1. Solve the following simultaneous equations for i_1, i_2, and i_3:

$$\text{①}\quad (-4i_1+3i_2)+(3i_2-i_1+6i_3)-2=0$$

$$\text{②}\quad i_2+4(3i_1+i_3)-2i_1=0$$

$$\text{③}\quad 5i_1-1-i_3=0$$

from ③ $5i_1 = 1+i_3$

$$i_1 = \frac{(1+i_3)}{5}$$

From ② using ③ $\Rightarrow$ $i_2 + 12\left(\frac{1+i_3}{5}\right) + 4i_3 - \frac{2}{5}(1+i_3) = 0$

$$i_2 = -\frac{12}{5} + \frac{2}{5} - \frac{12i_3}{5} - \frac{20}{5}i_3 + \frac{2}{5}i_3$$

$$i_2 = -\frac{10}{5} - \frac{30}{5}i_3 = -2-6i_3$$

From ① using ② and ③ reduced above:

$$-\frac{4}{5}(1+i_3) + 3(-2-6i_3) + 3(-2-6i_3) - \frac{(1+i_3)}{5} + 6i_3 - 2 = 0$$

$$-\frac{4}{5}i_3 - \frac{18(5)}{5}i_3 - \frac{18(5)}{5}i_3 - \frac{1}{5}i_3 + \frac{30}{5}i_3 = \frac{4}{5} + \frac{30}{5} + \frac{30}{5} + \frac{1}{5} + \frac{10}{5}$$

$$-155\, i_3 = 75$$

$$\boxed{i_3 = \frac{-75}{155}} \text{ or } \frac{-15}{31}$$

plug back into ②: $i_2 = -2 - \frac{6(-15)}{31} = \frac{-62+90}{31} = \boxed{\frac{28}{31}}$

plug back into ③: $i_1 = \frac{\left(1+\frac{-15}{31}\right)}{5} = \frac{1}{5} - \frac{15}{(5)(31)}$

$$i_1 = \frac{31-15}{5(31)} = \boxed{\frac{+16}{155}}$$

2. Perform the following calculations. Write the answers with appropriate prefixes (such as μ, m, k etc.) for engineering untis:

a) $P = 7.2\,\mathrm{MA} \times 6\,\mathrm{mV}$ (Note: V*A=W)

b) $R = 4.5\,\mu\Omega + 1600\,\mathrm{n}\Omega$

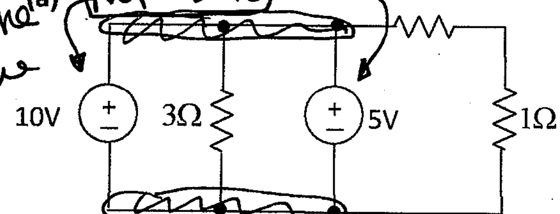
(a) $p = 7.2 \times 10^{6} \times 6 \times 10^{-3} = \boxed{43{,}200\,W}$

(b) $R = 4.5 \times 10^{-6} + 1600 \times 10^{-9} = \boxed{6.1\,\mu\Omega}$

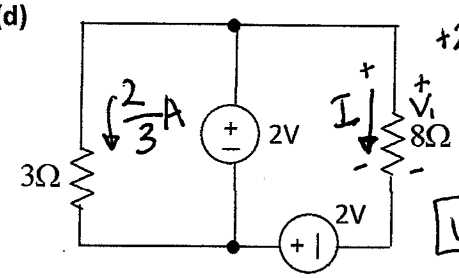
3. Determine whether each of the following circuits is valid or invalid.

(a) Not Valid

not the same



(d)



