

$$I = \frac{Q}{T} = \frac{q \times N}{T} = \frac{q \times n \times \text{VOL}}{T}$$

$N = n \times \text{VOL} = \frac{q \times n \times d \times A}{T}$

$I = qn v A$

*Annotations:*  
 -  $n$ : concentration #/cm<sup>3</sup>  
 -  $v$ : for velocity  
 -  $d \times A$ : circled in blue in the original image

$$\frac{I}{A} = qn v = \vec{J}(x, y, z)$$

$-\frac{dV}{dl} = \vec{E}(x, y, z)$

$V = - \int E \cdot dl$

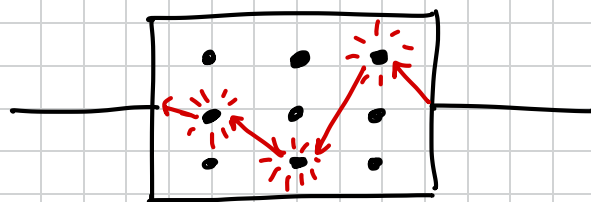
*Annotations:*  
 -  $\vec{E}$ : Electric field  
 -  $\vec{J}$ : current density  
 - Red arrow pointing from high to low potential:  $-\frac{dV}{dl}$

$$R = \frac{V}{I} = \frac{E \times l}{qn v A} = \frac{1}{qn} \times \frac{l}{v A}$$

$v = \text{average horizontal velocity}$

$\frac{1}{qn}$ : intensive (circled in red)  
 $\frac{l}{v A}$ : extensive

$\frac{1}{qn}$ : mobility



$$R = \frac{1}{qn\mu} \times \frac{l}{A} = \rho \frac{l}{A} \quad \rho = \rho(x,y,z)$$

Resistivity

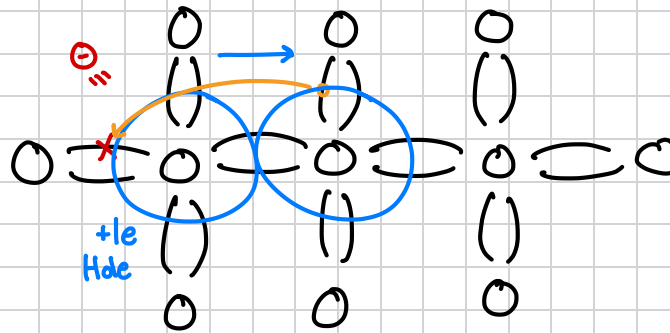
$$G = \frac{1}{R} = qn\mu \times \frac{A}{l} = \sigma \frac{A}{l}$$

Conductivity

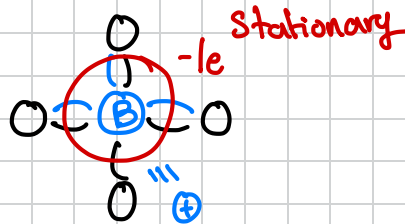
$$J = \frac{I}{A} = qnv = qn\mu E$$

$$J = \sigma E$$

$$E = \rho J$$



Electron - Hole Pair EHP



Boron - Doping

★ Holes are mobile

