Homework 6

P5.2.5 Determine V_O in Figure P5.2.5 using scaling.

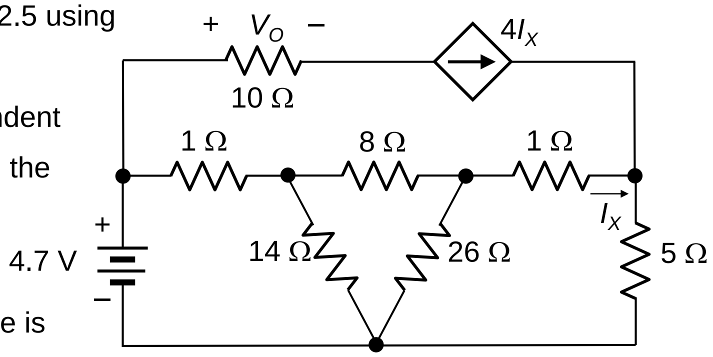

Figure P5.2.5

Solution: Assume I_X = 1 A; the dependent source is 4 A, the current in the 5 Ω resistor is 5 A, and the voltage across it is 25 V. The voltage at the next node is 26 V and the current in the 26 Ω resistor is 1 A. The current in the 8 Ω resistor is 2 A, and the voltage at the next node is 42 V. The current in the 14 Ω resistor is 3 A. The current in the 1 Ω resistor is 5 A, and the voltage at the source is 47 V. Since the given source voltage is 4.7 V, all voltages and currents are divided by 10. The dependent source current is therefore 0.4 A, and $V_O = 10 \times 0.4 = 4$ V.

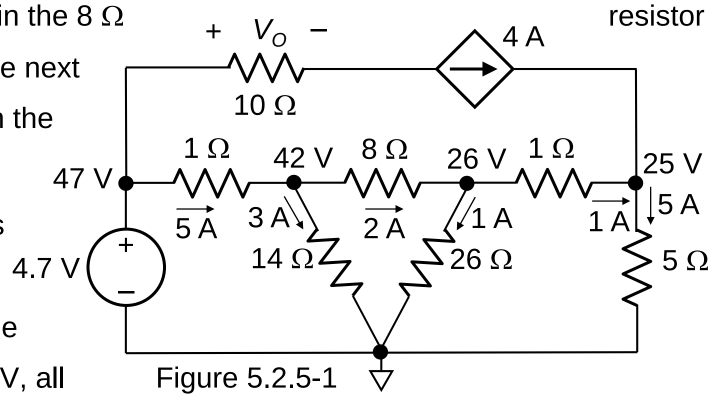

Figure 5.2.5-1

P5.2.7 Determine I_O in Figure P5.2.7.