$+2 - I8 + 2 = 0$

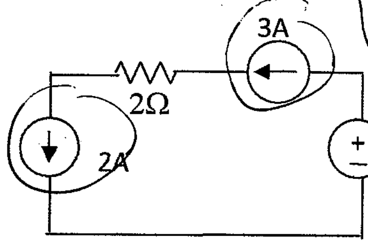
$I = \frac{4}{8} = \frac{1}{2}A$

$V_1 = \frac{1}{2}(8) = +4V$

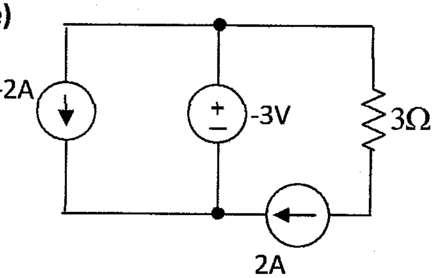
VALID

(b) Not valid

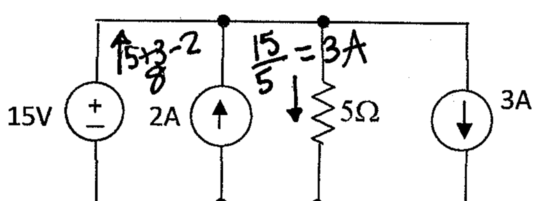
going in opposite directions



(e) VALID

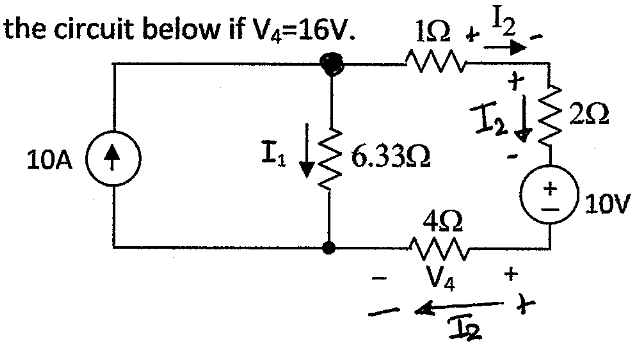


(c)



VALID

5. **Find I_1 in the circuit below if V_4=16V.**



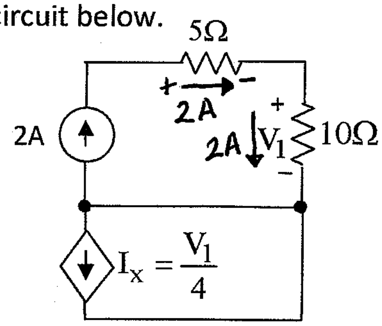
Ohm's Law: $V_4 = I_2(4)$, if $V_4=16$ then $16=I_2(4)$

$\therefore I_2 = 4A$

Current summation at top node: $-10+I_1+I_2=0$

$\therefore I_1 = 10-I_2 = 10-4 = \boxed{6A}$

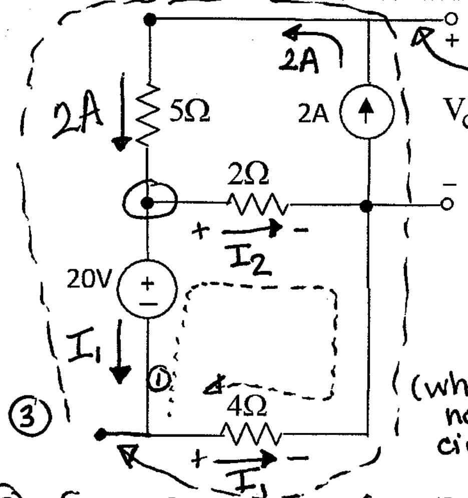
4. Find I_x in the circuit below.



$V_1 = 2A(10) = 20V$

$I_X = \frac{V_1}{4} = \frac{20}{4} = \boxed{5A}$

6. Use Kirchoff's laws and Ohm's Law to find the value of Vc.



An open wire does not conduct current. No current in this wire.

V-loop:

$① +20 - I_2(2) + I_1(4) = 0$

$\Sigma I:\ ② -2A + I_2 + I_1 = 0$

(where node is circled)

solving ② for I_1: $I_1 = (2 - I_2)$

plug into ① : $+20 - I_2(2) + (4)(2 - I_2) = 0$

$20 + 8 - I_2(2) - 4I_2 = 0$

$I_2(6) = 28$

$I_2 = \frac{28}{6}\ A$

$I_1 = (2 - I_2) = \frac{12}{6} - \frac{28}{6} = -\frac{16}{6}$

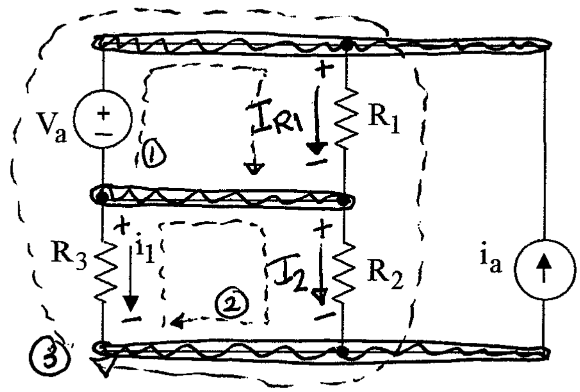
Taking a loop with V_c (desired value) in it.

follow path ③ $+20 + 2(5) - V_c + I_1(4) = 0$

$V_c = 20 + 10 + (-\frac{16}{6})(4)$

$V_c = 30 - 10.67 = \boxed{19.3V}$

7. Use Kirchoff's laws and Ohm's Law to find the expression for i_1. The expression can contain no other parameters than V_a, i_a, R_1, R_2, and/or R_3.



