13- 1Work

Whenever a force of any kind causes motion, work is accomplished. If a force were exerted without causing motion, then no work is done.

13-2 Electric Power:

In an electrical circuit, voltage applied to a conductor will cause electrons to flow. Voltage is the force and electron flow are the motion. The rate at which work is done is called power and is represented by the symbol "P". Power is measured in watts and is represented by the symbol "W". The watt is defined as the rate work is done in a circuit when 1 amp flows with 1 volt applied.

13-3 Power Formulas

Power consumed in a resistor depends on the amount of current that passes through the resistor for a given voltage. This is expressed as voltage times current.

$P = E \times I$ or $P = EI$

Power can also be calculated by substituting other components of Ohm's Law.

$P = I^2 R$ and $P = \frac{E^2}{R}$

13-3-1 Solving a Power Problem:

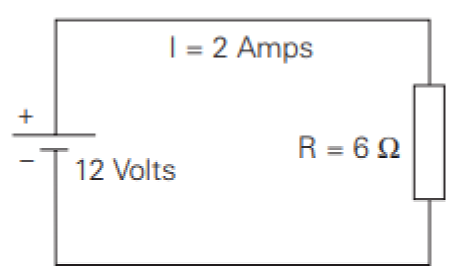
In the following illustration power can be calculated using any of the power formulas.

$P = EI$

$P = 12 \text{ Volts} \times 2 \text{ Amps} \longrightarrow P = 24 \text{ Watts}$

$P = I^2R$

$P = (2 \text{ Amps})^2 \times 6\ \Omega \longrightarrow P = 24 \text{ Watts}$



13-3-2 Power Rating of Equipment:

Electrical equipment is rated in watts. This rating is an indication of the rate at which electrical equipment converts electrical energy into other forms of energy, such as heat or light. A common household lamp may be rated for 120 volts and 100 watts. Using Ohm's Law, the rated value of resistance of the lamp can be calculated.

$P = \frac{E^2}{R}$ which can be transposed to $R = \frac{E^2}{P}$

$$R = \frac{(120 \text{ volts})^2}{100 \text{ watts}} = 144\ \Omega$$

Using the basic Ohm's Law formula, the amount of current flow for the 120volt, 100watt lamp can be calculated.

$$I = \frac{E}{R} = \frac{120 \text{ volts}}{144\ \Omega} = 0.833\text{Amps}$$

A lamp rated for 120 volts and 75 watts has a resistance of 192 Ω and a current of 0.625 amps would flow if the lamp had the rated voltage applied to it.

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

$$R = \frac{(120 \text{ volts})^2}{75 \text{ watts}} = 192\ \Omega$$

$$I = \frac{E}{P}$$

$$I = \frac{120 \text{ volts}}{192\ \Omega} = 0.625 \text{ Amps}$$

It can be seen that the 100-watt lamp converts energy faster than the 75-watt lamp. The 100-watt lamp will give off more light and heat.

Current flow through a resistive material causes heat. An electrical component can be damaged if the temperature is too high. For this reason, electrical equipment is often rated for a maximum wattage. The higher the wattage rating, the more heat the equipment can dissipate.

Example 1)

An electric heater is constructed by applying a potential difference of 110volt to a nichrome wire of total resistance 8Ω. Find the current carried by the wire and the power rating of the heater.

Solution:

$$I = \frac{E}{R} = \frac{110 \text{ volts}}{8\Omega} = 13.8 \text{ Amps.}$$

$$P = I^2R = (13.8 \text{ Amps})^2 \times 8\Omega = 1520 \text{ Watts}$$

Example 2)

A light bulb is rated at 130v/70W. The bulb is powered by a 130v. Find the current in the bulb and its resistance.

Solution:

$$P = EI$$

$$\therefore I = \frac{P}{E} = \frac{70 \text{ watts}}{130 \text{ volts}} = 0.53 \text{ Amps}$$

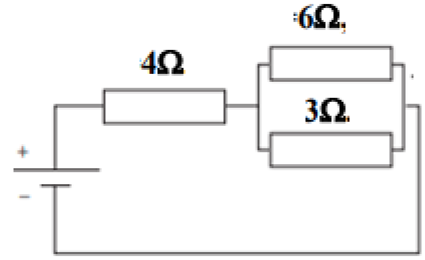
$$R = \frac{E}{I} = \frac{130 \text{ volts}}{0.538 \text{ Amps}} = 241\ \Omega \quad \text{or } R = \frac{E^2}{P} = \frac{130 \text{ volts}^2}{70 \text{ watts}} = 241\ \Omega$$

13-4 Physical facts for the series and parallel combination of resistors

No.	**Series combination**	**Parallel combination**
1	Current is the same through all resistors	Potential difference is the same through all resistors
2	Total potential difference = sum of the individual potential difference	Total Current = sum of the individual current
3	Individual potential difference directly proportional to the individual resistance	Individual current inversely proportional to the individual resistance
4	Total resistance is greater than greatest individual resistance	Total resistance is less than least individual resistance

Example3)

Find the equivalent resistance for the circuit shown in figure 7.6. R1=3Ω, R2=6Ω, and R3=4Ω.

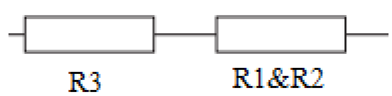


Solution:

Resistance R1 and R2 are connected in **parallel** therefore the circuit is simplify as shown

$$\frac{1}{Rt} = \frac{1}{R1} + \frac{1}{R2}$$

$$\frac{1}{Rp} = \frac{1}{3} + \frac{1}{6} = \frac{3}{6} \quad \therefore R_p = 2\Omega \rightarrow$$



$\therefore Rt = R_p + R_3 = 4 + 2 = 6\Omega$