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Class	10th	Chapter	17
Subject	Physics	Board	Federal

CHAPTER 17: ELECTRIC CIRCUIT

1. Two resistances of 4 Ω are connected in parallel, and this combination is connected to another 6-Ω resistance in series. The equivalent resistance will be:

A. 4 Ω \quad | \quad B. 6 Ω \quad | \quad **C.** 8 Ω \quad | \quad D. 10 Ω

2. In series connection of resistors, the current across each resistor:

A. increases \quad | \quad B. decreases \quad | \quad **C. remain the same** \quad | \quad D. first increases then decreases

3. A resistor's first three colours are brown, black and red, its value is:

A. 10 Ω \quad | \quad B. 10 kΩ \quad | \quad C. 200 Ω \quad | \quad **D.** 1000 Ω

4. The relation for electric power in a circuit is $P =$

A. IV \quad | \quad B. I^2R \quad | \quad C. V^2/R \quad | \quad **D. all of these**

5. In the given figure, the current passing through 6 Ω resistor is:

A. 0.40 A \quad | \quad B. 0.48 A \quad | \quad C. 0.72 A \quad | \quad D. 0.80 A

(Note: Correct calculation gives 0.48 A*)* → **Correction: B.** 0.48 A

6. When four cells, each with an emf of 0.5 V, are connected in parallel, the net emf is:

A. 4.5 V \quad | \quad B. 2.0 V \quad | \quad C. 0.75 V \quad | \quad **D.** 0.5 V

7. The purpose of grounding electrical systems is to:

A. provide a path for current to flow \quad | \quad **B. protect against electric shocks** \quad | \quad C. reduce electrical resistance \quad | \quad D. increase energy efficiency

8. The purpose of a circuit breaker is to:

A. Increase electrical resistance \quad | \quad B. prevent electrical shock \quad | \quad C. regulate voltage \quad | \quad **D. interrupt the flow of electricity in case of a fault**

9. Which electrical element control the flow of the electric current in a circuit?

A. conductor \quad | \quad B. Insulator \quad | \quad **C. Resistor** \quad | \quad D. capacitor

10. A and B are two bulbs connected in parallel. A is glowing brighter than B, then the relation between R_A and R_B is:

A. $R_A > R_B$ \quad | \quad **B.** $R_A < R_B$ \quad | \quad C. $R_A = R_B$ \quad | \quad D. $R_A = 0$

11. The S.I. unit for electrical power is:

A. watt \quad | \quad B. Joule \quad | \quad C. volt \quad | \quad D. kwh

12. A wire of resistance R is divided into 10 equal parts. These parts are connected in parallel, the equivalent resistance of such connection will be:

A. $10R$ \quad | \quad B. R \quad | \quad C. $0.1R$ \quad | \quad **D.** $0.01R$

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Constructed Response Questions

Q1. A battery of voltage V is connected to 30 W bulb and 60 W bulb as shown in the figure.

(a) Identify brightest bulb

- **Answer: The** 60 W **bulb** glows brighter.
- **Reason:** In parallel connection, both bulbs receive the same supply voltage V. Power consumed is given by $P = \frac{V^2}{R}$, so the bulb with higher wattage rating (60 W) consumes more power and dissipates more light energy.

(b) Which bulb has greater resistance?

- **Answer: The** 30 W **bulb** has greater resistance.
- **Reason:** From the power relation $R = \frac{V^2}{P}$, resistance is inversely proportional to rated power ($R \propto \frac{1}{P}$). Therefore, the lower-wattage bulb (30 W) has double the resistance of the 60 W bulb ($R_{30} = 2R_{60}$).

(c) Suppose the two bulbs are connected in series, which bulb will glow brighter?

- **Answer: The** 30 W **bulb** will glow brighter in series.
- **Reason:** In series connection, the same electric current I passes through both bulbs. Power consumed in series is given by $P = I^2R$, making power directly proportional to resistance ($P \propto R$). Since the 30 W bulb has a greater resistance, it dissipates more power and glows brighter in series.

Q2. What is the value of resistance of the following resistors?

