

Block A: Unit 1

Q1. [Problem 2.13]

Solution:

- Known quantities:

Circuit shown in Figure P2.13 with currents $I_0 = -2\text{A}$, $I_1 = -4\text{A}$, $I_S = 8\text{A}$, and voltage source $V_S = 12\text{V}$.

- Find:

The unknown currents.

- Analysis:

Applying KCL to node (a) and node (b):

$$\begin{cases} I_0 + I_1 + I_2 = 0 \\ I_0 + I_S + I_1 - I_3 = 0 \end{cases} \Rightarrow \begin{cases} I_2 = -(I_0 + I_1) = 6\text{A} \\ I_3 = I_0 + I_S + I_1 = 2\text{A} \end{cases}$$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

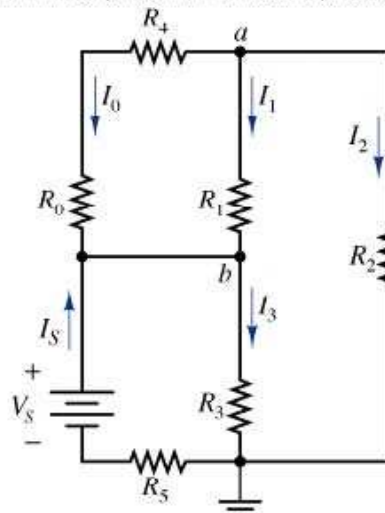


Figure P2.13

Q2. [Problem 2.24]

Solution:

- Known quantities:

Circuit shown in Figure P2.24.

- Find:

Determine power absorbed or power delivered and corresponding amount.

- Analysis:

If current direction is out of power source, then power source is supplying, otherwise it is absorbing.

A absorbs [voltage drop in direction of current] $(5\text{V})(4\text{A}) = 20\text{W}$

B supplies [voltage gain in direction of current] $(2\text{V})(6\text{A}) = 12\text{W}$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

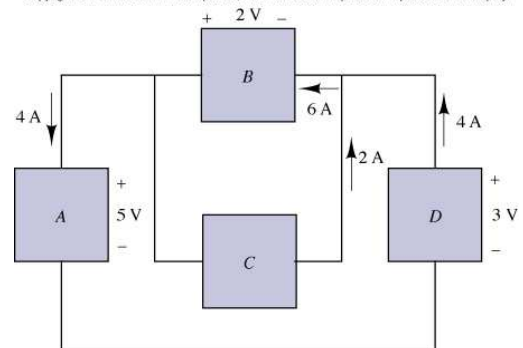


Figure P2.24

D supplies [voltage gain in direction of current] $(3V)(4A) = 12W$

Since conservation of power is satisfied, Tot. power supplied = Tot. power absorbed

Total power supplied = $12W + 12W = 24W$

$\therefore$ C absorbs $24W - 20W = 4W$

- Check:

Voltage across C is the same as B, therefore 2V (positive on the left)

Current through C is 2A (from left to right through C)

Voltage drops in direction of current through C – power absorbed

Therefore, C absorbs $(2V)(2A) = 4W$

Q3. [Problem 2.18]

Solution:

- Known quantities:

Circuit shown in Figure P2.18.

- Find:

Voltages and currents in every figure.

- Analysis:

(a) Using $I = \frac{15}{30+20}$ (clockwise current) : $I_1 = -0.3A$; $I_2 = 0.3A$; $V_1 = 6V$.

(b) The voltage across the $20\ \Omega$ resistor is $\frac{20}{4} = 5V$; since the current flows from top to bottom, the polarity of this voltage is positive on top. Then it follows that $V_1 = 5V$ and $I_2 = \frac{5}{30} = -0.167A$ (the negative sign follows from the direction of I_2 in the drawing).

