BAL BHARATI PUBLIC SCHOOL PITAMPURA

SESSION 2020-21 CLASS 12 PHYSICS

Chapter–3 NCERT *Current Electricity* PART 2

INSTRUCTIONS

In this lecture we are going to do the following topics

Carbon resistors, colour code for carbon resistors; series and parallel combinations of resistors

Kindly do the assignment in your physics registers. It is very important to attempt the numericals simultaneously .

Main points of the chapter

Carbon resistors

Resistors are devices which make use of poor conductors to limit the flow of electricity through a circuit.

(a) symbol of a resistor (b) Colour coded carbon resistors

The symbol of a resistor is shown above.

Resistors are generally made of substances which only partially conduct electricity.

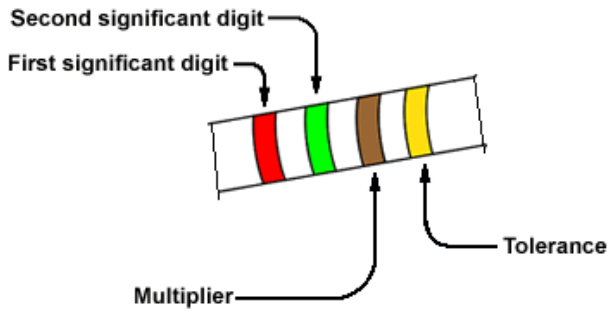
The most common type of resistor is the Carbon resistor.

Inside a carbon resistor is a 'ceramic 'core' on which is deposited a spiral carbon 'track'. The track may have been machined, or 'burnt'

away with a laser beam such as carbon, special alloys and some metal oxides.

Colour code for carbon resistors

Carbon-composition and carbon film resistors are too small to have the resistance value printed on their bodies. Therefore, bands of colour are used to represent the resistance value.



The first and second band represents the numerical value of the resistor, and the colour of the third band specifies the power-of-ten multiplier. The colour bands are always read from left to right starting with the side that has a band closer to the edge.

For carbon resistors, the common tolerances are 5%, 10%, and 20%, indicating that the actual value of the resistor can vary from the specified value by ±5%, ±10% and ±20%.

A gold band indicates a 5% tolerance; silver specifies a 10% tolerance; if no band is present, the tolerance is 20%.

There is a very interesting memory device called a mnemonic which will help you to remember the colour code. If you remember the sentence

"B B ROY of Great Britain has a Very Good Wife"

See the alphabets in bold type above. If you look carefully it is the first alphabet of all the colours in the table above!

Color	First-band Digit	Second-band Digit	Third-band Multiplier	Fourth-band Tolerance
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold				5%
Silver				10%
None				20%

Illustration

What is the resistance of a Carbon resistor with a colour code of: orange, orange, yellow? The resistor has a value of $33 \times 10^4 \Omega$.

Get to know more about types of carbon resistance and resistances at

http://www.electronics-tutorials.ws/resistor/res_1.html

http://www.howtodothings.com/home-garden/how-to-calculate-resistance-using-a-resistor-calculator

Combination of resistances

Resistances can be combined in two ways: called series and parallel combination. Let us first understand series connection.

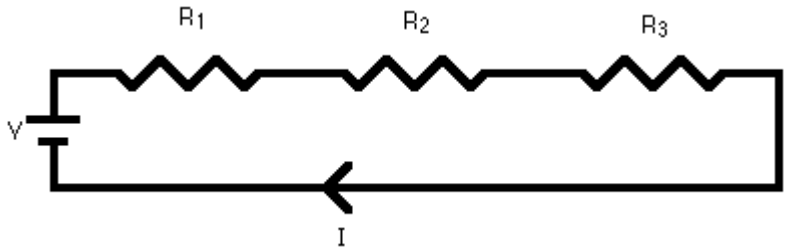
Series circuits

Series connection is like a group of people standing forming a human chain, so that the left hand of a person is held by the right hand of the next person and the left hand of the second person is held by the right hand of the third person and so on.

In this type of arrangement, since the resistors are arranged in a chain, so the current has only one path to take. The current is the same through each resistor.

The total resistance of the circuit is found by simply adding up the resistance values of the individual resistors:

Let us find a formula for equivalent resistance of a series combination of three resistances.



