Homework 4

P3.1.11 Determine V_O in Figure P3.1.11 using node-voltage analysis. Do not transform the voltage source. Consider that the current entering node a due to this source is $0.25(10-V_a)$

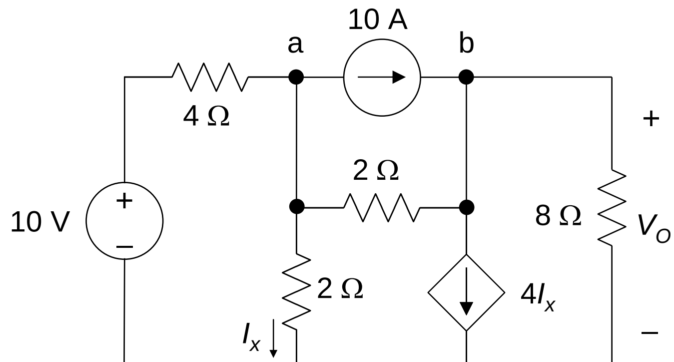
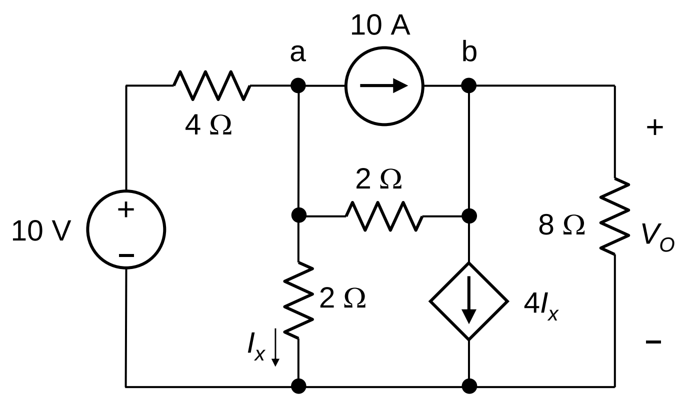


Figure P3.1.11

Solution P3.1.11



Considering that a current source $(10-V_a)/4$ is connected to node a, the KCL node voltage equation for this node may be written as: $(0.5+0.5)V_a - 0.5V_b = 0.25(10-V_a) - 10$, which may be rearranged as:

$$1.25V_a - 0.5V_b = -7.5.$$

The equation for node b is: $-0.5V_a + 0.625V_b = 10 - 4I_x = 10 - 2V_a$, which may be rearranged as:

$$1.5V_a + 0.625V_b = 10$$

Solving, $V_a = 0.204$ V and $V_b = 15.5$ V = V_O.

P3.1.23 Determine I_O in Figure P3.1.23 using node-voltage analysis.

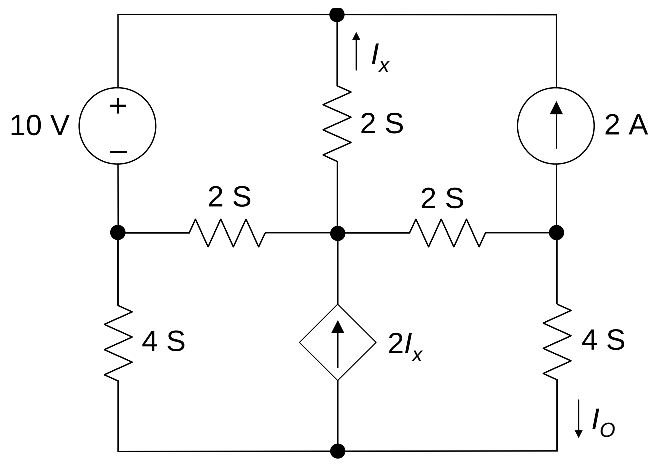
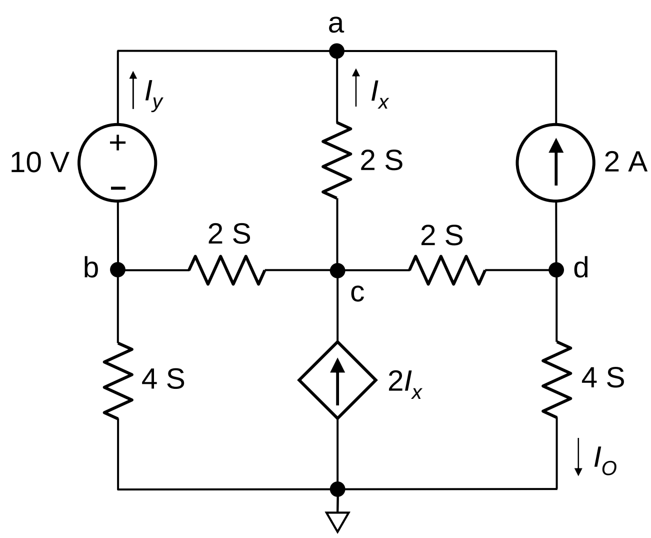


