ENGG*4820 Atmospheric Emission Control: Combustion Systems

01

Winter 2024
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 05, 2024

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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-Requisites:	ENGG*2560, ENGG*3260
Co-Requisites:	ENGG*3430
Restrictions:	Non-BENG students may take a maximum of 4.00 ENGG credits.

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., Thu.	1:00pm-2:20pm	MACS 301
Tutorials/Labs		
Wed.	12:30pm-2:20pm	THRN 1004/1012

- Most weeks students will attend only the tutorials in THRN 1004; labs in THRN 1012 are held in select weeks in parallel with tutorials on a group-by-group basis.

1.4 Final Exam

There is no written Final Exam. The Combustion Model Presentation is scheduled during the Final Exam Week for Tuesday 23rd April from 08:30 AM to 10:30 AM. Location to be announced.

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2 Instructional Support

2.1 Instructional Support Team

Instructor: Fatima Haque Ph.D.
Email: fhaque@uoguelph.ca
Office: THRN 2127
Office Hours: TBA and by appointment.

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

2.2 Teaching Assistants

Teaching Assistant (GTA): Francisco Araujo
Email: faraujo@uoguelph.ca
Office Hours: Contact time is in tutorials or by email/appointment.

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3 Learning Resources

3.1 Required Resources

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 Resources

Air Pollution Control Technology Handbook (Textbook)
https://doi-org.subzero.lib.uoguelph.ca/10.1201/9781420036435

Schnelle, K.B., Brown. C.A. (2002). Air Pollution Control Technology Handbook. Boca Raton, FL: CRC Press LLC.

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. Available online through University of Guelph Library.

Air Pollution Control: A Design Approach (Textbook)
https://ocul-gue.primo.exlibrisgroup.com/permalink/01OCUL_GUE/1lvr4dh/alma9941028223505154
Cooper, C.D., Alley, F.C. (2011). Air Pollution Control, A Design Approach (4^{th} ed.). Long Grove, IL: Waveland Press Inc.

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. Available as physical copy at the University of Guelph Library.

Sources and Control of Air Pollution (Textbook)
https://ocul-gue.primo.exlibrisgroup.com/permalink/01OCUL_GUE/1cpuvlv/alma9930378683505154
Heinsohn, R.J., Kabel, R.L. (1999). Sources and Control of Air Pollution. New Jersey, NJ: Pearson Prentice Hall.

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. Available as physical copy at the University of Guelph Library.

Air Pollution Control Engineering (Textbook)

De Nevers, N. (2017). Air Pollution Control Engineering (3rd ed.). Long Grove, IL: Waveland Press Inc.

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. Available as inter-university loan through the University of Guelph Library.

3.3 Additional Resources

Lecture Information (Notes)
Lecture notes and supporting material will be posted on Courselink, generally before the specific lecture. Note that posted 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
8. **Discuss** how engineering decisions on emissions and pollution have an impact on the environment, workplace safety, human health and social justice.

4.2 Engineers Canada - Graduate Attributes (2018)

Successfully completing this course will contribute to the following:

#	Outcome	Learning Outcome
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
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

#	Outcome	Learning Outcome
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, 8
9.1	Analyze the safety, social, environmental, and legal aspects of engineering activity	8
9.2	Evaluate the uncertainties and risks associated with engineering activities	8
9.3	Anticipate the positive and negative impacts of introducing innovative technologies to solve engineering problems	3
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*2230: Transport and mixing processes are based on fluid mechanics principles

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

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*3260: Energy and emissions dominantly build on thermodynamic principles

ENGG*3410 or ENGG*3440: Automated control systems play an integral role in the operation and success of a very large fraction of emission control technology

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

ENGG*4810: Control of Atmospheric Particulates complements the air pollution topics covered in ENGG*4820

Follow-on Courses:

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

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5 Teaching and Learning Activities

5.1 Lecture

Module 1

Topics:	Introduction to Air Pollution and Control
References:	Ch. 1, notes
Learning Outcome:	1, 7

Module 2

Topics:	Combustion Fuels and Stoichiometry
References:	Ch. 2 Sec. 2.1-2.2, notes
Learning Outcome:	1, 7

