Standard

# Unit 2

# Power and Units

ACMA Syllabus February 2024 Chapters 4.4 and 4.2

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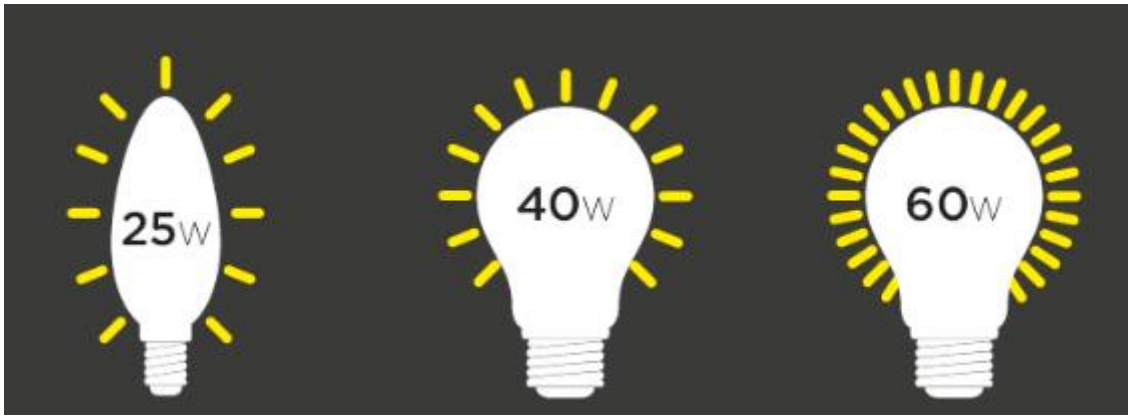
## Electric Power

The rate of doing work in an electrical circuit is termed *electrical power* and is measured in watts. A common misconception is that electric power is supplied to your house. In reality "electrical energy" is traded and delivered to your house. Electrical energy will be addressed later.

The first place you probably encounter watts is in light bulbs. Brake lights in cars are around 20 watts and taillights are around 10 watts. From this we now know that the higher the wattage of the bulb, the brighter it is.

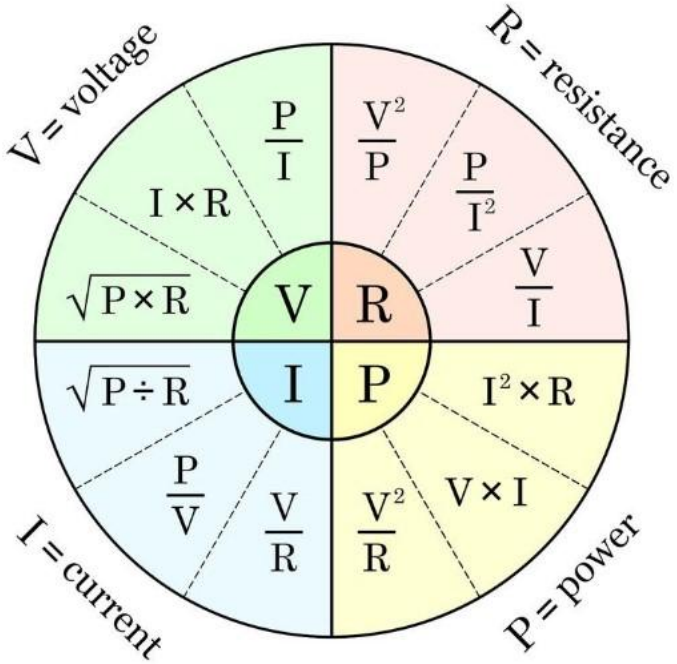



The formula for electrical power in a resistive circuit is shown below.

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

P = electrical power in watts
I = current in amperes
E = electromotive force in volts
R = resistance in ohms

Ohm's law tied I, E and R together. So now if we know two of the quantities, we can calculate the other two. This relationship is depicted in the formula circle below.

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**Examples**: What power is dissipated when 12 V is applied across a load with 0.5 A flowing?

$$P = I \times E$$

$$P = 0.5 \times 12$$

$$P = 6 \text{ W}$$

What power is dissipated when 2 A flows through a 10 Ω load?

$$P = I^2 \times R$$

$$P = 2^2 \times 10$$

$$P = 4 \times 10$$

$$P = 40 \text{ W}$$

What power is dissipated when 12 V is applied to a 10 Ω load?

$$P = E^2 \div R$$

$$P = 12^2 \div 10$$

$$P = 144 \div 10$$

$$P = 14.4 \text{ W}$$

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# Electric Energy

Distinction between kW (power) and kWh (energy)

A kilowatt is a unit of power.

A kilowatt hour is a unit of energy.

Work is the amount of energy transferred to a system; power is the rate of delivery of energy. Energy is measured in joules, or watt-seconds. Power is measured in watts, or joules per second.

For example, a battery stores energy. When the battery delivers its energy, it does so at a certain power, that is, the rate of delivery of the energy. The higher the power, the quicker the battery's stored energy is delivered. A higher power output will cause the battery's stored energy to be depleted in a shorter period.

