1. Consider a 2-dimensional field effect transistor channel with a carrier density of $3 \times 10^{11}/\text{cm}^2$. If the electrons are slowed down by viscous drag on average within $\tau = 7 \times 10^{-14}$ seconds, what is the sheet resistance of the FET channel in units of Ohms per square? (Sheet resistance is the resistance of a square conductor area, and is independent of the size of that area.) Take the electron mass to be the normal mass of electrons in vacuum.

2. A Si wafer will tend to cleave (break apart) along \{111\} planes if sufficient stress is applied to the surface of the wafer. If the top surface is a \{100\} plane:

(a) What are the possible angles between the normal’s to the top surface, and the cleavage planes?

(b) If pressure is applied to a point on the surface of the wafer and cleavage occurs along \{111\} planes, through the pressure point, into how many pieces at maximum, will the wafer break? (A million pieces is not the correct answer.)

(c) Assuming cleavage occurs along a \{111\} plane, how will the broken edge of the wafer be oriented relative to the primary wafer flat? (The wafer is circular except for the wafer flat, a small straight edge, perpendicular to the \{011\} direction.)

3. In class you learned about a Fermi Sphere in 3-dimensional k-space, and the Fermi Disk in 2-dimensions. In a narrow one-dimensional wire you have the Fermi Line in a 1-dimensional k-space. The occupied states are indicated by the dashed line:

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-10^9 m^{-1} & 0 & 10^9 m^{-1} \\
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Thus the Fermi wave vector is $|k_F| = 10^9$ m^{-1}

(a) What is the average velocity, $|v|$ of the electrons in the wire? (numerical answer in m/sec)
(b) What is the root mean square velocity of electrons in the wire? (numerical answer in m/sec)

(c) How many electrons are there per centimeter of wire length? (numerical answer please)

(d) An electric field shifts the Fermi Line to the right by $0.5 \times 10^6$ m$^{-1}$:

\[ \begin{array}{c|c|c}
\text{\footnotesize{$-10^9$ m$^{-1}$}} & \text{0} & \text{10$^9$ m$^{-1}$} \\
\end{array} \]

What is the current in the wire, in Amperes?

4. In problem 2 of homework set No. 3, the Fermi Level had a slight dependence on temperature:

\[ E_f(T) = kT \ln\left( e^{E_f(0)/kT} - 1 \right), \text{ where } E_f(0) = Nh^2/(4 \pi m_A) \]

This can be used to make a thermocouple. Set the carrier density $N/A$ to be $1 \times 10^{12}$/cm$^2$, and let all the other fundamental constants have their usual values. What voltage would be generated by a temperature difference between 293$^\circ$K and 297$^\circ$K?

5. A neutron of charge zero and mass $1.675 \times 10^{-27}$ kg falls vertically from a height $z$ onto an InP crystal whose cubic lattice spacing is 0.5860 nano-meters (5.86 Angstroms). (InP is used to make opto-electronic devices for tele-communications. It has the zinc-blende structure, similar to GaAs, and slightly modified from Silicon, since the two atoms in the unit cell are different.) The crystal is oriented so that the <001> planes are parallel to the earth’s surface. What is the smallest reciprocal lattice vector that can produce backscattering? What is the minimum value of height $z$ that will allow the neutron to undergo reflection from the <001> planes, instead of just falling through the crystal lattice.

Hint: TAKE THE STRUCTURE FACTOR INTO ACCOUNT.