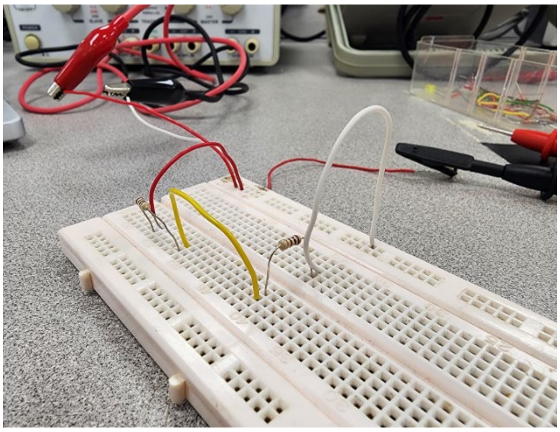
EEP1 ELogBook – Week 4

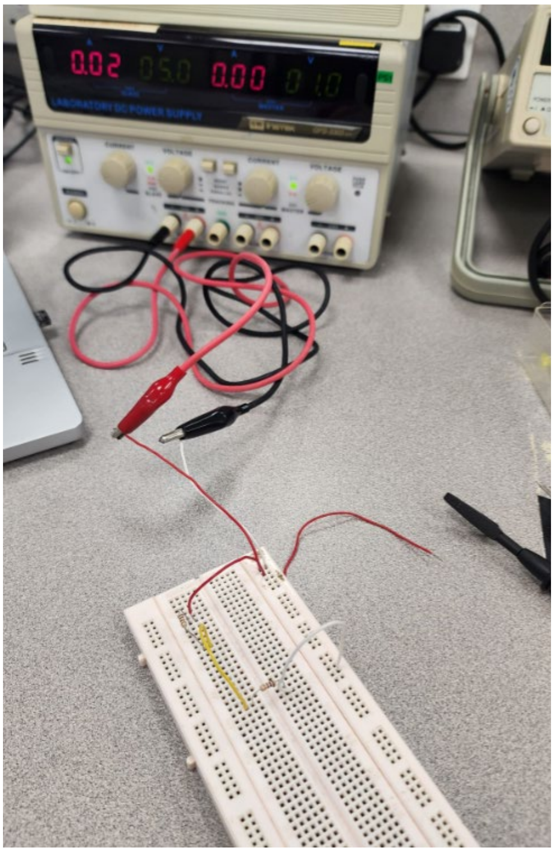
AXXXXXXX - Brians Tjipto Meidianto

Lab

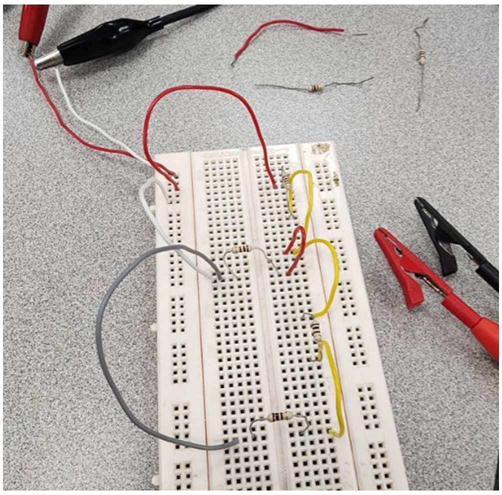
Activity 1



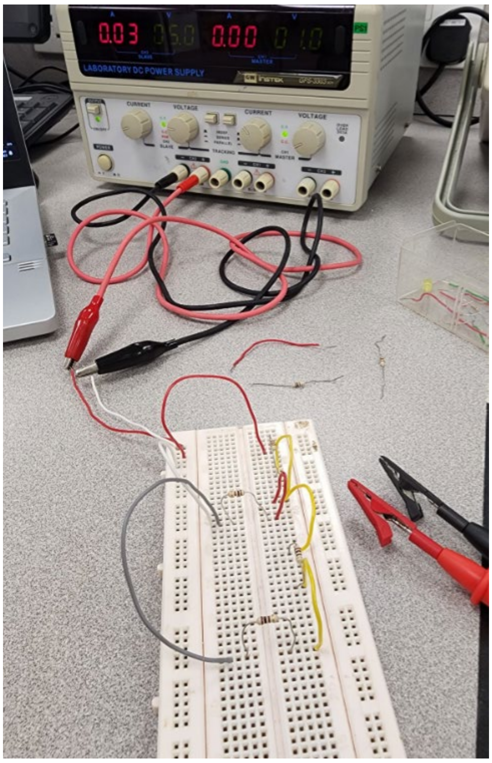
1. **V1** = 2.52V
2. **V2** = 2.53V
3. **Vs = V1 + V2** = 2.52 + 2.53 = 5.05V
4. Conclusion: The KVL checks out stating that the sum of a closed loop path is 0.