Using the 4-band resistor color code chart:

$$\text{Resistance} = \left(\text{Digit}_1 \times 10 + \text{Digit}_2\right) \times 10^{\text{Multiplier}} \pm \text{Tolerance}$$

- **Color Codes Reference:**
  - Black = 0, Brown = 1, Red = 2, Orange = 3, Yellow = 4, Green = 5, Blue = 6, Violet = 7, Grey = 8, White = 9
  - Multipliers: Black = 10^0 (1), Brown = 10^1 (10), Red = 10^2 (100), Orange = 10^3 (1 kΩ), Yellow = 10^4 (10 kΩ)
  - Gold tolerance = ±5%, Silver tolerance = ±10%

Left Column:

1. **Yellow – Violet – Brown – Gold:**

$47 \times 10^1 = 470\,\Omega \pm 5\% \rightarrow 470\,\Omega$

2. **Brown – Black – Red – Gold:**

$10 \times 10^2 = 1000\,\Omega \pm 5\% \rightarrow 1000\,\Omega$ **(1 kΩ)**

3. **Red – Red – Orange – Gold:**

$22 \times 10^3 = 22000\,\Omega \pm 5\% \rightarrow 22000\,\Omega$ **(22 kΩ)**

Right Column:

1. **Brown – Black – Brown – Gold:**

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$10 \times 10^1 = 100\,\Omega \pm 5\% \rightarrow 100\,\Omega$

2. **Green – Blue – Yellow – Gold:**

$56 \times 10^4 = 560000\,\Omega \pm 5\% \rightarrow 560000\,\Omega$ **(560 kΩ)**

3. **Orange – Orange – Black – Gold:**

$33 \times 10^0 = 33\,\Omega \pm 5\% \rightarrow 33\,\Omega$

Q3. Calculate the equivalent resistance between points A and B in the given circuit.

The circuit consists of three parallel pairs connected in series with each other.

1. **First parallel pair (2 Ω and 2 Ω):**

$$R_1 = \frac{2 \times 2}{2 + 2} = \frac{4}{4} = 1\,\Omega$$

2. **Second parallel pair (4 Ω and 4 Ω):**

$$R_2 = \frac{4 \times 4}{4 + 4} = \frac{16}{8} = 2\,\Omega$$

3. **Third parallel pair (6 Ω and 6 Ω):**

$$R_3 = \frac{6 \times 6}{6 + 6} = \frac{36}{12} = 3\,\Omega$$

4. **Total equivalent resistance (R_{AB}):**

$$R_{AB} = R_1 + R_2 + R_3 = 1\,\Omega + 2\,\Omega + 3\,\Omega = 6\,\Omega$$

- **Answer:** $R_{AB} = 6\,\Omega$

Q4. Consider a circuit in which a heater is in series with the supply voltage. Which device out of the following should be placed to present a higher resistance initially, preventing large currents from flowing at turn-on?

- **Answer: (c) Thermistor (specifically an NTC Thermistor)**
- **Reason:** A Negative Temperature Coefficient (NTC) thermistor has high resistance when cold (at turn-on), which limits inrush current. As current flows and heats the thermistor up, its resistance drops rapidly, allowing normal current flow during operation.

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SHORT RESPONSE QUESTIONS

1. How does the color code on a carbon resistor provide information about its properties, and why is this method chosen over other labeling techniques?

Colored bands represent numerical digits, multipliers, and tolerance values to determine exact resistance. This is preferred because numerical text is too small to read on tiny physical components.

2. Why are electrical devices in homes connected in parallel rather than in series? How would household functionality be impacted if they were connected in series?

Parallel connection ensures independent operation and a constant operating voltage across all devices. In series, turning off one appliance would break the circuit, and voltage drops would occur across each load.

3. When resistors are connected in parallel, why does total resistance decrease? How does this principle relate to efficiency?

Parallel connections provide multiple independent conducting pathways, effectively increasing cross-sectional area. This reduces overall resistance, lowers Joule heating losses, and improves system energy efficiency.

4. How can incorrect parallel placement of ammeters damage circuits, suggesting ways to prevent this?

Ammeters have near-zero internal resistance; placing them in parallel creates a dangerous short circuit. Prevent this by always wiring ammeters strictly in series with the load.

5. Why is it unsafe to touch electrical switches with wet hands? What principles of conductivity and human safety apply?

Water significantly lowers human skin resistance, allowing dangerous amounts of current to flow. Principles of ionic conductivity and current-induced ventricular fibrillation govern this severe safety hazard.

6. What makes touching a live wire while barefoot on the ground particularly dangerous? How do factors involved influence severity?

It completes a direct low-resistance path to Earth, enabling large currents to traverse the heart. Severity depends directly on current magnitude, pathway duration, frequency, and contact area.

7. How does a circuit breaker protect a household's electrical system? What might happen in the absence of a circuit breaker during a power surge or overload?

