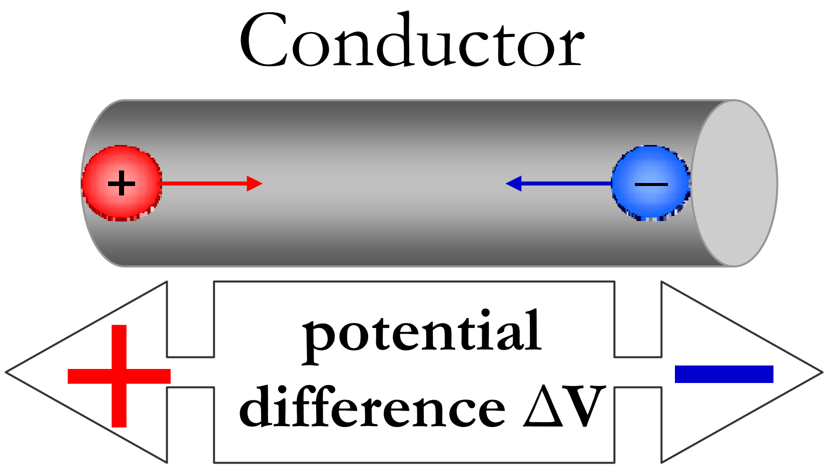
from Electrostatic to *ElectroDynamics*

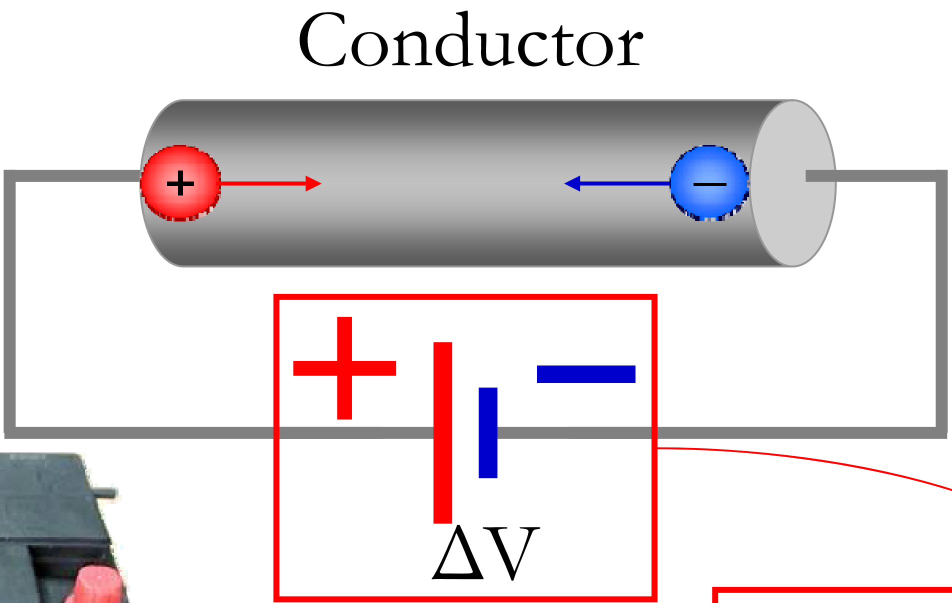


The motion of free charges of conductor balances the potential difference

(E = 0 in conductor

Surface is equipotential)

To keep constant a potential difference what is needed ?

