7a

Procedure Summary to find I and V:

Note: find equation for dependent variable.

1.a. Label every current through R's

b. Label polarity with (-) at arrow side

2. Take a voltage loop for every possible path.

[NOTE!] → • Do not take a loop across a current source

3. Write all node current summations.

[Note!] → • Do not use a node with a branch having only a V src in it.

4. Use Ohm's law for every R.

5. Reduce equation set to solve for unknown's (i.e. use a set with common unknown variables)

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power summary:

$$P = I * V = I^2 R \quad [W] \text{ Watts}$$

+ consuming

- generates

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HOMEWORK #1 Solution Problem 2

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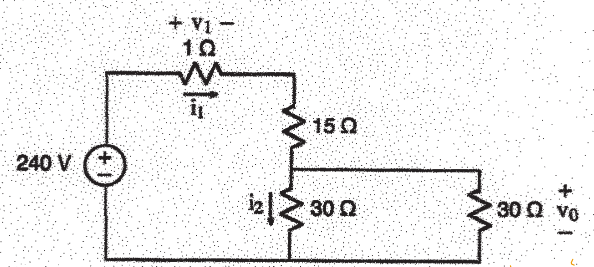
Ex:



Calculate i_1, i_2, and v_0.

$0 = +i_2(30) - i_0(30)$

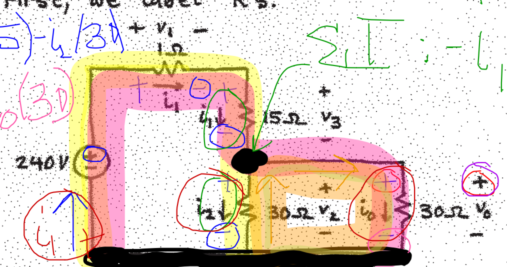
soln: First, we label R's.

$0 = +240 - i_1(1) - i_1(15) - i_2(30)$

$0 = +240 - i_1(1) - i_1(15) - i_0(30)$

$\Sigma I: -i_1 + i_2 + i_0 = 0$

$V_0 = iR$



$V_0 = -i_4(30)$

Second, we write v-loop eq'ns. We write eq'ns for both inner loops.

$+240V - v_1 - v_3 - v_2 = 0V$ $\qquad + i_1 - i_2 - i_0 = 0$

$+v_2 - v_0 = 0V$

Third, we write current-sum eq'ns for all but one node. For the node between R's on the right side we have

$-i_1 + i_2 + i_0 = 0A$

Fourth, we equate currents for components in series. We have already done this, however, by using i_1 for both the 1Ω and 15Ω R's.

Fifth, we write Ohm's law eq'ns for every R:

$$v_1 = i_1 \cdot 1\Omega$$

$$v_3 = i_1 \cdot 15\Omega$$

$$v_2 = i_2 \cdot 30\Omega$$

$$v_0 = i_0 \cdot 30\Omega$$

Now we use the Ohm's law eq'ns to substitute for v's:

$$+240V - i_1 \cdot 1\Omega - i_1 \cdot 15\Omega - i_2 \cdot 30\Omega = 0V$$

$$+ i_2 \cdot 30\Omega - i_0 \cdot 30\Omega = 0V$$

Our current sum eq'n is unchanged:

$$-i_1 + i_2 + i_0 = 0A$$

From the 2nd of the above 3 eq'ns we have

$$i_0 = i_2$$

Using this in the 3rd eq'n gives

$i_1 = 2 i_2$

Using this in the 1st eq'n gives

$$+240V - 2i_2(1\Omega + 15\Omega) - i_2 \cdot 30\Omega = 0V$$

or $$i_2(2 \cdot 16\Omega + 30\Omega) = 240V$$

or $$i_2 = \frac{240V}{62\Omega} = \boxed{\frac{120}{31}} A \approx 3.87A$$

$$i_1 = 2 i_2 = \boxed{\frac{240}{31}} A \approx 7.74A$$

$$v_o = i_o \cdot 30\Omega = i_2 \cdot 30\Omega = \frac{120}{31}(30) V$$

or $$v_o = \frac{3600}{31} V \approx \boxed{116 V}$$

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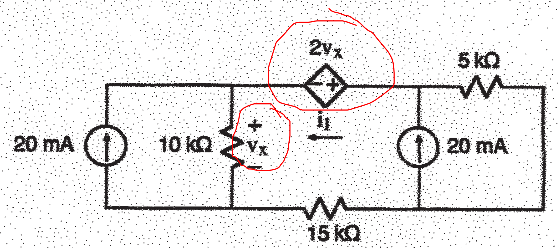
HOMEWORK #1 Solution Prob 3.