Resistors connected in series

Let I be the current flowing through all the resistors then the potential drop across them is given by Ohm's law as follows.

$$V_1 = IR_1$$

$$V_2 = IR_2$$

$$V_3 = IR_3$$

Since potential differences are added in series

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

$$V = I(R_1 + R_2 + R_3)$$

Writing $V = IR_{eq}$

$$IR_{eq} = I(R_1 + R_2 + R_3)$$

$$R_{eq} = R_1 + R_2 + R_3$$

Hence in series the equivalent resistance is found by adding the individual resistances.

Illustration

If in a series circuit, three resistors of 3Ω, 6Ω and 9Ω are connected. Calculate the net resistance of the circuit. How much current will this combination draw from a 10 V battery?

Equivalent resistance is 3Ω+ 6Ω + 9Ω=18Ω

With a 10 V battery, by V = I R the total current in the circuit is:

I = V / R = 10 / 18 = 0.48 A. The current through each resistor would be same.

Parallel circuits

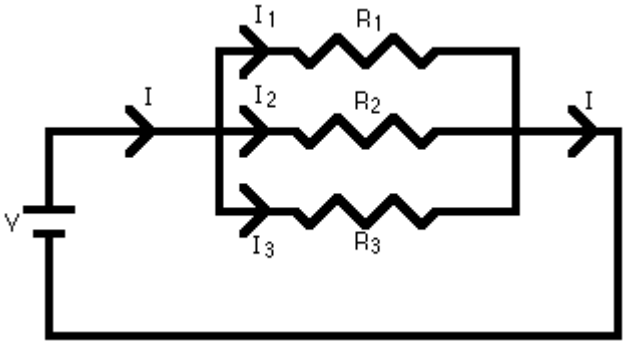
A parallel circuit is a circuit in which the resistors are arranged with their heads connected together, and their tails connected together.

We can compare it to how students stand in a queue during a school assembly!

If they were to raise their hands sideways, all the right hands would be on one side and all the left hands on the other side. This is how resistors are arranged in parallel.

The current in a parallel circuit breaks up, with some flowing along each parallel branch and re-combining when the branches meet again. The voltage across each resistor in parallel is the same.

Let us find a formula for equivalent resistance of a series combination of three resistances.



A parallel circuit is shown in the diagram above.

In this case the current supplied by the battery splits up, and the amount going through each resistor depends on the resistance. If the values of the three resistors are:

Let I_1 , I_2 , I_3 be the currents flowing through all the resistors then the currents are related to the potential drops across them according to Ohm's law as follows.

$$I_1 = \frac{V}{R_1}$$

$$I_2 = \frac{V}{R_2}$$

$$I_3 = \frac{V}{R_3}$$

Since potential differences remains same in parallel and currents are added.

$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

The total resistance of a set of resistors in parallel is therefore by adding up the reciprocals of the resistance values, and then taking the reciprocal of the total:

How to do problems on series and parallel combinations

If the resistors in parallel are identical, it can be very easy to calculate the equivalent resistance.

In this case the equivalent resistance of N identical resistors is the resistance of one resistor divided by N, the number of resistors. So, two 20-ohm resistors in parallel are equivalent to one 10-ohm resistor; five 100-ohm resistors in parallel are equivalent to one 20-ohm resistor.

When calculating the equivalent resistance of a set of parallel resistors, students often forget to take the reciprocal of the 1/R in the end, putting 1/5 of an ohm instead of 5 ohms, for instance.

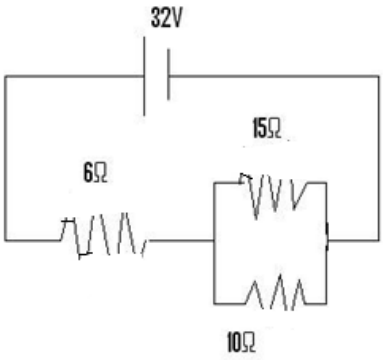
Here's a way to check your answer. If you have two or more resistors in parallel, look for the one with the smallest resistance. The equivalent resistance will always be between the smallest resistance divided by the number of resistors, and the smallest resistance. Here's an example.

You have three resistors in parallel, with values 6 ohms, 9 ohms, and 18 ohms. The smallest resistance is 6 ohms, so the equivalent resistance must be between 2 ohms and 6 ohms (2 = 6 /3, where 3 is the number of resistors).

