ENVE 576: Indoor Air Pollution — Spring 2013

Illinois Institute of Technology — 3 credit hours
Department of Civil, Architectural and Environmental Engineering

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Course Unique Number(s)
ENVE 576 Section 1: 24899 (graduate) | ENVE 576 Section 2: 25173 (graduate online)

Classroom and Meeting Time
Stuart Building, Room 239, Tuesdays 5:00 PM – 7:40 PM

Course Website
http://built-envi.com/courses/enve-576-iap-sp13/

Prerequisites
ENVE 405 or ENVE 520 Environmental Monitoring and Assessment (flexible)

Instructor
Brent Stephens, Ph.D.
Assistant Professor, CAEE
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Website: www.built-envi.com

Office Hours
Office hours are by appointment. I am generally around my office, Alumni Hall Room 212, most of the day Monday through Friday, and you can always stop by. To ensure that I will be there, please email me to schedule an appointment.

Course Catalog Description
Indoor air pollution sources, indoor pollutant levels, monitoring instruments and designs; indoor pollution control strategies: source control, control equipment and ventilation; energy conservation and indoor air pollution; exposure studies and population time budgets; effects of indoor air population; risk analysis; models for predicting source emission rates and their impact on indoor air environments.

Course Objectives
To introduce students to important concepts of indoor airborne pollutants, including their physical and chemical properties, emission sources, and removal mechanisms. By taking this course students will be able to:

1. Describe particle-phase, gas-phase, and biological pollutants found in indoor environments
2. Model indoor pollutant emission, transport, and control
3. Manipulate and perform calculations with aerosol distributions and gas-phase compounds
4. Analyze indoor pollutant control technologies and determine their effectiveness
5. Read and critically analyze articles in the technical literature on indoor air pollution
6. Prepare and review written and oral technical communication

Textbook
There is no required textbook for this course. We will rely on peer-reviewed literature and handouts from reference texts for the majority of our topics. Reference texts include the following:

Hinds, W. C., *Aerosol technology: Properties, behavior, and measurement of airborne particles*, Wiley (1999).
Morawska, L. and Salthammer, T., *Indoor environment: airborne particles and settled dust*, Wiley-VCH (2003).
Salthammer, T. and Uhde, E., *Organic Indoor Air Pollutants: occurrence, measurement, evaluation*, Wiley-VCH (2009).
Seinfeld, J. H. and Pandis, S. N., *Atmospheric chemistry and physics: from air pollution to climate change*, Wiley (2006).
Spengler, J., McCarthy, J., and Samet, J. *Indoor air quality handbook*, McGraw-Hill Professional (2001).

Homework Assignments
There will be 5 homework assignments during the course that will involve hand calculations and development of spreadsheets. Some general rules for homework assignments are as follows:

- Homework (HW) assignments will be posted on blackboard
- HW assignments will typically be due one week after they are assigned
- Students should submit neatly printed HW
- Hard copies of multiple page submissions must have all pages stapled together
- Students enrolled in the online course will submit HW via the Blackboard digital drop box. Handwritten HW must be scanned and converted to PDF by online students. Multiple pages must be converted to a single PDF for submission.

Exams
One take-home exam will be given with a tentative date of March 26, 2013. Students will have one week to complete the exam and return to Dr. Stephens, tentatively scheduled for April 2, 2013. A final exam is not scheduled for this course. A final report and presentation is currently scheduled to take place during the scheduled final exam period.

Projects
There will be one major research project in this course in lieu of a final exam. This final project is a research project where students research an indoor air pollution issue. Students will develop a technical research report describing their motivation, literature review, methods, and results, and will summarize their research with a classroom presentation at the end of the semester. Graduate students are expected to perform a more detailed analysis and format their report as a more formal research article/conference paper.

