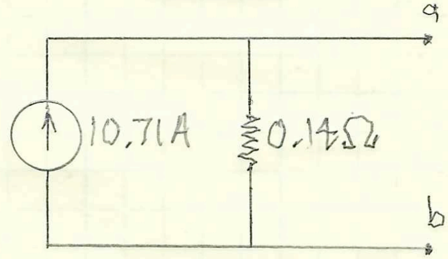
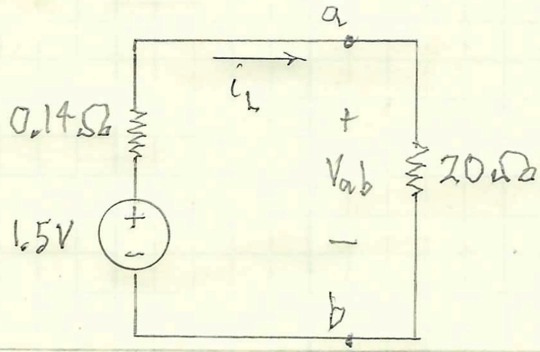
1) a) $I_{sc} = I_N = \dfrac{1.5V}{0.14\Omega} = \underline{\underline{10.71A}}$

$R_N = R_{th} = \underline{\underline{0.14\Omega}}$

$\Rightarrow$



b) $R_L = 20\Omega$. Use Thévenin circuit to obtain values.



Voltage division:

$V_{ab} = \dfrac{20}{20+0.14} 1.5V = \underline{\underline{1.48956\ V}}$

$i_L = \dfrac{V_{ab}}{20\Omega} = \underline{\underline{0.07448A = 74.48mA}}$

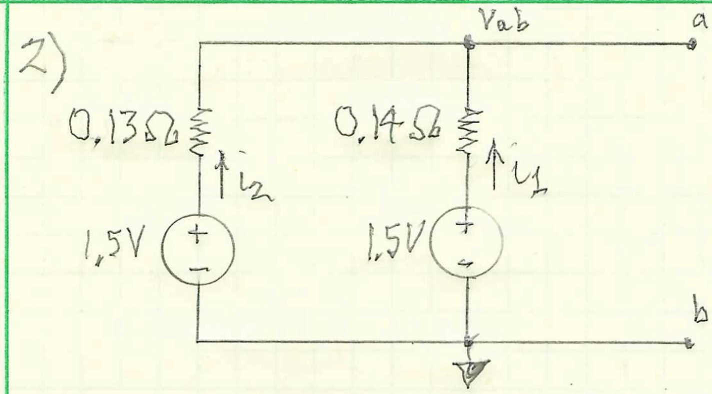
Or, could have used Norton circuit.

$R_{eq} = 20\Omega \| 0.14\Omega = 0.13903\Omega$

$\Rightarrow V_{ab} = I_N R_{eq} = \underline{\underline{1.48956\ V}}$ Same as above.

$i_L = \dfrac{R_{eq}}{20\Omega} I_N = \underline{\underline{74.48\ mA}}$

2)

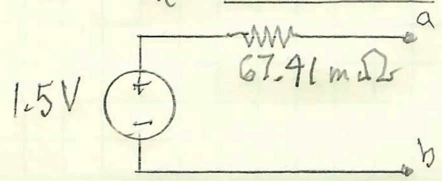


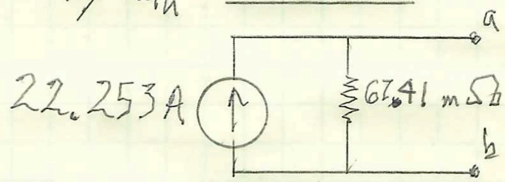
a) With open circuit, apply KCL to top node:

$$\frac{V_{ab}-1.5}{0.13}+\frac{V_{ab}-1.5}{0.14}=0 \Rightarrow \left(\frac{1}{0.13}+\frac{1}{0.14}\right)V_{ab}=\left(\frac{1}{0.13}+\frac{1}{0.14}\right)1.5V \Rightarrow \underline{\underline{V_{ab}=1.5V=V_{th}}}$$

