電工作業第二章
2012版（雙號題）

謝志誠

Exercise 1

- If $24{\times}10^{16}$ electrons pass through a conductor in ½ min. determine: a. Charge in coulombs. b. Current.

a. $24{\times}10^{16}$ electrons $\times \dfrac{1.6\times10^{-19}\text{coulombs}}{1\ \text{electron}} = 38.45\times10^{-3}\text{coulombs}$

b. Current $= \dfrac{Q}{t} = \dfrac{38.45\times10^{-3}\text{C}}{30\text{s}} = 1.282\text{mA}$

Exercise 2

- How long will it take 1600 mC to pass through a copper conductor if the current is 0.5 A ?

$$I = \frac{Q}{t}$$

$$t = \frac{Q}{I} = \frac{1600mC}{0.5A} = 3.2s$$

Exercise 3

- How much charge has passed through a conductor if the current is 16 μA for 10 s ?

Charge Q = $It = (16\mu A)(10s) = 160\mu C$

Exercise 4

- For a current of 1 mA, how many electrons will pass a particular point in the circuit in 1 s ? Write the number out of in full decimal form (all the zeros). Is it a significant number for such a small current level ?

Charge Q = $It = (1mA)(1s) = 1mC = 1 \times 10^{-3} C$

每個電子帶1.6×10^{-19}Coulombs，
相對之下，每個coulomb含有✓6.242×10^{18}個電子。
所以，

$$1 \times 10^{-3} C \times \frac{6.242 \times 10^{18} \text{elctrons}}{1C} = 6.24210^{15} \text{elctrons}$$

Exercise 5

- Write the following quantities in the most convenient form using the prefixes in Table 2.1.

  a. 0.05 A = 50 mA

  b. 0.0004 V = 0.4 mV

  c. 3 + 10^4 V = 10 kV

  d. 1200 V = 1.2 kV

  e. 0.0000007 A = 0.7 µ A

  f. 32,000,000 V = 32 MV

1,000,000,000,000	$= 10^{12}$	= terra	= T
1,000,000,000	$= 10^{9}$	= giga	= G
1,000,000	$= 10^{6}$	= mega	= M
1000	$= 10^{3}$	= kilo	= k
$\frac{1}{1000} = 0.001$	$= 10^{-3}$	= milli	= m
$\frac{1}{1,000,000} = 0.000001$	$= 10^{-6}$	= micro	= μ
0.000000001	$= 10^{-9}$	= nano	= n
0.000000000001	$= 10^{-12}$	= pico	= p

Exercise 6

- What is the resistance of 1000 ft of No. 12 house wire?

No.12者，每1,000 ft電阻1.588Ω。因此，1000 ft的電線的電阻為 1.588Ω。

$$R = 1{,}000\text{ft} \times \frac{1.588\Omega}{1000\text{ft}} = 1.588\Omega$$

Exercise 7

- What is the area in circular mils of wires having the following diameters?
  a. 1/32 in
  b. 0.01 ft
  c. 0.1 cm

a. $d = \frac{1}{32} in = 0.03125 in \qquad d_{mils} = 31.25 mils$

$$A_{CM} = (d_{mils})^2 = 976.56 CM$$

b. $d = 0.01 ft = 0.12 in \qquad d_{mils} = 120 mils$

$$A_{CM} = (d_{mils})^2 = 14{,}400 CM$$

c. $d = 0.1 cm = 0.03937 in \qquad d_{mils} = 39.37 mils$

$$A_{CM} = (d_{mils})^2 = 1{,}550 CM$$

Exercise 8

- What is the diameter in inches of wires having the following areas in circular mils?
  a. 10,000 CM
  b. 625 CM
  c. 50,000 CM

a. $d_{mils} = \sqrt{10{,}000CM} = 100mils \qquad d = 0.1in$

b. $d_{mils} = \sqrt{625CM} = 25mils \qquad d = 0.025in$

c. $d_{mils} = \sqrt{50{,}000CM} = 223.61mils \qquad d = 0.2236in$

Exercise 9

- Determine the energy expended (in joules) to bring a charge of 40 mC through a potential difference of 120 V.

推動40 mC的電荷跨越120 V的電位差，能量要用多少？

$$W = VQ = (120V)(40mC) = 4.8Joules$$

Exercise 10

- What is the potential difference between two points in an electric circuit if 200 mJ of energy is required to bring a charge of 40 μC from one point to the other?

在多大的電位差下，推動40 μC的電荷
需要使用200 mJ的能量？

$$W = VQ$$

$$V = \frac{W}{Q} = \frac{200\text{mJ}}{40\mu\text{C}} = 5\text{kV}$$

Exercise 11

- How much energy is required to move 18×10^{18} electrons through a potential difference of 12 V?

推動18×10^{18}個電子跨越12V的電位差，能量要用多少？

先算出18×10^{18}個電子帶有多少電荷，

$$Q = 18 \times 10^{18} \text{electrons} \times \frac{1.6 \times 10^{-19} \text{C}}{\text{electron}} = 2.88\text{C}$$

$$W = VQ = (12\text{V})(2.88\text{C}) = 34.6\text{Joules}$$

Exercise 12

- How much energy is expended to maintain a current of 10 mA between two points in an electric circuit for 5 s if the potential difference between two points is 20 mV?

電位差20 mV下，推動10 mA的電流達5 seconds，
需要多少的能量？
先求出推動的電荷量……

Q?

$$Q = It = (10mA)(5s) = 50mC$$

$$W = VQ = (20mV)(50mC) = 1mJ$$

Exercise 13

- Determine the internal resistance of a battery-operated clock if a current of 1.8 mA results from an applied voltage of 1.5 V.

利用歐姆定律 Ohm's law

$$R = \frac{E}{I} = \frac{1.5V}{1.8mA} = 833.33\Omega$$

電源電壓，使用符號E，非V

Exercise 14

- Determine the current through a soldering iron if 120 V is applied. The iron has a resistance of 18Ω.

利用歐姆定律 Ohm’s law

$$I = \frac{E}{R} = \frac{120V}{18\Omega} = 6.67A$$

Exercise 15

- Determine the voltage drop across a 2.2 MΩ resistor with a current 0f 30 μA pass through it. What resistance would be required to limit the current to 1.5 A if the applied voltage is 64 V?

跨越2.22 MΩ電阻的電壓降 V

$$V = RI = (2.2M\Omega)(30\mu A) = 66V$$

若施予的電壓為64 V， 電流限於 1.5 A，
則使用的電阻的電阻值

$$R = \frac{V}{I} = \frac{64V}{1.5A} = 42.67\Omega$$

Exercise 16

- Determine the resistance of 50 ft of 1/16-in. diameter copper wire.