Doing the calculation gives 1/6 + 1/12 + 1/18 = 6/18. Flipping this upside down gives 18/6 = 3 ohms, which is certainly between 2 and 6.

SOLVED examples

Calculate the equivalent resistance of the given network and also current supplied by the battery



Here 15 Ω and 10Ω resistors are in parallel, so their equivalent resistance is

$$\frac{\mathbf{15 \times 10}}{\mathbf{15 + 10}} = \frac{\mathbf{150}}{\mathbf{25}} = \mathbf{6\Omega}$$

This 6Ω is in series with another 6Ω, so the equivalent is 12Ω.

Hence current drawn from the battery is $\frac{\mathbf{32}}{\mathbf{12}}$ Ampere.

Illustration

You are given a 8 Ω resistor. What length of wire of resistance 120 Ω/m should be joined in parallel with it to get a value of 6 Ω?

We need a equivalent resistance of 6Ω ,so using

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

$$\frac{1}{6} = \frac{1}{8} + \frac{1}{R_2}$$

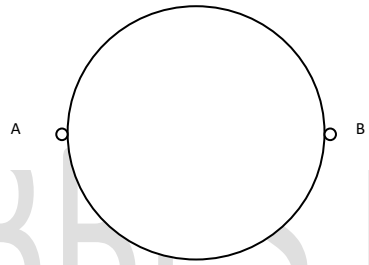
Or $$R_2 = \frac{48}{2}$$

$$R_2 = 24\Omega$$

Since the wire has a resistance 120 Ω per meter, we will need 0.2 meters of this wire.

Illustration

A wire of resistance 4R is bend in the form of circle .What is the effective resistance between the ends of diameter?



The resistances of two equal parts of wire is 2R and 2R respectively. They are connected in parallel .

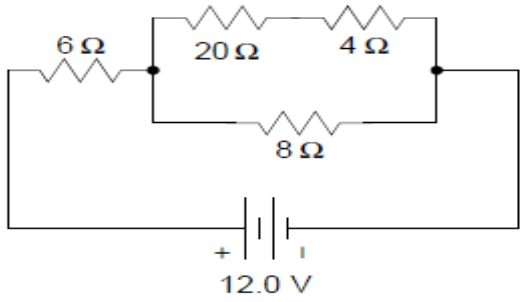
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_{eq}} = \frac{1}{2R} + \frac{1}{2R}$$

$$\frac{1}{R_{eq}} = \frac{1}{R}$$

Or the equivalent resistance is R.

In the diagram below, find the current through the 20-ohm resistor.



Here Net resistance is obtained by considering 20Ω in series with 4Ω which is 24Ω .This 24Ω is in parallel to 8Ω. So resistance is $R = \frac{24\times8}{24+8}=6\Omega$

This 6 Ω is in series with another 6 Ω so the net resistance of the circuit is 12 Ω.

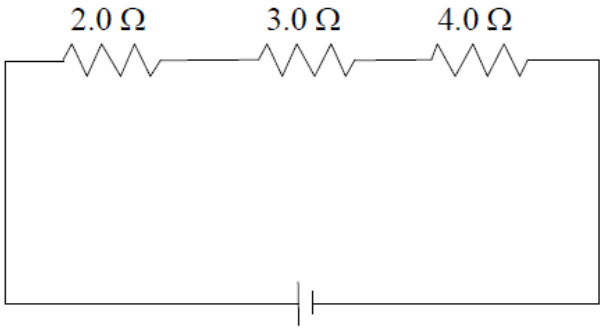
Current drawn by the circuit is $I = \frac{12}{12}$ which is 1 ampere.

Net p.d across the first 6 Ω resistor is therefore 6 V. The remaining 6 V drops across the second part of the circuit.

Which means that the current in the 20Ω in series with 4Ω is $\frac{6}{24}$or 0.25 A

Hence p.d across the 20Ω resistor is 20ΩX0.25=5 V

Q Three known resistances are connected in series to the terminals of battery. The potential difference at the terminals of the 3.0 Ω resistance is 12 V.



A What is the potential difference of the power source?
b. What is the voltage drop across the 4.0 Ω resistor?
c. What is the voltage drop across the 2.0 Ω resistor?

