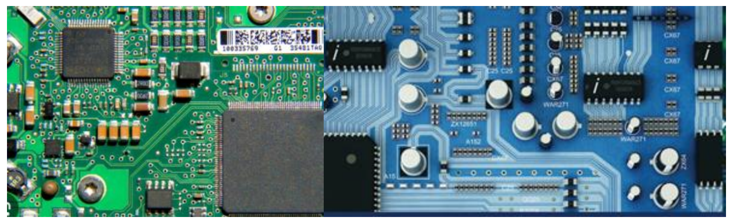
电子科技大学
格拉斯哥学院
Glasgow College, UESTC



URL
classpoint.app

Class code
CADIE

Circuit Analysis and Design

Academic year 2025/2026 – Lecture 4

Muhammad Aslam, Masood Ur Rahman, Ali Imran

{Muhammad.Aslam.2, Masood.UrRehman, Ali.Imran}@*glasgow.ac.uk*

"A good student never steal or cheat"

Agenda

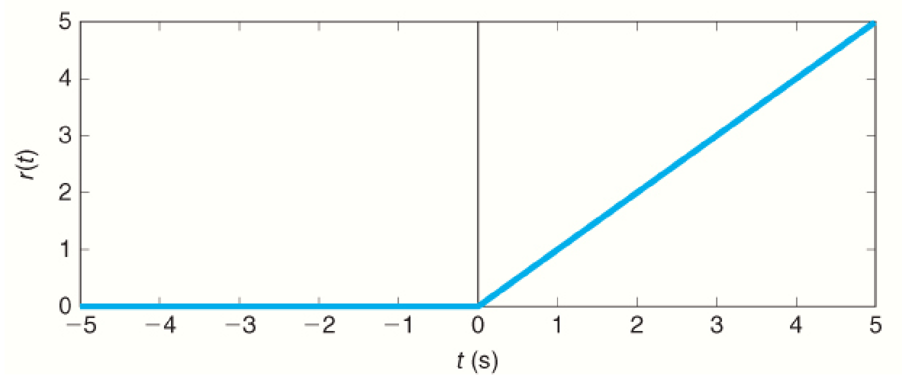
- ❑ **Revise Signal Functions**
  - Delta Function
  - Step Function
  - Ramp Function
  - Exponential Functions
  - Rectangular and Triangular Functions
- ❑ **Revise Equivalent Resistance**
- ❑ **Voltage divider rule**
- ❑ **Current divider rule**
- ❑ Summary

Ramp Function

- A unit ramp function is defined by

$$r(t) = t\,u(t)$$

- Unit ramp function is shown here



- Unit ramp function is the integral of the unit step function:

$$r(t) = \int_{-\infty}^{t} u(\lambda)\,d\lambda$$

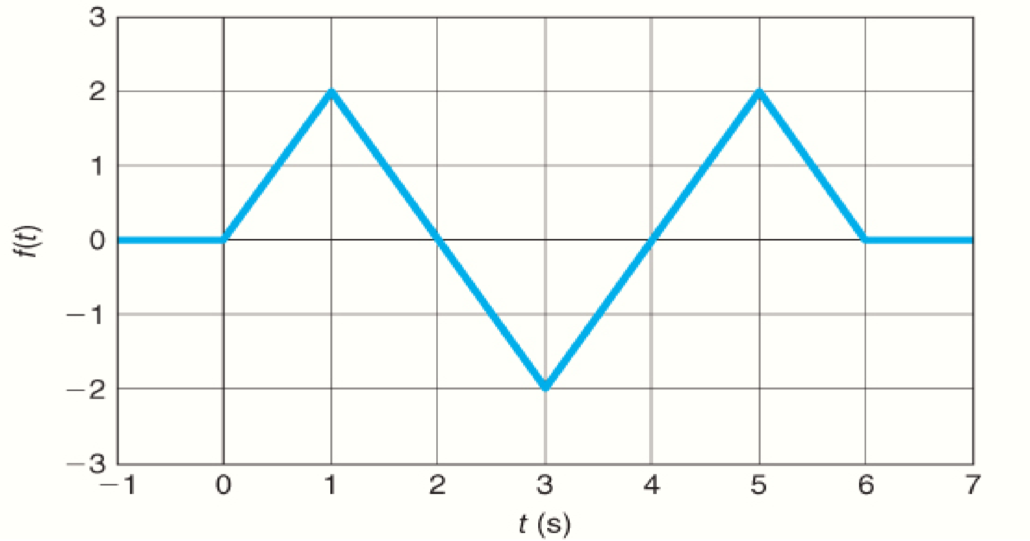
- Derivative of unit ramp function is unit step function:

$$u(t) = \frac{dr(t)}{dt}$$

EXAMPLE 1.9

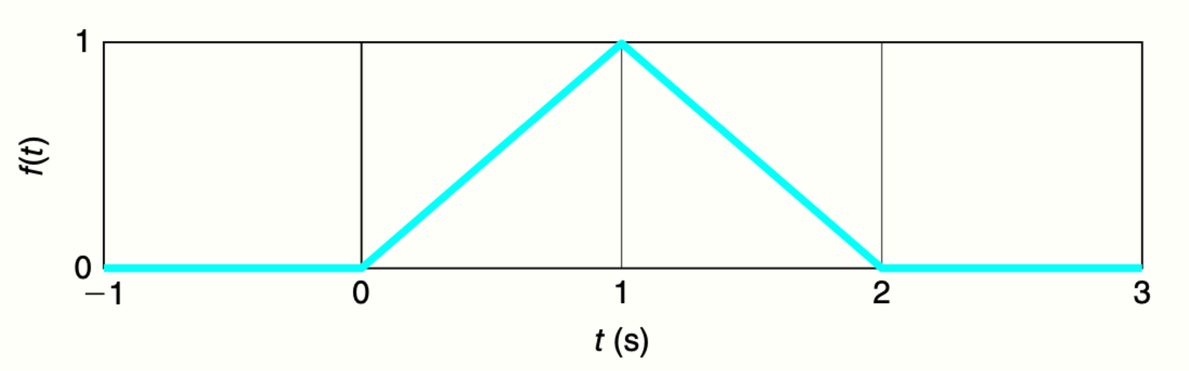
- **Plot $f(t) = 2tu(t) - 4(t-1)u(t-1) + 4(t-3)u(t-3) - 4(t-5)u(t-5) + 2(t-6)u(t-6)$**
- For $t < 0$, $f(t) = 0$

- Step 1: For $0 \le t < 1$, $f(t)$ is a linear line with slope of 2. (Slope = 2)
- Step 2: For $1 \le t < 3$, $f(t)$ is a linear line with slope of –2. (Slope = 2 – 4 = -2)
- Step 3: For $3 \le t < 5$, $f(t)$ is a linear line with slope of 2. (Slope = -2 + 4 = 2)
- Step 4: For $5 \le t < 6$, $f(t)$ is a linear line with slope of –2. (Slope = 2 – 4 = -2)
- Step 5: For $6 \le t$, $f(t) = 0$. (Slope -2 + 2 = 0)



Class work

❑ Find the equation



- **Options**

A. $tu(t) + 2(t-1)u(t-1) - (t-2)u(t-2)$

B. $tu(t) - 2(t-1)u(t-1) + (t-2)u(t-2)$

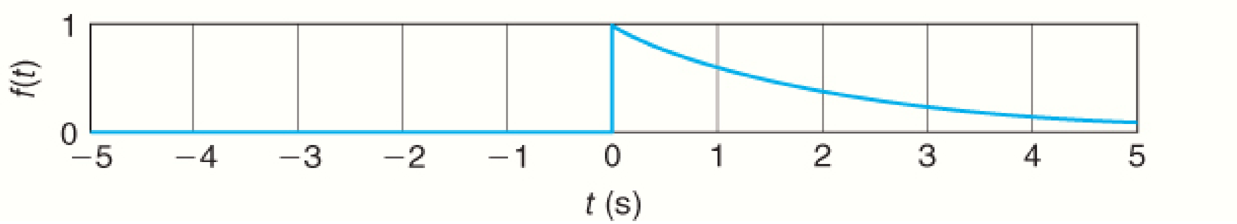
C. $tu(t) + (t-2)u(t-2)$

Exponential Decay Functions

- A signal that decays exponentially can be written as

$$f(t) = e^{-at}\, u(t)\,,\, a > 0.$$

- The signal f(t) for a = 0.5 is shown in Figure 1.37.

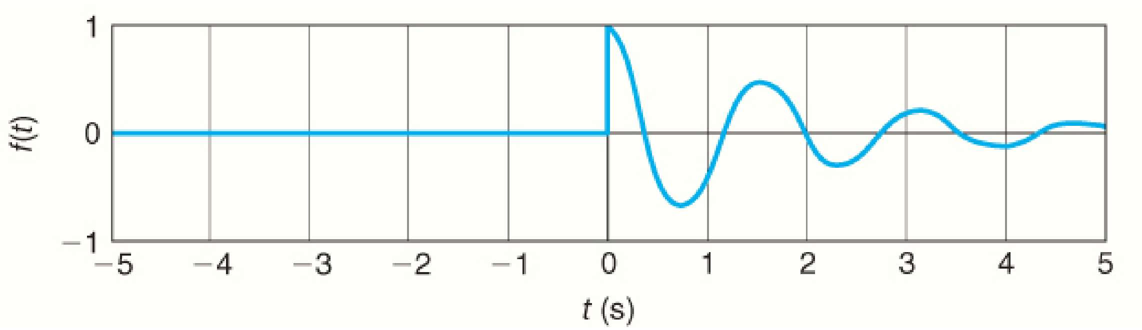


- Damped cosine and damped sine can be written respectively as

$f(t) = e^{-at}\cos(bt)u(t)$, $a > 0$

$f(t) = e^{-at}\sin(bt)u(t)$, $a > 0$

- Damped cosine signal is shown 1.38 for a = 0.5 and b = 4.

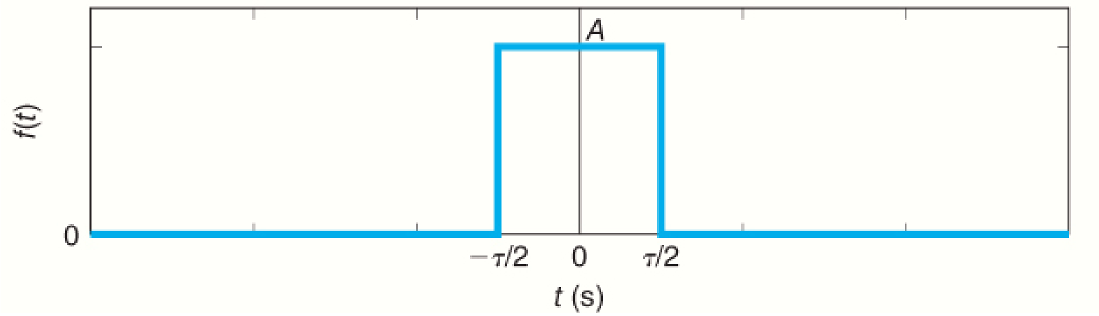


Rectangular Pulse and Triangular Pulse

- **A rectangular** pulse with amplitude A pulse width τ is shown in Figure. Center of the pulse is at t = 0.