先求1/16in為多少A_{CM}？

$$d_{mils} = 62.5\text{mils}$$

$$A_{CM} = (d_{mils})^2 = 3{,}906.25\text{CM}$$

$$R = \rho\frac{\ell}{A} = (10.37\text{CM}-\Omega/\text{ft})\frac{(50\text{ft})}{3{,}906.25\text{CM}} = 132.74\text{m}\Omega$$

ρ 的單位

Exercise 17

- Calculate the resistance of 600 ft of No 14 wire using Table 2.2.

AWG No.	Area (CM)	Ω/1000 ft at 20°C	Maximum Allowable Current for RHW Insulation (A)[a]	AWG No.	Area (CM)	Ω/1000 ft at 20°C
0000	211,600	0.0490	**360**	19	1288.1	8.051
000	167,810	0.0618	**310**	20	1021.5	10.15
00	133,080	0.0780	**265**	21	810.10	12.80
0	105,530	0.0983	**230**	22	642.40	16.14
1	83,694	0.1240	**195**	23	509.45	20.36
2	66,373	0.1563	**170**	24	404.01	35.67
3	52,634	0.1970	**145**	25	320.40	32.37
4	41,742	0.2485	**125**	26	254.10	40.81
5	33,102	0.3133	—	27	201.50	51.47
6	26,250	0.3951	**95**	28	159.79	64.90
7	20,816	0.4982	—	29	126.72	81.83
8	16,509	0.6282	**65**	30	100.50	103.2
9	13,094	0.7921	—	31	79.70	130.1
10	10,381	0.9989	**40**	32	63.21	164.1
11	8,234.0	1.260	—	33	50.13	206.9
12	6,529.9	1.588	**25**	34	39.75	260.9
13	5,178.4	2.003	—	35	31.52	329.0
14	4,106.8	2.525	**20**	36	25.00	414.8
15	3,256.7	3.184		37	19.83	523.1
16	2,582.9	4.016		38	15.72	659.6
17	2,048.2	5.064		39	12.47	831.8
18	1,624.3	6.385		40	9.89	1049.0

From the 1965 National Electrical Code, ® published by the National Fire Protection Association.

No.14者，每1,000 ft電阻2.525 Ω。因此，600 ft的電線的電阻為

$$R = 600\text{ft} \times \frac{2.525\Omega}{1000\text{ft}} = 1.515\Omega$$

Exercise 18

- Determine the diameter (in inches) of a copper inductor having a length of 200 ft and a resistance of 0.2 Ω.

$$R = \rho \frac{\ell}{A} \rightarrow$$

$$A_{CM} = \rho \frac{\ell}{R} = (10.37CM - \Omega / ft) \frac{(200ft)}{0.2\Omega} = 10,370CM$$

$$d_{mils} = \sqrt{10,370CM} = 101.83mils$$

$$d = 0.102in$$

Exercise 19

- What is the resistance of 1 mi of No.12 house wire? How does it compare with the resistance of 1 kΩ connected to the end the conductor?

AWG No.	Area (CM)	Ω/1000 ft at 20°C	Maximum Allowable Current for RHW Insulation (A)[a]	AWG No.	Area (CM)	Ω/1000 ft at 20°C
0000	211,600	0.0490	**360**	19	1288.1	8.051
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11	8,234.0	1.260	—	33	50.13	206.9
12	6,529.9	1.588	**25**	34	39.75	260.9
13	5,178.4	2.003	—	35	31.52	329.0
14	4,106.8	2.525	**20**	36	25.00	414.8
15	3,256.7	3.184		37	19.83	523.1
16	2,582.9	4.016		38	15.72	659.6
17	2,048.2	5.064		39	12.47	831.8
18	1,624.3	6.385		40	9.89	1049.0

From the 1965 National Electrical Code, ® published by the National Fire Protection Association.

No.12者，每1,000 ft 電阻1.588 Ω。因此，1 mi的電線的電阻為（1 mi = 5,280 ft）

$$R = 5{,}280\text{ft} \times \frac{1.588\Omega}{1000\text{ft}} = 8.38\Omega << 1\text{k}\Omega$$

Exercise 20

- If the resistance of a copper conductor is $2\,\Omega$ at room temperature (T = 20°C), what is its resistance at 100°C (the boiling point of water)?

$$\frac{T + t_1}{R_1} = \frac{T + t_2}{R_2}$$

$$\frac{234.5 + 20}{2\Omega} = \frac{234.5 + 100}{R_2}$$

$$R_2 = \frac{334.5(20)}{254.5} = 2.63\Omega$$

Exercise 21

- At what temperature will the resistance of a No. 8 copper wire double if its resistance at T = 20°C is 1 Ω?

$$\frac{T+t_1}{R_1} = \frac{T+t_2}{R_2}$$

$$\frac{234.5+20}{1\Omega} = \frac{234.5+t_2}{2\Omega}$$

$$t_2 = 234.5°C$$

Exercise 22

- If the resistance of a copper conductor 400 ft long is 10 Ω at room temperature (T = 20°C), what is its resistance at -20°C?

$$\frac{T+t_1}{R_1}=\frac{T+t_2}{R_2}$$

$$\frac{234.5+20}{10\Omega}=\frac{234.5-20}{R_2}$$

$$R_2=\frac{214.5(10)}{254.5}=8.43\Omega$$

Exercise 23

a. Determine the resistance of a modeled composition resistor with the following color bands: red, red, brown, gold.

b. Indicate its expected range of values.

a. Resistance is 220 Ω ± 5%

b. Expected range of values: 209 Ω ~231 Ω

Exercise 24

- Determine the color bands of a 100 kΩ resistor with a tolerance of 5%.

  $100\ k\Omega = 10 \times 10^4$

  brown/black/yellow/Gold

Exercise 25

- Determine the color bands of a 3,952 Ω resistor with a tolerance of 10%.

orange/white/gold/silver

橙、白、金、銀

Exercise 26

- Determine the power delivered by a 12 V battery at a current drain of 240 mA.

$$P = EI = (12V)(240mA) = 2.88W$$

Exercise 28

- A 280 W television set is connected to a 120 V outlet. Determine the current drawn by the set.

$$P = EI$$

$$I = \frac{P}{E} = \frac{280W}{120V} = 2.33A$$

Exercise 30

- Calculate the cost of using the following appliances for the indicated time period if the unit cost is 9 cents/kWh.

  a. Six 60 -W bulbs for 6 h.

  b. 8-W clock for 30 days (1 month).

  c. 160-W television set for 4 h 30 min.

  d. 5000-W clothes dryer for 45 min.

$$\mathrm{kWh} = \sum = \frac{(6)(60\mathrm{W})(6\mathrm{h}) + (8\mathrm{W})(30\mathrm{days})(24\mathrm{h}/\mathrm{day})}{1000} +$$

$$\frac{(160\mathrm{W})(4.5\mathrm{h}) + (5000\mathrm{W})(3/4\mathrm{h})}{1000} = 12.39\mathrm{kWh}$$

$$\mathrm{Cost} = (12.39\mathrm{kWh})(9\mathrm{cents}/\mathrm{kWh}) = 111.51\mathrm{cents}$$

Exercise 32

- How long can we use a welding unit for \$1.00 if the unit draws 14 A at 220 V and the cost is 9 cents/kWh?

