ENGG*4820 Atmospheric Emission Control: Combustion Systems

Winter 2018
Section(s): C01

School of Engineering
Credit Weight: 0.50
Version 1.00 - January 10, 2018

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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 critique emissions control technologies and identify opportunities for improvement.

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

1.3 Timetable

Lectures:

Tues., Thur.	4:00 pm – 5:20 pm	Alexander Hall 259

Labs/Tutorials:

Section 01	Tues.	11:30 am – 1:20 pm	THRN 1004, 1012
Section 02	Mon.	3:30 pm – 5:20 pm	THRN 1004, 1012

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

1.4 Final Exam

Exam is scheduled for Thursday 19th April from 07:00PM to 09:00PM. Location to be announced. Please see WebAdvisor for the latest information.

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2 Instructional Support

2.1 Instructor(s)

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

2.2 Instructional Support Team

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

2.3 Teaching Assistant(s)

Teaching Assistant: Patrick McGrath
Email: mcgrathp@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)
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 (or http://www.webcitation.org/6w54rRgZ2)

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** thermodynamic models of combustion systems for the estimation of emissions and system performance
2. **Develop** computer-based models to execute thermodynamic calculations
3. **Critique** models of combustion systems for the estimation of emissions and system performance
4. **Analyze** conventional and emerging air pollution control technologies
5. **Plan and execute** experimental investigations to test hypotheses
6. **Summarize** the mechanisms of greenhouse gases on climate change, and of fugitive emissions

7. **Research and Communicate** historical and background information relevant to air pollution

4.2 Engineers Canada - Graduate Attributes

Successfully completing this course will contribute to the following:

#	Outcome Set Name	Course Learning Outcome
1	Knowledge base	1, 3, 4, 6
1.1	Recall, describe and apply fundamental mathematical principles and concepts	1, 3, 4, 6
1.2	Recall, describe and apply fundamental concepts and principles in natural sciences	1, 3, 4, 6
1.3	Comprehend and apply fundamental engineering concepts	1, 3, 4, 6
1.4	Comprehend and apply program-specific engineering concepts	1, 3, 4, 6
2	Problem analysis	1, 2, 3, 4, 5
2.1	Formulate a problem statement in engineering and nonengineering terminology	1, 2, 3, 4, 5
2.2	Construct a conceptual framework	1, 2, 3, 4, 5
2.3	Identify, organize and justify appropriate information	1, 2, 3, 4, 5
2.4	Execute an engineering solution	1, 2, 3, 4, 5
2.5	Critique and appraise results	1, 2, 3, 4, 5
3	Investigation	3
3.1	Propose and test working hypotheses	3
3.2	Design and apply an investigation plan	3
3.3	Analyze and interpret experimental data	3
3.4	Assess validity of conclusions within limitations of data and methodologies	3
4	Design	5
4.1	Describe the design process	5
4.2	Construct design-specific problem statements	5
4.3	Create engineering design solutions	5
4.4	Develop engineering design solutions	5
4.5	Assess engineering design solutions	5
4.6	Implement engineering design solutions	5
5	Use of engineering tools	2, 4

#	Outcome Set Name	Course Learning Outcome
5.1	Select appropriate engineering tools from various alternatives	2, 4
5.2	Apply selected engineering tools	2, 4
5.3	Recognize limitations of selected engineering tools	2, 4
6	Individual and team work	1, 2, 3, 5
6.1	Act as an individual team member to promote team success	1, 2, 3, 5
6.2	Demonstrate leadership through team building, providing feedback and positive attitude	1, 2, 3, 5
7	Communication skills	3, 5, 7
7.1	Develop and deliver clear, key concepts using methods appropriate for the intended audience	3, 5, 7
7.2	Critically evaluate received information	3, 5, 7
7.3	Demonstrate active listening and follow instructions	3, 5, 7
12	Life-long learning	7
12.1	Identify personal career goals and opportunities for professional development	7
12.2	Analyze a self-assessment of skills relative to SOE defined learning outcomes	7
12.3	Identify and critique limits of their field	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

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

Week 3
Topic(s): Enthalpy, Adiabatic Flame Temperature
Reference(s): Sec. 2.3, notes