Activity 2

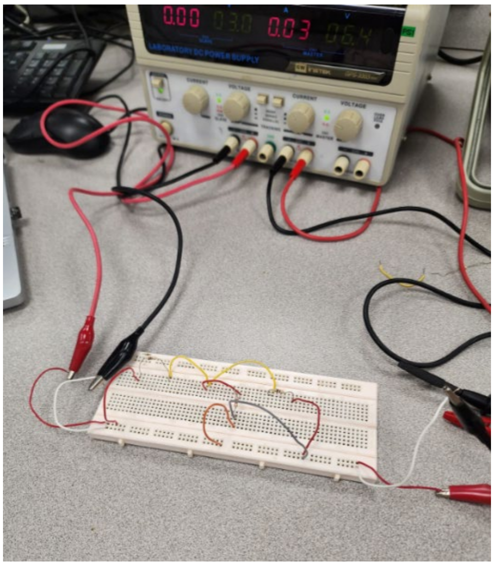
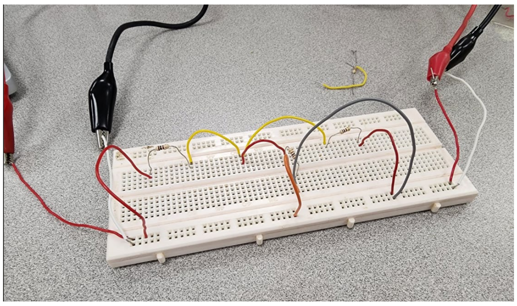


1. **I1** = 29.3 mA
2. **I2** = 19.6mA
3. **I3** = 9.8mA
4. **I1 = I2 + I3** = 19.6 + 9.8 = 29.4mA
5. Conclusion: The KCL checks out stating that the sum enters a node is equal to the sum leaving the node.

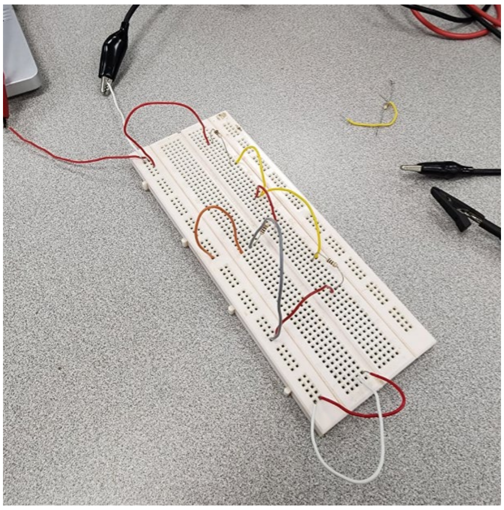


Activity 3

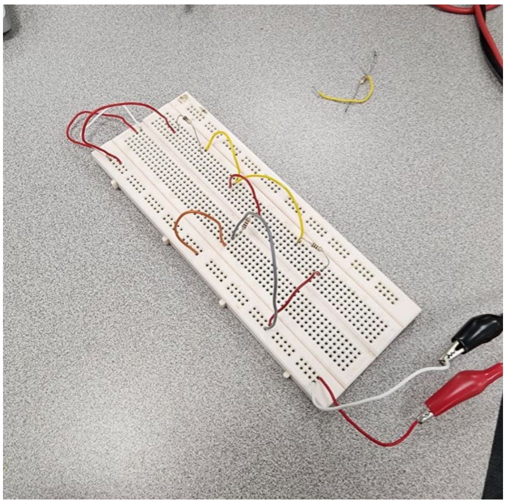
1. **i** = 30.2mA

2. **i1** = 9.5mA



3. **i2** = 20.6mA



4. **i = i1 + i2** = 9.5 + 20.6 = 30.1mA
5. The Superposition Theorem checks out as the sum of i1 and i2 is 30.1mA, while the i from the total measurement is 30.2mA.

6. Analytical verification of superposition principle

$$R_T = 100 + \left(\frac{100 \times 100}{100+100}\right)$$

$$= 150\,\Omega$$

$$I_{T_1} = \frac{V_1}{R_T} = \frac{3}{150} = 20mA$$

$$i1 = \frac{R_2}{R_1+R_2} \times I_{T_1}$$

$$= \frac{100}{100+100} \times 20 = 10mA$$

$$I_{T_2} = \frac{V_2}{R_T} = \frac{6}{150} = 40mA$$

$$i_2 = \frac{R_3}{R_2+R_3} \times I_{T_2}$$

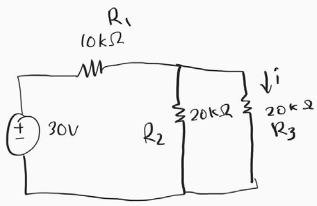
$$= \frac{100}{100+100} \times 40 = 20mA$$

