Homework 5

P4.1.50 Derive NEC between terminals 'ab' in Figure P4.1.50, assuming all resistances are 2 Ω.

Solution: **Initialize.** All given values and the required I_N are entered. The nodes are labeled.

Simplify. The circuit is in a simple enough form.

Deduce. The branches 'ha' and 'hcb' are in parallel, so that by current division, I_{cb} = 1/3 A. It follows that $I_{bd} = I_N + 4/3$. Since the voltage across the branch 'bdf' is the same as the V_{af}, then $I_{af} = 2(I_X + 4/3)$ and $I_{fg} = 3(I_N + 4/3) = 3I_N + 4$; From KCL at node 'g', $I_{ga} = 3I_N + 3$. From KVL around the mesh 'afga', $2\times2(I_N + 4/3)$ $4(3I_N + 4) + 2(3I_N + 3) = 0$, which gives I_N = -41/33 A.

When the current sources are set to zero, $R_{af} = 2||6 = 1.5$ Ω; R_{fb} = 4 Ω; R of the branch on the RHS is 6 Ω; it follows that $R_N = (6\times5.5)/11.5$ = 66/23 Ω.

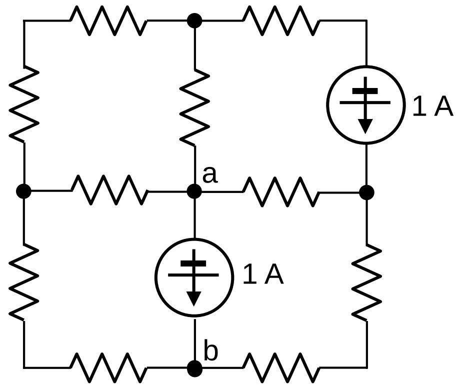


Figure P4.1.50

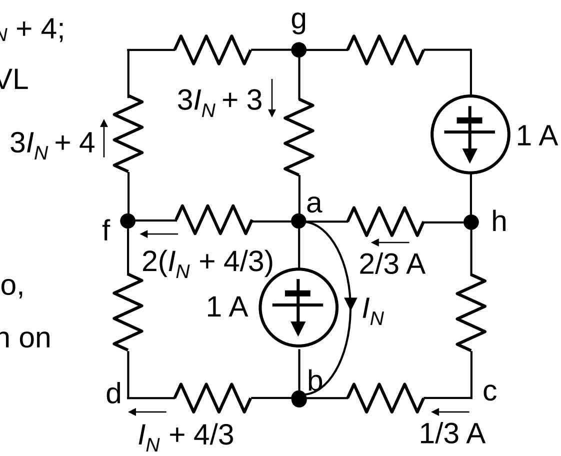
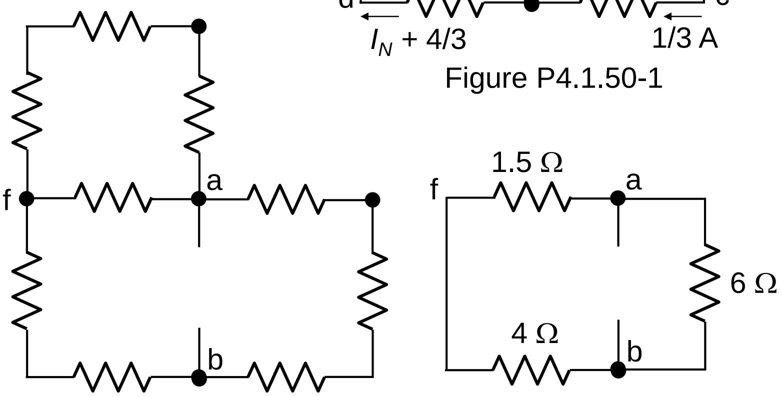


Figure P4.1.50-1



(a) Figure P4.1.50-2 (b)

P4.2.2 Determine V_X in Figure P4.2.2 by using the substitution theorem, where N_A is an unspecified circuit that passes a current of 0.5 A.

Solution: N_A is replaced by a 0.5 A current source. The current in the 7.5 Ω resistor is $V_X/7.5$ A. The current in the 10 Ω resistor is $(V_X/7.5 - 0.5)$. From KVL around the mesh on the LHS, $30 - V_X - 10(V_X/7.5 - 0.5) = 0$, which gives $I_X = 2$ A, so that $V_X = 15$ V.

