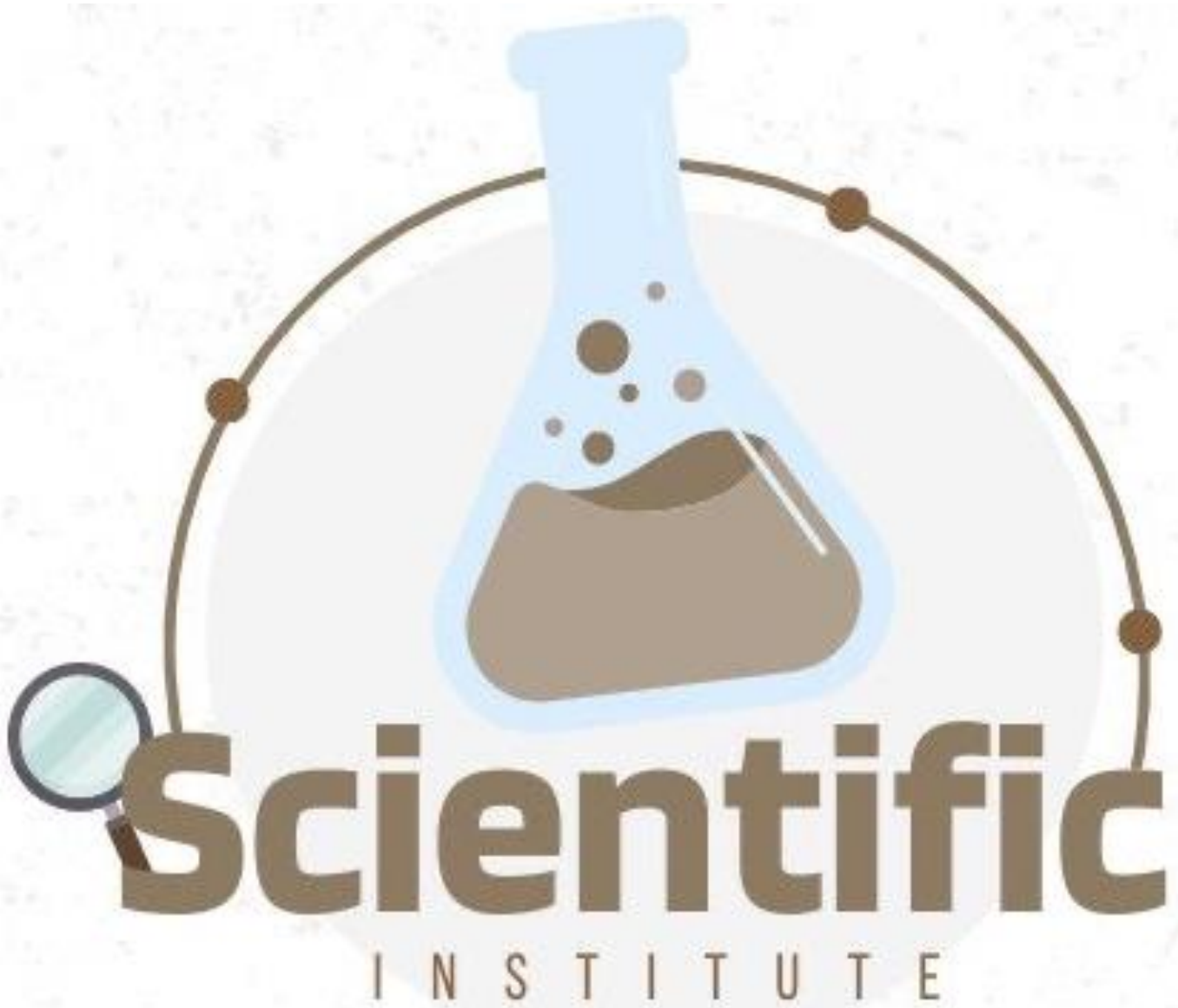




physics

12ADV - 2025/2024

Unit (6) - Direct Current Circuits



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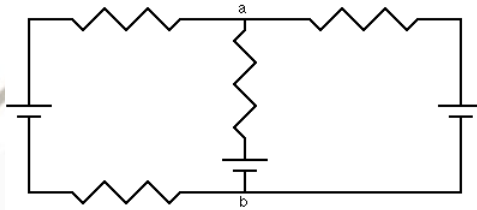
Lesson 1 – Kirchhoff's Rule