\$1.00使用多少kWh？

$$\frac{\$1.00}{9\text{cents}/\text{kWh}} = \frac{100\text{cents}}{9\text{cents}/\text{kWh}} = 11.11\text{kWh}$$

$$\text{kWh} = \frac{\text{Pt}}{1000} \rightarrow 11.11\text{kWh} = \frac{(220\text{V})(14\text{A})\text{t}}{1000}$$

$$\Rightarrow \text{t} = 3.61\text{h}$$

Exercise 34

a. A 2.2-hp motor has an input power demand of 2,400 W. Determine its efficiency.

b. If the applied voltage is 120 V, find the input current.

c. What is the power lost in the energy transfer (in watts)?

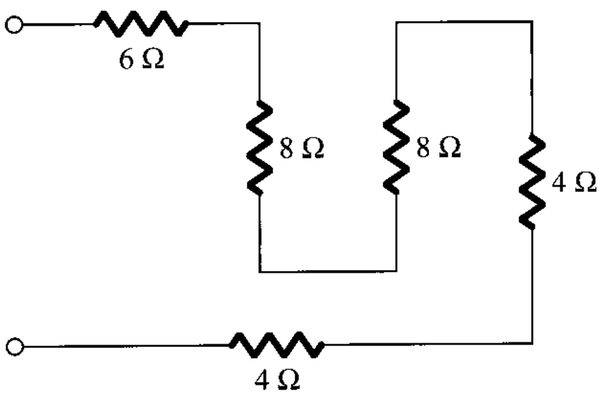
a. $\eta = \frac{P_o}{P_i} = \frac{(2.2\text{hp})(746\text{W/hp})}{2{,}400\text{W}} \times 100\% = 68.4\%$

b. $P_i = EI \qquad I = \frac{P_i}{E} = \frac{2{,}400\text{W}}{120\text{V}} = 20\text{A}$

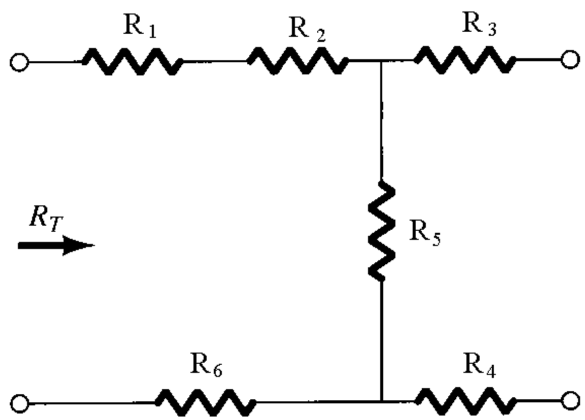
c. $\text{Power lost} = P_i - P_o = 2400\text{W} - 1641\text{W} = 759\text{W}$

Exercise 36

- Find the total resistance of the networks in Fig. 2.55.



(a)



a. $R_T = 6\Omega + 8\Omega + 8\Omega + 4\Omega + 4\Omega = 30\Omega$

b. $R_T = R_1 + R_2 + R_5 + R_6$

Exercise 38

- For the circuit in Fig. 2.57, determine:
  a. R_T.
  b. I.
  c. V_3.
  d. P_2.

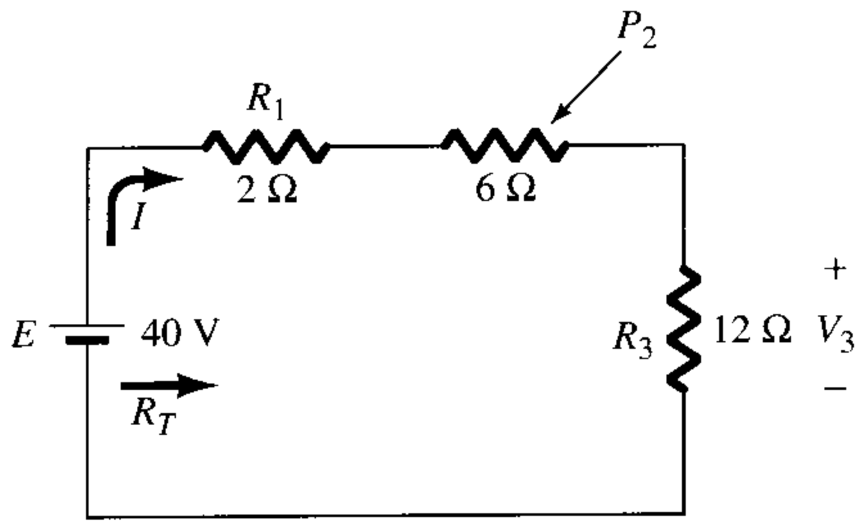


FIG. 2.57

a. $R_T = 2\Omega + 6\Omega + 12\Omega = 20\Omega$

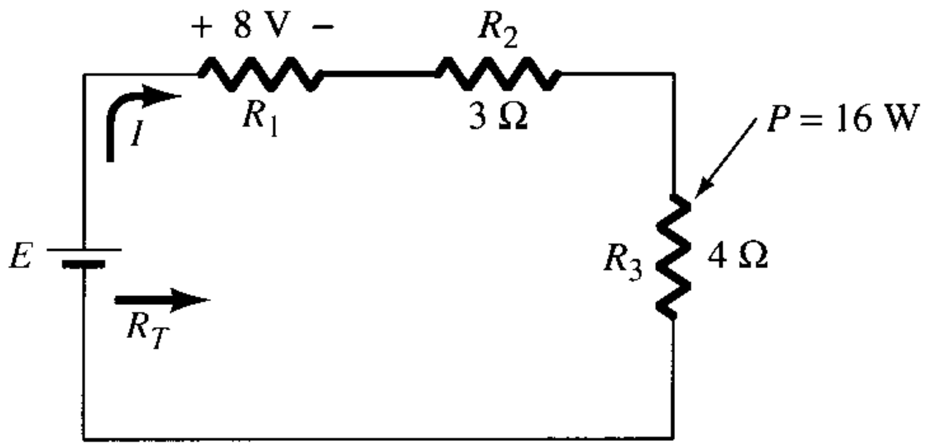
b. $I = \frac{E}{R_T} = \frac{40V}{20\Omega} = 2A$

c. $V_3 = IR_3 = (2A)(12\Omega) = 24V$

d. $P_2 = I^2R_2 = (2A)^2(6\Omega) = 24W$

Exercise 39-a

- Determine the unknown quantities for the networks in Fig. 2.58a.



