Tutorial '1'

Ashwani kr. Chaudhary [019]

(1) A 60 W, 240 V incandescent filement lamp is switched on at 20°C. The operating temp of the filament is 2000°C. Determine current taken by lamp at the instant of switching on. The temp. coeff. of resistance of the filement material is 0.0045 °/K

⇒ Sol^n

$$R_{2000} = \frac{V^2}{P} = \frac{(240)^2}{60} = 960\,\Omega$$

If lamp is switched on at 20°C.

$$I = \frac{V}{R_{20}}$$

$$\alpha_{20} = \frac{\alpha_0}{1+\alpha_0(20-0)}$$

$$= \frac{0.00415}{1+0.0045\times 20}$$

$$= 4.12\times 10^{-3}\ /°C.$$

Hence, $R_{2000} = R_{20}\left[1+\alpha_{20}(2000-20)\right]$

$$R_{20} = \frac{960}{1+(4.12\times 10^{-3}\times 1980)}$$

$$= 104.83\,\Omega$$

Here, current at ~ is $= \frac{V}{R_{20}} = \frac{240}{104.83}$

$$= 2.28\,A$$

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2) At 30°C two coils C_1 & C_2 connected in series have respectively resistance of 800 Ω & 400 Ω & temp. coeff. of resistance C_1 & C_2 are 0.002 & 0.0041°C resp. Find.

i) the resistance of combination at 60°C.

ii) the effective temp coeff. of resistance of combination

⇒ Sol^n

given temp is 30°C at t

At 60°C

the resistance of 800 Ω conductor

$$R_1^{60} = R_1^{30}(1+\alpha_1 \Delta t)$$
$$= 800\,[1+0.002\,(60-30)]$$
$$= 843\ \Omega$$

The resistance of 400 Ω conductor.

$$R_2^{60} = R_1^{30}\,[1+\alpha_2 \Delta t]$$
$$= 400\,[1+0.004\,(60-30)]$$
$$= 448\ \Omega$$

Total combined resistance at 60°C = 848 to 448
= 1296 Ω

Combined resistance at 30°C. = 800 + 400
= 1200 Ω

If β be the combined effective temp at 30°C.

$$R^{60} = R^{30}(1+\beta \Delta t)$$
$$1296 = 1200\,(1+\beta\, 30°)$$
$$\beta = 2.6\times10^{-3}\ °C.$$

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3) A carbon resistor has a resistance of 800 Ω at 20°C. Determine its resistance
a) +100°C b) -100°C. The temp coeff. of resistance of carbon at 20°C is -0.0047.

=> Soln,

At +100°C

$R_{100} = R_{20}(1+\alpha\Delta t)$

$= 800[1+(-0.00047\times 80)]$

$= 769.92$

$= 770\ \Omega.$

At -100°C

$R_{-100} = R_{20}(1+\alpha\Delta t)$

$= 800[1+(-0.00047\times(-100-20)]$

$= 845.12\ \Omega$

4) The temp rise of a machine field winding was determined by the measurement of winding resistance. At 20°C the field resistance was 150 Ω. After running machine for 6 hr. at full load, the resistance was 175 Ω. If the temp. coeff. of resistance ~~was~~ of the copper winding is 4.3×10^{-3} /K at 0°C, determine temp rise of machine.

=> Given,

resistance at 20°C (R_{20}) = 150 Ω

resistance at full load (R) = 175 Ω

temp coeff (α_0) = 4.3×10^{-3} K.

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we know,

$$\alpha_{20} = \frac{\alpha_0}{1+\alpha_0 \Delta t}$$

$$\alpha_{20} = \frac{4.3 \times 10^{-3} /K}{1+[4.3 \times 10^{-3} \times (20-0)]}$$

$$= 3.59 \times 10^{-3}$$

now,

$$R_t = R_{20} [1+\alpha_{20} \Delta t]$$

$$175 = 150 [1+3.5 \times 10^{-3} \Delta t]$$

$$\Delta t = 42.09 °C.$$

5) A semicircular ring of copper has an inner radius of 80mm, radial thickness 40mm & axial thickness 60 mm. Calculate the resistance of the ring at 50°C betn it two end faces. Resistivity of copper at 20°C is 1.724×10^{-8} Ωm. Resistance temp. coefficient of copper at 0°C is 0.0043/K.

