Problem Set 1: Resistive Networks

1.1 Calculate the current $I$.

1.2 a. Given that $V_{AB} = 5 \text{ V}$, $V_{CB} = 14 \text{ V}$, $V_{CD} = -2 \text{ V}$, find $V_{DA}$.

b. The current through a resistor $R$ is 1 and the voltage is $V$. Prove that the dissipated power is $P = IR = V^2R$.

1.3 Find the voltage across the current source.

1.4 Find the current through the voltage source.

1.5 Find $R_{ab}$.

1.6 Find $G_{ab}$.

1.7 Calculate $V$.

1.8 Calculate $I$.

1.9 Give the solution of this network. Find the power given by the 12 V-source.

1.10 Calculate $V_{ab}$.

1.11 Find the power supplied by each source and calculate the power consumed by the resistor.

1.12 Find $I_1$.

1.13 Find $I_1$ with
   a. the branch method,
   b. the mesh method.

1.14 Find $V_{ab}$.
   Calculate the substitute resistance measured at the nodes a and b.

1.15 Calculate $I_1, I_2$ and $I_3$.

1.16 Find $V$. 

Find the power supplied by the
1.17 Find the voltages $V_1$ and $V_2$ with respect to earth by means of the node method.

1.18 Give the solution with
   a. the mesh method,
   b. the node method.

1.19 Find $V_a$, $V_b$, and $V_c$ using the node method.

1.20 Find $I_a$, $I_b$, and $I_c$ using the mesh method.

1.21 State if this graph is planar.

1.22 Find $I$.

1.23 Find $V$.

1.24 Find $I$.

1.25 a. Find the node voltages using the node method.
   b. Draw the graph of the circuit and indicate the branch currents.

1.26 The bridge circuit in which the resistor $R$ is variable is given. The other resistances are constant.

1.27 One wants to solve this network with the node method.
   a. Write the equations necessary to do this. (Solution is not necessary).

1.28 Find the power that each of the sources delivers.
   Find the power that each of the resistors dissipates.

1.29 a. Find $V_1$ and $V_2$ with the node method.
   b. Give all branch currents in the graph of the network.

b. Might we solve this network with the mesh method? Explain your answer.

c. Calculate the current in the conductor of 9 S directly from the circuit.
1.30 a. Use the node method to calculate the node voltages with respect to earth.
    b. Give all branch currents in the graph of the network.

1.31 a. Use the node method to solve this network.
    b. Give all branch currents in the graph of the network.
    c. Find the power supplied by each of the sources.

1.32 Use the node method to find the node voltages with respect to earth.

1.33 State whether $I_k$ is larger than, smaller than or equal to $I_y$.

1.34 a. Use the node method to find the node voltages with respect to earth.
    b. Give all branch currents in the graph of the network.

1.35 A network consists of two d.c. current sources, $I_1$ and $I_2$, and also of resistors. A voltage $V$ is measured between two arbitrary nodes, using different values of the current source intensities.

The following result is found:
If one chooses the source intensities $I_1 = 2\ \text{A}$ and $I_2 = 1\ \text{A}$, then $V = 2\ \text{V}$, while for $I_1 = 1\ \text{A}$ and $I_2 = 2\ \text{A}$, $V = 3\ \text{V}$.
Find $V$ if $I_1$ is 8 A and $I_2 = 1\ \text{A}$.

1.36 A network consists of a voltage source $V$, a current source $I$ and further of positive, constant resistors. One observes the current $I_k$ through a certain resistor. $V$ is given two different values in succession, but $I$ is kept constant ($I \neq 0$).

One finds that $I_k = 5\ \text{A}$ if $V = 8\ \text{V}$.
One finds that $I_k = 3\ \text{A}$ if $V = 14\ \text{V}$.
Find $I_k$ if $V = 12\ \text{V}$ and explain your answer.

1.37 Can one use the mesh method and the node method for a non-linear network?

1.38 A diode is characterised in the forward region by the voltage-current equation

$$I = 2(e^{U/V} - 1).$$

a. Give a plot of this equation.
    b. Is this a linear element?

1.39 Solve Problem 1.13 with superposition.

1.40 Solve Problem 1.15 with superposition.

1.41 a. Use the node method to find the node voltages with respect to earth.
    b. Use the superposition rule to find the voltage $V_{30}$.

