*CHE 596-009/CHE 456/CHE 596-603**
Colloid Science and Nanoscale Engineering

Spring 2024
Tue, Thu, 3:00 – 4:15 PM, Room MRC 313

* Gray-highlighted areas apply to EOL students

Instructor: **Professor Orlin D. Velev**
Office: **2030 EB 1**, https://sites.google.com/ncsu.edu/velev/
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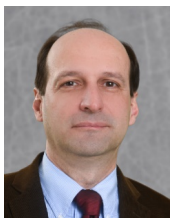

Office Hours: ***In person + Online via zoom***
Tuesday, 4:30 PM - 6:00 PM
Wednesday 1:30 – 3:00 PM

TA: **Yara Abu Dahab**
E-mail: **yiabudah@ncsu.edu**

TA Office Hours: ***In person + Online via zoom***
Monday 5:00 – 6:00 PM (EB1 atrium)
Wednesday 3:00 – 4:00 PM (EB1 atrium)
Online via zoom
Wednesday 6:30 – 8:30 PM (zoom only)
Further zoom office hours by appointment for EOL students

Course webpage (Moodle): https://moodle-courses2324.wolfware.ncsu.edu/course/view.php?id=5467

Recorded lectures Panopto link:
https://ncsu.hosted.panopto.com/Panopto/Pages/Sessions/List.aspx#folderID=%227ea53652-14ef-490b-91b6-b0d50172354f%22

Office hours Zoom: https://ncsu.zoom.us/j/91418814733?pwd=akhkY0c3RitSYThqRDg2SDZrMFRtQT09

Brief description

This course begins with an in-depth coverage of the fundamentals of colloidal interactions between surfaces, particles, surfactants and biomolecules, and their relevance to self-assembly. The theory and practice of particle characterization by scattering methods and their manipulation by external fields are presented. In the second part of the course, we will discuss emerging colloid-related technologies including microfluidics, bioassays, soft robotics, active matter, and sustainable nanomaterials.

Course Objectives

The course will teach the attendees to perform the following:

- Identify the intermolecular and surface forces acting in various colloidal suspensions and nanoscale systems and be able to develop quantitative estimates of the strength and magnitude of these forces.

- Develop solutions to scientific and technological problems in colloidal and microfabricated systems by application of the theory of colloidal interactions.
- Understand the principles of colloidal and biological self-assembly, and their application, advantages and limitations in technology.
- Apprehend various light-scattering and electric-field based techniques for characterization and manipulation of colloidal nanoparticles and be able to apply them in research.
- Be familiar with latest concepts in the areas of microfluidics, bioassays, soft robotics, and sustainable nanotechnology. Be able to propose and engineer simple new devices by microfabrication and/or self-assembly.

Textbooks and other resources

- "Intermolecular and Surface Forces", J. N. Israelachvili, Academic Press, 3rd edition, 2011.
- "The Colloidal Domain: Where Physics, Chemistry, Biology and Technology Meet", D. F. Evans and H. Wennerstrom, Wiley-VCH, 1999.
- Selected representative papers from all science areas covered by the class are available for download from the class website. The attendees are encouraged to read them to see examples of the application of the class material to current research and to widen their knowledge in the area.

Lecture notes and lecture recordings

- The lecture notes will be posted for downloading from the course moodle page before each lecture (typically on the afternoon before). *Downloading and reading the lecture notes can't be a substitution for attending the class in person.*
- The recorded lectures will be available following each class on the Panopto link above.
- When needed, selected electronic recordings of lectures from previous teaching of the course may be made available to the students on moodle.

Optional **textbooks for additional practice and information**

- "Foundations of Colloid Science", R. J. Hunter, Oxford Univ. Press, 2001.
- "Colloidal Dispersions", W. B. Russel, D. A. Saville and W. R. Schowalter, Cambridge Univ. Press, 1989.
- "Physical Chemistry of Surfaces", A. W. Adamson and A. P. Gast, Wiley Interscience, 1997.
- “An Introduction to Interfaces and Colloids: The Bridge to Nanoscience,” John C Berg, World Scientific, 2009.
- "AC Electrokinetics: Colloids and nanoparticles", H. Morgan and N. Green, Research Studies Press, 2003.

