SYLLABUS

Fall 2012
ENVR 416: Aerosol Physics and Chemistry (4 credit hours)

Class Meets: Tuesdays & Thursdays 12:30-1:45 PM, McGavran-Greenberg 2305
Instructor: Dr. Jason Surratt
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Office Hours: By appointment

Course Description and Goals:

The physical and chemical properties of aerosols impact the world around us, explaining many natural phenomena (e.g., the color of the sky, presence of clouds, and blue haze commonly observed in the Smoky Mountains), as well as impacting global climate change, air quality, and human health. In order to understand how aerosols impact our environment (both indoors and outdoors), this course will consist of two major sections; aerosol physics and aerosol chemistry.

First, in the aerosol physics section we will discuss the physical principles underlying the behavior of particles suspended in air, which includes rectilinear and curvilinear motion of particles in a force field, diffusion, evaporation, condensation, coagulation and electrical properties. The principles learned from the aerosol physics section of the course will allow students to understand how to size and collect/remove aerosols.

Owing to the fact that the second section of this course is devoted to understanding the chemistry that leads to atmospheric aerosol formation, principles gained from the first section will be important to understanding sources and fates of atmospheric aerosols. Primary focus in this section will be given on the chemistry that leads to the formation, evolution, and aging of organic aerosols, especially since organic compounds contribute a large fraction (i.e., 20-90%) towards the total mass of atmospheric fine (i.e., 2.5 μm and smaller) aerosol. High concentrations of atmospheric fine aerosol are known to have adverse human health effects and play a role in the Earth's climate system. The impact of atmospheric fine aerosols on climate and health cannot be fully assessed without understanding their detailed chemical processes. In addition, students will learn how to chemically characterize aerosols using both off-line and on-line analytical techniques.

Although the aerosol physics and chemistry examined in this course is primarily related to atmospheric aerosols, which is critical to those graduate students pursuing careers in air pollution control, air quality and atmospheric chemistry, the physical and chemical principles learned during this course will also be invaluable to those students pursuing careers in industrial hygiene, nanotechnology, atmospheric science (or meteorology), chemical manufacturing, pharmaceuticals (e.g., drug delivery), public health, epidemiology, toxicology and material science.

Prerequisites:

This is an introductory graduate level course to aerosol physics and chemistry; however, this course is also open to advanced undergraduates, especially those students who have: (1) had at least one undergraduate course in chemistry (organic chemistry is strongly recommended); (2) had at least one undergraduate course in physics; (3) comfort with doing some math.

Grading and Course Requirements:

In-class quizzes	30%
In-class midterm exam	20%
In-class final exam	20%
Problem sets (i.e., homework assignments)	20%
Labs	10%
	100%

Final Grades Assigned:
High pass (H) – students in top 10% of class will receive this grade
Pass (P) – most students receive this grade if course work completed adequately
Low Pass (L)
Fail (F) – given if failure to attend lectures or labs, turn in assignments, or adequately complete quizzes/exams

Instructor's Philosophy of Grading Scale: This is a graduate level course, and as a result, no letter grades are given (see Graduate School Handbook for details). The purpose of graduate school (in the opinion of the instructor) is for students to produce original research that advances the scientific knowledge in one's field of study. Thus, the lack of letter grades will hopefully stimulate an atmosphere of self learning and thinking during this course that will be a useful skill to apply during one's graduate student career. Although the grading scheme is on a pass/fail system, please do not assume the instructor will not fail students in this course, especially if you do not attend class or do very poorly on quizzes/exams and other assignments. You are expected to participate in all lab sessions.

In-Class Quizzes (30% of grade): Except for the first week of class, in-class quizzes will be given at the beginning of each Tuesday class period. These quizzes will be closed book and closed notes and should only last you 10 minutes (unless otherwise specified by the instructor). The purpose of the in-class quizzes is to motivate each student to review their lecture notes from the prior week as well as any required readings from the prior week so they stay up-to-speed on the course material. It is possible we may not have a quiz every Tuesday; however, you should be prepared each Tuesday regardless. I will discard your lowest quiz grade before determining your final grade for the course. If you miss a Tuesday class when a quiz is given, you will receive a grade of zero for that quiz but that grade will be the one I discard. You will also receive a grade of zero for each additional quiz missed after the first. We will likely have up to 10-12 quizzes throughout the semester, and as a result, do not worry if you miss one or do poorly on a couple of quizzes. This is graduate school, so if you must miss a Tuesday class for training on an instrument, a necessary scientific workshop or conference, or some understandable personal reason, then an alternative quiz (or solution) will be worked out between the student and the instructor.