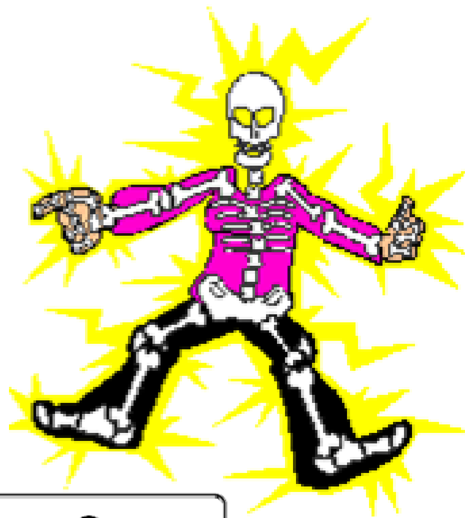


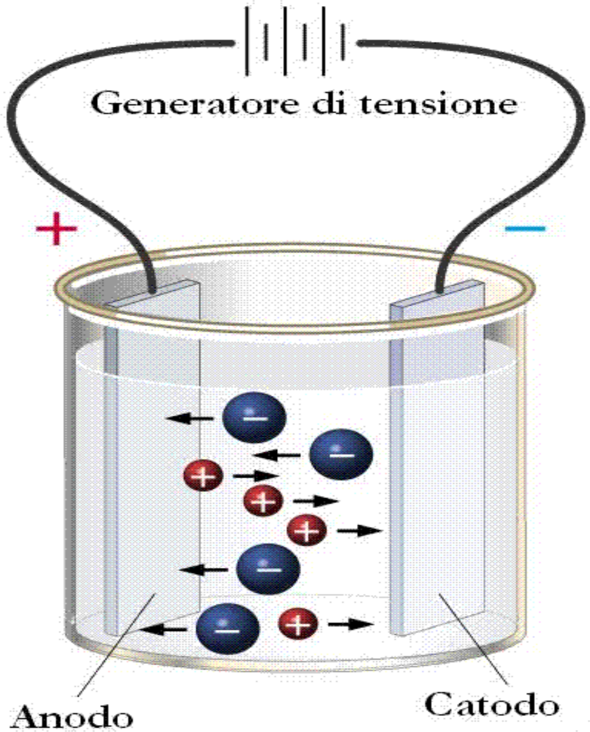
Pot. Diff. Generator

The moving charges

Type 1 Conductors

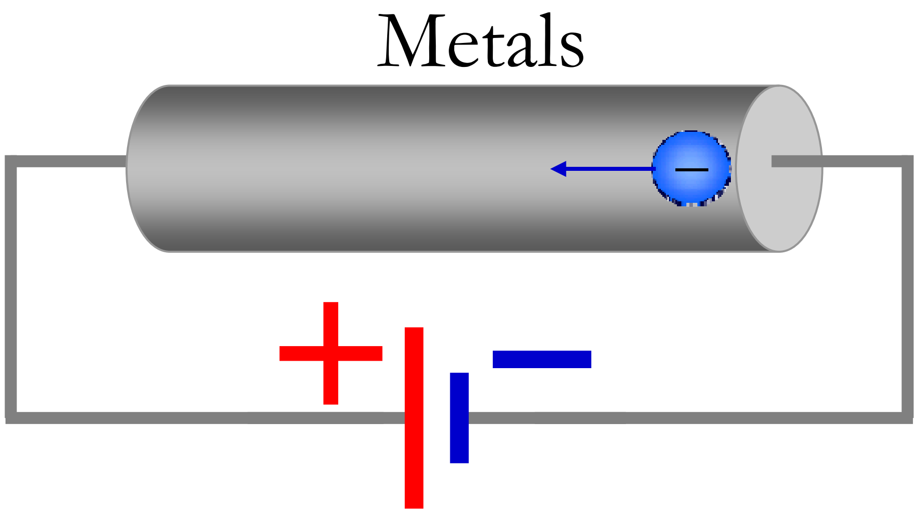
Electrolitic Solutions





The moving charges in Metals

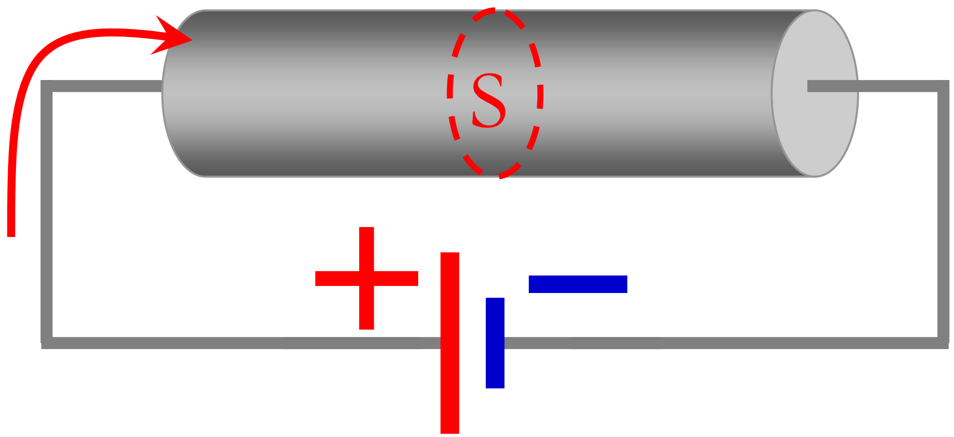
Type 2 Conductors



Electrons are the charges that move

Electric current

I= quantity of charge through S in unit time



[I]= [Q/t]   Ampere (A)