$$i = i_1 + i_2 = 10 + 20$$

$$= 30mA$$

Activity 4

a)



$$R_T = 10k + \left(\frac{20k \times 20k}{20k + 20k}\right)$$

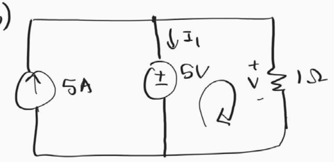
$$= 20k$$

$$I_T = \frac{V_s}{R_T} = \frac{30}{20k} = 1.5mA$$

$$I_{R_3} = \frac{R_2}{R_2 + R_3} \times I_T$$

$$= \frac{20}{20+20} \times 1.5 = 0.75mA$$

b)

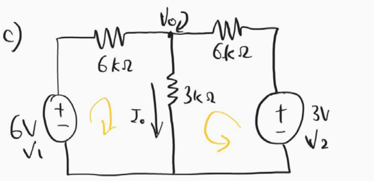


$$V = 5 \times 1 = 5V$$

$$i_1 = \frac{0}{0+1} \times 5A$$

$$= 0A$$

c)



$$R_T = 6k + \left(\frac{6k \times 3k}{6k + 3k}\right) = 8k\Omega$$

$$I_{V_1} = \frac{6}{8k} = 0.75\ mA$$

$$I_{o_1} = 0.75 \times \frac{6k}{3k + 6k} = 0.5mA$$

$$I_{V_2} = \frac{3}{8k} = 0.375mA$$

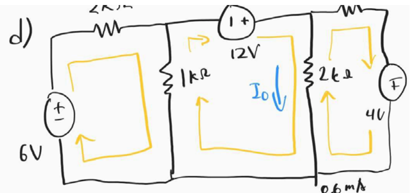
$$I_{o_2} = 0.375 \times \frac{6k}{3k + 6k} = 0.25mA$$

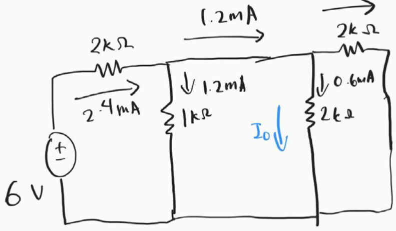
$$I_{oT} = 0.5 + 0.25 = 0.75mA$$

$$V_0 = 0.75mA \times 3k\Omega$$

$$= 2.25V$$

d)





$$R_T = 2k + \left(\frac{1}{1k} + \frac{1}{2k} + \frac{1}{2k}\right)^{-1}$$

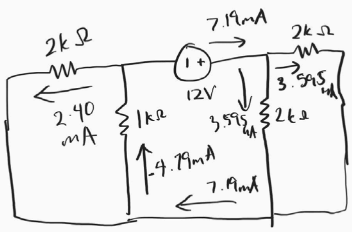
$$= 2.5k\Omega$$

$$R = \left(\frac{1}{2k} + \frac{1}{2k}\right)^{-1} = 1k\Omega$$

$$I_{V_T} = \frac{6}{2.5} = 2.4\ mA$$

$$I = \left(\frac{1}{1+1}\right) \times 2.4 = 1.2mA$$

$$I = \left(\frac{2}{2+2}\right) \times 1.2 = 0.6mA$$



$$R_T = \left(\frac{2 \times 2}{2+2}\right) + \left(\frac{2 \times 1}{2 \times 2}\right)$$

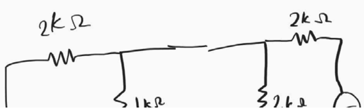
$$= 1.67\ k\Omega$$

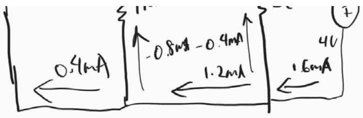
$$I_{R_T} = \frac{12}{1.67} = 7.19mA$$

$$I = 7.19 \times \left(\frac{2}{2+2}\right) = 3.595\ mA$$

$$I = 7.19 \times \left(\frac{2}{1+2}\right) = 4.79mA$$

$$I = 7.19 \times \left(\frac{1}{1+2}\right) = 2.40mA$$





$$R_T = \left(\frac{1}{2} + \frac{1}{1} + \frac{1}{2}\right)^{-1} + 2 = 2.5k\Omega$$

