#420108

Topic: Cells and EMF

The storage battery of a car has an emf of 12 V. If the internal resistance of the battery is 0.4 Ω, what is the maximum current that can be drawn from the battery?

Solution

The maximum current is given by $I = \dfrac{\text{Voltage}}{\text{Internal resistance}} = \dfrac{12}{0.4} = 30A$

#420110

Topic: Cells and EMF

A battery of emf 10 V and internal resistance 3 W is connected to a resistor. If the current in the circuit is 0.5 A, what is the resistance of the resistor? What is the terminal voltag of the battery when the circuit is closed?

Solution

$E = V + IR$,

$R = E/I - V = 17\,\Omega$

Again using $E = V + Ir$, we get

$V = E - Ir = 10 - 0.5 \times 3$

$\quad = 10 - 1.5 = 8.5V$.

#420114

Topic: Equivalent Resistance in Series-Parallel

(a) Three resistors $1\Omega, 2\Omega$ and 3Ω are combined in series. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 12 V and negligible internal resistance, obtain the potential drop across each resistor.

Solution

(a)

Equivalent resistance is

$R_{eq} = R_1 + R_2 + R_3 = (1 + 2 + 3)\Omega = 6\Omega$

(b)

Current in the circuit is given by $I = \dfrac{E}{R}$

$I = \dfrac{12}{6} = 2\Omega$

Potential drop across $1\Omega,\ V_1 = IR_1 = 2 \times 1 = 2V$

Potential drop across $2\Omega, V_2 = IR_2 = 2 \times 2 = 4V$

Potential drop across $3\Omega, V_3 = IR_3 = 2 \times 3 = 6V$

#420118

Topic: Equivalent Resistance in Series-Parallel

(a) Three resistors $2\Omega, 4\Omega$ and 5Ω are combined in parallel. What is the total resistance of the combination?

(b) If the combination is connected to a battery of emf 20 V and negligible internal resistance, determine the current through each resistor, and the total current drawn from the battery.

Solution

(a) For Parallel connection,

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$
$$\frac{1}{R_p} = \frac{1}{2} + \frac{1}{4} + \frac{1}{5}$$
$$\frac{1}{R_p} = \frac{10+5+4}{20}$$
$$R_p = \frac{20}{19}\Omega$$

(b) $R_1 = 2\Omega, R_2 = 4\Omega, R_3 = 5\Omega$

$$I_1 = \frac{V}{R_1} = 20/2 = 10A$$
$$I_2 = \frac{V}{R_2} = 20/4 = 5A$$
$$I_3 = \frac{V}{R_3} = 20/5 = 4A$$

Total current = $I_1 + I_2 + I_3 = 19A$

#420126

Topic: Resistance and Resistivity

At room temperature (27.0^oC) the resistance of a heating element is 100Ω . What is the temperature of the element if the resistance is found to be 117Ω, given that the temperature coefficient of the material of the resistor is $1.70 \times 10^{-4}C^{-1}$.

Solution

at $T = 27^oC, R = 100\Omega$

$R_1 = 117\Omega$

thermal coefficient, $\alpha = \dfrac{R_1 - R}{R(T_1 - T)} = 1.70 \times 10^{-4}C^{-1}$

$\Rightarrow T_1 = 1027^oC$

#420129

Topic: Resistance and Resistivity

A negligibly small current is passed through a wire of length 15 m and uniform cross-section $6.0 \times 10^{-7}m^2$, and its resistance is measured to be 5.0Ω. What is the resistivit of the material at the temperature of the experiment?

Solution

Let resistivity coefficient be ρ

$$R = \rho\frac{l}{A}$$
$$\rho = \frac{RA}{l}$$
$$\rho = 2 \times 10^{-7}\Omega m$$

#420131

Topic: Resistance and Resistivity

A silver wire has a resistance of 2.1Ω at 27.5^oC, and a resistance of 2.7Ω at 100^oC. Determine the temperature coefficient of resistivity of silver.

Solution

$T_1 = 27.5^oC, R_1 = 2.1\Omega, T_2 = 100^oC, R_1 = 2.7\Omega$

Temperature coefficient of resistivity is:

$$\alpha = \frac{R_2 - R_1}{R_1(T_2 - T2)} = 0.0039^oC^{-1}$$

#420134

Topic: Resistance and Resistivity

A heating element using nichrome connected to a 230 V supply draws an initial current of 3.2 A which settles after a few seconds to a steady value of 2.8 A. What is the stead temperature of the heating element if the room temperature is 27.0^oC? Temperature coefficient of resistance of nichrome averaged over the temperature range involved is $1.70 \times 10^{-4}\,^oC^{-1}$.