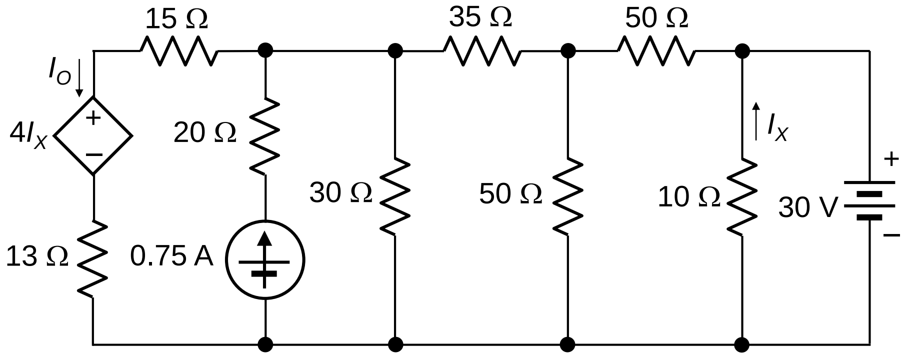

Figure P5.2.7

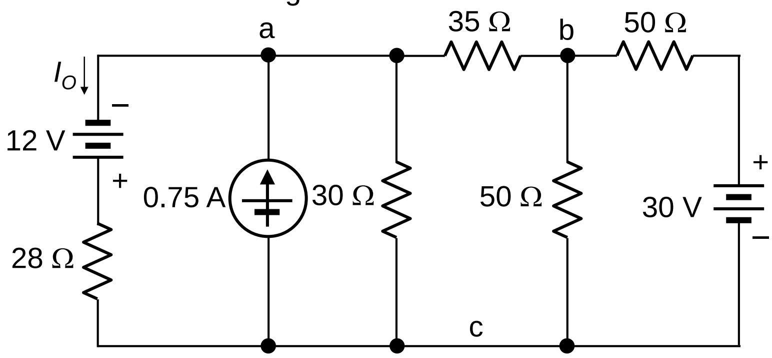

Figure P5.2.7-1

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

Simplify. With I_X = -3 A, the dependent source becomes an independent source of 12 V and reversed polarity. The 10 Ω resistor in parallel with the 30 V source and the 20 Ω resistor in series with the 0.75 A source are redundant for the purpose of calculating I_O and are removed. The 15 Ω and 13 Ω resistances are combined into a 28 Ω resistance, the circuit becoming as shown.

The circuit can be simplified to a single mesh circuit by successive source transformations, Thus, the 30 V source in series 50 Ω is transformed to a 0.6 A current source in parallel with 50 Ω. This, in parallel with 50 Ω becomes 25 Ω. The 0.6 A current source in parallel with 25 Ω is transformed to a voltage source of 15 V in series with 25 Ω. This, in series with 35 Ω becomes 60 Ω. The 15 V source in series with 60 Ω is transformed to a current source of 0.25 A in parallel with 60 Ω. This, in parallel with 30 Ω becomes 20 Ω and the 0.25 A source is added to the 0.75 A source to give a 1 A source in parallel with 20 Ω. This is transformed to a 20 V source in series with 20 Ω, the circuit becoming as shown.

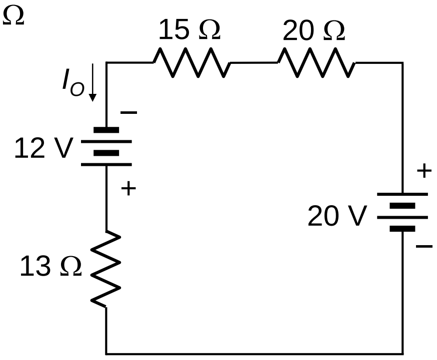

Figure P5.2.7-2

Deduce. It follows from KVL that I_O = (12 + 20)/(20 + 15 + 13) = 32/48 = 2/3 A.

P5.2.25 Determine TEC between terminals 'ab' in Figure P5.2.25, assuming all resistances are 5 Ω.

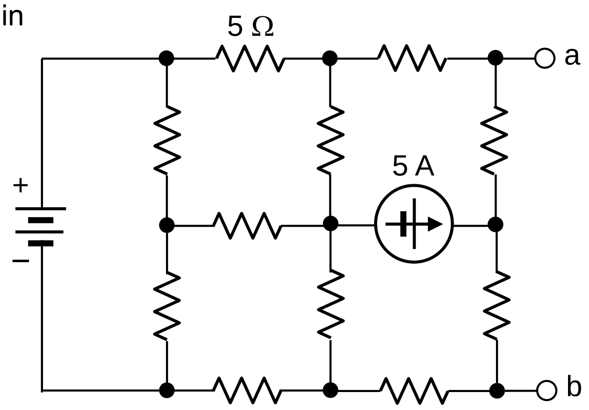

Figure P5.2.25

Solution: When the 5 A source is applied alone, it follows from symmetry that $V_{ab} = 0$. When the 12 V source is applied alone, it follows from symmetry that nodes 'd' and 'f' are at the same voltage, so that the resistor connecting these nodes does not carry current. When this resistor is removed and the 5 A source is set to zero, the resistance between nodes 'c' and 'd' is 10||20 = 20/3 Ω. From voltage division, V_{ce} = 12(20/3)/(10 + 20/3) = 24/5 V. From voltage division, $V_{Th} = V_{ab}$ = (24/5)/2 = 2.4 V.

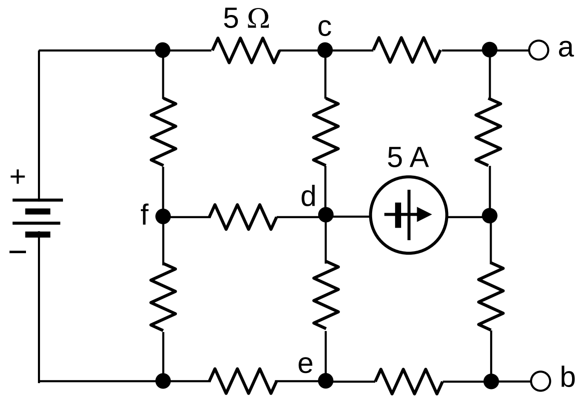

Figure P5.2.25-1

When the sources are set to zero, and a test voltage is applied to determine R_{Th}, it follows from symmetry, as argued previously, that the resistor connecting nodes 'd' and 'f' does not carry current and could be removed,, the circuit becoming as shown. It is seen that resistors R_2 and R_3 are short circuited, so that resistors R_1 and R_4 are in series. The resistance between nodes 'c' and 'e' is 10||10 = 5 Ω. The resistance seen by the source is R_{Th} = 15||10 = 6 Ω.

