Name:	ID:	Section:

Problem Set 0 (CSE 250 Review)

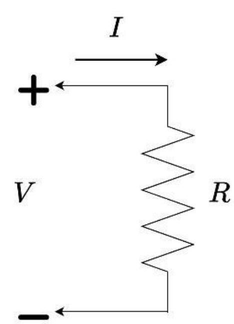
BRAC Unviversity

Semester: Spring 2024

Course No.: CSE251	Marks: 100
Course title: Electronic Devices and Circuits	Upload Date: 31/1/2024
Faculty: TMT	Submission Date: 14/1/2024

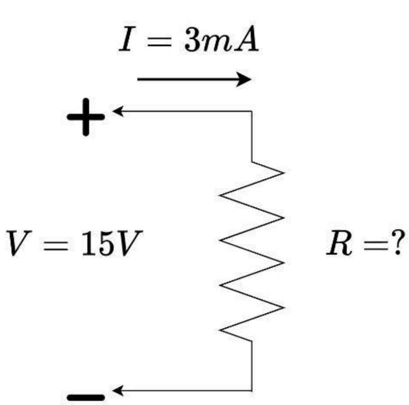
Ohm's Law:

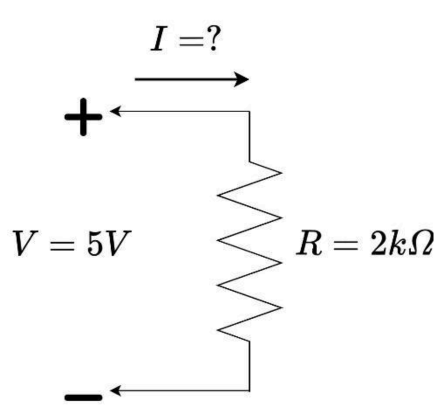
1) (CO1, marks: 15) Ohm's Law relates the voltage across the resistor with the current flowing through it. The circuit convention to be followed can be understood from the figure below:

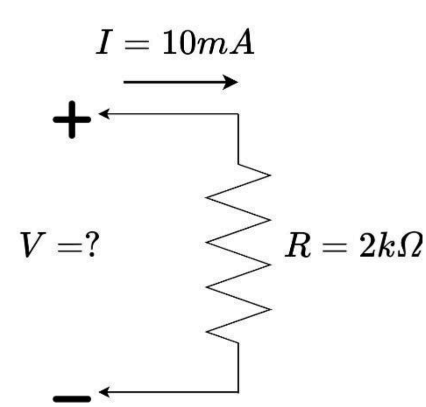


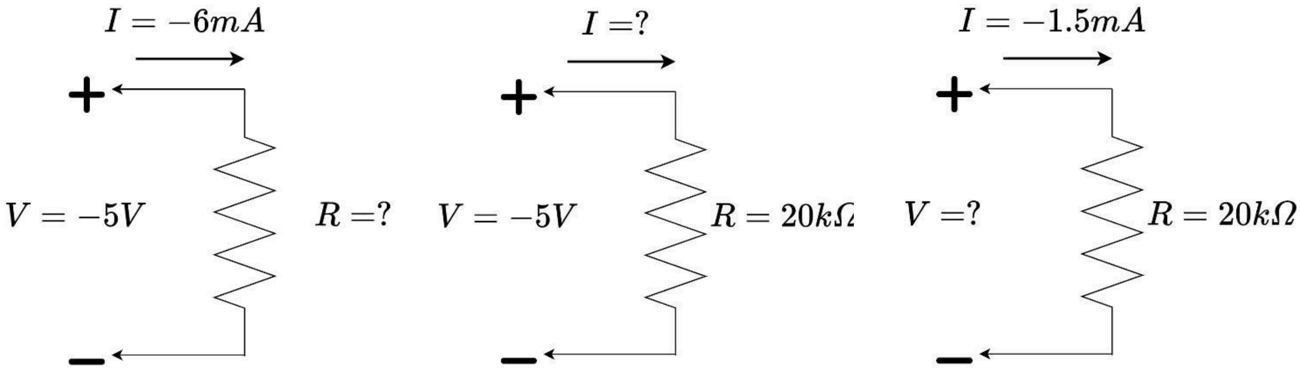
V = IR

Below, there are six figures where two of the three values, namely, V, I and R are given. Also, if there are negative values, try to redraw the circuit by reverting the necessary directions of current or polarities of voltage.



