EML 4930/5131: Combustion

Class Periods: MWF, 6th Period, 12:50-1:40
Location: CSE E119
Academic Term: Fall 2022

Instructor
Ryan Houim
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(352)-392-7164

Office Hours: **TBD**
Preferred Contact: Please contact through the canvas website https://ufl.instructure.com

Teaching Assistants
NA

Course Website
https://ufl.instructure.com/ (Canvas)
Additional material will be uploaded on the Canvas website. Please check Canvas before each lecture.

Course Description
Chemical thermodynamics, chemical kinetics, flame propagation, detonation and explosion, combustion of droplets and spray. (Credits 3)

Course Pre-Requisites / Co-Requisites
EML 3100 – Thermodynamics
It is expected that students will have had course work in basic fluid mechanics and numerical methods (root finding, plotting, curve fitting, solving systems of ODEs, etc.). Course work in heat transfer will be useful but is not necessary.

Course Objectives
This course is an introduction to combustion. The concepts learned in this class serve as the basis for computing and understanding chemical equilibrium, adiabatic flame temperature, heat of combustion, chemical kinetics, premixed flames, non-premixed flames, droplet combustion, detonations, and pollutant formation. The concepts in this can be applied to model a simplified homogeneous charge compression ignition engine, determine the minimum length of a liquid-fueled combustor, and understand how a Davy lamp works.

Learning Outcomes:
Specifically, students will have the ability to:
1. Analyze thermochemistry of fuel/oxidizer mixtures and calculate chemical equilibrium and adiabatic flame temperature.
2. Understand basic principles related to chemical reaction kinetics, reaction pathways of hydrocarbon fuels and pollutant formation.
3. Analyze the transient behavior of chemical reactors and model a simplified homogeneous charge compression ignition engine.
4. Understand and analyze the propagation modes and structure of combustion waves in premixed systems.
5. Estimate the lifetime of fuel droplets and the length of non-premixed flames and apply them to the design of combustors.
6. Understand contemporary issues of combustion such as emissions and pollutant formation.
7. Apply and writing computer software to conduct calculations and make graphics for 1) – 4).

Materials and Supply Fees
None

Required Textbooks and Software
- Stephen R. Turns and Daniel C. Haworth, Introduction to Combustion, McGraw-Hill, 4th Edition, 2021, ISBN: 978-1-260-47769-6 (Required)
- Kenneth K. Kuo, Principles of Combustion, Wiley, 2nd Edition, 2005, ISBN: 978-0471046899 (Optional for EML 4930 students, mandatory for EML 5131 students)
- Access to Python3 (which is open source, freely available, and multiplatform)

Important Dates
Classes Begin: Aug 24 (Wednesday)
Holidays/Reading Days: Sept 5, Oct. 8-9, Nov. 11, Nov. 23-26
Classes End: Dec. 7

Course Outline
1. Introduction: Turns: *Chapter* 1
2. Combustion and Thermochemistry: Turns: *Chapter 2*, Kuo: *Chapter 1*
    a. Thermodynamics of ideal gas mixtures
    b. Flame temperature, heat of combustion
    c. Chemical equilibrium
3. Chemical Reaction Kinetics: Turns: *Chapters 4, 5*, Kuo: *Chapter 2*
4. Combustion in Homogenous Systems: Turns: *Chapter 6*
5. Chemically Reacting Flow Equations: Turns: *Chapters 3, 7*, Kuo: *Chapter 3*
    a. Fick's law of diffusion
    b. Fourier's law of heat conduction
    c. Conservation equations for chemically reactive flow
6. Combustion in Laminar Premixed Systems: Turns: *Chapters 8, 16*, Kuo: *Chapters 4, 5*
    a. The Rankine-Hugoniot curve
    b. Detonation
    c. Laminar premixed flames
7. Aspects of turbulent in premixed systems: Turns: *Portions of chapters 11-12*
8. Combustion in Laminar Non-Premixed Systems: Turns: *Chapter 9, 10*, Kuo: *Chapter 6*
    a. Diffusion flames
    b. Turbulent Diffusion Flames: Turns: *portions of chapter 13*
    c. Droplet combustion
9. Emissions and Pollutant Formation: Turns: *Chapter 15* (Time permitting)

Exams
Exam 1: October 12 (Wednesday)
Exam 2: 12/15/2022 - 12:30 – 2:30 (Thusday during the finals period)
Final Exam: None

Each exam will be given in two parts. One portion will be taken in-class with closed book and closed notes. The second portion of the exams will be take-home with open book and open notes. The take-home portion will be assigned no later than 8:00 PM on the day before they are due. The take-home exam will be due by the start of the in-person exam. ***Students must work on the exams individually***. Talking with your colleagues about the exams, comparing answers, etc. prior to the exam due-time will be considered cheating and will not be tolerated.

