

BBE 4753 / 5753
Air Quality and Pollution Control Engineering
Spring Semester 2017 (3 credits)
MWF yyyy

INSTRUCTOR

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Office Hours: To be determined if needed. You are welcome to contact me by phone or email to make an appointment or to stop by to see if I am available to meet. The hour before class is not a good time to meet because I commonly use this time for last minute prep.

COURSE DESCRIPTION

This engineering course will introduce students to concepts and engineering principles related to air quality and air pollution control engineering systems. Students will learn about and explore important air pollutants, their sources and impacts on humans, plants, animals, structures, soil, water, the atmosphere and planet. They will gain knowledge about emission rates, measurement, dispersion modeling and control technologies. Students will be introduced to air pollution and air quality laws, regulations and permits. They will learn about air pollution control technologies and their use to address short and long term air pollution problems and their impacts.

Students that take the special topics engineering course BBE 4xxx/5xxx, Air Quality and Pollution Control Engineering, will learn to identify air quality and pollution problems based on current air quality and pollution regulations and emissions data. The students will learn about applicable US Environmental Protection Agency (EPA), Minnesota Pollution Control Agency (MPCA) and US Occupational Safety and Health Agency (OSHA) regulations related to air quality and air pollution. Students will also learn about air pollutant generation, emissions, transformations, dispersion, fate and impacts. Finally students will learn about air quality management and the design of air pollution control technologies (ex. energy conservation, cyclones, electrostatic precipitators, fabric filters, absorbers, adsorbers, incinerators and biofilters) to mitigate airborne emissions.

This course will help students with four out of seven of the University of Minnesota Undergraduate Student Learning and Development Outcomes. They are: identify, define and solve problems; locate and critically evaluate information; master a body of knowledge and mode of inquiry; and communicate effectively. You will develop your skills in these areas through reading assignments, active learning activities, weekly writing, final presentation, journal and news assignments and exams.

COURSE PREREQUISITES

- BBE 3012, 3043, upper division CSE, graduate student or instructor consent
- Credit will not be granted if credit has been received for CEGE 5561

COURSE GOALS

This course is designed to:

1. Introduce you to air pollutants, sources and emission rates of these pollutants
2. Have you learn to calculate conversion factors, emission rates and collection efficiencies and other design characteristics for the common air pollutants
3. Introduce you to the effects of air pollution on human health, plants, animals, materials and the atmosphere
4. Have you compare and contrast ambient air quality and indoor air quality
5. Introduce you to air sampling and analysis techniques
6. Introduce you to air pollution control devices, technologies, and systems

7. Introduce you to laws and regulations related to air pollution and air quality
8. Have you gain experience using publicly reported air pollution data to assess air pollution problems, sources, mitigation practices and public policies to manage air pollution and indoor air quality.
9. Have you gain experience assessing air pollution problems, proposing mitigation and management practices to manage the problem.
10. Introduce you to online resources related to air quality and air pollution

COURSE OUTCOMES

At the end of this course you will be able to:

- A. Define important air pollutants and major sources of these pollutants.
- B. Explain air pollutant generation, transformation and transportation processes.
- C. Explain the impact of air pollutants on people, plants, animals, and the atmosphere.
- D. Explain potentials ways to measure and monitor the air pollutant emissions rates.
- E. Design air pollution control systems to manage emissions and enhance air quality.
- F. Demonstrate knowledge of current air pollution and air quality laws, regulations, and standards
- G. Demonstrate an ability to communicate in written form the results of your investigation into an air pollution problem, the impacts of the pollutant, your assessment, and recommendations, either technical, management or policy relate, for addressing the problem.

This course will help you attain four out of seven of the University of Minnesota Undergraduate Student Learning and Development Outcomes (http://academic.umn.edu/provost/teaching/cesl_loutcomes.html).

