جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Combustion - ME 244

Division	Physical Science and Engineering Division
Course Number	ME 244
Course Title	Combustion
Academic Semester	Spring
Academic Year	2018/2019
Semester Start Date	01/27/2019
Semester End Date	05/23/2019
Class Schedule (Days & Time)	04:00 PM - 05:30 PM | Sun Thu

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Gaetano Magnotti	GAETANO.MAGNOTTI@KAUST.EDU.SA	+966128082874	4335, 5, Al-Kindi (bldg. 5)	Wednesday 8:30-9:30 AM Sunday and Thursday 5:30-6:30 PM

Teaching Assistant(s)

Name	Email
TA available if 10 or more students enroll	

Course Information

Comprehensive Course Description	Fundamentals of Combustion. Basic flame types. Brief review of thermodynamics. Reactand and product mixtures. Chemical equilibrium and adiabatic flame temperature. Transport phenomena. Fundamentals of chemical kinetics. Reaction mechanisms: The H2-O2 system, CO oxidation, methane combustion, NO formation. Analysis of reaction mechanisms. Chemical and thermal analysis of reacting systems: Constant pressure reactor, constant volume reactor, well stirred reactor and plug-flow reactor. Conservation equations in reacting flows. Laminar premixed flames. Laminar diffusion flames. Ignition process. Fundamentals of turbulent combustion. Turbulent premixed flames. Turbulent diffusion flames.
Course Description from Program Guide	Basic principles including chemical equilibrium, Arrhenius law, and Rankine-Hugoniot relations will be first discussed. Multi-component conservation equations with chemical reaction will be introduced. Various characteristics of premixed and diffusion flames will be studied which covers flame structure, flame stability, flame stabilization, flammability limit, quenching distance, and thermal explosion. Combustion phenomena in gas turbines, gasoline engines, diesel engines and power plants will be discussed. A matched asymptotic expansion technique will be introduced and applied in analyzing flame structures.
Goals and Objectives	Introduce the fundamental of combustion. The students will be able to write conservation equations in presence of reaction and correctly apply them to describe fundamental combustion processes. They will learn the fundamental of chemical kinetics, and apply those concepts to the analysis of reactors, laminar premixed and non-premixed flames. During the course, the students will also learn how to use CEA and Chemkin software to compute chemical equilibrium, and simulate laminar flames.
Required Knowledge	Thermodynamics, and basic knowledge of continuum mechanics or fluid mechanics.
Reference Texts	"An Introduction to Combustion, Concepts and Applications" by Stephen R. Turns, published by McGraw-Hill "Combustion" by Warnatz, Maas, and Dibble

Method of evaluation	**10.00**% - Attendance and Participation **35.00**% - Final exam **25.00**% - Homework /Assignments **30.00**% - Midterm exam
Nature of the assignments	Homeworks will consist of multiple answer questions, problems to solve manually and others that will require the use of software (NASA CEA and Chemkin or Cantera). Collaboration for the homeworks is allowed, but copying from each other is strictly prohibited.
Course Policies	Attendance and participation are important, and accounted for in the final grade. Absences should be avoided, and must be justified. Homeworks must be returned in time. Late homeworks will be graded, but points will be detracted for each day of delay.
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 01/27/2019	Introduction to Combustion. Fundamental Definitions and basic flame types.
1	Thu 01/31/2019	Brief Review of Thermodynamics.
2	Sun 02/03/2019	Standard Enthalpies of formation. Chemical Equilibrium. Determination of Equilibrium Composition in gases. Determination of adiabatic flame temperature.
2	Thu 02/07/2019	Transport Phenomena.
3	Sun 02/10/2019	Introduction to Chemical Kinetics. Global versus elementary reactions. Elementary reaction rates. Rates of reaction for multistep mechanisms.
3	Thu 02/14/2019	Analysis of reaction mechanisms . Sensitivity analysis, Reaction flow analysis, eigenvalue analisys. Reduced Mechanisms.
4	Sun 02/17/2019	The H2-O2 system. CO oxidation. Oxidation of hydrocarbons.
4	Thu 02/21/2019	Methane combustion. Oxides of Nitrogen formation.
5	Sun 02/24/2019	Introduction to Chemkin.
5	Thu 02/28/2019	Contant-pressure reactor. Constant volume reactor.
6	Sun 03/03/2019	Well stirred reactor. Plug-flow reactor.
6	Thu 03/07/2019	Conservation of mass and momentum in reacting flows.
7	Sun 03/10/2019	Conservation of energy in reacting flows. The concept of conserved scalar.
7	Thu 03/14/2019	Laminar premixed flames. Zeldovich's analysis of flame propagation. Structure of CH4-air flame.
8	Sun 03/17/2019	Flame velocity and flame thickness in laminar premixed flames.
8	Thu 03/21/2019	Quenching, flammability and ignition in laminar premixed flames. Flame stabilization.
9	Sun 03/24/2019	Spring Break
9	Thu 03/28/2019	Spring Break
10	Sun 03/31/2019	Laminar diffusion flames. Mixing in non-reacting jets. Jet-flame physical description.
10	Thu 04/04/2019	Simplified model for laminar jet non-premixed flames.
11	Sun 04/07/2019	Laminar diffusion jet flames:flame length for circular port and slot burners. Basics of soot formation and destruction.
11	Thu 04/11/2019	Counterflow flames.
12	Sun 04/14/2019	Flame stretch: Phenomenology
12	Thu 04/18/2019	Flame stretch: analysis
13	Sun 04/21/2019	Fundamentals of turbulent combustion. Definition of turbulence. Length scale in turbulent combustion.
13	Thu 04/25/2019	RANS of turbulent reacting flows. Axissymmetric turbulent jets.
14	Sun 04/28/2019	Turbulent premixed flames. Practical applications. Turbulent flame speed.
14	Thu 05/02/2019	Structure of turbulent premixed flames.
15	Sun 05/05/2019	Wrinkled laminar flame regime. Distributed Reaction regime. Flamelet model.
15	Thu 05/09/2019	Flame stabilization.
16	Sun 05/12/2019	Turbulent non-premixed jet flames.
16	Thu 05/16/2019	Turbulent non-premixed jet flames.
17	Sun 05/19/2019	Final Exam Week
17	Thu 05/23/2019	Final Exam Week

Note

The instructor reserves the right to make changes to this syllabus as necessary.