It automatically trips and interrupts excessive current flow when faults or overloads occur. Without it, sustained overheating could melt insulation and trigger catastrophic electrical fires.

8. In what ways does grounding an appliance's case enhance user safety? How does grounding mitigate potential electrical hazards?

Grounding provides a low-resistance path to direct fault currents safely into the earth. This prevents dangerous voltages from building up on exposed metal casings, preventing electric shock.

9. How does an appliance's wattage influence its energy consumption and operational cost? How can understanding this relationship help in making energy-efficient choices?

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Higher wattage means faster electrical energy conversion per second, raising operational costs. Knowing this helps consumers select energy-efficient appliances to minimize electricity bills.

10. In what ways do electrical energy and electrical power differ in function and application? How do these differences impact our understanding and measurement of electricity?

Energy is total work done over time ($E = Pt$), whereas power is the rate of energy transfer. This distinction clarifies total consumption billing versus instantaneous device capacity ratings.

11. How does the kilowatt-hour serve as a unit of energy consumption, and what steps can you take to convert energy usage from joules to kilowatt-hours?

A kilowatt-hour measures total electrical energy used at a rate of 1 kW for 1 hour. Convert joules by dividing the total energy value by 3.6×10^6 J.

12. Describe a situation in your daily life where electrical energy is essential. How does this energy transform to allow the device to perform its function?

Refrigerators use electrical energy to run a compressor motor, transforming electrical into mechanical work. This extracts heat from the interior to preserve food freshness.

13. What are three common sources of electrical energy, and how do their advantages and disadvantages influence our choice of energy sources?

Fossil fuels, solar, and hydroelectric power are primary sources with varying reliability and emissions. Advantages in cost or eco-friendliness drive our choices despite storage and intermittency challenges.

14. Examine the effects and risks of connecting different emf sources in parallel, and suggest safe ways to combine power sources.

Connecting mismatched EMF sources in parallel causes high internal current loops and rapid discharging. Safely combine sources by ensuring identical voltages and using matching battery specifications.

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LONG RESPONSE QUESTIONS

1. What is the significance of different types of resistors in electronic circuits, and how do their characteristics influence circuit design?

Resistors are fundamental passive components used to control current flow, divide voltages, and set bias points in electronic systems.

- **Types:** Carbon-composition resistors are cost-effective for general use; wire-wound resistors handle high power dissipation; metal-film resistors offer high precision and low thermal noise; and thermistors/varistors provide sensitivity to environmental changes (temperature and voltage).
- **Design Influence:** Engineers select resistor characteristics—such as wattage rating, temperature coefficient, tolerance, and resistance value—to ensure circuit stability, prevent thermal breakdown, minimize noise interference, and guarantee long-term reliability under varying operating conditions.

2. Explain the principles behind the series combination of resistances and illustrate how the total resistance changes when more resistors are added?

- **Principle:** In a series circuit, resistors are connected end-to-end so that the same electric current flows sequentially through each component without branching. The total voltage supplied is the sum of the potential drops across individual resistors ($V = V_1 + V_2 + V_3$).
- **Derivation:** Applying Ohm's law ($V = IR$), we get $IR_{eq} = IR_1 + IR_2 + IR_3$. Cancelling the common current I yields the equivalent resistance formula:

$$R_{eq} = R_1 + R_2 + R_3 + \cdots + R_n$$

- **Effect of Adding Resistors:** Because each added resistor introduces an additional path restriction in the single current loop, the total equivalent resistance increases additively. Consequently, adding more resistors in series decreases the total circuit current.

3. How does the concept of equivalent resistance in parallel circuits differ from that in series circuits, and what practical applications can you identify for each?

- **Concept Difference:** While series resistance adds directly to increase total resistance, parallel resistance decreases because adding branches creates multiple alternative pathways for current flow. The reciprocal of the equivalent resistance equals the sum of the reciprocals of individual resistances:

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

- **Applications:**
  - *Series Circuits:* Used in voltage dividers, string lights (historically), and safety fuses where current limiting is required.
  - *Parallel Circuits:* Universally used in household electrical wiring, automotive electrical systems, and power distribution networks to ensure all devices receive the same operating voltage and can be switched independently.