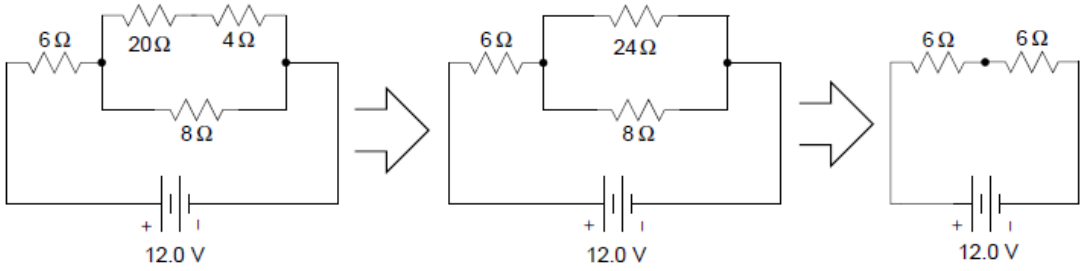
Here if the potential difference at the terminals of the 3.0 Ωresistance is 12 V.it means

$$3 \times I = 12$$

Or $I = 4A$

So potential difference at the terminals of the 2.0 Ω resistance is 8 V
So potential difference at the terminals of the 4.0 Ω resistance is 16 V
So net potential difference of the battery is sum of all the above potential differences which is 36 V.

Rearranging the circuit



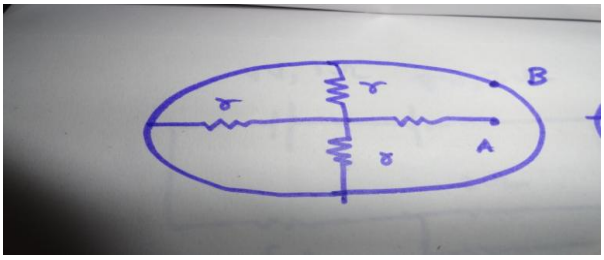
Total resistance is 12 Ω.
Current in the circuit

$$I = \frac{12}{12} = 1A$$

Therefore, the voltage drop across the parallel combination is
V = IR = 1.0 A x 6 = 6.0 V.
The current through the 20 Ω and 4 Ω series combination is

$$I = \frac{6}{24} = .25A$$

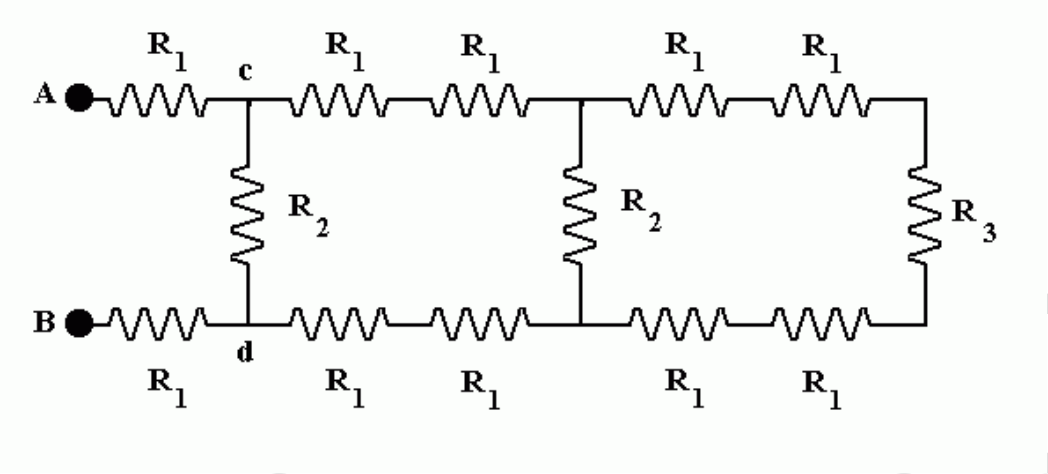
Calculate equivalent resistance for the following circuit between A and B



Here the three resistance arranged radially in the circle are in parallel so their equivalent becomes $\frac{r}{3}$.This resistance is in series with the resistance connected to A sso the equivalent resistance is $\frac{r}{3} + r = \frac{4r}{3}\Omega$

