University of Kentucky
Department of Physics and Astronomy
PHY 525: Solid State Physics II
Fall 2000
Test 1

Date: October 9, 2000 (Monday)

Time allowed: 50 minutes.

Answer all questions.

1. ***Specific heat of a d-dimensional insulator.*** Consider a d-dimensional crystal with the dispersion relation given as $\omega = Ak^{\lambda}$ where A and λ are constants. Let N be the number of lattice points in the sample. (a) Calculate group velocity in terms of k. (b) If the Debye temperature θ_D is proportional to N^{α}. Calculate α in terms of λ and d. (c) If the phonon density of states $D(\omega)$ is proportional to ω^{β}. Calculate β in terms of λ and d. (d) If the heat capacity C at low temperatures is proportional to T^{δ}. Calculate δ in terms of λ and d. Discuss your results for the particular case of linear dispersion relation, with d=1, 2, and 3.

2. ***Quantum Hall Effect.*** Consider a two dimensional electron gas in a magnetic field B. Note that one flux quanta $\Phi_0 = \frac{2\pi\hbar c}{e}$

(a) What is the separation (in energy) between the Landau levels? (b) Calculate the number of states in one Landau level, in terms of electron surface density and other physical constants. (c) From your result in (b) derive the quantum of conductance. (d) Consider the experimental data provided in the following figure. Estimate the current through the strip with the step indexed as given. (e) Estimate the electron surface density from the figure.

Useful constants: $h = 6.626\times10^{-27}$ erg s $= 6.626\times10^{-34}$ Js

$e = 4.803\times10^{-10}$ esu $= 1.602\times10^{-19}$ C