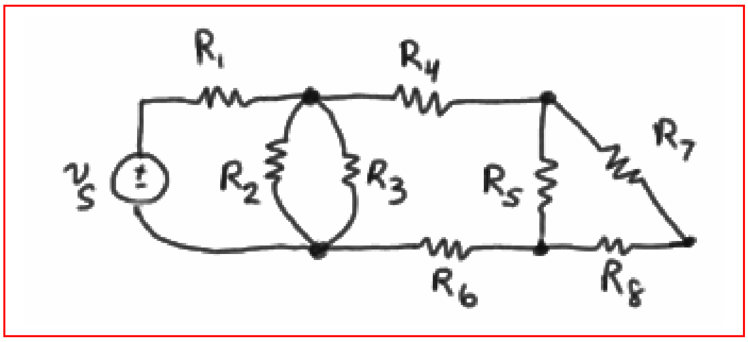
1. 

2. (*a*) $\boxed{\text{six nodes;}}$ (*b*) $\boxed{\text{nine branches.}}$

3. (*a*) Four nodes; (*b*) five branches; (*c*) path, yes – loop, no.

4. (*a*) $\boxed{\text{Five nodes;}}$

(*b*) $\boxed{\text{seven branches;}}$

(*c*) $\boxed{\text{path, yes – loop, no.}}$

5. (a) The number of nodes remains the same – four (4).

(b) The number of nodes is increased by one – to five (5).

(c)

i)	YES	
ii)	NO	– does not return to starting point
iii)	YES	
iv)	NO	– does not return to starting point
v)	NO	– point B is crossed twice

6. (a) By KCL at the bottom node: $2 - 3 + i_Z - 5 - 3 = 0$

So $\boxed{i_Z = 9 \text{ A.}}$

(b) If the left-most resistor has a value of 1 Ω, then 3 V appears across the parallel network (the '+' reference terminal being the bottom node) Thus, the value of the other resistor is given by

$$R = \frac{3}{-(-5)} = \boxed{600 \text{ m}\Omega\,.}$$

7. (*a*) $\boxed{3\text{ A};}$

(*b*) $\boxed{-3\text{ A};}$

(*c*) $\boxed{0.}$

8. By KCL, we may write:

$$5 + i_y + i_z = 3 + i_x$$

(*a*) $i_x = 2 + i_y + i_z = 2 + 2 + 0 = \boxed{4 \text{ A}}$

(*b*) $i_y = 3 + i_x - 5 - i_z$
$i_y = -2 + 2 - 2\, i_y$

Thus, we find that $\boxed{i_y = 0.}$

(*c*) $5 + i_y + i_z = 3 + i_x \rightarrow 5 + i_x + i_x = 3 + i_x$ so $i_x = 3 - 5 = \boxed{-2\text{A.}}$

9. Focusing our attention on the bottom left node, we see that $\boxed{i_x = 1 \text{ A.}}$

Focusing our attention next on the top right node, we see that $\boxed{i_y = 5 \text{ A}}$.

10. We obtain the current each bulb draws by dividing its power rating by the operating voltage (115 V):

$I_{100W} = 100/115 = 896.6$ mA

$I_{60W} = 60/115 = 521.7$ mA

$I_{40W} = 347.8$ mA

Thus, the total current draw is $\boxed{1.739 \text{ A.}}$

11. The DMM is connected in parallel with the 3 load resistors, across which develops the voltage we wish to measure. If the DMM appears as a short, then all 5 A flows through the DMM, and none through the resistors, resulting in a (false) reading of 0 V for the circuit undergoing testing. If, instead, the DMM has an infinite internal resistance, then no current is shunted away from the load resistors of the circuit, and a true voltage reading results.

12. In either case, a bulb failure will adversely affect the sign.

Still, in the parallel-connected case, at least 10 (up to 11) of the other characters will be lit, so the sign could be read and customers will know the restaurant is open for business.

13. (*a*) $v_y = 1(3v_x + i_z)$

v_x = 5 V and given that i_z = –3 A, we find that

$$v_y = 3(5) - 3 = \boxed{12 \text{ V}}$$

(*b*) $v_y = 1(3v_x + i_z) = -6 = 3v_x + 0.5$

Solving, we find that $v_x = (-6 - 0.5)/3 = \boxed{-2.167 \text{ V}}$.

14. (*a*) $i_x = v_1/10 + v_1/10 = 5$

$2v_1 = 50$

so $\boxed{v_1 = 25 \text{ V.}}$

By Ohm's law, we see that $i_y = v_2/10$

also, using Ohm's law in combination with KCL, we may write

$$i_x = v_2/10 + v_2/10 = i_y + i_y = 5 \text{ A}$$

Thus, $\boxed{i_y = 2.5 \text{ A.}}$

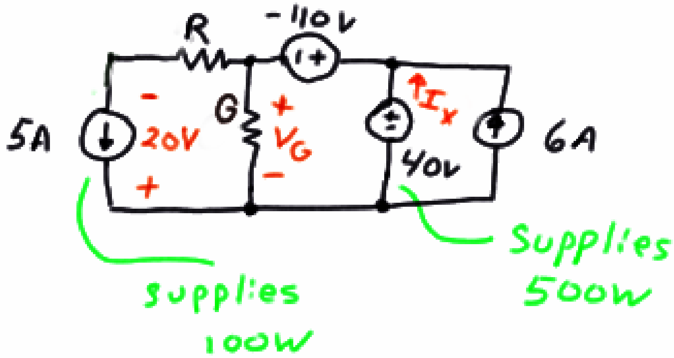
(*b*) From part (*a*), $i_x = 2\, v_1/\, 10$. Substituting the new value for v_1, we find that

$\boxed{i_x = 6/10 = 600 \text{ mA.}}$

Since we have found that $i_y = 0.5\, i_x$, $\boxed{i_y = 300 \text{ mA.}}$

(*c*) $\boxed{\text{no value – this is impossible.}}$

15. We begin by making use of the information given regarding the power generated by the 5-A and the 40-V sources. The 5-A source supplies 100 W, so it must therefore have a terminal voltage of 20 V. The 40-V source supplies 500 W, so it must therefore provide a current I_X of 12.5 A.



(1) By KVL, $-40 + (-110) + R(5) - 20 = 0$

Thus, $\boxed{R = 34\ \Omega.}$

(2) By KVL, $-V_G - (-110) + 40 = 0$

So $V_G = 150$ V

Now that we know the voltage across the unknown conductance G, we need only to find the current flowing through it to find its value by making use of Ohm's law.

KCL provides us with the means to find this current: The current flowing into the "+" terminal of the –110-V source is 12.5 + 6 = 18.5 A.

Then, $I_x = 18.5 - 5 = 13.5$ A

By Ohm's law, $I_x = G \cdot V_G$

So $G = 13.5/ 150$ or $\boxed{G = 90 \text{ mS}}$

16. (*a*) $-1 + 2 + 10i - 3.5 + 10i = 0$

Solving, $\boxed{i = 125 \text{ mA}}$

(*b*) $+10 + 1i - 2 + 2i + 2 - 6 + i = 0$

Solving, we find that $4i = -4$ or $\boxed{i = -1 \text{ A.}}$

17. **Circuit I.**

Starting at the bottom node and proceeding clockwise, we can write the KVL equation

$+7 - 5 - 2 - 1(i) = 0$

Which results in $\boxed{i = 0.}$

Circuit II.

Again starting with the bottom node and proceeding in a clockwise direction, we write the KVL equation

$-9 + 4i + 4i = 0$ (no current flows through either the -3 V source or the 2 Ω resistor)

Solving, we find that $i = 9/8$ A = $\boxed{1.125 \text{ A.}}$

18. Begin by defining a clockwise current i.

$-v_S + v_1 + v_2 = 0$ so $v_S = v_1 + v_2 = i(R_1 + R_2)$

and hence $i = \dfrac{v_S}{R_1 + R_2}$.

Thus, $v_1 = R_1 i = \dfrac{R_1}{R_1 + R_2} v_S$ and $v_2 = R_2 i = \dfrac{R_2}{R_1 + R_2} v_S$.

Q.E.D.

19. Given: (1) $V_d = 0$ and (2) no current flows into either terminal of V_d.

Calculate V_{out} by writing two KVL equations.

Begin by defining current i_1 flowing right through the 100 Ω resistor, and i_2 flowing right through the 470 Ω resistor.

$$-5 + 100i_1 + V_d = 0 \qquad [1]$$

$$-5 + 100i_1 + 470i_2 + V_{out} = 0 \qquad [2]$$

Making use of the fact that in this case $V_d = 0$, we find that i1 = 5/100 A.

Making use of the fact that no current flows into the input terminals of the op amp, $i_1 = i_2$. Thus, Eq. [2] reduces to

$-5 + 570(5/100) + V_{out} = 0$ or

$\boxed{V_{out} = -23.5 \text{ V}}$ (hence, the circuit is acting as a voltage amplifier.)