In-Class Midterm Exam (20% of grade): The date of the in-class midterm exam is Tuesday, October 23, 2012. This midterm exam will focus only on the aerosol physics material presented through October 9, 2012. This exam will be closed notes and closed book. All necessary equations will be provided to you but no description of what the symbols or meaning of these equations will be provided.

In-Class Final Exam (20% of grade): The date of the in-class final exam is Tuesday, December 11, 2012 from 12:00 until 3:00 PM, in accordance with the UNC exam schedule for classes that meet TH at 12:30 PM. Like the midterm exam, the in-class final exam be 75 minutes long and will also be closed notes and closed book. The main focus will be on atmospheric aerosol chemistry and not so much on the physics.

Problem Sets (20% of grade): Periodically (i.e., 4-6 times) during the semester, I will handout take home problem sets for you to work through. Except for the problem set that is associated with a critical review of a relevant aerosol publication, you are encouraged to work together with your classmates on all other problem sets. If you have difficulty with any of these assignments please feel free to schedule a time to meet with me. Problem sets are expected to be turned in on time. Late problem sets will lose 10% for each day it is late. Problem sets may be turned in late only if prior approval of the instructor is given or if there is some very exceptional circumstance that arises (e.g., severe illness, accident). The amount you learn in this course will directly relate to your ability to work problems of this level. In addition to doing the reading assignments and reviewing your lecture notes, understanding the problem sets should help prepare you for any in-class quizzes and exams.

Labs (10% of grade): Two major lab sessions are included in this course and are required by all students to attend. The lab sessions will be at the conclusion of the aerosol physics and aerosol chemistry sections. In each lab session you will work together with a partner (or partners depending on the class size) to do the experiment planned. For both of the major labs planned, we will use two lecture periods and an outside lecture lab session. The first lecture period will allow for the Lab TA brief you on the planned experiment. The second lecture period scheduled for the lab will allow all students an opportunity to tie up any loose ends on their labs. It should be noted that an additional 4 hr lab period outside of the scheduled lecture periods will likely be needed for one or both of the lab sessions due to the time needed to complete the planned experiment in the lab. As a result, a schedule will be posted for partners to sign up for. We understand that the extra meeting may cause conflict for some students, and as a result, we will work with you to find a time that minimizes any such problems. This course carries four hours of credit rather than three; the additional hour of credit is due to the additional effort involved with the laboratory assignments. After completion of the labs, you will then be asked to prepare a brief report of your findings. These will be due one week after the lab periods are completed.

Honor Code: The University of North Carolina at Chapel Hill has had a student-administered honor system and judicial system for over 100 years. The system is the responsibility of students and is regulated and governed by them, but faculty share the responsibility. If you have questions about your responsibility under the honor code, please bring them to your instructor or consult with the office of the Dean of Students or the Instrument of Student Judicial Governance. This document, adopted by the Chancellor, the Faculty Council, and the Student Congress, contains all policies and procedures pertaining to the student honor system. Your full participation and observance of the honor code is expected.

Students have four general responsibilities under the Honor Code:

1. Obey and support the enforcement of the Honor Code;
2. Refrain from lying, cheating, or stealing;
3. Conduct themselves so as not to impair significantly the welfare or the educational opportunities of others in the University community; and
4. Refrain from conduct that impairs or may impair the capacity of University and associated personnel to perform their duties, manage resources, protect the safety and welfare of members of the University community, and maintain the integrity of the University.

Textbooks and Other Readings:

Required Textbooks:

John H. Seinfeld and Spyros Pandis, Atmospheric Chemistry and Physics: From Air pollution to Climate Change, 2nd Edition, 2006, Wiley.

William C. Hinds, Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles, 2nd Edition, 1999.

Additional Required Readings: Research articles or photocopies of chapters from other textbooks may be handed out in class from time to time to supplement any of the material that is not adequately covered in the required textbook. Students will be required to read these in order to be better prepared for lectures, quizzes and exams.