Do it yourself

Calculate the equivalent resistance between A and B.(here $R_1 = 2\Omega, R_2 = 4\Omega$ and $R_3 = 4\Omega$



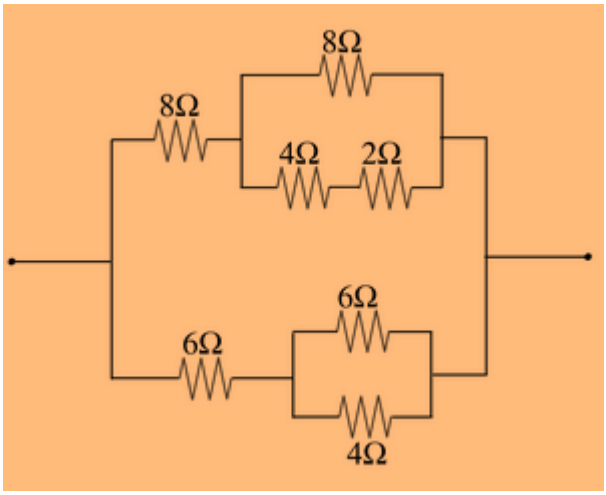
Hint .(You can start solving from extreme right and reduce the problem to a single resistor between A and B)

ASSIGNMENT

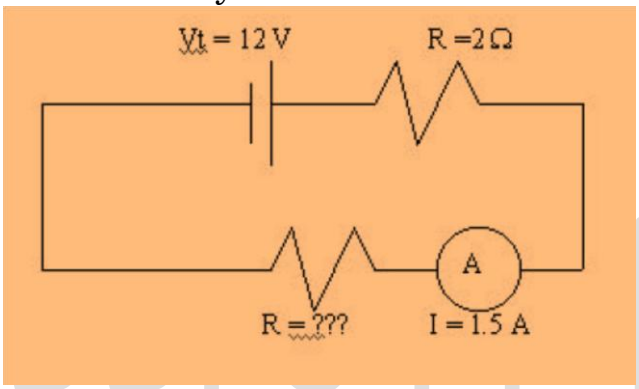
1The sequence of bands marked on a carbon resistor is: Red, Red, Red, Silver. Write the value of resistance with tolerance.

2 A portable mobile phone is designed to operate at a potential difference of 5.0 V and a current of 0.200 A, but the only source available has a potential of 12.0 V. What resistance must be added in series with the phone to make it operate?

3Calculate equivalent resistances of the given electrical circuits

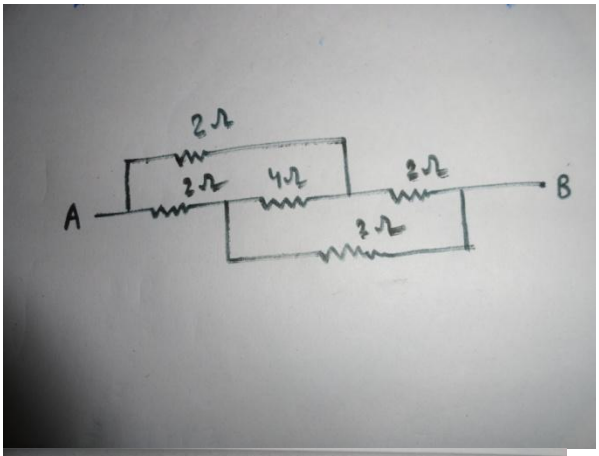


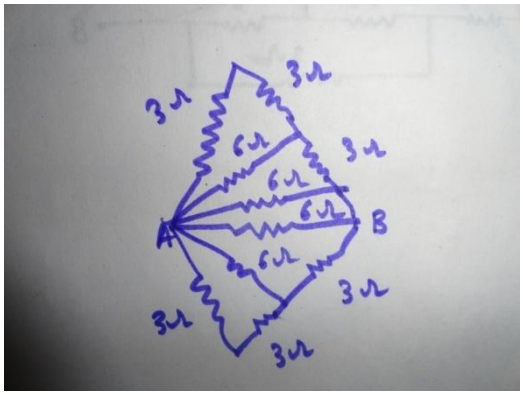
4 Find the missing resistance in the circuit shown, which consists of a12 V battery connected to two resistors.

