Soft matter theory

week		lectures	tutorials
1	2-Mar	Introduction. Phenomena and features of soft matter. Interparticle forces, Viscoelastic response, microscopic interpretation of elasticity and viscosity. Generalized susceptibility.	*(lectures)*
2	9-Mar	Liquid state I. Equilibrium themodynamics, ideal and excess quantities, grand canonical formalism. *n*-particle densities and *n*-particle distribution functions. Radial distribution function. YBG hierarchy. Energy, pressure, and compressibility equations of state.	Thermodynamic inconsistency. Third virial coefficient for hard spheres.
3	16-Mar	Liquid state II. Distribution function theories, Ornstein-Zernike equation; Yvon, Percus-Yevick, and hyernetted chain approximations. Virial expansion. Hard-sphere equation of state: Percus-Yevick and Carnahan-Starling equations of state. Petrurbation theories: van der Waals equation of state.	Phase diagram of binary liquid mixtures. Tonks gas.
4	23-Mar	Liquid crystals I. Onsager theory. Elastic theory of nematics: Director, Frank elastic energy, splay, twist and bend deformations.	Frank free energy. Hybrid nematic cell.
5	13-Apr	Liquid crystals II. Surface anchoring: Extrapolation length; twisted cell. Nematic in magnetic field. Line defects: classification, strength, energy, stability.	Frederiks transition. Maier-Saupe theory.
6	20-Apr	Liquid crystals III. Tensorial nematic order parameter. Landau-de Gennes theory of nematic-isotropic transition. Smectic elasticity: Order parameter, layer compression and bending.	Landau-de Gennes theory. Undulation instability in smectics. Analogy between smectics and superconductors.
7	27-Apr	Polymers I. Single polymer chain: Freely jointed chain, radius of gryation, entropic elasticity. Persistence and Kuhn lengths. Expanded coil. Coil-globule transition.	Worm-like chain. Confined polymer chain.
8	4-May	Polymers II. Polymer solutions: dilute and semidilute solutions, osmotic pressure. Dynamical models: Rouse modes, reptation.	Self-consistent field theory for polymers. Polyelectrolytes. Rotational isomeric state model.
9	11-May	Polymers III. Gels: Flory-Stockmayer theory. Rubber elasticity.	Mean-field self-consistent-field-theory treatment of a polymer brush. Renormalization-group analysis of percolation. Complex amphiphile/diblock copolymer morphologies.
10	18-May	Colloids I. Classification, characteristic energies. Brownian motion: Einstein-Stokes relation. van der Waals forces: nonretarded and retarded interaction; Casimir interaction.	Depletion interaction between spheres. Derjaguin approximation.
11	1-Jun	Colloids II. Electrostatic interaction: screening, Poisson-Boltzmann equation, Debye-Hueckel approximation, force between like-charge plates. Depletion interaction. Derjaguin-Landau-Verwey-Overbeek theory. Aggregation and stabilization of colloids.	Van der Waals forces.
12	8-Jun	Colloids III. Phase diagram of hard spheres.	TBA
13	25-May	Amphiphiles I. Types of micelles, critical micelle concentration. Spherical micelles; cylindrical micelles: distribution of micelle size; bilayers.	Relative stability of disk- and sphere-like membranes. Energy of model neck in a lipid membrane.
14	15-Jun	Amphiphiles II. Theory of membrane elasticity: bending and stretching moduli.	Minimal surfaces in soft matter. Persistence length of membranes.
15	22-Jun	Amphiphiles III. Vesicles: reduced volume, ADE theory, vesicle shapes.	Limiting shapes of lipid vesicles.
16	29-Jun	Granular matter	TBA