$$I_{R_T} = \frac{4}{2.5} = 1.6mA$$

$$R = \left(\frac{1 \times 2}{1+2}\right) = 0.67k\Omega$$

$$I = \left(\frac{0.67}{0.67+2}\right) \times 1.6 = 0.40\ mA$$

$$I = \left(\frac{2}{0.67+2}\right) \times 1.6 = 1.20mA$$

$$I = \left(\frac{2}{1+2}\right) \times 1.2 = 0.8mA$$

$$I = \left(\frac{1}{1+2}\right) \times 1.2 = 0.4mA$$

$$I_o = 0.6 + 3.595 + (-0.4)$$

$$= 3.795mA$$

$$V_1 = 6V$$

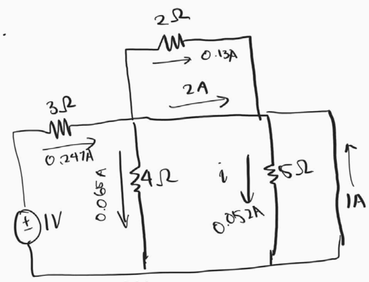
$$V_2 = (1.2 \times 1) + (-4.79 \times 1) + (-0.8 \times 1)$$

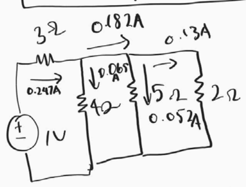
$$= -4.39V$$

$$V_3 = (0.6 \times 2) + (3.595 \times 2) + (-0.4 \times 2)$$

$$= 7.59\ mA$$

e).





$R_T = 3 + (4 + 5$ [illegible]

$= 4.05\,\Omega$

$R = \frac{5 \times 2}{5+2} = 1.43\,\Omega$

$I_{R_T} = \frac{1}{4.05} = 0.247A$

$I = 0.247 \times \left(\frac{1.43}{1.43+4}\right)$

$= 0.065A$

$I = 0.247 \times \left(\frac{4}{4+1.43}\right)$

$= 0.182\,A$

$I = 0.182 \times \left(\frac{2}{5+2}\right)$

$= 0.052A$

$I = 0.182\left(\frac{5}{5+2}\right)$

$= 0.13A$

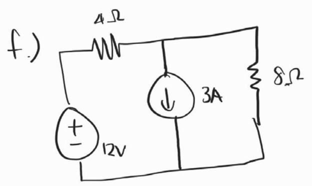
$i = 2 + (-1) + (-0.052)$

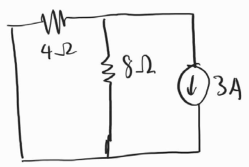
$= 0.948A$ //

$e_2 = 0.948 \times 5$

$= 4.74V$ //

f.)

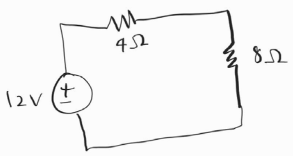




$R_T = \frac{4 \times 8}{4+8} = 2.67$

$V_{3A} = 2.67 \times 3$

$= 8.01V$ //



$V_{4\Omega} = \frac{4}{4+8} \times 12 = 4V$

$V = V_{12V} + V_{3A}$

$= 4 + 8 = 12V$ //

Studio

Circuit analysis practice problems

1. Using KVL and KCL, determine the unknown currents I_C, I_D and the unknown voltages V_B and V_D in the circuit given in Fig.1.

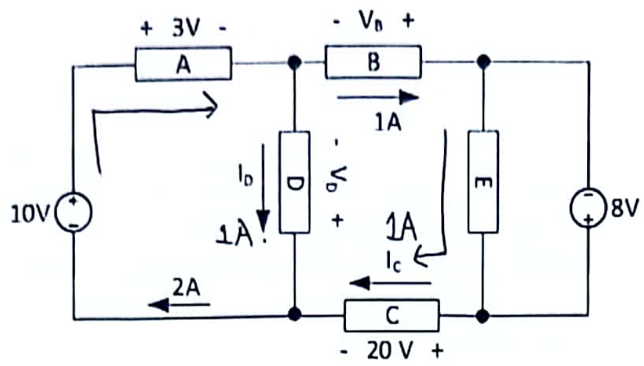


Figure 1: KVL KCL practice problem

$I_C = 1A$ //

$I_D = 2 - 1 = 1A$ //

KVL $= 3 + V_D + 20 - 10 = 0.$

$V_D = -7V$ //

KVL $= -8 + 20 + 3 + V_B + 10$

$= 5V$ //

2. For the circuit given in Fig.2,

   (a) write the KVL equations for the loop1 and loop2.

   (b) write the KCL equations for the Node 2 and the super-node.

in terms of the unknown branch currents, and given voltage and current sources.

