Mobility

$$F = -qE$$

$$F = m_e^* \frac{dv}{dt}$$

Clean System

Pure Crystal

→ Periodic potential exists

$$\psi = \psi_0 e^{ikr}$$

$$\psi = \psi_k e^{ikr}$$

Bloch fr.

→ periodic with periodicity of crystal

→ Crystals are not perfect

→ In presence of imperfections, periodicity of potential is disturbed

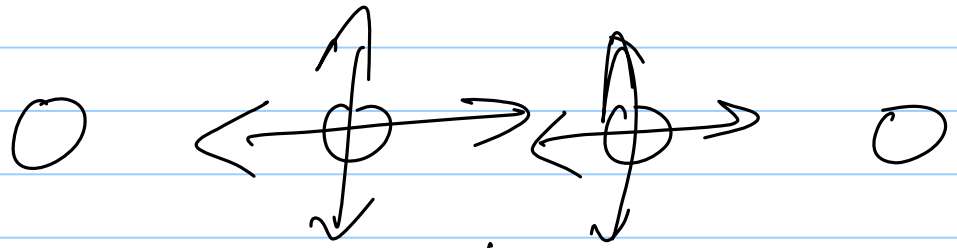
→ local $\mathcal{E}$ is generated.

→ ψ comes in that region, it interacts with the local $\mathcal{E}$

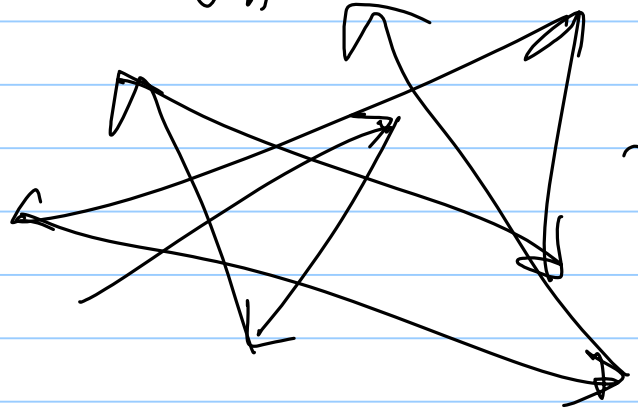
→ electrons are scattered

① Lattice scattering (phonon scattering)