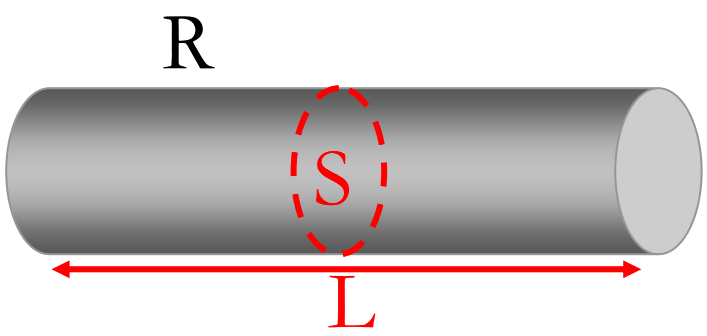
ΔV can also be written **V**

V=RI   **I Ohm's Law**

R = resistence
in V/A ohm (Ω)

R depends on type of conductor

II Ohm's Law



$$R = \sigma\,(L/S) = (1/c)(L/S)$$

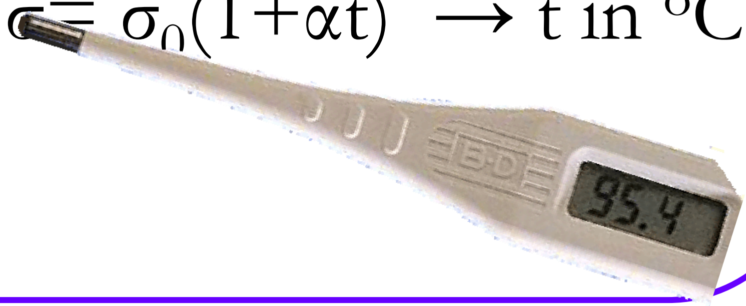
σ = resistivity in Ω·m

c = conductivity in $\Omega^{-1}m^{-1}$

	σ_0 (in Ωm)	α (in $^oC^{-1}$)
Ag	1.6×10^{-8}	0.0038
Cu	1.7×10^{-8}	0.0039
Au	2.4×10^{-8}	0.0039
Al	2.8×10^{-8}	0.0039
Fe	10×10^{-8}	0.0050
Glass	10^{12}	
China	10^{13}	

σ(material, T)

$\sigma = \sigma_0(1+\alpha t) \rightarrow$ t in ^oC



Esercise

A 9.00 V power supply is in a circuit made with Cu wire. The diameter is 2 mm, the temperature = 0°C, the resistence = 5.41 Ω

