Unit-2 ELECTRICAL FUNDAMENTALS

(SESSION-5)

Topics:

- Equation to find the effective resistance of resistances connected in series
- Equation to find the effective resistance of resistances connected in parallel
- Resistances connected in series and parallel combinations
- Simple problems

5.1 Equation to find the effective resistance of resistances connected in series:

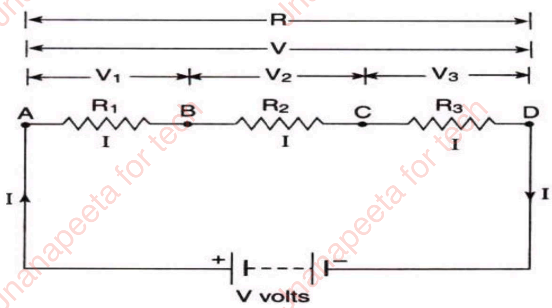


Fig. shows three resistances R1, R2 and R3 Connected in series with a battery of V volts. Let the p.d. across R1, R2 and R3 is V1, V2 and V3 respectively. Total voltage across the combination divides among each resistance according to its value

i.e. V = V1 + V3 + V2 ------ (1)

Let the equivalent resistance be R & current flowing through whole circuit is I.

By ohm's law, we know that

$V = I \times R$ ----------- (2)

Applying ohm's law to both R1, R2 and R3,

$V_1 = I \times R_1$ --------- (3)

$V_2 = I \times R_2$ --------- (4)

$V_3 = I \times R_3$ --------- (5)

Substituting equations (2), (3), (4) and (5) in (1) we get,

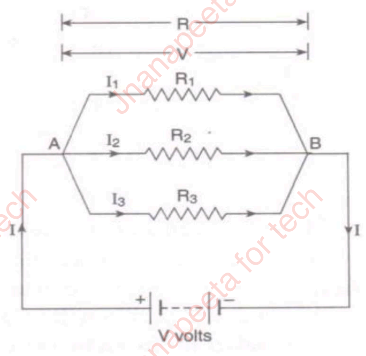
$I \times R = I \times R1 + I \times R2 + I \times R3$

$I \times R = I \times (R1 + R2 + R3)$

$R = R1 + R2 + R3$ ----------- (6)

Therefore as per equation (6), the effective resistance of resistances connected in series is the sum of individual resistances.

5.2 Equation to find the effective resistance of resistances connected in parallel:



Suppose total current flowing in the circuit is I, then the current passing through resistance R_1 will be I_1, current passing through resistance R_2 will be I_2 and current passing through resistance R_3 will be I_3.

By inspection we know that,

Total current $I = I_1+I_2+I_3$ ---------- (1)

Let the effective resistance of this parallel combination is R. By applying the Ohm's law to the whole circuit, we get,

$I = V/R$ ------ (2)

Since the potential difference across all the resistances is same, applying the Ohm's law to each resistance we get,

$I_1 = V/R_1$; $I_2 = V/R_2$; $I_3 = V/R_3$ ------------ (3)

Substituting eqns. (2) & (3) in (1) we get,

$V/R = V/R_1 + V/R_2 + V/R_3$

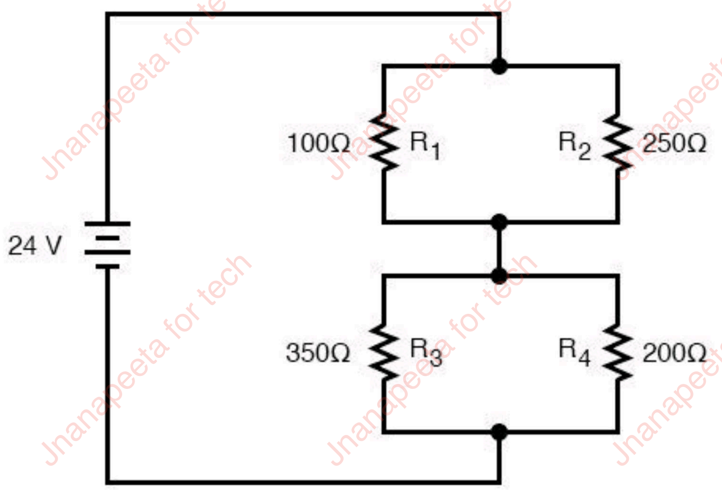
$1/R = 1/R1 + 1/R2 + 1/R3$ --------- (4)

Therefore, Effective resistance of parallel circuit is the sum of reciprocals of individual resistances.

5.3 Resistances connected in series and parallel combinations:

If circuit components are series-connected in some parts and parallel in others, we won't be able to apply a *single* set of rules to every part of that circuit. Instead, we will have to identify which parts of that circuit are series and which parts are parallel, then selectively apply series and parallel rules as necessary to determine what is happening. Take the following circuit, for instance:

A series-parallel combination circuit

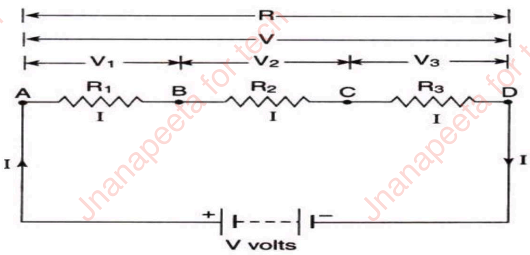


This circuit is neither simple series nor simple parallel. Rather, it contains elements of both. The current exits the bottom of the battery splits up to travel through R_3 and R_4, rejoins, then splits up again to travel through R_1 and R_2, then rejoin again to return to the top of the battery. There exists more than one path for current to travel (not series), yet there are more than two sets of electrically common points in the circuit (not parallel).