Solution

V=230 volts

Initial current, $I_1 = 3.2\ A$

$R = V/I_1 = 71.9\Omega$

steady state current,

$I_2 = 2.8\ A$

$R_2 = 230/2.8 = 82.14\Omega$

$\alpha = 1.7 \times 10^{-4}, T_1 = 27^oC$

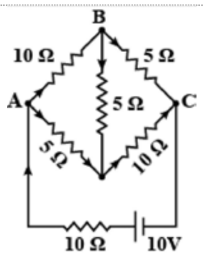
coefficient of resistance

$\alpha = \dfrac{R_2 - R_1}{R_1(T_2 - T_1)}$

$\Rightarrow T_2 = 867.5^oC$

#420139

Topic: Wheatstone Bridge



Determine the current in each branch of the network shown in Fig.

Solution

Current flowing through various branches of the circuit is represented in the given figure.

$I_1 =$ Current flowing through the outer circuit

$I_2 =$ Current flowing through branch AB

$I_3 =$ Current flowing through branch AD

$I_2 - I_4 =$Current flowing through branch BC

$I_3 + I_4 =$Current flowing through branch CD

$I_4 =$ Current flowing through branch BD

For the closed circuit ABDA, potential is zero i.e.,

$10I_2 + 5I_4 - 5I_3 = 0$

$2I_2 + I_4 - I_3 = 0$

$I_3 = 2I_2 + I_4$ ...(1)

For the closed circuit BCDB, potential is zero i.e.,

$5(I_2 - I_4) - 10(I_3 + I_4) - 5/4 = 0$

$5I_2 + 5I_4 - 10I_3 - 10I_4 - 5I_4 = 0$

$5I_2 - 10I_3 - 20I_4 = 0$

$I_2 = 2I_3 + 4I_4$ ...(2)

For the closed circuit ABCFEA, potential is zero i.e.,

$-10 + 10(I_1) + 10(I_2) + 5(I_2 - I_4) = 0$

$10 = 15I_2 + 10I_1 - 5I_4$

$3I_2 + 2I_1 - I_4 = 2$ ...(3)

From equations (1) and (2), we obtain

$I_3 = 2(2I_3 + 4I_4) + I_4$

$I_3 = 4I_3 + 8I_4 + I_4$

$-3I_3 = 9I_4$

$-3I_4 = +I_3$ ...(4)

Putting equation (4) in equation (1), we obtain

$I_3 = 2I_2 + I_4$

$-4I_4 = 2I_2$

$I_2 = -2I_4$ ...(5)

It is evident from the given figure that,

$I_1 = I_3 + I_2$ ...(6)

Putting equation (6) in equation (1), we obtain

$3I_2 + 2(I_3 + I_2) - I_4 = 2$

$5I_2 + 2(I_3 + I_2) - I_4 = 2$ ...(7)

Putting equations (4) and (5) in equation (7), we obtain

$5(-2I_4) + 2(-3I_4) - I_4 = 2$

$-10I_4 - 6I_4 - I_4 = 2$

$17I_4 = -2$

$I_4 = \frac{-2}{17}A$

Equation (4) reduces to

$I_3 = -3(I_4)$

$= -3\left(\frac{-2}{17}\right) = \frac{6}{17}A$

$I_2 = -2(I_4)$

$= -2\left(\frac{-2}{17}\right) = \frac{4}{17}A$

$I_2 - I_4 = \frac{4}{17} - \left(\frac{-2}{17}\right) = \frac{6}{17}A$

$I_3 + I_4 = \frac{6}{17} + \left(\frac{-2}{17}\right) = \frac{4}{17}A$

$I_1 = I_3 + I_2$

$= \frac{6}{17} + \frac{4}{17} = \frac{10}{17}A$

Therefore, Current in branch $AB = \frac{4}{17}A$

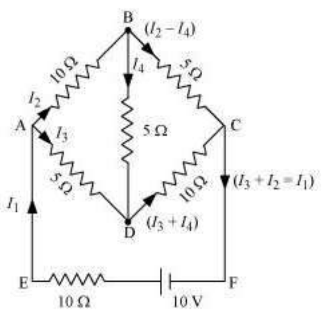
In branch BC $= \frac{6}{17}A$

In branch CD $= \frac{-4}{17}A$

In branch AD $= \frac{6}{17}A$

In branch BD $= \left(\frac{-2}{17}\right)A$

Total current $== \frac{4}{17} + \frac{6}{17} + \frac{-4}{17} + \frac{6}{17} + \frac{-2}{17} = \frac{10}{17}A$



#420146

Topic: Cells and EMF

A storage battery of emf 8.0 V and internal resistance 0.5Ω is being charged by a 120 V dc supply using a series resistor of 15.5Ω. What is the terminal voltage of the battery during charging? What is the purpose of having a series resistor in the charging circuit?

