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.


**Assignments:** There will be homework over the course of the semester. Late HW receives 1/2 credit. All students taking the class will write a term paper, due on **Nov 28th, 2020. See instructions in Section III of “ADDITIONAL NOTES FOR ONLINE TEACHING”**.

**Exams:** There will be one midterm and one final, both of which will be conducted online.

**Tentative midterm date:** Oct. 8, 2020. **Final date:** TBA

**Grading:**

3 credit hours:

- Midterm (30%) + Final (35%) + Homework (20%) + Term paper (15%)

4 credit hours:

- Midterm (25%) + Final (35%) + Homework (15%) + Term Paper (25%)

**Teaching Assistant (TA):**

Alan (Subing) Qu, email: squ6@illinois.edu
Lectures:

We will do synchronous zoom lectures at the designated lecture time: 12:30 – 13:50 pm (Central time) on Tuesdays and Thursdays. All zoom lectures would be recorded and uploaded to compass.

Office hours:

Alan Qu (TA)

We have two forms of office hours:

Form 1: Fridays 2–3 pm, by Alan through Zoom:

Form 2: “Office Hour Forum” on Compass where you can ask any questions you may have on homework, or other issues relating to the class

- Alan will be online at the usual office hour time (Fridays 2-3pm) to respond to your questions as best and quickly as he can. If you have questions outside of this time frame, you may still post in the forum and he will try to answer you in a timely manner, but emailing him is probably a better option.
- To post a question, click the “Create Thread” button and type your question in the subject box.

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 email official documentation (or scanned version) about the conflict at least **two weeks** before the homework due date. The HW due date will be extended.
   Regarding the exam, please email official documentation (or scanned version) about the conflict at least **three weeks** before our exam date. An online 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 emails to the TA (squ6@illinois.edu) and the instructor (qchen20@illinois.edu) at the earliest possible opportunity, and submit a statement (or scanned version) 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 an online make-up exam will be scheduled for exam.

**ADDITIONAL NOTES FOR ONLINE TEACHING**

I. **Homework Submission Instruction**
Homework will be given and submitted via Compass system.

Note:

1. **Multiple attempts** are allowed for submission but **only the last attempt will be graded**.
2. Both pdf and word document are acceptable, but typed answer is preferred. If you decide to write your homework, it is suggested to write it electronically using a tablet. If you decide to scan your homework, **make sure your scanned document is readable** to avoid losing points.

Submission steps:

- **Click on the homework and navigate to the session you want to submit.**
- **Upload homework following the naming convention: lastname_firstname_HW#** (e.g., Smith_John_HW1).
- **Click submit!**

II. **Midterm and Final Instruction (Online)**

- Both exams will be held online and proctored via Zoom (more instructions to follow).
- The exams will be given on Compass and we will provide a sample exam two weeks ahead of time for you to check on the system.
- For questions during the exam, we will set an exam forum (the same format as office hour forum) accessible during the exam, you can post your questions on the exam content and the TA will answer them if appropriate. Discussing answers on the exam questions will be prohibited and penalized.

III. **Term Paper Instruction**

- A term paper will be required for the class **due on 11 pm CST, Nov 28th, 2020. This is a hard deadline**.
- The term paper will be submitted to Compass after a plagiarism check offered by Compass.
- Students who are taking the course for 3 **credit hours** will need to submit a critique of a paper (journal article) that is related to the topics covered in class. The review will be 3 pages (strict cut off), **double spaced**, Times New Roman 12 pt font, justified text alignment, with a maximum of 1 figure that is no larger than half the page.

- Students who are taking the course for **4 credit hours** will need to submit a review of a topic in surface and colloids. This will account for 25% of your grade. The review will need to be at least 5 pages, **single spaced** with only text, Times New Roman 12 pt font, justified text alignment. You may add figures to your review and go beyond 5 pages, but the text alone needs to cover 5 pages. There is an upper limit of 8 pages total for the review.  

