Physics 238C **Spring 2011**

Condensed Matter Physics **due 2:00 pm Thursday May 19**

PROBLEM SET 7

Reading: AM Chapter 34 or Marder (2nd Ed) Chapter 27 or Kittel (8th Ed) Chapter 10

1. **Josephson Inductance** Starting from

$$I = I_c \sin\delta \tag{1}$$

show that the nonlinear inductance L_J of a Josephson junction is given by

$$L_J = \frac{\phi_o}{2\pi}\frac{1}{I_c \cos\delta} \tag{2}$$

where ϕ_o is the flux quantum given by

$$\phi_o = \frac{2\pi\hbar c}{2e} \tag{3}$$

Remember that the inductance is positive.

2. **Ginzburg-Landau Equation and the Proximity Effect** When a normal metal is placed in contact with a superconductor, the superconducting wave function can leak into the metal and make the metallic region near the interface superconducting. This is known as the proximity effect.

Consider a metal (in the half-space $x > 0$) in contact with a superconductor (occupying a region $x < 0$). Assuming that the normal metal can be described by a Ginzburg-Landau model but with $a > 0$, show that the superconducting order parameter $\psi(x)$ induced in the metal by the contact with the superconductor is approximately

$$\psi(x) = \psi(0)e^{-x/\xi(T)} \tag{4}$$

where

$$\frac{\hbar^2}{4m\xi(T)^2} = a > 0 \tag{5}$$

and $\psi(0)$ is the order parameter of the superconductor at the interface.

Hint: Start from the Ginzburg-Landau equation

$$-\frac{\hbar^2}{4m}\nabla^2\psi + a\psi + b|\psi|^2\psi = 0 \tag{6}$$