Semester

Spectroscopy & Lasers			
Course Code	21PHY751	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course objectives:

- To enable the students to gain the basic knowledge of molecular spectroscopy Raman spectroscopy and their applications.
- Understand the Lasing Concepts with different types of lasers and their applications in different fields.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics.
2. State the necessity of physics in engineering studies and offer real life examples.
3. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
4. Encourage the students for group learning to improve their creativity and analytical skills.
5. While teaching show how every concepts can be applied to the real world. This helps the students to expand understanding level.
6. Support and guide the students for self-study.
7. Ask some higher order thinking questions in the class, which promotes critical thinking.
8. 8. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Spectroscopy:
(08 hours)

Different energy levels in molecules – Brief explanation of Electronic, Vibrational & Rotational levels with energy level diagram. Qualitative discussion on (Mention of the expression) Electronic, Vibrational & Rotational energy.

Mention of expression for harmonic oscillator, Discussion on zero-point energy, Representation of energy levels in potential energy curve and Discussion on vibrational spectra with selection rule. Short note on anharmonic oscillator.

Spectroscopic Experimental Techniques:

Sources and their types, Detectors, IR- spectrometer and applications ,UV- Visible absorption and fluorescence spectrophotometers and applications, Single and double beam spectrophotometer, Fluorescence and Phosphorescence, Spectro fluorometer, IR spectrophotometer, Fourier transform infrared spectroscopy, Nuclear magnetic resonance (NMR) spectroscopy, Time- correlated single photon counting (TCSPC).

Pedagogy	Chalk and talk, Power point presentation, Videos **Self study Component:** Sources and their types, Detectors

Module-2

Raman Spectroscopy:
(08 hours)

Scattering of light: Coherent and incoherent scattering with examples. Raman effect, Stoke's and anti Stoke's lines, Characteristics of Raman spectra Experimental study of Raman effect: Experimental set up, Description and working. Classical theory of Raman effect based on polarisability (qualitative), Quantum theory of Raman effect based on law of conservation of energy.

Rotational Raman spectra (qualitative)- Energy expression, selection rule and spectra, Vibrational Raman spectra (qualitative) - Energy expression, selection rule and spectra Resonance Raman effect: Explanation Comparison between Raman effect and Resonance Raman effect, Raman Spectrometer,

Applications of Raman spectroscopy (qualitative): Detailed discussion of role of Raman spectroscopy in Forensic science, Environmental studies: Pollution monitoring. Industrial applications: Semiconductor industry, Manufacturing industry.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self study Component:** Scattering of light: Coherent and incoherent scattering

Module-3

Lasers: : (08 hours)

Lasers: Coherence, spatial and temporal coherence, measurement of spatial and temporal coherence, coherence time, coherence length, line width and monochromaticity; coherence time and line width via Fourier analysis, complex degree of coherence and fringe visibility in Young's double hole experiment.

Laser rate equations:

Basic structure of a Laser, theory of laser oscillations, round-trip power gain and threshold condition. Rate equations for two, three and four level lasers; variation of laser power around threshold, optimum output coupling.

Optical resonators:

Plane-parallel resonator, spherical resonator, confocal resonator, unstable resonator, losses in optical resonator, quality factor *Q*.

Line broadening mechanisms and laser modes:

Line shape broadening: Doppler broadening, collision broadening, natural radiative lifetime broadening, homogeneous and inhomogeneous broadening.

Laser modes: Longitudinal and transverse modes, experimental arrangement for mode selection.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self study Component: Wave**- Fundamentals of laser : properties, condition and requisites

Module-4

Types of Lasers: :
(08 hours)

Types of Laser: Mention types of laser like Solid, Liquid and Gas laser, etc.
Construction and working with energy level diagram/chemical reactions of

i. Solid state Laser: Ruby laser & Nd-YAG Laser,
ii. Gas Laser, He-Ne, Excimer Laser
iii. Liquid Laser- Dye Laser (Rhodamine 6-G)
iv. Chemical Laser: HF Laser
v. Qualitative discussion of X -Ray Laser and free electron laser

Pedagogy	Chalk and talk, Power point presentation, Videos **Self study Component: Wave**-Basic laser mechanism of solid, liquid, gas & chemical lasers

Module-5

Applications of Lasers: : (08 hours)

1. Industrial applications: Cutting, Drilling and Welding.
2. Laser printing: Construction and working of laser printer along with either ray diagram or with actual 3-d diagram.
3. Research and development applications:
   - *i.* Lithography: Definition of lithography. Photolithography, Qualitative explanation of Deep UV Lithography using Excimer laser with block diagram.
   - *ii.* Laser cooling: Principle of laser cooling. Working of laser cooling (Doppler cooling)
   - *iii.* Laser fusion: Brief explanation of condition for fusion. Explanation of Laser Inertial Fusion Energy (LIFE). Mention of 2 laser fusion devices namely SHIVA and NOVA
4. Biomedical applications:
   - i. Endoscopy: Define endoscopy. Explain the procedure in brief with block diagram
   - ii. Dentistry: Qualitative explanation of any cavity treatment, root canal
5. Light Detection and Ranging (LIDAR): To measure atmospheric pollutants.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics:** **Self study Component:** LIDAR

Course outcome (Course Skill Set)

At the end of the course the student will be able to :
1) Understand the basic of molecular spectroscopy and its characterisations.
2) Apply the concept of Raman spectroscopy to various fields including engineering and medicine.
3) Proficient to understanding fabrication and working of different types of lasers.
4) Learn the applications of lasers in various fields

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)
1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**
4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)
6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**
(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**
1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module. Marks scored out of 100 shall be reduced proportionally to 50 marks

Suggested Learning Resources:

Text books:

1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash, Tata McGraw-Hill Publishing Company Limited, New Delhi.
2. Spectroscopy by H. Kaur, Pragati Prakashan, Meerut.
3. Lasers: Theory & Applications by K. Thyagarajan and A.K.Ghatak, Springer (1981).
4. Laser and Fundamentals by W.T.Silfvast, Cambridge university Press (2004).
5. Lasers and Nonlinear Optics by B.B.Laud, John Wiley & Sons Inc (1985)

Reference books:

1. Introduction to Molecular Spectroscopy, G M Barrow, McGraw Hill. **1962**
2. Modern Spectroscopy, Hollas, Michael J, Wiley, **4 th Ed-2003**
3. LASERS: Principles, Types and Applications by K.R.Nambiar, New Age international Publishers.

Web links and Video Lectures (e-Resources):

https://onlinecourses.nptel.ac.in/noc22_cy23/preview https://nptel.ac.in/courses/104101099 https://www.youtube.com/watch?v=pXVS0Q0WuUY https://www.youtube.com/watch?v=jzFnvSPbwzM https://nptel.ac.in/courses/104106122 https://edu.rsc.org/resources/spectroscopy-videos/1041.article
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning http://nptel.ac.in https://swayam.gov.in