

## Critical Phenomena

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The Hamiltonian of a system is given by

$$H = \int d^3x \left( \frac{1}{2} (\partial_\mu \varphi)^2 + \frac{1}{2} r_0 \varphi^2 + \frac{1}{4!} u_0 \varphi^4 \right) \quad (1)$$

Introduce a magnetic field  $B(x)$ , and write down the expression for  $Z[B(x)]$ !

- 1) Use the saddle point expansion to derive a formula for  $Z[B(x)]$  in terms of a loop expansion, for a general  $H(\varphi)$ .
- 2) Derive the expression for  $\Gamma[M]$ , with the help of a Legendre transform including the first order term beyond meanfield.
- 3) Calculate the first contribution of the loop expansion to  $\Gamma[M]$ , that is

$$\frac{1}{2} \text{Tr} \ln \frac{\delta^2 H}{\delta M^2} \quad (2)$$