1. Identify nodes
2. Label currents through all R's.
3. Take V-loops (use Ohm's Law)
4. Take current summations.
5. State Ohm's Law (if needed)
6. Solve equation set

V-loops:

① $+V_a - I_{R1} R_1 = 0 \Rightarrow I_{R1} = \frac{V_a}{R_1}$

② $+i_1 R_3 - I_2(R_2) = 0$

ΣI: (bottom node): ③ $-i_1 - I_2 + i_a = 0$

- ① in terms of only I_{R1}
- solve ② for I_2: $I_2 = \frac{i_1 R_3}{R_2}$

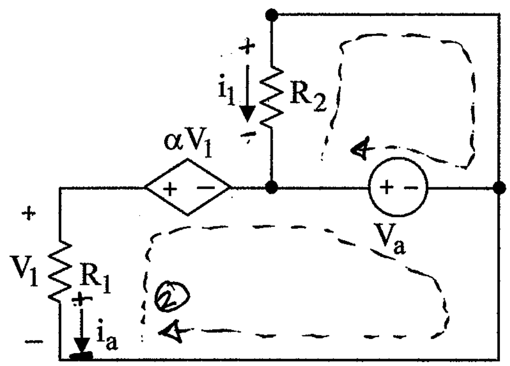
solve ③ for $I_2 = i_a - i_1$

plug into ②

$i_1 R_3 - i_a R_2 + i_1 R_2 = 0$

$$\boxed{i_1 = \frac{i_a R_2}{(R_3 + R_2)}}$$

8. Use Kirchoff's laws and Ohm's Law to find the expression for i_1. The expression can contain no other parameters than V_a, α, R_1, and/or R_2. (Hint: Eliminate V_1 from the expression)



V-loop: $+i_1 R_2 + V_a = 0$

$$\boxed{i_1 = -\frac{V_a}{R_2}}$$

If solving for i_a:

$$+ i_a R_1 - \alpha V_1 - V_a = 0$$

Use Ω Law: $V_1 = i_a \cdot R_1$

$$\therefore\ i_a R_1 - \alpha i_a R_1 - V_a = 0$$

$$i_a (1-\alpha) R_1 - V_a = 0$$

$$\boxed{i_a = \frac{V_a}{(1-\alpha)R_1}}$$

9. (a) Find i_1, i_2, i_3, and v_o.

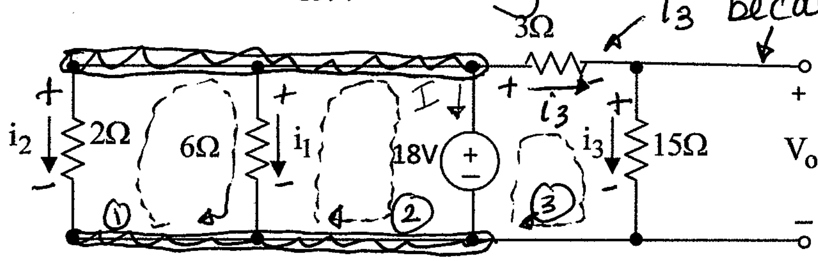
(b) Find the power dissipated in the 3Ω resistor and the power supply.

Note that 18 V is across each R. Using Ω Law:

$\frac{18}{2} = \boxed{9A = i_2}$

$\frac{18}{6} = \boxed{3A = i_1}$

$\frac{18}{18} = \boxed{1A = i_3}$



$+18 - i_3(3) - V_o = 0$

$18 - 3 - V_o = 0$

$\boxed{V_o = 15V}$

$power_{3\Omega} = i_3^2 \cdot (3) = \boxed{I^2 R}$

$power_{3\Omega} = (1)^2(3) = \boxed{3W}$

+ value means "absorbing"

