ROYAL GLOBAL UNIVERSITY
GUWAHATI

Royal School of Applied and Pure Sciences

Department of Physics

M.Sc. Physics

Learning Outcomes Based Curriculum Framework (LOCF)

2021

COURSE STRUCTURE & SYLLABUS

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Preamble

The role of higher education is very important in securing the gainful employment and / or providing further access to higher education comparable to the best available in the world class institutions elsewhere. The improvement in the quality of higher education, therefore, deserves to be given highest priority to enable the young generation of students to acquire skill, training and knowledge in order to enhance their thinking, comprehension and application abilities and prepare them to compete, succeed and excel globally. Sustained initiatives are required to reform the present higher education system for improving and upgrading the academic resources and learning environments by raising the quality of teaching and standards of achievements in learning outcomes across all postgraduate programs in science, humanities, commerce and professional streams of higher education. One of the significant reforms in the postgraduate education is to introduce the Learning Outcomes-based Curriculum Framework (LOCF) which makes it student -centric, interactive and outcome-oriented with well-defined aims, objectives and goals to achieve. The University Grants Commission (UGC) took the initiative of implementing the LOCF in the Colleges and the Universities of the country and Prof. D P Singh, the honorable chairman constituted a Core Expert Committee (CEC) which formulated the modalities for developing the LOCF in various subjects being taught in the postgraduate courses in sciences, humanities and commerce.

Learning Outcomes-based Curriculum Framework for Master's Degree program in Physics

1. Introduction

The learning outcomes-based curriculum framework (LOCF) for the postgraduate programs in Physics is intended to provide a broad framework in Physics, which help to create an academic base that responds to the need of the students to continue to the higher study like M. Phil or Ph.D with practical applications explaining all the observed natural phenomenon as well as predicting the future applications to the new phenomenon with a global perspective. The curriculum framework is designed and formulated in order to acquire and maintain standards of achievement in terms of knowledge, understanding and skills in Physics and their applications to the natural phenomenon as well as the development of scientific attitudes and values appropriate for rational reasoning, critical thinking and developing skills for problem solving and initiating research which are competitive globally and are on par in excellence with the standard Higher Education Institutions (HEI) in the advanced countries of America, Asia and Europe. The multicultural fabric of our nation requires that the institutions involved in implementing this curriculum framework also work hard towards providing an environment to create, develop and inculcate rational, ethical and moral attitudes and values to help the creation of knowledge society needed for scientific advancement of our nation. The learning outcome based curriculum framework in Physics should also allow for the flexibility and innovation through the project work in the PG course in Physics. The process of learning is defined by the following steps which should form the basis of final assessment of the achievement at the end of the program.

- The accumulation of facts of nature and the ability to link with the problems to be solved in theoretical as well as experimental physics in versatile branches.
- The ability to use this skill to solve problems to analyze new situations, research projects in science and technology to find the solution, interpret the results and make predictions for the future developments in the respective branch of Physics.
- The ability to analyze and execute the research projects could be helpful in understanding and to experience a better and improved comprehension of the real research problems in nature and to create new skills, methods, and tools for their possible solutions to form a research paper.

2. Learning Outcomes based approach to Curriculum Planning

2.1 Nature and extent of the Master's Degree program in Physics:

The PG program in Physics builds on the conceptual Physics taught at the B.Sc. level in all the colleges, universities in the country. Ideally, the graduate level education should aim and achieve a sound grounding in understanding the all branches of Physics with sufficient content of topics from Mathematical Physics, Mechanics, Thermodynamics, Solid state Physics, Quantum mechanics etc. to ignite the young minds. The curricula and syllabi should be framed and implemented in such a way that the basic connection between theory and experiment and its importance in research work in Physics should be convenient to the student.

2.2 Aims of Master's Degree Program in Physics

The aims and objectives of our PG educational programs in Physics in particular should be structured to

- motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics for further higher study.
- learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.
- develop the ability to share physics with others, that could be helpful in teaching profession in high school and college level.
- expose the student to the vast scope of Physics as a theoretical and experimental science with applications in different specialization in Physics.

In view of opening the new windows in higher education and research and opening job opportunities at all levels from technicians to innovator scientists and engineers, post graduate program in Physics is offered in our university.

3. Post Graduate Attributes in Physics

Some of the post graduate attributes in Physics are listed below:

3.1 Disciplinary knowledge and skills: Capable of demonstrating

i) good knowledge and understanding of major concepts, theoretical principles its different subfields like Astrophysics and Cosmology, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics along with DSE papers like Advanced Quantum Mechanics, Condensed Matter Physics, Laser Physics, Electronics and Astrophysics.

ii) ability to use recent advancements in different branches of physics to execute quality project work which can be used in further research work.

3.2 Skilled communicator: Ability to transmit complex technical information relating all areas in Physics in a clear and concise manner in writing and oral ability to present complex and technical concepts in a simple language for better understanding.

3.3 Critical thinker and problem solver:

Ability to employ critical thinking and efficient problem-solving skills in all the specialization of Physics.

3.4 Sense of inquiry:

Capability for asking relevant/appropriate questions relating to the issues and problems in the field of Physics, and planning, executing and reporting the results of a theoretical or experimental investigation through project reports.

3.5Team player/worker:

Capable of working effectively in diverse teams in both classroom, laboratory, Physics workshop, project research group and in industry and field-based situations.

3.6 Skilled project manager:
Capable of identifying/mobilizing appropriate resources required for a project, and manage a project through to completion, while observing responsible and ethical scientific conduct; and safety and laboratory hygiene regulations and practices.

3.7 Digitally efficient: Capable of using computers for simulation studies in Physics and computation and appropriate software for numerical and statistical analysis of data, and employing modern e-library search tools like Inflibnet, various websites of the renowned Physics labs in countries like the USA, Europe, Japan etc. to locate, retrieve, and evaluate Physics information.

3.8 Ethical awareness/reasoning: The post graduates should be capable of demonstrating ability to think and analyze rationally with modern and scientific outlook and identify ethical issues related to one's work, avoid unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

3.9 National and international perspective:

The post graduates should be able to develop a national as well as international perspective for their career in the chosen field of the academic activities. They should prepare themselves during their most formative years for their appropriate role in contributing towards the national development and projecting our national priorities at the international level pertaining to their field of interest and future expertise.

3.10 Lifelong learning: Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and reskilling in all areas of Physics to motivate others in physics higher studies.

4. Qualification descriptors for M.Sc. Physics.
The post graduates should be able to:

- Demonstrate
  - (i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Space science and applications,
  - (ii) procedural knowledge that creates different types of professionals related to different areas of study in Physics outlined above, including research and development, teaching and government and public service;
  - (iii) skills in areas related to specialization area relating the subfields and current developments in the academic field of Physics.
- Use knowledge, understanding and skills required for identifying problems and issues relating to Physics, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources from various Physics laboratories of the world, and their application, analysis and evaluation using methodologies as appropriate to Physics for formulating new theories and concepts.
- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data drawing on a wide range of sources from the Physics labs around the world, analysis and interpretation of data using methodologies as appropriate to the subject of Physics in the area of

his specialization.

- Use knowledge, understanding and skills in Physics for critical assessment of a wide range of ideas and complex problems and issues relating to the various sub fields of Physics.
- Communicate the results of studies undertaken in the academic field of Physics accurately in a range of different contexts using the main concepts, constructs and techniques of the subject of Physics;
- Address one's own learning needs relating to current and emerging areas of study relating to Physics, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge in Physics.
- Apply one's knowledge and understandings relating to Physics and skills to new/unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstrate subject-related and transferable skills that are relevant to some of the Physics related jobs and employment opportunities

5. Program Learning Outcomes of M.Sc. Physics

The student graduating with the Degree M.Sc. Physics should be able to acquire

(i) a fundamental/systematic or coherent understanding of the academic field of Physics, its different learning areas and applications in basic Physics like Astrophysics, Material science, Nuclear and Particle Physics, Condensed matter Physics, Atomic and Molecular Physics, Mathematical Physics, Analytical dynamics, Space science, and its linkages with related disciplinary areas/subjects like Chemistry, Mathematics, Life sciences, Environmental sciences, Atmospheric Physics, Computer science, Information Technology

(ii) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Physics, including professionals engaged in research and development, teaching and government/public service;

(iii) skills in areas related to one's specialization area within the disciplinary/subject area of Physics and current and emerging developments in the field of Physics.

- Demonstrate the ability to use skills in Physics and its related areas of technology for formulating and tackling Physics-related problems and identifying and applying appropriate physical principles and methodologies to solve a wide range of problems associated with Physics.
- Recognize the importance of mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.
- Plan and execute Physics-related experiments or investigations, analyze and interpret data/information collected using appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories of Physics.
- Demonstrate relevant generic skills and global competencies such as
  - (i) problem-solving skills that are required to solve different types of Physics-related problems with well-defined solutions, and tackle open-ended problems that belong to the disciplinary area boundaries;
  - (ii) investigative skills, including skills of independent investigation of Physics-related issues and problems;
- Demonstrate professional behavior such as
  - (i) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;
  - (ii) the ability to identify the potential ethical issues in work-related situations;

(iii) appreciation of intellectual property, environmental and sustainability issues; and
(iv) promoting safe learning and working environment.