=> give,

Inner radius = 80 mm

radial thickness = 40 mm

outer thickness = Inner + radial

= 120 mm.

mean radius (r) = $\frac{r_{in} + r_{out}}{2}$ = 100mm

mean ring length (l) = $\frac{2\pi r}{2}$

$= \pi r$

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$= 100\ \pi$

$= 100 \times 10^{-3}\ \pi$ cm.

CSA of ring (A) = radial thick × axial

$= 40 \times 60$

$= 40 \times 10^{-3} \times 60 \times 10^{-3}$

$= 2.4 \times 10^{-3}\ m^2$

resistivity at 20°C (ρ_{20}) = $1.724 \times 10^{-8}\ \Omega m$

now

resistance at 90°C $R_{50} = \rho_{50} \times \frac{l}{A}$

So,

$\rho_{50} = \rho_{20} [1 + \alpha_{20} (50 - 20)]$

now,

$\alpha_{20} = \frac{\alpha_0}{1 + \alpha_0 (20 - 0)} = \frac{0.0043}{1 + 0.0043 \times 20}$

$= 0.00395$ °C.

Now,

$\rho_{50} = 1.724 \times 10^{-8} [1 + 0.00395 \times 30]$

$= 1.928 \times 10^{-8}\ \Omega m$

Hence,

$R_{50} = \rho_{50} \times \frac{l}{A}$

$= 1.928 \times 10^{-8} \times \frac{100 \times 10^{-3} \times 22}{2.4 \times 10^{-3} \times 7}$

$= 2.52 \times 10^{-6}\ \Omega$

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6) The coil of a relay take a current of 0.12 A when it is at the nom temp. of 15°c & connected across a 60 V supply. If the minimum operating current of the relay is 0.1 A. calculate the temp. above which the relay will fail to operate when connected same supply. The temp. coeff. above which the relay will fail to operate when connected to the same supply. The temp. coeff. of resistance of the material of the relay coil is 0.0043/K at 0°C.

=> Sol^n,

source voltage (V) = 60V

current at 15°c = 0.12 A

$$R_{15} = \frac{V}{I} = \frac{60}{0.12} = 500\,\Omega$$

operating min current = 0.1A.

so,

operating resistance at operating temp. t°c is $R_t = \frac{60}{0.1} = 600\,\Omega$

Temp coeff. of coil. at 0°c is = 0.043 /K

temp at 15°c is

$$\alpha_{15} = \frac{1}{\frac{1}{\alpha_0} + \Delta t} = \frac{1}{\frac{1}{0.0043} + 15}$$

$$= 4.03 \times 10^{-3} \text{ per °c}$$

now,

$$R_t = R_{15}\,[1 + \alpha_{15} \times \Delta t]$$

$$600 = 500\,[1 + 4.03 \times 10^{-3}\,\Delta t]$$

$$\Delta t = 49.62°C$$

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Now,

$\theta - 15°C = \Delta t$

$\therefore \theta = (49.62 + 15)°C$

$\theta = 64.62°C.$

7) Two resistor made of different material having temp. coeff. of resistance $\alpha_1 = 0.004°C^{-1}$ & $\alpha_2 = 0.005°C^{-1}$ are connected in parallel & consume equal power at 15°C. What is the ratio of power consumed in resistance R_2 to that in R_1 at 70°C?

⇒ Given

For parallel combination.

