18PHY517	Atomic and Molecular Spectroscopy	3 1 0 4

Description: The course introduces students to the basic physics of atoms, molecules, their spectra and the interaction of light with matter.

Course Outcomes: After successful completion of the course, students will be able to

1) Justify and deduce wave functions of H-atom from Rodrigues formulas, write down energy levels, degeneracies, formulate and derive perturbation corrections.
2) Describe models for helium and multielectron atoms, and their electronic spectra, and distinguish various angular momentum coupling schemes and their consequences.
3) Apply time-dependent perturbation theory to analyse emission and absorption spectra of atoms, transition probabilities, apply selection rules to explain electronic spectra of atoms and their line-widths, describe and classify basic laser types and their operation principles.
4) Describe models, Franck-Condon principle, and analyse consequences to explain electronic, rotational, and vibrational spectra of diatomic molecules, explain IR spectroscopy.
5) Describe and apply the models of polyatomic molecules to explain electronic, vibrational and rotational levels, classical and quantum theory of Raman effect and spectroscopy, calculate parameters of interest.

Unit1

One-electron atoms: H-atom, quantum numbers, wavefunctions, relativistic corrections; electron spin, Einstein–de Haas effect, spin-orbit coupling and fine-structure, Normal and anomalous Zeeman effects, hyperfine structure, complete description of the Hydrogen atom, Lamb shift, correspondence principle; Stark effect in Hydrogen, weak field and strong field effect.

Unit 2

Helium and multi electron atoms: Approximation models, Pauli principle and symmetry of wavefunctions, Helium spectrum, building-up principle of the electron shell for larger atoms, model of electron shells, periodic system of the elements, alkali atoms, coupling schemes for electronic angular momenta, Rydberg states.

Unit 3

Electronic transitions and selection rules: emission and absorption of electromagnetic radiation by atoms, transition probabilities, Einstein coefficients; parity selection rules, selection rules for spontaneous emission, induced absorption and emission, selection rules for the magnetic and spin quantum numbers; lifetimes of excited states, line profiles of spectral lines, natural line width and broadening mechanisms.

Introduction to Lasers: Threshold condition, generation of population inversion; Optical resonators: quality factor, open resonators, modes, diffraction losses, frequency spectrum; Single mode lasers; Basic ideas on solid-state, semiconductor, dye and gas lasers.

Unit 4

Diatomic molecules: spectra of diatomic molecules, structure of electronic transitions, rotational structure, vibrational structure and the Franck–Condon Principle, continuous spectra, IR spectroscopy.

Unit 5

Polyatomic molecules: electronic states of polyatomic molecules CO_2 molecule, rotation and vibration of polyatomic molecules, spectra of polyatomic molecules, Raman spectroscopy, classical and quantum theory of Raman effect, Stokes and anti-Stokes Raman lines.

References:

1. Atoms, Molecules and Photons, 2E: W. Demtroder Springer (Text)
2. Physics of Atoms and Quanta: H. Haken and H.C. Wolf, Springer (2005)
3. Physics of Atoms and Molecules: B.H. Bransden and C.J. Joachain, Pearson India (2003)
2. Molecular spectroscopy, 4E: Banwell, Tata McGraw Hill, 1995

Skills and Employability: The entire contents of this course, tutorials and assignments lays conceptual/theoretical foundation for application of laws of physics to problems of scientific interest and builds skills required for a career as an educator/academician in schools, colleges, universities and coaching centres, as a professional researcher in government/industrial research organizations, and as a communicator of science in general.

Evaluation Pattern: As in the rules for *Assessment Procedure* (R.13) & *Grading System* (R.16)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				1	1		1			2
CO2	3	3				1	1		1			2
CO3	3	3				1	1		1			2
CO4	3	3				1	1		1			2
CO5	3	3				1	1		1			2

18PHY518 ADVANCED ELECTRONICS 3 1 0 4

Course Outcomes: After successful completion of the course, students will be able to

1. To introduce the basic concepts regarding semiconductor optoelectronic devices and its applications
2. To design and analyse op-amp based circuits for different applications
3. To understand the frequency response of different filter circuits
4. To introduce the basic concepts of microprocessor programming

Unit 1

Optoelectronic devices, solar cells, photodetectors, and LEDs.