- Rectangular pulse shown in is denoted by:

$$f(t) = A\,rect\left(\frac{t}{\tau}\right)$$

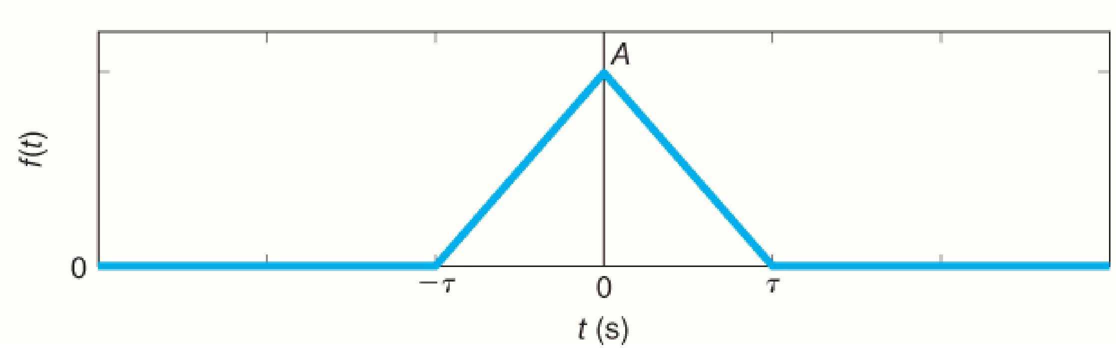


- **A triangular** pulse with amplitude **A** and base 2τ is shown in Figure. The center of the pulse is at t = 0.

- Triangular pulse shown in

Figure 1.42 is denoted by

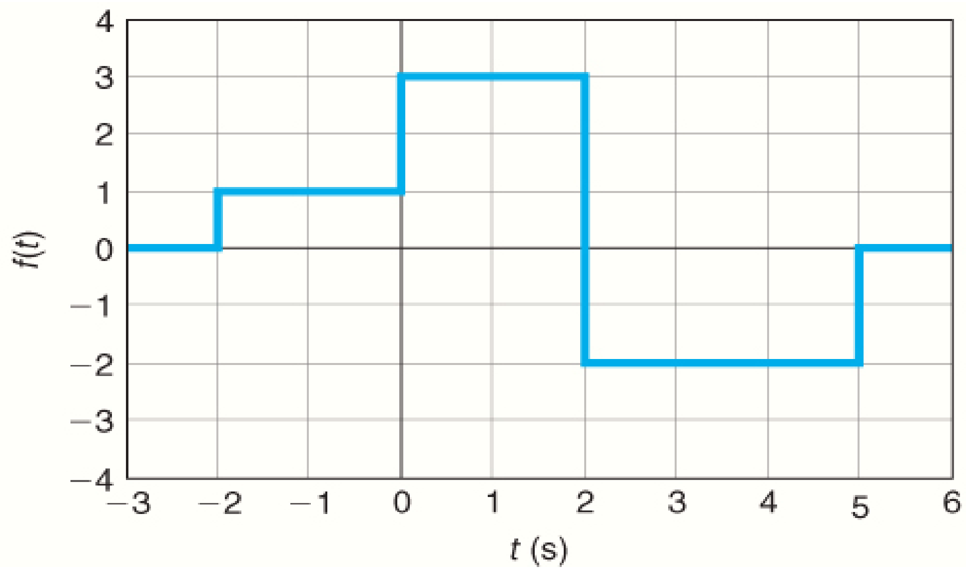
$$f(t) = A\ tri\left(\frac{t}{\tau}\right)$$



EXAMPLE 1.11

- Plot $$f(t) = rect\left(\frac{t+1}{2}\right) + 3\,rect\left(\frac{t-1}{2}\right) - 2\,rect\left(\frac{t-3.5}{3}\right)$$

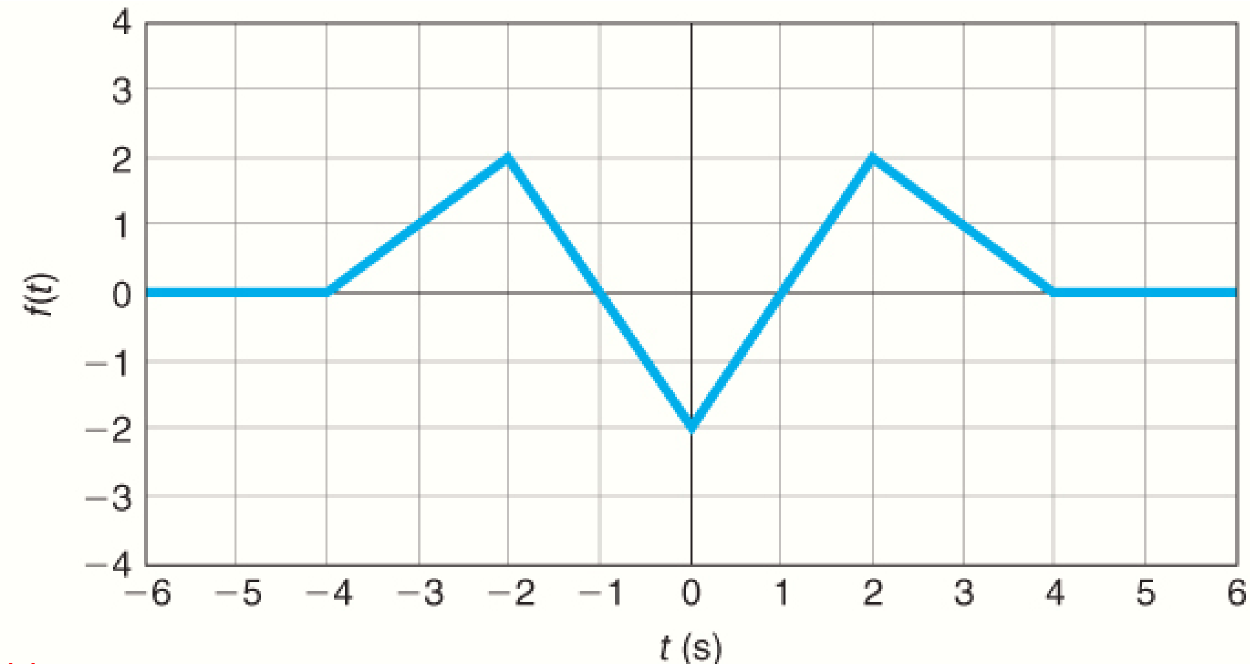
- The first rectangle is centered at t = –1 and has a height of 1 and width of 2. The second rectangle is centered at t = 1 and has a height of 3 and width of 2. The third rectangle is centered at t = 3.5 and has a height of –2 and width of 3. The waveform f(t) is shown in Figure 1.40.



EXAMPLE 1.12

- Plot $$f(t) = 2\,tri\left(\frac{t+2}{2}\right) - 2\,tri\left(\frac{t}{2}\right) + 2\,tri\left(\frac{t-2}{2}\right)$$

1. The first triangle is centered at t = –2 and has a height of 2 and base of 4.
2. The second triangle is centered at t = 0 and has a height of -2 and base of 4.
3. The third triangle is centered at t = 2 and has a height of 2 and base of 4. The waveform f(t) is shown in Figure 1.43.



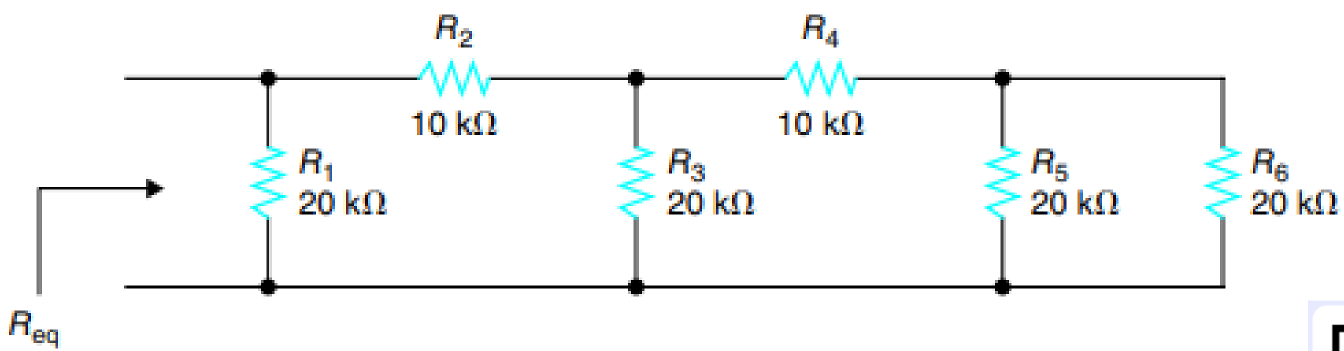
Home work: Problem 1.27 to 1.32

Problem 2.39

Find the Equivalent Resistance

Fill in the Blanks

FIGURE P2.39



- **What is the value of equivalent resistance ----------------** $k\Omega$

URL
classpoint.app
Class code
CADIE

Solution will be provided in class

EXAMPLE 2.12

- **Find the equivalent resistance seen from the voltage source**. Also find **I, I_1, I_2, V_1, V_2, V_3**, and power absorbed by resistors and power released by the voltage source.

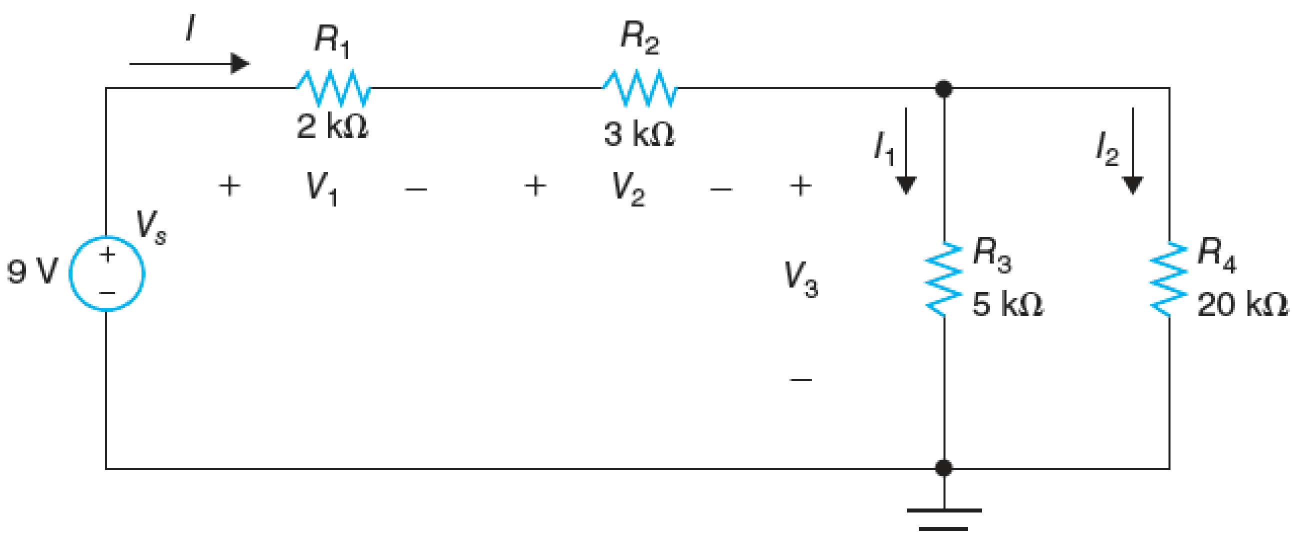


FIGURE 2.40

- The value of R_{eq}

A. 9 kΩ

B. 10 kΩ

Solution will be provided in the class

EXAMPLE 2.12

- Find the equivalent resistance seen from the voltage source. Also find I, I_1, I_2, V_1, V_2, V_3, and power absorbed by resistors and power released by the voltage source.
  - $R_a = R_3 \,||\, R_4 = R_3 \times R_4/(R_3+R_4) = 100/25\ k\Omega = 4\ k\Omega$, $R_{eq} = R_1 + R_2 + R_a = 9\ k\Omega$
  - $I = V_s/R_{eq} = 9/9000\ A = 1\ mA$
  - $V_1 = R_1I = 2\ V$, $V_2 = R_2I = 3\ V$, $V_3 = R_aI = 4\ V$
  - $I_1 = V_3/R_3 = 0.8\ mA$, $I_2 = V_3/R_4 = 0.2\ mA$
  - $P_{R1} = IV_1 = 2\ mW$, $P_{R2} = IV_2 = 3\ mW$, $P_{R3} = I_1V_3 = 3.2\ mW$, $P_{R4} = I_2V_3 = 0.8\ mW$
  - $P_{Vs} = -IV_s = -9\ mW$
  - Power absorbed by resistors = 9 mW
  - Power released by voltage source = 9 mW