1 Calculate the current in the circuit

$$I=V/R \quad =9.00/5.41 =1.66 \text{ A}$$

2 Calculate the lenght of the wire

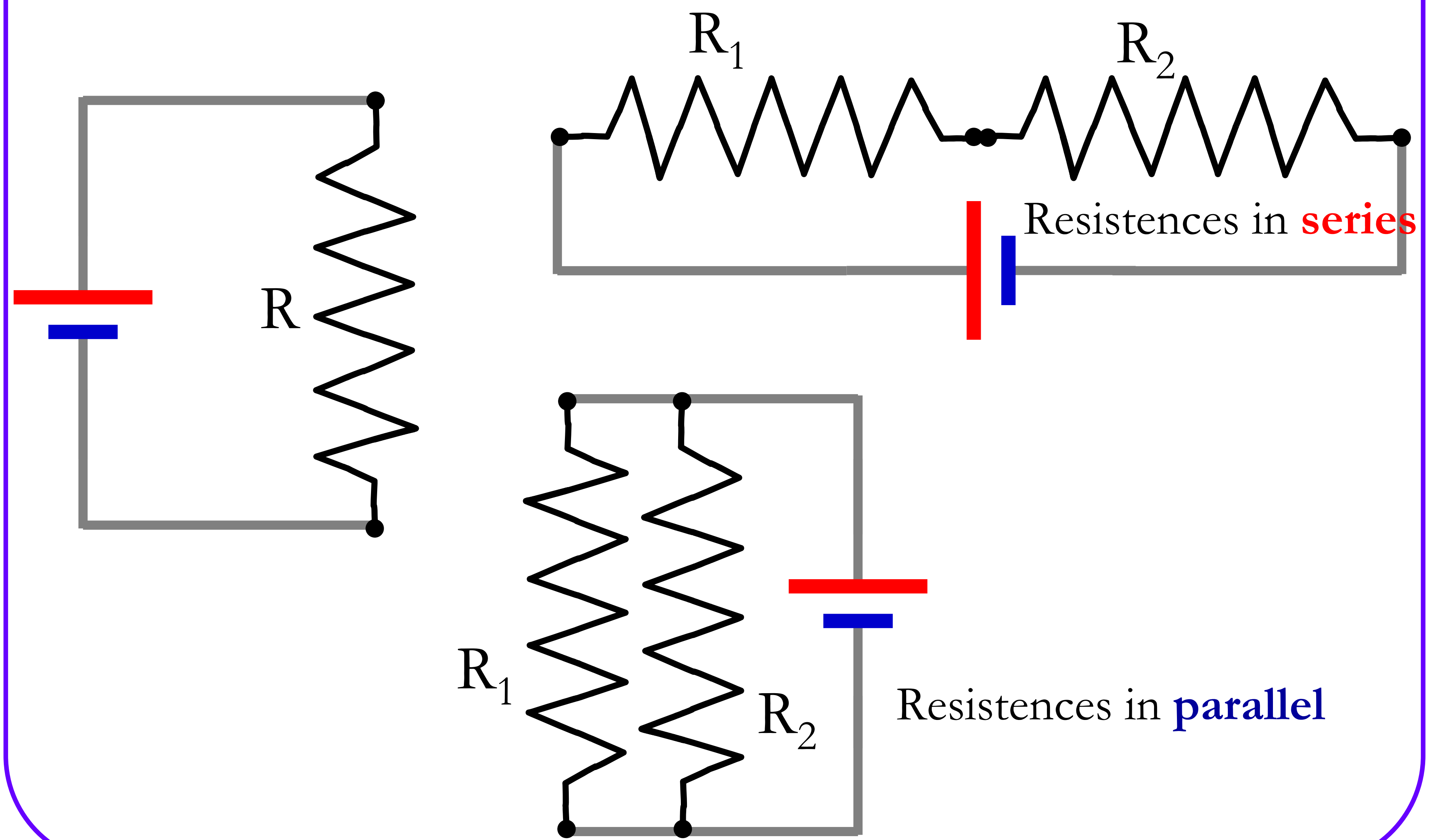
$$R = \sigma(L/S)$$

$$\sigma = \sigma_0(1+\alpha T) \quad T=0 \rightarrow \sigma = \sigma_0 = 1.7\times10^{-8}\ \Omega\text{m}$$

