An introduction to Renormalization Group

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The course will focus on a general development of the renormalization group (RG) as a systematic way to explore the large scale "emergent" behaviour of different types of systems. Technical aspects of RG will be discussed by considering specific cases, like, polymers, quantum systems, and critical phenomena. The approach taken will help us to see how RG can lead to a proper description of a system, avoiding any prior knowledge of its phenomenology. With a quick recapitulations of the real space RG we go over to various avatars of the field theoretic RG, and functional RG.

1. General introduction, coarse graining, role of length scale, idea of scale invariance
2. scaling, dimensions and anomalous dimensions; power laws;
   relevance and irrelevance, flow equations, fixed points— introduction with examples
3. Quick review of Real space renormalization group (RSRG)
4. Continuum models — ϵ-expansion: polymers
   momentum shell technique and dimensional regularization, Comparison with RSRG. Examples would include interacting polymers (like DNA) and single self-avoiding walk (real polymer)
5. ϕ^4 model: RG and critical phenomena; Flow equation, RG equation (Gell-Mann–Low)
   Beyond ϕ^4: tricritical point, first-order transition
6. Revisit item 2 at a more technical level
7. Functional RG: introduction
8. The Kosterlitz–Thouless transition (xy model)
9. If time permits, one or more of the following:
   (a) Quantum systems like dynamical quantum phase transitions,
   (b) the Kardar-Parisi-Zhang equation,
   (c) or other problems of interest.
10. General discussions on the global picture from RG

Prerequisites: Basic statistical mechanics (at the level of Reif or Pathria).
No prior knowledge of phase transitions or critical phenomena needed. RG results will be used to explore the nature of the critical point.

Ref:

1. Chaikin-Lubensky covers most of the topics,
2. D. Amit's book is complementary to Ref. 1.
3. relevant reviews and papers.
