Current density derivation wrt conductivity and Electric Field

Or

Conductivity derivation

- When an electric field E (V/m) is applied across a conductor, the electrons move with a velocity called drift velocity v_d (m/s), given by

$$v_d = \mu E \Rightarrow \boxed{\mu = v_d / E}$$

μ is called mobility (m^2/V-s) ← ((m/s)/(V/m))

- The directed flow of these electrons will constitute current.
- The current density (J) is given by

$$J = \frac{current}{area\ of\ cross\ section\ of\ conductor} = \frac{I}{A}$$

$$J = nqv_d$$

Here, n = electron concentration (number of electrons/unit volume)

q = charge on electron (- 1.6x 10^{-19} C)

Substituting for drift velocity (v_d) in J, we get

$$J = nqv_d = nq(\mu E)$$

$$J = \sigma E$$

Where σ is called conductivity $(\Omega - m)^{-1}$ of the material

$$\boxed{\sigma = n\mu q}$$