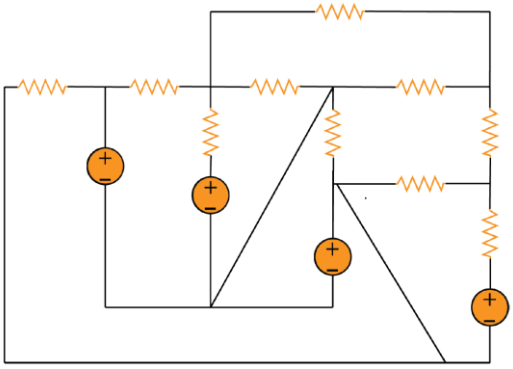
School of Electrical Engineering & Telecommunications

ELEC1111

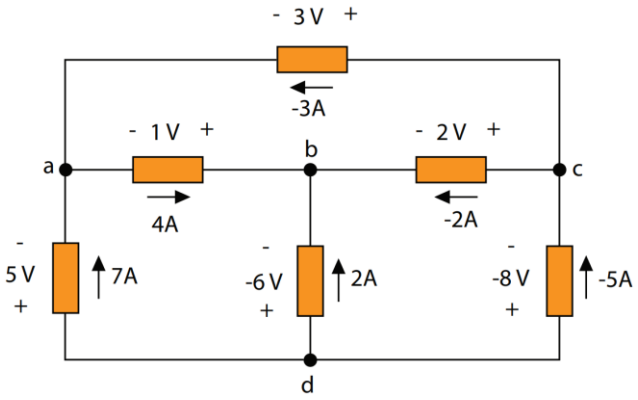
Topic 2: Kirchhoff's Laws, Nodal & Mesh Analysis

1. Identify all the nodes, branches, and meshes in the following figure.



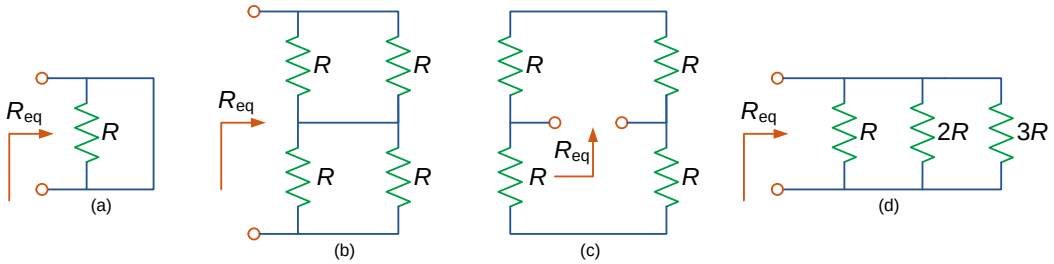
Answer: There are 14 branches, 8 nodes and 7 meshes.

2. In the following circuit (Q3 in Online Tutorial1) the total sum of powers being consumed and generated is not equal to zero, violating the conservation of energy law.
   (a) Identify the error in the circuit using Kirchhoff's Current and Voltage Laws.
   (b) Confirm your answer by calculating the powers and their total sum.



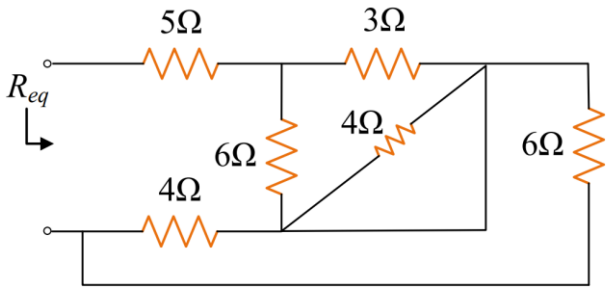
Answer: Branches bd and ad.

