GUJARAT TECHNOLOGICAL UNIVERSITY
MECHANICAL ENGINEERING
PRINCIPLES OF COMBUSTION ENGINEERING
SUBJECT CODE: 2181918
B.E. 8TH SEMESTER

Type of course: Fundamental

Prerequisite: Thermodynamics, Fluid Mechanics & Heat Transfer

Rationale: Fundamental Understanding of Combustion Process

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction to Chemical Thermodynamics** Introduction, Heat of reaction and formation, Free energy and the equilibrium constants, Flame temperature calculations – Analysis & Practical considerations, Sub and supersonic combustion thermodynamics – Comparisons & Stagnation pressure considerations	4	10
2	**Chemical Kinetics** Introduction, Rates of reactions and their temperature dependence - The Arrhenius rate expression & Transition state and recombination rate theories, Simultaneous interdependent reactions, Chain reactions, Pseudo-first-order reactions and the "fall-off" range, The partial equilibrium assumption, Pressure effect in fractional conversion, Chemical kinetics of large reaction mechanisms – Sensitivity analysis, Rate of production analysis, Coupled thermal and chemical reacting systems & Mechanism simplification	9	25
3	**Chemical and Thermal Systems** Constant pressure fixed mass reactor, constant volume reactor, well stirred reactor, plug flow reactor, application to combustion system modelling	5	10
4	**Conservative Equations** Mass conservation, Species mass conservation, Multi component diffusion, momentum conservation, Energy conservation, Conserved Scalar Concept	6	10
5	**Laminar Flames** Laminar Premixed Flames - Physical Description, Simplified Analysis, Detailed analysis Factors influencing flame velocity and thickness, flame stabilization, ignition Laminar Diffusion Flames – non reacting constant density laminar jet, jet flame, flame lengths, soot formation and destruction, counter flow flames	9	20
6	**Turbulent Flames** Applications of turbulent flames, Definition of turbulent flame speed, structure of turbulent premixed flames, wrinkled flame regime, flamelets, flame stabilization, Jet Flames	9	25

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks

R Level	U Level	A Level	N Level	E Level	C Level
7	15	15	13	10	10

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Combustion Physics, C.K. Law, 1st Edition, Cambridge University Press, 2006,
2. Combustion Theory, Forman A Williams, 2nd Edition, Addison-Wesley, 1985.
3. Combustion, Flames and Explosions of Gases, Bernard Lewis and Guenther von Elbe, 3rd Edition, Academic Press, 1987.
4. Combustion, Irvin Glassman, 3rd Edition, Academic Press, 1996.
5. An Introduction to Combustion, Concepts and Applications, Stephen R. Turns, 2nd Edition, McGraw-Hill, 2000.
6. Chemical Kinetics, Keith Laidler, 3rd Edition, Harper and Row, 1987.
7. Thermochemical Kinetics, Sidney W. Benson, John Wiley & Sons, 1968.

Course Outcome:

After learning the course, the students should be able to:

- Understanding of thermodynamics of combustion
- Study of flames and its structure

List of Experiments:

1. Find the smoke point of different fuels.
2. Find the pour point and cloud point of various lubricants.
3. Find the calorific value of fuels with the help of Bomb Calorimeter.
4. Find the calorific value of fuels with the help of Junker's Gas Calorimeter.
5. Test the performance of fuel pump with fuel pump test rig.
6. Study of various spray characteristics of fuel.
7. Study of flame stabilization at different equivalence ratio.
8. Study of laminar premixed flames.
9. Study of turbulent flames.
10. Model different H_2/O_2 mechanism and find equilibrium temperatures at different equivalence ratios.

Design based Problems (DP)/Open Ended Problem:

1. Experimentally distinguish the laminar and turbulent flame regimes.
2. Design an industrial gas burner.
3. Analyze domestic stove.

Major Equipment:

1. Bomb Calorimeter and Junker's Gas Calorimeter
2. Fuel pump test rig
3. Bunsen Burner
4. Temperature measurement apparatus
5. Fuel supply system
6. Ignition system

List of Open Source Software/learning website:

1. http://nptel.ac.in/courses/101104014/
2. http://www.princeton.edu/cefrc/combustion-summer-school/

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.