Ex:



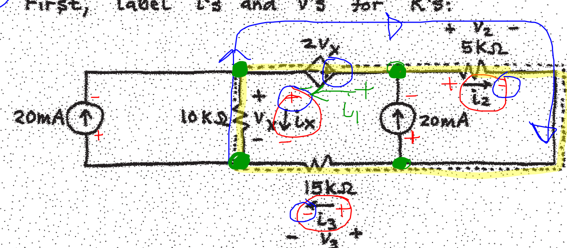
Find v_x, i_1, and the power dissipated by the dependent source.

sol'n: We find i_1, the current for the dependent v-src *after* we solve the circuit.

$$+i_x(10K)+2V_x-i_2(5K)-i_3(15K)=0$$

$$V_x=i_x(10K)$$

First, label i's and v's for R's:



Second, write v-loop eq'ns for loops not containg current src's. There is only one such loop, indicated by the dotted line:

$$+v_x + 2v_x - v_2 - v_3 = 0V$$

Third, write current-sum eq'ns for nodes (unless nodes are connected only by v src's). We don't use the nodes on top since they are connected by only the $2v_x$ source.

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HOMEWORK #1 Sol'n prob 3 (cont.) THE UNIVERSITY OF UTAH

$$20\,mA - i_x - (i_2 - 20\,mA) = 0\,A$$

$$i_x(10k\Omega + 20k\Omega) - i_2(5k\Omega) - (i_2 - 20mA)\,15k\Omega = 0V$$

Solving the first of these eq'ns for i_2 gives

$$i_2 = 40\,mA - i_x$$

Using this in the second of the two eq'ns gives:

$$i_x(30k\Omega) - (40\,mA - i_x)(5k\Omega + 15k\Omega) = -20mA \cdot 15k\Omega$$

or $$i_x(30k\Omega + 20k\Omega) = 40mA(20k\Omega) - 20mA \cdot 15k\Omega$$

or $$i_x(50k\Omega) = 500\,V$$

or $$i_x = \frac{500V}{50k\Omega} \boxed{= 10\,mA}$$

Now we can find i_1 from a current sum at the node on top to the left of center.

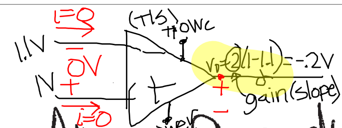
$$-20\,mA + i_x - i_1 = 0\,mA$$

or $$i_1 = -20\,mA + i_x = -20\,mA + 10\,mA = -10\,mA$$

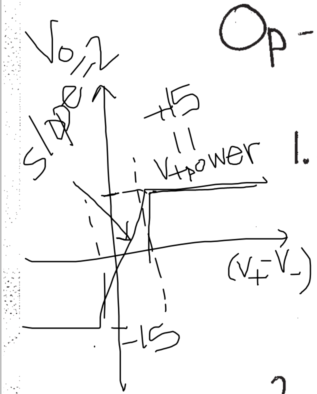
The power dissipated by the dependent source is

$$p = i_1 \cdot 2v_x = -10mA \cdot 2 \cdot \overbrace{10\cancel{m}A \cdot 10\cancel{k}\Omega}^{v_x \text{ from Ohm's Law}}$$

or $$p = -2\,W$$



Op-Amp Procedure:
(Linear Operation)



$V_0 = 2(V_+ - V_-)$

1. a. Replace Op-Amp with V_0 source
   b. 0V across +, - inputs
   c. $i=0$ into +, - inputs

2. Follow procedure to solve for I & V (pg. 7a) by using the V-loop that includes the 0V drop across +, - inputs
   - 2 <u>different</u> loops can be obtained
   - make sure to use V_0 in 1 loop