Make-up Exam Policy

Make-up exams will be allowed only under the most extenuating circumstances as required by University policy. Please notify the instructor of any anticipated conflicts prior to the exam. See https://care.dso.ufl.edu/instructor-notifications. Note that, "Professors have the right to accept or reject the notification."

Attendance Policy
There is no attendance policy for this course. Lectures will be given in person during class time.

Homework
Homework will be collected on a roughly weekly basis and is due at the start of class on the announced due date. Homework will be assigned at least three weeks before the due date. Thus, late homework submissions will not be accepted.

Students are encouraged to collaborate with their colleagues; however, each student will turn in their homework individually. Copying homework problems from solution manuals and other resources will be considered cheating and will not be tolerated.

Computer software
Many homework problems and class projects will require the use of Cantera. Cantera is freely available at http://cantera.org/docs/sphinx/html/index.html. When stated, a zipped folder that includes all of the necessary Python files and instructions on how to run the script must be electronically submitted before start of class on the announced due date.

Students are **required** to use the Python3 version of Cantera. While there is a Matlab version of Cantera, the Python3 version of Cantera is 1) easier to use than the Matlab version, 2) better documented than the Matlab version, 3) Python is completely free, 4) the Python version is more fully featured, and, most importantly, almost all examples of Cantera that are provided in class and through the textbook have almost all of their examples in Python.

Computer Projects
Two computer projects will be assigned throughout this course. A report is required for each computer project. Proper use of jargon, grammar, and professional English will be required to receive full credit for the computer projects.

EML 4930 students may work in groups of up to 3 for the computer projects. EML 5131 Students must work independently.

Evaluation of Grades

	EML 4930	EML 5131
Homework	30%	30%
Computer Projects	50%	30%
Midterm Exam I	10%	20%
Midterm Exam II	10%	20%

EML 5131 Students
EML 5131 students will have extra questions and problems for their homework assignments, quizzes, and exams.

Grading Policy
The instructor may adjust this scale in the final analysis, but in no case will scores be higher than those listed be required to achieve the stated letter grades.

Percent	Grade	Grade Points
93.0 - 100.0	A	4.00

90.0 – 92.3	A-	3.67
87.0 - 89.9	B+	3.33
83.0 – 86.9	B	3.00
80.0 - 82.9	B-	2.67
77.0 - 79.9	C+	2.33
73.0 – 74.9	C	2.00
70.0 - 72.9	C-	1.67
67.0 - 69.9	D+	1.33
63.0 - 66.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
http://gradcatalog.ufl.edu/content.php?catoid=10&navoid=2020#grades
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Grade Dispute

If there is a mistake in grading or you think that you have been graded unfairly, explain your dispute with the instructor within ***one week*** after the assignment, quiz, exam, etc. is returned. After one week, the grade dispute will ***not*** be considered.

Use of Class Materials

The materials used in this class, including, but not limited to, exams, quizzes, and homework assignments are copyright protected works. Any unauthorized copying of the class materials is a violation of federal law and may result in disciplinary actions being taken against the student. Additionally, the sharing of class materials without the specific, express approval of the instructor may be an act of academic dishonesty, which could result in further disciplinary action. This includes, among other things, uploading class materials to websites for the purpose of sharing those materials with other current or future students.

Class Expectations

- The student is solely responsible for their education. The professor is the guide to their understanding of the field.
- Cell Phones, Laptops, etc.: Under no circumstances will electronic devices be used in the classroom without the permission of the professor. Students are expected to take hand-written notes.
- Respect and Disruption: The professor and students will be respectful at all times. Classroom disruption of any kind will not be tolerated.

Relation to Program Outcomes for EML 4930 (ABET):

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Outcome	**Coverage***
1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	High
2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3) an ability to communicate effectively with a range of audiences	Low
4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	Medium

6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	Low

*Coverage is given as high, medium, or low. An empty box indicates that this outcome significantly addressed by this course.

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or

implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0904, jpennacc@ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html

Campus Resources:

Health and Wellness

U Matter, We Care:

Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: https://counseling.ufl.edu, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence

If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)

Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall*,* 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.