(c) Since $-0.5A$ pointing upward is the same current as $0.5A$ pointing downward, the voltage across the $30\ \Omega$ resistor is $V_{30\Omega} = 15V$ (positive on top);

and $I_2 = \frac{15}{20} = 0.75A$, since $V_{30\Omega}$ is also the voltage across the $20\ \Omega$ resistor.

Finally, $I_1 = -(I_2 + 0.5) = -1.25A$, and $V_1 = -30 I_1 + 15 = 52.5V$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

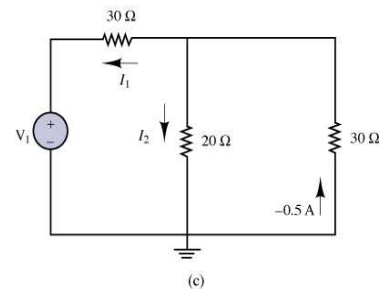
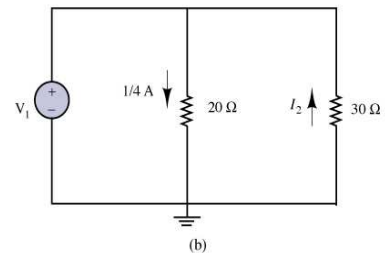
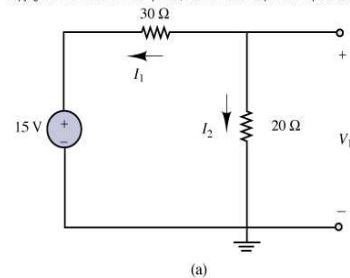


Figure P2.18

Q4. [Problem 2.46]

Solution:

- Known quantities:

Circuits of Figure P2.46.

- Find:

Resistance R

- Analysis:

First combine the elements to the right of the $15\ \Omega$ resistor:

The two 4Ω parallel resistors are in series with the 6Ω resistor;
 This combo of $4\Omega \parallel 4\Omega + 6\Omega$ is in parallel with the 24Ω resistor.
 Finally, this combo of $(4\Omega \parallel 4\Omega + 6\Omega) \parallel 24\Omega$ is in series with the 4Ω resistor next to R.

Therefore:

$$R_{eq} = ((4 \parallel 4) + 6) \parallel 24 + 4 = 10 \Omega.$$

The power dissipated by the 15Ω resistor is

$$P_{15\Omega} = \frac{v^2}{15} = 15 \text{ W}.$$

Therefore, $v_{15\Omega} = 15 \text{ V}$ and $i_1 = 1 \text{ A}$.

Using the current divider rule:

$$i_2 = \frac{15}{10} (i_1) = 1.5 \text{ A}.$$

Applying KCL, we can find i_R :

$$i_R = i_1 + i_2 = 2.5 \text{ A}.$$

Using KVL:

$$25 + 2.5R + 15 = 0$$

Therefore, $R = 4\Omega$.

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

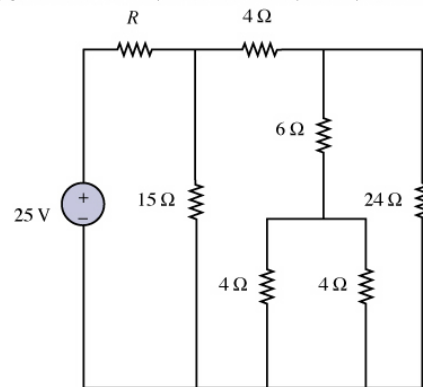
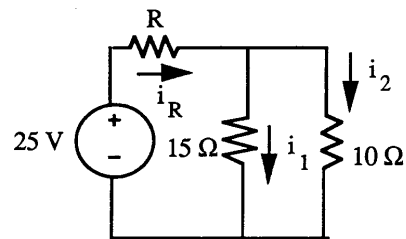


Figure P2.46



Q5. [Problem 2.21]

Solution:

- Known quantities:

Circuit shown in Figure P2.21.

- Find:

Power absorbed by resistant R and power delivered by current source.

- Analysis:

Power absorbed by $R = (10V)(3A) = 30W$.