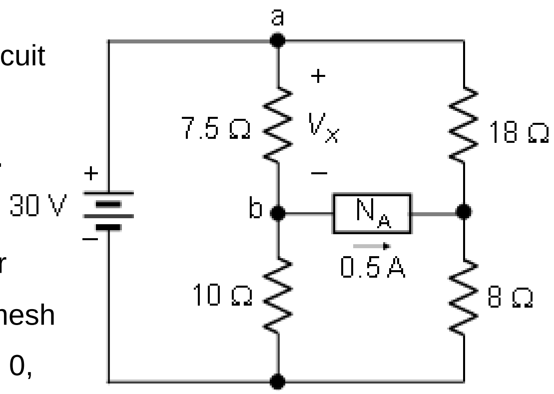


Figure P4.2.2

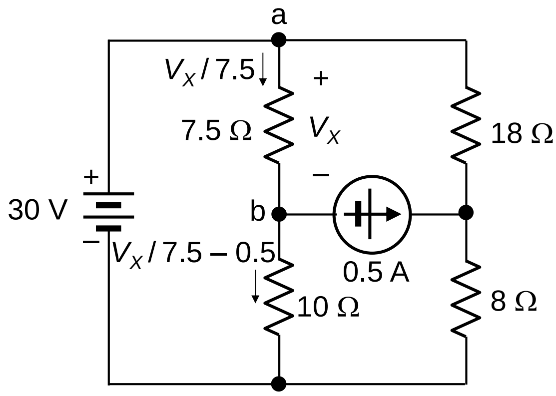


Figure P4.2.2-1

P4.2.10 Determine R_{in} in Figure P4.2.10 by applying the source absorption theorem.

Solution: The voltage across the 2 Ω resistor is 4 V_O, so that the current in the middle branch is $2V_O$ in the direction of a voltage rise across the VCVS. This source is equivalent to a resistance of -2.5 Ω. In series with 2 Ω, the resistance of this branch is -0.5 Ω, which cancels out the 0.5 Ω resistance of the branch on the RHS. The current in the branch on the LHS is V_A A in the direction of a voltage drop through the VCVS, so that this source is equivalent to a resistance of 0.25 Ω. Added to 1 Ω, this gives R_{in} = 1.25 Ω.

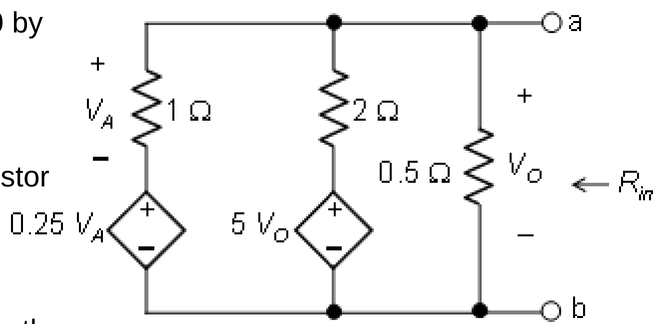


Figure P4.2.10

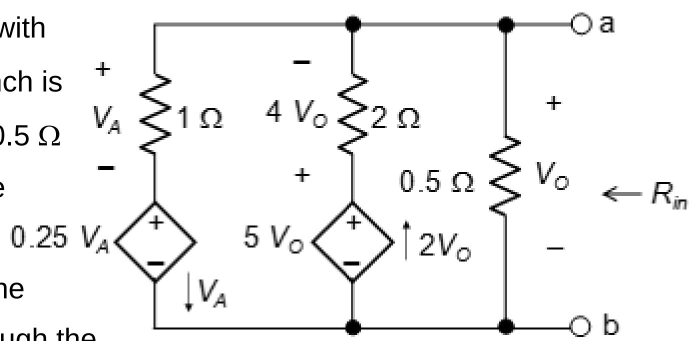


Figure P4.2.10-1

P5.1.10 Determine I_X in Figure P5.1.10.

Solution: The sources can be split in two resulting in two half circuits as shown. These two half circuits are symmetrical about the midline, so they have the same currents at symmetrtical nodes. Thus, if a current I enters node 'a'. then an equal current *I* enters node 'a′'. this means that *I* = -*I*, so that *I* is zero. Similarly, no current flows between nodes 'b' and 'b′' and betwee nodes 'c' and 'c′'. the two half circuts can therefore be separated. It follows that IX = 0.5 A.

