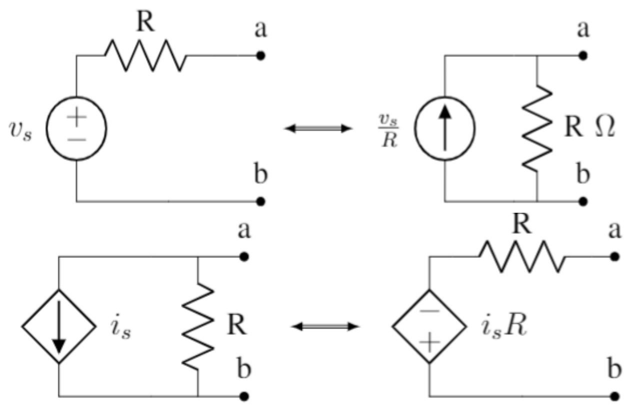
EC2015 Electric Circuits and Networks - Tutorial 6 Notes (Network Theorems)

Superposition theorem:
The superposition principle states that the voltage across (or current through) an element in any linear circuit is the algebraic sum of the voltages across (or currents through) that element due to each independent source acting alone.

Steps:
1. Turn off all independent sources except one source. Find the output (voltage and/ or current) due to that active source using any technique (e.g., mesh or nodal analysis).
2. Repeat step 1 for each of the other independent sources.
3. Find the total contribution by adding algebraically all the contributions due to all independent sources.

Note: don't remove dependent sources from the circuit during this process.

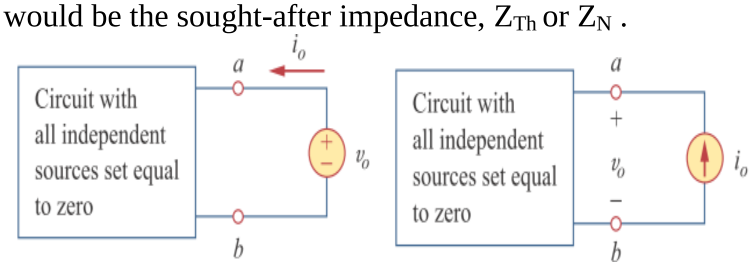
Source transformation theorem:
A source transformation is the process of replacing a voltage source v_s in series with a resistor R by a current source i_s in parallel with the same resistor R, or vice versa.



Thevenin theorem:
Any linear circuit, with respect to its any two terminals can be replaced by an equivalent circuit consisting of an effective voltage source V_{Th} in series with an impedance Z_{Th} (or resistor R_{Th} for resistive network), where V_{Th} is the open-circuit voltage between the two terminals and Z_{Th} is the input or equivalent impedance (or resistance) appearing between the two terminals when all independent sources of the network are turned off.

Norton theorem:
Any linear circuit, with respect to its any two terminals can be replaced by an equivalent circuit consisting of a current source I_N in parallel with an impedance Z_N (or resistor R_N for resistive network), where is I_N the short-circuit current through the terminals and Z_N is the input or equivalent impedance (or resistance) appearing between the terminals when all independent sources of the network are turned off.

Different methods to find out equivalent networks:
1. Open the branch between the two nodes at which we need to find an equivalent circuit and find the voltage across open circuited branch V_{oc} and by shorting the two nodes find the short circuited branch current I_{sc}. Calculate $Z_{Th}= Z_N = V_{oc}/I_{sc}$.
2. Find either $V_{oc}(=V_{Th})$ or $I_{sc}(=I_N)$. Then, turnoff all independent sources and find out the equivalent impedance (Z_{Th} or Z_N) seen from the two terminals.
3. In case the linear network has one or more number of dependent sources, in order to find out Z_{Th} or Z_N, it is advisable to connect a known independent current source of 1A between the two terminals or a known independent voltage source and as shown below. Measure the values of v_o and i_o and calculate $Z_{Th} = Z_N = v_o/i_o$. Note that in case 1A current source is used, the amount of voltage generated between the two terminals would be the sought-after impedance, Z_{Th} or Z_N .



If the circuit doesn't have any independent sources, one finds $V_{oc}=0$ and $I_{sc}=0$ effectively leading to an equivalent impedance only network with $Z_{Th} = Z_N= Z_{in}$. This can be calculated using series, parallel and star-delta reduction techniques or by connecting an independent current source of 1A and measuring the voltage across it as outlined above.