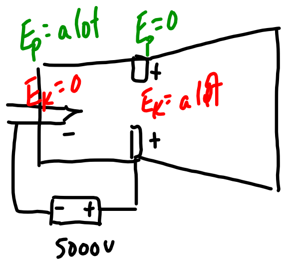
Example

In an electron gun, electrons are emitted by a hot filament in a process called thermionic emission. The electrons are then accelerated across a gap towards a positive electrode (the anode). The potential difference between the filament and the anode is 5000V.



Determine:

a) the electric potential energy of the electrons at the filament

$$V = \frac{\Delta E_p}{q}$$

$$\Delta E_p = Ve$$ ← elementary charge

$$\Delta E_p = (5000\ J\ C^{-1})(1.6 \times 10^{-19}\ C)$$

$$\Delta E_p = 8.0 \times 10^{-16}\ J$$ ← electric potential energy.

b) the gain in kinetic energy of the electrons as they reach the anode.

loss in E_p = gain in E_K

$$\therefore \Delta E_K = 8.0 \times 10^{-16}\ J$$

c) the speed of the electrons as they pass through the hole in the anode (assuming they start from rest)

$$E_{K\ final} = 8.0 \times 10^{-16}\ J \quad (\text{since } E_{K\ initial} = 0)$$

$$E_K = \frac{1}{2}mv^2$$

$$v^2 = \frac{2E_K}{m}$$ ← mass of electron

$$v^2 = \frac{2(8.0 \times 10^{-16}\ J)}{(9.1 \times 10^{-31}\ kg)}$$

$$v = 4.2 \times 10^7\ m\ s^{-1}$$

Example

An alpha particle is a helium nucleus. It is stable and consists of 2 neutrons + 2 protons. The alpha particle is positively charged ($2e = 2(1.6\times10^{-19}C) = 3.2\times10^{-19}C$)

Recall Rutherford used alpha particles in his "Gold Foil Experiment" to investigate the structure of the gold atoms. He accelerated alpha particles across a large potential difference such that their kinetic energy was $3.6\times10^{-16}J$. The mass of the alpha particle is $6.7\times10^{-27}kg$.

Determine the speed of the alpha particles:

$$E_K = \frac{1}{2}mv^2$$

$$v^2 = \frac{2E_K}{m}$$

$$v^2 = \frac{2(3.6\times10^{-16}J)}{6.7\times10^{-27}kg}$$

$$v = 3.3\times10^{5}\ ms^{-1}$$

Determine the potential difference needed to accelerate them from rest to this speed.

$E_{K\ initial} = 0$

$E_{K\ final} = 3.6\times10^{-16}J$

$\Delta E_K = 3.6\times10^{-16}J$

$$V = \frac{\Delta E_K}{q}$$

$$V = \frac{3.6\times10^{-16}J}{3.2\times10^{-19}C}$$

$$V = 1.1\times10^{3}\ V$$

potential difference (quantity) — volts (unit)

The electronvolt (eV)

The joule is not very convenient to use when working with very small objects. (like subatomic particles)

Atomic + Nuclear Physicists use the electronvolt

The electron volt is not an SI unit.

(The work done on a charge of "e" across a pot. diff. of 1 V)

$$V = \frac{\Delta W}{q}$$

$$\Delta W = Vq$$

$$\Delta W = V \cdot e$$ ← V times e

$$\Delta W = (1\ JC^{-1})(1.6 \times 10^{-19} C)$$

$$\Delta W = 1.6 \times 10^{-19} J$$

$$\therefore\ 1\ eV = 1.6 \times 10^{-19} J$$

(eV: unit)

3.2 eV, $3.2(1.6 \times 10^{-19} J)$

Example

An electron accelerates across a pot. diff of 1.0×10^3 V.

What is its KE in J?

$$\Delta E_K = Vq$$

$$\Delta E_K = (1.0 \times 10^3 JC^{-1})(1.6 \times 10^{-19} C)$$

$$\Delta E_K = 1.6 \times 10^{-16} J$$

What is its KE in eV?

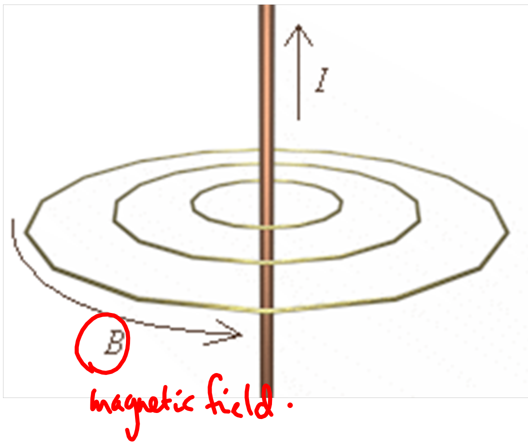
$$\Delta E_K = 1.6 \times 10^{-16} J \left(\frac{1 eV}{1.6 \times 10^{-19} J} \right)$$

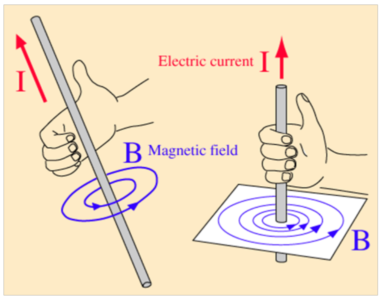
$$\Delta E_K = 1.0 \times 10^3 eV$$

match

Recall $V = 1.0 \times 10^3 V$

If an electron accelerates across a pot. diff of $5.0 \times 10^3 V \Rightarrow E_K = 5.0 \times 10^3 eV$





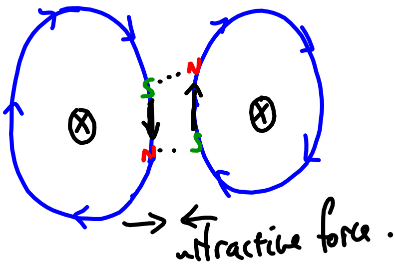
- If a conductor is grasped in the right hand, with the thumb pointing in the direction of the current, the curled fingers point in the direction of the field

So what about the force between two parallel current-carrying conductors.

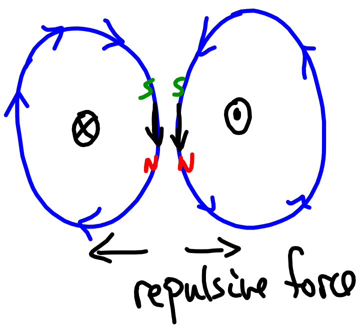
Consider two wires with the current flowing in the same direction:

• ← out of the board

X ← into the board.



Consider two wires with the currents flowin in opposite directions:



Current
→ force per unit length.