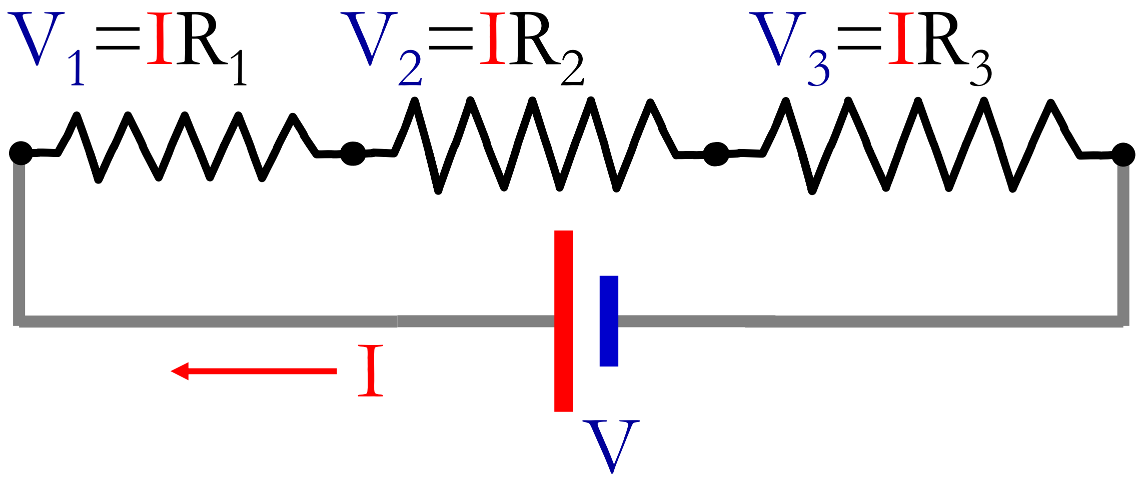
$$L= RS/\sigma_0 = R\pi d^2/4\sigma_0$$

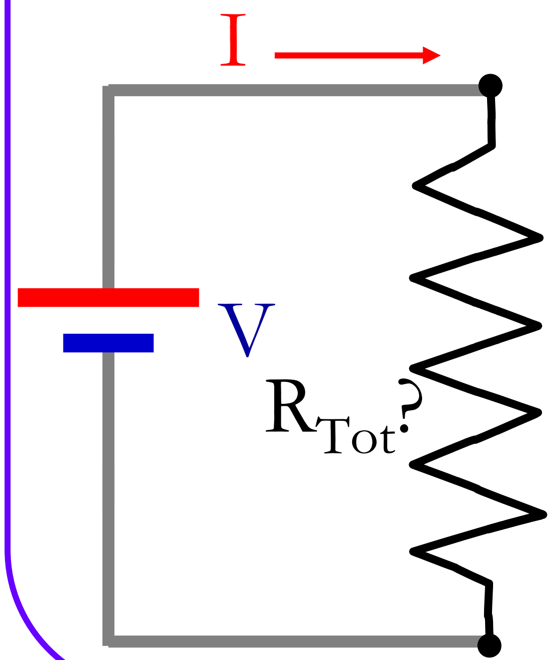
$$= 5.41\cdot3.14\cdot4\times10^{-6}/(4\cdot1.7\times10^{-8}) = 999 \text{ m}$$

