PHYS 782 # Condensed Matter Physics **Spring 2011**

22127 (3 credits)

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Meetings: TTh 9:00-10:30 a.m., SE 221 **Office Hours:** To be arranged

Bulletin Description: An introduction to the field of soft condensed matter, focusing on colloids, polymers, liquid crystals, surfactants, membranes, and other biological systems. Topics will include characterization of soft materials, interparticle interactions, structure, equilibrium phase behavior, nonequilibrium properties, and practical applications.

Preparation: Advanced knowledge of mechanics, electrostatics, thermodynamics, and statistical mechanics. Experience with numerical methods and computer programming.

Student Responsibilities: Attend all lectures. Read assigned material in advance. Come prepared for discussion. Be curious; ask questions. Complete assignments on time.

Objectives:
- Develop conceptual understanding and practical expertise in modern theoretical and computational methods applied to soft matter systems.
- Gain an appreciation for the remarkable physical properties and industrial applications of soft materials.

Topics: Colloids, polymers, liquid crystals, and amphiphiles (see p. 2).

References: T. A. Witten and P. A. Pincus, *Structured Fluids* (Oxford, 2004).

Evaluation:

Homework	30%	All assignments and the research project must be completed to pass the course.
Research Project	20%	
Exams (2)	40%	
Participation	10%	

Lateness: Late homework will be accepted with a 20% penalty/day until next class.

Grading: A: $\geq$ 85%, B: 70-84.9%, C: 60-69.9%, F: $<$ 60%

All work in this course must be completed in a manner consistent with NDSU University Senate Policy, section 335: Code of Academic Responsibility and Conduct (http://www.ndsu.nodak.edu/policy/335.htm).

Any students with special needs are encouraged to contact the instructor promptly to make appropriate arrangements.

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Topics

I. INTRODUCTION

- Defining characteristics of soft condensed matter
- States of matter, self-assembly, and phase transitions
- Applications of soft materials
- Review of statistical physics

II. COLLOIDS

	Applications
• Brownian motion	paints and inks
• Interparticle interactions and stabilization	food colloids (*e.g.*, milk)
• Effective interactions and DLVO theory	sedimentation and flotation
• Structure and phase behavior	photonic materials
• Nanoparticles	quantum dots
• Dynamics: Aggregation, rheology	drug delivery

III. POLYMERS

• Fractal nature of polymers	rubbers and plastics
• Statistical mechanics of chain molecules	food polymers
• Polymer solutions, melts, and thin films	biopolymers (proteins, DNA, actin)
• Block copolymers	viscoelastic fluids
• Phase separation, glass transition	synthetic materials

IV. AMPHIPHILES

• Micelles, bilayers, and vesicles	soaps and detergents
• Langmuir monolayers	thin films
• Microemulsions	foams
• Membranes, carbon nanotubes	biological cells

V. LIQUID CRYSTALS

• Classification by symmetry	display devices (LCD)
• Nematics and cholesterics	heat sensors
• Smectics and columnar phases	
• Phase transitions	