3. Find the equivalent resistance of the following networks.



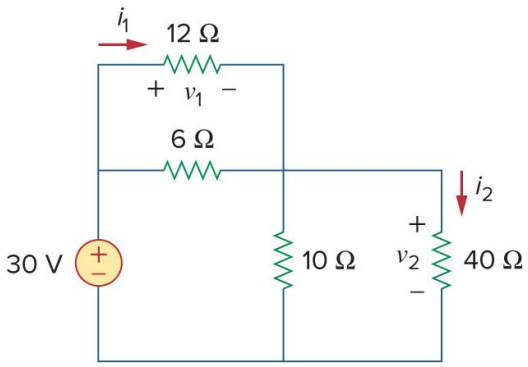
Answer: 0, *R*, *R*, 6*R*/11

4. (**Midterm Exam - S1, 2016**) For the circuit below, calculate the equivalent resistance R_{eq} of the network as seen from the terminals



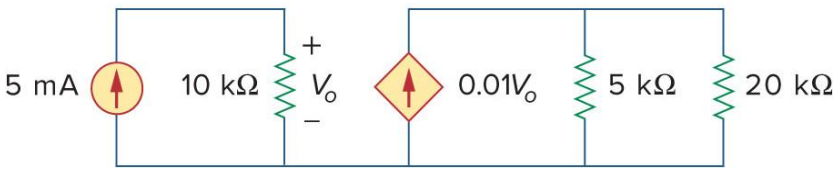
Answer: 9.4 Ω

5. Find v_1 and v_2 in the circuit shown below. Also the currents i_1 and i_2.



Answer: 10 V, 20 V, 833.3 mA, 500 mA

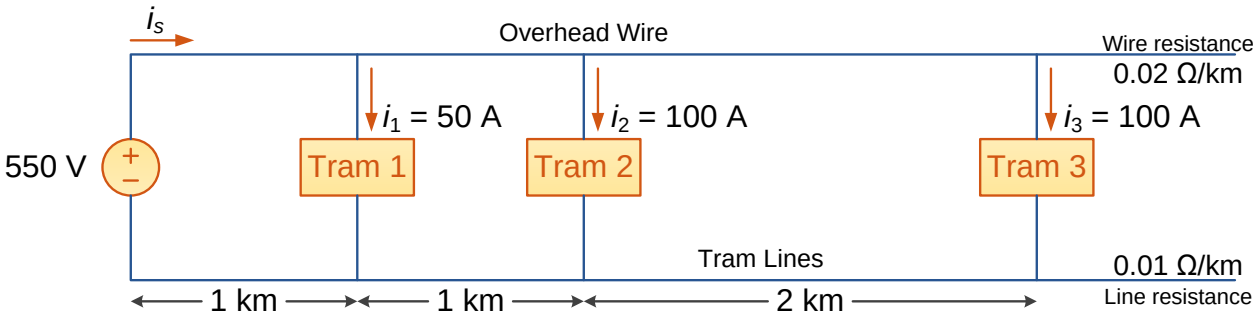
6. In the following circuit, calculate the current and voltage of the 20 kΩ resistor. What is the power generated/supplied by the dependent current source?



Answer: 1 kW

7. The DC traction power supply system (TPSS) of a light rail network, as shown in the following figure, consists of a DC Voltage source, overhead wires and an earth return. At a given moment, three trams travel within one section post and absorb 50 A, 100 A, and 100 A, respectively. Considering the overhead wires electric resistance given in units of Ω/km, calculate the power that is absorbed by each trams. What is the overall efficiency of this TPSS?

   Efficiency η is defined as the ratio of the total useful power consumed by a system (to perform a task) to the total power supplied to it. Efficiency is an indication of how much of the supplied power is being lost like the heat dissipation by wires resistances.

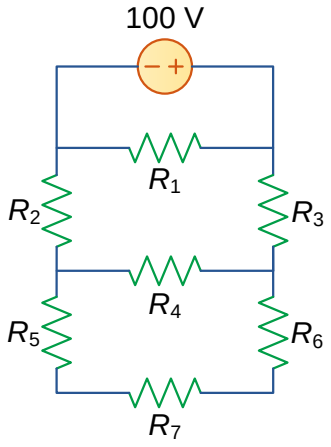


Answer: 97.3%

8. An industrial heating application can be modelled by using a connection of resistive elements as shown in the figure below. The two requirements for this industrial heating application are stated as below,