Solution

$E = 8V$, internal resistance $R_1 = 0.5\Omega$

$V = 120V$, resistance $R_2 = 15.5\Omega$

Effective voltage $V^{'} = V - E = 112\ V$

$I = \dfrac{V^{'}}{R_1 + R_2} = 7\ A$

Voltage across $R_1 = IR_1 = 3.5\ V$

Terminal voltage $= 8 + 3.5 = 11.5\ V$

Series resistor in the charging circuit limits the current drawn from the external source.

#420147

Topic: Potentiometer

In a potentiometer arrangement, a cell of emf 1.25 V gives a balance point at 35.0 cm length of the wire. If the cell is replaced by another cell and the balance point shifts to 63 cm, what is the emf of the second cell?

Solution

This can be solved by the formula $\dfrac{V_1}{l_1} = \dfrac{V_2}{l_2}$

$\therefore \dfrac{1.25}{35} = \dfrac{V_2}{63}$

$\therefore V_2 = 2.25V$

#420167

Topic: Electric current

The earths surface has a negative surface charge density of $10^{-9}Cm^{-2}$. The potential difference of 400 kV between the top of the atmosphere and the surface results (due tc the low conductivity of the lower atmosphere) in a current of only 1800 A over the entire globe. If there were no mechanism of sustaining atmospheric electric field, how much time (roughly) would be required to neutralise the earths surface? (This never happens in practice because there is a mechanism to replenish electric charges, namely the continual thunderstorms and lightning in different parts of the globe). (Radius of earth = 6.37×10^6 m.)

Solution

Surface charge density of the earth, $\sigma = 10^{-9}\ Cm^{-2}$

Current over the entire globe, $I = 1800\ A$

Radius of the earth, $r = 6.37 \times 10^6\ m$

Surface area of the earth,

$A = 4\pi r^2 = 5.09 \times 10^{14}\ m^2$

Charge on earth surface, $q = \sigma A = 5.09 \times 10^5\ C$

Time taken to neutralize the earth's surface = t.

Current $I = \dfrac{q}{t}$

$\implies t = 5.09 \times 10^5 / 1800 = 283\ s$

#420175

Topic: Cells and EMF

(a) Six lead-acid type of secondary cells each of emf 2.0 V and internal resistance 0.015Ω are joined in series to provide a supply to a resistance of 8.5Ω. What are the curren drawn from the supply and its terminal voltage?

(b) A secondary cell after long use has an emf of 1.9 V and a large internal resistance of 380Ω. What maximum current can be drawn from the cell? Could the cell drive the starting motor of a car?

Solution

(a)

Total resistance in circuit = $R = 6 \times 0.015 + 8.5 = 8.59\Omega$

Total EMF, $E = 12\ V$

So current in the circuit $I = E/R = 1.4A$

Terminal voltage, $V = 1.4 \times 8.5 = 11.9\ V$

(b)

The current will be $1.9/380 = 0.005A$. It is impossible to start a motor because a starter motor requires large current ($\sim$100 A) for a few seconds

#420193

Topic: Resistance and Resistivity

Two wires of equal length, one of aluminium and the other of copper have the same resistance. Which of the two wires is lighter? Hence explain why aluminium wires are preferred for overhead power cables. ($\rho_{AI} = 2.63 \times 10^{-8}\Omega m,\ \rho_{Cu} = 1.72 \times 10^{-8}\Omega m$ Relative density of Al = 2.7, of Cu = 8.9.)

Solution

Resistivity of aluminium, $\rho_{AI} = 2.63 \times 10^{-8} \Omega m$ρ

Relative density of aluminium, $d_1 = 2.7$

Let l_1 be the length of aluminium wire and m 1 be its mass.

Resistance of the aluminium wire $= R_1$

Area of cross-section of the aluminium wire $= A_1$

Resistivity of copper, $\rho_{Cu} = 1.72 \times 10^{-8} \Omega m$

Relative density of copper, $d_2 = 8.9$

Let l_2 be the length of copper wire and m 2 be its mass.