Unit 2

Digital technique and applications: registers, counters, comparators and similar circuits.

Unit 3

Introduction to operational amplifiers, concept of negative feedback and virtual short, analysis of simple operational amplifier circuits, frequency response of amplifiers, feedback topologies and analysis of discrete transistor amplifiers; signal conditioning and recovery in measurement and control systems.

Unit 4

Active filters and switched capacitor filters; Wave form generators, A/D instruction set, programmable peripheral devices.

Unit 5

Introduction to 8086 microprocessor and its instruction set Assembly level programming, Introduction to microcontrollers and embedded systems.

References:

1. *Malvino & Leech Digital principles and applications, TMH,2003*
2. *John D. Ryder, Electronic Fundamentals and applications PHI, 1999*
3. *Gayakwad, operational Amplifiers & Linear Integrated Circuits, 4E, Pearson India, 2015*
4. *Millman & Halkias, Integrated Electronics, TMH,1991*
5. *Gaonkar, Microprocessor Architecture Programming and Applications with the 8085, penram international, 1999*

Skills and Employability: The entire contents of this course, tutorials and assignments lays conceptual and theoretical foundation in electronics required for basic physics lab equip-ment and instrumentation and builds skills required for a career as an educator in physics in schools, colleges and universities, and as a researcher in experimental physics, and as a communicator of science in general.

Evaluation Pattern – As in R. 13 (Assessment Procedure) & R. 16 (Grading System)

CO-PO-Mapping

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3				1	1		1			2
CO2	3	3				1	1		1			2
CO3	3	3				1	1		1			2
CO4	3	3				1	1		1			2

18PHY586 PHYSICS LAB A 0 0 6 2

Course Outcomes: After successful completion of the course, students will be able to

CO1: perform some advanced experiments in physics

CO2: apply the measurement techniques and develop skill and analyze data, and draw inferences

CO3: infer some specified properties standard atomic and molecular physics related experiments based on electromagnetic absorptions

CO4: use skillfully modern equipment such as Michelson and Fraby-Pero interferometers

CO5: link some of the modern concepts and advanced experiments in electrical, dielectric and magnetic properties of matter and their applications

CO6: perform some of the advanced level experiments to strengthen students' caliber towards research and development

A selection of experiments from the following list:

Michelson's interferometer; Ultrasonic interferometer; Photoelectric effect; Fourier Analysis Kit; Four Probe and measurement of band gap of Ge; Hall effect of doped semiconductors; Magneto-resistance of Ge; Quincke's tube experiment for measurement of magnetic susceptibility; Electron-spin resonance.

Experiments from Dr. R.Srinivasan's kit:

Calibration of Cu-Constantan thermocouples as temperature sensors, Stefan's constant of radiation, Thermal and electrical conductivities of Cu and its Lorenz number, Thermal conductivity of a poor conductor, Thermal diffusivity of brass; Temperature coefficient of resistance of Cu, Energy band gap of Si, Determination of k/e using a transistor; Dielectric constant of a non-polar liquid, Dipole moment of an organic molecule – acetone, Verification of Curie-Weiss law for a ferroelectric material – temperature dependence of a ceramic capacitor; Magnetic hysteresis and B-H curve of a ferromagnetic material; Principle of phase sensitive detection and the calibration of a lock-in amplifier, Measurement of mutual inductance and low resistance with a lock-in amplifier; Experiments in non-linear dynamics: Chua circuit, Feigenbaum circuit for period doubling.

References

1. *R. Srinivasan, K.R. Kriolkar, Instruction Manual for Kit Developed for Doing Experiments in Physics, Indian Academy of Sciences.*
2. *Other Lab manuals and Handouts.*

Evaluation Pattern: As in the rules for Assessment Procedure (R.13) & Grading System (R.16)

Skills & Employability: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

CO-PO Mapping

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1			1	2		2			2
CO2	1	1		2	1	2	2		2			2
CO3	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2

18PHY587	PHYSICS LAB B	0 0 6 2

Course Outcomes: After successful completion of the course, students will be able to

CO1: perform some more advanced experiments in modern physics viz. Michelson interferometer.

