EECE 210 – Quiz 1

September 28, 2015

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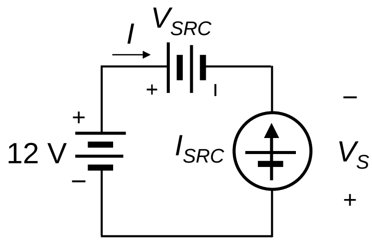
A. Determine I and V_S, assuming V_{SRC} = 2 V and I_{SRC} = 1 A.



Solution: From KCL at the upper node of I_{SRC}, $I + I_{SRC} = 0$, or $I = -I_{SRC}$; from KVL around the mesh, starting from the bottom node and going clockwise, $12 - V_{SRC} + V_S = 0$, or $V_S = -12 + V_{SRC}$

Version 1: V_{SRC} = 2 V, I_{SRC} = 1 A; I = -1 A, V_S = -10 V

Version 2: V_{SRC} = 3 V, I_{SRC} = 2 A; I = -2 A, V_S = -9 V

Version 3: V_{SRC} = 4 V, I_{SRC} = 3 A; I = -3 A, V_S = -8 V

Version 4: V_{SRC} = 5 V, I_{SRC} = 4 A; I = -4 A, V_S = -7 V

Version 5: V_{SRC} = 6 V, I_{SRC} = 5 A; I = -5 A, V_S = -6 V

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B. Determine the power actually delivered or absorbed by each source in the preceding problem.

Solution: Power absorbed by $I_{SRC} = V_S I_{SRC}$; power delivered by 12 V source is $12I$; power absorbed by V_{SRC} is $V_{SRC}I$.

Version 1: V_{SRC} = 2 V, I_{SRC} = 1 A, I = -1 A, V_S = -10 V; power absorbed by $I_{SRC} = V_S I_{SRC}$ = -10 W, source actually delivers 10 W, power delivered by 12 V source is $12I$ = -12 W, source actually absorbs 12 W; power absorbed by V_{SRC} is $V_{SRC}I$ = -2W, source actually delivers 2 W.

Version 2: V_{SRC} = 3 V, I_{SRC} = 2 A, I = -2 A, V_S = -9 V; power absorbed by $I_{SRC} = V_S I_{SRC}$ = -18 W, source actually delivers 18 W, power delivered by 12 V source is $12I$ = -24 W, source actually absorbs 12 W; power absorbed by V_{SRC} is $V_{SRC}I$ = -6 W, source actually delivers 6 W.

Version 3: V_{SRC} = 4 V, I_{SRC} = 3 A, I = -3 A, V_S = -8 V; power absorbed by $I_{SRC} = V_S I_{SRC}$ = -24 W, source actually delivers 24 W, power delivered by 12 V source is $12I$ = -36 W, source actually absorbs 36 W; power absorbed by V_{SRC} is $V_{SRC}I$ = -12 W, source actually delivers 12 W.

Version 4: V_{SRC} = 5 V, I_{SRC} = 4 A, I = -4 A, V_S = -7 V; power absorbed by $I_{SRC} = V_S I_{SRC}$ = -28 W, source actually delivers 28, power delivered by 12 V source is $12I$ = -48 W, source actually absorbs 48 W; power absorbed by V_{SRC} is $V_{SRC}I$ = -20 W, source actually delivers 20 W.

Version 5: V_{SRC} = 6 V, I_{SRC} = 5 A, I = -5 A, V_S = -6 V; power absorbed by $I_{SRC} = V_S I_{SRC}$ = -30 W, source actually delivers 30, power delivered by 12 V source is $12I$ = -60 W, source actually absorbs 60 W; power absorbed by V_{SRC} is $V_{SRC}I$ = -30 W, source actually delivers 30 W.

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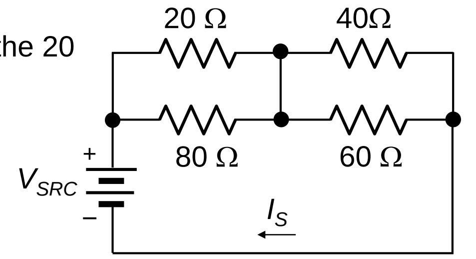
C. Determine the current I_S and the power dissipated in the 20 Ω resistor, assuming V_{SRC} = 20 V.



