ME 433, *Fundamentals of Air Pollution*

Syllabus for Spring Semester 2026

John M. Cimbala, Penn State University. Latest update: 05 January 2026

Lectures: **In-person lectures, and examples: Monday, Wednesday,** (and Friday when Monday or Wednesday classes are cancelled due to holiday, weather, etc.), **1:25-2:15 in 220 Hammond Building.** Note that all lesson videos, annotated notes, quizzes, and homework are online (on Canvas).

Text: ***Introduction to Air Pollution Science***, R. F. Phalen and R. N. Phalen, Jones & Bartlett Learning, LLC, Burlington, MA, any edition – ***recommended, but not required***.

Prerequisites: ME 201 or ME 300 or equivalent, plus basic understanding of fluid mechanics and statistics.

Instructor:
- **John M. Cimbala**, jmc6@psu.edu. Professor of Mechanical Engineering, 234 Reber Building, 814-863-2739 www.me.psu.edu/cimbala. ←Weekly schedule is posted on this website.
- Office hours: **Wednesdays 1:00-3:00 pm** in **234 Reber Building**.

TA: **TBA,** abc1234@psu.edu**.** Office hours **Wednesdays 4:00 to 6:00 pm** in **TBA**.

Course Description: This course is an introduction to air pollution, with an emphasis on outdoor rather than indoor air pollution. Topics to be covered include sources (emissions) of air pollution, both gaseous and particulate, interaction of air pollution with our bodies and the environment, and methods of measuring, quantifying, analyzing, and controlling air pollution. A brief introduction to government regulations related to air pollution will also be provided. Students are expected to be proficient in applying mathematics (e.g., integration, differentiation, and application of differential equations), and some basic chemistry, statistics, thermodynamics, and fluid mechanics. It is critical for many portions of this course that students know how to use software to solve equations, create plots, etc. Students can use any software they choose, such as Excel, Matlab, etc. Many of the class examples are shown in Excel.

Web Pages: The main website for this course is on Penn State's Canvas site at **https://psu.instructure.com/**. Professor Cimbala also maintains a second website at **http://www.me.psu.edu/cimbala/me433** where he will post lecture videos, etc. in the event that Canvas is down. Use this website only if you have trouble connecting or finding something on Canvas. Students are expected to check Canvas regularly for lesson notes and videos, homework assignments, quizzes, and other information. Hardcopies (handouts) of homework assignments will *not* be provided.

Grading: All quizzes, exams, and homework assignments are *comprehensive*, making use of previous material. Automatic late penalties of 20% per day are assessed in Canvas for late submissions of homework and quizzes.

Homework	**21%**	One homework assignment per week; due the **next** Wednesday each week at midnight; highest 14 scores counted out of 15 total (drop lowest score)
Lesson Quizzes	**60%**	Typically one quiz per lesson; due the **next** Wednesday each week at midnight; highest 60 scores counted out of 70 total (drop 10 lowest scores)
Final Exam	**19%**	**3 hours online – Monday 12:01 am through Wednesday 11:59 pm during finals week**

Grading Scale: The following are PSU's standard grade assignments:

• **A** = 93% to 100%	• **B** = 83% to 87%	• **C** = 70% to 77%
• **A-** = 90% to 93%	• **B-** = 80% to 83%	• **D** = 60% to 70%
• **B+** = 87% to 90%	• **C+** = 77% to 80%	• **F** = less than 60%

Course Objectives: Upon completion of this course, students should be able to:

1. Identify substances (gases and particles) considered to be air pollutants, and how to quantify them.
2. Identify sources (emissions) of air pollutants, and how they disperse in the atmosphere.
3. Apply basic principles of thermodynamics and chemistry to model the formation of selected air pollutants.
4. Identify specific impacts of air pollution on human health and on the environment.
5. Identify and explain specific methods of controlling air pollution emissions.
6. Demonstrate knowledge of major air pollution legislation and its historical context.
7. Demonstrate ability to separate facts from rhetoric or opinion and to identify bias when reading and interpreting news articles and the scientific literature in regards to air pollution and climate change.
8. Demonstrate ability to use software (Excel, Matlab, etc.) to analyze experimental data and mathematical models.
9. Demonstrate professionalism and respectful interaction with faculty and colleagues.

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Lecture Schedule: We will follow the schedule on the next page as closely as possible, ***subject to change***. Note that the **Modules** on Canvas correspond to **Calendar Weeks** since there are 15 modules and 15 weeks in the semester.