Grading
Course grading will be done primarily through homework assignments, one exam, and one project. This is a graduate course; higher expectations will be placed upon deliverables from graduate students than any undergraduate students that may enroll in the course. Grades will be determined by the total number of points accumulated through homework assignments, projects, and exams, with a small amount of potential credit for class participation. The total number of points available in each category is listed in the table below. The number of required points for various grades is also given below.

Grading Table

Category	**Available Points**
Homework	300 (30%)
Take-home exam	300 (30%)
Final project	400 (40%)
Total	1000 (100%)

Grade	**Required Points**
A	≥ 900 (90%)
B	800-899 (80-89.9%)
C	700-799 (70-79.9%)
D or below	<699 (<69.9%)

Tentative Course Schedule (Updated April 15, 2013)

Week	Date	Lecture Topics	Reading*	Assignment:
1	Jan 15	Introduction to topic/field • Time activity and human exposure • Indoor and outdoor atmospheres • Fundamental air principles	1–3	
2	Jan 22	Reactor models • Steady-state and dynamic Ventilation and air exchange rates Human exposure patterns • Inhalation and intake fractions	4–6	
3	Jan 29	Overview of indoor pollutants • Particulate matter • Gas-phase compounds ⇒ Organic and inorganic • Biological	7	HW1 due
4	Feb 5	Gaseous pollutants • Sources • Emission models	8–11	
5	Feb 12	Gaseous pollutants • Adsorption/desorption • Reactive surface deposition • Homogenous chemistry • Byproduct formation (incl. SOA)	12–14	HW2 due
6	Feb 19	Particulate matter • Single particle physics • Particle size distributions • Respiratory deposition	15–17	
7	Feb 26	Particulate matter • Particle sources (indoor and outdoor) • Deposition and resuspension	18–20	HW3 due
n/a	Mar 5	***Postponed lecture for family emergency***		
8	Mar 12	Particulate matter • Filtration and air cleaners	21–23	HW4 due
n/a	Mar 19	**No class - Spring break**		
9	Mar 26	Particulate matter • Penetration/infiltration		Exam assigned
10	April 2	SVOCs Health effects • Epidemiology and physical responses	24,25,26,27	Exam due
11 (guest)	April 9	Guest lecturer: Biological pollutants Measurement technologies		
12	April 16	Developing countries	28–30	~~HW5 due~~
13	April 23	Infectious disease transmission Applications • Standards and manufacturer ratings • Software	31–33	
14	April 30	Final presentations		Final project due
Final	TBD	No final exam		

*Suggested readings are listed on the following page. These readings are not required unless stated otherwise.

