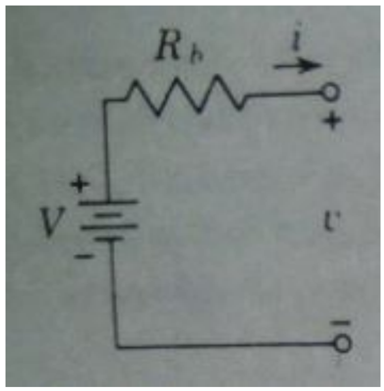
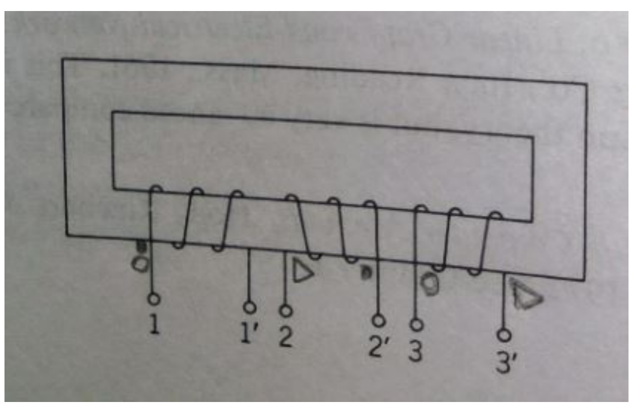
IIT Bombay

EE225 Network Theory
Homework 1

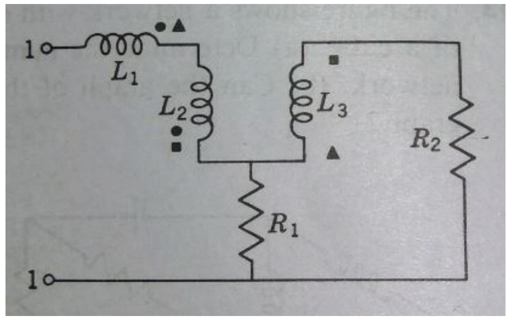
Q.1) The network of the accompanying figure is a model for a battery of open-circuit terminal voltage V and internal resistance R_b. For this network, plot i as a function v. Identify features of the plot such as slopes, intercepts, and so on. **Valkenburg 2.3**



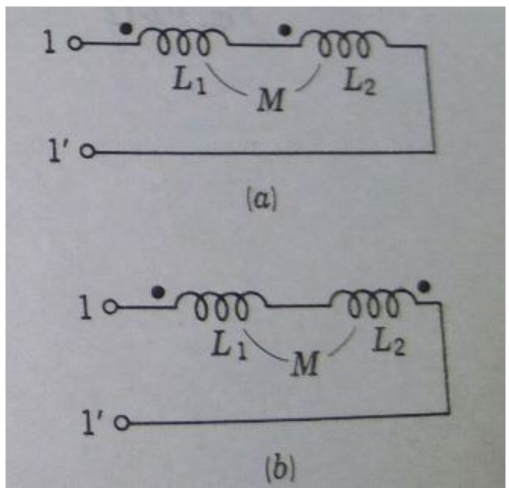
Q.2) The magnetic system shown in the figure has three windings marked 1-1', 2-2' and 3-3'. Using three different forms of dots, establish polarity markings for these windings. **2.4**



Q.3) The accompanying schematic shows the equivalent circuit of a system with polarity marks on the three coupled coils. Draw a transformer with a core and place windings on the legs of the core in such a way as to be equivalent to the schematic. Show connections between the elements in the same drawing. **2.7**



Q.4) The accompanying schematics each show two inductors with coupling but with different dot markings. For each of the two systems, determine the equivalent inductance of the system at terminals 1-1' by combining inductances. **2.8**



Q.5) Show that the power absorbed by a positive resistor is always non-negative, that by a negative resistor is always non-positive and that by sources can be positive, negative or zero. The reference convention is that for a two terminal device a single arrow is shown for both $v(.)$ and $i(.)$ associated with the device with $v(.)$ being the 'voltage drop across the device in the direction of the arrow and $i(.)$ the 'current through the device in the direction of the arrow. Power absorbed (in watts) by the device at some time t is defined to be the product $v(t)i(t)$.**H Narayanan 5.1(ii)**

Q.6) (i) Suppose a network contains a voltage source circuit. If the network has a solution, then show that the current through the voltage sources in the circuit cannot be determined uniquely.

(ii) If the network contains a current source cutset and is known to have a solution, then show that the voltage across the current sources in the cutset cannot be determined uniquely. **5.2**

Q.7) Let the network contain only voltage sources $\mathbf{v}_\varepsilon = \mathbf{e}$, current sources $\mathbf{i}_J = \mathbf{j}$ and $\mathbf{v}_R = \mathbf{R}\,\mathbf{i}_R$. Suppose $(\mathbf{v}^1, \mathbf{i}^1)$ is a solution of the network when voltage sources value is given by the vector $\mathbf{e}^1$ and the current sources value by the vector $\mathbf{j}^1$. Let $(\mathbf{v}^2, \mathbf{i}^2)$ correspond to $(\mathbf{e}^2, \mathbf{j}^2)$. Show that there is a solution of the network $(\alpha\mathbf{v}^1 + \beta\mathbf{v}^2, \alpha\mathbf{i}^1 + \beta\mathbf{i}^2)$ corresponding to $(\alpha\mathbf{e}^1 + \beta\mathbf{e}^2, \alpha\mathbf{j}^1 + \beta\mathbf{j}^2)$. **5.3**

Q.8) Show how to model cccs and vcvs using the other two controlled sources. **5.4(ii)**

Q.9) (i) Show that the power absorbed by an ideal transformer is always zero.

(ii) Let a resistor R be connected across the secondary of a $(1 : n)$ ideal transformer, i.e., $v_2 = v_R$, $i_2 = i_R$. (Observe that the current through the secondary has to be taken to be the negative of the current through the resistor if the voltages are taken to be the same). Find the relation between the primary voltage v_1 and the primary current i_1.

(iii) Repeat the above if the secondary were terminated alternatively by inductor L, capacitor C, current source $j(.)$ and voltage source $e(.)$.

(iv) Let an ideal transformer be defined by the current equations

$$\begin{bmatrix} \mathbf{K} & \mathbf{I} \end{bmatrix} \begin{matrix} \mathbf{i}_A \\ \mathbf{i}_B \end{matrix}$$

Suppose we terminate the B ports by resistors with the characteristic $\mathbf{v}_R = \mathbf{R}\ \mathbf{i}_R$. What would be the relation between v_A and i_A?

5.9