Structure of the Program in M.Sc. Physics

1st Semester							
Sl.No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	PHY014C101	Classical Mechanics	4	0	0	4	4
2	PHY014C102	Quantum Mechanics – I	4	0	0	4	4
3	PHY014C103	Mathematical Physics	4	0	0	4	4
4	PHY014C114	Physics Lab - I	0	0	4	4	8
Ability Enhancement Compulsory Courses (AECC)							
5	CEN984A101	Communicative English – I	1	0	0	1	1
6	BHS984A103	Behavioural Science-I	1	0	0	1	1
Elective: Discipline Specific (DSE) (Choose any one)							
7	PHY014D101	Nuclear and Particle Physics	4	0	0	4	4
8	PHY014D102	Theory of Relativity	4	0	0	4	4
			Total Credit = 22				

2nd Semester							
Sl.No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	PHY014C201	Condensed Matter Physics	4	0	0	4	4
2	PHY014C202	Electrodynamics	4	0	0	4	4
3	PHY014C203	Quantum Mechanics – II	4	0	0	4	4
4	PHY014C214	Physics Lab - II	0	0	4	4	8
Ability Enhancement Compulsory Courses (AECC)							
5	CEN984A201	Communicative English – II	1	0	0	1	1
6	BHS984A203	Behavioral Science-II	1	0	0	1	1
Ability Enhancement Elective Courses (AEEC) (Skill Based)							
7		AEEC-1	2	0	0	2	2
Elective: Discipline Specific (DSE) (Choose any one)							
8	PHY014D201	Optoelectronics and Nonlinear Optics	4	0	0	4	4
9	PHY014D202	Plasma and Space Physics	4	0	0	4	4
			Total Credit = 24				
3rd Semester							
Sl.No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	PHY014C301	Atomic and Molecular Physics	4	0	0	4	4
2	PHY014C302	Statistical Mechanics	4	0	0	4	4
3	PHY014C313	Physics Lab - III	0	0	4	4	8

Ability Enhancement Compulsory Courses (AECC)							
4	CEN984A301	Communicative English – III	1	0	0	1	1
Ability Enhancement Elective Course (AEEC) (Skill Based)							
5		AEEC-2	2	0	0	2	2
Elective: Discipline Specific (DSE) (Choose any three)							
6	PHY014D301	Non - Linear Optics and Laser Spectroscopy - I	4	0	0	4	4
7	PHY014D302	Physics of Nanomaterials -I	4	0	0	4	4
8	PHY014D303	Advanced Quantum Mechanics - I	4	0	0	4	4
9	PHY014D304	Astrophysics - I	4	0	0	4	4
10	PHY014D305	Physics of Semiconductors-I	4	0	0	4	4
11	PHY014D306	Condensed Matter Physics-I	4	0	0	4	4
12	PHY014D307	High Energy Physics - I	4	0	0	4	4
13	PHY014D331	Seminar/ Literature survey	4	0	0	4	4
			Total Credit = 27				

4th Semester							
Sl.No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
Core Subjects							
1	PHY014C401	Laser and Raman Spectroscopy	4	0	0	4	4
2	PHY014C402	Semiconductor Devices	4	0	0	4	4
Ability Enhancement Compulsory Courses (AECC)							
3	CEN984A401	Communicative English – IV	1	0	0	1	1
Elective: Discipline Specific (DSE) (Choose any two)							
4	PHY014D401	Non - Linear Optics and Laser Spectroscopy - II	4	0	0	4	4
5	PHY014D402	Physics of Nanomaterials -II	4	0	0	4	4
6	PHY014D403	Advanced Quantum Mechanics - II	4	0	0	4	4
7	PHY014D404	Astrophysics - II	4	0	0	4	4
8	PHY014D405	Physics of Semiconductors-II	4	0	0	4	4
9	PHY014D406	Condensed Matter Physics - II	4	0	0	4	4
10	PHY014D407	High Energy Physics - II	4	0	0	4	4
Project							
11	PHY014D431	Project / Seminar	0	0	0	12	12
			Total Credit = 29				

Elective Discipline Specific DSE			
FIRST SEMESTER (Choose any one)	**SECOND SEMESTER (Choose any one)**	**THIRD SEMESTER (DSE 5 is compulsory and choose any two, each from DSE 3 and DSE 4)**	**FOURTH SEMESTER (Choose any two, each from DSE 6 and DSE 7)**
DSE - 1 1. Nuclear and Particle Physics 2. Theory of Relativity	**DSE - 2** 1. Optoelectronics and Nonlinear Optics 2. Plasma and Space Physics	**DSE - 3** 1. Nonlinear Optics and Laser Spectroscopy-I 2.Physics of Nanomaterials - I 3. Advanced Quantum Mechanics - I	**DSE - 6** 1. Nonlinear Optics and Laser Spectroscopy-II 2.Physics of Nanomaterials - II 3. Advanced Quantum Mechanics - II
		DSE - 4 1. Astrophysics - I 2.Physics of Semiconductors - I 3. Condensed Matter Physics - I 4. High Energy Physics - I	**DSE - 7** 1. Astrophysics - II 2.Physics of Semiconductors - II 3. Condensed Matter Physics - II 4. High Energy Physics - II
		DSE 5-Seminar/Literature Survey	

Ability Enhancement Elective Course (AEEC) (Skill Based)							
AEEC/SEC-1 (2nd Semester) (Choose any one)							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
1	ILD9945203	ILD-1	2	0	0	2	2
2	FLG9945202	FRENCH-1	2	0	0	2	2
3		C++	1	0	1	2	3
4		SCILAB	1	0	1	2	3
5		MATLAB	1	0	1	2	3
6		Any other courses offered by other schools of RGU and opted by Student	2	0	0	2	2
Ability Enhancement Elective Course (AEEC) (Skill Based)							
AEEC/SEC-2 (3rd Semester) (Choose any one)							
Sl. No.	**Subject Code**	**Names of subjects**	**L**	**T**	**P**	**C**	**TCP**
1	ILD9945303	ILD-2	2	0	0	2	2
2	FLG9945302	FRENCH-2	2	0	0	2	2
3		LATEX/MATLAB	1	0	2	2	2
4		Any other courses offered by other schools of RGU and opted by Student	2	0	0	2	2

Summary of Credits	
Semester	**Credits**
Sem-I	22
Sem-II	24
Sem-III	27
Sem-IV	29
TOTAL	102

Scheme of Evaluation

Theory Papers (T):

- **Continuous Evaluation: 15%** (Assignment, Class Test, Viva, Seminar, Quiz : Any Three)
- **Mid-term examination:** 10%
- **Attendance: 5%**
- **End Term Examination: 70%**

Practical Papers (P):

- **Continuous Evaluation: 25%** (Skill Test, lab copy, viva, lab involvement: Any Three)
- **Attendance:** 5%
- **End term examination:** 70 %

Combined Theory & Practical Papers (TP):

- **Continuous Evaluation: 15%** (Assignment. Class Test, Lab Experiment, Lab Copy, Viva: Any Three)
- **Mid-term examination:** 10%
- **Attendance: 5%**
- **End term examination:** 70 %

1st Semester Syllabus

SYLLABUS (1st SEMESTER)

Paper I/Subject Name: Classical Mechanics		**Subject Code: PHY014C101**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation	
1. To know about the Lagrangian formulation and its application, central force problem, Hamiltonian formulation, Euler's theorem etc.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Mechanics of a system of particles, constraints, d'Alembert's principle and Lagrangian equations 2. Kepler problem and planetary motion, scattering in central force field 3. Hamiltonian equation of motion, cyclic coordinates, phase space. Hamilton's principle 4. kinetic energy of a rotating body, tensor of inertia, Euler's angles, Euler's equations of motion	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)	

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	Lagrangian Formulation: Mechanics of a system of particles – constraints – d'Alembert's principle and Lagrangian equations – conservation theorems and symmetry properties – applications of Lagrangian formulation.	**10**
II.	Central Force Problem: Reduction to one body problem – equation of motion and first integral – one dimensional problem and classification of orbits – Kepler problem and planetary motion – scattering in central force field – transformation to laboratory Frames.	**10**
III.	Hamiltonian Formulation: Legendre transformation – Hamiltonian equation of motion –cyclic coordinates – phase space. Hamilton's principle and invariance of it. Characteristic function. Liouville's theorem – Poisson bracket.	**11**
IV.	Rigid Body and Vibrating System: Euler's theorem, angles – kinetic energy of a rotating body, tensor of inertia, Euler's angles – Euler's equations of motion – symmetric top. Vibrating string – solution wave equation –normal vibrations – Dispersion.	**9**
Total		**40**

Texts:

1. *Classical Mechanics*; Goldstein H., Narosa Publishing house, 2nd Ed., 2018, New Delhi