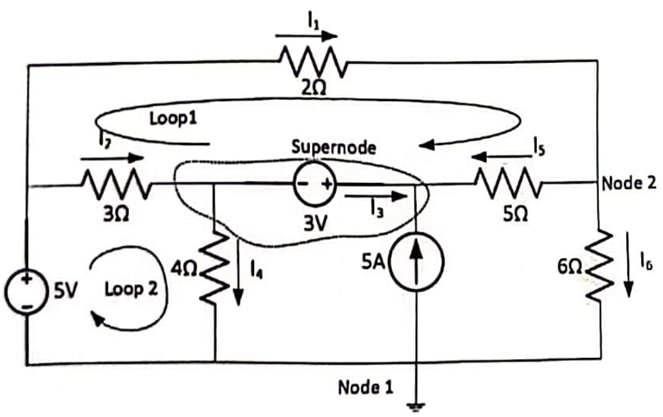


Figure 2: KVL KCL practice problem

2.a)

KVL $= I_1 + I_5 + 3V - I_2 = 0.$

$= 2I_1 + 5I_2 + 3V - 3I_2 = 0$ //

$-5V + I_2 + I_4 = 0.$

$-5V + 3I_2 + 4I_4 = 0$ //

b) KCL $= I_1 = I_5 + I_6$ //

$I_2 + I_5 + 5A = I_4$

3. Using series/parallel rule, determine the equivalent resistance seen by the source in Fig.3. Hence, find the current I drawn from the source.

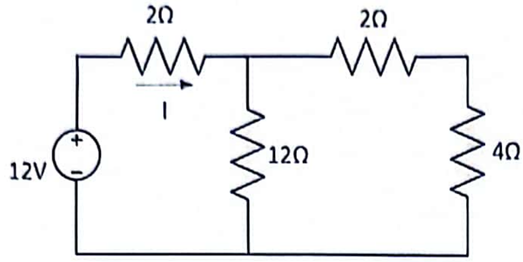


Figure 3: Equivalent resistance practice problem

$R_T = \left(\frac{12 \times 6}{12+6}\right) + 2 = 6\,\Omega$

$I = \frac{V}{R} = \frac{12}{6} = 2A$

4. Branch current method: use KVL/KCL to write three independent equations containing the unknown branch currents I_1, I_2 and I_3 in the circuit given in Fig.4. Solve the linear system of equations.

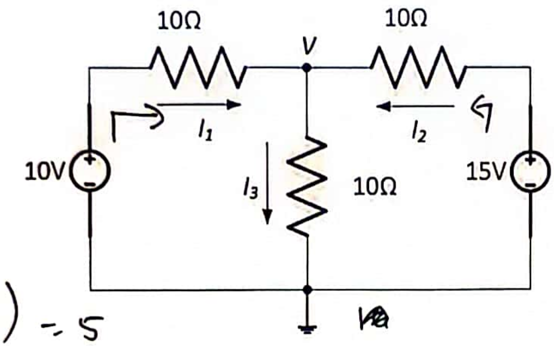


Figure 4: Branch current practice problem

KCL $= I_1 + I_2 = I_3$

KVL $= 10 + 10I_1 + 10I_3 = 0.$

KVL $= 15 + 10I_2 + 10I_3 = 0.$

$\left(\frac{10 \times 10}{10+10}\right) = 5$

$5 + 10 = 15\,\Omega.$

10 V	15 V
$I_1 = \frac{10}{15} = \frac{2}{3}$	$I_2 = \frac{15}{15} = 1$
$I_3 = \frac{10}{20} \times \frac{2}{3} = \frac{1}{3}$	$I_3 = 0.5$
$I_2 = \frac{1}{3}$	$I_3 = 0.5.$

$\therefore I_1 = \frac{2}{3} - 0.5 = \frac{1}{6}A$

$I_2 = 1 - \frac{1}{3} = \frac{2}{3}A$

$I_3 = \frac{1}{3} + 0.5 = \frac{5}{6}A$

5. Using voltage divider principle, determine voltages V_a and V_b in Fig.5. Hence, find the voltage V_{ab}.

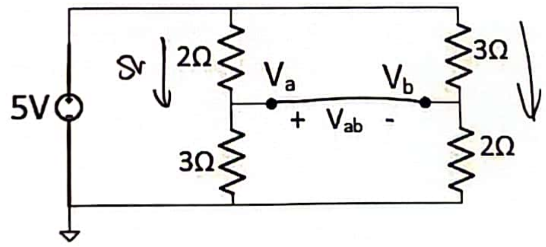


Figure 5: Voltage divider practice problem

$V_a = \frac{2}{3+2} \times 5 = 2.$

$V_b = \frac{3}{3+2} \times 5 = 3.$

$V_{ab} = V_b - V_a$

$= 3 - 2 = 1V$

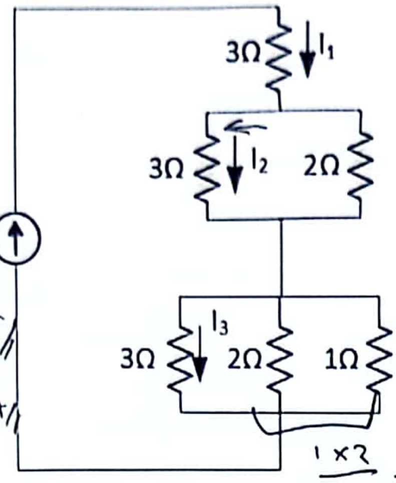
6. Using current divider principle, determine currents I_1, I_2 and I_3 in Fig.6.