The outcomes are:

1. Identify, define and solve problems,
2. Locate and critically evaluate information,
3. Master a body of knowledge and mode of inquiry, and
4. Communicate effectively

COURSE TEXT

- Cooper, C.D. and F.C. Alley. 2011. Air Pollution Control: a Design Approach 4th Ed., Waveland Press, Long Grove, IL USA.

WEB-RESOURCES

- US EPA Air and Radiation website <http://www.epa.gov/air/index.html>
 - US EPA <http://www.epa.gov/air/airpollutants.html> (air pollutants, health effects, measurement and control methods, standards and guidelines)
 - US EPA <http://www.epa.gov/clean-air-act-overview> (Clean Air Act website)
 - AP-42 Emission Factors <https://www3.epa.gov/ttnchie1/ap42/>
 - Greenhouse Gas Reporting Program <https://www.epa.gov/ghgreporting>
- Air Now <http://airnow.gov> (Current AQI forecast and regional air quality information)
- Title 40 – Electronic Code of Federal Regulations http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title40/40tab_02.tpl

Emissions Information

- National Public Radio Toxics Release Interactive Map <http://www.npr.org/news/graphics/2011/10/toxic-air/#4.00/39.00/-84.00>
- US EPA Air Emissions Sources <http://www.epa.gov/air/emissions/where.htm>
- US EPA National Air Toxics Assessment <http://www.epa.gov/national-air-toxics-assessment>

Other Air Pollution and Air Quality Information

- Medline Plus <http://www.nlm.nih.gov/medlineplus/airpollution.html> (air quality index)
- Centers for Disease Control and Prevention <http://www.cdc.gov/nceh/airpollution/> (air pollution and respiratory health)
- Lawrence Berkeley National Laboratory Indoor Air Quality <http://www.iaqscience.lbl.gov> (indoor air quality)

COURSE WEBSITE

A Moodle website will be used for this class. You can access the website by going to <http://myu.umn.edu>, go to myU Home and click on the Sign-In link.

The course website will be used to post narrated PowerPoint videos, assignments, and class and lab handouts. The narrated PowerPoint lectures will be recorded and posted on the class website for viewing prior to class meeting times when you will be solving problems and completing assigned work in small groups. Occasionally you will be asked to complete online quizzes to assess your understanding of recorded and posted material prior to class. You will submit writing assignments through links on the class website during each week that an assignment is due. You are encouraged to visit the course website routinely to see the latest material posted for the class. You will also be able to view your grades on the course website as they are posted. You are expected to check your University of Minnesota e-mail accounts since announcements may be distributed using e-mail.

In this class, our use of technology will sometimes make students' names and U of M Internet IDs visible within the course website, but only to other students in the same class. Since we are using a secure, password-protected course website, this will not increase the risk of identity theft or spamming for anyone in the class. If you have concerns about the visibility of your Internet ID, please contact me for further information.

ASSESSMENTS AND GRADING

Grades of this course will depend on:

BBE 4xxx Undergraduate students

Homework problems	25%
Class activities (in class and online)	15%
Term project	15%
Three exams (15% each)	45%

ESPM 5xxx Graduate students

Homework problems	20%
Class activities (in class and online)	10%
Term project	15%
Research paper review	10%
Three exams 15% (each)	45%

- You are **not** permitted to submit extra work in an attempt to raise your grade.
- You may take a make-up exam **only if** you have a **documented** medical/family emergency.
- All work submitted should be **legible**, well organized, and stapled.

Late materials

- Failure to complete any of the work will result in receiving a zero for that assignment.
- Materials for grading handed in late will be penalized 20%. Materials handed a week past the due date will be penalized 50%.
- Materials handed in more than two weeks past the due date will be penalized 100%.

University of Minnesota grading policies

Grades are assigned in alignment with University of Minnesota grading policies. For more information see <http://policy.umn.edu/Policies/Education/Education/GRADINGTRANSCRIPTS.html>

COURSE ASSIGNMENTS

Several types of assignments are used to help you learn the concepts, principles and information provided in this course. The following describes the types of assignments that can be assigned.

