Electricity: Exercise Question

Q.1 A piece of wire of resistance R is cut into five equal parts. These parts are then connected in parallel. If the equivalent resistance of this combination is R′, then the ratio R/R′ is –

(a) 1/25 (b) 1/5 (c) 5 (d) 25

Sol. (d) 25

Explanation: The piece of wire with resistance R is cut into five equal parts.
Therefore, resistance of each of the part will be equal to R/5.
All parts are connected in parallel, then equivalent resistance is = R' as given

the equivalent resistance, $\frac{1}{R'} = \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} + \frac{5}{R} = \frac{5+5+5+5+5}{R} = \frac{25}{R}$

Or, $R' = \frac{R}{25}$

Thus, $\frac{R}{R'} = 25$

Q.2 Which of the following terms does not represent electrical power in a circuit?

(a) I^2R (b) IR^2 (c) VI (d) V^2/R

Sol. (b) IR^2

Explanation: Power (P) = VI .... (i)
According to ohm law V = IR , put in value in equation (i)
P = (IR) I = I x R x I = I^2R, Thus P = I^2R

Since I=V/R, therefore, after putting this value in above equation we get

$$P = \left(\frac{V}{R}\right)^2 R = \frac{V^2}{R}$$

Therefore, P cannot be expressed as IR^2

Q.3 An electric bulb is rated 220 V and 100 W. When it is operated on 110 V, the power consumed will be

(a) 100 W (b) 75 W (c) 50 W (d) 25 W

Sol. Given, Potential difference, V = 220V,
Power, P = 100W
Power consumption at 100V =?

For solving this problem, first of all, we need to find out the resistance of the bulb.
As we know that P = V^2/R

$100W = (220V)^2 / R \Rightarrow R = (220 \times 220) / 100\Omega = 484\Omega$

Now, when bulb is operated at 110V
so, the power consumption $P = V^2 / R = (110V)^2 / 484\Omega$
$= 12100V^2 / 484\Omega = 25W$

Therefore, the bulb will consume power 25W at 110V.

Q.4 Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then parallel in a circuit across the same potential difference. The ratio of heat produced in series and parallel combinations would be

(a) 1:2 (b) 2:1 (c) 1:4 (d) 4:1

Sol. (c) 1: 4

Sol: Let the potential difference = V,
Resistance of the wire = R
Heat produced when wires are connected in series = H_s
Heat produced when wires are connected in parallel = H_p

Thus, the Equivalent resistance when wires connected in series

$R_s = R + R = 2R$
The Equivalent resistance when the wires connected in parallel R_P =

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

$R_P = R/2$

We know that, $H = I^2Rt = (V/R)^2 R t = \frac{V}{R}$ t, (since, I=V/R)
Thus, ratio of heat produced in both conditions:

$$H_S : H_P = \frac{V_t}{R_s} : \frac{V_t}{R_p} = \frac{V_t}{R_s} \text{x} \frac{R_p}{V_t} = \frac{R_p}{R_s}$$

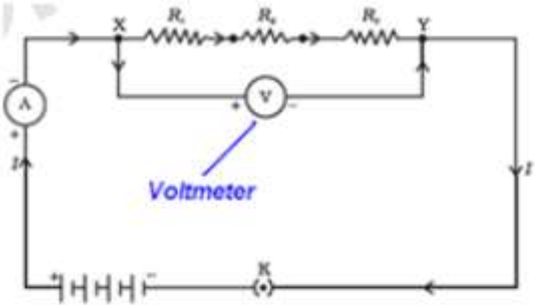
After putting the value of R_P and R_S, we get

$$\frac{H_s}{H_p} = \frac{R/2}{2R} = \frac{1}{4}$$

Thus, the ratio $H_S : H_P$ = 1:4

Q.5 How is a voltmeter connected in the circuit to measure the potential difference between two points?

Sol. Voltmeter is connected into parallel manner to measure the potential difference between two points in a circuit.