and

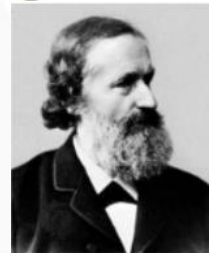
Lesson 2 – Single-Loop Circuits

Kirchhoff's Rules and single-loop circuits

Some electric circuits are complicated in which we cannot solve them normally with ohm's law.

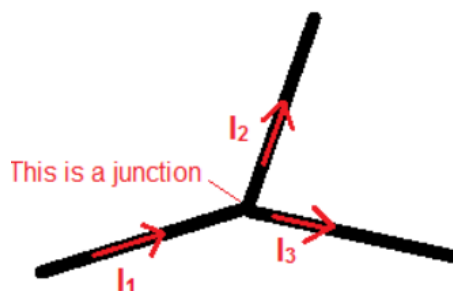


Two rules have been implemented by Kirchhoff to make complex and multiloop circuits easy to solve.



The first rule is the junction rule:

The **junction** is a point in which there is more path for the electric current to flow, in which the current divides into branches.



junction rule:

The rule states that the sum of the current entering a junction must equal the sum of the current leaving junction.

Junction:
$$\sum_{k=1}^n i_k = 0.$$

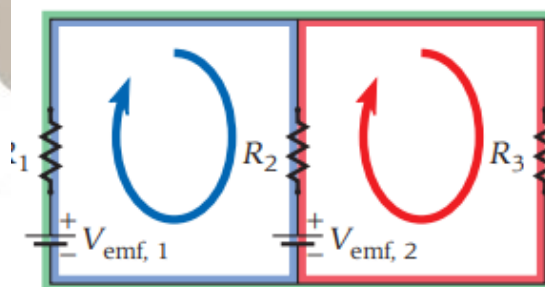
The junction rule is based on the conservation of charge.

The law of Conservation of charge:

Charge cannot be created or destroyed

If a question was solved by the junction rule and the current was calculated to be negative that means the current flows in opposite direction of assumed one.

The second rule is the loop rule:



The loop rule is based on the conservation of energy.

Loop rule:

The loop rule states that the electric potential supplied equal to the electric potential consumed through a closed loop.

Closed loop:
$$\sum_{j=1}^m V_{\text{emf},j} - \sum_{k=1}^n i_k R_k = 0.$$

Notes:

In the book formula they moved the consumed voltage to the side as the supplied voltage.

The direction of the closed loop could be **clockwise** or **antilock** wise, both are correct.

resistors:

If the current flows in the **same** direction of the closed loop, then we assume that the electric potential is **consumed**.

If the current flows in the **opposite** direction of the closed loop, then we assume that the electric potential is **supplied** by the resistor.

batteries:

If the battery poles are in the **same** direction as the closed loop, then we assume the battery is **supplying** electric potential (energy)

If the battery poles are in the **opposite** direction as the closed loop, then we assume the battery is **consuming** electric potential (the battery is charging)

Generally, if the two batteries are connected in a one loop circuits in which their poles align in the **same** direction the supplied electric potential is the **sum** of their potential

While if they have **opposing** poles, then the supplied electric potential is the subtraction of their values in which the direction of the electric current is determined by the **stronger** battery

Note: In the book formula they moved the consumed potential to other side, so the way of thinking about it is different (more difficult)

Element	Direction of Analysis	Potential Change
R	Same as current	$-iR$ (a)
R	Opposite to current	$+iR$ (b)
V_{emf}	Same as emf	$+V_{\text{emf}}$ (c)
V_{emf}	Opposite to emf	$-V_{\text{emf}}$ (d)

Questions

Easy

1) For the junction shown in the figure, which equation correctly expresses the sum of the currents?

