

BAE 495B/590B – 002: AEROSOL MECHANICS

Department of Biological and Agricultural Engineering

Syllabus – Spring 2007

M.W.F. 10:15 – 11:05, 142 Weaver Labs

Instructor Information:

Dr. Lingjuan Wang

Office: 186 Weaver Labs

Phone: 919-515-6762

Fax: 919-515-7760

Email: Lwang5@ncsu.edu

Office Hours: by appointment

***Prerequisite:** Senior / Graduate status or approval of instructor*

Instructional Objectives: This course is designed for graduate or senior undergraduate students who have a desire to work in the area of air quality. Upon completion of this course, students will be able to (1) identify the governing mechanism(s) for aerosol behavior under different circumstances; (2) evaluate various aerosol measurement techniques and analyze their limitations; (3) design particulate matter (aerosol) sampling systems for source emission determination; ambient air monitoring; workplace air quality monitoring; and laboratory experiments; and (4) apply aerosol fundamentals in control of particulate matter (aerosol) emission.

Course Text: Hinds, W.C. *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles*, 2nd edition. John Wiley & Sons, New York, 1999. ISBN0471194107. \$95.95 (new), \$77.98 (used).

except for University Excused Absences. In order to take a makeup exam, students have to inform instructor about the absence **before** the exam unless there is an unexpected accident.

Term Project: There will be a term project for graduate students, which represents 15% of the grade for this course. The project topic is of student's choosing. Each student should have a topic selected upon instructor's approval by February 5. Each student is expected to give a 15 – 20 minutes oral presentation on the term project research on April 27. The final paper is also due on April 27, and should be written in the style of a paper to be submitted to a major journal for publication.

Grade Determination: The final grade will not be graded on a curve, and will be determined based upon the following components:

Components	Homework	Quizzes	Exam 1	Exam 2	Final	Term Project
BAE495B	30%	5%	20%	20%	25%	No term project is required
BAE590B	20%	5%	20%	20%	20%	15%

Grading: border-line grades may be upgraded based upon attendance, class participation, and evidence of improvements.

A+	98-100	B+	87-89	C+	77-79	D+	67-69	F	<60
A	95-97	B	84-86	C	74-76	D	64-66		
A-	90-94	B-	80-83	C-	70-73	D-	60-63		

Academic Integrity: The Code of Student Conduct at North Carolina State University sets out a code of ethics and personal dignity. Students should refer to this code and value honesty and integrity. The code could be found at www.ncsu.edu/policies/student_services/student_discipline/POL11.35.1.php.

It is permissible in this course to discuss the interpretation of the problem statement, share ideas or approaches for solving the problem, and explain the concepts involved in the problem. Any other aid is not permissible and considered as a violation of the academic integrity policy. No academic misconduct will be tolerated in this course.

Attendance: Students are expected to attend class on time. In case of absence, the student must provide documentation substantiating the reason for the absence that is satisfactory to the instructor, within one week of the last date of the absence. For illness, documentation should include a note from a doctor or clinic. For further information, students should refer to the University attendance policy at www.ncsu.edu/provost/academic_regulations/attend/reg.htm.

Students with University Excused Absences will be allowed to makeup missing exam and late homework without any penalty. However, it is the student's responsibility to identify the materials covered during the absence and to contact instructor for scheduling makeup exam.

Students with Disabilities: Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register with Disability Services for Students at 1900 Student Health Center, Campus Box 7509, 515-7653. http://www.ncsu.edu/provost/offices/affirm_action/dss/

Tentative Course Outline:

Part I: Aerosol Fundamentals

1. Introduction: overview and definitions (*Hinds, Ch.1*)
 - a. Overview and definitions
2. Properties of gases (*Hinds, Ch.2; Zhang, Ch.5; Cooper & Alley, Ch.10*)
3. Particle size statistics (*Hinds, Ch.4; Zhang, Ch.3*)
 - a. Properties of size distribution
 - b. Number distribution
 - c. Mass distribution
 - d. The log-normal distribution
4. Particle mechanics – 1 (*Hinds, Ch.3; Zhang, Ch.4*)
 - a. Uniform particle motion
5. Particle mechanics – 2 (*Hinds, Ch.5*)
 - a. Straight-line acceleration and curvilinear particle motion
6. Adhesion of particle (*Hinds, Ch.6*)
7. Diffusion (*Hinds, Ch.7, Ch.12; Zhang, Ch.6*)
 - a. Brownian motion
 - b. Diffusion coefficient
 - c. Diffusive deposition
8. Thermal and Radiometric forces (*Hinds, Ch.8*)
9. Coagulations of aerosols (*Hinds, Ch.12*)
 - a. Monodisperse coagulation
 - b. Polydisperse coagulation
 - c. Kinematical coagulation
10. Condensation and evaporation (*Hinds, Ch.13*)
 - a. Thermodynamics
 - b. The Kelvin-Helmholz equation
 - c. Growth by condensation
 - d. Evaporation
11. Filtration of aerosols (*Hinds, Ch.9; Zhang, Ch.10*)
 - a. Properties of filters
 - b. Filtration mechanisms
 - c. Filter efficiency
 - d. Pressure drop
12. Electrical behavior of aerosols (*Hinds, Ch.15; Zhang, Ch.12*)
 - a. Basic considerations
 - b. Charging mechanisms
 - c. Electrical measurement of aerosols
13. Optical characteristics of aerosols (*Hinds, Ch.16*)
 - a. Scattering of light
 - b. Extinction
 - c. Optical measurement
14. Spray and atomization (*Hinds, Ch.21, handout*)
15. Atmospheric aerosols (*Seinfeld, Ch.7; Hinds, Ch.14; Handout*)
 - a. Introduction and background
16. Bioaerosols (*Hinds, Ch.19; Baron & Willeke, Ch.24*)
 - a. Definition and classification