$I_1 = 5A$

$I_2 = \frac{2}{3+2} \times 5 = 2A.$

$I_3 = \frac{\frac{2}{3}}{\frac{2}{3}+3} \times 5 = \frac{10}{11} A$

$\approx 0.91 A$



$\frac{3\times2}{3+2} = \frac{6}{5} = 1.2\Omega.$

$\left(\frac{1}{3}+\frac{1}{2}+\frac{1}{1}\right)^{-1} = \frac{6}{11}\Omega \approx 0.55\Omega$

$\frac{1\times2}{1+2} = \frac{2}{3}.$

~~$R_T = 3 + 1.2 + 0.55 = 4.75$~~

Figure 6: Current divider practice problem

7. Determine the unknown currents I_1, I_2 in the circuit given in Fig.7 using Node voltage analysis method.

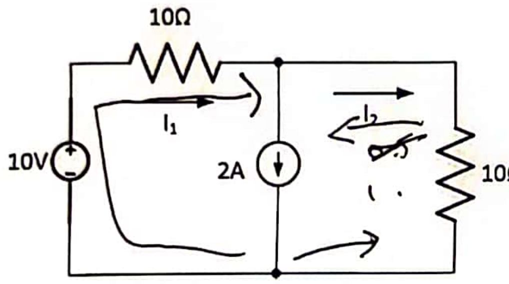


Figure 7: Node voltage analysis practice problem

$I_1 = 1 + 0.5 = 1.5A$

$5A.\ I_2 = 0.5 - 1 = -0.5A$

$10 + 10 = 20\Omega$

$I_{V_s} = \frac{10}{20} = 0.5A$

$2 \times \frac{10}{10+10} = 1A.$

8. Write the KCL equations (in terms of the node voltages V_1, V_2, and V_3) for the nodes V_1 and the super-node, in the circuit given in Fig.8. For branches where the current direction is not given, you may write an expression for the current leaving the node/super-node via that branch.

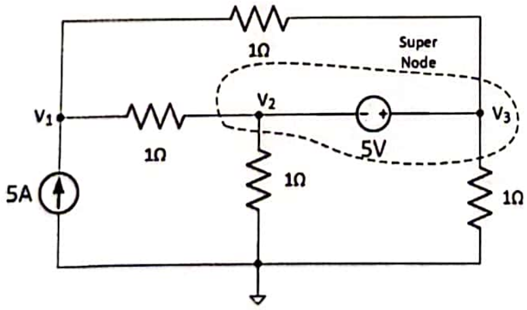
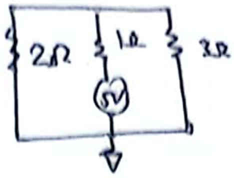


Figure 8: Node voltage analysis practice problem

$V_1 = 5V = V_1 - V_2 + V_1 - V_3$

Super node $= V_2 - V_1 + V_2 - 0 + V_3 - V_1 + V_3 - 0 = 0$



9. Determine the values of currents I_1, I_2 and I_3 for the circuit in Fig.9 using node voltage analysis method.

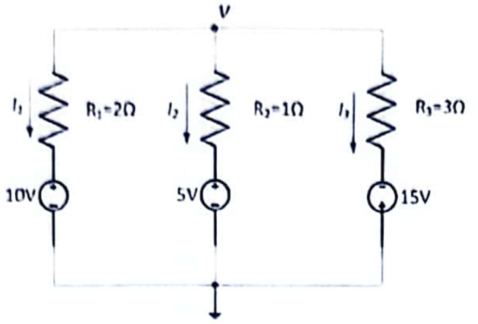


Figure 9: Node voltage analysis practice problem

10V → $R_T = \left(\frac{1}{3} + \frac{1}{1}\right)^{-1} + 2 = \frac{11}{4}$ A.

$I_{R_1} = \frac{10}{11/4} = -\frac{40}{11}$ A

$I_{R_2} = \frac{3}{3+1} \times \frac{40}{11} = -\frac{30}{11}$ A

$I_{R_3} = \frac{1}{3+1} \times \frac{40}{11} = \frac{10}{11}$ A.