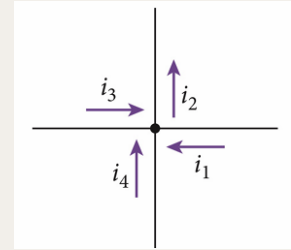
A) $i_1 + i_2 + i_3 + i_4 = 0$

B) $i_1 - i_2 + i_3 + i_4 = 0$

C) $-i_1 + i_2 + i_3 - i_4 = 0$

D) $i_1 - i_2 - i_3 - i_4 = 0$

e) $i_1 + i_2 - i_3 - i_4 = 0$



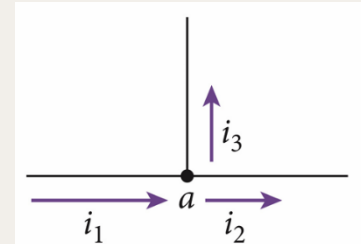
2) For the junction shown in the figure, which equation correctly expresses the sum of the currents?

A) $i_1 = i_2 + i_3$

B) $i_2 = i_1 + i_3$

C) $i_3 = i_1 + i_2$

D) $0 = i_1 + i_2 + i_3$



3) Kirchhoff's Junction Rule states that?

A) the algebraic sum of the currents at any junction in a circuit must be zero.

B) the algebraic sum of the potential changes around any closed loop in a circuit must be zero.

C) the current in a circuit with a resistor and a capacitor varies exponentially with time.

D) the current at a junction is given by the product of the resistance and the capacitance.

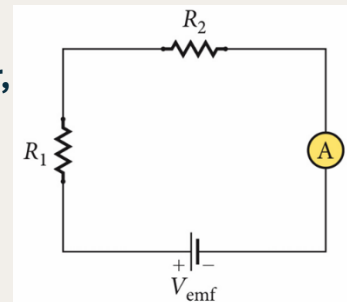
E) the time for the current development at a junction is given by the product of the resistance and the capacitance.



4) Which of the following has the same unit as the electromotive force (emf)?

- A) current
- B) electric potential
- C) electric field
- D) electric power
- e) none of the above

5) Two resistors, $R_1 = 3.00 \, \Omega$ and $R_2 = 5.00 \, \Omega$, are connected in series with a battery and an ammeter, as shown in the figure. The battery supplies $V_{\text{emf}} = 8.00 \, \text{V}$, and the ammeter has the resistance $R_A = 1.00 \, \Omega$. What is the current measured by the ammeter?



- A) 0.500 A
- B) 0.750 A
- C) 0.889 A
- D) 1.00 A
- e) 1.50 A

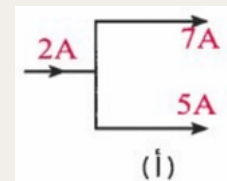
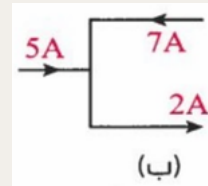
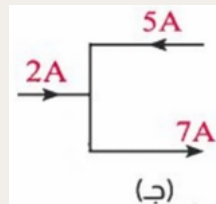
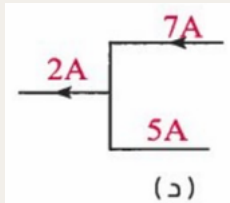
6) Kirchhoff's Loop Rule states that

- A) the algebraic sum of the currents around a complete circuit loop must be zero.
- B) the resistances around a complete circuit loop must sum to zero.
- C) the sources of emf around a complete circuit loop must sum to zero.
- D) the sum of the potential differences around a complete circuit loop must be greater than zero.
- E) the potential differences around a complete circuit loop must sum to zero.