20. (a) By KVL, $-2 + v_x + 8 = 0$

so that $\boxed{v_x = -6 \text{ V.}}$

(b) By KCL at the top left node,

$i_{in} = 1 + I_S + v_x/4 - 6$

or $\boxed{i_{in} = 23 \text{ A}}$

(c) By KCL at the top right node,

$I_S + 4\, v_x = 4 - v_x/4$

So $\boxed{I_S = 29.5 \text{ A.}}$

(d) The power provided by the dependent source is $8(4v_x) = \boxed{-192 \text{ W.}}$

21. (a) Working from left to right,

$v_1 = 60$ V
$v_2 = 60$ V
$i_2 = 60/20 = 3$ A
$i_4 = v_1/4 = 60/4 = 15$ A
$v_3 = 5i_2 = 15$ V

By KVL, $-60 + v_3 + v_5 = 0$
$v_5 = 60 - 15 = 45$ V
$v_4 = v_5 = 45$

$i_5 = v_5/5 = 45/5 = 9$ A
$i_3 = i_4 + i_5 = 15 + 9 = 24$ A
$i_1 = i_2 + i_3 = 3 + 24 = 27$

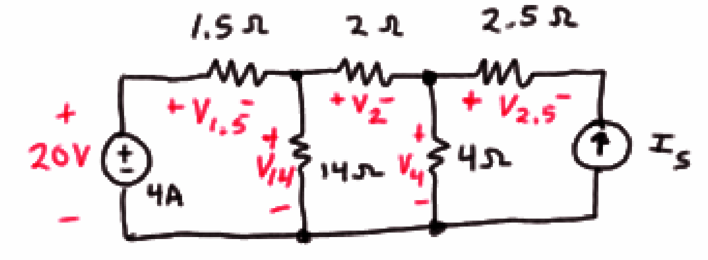
$v_1 = 60$ V	$i_1 = 27$ A
$v_2 = 60$ V	$i_2 = 3$ A
$v_3 = 15$ V	$i_3 = 24$ A
$v_4 = 45$ V	$i_4 = 15$ A
$v_5 = 45$ V	$i_5 = 9$ A

(b) It is now a simple matter to compute the power absorbed by each element:

p_1	$= -v_1i_1$	$= -(60)(27)$	$= -1.62$ kW
p_2	$= v_2i_2$	$= (60)(3)$	$= 180$ W
p_3	$= v_3i_3$	$= (15)(24)$	$= 360$ W
p_4	$= v_4i_4$	$= (45)(15)$	$= 675$ W
p_5	$= v_5i_5$	$= (45)(9)$	$= 405$ W

and it is a simple matter to check that these values indeed sum to zero as they should.

22. Refer to the labeled diagram below.



Beginning from the left, we find

$\boxed{p_{20V} = -(20)(4) = -80 \text{ W}}$

$v_{1.5} = 4(1.5) = 6$ V therefore $\boxed{p_{1.5} = (v_{1.5})^2/\ 1.5 = 24 \text{ W.}}$

$v_{14} = 20 - v_{1.5} = 20 - 6 = 14$ V $\boxed{\text{therefore } p_{14} = 14^2/\ 14 = 14 \text{ W.}}$

$i_2 = v_2/2 = v_{1.5}/1.5 - v_{14}/14 = 6/1.5 - 14/14 = 3$ A

Therefore $v_2 = 2(3) = 6$ V and $\boxed{p_2 = 6^2/2 = 18 \text{ W.}}$

$v_4 = v_{14} - v_2 = 14 - 6 = 8$ V therefore $\boxed{p_4 = 8^2/4 = 16 \text{ W}}$

$i_{2.5} = v_{2.5}/\ 2.5 = v_2/2 - v_4/4 = 3 - 2 = 1$ A

Therefore $v_{2.5} = (2.5)(1) = 2.5$ V and so $\boxed{p_{2.5} = (2.5)^2/2.5 = 2.5 \text{ W.}}$

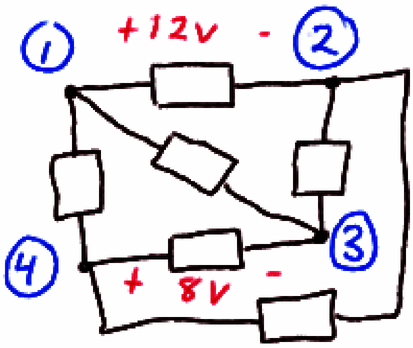
$I_{2.5} = -I_S$, thefore $I_S = -1$ A.

KVL allows us to write $-v_4 + v_{2.5} + v_{IS} = 0$

so $V_{I_S} = v_4 - v_{2.5} = 8 - 2.5 = 5.5$ V and $\boxed{p_{I_S} = -V_{I_S} I_S = 5.5 \text{ W.}}$

A quick check assures us that these power quantities sum to zero.

23. Sketching the circuit as described,



(*a*) $v_{14} = 0$.

$$\boxed{\begin{array}{ll} v_{13} = v_{43} & = 8\text{ V} \\ v_{23} = -v_{12} - v_{34} = -12 + 8 & = -4\text{ V} \\ v_{24} = v_{23} + v_{34} = -4 - 8 & = -12\text{ V} \end{array}}$$

(*b*) $v_{14} = 6$ V.

$$\boxed{\begin{array}{ll} v_{13} = v_{14} + v_{43} = 6 + 8 & = 14\text{ V} \\ v_{23} = v_{13} - v_{12} = 14 - 12 & = 2\text{ V} \\ v_{24} = v_{23} + v_{34} = 2 - 8 & = -6\text{ V} \end{array}}$$

(*c*) $v_{14} = -6$ V.

$$\boxed{\begin{array}{ll} v_{13} = v_{14} + v_{43} = -6 + 8 & = 2\text{ V} \\ v_{23} = v_{13} - v_{12} = 2 - 12 & = -10\text{ V} \\ v_{24} = v_{23} + v_{34} = -10 - 8 & = -18\text{ V} \end{array}}$$

24. (*a*) By KVL, $-12 + 5000I_D + V_{DS} + 2000I_D = 0$

Therefore, $\boxed{V_{DS} = 12 - 7(1.5) = 1.5 \text{ V.}}$

(*b*) By KVL, $- V_G + V_{GS} + 2000I_D = 0$

Therefore, $\boxed{V_{GS} = V_G - 2(2) = -1 \text{ V.}}$

25. Applying KVL around this series circuit,

$$-120 + 30i_x + 40i_x + 20i_x + v_x + 20 + 10i_x = 0$$

where v_x is defined across the unknown element X, with the "+" reference on top. Simplifying, we find that $100i_x + v_x = 100$

To solve further we require specific information about the element X and its properties.

(*a*) if X is a 100-Ω resistor,

$$v_x = 100i_x \text{ so we find that } 100\,i_x + 100\,i_x = 100.$$

Thus

$$i_x = 500 \text{ mA and } \boxed{p_x = v_x\, i_x = 25 \text{ W.}}$$

(*b*) If X is a 40-V independent voltage source such that $v_x = 40$ V, we find that

$$i_x = (100 - 40) / 100 = 600 \text{ mA and } \boxed{p_x = v_x\, i_x = 24 \text{ W}}$$

(*c*) If X is a dependent voltage source such that $v_x = 25ix$,

$$i_x = 100/125 = 800 \text{ mA and } \boxed{p_x = v_x\, i_x = 16 \text{ W.}}$$

(*d*) If X is a dependent voltage source so that $v_x = 0.8v_1$,
where $v_1 = 40i_x$, we have

$$100\,i_x + 0.8(40i_x) = 100$$

or $i_x = 100/132 = 757.6$ mA and $\boxed{p_x = v_x\, i_x = 0.8(40)(0.7576)^2 = 18.37 \text{ W.}}$

(*e*) If X is a 2-A independent current source, arrow up,

$$100(-2) + v_x = 100$$

so that $v_x = 100 + 200 = 300$ V and $\boxed{p_x = v_x\, i_x = -600 \text{ W}}$

26. (*a*) We first apply KVL:

$$-20 + 10i_1 + 90 + 40i_1 + 2v_2 = 0$$

where $v_2 = 10i_1$. Substituting,

$$70 + 70\, i_1 = 0$$

or $\boxed{i_1 = -1\text{ A.}}$

(*b*) Applying KVL,

$$-20 + 10i_1 + 90 + 40i_1 + 1.5v_3 = 0 \qquad [1]$$

where

$$v_3 = -90 - 10i_1 + 20 = -70 - 10\, i_1$$

alternatively, we could write

$$v_3 = 40i_1 + 1.5v_3 = -80i_1$$

Using either expression in Eq. [1], we find $\boxed{i_1 = 1\text{ A.}}$

(*c*) Applying KVL,

$$-20 + 10i_1 + 90 + 40i_1 - 15\, i_1 = 0$$

Solving, $\boxed{i_1 = -2\text{A.}}$

27. Applying KVL, we find that

$$-20 + 10i_1 + 90 + 40i_1 + 1.8v_3 = 0 \qquad [1]$$

Also, KVL allows us to write

$$v_3 = 40i_1 + 1.8v_3$$

$$v_3 = -50i_1$$

So that we may write Eq. [1] as

$$50i_1 - 1.8(50)i_1 = -70$$

or $i_1 = -70/-40 = 1.75$ A.