Because there are only independent sources, deactivate and find remaining resistance. $R_{eq}=0.13||0.14=0.06741\Omega=\underline{\underline{67.41\,m\Omega=R_{th}}}$

b) $R_N=R_{th}=\underline{\underline{67.41\,m\Omega}}$, $I_N=V_{th}/R_{th}=\underline{\underline{22.253A}}$





c) Voltage division: $V_{ab}=\frac{20}{20+0.06741}1.5V=\underline{\underline{1.495V}}=V_L$

$i_L=V_L/20\Omega=0.07478A=\underline{\underline{74.75\,mA}}=i_L$

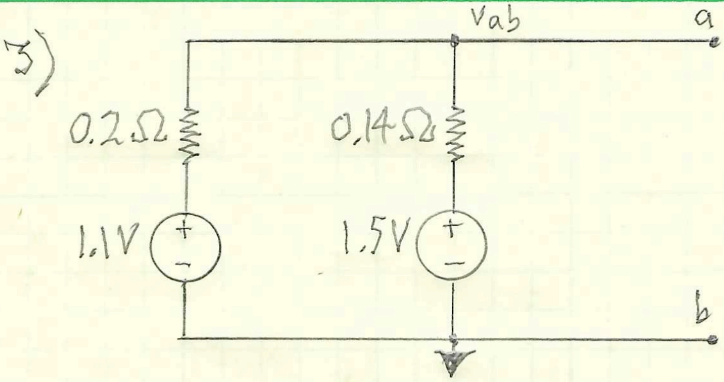
d)

$$i_2=\frac{1.5V-V_L}{0.13\Omega}=0.03876A=\underline{\underline{38.76\,mA}}$$

$$i_1=\frac{1.5V-V_L}{0.14\Omega}=0.03599A=\underline{\underline{35.99\,mA}}$$

Note that the voltage across and the current through the load are almost identical to the single-battery case, But, the current trough the batteries is now approximately half of what it was before, Thus, the two batteries are each delivering about half the power that a single battery had to deliver.

3)

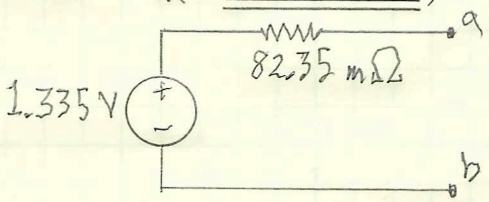


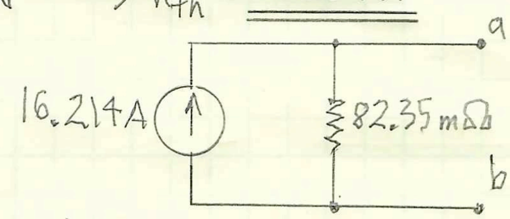
a) With open circuit, apply KCL to top node:

$$\frac{V_{ab}-1.1}{0.2}+\frac{V_{ab}-1.5}{0.14}=0 \Rightarrow \left(\frac{1}{0.2}+\frac{1}{0.14}\right)V_{ab}=\frac{1.1V}{0.2}+\frac{1.5V}{0.14} \Rightarrow \underline{\underline{V_{ab}=1.335V=V_{th}}}$$

Because there are only independent sources, deactivate them and find remaining resistance: $R_{eq}=0.2\|0.14=0.08235\Omega=\underline{\underline{82.35\ m\Omega=R_{th}}}$

b) $R_N=R_{th}=\underline{\underline{82.35\ m\Omega}}$, $I_N=V_{th}/R_{th}=\underline{\underline{16.214\ A}}$





c) Voltage division: $V_{ab}=\frac{20}{20+0.08235}1.335V=\underline{\underline{1.3298\ V}}=V_L$