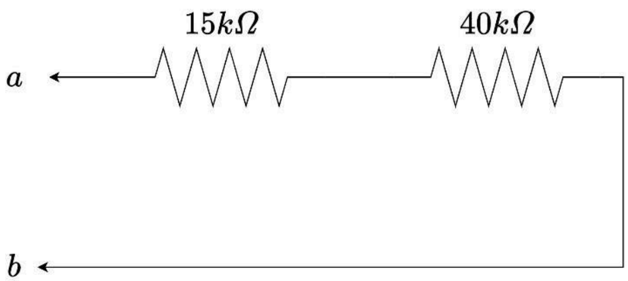


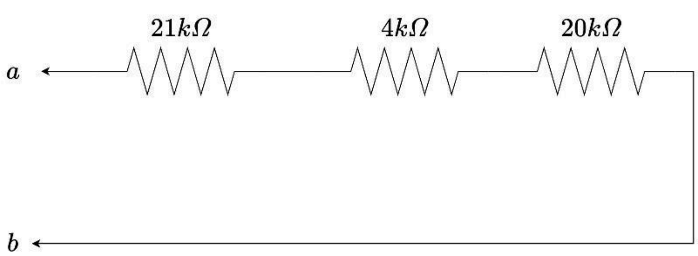


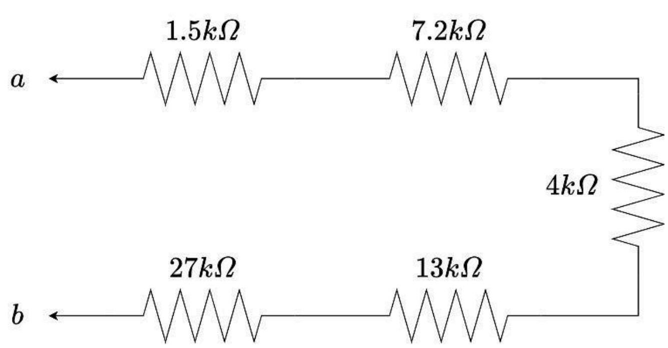


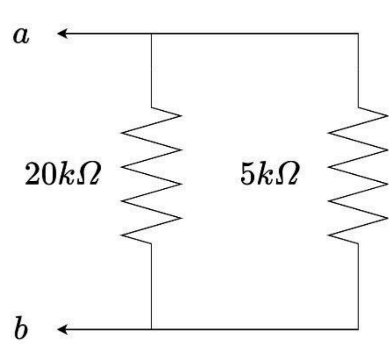
Series and Parallel Circuits and their Equivalent representations:

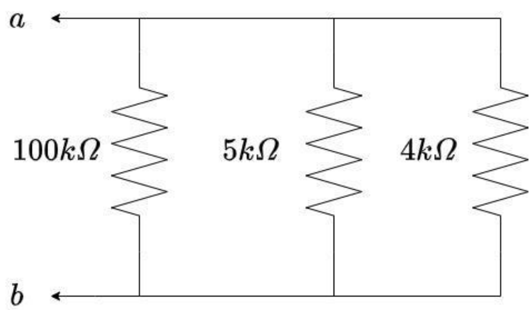
2) (CO1, marks: 15) Series and Parallel connections of resistances can be replaced by equivalent resistances in order to simplify circuit analysis. Given below are a few circuits that have series combination or, parallel combination of resistors, or both. Try to find the equivalent resistances of these circuits:

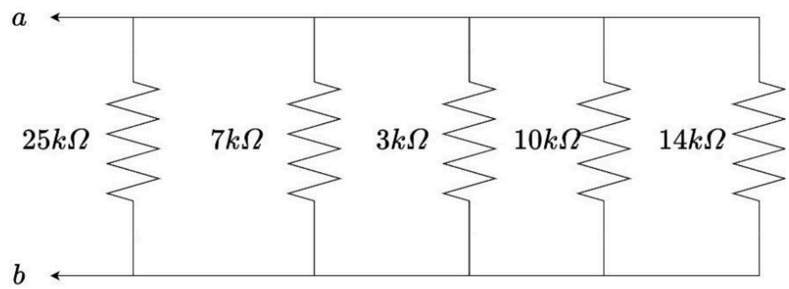








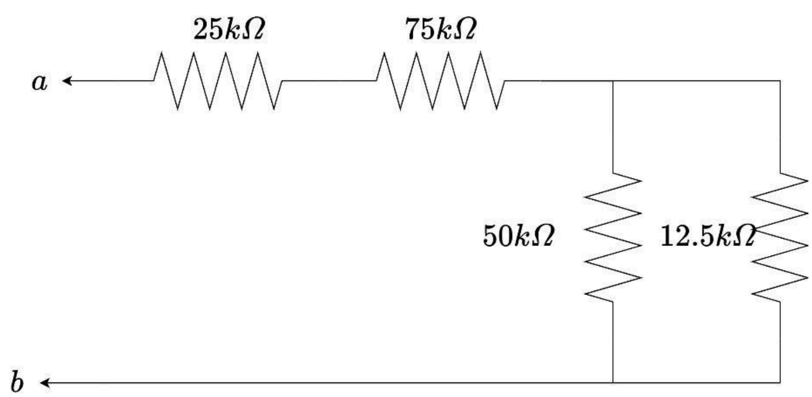




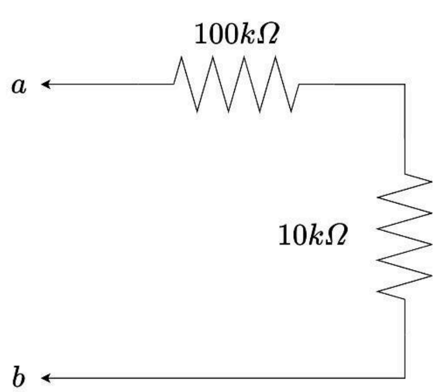
Below are 4 circuits that are combinations of series and parallel circuits. Try to find the equivalent resistances between them:

[Hint: try to spot a collection of resistors that can be lumped together as either series or parallel. Simplify and redraw the circuit with their equivalent resistances and repeat to obtain the entire circuit's equivalent representation]

Here is an example:



In this circuit, the first two resistors are in series and the last two are in parallel. So, the series equivalent of 25k and 75k is simply their addition, (25+75) = 100k. Whereas, the parallel equivalent of the parallel branch is simply the inverse of addition of their conductances (As covered in the class lectures), i.e., 1/((1/50)+(1/12.5)) = 10k. We can redraw by replacing these combinations with their respective equivalences as:



Now the circuit is simply a series combination of two resistors, the equivalent of which is simply (100+10) = 110k!

In general, resistors R_1, R_2, … , R_n in series have an equivalent resistance of:

$$R_{eq} = R_1+R_2+\ldots+R_n = \sum R_i$$

While resistors R_1, R_2, … , R_n in parallel have an equivalent resistance of:

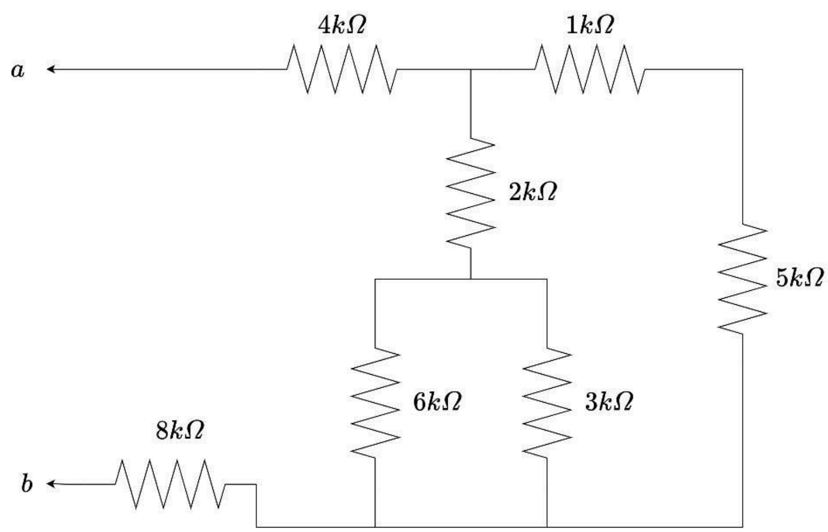
$$R_{eq} = 1 / G_{eq}$$

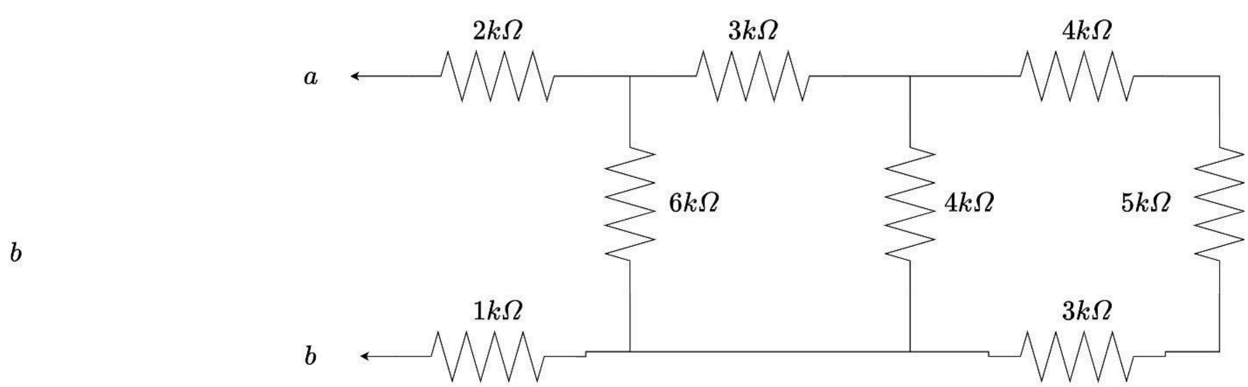
Where, G_{eq} is the equivalent conductance given by:

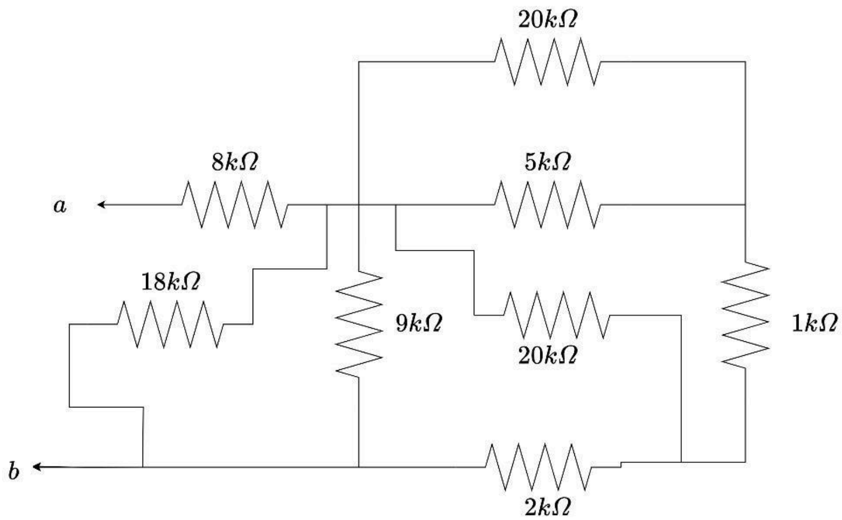
$$G_{eq} = G_1+G_2+\ldots+G_n = \sum G_i$$

[Try to think about why this is the case. A brief proof was presented in the class lectures, you can try to revisit the class notes]

3) (CO1, marks: 15) Now with this idea, try to find the equivalent resistances of the following four circuits below:







[Small hint on the third circuit: Try to find the equivalent circuits of small group of resistors from the upper rightmost side of the circuit]

Voltage Divider Law:

A series branch with a voltage value V and resistors R_1, R_2, … , R_n in series will have the voltage drop across any resistor R_j as:

$$V_j = [R_j / (\sum R_i)] * V$$

Where, $(\sum R_i)$ is the sum of all resistances of the resistors in the series branch.

Current Divider Law:

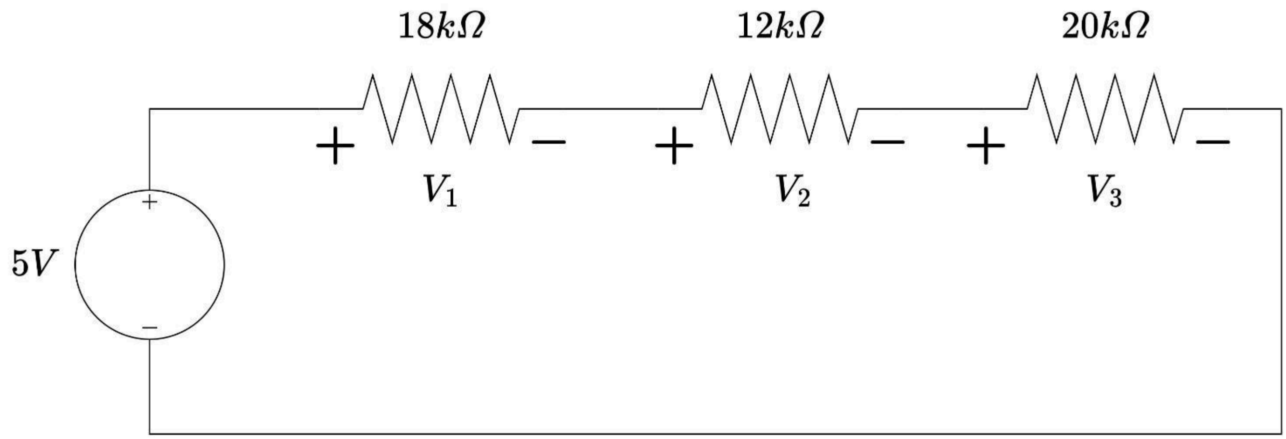
A parallel branch with a current value I and resistors R_1, R_2, … , R_n in parallel will have the current flowing through any resistor R_j as:

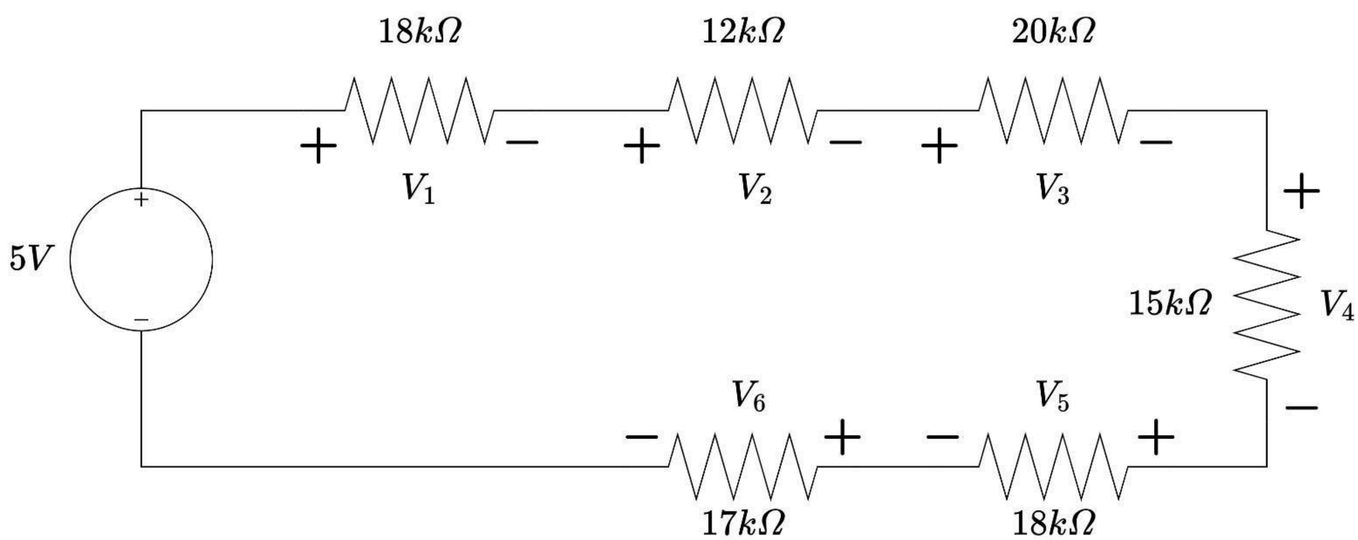
$$I_j = [G_j / (\sum G_i)] * I$$

Where, $(\sum G_i)$ is the sum of all conductances of the resistors in the parallel branch.

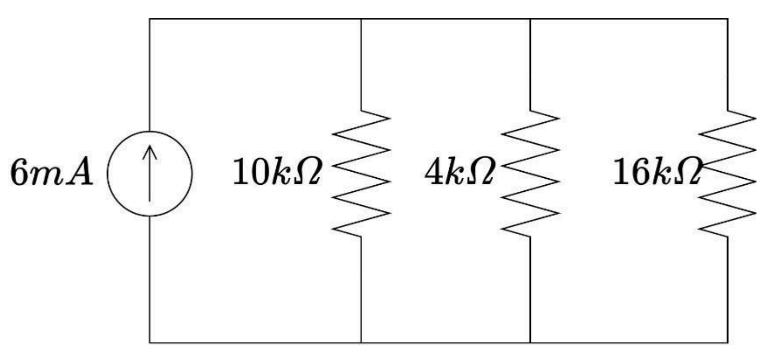
4) (CO1, marks: 10) Now equipped with these ideas, solve the following:

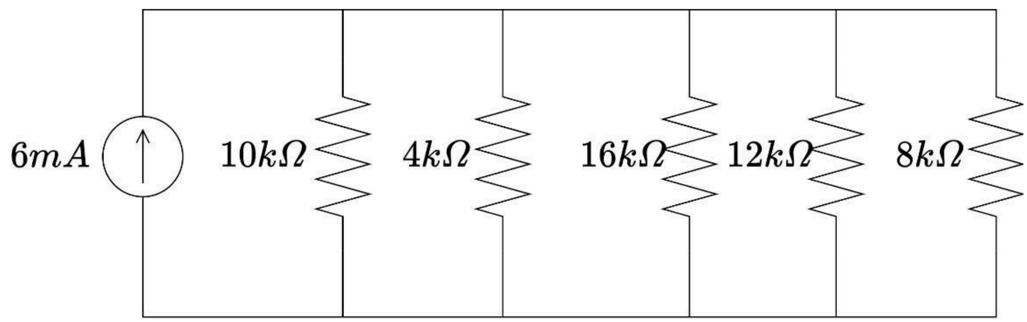
i) find the voltages across the resistors in the following two circuits:





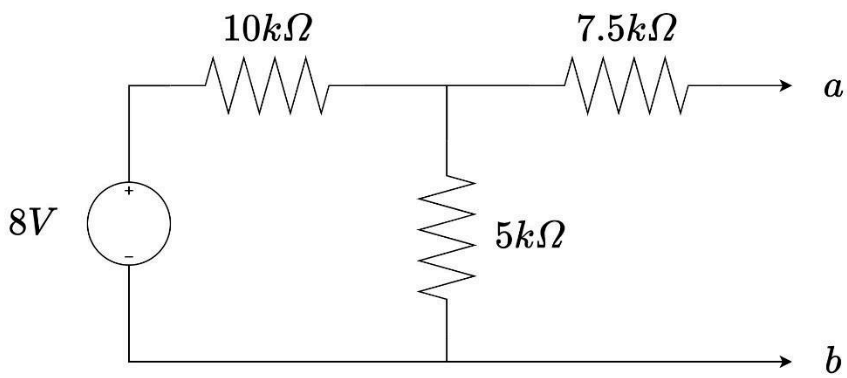
ii) Now, for the next two circuits, first find the conductances of all the resistors and redraw the circuit. Then find the current through each of the resistors:



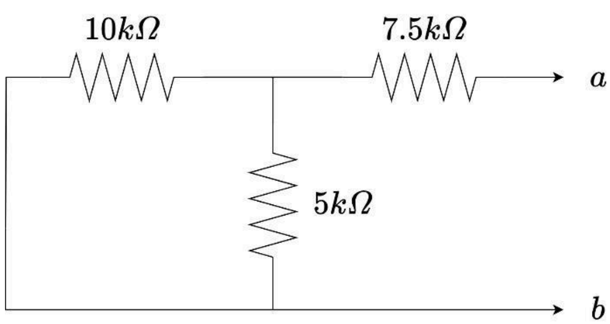


Thevenin's Theorem:

Thevenin's theorem states that any linear circuit with two ports can be represented by a Thevenin voltage (obtained as the open circuit voltage in those two ports) and a Thevenin resistance (obtained as the equivalent resistance as seen from those two ports). Here is an example:



Suppose we want to find the Thevenin circuit for the circuit above at the points a and b. At first we find the Thevenin resistance R_{th}. This is done by turning off all the sources first(setting voltage sources to zero -> shorting voltage sources, and setting current sources to zero -> open circuiting current sources). The circuit should now look like this:

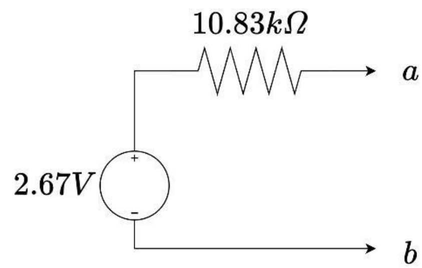


This should look familiar to you as you've learned to compute equivalent resistances. The 10k and 5k are in parallel, which comes out to be 3.33k. The 3.33k and 7.5k are now in series which gives 10.83k. This is our Thevenin resistance.

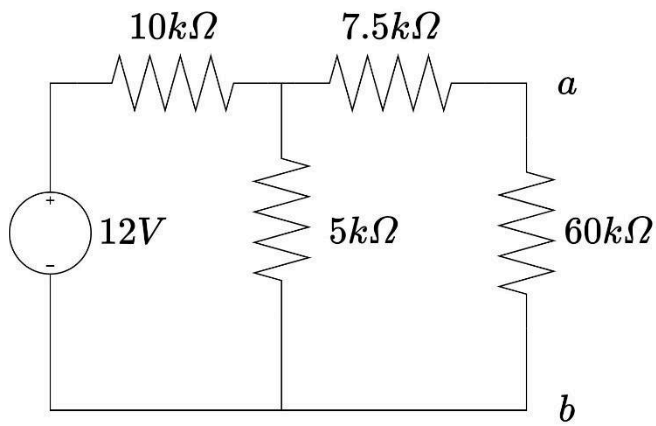
Now, we find the open circuit voltage across a and b, which is simply just obtained by doing voltage division law considering 10k and 5k as series (the 7.5k is a 'dead' component in the circuit now as no current flows through it when a and b are open). This gives us:

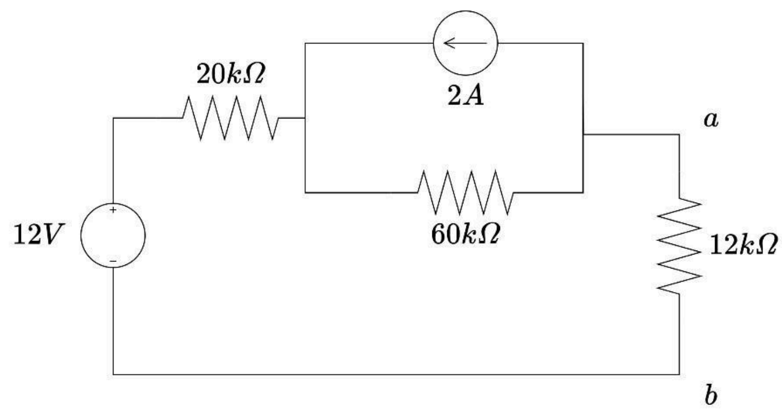
$$V_{th} = (5/(5+10)) * 8 = 2.67 \text{ V}$$