Since $v_3 = -50i_1 = -87.5$ V, no further information is required to determine its value.

The 90-V source is absorbing $(90)(i_1) = 157.5$ W of power and the dependent source is absorbing $(1.8v_3)(i_1) = -275.6$ W of power.

Therefore, *none of the conditions specified in (a) to (d) can be met by this circuit*.

28. (*a*) Define the charging current i as flowing clockwise in the circuit provided. By application of KVL,

$$-13 + 0.02i + Ri + 0.035i + 10.5 = 0$$

We know that we need a current $i = 4$ A, so we may calculate the necessary resistance

$$\boxed{R = [13 - 10.5 - 0.055(4)]/\ 4 = 570\ \text{m}\Omega}$$

(*b*) The total power delivered to the battery consists of the power absorbed by the 0.035-Ω resistance ($0.035i^2$), and the power absorbed by the 10.5-V ideal battery ($10.5i$). Thus, we need to solve the quadratic equation

$$0.035i^2 + 10.5i = 25$$

which has the solutions $i = -302.4$ A and $i = 2.362$ A.

In order to determine which of these two values should be used, we must recall that the idea is to charge the battery, implying that it is absorbing power, or that i as defined is positive. Thus, we choose $i = 2.362$ A, and, making use of the expression developed in part (*a*), we find that

$$\boxed{R = [13 - 10.5 - 0.055(2.362)]/\ 2.362 = 1.003\ \Omega}$$

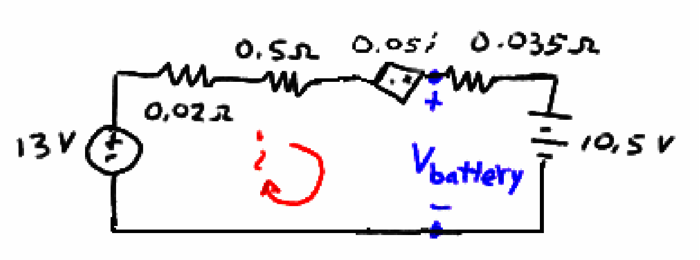
(*c*) To obtain a voltage of 11 V across the battery, we apply KVL:

$$0.035i + 10.5 = 11 \quad \text{so that } i = 14.29 \text{ A}$$

From part (*a*), this means we need

$$\boxed{R = [13 - 10.5 - 0.055(14.29)]/\ 14.29 = 119.9\ \text{m}\Omega}$$

29. Drawing the circuit described, we also define a clockwise current *i*.



By KVL, we find that

$$-13 + (0.02 + 0.5 - 0.05)i + 0.035i + 10.5 = 0$$

or that $i = (13 - 10.5)/0.505 = \boxed{4.951 \text{ A}}$

and $V_{battery} = 13 - (0.02 + 0.5)i = \boxed{10.43 \text{ V.}}$

30. Applying KVL about this simple loop circuit (the dependent sources are still linear elements, by the way, as they depend only upon a sum of voltages)

$$-40 + (5 + 25 + 20)i - (2v_3 + v_2) + (4v_1 - v_2) = 0 \qquad [1]$$

where we have defined i to be flowing in the clockwise direction, and $v_1 = 5i$, $v_2 = 25i$, and $v_3 = 20i$.

Performing the necessary substition, Eq. [1] becomes

$$50i - (40i + 25i) + (20i - 25i) = 40$$

so that $i = 40/\text{-}20 = -2$ A

Computing the absorbed power is now a straightforward matter:

p_{40V}	$= (40)(-i)$	= 80 W
$p_{5\Omega}$	$= 5i^2$	= 20 W
$p_{25\Omega}$	$= 25i^2$	= 100 W
$p_{20\Omega}$	$= 20i^2$	= 80 W
$p_{depsrc1}$	$= (2v_3 + v_2)(-i) = (40i + 25i)$	= -260 W
$p_{depsrc2}$	$= (4v_1 - v_2)(-i) = (20i - 25i)$	= -20 W

and we can easily verify that these quantities indeed sum to zero as expected.

31. We begin by defining a clockwise current i.

(a) $i = 12/(40 + R)$ mA, with R expressed in kΩ.

We want $i^2 \cdot 25 = 2$

or
$$\left(\frac{12}{40+R}\right)^2 \cdot 25 = 2$$

Rearranging, we find a quadratic expression involving R:

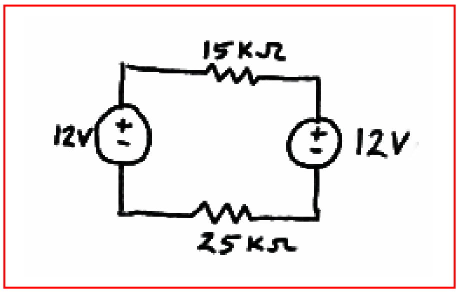
$$R^2 + 80R - 200 = 0$$

which has the solutions R = -82.43 kΩ and R = 2.426 kΩ. Only the latter is a physical solution, so

$$\boxed{R = 2.426 \text{ k}\Omega.}$$

(b) We require $i \cdot 12 = 3.6$ or $i = 0.3$ mA
From the circuit, we also see that $i = 12/(15 + R + 25)$ mA.
Substituting the desired value for i, we find that the required value of R is $\boxed{R = 0.}$

(c)



32. By KVL,

$$-12 + (1 + 2.3 + R_{\text{wire segment}})\, i \;=\; 0$$

The wire segment is a 3000–ft section of 28–AWG solid copper wire. Using Table 2.3, we compute its resistance as

$$(16.2\ \text{m}\Omega/\text{ft})(3000\ \text{ft}) \;=\; 48.6\ \Omega$$

which is certainly *not* negligible compared to the other resistances in the circuit!

Thus,

$$i \;=\; 12/(1 + 2.3 + 48.6) \;=\; \boxed{231.2\ \text{mA}}$$

33. We can apply Ohm's law to find an expression for v_o:

$$v_o = 1000(-g_m v_\pi)$$

We do not have a value for v_π, but KVL will allow us to express that in terms of v_o, which we *do* know:

$$-10\times10^{-3} \cos 5t + (300 + 50\times10^{3})\, i = 0$$

where i is defined as flowing clockwise.

Thus, $v_\pi = 50\times10^{3}\, i = 50\times10^{3}\,(10\times10^{-3} \cos 5t) / (300 + 50\times10^{3})$

$= 9.940\times10^{-3} \cos 5t$ V

and we by substitution we find that

$$v_o = 1000(-25\times10^{-3})(9.940\times10^{-3} \cos 5t)$$

$$= \boxed{-248.5 \cos 5t \text{ mV}}$$

34. By KVL, we find that

$$-3 + 100\, I_D + V_D = 0$$

Substituting $I_D = 3\times10^{-6}(e^{V_D / 27\times10^{-3}} - 1)$, we find that

$$-3 + 300\times10^{-6}(e^{V_D / 27\times10^{-3}} - 1) + V_D = 0$$

This is a transcendental equation. Using a scientific calculator or a numerical software package such as MATLAB®, we find

$$V_D = \boxed{246.4\text{ mV}}$$

Let's assume such software-based assistance is unavailable. In that case, we need to "guess" a value for V_D, substitute it into the right hand side of our equation, and see how close the result is to the left hand side (in this case, zero).

GUESS	RESULT
0	–3
1	3.648×10^{12}
0.5	3.308×10^{4}
0.25	0.4001
0.245	–0.1375
0.248	0.1732
0.246	–0.0377

oops

better

At this point, the error is getting much smaller, and our confidence is increasing as to the value of V_D.

35. Define a voltage v_x, "+" reference on the right, across the dependent current source. Note that in fact v_x appears across each of the four elements. We first convert the 10 mS conductance into a 100–Ω resistor, and the 40–mS conductance into a 25–Ω resistor.

(*a*) Applying KCL, we sum the currents flowing into the right–hand node:

$$5 - v_x / 100 - v_x / 25 + 0.8\, i_x = 0 \quad [1]$$

This represents one equation in two unknowns. A second equation to introduce at this point is

$i_x = v_x /25$ so that Eq. [1] becomes

$$5 - v_x / 100 - v_x / 25 + 0.8\,(v_x / 25) = 0$$

Solving for v_x, we find $v_x = 277.8$ V. It is a simple matter now to compute the power absorbed by each element:

P_{5A}	$= -5\, v_x$	$= -1.389$ kW
$P_{100\Omega}$	$= (v_x)^2 / 100$	$=$ 771.7 W
$P_{25\Omega}$	$= (v_x)^2 / 25$	$=$ 3.087 kW
P_{dep}	$= -v_x(0.8\, i_x) = -0.8\,(v_x)^2 / 25$	$= -2.470$ kW

A quick check assures us that the calculated values sum to zero, as they should.

