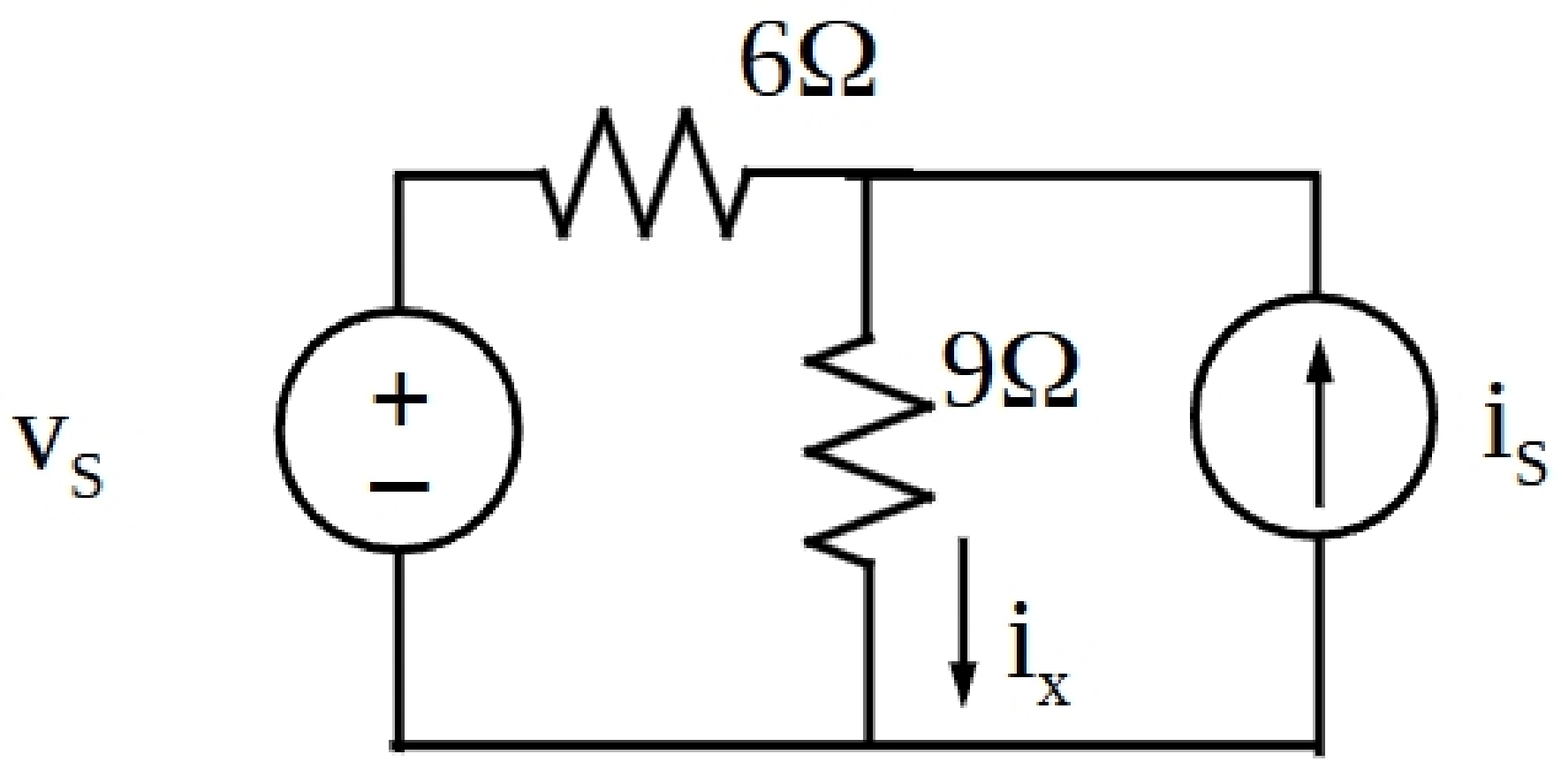
Linearity and Superposition

Consider the circuit:



We can solve for the 'output' i_x using mesh analysis.

