ELECTRICAL POWER

PURPOSE:

In this section you will learn about power dissipation in a DC circuit and methods to calculate and measure power consumption.

TO ACHIEVE THE PURPOSE OF THIS SECTION:

At the end of this section the student will be able to:

- State the relationship between power, voltage, current and resistance in a DC circuit.
- State and show by calculation the relationship that exists in a DC circuit between -
  - resistance and power consumption.
  - voltage and power consumption.
- Illustrate, using a circuit diagram, the connections for a wattmeter in a DC circuit.
- Correctly select, on the basis of power rating, a resistor for use in a DC circuit.
- Use a the volt-ammeter method to determine the power consumption in a DC circuit.
- Connect a wattmeter to measure the power consumed in a DC circuit.

1. ELECTRICAL POWER

Electrical equipment is rated in terms of -

- ______________________________

  and

- ______________________________.

For example - light globe- ______________________________

hotplate - ______________________________

electric motor - ______________________________.

Power is ____ and is measured in ___________ (   ).

Suppose, for example, that a motor-driven lift is to be selected for raising a certain load. If the load has to be raised quickly, a more powerful lift and a larger driving motor must be provided than would be the case if more time is allowed to do the job.

The power supplied to or consumed by a circuit is dependent upon -

- __________________________

  and

- __________________________.

To calculate the power associated with a circuit or component, the following equation may be used -

where: P = power in watts
V = voltage in volts
I = current in amperes

Example: 1

Calculate the power supplied to the circuit of figure 1.

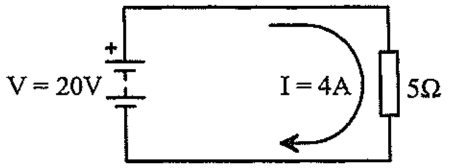


Figure 1

Example: 2

What happens to the power consumed in the circuit of figure 1, if the applied voltage is doubled?

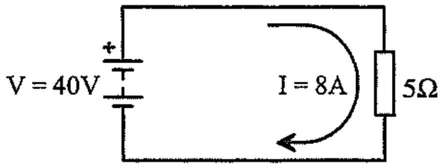


Figure 2

The power taken by the circuit has increased by ______________________.

Therefore, it can be said -

Power is ______________________ to the voltage _______________.   ______________________

What effect does varying the resistance of a circuit have on the power consumed by the circuit?

Example: 3

Calculate the power consumed by the circuit shown in figure 3.

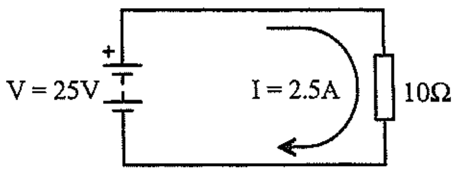


Figure 3

Example: 4

Calculate the power consumed by the circuit of figure 3 if the circuit resistance is doubled.

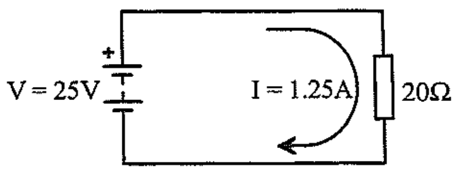


Figure 4

If the resistance of a circuit is doubled, the power taken is ________________.