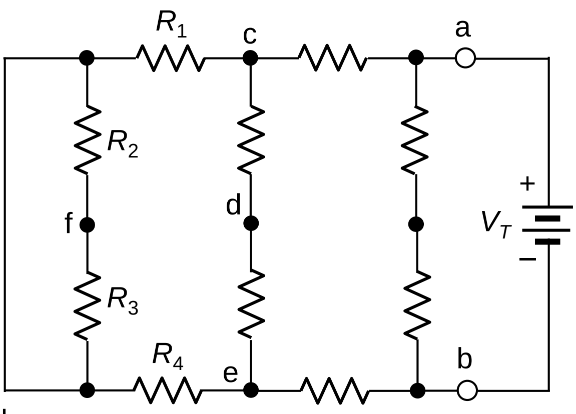

Figure P5.2.25-2

P5.2.27 **D**etermine I_{SRC} in Figure P5.2.27, assuming all resistances are 1 Ω, except for the two 4 Ω resistances indicated.

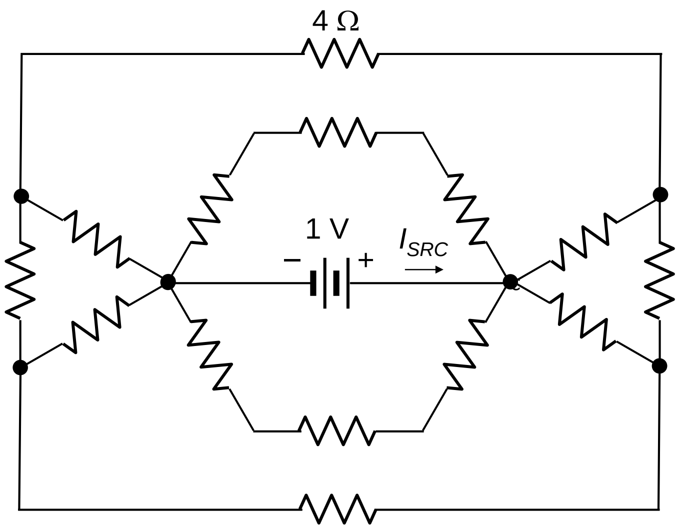

Figure P5.2.27

Solution: From symmetry, the two nodes on either side are at the same voltage so that the resistors oriented vertically do not carry current and could be removed. Moreover, the circuit is symmetrical about the horizontal midline and could be split into two half circuits, as shown in the figure for one half circuit. The resistance seen by the source in one half-circuit is 6||3 = 2 Ω and is 1 Ωin the original circuit. It follows that I_{SRC} = 1/1 = 1 A.

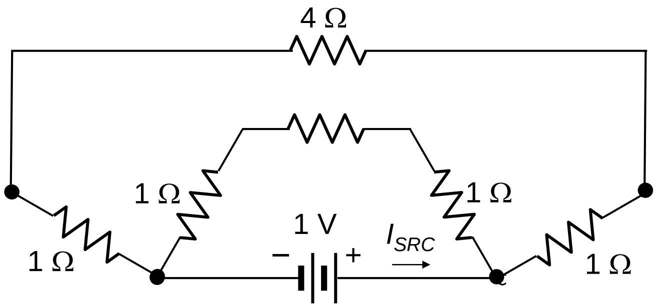

Figure P5.2.27-1

P5.2.28 It is seen from symmetry that nodes ‘c’ and ‘e’ are at the same voltage, as are nodes ‘d’ and ‘f’. If nodes ‘c’ and ‘e’ are connected together, and nodes ‘d’ and ‘f’ are also connected together, $R_{ab} = 2||2 + 2||4||4||3 + 2||2 = 1 + 2/3 + 1 = 8/3\ \Omega$.

