ENGG*4820 Atmospheric Emission Control: Combustion Systems

Winter 2019
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2019

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1 Course Details

1.1 Calendar Description

Combustion systems are an essential part of our society, however, they are also the dominant source of atmospheric pollutants. This course will focus on investigation of combustion systems for the purpose of reducing atmospheric emissions.

Pre-Requisite(s): ENGG*2560, ENGG*3260
Co-Requisite(s): ENGG*3430
Restriction(s): ENGG*4330

1.2 Course Description

This course aims to have students think deeply about energy systems involving combustion and their corresponding atmospheric emissions, and to analyze various other sources of harmful gases and vapours. Students will be able to predict the formation of transient and stable pollutant species, to critique emissions control technologies, and to identify opportunities for improvement.

These aims will be pursued through experimental and theoretical investigation, advancing fundamental air pollution chemistry, process engineering, transport phenomena and thermodynamics principles. Thus, the course also aims to enhance student's foundational skills that have value well beyond the atmospheric emissions control domain.

1.3 Timetable

Lectures:

Tue., Thur.	1:00 pm – 2:20 pm	ANNU 204

Labs/Tutorials:

Wed.	11:30 am – 1:20 pm	THRN 1004, 1012

- most weeks the labs/tutorials will be in THRN 1004.

1.4 Final Exam

Exam is scheduled for Tuesday 16th April from 08:30AM to 10:30AM. Location to be announced. Please refer to the Final Exam Schedule to confirm time and location.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Rafael Santos Ph.D., P.Eng.
Email: santosr@uoguelph.ca
Telephone: +1-519-824-4120 x52902
Office: THRN 2342
Office Hours: By appointment.

Lab Technician: Joanne Ryks
Email: jryks@uoguelph.ca
Telephone: +1-519-824-4120 x54087
Office: THRN 1114

2.2 Teaching Assistant(s)

Teaching Assistant: Francisco Araujo
Email: faraujo@uoguelph.ca
Office Hours: Has no office hours. Contact time is in labs/tutorials.

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3 Learning Resources

3.1 Required Resource(s)

Course Website (Website)
https://www.courselink.uoguelph.ca
Course material, news, announcements, and grades will be regularly posted to the ENGG*4820 Courselink site. You are responsible for checking the site regularly. As per University regulations, all students are required to check their <mail.uoguelph.ca> email account regularly; e-mail is the official route of communication between the University and

students.

Fundamentals of Air Pollution Engineering (Textbook)
http://authors.library.caltech.edu/25069/1/AirPollution88.pdf
Flagan, R. C. and Seinfeld, J. H. 1988. Prentice-Hall, Englewood Cliffs, New Jersey, U.S.A.

An electronic version is posted on Courselink, and alternatively can be downloaded from http://authors.library.caltech.edu/25069/1/AirPollution88.pdf

Newer versions of this text (e.g. 2012 edition) are also acceptable.

3.2 Recommended Resource(s)

Air Pollution Control: A Design Approach (Textbook)
Cooper, C. D., Alley, F. C. 2011. 4th Ed. Waveland Press, Prospect Heights, IL, USA.

Some material and ideas from this textbook will be used in the course. It is not required that students possess a copy of this book, but you may wish to consider purchasing it for your library if you intend to pursue further studies or a career in air pollution engineering. This book is available at the university library.

3.3 Additional Resource(s)

Lecture Information (Notes)
Some lecture notes and supporting material will be posted on Courselink, generally before the specific lecture. Note that posted notes may be incomplete, prepared with the intention that students will take additional notes during lectures.

Lab Information (Notes)
Requirements will be posted on Courselink.

Assignment Information (Notes)
Requirements will be posted on Courselink.

Problem Sets (Notes)
Will be posted on Courselink.

Tests (Notes)
Information about content and format will be posted on Courselink.

Miscellaneous Information (Notes)
Other relevant information will be posted on Courselink.

