# QFT Homework 1 Due 17 Sept 2012

This homework is due in the dropbox outside 2L26 by 11:59PM on the due date. If you wish to turn it in ahead of time, you may email a PDF (prepared with LaTeX) to Dr. Frey.

**Reading:** Tong's notes chapter 1. Also, read as much of Srednicki chapters 1 & 2 as possible.

**To Be Marked:**

1. **Noether's Theorem** *From Lahiri & Pal 2.9*

   Consider a complex scalar field with Lagrangian density

   $$\mathcal{L} = -\partial_\mu \bar{\phi} \partial^\mu \phi - V\left(|\phi|^2\right) \ , \tag{1}$$

   where $\bar{\phi}$ is the conjugate of $\phi$. This Lagrangian is invariant under the transformation $\phi \to \exp[-iq\theta]\phi$ and its conjugate.

   (a) Find the equation of motion for $\phi$ from the given Lagrangian (remember to treat $\phi$ and $\bar{\phi}$ as independent variables).

   (b) Use Noether's theorem to find the corresponding conserved current $j^\mu$ and verify that $\partial_\mu j^\mu = 0$.

   (c) If we include the electromagnetic field, the Lagrangian becomes

   $$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \left[(\partial - iqA)_\mu \bar{\phi}\right] \left[(\partial + iqA)^\mu \phi\right] - V\left(|\phi|^2\right) \ , \tag{2}$$

   where $F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$. Find the conserved current $j^\mu$ for this Lagrangian.

   (d) Find the equation of motion for $A_\mu$ and show that it takes the form $\partial_\mu F^{\mu\nu} = j^\nu$, where $j^\mu$ is the same current you found in part (c).

**Useful Excercises To Do On Your Own** (not to be marked):

2. **Filling In Blanks** *Srednicki problems 2.1 to 2.6*