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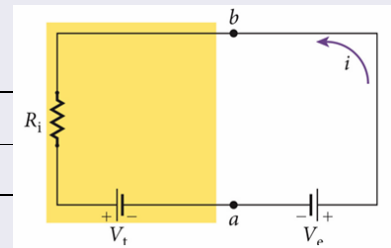
7) Which of the following circuits is correct?



Medium

8) A 12.0-V battery with internal resistance $R_i = 0.200 \, \Omega$ is being charged by a battery charger that is capable of delivering a current of magnitude $i = 6.00 \, \text{A}$.

What is the minimum emf the battery charger must supply to be able to charge the battery?

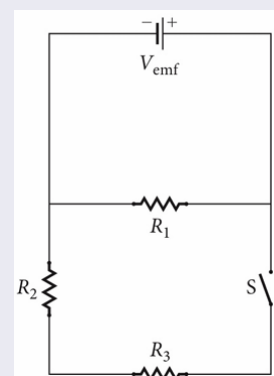


9) In the circuit in the figure, there are three identical resistors. The switch, S , is initially open. When the switch is closed, what happens to the current flowing in R_1 ?

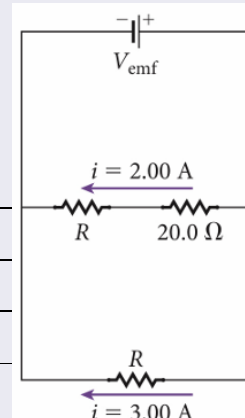
A) The current in R_1 decreases.

B) The current in R_1 increases.

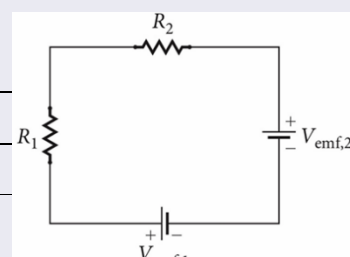
C) The current in R_1 stays the same.



10) Three resistors are connected across a battery as shown in the figure. What values of R and V_{emf} will produce the indicated currents?



11) The single-loop circuit shown in the figure has $V_{\text{emf},1} = 21.01 \text{ V}$, $V_{\text{emf},2} = 10.75 \text{ V}$, $R_1 = 23.37 \Omega$, and $R_2 = 11.61 \Omega$. What is the current flowing in the circuit?



Hard

12) Two resistors, R_1 and R_2 , are connected in series across a potential difference, ΔV_0 . Express the potential drop across each resistor individually, in terms of these quantities. What is the significance of this arrangement?

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13) A battery has $V_{\text{emf}} = 12.0 \text{ V}$ and internal resistance $r = 1.00 \Omega$. What resistance, R , can be put across the battery to extract 10.0 W of power from it?

14) A 11.45-V battery with internal resistance $R_i = 0.1373 \Omega$ is to be charged by a battery charger that is capable of delivering a current $i = 9.759 \text{ A}$. What is the minimum emf the battery charger must be able to supply in order to charge the battery?

15) A battery with internal resistance $R_i = 0.1415 \Omega$ is being charged by a battery charger that delivers a current $i = 5.399 \text{ A}$. The battery charger supplies an emf of 14.51 V . What is the potential difference across the terminals of the battery?

I N S T I T U T E



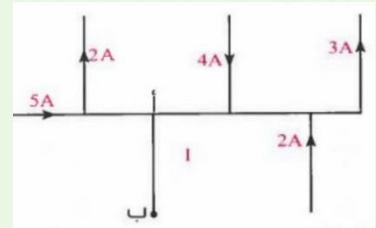
16) In the figure, the magnitude and direction of the current (I) are:

A) 6A from A to B

B) 6A from B to A

C) 4A from A to B

D) 4A from B to A



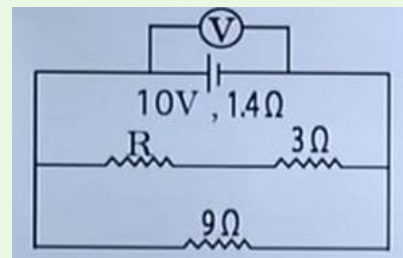
17) In the electric circuit shown in the figure, if the voltmeter reading is 7.2 V, then the value of R is equal to:

A) 1.5 Ω

B) 3.0 Ω

C) 4.5 Ω

D) 6.0 Ω



18) In the circuit shown above, what is the resistance R ?

