Quiz Answers: Week 7
ECE 656: Electronic Conduction In Semiconductors
Mark Lundstrom
Purdue University, Fall 2013

Lecture 15 Quiz :

1) The electron current equation commonly used in semiconductor physics is written as $J_n = \sigma_n d(F_n/q)/dx$. To derive this from the Landauer approach, what assumptions are needed?

   a) Near-equilibrium transport.
   b) Constant temperature.
   c) A conductor that is many mean-free-paths long.
   d) Answers a) and c) above
   e) Answers a) b), and c) above.

2) The drift-diffusion equation commonly used in semiconductor physics is written as $J_{nx} = nq\mu_n \mathcal{E}_x + qD_n\, dn/dx$. What assumption is **NOT needed** to derive this equation from the Landauer approach?

   a) Near-equilibrium transport.
   b) Constant temperature.
   c) A conductor that is many mean-free-paths long.
   d) Maxwell-Boltzmann statistics.
   e) Steady-state conductions.

3) Which of the following is correct about the conductivity of a 2D metal?

   a) $\sigma_S = q^2 D_n(E_F) D_{2D}(E_F)$
   b) $\sigma_S = q^2 D_{2D}(E_F) \dfrac{\upsilon^2(E_F)\tau(E_F)}{2}$
   c) $\sigma_S = \dfrac{2q^2}{h} M_{2D}(E_F)\lambda(E_F)$
   d) $\sigma_S = n_S q\left(\dfrac{q\tau(E_F)}{m^*}\right)$
   e) All of the above are correct.

continued on next page

4) What is the quantity: $\frac{2q}{hn_S}\int \lambda(E) M_{2D}(E)\left(-\frac{\partial f_0}{\partial E}\right) dE$?

a) The conductivity of a 2D material.
b) The mobility of a 2D material.
c) The diffusion coefficient of a 2D material.
d) The average mean-free-path of a 2D material.
e) The resistivity of a 2D material.

5) How can we determine is a long resistor is operating in near-equilibrium conditions?
a) The voltage across the resistor must be less that $k_B T/q$.
b) The measured current is proportional to the applied voltage.
c) The magnitude of the electric field satisfies $\mathcal{E} << (k_B T/q)/\lambda_E$ where λ_E is the energy relaxation length.
d) a) and b) above.
e) a), b), and c) above.

Lectures 16-17 Quiz:

1) The expression for the ballistic conductance, $G_{ball} = \frac{2q^2}{h} M(E_F)$ is valid when?

a) In the degenerate limit.
b) For 1D and 2D conductors.
c) For isothermal conditions.
d) For ballistic conductors
e) All of the above.

2) In general, we can write the ballistic conductance as $G_{ball} = \frac{2q^2}{h}\langle M \rangle$. What is $\langle M \rangle$?
a) The number of channels.
b) The number of channels at the Fermi energy.
c) The average number of channel in the Fermi window.
d) The number of channels at the bottom of the conduction band.
e) The total number of channels in the Fermi window.

continued on next page

3) The expression for the resistance, $R = R_{\text{ball}}\left(1 + L/\lambda_0\right)$ is **not valid** under what conductions?

a) In the ballistic limit.
b) In the diffusive limit.
c) In between the ballistic and diffusive limits
d) When the mean-free-path depends on energy
e) Under non-degenerate conductions.

4) For a ballistic resistor, the power dissipated is $P_D = IV = V^2/R$. Where is this power dissipated?

a) Uniformly within the resistor
b) Near the two ends of the resistor
c) In the contact with the most positive voltage
d) In the contact with the most negative voltage
e) In the two contacts.

5) For a ballistic resistor, with a voltage, V, applied across it, where does the voltage drop?

a) Uniformly within the resistor
b) Near the two ends of the resistor
c) In the contact with the most positive voltage
d) In the contact with the most negative voltage
e) In the two contacts.