(*b*) Again summing the currents into the right–hand node,

$$5 - v_x / 100 - v_x / 25 + 0.8\, i_y = 0 \quad [2]$$

where $i_y = 5 - v_x/100$

Thus, Eq. [2] becomes

$$5 - v_x / 100 - v_x / 25 + 0.8(5) - 0.8\,(i_y) / 100 = 0$$

Solving, we find that v_x x = 155.2 V and $i_y = 3.448$ A

So that

P_{5A}	$= -5\, v_x$	$= -776.0$ W
$P_{100\Omega}$	$= (v_x)^2 / 100$	$=$ 240.9 W
$P_{25\Omega}$	$= (v_x)^2 / 25$	$=$ 963.5 W
P_{dep}	$= -v_x(0.8\, i_y)$	$= -428.1$ W

A quick check shows us that the calculated values sum to 0.3, which is reasonably close to zero compared to the size of the terms (small roundoff errors accumulated).

36. Define a voltage v with the "+" reference at the top node. Applying KCL and summing the currents flowing out of the top node,

$$v/5{,}000 \ + \ 4\times10^{-3} \ + \ 3i_1 \ + \ v/20{,}000 \ = \ 0 \quad [1]$$

This, unfortunately, is one equation in two unknowns, necessitating the search for a second suitable equation. Returning to the circuit diagram, we observe that

$$i_1 \quad = \quad 3\, i_1 \ + \ v/2{,}000$$

or

$$i_1 \quad = \quad -v/40{,}000 \qquad [2]$$

Upon substituting Eq. [2] into Eq. [1], Eq. [1] becomes,

$$v/5{,}000 \ + \ 4\times10^{-3} \ - \ 3v/40{,}000 \ + \ v/20{,}000 \ = \ 0$$

Solving, we find that

$$v = -22.86 \text{ V}$$

and

$$i_1 \ = \ 571.4 \ \mu\text{A}$$

Since $i_x = i_1$, we find that $i_x = \boxed{571.4 \ \mu\text{A}.}$

37. Define a voltage v_x with its "+" reference at the center node. Applying KCL and summing the currents into the center node,

$$8 - v_x/6 + 7 - v_x/12 - v_x/4 = 0$$

Solving, $v_x = 30$ V.

It is now a straightforward matter to compute the power absorbed by each element:

P_{8A}	$= -8\ v_x$	$= -240$ W
$P_{6\Omega}$	$= (v_x)^2 / 6$	$= 150$ W
P_{8A}	$= -7\ v_x$	$= -210$ W
$P_{12\Omega}$	$= (v_x)^2 / 12$	$= 75$ W
$P_{4\Omega}$	$= (v_x)^2 / 4$	$= 225$ W

and a quick check verifies that the computed quantities sum to zero, as expected.

38. (a) Define a voltage v across the 1–kΩ resistor with the "+" reference at the top node. Applying KCL at this top node, we find that

$$80\times10^{-3} - 30\times10^{-3} = v/1000 + v/4000$$

Solving,

$$v = (50\times10^{-3})(4\times10^{6} / 5\times10^{3}) = 40 \text{ V}$$

and $P_{4k\Omega} = v^2/4000 = \boxed{400 \text{ mW}}$

(b) Once again, we first define a voltage v across the 1–kΩ resistor with the "+" reference at the top node. Applying KCL at this top node, we find that

$$80\times10^{-3} - 30\times10^{-3} - 20\times10^{-3} = v/1000$$

Solving,

$$v = 30 \text{ V}$$

and $P_{20mA} = v \cdot 20\times10^{-3} = \boxed{600 \text{ mW}}$

(c) Once again, we first define a voltage v across the 1–kΩ resistor with the "+" reference at the top node. Applying KCL at this top node, we find that

$$80\times10^{-3} - 30\times10^{-3} - 2i_x = v/1000$$

where

$$i_x = v/1000$$

so that

$$80\times10^{-3} - 30\times10^{-3} = 2v/1000 + v/1000$$

and

$$v = 50\times10^{-3}(1000)/3 = 16.67 \text{ V}$$

Thus, $P_{dep} = v \cdot 2i_x = \boxed{555.8 \text{ mW}}$

(d) We note that $i_x = 60/1000 = 60$ mA. KCL stipulates that (viewing currents into and out of the top node)

$$80 - 30 + i_s = i_x = 60$$

Thus, $i_s = 10$ mA

and $P_{60V} = 60(-10) \text{ mW} = \boxed{-600 \text{ mW}}$

39. (*a*) To cancel out the effects of both the 80-mA and 30-mA sources, i_S must be set to

$\boxed{i_S = -50 \text{ mA.}}$

(*b*) Define a current is flowing out of the "+" reference terminal of the independent voltage source. Interpret "no power" to mean "zero power."

Summing the currents flowing into the top node and invoking KCL, we find that

$$80\times10^{-3} - 30\times10^{-3} - v_S/1\times10^{3} + i_S = 0$$

Simplifying slightly, this becomes

$$50 - v_S + 10^3 i_S = 0 \qquad [1]$$

We are seeking a value for v_S such that $v_S \cdot i_S = 0$. Clearly, setting $v_S = 0$ will achieve this. From Eq. [1], we also see that setting $v_S = 50$ V will work as well.

40. Define a voltage v_9 across the 9-Ω resistor, with the "+" reference at the top node.

(*a*) Summing the currents into the right-hand node and applying KCL,

$$5 + 7 = v_9 / 3 + v_9 / 9$$

Solving, we find that $v_9 = 27$ V. Since $i_x = v_9 / 9$, $\boxed{i_x = 3 \text{ A.}}$

(*b*) Again, we apply KCL, this time to the top left node:

$$2 - v_8 / 8 + 2i_x - 5 = 0$$

Since we know from part (*a*) that $i_x = 3$ A, we may calculate $\boxed{v_8 = 24 \text{ V.}}$

(*c*) $p_{5A} = (v_9 - v_8) \cdot 5 = \boxed{15 \text{ W.}}$

41. Define a voltage v_x across the 5-A source, with the "+" reference on top.

Applying KCL at the top node then yields

$$5 + 5v_1 - v_x / (1 + 2) - v_x / 5 = 0 \qquad [1]$$

where $v_1 = 2[v_x /(1 + 2)] = 2 v_x / 3$.

Thus, Eq. [1] becomes

$$5 + 5(2 v_x / 3) - v_x / 3 - v_x / 5 = 0$$

or $75 + 50 v_x - 5 v_x - 3 v_x = 0$, which, upon solving, yields $v_x = -1.786$ V.

The power absorbed by the 5-Ω resistor is then simply $(v_x)^2/5 = \boxed{638.0 \text{ mW.}}$

42. Despite the way it may appear at first glance, this is actually a simple node-pair circuit. Define a voltage v across the elements, with the "+" reference at the top node.

Summing the currents leaving the top node and applying KCL, we find that

$$2 + 6 + 3 + v/5 + v/5 + v/5 = 0$$

or $v = -55/3 = -18.33$ V. The power supplied by each source is then computed as:

$$\boxed{\begin{aligned} p_{2A} &= -v(2) = 36.67 \text{ W} \\ p_{6A} &= -v(6) = 110 \text{ W} \\ p_{3A} &= -v(3) = 55 \text{ W} \end{aligned}}$$

The power absorbed by each resistor is simply $v^2/5 = 67.22$ W for a total of 201.67 W, which is the total power supplied by all sources. If instead we want the "power supplied" by the resistors, we multiply by -1 to obtain $\boxed{-201.67 \text{ W}}$. Thus, the sum of the supplied power of each circuit element is zero, as it should be.

43. Defining a voltage V_x across the 10-A source with the "+" reference at the top node, KCL tells us that $10 = 5 + I_{1\Omega}$, where $I_{1\Omega}$ is defined flowing downward through the 1-Ω resistor.

Solving, we find that $I_{1\Omega} = 5$ A, so that $V_x = (1)(5) = 5$ V.

So, we need to solve

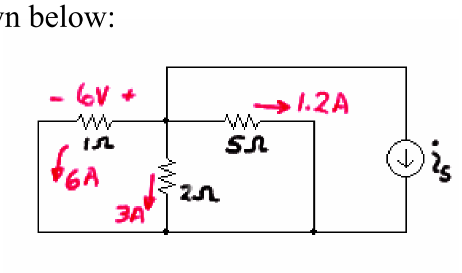
$$V_x = 5 = 5(0.5 + R_{segment})$$

with $R_{segment} = 500$ mΩ.