Solution: 20||80 = 20×80/(20 + 80) = 16 Ω;

40||60 = 40×60/(40 + 60) = 24 Ω; 16 + 24 = 40 Ω;

$I_S = V_{SRC}/40$ A ; I_S divides between the 20 Ω and 80 Ω resistors in the ratio of 4:1. Hence, the current in the 20 Ω resistor is $4I_S/5$ = A, and the power dissipated is $20(4I_S/5)^2 = 12.8I_S^2$ W.

Version 1: V_{SRC} = 20 V; I_S = 20/40 = 0.5 A, $P_{20\Omega} = 12.8I_S^2$ = 3.2 W

Version 2: V_{SRC} = 30 V; I_S = 30/40 = 0.75 A, $P_{20\Omega} = 12.8I_S^2$ = 7.2 W

Version 3: V_{SRC} = 40 V; I_S = 40/40 = 1 A, $P_{20\Omega} = 12.8I_S^2$ = 12.8 W

Version 4: V_{SRC} = 50 V; I_S = 50/40 = 1.25 A, $P_{20\Omega} = 12.8I_S^2$ = 20 W

Version 5: V_{SRC} = 60 V; I_S = 60/40 = 1.5 A, $P_{20\Omega} = 12.8I_S^2$ = 28.8 W.

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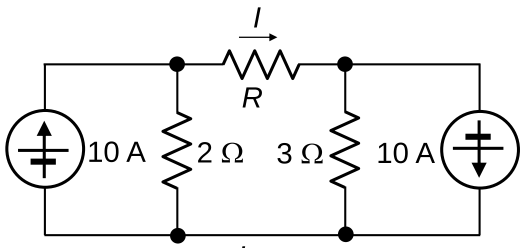
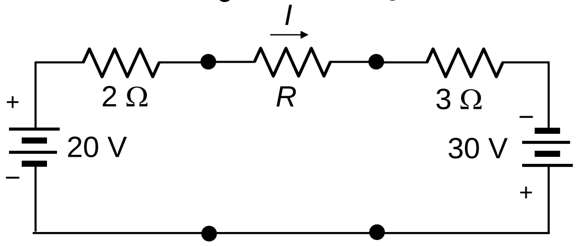
D. Determine the current I **<u>by transforming both linear-output current sources to their equivalent linear-output voltage sources</u>**, assuming R = 5 Ω.



Solution: The transformed sources are as shown. It follows that $I = 50/(R + 5)$ A.



Version 1: R = 5 Ω; $I = 50/(R + 5)$ = 5 A

Version 2: R = 10 Ω; $I = 50/(R + 5)$ = 10/3 A

Version 3: R = 15 Ω; $I = 50/(R + 5)$ = 2.5 A

Version 4: R = 20 Ω; $I = 50/(R + 5)$ = 2 A

Version 5: R = 25 Ω; $I = 50/(R + 5)$ = 5/3 A.

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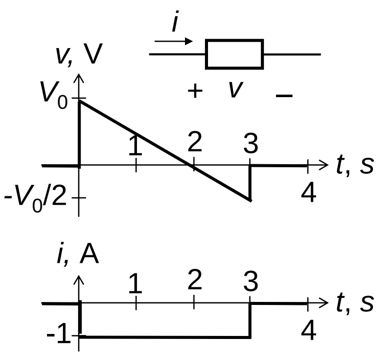
1. The voltage v across a device and the current i through the device are as shown. Determine the largest value of the magnitude of the energy absorbed or delivered by the device during the interval 0 < t < 3 s, assuming V_0 = 1 V.



Solution: The largest magnitude of the energy absorbed occurs at t = 2 s, and is $w(2) = (1/2)(V_0\times2)(-1) = -V_0$ J.

Version 1: V_0 = 1 V; $w(2) = -V_0 \equiv 1$ J delivered

Version 2: V_0 = 2 V; $w(2)$ = -V_0 ≡ 2 J delivered

Version 3: V_0 = 3 V; $w(2)$ = -V_0 ≡ 3 J delivered

Version 4: V_0 = 4 V; $w(2)$ = -V_0 ≡ 4 J delivered

Version 5: V_0 = 5 V; $w(2)$ = -V_0 ≡ 5 J delivered.

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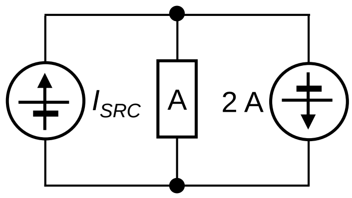
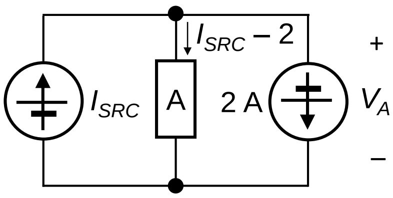
2. Element ‘A’ absorbs 4 W when I_{SRC} = 3 A. Determine the power delivered or absorbed by the 2 A source.





