Exercise 2.1: Determine the resistance of each network shown below as viewed from its port.

![Networks (A), (B), (C), (D)]

Exercise 2.2: For both networks shown below, find the voltage across each resistor. Hint: make use of the results of Exercise 2.1.

![Networks (a), (b)]

Exercise 2.3: Following the node method, develop a set of simultaneous equations for the network shown below that can be used to solve for the three unknown node voltages in the corresponding network. Express these equations in the form

$$
\begin{bmatrix}
    e_1 \\
    e_2 \\
    e_3
\end{bmatrix} = GS
$$

where $G$ is a $3 \times 3$ matrix of conductance terms and $S$ is a $3 \times 1$ vector of terms involving the sources. You need not solve the set of equations for the node voltages.
Problem 2.1: Find the Thevenin and Norton equivalents of the following networks, and graph their i-v relations as viewed from their ports.

Problem 2.2: This problem analyzes the network shown below by two methods: superposition and the direct application of the node method. You should compare the work required to analyze the network by these two methods.

(A) First, use superposition to determine $e_1$ and $e_2$. That is, superpose the two partial node voltages obtained with only single sources active to find the total node voltages. Remember that a zero-valued voltage source is a short circuit, and a zero-valued current source is an open circuit. Hint: rather than employing the node method twice, once for each partial analysis, consider employing alternative simpler analyses using the results of Exercises 2.1 and 2.2.

(B) Second, use the node method to directly determine $e_1$ and $e_2$ in total.

(C) Compare the solutions to Parts (A) and (B). The two solutions should be the same.
**Problem 2.3:** Two networks, N1 and N2, are described in terms of their $i$-$v$ relations, and connected together through a single resistor, as shown below.

(A) Find the Thevenin and Norton equivalents of N1 and N2.

(B) Find the currents $i_1$ and $i_2$ that result from their interconnection.

![Network Diagram]

**Problem 2.4:** This problem studies the network shown below. The network contains a nonlinear resistor having the terminal relation $i_N = \alpha v_N^2$ for $v_N \geq 0$ and $i_N = 0$ for $v_N \leq 0$, where $\alpha$ is a constant with units A/V$^2$. Assume that $\alpha$ and $i_S$ are both positive.

(A) Analyze the network graphically to determine $i_N$ and $v_N$ in terms of $i_S$ and the network parameters. To do so, note that the current source and linear resistor together constrain the relation between $i_N$ and $v_N$, and that the nonlinear resistor also constrains this relation. State the two constraints, and on a single graph sketch both constraints and identify the solution for $i_N$ and $v_N$. Within what voltage range will $v_N$ lie?

(B) Analytically solve for $v_N$ in terms of $i_S$. Check that this solution is consistent with the graphical solution from Part (A).

(C) Now let $i_S = I_S + i_s$ and let $v_N = V_N + v_n$, where $I_S$ and $V_N$ are a constant large-signal current and voltage, respectively, which together form an operating point, and $i_s$ and $v_n$ are a varying small-signal current and voltage respectively. Using the solution from Part (B), determine $V_N$ in terms of $I_S$. Then, linearize the solution from Part (B) around the operating point to determine $v_n$ in terms of $i_s$ and $I_S$.

![Nonlinear Resistor Diagram]