From Table 2.3, we see that 28-AWG solid copper wire has a resistance of 65.3 mΩ/ft. Thus, the total number of miles needed of the wire is

$$\frac{500 \text{ m}\Omega}{(65.3 \text{ m}\Omega/\text{ft})(5280 \text{ ft/mi})} = \boxed{1.450 \times 10^{-3} \text{ miles}}$$

44. Since $v = 6$ V, we know the current through the 1-Ω resistor is 6 A, the current through the 2-Ω resistor is 3 A, and the current through the 5-Ω resistor is 6/5 = 1.2 A, as shown below:



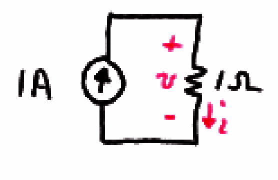
By KCL, $6 + 3 + 1.2 + i_S = 0$ or $\boxed{i_S = -10.2 \text{ A.}}$

45. (*a*) Applying KCL, $1 - i - 3 + 3 = 0$ so $\boxed{i = 1 \text{ A.}}$

(*b*) Looking at the left part of the circuit, we see 1 + 3 = 4 A flowing into the unknown current source, which, by virtue of KCL, must therefore be a 4-A current source. Thus, KCL at the node labeled with the "+" reference of the voltage *v* gives

$$4 - 2 + 7 - i = 0 \qquad \text{or} \qquad \boxed{i = 9 \text{ A}}$$

46. (*a*) We may redraw the circuit as

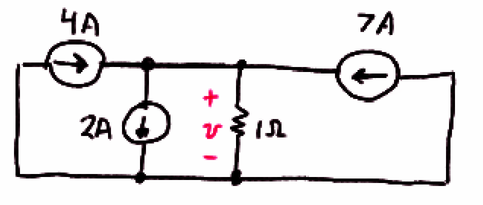


Then, we see that v = (1)(1) = $\boxed{1\text{ V.}}$

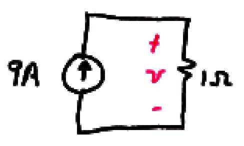
(*b*) We may combine all sources to the right of the 1-Ω resistor into a single 7-A current source. On the left, the two 1-A sources in series reduce to a single 1-A source.

The new 1-A source and the 3-A source combine to yield a 4-A source in series with the unknown current source which, by KCL, must be a 4-A current source.

At this point we have reduced the circuit to



Further simplification is possible, resulting in

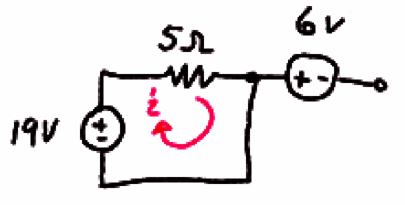


From which we see clearly that v = (9)(1) = $\boxed{9\text{ V.}}$

47. (*a*) Combine the 12-V and 2-V series connected sources to obtain a new 12 – 2 = 10 V source, with the "+" reference terminal at the top. The result is two 10-V sources in parallel, which is permitted by KVL. Therefore,

$$\boxed{i = 10/1000 = 10 \text{ mA.}}$$

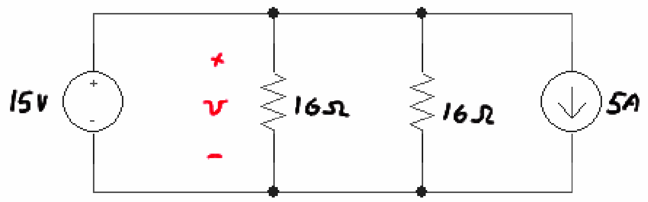
(*b*) No current flows through the 6-V source, so we may neglect it for this calculation. The 12-V, 10-V and 3-V sources are connected in series as a result, so we replace them with a 12 + 10 –3 = 19 V source as shown



Thus, $\boxed{i = 19/5 = 3.8 \text{ A.}}$

48. We first combine the 10-V and 5-V sources into a single 15-V source, with the "+" reference on top. The 2-A and 7-A current sources combine into a 7 – 2 = 5 A current source (arrow pointing down); although these two current sources may not appear to be in parallel at first glance, they actually are.

Redrawing our circuit,



we see that v = 15 V (note that we can completely the ignore the 5-A source here, since we have a voltage source directly across the resistor). Thus,

$$P_{16\Omega} = v^2/16 = \boxed{14.06 \text{ W.}}$$

Returning to the original circuit, we see that the 2 A source is in parallel with both 16 Ω resistors, so that it has a voltage of 15 V across it as well (the same goes for the 7 A source). Thus,

$$P_{2A}\Big|_{abs} = -15(2) = \boxed{-30 \text{ W}}$$
$$P_{7A}\Big|_{abs} = -15(-7) = \boxed{105 \text{ W}}$$

Each resistor draws 15/16 A, so the 5 V and 10 V sources each see a current of

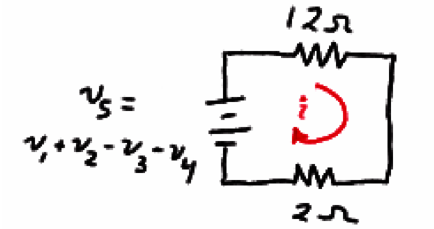
30/16 + 5 = 6.875 A flowing through them.

Thus,

$$P_{5V}\Big|_{abs} = -5(6.875) = \boxed{-34.38 \text{ W}}$$
$$P_{10V}\Big|_{abs} = -10(6.875) = \boxed{-68.75 \text{ W}}$$

which sum to -0.01 W, close enough to zero compared to the size of the terms (roundoff error accumulated).

49. We can combine the voltage sources such that



$i = v_S / 14$

(*a*) $v_S = 10 + 10 - 6 - 6 = 20 - 12 = 8$
Therefore

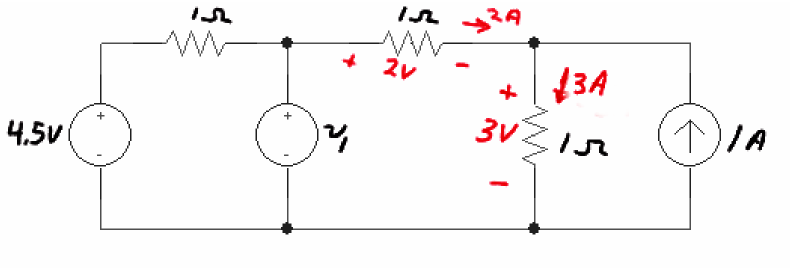
$$i = 8/14 = \boxed{571.4 \text{ mA.}}$$

(*b*) $v_S = 3 + 2.5 - 3 - 2.5 = 0$ Therefore $\boxed{i = 0.}$

(*c*) $v_S = -3 + 1.5 - (-0.5) - 0 = -1$ V
Therefore

$$i = -1/14 = \boxed{-71.43 \text{ mA.}}$$

50. We first simplify as shown, making use of the fact that we are told $i_x = 2$ A to find the voltage across the middle and right-most 1-Ω resistors as labeled.



By KVL, then, we find that $\boxed{v_1 = 2 + 3 = 5 \text{ V.}}$

51. We see that to determine the voltage v we will need v_x due to the presence of the dependent current soruce. So, let's begin with the right-hand side, where we find that

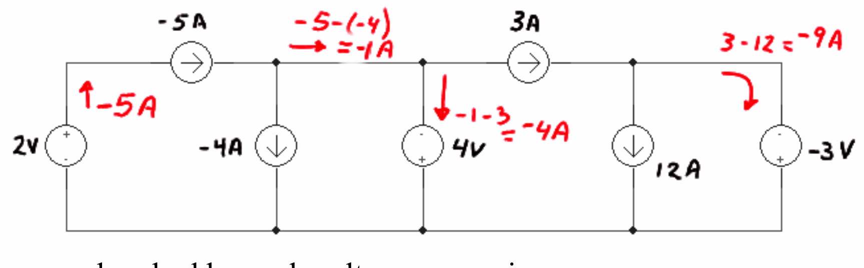
$$v_x = 1000(1 - 3) \times 10^{-3} = -2 \text{ V.}$$

Returning to the left-hand side of the circuit, and summing currents into the top node, we find that

$$(12 - 3.5) \times 10^{-3} + 0.03\, v_x = v/10\times 10^3$$

or $\boxed{v = -515 \text{ V.}}$

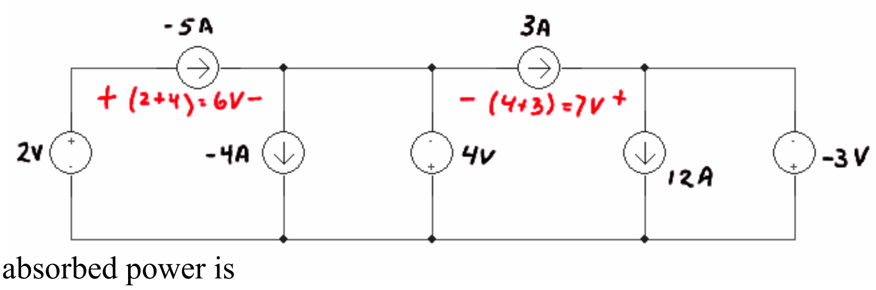
52. (*a*) We first label the circuit with a focus on determining the current flowing through each voltage source:



Then the power absorbed by each voltage source is

P_{2V}	$= -2(-5)$	$= 10$ W
P_{4V}	$= -(-4)(4)$	$= 16$ W
P_{-3V}	$= -(-9)(-3)$	$= -27$ W

For the current sources,



So that the absorbed power is

P_{-5A}	$= +(-5)(6)$	$= -30$ W
P_{-4A}	$= -(-4)(4)$	$= 16$ W
P_{3A}	$= -(3)(7)$	$= -21$ W
P_{12A}	$= -(12)(-3)$	$= 36$ W

A quick check assures us that these absorbed powers sum to zero as they should.

