Problem Set 1.1 Hint Sheet

Please note this document is a hint sheet. The information contained herein is meant to guide you up to the main equations required to solve a given circuit. If you are able to get up to this point, then this document has served its chief purpose. The main focus of this course is on the concepts behind these equations. Therefore, the details on how to solve these equations lies outside of this course and therefore omitted from this document. The details contained in this document are meant to supplement the numerical answers given at the end of the problem set.

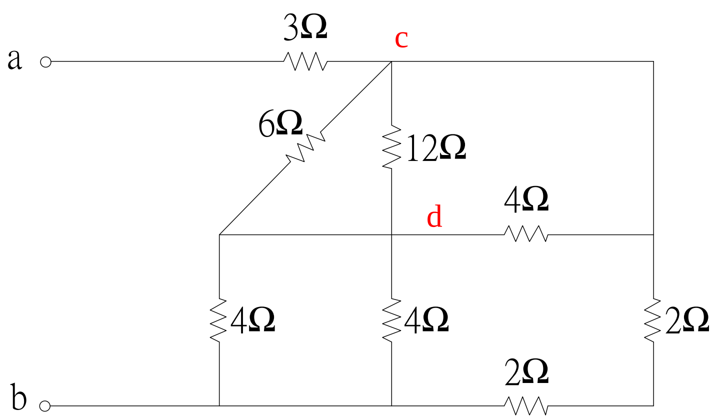
Q1

Apply KCL at node a (3 branch currents involved) to find I_2.
Then apply KCL at the ground node (3 branch currents involved) to find I_S.

Q5

$R_{eq} = R_1 + [R_2 \parallel R_3 \parallel (R_5 + (R_4 \parallel R_6))]$

Q6



When networks get complicated, one handy trick is to label nodes. This will help you to check if you have broken any connections by mistake as you move resistors around. When finding the equivalent resistance, the trick is to make sure a given terminal of a resistor never gets disconnected from its original node.

For the network given in this problem, this means adding two additional node symbols (c and d) as seen in the above figure.

For the network given in this problem, we start by analyzing the resistors between each pair of nodes:

Between a-c: 3 Ω

Between c-d: Connection between these two nodes can be made through any of the following 3 resistors -- 6 Ω, 12 Ω, and 4 Ω (parallel)

Between c-b: Current has to pass through two 2 Ω resistors (series)

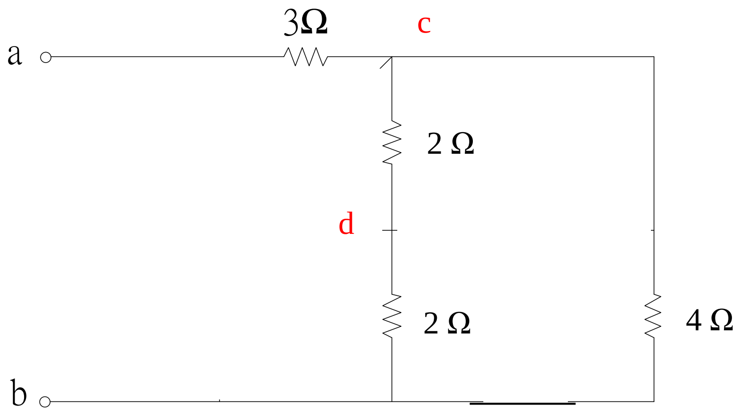
Between d-b: Connection between these two nodes can be made through any of the 4 Ω resistors (parallel)

We can then start to combine resistors between these nodes:

Between c-d: 6 Ω || 12 Ω || 4 Ω = 2 Ω; Between c-b: 4 Ω

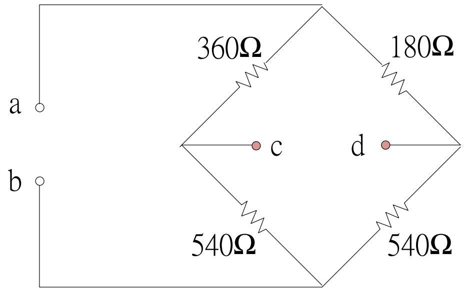
Between d-b: 4 Ω || 4 Ω = 2 Ω

We draw these reduced resistor values back into the circuit between the nodes where they belong to. We do this node by node, simplifying the circuit to become what you see below:



Q7

a(i) Find the equivalent resistance across terminals *a-b* when terminals *c-d* are open:



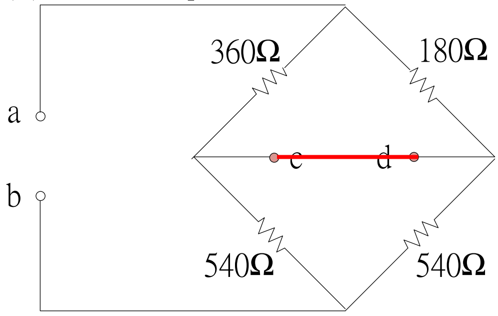
Between terminals a-b, the connection be made by 2 options (i.e. parallel):

(1) Going through the left path passing through 360 Ω and then through 540 Ω (i.e. series), in other words from a to c and then c to b ⇨ 900 Ω, OR

(2) Going through the right path passing through 180 Ω and then through 540 Ω one at a time (i.e. series)), in other words a to d and then d to b ⇨ 720 Ω

Therefore, R_{ab} = 720 Ω || 900 Ω

a(ii) Find the equivalent resistance across terminals *a-b* when terminals *c-d* are shorted:

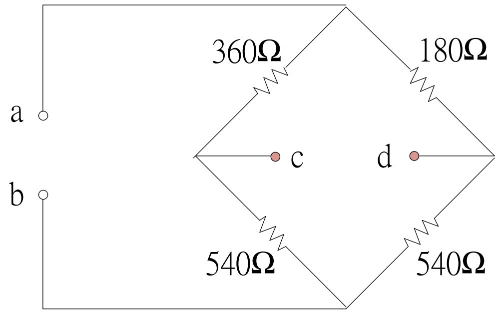


Terminals c-d are now the same node.

