1. a) What is the temperature dependence of the electronic specific heat at very low temperature?
   b) Briefly explain why there is such a temperature dependence in (a). Use figures or equations to clarify your explanation if necessary.
   c) Calculate the density of states $D(E)$ for a two-dimensional free electron gas.

2. Consider a square (empty) lattice with lattice constant $a$. The symmetry directions of the reciprocal lattice are shown in figure.  

(a) Draw $E(k)$ for the first and second energy bands along the $\Gamma X$ direction in the first Brillouin zone. Include as much details as you can.
   (b) Similar to (a), draw $E(k)$ for the first and second energy bands along $\Gamma M$.
   (c) In the presence of a weak lattice potential, what would the result in (a) be changed?

3. The energy of an electron in a one-dimensional lattice is given by 
   \[ E(k) = E_0 + (E_2 - E_1) \sin^2 \left( \frac{ka}{2} \right); \] 
   $E_2 > E_1$.
   a) Find and sketch (in the repeated zone scheme) the group velocity of an electron in this band as a function of $k$.
   b) A uniform electric field $E$ is applied in the x-direction. Determine the period of electron oscillation.

4. The DC resistance of a two-dimensional electron gas is measured as a function of magnetic field at low temperature and it has the behavior shown below.

(a) Explain why there is such an oscillation? Use figures or equations to help you clarify your explanation.
   (b) Find out the area density of the two-dimensional electron gas. Express your answer in physical constants and $\Delta(1/B)$. Hint: $S\Delta(1/B) = 2\pi e/hc$. 
   \[ R = 1, 3, 5, 7, 9 \]  
   $1/B - 1/B_0 (1/$gauuss$)$