Solution: The current through ‘A’ is (I_{SRC} – 2) A; V_A = 4/(I_{SRC} – 2) V; the power absorbed by the 2 A source Is P_{2A} = 8/(I_{SRC} – 2) W.

Version 1: I_{SRC} = 3 A; P_{2A} = 8/(I_{SRC} – 2) = 8 W absorbed

Version 2: I_{SRC} = 4 A; P_{2A} = 8/(I_{SRC} – 2) = 4 W absorbed

Version 3: I_{SRC} = 5 A; P_{2A} = 8/(I_{SRC} – 2) = 2.67 W absorbed

Version 4: I_{SRC} = 6 A; P_{2A} = 8/(I_{SRC} – 2) = 2 W absorbed

Version 5: I_{SRC} = 7 A; P_{2A} = 8/(I_{SRC} – 2) = 1.6 W absorbed.

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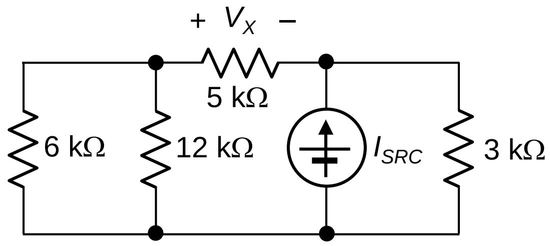
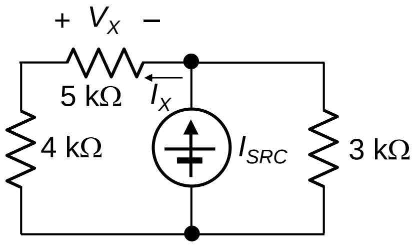
3. Determine I_{SRC} given that V_X = 5 V.





Solution: 6||12 = 72/18 = 4 kΩ; from current division, $I_X = 3I_{SRC}/(3 + 9) = I_{SRC}/4$ mA; $V_X = -5I_X = -5I_{SRC}/4$ V; hence, $I_{SRC} = -4V_X/5$.

Version 1: V_X = 5 V; I_{SRC} = -4 mA

Version 2: V_X = 10 V; I_{SRC} = -8 mA

Version 3: V_X = 15 V; I_{SRC} = -12 mA

Version 4: V_X = 20 V; I_{SRC} = -16 mA

Version 5: V_X = 25 V; I_{SRC} = -20 mA.

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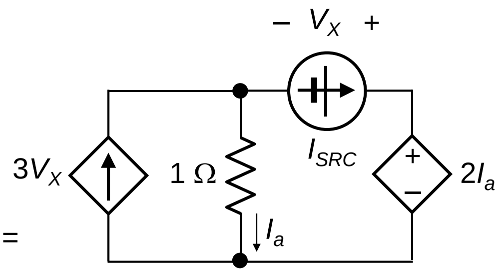
4. Determine the power delivered or absorbed by the independent source, assuming I_{SRC} = 1 A.



Solution: From KVL on the RHS mesh, $I_a \times 1 + V_X - 2I_a = 0$, or $V_X = I_a$ V; from KCL at the upper node, with I_a replaced by V_X, $3V_X = V_X + I_{SRC}$, which gives $V_X = I_{SRC}/2$ V; independent source delivers a power $P = (I_{SRC})^2/2$ W.

Version 1: I_{SRC} = 1 A; P = 1/2 = 0.5 W delivered

Version 2: I_{SRC} = 2 A; P = 4/2 = 2 W delivered

Version 3: I_{SRC} = 3 A; P = 9/2 = 4.5 W delivered

Version 4: I_{SRC} = 4 A; P = 16/2 = 8 W delivered

Version 5: I_{SRC} = 5 A; P = 25/2 = 12.5 W delivered.