1. Active learning activities (ALAs)

a. Reading assignments

- Reading assignments are given in the course schedule.
- You are expected to read the assigned texts before coming to the class to participate in-class active learning activities.
- Online quizzes may be used to check your understanding of some readings.

b. Class activities

- You will be asked to discuss course concepts and principles in small in-class groups, summarize the group's thoughts in a paragraph or two and share key discussion points in class discussions.
- Students will either hand in their summaries or post them online as part of online discussions.
- Some class activities will involve group problem solving which may be collected and graded.

c. Problem solving

- Problem sets will be given to students to solve. Some problem sets will be completed in class and some will be completed outside of class.

d. Informal writing (not graded):

- *Write-pair-share.* You are asked a question (e.g., the difference between concentration and dose) and given a short time to write your thoughts, which you will be asked to share with a classmate. Pairs will be randomly chosen to share their answers with the rest of the class.
- *Muddiest point.* You are asked to write what might be the most confusing part of a class (e.g., what is the muddiest point of the nitrogen cycle, ethic codes). This will help the instructor to determine content needing additional instruction.
- *One sentence summary.* You are asked to summarize your knowledge of a topic by constructing a single sentence (e.g., define a professional). This helps you identify defining features of an idea.

2. Online posts and reviews

a. Find and describe organizations or journals

- You will be assigned to find three organizations or journals related to air pollution or air quality.
- You will post your reports online. See the separate handout for details on content and format.
- You will review reports by your classmates and comment online your thoughts and reactions.
- You will write **respectful** comments (agree, disagree, partially agree/disagree and why) for three other classmates based on your review of the organization review the posted.
- You can reply back to the comments in a respectful manner or continue to write comments for other classmates.
- You should keep in mind that respect for others and rational support for arguments are just as important online as in the classroom.

b. Find and describe research papers (only graduate students)

- Graduate students will find and describe two research paper related to air pollution or air quality.
- Graduate students will post their reports online and respond to questions and comments online.

c. Find and share news

- You are encouraged to find air pollution/quality items in the news and post them online
- You will discuss the environmental and health impacts, regulatory context, values associated with these events/news, and your points of view in class or online.

3. Term project

a. Written term project

- The purpose of these writing assignments is to apply the course material to an air pollution problem of interest to you and compile the revised assignments into a term project.
- You will identify an important air contaminant; source; processes that generate, transport, cause atmospheric reactions and deposition of the pollutant; and impacts on people, plants, animals and the environment.
- You will discuss current regulations and potential ways to mitigate emissions and their impacts.
- The specific writing assignments and due dates are described in detail in a separate handout.
- The first two reports will be reviewed. You will be given feedback and may be asked to rewrite if necessary.

4. Exams

- There will be three open-book open-note exams given during the course. Dates are indicated in the course schedule.

5. Graduate Student Research Paper Review

- Graduate students will prepare brief written reviews of three refereed research papers published in the last 5 years.

COURSE POLICIES

Attendance and participation

Attendance at each class session is expected. While attendance is not used explicitly in the grading, it is noted. Please arrive on time and attend the full class period. Students who need to miss class for a pressing personal/family matter, to attend an academic meeting, for preliminary exams/final defense or for religious observance should **contact the instructor in advance** or as soon as possible either by email or phone (leave a message if I am out). Students should get the information about the missed class from a classmate. Handouts will be posted on the class website.

Incompletes and Add and drop/withdrawal

- Check <http://onestop.umn.edu/calendars/index.html> for add, drop or withdrawal policies
- An incomplete (I grade) is not encouraged. An incomplete will be used when there is reason to believe that the incomplete work will be completed. For an incomplete you must make arrangements with the instructor before the third exam.