$i_L=V_L/20\Omega=0.06649A=\underline{\underline{66.49\ mA}}=i_L$

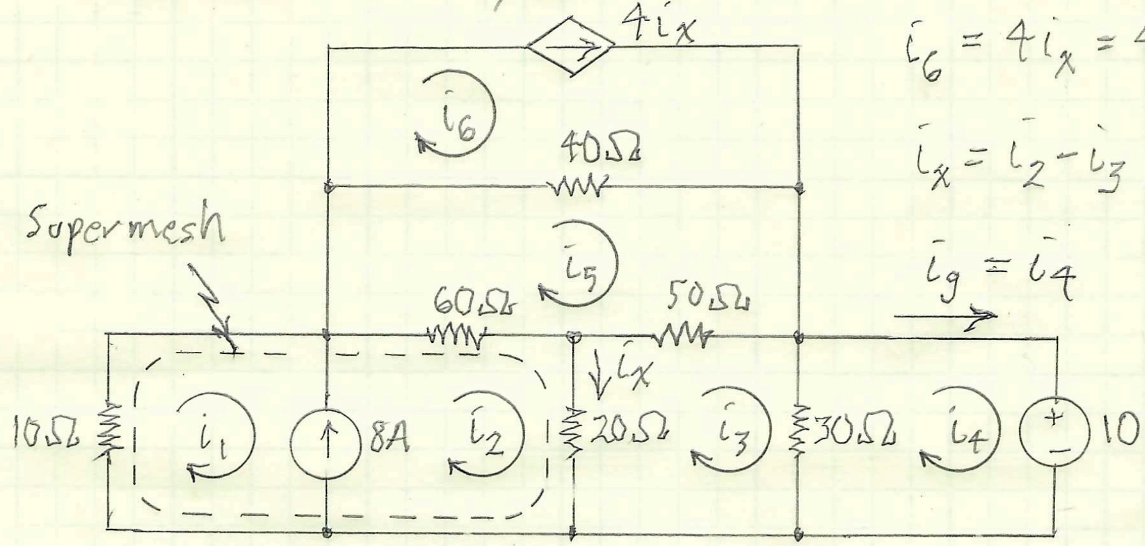
$i_2=\frac{1.1V-V_L}{0.2}=\underline{\underline{-1.149A}}$

$i_1=\frac{1.5-V_L}{0.14}=\underline{\underline{1.216\ A}}$

Note that the voltage across the load hasn't changed much from when there were two fresh batteries. But there is a huge change in the currents flowing through the batteries. The current through Battery 1 has now increase by a factor of more than 33 from when it was in parallel with another fresh battery.

4) Parallel resistors: $72\,\Omega \,||\, 90\,\Omega = 40\,\Omega$

Could swap 8A & $10\,\Omega$ resistor, which would dictate one of the mesh currents is 8A, but leave it where it is and use supermesh.



$i_6 = 4i_x = 4(i_2 - i_3)$

$i_x = i_2 - i_3$

$i_g = i_4$

Supermesh: $10i_1 + 60(i_2 - i_5) + 20(i_2 - i_3) = 0 \Rightarrow 10i_1 + (60+20)i_2 - 20i_3 - 60i_5 = 0$

Mesh 3: $20(i_3 - i_2) + 50(i_3 - i_5) + 30(i_3 - i_4) = 0 \Rightarrow -20i_2 + (20+50+30)i_3 - 30i_4 - 50i_5 = 0$

Mesh 4: $30(i_4 - i_3) + 10 = 0 \Rightarrow -30i_3 + 30i_4 = -10$

Mesh 5: $40(i_5 - 4[i_2 - i_3]) + 50(i_5 - i_3) + 60(i_5 - i_2) = 0$

$\Rightarrow (-160-60)i_2 + (160-50)i_3 + (40+50+60)i_5 = 0$

Constraint equation: $i_2 = 8 + i_1 \Rightarrow -i_1 + i_2 = 8$

Using MATLAB:

```
r = [10,   (60+20),         -20,    0,         -60;
      0,       -20, (20+50+30),  -30,         -50;
      0,         0,         -30,   30,           0;
      0, (-160-60),    (160-50),    0, (40+50+60);
     -1,         1,           0,    0,           0];
is = r \ [0; 0; -10; 0; 8]

is = 5×1
  -4.423913043478268
   3.576086956521739
   3.035326086956521
   2.701992753623188
   3.019021739130434
```

$-4.423913043478268 = i_1$, $3.576086956521739 = i_2$, $3.035326086956521 = i_3$, $2.701992753623188 = i_4 = i_g$

$$\underline{\underline{i_x = i_2 - i_3 = 3.576 - 3.035 = 0.541\,A}} \qquad \underline{\underline{i_g = 2.702\,A}}$$