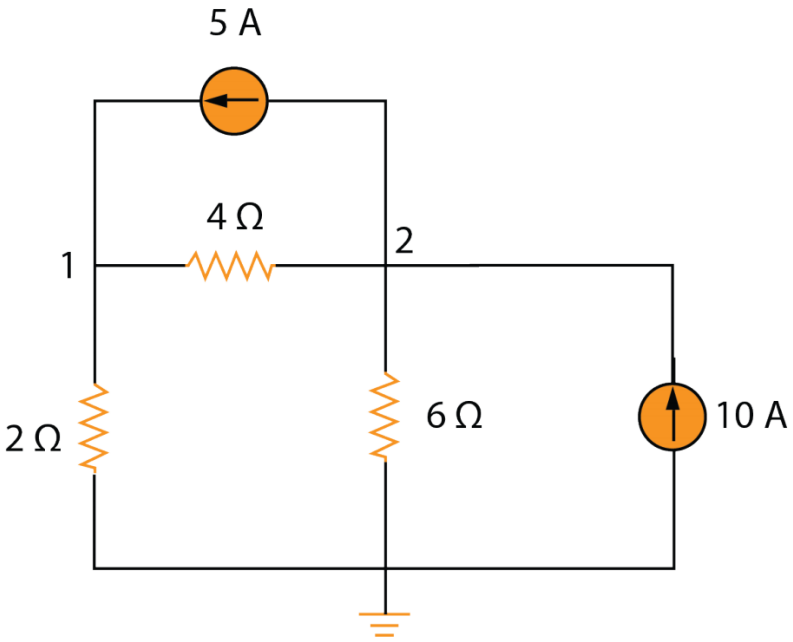
   a) The total power consumed is equal to 3500 W.
   b) The elements generate heat uniformly (this means that they dissipate equal power).

   Based on the above requirements, calculate the values of the resistances R_1 to R_7.



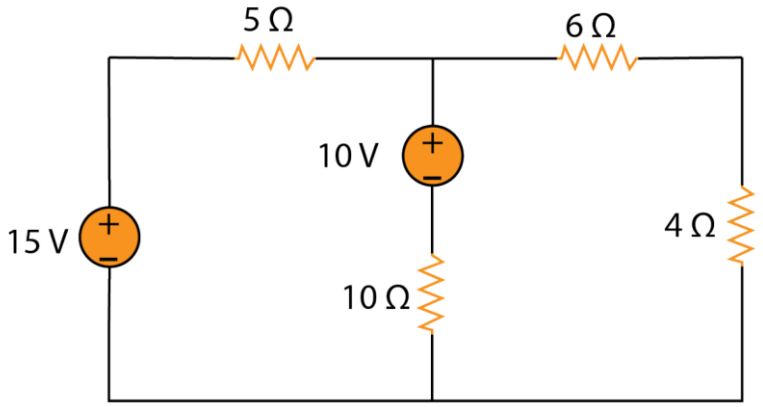
Answer: 20 Ω, 0.56 Ω, 0.56 Ω, 8.89 Ω, 0.987 Ω, 0.987 Ω, 0.987 Ω

9. Find the node voltages in the circuit given below.



Answer: $v_1 = \frac{40}{3} = 13.333$ V and $v_2 = 20$ V

10. In the following circuit, find all the branch currents using mesh analysis. (Assign mesh currents and branch currents individually)

