

Electrical Calculation Notes

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There are a number of different ways that we could encounter calculations on the topic of electricity but in general they tend to fall into one of four categories, **charge (Q)**, **potential difference (V)**, **power (W)** and **energy (J)**.

But we can also be asked to calculate other things of course, like **resistance (Ω)**, **current (I)** and **time (s)**. Before we look at formulae and example calculations let's define the items we are going to calculate.

Charge: the property of an object to experience a force in an electric field. It is measured in Coulombs.

So, a positively charged particle will be repelled by a positively charged electric field. It's the charges that lead to the force 😊

1 amp is the flow of 1 coulomb of charge per second. So, a 5 amp reading tells us that 5 coulombs of charge passed that point in a circuit in one second.

Potential difference: the energy transferred per unit charge. It is the "work done" on each coulomb of charge that passes between two points. It is measured in volts (V).

A potential difference produces an electric field, this will then produce a force on the charged particles in the field. The bigger the potential difference the bigger the force on the particles 😊

Power: the rate at which energy is passed from one place to another, or one form to another. It is measured in Watts (W).

Energy: the ability to do work. It is measured in Joules (J).

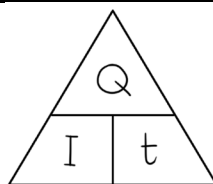
Resistance: the ability of a component or a material to resist the movement of current through it.
Resistance is measured in Ohms (Ω)

Current: the rate of flow of charged particles (usually electrons) which is measured in Amps (A).

Calculating Charge 1

Charge = current $\times$ time

$$Q = I \times t$$



Where:

Q = charge (C)

I = current (A)

t = time (s)

Example 1: 5 amps of current pass through a component in 10 seconds.

Calculate the charge across the component.

$$Q = I \times t$$

$$Q = 5 \times 10$$

$$Q = 50 \text{ C}$$

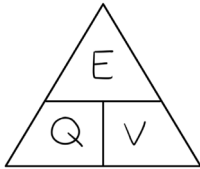
Example 2: A component has 18 C of charge pass through it in 6 seconds.

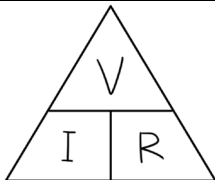
Calculate the current flowing through the component.

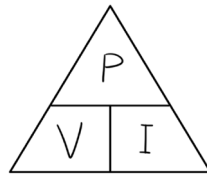
$$Q = I \times t \quad \therefore I = Q \div t$$

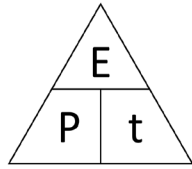
$$I = 18 \div 6$$

$$I = 3 \text{ A}$$

Calculating Charge 2		
Charge = energy ÷ potential difference $Q = E \div V$		Where: $Q = \text{charge (C)}$ $E = \text{energy (J)}$ $V = \text{potential difference (V)}$
Example 1: There is a potential difference of 12 V across a bulb in 1 minute. It transfers 240 J of energy. Calculate the charge transferred in that time. $Q = E \div V \quad Q = 240 \div 12 \quad Q = 20 \text{ C}$		
Example 2: A 5 A current flows through a component with a power rating of 100 W in 1 minute. It transfers 1000 J of energy in that time. Calculate the charge transferred in that time. Note: we have the energy but to use the equation above we need first calculate the potential difference. We'll need to use another equation. $P = I \times V \quad V = P \div I \quad V = 100 \div 5 \quad V = 20 \text{ V}$ Now we can use the $Q = E \div V$ $Q = 1000 \text{ J} \div 20 \text{ V} \therefore Q = 50 \text{ C}$		

Calculating Potential Difference 1		
Potential difference = current × resistance $V = I \times R$		Where: $V = \text{potential difference (V)}$ $I = \text{current (A)}$ $R = \text{resistance } (\Omega)$
Example 1: A current of 8 A flows through a 20 Ω fixed resistor. Calculate the potential difference across resistor. $V = I \times R$ $V = 8 \times 20$ $V = 160 \text{ V}$	Example 2: A variable resistor of 50 Ω has a potential difference of 10 V. Calculate the current flowing through the resistor. $R = V \div I$ $I = 10 \div 50$ $I = 0.2 \text{ A}$	
Example 3: The potential difference across a battery is 480 V. There is a current of 15 A in the circuit connecting a battery to a motor of an electric car. Calculate the resistance of the motor. $R = V \div I \quad R = 480 \div 15 \quad R = 32 \Omega$		

Calculating Potential Difference 2		
Potential difference = power ÷ current $V = P \div I$		Where: $V = \text{potential difference (V)}$ $P = \text{Power (W)}$ $I = \text{current (A)}$
Example 1: A current of 0.5 A flows through a lamp with a power rating of 30 W. Calculate the potential difference across the bulb. $V = P \div I$ $V = 30 \div 0.5$ $V = 60 \text{ V}$	Example 2: A component has a potential difference of 15 V and a current of 2 A. Calculate the power across the component. $P = V \times I$ $P = 15 \times 2$ $P = 30 \text{ W}$	

Calculating Power 1		
Power = energy ÷ time $P = E \div t$		Where: P = power (W) E = energy (J) t = time (s)
Example 1: 7800 J of energy is supplied to a component for 8 seconds. Calculate the power supplied to the component. $P = E \div t$ $P = 7800 \div 8$ $P = 975 \text{ W}$	Example 2: 12000 J of energy is transferred to an LED with a power rating of 80 W. Calculate the time that it took for this transfer to occur. $t = E \div P$ $t = 12000 \div 80$ $t = 150 \text{ s}$	
Example 3: A power of 125 W is supplied to a thermistor for 50 seconds. Calculate the energy that is supplied to the thermistor during this time. $E = P \times t$ $E = 125 \times 50$ $E = 6250 \text{ J}$		

Wait... Can you combine these two last two equations into one equation? Yes indeed 😊

Electrical power is calculated using $P = V \times I$ and energy transferred is calculated $E = P \times t$ we can sub in $V \times I$ instead of P in the energy transferred equation to get...

$$E = V \times I \times t$$

Let's have a look at an example 😊

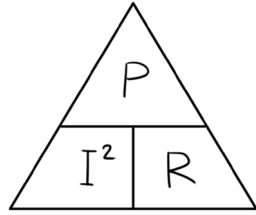
A kettle is connected to the 230 V mains supply. A current of 10 A flows through the kettle element.

Calculate the total energy transferred by the kettle if it takes 2.5 minutes to boil the water.

$$2.5 \times 60 = 150 \text{ seconds.}$$

$$E = 230 \times 10 \times 150$$

$$E = 345\,000$$

Calculating Power 2		
Power = current squared × resistance $P = I^2 \times R$		Where: P = power (W) I = current (A) R = resistance (Ω)
Example 1: A current of 5 A flows through a 50 Ω fixed resistor. Calculate the power being delivered to the resistor. $P = I^2 \times R$ $P = 5^2 \times 50$ $P = 1250 \text{ W}$	Example 2: A component has a power rating of 108 W and a current of 6 A flowing through it. Calculate the resistance of the component. $R = P \div I^2$ $R = 108 \div (6)^2$ $R = 3 \Omega$	
Example 3: A light emitting diode (LED) has a power rating of 125W and a resistance value of 5 Ω . Calculate the current that is flowing through the light emitting diode? $I^2 = P \div R$ $I^2 = 125 \div 5$ $I = \sqrt{25} = 5 \text{ A}$		