

ECE 215/S – Principles of Electronic Cyber Warfare

Block 1: Resistive Circuits and Power Distribution

Lesson 3: Kirchhoff's Laws

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Fall 2026

Objective 1.1 (continued)

I can calculate the voltages, currents, and power associated with devices in a simple DC-powered circuit using tools such as KVL, KCL, voltage and current dividers, Ohm's Law, and the power equation.

- L2 gave you Ohm's Law, which handles **one** resistor at a time
- Today: **KVL and KCL** — the two laws that let you handle a circuit with more than one loop
- Assessed on **Quiz 1** along with Objective 1.2

Where We Are Going

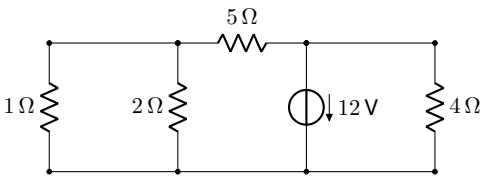
By the end of this lesson, you will be able to:

- Identify the **nodes**, **branches**, and **loops** in a circuit
- State and apply **Kirchhoff's Voltage Law** around any closed loop
- State and apply **Kirchhoff's Current Law** at any node
- Use **conservation of power** to check that your answer is right

Circuit Vocabulary

- **Branch** — a two-terminal element (one resistor, one source)
- **Node** — a connection of two or more elements. Everything joined by plain wire is the *same* node
- **Loop** — any closed path through the circuit

Getting these right is most of the battle. Students who miscount nodes write the wrong equations.



How many nodes? How many loops?

Kirchhoff's Voltage Law

The algebraic sum of voltages around any closed loop is zero.



Walk the loop, add up every voltage, set the total to zero:

$$\sum_{n=1}^{N} V_n = 0 \qquad \text{so here} \qquad +V_s - V_1 = 0$$

Physically: the energy a charge gains at the source is exactly the energy it gives up going around the loop.

Labeling Polarity and Writing the Equation

The law is easy. The bookkeeping is where points are lost.

1. **Label every voltage polarity** before writing anything. For a resistor, the $+$ goes where current *enters*
2. **Pick a direction** around the loop and commit to it
3. **Write each voltage as you meet it.** Use the *first* sign you encounter as the term's sign — or use the second consistently. Either convention works; mixing them does not
4. **Set the sum to zero** and solve

Pick a convention, write it down, and never change it mid-problem.

Kirchhoff's Current Law

The algebraic sum of currents at any node is zero.

$$\sum_{n=1}^{N} I_n = 0 \qquad \text{or} \qquad \sum I_{\text{in}} = \sum I_{\text{out}}$$

- Charge cannot pile up at a junction
- Whatever flows in must flow out

Where you use each law:

- **KVL** when you know currents and want voltages
- **KCL** when you know voltages and want currents
- Most real problems need **both**, plus Ohm's Law to connect them

Conservation of Power: Your Answer Check

Power supplied by the sources must equal power absorbed by the loads:

$$\sum P_{\text{supplied}} = \sum P_{\text{absorbed}}$$

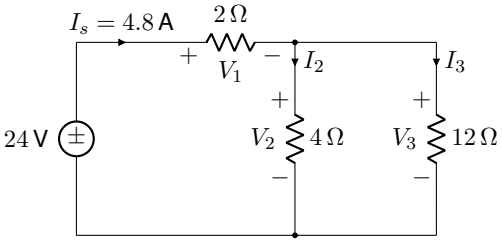
- Compute $P = IV$ for *every* element once you have all the voltages and currents
- If the two sides do not balance, you have an error — go find it before you turn the page
- This costs thirty seconds and catches most sign mistakes

Free error checking. Use it on every problem.

Method: Analyzing a Circuit

1. Label all **nodes**
2. Label **current direction** in each branch (guess freely — a negative answer just means you guessed backward)
3. Label **voltage polarity** on each element, consistent with your current directions
4. Write **KVL** around enough loops, and **KCL** at enough nodes, to get as many equations as unknowns
5. Use **Ohm's Law** to relate the two
6. Solve, then **check with conservation of power**

Worked Example



Given: $V_s = 24\,\text{V}$ and $I_s = 4.8\,\text{A}$

Find:

1. V_1, V_2, and V_3
2. I_2 and I_3
3. Verify conservation of power

Try it before the next slide.

Next lesson: how to find I_s yourself.

Worked Example — Solution

Ohm's Law on the $2\,\Omega$

- $V_1 = I_s R = (4.8)(2) = 9.6\,\text{V}$

KVL around the left loop

- $-24 + V_1 + V_2 = 0 \;\Rightarrow\; V_2 = 14.4\,\text{V}$
- Right loop: both resistors connect the same two nodes, so $V_3 = V_2 = 14.4\,\text{V}$

Ohm's Law in each branch

- $I_2 = 14.4/4 = 3.6\,\text{A}$
- $I_3 = 14.4/12 = 1.2\,\text{A}$

KCL at the top junction

- $I_s = I_2 + I_3$
- $4.8 = 3.6 + 1.2$ ✓

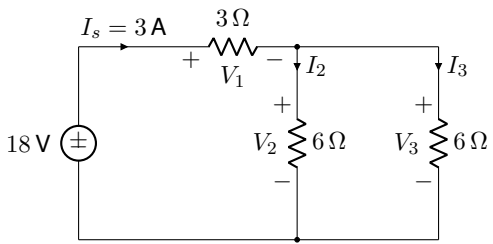
Conservation of power

- Supplied: $P = I_s V_s = (4.8)(24) = 115.2\,\text{W}$
- Absorbed, one resistor at a time:

$$\frac{9.6^2}{2} + \frac{14.4^2}{4} + \frac{14.4^2}{12}$$

$$= 46.08 + 51.84 + 17.28 = 115.2\,\text{W}\ \checkmark$$

Your Turn



Given: $V_s = 18\,\text{V}$ and $I_s = 3\,\text{A}$

Find:

1. V_1, V_2, and V_3
2. I_2 and I_3
3. Verify conservation of power

Wrap-Up

Key ideas:

- **KVL** — voltages around any closed loop sum to zero
- **KCL** — currents at any node sum to zero
- Label polarity and current direction **before** writing equations, and hold one convention throughout
- **Conservation of power** is a free check on every answer

Next lesson:

- **Lesson 4 — Series, Parallel, and Dividers:** shortcuts that replace most of today's algebra
- **Quiz 1** (Objectives 1.1–1.2) is due at Lesson 6