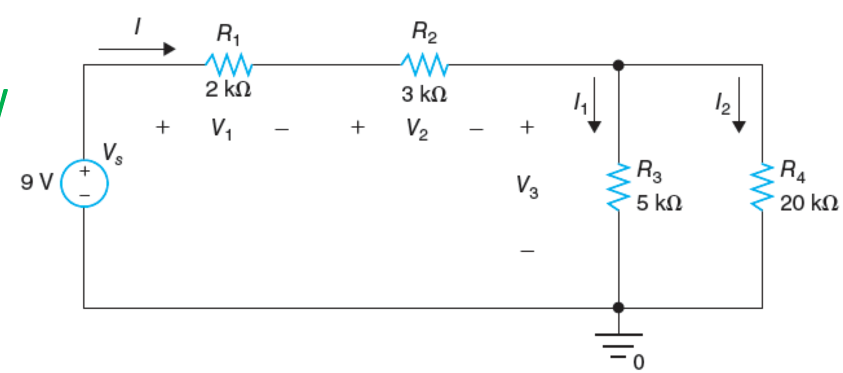


FIGURE 2.40

Circuits with Parallel and Series Resistors

- **Example 2.14**: Find the equivalent resistance seen from the current source. Also find I_a, I_1, I_2, I_3, I_4, I_5, I_6, I_7, V_1, V_2, V_3 for the circuit shown in Figure 2.46.

- $R_8 = R_1 \,||\, R_2 = R_1 \times R_2/(R_1+R_2) = 1200/80\ \text{k}\Omega = 15\ \text{k}\Omega$, $R_9 = R_3 + R_8 = 20\ \text{k}\Omega$
- $R_a = R_4 \,||\, R_9 = R_4 \times R_9/(R_4+R_9) = 600/50\ \text{k}\Omega = 12\ \text{k}\Omega$
- $R_{10} = R_6 \,||\, R_7 = R_6 \times R_7/(R_6+R_7) = 960/64\ \text{k}\Omega = 15\ \text{k}\Omega$, $R_b = R_5 + R_{10} = 36\ \text{k}\Omega$
- $R_{eq} = R_a \,||\, R_b = R_a \times R_b/(R_a+R_b) = 432/48\ \text{k}\Omega = 9\ \text{k}\Omega$
- $V_1 = R_{eq} I_s = 9000 \times 0.002 = 18$ V, $I_a = V_1/R_a = 18/12000$ A $= 1.5$ mA, $I_5 = I_s - I_a = 0.5$ mA
- $I_4 = V_1/R_4 = 18/30000$ A $= 0.6$ mA, $I_3 = I_a - I_4 = 0.9$ mA, $V_2 = V_1 - R_3 I_3 = 13.5$ V
- $I_1 = V_2/R_1 = 0.675$ mA
- $I_2 = V_2/R_2 = 0.225$ mA
- $V_3 = V_1 - R_5 I_5 = 7.5$ V
- $I_6 = V_3/R_6 = 0.3125$ mA
- $I_7 = V_3/R_7 = 0.1875$ mA

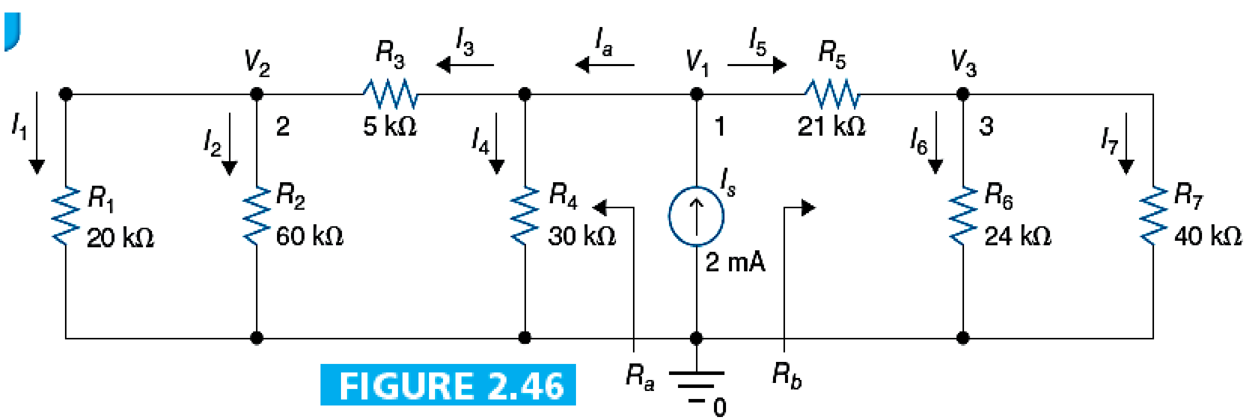


FIGURE 2.46

Home work: Problem 2.32 to 2.46

Voltage Divider Rule for Two Resistors in Series

- A voltage source is connected to a series connection of resistors R_1 and R_2 as shown in Figure 2.49.
- Current through the resistors is given by → $I = \dfrac{V_s}{R_1 + R_2}$
- Voltage across R_1 is given by

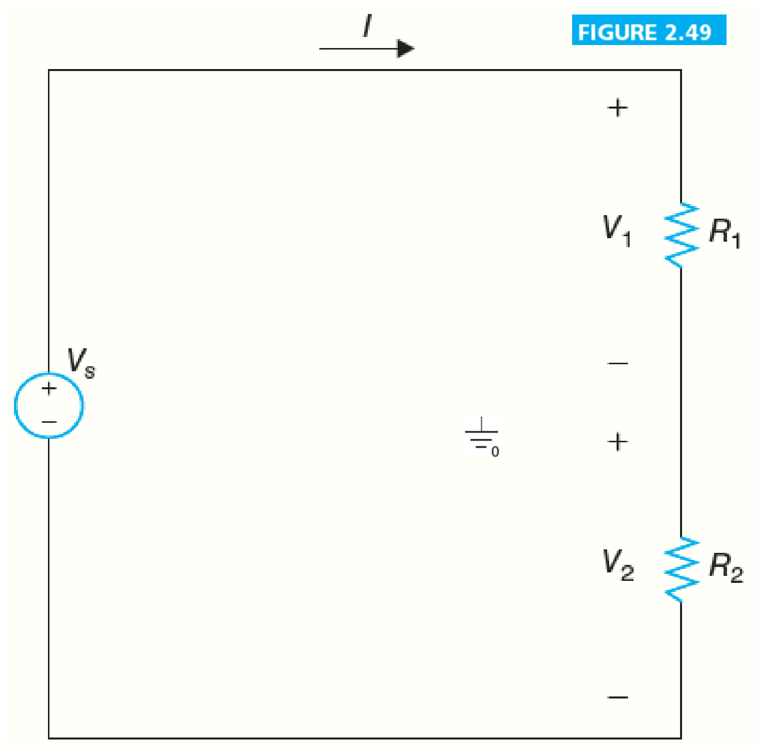
$$V_1 = I \times R_1 = \frac{V_s}{R_1 + R_2} \times R_1 = V_s \times \frac{R_1}{R_1 + R_2}$$

- Voltage across R_2 is given by

$$V_2 = I \times R_2 = \frac{V_s}{R_1 + R_2} \times R_2 = V_s \times \frac{R_2}{R_1 + R_2}$$

- If two resistors are connected in Series, **Voltage from voltage source is divided between R_1 and R_2 in proportion to the resistance values.**

FIGURE 2.49



Voltage Divider Rule for n Resistors

- A voltage source is connected to a series connection of n resistors R_1, R_2, …, R_n.
- The current through the resistors is given by

$$I = \frac{V_s}{R_1 + R_2 + \ldots + R_n}$$

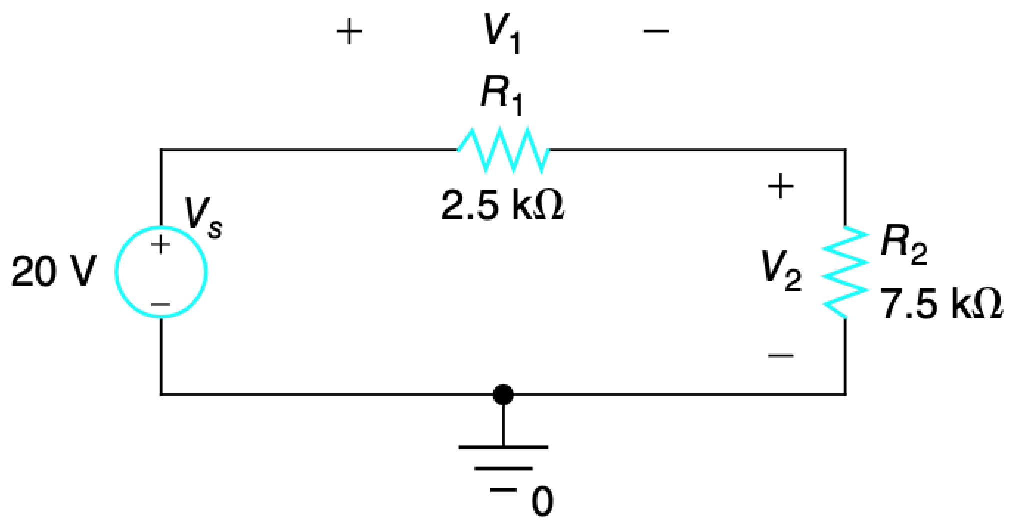
- The voltage across R_i is given by

$$V_i = I \times R_i = \frac{V_s}{R_1 + R_2 + \ldots + R_n} \times R_i = V_s \times \frac{R_i}{R_1 + R_2 + \ldots + R_n}$$

- The voltage from the voltage source is divided among n resistors in proportion to the resistance values.

Problem 2.47

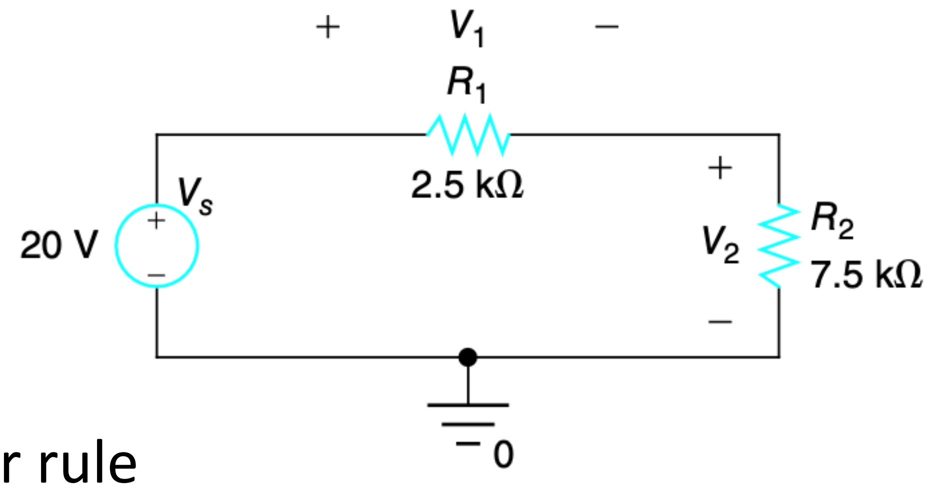
- Use voltage divider rule to find voltage Vs and V2 in the circuit



- Options
  - A. V1 = 10, V2 = 10
  - B. V1 = 4, V2 = 16
  - C. V1 = 5, V2 = 15

Solutions will be provided in the class

Problem 2.47 (Solution)



- According to Voltage divider rule
  - $V_1 = V_s \times \frac{R_1}{(R_1+R_2)}$
  - $V_1 = 20 \times \frac{2.5k}{2.5k+7.5k} = 5V$
  - $V_2 = V_s \times \frac{R_2}{(R_1+R_2)}$
  - $V_1 = 20 \times \frac{7.5k}{2.5k+7.5k} = 15V$

Circuit Analysis Using Voltage Divider Rule

- We are interested in finding V_1, V_2, and V_3.