Op Amp Example

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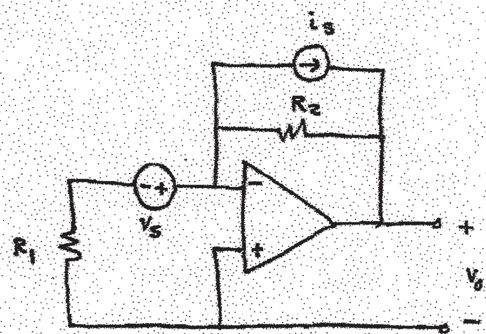
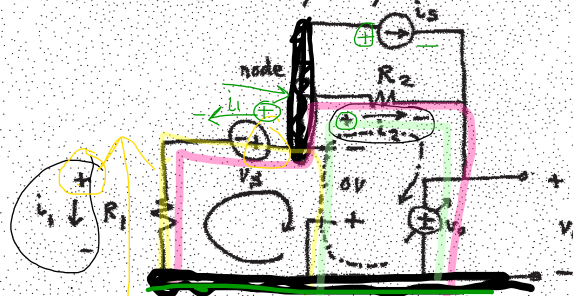


Derive expression for v_0 in terms of not more than v_s, i_s, R_1, and R_2.

sol'n: Replace op-amp with v_0 source and assume 0V across +,− inputs.



Use v-loop on left that includes 0V drop across +,− inputs.

$$+i_1 R_1 + v_s + 0V = 0V$$

$$\text{or} \quad i_1 = -\frac{v_s}{R_1}$$

Use v-loop on right that includes 0V drop across +,− inputs.

$$-0V - i_2 R_2 - v_0 = 0V$$

$$\text{or} \quad v_0 = -i_2 R_2$$

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OpAmp sol'n: cont.

Use current sum at node next to − input.

$$i_1 + i_2 + i_s = 0\,A$$

or $$i_2 = -(i_1 + i_s) = -\left(-\frac{v_s}{R_1} + i_s\right) = \frac{v_s}{R_1} - i_s$$

Use this in 2nd v-loop eq'n.

$$v_o = -i_2 R_2 = -\left(\frac{v_s}{R_1} - i_s\right) R_2$$

$$\boxed{v_o = \left(i_s - \frac{v_s}{R_1}\right) R_2}$$

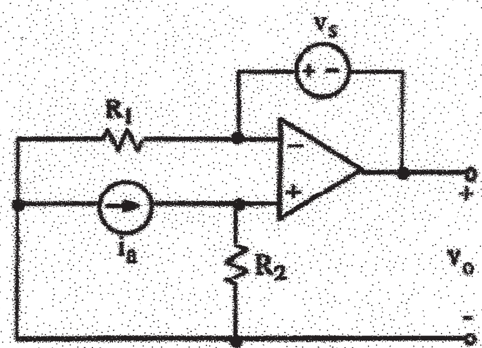
Consistency check:

If $R_2 = 0$ then 2nd v-loop implies $v_o = 0V$. $v_o = \left(i_s - \frac{v_s}{R_1}\right) \cdot 0 = 0V$ ✓

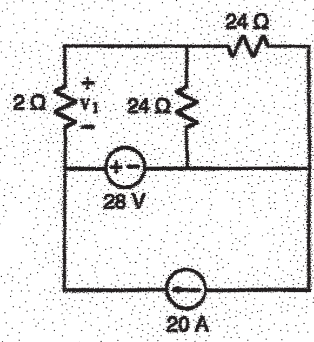
If $i_s = 0A$ and $v_s = 0V$, we should get $v_o = 0V$. $v_o = \left(0 - \frac{0}{R_1}\right) R_2 = 0V$ ✓

Op Amp Examples

5. The op-amp operates in the linear mode. Using an appropriate model of the op amp, derive an expression for v_o in terms of not more than v_s, i_a, R_1, and R_2.



Ex:



Calculate v_1.

soln: We can use a voltage divider consisting of the 28V src, the 2Ω Resistor, and the two 24Ω resistors in parallel:

$$v_1 = -28V \cdot \frac{2\Omega}{2\Omega + 24\Omega \| 24\Omega}$$

$$= -28V \cdot \frac{2\Omega}{2\Omega + 24\Omega \cdot 1\|1} \qquad 1\|1 = \frac{1 \cdot 1}{1+1} = \frac{1}{2}$$

$$= -28V \cdot \frac{2\Omega}{2\Omega + 12\Omega}$$

$$v_1 = -4V$$

Note: We have a minus sign whenever the + sign of the resistor voltage measurement is on the side away from the + sign of the v src.