From Problem 2.16, $v_1 = 12 \text{ V}$. Therefore, power delivered by the current source = $(12V)(3A) = 36W$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

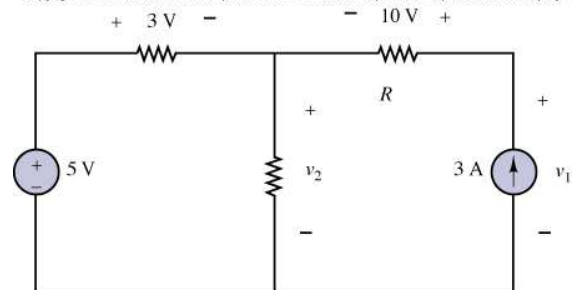


Figure P2.21

Q6. [Problem 2.63]

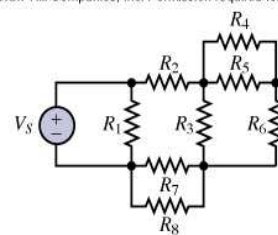
Solution:

- Known quantities:

Schematic of the circuit shown in Figure P2.63 with source voltage,

$V_s = 110V$; and resistances,

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.



$R_1 = 90\Omega, R_2 = 50\Omega, R_3 = 40\Omega, R_4 = 20\Omega, R_5 = 30\Omega, R_6 = 10\Omega, R_7 = 60\Omega, R_8 = 80\Omega$.

Figure P2.63

- Find:
 - The equivalent resistance of the circuit seen by the source.
 - The current through and the power absorbed by the resistance 90-Ω resistance.
- Analysis:
 - Starting from the right side, we can combine the two parallel resistors, namely the 20 Ω resistor (R_4) and the 30 Ω resistor (R_5):

$$\frac{1}{R_{parallel}} = \frac{1}{20} + \frac{1}{30} (\Omega^{-1}) \Rightarrow R_{parallel} = 12\Omega$$

Then we can combine the two parallel resistors in the bottom, namely the 60 Ω resistor (R_7) and the 80 Ω (R_8), and the two resistors in series ($R_4 \parallel R_5$ with 10Ω):

$$\frac{1}{R_{parallel}} = \frac{1}{60} + \frac{1}{80} (\Omega^{-1}) \Rightarrow R_{parallel} = 34.3\Omega.$$

Then we can combine the two parallel resistors on the right, namely the 40 Ω resistor and the 22Ω:

$$\frac{1}{R_{parallel}} = \frac{1}{40} + \frac{1}{22} (\Omega^{-1}) \Rightarrow R_{parallel} = 14.2\Omega.$$

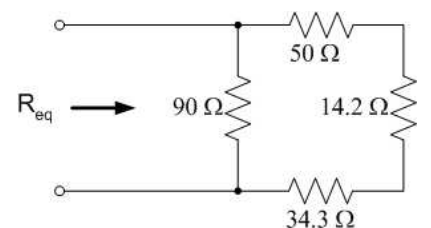
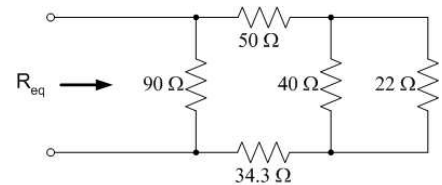
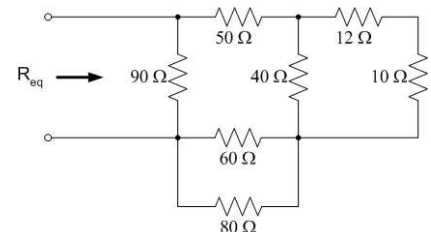
We can now see that the 50Ω, 14.2Ω, and 34.3Ω resistors are in series, and this series combination is in parallel with the 90Ω resistor:

$$\text{Therefore: } \frac{1}{R_{eq}} = \frac{1}{90} + \frac{1}{(50 + 14.2 + 34.3)} (\Omega^{-1}) \Rightarrow R_{eq} = 47\Omega.$$

- The current through and the power absorbed by the 90-Ω resistor are:

$$I_{90\Omega} = \frac{V_S}{R_1} = \frac{110}{90} = 1.22 \text{ A}$$

$$P_{90\Omega} = \frac{(V_S)^2}{R_1} = \frac{110^2}{90} = 134.4 \text{ W}$$



Q7. [Problem 2.47]

Solution:

- Known quantities:
Circuits of Figure P2.47.