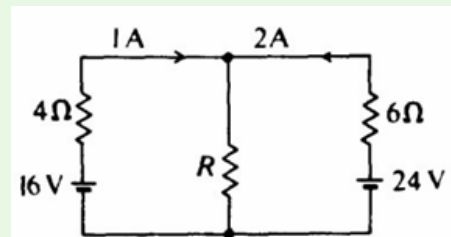
A) 3 Ω

B) 4 Ω

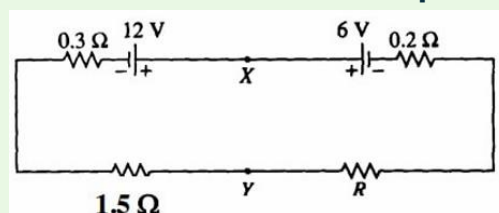
C) 6 Ω

D) 12 Ω

E) 18 Ω



19) In the circuit below, the emf's and the resistances have the values shown. The current I in the circuit is 2 amperes.



a) The resistance R is:

A) 1 Ω

B) 2 Ω

C) 3 Ω

D) 4 Ω

b) How much energy is dissipated by the 1.5-ohm resistor in 60 seconds?

A) 6 J

B) 180 J

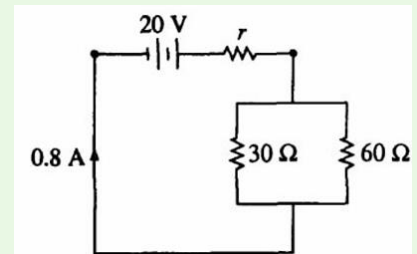
C) 360 J

D) 720 J

E) 1440 J

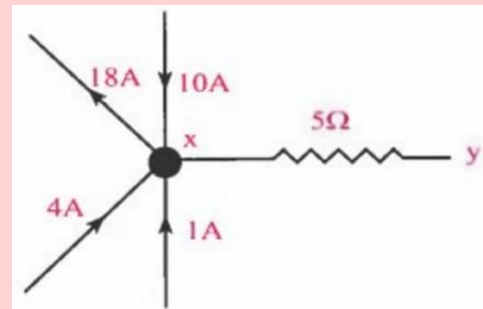


20) A 30-ohm resistor and a 60-ohm resistor are connected as shown above to a battery of emf 20 volts and internal resistance r . The current in the circuit is 0.8 ampere. What is the value of r ?

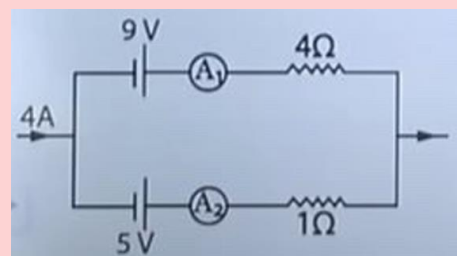
A) 0.22Ω B) 4.5Ω C) 5Ω D) 16Ω E) 70Ω 

Very Hard

21) In the figure, the potential difference between x and y is:

A) 15 V, y is at a higher potential.B) 15 V, x is at a higher potentialC) 5 V, x is at a lower potentialD) 20 V, y is at a lower potential

22) The figure represents a part of a closed electric circuit, neglecting the internal resistance of the power sources. The ratio between the readings of the two ammeters (A_1 / A_2) is equal to:

A) $1/4$ B) $1/3$ C) $3/4$ D) $2/3$ 



"We hope this booklet has provided you with the understanding and support needed to excel in physics, and we wish you continued success and prosperity."

