Introduction to Soft Condensed Matter Physics: PHZ 5432

Lecture – ENG1 0286, MW 9:00 AM – 10:20 AM

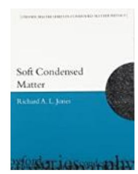
Instructor: Dr. Aniket Bhattacharya

Office: PSB 452, *email:* Aniket.Bhattacharya@.ucf.edu

Office hours: MW 2:30 PM – 3:30 PM or by appointment

This is an introductory course on Soft Matter Systems (PHZ 5432). 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:

Textbooks:

R. A. L. Jones, *Soft Condensed Matter*, Oxford University Press (2002), ISBN 019 850 589 2 (PbK) (Oxford Master Series in Condensed Matter) Additional lecture materials will be provided by the instructor	

Additional References:

- P. G. de Gennes, *Scaling Concepts in Polymer Physics* (Cornell University Press, Ithaca, New York, 1979).
- J. N. Israelachvili, *Intermolecular and surface forces*, Academic, New York (1985).
- 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.

Course Outline:

- 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 following weights:

Homework	Project	Midterm	Final
30%	30%	20%	20%

The final grade will be calculated according to the following grading scheme:

A	A-	B+	B	C	D	F
>= 85%	(80 - 85) %	(75-80) %	(70 -75) %	(60 -70) %	(50 - 60) %	< 50%

Make-up Exams and Assignments

Per university policy, you are allowed to submit make-up work (or an equivalent, alternate assignment) for authorized university-sponsored activities, religious observances, or legal obligations (such as jury duty). If this participation conflicts with your course assignments, I will offer a reasonable opportunity for you to complete missed assignments and/or exams. The make-up assignment and grading scale will be equivalent to the missed assignment and its grading scale. In the case of authorized university activity, it is your responsibility to show me a signed copy of the Program Verification Form for which you will be absent, prior to the class in which the absence occurs. In any of these cases, please contact me ahead of time to notify me of upcoming needs. At the discretion of the instructor, the make-up may take any reasonable and appropriate form including, but not limited to the following: allowing a replacement exam, replacing the missed work with the same score as a later exam. All assignment and exam grades are final 72 hours after they have been returned. Please contact me before this 72-hour period is over if you have a grading dispute.

Academic Integrity:

Students should familiarize themselves with UCF's Rules of Conduct. According to Section 1, "Academic Misconduct," students are prohibited from engaging in:

- *Unauthorized assistance*: Using or attempting to use unauthorized materials, information or study aids in any academic exercise unless is specifically authorized by the instructor of record. The unauthorized possession of examination or course-related material also constitutes cheating
- ***Communication to another through written, visual, electronic, or oral means***: The presentation of material which has not been studied or learned, but rather was obtained through someone else's efforts and used as part of an examination, course assignment, or project.
- *Commercial Use of Academic Material*: Selling of course material to an extent person, student, and/or uploading course material to a third-party vendor without authorization or without the express written permission of the university and the instructor. Course materials include but are not limited to class notes, Instructor's PowerPoints, course syllabi, tests, quizzes, labs, instruction sheets, homework, study guides, handouts, etc.
- ***Falsifying or misrepresenting*** the student's own academic work.
- *Plagiarism*: Using or appropriating another's work without any indication of the source, thereby attempting to convey the impression that such work is the student's own.
- *Multiple Submissions*: Submitting the same academic work for credit more than once without the express written permission of the instructor.
- ***Helping another violate*** academic behavior standards.

For more information about Academic Integrity, students may consult The Center for Academic Integrity Links to an external site..

For more information about plagiarism and misuse of sources, see "Defining and Avoiding Plagiarism: The WPA Statement on Best Practices Links to an external site.".

Responses to Academic Dishonesty, Plagiarism, or Cheating

Students should also familiarize themselves with the procedures for academic misconduct in UCF's student handbook, The Golden Rule. UCF faculty members have a responsibility for students' education and the value of a UCF degree, and so seek to prevent unethical behavior and when necessary, respond to academic misconduct.

