*CHE 596-009/CHE 465/CHE 596-609**
Colloid Science and Nanoscale Engineering

Spring 2026
Tue, Thu, 3:00 – 4:15 PM, Room 01230 EB2

* Gray-highlighted areas apply to EOL students

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

Prof. Velev Office Hours:
Tuesday, 4:30 PM - 6:00 PM (*In person + Online via zoom*)
Tuesday, 6:00 PM – 7:00 PM (*Online via zoom*)

TAs: **Seonghyeon Park (Parker),** E-mail: **spark62@ncsu.edu**
Byeunggon Kim, E-mail: **bkim26@ncsu.edu**

TA Office Hours:

Monday, 4:00 – 5:30 PM (SP, *Online via zoom*)
Tuesday, 7:00 – 8:30 PM (BK, *Online via zoom*)
Wednesday, 3:00 – 4:30 PM (BK, i*n person, EB1 + Online via zoom*)
Wednesday, 4:30 – 6:00 PM (SP, *In person, EB1 + Online via zoom*)
Further zoom office hours by appointment for EOL students.

Course webpage (Moodle): https://moodle-courses2527.wolfware.ncsu.edu/course/view.php?id=6879

Recorded lectures Panopto link:
https://ncsu.hosted.panopto.com/Panopto/Pages/Sessions/List.aspx#folderID=95b2a4dd-dce9-4984-95f7-b3b001462ef5

Office hours Zoom: https://ncsu.zoom.us/j/96085766337?pwd=CZK1g7KAWm0Ythllm4yxkNo7EqjyXm.1

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.

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. Other readings and recorded materials can be posted as needed.

Textbooks and other resources (highly recommended, though optional)

- "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.

Suggested further optional textbooks for supplemental reading

- "Foundations of Colloid Science", R. J. Hunter, Oxford Univ. Press, 2001.
- "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 assignments will be posted on the moodle site weekly. **The assignments will be due by electronic submission on Gradescope before the beginning of the next Thursday class.**

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 short 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.

Note: Due to the large size of the class in the Spring 2026 the format of the discussion sessions will be established based on student input and feedback.

Exams

During the semester, there will be two "mid-term" exams based on solving quantitative problems in colloidal forces and interactions. The exams will be timed during the evening times indicated in the syllabus, their location and format may be subject of further adjustments. The course will have one final short-term paper, which can be based on individual assignments including literature research, numerical estimates, and simple design problems. **The exams and the final term paper will be submitted as scanned PDF files via Gradescope.**

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 the WWW can be done only by acknowledging or referring to the source. The use of AI sources such as Chat GPT could only be supplemental and could lead to 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) Presenting an interesting original approach or problem.

(3) Critically evaluating background information, references from the recent literature or other sources.
(4) Presenting or suggesting an appropriate solution, formulae, estimation, numerical procedure or computer spreadsheet.
(5) Technical quality of the text and graphical material.

Distance education students

The arrangements for submitting and receiving the graded homeworks, exams, and final short paper are the same, and include scanning and submitting them via Gradescope. Arrangements for other ongoing issues will be made on individual basis. The point of contact will be the TA (Parker).

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.

GENERAL POLICIES AND PROCEDURES

Consulting with instructor and TA. We strongly encourage you to discuss course or personal questions with Dr. Velev and TAs during the in-person or online office hours. ***The instructor will try to be available at other times as well, however, e-mails to Dr. Velev asking how to solve specific homework problems are discouraged***. ***E-mail questions asking for hints how to solve the homeworks should be addressed to the TA only***.

Test and homework grading. The responsibility for grading tests and homework assignments resides with the teaching assistant (TA). **Regrading rules:** ***If you believe an error has been made in grading on a problem set, please first discuss it with the TA during the office hours or during a pre-arranged appointment.*** If after that discussion with the TA you believe that you should have gotten more points than you got, please write a brief statement making your case and e-mail it to the TA and the instructor. If you are not satisfied with the TA's decision, Dr. Velev will then make the final decision.

Academic integrity. Students should refer to the University policy on academic integrity found in the Code of Student Conduct (https://policies.ncsu.edu/regulation/reg-11-35-05-code-of-student-conduct/). It is the instructor's understanding and expectation that the student's signature on any test or assignment means that they neither gave nor received unauthorized aid. Similarly, the homework assignments should be prepared in accordance with the policy above.

Cell phone and electronic device use in class. ***The use of electronic devices is allowed only for the purpose of taking notes and other class activities.*** Texting, e-mailing, browsing, and other distracting activities will be considered demonstrations of social ineptitude and lack of professional skills.

Missed exams. If you miss a test for a well-explained reason, but without a certified medical excuse or prior instructor approval, you may take a makeup exam at a designated time during the last week of the semester. The makeup exam will be fair, but comprehensive and challenging. Tests missed with certified medical excuses will be dealt with individually.

Homework format. Use white paper or text editing software; begin each problem on a new page, and box the final answers. Scan the pages and save them as PDF files before submission via Gradescope.