(a)

$$P = I^2 R_3 = 16W \rightarrow I = 2A$$

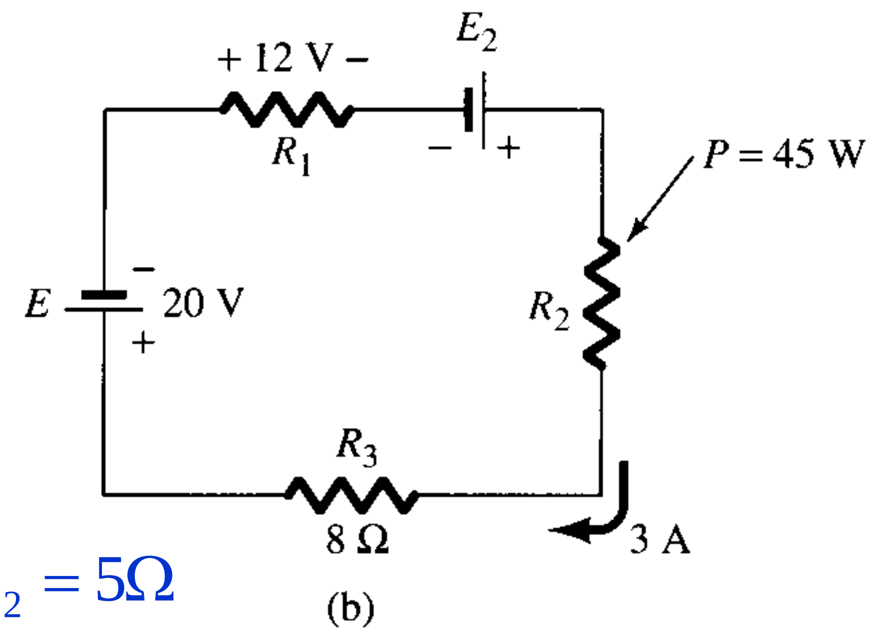
$$R_1 = \frac{8V}{2A} = 4\Omega$$

$$R_T = R_1 + R_2 + R_3 = 11\Omega$$

$$E = I \times R_T = (2A)(11\Omega) = 22V$$

Exercise 39-b

- Determine the unknown quantities for the networks in Fig. 2.58b.



$$P = I^2 R_2 = 9 \times R_2 = 45\text{W} \rightarrow R_2 = 5\Omega$$

$$R_1 = \frac{12\text{V}}{3\text{A}} = 4\Omega$$

$$R_T = R_1 + R_2 + R_3 = 17\Omega$$

$$E_2 - 20\text{V} = I \times R_T = (3\text{A})(17\Omega) = 51\text{V}$$

$$E_2 = 71\text{V}$$

Exercise 40[-a]

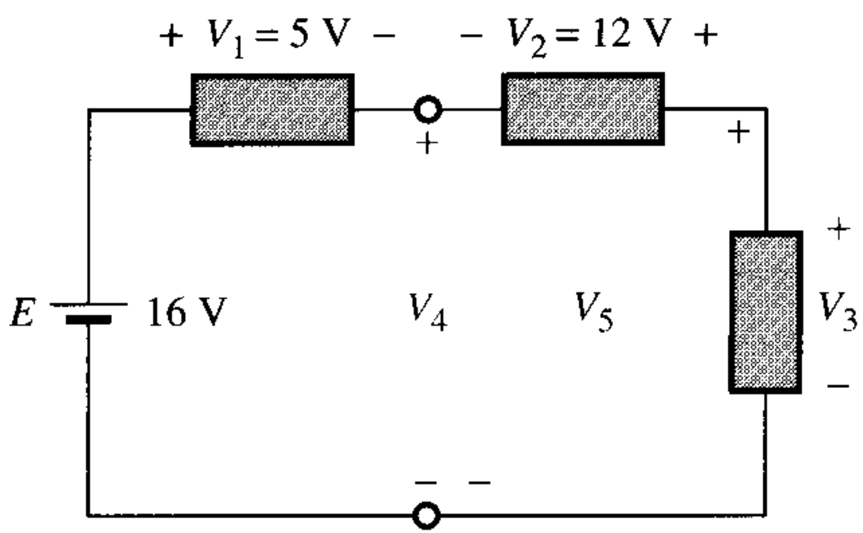
- Determine the unknown voltage for the circuit in Fig. 2.59 using Kirchhoff's voltage law.

$$16V - 5V + 12V - V_3 = 0$$

$$V_3 = 23V$$

$$V_4 = 16V - 5V = 11V$$

$$V_5 = V_3 = 23V$$



(a)

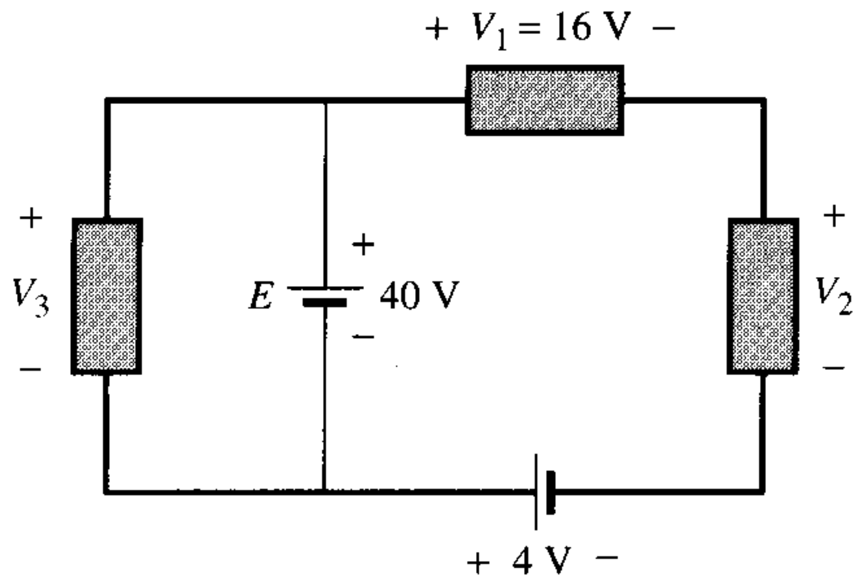
Exercise 40^{-6}

- Determine the unknown voltage for the circuit in Fig. 2.59 using Kirchhoff's voltage law.

$$V_3 = E = 40V$$

$$40V - 16V - V_2 + 4V = 0$$

$$V_2 = 44V - 16V = 28V$$



(b)

Exercise 41

- Determine the voltage V_3 and V_4 using the voltage-divider rule for the network in Fig. 2.60.