Representations



Resistences in series

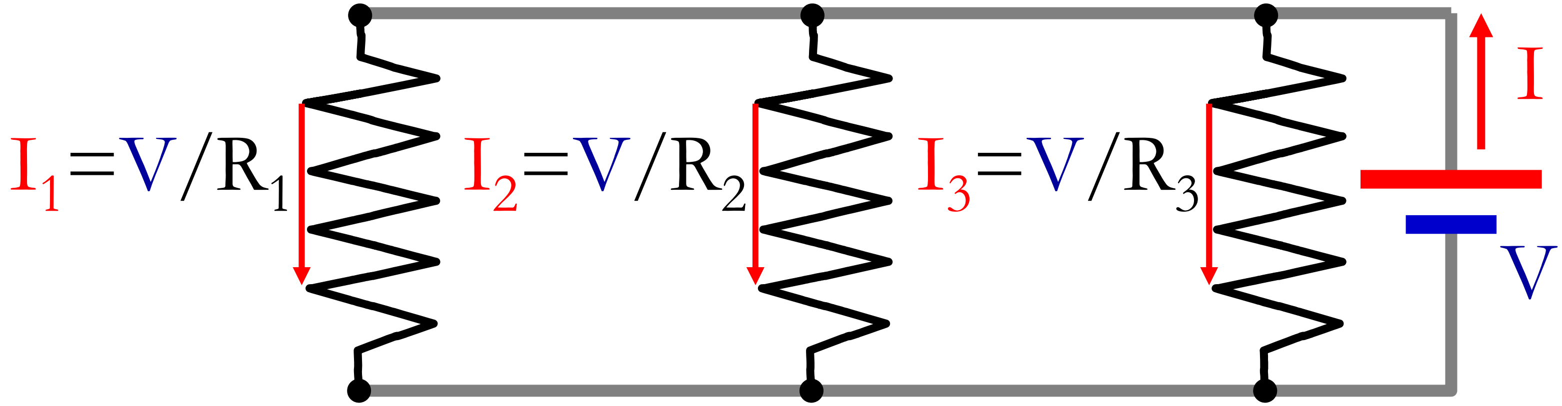


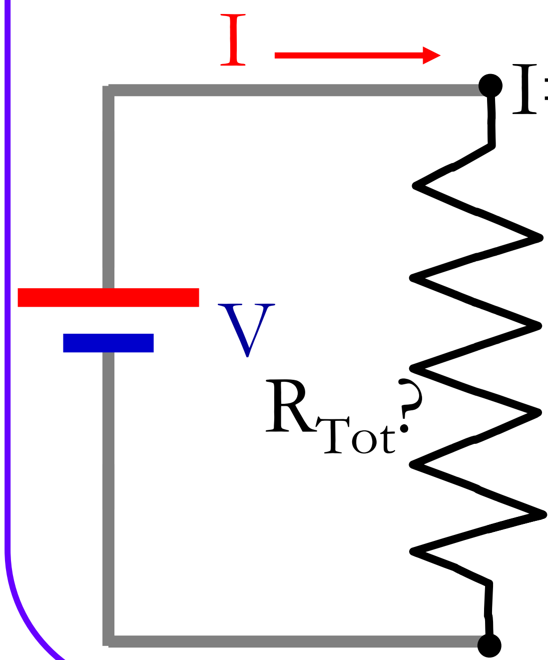


$$V=V_1+V_2+V_3=I(R_1+R_2+R_3)=IR_{Tot}$$

$$R_{Tot}=\sum_{1}^{n}R_i$$

Resistences in Parallel





$$I=I_1+I_2+I_3=V(1/R_1+1/R_2+1/R_3)=V/R_{Tot}$$

$$\frac{1}{R_{Tot}} = \sum_{1}^{n} \frac{1}{R_i}$$

Esercise

A continous 60 V power supply is in a circuit with three resistences in series, 9.5 kΩ, 11.2 kΩ, 17.1 kΩ. Calculate the current

$I=V/R_{Tot}$ $R_{Tot}=R_1+R_2+R_3$ $I=V/(R_1+R_2+R_3)$

$=60/[(9.5+11.2+17.1)\times 10^3]=1.57\ mA$

The same resistences are now in parallel. Calculate the current

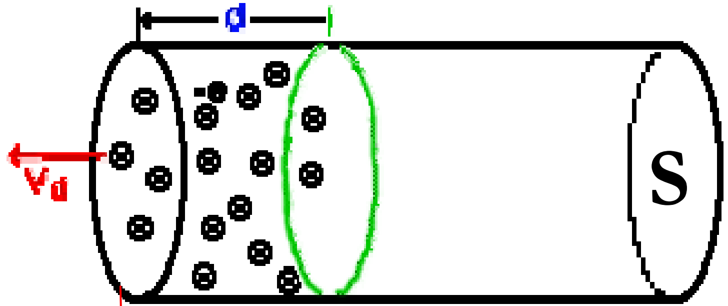
$I=V/R_{Tot}$ $1/R_{Tot}=1/R_1+1/R_2+1/R_3$

$=[1/9.5+1/11.2+1/17.1]\times 10^{-3}=0.25\times 10^{-3}\Omega^{-1}$

$R_{Tot}=4\times 10^3\ \Omega=4\ k\Omega$ $I=60\cdot(0.25\times 10^{-3})=15\ mA$

Microscopic Interpretation of Current

n = number of free e per unit volume



Q = e n S d free charge in volume =d S

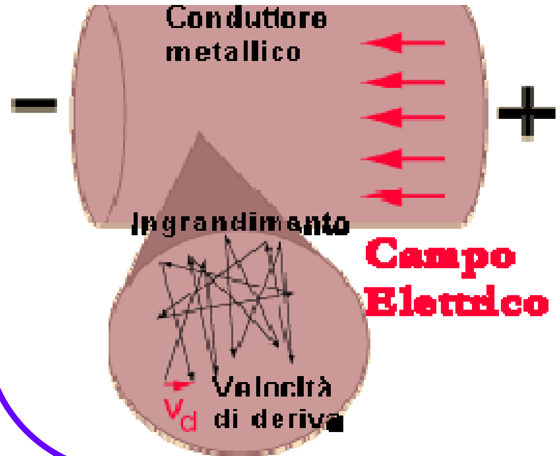
t = d/v_d time for Q going through **P**