4. Discuss the effects of connecting emf sources in series or parallel and their practical uses.

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- **Series Connection of EMF Sources:**
    - *Effect:* Positive terminals are connected to negative terminals of adjacent sources, causing their EMFs and internal resistances to add up ($E_{total} = E_1 + E_2 + \cdots$). This increases the total voltage delivered to the load.
    - *Practical Use:* Flashlights, multi-cell battery packs, and portable electronics requiring higher operating voltages.
- **Parallel Connection of EMF Sources:**
    - *Effect:* Like terminals are connected together, keeping the total output voltage equal to a single cell ($E_{total} = E_1$) while reducing equivalent internal resistance and sharing the load current.
    - *Practical Use:* Solar farm arrays, uninterruptible power supplies (UPS), and automotive battery boosting to increase current capacity and extend operational run-time.

5. In what ways can electric power be measured, and why is it important to understand the different formulas for calculating power in electrical systems?

- **Measurement Methods:** Electric power (P) can be measured directly using a wattmeter, or indirectly by measuring current (I) with an ammeter and voltage (V) with a voltmeter, then computing $P = IV$.
- **Core Formulas:** Derived from Ohm's law, power can be expressed in three primary ways:
    1. $P = IV$ (when voltage and current are known)
    2. $P = I^2R$ (when current and resistance are known, crucial for calculating I^2R copper heating losses in transmission lines)
    3. $P = \frac{V^2}{R}$ (when voltage and resistance are known, essential for evaluating home appliance power consumption)
- **Importance:** Understanding these formulas enables engineers to design safe wiring, choose appropriately rated fuses and circuit breakers, minimize energy wastage, and prevent overheating hazards.

6. What are the common hazards associated with household electricity, and how can individuals effectively mitigate these risks through safety measures?

- **Common Hazards:** Damaged insulation, overloaded circuits, wet conditions, short circuits, and improper grounding can lead to severe electric shocks, thermal burns, and electrical fires.
- **Mitigation Measures:**
    - Regularly inspect electrical cords and replace frayed wiring.
    - Avoid overloading wall outlets by using multi-plug power strips correctly.
    - Install Ground Fault Circuit Interrupters (GFCIs) in moisture-prone areas like kitchens and bathrooms.
    - Ensure all heavy appliances are properly grounded.

- Never touch switches or plug in devices with wet hands or while barefoot on conductive floors.

7. In what various ways is electricity utilized in everyday life, and how has its application evolved over time?

- **Everyday Utilization:** Electricity powers heating and cooling systems, lighting, refrigeration, communication networks, industrial machinery, transportation, and medical equipment.
- **Historical Evolution:** Early applications were primarily restricted to incandescent lighting and telegraphy. Over time, the invention of alternating current (AC) power grids, semiconductors, microprocessors, and renewable energy integration transformed electricity into the invisible backbone of modern automation, digital computing, and global communication.

8. Describe the working principle of a potential divider and discuss its practical uses in electronic circuits?

- **Working Principle:** A potential divider (voltage divider) is a simple circuit consisting of two or more resistors connected in series across a source voltage (V_{in}). By dividing the voltage proportional to resistance values, the output voltage across one resistor is given by:

$$V_{out} = V_{in}\left(\frac{R_2}{R_1 + R_2}\right)$$

- **Practical Uses:**
  - Volume control knobs (potentiometers) in audio amplifiers.
  - Sensor interface circuits (combining thermistors or photoresistors to translate temperature/light changes into variable voltage signals).
  - Microcontroller analog input signal scaling.

9. What are thermistors, and how do their types (NTC and PTC) differ in terms of functionality and applications in temperature sensing and control?

- **Definition:** A thermistor is a type of temperature-sensitive semiconductor resistor whose resistance changes significantly with temperature variations.
- **Types and Differences:**
  - **NTC (Negative Temperature Coefficient):** Resistance decreases as temperature increases. Widely used for digital thermometers, inrush current limiters, and temperature compensation.
  - **PTC (Positive Temperature Coefficient):** Resistance increases as temperature increases. Widely used in self-regulating heating elements, overcurrent circuit protection, and motor start windings.

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NUMERICALS RESPONSE QUESTIONS

Question 1

Given Data:

- Voltage (V) = 12 V
- Resistance of Fan (R_1) = 6 Ω
- Resistance of Heater (R_2) = 10 Ω
- Resistance of LED Bulb (R_3) = 18 Ω

(a) Equivalent Resistance (R_e)

Since all three devices are connected in parallel:

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

$$\frac{1}{R_e} = \frac{1}{6} + \frac{1}{10} + \frac{1}{18}$$

Find the common denominator (90):

$$\frac{1}{R_e} = \frac{15 + 9 + 5}{90} = \frac{29}{90}$$

$$R_e = \frac{90}{29} \approx 3.1\ \Omega$$

(b) Current passing through each device

In a parallel circuit, the voltage across each device is equal to the supply voltage ($V = 12$ V).

