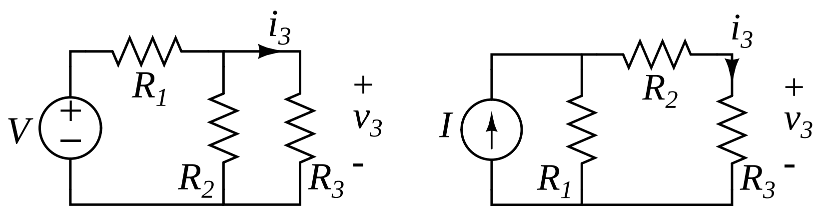
Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

**6.002 – Electronic Circuits**
**Spring 2002**

# Homework #2

**Issued 2/13/02 – Due 2/20/02**

**Exercise 2.1:** For both networks shown below, determine the voltage $v_3$ across, and the current $i_3$ through, $R_3$.

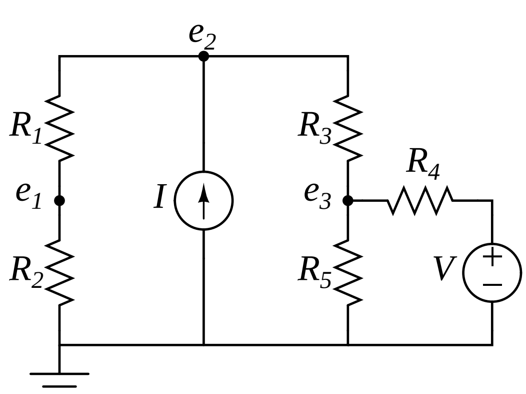



*Network (a)* *Network (b)*

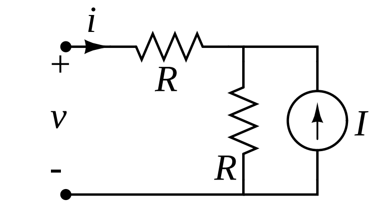
**Exercise 2.2:** Using the node method, develop a set of simultaneous equations for the network shown below that can be used to solve for the three unknown node voltages in the network. Express these equations in the form

$$G \begin{bmatrix} e_1 \\ e_2 \\ e_3 \end{bmatrix} = S$$

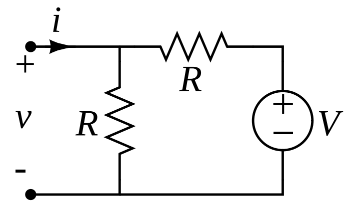
where $G$ is a $3 \times 3$ matrix of conductance terms and $S$ is a $3 \times 1$ vector of terms involving the sources. You need not solve the set of equations for the node voltages.



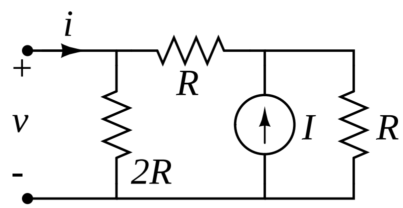
**Problem 2.1:** Find the Thevenin and Norton equivalents of the following networks, and graph their $i$-$v$ relations as viewed at their ports.



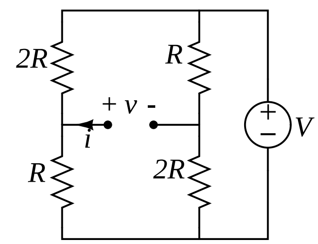

*Network (a)*




*Network (b)*

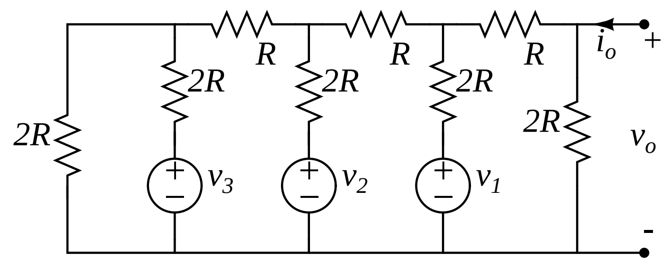



*Network (c)*




*Network (d)*

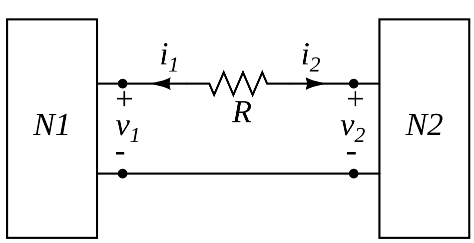
**Problem 2.2:** Given the network shown below, find $v_0$ as a function of $v_1$, $v_2$ and $v_3$ assuming $i_0 = 0$. Hint: use superposition. Also, find the Thevenin equivalent of the network as viewed from its port. Finally, of what electronic circuit might the network be a part?

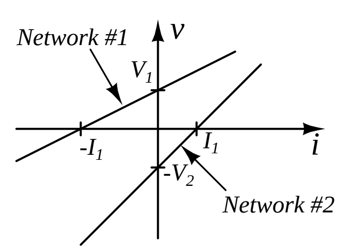



**Problem 2.3:** Two networks, N1 and N2, are described in terms of their $i$-$v$ relations, and connected together through a single resistor, as shown below.

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

(B) Find the voltages $v_1$ and $v_2$ that result from the interconnection of N1 and N2 through a resistor as shown below.



**Problem 2.4:** This problem studies the network shown below. The network contains two current sources and a nonlinear resistor. The nonlinear resistor has the terminal relation $i_\text{N} = \alpha|v_\text{N}|v_\text{N}$, where $\alpha$ is a positive constant with units $\text{A/V}^2$. One current source produces the current $i_\text{A}$ while the second current source produces the current $i_\text{B}$.

(A) Determine $v_N$ in terms of $i_\text{A}$ and $i_\text{B}$.

(B) Let $i_\text{A} = I_\text{A}$, where $I_\text{A}$ is a constant current, and let $i_\text{B} = i_\text{b}(t)$. Further, assume that $I_\text{A} \gg |i_\text{b}(t)| > 0$ so that $i_\text{A}$ can be thought of as being only a large-signal bias current, and $i_\text{B}$ can be thought of as being only a small-signal time-varying current. Using the result from Part (A), linearize $v_\text{N}$ and express it in the form $v_\text{N} = V_\text{N} + v_\text{n}(t)$ where $V_\text{N}$ is a constant large-signal bias voltage and $v_\text{n}(t)$ is small-signal time-varying voltage proportional to $i_\text{b}(t)$.

(C) Using the result of Part (B), determine $R$ such that $v_\text{N}(t) = Ri_\text{b}(t)$. Show that $R$ is the incremental resistance of the nonlinear resistor, namely that $R = dv_\text{N}/di_\text{N}$ evaluated at the bias current $I_\text{A}$.

(D) From Part (C), it is apparent that the small-signal gain from the input current $i_\text{b}(t)$ to the output voltage $v_\text{n}(t)$ can be controlled by the bias current $I_\text{A}$. What problem can you see in using the circuit shown below as a controllable gain from the input current $i_\text{b}(t)$ to the output voltage $v_\text{n}(t)$?