F20 PHYSICS 137B: HW 12

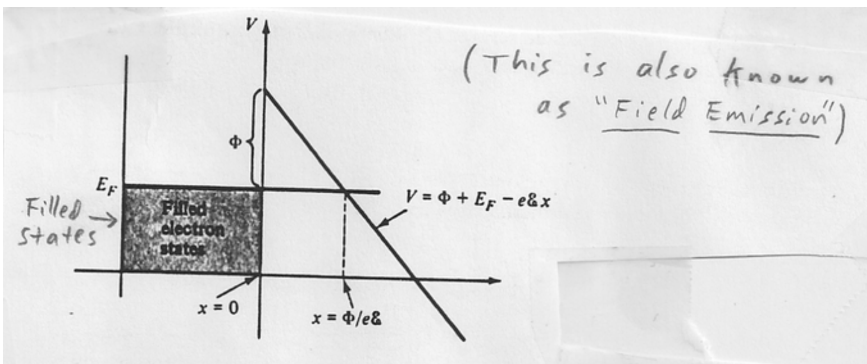
Due December 4 at 11:59 pm

November 17, 2020

1 Griffiths problems

Do the following problems from Griffiths: 9.1, 9.3, 9.8

2 Other problems



2.1

In the phenomenon of *cold emission*, electrons are drawn form a metal (at room temperature) by an externally supported electric field. The potential well that the metal presents tot he free electrons before the electric field is turned on is depicted in the figure above. After application of the constant electric field $\mathbf{E}$, the potential at the surface slopes down as shown in the figure, thereby allowing electrons in the Fermi sea to "tunnel" through the potential barrier. If the surface of the metal is taken as the $x = 0$ plane, the new potential outside the surface is:

$$V(x) = \Phi + E_F - eEx, \tag{2.1}$$

where E_F is the Fermi level and Φ is the work function of the metal.

a) Use the WKB approximation to calculate the transmission coefficient for cold emission.

b) Estimate the field strength E, in volt/cm, necessary to draw current density J_t of the order of mA/cm^2 from a potassium surface. The transmission coefficient is given by $T = \left|\frac{J_t}{J_{\text{inc}}}\right|$. For J_{inc}, use the expression $J_{\text{inc}} = env$, where n is the electron density and v is the speed of the electrons at the top of the Fermi sea. The relevant expression for E_F is

$$E_F = \frac{\hbar^2}{2m}\left(\frac{3n}{8\pi}\right)^{2/3}, \tag{2.2}$$

and $E_F = 2.1$ eV, $\Phi = 2.1$ eV for potassium.