Prof. Dr. K. Kroy WS 2011/12

# Soft Matter Theory
# Problem Set 1

Due: Thursday, 27. October 2011, till 11:00 am, post box, Linnéstraße 5

1. **Strength of materials** **(6 points)**

   a) What is the characteristic interaction energy and size of a unit cell
      i) for an ionic crystal (made of atoms)
      ii) for a colloidal crystal made of colloidal hard spheres of radius $R = 0.1\,\mu m$ at room temperature?

   b) Estimate the elastic modulus of both by dimensional arguments.

2. **Functional derivative** **(3 points)**

   The functional derivative $\delta F[\phi]/\delta\phi$ of a functional $F$ of the function $\phi(\mathbf{r})$ is defined via

$$\left.\frac{d}{d\varepsilon}F[\phi+\varepsilon\eta]\right|_{\varepsilon=0} = \int d^d r \frac{\delta F[\phi(\mathbf{r})]}{\delta\phi(\mathbf{r})}\eta(\mathbf{r}).$$

   Calculate the functional derivative with respect to $\phi(\mathbf{r})$ for the following examples:

   a) $F[\phi] = \phi(\mathbf{r}')$,
   b) $F[\phi] = \int d^d r'\, V(\phi(\mathbf{r}'))$,
   c) $F[\phi] = \frac{1}{2}\int d^d r'\, [\nabla\phi(\mathbf{r}')]^2$.

   Choose a suitable test function $\eta(\mathbf{r})$, e.g. a $\delta$-function. If necessary, use integration by parts, where the variation on the boundary of the volume (at infinity) vanishes.

**sum: 9 points**