

MEEN 5900: Special Topics on Nanotechnology  
Homework 3  
Due by Oct 22, 2007

1. Solve 4.1, 4.5, 4.8, 4.11.
2. Given a two-dimensional electron gas (mass  $m$ , spin  $\frac{1}{2}$  and charge  $e$ ) of  $N$  particles confined in a square of size  $L$ ,
  - a. calculate its density of states
  - b. calculate its Fermi energy
  - c. Using only simple physical arguments predict how the heat capacity of this 2D electron gas will depend on temperature  $T$  at low  $T$  (i.e.  $k_B T \ll$  Fermi energy).
3. Show that in the limit of low energies the density of states of phonon waves in an  $n$ -dimensional space ( $n=1,2$ , and  $3$ ) depends on the phonon energy  $E$  as  $E^{n-1}$ .
4. Determine for Al: (a) the electronic specific heat, (b) the mean free path of electrons at room temperature assuming that thermal conductivity of Al at room temperature is  $235 \text{ W/mK}$ . Compare the electronic specific heat to that given in any handbook. Are they very different? If so, why?

Given:

$$T=300 \text{ K}$$

$$k_B=1.38 \cdot 10^{-23} \text{ J/K}$$

$$n_e=18.1 \cdot 10^{28} \text{ m}^{-3}$$

$$E_F=11.7 \text{ eV}$$

$$v_F=2.03 \cdot 10^6 \text{ m/s.}$$