Module 3

Topics: Combustion Thermodynamics

References: Ch. 2 Sec. 2.3, notes

Learning Outcome: 1, 2, 5

Module 4

Topics: Combustion Equilibrium

References: Ch. 2 Sec. 2.3, notes

Learning Outcome: 1, 2, 5

Module 5

Topics: Combustion Engine and Combustion Kinetics

References: Ch. 2 Sec. 2.4, notes

Learning Outcome: 1, 2, 5

Module 6

Topics: NOx

References: Ch. 3, notes
Learning Outcome: 1, 2, 5

Module 7

Topics: Gas Contaminant Control Processes

References: Ch. 8, Cooper & Alley Ch. 11-16, notes

Learning Outcome: 3, 7

Module 8

Topics: Solid Waste Incineration

References: Notes

Learning Outcome: 3, 7

Module 9

Topics: Global Warming

References: Notes
Learning Outcome: 6, 7, 8

Module 10

Topics: Fugitive Emissions

References: Notes

Learning Outcome: 6, 7, 8

5.2 Lab

Week 3

Topics: Lab Safety Training

Week 4 or 5

Topics: Lab 1 - Engine System Energy & Mass Balance

Learning Outcome: 1, 2, 4

Week 7 or 8

Topics: Lab 2 - Engine System Emissions Experiment

Learning Outcome: 1, 2, 4

Weeks 10 to 12

Topics: Lab 3 - Combustion Model

Learning Outcome: 1, 2, 5

5.3 Other Important Dates

Monday, Jan. 8th – First day of classes

Friday, Jan. 12th – Last day to add winter semester courses

Saturday, Feb. 17th to Sunday, Feb. 25th – Winter Break

Friday, Mar. 8th – 40th Class Day

Thursday, Apr. 6th – Last day of classes

Friday, Apr. 7th – Holiday (classes re-scheduled to Monday, Apr. 10th)

Monday, Apr. 8th – Last day to drop winter semester courses

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6 Assessments

6.1 Marking Schemes & Distributions

Assessments	Weightage
Assignment 1	5%
Assignment 2	10%
Lab 1 Report	15%
Lab 2 Report	15%
Lab 3 Model and Presentation	15%
Term Exam	40%

6.2 Assessment Details

Assignment 1 (5%)
Date: Week 3, In tutorial period
Learning Outcome: 8

Assignment 2 (10%)
Due: Fri, Feb 16, 11:59 PM
Learning Outcome: 7, 8

Lab 1 (Engine System Energy & Mass Balance) Report (15%)
Due: One week after performing the lab, by 11:59pm
Learning Outcome: 1, 2, 4
Lab Report
Submit via Courselink Dropbox

Lab 2 (Engine System Emissions Experiment) Report (15%)
Due: One week after performing the lab, by 11:59pm
Learning Outcome: 1, 2, 4
Lab Report
Submit via Courselink Dropbox

Term Exam (40%)
Due: Thu, Mar 28, 1:00 PM - 2:20 PM, MACS 301 (in lecture room)

Learning Outcome: 1, 2, 3, 6
Written exam

Lab 3 (Combustion Model) Presentation (15%)
Date: Tue, Apr 23, 8:30 AM - 10:30 AM, To be confirmed
Learning Outcome: 1, 2, 5

Group presentation; submit model files to Courselink Dropbox

6.3 Additional Information

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

Labs will be completed in teams from your section (number of team members will depend on section enrollment).

Term Exam will be closed book. An 8½" by 11" student-generated aid sheet (hand-written, double-sided) will be permitted.

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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: https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-consideration-appeals-petitions/

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: https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-accommodation-religious-obligations/

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 (cumulative average of assignment 2 and the term 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 (assignment 1 and labs 1, 2 and 3) is higher (or greater than 50%).

Missed Exam: If you miss the Term Exam and there are grounds for granting academic consideration or religious accommodation, you will be required to write a make-up or deferred exam.

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 to complete a make-up 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.

Teamwork: Teamwork 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 logbook may be one effective means to help demonstrate your contributions.

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.

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

Associate Diploma Calendar - Academic Consideration, Appeals and Petitions
https://www.uoguelph.ca/registrar/calendars/diploma/current/index.shtml

9.3 Drop Date

Students will have until the last day of classes to drop courses without academic penalty. The deadline to drop two-semester courses will be the last day of classes in the second semester. This applies to all students (undergraduate, graduate and diploma) except for Doctor of Veterinary Medicine and Associate Diploma in Veterinary Technology (conventional and alternative delivery) students. The regulations and procedures for course registration are available in their respective Academic 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

Associate Diploma Calendar - Dropping Courses
https://www.uoguelph.ca/registrar/calendars/diploma/current/c08/c08-drop.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 make a booking at least 14 days in advance, and no later than November 1 (fall), March 1 (winter) or July 1 (summer). Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time.

For Guelph students, information can be found on the SAS website
https://www.uoguelph.ca/sas

For Ridgetown students, information can be found on the Ridgetown SAS website
https://www.ridgetownc.com/services/accessibilityservices.cfm

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

9.9 Illness

Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g.. final exam or major assignment).