APPLIED PHYSICAL SCIENCES

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

APPL 465-001

SpongeBob SquarePants and other soft materials

Fall, 2023

Introduction	What kind of material is Sponge Bob made of? What about the slime of his pet snail, Gary? We are taught that there are three states of matter: solid, gas, and liquid. However, in our daily lives we encounter materials that challenge this simple description, such as foams, pastes, gels, soap, and rubber, as well as our skin, hair, nails, and cells. These are Soft Materials, and in this course, we will learn about their special physical properties and how to describe them mathematically.
Methods	This class is an active one, everyone participates and everyone learns from and helps one another. We will use various in-class activities to make the class more engaging. We will discuss, take quizzes, and do presentations. We will also evaluate each other's homework. We might even make some ice-cream as homework. Be prepared to come to class and participate in all the activities!
Results	By the end of this course, students should be able to do the following: • Learn the basics of soft matter, classes of materials, their basic properties, their unifying properties and their differences, be able to give examples from every-day life and describe different methods to study them. • Read papers in soft matter and present your understanding to an audience of your peers. • Work in a team towards the common goal of a project. • Be able to assess the importance of team and entrepreneurial work through various group activities within the classroom and through the final project. • Learn to use the material taught throughout the course in order to come up with new ideas, formulate new questions, as well as engineer and design new systems and new products. More specifically: • Identify classes of soft materials: polymers, surfactants, granular materials, colloids, liquid crystals, foams. • Identify the kinds of "phases" or structures soft materials form such as gels, glasses, crystals, liquids, colloidal suspensions etc. • Familiarize yourself with important concepts in soft matter such as self-assembly, kinetic traps, random packing, origami, self-replication, segregation and mixing. • Use your critical thinking, to envision new systems and solutions to current problems.
Discussion	The technical material that you will learn will provide you with a valuable skillset. In addition, a goal of this class is to help you develop an entrepreneurial mindset so that you will understand the bigger picture; draw connections between the material in this class and what you have learned in other classes; recognize opportunities; and learn from mistakes to create value for yourself and others.

Engineering Student Outcomes	
	• An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. • An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. • An ability to communicate effectively with a range of audiences • An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts. • An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Class Essentials

CONTACT INFORMATION

Dr. Daphne Klotsa	Teaching assistants
Office Location Murray Hall, Room 1114 **Email** dklotsa@email.unc.edu **Phone** --	N/A

LOGISTICS

Class meeting times
T/Th 11:00am-12:15pm

Class meeting location
Morehead Lab Room 0213

Office Hours
Tuesdays 4pm-5pm

Required Texts & Software
"Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials", by Ian W. Hamley, Wiley.

Pre-requisites
Required: PHYS 114/118: Mechanics and CHEM 101/102: General Chemistry,

Suggested: PHYS 441 / BMME 441: Thermal Physics or CHEM 481: Physical Chemistry

Or permission of the instructor.

Course content

COURSE TOPICS

- Intermolecular forces
- Basic phases of matter: gases, solids, liquids. Out-of-equlibrium phases: gels, glasses
- Self-assembly

- Colloids, polymers, granular materials, active matter, origami

➢ COURSE SCHEDULE

Weeks 1+2: Introduction to soft matter through examples and applications. Hands-on activities with corn-starch, sand, putty, sponges, soap and link them to soft materials polymers, liquid crystals, granular materials, colloids, surfactants.

Week 3+4: Intermolecular forces in soft materials. Compare with basic phases of matter: gases, solids, liquids. Basic concepts of Brownian motion, diffusion, phase transitions, equilibrium and free energy.

Week 5+6: Self-assembly. Can we design systems to assemble what we want? Definition and applications in biological and synthetic systems. Programmable self-assembly.

Week 6: Role of entropy, importance of simulations. Entropy as a drive for assembly.

Week 7: Folding and DNA origami.

Week 8: Colloids I: designing colloidal “molecules”.

Week 9: Colloids II: self-replication. Living versus nonliving systems.

Week 10: Granular materials I: from ordered to random packings. Design granular materials through machine learning.

Week 11: Granular materials II: a granular robot.

Week 12: Active matter I: from bird flocking to robot swarming, understanding the properties of swarms.