Suggested Readings:
1. Sundell, J. On the history of indoor air quality and health. *Indoor Air* **14 Suppl 7**, 51–58 (2004).
2. Nazaroff, W. W., Weschler, C. J. & Corsi, R. L. Indoor air chemistry and physics. *Atmospheric Environment* **37**, 5451–5453 (2003).
3. Ott, W. R. & Roberts, J. W. Everyday exposure to toxic pollutants. *Sci. Am* **278**, 86–91 (1998).
4. Bennett, D. H. *et al.* Defining intake fraction. *Environ. Sci. Technol.* **36**, 207A–211A (2002).
5. Murray, D. M. & Burmaster, D. E. Residential air exchange rates in the United States: empirical and estimated parametric distributions by season and climatic region. *Risk Analysis* **15**, 459–465 (1995).
6. Klepeis, N. E. *et al.* The National Human Activity Pattern Survey (NHAPS): a resource for assessing exposure to environmental pollutants. *J Expo Anal Environ Epidemiol* **11**, 231–252 (2001).
7. Weschler, C. J. Changes in indoor pollutants since the 1950s. *Atmospheric Environment* **43**, 153–169 (2009).
8. Meininghaus, R., Gunnarsen, L. & Knudsen, H. N. Diffusion and sorption of volatile organic compounds in building materials: Impact on indoor air quality. *Environmental Science & Technology* **34**, 3101–3108 (2000).
9. Guo, Z. Review of indoor emission source models. Part 1. Overview. *Environ. Pollut.* **120**, 533–549 (2002).
10. Sparks, L. E., Tichenor, B. A., Chang, J. & Guo, Z. Gas-phase mass transfer model for predicting volatile organic compound (VOC) emission rates from indoor pollutant sources. *Indoor Air* **6**, 31–40 (1996).
11. Hodgson, A. T., Rudd, A. F., Beal, D. & Chandra, S. Volatile organic compound concentrations and emission rates in new manufactured and site-built houses. *Indoor Air* **10**, 178–192 (2000).
12. Cano-Ruiz, J. A., Kong, D., Balas, R. B. & Nazaroff, W. W. Removal of reactive gases at indoor surfaces: Combining mass transport and surface kinetics. *Atmospheric Environment. Part A. General Topics* **27**, 2039–2050 (1993).
13. Weschler, C. J. Ozone in indoor environments: concentration and chemistry. *Indoor Air* **10**, 269–288 (2000).
14. Waring, M. S., Wells, J. R. & Siegel, J. A. Secondary organic aerosol formation from ozone reactions with single terpenoids and terpenoid mixtures. *Atmospheric Environment* **45**, 4235–4242 (2011).
15. Hinds, W. C. Chapter 3: Uniform Particle Motion. *Aerosol Technology* (1999).
16. Hinds, W. C. Chapter 11: Respiratory Deposition. *Aerosol Technology* (1999).
17. Seinfeld, J. H. & Pandis, S. N. Chapter 8: Properties of the Atmospheric Aerosol. *Atmospheric Chemistry and Physics* (2006).
18. Nazaroff, W. W. Indoor particle dynamics. *Indoor Air* **14**, 175–183 (2004).
19. Wallace, L. Indoor sources of ultrafine and accumulation mode particles: size distributions, size-resolved concentrations, and source strengths. *Aerosol Science & Technology* **40**, 348–360 (2006).
20. Chen, C. & Zhao, B. Review of relationship between indoor and outdoor particles: I/O ratio, infiltration factor and penetration factor. *Atmos. Environ.* **45**, 275–288 (2011).
21. Hinds, W. C. Chapter 9: Filtration. *Aerosol Technology* (1999).
22. Stephens, B. & Siegel, J. A. Comparison of test methods for determining the particle removal efficiency of filters in residential and light-commercial central HVAC systems. *Aerosol Science and Technology* **46**, 504–513 (2012).
23. US EPA *Evaluation of in-room particulate matter air filtration devices*. (United States Environmental Protection Agency: 2008).
24. Hospodsky, D. *et al.* Human occupancy as a source of indoor airborne bacteria. *PLoS ONE* **7**, e34867 (2012).
25. Weschler, C. J. & Nazaroff, W. W. Semivolatile organic compounds in indoor environments. *Atmospheric Environment* **42**, 9018–9040 (2008).
26. Chen, C., Zhao, B. & Weschler, C. J. Indoor exposure to ‘outdoor PM10’. *Epidemiology* **23**, 870–878 (2012).

27. Logue, J. M., Price, P. N., Sherman, M. H. & Singer, B. C. A method to estimate the chronic health impact of air pollutants in U.S. residences. *Environmental Health Perspectives* **120**, 216–222 (2012).
28. Bruce, N., Perez-Padilla, R. & Albalak, R. Indoor air pollution in developing countries: a major environmental and public health challenge. *Bull World Health Organ* **78**, 1078–1092 (2000).
29. Lopez, A. D., Mathers, C. D., Ezzati, M., Jamison, D. T. & Murray, C. J. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. *The Lancet* **367**, 1747–1757 (2006).
30. Lim, S. S. *et al.* A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The Lancet* **380**, 2224–2260 (2012).
31. ASHRAE Standard 52.2: Method of testing general ventilation air-cleaning devices for removal efficiency by particle size. (2007).
32. ASHRAE Standard 62.2: Ventilation and acceptable indoor air quality in low-rise residential buildings. (2007).
33. ASHRAE Standard 62.1: Ventilation for acceptable indoor air quality. (2010).