Figure P3.1.23

<u>**Solution P3.1.23**</u>



The node-voltage equation for node a is:

$$2V_a - 2V_c = 2 + I_y$$

For node b:

$$6V_b - 2V_c = -I_y$$

Adding these equations and dividing by 2:

$$V_a + 3V_b - 2V_c = 1$$

For node c:

$$-2V_a - 2V_b + 6V_c - 2V_d = 2I_x = 4(V_c - V_a)$$

Collecting terms and dividing by 2:

$$V_a - V_b + V_c - V_d = 0$$

For node d:

$$-2V_c + 6V_d = -2, \text{ or } V_c - 3V_d = 1$$

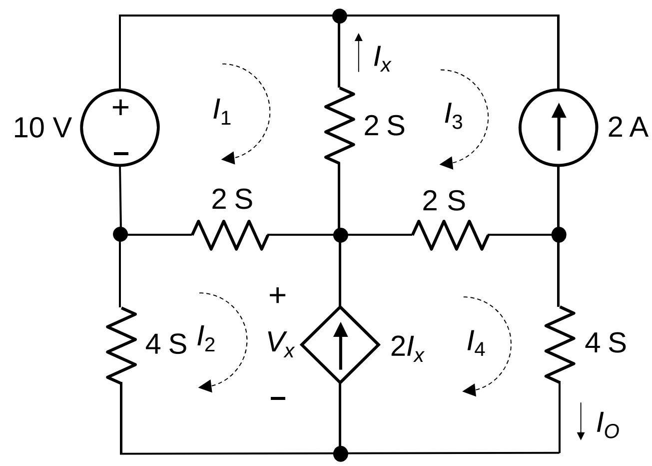
Moreover, $V_a - V_b = 10$.

Solving, $V_d = -5.5$ V;

hence, $I_O = -22$ A.

P3.1.24 Determine I_O in Figure P3.1.23 using mesh-current analysis.

Solution P3.1.24



The mesh-current equation for mesh 1 is:

$$I_1 - 0.5I_2 - 0.5I_3 = 10$$

Substituting $I_3 = -2$:

$$I_1 - 0.5I_2 = 9$$

For mesh 2:

$$-0.5I_1 + 0.75I_2 = -V_x$$

For mesh 4:

$$-0.5I_3 + 0.75I_4 = V_x$$

Adding and substituting for I_3:

$$-0.5I_1 + 0.75I_2 + 0.75I_4 = -1$$

For the dependent source:

$$I_4 - I_2 = 2I_x = 2(I_3 - I_1) = -4 - 2I_1, \text{ or } 2I_1 - I_2 + I_4 = -4$$

Solving, $I_4 = I_O = -22$ A.

P3.2.5 Determine V_{SRC1} and V_{SRC2} in Figure P3.1.5 using Δ-Y transformation and superposition.