Scholastic Misconduct and Cheating:

Presenting someone else's work as your own is cheating. Cheating will not be tolerated. Students caught cheating will be given a zero for the graded activity they cheated on. A report of the cheating will be sent to the student's home college. Students caught cheating a second time will be given an F for the course. Specific behaviors that are considered cheating include:

- Submitting an assignment for credit when you did not do the work, you do not understand the answer, or you cannot explain how the answer was obtained;
- Plagiarism, copying someone else's work or answer (ex. another student, textbook, magazine, research publication, or information from the web) without appropriate citation;
- Copying answers from another person during an exam; or
- Using notes or crib sheets during a closed-book or closed-note exam.

Note that the TurnItIn plagiarism plugin is used to assess written materials submitted for this course. This is an online originality checker.

The University Student Conduct Code defines plagiarism as “representing the words, creative work, or ideas of another person as one’s own without providing proper documentation of source.” The University Student Conduct Code gives several examples of plagiarism including, but are not limited to:

- “Copying information word for word from a source without using quotation marks and giving proper acknowledgement by way of footnote, endnote, or in-text citation;
- Representing the words, ideas, or data of another person as one’s own without providing proper attribution to the author through quotation, reference, in-text citation, or footnote;
- Producing, without proper attribution, any form of work originated by another person such as a musical phrase, a proof, a speech, an image, experimental data, laboratory report, graphic design, or computer code;
- Paraphrasing, without sufficient acknowledgment, ideas taken from another person that the reader might reasonably mistake as the author’s; and
- Borrowing various words, ideas, phrases, or data from original sources and blending them with one’s own without acknowledging the sources.”

For more information see the University Student Conduct Code at http://onestop.umn.edu/u_resources/policies_and_administration/consumer_information.html

Sexual harassment

- Sexual harassment includes unwelcome sexual advances and requests for sexual favors, etc.
- University policies prohibit sexual harassment. For more information please see <http://policy.umn.edu/hr/sexualharassment>

Accommodations for students with disabilities

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. Disability Services (DS) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations.

If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact DS at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations.

If you are registered with DS and have a current letter requesting reasonable accommodations, you are encouraged to contact me early in the semester to review how the accommodations will be applied in this course. All contacts will remain confidential.

Diversity and collegiality

- The students of this course come from widely diverse ethnic and cultural backgrounds. You are expected to communicate respectfully inside and outside of the class.
- Students who violate the University Student Conduct Code will be referred to the Office <http://policy.umn.edu/hr/sexualharassment>. For more information please see <http://www1.umn.edu/oscai>

Having problems? If you miss class, get behind in class, have a hard time with the material, or are having problems that are not allowing you to do your best work for this class, we expect you to come in and see one of us. When we meet we can discuss your situation and negotiate a way for you to make up the work or prove your abilities. If you need assistance of any sort, please let us know.

Student Mental Health and Stress Management: As a student you may experience a range of issues that can either be or cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating, and/or lack of motivation. These mental

health concerns or stressful events may lead to diminished academic performance or reduce your ability to participate in daily activities. University of Minnesota services are available to assist you with addressing these and other concerns you may be experiencing. You can learn more about the broad range of confidential mental health services available on campus via www.mentalhealth.umn.edu.

Student Writing Support (SWS) (from <http://writing.umn.edu/sws/instructors.html>)

Student Writing Support (SWS) at the Center for Writing offers free writing instruction for all University of Minnesota students—graduate and undergraduate—at all stages of the writing process. In face-to-face and online collaborative consultations, SWS consultants help students develop productive writing habits and revision strategies. SWS consultants are teachers of writing: graduate and undergraduate teaching assistants and professional staff. Some consultants specialize in working with non-native speakers, and others have experience with writing in specific disciplines. Consulting is available by appointment online and in Nicholson Hall, and on a walk-in basis in Appleby Hall. For more information, go to writing.umn.edu/sws or call 612.625.1893. In addition, SWS offers a number of web-based resources on topics such as avoiding plagiarism, documenting sources, and planning and completing a writing project at <http://writing.umn.edu/sws/>

To do well in this course:

