University Karlsruhe - International Department

**Physics Course - Exercises Summer 2009**

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**Sheet 7**
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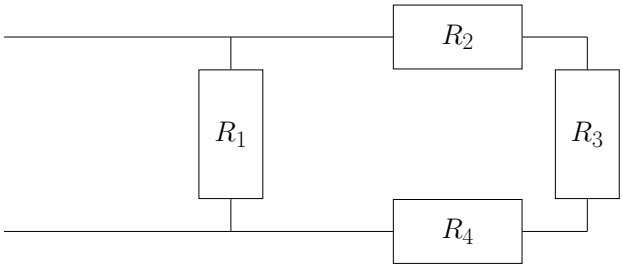
## 1. Exercise: Resistor network

Consider the following the following resistor network with $R_1 = 2\,\Omega$, $R_2 = R_4 = 1\,\Omega$:




(i) Determine the resistance $R_3$ when the resistor consists of a $\ell = 4\,\mathrm{m}$ long Nichrome wire ($\rho_s = 10^{-6}\,\Omega\,\mathrm{m}$) with radius of $r = 0.65\,\mathrm{mm}$.

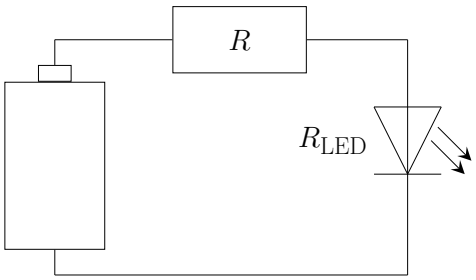
(ii) What is the equivalent resistance between the left points?

(iii) Calculate the current that would flow through the whole system (in the left wires) when between the left points a potential difference of $U = 1\,\mathrm{V}$ is applied.

## 2. Exercise: Light emitting diodes

**Background:** Light emitting diodes (LED) are a fast evolving part of lighting economy. However, diodes possess a very steep increase in their characteristic curve ($U$-$I$-diagram) above a critical applied voltage. In this way a naive installation might result in overheating and destruction of the LED. To prevention this, they are often used with series resistors.

Consider a circuit with a LED with inner resistance $R_{\mathrm{LED}} = 100\,\Omega$ (at a voltage of $U_{\mathrm{LED}} = 2\,\mathrm{V}$) and a resistor with resistance $R$ connected to a battery with $U_0 = 3\,\mathrm{V}$ as sketched in the figure below.




(i) Determine the necessary current and from it the necessary series resistance $R$, if the LED should be operated at $U_{\mathrm{LED}} = 2\,\mathrm{V}$.

(ii) How might this resistance be assembled by 100 Ω-resistors?

(iii) Calculate the power $P_{\mathrm{LED}}$ dissipated in the LED.

(iv) Now include an inner resistance of the battery of $R_b = 1\,\Omega$ in your considerations. How large should now be the series resistance?

(v) For this case, state the power $P$ provided by the battery as well as the one dissipated in the series resistor.

**3. Exercise: Conductive level sensor**

**Background:** Conductive level sensors provide an easy way to measure continuously the presence of solids and liquids, e.g. the tank filling height. They are often seen as small cylinders which are inserted in the storage area.

A parallel plane capacitor with area $A = \ell^2$ and distance $d$ between the vertical positioned planes is filled with petrol (relative permittivity $\epsilon_r$) to a height $h$.

(i) State the equivalent circuit diagram with homogeneous filled capacitors.

(ii) What is the total capacitance of this circuit dependend on its consisting capacitances?

(iii) Determine the dependence of the capacitance of this system from the volume $V_{\mathrm{petrol}}$ of petrol in the capacitor?