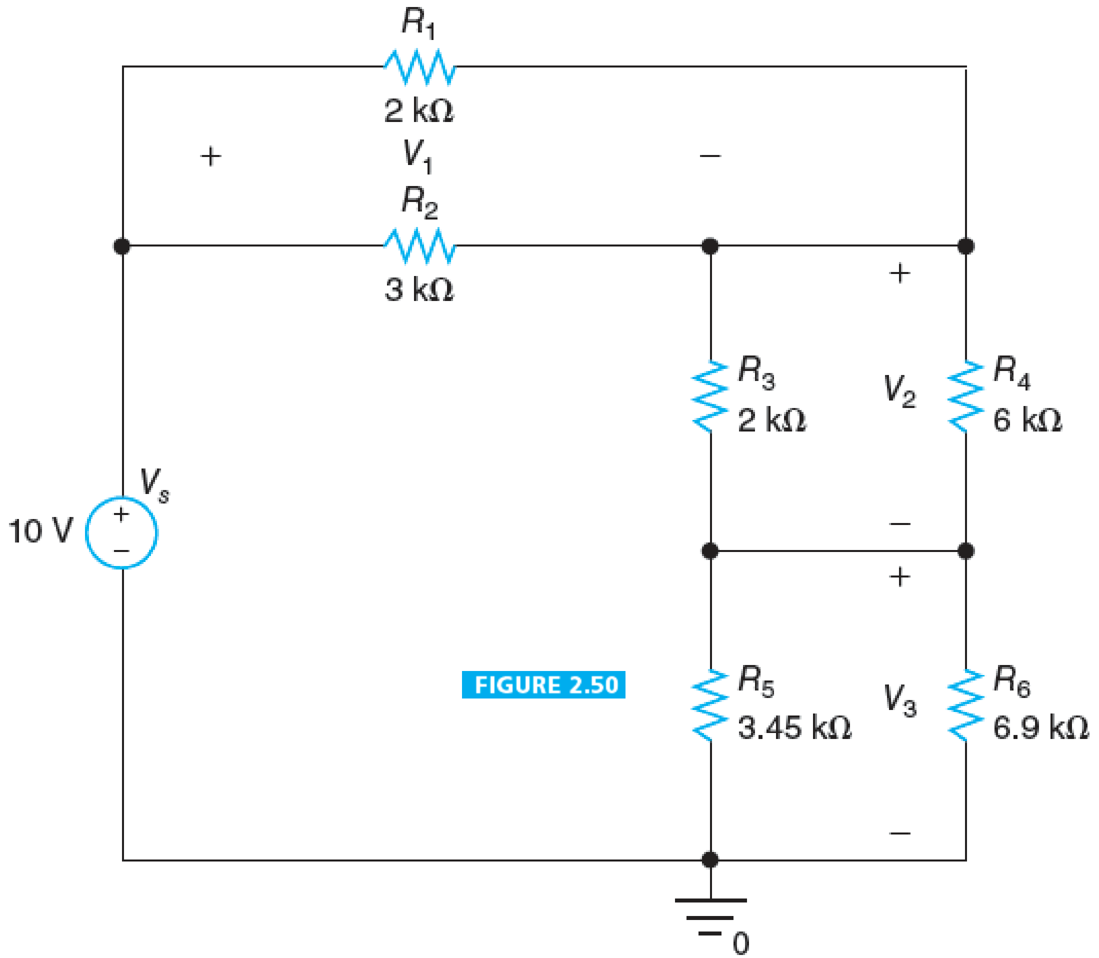


FIGURE 2.50

Circuit Analysis Using Voltage Divider Rule

- We are interested in finding V_1, V_2, and V_3.

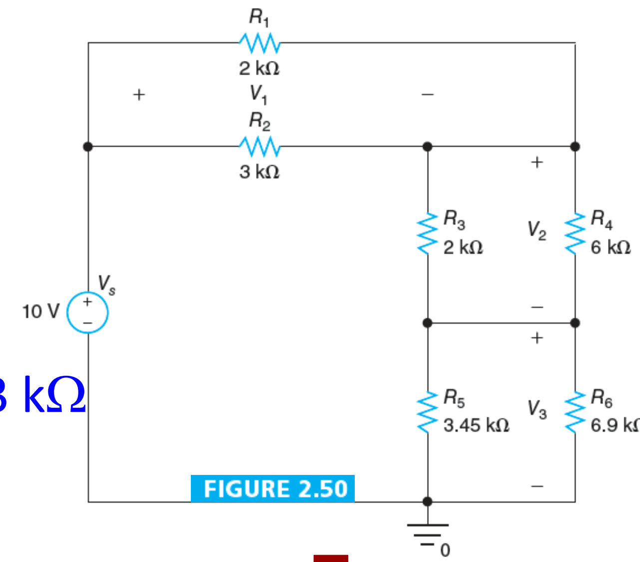


FIGURE 2.50

- $R_a = R_1 \,||\, R_2 = R_1 \times R_2/(R_1+R_2) = 6/5\ k\Omega = 1.2\ k\Omega$
- $R_b = R_3 \,||\, R_4 = R_3 \times R_4/(R_3+R_4) = 12/8\ k\Omega = 1.5\ k\Omega$
- $R_c = R_5 \,||\, R_6 = R_5 \times R_6/(R_5+R_6) = 23.805/10.35\ k\Omega = 2.3\ k\Omega$

$$V_1 = V_s \times \frac{R_a}{R_a + R_b + R_c} = 10 \times \frac{1.2}{1.2+1.5+2.3}\,\mathrm{V} = 10 \times \frac{1.2}{5}\,\mathrm{V} = 2.4\,\mathrm{V}$$

$$V_2 = V_s \times \frac{R_b}{R_a + R_b + R_c} = 10 \times \frac{1.5}{1.2+1.5+2.3}\,\mathrm{V} = 10 \times \frac{1.5}{5}\,\mathrm{V} = 3\,\mathrm{V}$$

$$V_3 = V_s \times \frac{R_c}{R_a + R_b + R_c} = 10 \times \frac{2.3}{1.2+1.5+2.3}\,\mathrm{V} = 10 \times \frac{2.3}{5}\,\mathrm{V} = 4.6\,\mathrm{V}$$

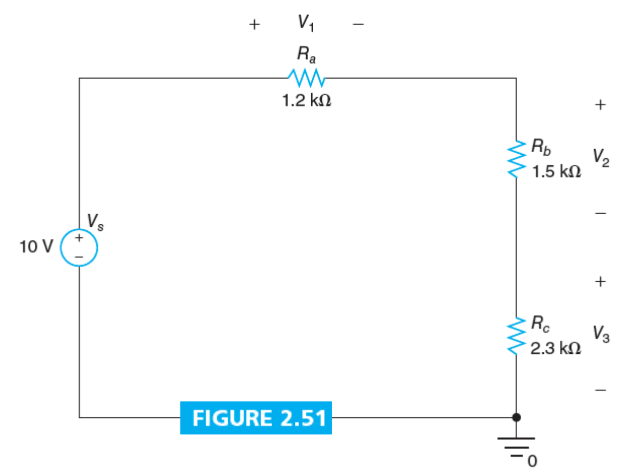
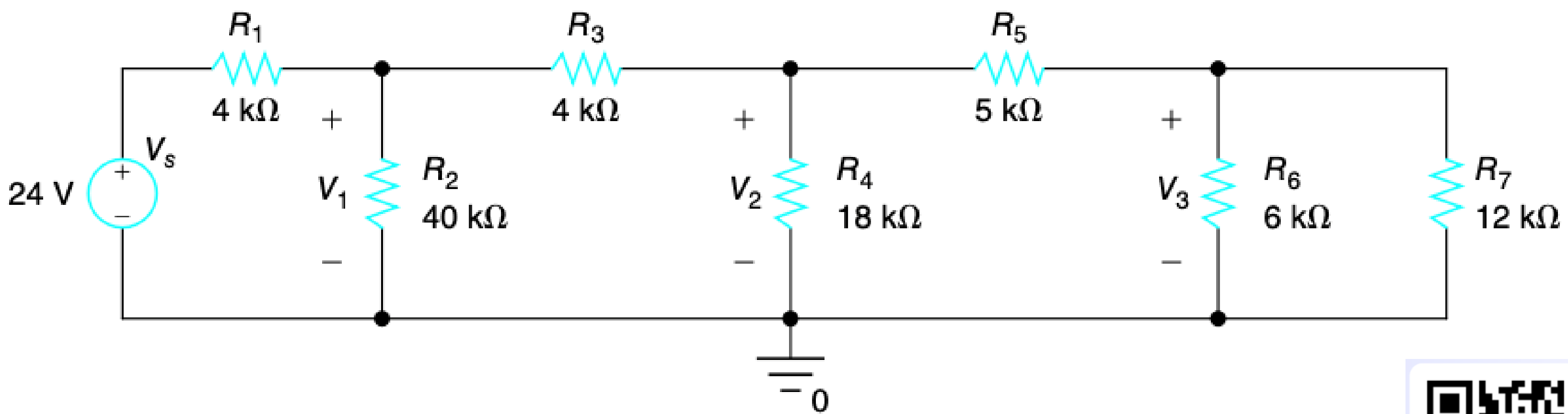


FIGURE 2.51

Problem 2.52

❑ Use the voltage divider rule to find voltages V1

Multiple Choice



Options

A. V1 = 8 V

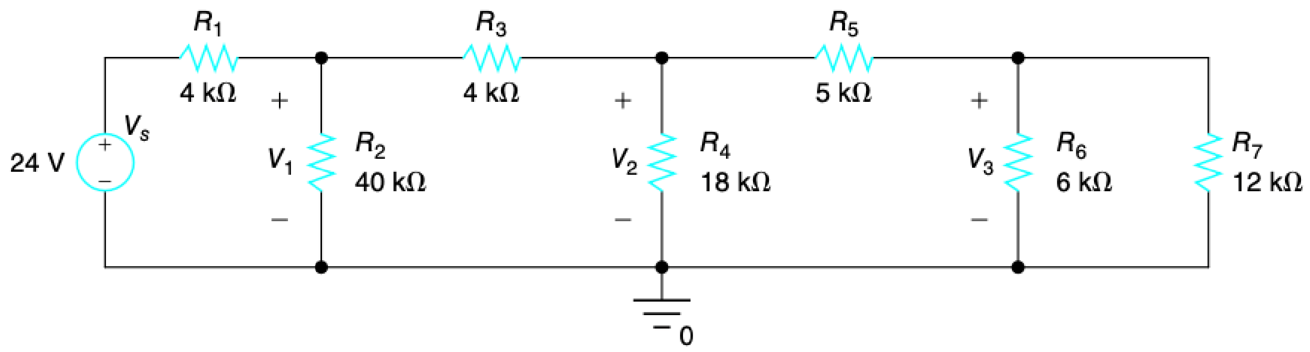
B. V1 = 12 V

C. V1 =16 V

Problem 2.52 (Solution)

- **First find equivalent resistance**
  - $R_a = R_7||R_6 + R_5 = 6||12 + 5 = 9k\Omega$
  - $R_b = R_a||R_4 + R_3 = 9||18 + 4 = 10k\Omega$
  - $R_{eq} = R_b||R_2 + R_1 = 10||40 + 4 = 8 + 4 = 12k\Omega$
- **Calculate voltage using voltage divider**

Solution will be provided in the class



EXAMPLE 2.15

- Find V_1, V_2, and V_3 in the circuit shown in Figure 2.52.