References:

1. Rana & Yoag; *Classical Mechanics*, Tata McGraw-Hill Publishing Company Limited, 1st Ed., 2017, New Delhi
2. Upadhaya J. C; *Classical Mechanics*, Himalaya Publishing House, 3rd Ed., 2014, Mumbai

SYLLABUS (1st SEMESTER)

Paper II/Subject Name: Quantum Mechanics-I **Subject Code: PHY014C102**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To be familiar about inadequacies of Classical Physics, Black-body radiation, application of Schrodinger equation to one-dimensional problems, angular momentum operator in quantum mechanics, approximation methods in quantum mechanics	2. Lecture 3. Assignment 4. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Photoelectric effect, Compton effect, de Broglie hypothesis, Wave-particle duality of radiation and matter 2. Particle in a box; linear harmonic oscillator; square well potentials; potential step; barrier potential; tunneling effect 3. commutation relations of the three components; Commutation relation between position and angular momentum 4. Time dependent perturbation theory for a non-degenerate case and for a degenerate case, Stark effect	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Inadequacies of Classical Physics, Black-body radiation, Plank's Law, Photoelectric effect, Compton effect, de Broglie hypothesis, Wave-particle duality of radiation and matter, Schrödinger equation (time-dependent and time- independent); Physical interpretation of wave function; Born interpretation; Equation of continuity; Probability density and Probability current density. Heisenberg's Uncertainty Principle; Ehrenfest's theorem; Linear momentum operator; Physical variables as operators; Expectation value of a physical variable.	**9**
II	Application of Schrodinger equation to one-dimensional problems; Particle in a box; linear harmonic oscillator; square well potentials; potential step; barrier potential; tunneling effect. General definition of an operator; different types of operators: linear, Hermitian, unitary etc. Commutator of two operators; Commutator algebra; Eigen values and Eigen functions of an operator; Commutator or position and momentum operators	**10**
III	Angular momentum operator in quantum mechanics; commutation relations of the three components; Commutation relation between position and angular momentum, between linear momentum and angular momentum; Angular momentum operator in spherical polar coordinates; particle in a central field, expressed in spherical polar coordinates; application of Schrodinger equation to hydrogen atom; the energy eigenvalues and eigenfunctions.	**11**
IV	Approximation methods in quantum mechanics; Time dependent perturbation theory for a non-degenerate case and for a degenerate case, Stark effect, Zeeman effect, Variational method, application to the helium atom, the WKB approximation.	**10**
	Total	**40**

Text:

1. *Introductory Quantum Mechanics*; Liboff R.L., Pearson Education, 4th Ed., 2007, New Delhi.

References:

1. L.I. Schiff, Bandhyopadhay J.; *Quantum Mechanics*, McGraw Hill Education; 4th Ed., 2017, New Delhi
2. Ghatak A. K. and Lokanathan S. *Quantum Mechanics*, Laxmi Publications Pvt. Ltd, 5th Ed., 2015, New Delhi
3. Merzbacher E.; *Quantum Mechanics*, John Wiley & Sons, 3rd Ed., 2011, New York
4. Satya Prakash. *Advanced Quantum Mechanics*, Kedar Nath Ram Nath, 2019, Meerut, India
5. Thankappan V.K., *Quantum Mechanics, New Age International* (P) Limited, 3rd Ed., 2012, New Delhi

SYLLABUS (1st SEMESTER)

Paper III/Subject Name: Mathematical Physics		**Subject Code: PHY014C103**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To get knowledge about Vector algebra and vector calculus, Complex variables, Theory of second order linear homogeneous differential equations, Special functions	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. linear independence, basis expansion, Schmidt orthogonalization; matrices: Eigenvalues and eigenvectors; 2. Complex numbers, function of a complex variable : Cauchy-Riemann equations and their applications; analytic function 3. regular and irregular singular points; Frobenius method, linear independence of solutions: Wronskian, Sturm-Liouville's theory 4. Hermite and Laguerre functions., generating function Integral transforms Fourier and Laplace transforms	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Vector algebra and vector calculus, linear independence, basis expansion, Schmidt orthogonalisation. Matrices: Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors, Concepts of tensors	**9**
II	Complex variables Recapitulation: Complex numbers, triangular inequalities, Schwarz inequality. Function of a complex variable : single and multiple-valued function, limit and continuity; Differentiation; Cauchy-Riemann equations and their applications; Analytic and harmonic function; Complex integrals ,Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy's Integral Formula and its corollaries; Classification of singularities; Residue theorem and evaluation of some typical real integrals using this theorem.	**11**
III	Theory of second order linear homogeneous differential equations Singular points: regular and irregular singular points; Frobenius method. Linear independence of solutions: Wronskian, second solution. Sturm-Liouville's theory; Hermitian operators; Completeness. Inhomogeneous differential equations: Green's functions	**10**
IV	Special functions Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions., generating function Integral transforms Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of Derivative and integral of a function; Solution of differential equations using integral transforms, Delta function.	**10**
Total		**40**

Text:

1. *Mathematical Physics;* Das H.K., S. Chand, 2018, New Delhi

References:

1. Dyke P P; *An Introduction to Laplace Transform and Fourier Series*, Springer, 2nd Ed.,2014, London
2. Rajput B.S; *Mathematical Physics*, Pragati Prakashan, 23rd Ed. 2011, Meerut
3. Arfken and Weber *Mathematical methods for physicists*, Elsevier India, 7th Ed. 2012, Gurgaon
4. Potter M.C. Goldberg J. *Mathematical Methods*, Prentice Hall, India, 2nd Ed., 2000, Delhi

SYLLABUS (1st SEMESTER)

Paper IV/Subject Name: Physics Lab-I		**Subject Code: PHY014C114**
L-T-P-C: 0-0-4-4	**Credit Units: 4**	**Scheme of Evaluation: P**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give the basics of physics and its application.	1. Demonstration 2. Experimentation 3. Correction	On completion of this course students will be able to gain interest on the following: 1. Stefan's constant – Black body radiation 2. Measurement of Planck's constant. 3. Determination of e/m by Thomson method.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Skill Test, lab copy, viva, lab involvement: Any Three: 25, Attendance: 05)

List of experiments:

1. Stefan's constant – Black body radiation
2. Resistivity of 'Ge' at various temperatures by Four Probe method and determination of band gap.
3. Measurement of Planck's constant.
4. Determination of ionization and excitation potential using Michelson interferometer.
5. Determination of ionization and excitation potential using Fabry-perot interferometer.
6. Determination of wavelength and separation of D-lines using Michelson interferometer
7. Determination of wavelength and separation of D-lines using Fabry-perot interferometer.
8. Determine the velocity of Ultrasonic wave in liquid by using spectrometer.
9. Determination of e/m by Thomson method.
10. Determination of e/m by Millikan's oil drop method.

Text:

1. *A text book on practical physics* Mazumdar K.G., Ghosh B, Sreedhar publishers, 16th Ed. 2011, Kolkata

References:

1. *Advance Practical Physics for students;* Worsnop B.L. Flint H.T. Facsimile Publisher, 2nd Ed. 2019, New Delhi

SYLLABUS (1^{st} SEMESTER)

Paper V/Subject Name: Nuclear & Particle Physics **Subject Code: PHY014D101**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	**Teaching Learning Process**	**Learning Outcomes**	**Course Evaluation**
1. To get knowledge about nuclear Properties: Size, shape and charge distribution, nuclear models, nuclear decay and radioactivity, elementary Particles	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Nuclear forces: Deuteron, Properties of the nuclear force, Spin dependence of nuclear force 2. The Semi empirical mass formula, mirror nuclei, Spin orbit coupling, liquid drop model 3. Fermi's theory of beta decay, allowed and forbidden transitions, selection rules 4. Types of Interactions, Conservation laws, CPT theorems, strangeness	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Nuclear Properties: Size, shape and charge distribution, spin and parity. Nuclear forces: Deuteron, Properties of the nuclear force, Spin dependence of nuclear force. Nuclear Reactions: The Q equation - theory of Nuclear reaction, Compound nucleus, Fission and fusion.	**11**
II	Nuclear Models: Binding energy, The Semi empirical mass formula –mirror nuclei, magic numbers, Spin orbit coupling, excited states, liquid drop model, the Shell Model and Single particle model of the nucleus.	**9**
III	Nuclear decay and radioactivity: Fermi's theory of beta decay, allowed and forbidden transitions, selection rules, non-conservation of parity in beta decay, direct evidence for the neutrino, gamma–decay and selection rules, Curie plots , selection rules, electron Capture , Parity violation.	**9**
IV	Elementary Particles: Classification – Types of Interactions, Conservation laws, CPT theorems, strangeness, hyper charge, Detection of Neutrino, Concept of Antiparticles, Elementary idea of quark model.	**11**
Total		**40**

Text:

1. *Introductory Nuclear Physics*- Krane Kenneth. S: S.CHAND, 1^{st} Ed., 2008, New Delhi

References:

1. Enge H., *Introduction to Nuclear Physics*, Addison Wesley, 5^{st} Ed. 2015, (available in open source only)
2. Tayal D.C., *Nuclear Physics*, Himalaya House, 5^{th} Ed., 2011, New Delhi
3. Burcham W.C., *Elements of Nuclear Physics*, ELBS paperback, 2nd Ed. 1979, Longman
4. Griffiths D., *Introduction to elementary particles*, Wiley-VCH, 2^{nd} Ed., 2008, New Jersey

SYLLABUS (1st SEMESTER)

Paper VI/Subject Name: Theory of Relativity **Subject Code: PHY014D102**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To know about Lorentz transformation equation, Space, Time and Gravity in Newtonian Physics, Covariant and contra variant vectors and tensors, quotient law, covariant differentiation	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. space time continuum, mass energy equivalence (E = Mc2), particles with zero rest mass 2. Space and time in relativity, four vector notation, velocity four vector, Newtonian Gravity 3. parallel displacement, geodesic equation alternative derivation from a Variational principle, curvature tensors 4. Newtonian theory from Einstein law, motion of a test particle in a weak gravitational field	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Special theory of Relativity (STR): Lorentz transformation equation- Time dilation and Twin paradox, Experimental verification of Time dilation , space time continuum- mass energy equivalence ($E = Mc^2$).particles with zero rest mass, Inverse Lorentz transformation, Velocity addition.	10
II	Space, Time and Gravity in Newtonian Physics: Space and time in relativity, four vector notation, velocity four vector, Newtonian Gravity, Gravitational and Inertial mass, Variational principle in Newtonian Mechanics, gravitational red shift.	10
III	General Theory of Relativity (GTR): Covariant and contra variant vectors and tensors, quotient law, covariant differentiation, parallel displacement, geodesic equation alternative derivation from a Variational principle, curvature tensors,	10
IV	Einstein's law of gravitation: Einstein field equation, weak field approximation-Newtonian theory from Einstein law, motion of a test particle in a weak gravitational field, Poisson's equation from Einstein's law, Gravitational waves.	10
Total		**40**

Text:

1. *Introduction to special relativity*, Robert Resnick, Wiley; 2st Ed. 2016, New Jersey

References:

1. Krori K.D., *Fundamentals of special and general relativity*, PHI. Learning Pvt. Ltd., 1st Ed. 2010, New Delhi.
2. Narlikar J. V., *Introduction to relativity*. Cambridge University Press, 1st Ed., 2011, New Delhi
3. Wald R. M., *General Relativity*, Chicago University Press, 1st Ed., 2010, Chicago
4. Weinberg S., *Principles and Applications of the General Theory of Relativity*, WSE; 1st Ed., 2008, New Jersey.

2nd Semester Syllabus

SYLLABUS (2^{nd} SEMESTER)

Paper I/Subject Name: Condensed Matter Physics **Subject Code: PHY014C201**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Detailed Syllabus:

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To know about: Free electron theory of metals, Free electron model, Band theory of solids, Magnetic properties of solids, Superconductors	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Electrons moving in one dimensional potential well, three dimensional potential well, quantum state and degeneracy 2. Bloch function. Kronig-Penney model, number of states in a band, Energy gap 3. Fundamental concepts, quantum theory of diamagnetism and Para magnetism, diamagnetic and paramagnetic susceptibilities of free electrons 4. Critical temperature-persistent current-occurrence of super conductivity	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Modules	Topics / Course content	Periods
I	Free electron theory of metals: Free electron model, Electrons moving in one dimensional potential well, three dimensional potential well, quantum state and degeneracy, the density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function, the electronic specific heat. Electrical conductivity of metals, relaxation time and mean free path, electrical conductivity and Ohm's law, Thermal conductivity, Wiedemann - Franz law, thermionic emission, Hall effect.	11
II	Band theory of solids: Elementary ideas of formation of energy bands. Bloch function. Kronig-Penney model, number of states in a band, Energy gap. Distinction between metals, insulators and semiconductors. Concept of holes, equation of motion for electrons and holes, effective mass of electrons and holes. Band structure of semi-conductors, Intrinsic and extrinsic semiconductors, expression for carrier concentration (only for intrinsic), ionization energies, charge neutrality equation.	11
III	Magnetic properties of solids: Fundamental concepts, quantum theory of diamagnetism and Para magnetism, diamagnetic and paramagnetic susceptibilities of free electrons, molecular field theory of ferromagnetism, anti-ferromagnetism and ferrimagnetism, anisotropic energy, electron paramagnetic resonance and nuclear magnetic resonance, Bloch equations, Heisenberg Hamiltonian for exchange interaction.	9
IV	Superconductors: Critical temperature-persistent current-occurrence of super conductivity, ideal and non-ideal superconductors-Destruction of super conductivity by magnetic field - Meissner effect- heat capacity-energy gap- microwave and infrared properties- Isotope effect- BCS theory (qualitative)- Josephson tunneling-exotic superconductors- high T_c superconductors.	9
	Total	**40**

Text:

1. *Solid State Physics; C.* Kittel, John Wiley & sons, Inc., 8^{th} Ed., 2005, New Delhi.
2. *Solid State Physics* Dekker A. J. Macmillan India Ltd, 1^{st} Ed., 2000, Bangalore

References:

1. Verma A.R. and Srivastava O.N.; *Crystallography Applied to Solid State Physics*, 2^{nd} edition, New Age International Publishers, 2001, Darya Ganj, Delhi
2. Pillai S. O.; *Solid state Physics*, New Age International Publication, 6^{th} Ed. 2018, Darya Ganj, Delhi

SYLLABUS (2nd SEMESTER)

Paper II/Subject Name: Electrodynamics		**Subject Code: PHY014C202**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To know about: Electrostatics: Magneto-statics: Electrodynamics: Maxwell's equations and their applications	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Differential and integral forms of Gauss's law, Cartesian coordinates, spherical coordinates 2. Biot-Savart law, divergence and curl of B, Gauge transformations, Scalar and vector potentials 3. Maxwell's equations, fixing of Ampere law by Maxwell, propagation of electromagnetic waves in vacuum 4. Macroscopic Maxwell equation, Relativistic electrodynamics	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Electrostatics: Field lines, flux and Gauss's law, differential and integral forms of Gauss's law, applications of Gauss's law; Electric potential: basic concept, Poisson's and Laplace's equations, Laplace equation in rectangular, cylindrical and spherical coordinates, the uniqueness theorem and boundary value problems; method of images: induced surface charge, force and energy; separation of variables, Cartesian coordinates, spherical coordinates; multipole expansion: approximate potential at large distances, the monopole and dipole terms; electric dipole and its field and potential	10
II	Magnetostatics: Biot-Savart law, divergence and curl of B, magnetic vector potential, force on a current and on moving charges in a B-field, the magnetic dipole, the energy of a dipole in an external electric and magnetic field, magnetic potential, boundary conditions, multipole expansion. Scalar and vector potentials, Gauge transformations; continuous charge distribution: retarded potential; point charges: Lienard-Wiechert potentials	10
III	Electrodynamics: Maxwell's equations, fixing of Ampere law by Maxwell, Maxwell's equations in matter, conservation of energy, Maxwell's stress tensor and conservation of momentum in electrodynamics, Poynting's theorem. Wave equation, reflection, refraction and propagation of electromagnetic waves in vacuum, dispersive media and conducting medium, concept of waveguide.	10
IV	Macroscopic electrodynamics: macroscopic Maxwell equation, averaged sources applications of macroscopic electrodynamics, Electrostatics in the presence of matter, Magnetostatics in the presence of matter. Relativistic electrodynamics: magnetism as a relativistic phenomenon, transformation of fields, field tensor, electrodynamics in tensor notation, relativistic potential	10
Total		**40**

Texts:

1. *Introduction to Electrodynamics*; Griffiths D.J., PHI, 4th Ed., 2013, New Delhi
2. *Classical Electrodynamics;* Jackson J. D., Wiley, 3rd Ed., 2007 New York

References:

1. Chakraborty B.; *Principles of Electrodynamics*, Books & Allied Ltd, 1st Ed., 2010, Kolkata

SYLLABUS (2^{nd} SEMESTER)