Week #	Topics to be Covered
1	**MODULE 01: Introduction and Fundamentals**: chemistry review, volume flow rates, ideal gas mixtures (mole fractions, partial pressures, partial volumes, etc.), bulk molecular weight
2	**MODULE 02: Introduction and Fundamentals (continued)**: concentrations, conversions, relative humidity, volatile liquids; **Classification of air pollutants**: EPA classifications (primary vs. secondary, CAPS, HAPS, NAAQS), visible air pollution, acid rain, ozone
3	**MODULE 03: Classification of air pollutants (continued)**: sources of air pollution, global warming gases and climate change; **Emission factors**: how to estimate source strength, definition of efficiency of air pollution control systems (APCSs), combustion
4	**MODULE 04**: **Emission factors (continued)**: flux chambers, tank filling; **Earth and the atmosphere**: Coriolis force, global wind patterns
5	**MODULE 05**: **Earth and the atmosphere (continued)**: Lapse rate and atmospheric stability; **Gradient diffusion**
6	**MODULE 06**: **Plume dispersion**: Gaussian plume model, how to predict hazardous areas downwind of plumes
7	**MODULE 07**: **Gaussian puff diffusion**: how to predict hazardous areas downwind of a puff of air pollution; **Steam vs. particle plumes**; **Particulate air pollution**: Introduction
8	**MODULE 08**: **Particulate air pollution (continued)**: particle number concentration, monodisperse and polydisperse aerosols, definitions, grade efficiency
9	**MODULE 09**: **Particle motion**: equations of motion, aerodynamic drag, particle settling speeds
10	**MODULE 10**: **Particle motion (continued)**: gravimetric settling, elutriators, curved flow inertial separation
11	**MODULE 11**: **Particle motion (continued)**: how to predict grade efficiency in curved ducts, cyclone separators, Lapple standard cyclone, air cleaners in series and parallel
12	**MODULE 12**: **Particle Measurement**: cascade impactors, optical particle counters, sampling with probes, aerosol particle sampling issues; **Air pollution control systems (APCSs) for particulate matter (PM)**: raindrops as air cleaners
13	**MODULE 13**: **APCSs for PM (continued)**: spray towers, wet scrubbers, air filters, baghouses
14	**MODULE 14**: **APCSs for PM (continued)**: electrostatic precipitators (ESPs); **Aerosol particle statistics**: mean, median, and geometric mean diameters, histograms, PDFs, cumulative distribution functions
15	**MODULE 15**: **Aerosol particle statistics (continued)**: cumulative distribution functions and log-probability plots, geometric standard deviation, comparison of number and mass distributions;

Grade Disputes: If a student feels that an exam or homework was graded unfairly, or if there is an error in the grading, it should be brought to the attention of the grader (TA: homework, Professor: quizzes and exams) within one week after the material is graded except under extenuating circumstances.

Policy on AI Usage in this Course: You are permitted to utilize AI to help you look up things and ask how to do certain tasks in MATLAB or Excel, etc., just as you can use Google to search for such information. What you are **not** allowed to do is type in something like **"Write me a MATLAB code that does …. (copy of homework or quiz assignment)…"** and then submit that code and its results for your homework. I consider this cheating.

College of Engineering's Academic Dishonesty Policy: Cheating is not tolerated in this course. You should refer to the College of Engineering's Academic Integrity website at http://www.engr.psu.edu/faculty-staff/academic-integrity.aspx which explains what behaviors are in violation of academic integrity, and the review process for such violations. Specifically for ***this*** course:

- First offense: Zero score for the item in question, and infraction reported to the College.
- Second offense: Failure of the course, and infraction reported to the College.

Penn State's Academic Dishonesty Policy:
Academic integrity is the pursuit of scholarly activity in an open, honest, and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle.

According to Penn State policy G-9: Academic Integrity, an academic integrity violation is "an intentional, unintentional, or attempted violation of course or assessment policies to gain an academic advantage or to advantage or disadvantage another student academically." Unless your instructor tells you otherwise, you must complete all course work entirely on your own, using only sources that have been permitted by your instructor, and you may not assist other students with papers, quizzes, exams, or other assessments. If your instructor allows you to use ideas, images, or word phrases created by another person (e.g., from Course Hero or Chegg) or by generative technology, such as ChatGPT, you must identify their source. You may not submit false or fabricated information, use the same academic work for credit in multiple courses, or share instructional content. Students with questions about academic integrity should ask their instructor **before submitting work**.

Students facing allegations of academic misconduct may not drop/withdraw from the affected course unless they are cleared of wrongdoing (see G-9: Academic Integrity). Attempted drops will be prevented or reversed, and students will be expected to complete course work and meet course deadlines. Students who are found responsible for academic integrity violations face academic outcomes, which can be severe, and put themselves at jeopardy for other outcomes which may include ineligibility for Dean's List, pass/fail elections, and grade forgiveness. Students may also face consequences from their home/major program and/or The Schreyer Honors College.

Educational Equity/Report Bias Statements:
Penn State University has adopted a "Protocol for Responding to Bias Motivated Incidents" that is grounded in the policy that the "University is committed to creating an educational environment which is free from intolerance directed toward individuals or groups and strives to create and maintain an environment that fosters respect for others." That policy is embedded within an institution traditionally committed to academic freedom. Bias motivated incidents include conduct that is defined in University Policy AD 91: Discrimination and Harassment, and Related Inappropriate Conduct. Students, faculty, or staff who experience or witness a possible bias motivated incident are urged to report the incident immediately by doing one of the following:

- Submit a report via the Report Bias webpage
- Contact one of the following offices:
  - University Police Services, University Park: 814-863-1111
  - Multicultural Resource Center, Diversity Advocate for Students: 814-865-1773
  - Office of the Vice Provost for Educational Equity: 814-865-5906
  - Office of the Vice President for Student Affairs: 814-865-0909
  - Affirmative Action Office: 814-863-0471
  - **Call 911 in cases where physical injury has occurred or is imminent**

Accommodating Disabilities and Disability Access Statement:
Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus. For further information, please visit Student Disability Resources website.

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines. If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

Counseling & Psychological Services (CAPS) Statement:
Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation. Contact information is shown below:

- Counseling and Psychological Services at University Park (CAPS): 814-863-0395
- Counseling and Psychological Services at Commonwealth Campuses
- Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
- Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741