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In[1]:= (*Applications of Kirchoff's equations -Lab 216*)
In[2]:= (* 2 batt.+3res. - fig.1, p.5*)
In[3]:= junc := {i1 + i2 == i3}
In[4]:= loopabcd := {v1 - r1 i1 - i3 r3 == 0}
In[6]:= loopbefc := {-v2 + i1 r1 - v1 - i2 r2 == 0}
In[7]:= kirch = Join[junc, loopabcd, loopbefc]
Out[7]= {i1 + i2 == i3, -i1 r1 - i3 r3 + v1 == 0, i1 r1 - i2 r2 - v1 - v2 == 0}
In[9]:= sol = Solve[kirch, {i1, i2, i3}][[1]]
Out[9]=  $\left\{ i2 \rightarrow -\frac{r3 v1 + r1 v2 + r3 v2}{r1 r2 + r1 r3 + r2 r3}, i1 \rightarrow -\frac{-r2 v1 - r3 v1 - r3 v2}{r1 r2 + r1 r3 + r2 r3}, i3 \rightarrow -\frac{-r2 v1 + r1 v2}{r1 r2 + r1 r3 + r2 r3} \right\}$ 
In[10]:= repl = {v1 → 10 volt, v2 → 14 volt, r1 → 6 ohm, r2 → 4 ohm, r3 → 2 ohm}
Out[10]= {v1 → 10 volt, v2 → 14 volt, r1 → 6 ohm, r2 → 4 ohm, r3 → 2 ohm}
In[11]:= sol /. repl
Out[11]=  $\left\{ i2 \rightarrow -\frac{3 \text{ volt}}{\text{ohm}}, i1 \rightarrow \frac{2 \text{ volt}}{\text{ohm}}, i3 \rightarrow -\frac{\text{volt}}{\text{ohm}} \right\}$ 
In[12]:= (*as expected*)
In[13]:=
    (*now bridge - fig 2 on p.7*)
In[14]:= junc := {i1 == i3 + i4}
In[22]:= juncg := {i2 == i0 + i4}
In[16]:= (*now loops*)
In[17]:= abcde := {v - r1 i1 - i3 r3 == 0}
In[18]:= bfgc := {-i0 r0 + r1 i1 + r4 i4 == 0}
In[19]:= cghd := {-i2 r2 + r3 i3 - r4 i4 == 0}
In[24]:= Clear[i0, i1, i2, i3, i4]; kirch = Join[junc, juncg, abcde, bfgc, cghd]
Out[24]= {i1 == i3 + i4, i2 == i0 + i4, -i1 r1 - i3 r3 + v == 0, -i0 r0 + i1 r1 + i4 r4 == 0, -i2 r2 + i3 r3 - i4 r4 == 0}
In[26]:= sol = Solve[kirch, {i0, i1, i2, i3, i4}][[1]];(*outcome too big*)
In[27]:= repl2 = {r0 -> 300 ohm, r1 → 470 ohm, r2 → 470 ohm, r3 → 300 ohm, r4 → 390 ohm, v → 12 volt}
Out[27]= {r0 → 300 ohm, r1 → 470 ohm, r2 → 470 ohm, r3 → 300 ohm, r4 → 390 ohm, v → 12 volt}

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In[29]:= sol /. rep2 // N

$$\text{Out[29]= } \left\{ \begin{array}{l} i_0 \rightarrow \frac{0.0177228 \text{ volt}}{\text{ohm}}, i_2 \rightarrow \frac{0.0142195 \text{ volt}}{\text{ohm}}, \\ i_4 \rightarrow -\frac{0.00350335 \text{ volt}}{\text{ohm}}, i_1 \rightarrow \frac{0.0142195 \text{ volt}}{\text{ohm}}, i_3 \rightarrow \frac{0.0177228 \text{ volt}}{\text{ohm}} \end{array} \right\}$$

In[30]:= (*as expected; now try analytical limits*)

In[31]:= req = v / (i0 + i1) /. sol // Simplify

$$\text{Out[31]= } \frac{(r_2 (r_3 r_4 + r_1 (r_3 + r_4)) + r_0 (r_3 (r_2 + r_4) + r_1 (r_2 + r_3 + r_4)))}{((r_2 + r_3) r_4 + r_0 (r_2 + r_3 + r_4) + r_1 (r_2 + r_3 + r_4))}$$

In[33]:=

In[34]:= Limit[req, r4 → Infinity]

$$\text{Out[34]= } \frac{(r_0 + r_2) (r_1 + r_3)}{r_0 + r_1 + r_2 + r_3}$$

In[35]:= (*as expected; now check the condition i4=0 for r0 r3=r1 r2*)

In[36]:= req /. {r3 → r1 r2 / r0} // Simplify

$$\text{Out[36]= } \frac{r_1 (r_0 + r_2)}{r_0 + r_1}$$

In[37]:= (*indeed r4 does no matter; or check current directly*)

In[39]:= i4 /. sol

$$\text{Out[39]= } - (r_1 r_2 v - r_0 r_3 v) / (r_0 r_1 r_2 + r_0 r_1 r_3 + r_0 r_2 r_3 + r_1 r_2 r_3 + r_0 r_1 r_4 + r_1 r_2 r_4 + r_0 r_3 r_4 + r_2 r_3 r_4)$$

In[40]:= % /. {r3 → r1 r2 / r0} // Simplify

$$\text{Out[40]= } 0$$

In[41]:= (*as expected*)