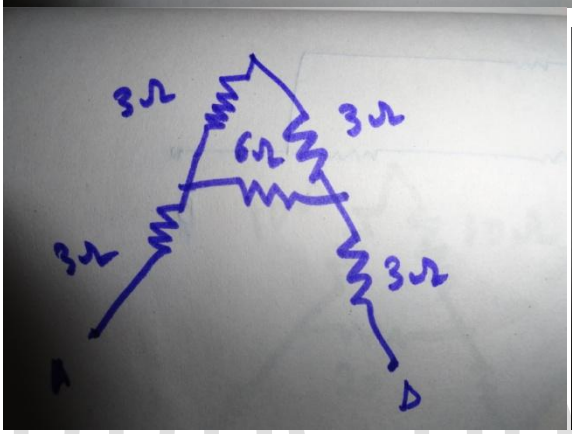


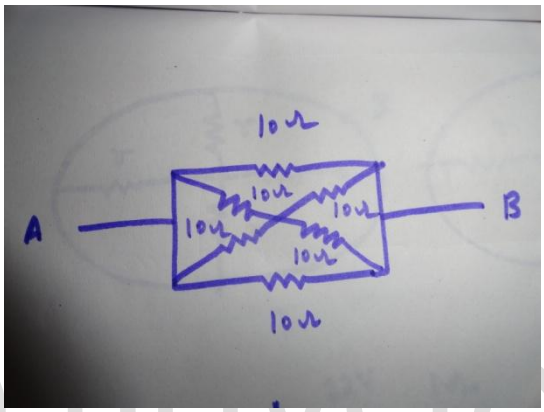
5 There are six electrical wires made of the same substance and having the same length :three have a diameter of 1.5 mm while the other three have a diameter of 3.0 mm. They are placed either end to end to increase the length of the wire or parallel to one another to increase the surface area of the wire.
Which three-wire arrangement offers the least resistance to the flow of electric current?

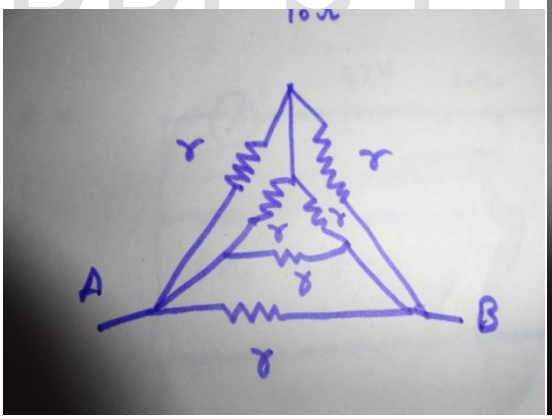
6Calculate resistance equivalent for the following circuits.

