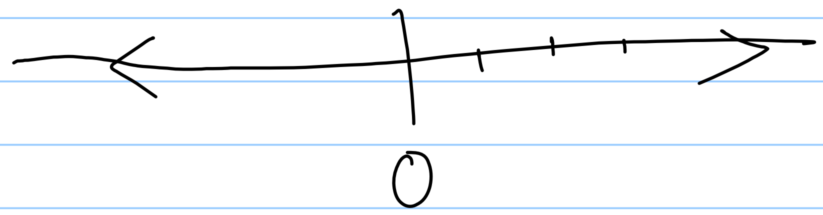
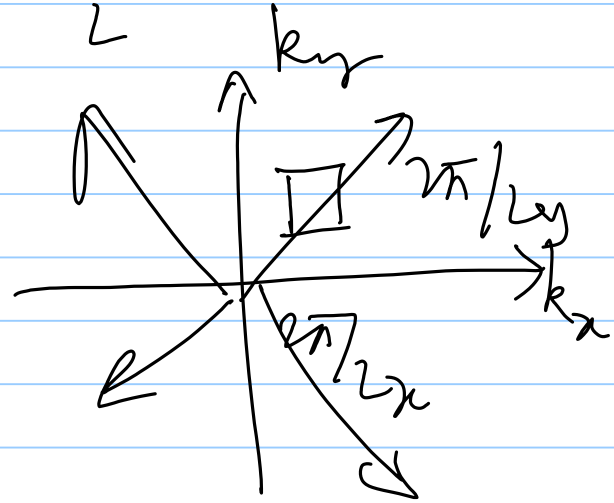
Calculation of n and p / cm^3

$D(E)$

k_n $\qquad k_1 = \frac{2\pi}{L}$ $\qquad \Delta k = \frac{2\pi}{L}$

$k_2 = \frac{4\pi}{L}$





$$\left(\frac{2\pi}{L_x}\cdot\frac{2\pi}{L_y}\cdot\frac{2\pi}{L_z}\right) \longrightarrow 1 \text{ k-state}$$

$N(k_r)$

$$N(k_r) = \left(\frac{4}{3}\pi k_r^3\right) \cdot \frac{L_x L_y L_z}{2\pi \cdot 2\pi \cdot 2\pi}$$

$$N(E) = \frac{V_\Omega}{\cancel{8}\pi^3_{\,2}} \cdot \frac{\cancel{4}}{3} \frac{\pi}{\hbar^3} \left\{2m^*(E-E_0)\right\}^{3/2} \qquad E = E_0 + \frac{\hbar^2 k_r^2}{2m^*}$$