10. Determine the value of voltage V_{R1} in the circuit given in Fig.10 using node voltage analysis method.

5V →

$$\frac{10-V}{10} = \frac{V_1}{10} + \frac{V_1+V_2}{10}$$

$$\frac{V_1-V_2}{10} + \frac{10-V_2}{10} = \frac{V_2}{10}.$$

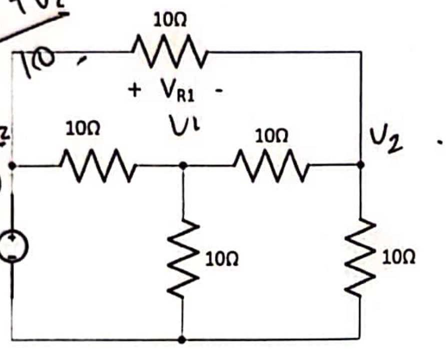


Figure 10: Node voltage analysis practice problem

$R_T = \left(\frac{2\times3}{2+3}\right) + 1 = 2.2\Omega.$

$I_1 = \frac{3}{2+3} \times \frac{25}{11} = -\frac{15}{11}$ A

$I_2 = \frac{5}{2.2} = -\frac{25}{11}$ A.

$I_3 = \frac{2}{2+3} \times \frac{25}{11} = \frac{10}{11}$ A

$V_2 = 5V$

$V_1 = 5$

E-logbook

Show your detailed step-by-step workings for all circuit analysis problems in your eLogbook. This will help you refer to them in future for revision.

$V_{R1} = 10 - 5 = 5V$

15V → $R_T = \left(\frac{2\times1}{2+1}\right) + 3 = \frac{11}{3}$

$I_1 = \frac{1}{1+2} \times \frac{45}{11} = \frac{15}{11}$ A

$I_2 = \frac{2}{1+2} \times \frac{45}{11} = \frac{30}{11}$ A

$I_3 = \frac{15}{11/3} = \frac{45}{11}$ A

$\therefore I_1 = -\frac{40}{11} - \frac{15}{11} + \frac{15}{11} = -\frac{40}{11}$ A

$I_2 = -\frac{30}{11} - \frac{25}{11} + \frac{30}{11} = -\frac{25}{11}$ A

$I_3 = \frac{10}{11} + \frac{10}{11} + \frac{45}{11} = \frac{65}{11}$ A

$\cancel{R_T = \frac{25}{4}}$

$\cancel{I_{R_T} = \frac{10}{25/4} = 1.6 A}$

$16 \times \frac{50/3}{50/3+10} =$

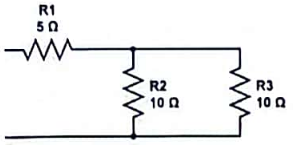
Take-home extra practice problems

(a) Find equivalent resistance of the circuit given in Fig.11.

$\left(\frac{1}{2}+\frac{1}{3}+\frac{1}{6}\right)^{-1} = 1\,\Omega$

Figure 11: Ans. 1 Ω

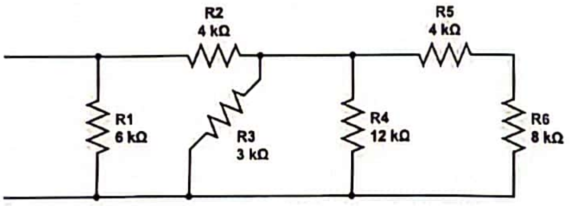
(b) Find equivalent resistance of the circuit given in Fig.12.



$\left(\frac{10\times 10}{10+10}\right)+5 = 10\,\Omega$

Figure 12: Ans. 10 Ω

(c) Find equivalent resistance of the circuit given in Fig.13.



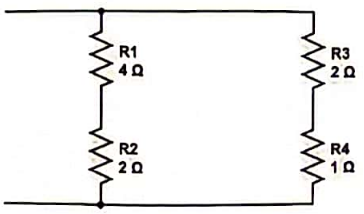
$8+4=12$

$\left(\frac{1}{12}+\frac{1}{12}+\frac{1}{3}\right)^{-1}+4=6.$

$\frac{6\times 6}{6+6}=3\,\Omega$

Figure 13: Ans. 3 kΩ

(d) Find equivalent resistance of the circuit given in Fig.14.



$2+1=3\,\Omega.$

$4+2=6\,\Omega.$

$\frac{6\times 3}{6+3}=2\,\Omega$

Figure 14: Ans. 2 Ω

(e) Solve the circuit in Fig.15 and find the value of V.

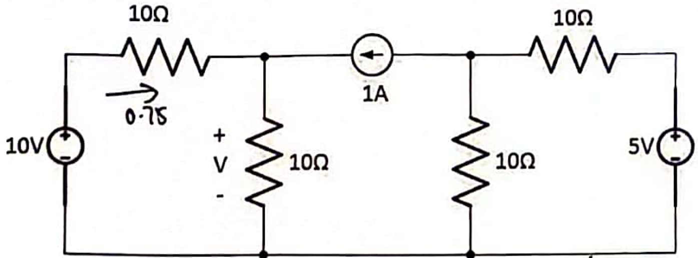


Figure 15: Additional practice problem

$\left(\frac{1}{10}+\frac{1}{10}+\frac{1}{10}\right)^{-1}=\frac{10}{3}.$

$10+\frac{10}{3}=\frac{40}{3}\,\Omega.$

$\frac{10\times 10}{10+10}=5\,\Omega.$

$I_{V_1}=\frac{10}{40/3}=0.75\,A.$

$\frac{5}{5+10}\times 0.75 = \underline{0.25\,A}.$

(f) Solve the circuit in Fig.16 and find the value of the current I_1.