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4 Learning Outcomes

4.1 Course Learning Outcomes

By the end of this course, you should be able to:

1. **Analyze** combustion systems for the relationship between system performance and gaseous emissions
2. **Develop** mathematical solutions for emissions problems involving thermodynamic, chemical kinetic, and fluid transport calculations
3. **Evaluate** conventional and emerging air pollution control technologies for harmful gaseous and volatile species
4. **Plan and execute** experimental investigations to test hypotheses
5. **Construct** models of combustion systems for the estimation of emissions and system performance
6. **Summarize** the mechanisms of greenhouse gases on climate change, and of fugitive emissions
7. **Research and interpret** historical and published information relevant to air pollution

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome(s)
1	Knowledge Base	1, 2, 3, 5, 6
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 2, 3, 5, 6
1.2	Recall, describe and apply fundamental principles and concepts in natural science	1, 2, 3, 5, 6
1.3	Recall, describe and apply fundamental engineering principles and concepts	1, 2, 3, 5, 6
1.4	Recall, describe and apply program-specific engineering principles and concepts	1, 2, 3, 5, 6
2	Problem Analysis	1, 2, 3, 5
2.1	Formulate a problem statement in engineering and non-engineering terminology	1, 2, 3, 5
2.2	Identify, organize and justify appropriate information, including assumptions	1, 2, 3, 5
2.5	Critique and appraise solution approach and results	1, 2, 3, 5
3	Investigation	4

#	Outcome	Learning Outcome(s)
3.1	Propose a working hypothesis	4
3.2	Design and apply an experimental plan/investigative approach (for example, to characterize, test or troubleshoot a system)	4
3.3	Analyze and interpret experimental data	4
3.4	Assess validity of conclusions within limitations of data and methodologies	4
5	Use of Engineering Tools	5
5.1	Select appropriate engineering tools from various alternatives	5
5.2	Demonstrate proficiency in the application of selected engineering tools	5
5.3	Recognize limitations of selected engineering tools	5
6	Individual & Teamwork	1, 4, 5
6.1	Describe principles of team dynamics and leadership	1, 4, 5
6.2	Understand all members' roles and responsibilities within a team	1, 4, 5
7	Communication Skills	4, 5, 7
7.1	Identify key message(s) and intended audience in verbal or written communication as both sender and receiver	4, 5, 7
7.2	Interpret technical documentation such as device specification sheets, drawings, diagrams, flowcharts, and pseudocode	4, 5, 7
7.3	Construct the finished elements using accepted norms in English, graphical standards, and engineering conventions, as appropriate for the message and audience	4, 5, 7
7.4	Substantiate claims by building evidence-based arguments and integrating effective figures, tables, equations, and/or references	4, 5, 7
7.5	Demonstrate ability to process oral and written communication by following instructions, actively listening, incorporating feedback, and formulating meaningful questions	4, 5, 7
9	Impact of Engineering on Society and the Environment	3
9.3	Anticipate the positive and negative impacts of introducing innovative technologies to solve engineering problems	3

#	Outcome	Learning Outcome(s)
12	Life Long Learning	7
12.3	Demonstrate capability for continuous knowledge and skill development in a changing world	7

4.3 Relationships with other Courses & Labs

Previous Courses:

ENGG*2560: Mass balances around reactor systems including reaction kinetics and equilibrium

ENGG*2230: Transport and mixing processes are based on fluid mechanics principles

ENGG*3260: Energy and emissions dominantly build on thermodynamic principles

ENGG*3100: Continuing to advance your design skills is essential for air pollution control

ENGG*3180: Air quality sets the context for the atmospheric control challenges that ENGG*4820 addresses

ENGG*3430 & ENGG*3470: Heat and mass transfer limitations can play a significant role in the effectiveness of many air pollution control solutions

ENGG*3410: Automated control systems play an integral role in the operation and success of a very large fraction of emission control technology

Follow-on Courses:

ENGG*4130: Many final design teams and projects will draw on ENGG*4820 skills, directly benefitting teams addressing air pollution challenges in their design work.