1.42 The value of $R$ depends on the current $I$ flowing through the resistor, according to the formula:

$$R = I.$$

Only positive values of $I$ are considered.

1.43 Find the branch voltages of network a and the branch currents of network b. Verify Tellegen's theorem for this combination.

a)  

b)
1.44 Prove that $V'' = V'$.

Give the equivalence of Thévenin and Norton of the following four networks.

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1.52 Find I with Thévenin’s theorem.

1.53 Find the value of $R$ with which a maximum power is developed in $R$.

1.54 One first sets $R = 12 \, \Omega$.

a. Find I.

b. Find the power $P$ dissipated by $R$ and examine for which other value of $R$ the same power is dissipated by $R$.

a. Calculate $V_{ab}$.

b. Calculate the current going from a to b if these terminals are short-circuited with Thévenin’s theorem.

c. Which resistor must be connected to a and b so that a maximum power will be developed in that resistor? Calculate the maximum power.

For each network:

- a. Find the Thévenin equivalence of the network to the left of the nodes a and b.
- b. Calculate the dissipated power in $R_b$ for

- $R_b = 0 \, \Omega$, $R_b = 2 \, \Omega$, $R_b = 3 \, \Omega$, $R_b = 4 \frac{1}{2} \, \Omega$, $R_b \to \infty$. 
1.55 Find the substitute resistance between the terminals a and b.

1.56 For the current source intensities $I_a$, $I_b$ and $I_c$ the values 0 A or 1 A are chosen. We want to know the voltage $V$ for all eight possible combinations of $I_a$, $I_b$ and $I_c$.

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Find $V$ for all eight cases.

1.57 Using superposition find the current I.

1.58 Give the Thévenin equivalence seen on the terminals a and b. Calculate the Thévenin resistance in two ways.

1.59 Using Thévenin's theorem find the current I.

1.60 Find $V_{ab}$ as a function of $V$ and I. See Figure at bottom of page.

1.61 Which transactor is formed if we cascade a voltage-current transactor and a current-voltage transactor?

1.62 Find the two-port equations of two cascaded gyrators with equal gyrator resistance R.

1.63 Find $V_1$.

1.64 Given $V_1 = 0.01$ V, find $V_2$.

1.65 Find the voltage transfer function $V_2/V_1$.

1.66 Find $V$.

1.67 Find $V_1$, $V_2$ and $V_3$.

Figure of Problem 1.65
1.68 Find I.

[Diagram]

1.69 Find V.

[Diagram]

1.70 Find I.

[Diagram]

1.71 Find the Thévenin equivalence seen at the terminals a and b.

[Diagram]

1.72

[Diagram]

\[ V_{30} = 10 \, V. \]

Find the Thévenin equivalence seen on the terminals 2 and 0.

1.73 Find the Thévenin equivalence seen on the terminals a and b.

[Diagram]

1.74 The network within the dotted rectangle is a voltage-voltage transactor for which it holds that:

\[ V_{23} = AV_{12}. \]

The voltage source intensity \( V_{10} \) is 1 volt. Compute the Thévenin equivalence at the terminals 2 and 0.

[Diagram]

1.75 This is a transistor circuit and the equivalence of a transistor.

In order to make the calculation not too implicated all resistors are set to 1 \( \Omega \). We further choose \( \alpha = 2 \). Find \( I_b \).

[Diagram]

transistor equivalence
1.76 Given is a network with an opamp. All conductances are G.
Find $V_1$. 

1.78 $\mu \to \infty$.
Use the node method to find the voltage $V_4$ with respect to earth.

1.77 a. Give the node equations for the nodes 4 and 5.
b. Express $V_3$ in $V_1$, $V_2$, the conductances and $K$.
c. Find $\lim_{K \to \infty} V_3$.

1.79 Use the node method to find the Thévenin equivalence seen on the nodes 3 and 0.

1.80 Find $V_{20}$.

1.82 Find the power supplied by each of the sources and find the power dissipated by each of the resistors.

1.83 Find $H = \frac{V_2}{V_1}$.

The above problems are extracted from the book "Electrical Networks" by A. Henderson (Edward Arnold International Student Edition), 1990.