P = point where **e are counted**

$$I = \frac{Q}{t} = \frac{enSd}{d/v_d}$$

$$I = enSv_d$$

f_a= - k v_d viscous friction in a conductor



f_e= - eE = eΔV/d electric force

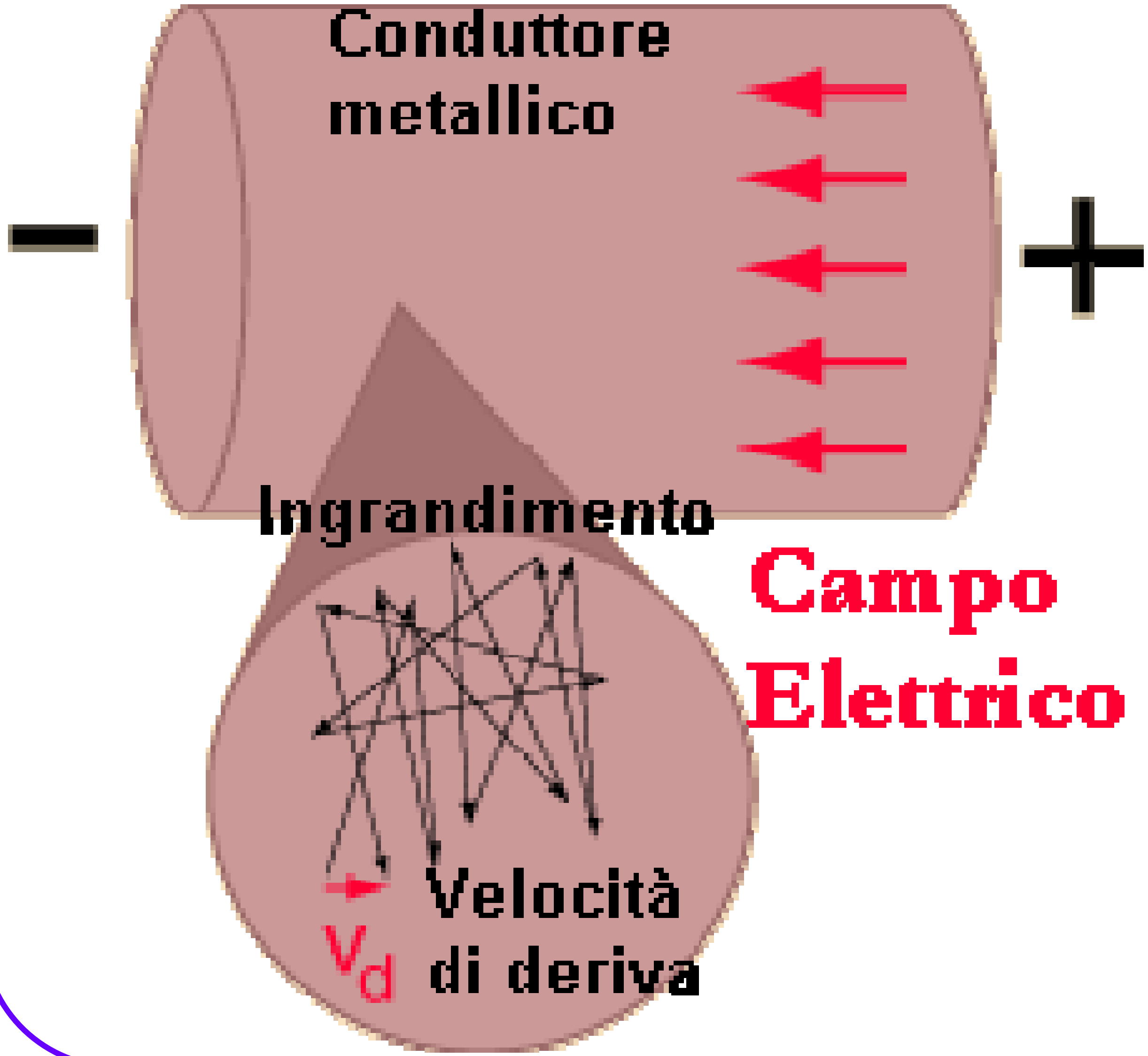
At equilibrium: f_e= - f_a ⇒ v_d = eΔV/(kd)

$$I = \frac{e^2 n}{k}\frac{S}{d}\Delta V = \frac{\Delta V}{R}$$

$$R = \frac{k}{e^2 n}\frac{d}{S}$$

$$\sigma = \frac{k}{e^2 n}$$

Drift velocity



Esercise

Calculate the drift velocity in a Cu wire (1 mm diameter), when the current is = 1 A. (m. w_{Cu}=63.5, ϱ_{Cu}=8.92×10^3 kg/m^3)