Other Course Information

Contribution to Meeting Curriculum Areas (ABET)

Curriculum Area	**Percentage**
Basic Science & Math	
Humanities/Social Sciences	
Basic Engineering	
Introductory Environmental Engineering	
Professional Level Environmental Engineering	100%

Learning Outcomes and Expected Knowledge Gain
Students will learn important concepts of indoor airborne pollutants, including their physical and chemical properties, emission sources, and removal mechanisms. By taking this course students will be able to describe particle-phase, gas-phase, and biological pollutants found in indoor environments; model indoor pollutant emission, transport, and control; analyze indoor pollutant control technologies and determine their effectiveness; and read and critically analyze articles in the technical literature on indoor air pollution.

Performance Indicators
Performance indicators used in student learning outcomes are marked with 'X' in the following table.

Performance Indicator	**Description**	
I	Presentation by students (oral, poster, PowerPoint, etc.)	X
II	Term papers	X
III	Group projects (periodic progress reports project final report are required)	X
IV	Presentation by outside speakers on contemporary topics	X
V	Ethics, presentation and case study discussions	
VI	Reports (lab report, summary report on design of experiment, data analysis, research findings, etc.)	X
VII	Group discussions on understanding of profession, liabilities, professional development, etc.	
VIII	Evaluation of students' work through interviews, one-to-one meetings with students, and class discussions	X
IX	Review of learning outcomes with students and quiz on specific program learning outcomes	X
X	Overall performance in exams, homework, projects, attendance, etc.	X

Personal Problems
If you have illness or personal problems that will affect your performance during the course of the semester, please let me know as soon as possible. "After the fact" provides little protection unless there are extreme circumstances. Contact me by phone or e-mail at any time.

Students with Disabilities
Reasonable accommodations will be made for students with documented disabilities. In order to receive accommodations, students must obtain a letter of accommodation from the Center for Disability Resources. The Center for Disability Resources (CDR) is located in Life Sciences Room 218, telephone (312) 567-5744 or email: disabilities@iit.edu.

Relationship of Course to ABET Outcomes

Outcome	Description	Extent of Coverage
a	Apply knowledge of math, engineering, science	3
b1	Design and conduct experiments	2
b2	Analyze and interpret data	3
c	An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability	4
d	An ability to function on multi-disciplinary teams	2
e	An ability to identify, formulate, and solve engineering problems	5
f	A respect for, and understanding, the professional and ethical responsibility	1
g	An ability to communicate effectively	4
h	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context	4
i	A recognition of the need for, and an ability to engage in life-long and continuing education	2
j	A knowledge of contemporary issues within civil engineering	3
k	An ability to use techniques, skills, and tools in engineering practice	4
l	Ability to use knowledge gained in courses in a major capstone design project	4

1 = minimum coverage in the course; 5 = major coverage in the course

Academic Honesty

It is your responsibility to be familiar with IIT's Code of Academic Honesty. The Code of Academic Honesty can be found on page 243 of the Undergraduate Bulletin: http://retention.iit.edu/resources/bulletin_2008_2010.pdf.

You must submit your own work for homework. You are encouraged to discuss and even work with other students on homework (unless explicitly told otherwise), but material that is submitted must be your own work. For group project assignments, each group is to submit their own work. For a first violation of the IIT Code of Academic Honesty for a homework or project, the homework will receive a grade of zero for all involved students and the students will be reported to the Designated Dean for Academic Discipline (DDAD). For a first violation of the Code of Academic Honesty for a major project or an examination, the student will receive a failing grade for the course and the student will be reported to the DDAD. For a second violation, the student will receive also failing grade for the course and be reported to the DDAD.