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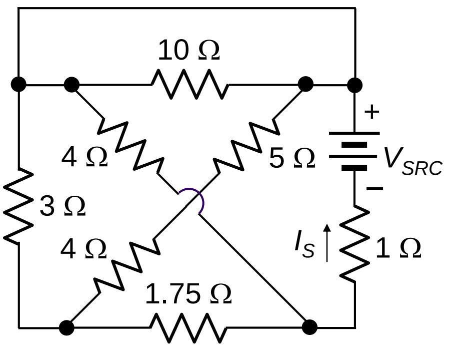
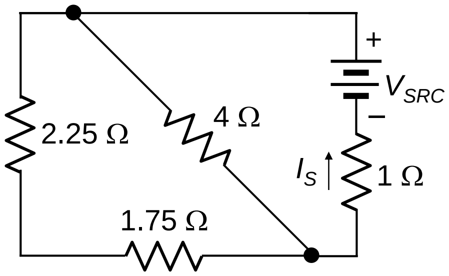
5. Determine I_S, assuming V_{SRC} = 6 V.



Solution: The 10 Ω resistor is short-circuited, and the 4 Ω and 5 Ω resistors are in series, the series combination being in parallel with the 3 Ω resistor. This gives an equivalent resistance of 9×3/12 = 9/4 = 2.25 Ω. In series with 1.75 Ω, this gives 4 Ω. In parallel with 4 Ω and in series with 1 Ω, the resistance seen by the source becomes 3 Ω. It follows that $I_S = V_{SRC}/3$ A.



Version 1: V_{SRC} = 6 V; I_S = 2 A

Version 2: V_{SRC} = 9 V; I_S = 3 A

Version 3: V_{SRC} = 12 V; I_S = 4 A

Version 4: V_{SRC} = 15 V; I_S = 5 A

Version 5: V_{SRC} = 18 V; I_S = 6 A.

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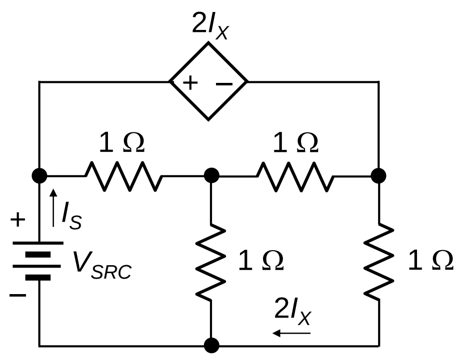
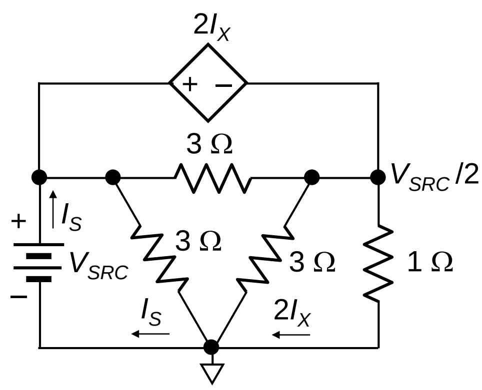
6. Determine I_S, assuming V_{SRC} = 5 V.



Solution: The three 1 Ω resistors in Y are transformed to three 3 Ω resistors in Δ. The voltage across the 1 Ω resistor is $2I_X$ V. It follows from KVL around the outer loop that $V_{SRC} = 4I_X$, so that the voltage of the rightmost node with respect to the bottom node is $V_{SRC}/2$. From KCL at the bottom node, $I_S = \frac{V_{SRC}}{2} + \frac{V_{SRC}}{6} + \frac{V_{SRC}}{3} =$ V_{SRC} A.



Version 1: V_{SRC} = 5 V; I_S = 5 A

Version 2: V_{SRC} = 10 V; I_S = 10 A

Version 3: V_{SRC} = 15 V; I_S = 15 A

Version 4: V_{SRC} = 20 V; I_S = 20 A

Version 5: V_{SRC} = 25 V; I_S = 25 A.

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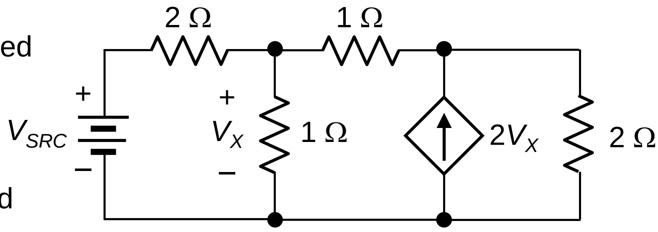
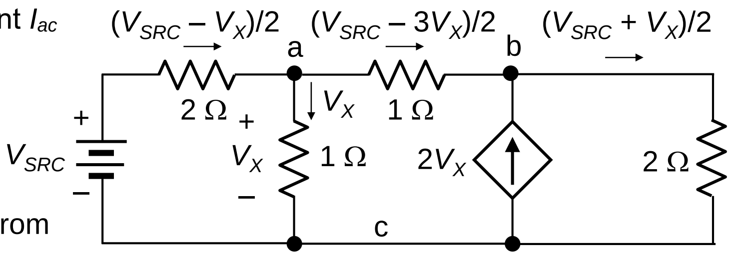
7. Determine the power delivered or absorbed by the dependent source, assuming V_{SRC} = 1 V.