Paper III/Subject Name: Quantum Mechanics -II **Subject Code: PHY014C203**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To know about: Time dependent phenomena: Heisenberg picture; Theory of scattering; Identical Particles: Consequences of indistinguishability of identical quantum particles; Relativistic Quantum Mechanics	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Time dependent phenomena, electric dipole approximation; Rayleigh scattering 2. Theory of scattering, Scattering by a Screened Coulomb potential. 3. Identical Particles, Particle number representation in quantum mechanics 4. Relativistic Quantum Mechanics, existence of spin of the Dirac particle.	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Time dependent phenomena: Heisenberg picture for a time-dependent Hamiltonian; the sudden approximation; Time-dependent perturbation theory; perturbation expansion; first order transition; harmonic perturbation; transition into a continuous spectrum; Fermi golden rule; interaction of matter with electromagnetic radiation; electric dipole approximation; Rayleigh scattering	**10**
II	Theory of scattering: Scattering cross-section in quantum mechanics; scattering amplitude; the inhomogeneous Schrodinger equation for a two-particle scattering; integral equation for the wave function using the technique of Green's function; the integral equation for the scattering amplitude; the successive Born approximations; the scattering amplitude in the first Born approximation for a Central potential; Scattering by a Screened Coulomb potential; the Rutherford Scattering formula; validity of Born approximation; Method of partial waves; asymptotic solution, the scattering amplitude; general expression for scattering cross-section, the S-wave scattering	**10**
III	Identical Particles: Consequences of the indistinguishability of identical quantum particles; the exchange operator; symmetric and antisymmetric wave functions; Pauli exclusion principle; inclusion of spin; Pauli spin matrices; spin functions for a two-electron system; the wave function for the ground state of helium atom. Particle number representation in quantum mechanics; application and creation operators; applications to fermions and bosons.	**10**
IV	Relativistic Quantum Mechanics: Klein-Gordon equation; problems related to its interpretation; Dirac Hamiltonian and equation for a free particle; determination of the Dirac matrices; probability density and probability current density; existence of spin of the Dirac particle; Dirac electron in an electromagnetic field; non-relativistic reduction; spin magnetic moment of the electron; negative energy states and Dirac's hole theory; prediction of positrons.	**10**
	Total	**40**

Text:

1. *Advanced Quantum Mechanics;* Schwabl F.,4^{th} Ed., 2008, Springer
2. *Quantum Mechanics;* Schiff L.I. , Mc Graw-Hill Book, 4^{th} Ed., 2017, Bangalore.

References:

1. Davydov A. S Pergamum, *Quantum Mechanics*, 2^{nd} Ed., 2013, Delhi.
3. A.K. Ghatak and Lokanathan; *Quantum Mechanics*: *Theory & application*, McMillan India Ltd. 5^{th} Ed., 2008, Bangalore
4. V. K. Thankappan, *Quantum Mechanics*, New Academic Science, 4^{th} Ed., 2015, London

SYLLABUS (2nd SEMESTER)

Paper IV/Subject Name: Physics Lab-II		**Subject Code: PHY014C214**
L-T-P-C: 0-0-4-4	**Credit Units: 4**	**Scheme of Evaluation: P**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give the basics of physics and its application.	2. Lecture 3. Assignment 4. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Forbidden Energy Gap 2. Characteristics of LED and PIN Photo Detector 3. Photo-diode and Solar-Cell Characteristics 4. Hall co-efficient, dielectric constant of solids.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Skill Test, lab copy, viva, lab involvement: Any Three: 25, Attendance: 05)

List of experiments:

1. Simple experiments using GM counter
2. Forbidden Energy Gap from P-N junction
3. Forbidden Energy Gap using four probe methods.
4. Study of characteristics of LED and PIN Photo Detector
5. Photo-diode Characteristics
6. Solar-Cell Characteristics.
7. Determination of Hall co-efficient, mobility using Hall Effect Set-up (Digital).
8. Determination of dielectric constant of solids
9. Measurement of numerical aperture and V-parameter using laser kit.
10. Determination of lattice vibrational frequency of monoatomic and diatomic lattice using lattice vibrational kit.

Text:

1. *A text book on practical physics* Mazumdar K.G., Ghosh B, Sreedhar publishers, 16th Ed. 2011, Kolkata

References:

1. B.L. Flint H.T., *Advance Practical Physics for students;* Facsimile Publisher, 2nd Ed. 2019, New Delhi

SYLLABUS (2nd SEMESTER)

Paper V/Subject Name: Optoelectronics and Non-linear optics **Subject Code: PHY014D201**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	**Teaching Learning Process**	**Learning Outcomes**	**Course Evaluation**
1. To know about: Optical sources: Direct and Indirect Band Gap materials, Light source Material Hetero junction structure; Photo Detectors: Principle of operation, Performance parameters, Introduction to Nonlinear response: graphical representation; Wave equations for non-linear medium	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Optical sources, Basic idea of Quantum dot, Quantum wire 2. Photo Detectors, Shot-Noise Signal to noise ratio, NEP (Noise Equivalent Power) 3. Nonlinear response, Models (illustration of non-linearity. 4. Wave equations for non-linear medium, Temporal Soliton, Self-Focusing	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Optical sources: Direct and Indirect Band Gap materials, Light source Material Hetero junction structure. Laser Diode, Modes and Threshold Condition, Temperature Effect, Modal, Partition and Reflection Noise. Basic idea of Quantum dot, Quantum wire Laser .	**11**
II	Photo Detectors: Principle of operation, Performance parameters, Quantum efficiency, Responsibility, Cut off wave length, Photo detector Material. Frequency Response , Thermal Noise, Shot-Noise Signal to noise ratio, NEP (Noise Equivalent Power)	**10**
III	Introduction to Nonlinear response: graphical representation, physical observation of non-linearity. Non-linear susceptibility: Basic relations, Properties, Models (illustration of non-linearity.	**9**
IV	Wave equations for non-linear medium, Coupled Wave Equation, Manley- Rowe relations. Second harmonic generation, phase matching and methods. Sum- and difference frequency generation, parametric amplification and oscillations, Self and Cross Phase Modulation, Temporal Soliton, Self-Focusing.	**11**
Total		**40**

Texts:

1. *Non-Linear Optics*; R.W. Boyd, Elsevier, 3rd Ed., 2011, New Delhi

References:

1. Y.R. Shen, *Principles of Non-linear Optics;* Wiley Classics Library,2nd Ed., 2002, Singapore
2. G.D. Baruah, *Essentials of Non-linear Optics and Lasers*, Pragati Prakashan,14th Ed., 2017 , New Delhi
3. Keiser, G., *Optical Fiber Communications*, McGraw-Hill, 5th Ed., 2013, New Delhi.
4. Kasap, S. O., *Optoelectronics and Photonics Principle and applications*, Pearson education, 2nd Ed. 2013, New Delhi

SYLLABUS (2nd SEMESTER)

Paper VI/Subject Name: Plasma and Space Physics		**Subject Code: PHY014D202**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To know about: Plasma Physics; Elementary concepts; Plasma as fluids: Relation of plasma physics to ordinary electromagnetics; Space Physics; Introduction: early studies on geomagnetic field; Ionosphere: Ion production and loss, determination of ionospheric density	2. Lecture 3. Assignment 4. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Plasma Physics , Plasma confinement, adiabatic invariants 2. Plasma as fluids, MHD waves: magneto-sonic and Alfven waves 3. Space Physics, Sunspots, Solar Wind 4. Ionosphere, magnetic field configuration of the Earth's magnetosphere.	A. Semester end examination: 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance: 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Plasma Physics; Elementary concepts: plasma oscillations, Debye shielding, plasma parameters, criteria for plasmas, Plasma confinement: single particle motion ($\nabla B \perp B$: Grad- B drift, curvature drift, $\nabla B \parallel B$: magnetic mirrors, non-uniform E Field, time-varying E Field, time-varying B Field, adiabatic invariants: first, second and third adiabatic invariant (Pinch effect, magnetic mirrors); Some applications of plasma	**10**
II	Plasma as fluids: Relation of plasma physics to ordinary electromagnetics: Maxwell's equations, dielectric constant of a plasma; fluid equation of motion, convective derivative, stress tensor, collisions, comparison with ordinary hydrodynamics, equation of continuity, equation of state; plasma approximation. MHD waves: magneto-sonic and Alfven waves, propagation at arbitrary directions: pure Alfven wave, fast and slow MHD waves, phase velocities, wave normal surfaces.	**10**
III	Space Physics; Introduction: early studies on geomagnetic field, ionosphere and magnetosphere, magnetospheric exploration, planetary and interplanetary exploration. Solar phenomena: structure of the Sun, Solar activity, prominences, coronal heating, Solar flares, Sunspots. Solar Wind: Properties, solar wind formations, interaction of Solar wind with magnetized and unmagnetized planets.	**10**
IV	Ionosphere: Ion production and loss, determination of ionospheric density. Magnetosphere: magnetopause, magnetotail, magnetic reconnection, plasma flow in the magnetosphere, magnetic field configuration of the Earth's magnetosphere, plasma in the Earth's middle and inner magnetosphere, Ionosphere-Magnetosphere coupling	**10**
	Total	**40**

Texts:

1. *Plasma Physics and Controlled Fusion*; Chen F.F., Springer International, 3rd Ed., 2016, Switzerland
2. *Fundamentals of Plasma Physics;* Bittencourt J.A. 3rd Ed., 2004, *Springer* (India)
3. *Introduction to Space Physics*; Russell C. T., Cambridge University Press ; 1st Ed., 1995, Cambridge

References:

1. Gurnett D. A. and Bhattacharjee A.; *Introduction to Plasma Physics with space and laboratory applications*, Cambridge University Press, 1st Ed., 2005, Cambridge.
2. Robert J. G. and Rutherford P. H.; *Introduction to Plasma Physics*, IOP Publishing Ltd, 1st Ed. (Reprint) 1995, Philadelphia