- Find:
Equivalent resistance.

- Analysis:

$$2\Omega + 2\Omega = 4\Omega$$

$$6\Omega \parallel 12\Omega = 4\Omega$$

$$4\Omega \parallel 4\Omega = 2\Omega$$

$$4\Omega \parallel 4\Omega = 2\Omega$$

$$2\Omega + 2\Omega = 4\Omega$$

$$R_{eq} = 3\Omega + 4\Omega \parallel 4\Omega = 5\Omega$$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

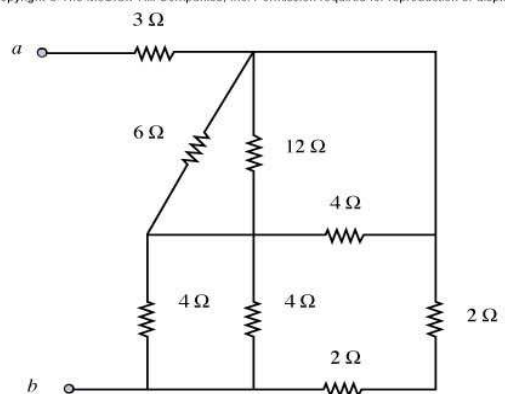


Figure P2.47

Q8. [Problem 2.64]Solution:

- Known quantities:

Schematic of the circuit shown in Figure P2.64.

- Find:

The equivalent resistance at terminals a,b in the case that terminals c,d are a) open b) shorted; the same for terminals c,d with respect to terminals a,b.

- Analysis:

With terminals c-d open, $R_{eq} = (360 + 540) \parallel (180 + 540) \Omega = 400 \Omega$,

with terminals c-d shorted, $R_{eq} = (360 \parallel 180) + (540 \parallel 540) \Omega = 390 \Omega$,

with terminals a-b open, $R_{eq} = (540 + 540) \parallel (360 + 180) \Omega = 360 \Omega$,

with terminals a-b shorted, $R_{eq} = (360 \parallel 540) + (180 \parallel 540) \Omega = 351 \Omega$.

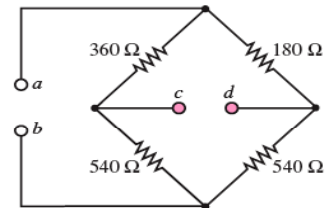


Figure P2.64

Q9. [Problem 2.49]Solution:

- Known quantities:

Circuits of Figure 2.49.

- Find:

Equivalent resistance.

- Analysis:

$(R_6 \parallel R_4) + R_5 = (1,000 \Omega \parallel 100 \Omega) + 9.1 \Omega \approx 100 \Omega$, resulting in the circuit shown below.

Therefore, the equivalent resistance is

$$R_{eq} = (100 \parallel R_3 \parallel R_2) + R_1 = (100 \parallel 100 \parallel 1000) + 5 = 52.6 \Omega$$

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

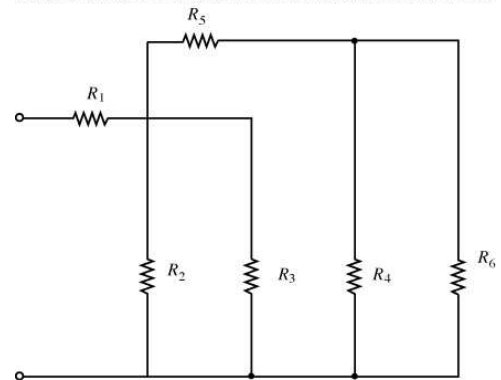
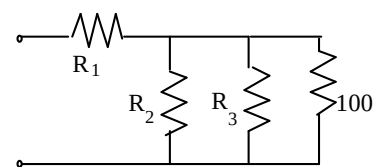