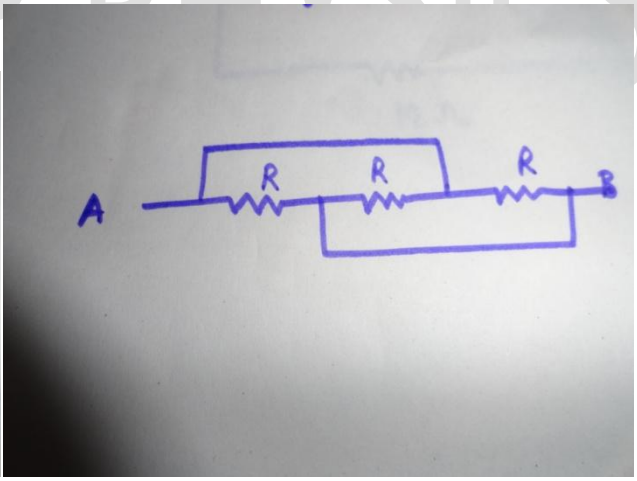




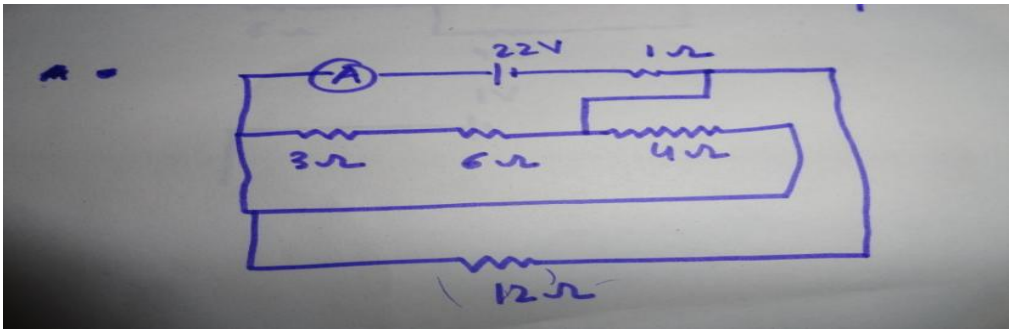






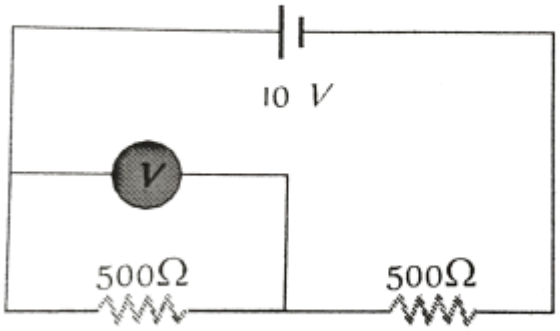


Q7 Calculate the current supplied by the battery in the following circuits

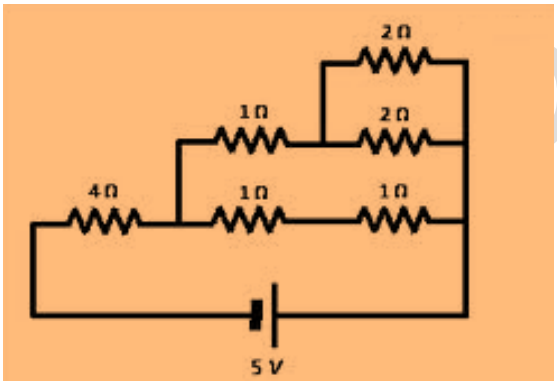


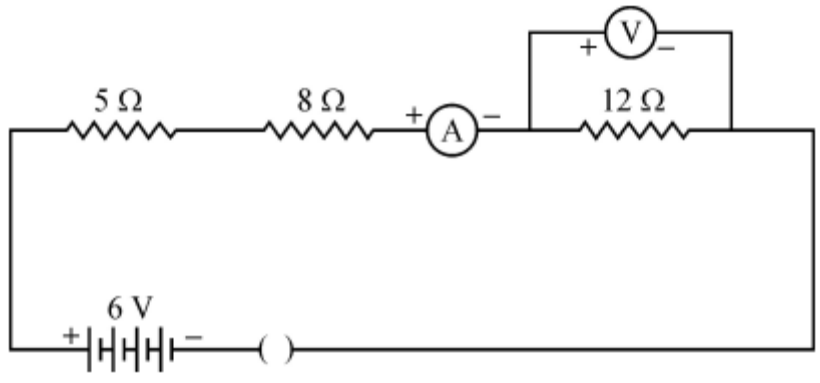
Q8 What will be the voltmeter reading in the given circuit?

A voltmeter of resistance 1000Ω is connected across a resistance of 500Ω in the given circuit. What will be the reading of voltmeter



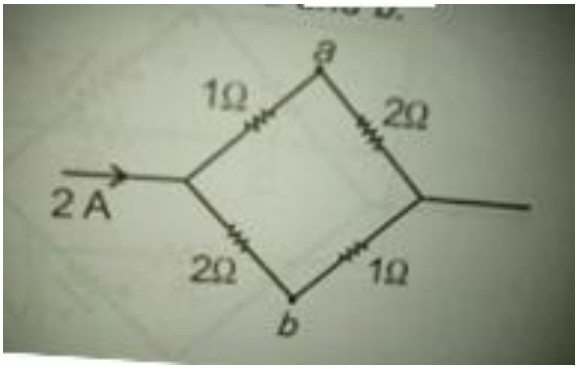
Q9 Calculate the current which will flow in each resistor in the given problem.





Q10

Find ammeters and voltmeters reading. You can take their resistances to be zero and infinite respectively.



Q11

Find p.d between a and b above

Find p.d between B and D below