Solution: Initialize: All given parameters and variables are entered. The nodes are labelled.

Simplify: The circuit is already in a simple enough form.

Deduce: From Ohm's law, the current I_{ac} is $V_X/1 = V_X$ A; from KVL around the mesh on the LHS, the voltage drop across the 2 Ω resistor is ($V_{SRC} - V_X$), and the current flowing from V_{SRC} to node 'a' is $(V_{SRC} - V_X)/2$. From KCL at node 'a', $I_{ab} = (V_{SRC} - V_X)/2 - V_X = (V_{SRC} - 3V_X)/2$. From KCL at node 'b', the current through the 2 Ω resistor on the RHS is $I_{bc} = (V_{SRC} - 3V_X)/2 + 2V_X = (V_{SRC} + V_X)/2$. From KVL around the outer loop $V_X - 1\times(V_{SRC} - 3V_X)/2 - 2\times(V_{SRC} + V_X)/2 = 0$, or $2V_X - V_{SRC} + 3V_X - 2V_{SRC} - 2V_X = 0$, which gives $V_X = V_{SRC}$. Hence, $V_{bc} = 2\times(V_{SRC} + V_X)/2 = 2V_{SRC}$. The power delivered by the dependent source is $P = 2V_{SRC}I_a = 4(V_{SRC})^2$ W.



Version 1: V_{SRC} = 1 V; P = 4 W

Version 2: V_{SRC} = 2 V; P = 16 W

Version 3: V_{SRC} = 3 V; P = 36 W

Version 4: V_{SRC} = 4 V; P = 64 W

Version 5: V_{SRC} = 5 V; P = 100 W.

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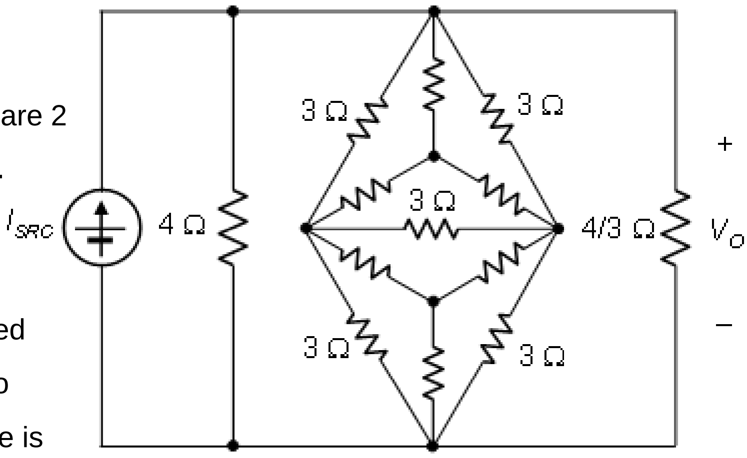
8. Determine V_O, given that the six, unmarked Y-connected resistors are 2 Ω each, and assuming I_{SRC} = 3 A.



Solution: The 2 Ω, Y-connected resistors are transformed to 6 Ω, Δ-connected resistors. 6 Ω are paralleled with each of the outer 3 Ω resistors to give 2 Ω. The resistance in the middle is 6||6||3 = 1.5 Ω. The resistive circuit in the middle becomes as shown. The upper delta is transformed to a Y-connection as shown. 3/5.5 Ω in series with 2 Ω is 14/5.5 Ω. The two 14/5.5 Ω in parallel are 7/5.5 Ω. In series with 4/5.5 Ω, this gives 2 Ω. The resistors reduce to 2 Ω in parallel with 4 Ω and 4/3 Ω; 2 Ω in parallel with 4 Ω is 4/3 Ω; in parallel with 4/3 Ω this gives 2/3 Ω. It follows that $V_O = 2I_{SRC}/3$ V.

