2018 Term 3 Week 9

Electrical Energy

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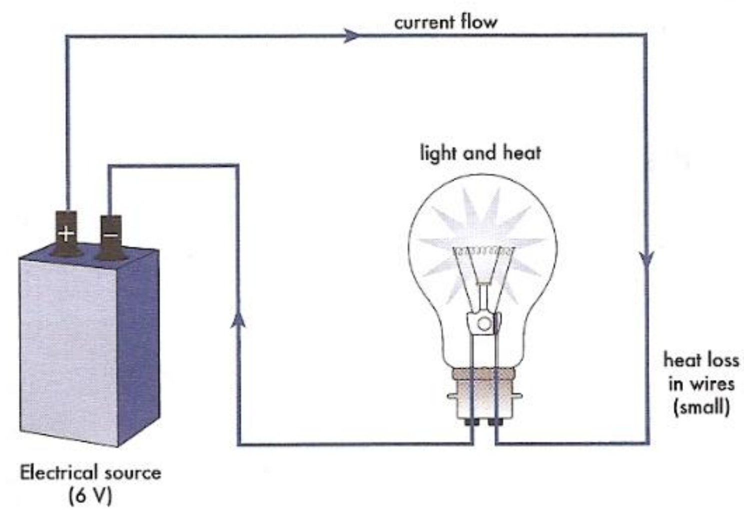


- Chemical energy
- Electric potential energy
- KE due to attraction
- Collisions = vibrational energy
- Heat and light

Recall That

- An electrical circuit is simply an energy transformation tool.
- Energy is provided to the circuit
- The rate at which this energy transformation occurs
- **Power** is the rate at which electrical energy is supplied to a circuit or consumed by a load.

$$\text{Power} = \frac{\text{Work Done on Charge}}{\text{Time}} = \frac{\text{Energy Consumed by Load}}{\text{Time}}$$

Electrical Power

- Rate of doing work or releasing energy

$$P = VI$$

V = voltage (volts) *potential energy given to each coulomb of charge*

I = current (amperes) *number of coulombs of charge flowing per second*

P = power (watts) *rate of energy use*

Watt

1 watt = 1 joule / second

- 120-watt light bulbs draws 120 joules of energy every second
- Electrical power refers to the rate at which the charge changes its energy

Power

Power is the rate of doing work, which is a way of measuring the rate at which energy changes from one form into another. For example:

An electric aquarium heater gives out 12 J of heat energy every 2 s; its power output is 6 J s^{-1} or 6 W.

A 1000 W (1 kW) electric hair-drier converts 1000 J of electricity into heat every second.

$$P=IV$$

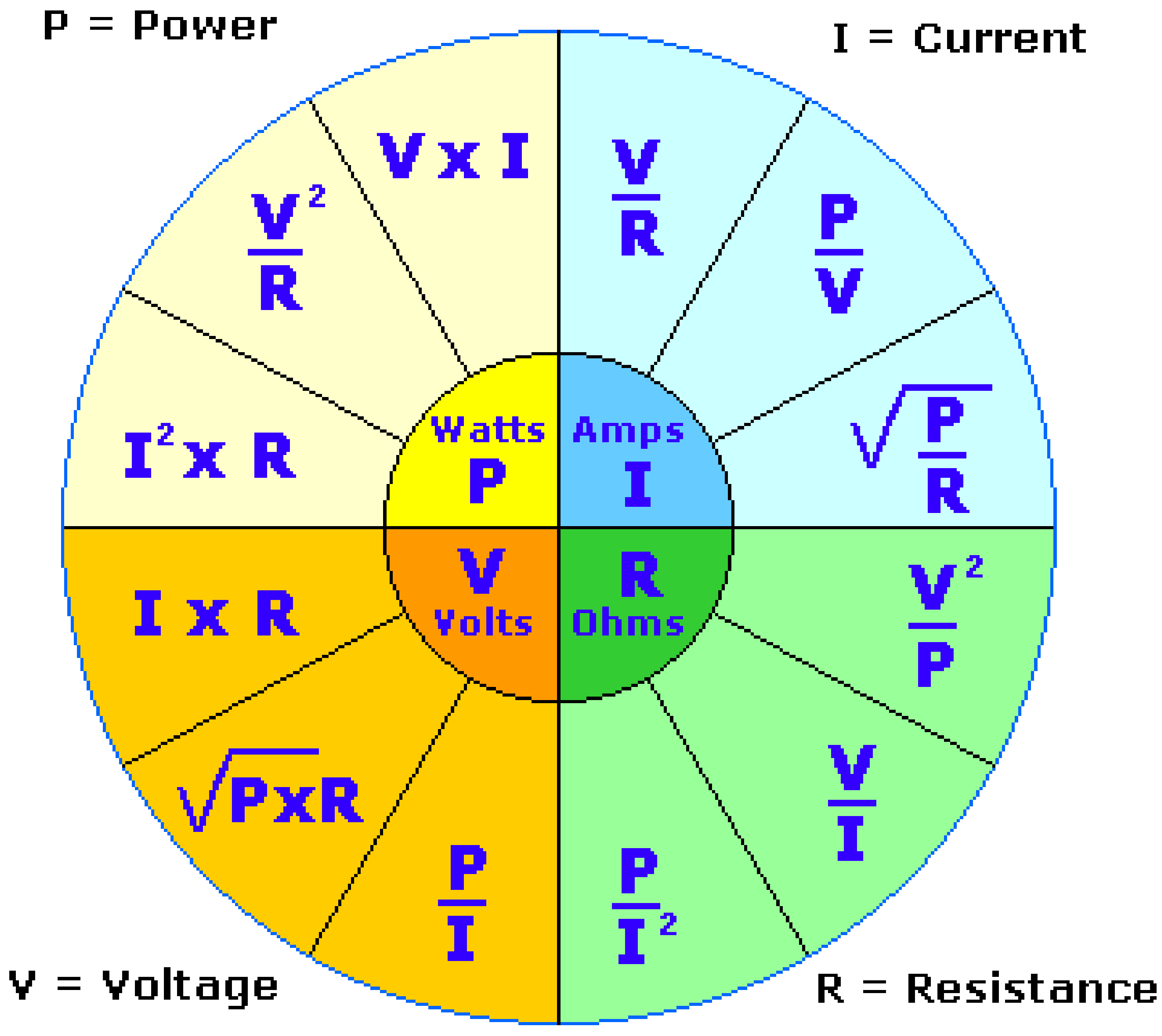
P is the power in watts (W)
I is the current in amperes (A)
V is the potential difference in volts (V)