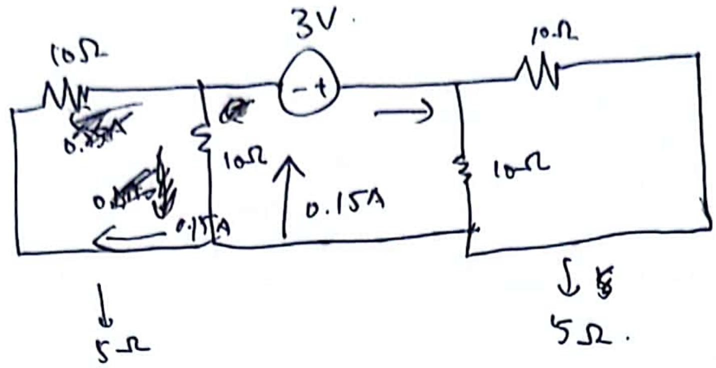
$\frac{10}{10+10}\times 1 = \underline{0.5\,A}$

$V = 1\times 10 = 10\,V$

$I_{V_2}=\frac{5}{40/3}=\frac{3}{8}\,A$

$\frac{10}{10+5}\times\frac{3}{8}=\underline{0.25}$

$I_V = 0.5+0.25+0.25 = 1A.$



$R_T = 5 + 5 = 10\,\Omega$

$I_{R_T} = \frac{3}{10}\,A$

$\frac{10}{10+10} \times \frac{3}{10} = \frac{3}{20} \approx \underline{0.15\,A}$

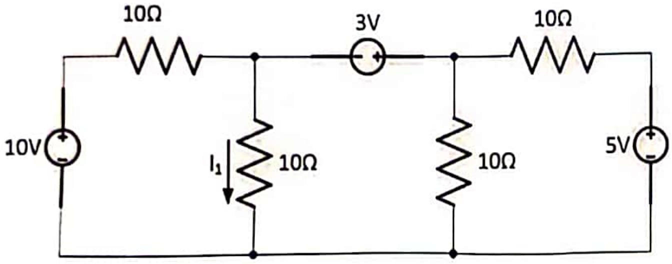
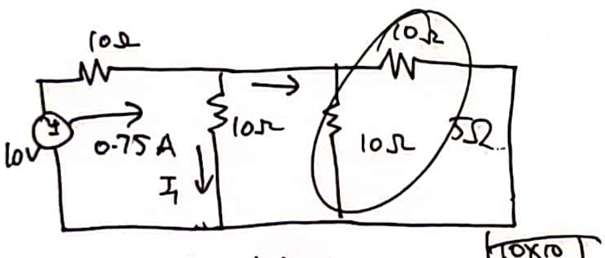


Figure 16: Additional practice problem



$\boxed{\frac{10\times10}{10+10} = 5}$

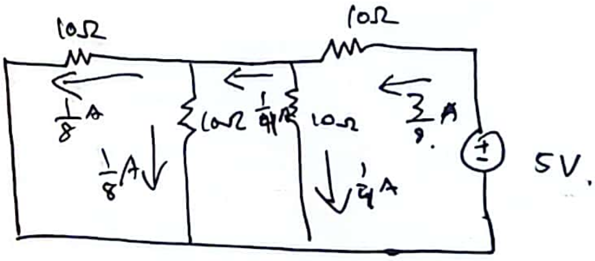
$\left(\frac{1}{10}+\frac{1}{10}+\frac{1}{10}\right)^{-1} = \frac{10}{3}$

$R_T = \frac{10}{3} + 10 = \frac{40}{3}\,\Omega$

$I_{R_T} = \frac{10}{40/3} = 0.75A$

$I_1 = \frac{5}{10+5} \times 0.75$

$= \underline{0.25\,A}$



$I_{R_T} = \frac{5}{40/3} = \frac{3}{8}$

$\frac{10}{10+5} \times \frac{3}{8} = \frac{1}{4}$

$\frac{1}{4} \times \frac{10}{10+10} = \frac{1}{8}A \approx \underline{0.125A}$

~~$\therefore 0.25 + 0.125 + 0.15 =$~~

$\therefore 0.25 + 0.125 - 0.15 = 0.225A$