Q.6 A copper wire has diameter 0.5 mm and resistivity of 1.6×10^{-8} Ω m. What will be the length of this wire to make its resistance 10 Ω? How much does the resistance change if the diameter is doubled?

Sol. Given: Diameter of wire d = 0.5 mm

So, radius $r = \frac{0.5mm}{2} = 0.25mm = \frac{0.25mm}{1000} = 0.00025m$

Resistivity, $\rho = 1.6 \times 10^{-8} \Omega m$
Resistance (R) = 10Ω, length (l) =?

As we know that, $R = \rho \frac{l}{A}$

Therefore, $l = \frac{RA}{\rho} = \frac{R\pi r^2}{\rho}$

$$l = \frac{10\Omega \text{x} 3.14 \text{x} (0.00025m)^2}{1.6x10^{-8}\Omega m}$$

$$l = \frac{10\text{x}10^8 \text{x} 0.000000196250}{1.6} m$$

$$l = \frac{196.25}{1.6} m = 12.656m$$

Resistance (R') when diameter is doubled =?
When diameter of the wire is doubted, i.e. diameter = 0.5mm × 2 = 1 mm
Therefore, radius = 1mm / 2 = 0.5mm=0.5 / 1000m = 0.0005m

Therefore, $R' = \rho \frac{l}{A} = \rho \frac{1}{\pi r^2}$

$= 1.6 x 10^{-8} x \frac{122.7m}{3.14 x 0.0005m x 0.0005m}$

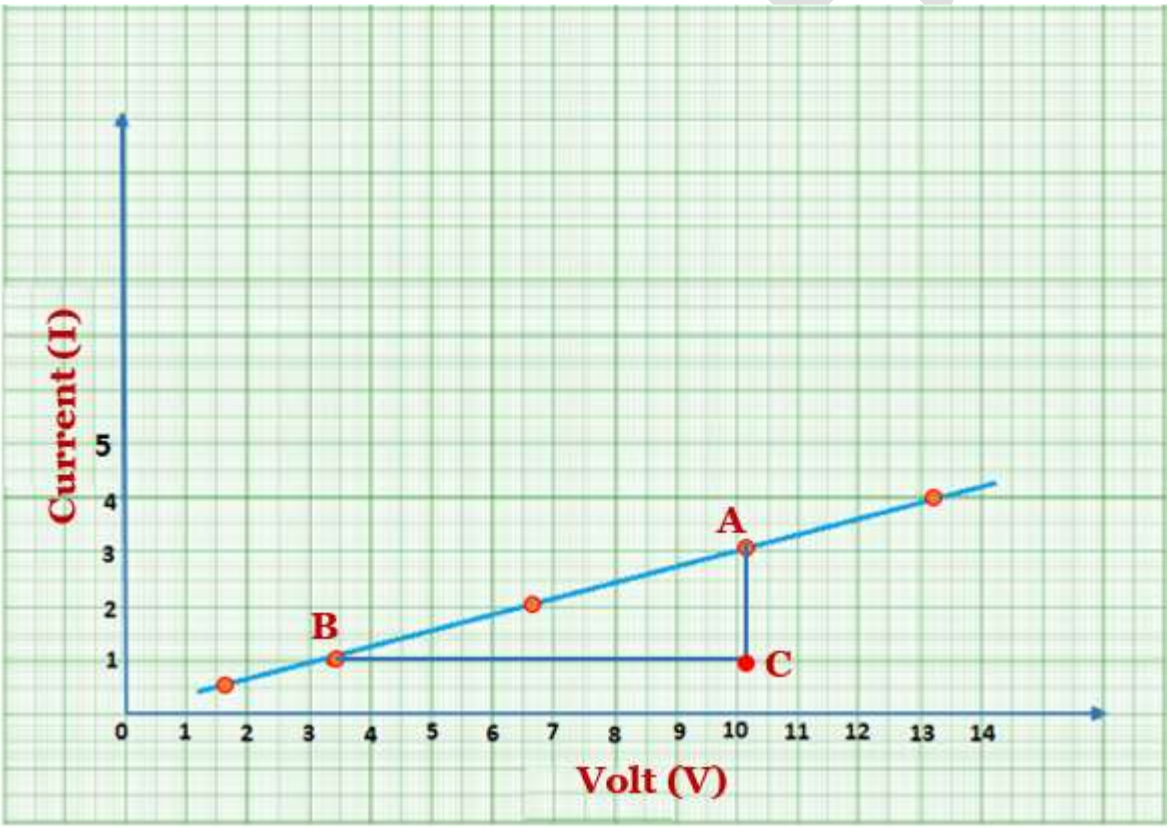
$= \frac{1.6 x 122.7}{3.14 x 0.000000025 x 10^{8}} \Omega$

