

MAE 504 – Fluid Dynamics of Combustion I

Fall 2024 - Sections 001, 601

Instructor: Prof. Alexei V. Saveliev
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1.1. Course Prerequisites: Undergraduate thermodynamics (MAE 201, 302 or equivalent), Undergraduate Compressible Flow or Engineering Fluid Dynamic (MAE 355 or MAE 308)

1.2. Textbook: Combustion Physics, Chung K. Law, First Ed., Cambridge University Press, 2006

1.3. Reference Material: Principles of Combustion, Kenneth Kuo, Second Ed., Wiley-Interscience, 2005

An Introduction to Combustion: Concepts and Applications, Stephen Turns, Third Ed., McGraw Hill, 2011

1.4. Course Support: <http://engineeringonline.ncsu.edu>
Moodle site - <https://wolfware.ncsu.edu/>

1.5. Course Motivation:

Gas-phase thermochemistry including chemical equilibrium and introductory chemical kinetics, homogeneous reaction phenomena, subsonic and supersonic combustion waves in premixed reactants (deflagration and detonation), premixed flames, introduction to diffusion flame theory.

1.6. Course Objectives:

This is an introductory course and the first in a two-course series in Combustion. The objectives of the course are the following:

- Introduce the foundations of combustion through its various disciplines - thermodynamics, chemical kinetics, oxidation and explosive behavior of fuels, transport processes, and a number of applications of combustion including laminar premixed and diffusion flame theories.
- Introduce the basic design and analysis tools that may be used to solve complex combustion problems.

1.7. Projected schedule of homeworks, tests, and exams

Homeworks will be assigned on Thursday of the current week of class and will be due on Thursday of the following week. The homeworks will be posted as Moodle Assignments set up for electronic submission and grading.

There will be two 75-minute exams and a 2.5-hour final examination. All exams will be closed-book, closed-notes. A formula/summary sheet may be provided. A scientific calculator may be used. The preliminary exam schedule is provided in the class syllabus. Exam dates and times for Distance Education students will be arranged by the student with their proctor at a mutually convenient time in the period starting 8 AM EST on the date listed in the syllabus to the following day by 6 PM EST.

1.8. Grading

Homeworks	15%
Exam 1	25%
Exam 2	25%
Final Exam	35%

The final grade will be based on the final average and determined as follows:

Letter	A+	A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
Highest,%	100.0	96.9	92.9	89.9	86.9	82.9	79.9	76.9	72.9	69.9	66.9	62.9	59.9
Lowest,%	97.0	93.0	90.0	87.0	83.0	80.0	77.0	73.0	70.0	67.0	63.0	60.0	0

Plus/minus grades will be used for the border line cases based on attendance, homework grades, and improvement in test and exam grades.

1.9. Tentative Course Outline

Introduction, Basic Concepts, Fuels mixtures and Properties (1 week)

Chemical Thermodynamics, First and Second Law of Thermodynamic, Enthalpy of Formation, Enthalpy of Reaction (1 week)

Energy Balances, Chemical Equilibrium (1 week)

Chemical Kinetics, Reaction Rates, Reaction Types (1 week)

Exam I *September 24*

Kinetics Approximations, Detailed Mechanisms (1 week)

NO Thermal Mechanism, Hydrogen Mechanism (1 week)

Explosion Limits, Hydrogen and CO Explosion Limits (1 week)

Chemical Kinetics of Combustion of Complex Hydrocarbons (1 week)

Exam II **October 29**

Transport Processes and Principles of Kinetic Theory (1 week)

Conservation Equations, Simplifying Assumptions (1 week)

Detonation and Deflagration, The Hugoniot Curve (1 week)

Laminar Premixed Flames, Thermal and Comprehensive Theories, Structure and Dynamics (1 week)

Laminar Diffusion Flames, Burke-Schumann Flame (1 week)

Final Exam **on-campus section, Thursday, December 5th, 3:30pm – 6pm**

2.0 Course Policies*2.1 Exams*

There will be three 75-minute exams and a 2.5-hour final examination. All exams will be closed-book, closed-notes. Tables and a formula/summary sheet may be provided. A scientific calculator may be used. The preliminary exam schedule is provided in the class syllabus. Exam dates and times for Distance Education students will be arranged by the student with their proctor at a mutually convenient time in the period starting 8 AM EST on the date listed in the syllabus to the following day by 6 PM EST. Credit will not be given for answers without supporting analyses, or for tests turned in late. There must be no collaboration on the exams. Arrangements for missed exams will be made on an individual basis provided you have an acceptable, certifiable excuse.

2.2 Homeworks

Homeworks are posted using Moodle Assignments and should be submitted electronically. Please submit your files as PDF (preferred) or web image files. There is a limit of 10 files/10 MB total for each submission. The homeworks will be graded electronically. The maximum for each homework will be 100 points. The homework solutions will be posted as pdf files.

Homework forums will be open to discuss homeworks and post questions. All students are encouraged to participate.

2.3 Office hours

I will conduct my office hours in the office and on Zoom. The times will be selected based on the poll posted on Moodle. Another option for irregular office hours: you can always set up a Zoom meeting and send me an invite. I will accept if I am available.

2.4 Instructor's policies on incomplete grades and late assignments

Incompletes are accepted only for medical reasons. Makeup work, if any, must be arranged within two weeks of due date at the option of the instructor, prior to two weeks before the end of

classes. Arrangements for missed tests will be made on an individual basis provided you have an acceptable, certifiable excuse.

2.5 Instructor's policies on attendance for on campus students

Attendance is expected and necessary for success. I will excuse a small number of absences under certain special conditions. *NCSU policy on attendance, including what constitutes an 'Excused absence,' is at <http://policies.ncsu.edu/regulation/reg-02-20-03>.*

Work that is late due to an excused absence will either be 'excused' from your grade, or it may be turned in late. It is the students' responsibility to contact the instructor as well as NC State Absence Verification as soon as possible to discuss the most appropriate action.

2.6 Academic Integrity statement

The faculty acknowledges the existence of the University policy on academic integrity found in <http://studentconduct.ncsu.edu/> and expects students to adhere to it. It is the expectation of faculty that students neither give nor receive unauthorized aid on any exam, or special assignment. The faculty recognizes the value of discussions by students regarding weekly homework assignments in student groups, with teaching assistants, and the faculty. However, homework assignments submitted for grading must be the product of the student submitting the work.

2.7 Student Wellness

As a student, you may experience a range of personal issues that can impede learning, such as strained relationships, increased anxiety, alcohol/drug concerns, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may impact your ability to participate in daily activities. It is very important that you have a support system and that you ask for help when you are struggling. The Counseling Center at NC State offers confidential mental health services for full time NC State students, including same-day emergency services. Please visit <https://counseling.dasa.ncsu.edu/> to get connected.

2.8 Statement for students with disabilities

Reasonable accommodation will be made for students with verifiable disabilities. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities at <http://policies.ncsu.edu/regulation/reg-02-20-01>.

2.9 Statement on personal communication devices

All personal communication devices must be turned off during the exams. The use of silent mode during regular class is allowed.

2.10 Class evaluation

Online class evaluations will be available for students to complete during the last week of class. Students will receive an email message directing them to a website where they can login using

their Unity ID and complete evaluations. All evaluations are confidential; instructors will never know how any particular student responded to any question, and students will never know the ratings for any particular instructor. More information about ClassEval is available at <https://isa.ncsu.edu/for-the-pack/classEval/for-students/>

Note: this syllabus is not a contract and can be altered at any point with advanced notice to accommodate the educational goals of the course.