Course Outline (2019)
ENVE 4003/5101: Air Pollution and Emission Control

Instructor: Amir Hakami (ME 2374, amir_hakami@carleton.ca); Office hours: Fridays, 14:00-15:00
Teaching Assistants: Sina Voshtani (sinavoshtani@email.carleton.ca) and Burak Oztaner (burakoztaner@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

Examinations:
Midterm: TBD

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 or cheat sheet 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- 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).

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

5- Discussion sessions: Published papers and articles related to the course material will be assigned for reading during the term. Students are expected to actively participate in these discussions during the scheduled laboratory periods. You are also encouraged to suggest issues that you find interesting/important for discussion. This active participation will constitute an important component of your laboratory/discussion grade. Graduate students are welcome to attend discussion sessions and 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:

Local/Regional Air Pollution

Global Air Pollution

Global warming: interaction of pollutants with radiative budget of the atmosphere.

Stratospheric ozone depletion: Chapman mechanism, ozone depletion and ozone depleting substances.

Local/Regional Air Pollution

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.

Ozone chemistry 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.

Ozone policy: regulation of air pollution, air pollution decision-making, sampling and measurement of pollutants, atmospheric diffusion equation, air quality modeling.

Aerosol dynamics and pollution: aerosol characteristics, major sources and budgets, size distribution and distribution modes, formation and removal processes, single particle dynamics.

Control of gas-phase species: combustion and thermodynamics of pollutant formation, NOx formation and Zeldovich mechanism, post-combustion NOx control, combustion modification techniques, Low-NOx burners, Flue Gas Recirculation (FGR), Selective Catalytic and Noncatalytic Reduction (SCR & SNCR).

Aerosol control: particle removal mechanisms; settling chambers design and efficiency, cyclone performance and design, electrostatic precipitators (ESP), filters and baghouse design, SO2 control and removal processes.

Pollution health impacts (time permitting/guest lecture): population exposure, pollution impacts on health and environment.

Schedule of lecture topics

1 General overview: temporal and spatial scales of air pollution, system approach to atmospheric pollution.

Global Air Pollution

2-3 Global warming: interaction of pollutants with radiative budget of the atmosphere.


Local/Regional Air Pollution

4-6 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.

7-9 Ozone chemistry 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.

10 Ozone policy: regulation of air pollution, air pollution decision-making, sampling and measurement of pollutants, atmospheric diffusion equation, air quality modeling.

11-13 Aerosol dynamics and pollution: aerosol characteristics, major sources and budgets, size distribution and distribution modes, formation and removal processes, single particle dynamics.

14-15 Control of gas-phase species: combustion and thermodynamics of pollutant formation, NOx formation and Zeldovich mechanism, post-combustion NOx control, combustion modification techniques, Low-NOx burners, Flue Gas Recirculation (FGR), Selective Catalytic and Noncatalytic Reduction (SCR & SNCR).

16-21 Aerosol control: particle removal mechanisms; settling chambers design and efficiency, cyclone performance and design, electrostatic precipitators (ESP), filters and baghouse design, SO2 control and removal processes.

22 Pollution health impacts (time permitting/guest lecture): population exposure, pollution impacts on health and environment.

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 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 for the deadline to request accommodations for the formally-scheduled exam (if applicable).