Mesoscopic and Nanoscale Thermodynamics
-Fundamentals for Emerging Technologies-

CHBE 477 – Undergraduate Elective (3 credits)
ENCH 648Q/CHPH 718E – Special Problems in Chemical Engineering/Special Topics in Chemical Physics

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Welcome to "Mesoscopic and Nanoscale Thermodynamics", an interdisciplinary course for students from engineering or science departments. The course assumes that you have had a prior course in classical thermodynamics or equivalent.

The course will be taught at two levels, undergraduate and graduate. While the topics covered in the class will be the same for undergraduate and graduate students, the requirements to the assignments will be different.

The course focuses on applications of fundamentals of equilibrium and nonequilibrium thermodynamics to emerging technologies and to phenomena at submicron and nano scales, which are not usually covered in traditional engineering disciplines. In particular, the following topics will be discussed:

Fluctuations of physical properties at nanoscale
Critical phenomena, phase transitions in soft matter; wetting, smooth interfaces
Finite-size and low-dimensional systems
Self-assembly and micellization: building a robust nanoparticle
Spinodal decomposition: designing a micro-porous material
Equilibrium polymerization; conformations of macromolecules in solution
Interconversion of molecular polymorphs; protein folding/unfolding

There will be no midterm and final exams. Instead a short (one week) lab research project at the UMD Light Scattering Center will be offered. The students enrolled in CHBE477 and ENCH 648Q/CHPH 718E will learn how to accurately measure the size and Brownian motion of nanoparticles by dynamic light scattering

Time and place

You will have two classes per week, TuTh 12:30 – 1:45 p.m.
Undergraduate and graduate students will be in the same classroom.
Class attendance is required. Office hours: Friday 3:00– 5:00 p.m.
Course information, schedule of classes and topics to be discussed, lectures notes, assignments, solutions, and grades will be posted at the course website http://www.elms.umd.edu/

Required Text
Richard A. L. Jones "Soft Condensed Matter", Oxford University Press, 2002.

I am currently writing a textbook on Meso Thermodynamics and will make a draft of the book posted on the course website.

Other useful but more professional books for a deeper study:

1. M. A. Anisimov and C. E. Bertrand, "*Thermodynamics of Fluids at Meso and Nano Scales*" Chapter 7 in *Applied Thermodynamics of Fluids*, A. Goodwin, C. Peters, and J. V. Sengers (Eds.), pp. 172-214, Royal Society of Chemistry, Cambridge, 2010.
2. M.A. Anisimov "*Critical Phenomena in Liquids and Liquid Crystals*", Gordon and Breach, 1991.
3. L. D. Landau and E. M. Lifshitz "Statistical Physics". Pergamon, 1980.
4. J. S. Rowlinson and B. Widom "*Molecular Theory of Capillarity*", Clarendon Press, 1982.
5. P. de Gennes "*Scaling Concepts in Polymer Physics*, Cornell University Press, 1979.
6. "*The Feynman Lectures on Physics*", Volume 1, Addison Wesley, 1977.

Any undergraduate text on classical thermodynamics will be very helpful to refresh your memory on the basic laws of thermodynamics, its concepts and definitions.

Course Website

All students enrolled in the course must have access to the site**.** Your comments and suggestions regarding the material posted at the site are welcome.

Homework assignments

Undergraduate and graduate students may have different homework assignments. Please submit the completed problem sets in time indicated in the class schedule. Electronic submission by e-mail is welcome. A personal computer and appropriate software may be needed for calculations and plotting graphs. Obey the due date. Late return 50%. Late return is a better option than no return.

Grading

The grade for the course will be based on class activity (quizzes, participation, and involvement) 20%, research project (30%), and ten homework problems (50%).

A-: 90-92, A: 93-97, A+: 98-100; B-: 80-92, B: 83-87, B+:88-89;
C-: 70-72, C: 73-77, C+: 78-79; D-: 60-62, D: 63-67, D+: 68-69; F: below 60

Research Project (two versions: undergraduate and graduate)

A short lab project (at the UMD Light Scattering Center) will be assigned before the Spring Break. It will require some theoretical study, literature and Internet search, as well as computer-based work, which include computation, data analysis, and plotting graphs.

No exams will be required