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

At 15°C both resistor consume equal power let P_1 & P_2 be power consumed.

$$P_1 = P_2$$

$$\frac{V^2}{R_1} = \frac{V^2}{R_2}$$

or $R_1 = R_2$

We know,

R' is resistance of 1st resistor at 0°C α_1 is its temp coeff. then,

$$R_1 = R'(1 + \alpha_1 \Delta t)$$

$$\therefore R_1 = R'(1 + 15\alpha_1)$$

Illy, $R_2 = R''(1 + \alpha_2 \Delta t)$

We know,

$$R_1 = R_2$$

$$R'(1+\alpha_1 15) = R''(1+\alpha_2 15).$$

$$\frac{R'}{R''} = \frac{1+15\alpha_2}{1+15\alpha_1}$$

At 70°C,

$$R_1 = R'(1+70\alpha_1)$$

$$R_2 = R''(1+70\alpha_2)$$

taking ratio of P_1 & P_2

$$\frac{P_2}{P_1} = \frac{\frac{V^2}{R}}{\frac{V^2}{R}} = \frac{R_1}{R_2}$$

$$= \frac{R' \times (1+70\alpha_1)}{R'' \times (1+70\alpha_2)}$$

now

$$\Rightarrow \frac{P_2}{P_1} = \frac{(1+15\alpha_2)}{(1+15\alpha_1)} \times \frac{(1+70\alpha_1)}{(1+70\alpha_2)}$$

$$= \frac{1+15\times 0.005}{1+15\times 0.004} \times \frac{1+70\times 0.004}{1+70\times 0.005}$$

$$= 0.96$$

8) A coil has a resistance of 100 Ω when the mean temp. is 20°C & 110 Ω, when the mean temp. is 45°C. Find the mean temp rise, when resistance 124 Ω & surrounding temp. is 15°C.

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⇒ Solⁿ,

let R_0 is the resistance & α_0 is the temp coeff of coil at 0°C then.

$$R = R_0(1+\alpha_0 t)$$

$$100 = R_0(1+20\alpha_0) \quad \text{--- (i)}$$

$$110 = R_0(1+45\alpha_0) \quad \text{--- (ii)}$$

Solving (1) & (2)

$$\frac{100}{110} = \frac{1+20\alpha_0}{1+45\alpha_0}$$

$$\Rightarrow 10(1+45\alpha_0) = 11(1+20\alpha_0)$$

$$\Rightarrow 10+450\alpha_0 = 11+220\alpha_0$$

$$\Rightarrow 230\alpha_0 = 1$$

$$\Rightarrow \alpha_0 = \frac{1}{230}$$

If t°C is the temp of coil when its resistance is 124 Ω

$$124 = R_0\left(1+\frac{t}{230}\right) \quad \text{--- (3)}$$

From (2) & (3)

$$\frac{124}{110} = \frac{1+\frac{t}{230}}{1+\frac{45}{230}}$$

$$\frac{124}{110} = \frac{230+t}{230+45}$$

$$\frac{62}{55} = \frac{230+t}{275}$$

$$12650+55t = 17050$$

$$55t = 4400$$

$$t = 80°C$$

~~Resistance.~~

temp = 80°C − 15°C

= 65°C

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9) Two coil A & B have resistance 600 Ω & 300 Ω resp. at 20°C. The resistance temp. coefficient for the two coil. at 20°C are 0.001 & 0.004 resp. Find resistance at their series combination at 50°C.

⇒ Solⁿ

given temp = 20°C
At 50°C

The resistance of 600 Ω conductor.

$$R_1^{50} = R_1^{20}(1+\alpha\Delta t)$$
$$= 600\,[1+0.001(50-20)]$$
$$= 618.$$

& Resistance of 300 Ω conductor.

$$R_2^{50} = R_2^{20}(1+\alpha_2\Delta t)$$
$$= 300\,[1+0.004\times 30]$$
$$= 336\ \Omega$$

Now,

Combined resistance at 50°C = 618 + 336
= 954 Ω

10) Find the resistance at 20°C of 2 km copper wire of CSA 0.1 cm² if the specific resistance of copper at this temp is 17.3×10^{-9} Ωm. what would be its resistance at 35°C, if $\alpha = 0.0043/°C$

