Quiz Answers: Week 1
ECE 656: Electronic Conduction In Semiconductors
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1) Which bandstructure below best describes graphene?
   a) \( E = E_C + \frac{\hbar^2 k^2}{2m^*} \)
   b) \( E = E_V - \frac{\hbar^2 k^2}{2m^*_p} \)
   c) \( E = \hbar \nu_F k \)
   d) \( E = \pm \hbar \nu_F k \)
   e) \( E = \pm \hbar \nu_F k^2 \)

2) What is the “crystal momentum” of an electron?
   a) \( \vec{p} = m_0 \vec{\nu} \)
   b) \( \vec{p} = m^*_n \vec{\nu} \)
   c) \( \vec{p} = (m^*_n + m^*_p) \vec{\nu} \)
   d) \( \vec{p} = \hbar \vec{k} \)
   e) \( \vec{p} = \hbar^2 k^2 \vec{k} \)

3) What is the quantity, \( \psi(\vec{r}) = u(\vec{r}) e^{i k \vec{r}} \), called?
   a) a plane wave electron wavefunction
   b) the envelope function
   c) an atomic orbital
   d) a Wannier function
   e) a Bloch wave

4) Consider a 2D semiconductor sheet in the x-y plane. The top surface is at \( z = 0 \) and the bottom at \( z = t \). What is the wavefunction of the second subband? (Assume infinite confining potentials on the top and bottom).
   a) \( \psi(\vec{r}) = \sin(\pi z / t) e^{i k_x \vec{x} \times e^{i k_y \vec{y}}} \)
   b) \( \psi(\vec{r}) = \cos(2\pi z / t) e^{i k_x \vec{x} \times e^{i k_y \vec{y}}} \)
   c) \( \psi(\vec{r}) = \sin(2\pi z / t) e^{i k_x \vec{x} \times e^{i k_y \vec{y}}} \)
   d) \( \psi(\vec{r}) = \cos(\pi z / t) e^{i k_x \vec{x} \times e^{i k_y \vec{y}}} \)
   e) \( \psi(\vec{r}) = \cos(2\pi z / t) e^{i k_x \vec{x} \times e^{i k_y \vec{y}}} \)
5) What is a “quasi-electric field” for electrons?
   a) A quantity that exerts a force on electrons due to variations in electron affinity
   b) A quantity that exerts a force on electrons due to variations in bandgap
   c) A quantity that exerts a force on electrons due to variations in effective mass
   d) A quantity that exerts a force on electrons due to variations in the density of states
   e) A quantity that exerts a force on electrons and that is obtained by solving the Poisson equation.

6) Which of the following is true about the density of states in k-space?
   a) It depends on the dimensionality of the semiconductor.
   b) States are spaced uniformly in k-space.
   c) It is independent of the semiconductor’s bandstructure.
   d) All of the above.
   e) None of the above.

7) Which of the following is true about the density of states in energy space?
   a) It depends on the dimensionality of the semiconductor.
   b) States are spaced uniformly in energy space.
   c) It is independent of the semiconductor’s bandstructure.
   d) All of the above.
   e) None of the above.

8) What is the quantity, \[
   \sum_{k_x>0,k_y,k_z} v_x f_0(E_k) \}
   \sum_{k_x<0,k_y,k_z} f_0(E_k) \]
   a) Zero.
   b) The average, thermal equilibrium electron velocity
   c) The average, thermal equilibrium velocity of electrons with a +x-directed velocity
   d) The rms thermal velocity
   e) The Richardson thermal velocity
9) What is the difference between a “script F” Fermi-Dirac integral, $\mathcal{F}_j(\eta_F)$ and a “roman F” Fermi-Dirac integral, $F_j(\eta_F)$?

a) There is no difference – they are the same quantity.

b) $\mathcal{F}_j(\eta_F) = \frac{dF_j}{d\eta_F}$

c) $F_j(\eta_F) = \frac{dF_j}{d\eta_F}$

d) $F_j(\eta_F) = \Gamma(j + 1) F_j(\eta_F)$

e) $F_j(\eta_F) = F_j(\eta_F)$ for $\eta_F << 0$

10) Which of the following is true when $\eta_F >> 0$?

a) $\mathcal{F}_j(\eta_F) \rightarrow \exp(\eta_F)$

b) $\mathcal{F}_j(\eta_F) > \exp(\eta_F)$

c) $\mathcal{F}_j(\eta_F) < \exp(\eta_F)$

d) $\mathcal{F}_j(\eta_F) \rightarrow \exp(\eta_F)$

e) $\mathcal{F}_j(\eta_F) \rightarrow 1$. 