- A student taking a two credit course that meets for two 50 minute periods a week is expected to spend an average of four hours a week on coursework outside the classroom.
- Recognize that learning and studying new material is hard work.
- Try to understand why the material is being taught and where you might use it.
- Read the assigned readings before class.
- Be aware you will need to work in groups.
- Be prepared to search papers, journals, news, and websites.
- Participate actively in in-class active learning activities. It is important to actively participate in group work and in class active learning activities to get the most out of this class. If this learning style is new for you, please do your best and consider this as an opportunity to practice collaboration with your colleagues.
- If you miss class, get behind in class, have a hard time with the material, or are having problems that are not allowing you to do your best work for this class, I expect you to come in and see me. When we meet we can discuss your situation and negotiate a way for you to make up the work or prove your abilities.
- **Please let me know** if you need any sort of assistance.

BBE 3xxx / 5xxx course schedule (tentative)

As a special topics course the course schedule is not well established because the course has not been taught before in this form. Much of this course was taught before for non-engineering students with much less quantitative material. The schedule below is subject to change.

Class	Topics and reading assignments
Week 1	
Class 1	<ul style="list-style-type: none"> • Course introduction and overview • EPA air pollution definition • Hazard versus Risk
To do	<ul style="list-style-type: none"> • Read: Plain English Clean Air Act p. 1-7 • Read: Cooper & Alley p. 1-6, 10-11
Class 2	<ul style="list-style-type: none"> • Agencies and organizations interested in air pollution and air quality • History of US Air Pollution legislation • National Ambient Air Quality Standards (NAAQS)
To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 6-8, 17-20, Table 1.2
Class 3	<ul style="list-style-type: none"> • Criteria pollutants; Toxic and hazardous air pollutants
To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 21-26, 48-60, 371
Week 2	
Class 4	<ul style="list-style-type: none"> • Air pollution management concepts • Regulations – CAAA90, EPCRA, CERCLA and OSHA • OSHA Part 1910 Subpart Z – Toxic and Hazardous Substances
To Do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 20-30
Class 5	<ul style="list-style-type: none"> • Air pollution history • Ideal gas law, Converting concentrations between volume and mass units
To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 30-38; Handout
Class 6	<ul style="list-style-type: none"> • Air pollution sources and emissions data, AP-42 • Emission rate calculations and uncertainty concepts
To do	<ul style="list-style-type: none"> • Read: Handout
Week 3	
Class 7	<ul style="list-style-type: none"> • Characterize and categorize emissions (ex. outdoor emissions, indoor emissions, work place settings, residential settings) • Pollutant generation, emission, transportation and transformation, Acid rain • Carbon, nitrogen and sulfur cycles
To do	<ul style="list-style-type: none"> • Read: Plain English Clean Air Act p. 10-15
Class 8	<ul style="list-style-type: none"> • Concentration, exposure and dose • Human health impacts of air pollution
To do	<ul style="list-style-type: none"> • Read:
Class 9	<ul style="list-style-type: none"> • Particulate matter characteristics, Cunningham correction, and gravity settling
To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 111 - 131
Week 4	
Class 10	<ul style="list-style-type: none"> • Atmospheric chemistry, pollutant changes during transport • Photochemical reactions, ozone formation, roles of hydrocarbons, NO_x and SO_x
To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 631-646
Class 11	<ul style="list-style-type: none"> • Air pollution transport factors (i.e. climate, weather patterns and terrain) • Wind roses • Air pollutant dispersion modeling introduction

