Week 9 Lecture 22 Quiz:
Phonon Transport
ECE 656: Electronic Conduction In Semiconductors

Mark Lundstrom
Purdue University, Fall 2013

Student's name: _____

Answer the **multiple choice questions** below by choosing the **one, best answer**. Then **ask a question** about the lecture.

1) The probability that an electron state is occupied is given by the Fermi function. The number of phonons in a particular state is given by the Bose-Einstein distribution, which is:

a) $n_0 = \dfrac{1}{e^{\hbar\omega/k_BT}+1}$

b) $n_0 = \dfrac{1}{e^{\hbar\omega/k_BT}-1}$

c) $n_0 = \dfrac{1}{e^{(\hbar\omega-E_F)/k_BT}+1}$.

d) $n_0 = \dfrac{1}{e^{(\hbar\omega-E_F)/k_BT}-1}$

e) $n_0 = \dfrac{1}{e^{(\hbar\omega-E_F)/k_BT}-2}$.

2) What is a plot of $\hbar\omega(\vec{q})$ vs. $\vec{q}$ for lattice vibrations called?

a) The Einstein approximation.
b) The Debye approximation.
c) The gray approximation.
d) The phonon dispersion.
e) The Brillouin zone.

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3) How can we obtain the phonon group velocity from a plot of $\hbar\omega(\vec{q})$ vs. $\vec{q}$?

a) The group velocity is $\vec{v}_g(\vec{q}_0) = \omega(\vec{q})/\vec{q}\big|_{\vec{q}=\vec{q}_0}$.

b) The group velocity is $v_g(\vec{q}_0) = d\omega(\vec{q})/d\vec{q}\big|_{\vec{q}=\vec{q}_0}$.

c) The group velocity is $\vec{v}_g(\vec{q}_0) = \omega(\vec{q}_0)\vec{q}_0$.

d) The group velocity is $v_g(\vec{q}_0) = \vec{c}$.

e) The group velocity is $v_g(\vec{q}_0) = \vec{v}_S$.

4) What is the biggest difference between the electron dispersion and the phonon dispersion of a material?

a) The size in q-space of the Brillouin zone for phonons is smaller than the Brillouin zone for electrons.
b) The size in q-space of the Brillouin zone for phonons is larger than the Brillouin zone for electrons.
c) The bandwidth in energy of the phonon dispersion is much less than the bandwidth of the electron dispersion.
d) The bandwidth in energy of the phonon dispersion is much greater than the bandwidth of the electron dispersion.
e) For a given material, the two dispersions are identical.

5) Comparing the electrical conductivity to the lattice thermal conductivity, which of the following statements is true?

a) The electrical conductivity can be positive or negative, but the lattice thermal conductivity is always positive.
b) The lattice thermal conductivity varies over many orders of magnitude.
c) The electrical conductivity varies over many orders of magnitude.
d) The two are related by the Wiedemann-Franz Law.
e) The two are related by the Lorenz number.

6) What question do you have about this lecture?

Turn in to Prof. Lundstrom in class on Friday.