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5 Teaching and Learning Activities

5.1 Lecture

Week 1

Topic(s): Introduction to Air Pollution and Control
Reference(s): Ch. 1, notes
Learning Outcome(s): 1,7

Week 2

Topic(s): Combustion Fuels and Stoichiometry
Reference(s): Ch. 2, Sec. 2.1-2.2, notes

Learning Outcome(s): 1,7

Week 3

Topic(s): Combustion Thermodynamics

Reference(s): Sec. 2.3, notes
Learning Outcome(s): 1,2,5

Week 4
Topic(s): Combustion Equilibrium
Reference(s): Sec. 2.3, notes
Learning Outcome(s): 1,2,5

Week 5

Topic(s): Combustion Kinetics

Reference(s): Sec. 2.4, notes
Learning Outcome(s): 1,2,5

Week 6
Topic(s): Flame Structure
Reference(s): Sec. 2.5-2.8, notes
Learning Outcome(s): 1,2,5

Week 7

Topic(s): NOx

Reference(s): Ch. 3, notes
Learning Outcome(s): 1,2,5

Week 8
Topic(s): Internal Combustion Engines
Reference(s): Ch. 4, notes
Learning Outcome(s): 1,4,5

Week 9

Topic(s): Gas Contaminant Control Processes

Reference(s): Ch. 8, Cooper & Alley Ch. 12-16, notes

Learning Outcome(s): 3,7

Week 10

Topic(s): VOC and Solid Waste Incineration

Reference(s): Cooper & Alley Ch. 11, notes

Learning Outcome(s): 3,7

Week 11

Topic(s): Fugitive Emissions

Reference(s): Notes

Learning Outcome(s): 6,7

Week 12

Topic(s): Global Warming

Reference(s): Notes
Learning Outcome(s): 6,7

5.2 Lab

Week 2

Topic(s): Lab Safety Training

Week 3 or 4

Topic(s): Lab 1 - Engine system energy and mass balance

Learning Outcome(s): 1,2,4

Week 7 or 8

Topic(s): Lab 2 - Engine system emissions experiment

Learning Outcome(s): 1,2,4

Week 12

Topic(s): Lab 3 - Combustion Model

Learning Outcome(s): 1,2,5

5.3 Other Important Dates

Monday Jan. 7 – Classes commence

Thursday Jan. 24 – 14th class day; no new student registrations permitted after this date

Monday Feb. 18 to Friday Feb. 22 – Winter Break

Friday Mar. 8 – 40th class day; last day to drop winter semester courses

Friday Apr. 5 – Last day of classes

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6 Assessments

6.1 Assessment Details

Individual Assignment (10%)
Due: Tue, Jan 29, 11:59 PM
Learning Outcome(s): 1,3,7
Written report
Submit via Courselink Dropbox

Lab 1 - Engine system energy and mass balance (15%)
Due: Two weeks after performing the lab, by 11:59pm
Learning Outcome(s): 1,2,4
Lab Report
Submit via Courselink Dropbox

Midterm exam (20%)
Date: Wed, Feb 13, In tutorial period
Learning Outcome(s): 1,2,3
Written exam

Lab 2 - Engine system emissions experiment (15%)
Due: Two weeks after performing the lab, by 11:59pm
Learning Outcome(s): 1,2,4
Lab Report
Submit via Courselink Dropbox

Lab 3 - Combustion Model (15%)
Due: Wed, Apr 3, 11:30 AM, Models presented in tutorial period (April 3rd)
Learning Outcome(s): 1,2,5
Model file(s)
Submit files to Courselink Dropbox

Final exam (25%)
Date: Tue, Apr 16, 8:30 AM - 10:30 AM, TBA
Learning Outcome(s): 1,2,3,6
Written exam

6.2 Additional Information

Additional tutorial problem sets will be given throughout the term but they will not be graded. Consider them as formative.

Midterm and Exam will be closed book. An 8½” by 11” student-generated aid sheet will be

permitted.

Labs 1, 2 and 3 will be completed in teams from your section (number of team members will depend on section enrollment).

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7 Course Statements

7.1 Course Grading Policies

Missed Assessments: If you are unable to meet an in-course requirement due to medical, psychological, or compassionate reasons, please email the course instructor. Please see below for specific details and consult the undergraduate calendar for information on regulations and procedures for Academic Consideration:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor within two weeks of the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Passing grade: The passing grade for this course is 50%. Students must also achieve a 50% or greater mark on the individual components of the course (cummulative average of individual assignment, midterm exam and final exam) to pass the course. If the mark for the individual components, weighted as above, is less than 50%, then this mark will be recorded as the student's course mark, even if the course mark including group components (labs 1, 2 and 3) is higher (or greater than 50%).