M1: $v_s - 6i_1 - 9(i_1 - i_2) = 0$

$v_s - 15i_1 + 9i_2 = 0$

M2: $i_2 = -i_s$

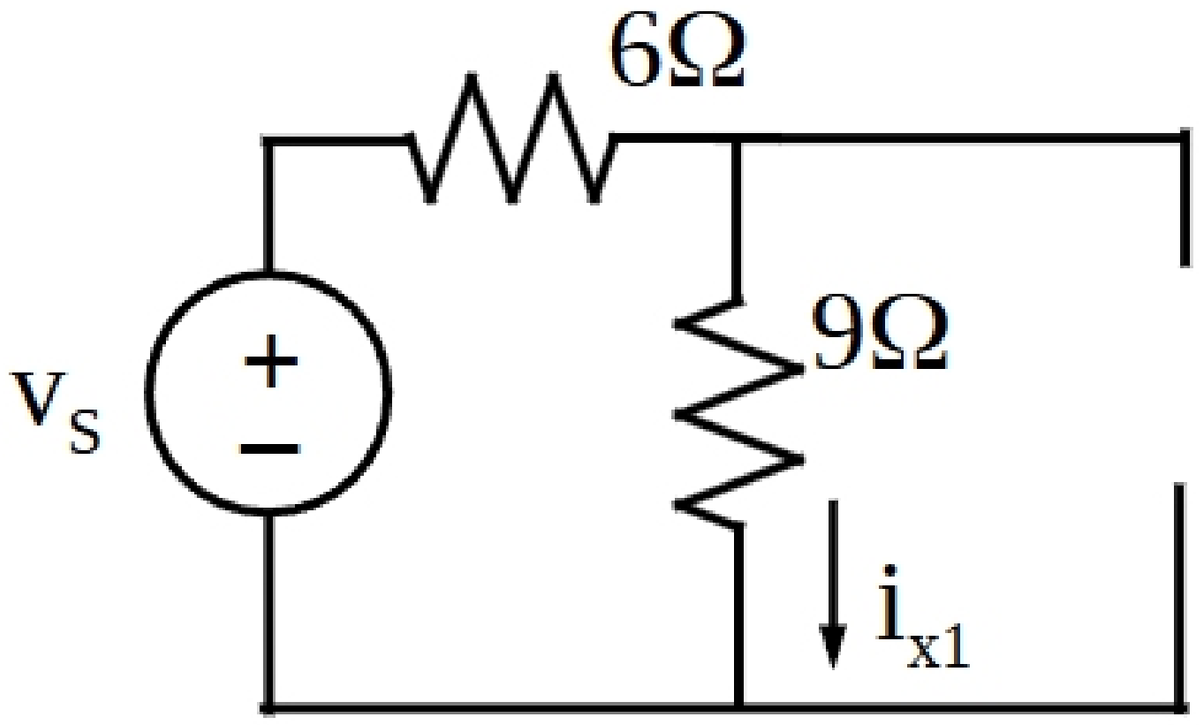
But, $i_x = i_1 - i_2$

$$\mathbf{i_x = (v_s / 15) + (6i_s / 15)}$$

Solution, $i_x = (v_s / 15) + (6i_s / 15)$ is linearly related to the 'inputs' v_s and i_s.

Solve for output i_x by considering the effect of **each** input separately.

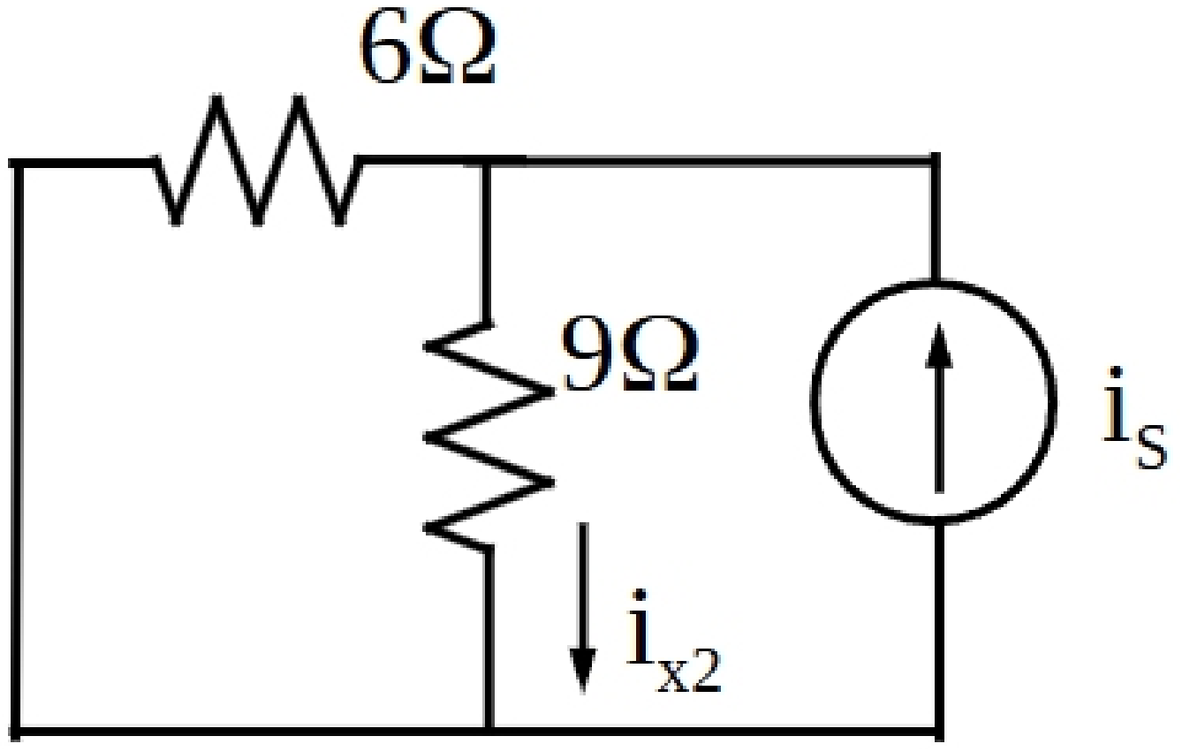
Step 1: Deactivate current source



Solve for i_{x1}.

$$i_{x1} = v_s / 15$$

Step 2: Deactivate voltage source



Solve for i_{x2}.

$$i_{x2} = [(1 / 9) / (5 / 18)]\, i_s = (2/5)\, i_s$$

Step 3: Add i_{x1} and i_{x2} to obtain solution.

$$i_x = (v_s / 15) + (2/5)\, i_s$$

$$\mathbf{i_x = (v_s / 15) + (6i_s / 15)}$$

This technique is called **superposition**. Superposition works because internal voltages and currents depend linearly on the independent sources.