Look around you: everything you see is a surface! Surfaces, interfaces, and the distinctive behavior owing to them, pervade most of daily life, including life itself. Processes at surfaces pervade technology. They pervade environmental issues (rain and smog, soils, aerosols). They are even the basis for much of bioengineering (milk and cheese, proteins -- and even we ourselves, who consist of a dynamic collection of biocolloids contained in about 75% water). In this course we will seek to understand the general principles which unify these seemingly disparate phenomena. To understand this subject is interesting for its own sake. Since you are also likely to encounter surface and colloid phenomena in whatever work you undertake in the real world, understanding will help you to do a better job.

**Textbook:** This class is mostly organized around class notes. The subject is too young to have one comprehensive textbook. All the following suggested references are reserved in Grainger.

4. The recommended textbook for the second half of the class is: Jacob N. Israelachvili, *Intermolecular and Surface Forces*, 3rd ed., Academic Press, New York, 2011. Beautifully written, this is the best single text for the second half of the class. The 1st edition (1985) was shortest and even easier to read than the 2nd and 3rd editions. Also available on Amazon as a Kindle book.

**Assignments:** There will be homework over the course of the semester. Late HW receives 1/2 credit. Graduate students taking the class for 4 credit hours will write a term paper, due on Nov 30th, 2017

**Exams:** There will be one in-class midterm and one final.

**Tentative midterm date:** Oct. 31, 2017. **Final date:** TBA

**Grading:**

3 credit hours:
Midterm (35%) + Final (45%) + Homework (20%)

4 credit hours:
Midterm (30%) + Final (40%) + Homework (15%) + Term Paper (15%)

**Teaching Assistant (TA):**
PART I: BASICS ABOUT SURFACES

1. Introduction

2. Distinctive features of interfaces
   - what is an interface? - how to describe an interface?
   - what are typical behavior patterns? real versus apparent area - surface to volume ratio -surface energy - surface structure and composition versus that of the bulk.

3. Surface energy
   - typical values -- how to measure it? -- reconstruction, relaxation, molecular orientation, melting, roughening -- how to evaluate surface structure?

4. Surface thermodynamics
   - origin of surface energy -- Gibbs dividing surface -- surface excess functions
   - Gibbs adsorption equation -- other implications

5. Adsorption isotherms
   - physisorption versus chemisorptions -- adsorption isotherms: Langmuir, BET, etc. -- internal interfaces: critical micelle concentration

6. Monomolecular films

7. Curved surfaces
   - capillary pressure: the Young-Laplace equation -- vapor pressure: the Kelvin equation -- implications: nanoparticles, adhesion, etc.

PART II: THE FORCES BETWEEN SURFACES

1. Introduction
   - Uses of colloids in technology - how to measure surface forces? Characterization of colloids.

2. Varieties of inter-particle forces
   - Scale-up from molecules to larger particles - van der Waals, electrostatic," structured liquids"

3. Van der Waals interactions
   - origin of r^-6 - Hamaker constant - competitive van der Waals attractions -implications

4. Electrostatic interactions
   - why all interfaces are charged or polarized - the electric double layer – the screened Coulomb potential - examples of calculations - Stern layer - typical
   - DLVO behavior - zeta potential – examples

5. Non-equilibrium and time-dependent interactions
   - diffusion; hydrodynamics; flocculation kinetics.

PART III: FORCES DUE TO STRUCTURE IN LIQUIDS

1. Polymers
types of polymers - general features of polymers in solution - examples

2. Structured liquids (small molecules)
   liquid structure at surfaces - forces that result - examples

3. Tribology and adhesion

PART IV: OUTLOOK

1. Review of the course
2. Frontier areas
   selected depending on interests of the class

Policy on conflicts or emergencies:

(1) For time conflicts with other events (e.g. another scheduled exam), or an official UIUC activity
   (e.g. varsity athletics, band concert),
   Regarding HW, please show official documentation about the conflict at least two weeks before
   the homework due date. The HW due date will be extended.
   Regarding the exam, please show official documentation about the conflict at least three weeks
   before our exam date. A make-up exam will be scheduled.

(2) If you will not be able to make it to the exam or submit HW on time due to serious illness or other
    emergent personal crisis (e.g. car accident) that are not described in (1), you must send email to
    the TA (bluo6@illinois.edu) and the instructor (qchen20@illinois.edu) at the earliest possible
    opportunity, and submit a statement from the professionals that are authorized to evaluate your
    situations (e.g. doctors, police). The statement needs to clearly explain that you are not physically
    capable of attending the exam or submitting HW on time. The HW due date will be extended for
    HW, and a make-up exam will be scheduled for exam.