Between terminals a-c, the connection can be made either through 360 Ω OR 180 Ω (i.e. parallel) ⇨ 120 Ω

Between terminals c-b, the connection can be made through any of the 540 Ω resistors (i.e. parallel) ⇨ 270 Ω

But to get from a to b, we must go through node c (i.e. series) ⇨ R_{ab} = 120 Ω + 270 Ω b(i) Find the equivalent resistance across c-b when terminals *a-b* are open:



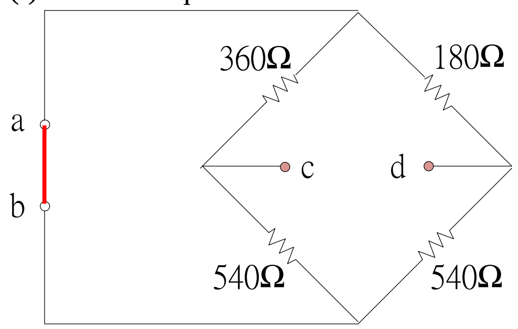
Between terminals a-b, the connection can be made by 2 options (i.e. parallel):

(1) Going through the upper path through 360 Ω and then 180 Ω, in other words from c to a and then a to d ⇨ 540 Ω

(2) Going through the lower path through the two 180 Ω resistors, in other words from c to b and then b to d ⇨ 1080 Ω

Therefore, R_{ab} = 540 Ω || 1080 Ω

b(i) Find the equivalent resistance across c-b when terminals *a-b* are shorted:



To go from node c to d, we find that at node c the path splits between 360 Ω and 540 Ω and the paths meet again at node a (which is the same as node b). So to get from c to a, we have two options 360 Ω or 540 Ω
⇨ Resistance between c to a = 360 Ω || 540 Ω = 216 Ω

From node a to d, we can either go through 180 Ω or 540 Ω.
⇨ Resistance between a to d = 180 Ω || 540 Ω = 135 Ω

In terms of the total journey from c to d, we need to through node a as the in between point through the above pathways (i.e. series).

Q8

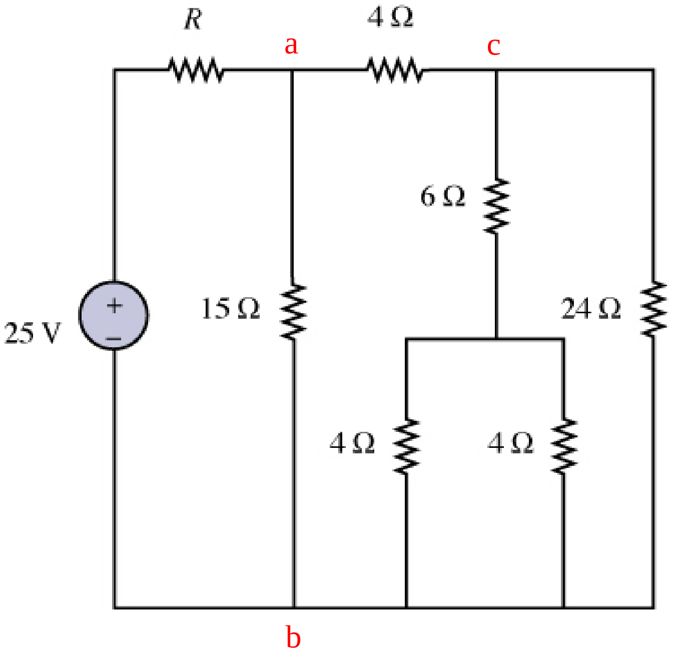
Apply KVL in the clockwise direction: Use a positive sign when you see the voltage increase and a minus sign when you see the voltage decrease as you move around the loop. The sum around a complete loop equals zero. We will apply this method in greater depth in Unit 2 (mesh current analysis)

30 – I*3 + 10 – I*5 – 8 = 0 (Highlighted part gives V_{ab})

Voltage rises: 30 V and 10 V (move from –ve to +ve)

Voltage drops: 3 Ω, 5 Ω and 8 V (move from +ve to –ve)

Q9



Given the information about the power consumed by the 15 Ω resistor, we can obtain the voltage drop across this resistor ($P = V^2/R$) ⇨ 15 V

This 15 V is in fact dropped across the resistor network to the right of the 15 Ω resistor.

Strategy: Obtain the equivalent resistance of the network to the right of resistor R (R_{eq}) → Note that this resistance is in series with resistor R → Applying voltage divider rule, we can equate the voltage drop across R_{eq} with 15 V.

Between nodes c-b, the equivalent resistance = ((4 Ω || 4 Ω) + 6 Ω) || 24 Ω = 6 Ω

Between nodes a-b, R_{eq} = 15 Ω || 10 Ω = 6 Ω

Apply voltage divider rule: 15/25 = 6/(R+6)