Combustion Reaction Engineering

Syllabus

Spring 2024

Course details:

3 credits
Course code: CHE721
Course title: Combustion Reaction Engineering

In person classes:

Location: Central King Building, Rm 315
Time: Mondays, 6:00 pm to 8:50 pm

Course Instructor and Office hours:

Instructor: Asst. Prof. Kerri-Lee Chintersingh, Tiernan 376
Office hours: Email to make appointment . I am also present on campus daily 10:00 am to 6 pm and you can stop by my office.
Email address: kerri.lee.chintersingh@njit.edu
Office number: 973-642-4468

Virtual office hours

Virtual meeting times can be arranged, subject to the instructor's availability week by week. To make these arrangements, please email the instructor to find a mutually convenient time. Once the time, date and mode (in-person or virtually) has been confirmed, the instructor will provide you with the Zoom/Webex meeting link and details.

Course description:

CHE 721 is a graduate level course that allows students to apply the core principles and theoretical concepts such as kinetics and thermodynamics to the field of combustion. The course builds upon the fundamental principles of reaction kinetics and mechanisms, flame measurements and flame types and leads to current technologies related clean energy generation, emissions, low-carbon fuels and solid fuels (metal combustion). Students will be exposed to important chemical combustion mechanisms, equilibrium calculations using state of the art NASA CEA code, among other combustion terminology and concepts.

Course organization:

The course is designed to bridge the concepts learnt in theory to application. It is also organized to encourage class discussion and participation. The class session includes a mixed-mode lecture and in-class problem solving facilitated by the instructor. This focuses on traditional core theoretical concepts and calculations relevant to combustion. There will also be online class

discussions (exit questions) as well as paper critiques. The emphasis in this case will be on identifying, reviewing, critiquing, and discussing directions for the current research and emerging technologies for the field.

Lecture slides and auxiliary notes (chapters, journal articles, review papers, etc.) will be available on CANVAS before each class session. Solutions for the assignment problems will be posted after in-class discussion. Resources provided should be used as a guide for studying. Taking notes is strongly encouraged.

Required software:

Microsoft Word, Excel and PowerPoint software will be required. These are available for download from NJIT software webpage: https://ist.njit.edu/software-available-download#v.

NASA Chemical Equilibrium with Applications code (NASA CEA) is a program which calculates chemical equilibrium product concentrations from any set of reactants and determines thermodynamic and transport properties for the product mixture. Built-in applications include calculation of theoretical rocket performance, Chapman-Jouguet detonation parameters, shock tube parameters, and combustion properties. This is required for the mini-project and is available for download by first setting up an account or you can run it online at the following link: https://cearun.grc.nasa.gov/. Further details on setting this up and using the software will be discussed in class.

Suggested/supportive texts:

There are several textbooks that can be utilized to support knowledge on combustion. Please note that you are NOT required to purchase textbooks for this course. The textbooks listed below may be useful in strengthening core materials science and engineering concepts and practicing problems relevant for this course.

The recommended text is:
An Introduction to Combustion. Concepts and Applications by Stephen R. Turns Third Edition, McGraw Hill, 2012 ISBN 978-0-07-338019-3

Other additional textbooks/handbooks are:
Combustion by I. Glassman, R. Yetter, Fourth Edition, Acad. Press, 2008; ISBN 978-0-12-088573-2
Combustion Physics by Chung K. Law, Cambridge University Press, NY, NY, 2006 ISBN-10: 0521870526; ISBN-13: 978-0521870528
Principles of Combustion by K.K. Kuo, Second Edition, John Wiley and Sons, 2005 ISBN-10: 0471046892; ISBN-13: 978-0471046899

Course goals/ objectives:

At the end of the course, student should be able to:

- State and apply concepts of core engineering principles such as thermodynamics, kinetics and characterization for combustion applications
- Utilize computer codes to determine combustion equilibrium products, pressures and temperatures
- Apply concepts learnt from traditional hydrocarbon-based fuel combustion to modern technology of low- carbon/solid fuels and lowering atmospheric emissions.
- Evaluate and critically assess research papers appropriate to the field.

Assignments and Grading Policies:

The breakdown for grades is as follows:

Table 1. Grade breakdown for CHE721- Combustion Reaction Engineering

Exit Questions	5%
Mini Project	15%
Test 1	25%
Test 2	25%
Research project report and presentation	30%

Exit Questions (5%)

A single question relevant to the topic taught or discussed in class for that week should be submitted by **11:59 pm every Monday**. The question can be related to theoretical concepts covered by the instructor or in- class discussion. The exit question should be submitted online via CANVAS and will be reviewed on the discussion board on CANVAS. The top exit question will be voted on and will receive extra credit. The selected question will be discussed the following week in class. Exit questions submitted will count towards attendance and participation in class.

Test 1 and 2 (25% per test)

The first written exam will be a 2-hour long written test assessing student problem solving and application of knowledge of topics covered up to Week 7. The test will be conducted in-class during Week 9. The second test will be administered in-class on Week 14 and cover concepts from Weeks 7 to 13. Both tests will be open book/open notes. Students will be assigned 3-4 problems to complete for each test. More details on the exam format and procedure will be provided during the first week of class.

Final Research Paper Review and Presentation (30%)

Students will be required to select **one** research paper published between 2016 and 2023 relevant to any of the topics covered throughout the course from the following journals: ***Combustion, Combustion Science and Technology, Journal of Energetic Materials or Propellants, Explosives and Pyrotechnics*** and prepare a 1 to 2-page written review with a summary of the accomplishments and constructive criticism of the conducted experiment or developed model. A copy of the reviewed paper, your review and a 10-minute power point presentation should be

submitted prior to the final presentation date. Each student will also be required to submit a critique of one of their peer's paper submissions and three (3) related questions to raise during the presentation. The final presentations will be given during the final exam time set by the University Registrar.