(*b*) We need to change the 4-V source such that the voltage across the –5-A source drops to zero. Define V_x across the –5-A source such that the "+" reference terminal is on the left. Then,

$$-2 + V_x - V_{needed} = 0$$

or $\boxed{V_{needed} = -2 \text{ V.}}$

53. We begin by noting several things:
(1) The bottom resistor has been shorted out;
(2) the far-right resistor is only connected by one terminal and therefore does not affect the equivalent resistance *as seen from the indicated terminals*;
(3) All resistors to the right of the top left resistor have been shorted.

Thus, from the indicated terminals, we only see the single 1-kΩ resistor, so that
$\boxed{R_{eq} = 1\ \text{k}\Omega.}$

54. (*a*) We see $1\Omega \parallel (1\ \Omega + 1\ \Omega) \parallel (1\ \Omega + 1\ \Omega + 1\ \Omega)$

$= 1\Omega \parallel 2\ \Omega \parallel 3\ \Omega$

$\boxed{= 545.5\ \text{m}\Omega}$

(*b*) $1/R_{eq} = 1 + 1/2 + 1/3 + \ldots + 1/N$

Thus, $\boxed{R_{eq} = [1 + 1/2 + 1/3 + \ldots + 1/N]^{-1}}$

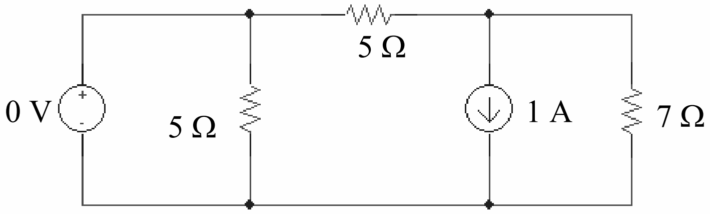
55. (*a*) 5 kΩ = $\boxed{10\ \text{k}\Omega \,\|\, 10\ \text{k}\Omega}$

(*b*) 57 333 Ω = $\boxed{47\ \text{k}\Omega + 10\ \text{k}\Omega + 1\ \text{k}\Omega \,\|\, 1\text{k}\Omega \,\|\, 1\text{k}\Omega}$

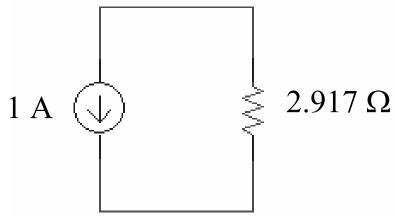
(*c*) 29.5 kΩ = $\boxed{47\ \text{k}\Omega \,\|\, 47\ \text{k}\Omega + 10\ \text{k}\Omega \,\|\, 10\ \text{k}\Omega + 1\ \text{k}\Omega}$

56. (*a*) no simplification is possible using only source and/or resistor combination techniques.

(*b*) We first simplify the circuit to



and then notice that the 0-V source is shorting out one of the 5-Ω resistors, so a further simplification is possible, noting that 5 Ω || 7 Ω = 2.917 Ω:

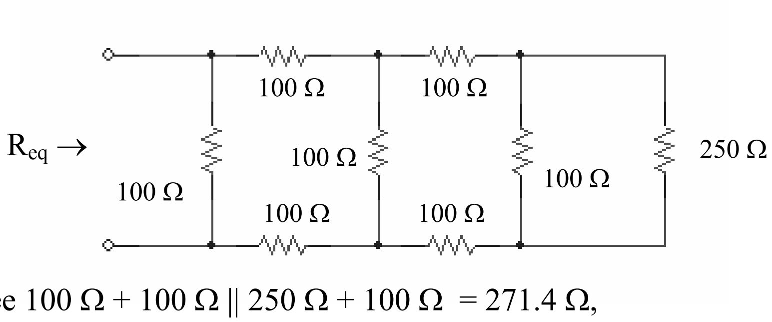


57. $R_{eq} = 1\ \text{k}\Omega + 2\ \text{k}\Omega \parallel 2\ \text{k}\Omega + 3\ \text{k}\Omega \parallel 3\ \text{k}\Omega + 4\ \text{k}\Omega \parallel 4\ \text{k}\Omega$

$= 1\ \text{k}\Omega + 1\ \text{k}\ \Omega + 1.5\ \text{k}\Omega + 2\ \text{k}\Omega$

$\boxed{= 5.5\ \text{k}\Omega.}$

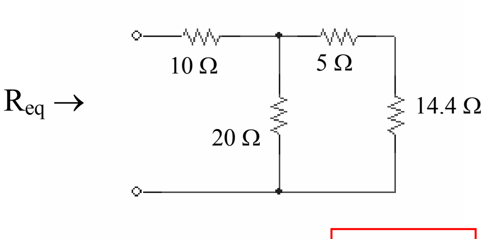
58. (*a*) Working from right to left, we first see that we may combine several resistors as $100\ \Omega + 100\ \Omega \parallel 100\ \Omega + 100\ \Omega = 250\ \Omega$, yielding the following circuit:



Next, we see $100\ \Omega + 100\ \Omega \parallel 250\ \Omega + 100\ \Omega = 271.4\ \Omega$,
and subsequently $100\ \Omega + 100\ \Omega \parallel 271.4\ \Omega + 100\ \Omega = 273.1\ \Omega$,
and, finally,

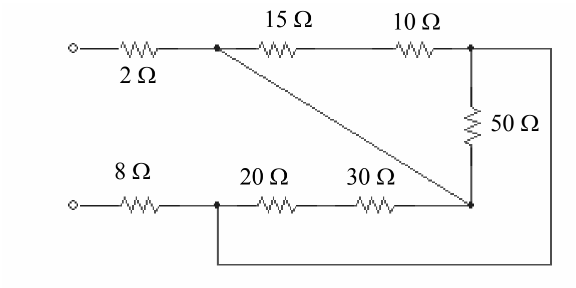
$$R_{eq} = 100\ \Omega \parallel 273.1\ \Omega = \boxed{73.20\ \Omega.}$$

(*b*) First, we combine $24\ \Omega \parallel (50\ \Omega + 40\ \Omega) \parallel 60\ \Omega = 14.4\ \Omega$, which leaves us with

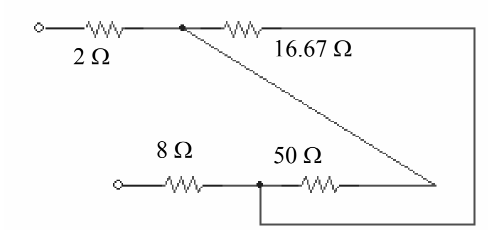


Thus, $R_{eq} = 10\ \Omega + 20\ \Omega \parallel (5 + 14.4\ \Omega) = \boxed{19.85\ \Omega.}$

(*c*) First combine the 10-Ω and 40-Ω resistors and redraw the circuit:



We now see we have $(10\ \Omega + 15\ \Omega) \parallel 50\ \Omega = 16.67\ \Omega$. Redrawing once again,



where the equivalent resistance is seen to be $2\ \Omega + 50\ \Omega \parallel 16.67\ \Omega + 8\ \Omega = \boxed{22.5\ \Omega.}$

59. (*a*) R_{eq} = [(40 Ω + 20 Ω) || 30 Ω + 80 Ω] || 100 Ω + 10 Ω = $\boxed{60\ \Omega.}$

(*b*) R_{eq} = 80 Ω = [(40 Ω + 20 Ω) || 30 Ω + R] || 100 Ω + 10 Ω

70 Ω = [(60 Ω || 30 Ω) + R] || 100 Ω

1/70 = 1/(20 + R) + 0.01

20+ R = 233.3 Ω therefore $\boxed{R = 213.3\ \Omega.}$

(*c*) R = [(40 Ω + 20 Ω) || 30 Ω + R] || 100 Ω + 10 Ω

R – 10 Ω = [20 + R] || 100

1/(R – 10) = 1/(R + 20) + 1/ 100

$3000 = R^2 + 10R - 200$

Solving, we find R = -61.79 Ω or R = 51.79 Ω.
Clearly, the first is not a physical solution, so $\boxed{R = 51.79\ \Omega.}$

60. (*a*) $25\ \Omega = \boxed{100\ \Omega \parallel 100\ \Omega \parallel 100\ \Omega \parallel 100\ \Omega}$

(*b*) $60\ \Omega = \boxed{[(100\ \Omega \parallel 100\ \Omega) + 100\ \Omega] \parallel 100\ \Omega}$

(*c*) $40\ \Omega = \boxed{(100\ \Omega + 100\ \Omega) \parallel 100\ \Omega \parallel 100\ \Omega}$

61. $R_{eq} = [(5\ \Omega \,||\, 20\ \Omega) + 6\ \Omega] \,||\, 30\ \Omega + 2.5\ \Omega = 10\ \Omega$

The source therefore provides a total of 1000 W and a current of 100/10 = 10 A.