- b. Characteristics
 - c. Collection and sampling
17. Health effect of aerosols – aerosols in air quality (*Hinds, Ch.11, handout*)

Part II: Aerosol Measurement

18. Uncertainty analysis in aerosol measurement (*Handout*)
- a. Basic concepts
 - b. Uncertainty analysis
19. Air flow rate control and PM concentration determination (*handouts*)
20. Stationary PM source sampling
21. Impaction and gravitational settling in aerosol measurements
22. Low Reynolds sampling cyclone
23. PSD measurement method
24. Open path technology
25. Diffusion denuders
26. FRM PM sampler performance
27. Interaction of PSD and sampler performance characteristics
28. Dispersion modeling of PM emissions
29. Aerosol measurement in the workplace (*Baron, Ch.25 and handout*)
- a. ACGIH sampling criteria for inhalable, thoracic and respirable fractions
 - b. Occupational exposure limits
 - c. Industrial hygiene aerosol samplers
30. Indoor aerosols (*Baron, Ch.29*)
- a. Measurement strategies
 - b. Sampling and analysis methods
 - c. Sampling of PM emission from building
31. Air quality regulatory process and ambient air monitoring (*Handout*)
32. National air emission monitoring study (NAEMS)

Part III: Aerosol Emission Control

33. Industrial cyclones for PM emission control (*handout*)
- a. Theory and design considerations
34. PM scrubbers (*handout*)
- a. Theory and design considerations
35. Electrostatic precipitators (ESP) - (*Zhang, Ch.12; Cooper & Alley, Ch.5*)
- a. Theory and design considerations
36. Fabric filters –PM bag house design (*handout*)
- a. Theory and design considerations
37. Case studies (*handout*)

Tentative Lecture Schedule & Topics:

Week	Class	Date	Topics	Assignments	Reading
1	1	01-10-07	Introduction: overview & definitions		Hinds, Ch.1
	2	01-12-07	Properties of gases		Hinds, Ch.2; Zhang, Ch.5
2		01-15-07	No class, holiday		
	3	01-17-07	Particle size statistics		Hinds, Ch.4
	4	01-19-07	Uniform particle motion	HW #1	Hinds, Ch.3
3	5	01-22-07	Straight-line acceleration and curvilinear particle motion		Hinds, Ch.5
	6	01-24-07	Adhesion of particle		Hinds, Ch.6
	7	01-26-07	Brownian motion and diffusion	HW #2	Hinds, Ch.7, Ch.12
4	8	01-29-07	Diffusive deposition/thermal and radiometric force		Hinds, Ch.7, Ch.8
	9	01-31-07	Coagulation		Hinds, Ch.12
	10	02-02-07	Condensation and evaporation	HW #3	Hinds, Ch.13
5	11	02-05-07	Filtration	Term paper topic due	Hinds, Ch.9, Zhang, Ch.12
	12	02-07-07	Electrical behavior of aerosol		Hinds, Ch.15, Zhang, Ch.12
	13	02-09-07	Optical characteristics of aerosol	HW #4	Hind, Ch.16
6	14	02-12-07	Spray and atomization/atmospheric aerosols		Hinds, Ch.21, 14 Seinfeld, Ch.7
	15	02-14-07	Bioaerosols		Hinds, Ch.19, Baron, Ch.24
	16	02-16-07	Health effect of aerosol	HW #5	Hinds, Ch.11, Handouts
7	17	02-19-07	Review for Exam 1		
		02-21-07	Exam 1	Closed book, closed notes	
	18	02-23-07	Review Exam 1		
8	19	02-26-07	Uncertainty analysis in aerosol measurement		Handouts
	20	02-28-07	PM concentration determination		Handouts
	21	03-02-07	Stationary PM source sampling	HW #6	Hind, Ch.10, Zhang, Ch8,
9		03-05-07	No class, spring break		
		03-07-07	No class, spring break		
		03-09-07	No class, spring break		
10	22	03-12-07	Impaction and gravitational settling in aerosol measurements	Term paper abstract due	Hinds, Ch.5, Zhang, Ch7., Baron, Ch.10
	23	03-14-07	Low Reynolds sampling cyclone/PSD measurement methods		Handout, Hinds, Ch.15, Baron, Ch.17
	24	03-16-07	Open path technology	HW #7	Handouts
11	25	03-19-07	Diffusive denuders		Handouts
	26	03-21-07	FRM PM sampler performance – Dr. Wiener, EPA		Handouts
	27	03-23-07	Interaction of PSD and sampler performance characteristics	HW #8	
12	28	03-26-07	Dispersion modeling of PM emissions		Handouts
	29	03-28-07	Air quality regulatory process and ambient air monitoring network		Handouts
	30	03-30-07	National air emission monitoring study (NAEMS)	HW #9	Handouts
13	31	04-02-07	Aerosol measurement in workplace		Barons, Ch.25, Handouts
	32	04-04-07	Review for Exam 2		
	33	04-06-07	No class, spring holiday		
14		04-09-07	Exam 2	Closed book, closed notes	
	34	04-11-07	Review Exam 2		
	35	04-13-07	Industrial cyclones for PM emission control		Handouts
15	36	04-16-07	PM scrubbers		Handouts
	37	04-18-07	Electrostatic precipitators	HW #10	Handouts
	38	04-20-06	Case studies		Handouts
16	39	04-23-07	Dead week - Review for Final		
	40	04-25-07	Dead week		
	41	04-27-07	Term project presentations	Term paper due	
05-02-07, 8:00 – 11:00 am			Final Exam	Closed book, closed notes	