=2.5 Ω
Therefore, length of the wire =122.7 m
Resistance, when diameter becomes double = 2.5Ω .

Q.7 The values of current I flowing in a given resistor for the corresponding values of potential difference V across the resistor are given below –

I (Amperes)	0.5	1.0	2.0	3.0	4.0
V (Volts)	1.6	3.4	6.7	10.2	13.2

Plot a graph between V and I and calculate the resistance of that resistor.
Sol.



As we know the value of resistance is given by slope of the graph, so we consider two points A and B on the slope.
From the graph,
Now, BC = 10.2 V – 3.4 V = 6.8 V
AC = 3 – 1 = 2 ampere
Slope = 1/R = AC / BC = 2 / 6.8 = 1/3.4
Therefore, resistance, R = 3.4Ω

Q.8 When a 12 V battery is connected across an unknown resistor, there is a current of 2.5 mA in the circuit. Find the value of the resistance of the resistor.

Sol. Given: Potential difference, V = 12V
Current (I) = 2.5mA = 2.5 x 10^{-3} = 0.0025 A
So, Resistance, R =?
We know that R=V / I = 12V / 0.0025A = 4800Ω

Q.9 A battery of 9 V is connected in series with resistors of 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5 Ω and 12 Ω, respectively. How much current would flow through the 12 Ω resistor?

Sol. Given: potential difference, V = 9V
Resistance of resistors = 0.2 Ω, 0.3 Ω, 0.4 Ω, 0.5 Ω and 12 Ω respectively
Current through resistor having resistance equal to 12Ω =?
Total effective resistance when these are connected in series manner,
R = 0.2 Ω + 0.3 Ω + 0.4 Ω + 0.5 Ω + 12 Ω = 13.4 Ω
According to ohm's law, current (I) = V / R = 9V / 13.4Ω = 0.671A

Since, resistors are connected in series and as we know that same current flow in series manner.
Thus, the current through the resistor having resistance 12 Ω = 0.671 A

Q.10 How many 176 Ω resistors (in parallel) are required to carry 5 A on a 220 V line?

Sol. Given: Resistance of each of the resistor = 176Ω
Electric current (I) = 5A
Potential difference (V) = 220V
Number of resistors connected in parallel =?
Let total n number of resistors are connected in parallel, and equivalent resistance = R

Therefore, $\frac{1}{R_{eq}} = x \text{ x } \frac{1}{176\Omega} = \frac{x}{176}$

$$R_{eq} = \frac{176}{x}$$

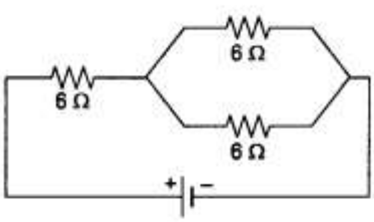
We know that, R = V/I Therefore, 176Ω / n = 220V / 5A
⇒ n×220V = 176Ω × 5A

$\Rightarrow n = \frac{176\text{x}5}{220} = 4$

Thus, there are 4 number of resistors are connected in parallel.

Q.11 Show how you would connect three resistors, each of resistance 6 Ω, so that the combination has a resistance of (i) 9 Ω, (ii) 4 Ω.