Late homework. Completed assignments should be uploaded on Gradescope by *beginning* of class on the due day (Thursday). Late solution sets will be accepted up to 8:00 PM on the due day. Late assignments will receive 80% of the total grade. *However, no more than 2 late homeworks will be accepted for each student or group per semester.*

Posted solutions. Problem set solutions will be posted on moodle. *As stated above, e-mails to Dr. Velev asking how to solve specific homework problems are discouraged, but you can ask the TA short and simple questions by e-mail.*

Final grades. The final grades are determined strictly on the basis of the total cumulative grade and class grade distribution. ***The instructor is committed to fairness and avoiding any subjectivity or favoritism in assigning the final grades.*** The grade cutoffs are determined by the overall class grade distribution with an added downslide to students' benefit.

Instructors' commitment. You can expect Prof. Velev to be courteous, respectful, and punctual; be well organized and prepared for the lectures and other class activities; answer questions promptly and in a non-negative fashion; be available online during office hours or notify you beforehand if unable to keep them; and assure grading process that is fair, uniform and consistent.

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." Reasonable accommodations will be made in this course for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with the Disability Resource Office at Holmes Hall, Suite 304, Campus Box 7509, 919-515-7653. Students with disabilities or some permanent or temporary impairments are also welcome and encouraged to discuss any hardships encountered in the course and seek ways to address them with the instructor. 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/

Pronoun Use. 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. Please note that the complexity and confidentiality of the student records may lead to unintentional mistakes that we will be glad to correct if you advise us accordingly.

Religious/Cultural Observance. We honor your cultural and religious holidays. Students who have religious or cultural observances that coincide with the class activities should let the instructor know by e-mail the end of the first two weeks of the class.

Health and virus-related provisions. The course will follow strictly the present NC State guidelines. Students who have health concerns are welcome to wear masks in class. **Lecture attendance requires strict adherence to common safety procedures required by the University, and lack of any viral infection symptoms**. If you have such circumstances, please inform the instructor and the TAs, to make alternative arrangements.

Wellness and health support. As a student you may experience a range of personal issues that can impede learning, such as strained relationships, increased anxiety, difficulty concentrating and/or lack of motivation. It is very important that you have a support system and that you ask for help when you are struggling. The

Counseling Center at NC State offers confidential mental health services for full time NC State students, including same-day emergency services. Please visit https://counseling.dasa.ncsu.edu/ to get connected.

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.

(See next page for lecture and exam schedule)

Lecture and discussions schedule: 596-009, Spring 2026 (Rev. 1)

1.	Jan. 13	Introduction: Types of colloidal and soft matter systems
2.	Jan. 15	Surface thermodynamics, surface tension
3.	Jan. 20	Contact angle, wetting and capillary phenomena
4.	Jan. 22	Surfactants and micellar thermodynamics, surfactant phase equilibria
5.	Jan. 27	Adsorption and adsorption isotherms
6.	Jan. 29	Langmuir-Blodgett layers and bilayers, SAMS, wetting, surface engineering
7.	Feb. 3	Molecular forces overview, self-diffusion and Brownian motion
8.	Feb. 5	Molecular interactions, dispersion forces, van der Waals colloidal forces
9.	Feb. 10	Electrostatics 1: Basics
10.	Feb. 12	Electrostatics 2: Effect of electrolyte and DLVO theory
-	Feb. 17	*No class – Wellness Day*
11.	Feb. 19	Discussion 1: Wetting, capillarity and surface engineering
12.	Feb. 19	EXAM 1 (Tentative time 5:30 PM, location TBA)
13.	Feb. 24	Colloidal interactions not described by DLVO theory
14.	Feb. 26	Interactions between biological molecules
15.	March 3	Electrophoresis, zeta potential
16.	March 5	Dielectrophoresis
-	March 10	*No class – compensation for Exam 1*
17.	March 12	Discussion 2: Soft matter, gels, non-DLVO and biological interactions
-	March 17&19	--- *Spring break* ---
18.	March 24	Optical phenomena and microscopy in colloidal systems
19.	March 26	Discussion 3: Nanoparticles, nanowires, nanotubes, graphenes, Q-dots, MOFs
20.	March 31	Scattering methods: Light, X-ray and neutron scattering
21.	April 2	Microfluidics 1: Microfabrication and fundamentals
22.	April 2	EXAM 2 (Tentative time 5:30 PM, location TBA)
23.	April 7	Microfluidics 2: Applications, bioassays and bioarrays
24.	April 9	Active colloidal systems, self-propulsion and microrobotics
-	April 14	*No class – compensation for Exam 2*
25.	April 16	Discussion 4: Lab-on-a-chip, active particles, soft robotics and microrobotics
26.	April 21	Soft matter applications in soft robotics, ionic electronics and photonics
27.	April 23	Discussion 5: Green colloids, bionanomaterials and sustainable manufacturing
28.	April 28	Sustainability and entrepreneurial case studies. General review.
***	May 5	FINAL TERM PAPERS due on Gradescope by 11:00 PM