Course Outline (2017)
ENVE 4003/5101: Air Pollution and Emission Control

Instructor: Amir Hakami (ME 2374, amir_hakami@carleton.ca); Office hours: Mondays, 14:30-16:00
Teaching Assistants: Robyn Chatwin-Davies (robynchatwindavies@cmail.carleton.ca), Burak Oztaner (BurakOztaner@cmail.carleton.ca), and Marjan Soltanzadeh (MarjanSoltanzadeh@cmail.carleton.ca)

Course components:
Lectures (3 hours a week), Tutorial (1 hour a week), Laboratory and discussion sessions (3 hours, alternate weeks).

Evaluation:
15% Assignments 15% Laboratory experiments & discussion sessions (discussion papers for ENVE 5101)
20% Midterm 50% Final exam 10% Class participation (for exceptional participation/contribution)

Examinations:
Midterm: October 18 (tentative)

All examinations are closed book and closed notes. The final exam covers material from the entire course, with emphasis on material after the midterm. You will be provided with all formulae needed, and thus no notes of any kind shall be brought to the exam. The final examination is for evaluation purposes only and exam papers will not be returned. Acquiring a passing grade in this course requires a) an overall passing grade, b) completion of all lab sessions (discussion papers for ENVE 5101, see below), and c) a minimum final exam grade of 40%. You are also required to attend lectures and PA sessions.

Guidelines and class activity:
1- Communications: All course materials (if applicable) will be posted to the connect web page for the course. Electronic communications with us must be carried out through your official Carleton email only. Students can stop by my office outside office hours, but I may be busy and ask you to come back at a later time.

2- Electronic etiquette in the classroom: While you are in the class please turn your cell phone off. This also includes not reading or sending text messages. If you use a computer to take notes, please make sure the computer is offline during the lecture.

3- Assignment submissions: All assignments/reports should be submitted at the beginning of the class or tutorial or lab session when they are due. Penalties for late submissions are 20% within an hour, and 50% between 1 and 24 hours. Submissions after 24 hours receive no credit. If solutions are posted within 24 hours of the due date, late submissions will not be accepted. Students can discuss assignments with each other, but the submitted material must be your individual work. Make sure what you submit is your work performed for the sole purpose of this course; see institutional guidelines on plagiarism (http://www.carleton.ca/cuuc/regulations/acadregsuniv14.html).

4- Laboratory experiments: There are six scheduled laboratory sessions throughout the term. Students will perform experiments and will participate in discussion sessions (see below). Details will be provided in an orientation session during the first scheduled laboratory period.

5- Discussion sessions: Research papers will be assigned for reading during the term. Students are expected to actively participate in a discussion of the paper during the scheduled laboratory periods. You are also encouraged to suggest issues that you find interesting/important for discussion. This will constitute an important component of your laboratory/discussion grade. Graduate students will submit three short written discussion papers in lieu of laboratory/discussion sessions. In preparing these discussion papers, graduate students are expected to conduct further reading and individual research on the topics as necessary.

Textbooks:
2- Schnelle, K. B.; Brown, C. A, Air pollution control technology handbook, CRC Press, 2002. [Available electronically through the library, only two simultaneous users]

Note that there will be additional material in the lectures. Your main source shall be your class notes.

Recommended books:
2- De Nevers, Noel, Air pollution control engineering by, McGraw-Hill, 2000 (2nd ed).
Course and lecture layout (subject to modification):

This course will prepare students to answer the following questions:
- What are the processes that contribute to transport and transformation of air pollution at regional and local scales?
- What are the current local, regional, and global air pollution problems facing us?
- What are the main scientific/engineering challenges that exist in air quality policy-making?
- What are the main engineering control approaches for air pollution control?

General course layout – a nonlinear version:

Local/Regional Air Pollution

- Sources 1,2,7,9
- Chemistry 7,9
- Control 3,12
- Policy 10,12

Pollution 7,12

Impact 10,12

Global Air Pollution

- Global Warming 5,6
- Ozone Depletion 12

Schedule of lecture topics

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
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<tbody>
<tr>
<td>1-2</td>
<td>General overview and air pollution fundamentals: temporal and spatial scales of air pollution, pressure structure, concentration measurement, general circulation, horizontal and vertical transport of pollution, stability and lapse rate (review), lifetime and characteristic times in the atmosphere.</td>
</tr>
<tr>
<td>3-4</td>
<td>Atmospheric physics: general circulation, horizontal and vertical transport of pollution, stability and lapse rate (review), turbulence and Reynolds decomposition (review), characteristic times in the atmosphere.</td>
</tr>
<tr>
<td>7-9</td>
<td>Photochemistry and pollution: atmospheric kinetics, major precursor sources and budgets, NOx chemistry, CO and Hydrocarbon oxidation, urban smog formation, ozone isopleth, chemical regimes and control options.</td>
</tr>
<tr>
<td>10-12</td>
<td>Air pollution policy: regulation of air pollution, air pollution and health, air pollution economics, air pollution decision-making, atmospheric diffusion equation, air quality modeling.</td>
</tr>
</tbody>
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Air Pollution Control (Fridays)

3-4  Control of gas-phase species: combustion and thermodynamics of pollutant formation, NOx formation and Zeldovich mechanism, combustion modification techniques, post-combustion NOx control.
5-7  Aerosol and air pollution: aerosol characteristics, major sources and budgets, size distribution and distribution modes, formation and removal processes, single particle dynamics, settling velocity, stopping distance.
8-12 Aerosol control: particle removal mechanisms; settling chambers design and efficiency, cyclone performance and design, electrostatic precipitators (ESP), filters and baghouse design.

Global Air Pollution (Wednesdays)

5-6  Global warming: Radiative budget of the atmosphere, simplified greenhouse effect model.
12  Stratospheric ozone depletion: Chapman mechanism, ozone depletion and ozone depleting substances.

**Academic Accommodation** You may need special arrangements to meet your academic obligations during the term. For an accommodation request the processes are as follows:

**Pregnancy obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see the [Student Guide](http://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf)

**Religious obligation:** write to me with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details see the [Student Guide](http://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf)

**Academic Accommodations for Students with Disabilities:** The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the [PMC website](http://carleton.ca/equity/) for the deadline to request accommodations for the formally-scheduled exam (if applicable).