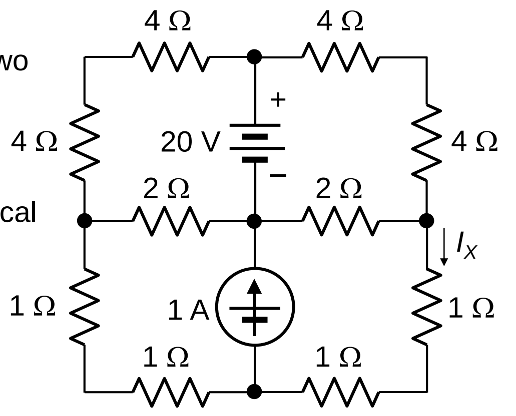


Figure P5.1.10

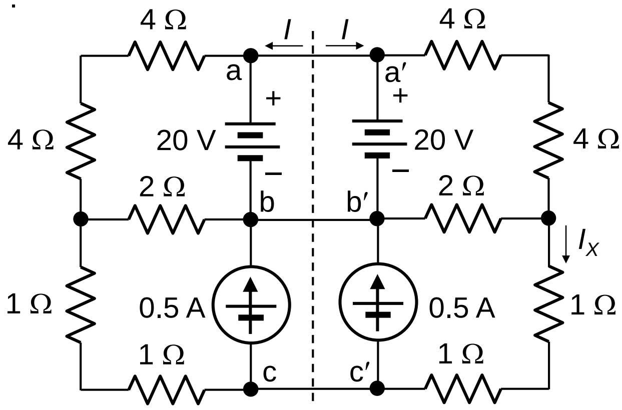


Figure P5.1.10-1

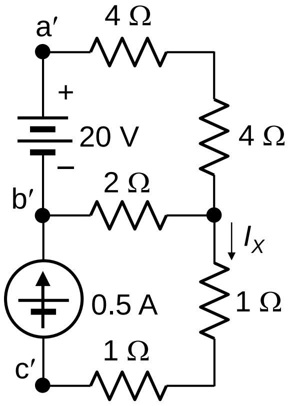


Figure P5.1.10-2

P5.1.15 Determine I_X in Figure P5.1.15. Note that I_X is independent of the 10 Ω resistor and the dependent source because the 5 A source partitions the circuit into two subcircuits. The upper subcircuit is independent of the lower subcircuit, but the lower subcircuit depends on the upper subcircuit through I_X.

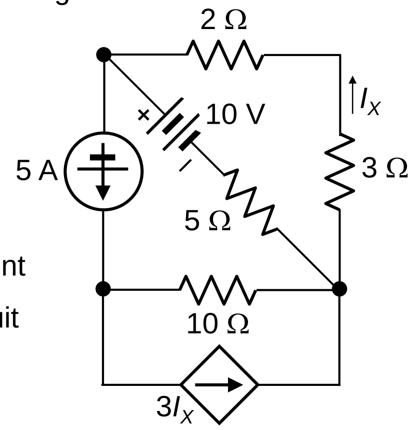


Figure P5.1.15

Solution: The current in the diagonal branch is, from KCL, $I_X – 5$. From KVL around the mesh on the RHS, $10 + 5I_X + 5(I_X – 5) = 0$, or $10I_X = 15$, so that $I_X = 1.5$ A.

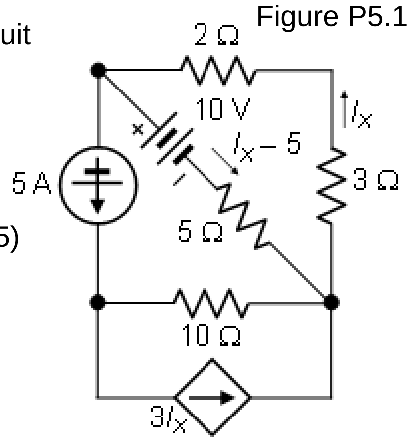


Figure P5.1.15

P5.1.22 Determine I_X in Figure P5.1.22.

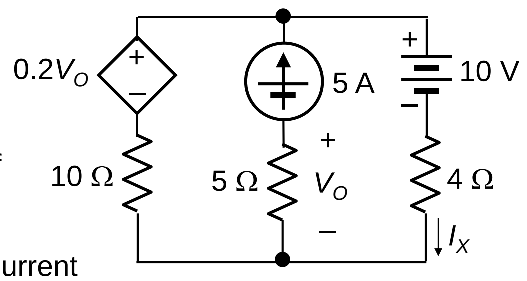


Figure P5.1.22

of V_O

Solution: $V_O = -5 \times 5 = -25$ V, so that the dependent source is replaced with an independent voltage source of 5 V, and of reversed polarity, as shown. When either voltage source is applied alone, with the current source replaced by an open circuit, the components are zero. When the current source is applied alone, $V_O = -25$ V.

From KCL at the upper node, the current in the left branch is $(5 - I_X)$ A. From KVL around the outer loop, starting with the lower node and moving CW: $10(5 - I_X) - 5 - 10 - 4I_X = 0$, or, $-14I_X + 35 = 0$, which gives $I_X = 2.5$ A.

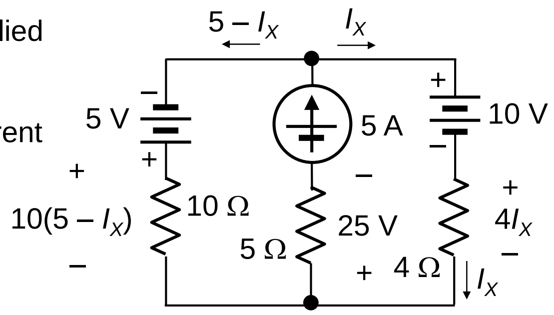


Figure P5.1.22-1

P5.1.25 Determine I_X in Figure P5.1.25.