$P_{2.5\Omega} = (10)^2 \cdot 2.5 = \boxed{250\text{ W}}$

$V_{30\Omega} = 100 - 2.5(10) = 75\text{ V}$

$P_{30\Omega} = 75^2/ 30 = \boxed{187.5\text{ W}}$

$I_{6\Omega} = 10 - V_{30\Omega}/30 = 10 - 75/30 = 7.5\text{ A}$

$P_{6\Omega} = (7.5)^2 \cdot 6 = \boxed{337.5\text{ W}}$

$V_{5\Omega} = 75 - 6(7.5) = 30\text{ V}$

$P_{5\Omega} = 30^2/ 5 = \boxed{180\text{ W}}$

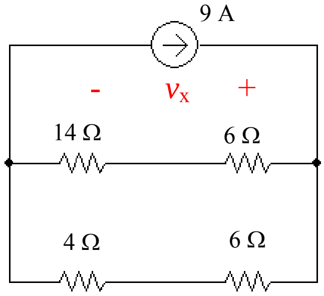
$V_{20\Omega} = V_{5\Omega} = 30\text{ V}$

$P_{20\Omega} = 30^2/20 = \boxed{45\text{ W}}$

We check our results by verifying that the absorbed powers in fact add to 1000 W.

62. To begin with, the 10-Ω and 15-Ω resistors are in parallel (= 6 Ω), and so are the 20-Ω and 5-Ω resistors (= 4 Ω).

Also, the 4-A, 1-A and 6-A current sources are in parallel, so they can be combined into a single 4 + 6 – 1 = 9 A current source as shown:



Next, we note that (14 Ω + 6 Ω) || (4 Ω + 6 Ω) = 6.667 Ω
so that

$$\boxed{v_x = 9(6.667) = 60 \text{ V}}$$

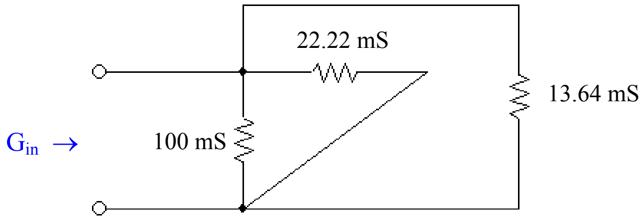
and

$$\boxed{i_x = -60/10 = -6 \text{ A.}}$$

63. (*a*) Working from right to left, and borrowing *x* || *y* notation from resistance calculations to indicate the operation *xy*/(*x* + *y*),

$$
\begin{aligned}
G_{in} &= \{[(6 \parallel 2 \parallel 3) + 0.5] \parallel 1.5 \parallel 2.5 + 0.8\} \parallel 4 \parallel 5 \text{ mS} \\
&= \{[(1) + 0.5] \parallel 1.5 \parallel 2.5 + 0.8\} \parallel 4 \parallel 5 \text{ mS} \\
&= \{1.377\} \parallel 4 \parallel 5 \\
&= 0.8502 \text{ mS} \quad = \boxed{850.2 \text{ mS}}
\end{aligned}
$$

(*b*) The 50-mS and 40-mS conductances are in series, equivalent to (50(40)/90 = 22.22 mS. The 30-mS and 25-mS conductances are also in series, equivalent to 13.64 mS. Redrawing for clarity,



we see that G_{in} = 10 + 22.22 + 13.64 = $\boxed{135.9 \text{ mS.}}$

64. The bottom four resistors between the 2-Ω resistor and the 30-V source are shorted out. The 10-Ω and 40-Ω resistors are in parallel (= 8 Ω), as are the 15-Ω and 60-Ω (=12 Ω) resistors. These combinations are in series.

Define a clockwise current I through the 1-Ω resistor:

$$I = (150 - 30)/(2 + 8 + 12 + 3 + 1 + 2) = 4.286 \text{ A}$$

$P_{1\Omega} = I^2 \cdot 1 = \boxed{18.37 \text{ W}}$

To compute $P_{10\Omega}$, consider that since the 10-Ω and 40-Ω resistors are in parallel, the same voltage V_x ("+" reference on the left) appears across both resistors. The current I = 4.286 A flows into this combination. Thus, $V_x = (8)(4.286) = 34.29$ V and

$P_{10\Omega} = (V_x)^2 / 10 = \boxed{117.6 \text{ W.}}$

$\boxed{P_{13\Omega} = 0}$ since no current flows through that resistor.

65. With the meter being a short circuit and no current flowing through it, we can write

$R_1 i_1 = R_2 i_2$
$R_3 i_3 = R i_R$ $\rightarrow$ $\frac{R_1 i_1}{R_3 i_3} = \frac{R_2 i_2}{R i_R}$ [1]

And since $i_1 = i_3$, and $i_2 = i_R$, Eq [1] becomes $\frac{R_1}{R_3} = \frac{R_2}{R}$, or $R = R_2 \frac{R_3}{R_1}$. *Q.E.D.*

66. The total resistance in the series string sums to 75 Ω.

The voltage dropped across the 2.2 Ω resistor is

$$V_{2.2\Omega} = 10\frac{2.2}{75} = \boxed{293.3\text{ mV}}$$

and the voltage dropped across the 47 Ω resistor is

$$V_{47\Omega} = 10\frac{47}{75} = \boxed{6.267\text{ mV}}$$

67. We first note that the 4.7 kΩ and 2.2 kΩ resistors can be combined into a single 1.5 kΩ resistor, which is then in series with the 10 kΩ resistor. Next we note that the 33 kΩ / 47 kΩ parallel combination can be replaced by a 19.39 kΩ resistance, which is in series with the remaining 33 kΩ resistor.

By voltage division, then, and noting that $V_{47k\Omega}$ is the same voltage as that across the 19.39 kΩ resistance,

$$V_{47k\Omega} = 2\frac{19.39}{10+1.5+33+19.39} = \boxed{607.0 \text{ mV}}$$

68. (a) The current downward through the 33 Ω resistor is calculated more easily if we first note that 134 Ω || 134 Ω = 67 Ω, and 67 Ω + 33 Ω = 100 Ω. Then,

$$I_{33\Omega} = 12 \frac{1/100}{1/10 + 1/10 + 1/100} = \boxed{571.4 \text{ mA}}$$

(b) The resistor flowing downward through either 134 Ω resistor is simply

$$571.4/2 = \boxed{285.7 \text{ mA}} \qquad \text{(by current division).}$$

69. We first note that 20 Ω || 60 Ω = 15 Ω, and 50 Ω || 30 Ω = 18.75 Ω.
Then, 15 Ω + 22 Ω + 18.75 Ω = 55.75 Ω.

Finally, we are left with two current sources, the series combination of 10 Ω + 15 Ω, and 10 Ω || 55.75 Ω = 8.479 Ω.

Using current division on the simplified circuit,

$$I_{15\Omega} = (30-8)\frac{\dfrac{1}{10+15}}{\dfrac{1}{10+15}+\dfrac{1}{8.479}} = \boxed{22.12\text{ A}}$$

70. One possible solution of many:

$$\boxed{\begin{aligned} v_S &= 2(5.5) = 11 \text{ V} \\ R_1 &= R_2 = 1 \text{ k}\Omega. \end{aligned}}$$

71. One possible solution of many:

$i_S = 11$ mA
$R_1 = R_2 = 1$ kΩ.

