Helpful readings for this homework: Nilsson and Riedel, Chapter 1, Chapter 2, and Chapter 3.

Grading Criteria

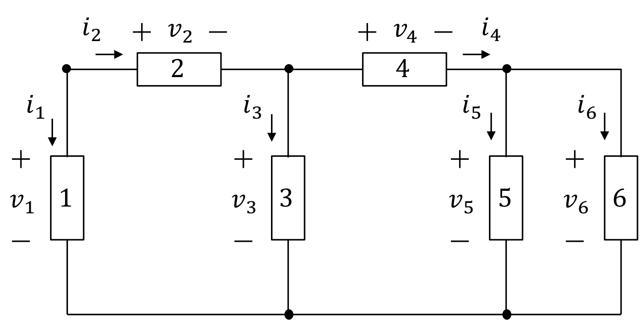
Show all work, as each problem will be graded using the grading criteria given below:

- 100% of maximum score if approach is correct and answer is also correct
- 80% of maximum score if approach is correct, but answer is incorrect due to algebraic or other math error
- 60% of maximum score if approach is mostly correct, but there is some conceptual error
- 40% of maximum score if problem has been seriously attempted, but approach is incorrect and/or there are major conceptual errors.
- 20% of maximum score if problem has been attempted, but is illegible.
- 0% of maximum score if there is no attempt to solve the problem.

Problem 1.1: ($8\frac{1}{3}$ points)

The figure below shows an electric circuit with a voltage and a current variable assigned to each of the six devices. The device voltages and currents are observed to be as follows:

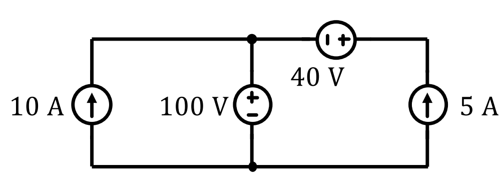
	v (V)	i (A)		v (V)	i (A)
Device 1	15	-1	Device 4	-10	-1
Device 2	5	1	Device 5	20	-3
Device 3	10	2	Device 6	20	2



Find the power associated with each device and state whether the device is absorbing or delivering power. Use power balance to check your work.

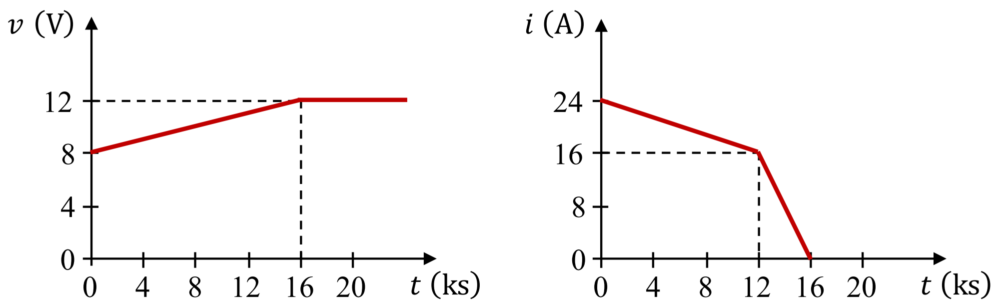
Problem 1.2: [Problem 2.3 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

If the interconnection in the figure below is valid, find the power developed by the current sources. If the interconnection is not valid, explain why.



Problem 1.3: [Problem 1.26(a)-(b) from Nilsson and Riedel] ($8\frac{1}{3}$ points)

The voltage and current at the terminals of an automobile battery during a charge cycle are shown below.

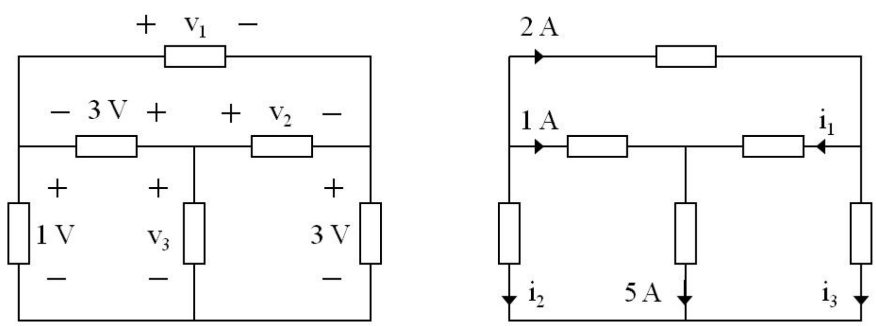


(a) Calculate the total charge transferred to the battery.