Because the circuit is a combination of both series and parallel, we cannot apply the rules for voltage, current, and resistance "across the table" to begin analysis like we could when the circuits were one way or the other. For instance, if the above circuit were simple series, we could just add up R_1 through R_4 to arrive at a total resistance, solve for total current, and then solve for all voltage drops. Likewise, if the above circuit were simple parallel, we could just solve for branch currents, add up branch currents to figure the total current, and then calculate total resistance from total voltage and total current. However, this circuit's solution will be more complex.

5.4 Simple problems:

Resistances connected in series:



Let 5 Ω = R1, 10 Ω = R2, 30 Ω = R3, V = 50 Volts

Total Resistance R = R1+R2+R3

R = 5+10+30 = 45ohms

Total Current I = V/R

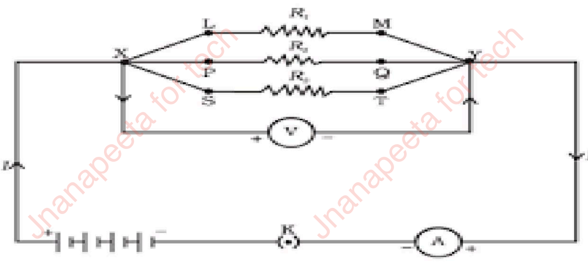
I = 50/45 = 1.11 Amps

Current through R1, R2 & R3 are same (one path for current)

i.e. I1 = I2 =I3 = 1.11 Amps

Resistances connected in parallel:

Consider the above problem with the same resistances (values) are connected in parallel across same voltage then,



Current divides in parallel resistances

Current through R1 = I1 = V/R1 = 50/5 = 10A

Current through R2 = I2 = V/R2 = 50/10 = 5A

Current through R3 = I3 = V/R3 = 50/30 = 1.66 A

Total current in the circuit I = I1 + I2 +I3; I = 10 + 5 + 1.66 = 16.66A

Effective resistance R is given by

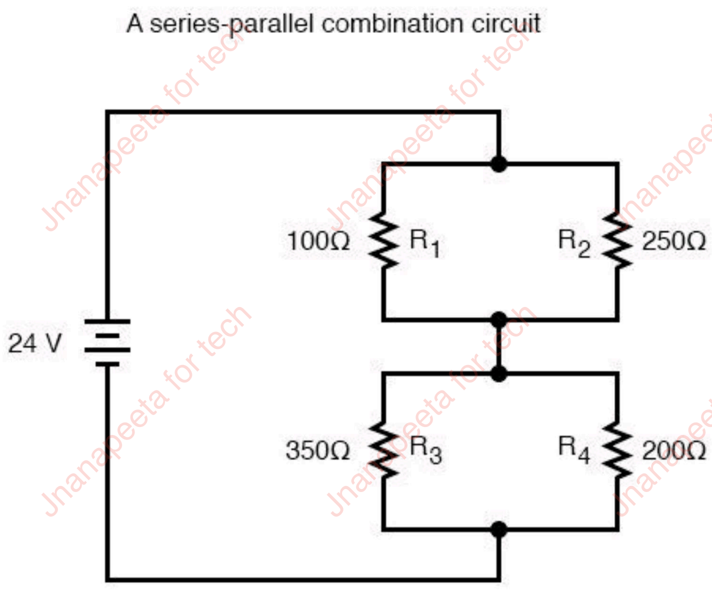
1/R = 1/R1 + 1/R2 + 1/R3

1/R= 1/5 + 1/10 + 1/30

1/R = (6 + 3 + 1)/30 = 10/30

R = 30/10 = 3 Ω

Resistances connected in series - parallel:



Find the Total Resistance (Effective) & Total current in the above circuit shown in figure.

Soln:

- R1 & R2 are connected in parallel, so effective resistance (Rp1) of R1 & R2 is given by

Rp1 = R1*R2/(R1+R2)

Rp1 = 100*250/(100+250) = 25000/350 = 71.4 Ohms

- Similarly, R3 & R4 are connected in parallel, so effective resistance (Rp2) of R3 & R4 is given by Rp2 = R3*R4/(R3+R4)

Rp2 = 350*200/(350+200) = 70000/550 = 127.3 Ohms

But, Rp1 & Rp2 are in series, so

Total resistance R = Rp1+Rp2 ------ (Series resistances)

R = 71.4 + 127.3 = 198.7 Ohms ------- Ans 1

Total current I is given by

I = V/R 24/198.7 = 0.12 Amps ---------- Ans 2