1. Elementary Random Walk (RW) models: Origin of flexibility, trans/gauche conformations, freely jointed chain, freely rotating chain, independent rotational potentials, end-to-end distance, gyration radius & gyration tensor, hydrodynamic radius, single-chain structure factor and its relation to $R_G$ and $R_H$, concept of characteristic ratio, Kuhnian segment length and persistence length

2. Gaussian Chain: Origin from the central limit theorem, relation to self-similarity considerations, Gaussian distribution of internal distances, harmonic Hamiltonian, concept of entropy elasticity, Edwards Hamiltonian, structure factor of a Gaussian chain (Debye function) and its interpretation, universal ratios $R_E/R_G$ and $R_G/R_H$

3. Wormlike Chain: Derivation of the elastic Hamiltonian

4. Self-Avoiding Walk (SAW): Problem of long-range interaction along the chain, Mean Field-like counting of contacts in a RW, upper critical dimension, power laws as a result of self-similarity and scale invariance, Flory theory for the estimation of $\nu$, outline of computer simulation algorithms, and results; scaling of the structure factor

5. Excursion: critical phenomena in magnetic systems, $n$-vector model, critical exponents and scaling relations between these, Ginzburg criterion

6. SAWs as the $n \to 0$ limit of the $n$-vector model (derivation like in the book by de Gennes, via high-temperature series expansion), scaling of the partition function, exponent $\gamma$

7. Mean Field Theory illustrated via the example of the Ising model

8. RW in an external potential. Edwards equation for the Green’s function, derived e.g. according to the de Gennes book (lattice model)

9. Self-Consistent Field Theory (SCFT) for many chain systems

10. “Proof” of Flory screening via SCFT, heuristic argument via lattice model (two monomers in an environment of dimers)

11. Flory-Huggins theory: Derivation of the free energy from SCFT (single chain, many chains of one sort, mixtures); derivation and discussion of the unmixing phase diagram

12. Blob theory I: Pincus blobs

13. Blob theory II: Blob picture of semidilute solutions and crossover scaling, $c^*$ and $c^{**}$
14. Blob theory III: Theta collapse

15. Blob theory IV: Phase diagram of (neutral) polymer solutions


17. Smoluchowski equation and Brownian dynamics, Einstein relation

18. Brownian motion in a harmonic potential

19. Random Walk Rouse model: exact solution

20. Dynamic scaling, dynamic exponent $z$, scaling relations for RW Rouse and SAW Rouse

21. Zimm model: Hydrodynamic interaction (HI), Langevin eq. for systems with HI, Kirkwood formula for the diffusion constant, hydrodynamic radius, scaling predictions for diffusion constant, Zimm time, mean square displacement

22. Hydrodynamic screening: Physical mechanism via randomization of momentum transport in the disordered medium; dynamic crossover scaling in terms of the blob picture, identity of hydrodynamic screening length and Flory screening length (via Darcy flow picture)

23. Reptation: Tube picture, disengagement time, sequence of regimes in the mean square displacement, packing length and entanglement length

24. Linear viscoelasticity: Green-Kubo relation for the viscosity, $G(t)$ and $G(\omega)$ / $G'$ and $G''$; predictions for various dynamic models

References