(b) Calculate the total energy transferred to the battery.

Problem 1.4: ($8\frac{1}{3}$ points)

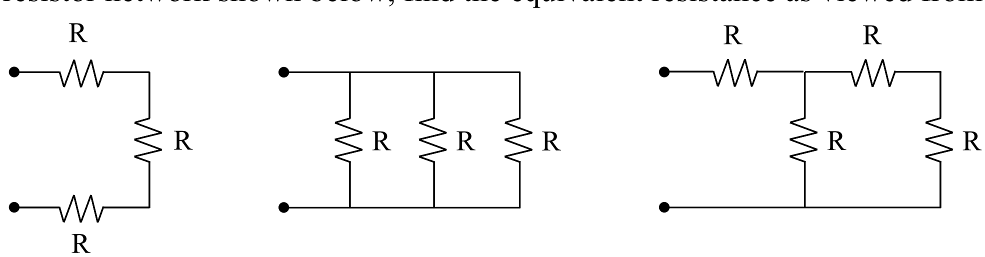
Each network shown below has several of its branch currents or voltages specified numerically. Several other branch currents or voltages are labeled as unknowns. Find all labeled unknown branch currents and voltages.



(A) (B)

Problem 1.5: ($8\frac{1}{3}$ points)

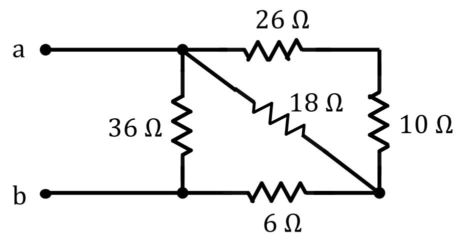
For each resistor network shown below, find the equivalent resistance as viewed from its port.



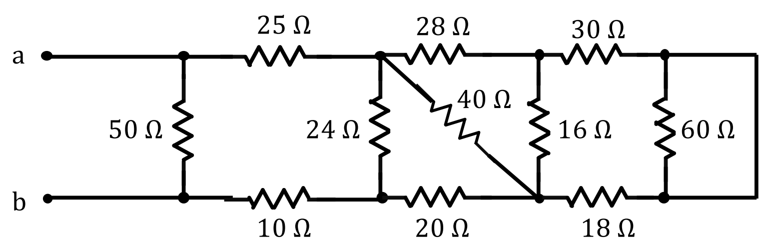
(A) (B) (C)

Problem 1.6: [Problem 3.9(a) and (d) from Nilsson and Riedel] ($8\frac{1}{3}$ points)

For the two circuits shown below, find the equivalent resistance R_{ab}



(a)



(b)

Problem 1.7: ($8\frac{1}{3}$ points)

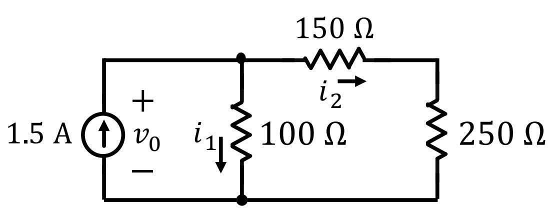
(a) What is the largest-valued resistor that can be fabricated by combining a 2-Ω resistor, another 2-Ω resistor, and a 6-Ω resistor?

(b) What is the smallest-valued resistor that can be fabricated by combining the same three resistors?

(c) How can one fabricate a 1.6-Ω resistor by combining the same three resistors?

(d) Suppose that each individual resistor can dissipate up to 1 W of power before burning up. How much power can the fabricated 1.6-Ω resistor dissipate before burning up?

Problem 1.8: [Problem 2.19 from Nilsson and Riedel] ($8\frac{1}{3}$ points)



For the circuit shown above:

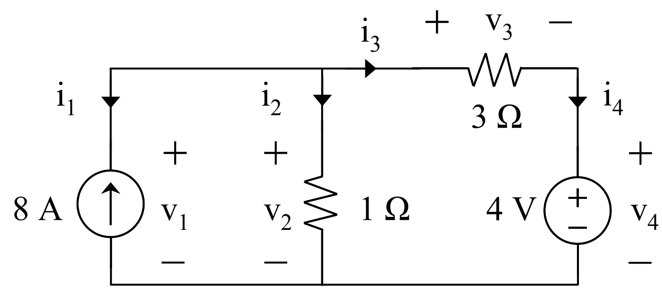
(a) Find the currents i_1 and i_2.