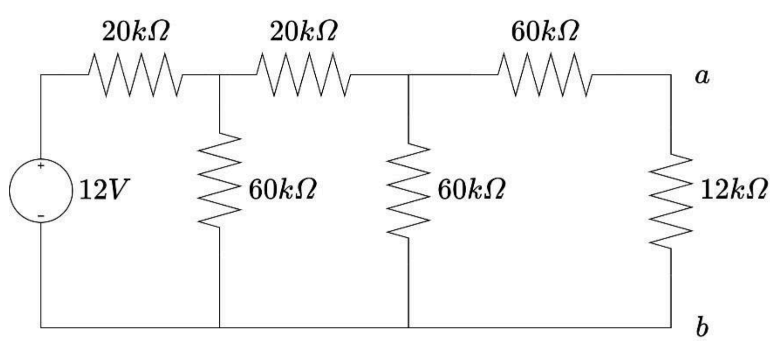
Our circuit can now be represented simply with V_{th} and R_{th} as:



5) (CO1, marks: 15) Geared with this idea, find the Thevenin representations across a and b of the following circuits:







[keep in mind that the rightmost resistor must be excluded while finding the thevenin equivalent].

ii) after finding the thevenin equivalent, redraw the simplified circuit. [it should become a voltage source with an R_{th} and the rightmost resistor (that will be excluded from calculations), in series]

Nodal Analysis and Line Diagrams:

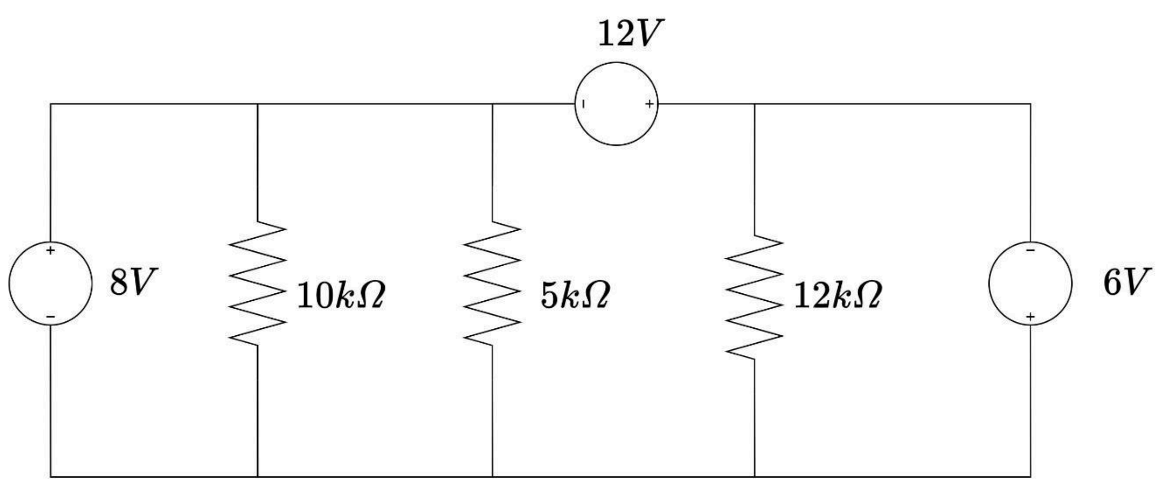
A few steps on how to perform nodal analysis:

1) Identify the nodes of the circuit.
2) Ground the node that is connected to the most number of voltage sources (This helps in reducing supernodes in the circuits).
3) Perform KCL on the remaining (n-1) nodes excluding the ground node. The idea is to substitute all the exiting currents in a node with voltage and resistor values. This gives you an equation in terms of node voltages.
4) In case of a node with a voltage source that is not grounded, we consider KCL combining both nodes of the voltage source (known as the supernode equation) while getting one other equation as the difference of two node voltages to be the source voltage.