$$V_3 = \frac{R_3}{R_1 + R_2 + R_3} \times E = 3.6V$$

$$V_4 = \frac{R_2 + R_3}{R_1 + R_2 + R_3} \times E = 9.6V$$

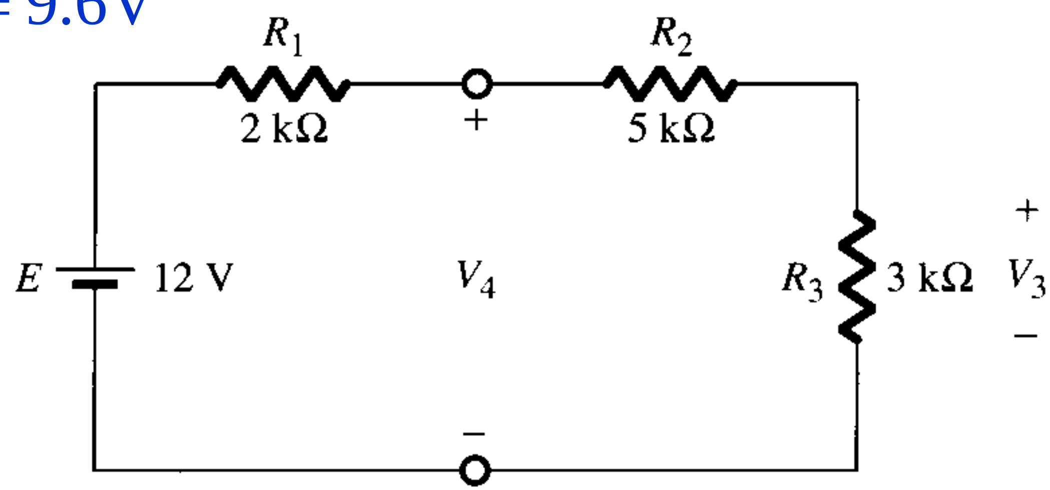


FIG. 2.60

Exercise 42

- Determine R_2 for the given voltage level for the network in Fig. 2.61 using the voltage-divider rule.

$$V_2 = \frac{R_2}{R_1 + R_2} \times E = 12V$$

$$R_2 = 6k\Omega$$

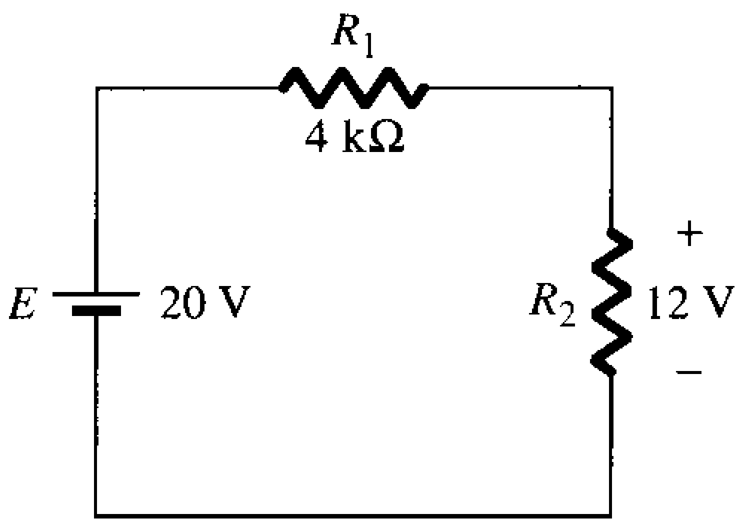


FIG. 2.61

Exercise 43

- Determine the voltage levels V_1 and V_3 and E for the circuit in Fig. 2.62.

$$\frac{V_1}{R_1} = \frac{2V}{R_2} \rightarrow V_1 = 6V$$

$$\frac{V_3}{R_3} = \frac{2V}{R_2} \rightarrow V_3 = 1V$$

$$E = V_1 + V_2 + V_3 = 9V$$

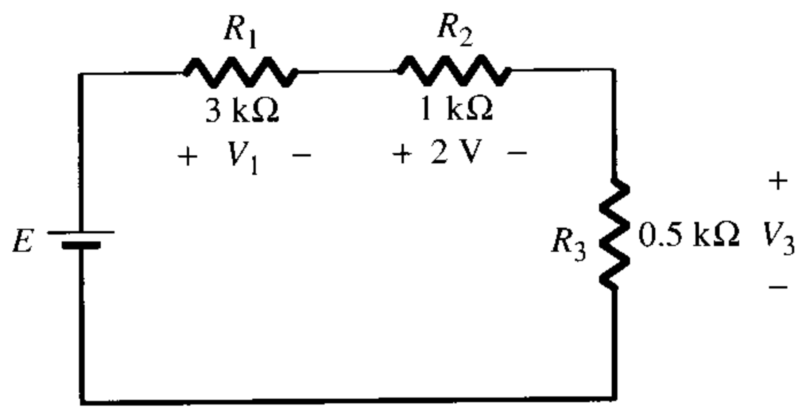
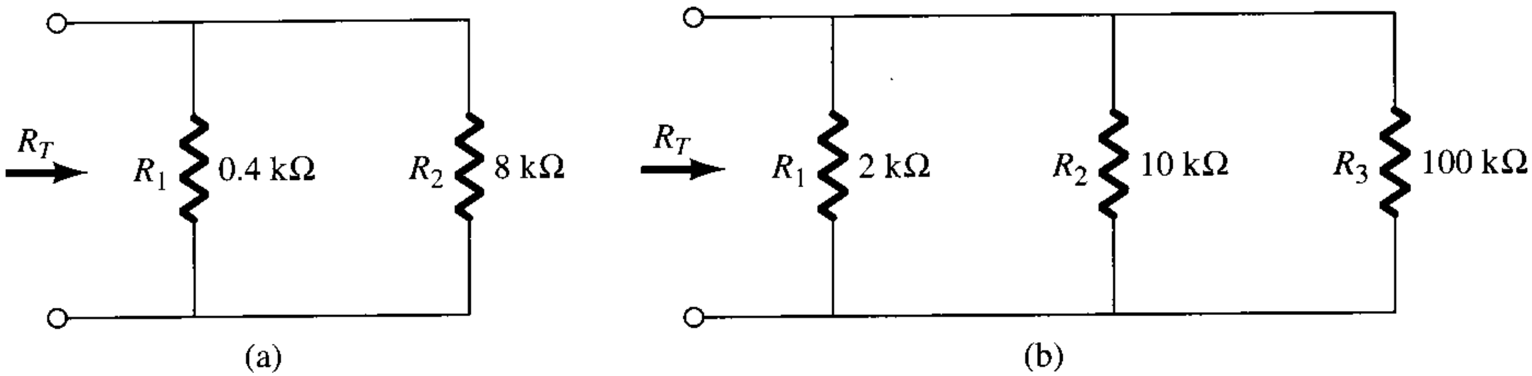


FIG. 2.62

Exercise 44

- Determine the total resistance of the networks in Fig. 2.63.