Therefore, it can be said -

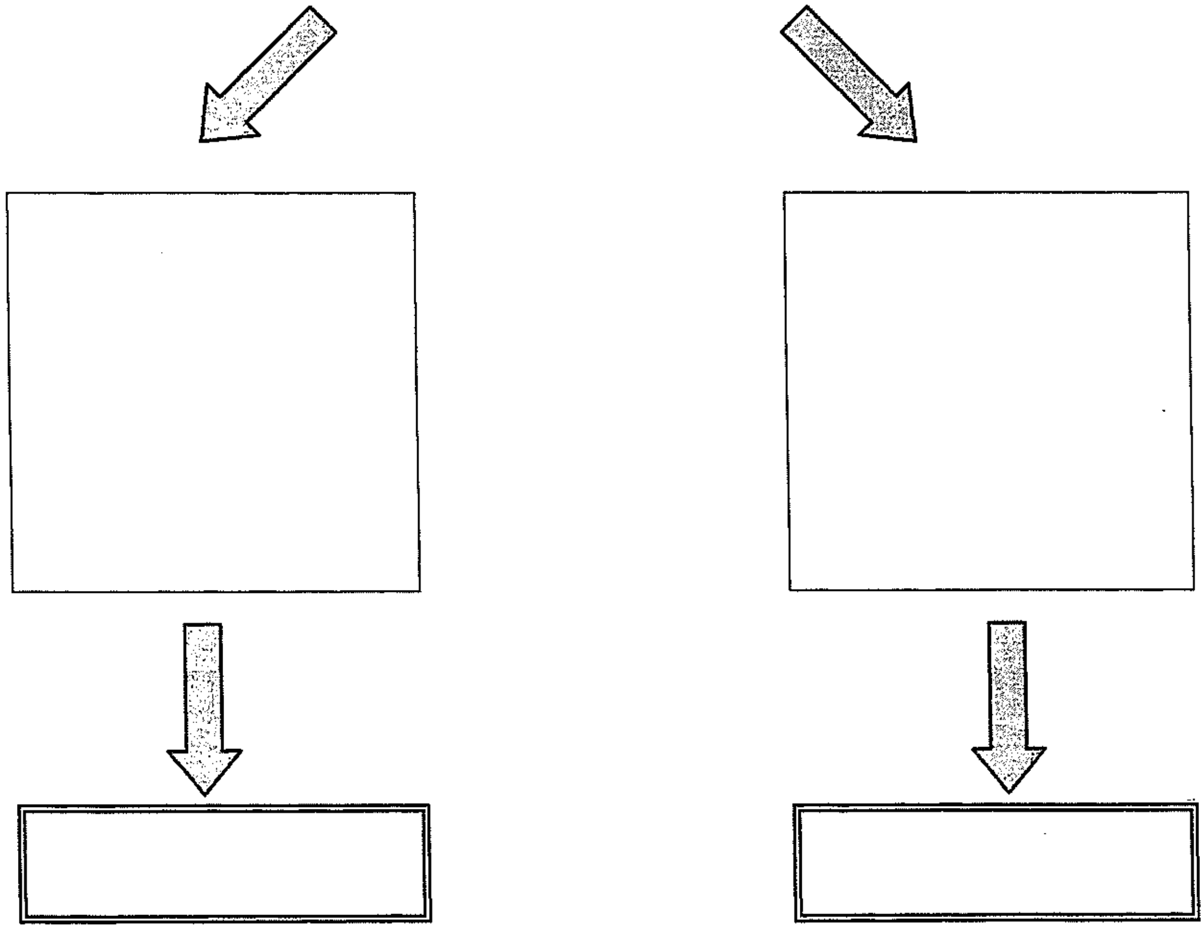
Power consumed is __________________________________ to circuit resistance.

____

2. POWER EQUATIONS

The basic power equation is written P = VI. This equation may be modified by the application of Ohm's Law to give us two other power equations.

$$P = V \times I \quad \text{watts}$$



Example: 5

Calculate the power consumed in the circuit of figure 5.

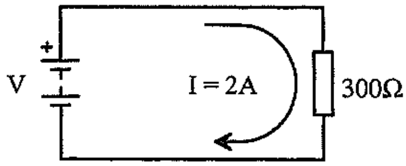


Figure 5

Example: 6

Calculate the power consumed in the circuit of figure 6.

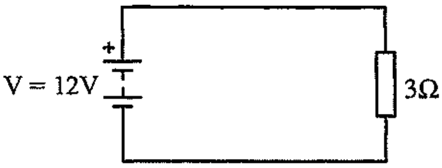


Figure 6

Example: 7

Calculate the power consumed in the circuit of figure 7, using all three power equations.