Homeworks

The homework assignment for the next week will be available for download on moodle after the Thursday lecture. ***The homeworks are due at the Thursday lecture in the following week.***

Discussions

The class will include discussion sessions on recent trends and developments in colloids and nanoscience. Each of the attendees will pick one topic for one of the discussion sessions and will prepare a 10-minute presentation on the problem and current state of the art in the field. A list of suggested (but not obligatory or exclusive) topics is available on the class website. The papers available for download could be used as a starting point for preparation of the discussion. The students could use the material prepared for the discussion sessions for their final short-term paper. The EOL students do not have to prepare discussion presentations but are welcome to present if they are able to join the class in person.

Exams

During the semester, there will be two "mid-term" exams based on solving quantitative problems in colloidal forces and interactions. The course will have one final short-term paper, which will be based of individual assignments including literature research, numerical estimates and simple design problems.

Grading

Exams 1 & 2:	**25% each, 50% total**
Homeworks:	**25% overall**
Short term paper:	**25%**

- Both exams are OPEN BOOK, OPEN NOTES, DONE INDIVIDUALLY.
- In grading the exams and homeworks, points are awarded for:

  (1) Correct formulation of the problem and the solution strategy, use or derivation of the appropriate theoretical expressions, explanation of the simplifications and limitations (if any).

  (2) Use of appropriate numerical values and physical dimensions and reaching the right numerical answer.

The weight of (1) vs. (2) for grading any specific problem is determined by the instructor or the assistant depending on the theoretical complexity of the expressions and the derivations. The points for numerical results (2) are awarded strictly for obtaining the precise answers.

Final short-term paper guidelines

- The goal of this assignment is to train the students in applying the material from the class in problems related to their research interests. The individual topics will be suggested by the students and finalized in discussion with the instructor.
- The students should seek out a few relevant recent papers and perform a critical review of how this material can be applied to their field of research. They are encouraged to include in the text estimates, expressions, qualitative or quantitative graphs, figures and schemes.
- The short paper can also be in the form of a proposal for a startup commercializing a novel product/process related to the course.

- Copying/repeating of material from papers or WWW can be done only with acknowledging of, or referring to, the source. The use of AI sources such as Chat GPT is discouraged and could include serious errors that will be graded accordingly low.
- The length of the text, including the reference list should not exceed 3 typed pages. This could be supplemented with up to 5 pages of figures and computer printouts, which however should be clearly numbered, captioned, and referred to in the text.
- The short term paper is graded for:
  (1) Clear and concise description of the aim, background and problem to be addressed.
  (2) Critically evaluating background information, references from the recent literature or other sources.
  (3) Presenting or suggesting an appropriate solution, formulae, estimation, numerical procedure or computer spreadsheet.
  (4) Technical quality of the text and graphical material.
  (5) Presenting an interesting original approach or problem.

Distance education students

Arrangements for submitting and receiving the graded homeworks, exams, and all other ongoing issues will be made on individual basis. The point of contact will be the TA (YAD).

Auditing students

- The auditing students should turn in solutions to at least 1/2 of all homework problems. The homeworks will not be formally graded, but they will receive feedback on whether the solutions are correct.
- The auditing students need not come to the mid-term exams.
- The auditing students should participate in the discussion classes and present on a topic.
- They are encouraged, but not obliged, to prepare a brief and simplified short term paper.

Inclusion statement

At NCSU, administrators, faculty, and staff are committed to the creation and maintenance of "inclusive learning" spaces, where you shall be treated with respect and dignity and where all individuals are provided equitable opportunity to participate, contribute, and succeed. In this course, all students are welcome regardless of race/ethnicity, gender identities, gender expressions, sexual orientation, socio-economic status, age, disabilities, religion, regional background, Veteran status, citizenship status, nationality and other diverse identities that we each bring to class. The success of an inclusive classroom relies on the participation, support, and understanding of you and your peers. When you speak up and share your views, please have in mind that you are doing so in a learning environment in which we all are expected to engage respectfully and with regard to the dignity of all others.