a. $R_T = R_1 // R_2 = 0.4k\Omega // 8k\Omega = 380.95\Omega$

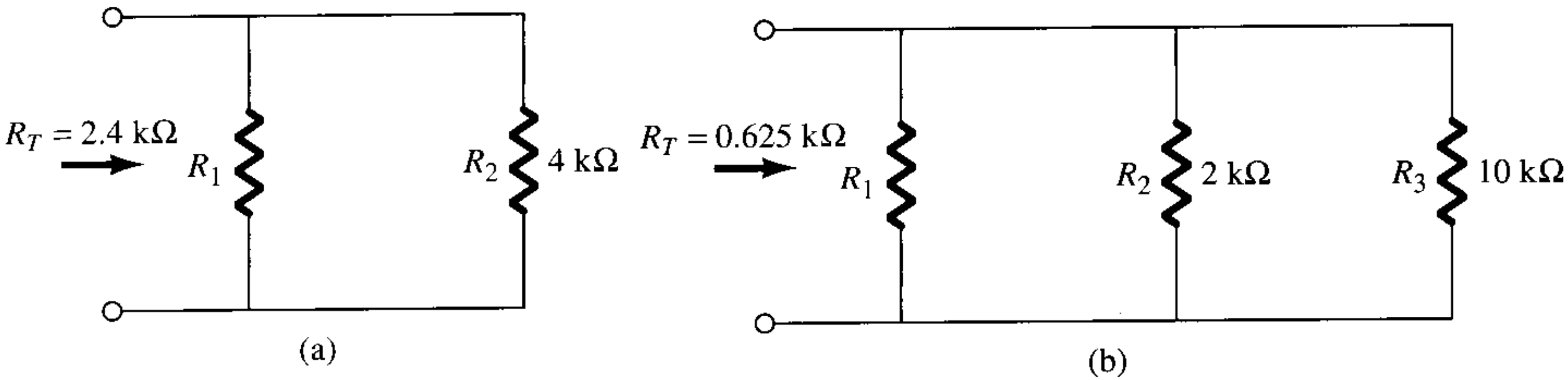
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

b. $R_T = R_1 // R_2 // R_3 = 2k\Omega // 10k\Omega // 100k\Omega = 1.639k\Omega$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Exercise 45

- Determine R_1 for the networks in Fig. 2.64.



a. $R_T = R_1 // R_2 = R_1 // 4k\Omega = 2.4k\Omega$

$$\rightarrow R_1 = 6k\Omega$$

b. $R_T = R_1 // R_2 // R_3 = R_1 // 2k\Omega // 10k\Omega = 0.625k\Omega$

$$\rightarrow R_1 = 1k\Omega$$

Exercise 46^{-1}

- For the network in Fig. 2.65 determine:

  a. R_T. b. I. c. V_1. d. V_3. e. P_2.

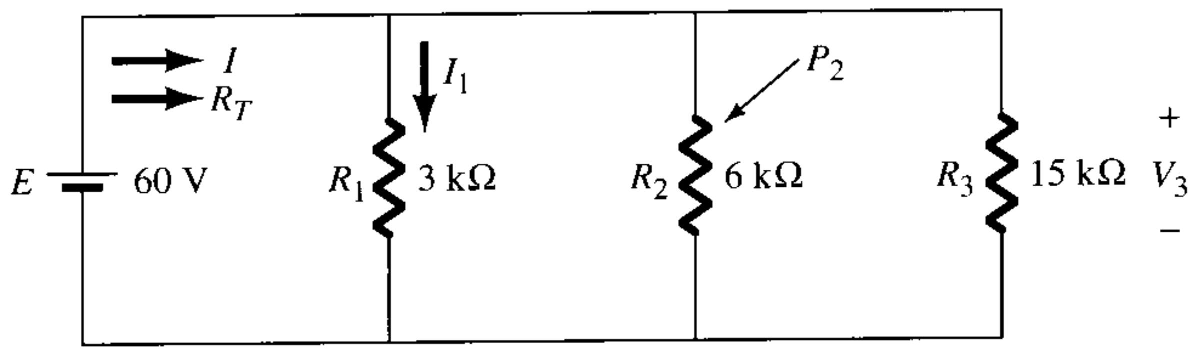


FIG. 2.65

a. $R_T = R_1 // R_2 // R_3 = 3k\Omega // 6k\Omega // 15k\Omega = 1.765k\Omega$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

Exercise 46-2

- For the network in Fig. 2.65 determine:

  a. R_T. b. I. c. V_1. d. V_3. e. P_2.

$$b.\ I = \frac{E}{R_T} = \frac{60V}{1.765k\Omega} = 33.99mA \qquad c.\ I_1 = \frac{V_{R_1}}{R_1} = \frac{E}{R_1} = 20mA$$

$$c.\ I_1 = \frac{V_{R_1}}{R_1} = \frac{E}{R_1} = 20mA \qquad d.\ V_3 = E = 60V$$

$$e.\ P_2 = \frac{V^2{}_{R_2}}{R_2} = \frac{E^2}{R_2} = \frac{(60V)^2}{6k\Omega} = 0.6W$$

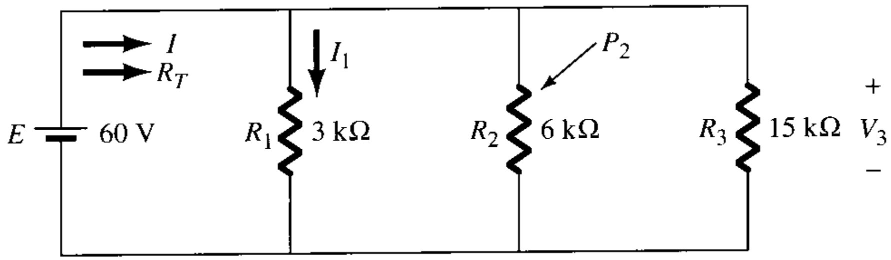
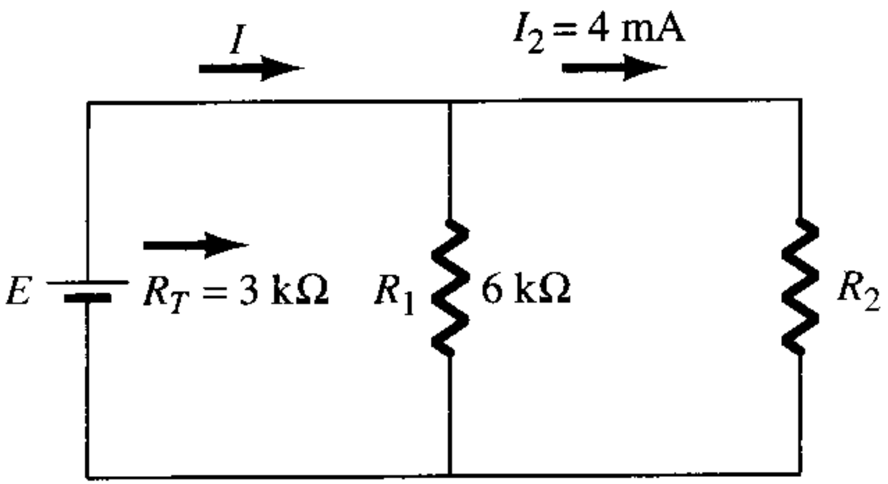


FIG. 2.65

Exercise 47-a

- Determine the unknown quantities for the networks in Fig. 2.66a.