Missed exams: No makeup midterm will be provided. If you miss the midterm exam and there are grounds for granting academic consideration or religious accommodation, the weight of the missed test will be added to the final exam weight.

Lab Work: You must attend and complete all laboratories. If you miss a laboratory due to grounds for granting academic consideration or religious accommodation, arrangements must be made with the teaching assistant to complete a makeup lab. If you do not complete the pre-lab safety quiz, you will not be permitted to complete the lab. Students who miss laboratories and are not granted accommodation will receive a mark of zero for the project associated with the lab, regardless of the mark received by other group members.

Late Lab Reports and Assignments: Late submissions (> 1 hour) will be penalized if there are not acceptable compassionate or medical grounds. A 10% penalty per day (including weekends) will be applied for reports/assignments submitted between 1 and 120 hours late. Reports received more than 120 hours (five days) late will be assigned a grade of zero.

Team Work: Team work is required for the lab assignments. If there is some observation or evidence that you have not made significant contributions to the work then you will be asked to provide evidence of your individual efforts, contributions and results. Keeping a log book may be one effective means to help demonstrate your contributions.

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8 School of Engineering Statements

8.1 Instructor's Role and Responsibility to Students

The instructor's role is to develop and deliver course material in ways that facilitate learning for a variety of students. Selected lecture notes will be made available to students on Courselink but these are not intended to be stand-alone course notes. Some written lecture notes will be presented only in class. During lectures, the instructor will expand and explain the content of notes and provide example problems that supplement posted notes. Scheduled classes will be the principal venue to provide information and feedback for tests and labs.

8.2 Students' Learning Responsibilities

Students are expected to take advantage of the learning opportunities provided during lectures and lab sessions. Students, especially those having difficulty with the course content, should also make use of other resources recommended by the instructor. Students who do (or may) fall behind due to illness, work, or extra-curricular activities are advised to keep the instructor informed. This will allow the instructor to recommend extra resources in a timely manner and/or provide consideration if appropriate.

8.3 Lab Safety

Safety is critically important to the School and is the responsibility of all members of the School: faculty, staff and students. As a student in a lab course you are responsible for taking all reasonable safety precautions and following the lab safety rules specific to the lab you are working in. In addition, you are responsible for reporting all safety issues to the laboratory supervisor, GTA or faculty responsible.

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9 University Statements

9.1 Email Communication

As per university regulations, all students are required to check their e-mail account regularly: e-mail is the official route of communication between the University and its students.

9.2 When You Cannot Meet a Course Requirement

When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons please advise the course instructor (or designated person, such as a teaching assistant) in writing, with your name, id#, and e-mail contact. The grounds for Academic Consideration are detailed in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Academic Consideration and Appeals
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Graduate Calendar - Grounds for Academic Consideration
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.3 Drop Date

Courses that are one semester long must be dropped by the end of the fortieth class day; two-semester courses must be dropped by the last day of the add period in the second semester. The regulations and procedures for course registration are available in the Undergraduate and Graduate Calendars.

Undergraduate Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Graduate Calendar - Registration Changes
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/genreg-reg-regchg.shtml

9.4 Copies of Out-of-class Assignments

Keep paper and/or other reliable back-up copies of all out-of-class assignments: you may be asked to resubmit work at any time.

9.5 Accessibility

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required; however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre requires students to book their exams at least 7 days in advance and not later than the 40th Class Day.

More information can be found on the SAS website
https://www.uoguelph.ca/sas

9.6 Academic Integrity

The University of Guelph is committed to upholding the highest standards of academic integrity, and it is the responsibility of all members of the University community-faculty, staff,

and students-to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff, and students have the responsibility of supporting an environment that encourages academic integrity. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it. Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

Undergraduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

Graduate Calendar - Academic Misconduct
https://www.uoguelph.ca/registrar/calendars/graduate/current/genreg/index.shtml

9.7 Recording of Materials

Presentations that are made in relation to course work - including lectures - cannot be recorded or copied without the permission of the presenter, whether the instructor, a student, or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

9.8 Resources

The Academic Calendars are the source of information about the University of Guelph’s procedures, policies, and regulations that apply to undergraduate, graduate, and diploma programs.

Academic Calendars
https://www.uoguelph.ca/academics/calendars