3rd Semester Syllabus

SYLLABUS (3rd SEMESTER)

Paper I/Subject Name: Atomic and Molecular Physics | **Subject Code: PHY014C301**

L-T-P-C: 4-0-0-4 | **Credit Units: 4** | **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To familiarize about the modern developments in experimental techniques especially spectroscopy and to realize the role and practical application of physics of atoms and molecules in the modern world	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Quantum states of Electron in atoms, Two electron systems, LS–JJ coupling Schemes 2. Hyperfine structure and isotopic shift, Zeeman and Paschen Back, Selection Rules , Stark effect 3. Classical and Quantum mechanical description, Nuclear interaction and Hyperfine Structure, 4. Born-Oppenheimer approximation, idea of symmetry for diatomic and polyatomic molecules.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I.	Quantum states of Electron in atoms, Hydrogen atom spectrum, relativistic correction for energy levels of hydrogen atoms, Electron Spin, Stern Gerlach Experiment, Spin Orbit interaction, Two electron systems, LS–JJ coupling Schemes ,Fine structure ,Spectroscopic terms and selection rules.	10
II.	Hyperfine structure and isotopic shift, width of spectral lines, spectrum of helium and alkali atoms, Zeeman and Paschen Back Effect of one and two electron systems, Lande's g factor, Selection Rules ,Stark effect, Inner Shell vacancy.	10
III.	Classical and Quantum mechanical description, Spin-spin and Spin-lattice relaxation times, Chemical shift. ESR, Basic principles, Nuclear interaction and Hyperfine Structure, Zero fields splitting.	10
IV.	Born-Oppenheimer approximation, rotation, vibration and electronic structure of diatomic molecules, the Franck-Condon principle, electron spin and Hund's cases, idea of symmetry for diatomic and polyatomic molecules	10
Total		**40**

Texts:

1. *Physics of Atoms and Molecules*, B.H. Bransden and C. J. Jochain, Pearson Education, 2nd Ed., 2003, Noida
2. *Fundamentals of Molecular Spectroscopy*, C.N. Banwell , McGraw-Hill, 4th Ed., 2004, New York

References:

1. H. E. White, *Introduction to Atomic Spectra*, , McGraw-Hill Book Company, 1st Ed., 1934, New Delhi
2. G. Herzberg, *Molecular Spectra and Molecular Structure*,2nd Ed.,2008, Vancouver
3. W. Demtroder, *Laser Spectroscopy*, Springer, 3rd Ed., 2003, New Delhi
4. Hollas, *Modern Spectroscopy*; Wiley India Pvt. Ltd, 4th Ed.,2010, Noida

SYLLABUS (3rd SEMESTER)

Paper II/Subject Name: Statistical Mechanics **Subject Code: PHY014C302**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To make the learners understand how Thermodynamics deals with the relationship between heat and other form of energy & how Statistical Physics explains the behavior of ideal gas.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Scope and aim of statistical mechanics, The canonical ensemble and its thermodynamics, partition function 2. Ideal Bose System, Thermodynamic behaviour of an ideal Fermi Gas. 3. Phase Transitions: Phenomenology, Brownian motion 4. Strongly interacting systems: Ising model, Bragg-William's approximation.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Scope and aim of statistical mechanics. Transition from thermodynamics to statistical mechanics, Ensemble Theory, Phase space and Liouville theorem, the micro canonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations. The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations.	10
II	Ideal Bose System: Thermodynamic behaviour of ideal Bose gas, Bose-Einstein condensation (Experimental evidences), Liquid Helium: two fluid hydrodynamics, Second sound. Ideal Fermi System, Black body radiation, Stefan Boltzmann law. Wien's displacement law, Thermodynamic behaviour of an ideal Fermi Gas, Degenerate Fermi Gas.	10
III	Phase Transitions: Phenomenology: First and Second order phase transitions, elementary idea of critical phenomena, Universality of critical exponents. Fluctuations. Thermodynamic fluctuations. Spatial correlations in a fluid. Brownian motion: Einstein-Smoluchowski's theory.	10
IV	Strongly interacting systems: Ising model. Idea of exchange interaction and Heisenberg Hamiltonian. Ising Hamiltonian as a truncated Heisenberg Hamiltonian. Exact solution of one-dimensional Ising system (Matrix methods). Bragg-William's approximation (Mean field theory) and the Bethe-Peierls approximation.	10
Total		**40**

Texts:

1. *Fundamentals of Statistical and Thermal Physics*; F. Reif, Sarat Book House Pvt. Ltd, 1st Ed., 2009, Kolkata

References:

1. Lokanathan S. and Gambhi R.S.; *Statistical and Thermal Physics- An introduction,* P.H.I., 1st Ed., 2008, New Delhi
2. R. K. Patharia; *Statistical Mechanics,* Academic Press, 3rd Ed., 2011, Cambridge
3. Gupta and Kumar; *Statistical Mechanics;* Pragati Prakashan, 24th Ed., 2015, Meerut

SYLLABUS (3rd SEMESTER)

Paper III/Subject Name: Physics Lab-III		**Subject Code: PHY014C313**
L-T-P-C: 0-0-4-4	**Credit Units: 4**	**Scheme of Evaluation: P**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give the basics of physics and its application.	1. Demonstration 2. Experimentation 3. Correction	On completion of this course students will be able to gain interest on the following: 1. characteristics of a GM tube, Holography 2. of harmonic generation, laser Raman spectra, BH curve 3. characteristics of JFET (Junction field effect transistor), 4. Trans conductance, using a CRO.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Skill Test, lab copy, viva, lab involvement: Any Three: 25, Attendance: 05)

List of experiments:

1. Study of the characteristics of a GM tube
2. To study double slit interference by Helium neon laser
3. Experiments on Holography: recording and reconstruction.
4. Study of harmonic generation, laser Raman spectra.
5. To study absorption spectra of Iodine molecule and to determine its dissociation energy using spectrometer.
6. To determine the angular diameter of the sun with the help of a Sextant.
7. To draw the BH curve of iron by using a Solenoid and to determine the energy loss due to Hysteresis.
8. To determine the mass susceptibility of $NiSO_4$ solution
9. To Study of the characteristics of JFET (Junction field effect transistor) in common source configuration and evaluation of: 1. AC drain resistance 2. Trans conductance 3. Amplification factor 4. Drain Resistance.
10. To measure (a) Voltage, (b) Frequency and (c) Phase Difference using a CRO.

Texts:

1. *A Text Book on Practical Physics;* K.G. Mazumdar and B. Ghosh, Sreedhar Publishers,5th Ed., 2014, Kolkata
2. *Basic Electronics: A text-lab manual;* P. B. Zbar and A. P. Malvino;, Tata McGraw Hill, 7th Ed., 1994, New York
3. *Advanced practical physics for student* ; Wersnop and Flint, Methuen 9th Ed., 1969, London
4. *Optical Physics;* A. Lipson, S G Lipson, H Lipson;, Cambridge University Press; 4th Ed., 2010, New York

SYLLABUS (3rd SEMESTER)

Paper IV/Subject Name: Non-Linear Optics and Laser Spectroscopy- I **Subject Code: PHY014D301**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To develop knowledge in the basics of nonlinearity in optical phenomenon and enhance comprehension in the knowledge of lasers spectroscopy 2. To understand higher order phenomenon's.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Nonlinear response, An harmonic Oscillator and free electron gas 2. Phase matching, sum frequency generation, 3. Rabi solution of Schrödinger equations, Quantum theory of non-linear susceptibility, 4. Self-focussing of light, Optical bistability and optical switching	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Nonlinear response: graphical representation, physical observation of non- linearity. Non-linear susceptibility: Basic relations, Properties, Models (illustration of non-linearity) : An harmonic Oscillator and free electron gas. Quantum theory of Non-linear Susceptibility.	10
II	Phase matching, quasi phase matching, sum frequency generation, optical parametric oscillator, sum-frequency generations, nonlinear optical interactions with focussed Gaussian beams.	10
III	Quantum theory of non-linear susceptibility : Schrödinger wave equations; perturbation theory. Calculation of probability amplitude. Derivation of first, second and third order susceptibilities. Two level approximation - density matrix equations, optical Bloch equations, Rabi solution of Schrödinger equations - atom initially in ground state.	10
IV	Self-focussing of light, self-trapping of light, laser beam breakup into many filaments, optical phase conjugation, polarization properties of phase conjugation. Optical bistability and optical switching.	10
Total		**40**

Text:

1. *Non-Linear Optics*; .R.W. Boyd; Elsevier, 3rd Ed., 2008, New Delhi
2. *Laser and nonlinear optics*, B.B.Laud, New Age International (P) limited, 3rd Ed., 2010, New Delhi
3. *The principles of nonlinear optics*, Y.R Shen, Wiley-Interscience, 1st Ed., 2002, New Jersey
4. *Physics of Atoms and Molecules*, B.H. Bransden and C. J. Jochain, Pearson Education, 2nd Ed., 2003, Noida