(a)

$$R_T = R_1 // R_2 = 6k\Omega // R_1 = 3k\Omega \qquad \rightarrow R_2 = 6k\Omega$$

$$V_2 = I_2 \times R_2 = (4ma)(6k\Omega) = 24V$$

$$E = V_2 = 24V \qquad I = \frac{E}{R_T} = 8mA$$

Exercise 47-b

- Determine the unknown quantities for the networks in Fig. 2.66b.

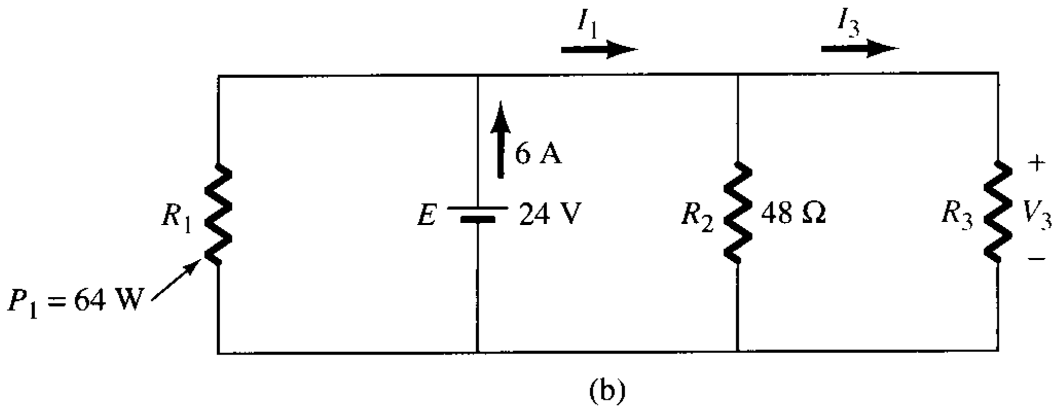


FIG. 2.66

$$V_1 = V_2 = V_3 = E = 24V \qquad I_2 = \frac{V_2}{R_2} = \frac{24V}{48\Omega} = 0.5A$$

$$P_1 = \frac{V_1^{\,2}}{R_1} = 64W \rightarrow R_1 = 9\Omega \qquad I = \frac{E}{R_T} = \frac{24V}{R_T} = 6A \rightarrow R_T = 4\Omega$$

$$R_T = R_1 // R_2 // R_3 = 4\Omega \rightarrow R_1 = 8.471\Omega$$

$$I_3 = \frac{V_3}{R_3} = \frac{24V}{8.471\Omega} = 2.833A \qquad I_1 = I_2 + I_3 = 3.333A$$

Exercise 48

- Determine the unknown currents for the circuits in Fig. 2.67 using Kirchhoff's current law.

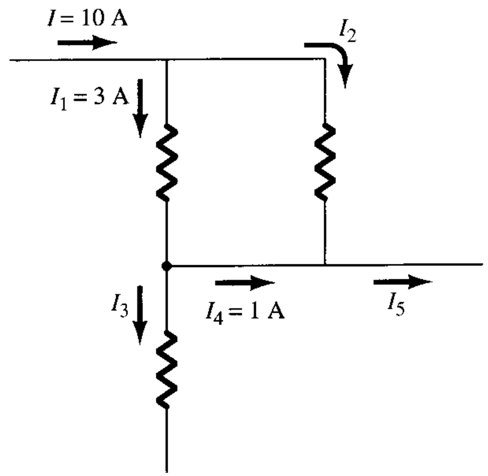
a. $10A = 3A + I_2$

$I_2 = 7A \qquad I_2 + 1A = I_5 \qquad I_5 = 8A$

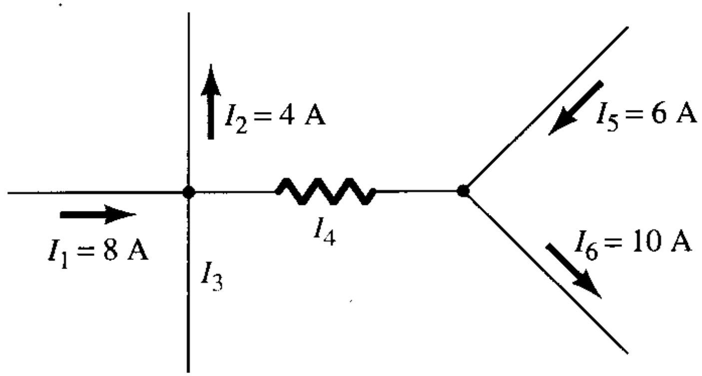
$3A = I_3 + 1A \qquad I_3 = 2A$

b. $I_4 + I_5 = I_6 \qquad I_4 + 6A = 10A \qquad I_4 = 4A$

$8A - 4A - 4A + I_3 = 0 \qquad I_3 = 0A$



(a)



Exercise 49

- Determine the currents I_1 and I_2 in Fig. 2.68 using the current divider rule. What is the ratio R_1/R_2? How does it compare with the ratio I_1/I_2?

$$I_1 = I \times \frac{R_2}{R_1 + R_2} = 10mA \times \frac{40k\Omega}{8k\Omega + 40k\Omega} = 8.333mA$$

$$I_2 = I - I_1 = 1.667mA$$

$$\frac{R_1}{R_2} = \frac{I_2}{I_1}$$

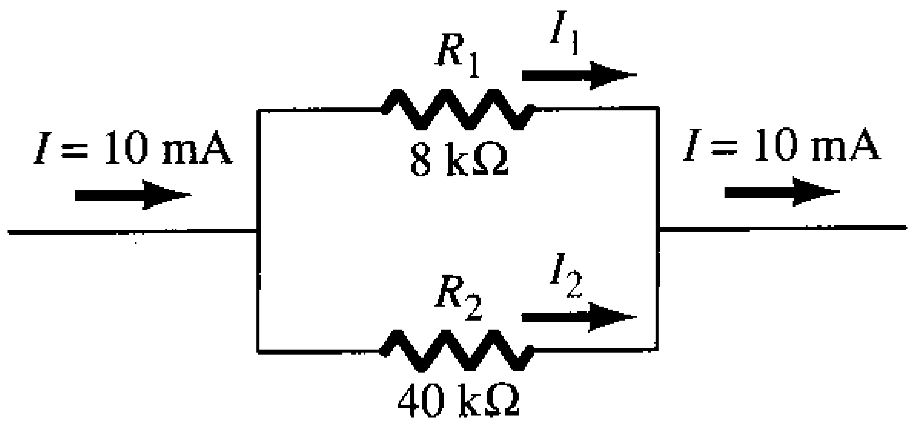


FIG. 2.68

Exercise 50

- Determine R_1 for the network in Fig. 2.69 using current-divider rule.