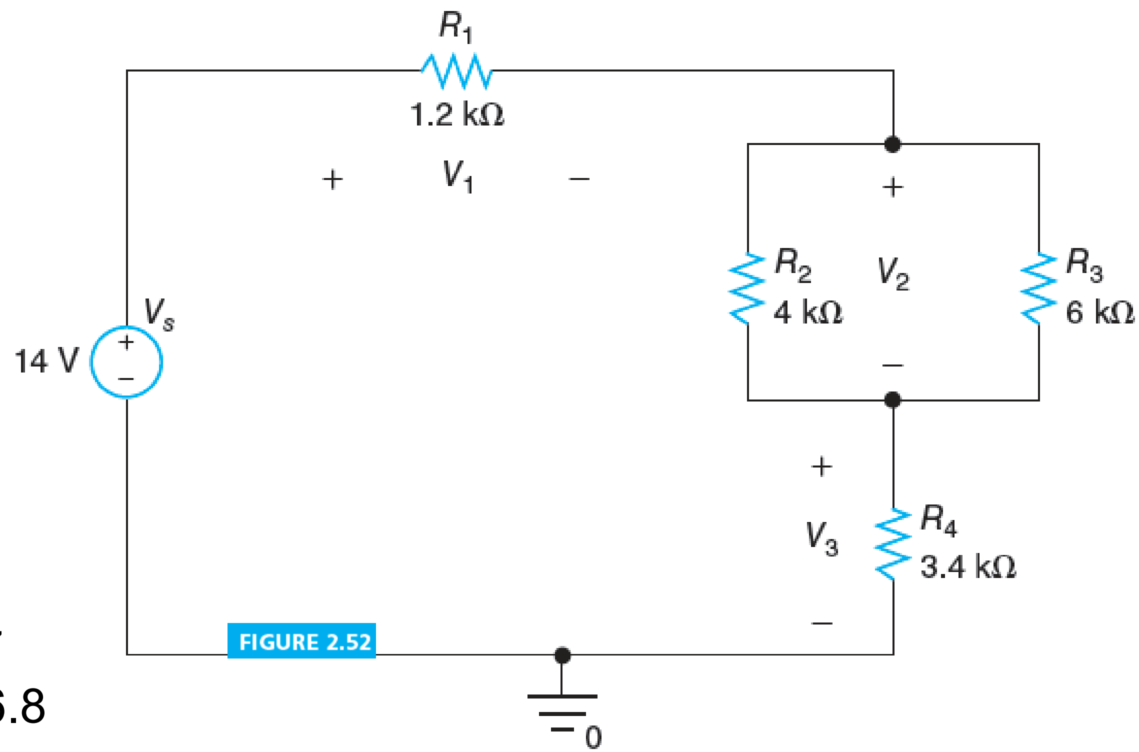
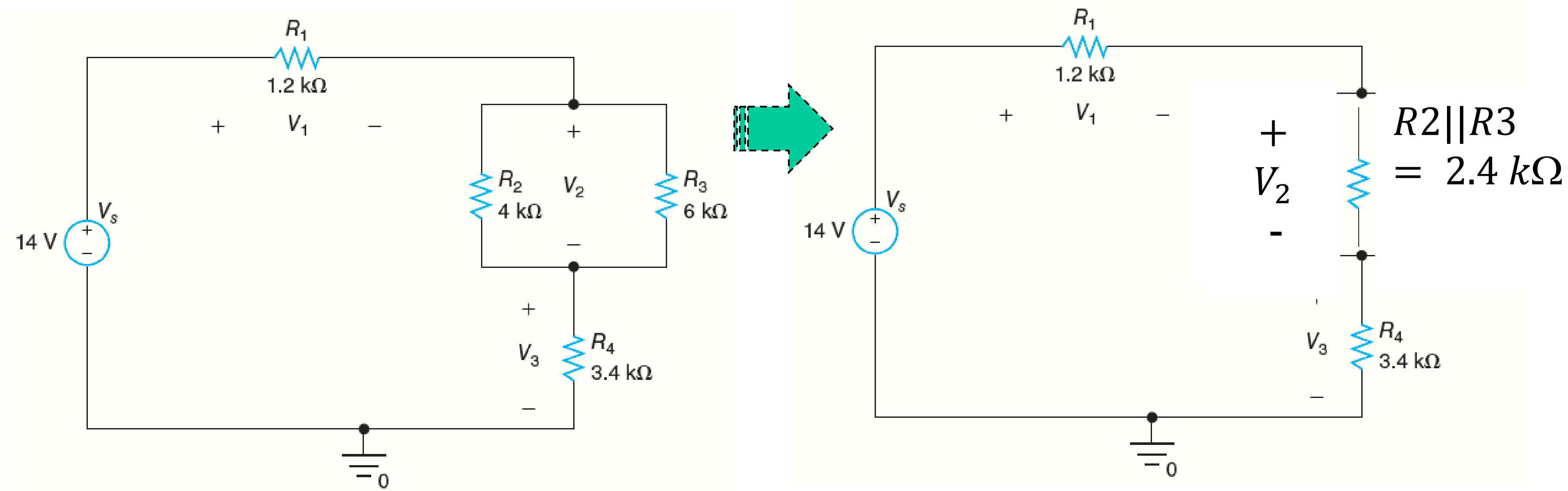


FIGURE 2.52

Options
(A) V1 = 2, V2 =4, V3 = 8
(B) V1 = 2.3, V2 =4.7, V3 = 7
(C) V1 = 2.4, V2 =4.8, V3 = 6.8

EXAMPLE 2.15

- Find V_1, V_2, and V_3 in the circuit shown in Figure 2.52.
  - **$R_a = R_2 \,||\, R_3 = R_2 \times R_3/(R_2+R_3) = 24/10\ k\Omega = 2.4\ k\Omega$**



- **Apply Voltage divider rule**

$$V_1 = V_s \times \frac{R_1}{R_1 + R_a + R_4} = 14 \times \frac{1.2}{1.2+2.4+3.4}\text{V} = 14 \times \frac{1.2}{7}\text{V} = 2.4\,\text{V}$$

$$V_2 = V_s \times \frac{R_a}{R_1 + R_a + R_4} = 14 \times \frac{2.4}{1.2+2.4+3.4}\text{V} = 14 \times \frac{2.4}{7}\text{V} = 4.8\,\text{V}$$

$$V_3 = V_s \times \frac{R_4}{R_1 + R_a + R_4} = 14 \times \frac{3.4}{1.2+2.4+3.4}\text{V} = 14 \times \frac{3.4}{7}\text{V} = 6.8\,\text{V}$$

EXAMPLE 2.16

- Find V_1, V_2, and V_3 in the circuit shown in Figure 2.54.

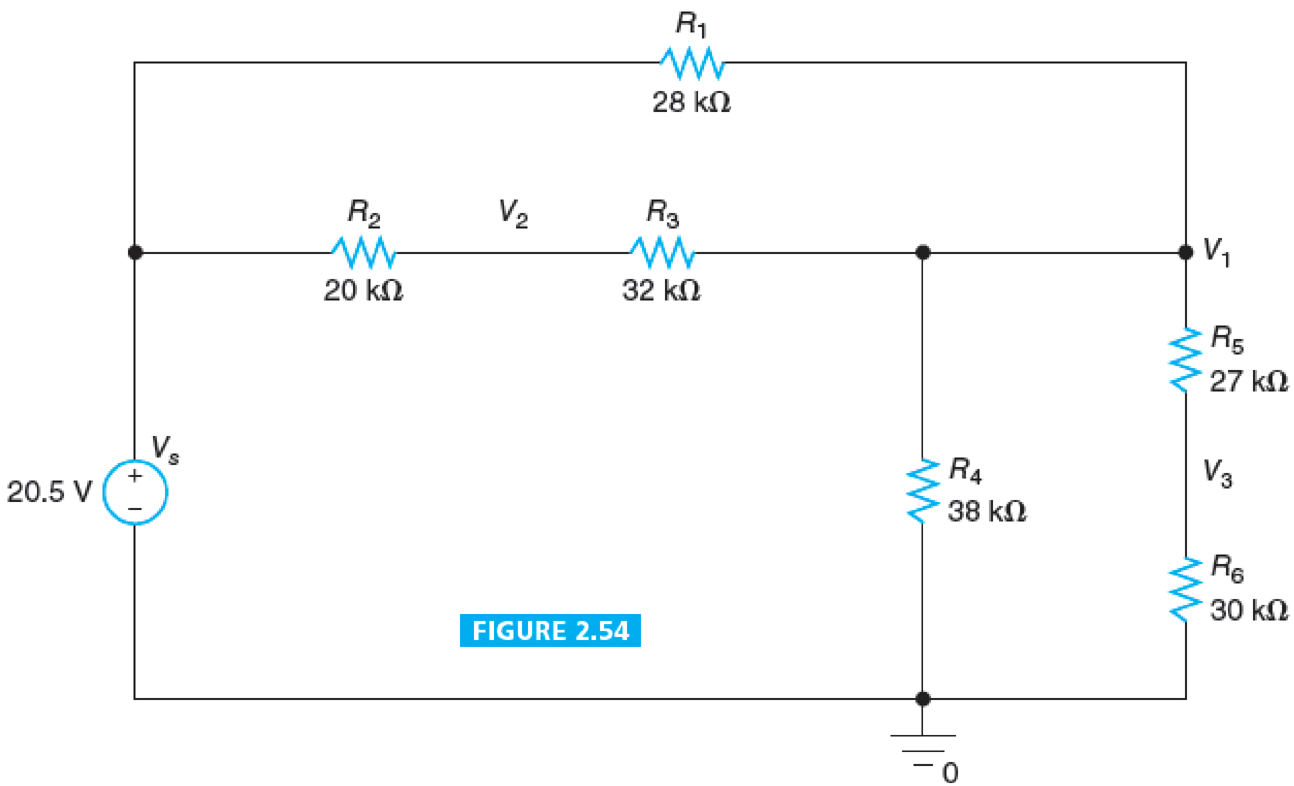


FIGURE 2.54

EXAMPLE 2.16

- Find V_1, V_2, and V_3 in the circuit shown in Figure 2.54.
- $R_a = R_1 \,||\, (R_2+R_3) = 28\times52/(28+52)$ kΩ = 18.2 kΩ
- $R_b = R_4 \,||\, (R_5+R_6) = 38\times57/(38+57)$ kΩ = 22.8 kΩ