72. $p_{15\Omega} = (v_{15})^2 / 15\times10^3$ A

$v_{15} = 15\times10^3$ (-0.3 v_1)

where $v_1 = [4 (5)/ (5 + 2)] \cdot 2 = 5.714$ V

Therefore $v_{15} = -25714$ V and $\boxed{p_{15} = 44.08 \text{ kW.}}$

73. Replace the top 10 kΩ, 4 kΩ and 47 kΩ resistors with 10 kΩ + 4 kΩ || 47 kΩ = 13.69 kΩ.

Define v_x across the 10 kΩ resistor with its "+" reference at the top node: then

$v_x = 5 \cdot (10\text{ k}\Omega \parallel 13.69\text{ k}\Omega) / (15\text{ k}\Omega + 10 \parallel 13.69\text{ k}\Omega) = 1.391\text{ V}$

$i_x = v_x/ 10\text{ mA} = \boxed{139.1\ \mu\text{A}}$

$v_{15} = 5 - 1.391 = 3.609\text{ V}$ and $p_{15} = (v_{15})^2/ 15\times10^3 = \boxed{868.3\ \mu\text{W.}}$

74. We may combine the 12-A and 5-A current sources into a single 7-A current source with its arrow oriented upwards. The left three resistors may be replaced by a 3 + 6 || 13 = 7.105 Ω resistor, and the right three resistors may be replaced by a 7 + 20 || 4 = 10.33 Ω resistor.

By current division, $i_y = 7\,(7.105)/(7.105 + 10.33) = \boxed{2.853\text{ A}}$

We must now return to the original circuit. The current into the 6 Ω, 13 Ω parallel combination is $7 - i_y = 4.147$ A. By current division,

$$i_x = 4.147\ .\ 13/\,(13 + 6) = \boxed{2.837\text{ A}}$$

$$\text{and } p_x = (4.147)^2 \cdot 3 = \boxed{51.59\text{ W}}$$

75. The controlling voltage v_1, needed to obtain the power into the 47-kΩ resistor, can be found separately as that network does not depend on the left-hand network.
The right-most 2 kΩ resistor can be neglected.

By current division, then, in combination with Ohm's law,

$$v_1 = 3000[5\times10^{-3}\ (2000)/\ (2000 + 3000 + 7000)] = 2.5 \text{ V}$$

Voltage division gives the voltage across the 47-kΩ resistor:

$$0.5v_1 \frac{47}{47 + 100 \,||\, 20} = \frac{0.5(2.5)(47)}{47 + 16.67} = 0.9228 \text{ V}$$

So that $p_{47k\Omega} = (0.9928)^2 / 47\times10^3 = \boxed{18.12\ \mu\text{W}}$

76. The temptation to write an equation such as

$$v_1 = 10\frac{20}{20+20}$$

must be fought!

Voltage division only applies to resistors connected in series, meaning that the *same* current must flow through *each* resistor. In this circuit, $i_1 \neq 0$, so we do not have the same current flowing through both 20 kΩ resistors.

77. (*a*)

$$v_2 = V_S \frac{R_2 \| (R_3 + R_4)}{R_1 + [R_2 \| (R_3 + R_4)]}$$

$$= V_S \frac{R_2\,(R_3 + R_4)/(R_2 + R_3 + R_4)}{R_1 + R_2\,(R_3 + R_4)/(R_2 + R_3 + R_4)}$$

$$\boxed{= V_S \frac{R_2\,(R_3 + R_4)}{R_1(R_2 + R_3 + R_4) + R_2(R_3 + R_4)}}$$

(*b*)

$$v_1 = V_S \frac{R_1}{R_1 + [R_2 \| (R_3 + R_4)]}$$

$$= V_S \frac{R_1}{R_1 + R_2\,(R_3 + R_4)/(R_2 + R_3 + R_4)}$$

$$\boxed{= V_S \frac{R_1\,(R_2 + R_3 + R_4)}{R_1(R_2 + R_3 + R_4) + R_2(R_3 + R_4)}}$$

(*c*)

$$i_4 = \left(\frac{v_1}{R_1}\right)\left(\frac{R_2}{R_2 + R_3 + R_4}\right)$$

$$= V_S \frac{R_1\,(R_2 + R_3 + R_4)R_2}{R_1[R_1(R_2 + R_3 + R_4) + R_2(R_3 + R_4)(R_2 + R_3 + R_4)]}$$

$$\boxed{= V_S \frac{R_2}{R_1(R_2 + R_3 + R_4) + R_2(R_3 + R_4)}}$$

78. (*a*) With the current source open-circuited, we find that

$$v_1 = -40 \frac{500}{500 + 3000 \| 6000} = \boxed{-8 \text{ V}}$$

(*b*) With the voltage source short-circuited, we find that

$$i_2 = \left(3\times 10^{-3}\right) \frac{1/3000}{1/500 + 1/3000 + 1/6000} = \boxed{400\ \mu\text{A}}$$

$$i_3 = \left(3\times 10^{-3}\right) \frac{500}{500 + 3000 \| 6000} = \boxed{600\ \mu\text{A}}$$

79. (*a*) The current through the 5-Ω resistor is 10/5 = 2 A. Define R as 3 || (4 + 5) = 2.25 Ω. The current through the 2-Ω resistor then is given by

$$I_S \frac{1}{1+(2+R)} = \frac{I_S}{5.25}$$

The current through the 5-Ω resistor is

$$\frac{I_S}{5.25}\left(\frac{3}{3+9}\right) = 2\text{ A}$$

so that $\boxed{I_S = 42\text{ A.}}$

(*b*) Given that I_S is now 50 A, the current through the 5-Ω resistor becomes

$$\frac{I_S}{5.25}\left(\frac{3}{3+9}\right) = 2.381\text{ A}$$

Thus, $v_x = 5(2.381) = \boxed{11.90\text{ V}}$

(*c*) $$\frac{v_x}{I_S} = \frac{\left[\frac{5I_S}{5.25}\left(\frac{3}{3+9}\right)\right]}{I_S} = \boxed{0.2381}$$

80. First combine the 1 kΩ and 3 kΩ resistors to obtain 750 Ω.
By current division, the current through resistor R_x is

$$I_{R_x} = 10 \times 10^{-3} \frac{2000}{2000 + R_x + 750}$$

and we know that $R_x \cdot I_{R_x} = 9$

so $$9 = \frac{20\,R_x}{2750 + R_x}$$

$$9\,R_x + 24750 = 20\,R_x \qquad \text{or } R_x = 2250\ \text{W. Thus,}$$

$$\boxed{P_{R_x} = 9^2/\,R_x = 36\ \text{mW.}}$$

81. Define R = $R_3 \parallel (R_4 + R_5)$

Then $v_R \;=\; V_S\left(\dfrac{R}{R+R_2}\right)$

$$= V_S\left(\frac{R_3\,(R_4+R_5)/(R_3+R_4+R_5)}{R_3\,(R_4+R_5)/(R_3+R_4+R_5)+R_2}\right)$$

$$= V_S\left(\frac{R_3\,(R_4+R_5)}{R_2\,(R_3+R_4+R_5)+R_3(R_4+R_5)}\right)$$

Thus,

$$v_5 \;=\; v_R\left(\frac{R_5}{R_4+R_5}\right)$$

$$\boxed{= V_S\left(\frac{R_3\,R_5}{R_2\,(R_3+R_4+R_5)+R_3(R_4+R_5)}\right)}$$

82. Define $R_1 = 10 + 15 \| 30 = 20\ \Omega$ and $R_2 = 5 + 25 = 30\ \Omega$.

(*a*) $I_x = I_1 . 15 / (15 + 30) = \boxed{4 \text{ mA}}$

(*b*) $I_1 = I_x . 45/15 = \boxed{36 \text{ mA}}$

(*c*) $I_2 = I_S R_1 / (R_1 + R_2)$ and $I_1 = I_S R_2 / (R_1 + R_2)$
So $I_1/I_2 = R_2/R_1$
Therefore

$$I_1 = R_2 I_2/R_1 = 30(15)/20 = 22.5 \text{ mA}$$

Thus, $I_x = I_1 \cdot 15/45 = \boxed{7.5 \text{ mA}}$

(*d*) $I_1 = I_S R_2/(R_1 + R_2) = 60(30)/50 = 36 \text{ mA}$

Thus, $I_x = I_1\ 15/45 = \boxed{12 \text{ mA.}}$

83. $v_{out} = -g_m v_\pi (100\ k\Omega \parallel 100\ k\Omega) = -4.762\times10^3\ g_m v_\pi$

where $v_\pi = (3 \sin 10t) \cdot 15/(15 + 0.3) = 2.941 \sin 10t$

Thus, $\boxed{v_{out} = -56.02 \sin 10t\ \text{V}}$

84. $v_{out} = -1000g_m v_\pi$

where $v_\pi = 3\sin 10t \dfrac{15\,||\,3}{(15\,||\,3) + 0.3} = 2.679 \sin 10t$ V

therefore

$$v_{out} = -(2.679)(1000)(38\times10^{-3}) \sin 10t = \boxed{-101.8 \sin 10t \text{ V.}}$$