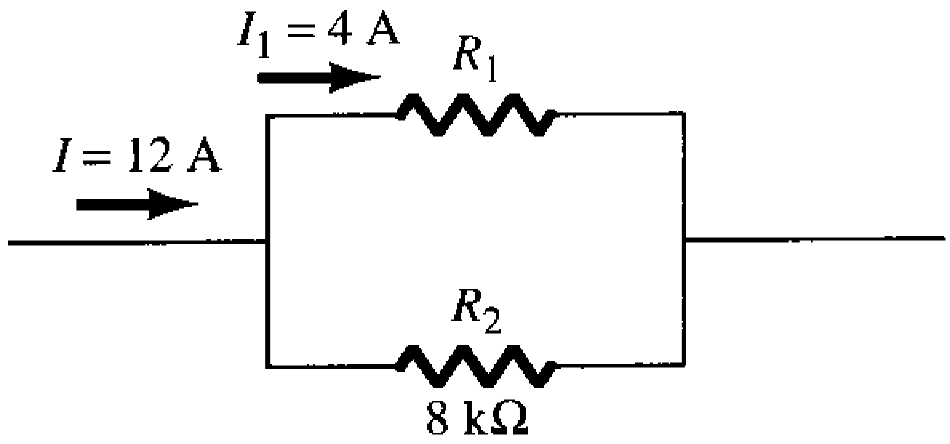


FIG. 2.69

$$I_{R_2} = I - I_1 = 12A - 4A = 8A$$

$$V_{R_2} = I_{R_2} \times R_2 = (8A)(8k\Omega) = 64kV$$

$$R_1 = \frac{V_{R_1}}{I_1} = 16k\Omega$$

Exercise 51

- Find I_1, I_3, and I for the network in Fig. 2.70.

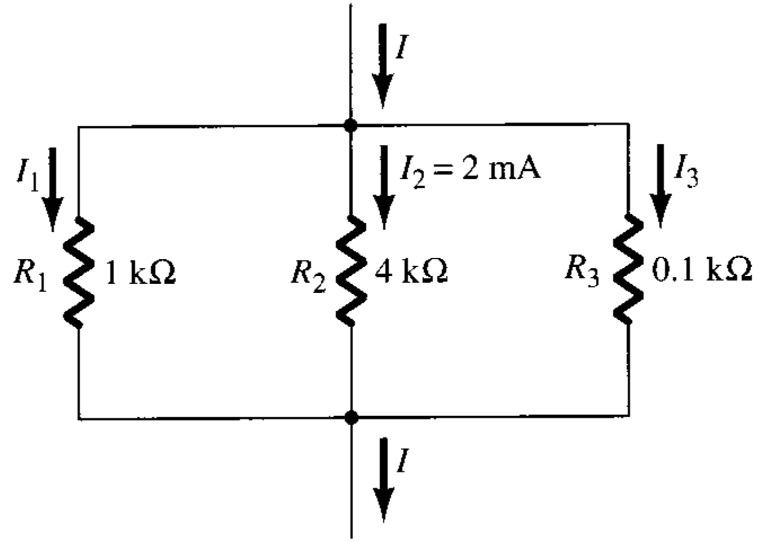


FIG. 2.70

$$V_2 = I_2 \times R_2 = (2mA)(4k\Omega) = 8V$$

$$V_1 = V_2 \qquad V_2 = V_3$$

$$I_1 = \frac{V_1}{R_1} = \frac{8V}{1k\Omega} = 8mA \qquad I_3 = \frac{V_3}{R_3} = \frac{8V}{0.1k\Omega} = 80mA$$

$$I = I_1 + I_2 + I_3 = 90mA$$

Exercise 52

a. Sketch the location and connecting of ammeters and voltmeters used to measure the currents I_1 and I_3 and voltages V_1 and V_3 in Fig. 2.71.

b. Using a voltmeter with an ohm-per-volt rating of 1000, determine the indication of meter when it is placed across the 4-kΩ resistor if the 50-V scale is used.

c. Repeat part (b) for a meter employing an ohm-per-volt rating of 20,000.

d. Repeat part (b) for a DMM with an internal resistance of 11 MΩ.

e. Show the connection for a wattmeter reading the power delivered to R_3 and R_4.

Exercise 52

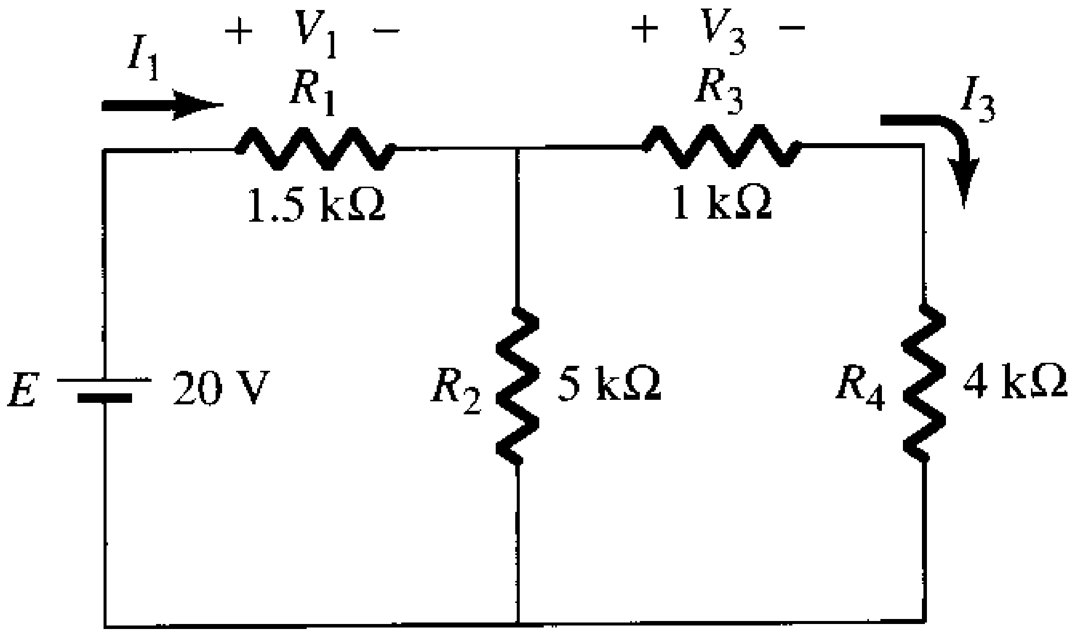


FIG. 2.71