References:

1. Arthur Beiser,*Concepts of Modern Physics*, Tata McGraw-Hill, , 6th Ed., 2003, New Delhi
2. G.D. Baruah, *Essentials of Non-linear Optics and Lasers*, Pragati Prakashan, 4th Ed., 2016, Meerut
3. M. C Gupta, *Atomic and molecular spectroscopy*, New Age International (P) limited, 2nd Ed., 2005, New Delhi
4. N. Bloembergen, *Non-linear Optics*, World Scientific, 4th Ed., 2002, Singapore

SYLLABUS (3rd SEMESTER)

Paper V/Subject Name: Physics of Nanomaterials-I **Subject Code: PHY014D302**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To let the students have a fundamental understanding of physical properties and study on basic relationships between physical properties and phenomena and material dimensions in the nanometer scale.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Nanoscale and its significance, Challenges in nanotechnology. 2. Properties of nanoparticles, Semiconducting nanoparticles 3. Molecular beam epitaxy, Lithography 4. Special Nanomaterials, Fullerenes and Nanotubes	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction: Nanoscale and its significance, surface to volume ratio, exciton, Emergence of Nano science and Nanotechnology, Challenges in nanotechnology.	**10**
II	Properties of nanoparticles: Introduction, Structural properties, optical properties - Blue shift, Emission Stokes shift, electrical properties, mechanical properties and magnetic properties, Metal nanoclusters- geometric structure, electronic structure, reactivity, Semiconducting nanoparticles.	**10**
III	Nanostructure growth and Synthesis Techniques: Homogeneous and heterogeneous nucleation, Growth of nanocrystals in solution, Top down and bottom up approaches-Chemical route, Chemical vapor deposition, Physical vapour deposition, Magnetron sputtering, Molecular beam epitaxy, Lithography.	**10**
IV	Some Special Nanomaterials: Introduction, Carbon nanostructures- Carbon Fullerenes and Nanotubes- structure, application of Nanotubes, Core-Shell Structures- Metal- oxide structures.	**10**
Total		**40**

Texts:

1. *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*; G. Cao, Y. Wang, World Scientific, 2nd Ed.,2011, Singapore
2. *Introduction to Nanotechnology;* C. P. Poole, J. F. J. Owens, Wiley India ,1st Ed.,2003, New Delhi

Reference:

1. T. Pradeep; *A Textbook of Nanoscience and Nanotechnology*, Tata McGraw Hill, 1st Ed., 2012, New Delhi

SYLLABUS (3^{rd} SEMESTER)

Paper VI/Subject Name: Advanced Quantum Mechanics -I | **Subject Code: PHY014D303**

L-T-P-C: 4-0-0-4 | **Credit Units: 4** | **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To prepare students for higher studies which require knowledge of relativistic quantum mechanics.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Lorentz transformations and the Dirac equation, Four dimensional probability current density, 2. Foldy-Wouthuysen transformation and relativistic corrections, Lamb shift 3. Solutions to the Dirac equation, application of the Dirac equation to the Hydrogen atom, 4. properties of the Dirac equation, time reversal in classical physics and in quantum mechanics	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Lorentz transformations and the Dirac equation: Four dimensional covariant form of Dirac equation; Expressions and properties of the Gamma matrices; Lorentz transformations; Lorentz covariance of the Dirac equation; Determination of the Lorentz transformation matrix; Bilinear form and their transformation properties; The Dirac ad-joint equation; Four dimensional probability current density.	**10**
II	Foldy-Wouthuysen transformation and relativistic corrections: Foldy- Wouthuysen transformation; statement and description of the problem; transformation for free particles; interaction with the electromagnetic filed; relativistic corrections and the Lamb shift; estimation of the Lamb shift; the Darwin term.	**10**
III	Solutions to the Dirac equation: Free particle solutions; interpretation of the four components spinors; orthogonality relations; wave packets and “Zitterbewegung” ; application of the Dirac equation to the Hydrogen atom; energy levels; the fine structure of the spectral lines; physical interpretations.	**10**
IV	Symmetries and properties of the Dirac equation: Invariance and conservation laws; the general transformation; rotations; translations; parity transformations (spatial reflections); charge conjugation; time reversal (motion reversal); time reversal in classical physics and in quantum mechanics; time reversal invariance of the Dirac equation	**10**
Total		**40**

Texts:

1. *Advanced Quantum Mechanics;* F. Schwabl, Springer, 4^{th} Ed., 2008, Berlin
2. *Quantum Mechanics;*A. S. Davydov,Pergamon,2n Ed, 1991, London
3. *Quantum Mechanics;*S.N. Biswas, Books and Allied Ltd., 2nd Ed.,2012, Kolkata
4. *Quantum Mechanics;* E. Merzbacher, Wiley,3rd Ed., 2011, New York

References:

1. J. J. Sakurai;*Advanced Quantum Mechanics*, Pearson, 5th Ed., 2009, New Delhi
2. J. D. Bjorken and S.D. Drell, *Relativistic Quantum Mechanics*, Tata Mc Graw Hill education,1st Ed.,2013, New York

SYLLABUS (3rd SEMESTER)

Paper VII/Subject Name: Astrophysics-I **Subject Code: PHY014D304**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To make the study of astronomy and astrophysics interesting and fascinating for the students.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. The celestial sphere, Constructing the HR diagram of stars and star clusters 2. Telescopes and Instrumentations, Different types of astronomical telescopes and their mounts. 3. Radiation theory, Saha's ionization equation, 4. Integral theorems of hydrostatic equilibrium of stars, Supernovae.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	The celestial sphere, coordinate systems and transformation equations. Concept of time — solar time and sidereal time. Magnitude scales, colour index, apparent, absolute, and instrumental magnitudes. Measuring stellar distance method parallax and other methods to determine stellar distances. Constructing the HR diagram of stars and star clusters and its importance in evolution of stars. Different types of astronomical telescopes and their mounts.	9
II	Telescopes and Instrumentations: Different optical configuration for astronomical telescope plate scale and diffraction limits-telescope for Γ-ray, X-ray UV, IR, mm and radio astronomy- photometry with photometers and CCD- spectrometry and polarimetry with various instruments. telescopes for □	11
III	Radiation theory. Equation of radiative transfer — concepts of flux, intensity, and temperature. Formation of emission and absorption lines, limb darkening. Ionisation and the concept of mean molecular weight. Saha's ionisation equation. Stellar opacity — radiative transfer of energy as convection, Rosseland mean opacity. Fully convective stars and pre main sequence stars	10
IV	Integral theorems of hydrostatic equilibrium of stars. Polytropic gas sphere, Lane Emden equation and its solutions,Virial theorem and stability of polytropes, mass- radius relations of polytrope, Eddington's quartic equation. Spectral classification and HR diagram, thermonuclear reactions and rates. Nucleosynthesis – hydrogen burning (pp chain and CNO cycle), triple alpha reaction. Advanced stages of nuclear burning. Supernovae and their types.	10
Total		**40**

Texts:

1. *Astrophysics: A Modern Prospective;* K.S Krishnaswamy, New Age International Publication, 2nd Ed., 2006 , New Delhi
2. *An Introduction to Astrophysics;* Baidyanath Basu, Prentice Hall Publication, 2nd Ed.,2013, New Delhi

References:

1. V.B.Bhatia; *Text Book on Astronomy and Astrophysics with elements of cosmology,* Narosa Publishing House, 2nd Ed., 2001, New Delhi
2. K. D. Abhayankar; *Astrophysics: Stars and Galaxies,* Abe Books,1st Ed., 2002, Hyderabad

SYLLABUS (3rd SEMESTER)

Paper VIII/Subject Name: Physics of Semi-conductor-I **Subject Code: PHY014D305**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To familiarize the student with different structural & working phenomena and properties of semiconductor.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Band structure of semiconductors, general band structure. 2. Fermi distribution, high frequency transport, continuity equation. 3. Recombination in semiconductor, Hall kinetics. 4. Optical properties of semiconductor, phonon broadening	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Band structure of semiconductors: Electrons in a periodic potential: Bloch's theorem, free electron dispersion, Kronig & Penney model; band structure of selected semiconductors: silicon, germanium, GaAs and perovskites; amorphous semiconductors; temperature dependence of semiconductor's band gap; electron dispersion: equation of motion, effective mass of electron; density of states: general band structure.	**10**
II	Electronic defect states in semiconductor: Fermi distribution; carrier concentration; intrinsic conduction; shallow defects: donors, acceptors, compensation, multiple impurities, amphoteric impurities, high doping ; quasi-fermi levels. Transport of charge carrier in semi-conductor: Conductivity; low field transport: mobility, microscopic scattering processes, temperature dependence, doping dependence; hall effect; high field transport: drift saturation velocity, negative differential resistivity, high frequency transport, continuity equation.	**12**
III	Recombination in semiconductor: Band to band recombination: spontaneous emission, absorption, stimulated emission, net recombination rate; exciton recombination: free excitons, bound excitons ; phonon replica; self-absorption; donor–acceptor pair transitions; inner-impurity recombination; auger recombination; band impurity recombination: Shockley Read Hall kinetics	**10**
IV	Optical properties of semiconductor: Reflection and diffraction; absorption; electron– photon interaction; band to band transitions: direct transitions, indirect transitions; amorphous semiconductors, excitons, exciton polariton, phonon broadening.	**8**
Total		**40**