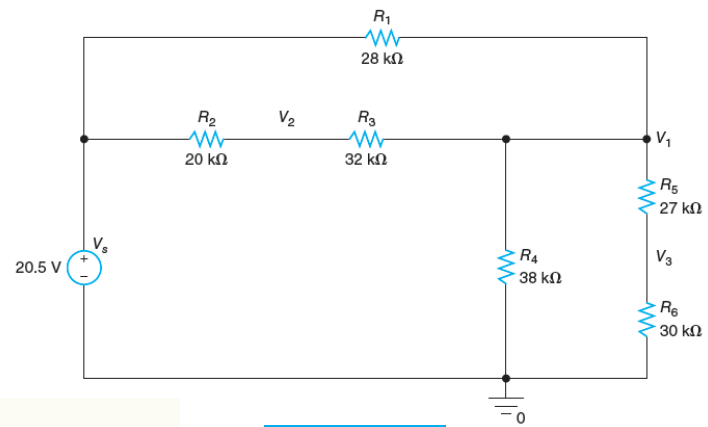


FIGURE 2.54

$$V_1 = V_s \times \frac{R_b}{R_a + R_b} = 20.5\times\frac{22.8}{18.2+22.8}\,\text{V} = 20.5\times\frac{22.8}{41}\,\text{V} = 11.4\,\text{V}$$

$$V_2 = V_1 + (V_s - V_1)\times\frac{R_3}{R_2+R_3} = 11.4\,\text{V} + 9.1\times\frac{32}{20+32}\,\text{V} = 11.4\,\text{V} + 5.6\,\text{V} = 17\,\text{V}$$

$$V_3 = V_1 \times \frac{R_6}{R_5+R_6} = 11.4\times\frac{30}{27+30}\,\text{V} = 6\,\text{V}$$

Home work: Problem 2.47 to 2.57

Current Divider Rule for Two Resistors in Parallel

- Two resistors are connected in parallel to a current source (Fig.2.58).
- The equivalent resistance of R_1 and R_2 is given by

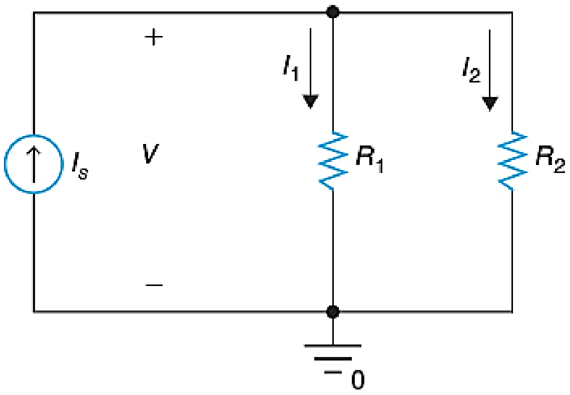
$$R = R_1 \| R_2 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

- The voltage across R_1 and R_2 is given by

$$V = I_s R = I_s \times \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}}$$

FIGURE 2.58

A circuit with two resistors in parallel.



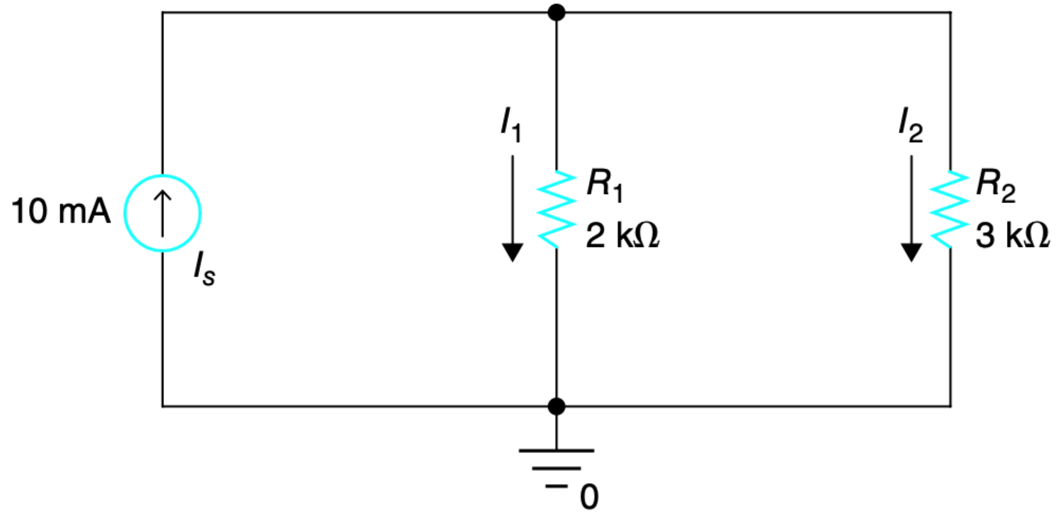
- The current through R_1 and R_2 are given respectively by

$$I_1 = \frac{V}{R_1} = I_s \times \frac{\frac{1}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}} = I_s \times \frac{G_1}{G_1 + G_2} = I_s \times \frac{R_2}{R_1 + R_2}, \quad I_2 = \frac{V}{R_2} = I_s \times \frac{\frac{1}{R_2}}{\frac{1}{R_1} + \frac{1}{R_2}} = I_s \times \frac{G_2}{G_1 + G_2} = I_s \times \frac{R_1}{R_1 + R_2}$$

- When resistors are in parallel, The current I_s from the current source is divided between R_1 and R_2 in proportion to the conductance (inverse of resistance) value. More current flows through smaller resistance.

Problem 2.58

- Use the current divider rule to find currents I1 and
- I2 in the circuit shown in the figure



- $I_1 = I_s \times \frac{R_2}{R_1+R_2} = 10 \times 10^{-3} \times \frac{3k}{5k} = 6mA$
- $I_2 = I_s \times \frac{R_2}{R_1+R_2} = 10 \times 10^{-3} \times \frac{2k}{5k} = 4mA$

Current Divider Rule for n Resistors in Parallel

- n resistors are connected in parallel to a current source with current I_s.
- The equivalent resistance is given by

$$R = R_1 \| R_2 \| \ldots \| R_n = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}}$$

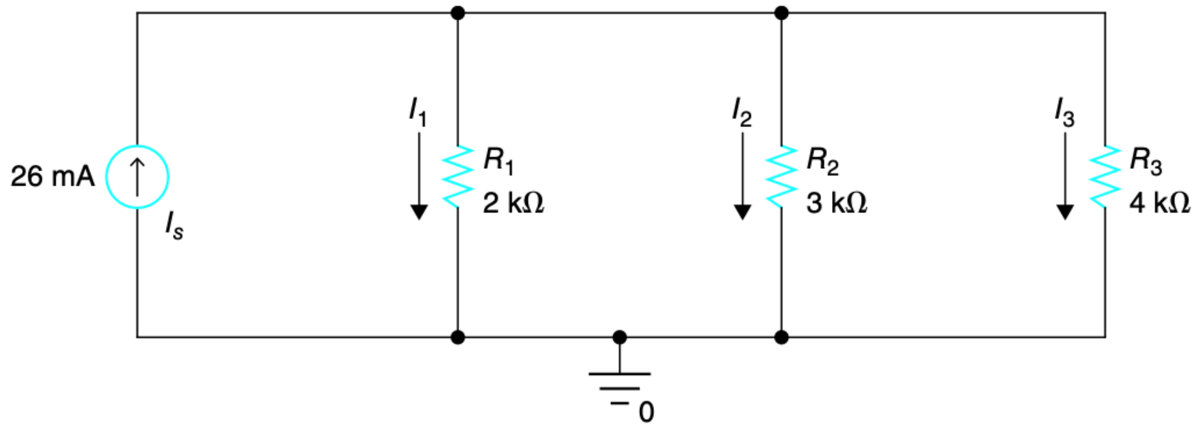
- The voltage across the resistors is given by → $V = I_s R = I_s \times \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}}$
- The current through the *i*th resistor R_i is

$$\boxed{I_i = \frac{V}{R_i} = I_s \times \frac{\frac{1}{R_i}}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}} = I_s \times \frac{G_i}{G_1 + G_2 + \ldots + G_n}}$$

- The current I_s from the current source is divided between resistors in proportion to the conductance (inverse of resistance) values.

Problem 2.59

- Use the current divider rule to find currents I1, I2 and I3 in the circuit



- $I_1 = I_s \times \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = 26 \times 10^{-3} \times \frac{12k}{2k} \times \frac{1}{13} = 12mA$
- $I_2 = I_s \times \frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = 26 \times 10^{-3} \times \frac{12k}{3k} \times \frac{1}{13} = 8mA$
- $I_3 = I_s \times \frac{\frac{1}{R_3}}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}} = 26 \times 10^{-3} \times \frac{12k}{4k} \times \frac{1}{13} = 6mA$

Problem

- ❑ Find I_1, I_2, I_3 in the circuit shown in Figure 2.59.

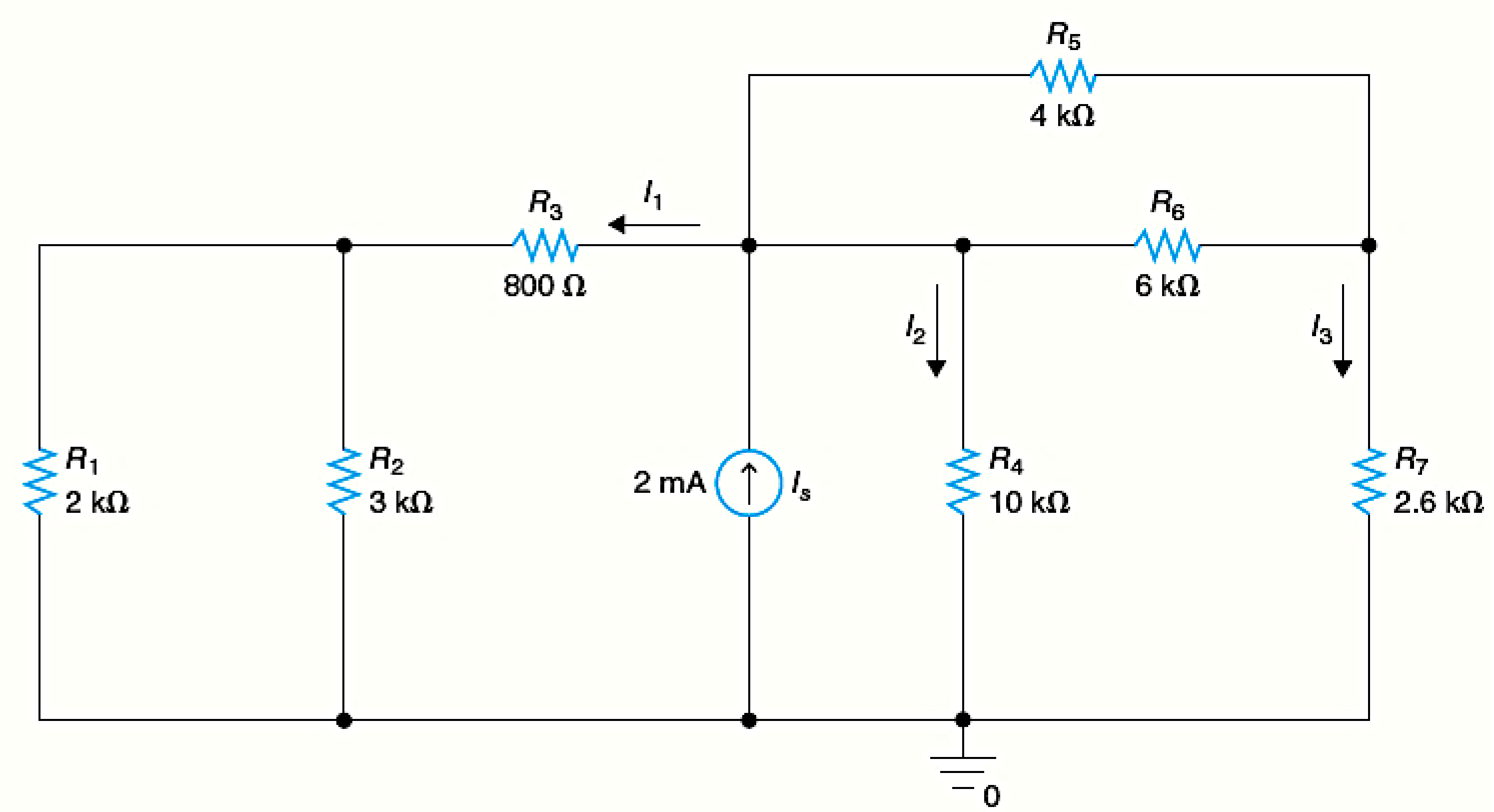


FIGURE 2.59

Circuit Analysis Using Current Divider Rule

- Find I_1, I_2, I_3 in the circuit shown in Figure 2.59.
  - $R_a = R_3 + (R_1 \,||\, R_2) = 0.8\ \mathrm{k}\Omega + 1.2\ \mathrm{k}\Omega = 2\ \mathrm{k}\Omega$
  - $R_b = R_7 + (R_5 \,||\, R_6) = 2.6\ \mathrm{k}\Omega + 2.4\ \mathrm{k}\Omega = 5\ \mathrm{k}\Omega$

