Generic mean-field model for phase transitions in nonuniform forces

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We look at the influence of external fields on systems described by generic free energy functional of the order parameter. The external force may have arbitrary spatial dependence, and the order parameter coupling may be nonlinear. The treatment generalizes seemingly disparate works, such as pure fluids, liquid and polymer mixtures, lipid monolayers, and colloidal suspensions in electric fields, fluids, and nematics in gravity, solutions in an ultracentrifuge, and liquid mixtures in laser radiation. The phase lines and thermodynamic behavior are calculated at the mean-field level. We find a ``surface'' critical point that can be shifted to higher or lower temperatures than the bulk critical point. Below this point, the transition from a ``gas'' phase to a ``liquid'' phase is first-order, while above it, the transition is second-order. The second-order line is affected by the spatial dependence of the force, while the first-order line is universal. Moreover, the susceptibility may diverge at a finite location $\boldsymbol{r}$. Several analytical expressions are given in the limit where a Landau expansion of the free energy is valid.