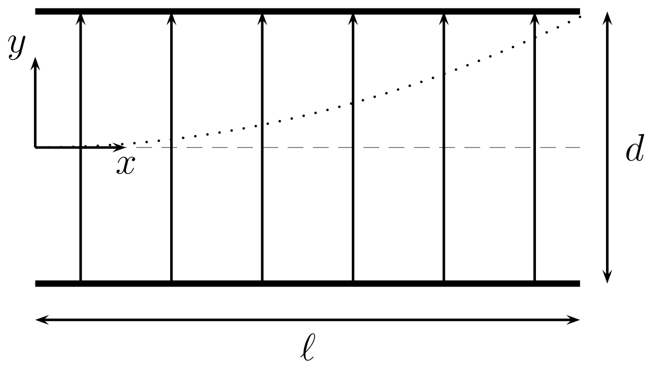
(c) Gravity is acting in the negative y-direction. The point starts in $x = y = 0$. Its initial velocity v makes an angle α with the horizontal (the x-direction).

(d) An electric field E points in the negative y-direction (neglect gravity). The point has a charge q and starts in $x = y = 0$. Its initial velocity v makes an angle α with the horizontal (the x-direction).

(e) Same situation as in the previous exercise. But now the initial velocity v makes an angle β with *the vertical* (the y-direction).

5. Last Year's Spotquiz Exercise

A point charge with $q > 0\,\mathrm{C}$ and mass m moves (with velocity v) to the right along the axis of the parallel plate capacitor as shown. The plates of the parallel plate capacitor are separated by a distance d, are of length ℓ, and their potential difference amounts to U.



(a) Write down the position of the particle either as vector $\vec{x}(t)$ or in component form (i.e. $x(t)$ and $y(t)$).

(b) Assume now $U = 1\,\mathrm{V}$, $\ell = 10\,\mathrm{cm}$, $d = 5\,\mathrm{cm}$, $v = 10^6\,\frac{\mathrm{m}}{\mathrm{s}}$, $m = 9.1 \cdot 10^{-31}\,\mathrm{kg}$ and $q = 1.6 \cdot 10^{-19}\,\mathrm{C}$: Find the angle with respect to the horizontal when the point charge leaves the parallel plate capacitor.

(c) What potential difference U has to be applied when the point charge should leave the capacitor at the upper right corner for $\ell = 10\,\mathrm{cm}$, $d = 5\,\mathrm{cm}$, $v = 10^6\,\frac{\mathrm{m}}{\mathrm{s}}$, $m = 9.1 \cdot 10^{-31}\,\mathrm{kg}$ and $q = 1.6 \cdot 10^{-19}\,\mathrm{C}$.

(d) *Topic not yet adressed in the lecture:* How large must a magnetic field be and in which direction must it point that the charge moves straight through the parallel plate capacitor (see dashed line in the figure)?