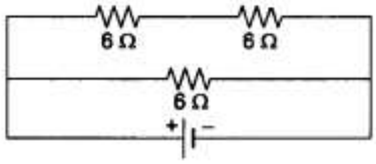
Sol. Given: We have three resistor of resistance 6 ohm.
For getting equivalent resistance 9 Ω: when two resistors are connected in parallel and third one in series of both these resistors as shown in figure:



$R_{eq} = R_1 + \frac{R_2 R_3}{R_2 + R_3} = 6 + \frac{6\text{x}6}{6+6} = 9\Omega$

Hence, total effective resistance = 9 Ω

For getting equivalent resistance 4 Ω: When two resistors are connected in series with one in parallel with both these resistors as shown in figure.



Two resistor are connected in series 6+6=12 Ω, then 12 Ω connected parallel with 6 Ω resistor, so equivalent resistor:

$$R_{eq} = \frac{12x6}{12+6} = 4\Omega$$

Total effective resistance = 4 Ω

Q.12 Several electric bulbs designed to be used on a 220 V electric supply line, are rated 10 W. How many lamps can be connected in parallel with each other across the two wires of 220 V line if the maximum allowable current is 5 A?

Sol. Given: potential difference (V) = 220 V
Power input (P) = 10W
Electric current (I) = 5A

The resistance of each of the lamp:
As we know that, power $P = V^2/ R$
So, $10W = (220V)^2/R$
⇒ R = 48400 /10 = 4840Ω
Let x number of bulb are to be connected in parallel so that electric current (I) = 5A

Therefore, $\frac{1}{R_{eff}} = x \text{ x } \frac{1}{4840} = \frac{x}{4840}$

Therefore, effective resistance $R_{eff} = \frac{4840}{x}\ \Omega$

Since, R=V / I

$$\Rightarrow \frac{4840}{x}\ \Omega = \frac{220V}{5A}\ \text{A}$$

$$\Rightarrow x = \frac{4840x5}{220} = 110$$

Therefore, total 110 bulbs are to be connected in parallel.

Q.13 A hot plate of an electric oven connected to a 220 V line has two resistance coils A and B, each of 24 Ω resistance, which may be used separately, in series, or in parallel. What are the currents in the three cases?

Sol. Given: Potential difference (V) = 220 V
Resistance of one coil = 24 Ω

Case-1: When coil is used separately
When used separately, the resistance, R = 24 Ω and V = 220V
Electric current, I=V/R=220V / 24Ω = 9.16A

Case-2: When the two coils are connected in series.
The equivalent resistance = 24 Ω + 24Ω = 48 Ω
Electric current, I=V / R = 220V / 48Ω = 4.58A

Case-3: When the two coils are connected in parallel.

Then equivalent resistance:

$$\frac{1}{R_{eq}} = \frac{1}{24} + \frac{1}{24}$$

$$\frac{1}{R_{eq}} = \frac{2}{24}$$

$$R_{eq} = 12\Omega$$

Therefore, total effective resistance, R=12Ω
Electric current, I = V/R = 220V / 12Ω = 18.33A
Therefore, electric current through the circuit
(1) When coil is used separately = 9.16 A
(2) When coils are used in series = 4.58 A
(3) When coils are used in parallel = 18.33 A

Q.14 Compare the power used in the 2 Ω resistor in each of the following circuits:
(i) a 6 V battery in series with 1 Ω and 2 Ω resistors, and
(ii) a 4 V battery in parallel with 12 Ω and 2 Ω resistors.