$$I_1 = I_s \times \frac{\frac{1}{R_a}}{\frac{1}{R_a}+\frac{1}{R_4}+\frac{1}{R_b}} = 2\times\frac{\frac{1}{2}}{\frac{1}{2}+\frac{1}{10}+\frac{1}{5}}\,\mathrm{mA} = 2\times\frac{5}{8}\,\mathrm{mA} = 1.25\,\mathrm{mA}$$

$$I_2 = I_s \times \frac{\frac{1}{R_4}}{\frac{1}{R_a}+\frac{1}{R_4}+\frac{1}{R_b}} = 2\times\frac{\frac{1}{10}}{\frac{1}{2}+\frac{1}{10}+\frac{1}{5}}\,\mathrm{mA} = 2\times\frac{1}{8}\,\mathrm{mA} = 0.25\,\mathrm{mA}$$

$$I_3 = I_s \times \frac{\frac{1}{R_b}}{\frac{1}{R_a}+\frac{1}{R_4}+\frac{1}{R_b}} = 2\times\frac{\frac{1}{5}}{\frac{1}{2}+\frac{1}{10}+\frac{1}{5}}\,\mathrm{mA} = 2\times\frac{2}{8}\,\mathrm{mA} = 0.5\,\mathrm{mA}$$

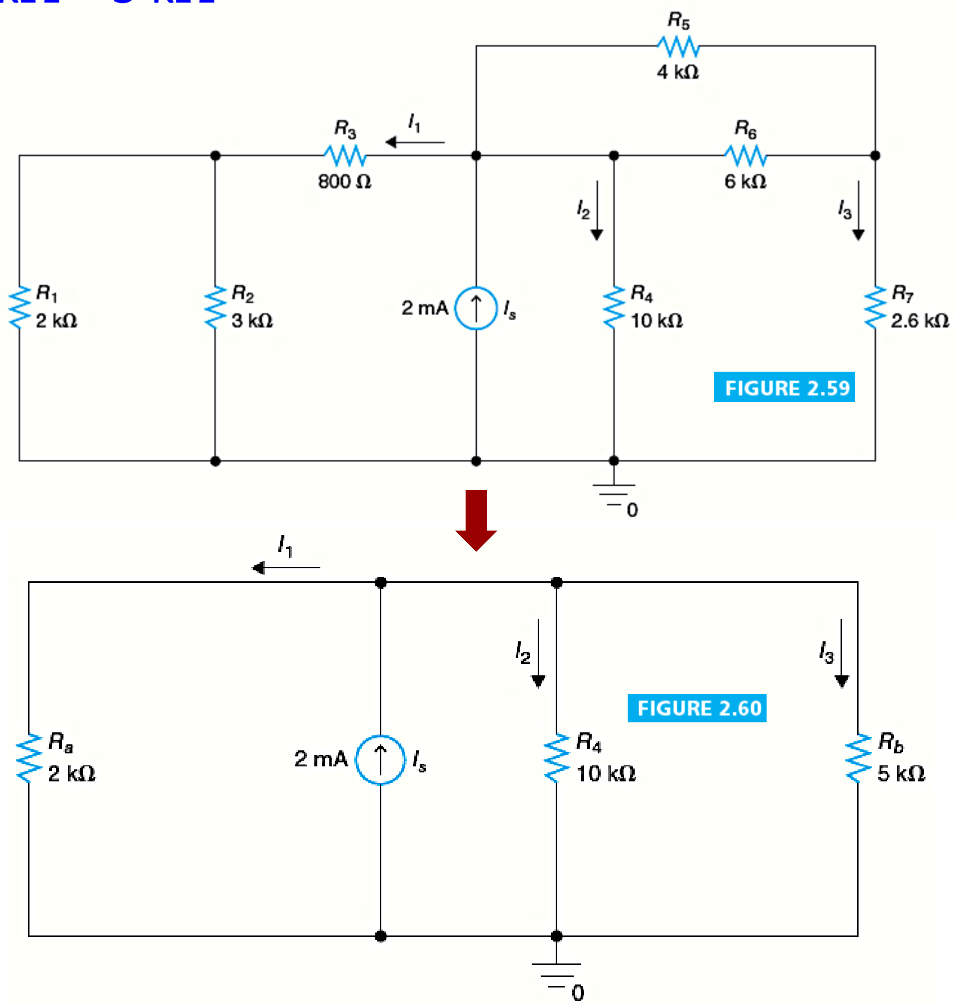


FIGURE 2.59

FIGURE 2.60

EXAMPLE 2.17

- In the circuit shown in Fig.2.61, use the current divider rule to find the currents I_1, I_2, I_3, I_4, I_5.

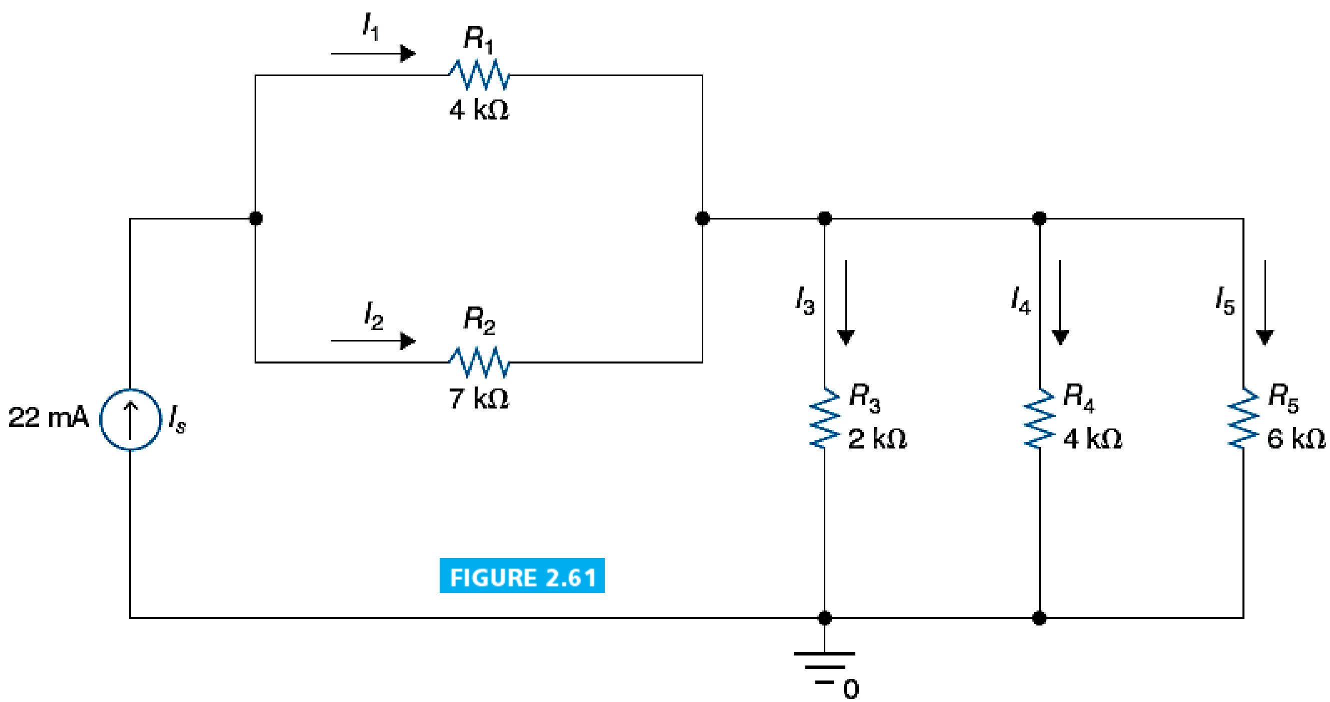


FIGURE 2.61

Find the value of I_5?

(A) 4 mA

(B) 6 mA

(C) 12 mA

EXAMPLE 2.17

- In the circuit shown in Fig.2.61, use the current divider rule to find the currents I_1, I_2, I_3, I_4, I_5.

$$I_1 = I_s \times \frac{R_2}{R_1 + R_2} = 22 \times \frac{7}{4+7}\,\text{mA} = 22 \times \frac{7}{11}\,\text{mA} = 14\,\text{mA}$$

$$I_2 = I_s \times \frac{R_1}{R_1 + R_2} = 22 \times \frac{4}{4+7}\,\text{mA} = 22 \times \frac{4}{11}\,\text{mA} = 8\,\text{mA}$$

$$I_3 = I_s \times \frac{\frac{1}{R_3}}{\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}} = 22 \times \frac{\frac{1}{2}}{\frac{1}{2} + \frac{1}{4} + \frac{1}{6}}\,\text{mA} = 22 \times \frac{6}{11}\,\text{mA} = 12\,\text{mA}$$

$$I_4 = I_s \times \frac{\frac{1}{R_4}}{\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}} = 22 \times \frac{\frac{1}{4}}{\frac{1}{2} + \frac{1}{4} + \frac{1}{6}}\,\text{mA} = 22 \times \frac{3}{11}\,\text{mA} = 6\,\text{mA}$$

$$I_5 = I_s \times \frac{\frac{1}{R_5}}{\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}} = 22 \times \frac{\frac{1}{6}}{\frac{1}{2} + \frac{1}{4} + \frac{1}{6}}\,\text{mA} = 22 \times \frac{2}{11}\,\text{mA} = 4\,\text{mA}$$

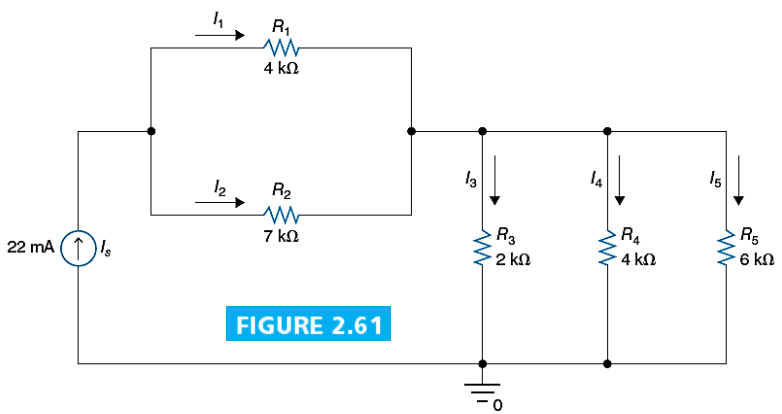


FIGURE 2.61

EXAMPLE 2.18

- Find I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_8, I_9 in the circuit shown in Figure 2.63.
  - $R_a = R_2 + (R_3 \,||\, R_4) = 3\ k\Omega$
  - $R_b = (R_5 \,||\, R_6) + (R_7 \,||\, R_8) = 3\ k\Omega + 2\ k\Omega = 5\ k\Omega$
  - Application of current divider rule on R_1, R_a, R_b, we obtain