CO2: apply measurement techniques and develop skills for efficient data collection, data and error analyzing skills, and draw inferences

CO3: perform condensed matter physics related experiments

CO4: understand and analyze some of the basic as well as advanced concepts of properties of matter and electronics related topics

CO5: perform some of the advanced level experiments to strengthen students' caliber towards research and development

A selection of experiments from the following list:

Michelson's interferometer; Ultrasonic interferometer; Photoelectric effect; Fourier Analysis Kit; Four Probe and measurement of band gap of Ge; Hall effect of doped semiconductors; Magneto-resistance of Ge; Quincke's tube experiment for measurement of magnetic susceptibility; Electron-spin resonance.

Experiments from Dr. R.Srinivasan's kit:

Calibration of Cu-Constantan thermocouples as temperature sensors, Stefan's constant of radiation, Thermal and electrical conductivities of Cu and its Lorenz number, Thermal conductivity of a poor conductor, Thermal diffusivity of brass; Temperature coefficient of resistance of Cu, Energy band gap of Si, Determination of k/e using a transistor; Dielectric constant of a non-polar liquid, Dipole moment of an organic molecule – acetone, Verification of Curie-Weiss law for a ferroelectric material – temperature dependence of a ceramic capacitor; Magnetic hysteresis and B-H curve of a ferromagnetic material; Principle of phase sensitive detection and the calibration of a lock-in amplifier, Measurement of mutual inductance and low resistance with a lock-in amplifier; Experiments in non-linear dynamics: Chua circuit, Feigenbaum circuit for period doubling.

References

1. *R. Srinivasan, K.R. Kriolkar, Instruction Manual for Kit Developed for Doing Experiments in Physics, Indian Academy of Sciences.*
2. *Other Lab manuals and Handouts.*

Evaluation Pattern: As in the rules for Assessment Procedure (R.13) & Grading System (R.16)

Skills & Employability: Lab sessions and experimentation help develop intuition for lab equipment and builds practical knowledge of using lab instruments, measurement techniques and experimental techniques needed for work involving communication of science such as lab instructor/ demonstrator, educator in schools, colleges and universities, technical staff and scientist in research labs, and builds skills needed for higher studies.

CO-PO Mapping

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2		1			1	2		2			2
CO2	1	1		2	1	2	2		2			2
CO3	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2
CO4	2	1	1			1	2		2			2

18PHY698 Seminar 0 0 2 2

Description: Seminars train students in presentation methods to prepare students as instructor/researcher in schools, colleges and universities, research labs, and as a science communicator in general, physics resource person in journalism and administrative services. Along with writing well referenced scientific report this course forms important part of the curricular training. This course will give a preliminary training for the project course in final semester.

Course Outcomes: After successful completion of the course, students will be able to

1) Research seminar material
2) Enhance comprehension skills and gain experience of presenting confidently within the time limitation.
3) Gain experience communicating scientifically expert audience and peers.

4) Gain experience writing a well reference scientific report.

Evaluation and Registration Policy:

This seminar could be based on a mini project or research work carried out by the students in earlier semesters guided by faculty of the department. If student take guidance from other institutions, students must take prior permission from the Chairperson. Students must note that they must start preparing for this seminar and report at least one semester earlier than the semester in which they register this course, with the guidance of a supervisor. This will enable seminar presentations to be conducted throughout the semester.

Students are required to present a 30-45 minute seminar with well referenced typed report, about 10-15 page long (with title page, abstract, table of contents, organization into chapters, including introduction, main content, and conclusion or a summary, with appropriate image credits and bibliography, typeset in LaTeX/PDF). The report must be approved by the course coordinator/instructor and must be submitted at least one week ahead of the date of presentation.

This course may be registered in an earlier semester to enable students to avail of internship or project opportunities in other institutions during the final semester of the program.

Skills & Employability: Tutorials, assignments and a project provide an exposure to research methods and gives an experience in documentation and presentation methods to prepare students as a science communicator, physics resource person in journalism and administrative services, instructor/researcher in schools, colleges and universities, research labs.

Evaluation Pattern: As in the rules for Assessment Procedure (R.13) & Grading System (R.16)

CO#	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	1				3	1		1			3
CO2	3	1				3	1		1			3
CO3	1	1				3	1		3			3
CO5	1	1				3	1		3			3