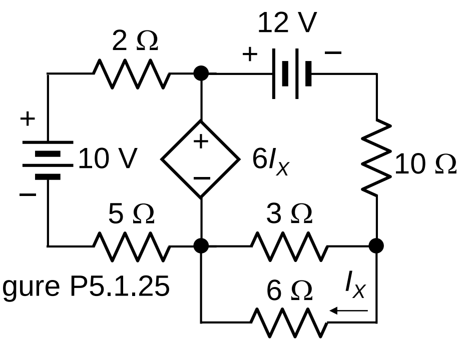


Figure P5.1.25

Solution: The dependent source is replaced by an independent source V_Y. If the 10 V source is applied alone, with the other sources set to zero. the component of I_X due to this source is zero. If the 12 V source is applied alone, the 12 V appears across 10 Ω in series with a parallel combination of 3 and 6 Ω. The source current is 12 V/12 Ω = 1 A. From current division, $I_{X1} = -1/3$ A. When V_Y is applied alone, the source current is $V_Y/12$. From current division, $I_{X2} = V_Y/36$. By superposition, and substituting $V_Y = 6I_X$, $I_X = -1/3 + I_X/6$. This gives $I_X = -0.4$ A.

P5.1.29 Determine in Figure P5.1.29: (a) V_O, and (b) the power delivered or absorbed by the 1 A source.

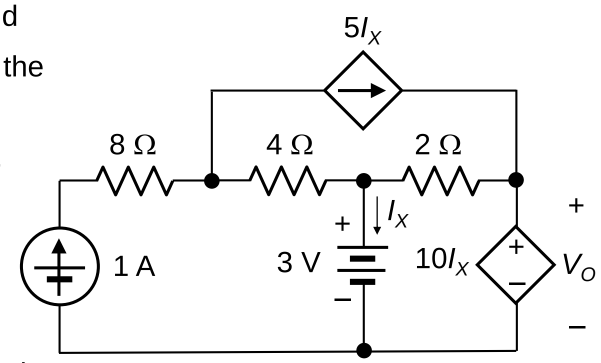


Figure P5.1.29

P5.1.29 (a) The 8 Ω resistor is redundant as far as I_X and V_O are concerned. If the 1 A source is applied alone, $I_{X1} = 1$ A. If the $5I_X$ source is replaced by an independent source I_Y and applied alone, $I_{X2} = -I_Y$. If the 3 V source is applied alone, $I_{X3} = -3/2$. If the $10I_X$ source is replaced by an independent source V_Y and applied alone, $I_{X4} = V_Y/2$. By superposition, and substituting $I_Y = 5I_X$ and $V_Y = 10I_X$, $I_X = 1 - 5I_X - 3/2 + 10I_X/2$, or $I_X = -0.5$ A. From the original circuit, $V_O = 3 - 2(1 - 6I_X) = 3 - 2(1 + 3) = -5$ V.

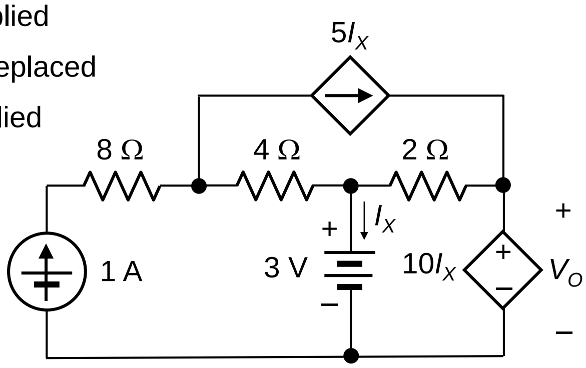


Figure P5.1.29

(b) The current in the 4 Ω resistor is $(1 - 5I_X) = 3.5$ A; hence, the voltage across the 1 A source is $3 + 4\times3.5 + 8 = 25$ V. The power delivered by the source is $P = 25$ W.

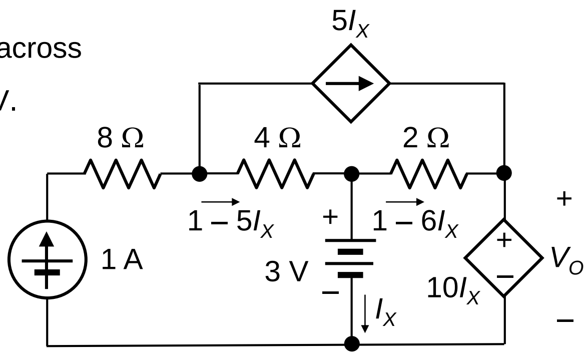


Figure P5.1.29-1