PRINCETON - COMBUSTION INSTITUTE
2024 SUMMER SCHOOL ON COMBUSTION AND THE ENVIRONMENT JUNE 16 – JUNE 21, 2024
https://cefrc.princeton.edu/combustion-summer-school

Exascale Computing and Reduced Order Modeling Towards Decarbonization of Power and Aviation
Dr. Jacqueline H. Chen
Sandia National Laboratories, USA

Dynamics of Flames and Detonations in Premixed Gas
Prof. Paul Clavin
Aix-Marseille Université, France

Combustion and Fuels Chemistry and Kinetics
Prof. William H. Green
Massachusetts Institute of Technology, USA

Plasma Aided Combustion and Manufacturing
Prof. Yiguang Ju
Princeton University, USA

Combustion Instability
Prof. Jacqueline A. O'Connor
Pennsylvania State University, USA

Combustion Fundamentals of Fire Safety
Prof. José L. Torero
University College London, UK

Organizer: Prof. Chung K. Law
Co-organizer: Prof. Michael E. Mueller

Our Mission

To provide the next generation of combustion researchers with a comprehensive knowledge in the technical areas of combustion theory, chemistry, experiment, computation and applications.

The 2024 Session

The 2024 **Princeton-Combustion Institute** **Summer School on Combustion and the Environment**, scheduled for **June 16 to June 21, 2024,** will offer the following courses: (1) Dynamics of Flames and Detonations in Premixed Gas; (2) Combustion and Fuels Chemistry and Kinetics; (3) Exascale Computing and Reduced Order Modeling Towards Decarbonization of Power and Aviation; (4) Plasma Aided Combustion and Manufacturing; (5) Combustion Instability; and (6) Combustion Fundamentals of Fire Safety.

Application Materials

Submit application at
https://cefrc.princeton.edu/combustion-summer-school
by March 29, 2024. Acceptance will be communicated by April 12, 2024.

Program Dates

Arrival & Welcome Dinner: Sunday, June 16, 2024; dinner at 6:30pm
Class Schedule: Monday, June 17, to Friday, June 21, 2024
Celebration & Farewell Banquet: Thursday, June 20, 2024
Departure/Check Out: Friday, June 21, 2024

Course Description

Dynamics of Flames and Detonations in Premixed Gas (Monday-Friday; AM)

Lecturer: **Prof. Paul Clavin**, Aix-Marseille Université, France

Course Content: The course will provide an overview of the fundamentals of the dynamics of flames in premixed gas and detonations. A large variety of phenomena will be covered including ignition, quenching, cellular fronts, thermo-acoustic instabilities, direct and spontaneous initiation of detonations as well as recent advances in the understanding of the deflagration to detonation transition. Both experiments and theoretical analyses will be presented.

Combustion and Fuels Chemistry and Kinetics (Monday-Friday; PM)

Lecturer: **Prof. William H. Green**, Massachusetts Institute of Technology, USA

Course Content: Combustion is the release of stored chemical energy through a rather complicated sequence of chemical reactions. Many important combustion phenomena, including most fuel-dependent effects, are controlled primarily by chemical kinetics. Fuel dependence is particularly important now, as society seeks ways to switch off fossil fuels to reduce greenhouse gas emissions. This course will help you understand why and how changing the fuel changes combustion performance, the important chemical reactions in different combustion regimes, how combustion chemistry is modeled on the computer, and the criteria for a fuel to be successful in various applications. The course will focus most on the methods for constructing accurate combustion chemistry models, estimating the values of missing thermochemical and kinetic parameters, conducting sensitivity analysis, and validating combustion chemistry models. The course will also cover some of the basics of chemical rate theory used to compute rate parameters from first principles. It will also lightly cover some of the numerical methods used to incorporate complicated chemistry models in combustion simulations, since usually it is impractical to solve the full-detail chemistry model in 3D time-dependent simulations.

Exascale Computing and Reduced Order Modeling Towards Decarbonization of Power & Aviation (Monday-Tuesday; AM)

Lecturer: **Dr. Jacqueline H. Chen**, Sandia National Laboratories, Livermore, USA

Course Content: This course provides an overview of the role of high-performance computing at the exascale towards decarbonization strategies for hard-to-electrify energy sectors. Computational strategies for high-fidelity multi-physics reacting flow codes coupled with on-the-fly model- and data-driven reduced order modeling will be described. Exemplars of exascale direct numerical simulations of 'turbulence-chemistry' interactions relevant to hydrogen/ ammonia combustion in gas turbines for power generation and multi-modal combustion of sustainable aviation fuels in aero-engine gas turbines will be presented.

Course Description (continued...)

Plasma Aided Combustion and Manufacturing (Wednesday-Friday; AM)

Lecturer: **Prof. Yiguang Ju**, Princeton University, USA

Course Content: Green fuels for transportation and electrified chemicals and materials manufacturing provide great opportunities to enable net zero carbon emissions. Non-equilibrium plasma is a promising technology to create excited states, active species, and new reaction pathways to enhance combustion, chemical conversion, and materials manufacturing. This course will provide an overview of the fundamentals and research frontiers of plasma aided combustion and manufacturing. The course will discuss the physics and chemistry of non-equilibrium plasma discharges, plasma dynamics and instability, plasma enhancement of ignition, flame propagation, and cool flames, plasma diagnostics and modeling, and plasma aided chemical synthesis (ammonia/hydrogen/e-fuels), and materials manufacturing.

Combustion Instability (Monday-Tuesday; PM)

Lecturer: **Prof. Jacqueline A. O'Connor**, Pennsylvania State University, USA

Course Content: Thermoacoustic combustion instability is one of the most challenging operational issues in several high-performance, low-emissions combustion technologies, including gas turbines, aircraft engines, rockets, and industrial boilers. Driven by the coupling between combustor acoustics and flame heat release rate fluctuations, thermoacoustic combustion instability can lead to reduced operability, increased emissions, and, in the most extreme cases, catastrophic failure of combustor components. In this course, we will discuss the basics of instability, including fundamentals of flow oscillations, acoustics, and flame kinematics, and put them together to understand the coupling that drives combustion oscillations. The course will conclude with several case studies that highlight the fundamentals and introduce instability suppression mechanisms.
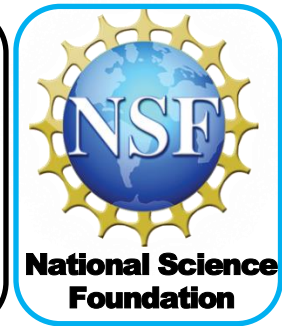
Combustion Fundamentals of Fire Safety (Wednesday-Friday; PM)

Lecturer: **Prof. José L. Torero**, University College London, UK

Course Content: This course will address the combustion processes that define fire safety for a wide variety of applications such as forest fires, battery fires, hydrogen and building fires. Fundamental processes such as pyrolysis, ignition, non-premixed flame dynamics and flame spread will be linked to material flammability. The structure of a buoyant diffusion flame will be developed to characterize mechanisms of heat transfer as they apply to fire safety. Non-premixed flame theory and buoyancy driven flows will be used to describe heat release rates and the evolution of a fire within a compartment. The generation of heat and products of combustion will be used to evaluate the performance of different fire protection measures such as fire resistance, sprinklers, smoke detectors and smoke management systems.