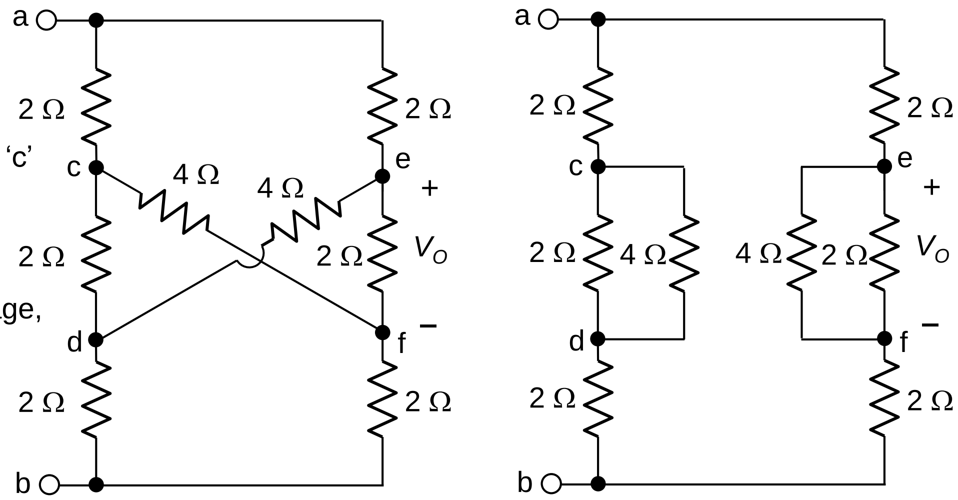

Figure P5.2.28-1

Note that in Figure P5.2.28-1a, nodes ‘d’ and ‘f’ can be connected together and then reconnected as shown in Figure P5.2.28-1b, without disturbing the circuit, since the voltages of nodes ‘c’, ‘d’, ‘e’, and ‘f’ remain the same. Then $4||2 = 4/3\Omega$ and $R_{ab} = (1/2)(2 + 4/3 + 2) = 8/3\ \Omega$ as before.

P6.1.9 Determine the power delivered or absorbed by the current sources in Figure P6.1.9.

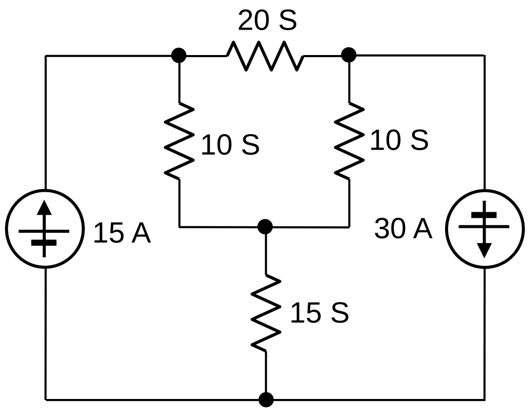

Figure P6.1.9

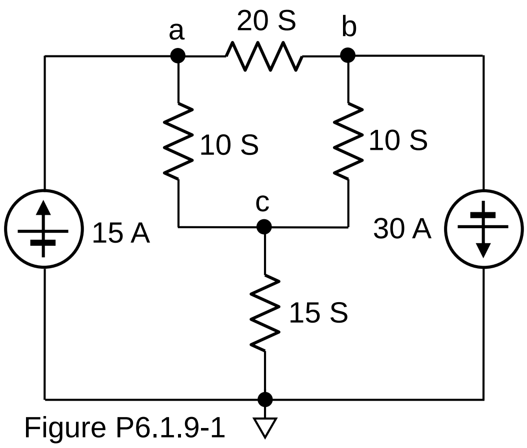

Figure P6.1.9-1

Solution: The node-voltage equations are:

Node 'a': $30V_a - 20V_b - 10V_c = 15$

Node 'b': $-20V_a + 30V_b - 10V_c = -30$

Node 'c': $-10V_a - 10V_b + 35V_c = 0$

Solving these equations gives $V_a = -1.3$ V, $V_b = -2.2$ V, and $V_c = -1$ V; power delivered by 15 A source is $15V_a = -19.5$ W, so the source actually absorbs 19.5 W; power absorbed by the 30 A source is $30V_b = -66$ W, so that the source actually delivers 66 W.

P6.1.14 Determine V_O in Figure P6.1.14.

