MID-TERM -1

**Physics 752, Fall, 2002**

1. Find the expression for the particle-hole bubble $\Pi(q,0)$ at arbitrary $q$ in two dimensions.

2. The optical conductivity $\sigma(\omega)$ is expressed via the particle-hole bubble $\Pi(q=0,\omega) = \Pi(\omega)$ as

$$\sigma(\omega) = -\frac{\omega_p^2}{4\pi}\ \frac{Im\Pi(\omega)}{\omega} \tag{1}$$

where $\omega_{pl}$ is the plasma frequency. Suppose that $\Sigma(k,\omega) = i\gamma$ (impurity scattering). Find $\sigma(\omega)$

3. For the problem (2), compute

$$\int_0^\infty \sigma(\omega)d\omega \tag{2}$$

(hint - use Kramers-Kronig relations). Explain the result.

4. Show that

$$S(k) = \int_{-\infty}^{\infty} S(k,\omega)\frac{d\omega}{2\pi}, \tag{3}$$

where

$$S(k,\omega) = \hbar\left(\coth\frac{\hbar\omega}{2T}\right) Im\chi(k,\omega), \tag{4}$$

can be re-expressed as

$$S(k,\omega) = T\sum_n \chi(k,\omega_n) \tag{5}$$

where $\omega_n$ are Matsubara frequencies

5. Find the Green's function of a phonon field (see \$31 in Landau).