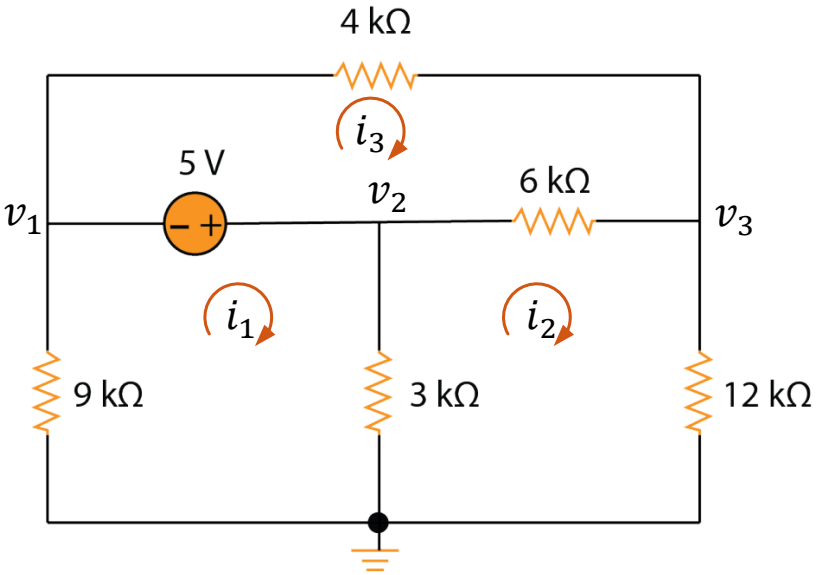


Answer: $I_1 = 1$ A (current in 15-V voltage source and 5-Ω resistor), $I_2 = 1$ A (current in 6-Ω and 4-Ω resistors), and $I_3 = 0$ A (current in 10-V voltage source and 10-Ω resistor).

11. For the circuit below,

a) Write nodal equations using nodal analysis.

b) Write mesh equations using mesh analysis.



Answer:

a) $\begin{cases} v_1 - v_2 = -5 \\ 13v_1 + 18v_2 - 15v_3 = 0 \\ 3v_1 + 2v_2 - 6v_3 = 0 \end{cases}$

b) $\begin{cases} 12i_1 - 3i_2 = 5 \\ 3i_1 - 21i_2 + 6i_3 = 0 \\ 6i_2 - 10i_3 = 5 \end{cases}$

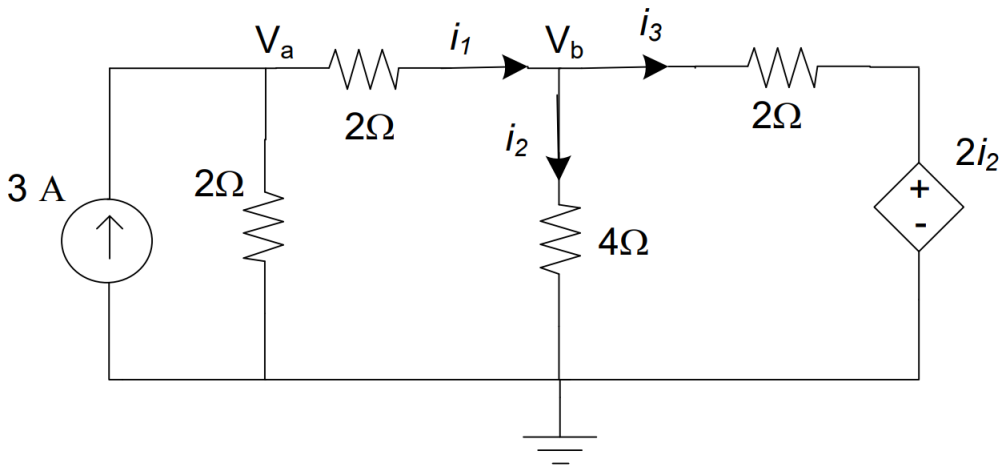
12. **(Mid-session Exam – S2, 2016)**

For the circuit below,

a) Apply nodal analysis to write down the node voltage equations at nodes V_a and V_b.

b) Solve the voltage equations in part (a) to find the voltages V_a and V_b.

c) Find the currents i_1, i_2 and i_3 based on your results in part (b).