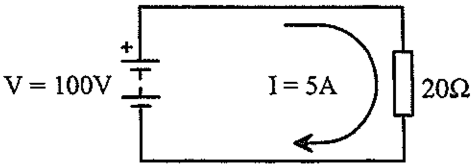


Figure 7

3. MULTIPLES and SUBMULTIPLES of POWER

Power values can range from thousands of megawatts (MW) to less than a microwatt (1µW). For example, some of today's coal-fired power stations can produce over 2000MW (2000 megawatts) of power, with each alternator in the power station delivering up to 600MW. An electric passenger train could need more than 1MW of power to pull out of the station. The sound system at an outdoors pop concert can produce some 50kW (kilowatts) of sound, needing about 100kW of power to drive the system.

On a much smaller scale, earphones used with portable radio-tape players use only a few milliwatts (mW) of power for a satisfying sound level. The liquid crystal display in a calculator or a digital watch takes only a few microwatts of power from the battery.

In other words, as with current, voltage and resistance values, multiples and submultiples are often used with power values. As the table below shows, scientific notation is also used when expressing power values, in the same way it's used with voltage, current and resistance values. Remember that the symbol for mega is the capital letter M, with a small m for milli.

Table 1

Term	Symbol	Equals	Scientific notation
megawatt		1,000,000 watts	1MW =
kilowatt		1,000 watts	1kW =
milliwatt		0.01 watts	1mW =
microwatt		0.000 001 watts	1µW =

Calculations involving power values expressed with multiples and submultiples are treated the same way as Ohm's law equations. This was described in section 4, and by now you'll know about scientific notation and how to use it in an equation.

Remember - when multiplying values expressed with scientific notation, you add the exponents. For division, the exponent with the term below the line is subtracted from the exponent with the term above the line.

Example: 8

A calculator is supplied from a 3V battery and takes a current of 70µA. Determine the power consumed by the calculator.

____

____

Example: 9

A large factory is connected to a 3.3kV supply and takes 1.2kA when operating at full production. How much power is taken from the supply?

4. THE WATTMETER

It has been observed that the power in watts delivered by a generator, or consumed by a lamp or a motor may be obtained by multiplying the volts by the amperes, that is, watts = volts x amperes. However, instead of using two separate instruments, a voltmeter and an ammeter, to obtain the power consumed in a certain part of a circuit, a single instrument called a wattmeter may be used.

Although it is not possible to explain the operating principle of the wattmeter at this stage, it should be understood that a wattmeter is a combination of a voltmeter and an ammeter using only one pointer. The voltmeter part is of high resistance to enable the line voltage to be applied to it, and the ammeter part is of low resistance (as it has to carry the line current). The pointer of the instrument indicates, on a scale, the product of the volts and the amperes, that is, the watts.

A wattmeter usually has four terminals, two for the current coil and two for the voltage coil. Extreme care must always be exercised to use the correct terminals, as an error in this regard may damage an expensive instrument. Figure shows the basic arrangement for the wattmeter.

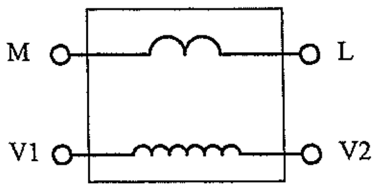


Figure 8

The Australian Standard symbol for the wattmeter is shown in figure 9.

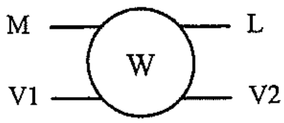


Figure 9

Figure 10 shows the correct method of connecting a wattmeter in the circuit to measure the power required by the load. It should be noted that the current coil is placed in series with the load, and the voltage coil is connected in parallel with the load.

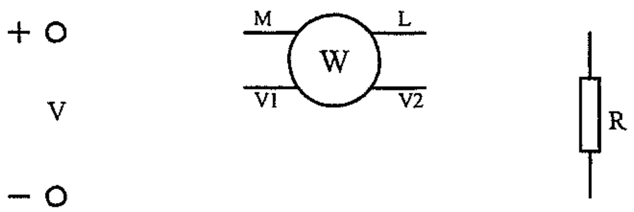


Figure 10

Example: 10

A heating element which has a power rating of 4.8kW is designed to operate from a 240V supply. Determine the -

(a) current taken by the element when operating

(b) element resistance.

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