Figure P2.49

**Q10. [Problem 2.60]**Solution:

- Known quantities:

Schematic of the circuit shown in Figure P2.60 with source voltage,

$V_s = 12V$; and resistances,

$R_0 = 4\Omega, R_1 = 2\Omega, R_2 = 50\Omega, R_3 = 8\Omega, R_4 = 10\Omega, R_5 = 12\Omega, R_6 = 6\Omega$.

- Find:

The equivalent resistance of the circuit seen by the source; the current i through the resistance R_2 .

Copyright © The McGraw-Hill Companies, Inc. Permission required for reproduction or display.

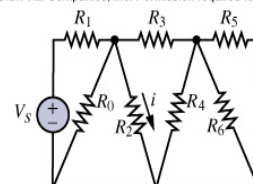


Figure P2.60

- Analysis:

Starting from the right side, we can combine the three parallel resistors, namely the $10\ \Omega$ resistor, the $12\ \Omega$ resistor and the $6\ \Omega$ resistor:

$$\frac{1}{R_{parallel}} = \frac{1}{10} + \frac{1}{12} + \frac{1}{6} (\Omega^{-1}) \Rightarrow R_{parallel} = \frac{20}{7}\ \Omega$$

Then, we can combine the two resistors in series, namely the $8\ \Omega$ and the $2.86\ \Omega$ resistor:

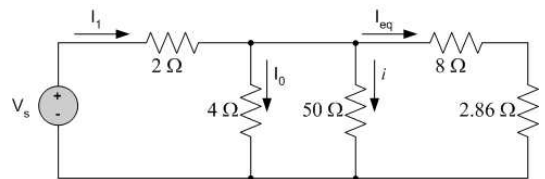
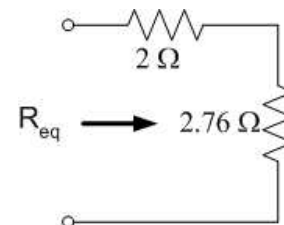
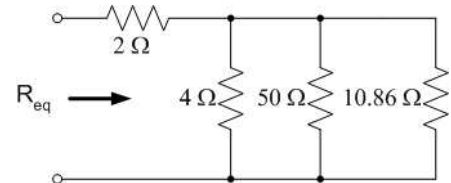
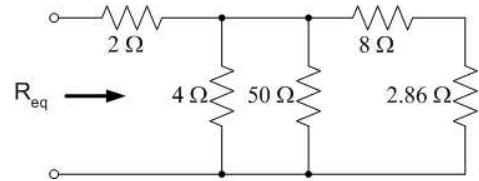
Then, we can combine the three parallel resistors, namely the $4\ \Omega$ resistor, the $50\ \Omega$ resistor and the $10.86\ \Omega$ resistor:

$$\frac{1}{R_{parallel}} = \frac{1}{4} + \frac{1}{50} + \frac{1}{10.86} (\Omega^{-1}) \Rightarrow R_{parallel} = 2.76\ \Omega$$

Therefore, $R_{eq} = 2 + 2.76 = 4.76\ \Omega$.

We can apply KVL and KCL to the equivalent circuit:

$$\begin{cases} V_s - 2I_1 - 4I_0 = 0 \\ I_1 = I_0 + i + I_{eq} \\ 4I_0 = 50i = 10.86I_{eq} \end{cases} \Rightarrow \begin{cases} I_0 = 12.5i \\ I_1 = 6 - 25i \\ I_{eq} = 4.604i \\ i = I_1 - I_0 - I_{eq} \end{cases} \Rightarrow i = 140\ \text{mA}$$



Q11. [Problem 2.73]

Solution:

- Known quantities:

Ammeter shown in Figure P2.73; Current for full-scale deflection; desired full scale values.

