PHY616A Soft Matter Physics

Instructor: Sivasurender Chandran

Course Description and Objectives:

In our day-to-day life, we observe many forms of matter that are neither solid nor liquid. For example, foam, paste, gel, shaving cream, cake, liquid crystal display, pile of sand, paints and any biological cells. These wide variety of materials systems are composed of materialslike colloids, polymers, micelles, liquid crystals, and emulsions, whose mesoscopiclength scales (intermediate between molecular and macroscopic dimensions) and the corresponding differences in the time and energy scalesoffer behaviour that are strikingly different from the conventional condensed matter.Understanding the behaviour of these systems, within a single framework, forms a vibrant discipline termed the soft condensed matter or, in short, soft matter.

The aim of this course is to emphasize the generic features common to various soft materials and develop simple models accounting for their behaviour. Subsequently, we will demonstrate how such methods allow understanding some of the interestingfeatures of everyday life andof the intriguing biological systems.

Prerequisite:

Fundamentals of statistical thermodynamics, and condensed matter physics.

Contents:

1. *Introduction to soft Matter*:Energy, length, and timescales in soft matter.
2. *Phase transitions and dynamics*: Phenomenological theories, and static and dynamic scaling laws, Brownian motion, and thermal fluctuations.
3. *Surface and interfacial phenomenon*:Capillarity and surface tension, capillarity and gravity, wetting, and dewetting.
4. *Colloids:* Measurements and interactions, DLVO theory: van der Waals vs electrostatic interactions, Depletion interaction.
5. *Liquid Crystals*: Classification, elasticity of nematics, alignment of liquid crystals in magnetic and electric field.
6. *Surfactants*: Amphiphilic molecules and their monomolecular films, soap films – bubbles and vesicles.
7. *Polymers*: Isolated polymers – structure and conformation, dynamics of polymer solutions and melts, polymers as entropic springs, viscoelastic properties of polymers.
8. *Experimental tools*: Rheology, light scattering, and microscopy.
9. *Interesting examples*: Droplets in a kitchen, cyclone formation in soap bubbles, Multicellular aggregates as liquids, and entangled active matter.

Reference books*:

1. *Essentials of Soft Matter Science*, F. Brochard-Wyart, P. Nassoy, P-H. Puech (CRC Press, 2019)
2. *Soft Matter Physics*, Masao Doi (Oxford University Press, 2013)
3. *Soft Matter Physics*: *An Introduction*, M. Kleman, O. D. Laventrovich (Springer 2003)

* Additional references will be provided during the lectures

Course grading:

We will follow the following grading scheme for this course:

- Assignments – 10 %
- Quizzes – 20 %
- Mid-semester – 30 %
- End-semester presentation – 40 %

Please be informed of the following:

- ✓ One assignment will be given for every module solving which will boost your understanding of the material covered in the corresponding module.
- ✓ We will have 3 – 4 quizzes and all of them will be surprise quizzes.
- ✓ There will be *no end-semester written exam*. Instead, you will be asked to choose a topic (of current research interest), from a list of topics provided by the instructor, and make a detailed presentation. The guidelines for the presentation will be discussed in the class.
- ✓ Relative grading will be followed for the award of final grades. In addition, students with scores below 40% can expect an **F** grade.
- ✓ Professional ethics will be given significant importance. If found cheating during the assignments, quizzes, and exams you may expect an **F** grade.