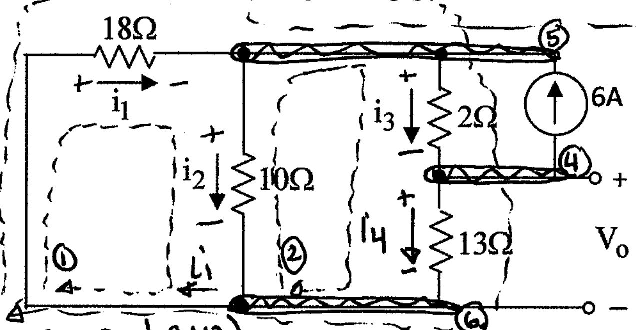
power power supply $= \boxed{I \ast V}$

$\Sigma I: +I_2 + I_1 + I + I_3 = 0$

$I = -(9+3+1) = -13$

power $= (-13)(18) = \boxed{-234W}$

10. Find i_1, i_2, i_3, and v_o.



V-loops: (use Ω Law)

① $-i_1(18) - i_2(10) = 0$

② $+i_2(10) - i_3(2) - i_4(13) = 0$

③ $-i_1(18) - i_3(2) - i_4(13) = 0$

ΣI:

④ $-i_3 + 6 + i_4 = 0$

⑤ $-i_1 + i_2 + i_3 - 6 = 0$

⑥ $+i_1 - i_2 - i_4 = 0$

use ① to solve for $i_2 \Rightarrow i_2 = \frac{-i_1 18}{10}$

use ④ to solve for $i_3 \Rightarrow i_3 = (6 + i_4)$

plug ①,④ into ②:

$-\frac{i_1(18)10}{10} - 12 - 2i_4 - i_4(13) = 0$

$i_4 = \frac{[-18i_1 - 12]}{15}$

plug into ⑥: $i_1 + i_1\frac{18}{10} + \frac{18}{15}i_1 + \frac{12}{15} = 0$

$i_1\left(\frac{150}{150} + \frac{18(15)}{150} + \frac{18(10)}{150}\right) = -\frac{12}{15}$

$i_1\left(\frac{150 + 270 + 180}{150}\right) = -\frac{12}{15}$

$i_1 = -\frac{12}{15} \cdot \frac{150}{600} = \boxed{-0.2A}$

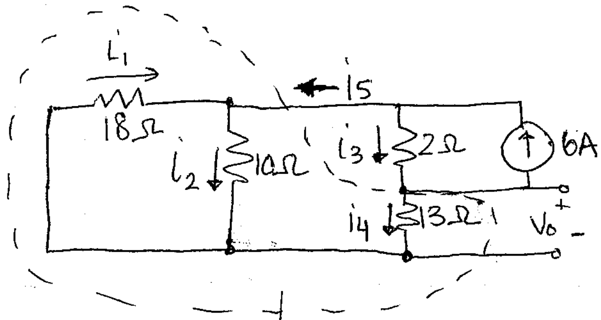
$\therefore i_4 = -\frac{18}{15}(-.2) - \frac{12}{15} = \boxed{-.56A}$

$\therefore i_2 = \frac{-18}{10}(-.2) = \boxed{.360A}$

use ohm's Law:

$V_o = i_4(13) = -.56(13) = \boxed{-7.3V}$

10.



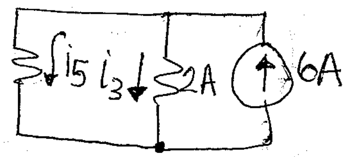
Using a current divider

Redraw: Combine

$(18 \| 10) + 13$

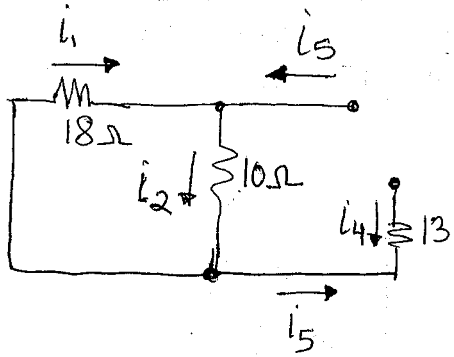
$= R$

$= \frac{18(10)}{28} + \frac{13(28)}{28} = \frac{544}{28}$



$$i_3 = \frac{6\left(\frac{544}{28}\right)}{\frac{544}{28} + 2} = \boxed{5.4\text{A}}$$

$$i_5 = 6 - 5.4 = \boxed{0.6\text{A}}$$



$$i_4 = -i_5 = \boxed{-0.6\text{A}}$$

$$i_1 = -\frac{i_5(10)}{28} = \frac{-0.6(10)}{28} = \boxed{-0.2\text{A}}$$

$$i_2 = \frac{i_5(18)}{28} = \boxed{0.4\text{A}}$$

$$V_o = i_4(13) = -0.6(13) = \boxed{-7.8\text{V}}$$