⇒ Solⁿ,

$\rho = 17.3\times10^{-9}\ \Omega m$
$l = 2\,km = 2000\,m$
$A = 0.1\,cm^2$
$R = \frac{\rho l}{A}$

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$$= \frac{17.3 \times 10^{-9} \times 2000}{1 \times 10^{-5}}$$

$$= 3.46\ \Omega$$

At 35°C its res. will be

$$R_{35} = R_{20}(1 + \alpha \Delta t)$$

$$= 3.46 [1 + 0.0043 \times 15]$$

$$= 3.68\ \Omega.$$

11) Three resistance $100\ \Omega$, $200\ \Omega$ & $300\ \Omega$ are connected in series to a 250 V supply. Determine the current in the circuit & the power dissipated in each resistor.

=> Sol^n,

$V = 250V$

total resistance $= 200 + 100 + 300$

$= 600\ \Omega$

$V = IR$

$I = \frac{V}{R} = \frac{250}{600} = 0.41$

now,

Ime each current circuit.

$P = VI = I^2 R$

So,

$P_1 = I^2 R_1 = 0.41 \times 0.41 \times 100 = 16.81\ W$

$P_2 = I^2 R_2 = 0.41 \times 0.41 \times 200 = 33.62\ W$

$P_3 = I^2 R_3 = 0.41 \times 0.41 \times 300 = 50.43\ W$

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12) A 20Ω resistance is connected in series with an unknown resistance R & the two connected accross 220 V dc supply. The power loss in R is 50 watt. Determine.

=> Sol^n:

The total resistance in circuit is

$R_T = 20 + R$

Hence, current in circuit $= \frac{220}{20+R} = I$

Power lossing R, is I^2R

$= \left(\frac{220}{20+R}\right)^2 R$

$= 50$ watt

$(220)^2 R = (20+R)^2 50$

$968R = R^2 + 40R + 400$

$R^2 - 928R + 400 = 0$

$R = \frac{928 \pm \sqrt{(928)^2 - 1600}}{2}$

$= \frac{928 \pm 927}{2}$

$R = [927.5 \text{ or } 0.5]\ \Omega$

For 0.5

Power loss $= \left[\frac{220}{20.5}\right]^2 \times 0.5 = 57$

For 927.5

Power loss $= \left(\frac{220}{947.5}\right)^2 \times 927.5 = 50$ W.

So, $R = 927.5\ \Omega$ #

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(3) Two coils are connected in parallel & a voltage of 200 V is applied to the terminal. The total current taken is 25 A and the power dissipated in one of the coils is 1500 W. Determine resistance of each coil.

⇒ Solⁿ,

$V = 200V$

$I = 25 A$

$P_1 = 150 W$

V, I are given so,

$$R = \frac{200}{25} = 8 \Omega$$

& $P_1 = \frac{V^2}{R_1}$

$$R_1 = \frac{V^2}{P_1} = \frac{200 \times 200}{1500} = \frac{80}{3} = 26.62 \Omega$$

Now,

$$\frac{1}{R_1} + \frac{1}{R_2} = R$$

$$\frac{3}{80} + \frac{1}{R_2} = \frac{1}{8}$$

$$\frac{1}{R_2} = \frac{1}{8} - \frac{3}{80}$$

$$\frac{1}{R_2} = \frac{7}{80}$$

$$R_2 = \frac{80}{7}$$

$$= 11.42 \Omega$$

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14) Three resistor of value 16 Ω, 24 Ω & 32 Ω are connected in parallel & take a total current of 5.2 A. Find current in each resistor & voltage across combination.

→ Soln.