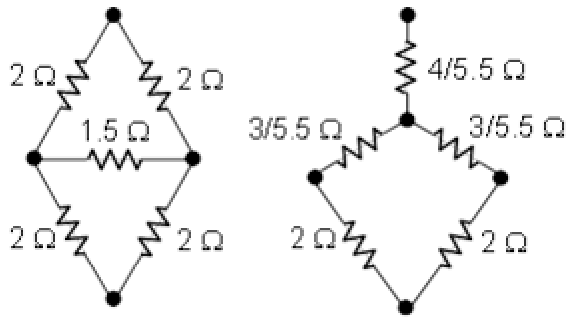
Version 1: I_{SRC} = 3 A; V_O = 2 V

Version 2: I_{SRC} = 6 A; V_O = 4 V

Version 3: I_{SRC} = 9 A; V_O = 6 V

Version 4: I_{SRC} = 12 A; V_O = 8 V

Version 5: I_{SRC} = 15 A; V_O = 10 V.



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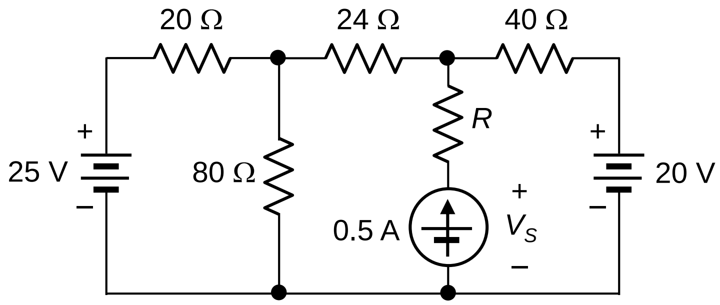
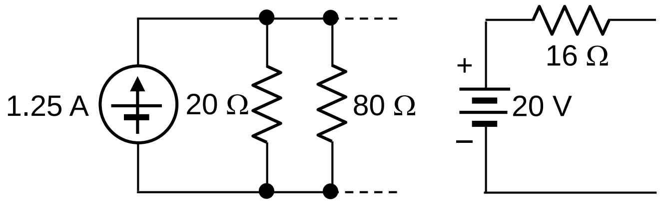
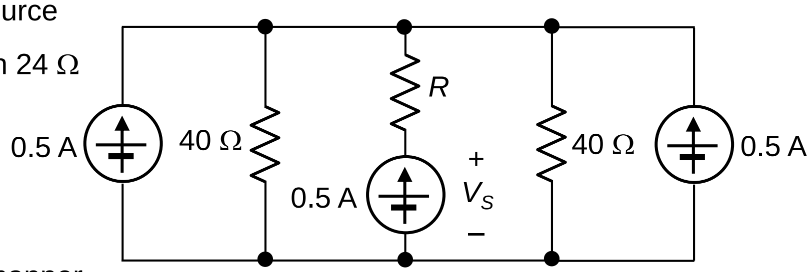
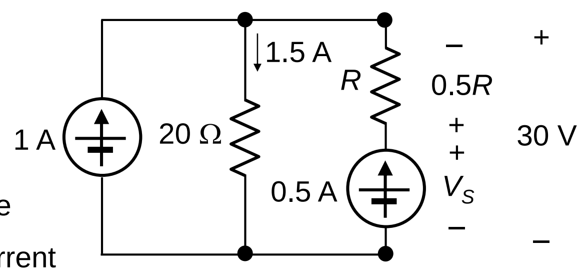
9. Determine V_S, assuming R = 10 Ω.









Solution: Successive source transformations are applied to reduce the circuit to a simple enough form. The 25 V source in series with 20 Ω is transformed to a 1.25 A current source in parallel with 20 Ω. In parallel with 80 Ω the resistance is 16 Ω. The 1.25 A current source in parallel with 16 Ω is transformed to a 20 V source in series with 16 Ω. In series with 24 Ω the resistance is 40 Ω. The 20 V source in series with 40 Ω is transformed to a 0.5 A source in parallel with 40 Ω. In the same manner, the 20 V source in series with 40 Ω on the RHS is transformed to a 0.5 A source in parallel with 40 Ω, as shown. The two 40 Ω resistors in parallel give a resistance of 20 Ω and the two 0.5 A source add to a 1 A source, as shown. From KCL, the current in the 20 Ω resistor is 1.5 A, and the voltage across the paralleled elements is 30 V. It follows that $V_S = 30 + 0.5R$ V.

Version 1: R = 10 Ω; V_S = 35 V

Version 2: R = 20 Ω; V_S = 40 V

Version 3: R = 30 Ω; V_S = 45 V

Version 4: R = 40 Ω; V_S = 50 V

Version 5: R = 50 Ω; V_S = 55 V.