***Sol.* Case-1: A 6 V battery in series with 1 Ω and 2 Ω resistors.**
Given: Potential difference = 6 V
Resistance of resistors = 1 Ω and 2 Ω
Power consumed through resistors of 2 Ω =?
The total effective resistance, R = 1 Ω + 2 Ω = 3 Ω
From the ohm's law, Current I=V / R = 6V / 3Ω = 2A
As we know that, current flowing in each resistance same when resistors are connected in series.
So, current through the 2Ω resistor = 2A
Thus, Power (P) = $I^2 \times R = (2A)^2 \times 2\Omega = 8W$

Case-2: A 4 V battery in parallel with 12 Ω and 2 Ω resistors.
Given: Potential difference, V = 4V
As we know, potential difference across the circuit remains same, if resistors are connected in parallel.
Thus, Power (P) consumed by resistance of $2\Omega = V^2/R$
$= (4V)^2 / 2\Omega = 16/2W = 8W$
Thus, power consumed by resistance of 2 Ω in both the case = 8 W

Q.15 Two lamps, one rated 100 W at 220 V, and the other 60 W at 220 V, are connected in parallel to electric mains supply. What current is drawn from the line if the supply voltage is 220 V?
Sol. Since, both the lamps are connected in parallel, thus, potential difference will be equal.
Given: Potential difference = 220 V
Power of one lamp, P_1 = 100W
Power of second lamp, P_2 = 60W
Since, Power (P) = VI, or I = P/V
Thus, total current through the circuit, $I = I_1 + I_2$

$$I = \frac{P_1}{V} + \frac{P_2}{V}$$

$$I = \frac{100W}{220V} + \frac{60W}{220V} = \frac{100+60}{220}A = \frac{160}{220}A = 0.727A$$

Q.16 Which uses more energy, a 250 W TV set in 1 hr, or a 1200 W toaster in 10 minutes?
Sol. Given: Power of TV (P) = 250W,
time (t) = 1 hr = 60 x 60 = 3600 s
Since, energy consumed by appliance = Power x time
E = P x t

Therefore, energy consumed by TV = 250 W x 3600 s = 900000 J = 9×10^5 J

Given: Power of toaster = 1200W
Time (t) = 10 minute = 60 x 10 = 600 s
Thus, energy consumed by toaster = 1200W x 600 s = 720000 J = 7.2×10^5 J

Therefore, TV set will use more energy than toaster.

Q.17 An electric heater of resistance 8 Ω draws 15 A from the service mains 2 hours. Calculate the rate at which heat is developed in the heater.

Sol. Given: Resistance, R = 8 Ω
Electric current (I) = 15A
Time (t) = 2 h = 2 x 60 x 60 s = 7200 s
Rate at which heat is developed in heater:
Since, rate of heat produced i.e. power $P = I^2R = (15A)^2 \times 8\ \Omega = 225 \times 8$ J/s = 1800 J/s or 1800W

Q.18 Explain the following.

(a) Why is tungsten used almost exclusively for filament of electric lamps?

(b) Why are the conductors of electric heating devices, such as bread-toasters and electric irons, made of an alloy rather than a pure metal?

(c) Why is the series arrangement not used for domestic circuits?

(d) How does the resistance of a wire vary with its area of cross-section?

(e) Why are copper and aluminium wires, usually employed for electricity transmission?

Sol.

(a) The melting point (i.e.3380°C) and resistivity (i.e. 4.9×10^{-8} Ωm) of tungsten is very high. Due to this, it does not melt at high temperature and retain most of the heat. It glows due to heating. This is the reason, tungsten is used almost exclusively for filament of electric lamps.

(b) For more production of heat, the high melting point of conductors is required. The alloys of metal have higher melting points than pure metals. Therefore, to get more heat, alloy is used rather than pure metal in electrical heating devices like bread-toaster, electric iron, etc.

(c) There is division of voltage in the series arrangement in the circuits. If any one electrical device stops working due to some reason, than all other devices will also stop working. That's why the series arrangement is not used for domestic circuits.

(d) Resistance of a wire is inversely proportional to the area of cross section. i.e. $R \alpha \frac{1}{A}$. Therefore, resistance decrease with increase in area of cross section and vice versa.

(e) Since copper and aluminium wires have lower resistivity than iron but more than that of silver. These wires are cheaper than silver. Due to this reason copper and aluminium wires are used for electricity transmission.