In parallel

$$\Rightarrow I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\Rightarrow 5.2 = V\left(\frac{1}{16} + \frac{1}{24} + \frac{1}{32}\right)$$

$$\Rightarrow \frac{134}{96} = 5.2$$

$$\therefore V = 38.4\,V.$$

Now,

$$I_1 = \frac{V}{R_1} = \frac{38.4}{16} = 2.4\,A$$

$$I_2 = \frac{V}{R_2} = \frac{38.4}{24} = 1.6\,A$$

$$I_3 = \frac{V}{R_3} = \frac{38.4}{32} = 1.2\,A$$

16) A direct current circuit comprises two resistor. A of value 25 Ω & b of unknow value connected in parallel together with a third resistor c of value 5 Ω. connected in series with the parralel group. The potential difference c is found to 90 V. If the total power in the circuit is 4320 W. Calculate (i) value of resistor B. (ii) the voltage applied to the end of the whole circuit.

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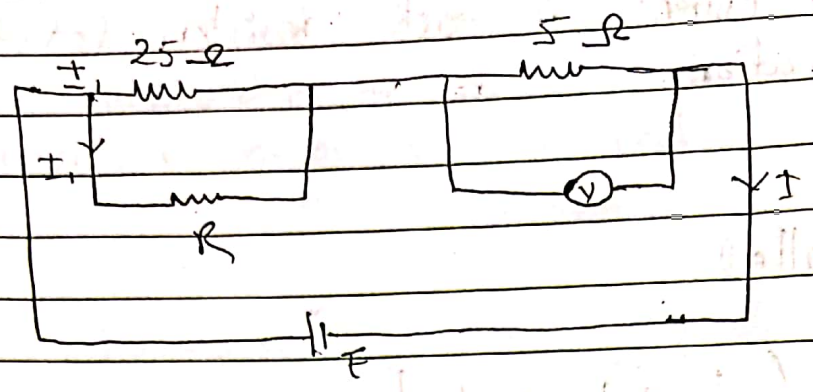
(ii) the current in each resistor.

=> Soln.



voltage drop in 5 Ω resistor V = 90 V.

power (P) = 4320 watt

current $(I) = \frac{V}{5} = \frac{90}{5}$

$= 18 A$

voltage in circuit $= \frac{P}{I} = \frac{4320}{18} = 240 V$.

$R_{eq} = \frac{E}{I} = \frac{240}{18} = 13.33 \Omega$

$R_{eq} = (R \parallel 25) + 5$

$13.33 = \frac{R \times 25}{R+25} + 5$

$R = 12.5 \Omega$

Current in resistor A $= I_1 = \frac{18}{12.5+25} \times 12.5 = 6 A$

Current in resistor B $= I - I_2 = 18 - 6 = 12 A$

Current in resistor C $= I = 18 A$ #

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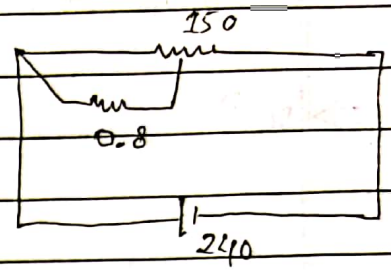
15) A 150Ω resistance coil AB is connected across 240V dc supply. Calculate the value of the resistance which when connected betn the midpoint of AB & end A. will carry current of 0.8 A.

=> Solⁿ,

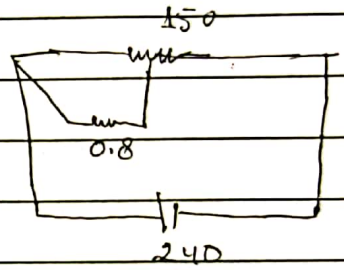
Before connecting no resistance



$V = IR$

$I = \frac{240}{156} = 1.6.$

After connection



I of AC

total - New $= 1.6 - 0.8$

$= 0.8$

And as in mid point,

$I = \frac{1}{2} \times 0.8$

$= 0.4$

Across A $= 0.4 \times 150$

$= 60$

now $V = \frac{(240-60)}{2}$

$= 90V.$

now

$V = IR$

$90 = I \times 0.8$

$I = 112.5$ #

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