② Impurity scattering



Lattice vibrations → phonons



v_{th} = thermal velocity

$$\frac{1}{2} m_e^* v_{th}^2 = \frac{3}{2} kT$$

$$\Rightarrow v_{th} = \sqrt{\frac{3kT}{m_e^*}} \cong 10^7 \text{ cm/sec}$$

$T = 300K$

$$I_n = A q n v_d$$

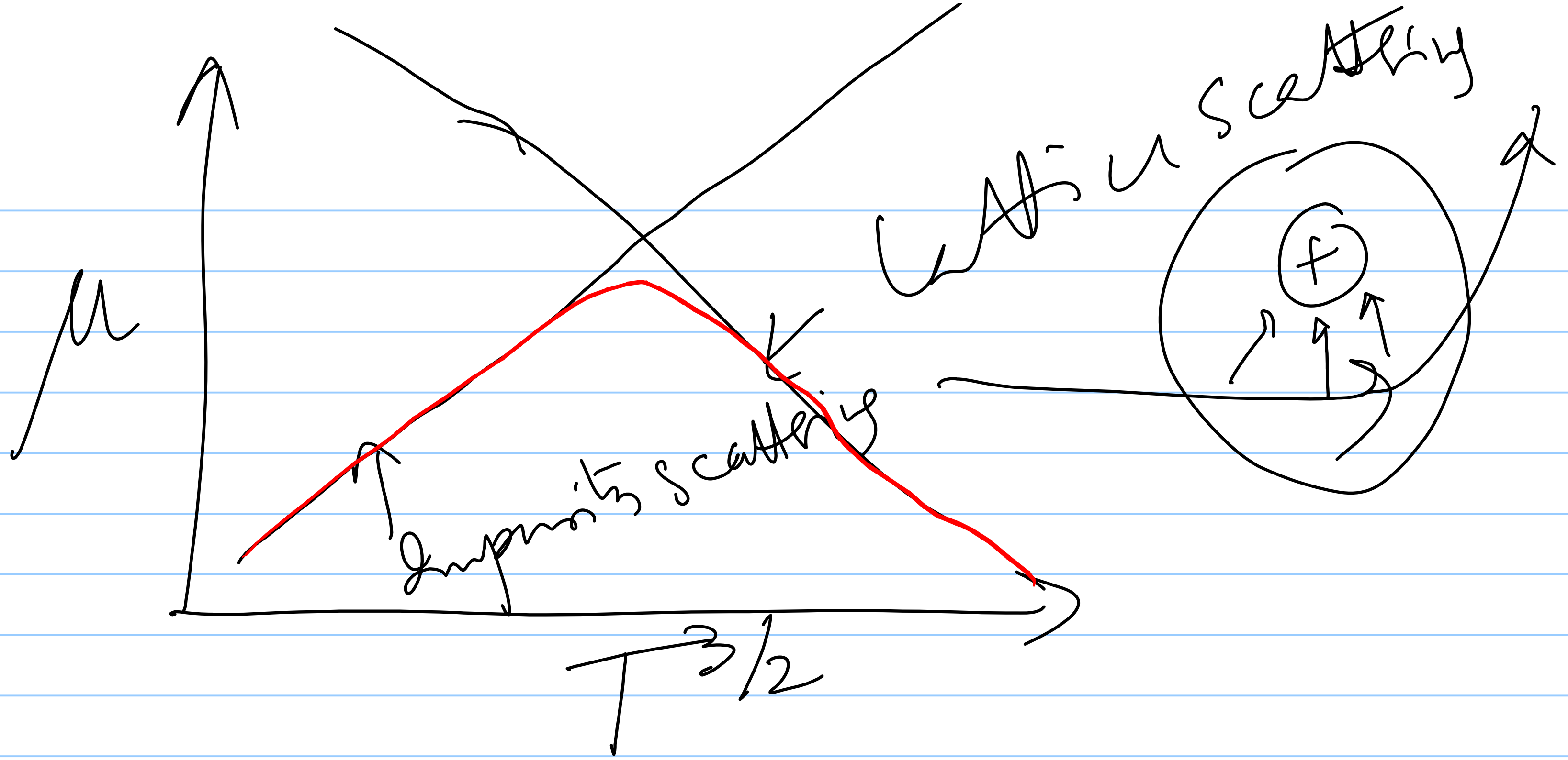
$$v_d \approx 10 \text{ cm/s}$$

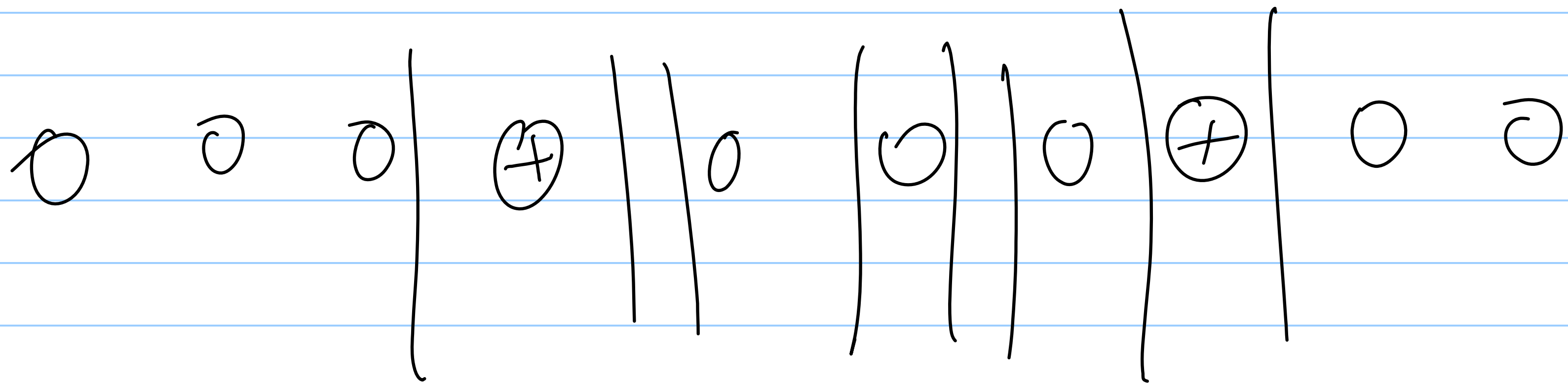
$I_n = 2 mA$

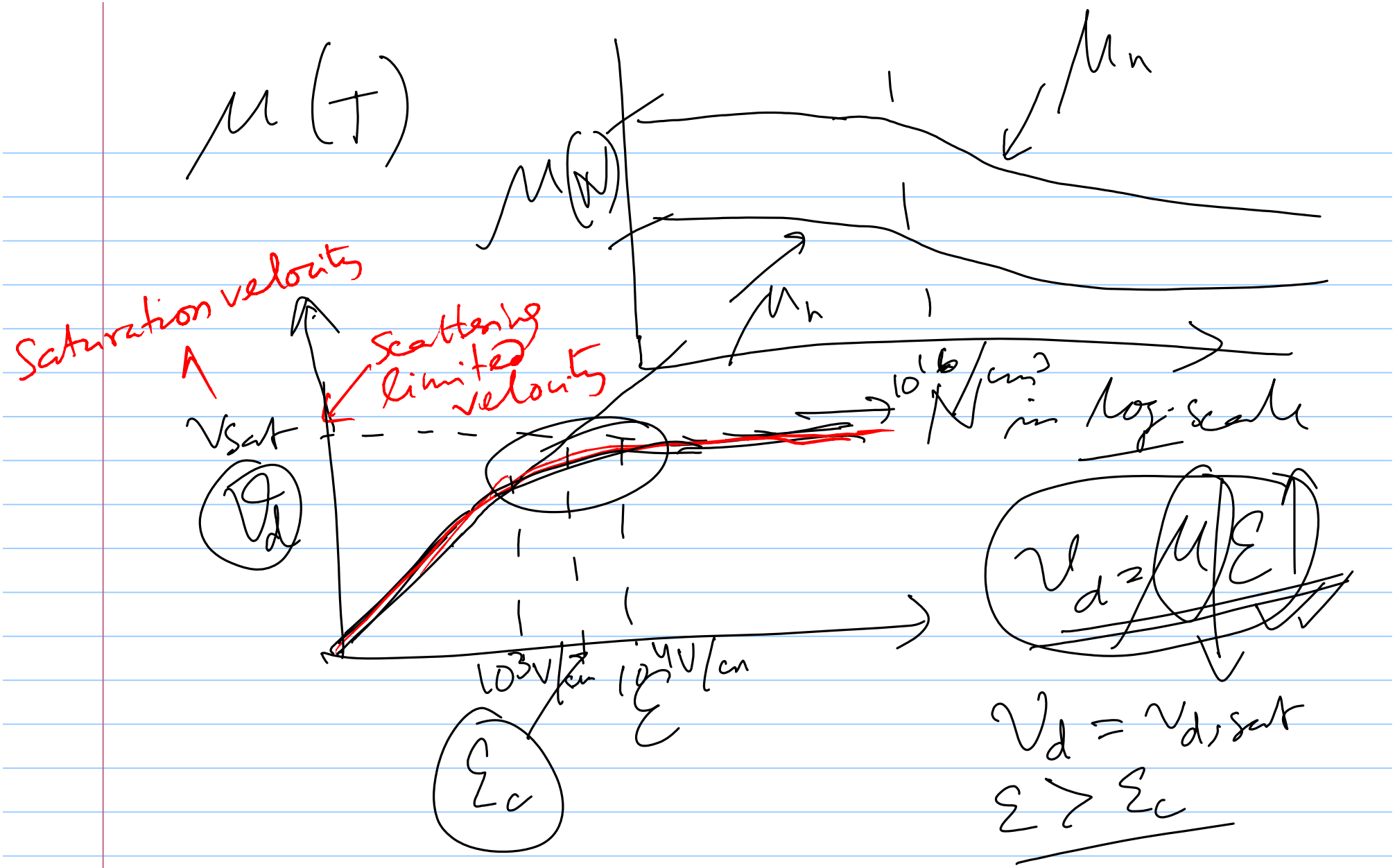
$A = 2 cm^2$

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

$n = 10^{16} / cm^3$


μ
Lattice scattering
Impurity scattering
$T^{3/2}$




μ (T)
μ (N)
μn
μn
Saturation velocity
Scattering limited velocity
vsat
vd
10^16/cm^3
in log-scale
10^3 V/cm
10^4 V/cm
ε
εc
vd = μ|ε|
vd = vd,sat
ε > εc

$$v_d = \mu \mathcal{E}$$

$$= \left(\frac{\mu_0}{1 + \frac{\mathcal{E}}{\mathcal{E}_c}} \right) \mathcal{E}$$

$v_{dsat} = 10^7 \text{ cm/s}$

$\mu_0 = 1000 \text{ cm}^2/\text{V-s}$

$\mathcal{E}_c = ? \; 10^4 \text{ V/cm}$

$$v_d = \left[\frac{\mu_0}{\sqrt{1 + \left(\frac{\mathcal{E}}{\mathcal{E}_c} \right)^2}} \right] \mathcal{E}$$

$\simeq \mu_0 \mathcal{E}$ for $\mathcal{E} \ll \mathcal{E}_c$

$\mathcal{E} \gg \mathcal{E}_c$

$\simeq \mu_0 \mathcal{E}_c = v_{dsat}$