$$= \frac{V_\Omega}{6\pi^2 \hbar^3} \left\{2m^*(E-E_0)\right\}^{3/2}$$

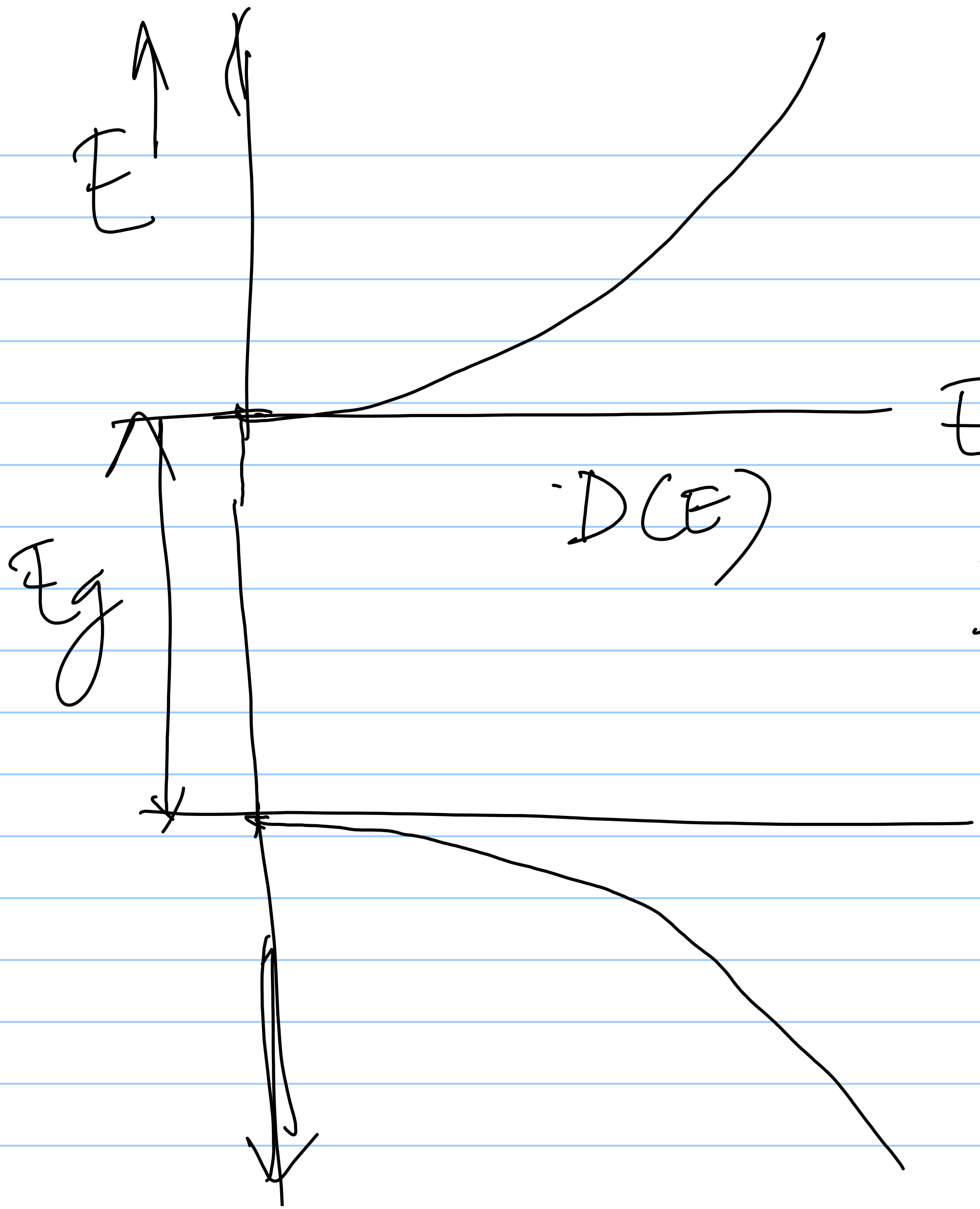
$$D(E)\,dE = \frac{1}{V_n}\,dN(E)$$

spin degeneracy

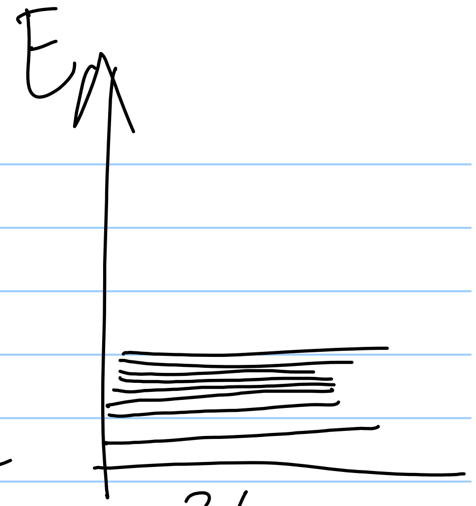
$$D(E) = \frac{2}{V_n}\,\frac{dN(E)}{dE}$$

$$= \frac{\cancel{2}\times(2m^*)^{3/2}}{\cancel{6}\,2\,\pi^2\hbar^3}\,\frac{\cancel{3}}{\cancel{2}}\sqrt{E-E_0}$$

