September, 15, 2010

$Force_E = eE$ →

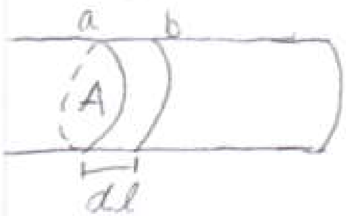
Particle flow-rate through cross-section from left to right.

= [(# particles crossing from left to right side)

− (" " " right to left side)]

divided by time elapsed

In a wire:

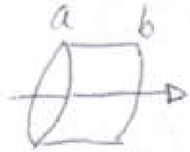


Cross-sectional area A = constant

n = Free electron density = $\frac{\text{\# Free electrons}}{\text{unit Volume}}$

Volume = $V = A\,dl$

dQ = net charge to cross



= [(charge entering at a)
+ (charge leaving b)
− (charge leaving at a)
− (charge entering b)] / 2 ← don't double count divide by 2

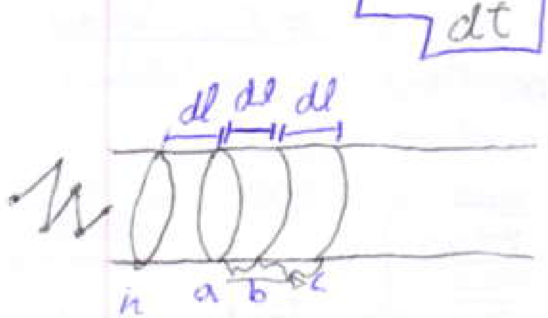
dt = (short) time elapsed

entering at a / leaving at a

Leaving at b / entering at b

↓

$I = \frac{dQ}{dt}$



I_f: $dl = V_d\,dt$ where V_d = average velocity of all free electrons (drift Velocity)

On average, over time dt, the free electrons between a & b end up between b & C, and the electrons between n & a end between a & b.

Magnitudes:

$$I = \left|\frac{dQ}{dt}\right| = \left|\frac{\overbrace{nV(-e)}^{dQ}}{dt}\right| = \frac{nVe}{dt} = nA \cdot \frac{dl}{dt} \cdot e = nAv_d e$$

# of free electrons in volume V
↑
$V = Al$

$$I = nAv_d e$$

Direction: $\vec{I}$ is in opposite direction of $\vec{v_d}$

= Examples of drift velocities =

- Copper wire at 20°C with 5.0A of current:

$v_d = 4.6 \times 10^{-5}$ m/s $= 0.46$ mm/s $= 3600 \cdot .046$ mm/hr $= 165.6$ mm/hr $=$ 16.6 cm/hr

How did they find V_d? We have $I = 5.0A$ & $I = nAv_d e$.

Need more info:
diameter of wire = 3.2 mm $A = \pi(1.6\text{ mm})^2$ $e = 1.60 \times 10^{-19}$ C

∴ Got A. Assume 1 free electron per copper atom. So, $n = \frac{\#\text{ copper atoms}}{\text{unit volume}}$ $n = \frac{\#\text{ free electrons}}{\text{unit volume}}$

We want: $\frac{\text{atoms}}{\text{Volume}} = \frac{\text{atoms/mass}}{\text{Volume/mass}} = \frac{\frac{\text{atom}}{\text{mass}}}{\frac{\text{Volume}}{\text{mass}}} = \frac{\frac{\text{mass}}{\text{Volume}}}{\frac{\text{mass}}{\text{atoms}}}$ } look up these

Copper = Cu = 29
63.546 = atomic mass

$$\frac{a}{b} \cdot \frac{d}{c} = \frac{\frac{a}{b}}{\frac{c}{d}} = \frac{\frac{d}{c}}{\frac{b}{a}} = \frac{d}{c} \cdot \frac{a}{b}$$

$\frac{mass}{Volume} = 8.9 \times 10^3\ kg/m^3$

page 340 For density Table at 20°C.

$\frac{mass}{atom} = 63.546\ g/mol$ 1 mol of Cu = 6.02×10^{23} Cu atoms.

$n = \frac{\#\text{Copper atoms}}{\text{unit Volume}} = \frac{8.9 \times 10^3\ kg/m^3}{63.549 / (6.02 \times 10^{23}\ \text{atoms})} = \frac{8.9 \times 10^3 \cdot 10^3 \cdot 6.02 \cdot 10^{23}}{63.546 \cdot m^3}$

$n = \frac{8.431 \times 10^{28}}{m^3}$

$A = \pi(1.6mm)^2 = \pi(2.56mm^2) = \pi(2.56(10^{-3}m)^2)$

$A = 8.00 \cdot 10^{-6}\ m^2$

$V_d = \frac{I}{nAe}$

$\frac{5.0\ A/s}{\frac{8.431 \times 10^{28}}{m^3} \cdot 8.00 \times 10^{-6}\ m^2 \cdot 1.60 \times 10^{-19}\ C}$

$= \frac{5.0\ m}{1.085 \times 10^7\ s} = \boxed{4.6 \times 10^{-5}\ m/s} = V_d$