Answer:

a) $\begin{cases} 2v_a - v_b = 6 \\ 2v_a - 4v_b = 0 \end{cases}$

b) $V_a = 4$ V, and $V_b = 2$ V

c) $i_1 = 1$ A, $i_2 = 0.5$ A, and $i_3 = 0.5$ A

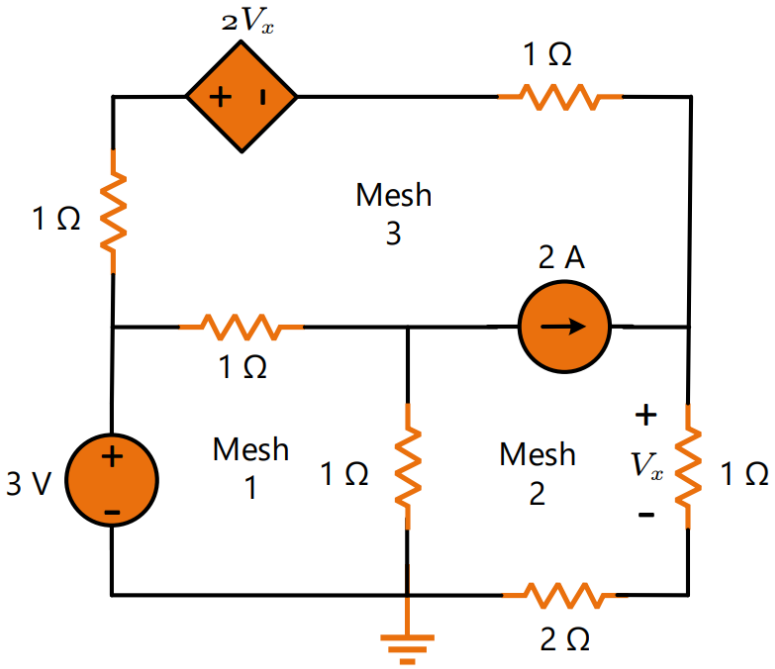
13. **(Mid-session Exam – Summer, 2017)**

For the circuit below,

a) Apply mesh analysis to write down the mesh current equations in Mesh 1, Mesh 2, and Mesh 3 (this part was only given in the actual exam).

b) Solve the current equations in part (a) to find the mesh current.

c) Find the power generated by the dependent voltage source based on your results in part (b).



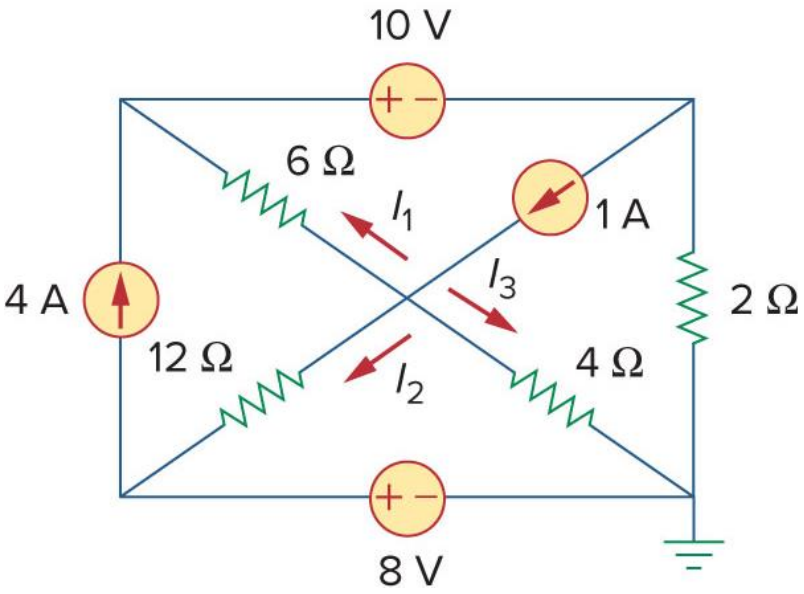
Answer:

a) $\begin{cases} 2i_1 - i_2 - i_3 = 3 \\ 2i_1 - 6i_2 - 3i_3 = 0 \\ i_2 - i_3 = 2 \end{cases}$

b) $i_1 = 1.5$ A, $i_2 = 1$ A, and $i_3 = -1$ A

c) $P = 2$ W supplied

14. In the circuit below, find the branch currents I_1, I_2, and I_3.



Answer: $I_1 = -1$ A, $I_2 = 0$ A, and $I_3 = 2$ A