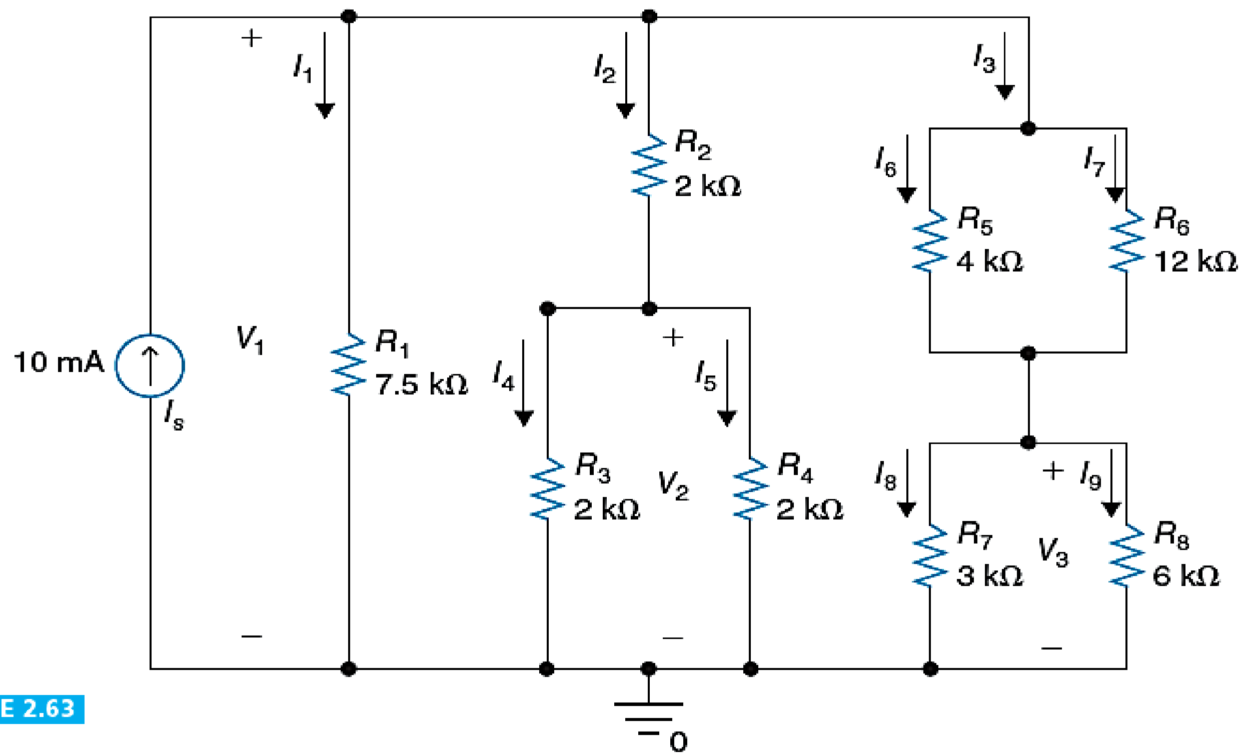


FIGURE 2.63

EXAMPLE 2.18

- Find $I_1, I_2, I_3, I_4, I_5, I_6, I_7, I_8, I_9$ in the circuit shown in Figure 2.63.
  - $R_a = R_2 + (R_3 \,||\, R_4) = 3\ \text{k}\Omega$
  - $R_b = (R_5 \,||\, R_6) + (R_7 \,||\, R_8) = 3\ \text{k}\Omega + 2\ \text{k}\Omega = 5\ \text{k}\Omega$
  - Application of current divider rule on R_1, R_a, R_b, we obtain

$$I_1 = I_s \times \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_a}+\frac{1}{R_b}} = 10 \times \frac{\frac{1}{7.5}}{\frac{1}{7.5}+\frac{1}{3}+\frac{1}{5}}\,\text{mA} = 10 \times \frac{2}{10}\,\text{mA} = 2\,\text{mA}$$

$$I_2 = I_s \times \frac{\frac{1}{R_a}}{\frac{1}{R_1}+\frac{1}{R_a}+\frac{1}{R_b}} = 10 \times \frac{\frac{1}{3}}{\frac{1}{7.5}+\frac{1}{3}+\frac{1}{5}}\,\text{mA} = 10 \times \frac{5}{10}\,\text{mA} = 5\,\text{mA}$$

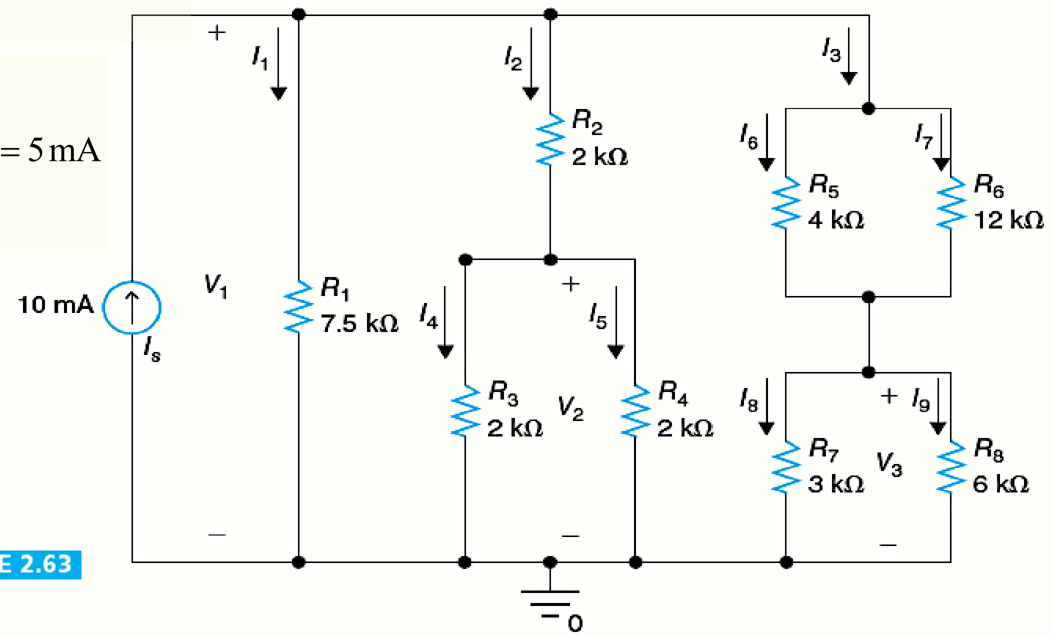
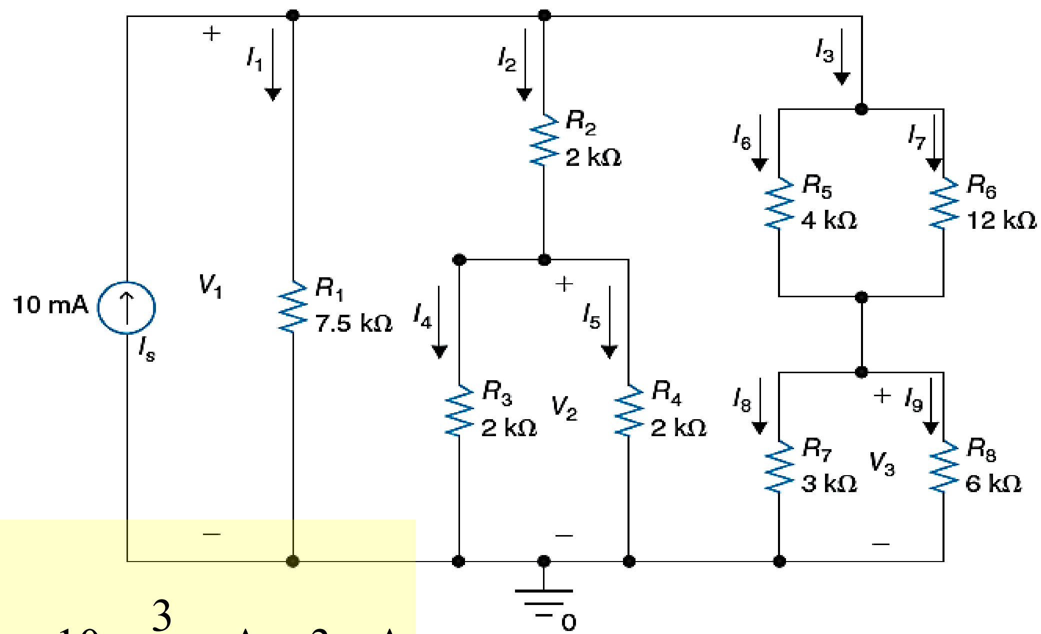


FIGURE 2.63

EXAMPLE 2.18 (Continued)

FIGURE 2.63



$$I_3 = I_s \times \frac{\frac{1}{R_b}}{\frac{1}{R_1}+\frac{1}{R_a}+\frac{1}{R_b}} = 10 \times \frac{\frac{1}{5}}{\frac{1}{7.5}+\frac{1}{3}+\frac{1}{5}}\,\text{mA} = 10 \times \frac{3}{10}\,\text{mA} = 3\,\text{mA}$$

$$I_4 = I_2 \times \frac{R_4}{R_3+R_4} = 2.5\,\text{mA} = I_5$$

$$I_6 = I_3 \times \frac{R_6}{R_5+R_6} = 2.25\,\text{mA},\ I_7 = 0.75\,\text{mA}$$

$$I_8 = I_3 \times \frac{R_8}{R_7+R_8} = 2\,\text{mA},\ I_9 = 1\,\text{mA}$$

Home work P2.58 to P2.67

Summary of key concepts weeks 2-3

- **Resistance** (definition and physical meaning)

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

- **Ohm**'s law

$$V = RI, \quad I = \frac{V}{R}, \quad R = \frac{V}{I}$$

- **KCL**

The sum of currents entering a node equals the sum of currents leaving the same node.

The sum of currents leaving a node is zero.

The sum of currents entering a node is zero.

Summary (Continued)

- **KVL**

  The sum of voltage drops around a loop or mesh is equal to zero.

- **Equivalent resistance of series** connection of n resistors

$$R_{eq} = R_1 + R_2 + \ldots + R_n$$

- **Equivalent resistance of parallel** connection of two resistors

$$R_{eq} = R_1 \parallel R_2 = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2}} = \frac{R_1 R_2}{R_1 + R_2}$$

Summary (Continued)

- Equivalent resistance of parallel connection of n resistors

$$R_{eq} = R_1 \parallel R_2 \parallel \ldots \parallel R_n = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}}$$

- **Voltage divider** rule (two resistors are connected in series to a voltage source)

$$V_1 = V_s \times \frac{R_1}{R_1 + R_2}, \quad V_2 = V_s \times \frac{R_2}{R_1 + R_2}$$

- **Voltage divider rule** (n resistors are connected in series to a voltage source)

$$V_i = V_s \times \frac{R_i}{R_1 + R_2 + \ldots + R_n}$$

Summary (Continued)

- **Current divider** rule (two resistors are connected in parallel to a current source)

$$I_1 = I_s \times \frac{\frac{1}{R_1}}{\frac{1}{R_1}+\frac{1}{R_2}} = I_s \times \frac{R_2}{R_1+R_2},\quad I_2 = I_s \times \frac{\frac{1}{R_2}}{\frac{1}{R_1}+\frac{1}{R_2}} = I_s \times \frac{R_1}{R_1+R_2}$$

- **Current divider** rule (n resistors are connected in parallel to a current source)

$$I_i = I_s \times \frac{\frac{1}{R_i}}{\frac{1}{R_1}+\frac{1}{R_2}+\ldots+\frac{1}{R_n}}$$

Summary (Continued)

- ❑ What will we study in next lecture.