Resistance of the copper wire $= R_2$

Area of cross-section of the copper wire $= A_2$

The two relations can be written as

$R_1 = \rho_1 \dfrac{l_1}{A_1}$ ...(1)

$R_2 = \rho_2 \dfrac{l_2}{A_2}$ ...(2)

It is given that,

$R_1 = R_2$

$\therefore \rho_1 \dfrac{l_1}{A_1} = \rho \dfrac{l_2}{A_2}$

And,

$l_1 = l_2$

$\therefore \dfrac{\rho_1}{A_1} = \dfrac{\rho_2}{A_2}$

$\dfrac{A_1}{A_2} = \dfrac{\rho_1}{\rho_2}$

$= \dfrac{2.63 \times 10^{-8}}{1.72 \times 10^{-8}} = \dfrac{2.63}{1.72}$

Mass of the aluminium wire,

$m_1 =$ Volume $\times$ Density

$= A_1 l_1 \times d_1 = A_1 l_1 d_1$ ...(3)

Mass of the copper wire,

$m_2 =$ Volume$\times$ Density

$= A_2 l_2 \times d_2 = A_2 l_2 d_2$ ...(4)

Dividing equation (3) by equation (4), we obtain

$\dfrac{m_1}{m_2} = \dfrac{A_1 l_1 d_1}{a_1 l_2 d_2}$

Foe $l_1 = l_2$,

$\dfrac{m_1}{m_2} = \dfrac{A_1 d_1}{A_2 d_2}$

For $\dfrac{A_1}{A_2} = \dfrac{2.63}{1.72}$,

$\dfrac{m_1}{m_2} = \dfrac{2.63}{1.72} \times 0.46$

It can be inferred from this ratio that m_1 is less than m_2. Hence, aluminium is lighter than copper.

Since aluminium is lighter, it is preferred for overhead power cables over copper.

#420197

Topic: Ohm's Law

What conclusion can you draw from the following observations on a resistor made of alloy manganin?

Current A	Voltage V	Current A	Voltage V
0.2	3.94	3.0	59.2
0.4	7.87	4.0	78.8
0.6	11.8	5.0	98.6
0.8	15.7	6.0	118.5
1.0	19.7	7.0	138.2
2.0	39.4	8.0	158.0

Solution

Since the resistance is constant even when current and Voltage are very high, Ohms law is valid to a high accuracy. This shows that resistivity of the alloy manganin is nearly independent of temperature.

#420207
Topic: Ohm's Law

Answer the following question:

(a) A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor: current, current density, electric field, drift speed?

(b) Is Ohms law universally applicable for all conducting elements?If not, give examples of elements which do not obey Ohms law.

(c) A low voltage supply from which one needs high currents must have very low internal resistance. Why?

(d) A high tension (HT) supply of, say, 6 kV must have a very large internal resistance. Why?

Solution

(a) Since current is given to be steady, it is constant. The current density, electric field and drift speed are inversely proportional to area of cross section.

(b) No, examples of non-ohmic elements are vacuum diode,semiconductor diode, etc.

(c) By Ohms Law, $I = V/R$. Now, if current required is high, the voltage should be high and the resistance should be low. Hence, a low voltage supply from which one needs high currents must have very low internal resistance.

(d) Any high tension supply must have a large internal resistance, because, if the circuit is shorted (accidentally), the current drawn will exceed safety limits. This can be dangerous for human life and can cause fatal accidents.

#464844
Topic: Equivalent Resistance in Series-Parallel

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 $\dfrac{R}{R'}$ is

A $\dfrac{1}{25}$

B $\dfrac{1}{5}$

C 5

$\boxed{\text{D}}$ 25

Solution

Let the length of resistance R be L

Let the resistance of each part after cutting be R_s

Since resistance is proportional to the length of the resistor,

$R_s = R/5$....................(i)

For resistors in parallel,

$\dfrac{1}{R'} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + \dfrac{1}{R_4} + \dfrac{1}{R_5}$

$\implies R' = R_s/5$................(ii)

From (i) and (ii),

$R' = R/25$

$R/R' = 25$

#464845
Topic: Energy and Power

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

A I^2R

$\boxed{\text{B}}$ IR^2

C VI

D V^2/R

Solution

$P = VI \quad ....(i)$

Hence, option (c) represents power.