1. **Current through Fan (I_1):**

$$I_1 = \frac{V}{R_1} = \frac{12}{6} = 2\ \text{A}$$

2. **Current through Heater (I_2):**

$$I_2 = \frac{V}{R_2} = \frac{12}{10} = 1.2\ \text{A}$$

3. **Current through LED Bulb (I_3):**

$$I_3 = \frac{V}{R_3} = \frac{12}{18} \approx 0.67\ \text{A}$$

Question 2

Given Data:

- $R_1 = 8\ \Omega$
- $R_2 = 12\ \Omega$
- $R_3 = 18\ \Omega$

Formula: For parallel combination:

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

$$\frac{1}{R_e} = \frac{1}{8} + \frac{1}{12} + \frac{1}{18}$$

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Find the common denominator (72):

$$\frac{1}{R_e} = \frac{9+6+4}{72} = \frac{19}{72}$$

$$R_e = \frac{72}{19} \approx 3.789\ \Omega$$

Question 3

Given Data:

- Resistance (R) = 10 Ω
- Voltage (V) = 120 V

Formula:

$$P = \frac{V^2}{R}$$

Calculation:

$$P = \frac{(120)^2}{10} = \frac{14400}{10} = 1440\ \text{W}$$

Question 4

Given Data:

- Power (P) = 60 W
- Time (t) = 5 hours

Formula:

$$E = P \times t$$

Calculation:

$$E = 60\ \text{W} \times 5\ \text{h} = 300\ \text{Wh}$$

Question 5

Given Data:

- Number of cells (n) = 100
- EMF of each cell (e) = 0.2 V

1. Resultant EMF when connected in series:

$$E_{\text{series}} = n \times e = 100 \times 0.2\ \text{V} = 20\ \text{V}$$

2. Resultant EMF when connected in parallel: In a parallel combination of identical cells, the net EMF equals the EMF of a single cell:

$$E_{\text{parallel}} = e = 0.2\ \text{V}$$

Question 6

Given Data:

- Series arm resistors: 2 Ω and 3 Ω
- Parallel top resistor: 6 Ω
- Outer series resistor: 4 Ω

Step 1: Combine the bottom series resistors:

$$R_{\text{bottom}} = 2\ \Omega + 3\ \Omega = 5\ \Omega$$

Step 2: Combine the bottom branch (5 Ω) in parallel with the top branch (6 Ω):

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$$\frac{1}{R_{\text{parallel}}} = \frac{1}{6} + \frac{1}{5} = \frac{5+6}{30} = \frac{11}{30}$$

$$R_{\text{parallel}} = \frac{30}{11} \approx 2.73\ \Omega$$

Step 3: Add the series resistor (4 Ω) to the equivalent parallel resistance:

$$R_{AB} = 4\ \Omega + R_{\text{parallel}} = 4 + 2.73 = 6.73\ \Omega$$

Question 7

Given Data:

- Resistance (R) = 50 Ω
- Voltage (V) = 120 V
- Time (t) = 5 hours (assumed standard daily operational duration, as indicated by the final value)

(a) Power consumed (P)

$$P = \frac{V^2}{R} = \frac{(120)^2}{50} = \frac{14400}{50} = 288\ \text{W}$$

(b) Current flowing through (I)

$$I = \frac{V}{R} = \frac{120}{50} = 2.4\ \text{A}$$

(c) Electrical energy consumed (E) Assuming $t = 5$ hours:

$$E = P \times t = 288\ \text{W} \times 5\ \text{h} = 1440\ \text{Wh}$$

Question 8

Given Data:

- Two parallel resistors: 12.5 Ω and 12.5 Ω
- Series resistor: 4.5 Ω

Step 1: Calculate the parallel resistance of the two 12.5 Ω resistors:

$$\frac{1}{R_p} = \frac{1}{12.5} + \frac{1}{12.5} = \frac{2}{12.5}$$

$$\frac{1}{R_p} = \frac{1}{12.5} + \frac{1}{12.5} = \frac{2}{12.5}$$

Step 2: Add the series resistor (4.5 Ω):

$$R_{\text{total}} = R_p + 4.5 = 6.25 + 4.5 = 10.75\ \Omega$$

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