Introduction to Soft Condensed Matter Physics: PHY 5937

Fall 2009, Tu-Th 12:00PM-01:15PM
Instructor: Dr. Aniket Bhattacharya
Tel: 823-5206
Office Hours (PS 304): Tu-Th 1:30PM-2:30PM, or by appointment
email: aniket@physics.ucf.edu

This is an introductory course on Soft Matter Systems (PHZ 5937). The objective is to give an overview of a selected but very common set of soft matter systems, *e.g.*, liquid crystals, polymers, colloids, surfactants,*etc.*. Certain recent developments in understanding physical properties of biopolymers will be qualitatively discussed. It is expected that students from a heterogeneous background will enroll in this course. Therefore, a substantial portion of the lectures will be descriptive, accordingly, the technical level will be kept at a bare minimum. An approximate course outline for a one semester course is as follows:

- **Introduction to polymers**
  1. Static conformation of polymer: a single chain
  2. Notion of an ideal chain: simple random walk
  3. A real chain in a good solvent: a self-avoiding random walk
  4. Flory exponents
  5. Polymer solution in good solvent: Flory-Huggins theory
  6. Polymer gels: sol-gel transition
  7. Dynamics of a single polymer chain: Rouse and Zimm dynamics
  8. Polymer melt and reptation dynamics.
  9. Properties of biopolymers: DNA, Actin etc.
- **Self-Assembly of Amphiphiles**
  1. Thermodynamics of self-assembly
  2. Exactly solvable simple models
  3. Mean-field approaches
  4. Di- and tri- block copolymers
- **Ordering in Liquid crystals**
  1. An overview of liquid crystals
  2. Statistical mechanical models
  3. Phase transitions: isotropic-nematic-smectic
  4. Liquid crystals under external field
- **van der Walls interaction and forces**
  1. Origin of the van der Walls interaction
  2. General theory of van der Wall forces between molecules

3. Casimir effect

- **Colloidal dispersion**
  1. Examples of colloidal particle in a liquid: Stokes' Law
  2. Brownian motion, Fluctuation-dissipation theorem & Stokes-Einstein equation
  3. Forces between colloidal particles: Casimir Effect
  4. Electrostatic double-layer forces: Poisson-Boltzmann equation & Debye-Huckel theory

Prerequisites: The prerequisite for this course is PHY 3503, or its equivalent, or by the consent of the instructor. Soft Matter Physics is a new emerging area of research. The course inherently has some interdisciplinary character. It is expected that enrollment will cover a wide spectrum of students. Therefore, the technical level will be kept at a minimum level or be taught as necessary. Emphasis will be given to a wide variety of soft matter systems.

Homework: Approximately one homework will be assigned every two weeks.

Group Assignments: In addition to the individual homework assignments a couple of group projects will be given to facilitate discussions, exchange different ideas, concepts. *etc.*.

Tests: There will be one **midterm** and a **comprehensive Final**. Each student will be assigned a project, submit a research report, and make a 20-25 minutes presentation.

Grade: The final grade will be determined by the overall performance weighted in the following approximate manner:

Homework and projects - 60%, Midterm I - 20%, , Final - 20%

The final evaluation will be done by assigning a grade, *e.g.*, **A-**, **A**, **B-**, **B**, **B+**,**C-**, **C**, **C+** *etc.*.

Textbooks:

1. R. A. L. Jones, *Soft Condensed Matter*, Oxford (2002).
2. J. N. Israelachvili, *Intermolecular and surface forces*, Academic, New York (1985).

Additional References:

- P. G. de Gennes, *Scaling Concepts in Polymer Physics* (Cornell University Press, Ithaca, New York, 1979).
- M. Doi and S.F. Edwards, *The Theory of Polymer Dynamics* Clarendon Press, Oxford (1986).
- P. G. de Gennes *Physics of Liquid Crystals*, Oxford.
- M. Doi *Introduction to Polymer Physics* Clarendon Press, Oxford (1986).
- S. A. Safran, *Statistical Thermodynamics of Surfaces, Interfaces, and Membranes*, Addison Wesley, New York (1994).
- *Soft and Fragile Matter*, edited by M. E. Cates & M. R. Evans, Institute of Physics Publishing, Bristol and Philadelphia.