$V = IR \quad ....(ii)$

From (i) and (ii),

$P = I^2R$

$P = V^2/R$

Hence, option (a) and (d)represents power too.

Option (b) does not represent power.

#464847

Topic: Energy and Power

Two conducting wires of the same material and of equal lengths and equal diameters are first connected in series and then in 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

$\boxed{\text{C}}$ 1:4

D 4:1

Solution

Since the two wires have same material, length and diameter, they have the same resistance. Let the resistance of each wire be R.

Let applied potential difference be V.

$$R_{series} = R_1 + R_2$$
$$= R + R = 2R$$
$$P_{series} = V^2/R_{series}$$
$$= V^2/(2R) \quad ....(i)$$

$$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$R_{parallel} = R/2$$

$$P_{parallel} = V^2/R_{parallel}$$
$$= 2V^2/R \quad ....(ii)$$

Dividing (ii) from (i),

$$\frac{P_{series}}{P_{parallel}} = 1/4$$

#464849

Topic: Resistance and Resistivity

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

Solution

Given, diameter, $d = 0.5\ mm$

resistivity, $\rho = 1.6 \times 10^{-8}\ \Omega m$

Resistance, $R = 10\ \Omega$

Let the length of wire be l.

$$A = \pi d^2/4$$

$$\begin{aligned} R &= \rho l/A \\ &= \frac{\rho l}{\pi d^2/4} \\ \implies l &= \frac{R\pi d^2}{4\rho} \\ &= \frac{10 \times 3.14 \times (0.5 \times 10^{-3})^2}{4 \times 1.6 \times 10^{-8}} \\ &= 122\ m \end{aligned}$$

$R \propto 1/d^2$

If diameter is doubled, resistance is one-fourth.

Hence, new resistance $= 2.5\Omega$

#464852
Topic: Ohm's Law

When a 12V 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.

Solution

Given: $V = 12\ V$

$I = 2.5\ mA$

Let the resistance be R

By Ohm's Law,

$V = IR$

$12 = 2.5 \times 10^{-3} R$

$R = 4.8 \times 10^3\ \Omega$

#464853
Topic: Ohm's Law

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

Solution

For resistors in series,

$$\begin{aligned} R_{eq} &= R_1 + R_2 + R_3 + R_4 + R_5 \\ &= 0.2 + 0.3 + 0.4 + 0.5 + 12 \\ &= 13.4\ \Omega \end{aligned}$$

By ohm's Law:

$V = IR_{eq}$

$9 = 13.4I$

$I = 0.67\ A$

When resistors are connected in series, current is same in all the resistors. Hence, current in $12\ \Omega$ resistor $= 0.67\ A$.

#464854
Topic: Equivalent Resistance in Series-Parallel

How many $176\ \Omega$ resistors (in parallel) are required to carry 5A on a 220V line?

Solution

Given: Individual resistance, $R = 176\ \Omega$

$I = 5\ A$

$V = 220\ V$

Let number of resistors be n.

Then, $R_1 = R_2 = \ldots\ldots = R_n = R = 176\ \Omega \quad \ldots\ldots\ldots\ldots (i)$

For resistors in parallel,

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \ldots.. \dfrac{1}{R_n} \quad \ldots\ldots\ldots. (ii)$

From (i) and (ii),

$R_{eq} = 176/n \quad \ldots\ldots\ldots. (iii)$

By ohm's Law,

$V = IR_{eq}$

$220 = 5R_{eq} \ldots\ldots\ldots\ldots\ldots (iv)$

Substituting (iii) in (iv),

$220 = 5 \times 176/n$

$n = 4$

Hence, four resistors are required.

#464855

Topic: Equivalent Resistance in Series-Parallel

Show how you would connect 3 resistors , each of resistance 6 ohm, so that the combination has a resistance of (i) 9 ohm (ii) 4 ohm

Solution

We are given 3 resistors each of resistance $6\ \Omega$. Equivalent resistance of resistors in series is more than the individual resistance of each resistor while equivalent resistance of resistance in parallel is less than the individual resistance of each resistor.

(i)

To get an equivalent resistance of $9\ \Omega$, atleast one six ohm resistor should be connected in series with the other resistors.

Since, $R_{eq} = R_1 + R_2$

$9 = 6 + R_2$

$R_2 = 3\ \Omega$

$\implies R_2 < 6\ \Omega$

Connecting the remaining two resistors in parallel will yield an equivalent resistance of $3\ \Omega$.

Hence, the first figure shows the configuration of resistors to get equivalent resistor of $9\ \Omega$.