Pronoun use statement

The instructor and TA will gladly honor your request to address you by your chosen name or gender

pronoun. Please advise us of this at any point in the semester so that we may make appropriate changes to the class records.

Statement for students with disabilities
The instructor is committed to following all regulations and assisting by all means possible students with special needs or disabilities. North Carolina State is subject to the Department of Health, Education, and Welfare regulations implementing Section 504 of the Rehabilitation Act of 1973. Section 504 provides that: "No otherwise qualified handicapped individual in the United States. . . shall, solely by reason of his handicap be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (REG02.20.01) https://policies.ncsu.edu/regulation/reg-02-20-01/

Academic integrity statement
The instructor takes academic integrity very seriously. Students should refer to the University policy on academic integrity found in the Code of Student Conduct. It is the instructor's understanding and expectation that the student will neither gave nor received unauthorized aid. Similarly, the homework assignments and the proctored exams should be prepared in accordance with the integrity policy above.

Statement for video recording of the course
This on campus course will be captured and distributed via the Internet and/or electronic media as part of the Engineering Online (EOL) program for the distance students. These video recordings may contain an image of you entering the classroom, asking questions or being a part of the studio class. Please notify Dr. Linda Krute, Director of EOL, in writing at ldkrute@ncsu.edu if you DO NOT want your image to be included in the lecture presentation. If she does not hear from you after the first week of the class, we will assume that you are in agreement with this procedure.

COVID-related statement
Please adhere to common safety procedures such as wearing a mask if you experience viral infection symptoms. For further consideration, please see the campus community standards.

(See next page for lecture and exam schedule)

Lecture and discussions schedule: 596-009, Spring 2024

1.	Jan. 9	Introduction: Types of colloidal and soft matter systems
2.	Jan. 11	Surface thermodynamics, surface tension
3.	Jan. 16	Contact angle, wetting and capillary phenomena
-	Jan. 18	*No class – compensation for Exam 1*
4.	Jan. 23	Surfactants and micellar thermodynamics, surfactant phase equilibria
5.	Jan. 25	Adsorption and adsorption isotherms
6.	Jan. 30	Langmuir-Blodgett layers and bilayers, SAMS, wetting, surface engineering
7.	Feb. 1	Molecular forces overview, self-diffusion and Brownian motion
8.	Feb. 6	Molecular interactions, dispersion forces, van der Waals colloidal forces
9.	Feb. 8	Discussion 1: Wetting, capillarity and surface engineering
-	Feb. 13	*No class – Wellness Day*
10.	Feb. 15	Electrostatics 1: Basics
11.	Feb. 15	EXAM 1 (Tentative time 5:30 PM, location TBA)
12.	Feb. 20	Electrostatics 2: Effect of electrolyte and DLVO theory
13.	Feb. 22	Colloidal interactions not described by DLVO theory
14.	Feb. 27	Interactions between biological molecules
15.	Feb. 29	Electrophoresis, zeta potential
16.	March 5	Dielectrophoresis
17.	March 7	Discussion 2: Soft matter, gels, non-DLVO and biological interactions
-	March 12&14	--- *Spring break* ---
18.	March 19	Discussion 3: Nanoparticles, nanowires, nanotubes, graphenes, Q-dots, MOFs
19.	March 21	Optical phenomena and microscopy in colloidal systems
20.	March 26	Scattering methods: Light, X-ray and neutron scattering
21.	March 28	EXAM 2 (Tentative time 5:30 PM, location TBA)
22.	April 2	Microfluidics 1: Microfabrication and fundamentals
23.	April 4	Microfluidics 2: Applications, bioassays and bioarrays
24.	April 9	Active colloidal systems, self-propulsion and microrobotics
25.	April 11	Soft matter applications in soft robotics, ionic electronics and photonics
26.	April 16	Discussion 4: Lab-on-a-chip, active particles, soft robotics and microrobotics
27.	April 18	Discussion 5: Green colloids, bionanomaterials and sustainable manufacturing
28.	April 23	Sustainability and entrepreneurial case studies. General review.
***	April 29	FINAL TERM PAPERS due by e-mail by 11:00 PM