

# SPH3U UNIVERSITY PHYSICS

ELECTRICITY & MAGNETISM

Kirchhoff's Laws  
(P.519-522)

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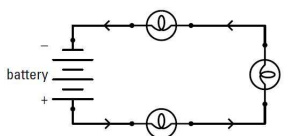
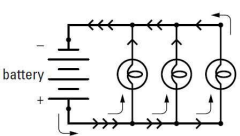
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## Kirchhoff's Laws for Electric Circuits

*To understand how simple series and parallel circuits operate, we need to answer two basic questions:*

- When charges have several loads to pass through, what governs the amount of electric potential energy they will lose at each load?*

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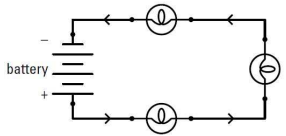
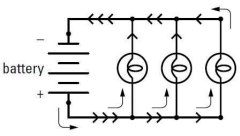
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## Kirchhoff's Laws for Electric Circuits

*To understand how simple series and parallel circuits operate, we need to answer two basic questions:*

- When charges may follow several possible paths, what governs the number of charges that will take each path?*

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### Kirchhoff's Laws for Electric Circuits

In 1845, German physicist Gustav Kirchhoff was able to answer these two questions. By performing careful experiments, he was able to describe two important laws: one law describes the electric potential difference and the other the electric current in circuits. They have since become known as **Kirchhoff's voltage law (KVL)** and **Kirchhoff's current law (KCL)**.



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### Kirchhoff's Voltage Law

Kirchhoff's voltage law (KVL) is stated as follows:

Around any complete path through an electric circuit, the sum of the increases in electric potential is equal to the sum of the decreases in electric potential.



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### Kirchhoff's Voltage Law

**NOTE!**

- A series circuit has only one complete path, so the loads must share the amount of electric potential.
- A parallel circuit has more than one complete path, so the electric potential decrease across each load must be the same as the electric potential increase at the source.

$V_{series} = V_1 + V_2 + V_3 + \dots$        $V_{parallel} = V_1 = V_2 = V_3 = \dots$

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### Kirchhoff's Voltage Law

**KIRCHHOFF'S VOLTAGE LAW (KVL)**

- ❖ in a **series** circuit the loads share the potential difference
- ❖ in a **parallel** circuit the potential difference is the same across each load

$V_{\text{series}} = V_1 + V_2 + \dots$

$V_{\text{parallel}} = V_1 = V_2 = \dots$

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### Kirchhoff's Voltage Law

**PRACTICE**

1. Calculate the potential difference,  $V_2$ , in the electric circuit given.

$V_2 = 100 \text{ V}$

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### Kirchhoff's Current Law

*Kirchhoff's current law (KCL) is stated as follows:*

*At any junction point in an electric circuit, the total electric current into the junction is equal to the total electric current out.*

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### Kirchhoff's Current Law

**NOTE!**

- A series circuit has only one path, so there can be only one possible current.
- A parallel circuit has more than one complete path, so the current can split, depending on the number of paths.

$I_{series} = I_1 = I_2 = I_3 = \dots$        $I_{parallel} = I_1 + I_2 + I_3 + \dots$

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### Kirchhoff's Current Law

**KIRCHHOFF'S CURRENT LAW (KCL)**

- in a **series** circuit the current through each load is the same
- in a **parallel** circuit the current splits depending upon the number of paths

$I_{series} = I_1 = I_2 = \dots$        $I_{parallel} = I_1 + I_2 + \dots$

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### Kirchhoff's Current Law

**PRACTICE**

2. Calculate the electric current,  $I_3$ , in the electric circuit given.

$I_3 = 6.0 \text{ A}$

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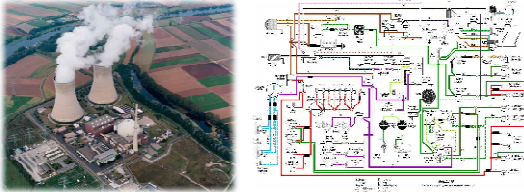
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### Kirchhoff's Laws

*It is critical to understand the properties of circuits so that they operate as intended. Whether controlling a power plant or designing a circuit, we can use Kirchhoff's laws to analyze circuits to find unknown voltages and currents.*



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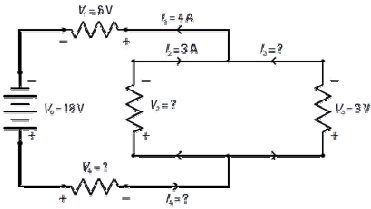
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### Kirchhoff's Laws

**PRACTICE**

3. Find the unknown values in the electric circuit given.

$V_2 = 3 \text{ V}$   
 $V_4 = 9 \text{ V}$   
 $I_3 = 1 \text{ A}$   
 $I_4 = 4 \text{ A}$



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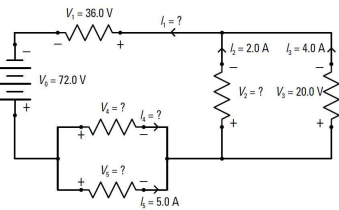
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### Kirchhoff's Laws

**PRACTICE**

4. Find the unknown values in the electric circuit given.

$I_1 = 6 \text{ A}$   
 $V_2 = 20 \text{ V}$   
 $I_4 = 1 \text{ A}$   
 $V_4 = 16 \text{ V}$   
 $V_5 = 16 \text{ V}$



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 Kirchhoff's Laws

**PRACTICE**

5. What is wrong with the following information? State whether you are applying KCL or KVL in your answer.

(a) The current going into a parallel circuit is listed as 0.50 A and the current coming out of the parallel circuit is listed as 0.30 A.

(a) in a parallel circuit the current out should be the same as the current in (KCL)

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 Kirchhoff's Laws

**PRACTICE**

5. What is wrong with the following information? State whether you are applying KCL or KVL in your answer.

(b) A student measures the voltage across each of the three loads in a series circuit to be 10 V each. The voltage across the source is measured to be 10 V.

(b) in a series circuit the voltage across the source should equal the sum of the voltages across each load (KVL)

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 Kirchhoff's Laws

**PRACTICE**

5. What is wrong with the following information? State whether you are applying KCL or KVL in your answer.

(c) For a circuit with two lamps connected in parallel, a student measures the voltage drop across one lamp to be 20 V. The student measures the voltage drop across the second lamp to be 10 V.

(c) in a parallel circuit the voltage drop across each lamp should be the same (KVL)

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 Kirchhoff's Laws

**PRACTICE**

5. What is wrong with the following information? State whether you are applying KCL or KVL in your answer.

(d) A student is using an ammeter and notes that it reads 0.15 A on the first lamp, 0.20 A on the second lamp, and 0.25 A on the third lamp. The student says the lamps are connected in series.

(d) if the lamps were connected in series the current through each load would be the same (KCL)

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 Check Your Learning

**TEXTBOOK**  
P.522 Q.1,2

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