**Example:** A 100 Amp Hour battery can discharge 100 A for 1 hour or 10 A for 10 hours or 2 A for 50 hours.

Electrical energy for public consumption is generated by central power stations and is usually provided through a grid system. Electrical energy is measured in the unit kilowatt-hour (kWh). One kilowatt of power for one hour and this is the common billing unit for electrical energy.

Electrical energy is usually sold by the kilowatt hour (1 kWh = 3.6 MJ) which is the product of the power in kilowatts multiplied by running time in hours. Electric utilities measure energy using an electricity meter, which keeps a running total of the electric energy delivered to a customer.

Energy = Power / Time

**Example:** A unit uses 1 MW of power a day, the energy consumed is 1,000,000 / 24 or 41.66 kW per hour.

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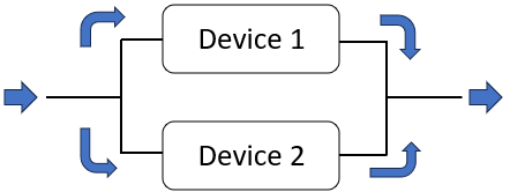
## Series and Parallel Voltage Sources

Voltage sources, e.g. batteries, can be connected in series or parallel depending on the system requirements.

**Series** circuit is defined as the configuration where current flows through one device then the then the second device.

**Parallel** is defined as the configuration where current splits and goes through two devices at the same time.

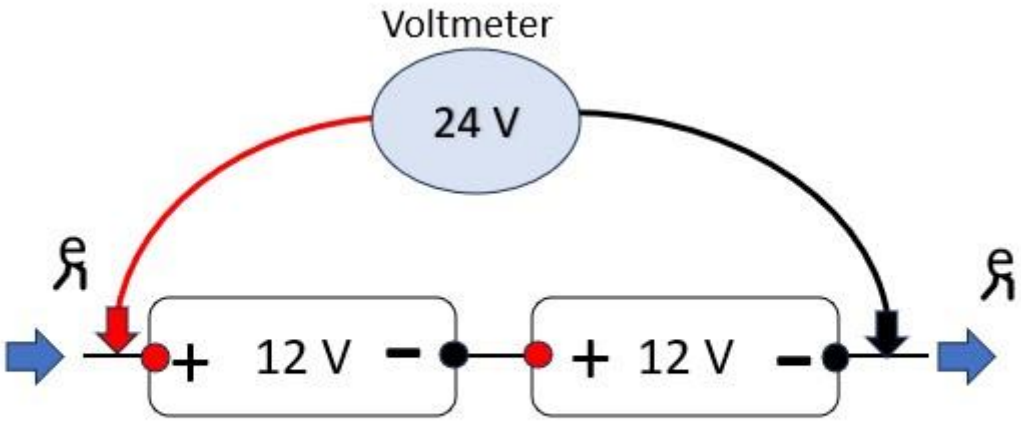
Series Connection




Parallel Connection

Connecting two or more voltage sources in series will increase the voltage or EMF across the devices.

In the case of a series connection, the voltage potential across the devices is the sum of the voltage sources.




Series Connection

Voltage doubles but current same as one device

For a parallel connection the voltage potential across the devices does not change but the current can increase.

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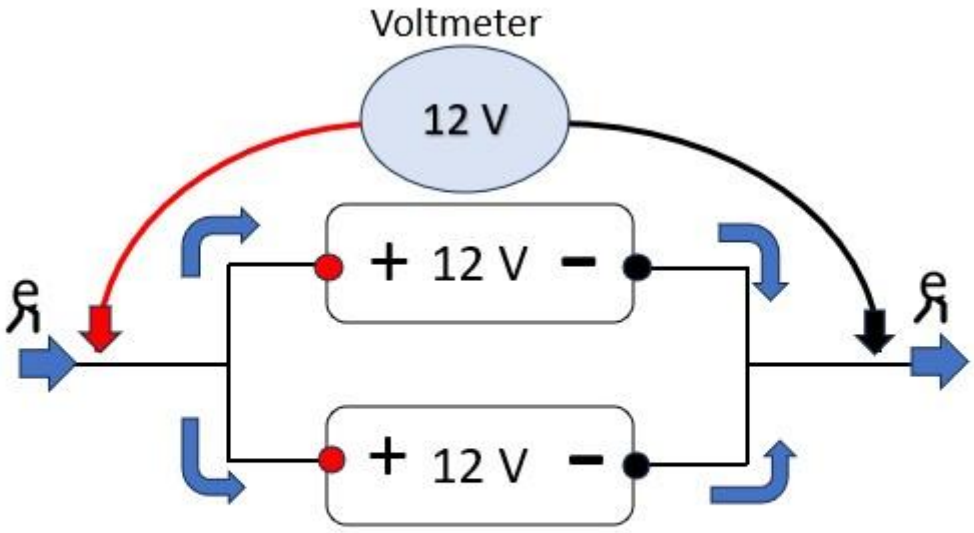


## Parallel Connection

Voltage remains the same, but this combination can deliver double the current.

Go to Unit 2 questions.

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