$$\boxed{D(E) = \frac{(2m_e^*)^{3/2}}{2\pi^2\hbar^3}\sqrt{E-E_0}}$$



$E_0 = E_c$



$$D_c(E) = \frac{(2m_e^*)^{3/2}}{2\pi^2\hbar^3}\sqrt{E-E_c}$$

$$D_v(E) = \frac{(2m_h^*)^{3/2}}{2\pi^2\hbar^3}\sqrt{E_v-E}$$

$$n = \int_{E_c}^{\infty} D(E)\, B(E)\, dE$$

Kinetic Theory of Gas

$$n_g = \text{Const.} \exp\left(\frac{-E}{kT}\right)$$ Boltzmann

$$n_{g0} = \text{Const.} \exp\left(-\frac{E_0}{kT}\right)$$

$$\boxed{\frac{n_g}{n_{g0}} = \exp -\left(\frac{E - E_0}{kT}\right)}$$

(B) Boltzmann factor

Conduction band electrons

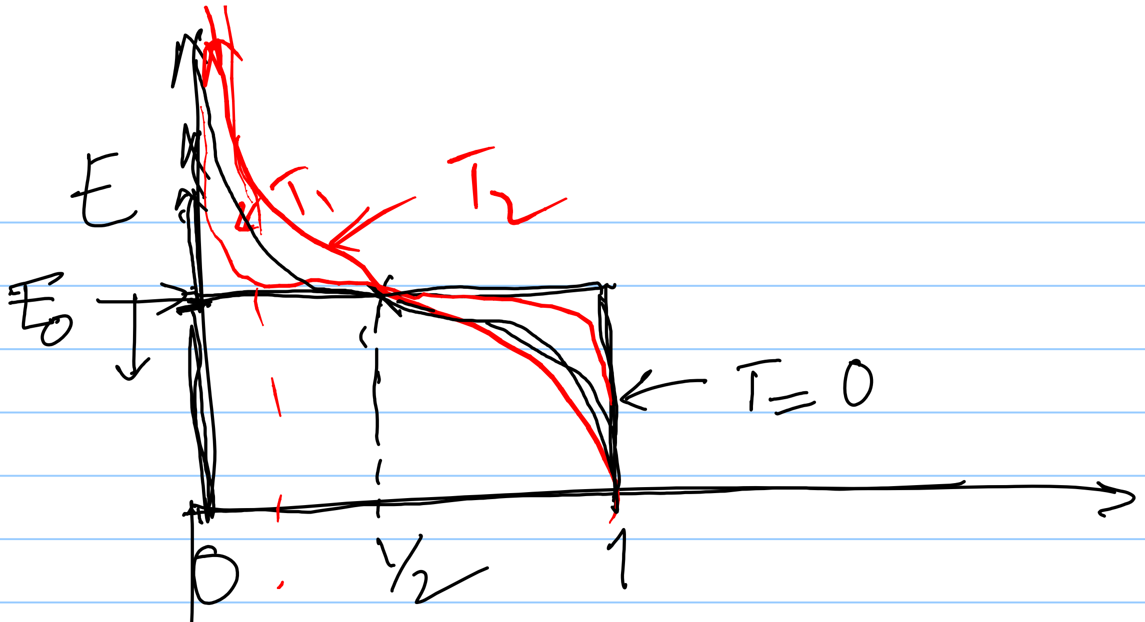
electron gas

obey exclusion principle

$$B(E) = \exp -\left(\frac{E - E_0}{kT}\right)$$

$$f_D(E) = \frac{1}{1 + \exp\left(\frac{E - E_0}{kT}\right)}$$

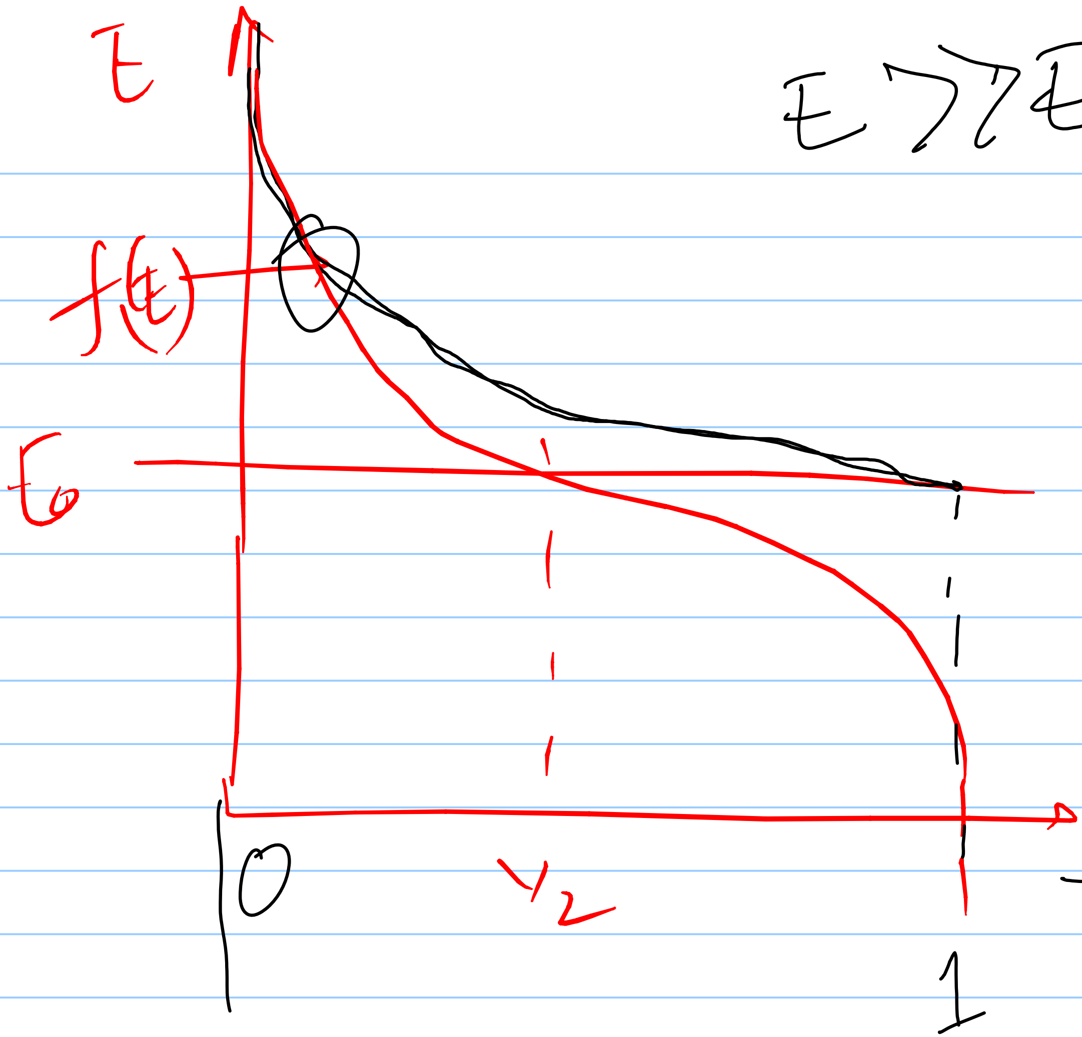
Fermi-Dirac factor



$f(E)$, $\cancel{B(E)}$

$$f(E) = \frac{1}{1 + \exp\left(\frac{E - E_0}{kT}\right)}$$

