HW1 Problem 4; EECS 277C *Nanotechnology*

2 dimensions

$$N_k dk = ?$$

Volume of circular shell

=2πkdk/4

4 is for upper right quadrant

Number of states in area=
area x States/area

States/area = 1 / (π/L)^2:

$$N_k dk = (2\pi kdk/4)\cdot\left(\frac{1}{(\pi/L)^2}\right)\cdot 2 = L^2\frac{kdk}{\pi}$$

$$\rho_k dk \equiv \frac{N_k dk}{\text{area}} = \frac{kdk}{\pi}$$

HW1 Problem 4; EECS 277C *Nanotechnology*

2 dimensions

$$\rho(E)dE = ?$$

We use:

$$\rho_k dk = \rho(E)dE$$

$$\rho_k dk = \frac{kdk}{\pi}$$

$$E = \frac{\hbar^2 k^2}{2m} \Rightarrow k = \sqrt{\frac{2mE}{\hbar^2}} \Rightarrow dk = \sqrt{\frac{2m}{\hbar^2}} \frac{dE}{2\sqrt{E}}$$

$$\boxed{\rho(E)dE = \frac{m}{\pi\hbar^2} dE}$$

HW1 Problem 5; EECS 277C *Nanotechnology*

1 dimension

$$N_k dk = ?$$

"Volume" of line segment
=dk

Number of states in length=
length x States/length

States/length = 1 / (π/L) :

$$N_k dk = (dk) \cdot \left(\frac{1}{(\pi / L)} \right) \cdot 2 = \frac{2}{\pi} L dk$$

$$\rho_k dk \equiv \frac{N_k dk}{\text{length}} = \frac{2}{\pi} dk$$

HW1 Problem 5; EECS 277C *Nanotechnology*

1 dimension

$$\rho(E)dE = ?$$

We use:

$$\rho_k dk = \rho(E)dE$$

$$\rho_k dk = \frac{2}{\pi} dk$$

$$E = \frac{\hbar^2 k^2}{2m} \Rightarrow k = \sqrt{\frac{2mE}{\hbar^2}} \Rightarrow dk = \sqrt{\frac{2m}{\hbar^2}} \frac{dE}{2\sqrt{E}}$$

$$\boxed{\rho(E)dE = \frac{2}{\pi}\sqrt{\frac{2m}{\hbar^2}} \frac{dE}{2\sqrt{E}} = \frac{1}{\hbar\pi}\sqrt{\frac{2m}{E}} dE}$$

HW1 Problem 6; EECS 277C *Nanotechnology*

Transmission prob:

$$T = \left[1 + \frac{V_0^2 \sinh^2 [ka]}{4E(V_0 - E)} \right]^{-1}$$

$$k = \sqrt{2m(V_0 - E)/\hbar^2}$$

$$V_0 = 10eV$$

$$E = 5eV$$

$$T = 1.5\ 10^{-10}$$

HW1 Problem 7; EECS 277C *Nanotechnology*

Fermi energy:

Al 11.7 eV   wavelength 0.5 nm

Problem 8:
In a 2d gas, the Fermi energy is well defined, and so is the Fermi wavevector.
The answers are: 3.5 meV and 80 nm.

Problem 9: There are many possible reasons for the non-linear I-V curve. The most obvious reason is that the applied voltage eV is comparable to the Fermi energy, so the approximation we made in integrating near the Fermi energy and taking the energy dependent term out as a constant breaks down.