Grading Scale (changes may apply):

Table 2. Grade scale assignment for CHE 721 Spring 2024

A	> 90
B+	80-90
B	75-80
C+	70-75
C	60-70
D	50-60
F	<50
I	Incomplete

Re-grade/Make-up policy:

Opportunities to improve grade score or complete assignments to improve overall grade can be discussed with the instructor on a case-by-case basis. For discrepancies or questions related to grades received during the semester, you can discuss and request a regrade or makeup for quizzes/critiques, assignments, and mid-semester tests within 1 week after the material was graded and returned to you. The new grade will be the final grade. If there are concerns with your final overall course grade and a grade change is requested, this will be done following University guidelines as outlined in the catalog: https://catalog.njit.edu/undergraduate/academic-policies-procedures/

University policies: Accommodation

If you need accommodations due to a disability or challenge please contact Scott Janz, Associate Director of Office of Accessibility Resources & Services (OARS), Kupfrian Hall 201 to discuss your specific needs. A Letter of Accommodation Eligibility from the OARS authorizing your accommodations will be required. Other resources for special support services can be found here: https://www.njit.edu/studentsuccess/support-services-and-accommodations

Academic Integrity

Academic Integrity is the cornerstone of higher education and is central to the ideals of this course and the university. **Cheating is strictly prohibited and devalues the degree that you are working on**. As a member of the NJIT community, it is **your responsibility** to protect your

educational investment by knowing and following the **academic code of integrity policy.** More details on this is provided at the following link:
https://www5.njit.edu/policies/sites/policies/files/NJIT-University-Policy-on-Academic-Integrity.pdf

Please note that it is my professional obligation and responsibility to report any academic misconduct to the Dean of Students Office. Any student found in violation of the code by cheating, plagiarizing or using any online software inappropriately will result in disciplinary action. This may include a failing grade of F, and/or suspension or dismissal from the university. If you have any questions about the code of Academic Integrity, please contact the Dean of Students Office at dos@njit.edu

COVID policy:

Based on the NJIT memo regarding Course Requirements and Expectations for Spring 2023, dated January 11, 2023 from the Interim Provost and Senior Executive Vice President:

"Although not mandated, both students and instructors are free to wear facemasks in the classroom, if they so desire. Instructors are not allowed to set their own rules on this issue. The university will be actively monitoring the situation and if the conditions call for it, the policy may be changed."

If you are feeling unwell and experiencing any of the COVID- like symptoms, please follow University guidelines as stipulated at the following website: https://www.njit.edu/healthservices/. Any student who has tested positive should inform the relevant University authorities at **covid.notify@njit.edu** so that proper contact tracing and COVID recovery measures can be completed. If he/she is unable to attend class sessions, measures for making up or conducting the presentations at a later date will be discussed on a case-by-case basis. This should be reported to the Dean of Students. More resources on COVID can be found here: https://www.njit.edu/counseling/c-caps-covid-19-bulletin

Attendance Policy

All students are required to attend all classes. If a student is unable to attend a class session, the instructor should be informed via email of your absence prior to the start of the class.
Class attendance will also be recorded by instructor.

Withdrawal

Student requests for withdrawals after the deadline *(end of the 10th week of classes)* will not be permitted unless extenuating circumstances are documented **through the Office of the Dean of Students**. If you are considering withdrawing, please contact the course instructor and the Dean of Students.

Course Schedule:

Table 3.Table showing week by week class schedule and topics for Spring 2024. This will be used as a guide for the course.

WEEK 1: Jan. 22	**Course Introduction:** Syllabus review and course expectations Introduction to combustion, terminology, fuels, oxidizers, equivalence ratio **EXIT QUESTION SUBMISSION #1**
WEEK 2: Jan. 29	**Thermodynamics of Combustion:** Chemical equilibrium and Equilibrium computations 1st law of thermodynamics Reactant and product mixtures Adiabatic flame temperatures Equilibrium products of combustion **MINI-PROJECT ON EQUILIBRIUM COMPUTATION** **EXIT QUESTION SUBMISSION #2**
WEEK 3: Feb. 5	**Chemical kinetics** Introduction **EXIT QUESTION SUBMISSION #3**
WEEK 4: Feb. 12	**Chemical kinetics** Multi-step, chain reactions, time scales **EXIT QUESTION SUBMISSION #4**
WEEK 5: Feb. 19	**Chemical Combustion mechanisms** **MINI-PROJECT DUE** **EXIT QUESTION SUBMISSION #5**
WEEK 6: Feb. 26	**Flame measurements** Spectroscopy Quenching Ignition **EXIT QUESTION SUBMISSION #6**
WEEK 7: March 4	**Premixed Flames** **EXIT QUESTION SUBMISSION #7**
WEEK 8: March 11	**SPRING BREAK**
WEEK 9: March 18	**TEST #1** **MID-COURSE REVIEW& FEEDBACK**
WEEK 10: March 25	**Diffusion Flames** **EXIT QUESTION SUBMISSION #8**
WEEK 11: April 1	**Droplet Combustion** **EXIT QUESTION SUBMISSION #9**
WEEK 12: April 8	**Solid fuel combustion/Metal combustion** Burning of carbon Coal combustion Aluminum combustion Boron combustion **EXIT QUESTION SUBMISSION #10**
WEEK 13: April 15	**Making combustion clean for the future** Green combustion and concept of clean energy Carbon capture and sequestration Low carbon fuels: Ammonia, hydrogen, natural gas De-carbonizing combustion systems Soot and atmospheric chemistry Emissions
WEEK 14: April 22	**TEST #2**
WEEK 15: TBA	**FINAL PRESENTATIONS and PROJECT SUBMISSION**