(b) Find the voltage v_0.

(c) Verify that the total power developed equals the total power dissipated.

Problem 1.9: ($8\frac{1}{3}$ points)

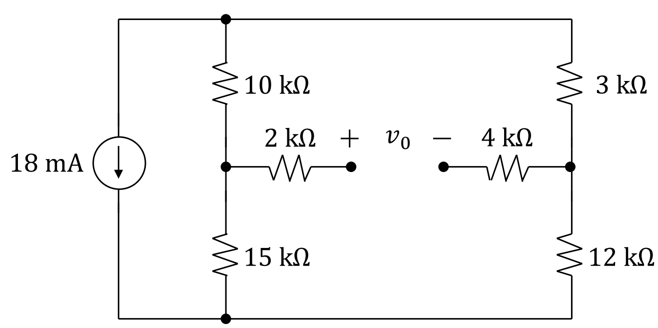
The circuit shown below has four elements: two resistors, a current source and a voltage source. The resistance of the resistors and the strengths of the sources are all given. Branch currents (i_k) and voltages (v_k) are also defined for each element.



(a) How many nodes are there in the circuit? Write a KCL equation for each node in terms of the branch currents i_k. How many of the KCL equations are independent?
(b) How many loops are there in the circuit? Write a KVL equation for each loop in terms of the branch voltages v_k. How many of the KVL equations are independent?
(c) Write an expression for the v-i relationship (i.e., constitutive relationship) for each element.
(d) By combining the independent equations from parts (a) and (b) with the equations from part (c), you should have a set of eight linear equations, matching in number the set of i_k plus v_k. Solve the equations to find all four i_k and all four v_k. Summarize your findings in a table.
(e) Find all four branch powers $v_k i_k$. Show that the sum of the four $v_k i_k$ is zero, and hence that energy is conserved in the circuit. (If energy is not conserved, then you made a mistake.) Which branch elements source power (i.e., deliver power) and which branch elements sink power (i.e., absorb power)?

Problem 1.10: [Problem 3.29 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

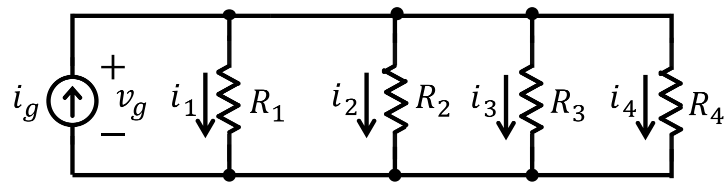
Find v_0 in the circuit shown below using voltage and/or current division.



Problem 1.11: [Problem 3.18 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Specify the resistors in the current divider circuit in the figure below to meet the following design criteria:

$$i_g = 50 \text{ mA};\ v_g = 25 \text{ V};\ i_1 = 0.6 i_2;\ i_3 = 2 i_2 \text{ and } i_4 = 4 i_1$$



Problem 1.12: ($8\frac{1}{3}$ points)

Many types of biological cell (neurons, muscle cells, pancreatic cells, etc.) can be characterized by the electrical properties of their membranes. To do this characterization, you sweep a test voltage V_{test} from -100 mV to +40 mV, and record the current through the membrane as tabulated below. However, your access to the inside of the cell is imperfect, so assume an intrinsic series resistance of 10 MΩ. (*Suggestion: For part (a) use MATLAB or Excel to generate the plot.*)

(a) De-embed the 10-MΩ resistor from the data, and plot the I-V curve of the cell membrane alone.

(b) If you disconnect the clamping voltage, such that $I_{test} = 0$ and now measure the voltage on your electrode, you observe a voltage of either -90 mV or -19 mV, Explain this result in terms of your I-V curve.

V_{test}(mV)	I_{test}(pA)
-100	-10
-90	0
-80	9
-70	15
-60	-1
-50	-230
-40	-755
-30	-416
-20	-47
-10	259
0	518
10	762
20	999
30	1235
40	1473