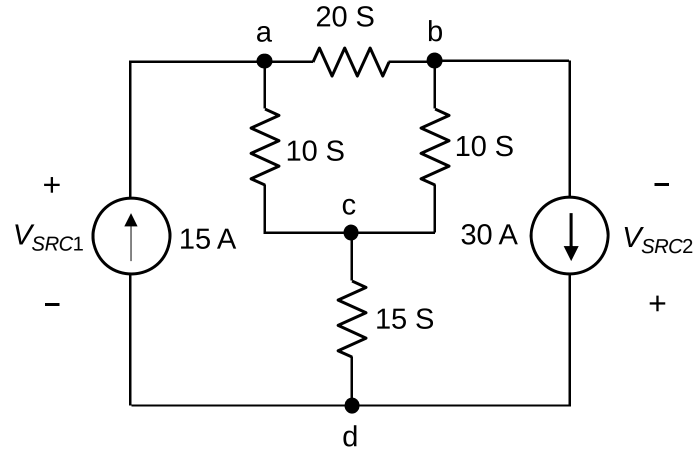


Figure P3.1.5

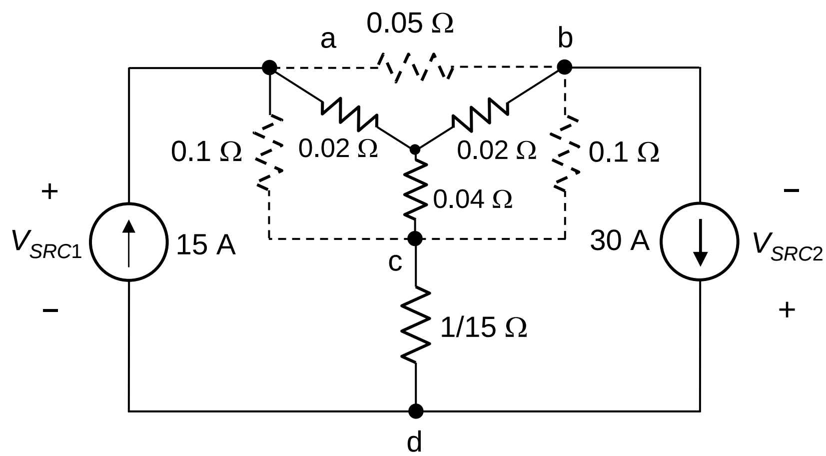
<u>Solution P3.2.5</u>

The resistances of the Y are:

$R_1 = \dfrac{0.005}{0.25} = 0.02\ \Omega$ connected to a,

$R_2 = 0.02\ \Omega$ connected to b,

$R_3 = 0.04\ \Omega$ connected to c.



With the 15 A source set to zero, V_{SRC11} = $-30(0.04+1/15) = -3.2$ V and V_{SRC21} = $30(0.06+1/15) = 3.8$ V

With the 30 A source set to zero, V_{SRC12} = $15(0.06+1/15) = 1.9$ and V_{SRC22} = $-15(0.04+1/15) = -1.6$ V.

It follows from superposition that V_{SRC1} = -3.2 + 1.9 = -1.3 V V_{SRC2} = 3.8 - 1.6 = 2.2.V.

P3.2.10 Determine I_O in Figure P3.1.13 using superposition and leaving the dependent source unaltered. Calculate the power dissipated in the 8S resistor.

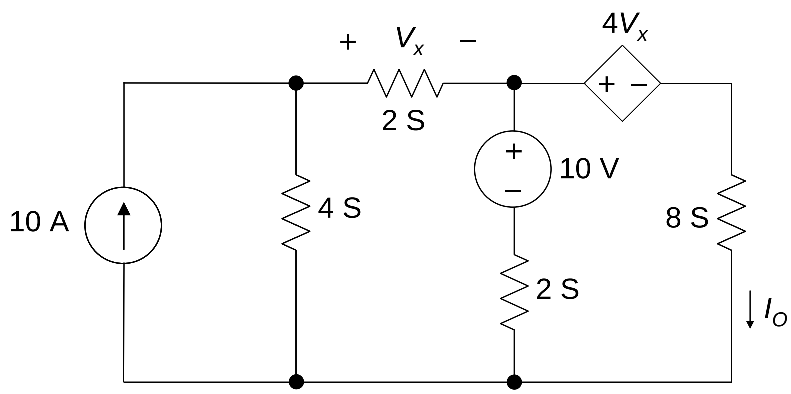
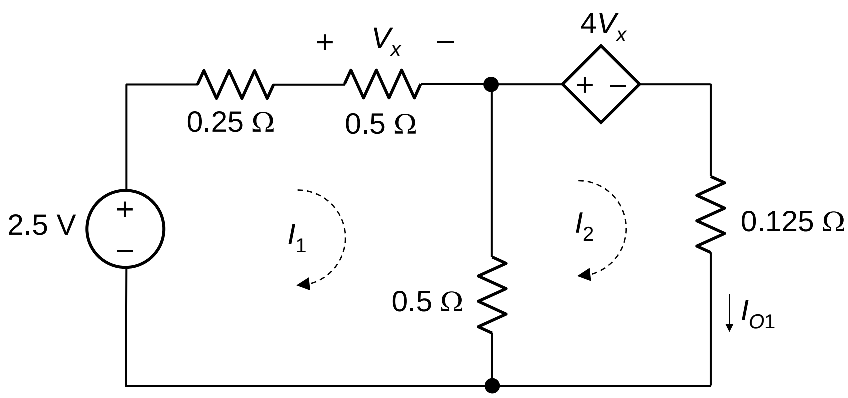


Figure P3.1.13

Solution P3.2.10

With the voltage source set to zero, and the current source transformed to a voltage source, the circuit becomes as shown. The mesh current equations are:



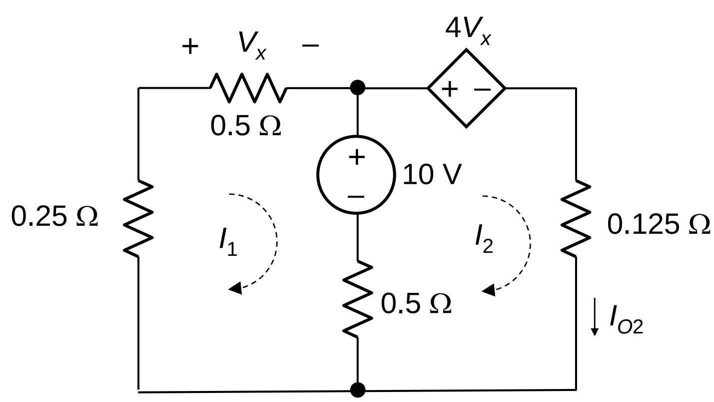
$$1.25I_1 - 0.5I_2 = 2.5$$

$$-0.5I_1 + 0.625I_2 = -4V_x = -2I_1,$$

or, $1.5I_1 + 0.625I_2 = 0$

Solving, $I_2 = I_{O1} = -2.4490$ A.

With the current source set to zero, the circuit becomes as shown. The mesh current equations are:



$$1.25I_1 - 0.5I_2 = -10$$

$$-0.5I_1 + 0.625I_2 =$$

$$10 - 4V_x = 10 - 2I_1$$

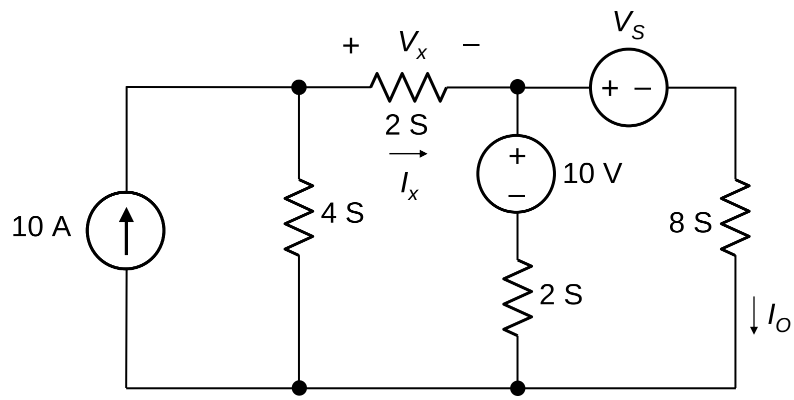
or, $1.5I_1 + 0.625I_2 = 10$

Solving, $I_2 = I_{O2} = 17.9592$ A.

From superposition, I_O = 15.5 A.

Power dissipated is $0.125(I_O)^2 = 30.03$ W.

P3.2.11 Repeat P3.2.10 considering the dependent source as an independent source and determining first the current through the 2 S resistor across which V_x is taken.



Solution P3.2.11

With the 10 A source acting alone, and the voltage sources replaced by short circuits, $\frac{2\times10}{12}=\frac{5}{3}$ S.

Hence, $I_{x1}=10\times\frac{5/3}{4+5/3}=\frac{50}{17}$ A.

With the 10 V source acting alone, and transforming the voltage source to a 20 A current source,

$I_{x2}=-20\times\frac{4/3}{2+8+4/3}=-\frac{40}{17}$ A.

With the V_S source acting alone, and transforming this to an $8V_S$ source,

$I_{x3}=-8V_S\times\frac{4/3}{2+8+4/3}=-\frac{16V_S}{17}$.

It follows that $I_x=\frac{10-16V_S}{17}$.

From the original circuit, $V_S = 4V_x = 2I_x$.

Substituting, $I_x=\frac{10}{49}$ A, and $V_x=\frac{5}{49}$ V.

The voltage across the 4 S resistor is $\frac{10-10/49}{4}=\frac{120}{49}$.

The voltage across the 8 S resistor is $\frac{120}{49}-\frac{5}{49}-\frac{20}{49}=\frac{95}{49}$ V.

Hence, $I_O=\frac{8\times95}{49}=\frac{760}{49}=15.5$ A.

P3.2.17 Determine $\mathbf{I_o}$ in Figure P3.2.17 using scaling, assuming all resistances are 1Ω. Note that because the controlling current is on the output side, it is convenient to work backward from the output.

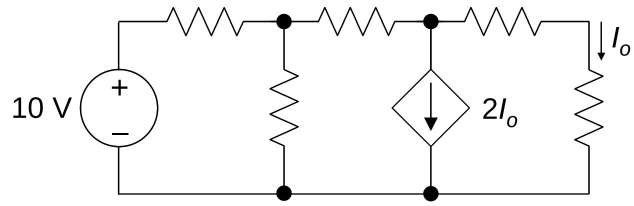


Figure P3.2.17

<u>Solution P3.2.17</u>

P3.2.17 Assuming I_O = 1A, the source voltage becomes 13 V as shown. Hence, the actual value of I_O is 10/13 A.