Semester	JAN 2022
Open to semester	8,14,22
Course code	**CHM410/CH6254**
Course title	**Advanced Molecular Spectroscopy**
Credits	4 /4
Course Coordinator & participating faculty (if any)	Aloke Das
Nature of Course	Lectures
Pre-requisites	Fundamentals of Molecular Spectroscopy or similar course
Objectives (goals, type of students for whom useful, outcome etc)	This course mainly deals with the applications of advanced spectroscopic techniques in chemistry, physics, material science and biology. This course will be useful for the students who would like to use variety of advanced spectroscopic techniques for their research. First part of the course will be an introduction to the fundamental concepts of light-matter interaction, optics, lasers and laser systems, and other relevant aspects of instrumentation necessary for spectroscopy. In the second part of the course we will discuss various modern spectroscopic techniques. Discussion of each technique will be followed by examples from classic and contemporary literature.
Course contents (details of topics /sections with no. of lectures for each)	Section #1- Light and its interaction with matter Topics: Introduction to electromagnetic radiation, Polarization of light, Linearly, circularly and elliptically polarized light, Absorption and emission of radiation, Einstein coefficients of A and B, Mechanism of light absorption and emission (Time-dependent perturbation theory), Selection rules, Line width and Line broadening. (6L) Section #2- Brief description of optics Various types of polarizers, Snell's law, Brewster angle, Birefringence property of various crystals, concept of ordinary and extraordinary rays, classification of crystals, concept of various types of wave plate and their applications. (3L) Section #3: Fundamentals of lasers and laser systems Topics: (i) Introduction to Lasers, Concept of spontaneous, stimulated emission and population inversion. Mechanism of

	population inversion, two-level, three level and four level laser systems. Frequency and spatial properties of laser radiation. Components of laser resonator. Loop gain in laser resonator. Gain in continuous-wave and pulsed lasers, Q-switching and the generation of nanosecond pulses, Mode locking and the generation of picosecond and femtosecond pulses. (7L) (ii) Fixed-wavelength gas lasers: He-Ne, rare-gas ion, CO2 and excimer lasers, Fixed-wavelength solid-state lasers: Nd:YAG laser, Semiconductor diode lasers, Tunable dye laser systems, Tunable Ti:sapphire laser systems. (3L) (iii) Non-linear crystal and frequency-mixing processes, Optical parametric oscillation. (2L) Section #4: Advanced Laser spectroscopic techniques and applications Topics: (i) Cavity ring-down absorption spectroscopy, Laser induced fluorescence, Steady-state and time-resolved electronic spectroscopy, Transient absorption spectroscopy, Supersonic jet spectroscopy, Laser studies of photo-ionization (7L) (ii) Resonance Raman spectroscopy, Surface Enhanced Raman Spectroscopy (SERS), (iii) Ultrafast spectroscopy, Laser femtochemistry, Selected applications of lasers (7 L) (iii) Ultra-violet Photoelectron Spectroscopy (UPS), X-ray Photoelectron Spectroscopy (XPS), X-ray Absorption Spectroscopy (XAS), Binding energy and chemical shift, Instrumentation. (4 L)
Evaluation /assessment	End-Sem Examination-50% Mid-Sem Examination-50% Others-%
Suggested readings (with full list of authors, publisher, year, edn etc.)	10 Suggested readings** (with full list of authors, publisher, year, edn etc.) 1. Modern spectroscopy, J. M. Hollas (Wiley, New York, 2004) 2. High Resolution Spectroscopy, J. M. Hollas (Wiley, 2ndedition, 1998) 3. Optics, Eugene Hecht and A. R. Ganeshan 4. Physical Chemistry - A Molecular Approach; Donald A. McQuarrie and John D. Simon (Viva Books Private Limited, New Delhi, 1997)

	5. Laser fundamentals: W. T. Silfvast (Cambridge University press, Published in South Asia by Foundation Books, New Delhi, 1998) 6. Laser Chemistry: Spectroscopy, Dynamics and Applications by H. H. Telle, A. G. Urena, R. J. Donovan (Wiley, 2007). 7. Photoelectron Spectroscopy – Principles and Applications. Stefan Hüfner (Springer, 2003). **Relevant scientific papers will be provided.