$$E \gg E_0 \quad B(E) \approx f(E)$$



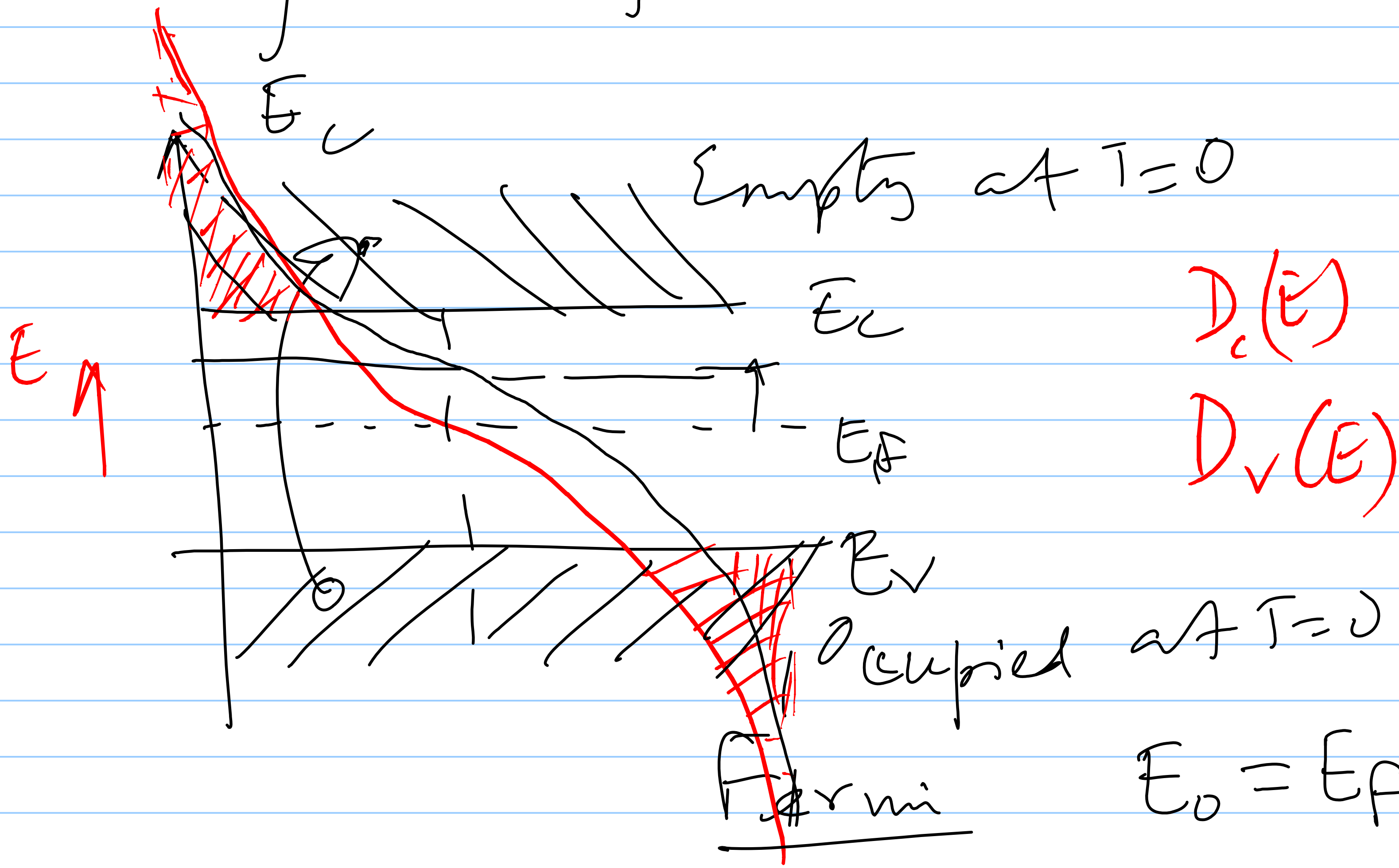
$$B(E) = \exp -\left(\frac{E-E_0}{kT}\right)$$

$$f(E) = \frac{1}{1+\exp\left(\frac{E-E_0}{kT}\right)}$$

$$\rightarrow f(E),\ B(E)$$

$$E - E_0 = n\,kT$$

$$n = \int_{E_c}^{E_c'} D(E)\, f(E)\, dE$$



$E_0 = E_F$

$$n = \int_{\Delta E} D_c(E)\, f(E)\, dE$$

$$\|$$

$$p = \int_{\Delta E} D_v(E)\,(1 - f(E))\, dE$$

$$E_F$$