- Find:

Value of the resistors required for the given full scale ranges.

- Analysis:

We desire R_1 , R_2 , R_3 such that $I_a = 30\ \mu\text{A}$ for $I = 10\ \text{mA}$, $100\ \text{mA}$, and $1\ \text{A}$, respectively. We use conductances to simplify the arithmetic:

$$G_a = \frac{1}{R_a} = \frac{1}{1000}\ \text{S}$$

$$G_{1,2,3} = \frac{1}{R_{1,2,3}}$$

By the current divider rule:

$$I_a = \frac{G_a}{G_a + G_x} I$$

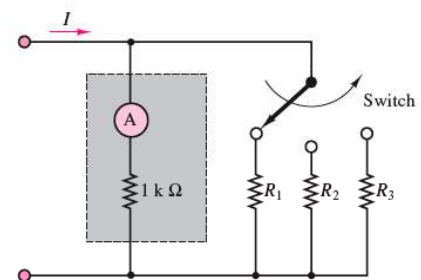


Figure P2.73

or:

$$G_x = G_a \left(\frac{I}{I_a} \right) - G_a \text{ or } \frac{1}{G_x} = \frac{1}{G_a} \left(\frac{I_a}{I - I_a} \right)$$

$$R_x = R_a \left(\frac{I_a}{I - I_a} \right).$$

We can construct the following table:

x	I	R_x (Approx.)
1	10^{-2} A	3Ω
2	10^{-1} A	0.3Ω
3	10^0 A	0.03Ω

Q12. [Problem 2.78]

Solution:

Known quantities:

Schematic of the circuit shown in Figure P2.78, value of the components.

Find:

The current through R_5 both with and without the ammeter, for the following values of the resistor R_5 :

- $R_5 = 1k\Omega$
- $R_5 = 100\Omega$
- $R_5 = 10\Omega$
- $R_5 = 1\Omega$.

Analysis:

First find an expression for the current through R_5 (I_{R5}) in terms of R_5 and the ammeter resistance, R_a . (Hint: you can determine the Thevenin equivalent across R_3 for V_s , R_s , R_1 and R_2 , followed by voltage divider rule)

We have:

$$V_{R3} = \frac{V_s R_1}{R_s + R_1} \frac{R_3 \parallel (R_4 + R_5 + R_a)}{R_3 \parallel (R_4 + R_5 + R_a) + R_2 + (R_1 \parallel R_s)}$$

$$\text{And } I_{R5} = \frac{V_{R3}}{R_4 + R_5 + R_a}$$

Therefore,

$$I_{R3} = \frac{V_s R_1}{R_s + R_1} \frac{R_3 \parallel (R_4 + R_5 + R_a)}{R_3 \parallel (R_4 + R_5 + R_a) + R_2 + (R_1 \parallel R_s)} \cdot \frac{1}{R_4 + R_5 + R_a}$$

If you find difficult to derive the above equation, you can simple substitute the circuits with exact values and find the answer.

Using the above equation will give us the following table:

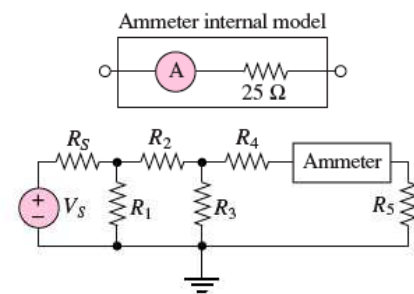


Figure P2.78

	without meter in circuit $R_a=0$	with meter in circuit $R_a=25\Omega$
a	9.90 mA	9.75 mA
b	23.44 mA	22.59 mA
c	27.15 mA	26.02 mA
d	27.60 mA	26.42 mA