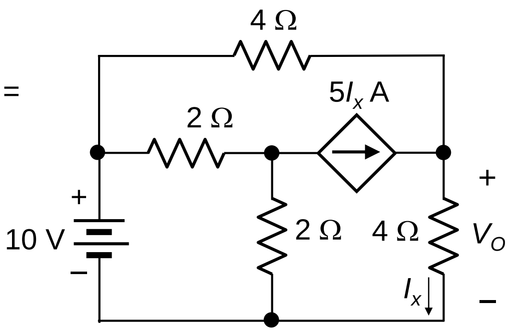

Figure P6.1.14

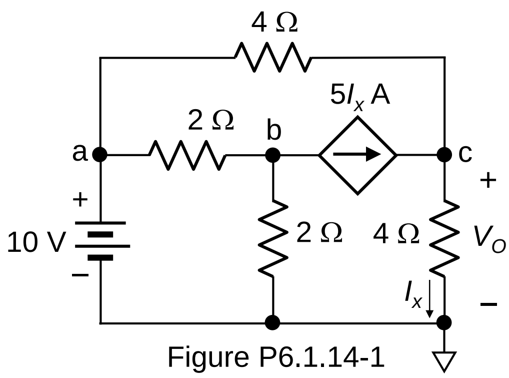

Figure P6.1.14-1

Solution: Taking the bottom node as reference makes $V_a = 10$ V. The node-voltage equation for node b is: $-0.5V_a + V_b = -5I_x = -1.25V_c$, or $V_b + 1.25V_c = 5$. The node-voltage equation for node c is: $-0.25V_a + 0.5V_c = 1.25V_c$. This gives $V_c = V_O = -10 \times 0.25/0.75 = -10/3$ V, and $V_b = 5 + 1.25 \times 10/3 = 55/6$ V.

P6.1.28 Determine V_O in Figure P6.1.28 assuming that all resistances are 2 Ω.

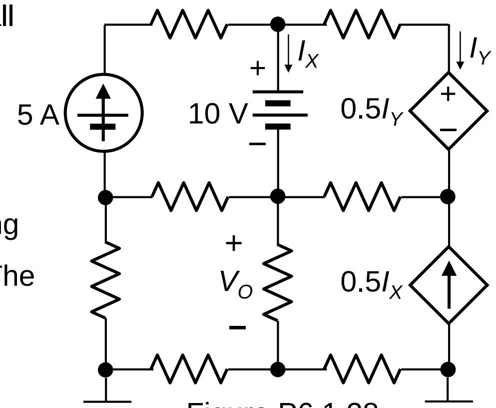

Figure P6.1.28

Solution: The resistance in series with the 5 A source is redundant as far as V_O is concerned, and the CCVS is equivalent to a 0.5 Ω resistance. Making these changes, the circuit becomes as shown. The node voltage equations are:

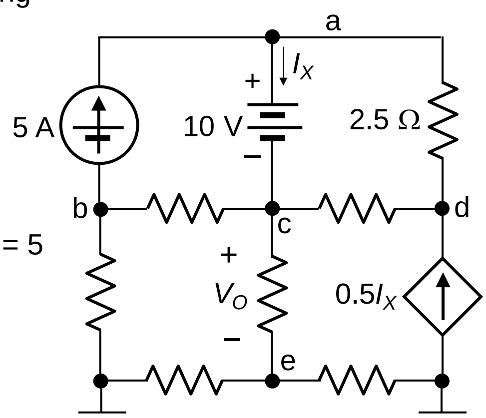

Figure P6.1.28-1

Node 'a': $0.4V_a - 0.4V_d = 5 - I_X$

Node 'c': $-0.5V_b + 1.5V_c - 0.5V_d - 0.5V_e = I_X$; adding these two equations:

$0.4V_a - 0.5V_b + 1.5V_c - 0.9V_d - 0.5V_e = 5$,

with $V_a - V_c = 10$.

Node 'b': $V_b - 0.5V_c = -5$

Node 'd': $-0.4V_a - 0.5V_c + 0.9V_d = 0.5I_X$, where $I_X = 5 - 0.4V_a + 0.4V_d$, or

$-0.2V_a - 0.5V_c + 0.7V_d = 2.5$

Node 'e': $-0.5V_c + 1.5V_e = 0$. Solving these equations gives: $V_a = 850/49$ V, $V_b = -65/49$ V, $V_c = 360/49$ V, $V_d = 675/49$ V, and $V_e = 120/49$ V. It follows that $V_O = V_c - V_e = 240/49 = 4.90$ V.