

University of California at San Diego – Department of Physics – Prof. John McGreevy

Physics 211C (239) Phases of Quantum Matter, Spring 2021 Assignment 1

Due 12:30pm Monday, April 5, 2021

- Homework will be handed in electronically. Please do not hand in photographs of hand-written work. The preferred option is to typeset your homework. It is easy to do and you need to do it anyway as a practicing scientist. A LaTeX template file with some relevant examples is provided [here](#). If you need help getting set up or have any other questions please email me. I am happy to give TeX advice.
- To hand in your homework, please submit a pdf file through the course's Canvas website, under the assignment labelled hw01.

Thanks in advance for following these guidelines. Please ask me by email if you have any trouble.

Here are some problems related to the first lecture. If you've done them before, you don't need to do them again.

1. **Energy of vortex.** Consider a vortex of winding number one in the plane. Evaluate the leading term in the energy of this configuration,

$$F_{\text{LG}}^0[\phi] = \int_{|x|<L} d^2x \partial_i \phi \partial^i \phi.$$

2. **Illustration of Goldstone's theorem.** Evaluate the free energy

$$F_{\text{LG}}[\Phi(x)] = \int_{\text{space}} d^d x \left(V(|\Phi|) + \kappa \vec{\nabla} \Phi^* \cdot \vec{\nabla} \Phi \right)$$

in the ordered phase on the configuration $\Phi(x) = (v + \delta\rho(x))e^{i\phi(x)}$ where v is the minimum of $V(|\Phi|)$. Just keep the terms to leading nonvanishing order in $\delta\rho$.