Penalties can include a failing grade in an assignment or in the course, suspension, or expulsion from the university, and/or a "Z Designation" on a student's official transcript indicating academic dishonesty, where the final grade for this course will be preceded by the letter Z. For more information about the Z Designation, see http://goldenrule.sdes.ucf.edu/zgrade.

Course Accessibility Statement:

The University of Central Florida is committed to providing access and inclusion for all persons with disabilities. This syllabus is available in alternate formats upon request. Students with disabilities who need specific access in this course, such as accommodations, should contact the professor as soon as possible to discuss various access options. Students should also connect with Student Accessibility Services (Ferrell Commons, 7F, Room 185, sas@ucf.edu, phone (407) 823-2371). Through Student Accessibility Services, a Course Accessibility Letter may be created and sent to professors, which informs faculty of potential access and accommodations that might be reasonable.

Please Approximate go to the next page for a tentative week-by-week topic covered

Week	Topic	Reading + Assignments
Week 1 Jan 9 – Jan 13	Introduction to Soft Matter – Jones Chapter 1 Forces energies, and time scales in condensed matter – Jones Chapter 2	Jones Chapter 1 – Review of Soft condensed matter
Week 2 Jan 17 - Jan 20	Forces energies, and time scales in condensed matter – Jones Chapter 2 Gas, liquids and solids, interatomic and molecular forces, different types of forces, van der Waals, ionic, covalent, and hydrogen bond, Phase diagram, viscosity of liquid, viscoelasticity	Jones Chapter 2 Homework 1 - assigned
Week 3 Jan 23 – Jan 27	An ideal chain and random walk; 1D, 2D, and 3D random walk and their distribution; distribution of end-to-end vector for a polymer chain	Jones Chapter 5, Additional references – Rubinstein Chapter 2
Week 4 Jan 30 – Feb 03	Self-avoiding random walk (SAW) Entropy and free energy for a SAW, Entropic spring constant, Flory exponent	Jones Chapter 5, Additional reference - Doi
Week 5 Feb 6 – Feb 10	Phase transition in soft matter; entropy and free energy of mixing – simple theory. Flory-Huggins parameter.	HW2 - Assigned
Week 6 Feb 13 – Feb 17	Self-Assembly in soft matter Thermodynamic principle of self-assemby Micellar aggregation – critical micelle concentration Optimal had group area – spherical micelles, bi-layers, rods	Jones Chapter 9 Preliminary presentation on the chosen topic. Additional reading - Israelachvili Midterm Assigned
Week 7 Feb 20 – Feb 24	Excluded volume interaction revisited – effect of the solvent on a polymer chain – coil-globule transition.	Jones Chapter Doi
Week 8	Liquid Crystals introduction	Jones Chapter 7

Feb 27 – Mar 03	Isotropic to nematic transition	
Week 9 Mar 06 – Mar 10	Liquid crystals continued - simple theory of isotropic to nematic transition; defects and elastic energy in liquid crystals, splay, bend, and twist	Jones Chapter 7
Week 10 Mar 13 – Mar 17	Spring Break – No Lecture	
Week 11 Mar 20 – Mar 24	Electric and magnetic properties of liquid crystals; Frederiks transition	Jones Chapter 7 HW3 assigned.
Week 12 Mar 27 – Mar 31	Helix-to-coil transition Simple theory of helix-to-coil transition	Jones Chapter 7 Take home Final assigned
Week 13 April 03 – April 07	Colloidal dispersion – introduction Brownian motion of a single Colloidal particle; Stokes' Law, Reynolds number, Brownian motion & Stokes-Einstein's equation	Jones Chapter 4
Week 14 April 10 - April 14	Forces between colloidal particles; Van der Waals forces between objects of different shapes.	Jones Chapter 4
Week 15 April 17 – April 21	Vacuum energy and Casimir effect	Jones Chapter 4
Week 16 April 24	Last lecture – April 24 – summing up – broad picture. **April 26: Final exam (7:00 AM – 9:50 AM)**	**Final take home due during final exam period + final presentations**