Recommended Textbooks:

Barbara J. Finlayson-Pitts and James N. Pitts, Jr., Chemistry of the Upper and Lower Atmosphere, 1999, Academic Press.

Pramod Kulkarni, Paul A. Baron, and Klaus Willeke. Aerosol Measurement: Principles, Techniques, and Applications, 3rd Edition, 2011, Wiley

Class Schedule (subject to updates – T = Tuesdays; H = Thursdays):

Day	**Day of Month**	**Month**	**Topic**	**Readings**	**Instructor**
T	21	Aug	Course introduction, objectives, policies, and schedule		Surratt
H	23	Aug	Particle size	H: 1-15 SP: 58-60	Surratt
T	28	Aug	Particle size distributions: number, surface area, volume and mass	SP: 350-360	Surratt
H	30	Aug	Particle size distributions: log-normal distributions and ambient size distributions	SP: 362-381 H: 90-97	Surratt
T	4	Sep	Properties of gases	H: 15-23; 27-31 SP: 396-400	Surratt
H	6	Sep	Uniform particle motion: Newton’s resistance law, Stoke’s law, and slip and shape correction factors	H: 42-55 SP: 403-407; 426-431	Surratt
T	11	Sep	Uniform particle motion: terminal settling velocity and mechanical mobility	H: 55-62 SP: 407-411	Surratt
H	13	Sep	Particle acceleration, stopping distance	H: 111-119	Surratt
T	18	Sep	Curvilinear motion and Stokes number	H: 119-136 SP: 422-426	Surratt
H	20	Sep	Electric Forces, motion in an electric field	H: 316-323 SP: 411-412	Surratt
T	25	Sep	Particle charging and charge limits	H: 323-338	Surratt
H	27	Sep	Brownian motion and diffusion	H: 150-160 SP: 412-421	Surratt
T	2	Oct	Kelvin effect, droplet equilibrium	H: 278-283	Surratt
H	4	Oct	Condensation, nucleation, and evaporation	H: 283-301	Surratt
T	9	Oct	Coagulation	H: 260-272	Surratt
H	11	Oct	Introduction to atmospheric aerosol ahemistry – atmospheric structure, sources, compositions	H: 304-314 SP: 381-388	Surratt
T	16	Oct	***Lab Session 1: Aerosol Generation and Sizing Measurement***	H: 428-445	Surratt

H	18	Oct	***NO CLASS – Fall Break***		
T	23	Oct	***IN-CLASS MIDTERM EXAM – Aerosol Physics Section***		Surratt
H	25	Oct	Review of chemical classes (including organics) important to aerosol formation	SP: 27-47	Surratt
T	30	Oct	Atmospheric organic aerosol – EC vs. OC	SP: 628-647	Surratt
H	1	Nov	Secondary Organic Aerosol (SOA): General mechanism and SOA Yields	SP: 647-666 Kroll & Seinfeld (2008, Atmos. Environ.)	Surratt
T	6	Nov	SOA: General gas-phase oxidation chemistry mechanisms – why they matter?	SP: 219-224	Surratt
H	8	Nov	SOA: Gas-phase oxidation chemistry of isoprene	SP: 261-265	Surratt
T	13	Nov	SOA: Role of heterogeneous chemistry in isoprene SOA formation	SP: 666-670 Kroll & Seinfeld (2008, Atmos. Environ.)	Surratt
H	15	Nov	Modeling of atmospheric organic aerosols	Kroll and Seinfeld (2008, Atmos. Environ)	Dr. Havala Pye (EPA)
T	20	Nov	Chemical characterization of SOA	Hallquist et al. (2009, Atmos. Chem. Phys.) – Section 3.3	Surratt
H	22	Nov	***NO CLASS – Thanksgiving Holiday***		
T	27	Nov	***LAB Session 2: SOA Generation in Indoor Smog Chamber***	T.B.A.	Surratt and TA
H	29	Nov	***LAB Session 2: SOA Chemical Characterization of Indoor Chamber-Generated SOA Sample***	T.B.A.	Surratt and TA
T	4	Dec	Finish up loose ends, including extra time for lab 2		Surratt and TA
T	11	Dec	***IN-CLASS FINAL EXAM - Aerosol Chemistry Section***		Surratt

Footnotes: SP = Seinfeld and Pandis textbook; H= Hinds textbook; TBA = to be announced.