To do	<ul style="list-style-type: none"> • Read: Cooper & Alley p. 613-630, 655-682
Class 12 To do	<ul style="list-style-type: none"> • Air pollutant dispersion modeling (continued) • Read: Cooper & Alley p. 685-690
Week 5	
Class 13 To do	<ul style="list-style-type: none"> • Particulate removal - Cyclones • Read: Cooper & Alley p. 129-131, 135 - 148
Class 14 To do	<ul style="list-style-type: none"> • Particulate removal – Cyclones, Electrostatic precipitators • Read: Cooper & Alley p. 161-185 • Submit writing assignment 1 online before class.
Class 15 To do	<ul style="list-style-type: none"> • Particulate removal - Electrostatic precipitators • Read:
Week 6	
Class 16 To do	<ul style="list-style-type: none"> • Exam 1 •
Class 17 To do	<ul style="list-style-type: none"> • Fabric filters, • Read: Cooper & Alley p. 193-219
Class 18 To do	<ul style="list-style-type: none"> • Fabric Filters • Read: Cooper & Alley p. 193-219
Week 7	
Class 19 To do	<ul style="list-style-type: none"> • Particulate scrubbers • Read: Cooper & Alley p. 231-256
Class 20 To do	<ul style="list-style-type: none"> • Gas and vapor properties, Volatile organic compound (VOC) incinerators • Read: Cooper & Alley p. 327-333; 343-374.
Class 21 To do	<ul style="list-style-type: none"> • Gas adsorption • Read: Cooper & Alley p. 385-401
Spring Break	
Week 8	
Class 22 To do	<ul style="list-style-type: none"> • Gas absorption • Read: Cooper & Alley p. 417-418, 440-446
Class 23 To do	<ul style="list-style-type: none"> • Acceptable indoor air quality (IAQ), IAQ problems, Sick building syndrome, Building related illness • Indoor air quality laws, regulations, standards (e.g. OSHA, ACGIH, ASHRAE) • Read: Cooper & Alley p. 695-703 • All About OSHA – class website
Class 24 To do	<ul style="list-style-type: none"> • Factors affecting indoor air concentrations, equations • Read: Cooper & Alley p. 6-8, 17-20, Table 1.2
Week 9	
Class 25 To do	<ul style="list-style-type: none"> • Indoor air pollutant sources and control via ventilation, filtration & air cleaning • Indoor air pollutant cases • Read: Cooper & Alley p. 703-717
Class 26 To do	<ul style="list-style-type: none"> • Indoor air quality control • Read: Cooper & Alley p. 703-717 • Writing assignment 2 due
Class 27	<ul style="list-style-type: none"> • Biofiltration • Read: Cooper & Alley p. 455-468

To do	<ul style="list-style-type: none"> Biofilter design guide
Week 10	
Class 28 To do	<ul style="list-style-type: none"> Biofilter design Biofilter design guide
Class 29 To do	<ul style="list-style-type: none"> SOx Control Read: Cooper & Alley p. 485-506
Class 30 To do	<ul style="list-style-type: none"> NOx Control Read: Cooper & Alley p. 523-550
Week 11	
Class 31 To do	<ul style="list-style-type: none"> Exam 2
Class 32 To do	<ul style="list-style-type: none"> Mobile source control Read: Cooper & Alley p. 573-608
Class 33 To do	<ul style="list-style-type: none"> Carbon dioxide management Read: Cooper & Alley p. 721-757
Week 12 April 18	
Class 34 To do	<ul style="list-style-type: none"> Greenhouse gas reporting GHGRP website
Class 35 To do	<ul style="list-style-type: none"> Air permits MPCA website
Class 36 To do	<ul style="list-style-type: none"> Guest speaker –Anatomy of Air Emission Permit
Week 13	
Class 37 To do	<ul style="list-style-type: none"> Ambient and stack sampling methods
Class 38 To do	<ul style="list-style-type: none"> Indoor air sampling methods
Class 39 To do	<ul style="list-style-type: none"> Odor measurement, analysis and variability Detection threshold, intensity, persistence, hedonic tone and character Read: Cooper & Alley p. 6-8, 17-20, Table 1.2
	<ul style="list-style-type: none">
Week 14	
Class 40 To do	<ul style="list-style-type: none"> Odor management, frequency, intensity, duration and offensiveness (FIDO) Odor From Feedlot Setback Estimation Tool (OFFSET) Read:
Class 41 To do	<ul style="list-style-type: none"> Guest speaker – MPCA?
Class 42 To do	<ul style="list-style-type: none"> Class review Class evaluation Submit final writing assignment