Week 4
Topic(s): Combustion Equilibrium
Reference(s): Sec. 2.3, notes

Week 5
Topic(s): Combustion Kinetics
Reference(s): Sec. 2.4, notes

Week 6
Topic(s): Flame Structure
Reference(s): Sec. 2.5-2.8, notes

Week 7
Topic(s): Reading Week

Week 8
Topic(s): Midterm exam, NOx
Reference(s): Ch. 3, notes

Week 9
Topic(s): Internal Combustion Engines
Reference(s): Ch. 4, notes

Week 10
Topic(s): Gaseous Pollutant Removal
Reference(s): Ch. 8, notes

Week 11
Topic(s): Incineration, VOCs
Reference(s): Cooper & Alley Ch. 11, notes

Week 12
Topic(s): Fugitive Emissions
Reference(s): Cooper & Alley Ch. 18, notes

Week 13
Topic(s): Global Warming, Closure
Reference(s): Notes

Topic(s): Final Exam Period

5.2 Lab

Week 1
Topic(s): Background recapture (Problem Set 0)
THRN 1004

Week 2
Topic(s): Problem Set 1
THRN 1004

Week 3
Topic(s): Problem Set 2, Lab Safety
THRN 1004, THRN 1012

Week 4
Topic(s): Problem Set 3, Engine Lab 1
THRN 1004, THRN 1012

Week 5
Topic(s): Problem Set 4, Engine Lab 1
THRN 1004, THRN 1012

Week 6
Topic(s): Problem Set 5
THRN 1004

Week 7
Topic(s): Reading Week – no labs/tutorials

Week 8
Topic(s): Problem Set 6
THRN 1004

Week 9
Topic(s): Combustion model evaluation
THRN 1004

Week 10
Topic(s): Problem Set 7
THRN 1004

Week 11
Topic(s): Problem Set 8, Engine Lab 2
THRN 1004, THRN 1012

Week 12
Topic(s): Problem Set 9, Engine Lab 2
THRN 1004, THRN 1012

Week 13
Topic(s): Exam review
THRN 1004

5.3 Other Important Dates

Monday Jan. 8 – first day of class

Friday Jan. 12 – last day to add classes

Monday Feb. 19 to Friday Feb. 23 – Reading Week

Friday Mar. 9 – 40th class day last day to drop

Friday Apr. 5 – last day of class

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6 Assessments

6.1 Assessment Details

Assignment 1 (10.00%)
Date: Tue, Jan 30, In lecture period
In-class quiz based on reading assignment

Lab 1 - Engine system energy and mass balance (10.00%)
Due: One week after performing the lab, by 11:59pm
Lab Report
Submit via Courselink Dropbox

Midterm exam (15.00%)
Date: Tue, Feb 27, In lecture period

Lab 2 – Combustion Model (15.00%)
Due: Sun, Mar 4, 11:59 PM, Models evaluated in tutorial (Mar 5th/6th)
Excel file(s)
Submit files to Courselink Dropbox

Assignment 2 (10.00%)
Due: Fri, Mar 23, 11:59 PM
Report and calculations (Excel file)
Submit files to Courselink Dropbox

Lab 3 - Engine system emissions experiment (15.00%)
Due: One week after performing the lab, by 11:59pm
Lab Report
Submit via Courselink Dropbox

Final exam (25.00%)
Date: Thu, Apr 19, 7:00 PM - 9:00 PM, TBA
Written exam

6.2 Additional Information

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. Teams will consist of 3 students (with 4

th students added to groups as needed due to 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 assignments 1 and 2, midterm exam and final exam) to pass the course. If the mark for the individual components, weighted as above, is less than 50%, than 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: If you miss the midterm exam due to grounds for granting academic consideration or religious accommodation, no makeup midterm will be provided; instead, the instructor will apply your final exam mark also as your midterm exam mark.

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 regulations and procedures for Academic Consideration are detailed in the Undergraduate Calendar.

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 Dropping Courses are available in the Undergraduate Calendar.

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: www.uoguelph.ca/sas

9.6 Academic Misconduct

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 discourages misconduct. 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.

The Academic Misconduct Policy is detailed in the Undergraduate Calendar.

9.7 Recording of Materials

Presentations which are made in relation to course work—including lectures—cannot be recorded or copied without the permission of the presenter, whether the instructor, a classmate 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 which apply to undergraduate, graduate and diploma programs.

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