Assignment 2
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Problem 1.
Figure 1 shows a voltage divider and battery circuit with (directed) edges and nodes labeled. There is a detailed explanation of how to apply the MNA method in this homework, as well as in the documentation of the code on the wiki: look at ”Strang Voltage Divider Example” and ”Strang RC Circuit Example”.

Ths matlab code is on the class wiki under SOFTWARE.

The assignment is to review this code, especially the way that sparse matrixes are handled in MATLAB, and also you should review how to use MATLAB's publish tools as a way of annotating a program in MATLAB.

Also, please solve this circuit by expicitly working through the MNA method linear algebra (by hand). This is not a lot of work, since the linear algebra reduces to the scalar case, but it is a good excercise to remember the three MNA equations. Hand in this detailed solution.

Using this figure, construct the corresponding MNA vectors and matrixes (i.e. following Strangs method of circuit analysis) to allow solution. Specifically, construct:

- The incidence matrix A_0. It has row rank equal to the number of edges and column rank equal to the number of nodes: $edge\ x\ nodes$.
- The reduced incidence matrix A (drop one column from A_0; if you drop node 1 column, then you have decided to “ground” node 1. $edge\ x\ (nodes-1)$).
- The battery vector b $edge\ x\ 1$
- The current vector y $edge\ x\ 1$
- The node potential vector u $(node-1)\ x\ 1$
- The conductance matrix G $edge\ x\ edge$
- The potential difference vector e $edge\ x\ edge$

Write matlab code to solve this system and demonstrate the solution. Turn in the code and indication that it produces the correct answer. You can do

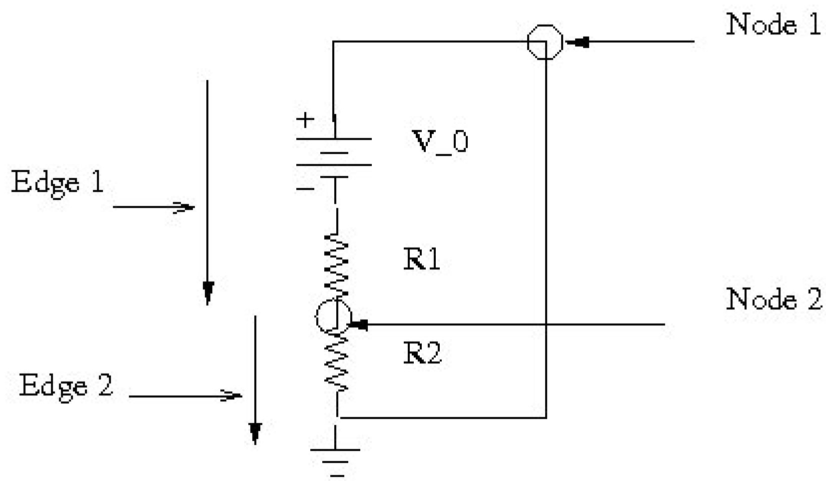

Figure 1: Voltage divided with edges and nodes labeled

this in matlab by omitting the semi-colon at the end of the line which prints out the voltage at node 2.

Summary of the MNA method.

- Label the edges and nodes in the circuit. Choose an assumed current direction for each edge. The convention for sign at each node is: Current out of a node is negative. Current into a node is positive. This means the a given row of the Incidence matrix, which represents an edge, will have a positive sign for the node that is entered and a negative sign for the node that is exited. This will produce an Incidence matrix A_0 which has entries of +1 and -1.

- Decide which node you would like to consider to be "ground". Drop the column corresponding to this node to construct the reduced Incidence matrix A.

- Remember that edges consist of a resistor (and maybe a battery).

- Construct the vector of battery (s) b. If the direction of the edge crosses the battery from + to -, then this entry will be negative. If the direction of the edge crosses the battery from - to +, this entry will be positive. **Explain in your homework why this is the correct sign choice**.

Solution method: In terms of the various vectors and matrices you have constructed:

Kirchoff KCL and Ohms laws may be be succinctly stated in matrix vector form as follows. beginitemize

- Ohms Law $y = Ge$
- Voltage Drop on Edges $e = b$ - Ax
- KCL balances to current sources f $A^t y = f$
- Solution found by concatenating above linear algebra relations $A^t G(b$ - $Au) = f$. Since there are no current sources f in this simple problem, set f = 0.
- Solving $u = (A^t GA)^{-1} A^t Gb$, recall that in MATLAB u = A'Gb\A'GA (the single quote represents matrix transpose and the backslash operator corresponds to matrix inversion in MATLAB).

Problem 2.
Derive the law of addition for two capacitors C_1 and C_2 in series and in parallel.

Problem 3.
Suppose someone gave you a preparation with neurons to record from, and a microelectrode. Outline how you would make use of a buffer amplifier, and an inverting (or non-inverting) amplifier to allow recording. Sketch out the schematic of a buffer (unity gain) and a non-inverting amplifier using the usual convention of a triangle with a + and a - sign to represent an operational amplifier. Derive the gain of a non-inverting amplifier made up of an operational amplifier and two resistors.