Week 13: Polymers, gels, glasses

Week 14: Surfactants, foams

Week 15: Recap. Work on your proposals.

Week 16: Presentations!

To help you succeed

➢ COURSE EXPECTATIONS AND POLICIES

- All students are expected to be respectful to one another.
- Do all reading assignments before coming to class (in-class quizzes will help to encourage you to do this).
- Participate in class discussions and problem-solving activities.
- During class time, do not use your phone or computer for something unrelated to class; research shows that this is distracting to other students in the class. If there is an urgent situation, then you can leave the classroom to use your phone or computer.
- Come to every scheduled class and let me know ahead of time if you cannot attend.
- Turn in assignments on time; if an assignment is up to 24 hours late, there is a 25% deduction, and if an assignment is beyond 24 hours late, you will get a zero. If you need an extension, you must ask at least 24 hours before the time that the assignment is due (you can avoid a grade deduction this way).
- I will let you know if an assignment should be done individually or as part of a group. While I encourage you to help each other for individual work, it is a violation of the honor code if you copy or obtain solutions from another student.

➢ Student Resources

SEE, SAY, DO SOMETHING We're happy you are here and eager to learn. Despite our best intentions to follow a plan, life may throw us a curve ball. If you or someone you know is experiencing some distress or you are concerned about the well-being of a student, please report it here: https://deanofstudents.unc.edu/carereport. It is important to support one another. If you see something, say, and do something.	**ACCESSIBILITY RESOURCES** UNC-CH provides accommodations for any students with documented disabilities. If you have a disability and believe you require accommodations, please contact the Department of Accessibility Resources at http://accessibility.unc.edu. Please contact me early in the semester so we can make any necessary arrangements and discuss the learning checks.

Assignments & Evaluation

➢ Your Course Grade

30%: Homework and quizzes	At the end of every class, or sometimes after a number of classes, there will be assignments for you to prepare and bring with you for the following class. These could be presentations, answering questions at home, etc. This is an essential part of the class. Therefore, attendance and participation are crucial. It is designed to test key concepts, knowledge introduced every time, and to ensure you will remember it. If you attend the class, the assignments will be straightforward.
10%: "I didn't quite understand" question sheet	You will prepare a list of questions of concepts, techniques, anything you have not understood so far or things you would like to know more about! This is your chance! You will submit this to me before the class and bring a printed copy with you into class. The list that you submit to me will give you 10% towards your final grade. It only has to be genuine, the questions well-posed and clear, no marks will be taken off otherwise. Some of these ideas may be excellent topics for your final project too!
35%: Final project	This is a group task. Each group will choose a topic within soft matter, usually that we have covered in the course, and write a mini proposal on it (~5-6 pages long). There will have to be an introduction, background literature, and a proposal for something new to study, or a product to design, and how the group will go about in order to study the topic, i.e. methods (experimental/theoretical/computational). We will discuss the details, and I will give you more guidelines on how to do this.
25%: Final presentation	Presentation of each group to show to the rest of us, what you proposed in your final project. All people in each group should take part in presenting. You will be evaluated on how well you explain ideas and background, and how you handle questions from the audience at the end. You do not need to know all the answers, but show critical thinking, i.e. how you would go about to answer that question.
100%: total	

➢ Grade Interpretation & Honor Code

Your final course grade will be determined from a standard scale:	
A	93+
A-	90.0 - 92.9
B+	87.0 - 89.9
B	83.0 - 86.9
B-	80.0 - 82.9
C+	77 - 79.9
C	73 - 76.9
C-	70 - 72.9
D+	67 - 69.9
D	60 - 66.9
F	<60

ACADEMIC HONESTY

There will be clear communication if assignments are individual or group. For individual assignments, while I encourage collaboration, it is a violation of the honor code if a student duplicates work or obtains solutions from another student and submits it on their own. Please reference the honor code: http://honor.unc.edu.

➢ MAJOR COURSE DUE DATES

Question sheet	Week 7
Final project	Week 14/15
Final presentation	Week 14/15

I reserve to right to make changes to the syllabus, including project due dates and test dates (excluding the officially scheduled final examination), when unforeseen circumstances occur. These changes will be announced as early as possible so that students can adjust their schedules.