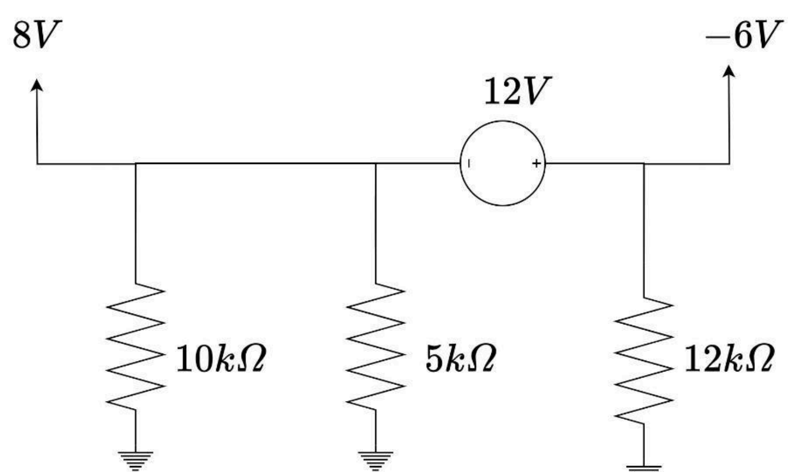
We will also try to convert these circuits into line diagrams, an alternative circuit representation. What we do here is:

1) The nodes connected to any grounded voltage sources are immediately replaced with the voltage source value and an arrow sign is drawn in the node replacing the voltage source entirely.
2) The ground nodes are deleted and every component connected to the ground node is redrawn with a small earth symbol.

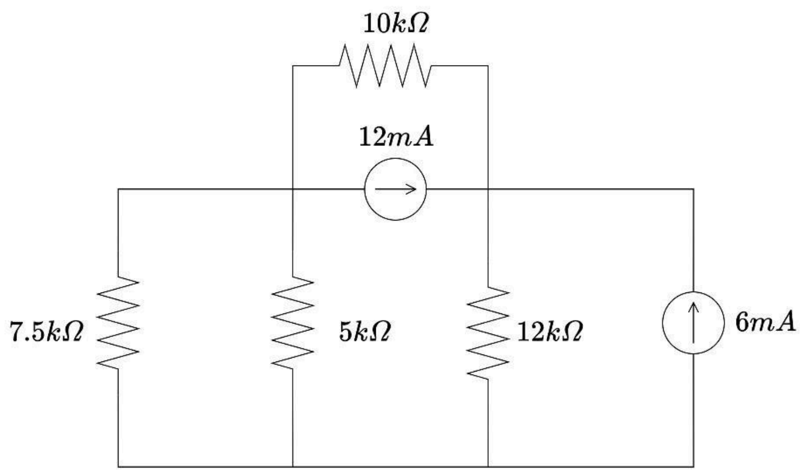
Here is an example of a circuit converted to a line diagram:



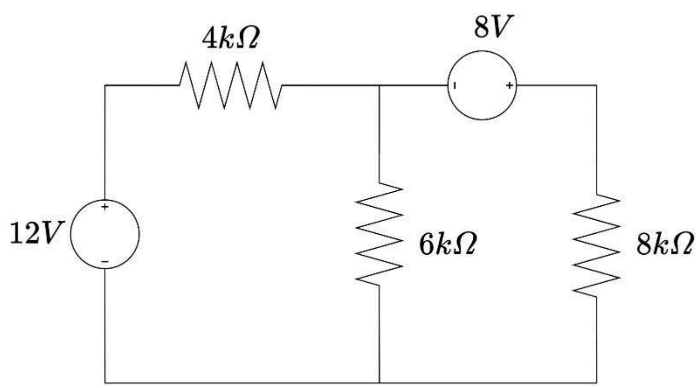
Bottom node is grounded and can be redrawn as:



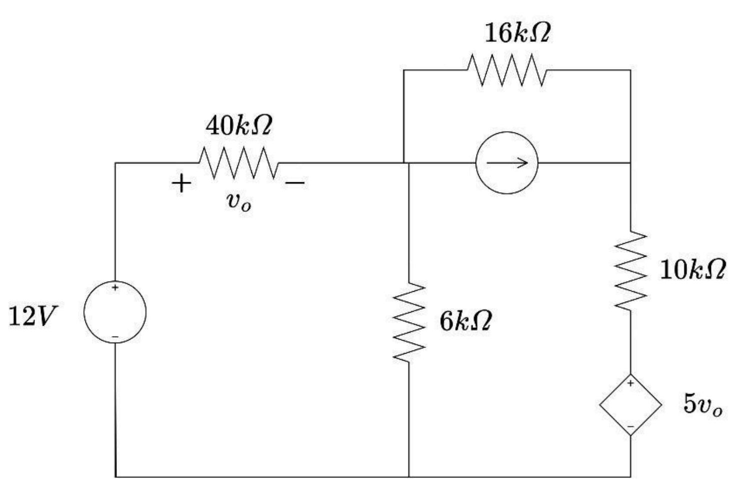
6) (CO1, marks: 30) Try and convert to line diagram and perform Nodal analysis to the following four circuits:



(This circuit has no voltage sources. No need to force the arrow signs if there aren't any sources that specify any node voltages by inspection)



(notice how the 8V stays in the diagram because it is not grounded on either ends)



[Submission Guidelines: Must be submitted in the google form given in the discord channel. Deadline is two weeks from uploading of problem set]