(ii)

To get an equivalent resistance of $9\ \Omega$, no six ohm resistor should be connected in series with the other resistors.

Let one of the branches have only one $6\ \Omega$ resistor.

Since, $\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

$\dfrac{1}{9} = \dfrac{1}{6} + \dfrac{1}{R_2}$

$R_2 = 12\ \Omega$

Connecting the remaining two resistors in series will yield an equivalent resistance of $12\ \Omega$.

Hence, the second figure shows the configuration of resistors to get equivalent resistor of $4\ \Omega$.

#464866

Topic: Equivalent Resistance in Series-Parallel

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 220 V line if the maximum allowable current is 5 A?

Solution

Given, $V = 220\ V$

Power rating of each bulb, $P = 10\ W$

Total current, $I_t = 5\ A$

Let number of lamps in parallel be n.

Let individual resistance of each lamp be R.

From Joule's law of heating,

$P = V^2/R$

$10 = 220^2/R$

$R = 4840 \quad \ldots\ldots\ldots\ldots.(i)$

$R_1 = R_2 = \ldots\ldots\ldots\ldots.. = R_n = R \quad \ldots\ldots\ldots\ldots..(ii)$

For resistances in parallel,

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots + \frac{1}{R_n} \quad \ldots\ldots..(iii)$$

From (ii) and (iii),

$R_{eq} = R/n \quad \ldots\ldots\ldots.(iv)$

Substituting (i) in (iv),

$R_{eq} = 4840/n \ldots\ldots\ldots\ldots\ldots(v)$

From Ohm's Law,

$V = I_t R_{eq} \ldots\ldots\ldots\ldots(vi)$

Substituting (v) in (vi),

$220 = 5 \times 4840/n$

$n = 110$

#464867

Topic: Ohm's Law

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

Solution

Case 1: Coils used separately.

$V = IR$

$220 = 24I$

$I = 9.167\ A$

Case 2: Coils used in series

$R_{eq} = R_1 + R_2$

$= 24 + 24 = 48\ \Omega$

$V = IR_{eq}$

$220 = 48I$

$I = 4.583\ A$

Case 3: Coils used in parallel

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

$R_{eq} = 12\ \Omega$

$V = IR_{eq}$

$220 = 12I$

$I = 18.334\ A$

#464868

Topic: Energy and Power

Compare the power used in the $2\ \Omega$ resistor in each of the following circuits:

(i) a 6 V battery in series with $1\ \Omega$ and $2\ \Omega$ resistors, and (ii) a 4V battery in parallel with $12\ \Omega$ and $2\ \Omega$ resistors.

Solution

(i)

For resistors in series,

$R_{eq} = R_1 + R_2$

$R_{eq} = 1 + 2 = 3\ \Omega$

From Joule's Law of heating,

$P = V^2/R_{eq}$

$= 6^2/3$

$= 12\ W$

(ii)

For resistors in parallel,

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$

$R_{eq} = 12/7\ \Omega$

From Joule's Law of heating,

$P = V^2/R_{eq}$

$= \dfrac{4^2}{12/7}$

$= 9.33\ W$

As calculated, power used in case (i) is more than power used in case (ii).

#464869

Topic: Ohm's Law

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 220 V?

Solution

From Joule's Law of heating,

$P = V^2/R$

For first lamp,

$R_1 = 220^2/100$

For second lamp,

$R_2 = 220^2/60$

When they are connected in parallel,

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$
$$= \frac{1}{220^2/100} + \frac{1}{220^2/60}$$
$$\implies R_{eq} = 220^2/160$$

From Ohm's Law,

$$V = IR_{eq}$$
$$220 = \frac{220^2}{160}I$$
$$I = 0.73\ A$$

#464870

Topic: Energy and Power

Which uses more energy, a 250 W TV set in 1 hr, or a 1200W toaster in 10 minutes?

Solution

$E = Pt$

For TV,

$E_1 = 250 \times 1 = 250\ Whr$

For toaster,

$$E_2 = 1200 \times \frac{10}{60} = 200\ Whr$$

Hence, TV uses more energy.

#464875

Topic: Energy and Power

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

Solution

Rate of generating heat is equal to the power used by the heater.

By Joule's Law of heating,

$$P = I^2R$$
$$= 15^2 \times 8$$
$$= 1800\ W$$

Hence, rate of generation of heat is $1800W$.

Total amount of heat generated, $E = Pt$

$E = 1800 \times 2 = 3.6\ kWh$