Combining

Combining with Ohm's Law, $\mathbf{V = IR}$,

$$\mathbf{P = I^2R}$$

$$\mathbf{P = \frac{V^2}{R}}$$


P = Power
I = Current
V = Voltage
R = Resistance
Watts
P
Amps
I
V
Volts
R
Ohms
V x I
$\frac{V^2}{R}$
I^2 x R
$\frac{V}{R}$
$\frac{P}{V}$
$\sqrt{\frac{P}{R}}$
I x R
$\sqrt{P x R}$
$\frac{P}{I}$
$\frac{V^2}{P}$
$\frac{V}{I}$
$\frac{P}{I^2}$

Electrical Energy

Electrical energy = Power x Time

$$E = Pt$$

$$E = IVt \qquad E = \frac{V^2 t}{R} \qquad E = I^2 R t$$

t is the time in seconds (s)
E is the energy in joules (J)

Electrical Energy Used

- Energy consumed depends on:-
- Rate of energy use (rating)
- Time

$$E = Pt$$

E = Energy used (or work done), joules (J)

P = Power rating, Js^{-1} or watts (W)

V = Voltage supplied, volts (V)

t = Time, seconds (s)

$$E = VIt$$

V = Voltage supplied, volts (V)

I = Current, amperes (A)

kWh

- Kilowatt hours
- 13c per unit

$$1\ kW = 1000\ Js^{-1}$$

$$1\ h = 3600\ s$$

$$1\ kWh = 3600000\ J$$

$$= 3.60\ MJ$$

Example 1

A motor car's two headlights are each rated at 50.0 W and operate on a 12.0 V power supply. Calculate

The current flowing in each headlight when they are in use.

$P = 50.0$ W each light
$V = 12.0$ V
$I = ?$
$q = ?$
$t = 2.00$ h

$$P = VI$$

$$I = \frac{P}{V} = \frac{50.0}{12.0} = 4.17 \text{ A} \quad \text{(for each light)}$$

The charge passing through each globe every second.

$$q = It = (4.17)(1) = 4.17 \text{ C}$$

The total energy consumed by the two headlights during a 2.00 hour night journey.

$$E = Pt = (50)(2)(2.0 \times 60 \times 60)$$

$$= 7.20 \times 10^5 \text{ J}$$

Example 2

What is the current drawn by a 1500 W electric kettle if it operates on a 240 V supply?

$P = 1500\ W$
$V = 240\ V$
$t = 4.5\ min$
$= 270\ s$

$P = VI$

$I = \frac{P}{V} = \frac{1500}{240} = 6.25\ A$

How much electrical energy (Joules) will it use if it is on for 4.50 minutes?

Calculate the cost of the energy used

$E = Pt$

$= (1500)(270)$

$= 4.05 \times 10^5\ J$

Calculate the cost of the energy used

$1\ kWh = 3.6 \times 10^6\ J$

No. of units of electricty used (kWh)

$= \frac{4.05 \times 10^5}{3.6 \times 10^6} = 0.113\ kWh$

$\therefore$ Cost = (units) × (12.67¢)

= (0.113) × (12.67¢) = 1.43¢