(Assume 1 free e per atom)

$$I = enSv_d$$

$$v_d = \frac{I}{enS}$$

n=(n. of moles in unit volume)$\cdot N_A = [\varrho_{Cu}/(p.m_{Cu}\times 10^{-3})]N_A$

$=[8.92\times 10^3/63.5\times 10^{-3}]\cdot 6.02\times 10^{23} = 8.5\times 10^{27}\ m^{-3}$

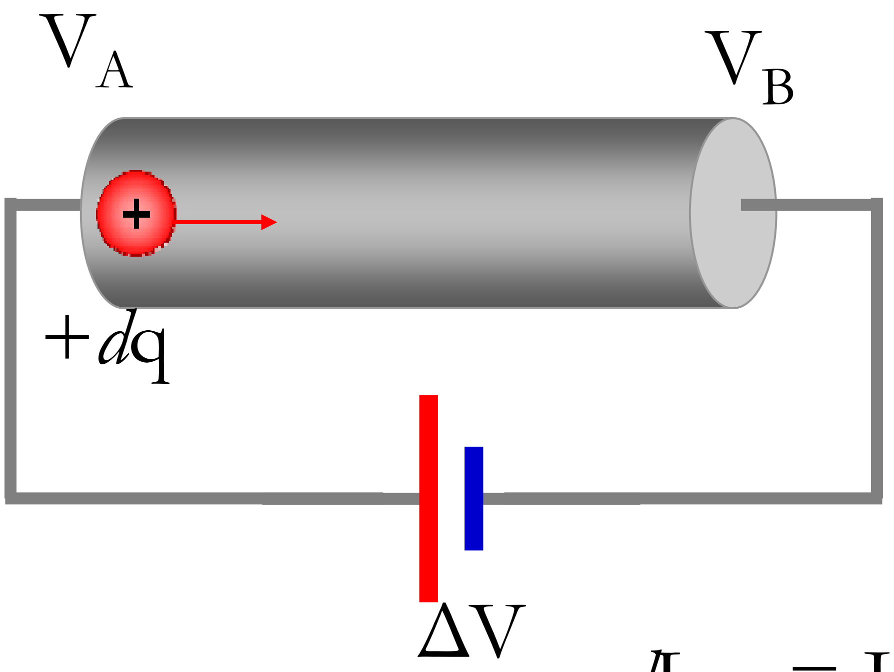
$e=1.6\times 10^{-19}$ C

$S=\pi d^2/4=3.14\cdot(1^2)\times 10^{-6}/4=7.85\times 10^{-7}$

$v_d=1/(1.6\times 10^{-19}\cdot 8.5\times 10^{27}\cdot 7.85\times 10^{-7})=9.4\times 10^{-4}$m/s=3.4 m/h

Energy Dissipated in a Conductor

Non conservative forces are acting !



$$dL_{AB} = -dq(V_B - V_A) = dq\Delta V$$

$$dq = I\,dt$$

$$dL_{AB} = I\,\Delta V\,dt$$

$$P = \frac{dL_{AB}}{dt} = VI = I^2R = \frac{V^2}{R}$$

Joule's Law

Esercise

A continuos 60 V generator is in a circuit with 3 resistences in parallel, respectively 9.5 kΩ, 11.2 kΩ, 17.1 kΩ. Calculate the power supplied by the generator

Joule's Law

$R_{Tot}=4\ k\Omega$ $P=V^2/R$ $P = (60)^2/4000 = 0.9\ w$

The same resistences are now in parallel. Calculate the poer

$$P = VI = 60 \times 1.57\ mA \times Volt = 94.2\ mw = 0.0942\ w$$