- We will be using a Google Sheets document for students to sign up for articles and review topics. This will be a first-come, first-serve basis. Only edit the boxes associated with your name. DO NOT change anyone else’s. We can track changes on Google Sheets if any foul play occurs.  

- If you have any questions, please feel free to email Prof. Chen or Alan.

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**Campus Policies and Procedures regarding COVID-19**

This section describes University policies and procedures that affect classroom operation during the COVID-19 pandemic. Listed only are the parts which may be related to online teaching, for thorough reference please go to: [https://covid19.illinois.edu/covid-19-classroom-management-info/](https://covid19.illinois.edu/covid-19-classroom-management-info/)

All students have been given the opportunity to remain off-campus and take courses remotely. Those who have chosen to return to campus must abide by our policies and procedures regarding face coverings, social distancing and mandatory COVID-19 training and testing. They must also cooperate with contact tracing, isolation and quarantine protocols.

**Mandatory COVID-19 training.** Every student enrolled for the Fall 2020 semester must complete the Division of Research Safety’s online COVID-19 training before Monday, August 24, the first day of instruction. Students will not be allowed to enter University classrooms or buildings on or after August 24 if they have not completed this training.

**Mandatory COVID-19 testing.** Every student enrolled for the Fall 2020 semester residing in the Champaign-Urbana community is required to participate in the University’s mandatory COVID-19 testing program. Students will be tested two times per week. Students will not be allowed to enter University classrooms or buildings if they have tested positive for COVID-19, if they have missed a mandatory test, or if they are currently awaiting a test result after notification of exposure.

Students must provide proof of compliance with testing requirements prior to entering a classroom. A Wellness Support Associate will be stationed at the classroom or building entrance checking status before students enter class. Students will show the Associate their status in the “Safer in Illinois” app or through an alternate method. Students who are COVID-positive, under quarantine, not in compliance with COVID-19 testing requirements, or not wearing a face covering will not be allowed to enter the classroom.

All University employees working in campus facilities are also required to undergo mandatory COVID-19 testing. Instructors may not enter a classroom or teach a class if they have tested positive for COVID-19, missed a mandatory test, or if they are currently awaiting a test result after notification of exposure.

**COVID-19 Test Notification.** All individuals (student, faculty, staff) will be notified of their University administered COVID-19 testing results by way of the “Safer in Illinois” app or through an email notification from McKinley Health Center. COVID-19 test results are shared only as permitted by law, including with
McKinley, Champaign-Urbana Public Health District (CUPHD) and the individual’s medical provider. Positive test results are reported directly to CUPHD. This is true regardless of whether the “Safer in Illinois” app is used or not.

We recommend that all members of the University community utilize the “Safer in Illinois” app. It does not do any location-tracking and does not share any user information with any third party. It is used for testing notification and results, and additionally provides a status screen that can show – without sharing any medical information – whether an individual is permitted to enter a building or classroom.

**COVID-19 Exposure Notification.** CUPHD is notified of all positive tests; they carry out contact tracing for each case. An individual identified as having had significant contact with a COVID-positive individual will be referred for testing and potential quarantine.

If a student in a class tests positive for COVID-19, the instructor will **not** be notified of the student’s test result. **The instructor will have access to verified absence information, including COVID-19 related issues (positive COVID-19 test, or an exposure that requires quarantine or further testing) but will not be provided with a specific reason.** We strongly recommend that verified student absences, including those related to COVID-19 be excused in order to discourage class attendance by those who are ill or might carry the virus. This process will be in effect for all courses, including online. For all other absences, standard University procedures for absences as described in the **Student Code** remain in effect.

Even if some students are absent from class due to COVID-19 reasons, it does not mean that the instructor needs to cancel class. Experts tell us that social distancing and face coverings greatly limit viral transmission. Having limited contact with someone who has the virus does **NOT** mean that other individuals will necessarily become infected. Further, some students may miss class for other reasons that arise in a typical academic year.