TEE-904 Laser Diagnostics for Thermal Engineering Applications

Course Objectives

1. The objectives of “Laser Diagnostics for Thermal Engineering Applications” course are:
   a. To develop fundamental understanding of various spectroscopic techniques relevant for thermal engineering applications
   b. To understand the theoretical concepts of molecular structure and their applications in spectroscopy and laser diagnostics
   c. To develop in-depth understanding of absorption based infra-red spectroscopic measurements
   d. To identify advantages and limitations of various spectroscopic techniques.

Course Contents

2. Contents with suggested contact hours

No.	Topics	Contact Hours
a.	**Introduction to Spectroscopy** • Role of Quantum Mechanics • Most Common Forms of Spectra • Typical Absorption Spectroscopy Set-up • Beer’s Law of Absorption • Elements of Spectroscopy • Plank’s Law • Wavelength / Frequency Conversion • Units and Conversion • Spectral Regions • Spectral Absorption Coefficient • Boltzmann Distribution	6
b.	**Diatomic Molecular Spectra** • Interaction of EM Radiation with Molecules	3

	• Rotational Spectra: Simple Model • Vibrational Spectra: Simple Model • Rotational and Vibrational Spectra: Improved Models • Vibrational Spectra: Simple Model • Vibrotational Spectra: Improved Model • Electronic Spectra of Diatomic Molecules	
c.	**Bond Dissociation Energies** • Absorption • Emission • Birge-Spooner Method • Thermochemical Approach • Predissociation	3
d.	**Polyatomic Molecular Spectra** • Rotational Spectra of Polyatomic Molecules • Vibrational Bands of Polyatomic Molecules • Vibrotational Spectra of Polyatomic Molecules	3
e.	**Effects of Nuclear Spin** • Nuclear Spin and Symmetry • Case-I: Linear Molecules • Case-II: Non-Linear Molecules	3
f.	**Rayleight and Raman Spectra** • Light Scattering • Quantum Model • Classical Theory • Rotational Raman Spectra • Vibrational Raman Spectra	3
g.	**Quantitative Emission and Absorption** • Spectral Absorption Coefficient • Einstein Theory of Radiation • Revised Treatment of Einstein Theory • Radiative Lifetime	6

	• Temperature Dependent Linestrength • Concept of Band Strength	
h.	**Spectral Lineshapes** • Line Broadening Mechanism • Voigt Profiles • Line Shifting Mechanisms • Quantitative Lineshape Measurements	6
i.	**Electronic Spectra of Atoms** • Electron Quantum Numbers • Single Electron Atoms • Multi-Electron Atoms	3
j.	**Laser Inducted Fluorescence** • Typical Experimental Setup • Two-Level Model • Detection Limits • Characteristics Times • Applications of LIF	3
k.	**Diagnostics for Gaseous Flows** • Photothermal Deflection (PTD) • Laser Optogalvanic (LOG) • Laser Ionization Spectroscopy • Spontaneous Raman Scattering (SRS) • Coherent Anti-Stokes Raman Spectroscpy (CARS)	3
l.	**Case Studies** • Infrared Spectrum of H_2O • Infrared Spectrum of CO • UV Absorption of OH	3
	Total	45

Course Outcomes

3. By the end of this course students will be able to:
   a. Recall the basic concepts of spectroscopy and laser diagnostics techniques
   b. Explain the theoretical concepts of molecular structure and its effect of spectroscopic behavior of molecule
   c. Distinguish between numerous laser diagnostic techniques
   d. List the advantages and limitations of numerous laser diagnostic techniques
   e. Propose experimental setup to perform laser diagnostic measurements
4. **Recommended Reading (including Textbooks and Reference books).**

S. No.	Title	Author(s)	Remarks
a.	Laser Diagnostics for Combustion Temperature and Species	A. C. Eckbreth	Text Book
b.	Laser Diagnostics and Optical Measurement Techniques in Internal Combustion Engines	Hua Zhao	Reference Book

5. Recommended journals
   a. Journal of Quantitative Spectroscopy and Radiative Transfer (JQSRT)
   b. Combustion and Flame (C&F)