Physics 238C **Spring 2011**

Condensed Matter Physics **due 2:00 pm Thursday April 28**

PROBLEM SET 4

1. (20 pts) In the Weiss (mean–field) theory of ferromagnetism the Gibbs free energy ($G = E(M) - HM - TS$, where H is the externally applied magnetic field, M is the magnetization, E is the internal energy, and S is the entropy) has the form

$$G = G_o(T) + a(T)M^2 + b(T)M^4 + O(M^6) - MH \tag{1}$$

where $G_o(T)$ is independent of M, and where the coefficient $b(T)$ is a slowly varying function of T but $a(T)$ is of the form $a_o(T - T_C)$, T_C being the critical temperature in Weiss theory. Assume that T is close to T_C and that M is small. Using the fact that in thermal equilibrium M will take the value which minimizes G, find (a) the equilibrium value of M for $H = 0$, for $T > T_C$ and $T < T_C$; (b) the form of M at T_C as a function of H; (c) the zero–field differential susceptibility $\chi = (\partial M/\partial H)_{T,H=0}$ for $T > T_C$ and $T < T_C$; and (d) the discontinuity in the specific heat at constant H ($C_H = -T(\partial^2 G/\partial T^2)_H$) at the point $T = T_C$ and $H = 0$. In other words find the difference between the limits of $C_H(T, H = 0)$ as $T \to T_C$ from above and from below.