Appendix B

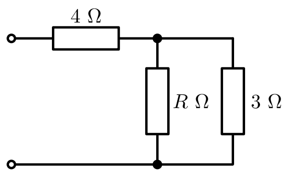
Problem B.1

Converting the resistors of Figure B.11 in the book to an equivalent single resistor can be done strictly by applying Kirschoff's and Ohm's laws. This results in a large system of equations, which may be a bit tedious to solve. A more practical approach is to reduce the circuit in steps where, in each step, serial and parallel resistors are replaced by their equivalents. The equivalent resistance becomes

$$R \approx \boxed{5.45\ \Omega.}$$

Problem B.2

Here we have a given circuit



where we are asked to find R so that the total resistance (let's call it R_{tot}) becomes some given values

All three cases can be solved using the same calculation, where we i) find an expression for the total resistance R_{tot}, expressed in terms of the unknown R, ii) solve for R, and iii) substitute the three values on R_{tot} we want to obtain.

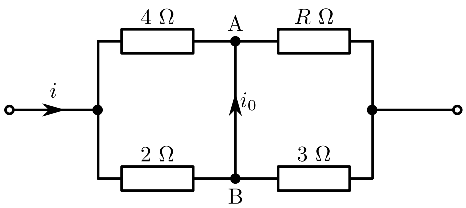
(a) $R_{\text{tot}} = 6 \Rightarrow R = \boxed{6\ \Omega}$

(b) $R_{\text{tot}} = 4 \Rightarrow R = \boxed{0\ \Omega}$ (A short circuit!)

(c) $R_{\text{tot}} = 7 \Rightarrow R = \boxed{\infty\ \Omega}$ (An open circuit – no connection!)

Problem B.3

In this problem we are given the circuit below. The circuit has been rotated 90° and two nodes are given names A & B, for easier reference.



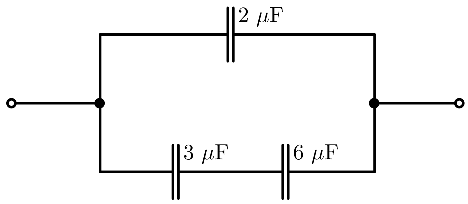
In the problem we are asked to find R so that the current i_0, between nodes A and B, is **zero**.

Here we can go all-in and use Kirchoff's and Ohm's laws to create a system of equations, where we force $i_0 = 0$ and solve for R. This will be a rather tedious task. A quicker solution is obtained by realizing that $i_0 = 0$ implies that we want to obtain a situation where it does not matter if the connection between nodes A and B is there or not (if it is there, no current is supposed to go through anyway). Using this knowledge, we study the circuit without the connection between A and B, and calculate what R is needed to make the voltage at points A and B equal. If it is, no current will flow through if we put back the connection between A and B. This gives

$$R = \boxed{6\ \Omega}.$$

Problem B.4

In this problem we are asked to calculate the value C of a single replacement capacitor for the circuit



Since we are now dealing with impedances we take a step into the $j\omega$-domain, where a capacitor C_1 is replaced by $\frac{1}{j\omega C_1}$ in the circuit diagram and we apply the standard expressions for serial and parallel impedances.

The total impedance of the circuit becomes

$$Z_{\text{tot}} = \frac{1}{4 \times 10^{-6} j\omega},$$

which we identify as the impedance of a 4 μF capacitor. Hence, the equivalent capacitor has capacitance

$$C = \boxed{4\ \mu\text{F}.}$$