Texts:

1. *The Physics of Semiconductors: An Introduction Including Nanophysics and Applications*; M. Grundmann Springer-Verlag, 2nd Ed., 2010, Berlin.
2. *Physics of Semiconductors Devices;* S. M. Sze Jhon Wiley & Sons, 3rdEd. 2013, Singapore.
3. *Physics of semiconductors;* A. F. Loffe, Springer, 1st Ed., Reprint 2012 , New Delhi

References:

1. Sapoval B. & Hermann C., Physics *of Semiconductors*, Springer-Verlag; 1st Ed., Reprint 2003, New York.
2. Donald A N., *Semiconductor Physics and Devices: Basic Principle;* McGraw-Hill, 3rd Ed., 2007, New Delhi
3. Colinge J.P. & Colinge C.A., *Physics of Semiconductor Devices;*, Springer,1st Ed., 2005, New York
4. Solanki C. S, *Solar Photovoltaics - Fundamentals, Technologies and Applications;* Prentice-Hall of India, 3rd Ed., 2015, New Delhi.

SYLLABUS (3rd SEMESTER)

Paper IX/Subject Name: Condensed Matter Physics-I		**Subject Code: PHY014D306**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give foundation for further higher studies in Condensed matter physics	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Lattice dynamics, general theory of harmonic approximation 2. Thermal properties of solids , phonon-phonon collisions, 3. Band theory of solids, energy bands in a general periodic potential 4. Heisenberg Hamiltonian and model of ferromagnetism, The Bloch Wall.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Lattice dynamics: The harmonic approximation; normal modes of a one dimensional mono-atomic lattice; Born-von Karman periodic boundary condition; the dispersion curve; normal modes of a one dimensional diatomic lattice; the salient features of dispersion curves; optical and acoustical modes; general theory of harmonic approximation; normal modes of a real crystal; quantization of lattice vibration; Phonons	10
II	Thermal properties of solids: Classical lattice heat capacity; quantum theory of lattice capacity; average energy of a quantum harmonic oscillator; the Einstein model; phonon density of sates; the Debye model; an-harmonic effects; thermal expansion; phonon-phonon collisions; normal and Umklapp processes	10
III	Band theory of solids: Consequences of lattice periodicity; Statement and proof of the Bloch theorem; periodicity of Bloch functions and the eigen values; nearly free electron model and band structure; energy bands in a general periodic potential; solution a the zone boundary; the tight-binding approximation; the Wigner-Seitz cellular method; ideas of OPW, APW and pseudopotential methods.	10
IV	Ferro-, anti-ferro and Ferri-magnetism: The exchange interaction and its origin; the Heisenberg Hamiltonian and model of ferromagnetism; anisotropic energy, The Bloch Wall; Origin of magnetic domains; Niel model of anti-ferromagnetism; Spin Waves, one-dimensional ferromagnet and magnons; magnon dispersion relations; Bloch $T^{3/2}$ law.	10
Total		**40**

Texts:

1. *An introduction to lattice dynamics;* A.K Ghatak and L.S. Kothari, Addison -Wesley, Ed. 1972,London
2. *Principles of the theory of lattice dynamics*. H Bottger, Physic, Verlog,1st Ed., 1983,Germany
3. *Solid State Physics:* N.W Ashcroft and N.D. Mermin, Cengage Learning, 1st Ed., 2017,New Delhi
4. *Introduction to Solid State Physics;* C. Kittle, John Wiley & Sons ,8th Ed. 2015, New Delhi

References

1. J.P Srivastva, *Elements of Solid State Physics;* Prentice-Hall of India,4th Ed.,2006, New Delhi
2. J.M Ziman, *Principles of the theory of Solids;* Cambridge University Press ,2nd Ed., 2013, Kolkata

SYLLABUS (3rd SEMESTER)

Paper X/Subject Name: High Energy Physics-I **Subject Code: PHY014D307**

L-T-P-C: 4-0-0-4 **Credit Units: 4** **Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give a thorough understanding of the elementary particles	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Introduction to elementary particles, electron- positron scattering, Compton scattering. 2. conservation laws, Translation and rotation operators 3. baryon and lepton conservation 4. Introduction to symmetries, gluonium and quark-gluon plasma.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Introduction to elementary particles: Introduction to elementary particles, spin and parity determination of pion and strange particles, eight fold ways classification (Gellmannan and Nishijima classification). Interactions and fields: Yukawa theory of quantum exchange, boson propagator, Feynman diagrams, renormalisation and gauge invariance, strong, weak and electroweak interactions, gravitational interactions, interaction cross-section, decays and resonances, electron-positron annihilation, electron-positron scattering, Compton scattering.	10
II	Invariance principles and conservation laws: Translation and rotation operators, concepts of spin, parity, isospin in particle physics, g-parity, time reversal, CP- violation and CPT theorems, vector bosons, fermion sector, helicity states, tests of parity conservation, charge conjugation invariance, charge conservation and gauge invariance, baryon and lepton conservation, CPT invariance, Noether's theorem, conservation of energy, momentum and charge of the field.	10
III	Quarks model: Properties and types of quarks, introduction to constituent quark model, bound states of quarks, quark spin and colour, quark-antiquark combinations, light vector mesons, isospin symmetry, mesons built of light and heavy quarks.	10
IV	Introduction to symmetries: Discrete and continuous symmetries, young's tables, elementary idea of lie groups, symmetry groups O(3), SU(2), SU(3) and SU(6). Quark interactions and QED, QCD: Colour quantum number, QCD potential at short distances, QCD potential at large distances, string model, gluon jets in e+e- annihilation, running couplings in QED and QCD, evolution of structure functions in deep inelastic scattering, gluonium and quark-gluon plasma.	10
Total		**40**

Texts:

1. *Introduction to High Energy Physics*, Perkins D.H.; Cambridge University Press, 4th Ed., 2014, Cambridge.
2. *Introduction to Elementary Particles*, Griffiths D.; Wiley-VCH, 2nd Ed., 2014, Weinheim, Germany
3. *Introduction to Particle Physics,* Khanna M.P.; Prentice-Hall of India, 3rd Ed., 2004, New Delhi

References:

1. Bettini A., *Introduction to Elementary Particle Physics*; Cambridge University Press, 2nd Ed., 2014, Cambridge.
2. Cottingham W.N., Greenwood D. A., *An Introduction to the Standard Model of Particle Physics*; Cambridge University Press, 2nd Ed., 2007, Cambridge.
3. Hughes I.S., *Elementary Particles;* Cambridge University Press, 3rd Ed., 1996, Cambridge.
4. Quigg C., *Gauge Theories of Weak, Strong and Electromagnetic Interactions;* Gorden& Breach, 2nd Ed., 2013, New York.

SYLLABUS (3rd SEMESTER)

Paper XI/Subject Name: Seminar/Literature survey		**Subject Code: PHY014D331**
L-T-P-C: 4-0-0-4	**Credit Units:4**	**Scheme of Evaluation:**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To improve the presentation skill and subject knowledge of the students	1. One to one guidance and supervision 2. Individual and Group Presentation	On completion of this course, students are expected to acquire confidence to present their research work in the future.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Class test, viva, Mid-term exam:25, Attendance : 05)

Seminar / Literature survey

4th Semester Syllabus

SYLLABUS (4th SEMESTER)

Paper I/Subject Name: Laser and Raman Spectroscopy		**Subject Code: PHY014C401**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To develop knowledge in the basics of lasers and enhance comprehension in the principles of lasers and to explore the control of laser properties and study Raman spectroscopy phenomenon's.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Interaction of radiation with matter, two and three level laser systems. 2. Solid state lasers, Gas lasers, Liquid and dye lasers 3. modes of resonators , mode locking 4. Raman spectroscopy, Rotational and vibrational Raman Spectra	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Interaction of radiation with matter: Interaction of light with atoms and molecules, absorption, emission, stimulated and spontaneous emission,. Principle of lasers, population inversion, conditions of lasing action, characteristics of a laser- coherence, monochromaticity, divergence, intensity, Einstein's co-efficient, laser pumping, two and three level laser systems.	10
II	Solid state lasers: the ruby laser, Nd: YAG Laser, Semiconductor lasers, features of semiconductor lasers, diode lasers, Gas laser: He-Ne laser, CO_2 laser, liquid lasers: dye lasers and chemical lasers.	10
III	Laser pumping, resonators, vibrational modes of resonators, number of modes/unit- volume, open resonators, confocal resonators, Q factor, losses in the cavity, threshold condition, quantum yield, mode locking (active and passive).	10
IV	Raman spectroscopy: Raman effect, Quantum theory of Raman effect, Rotational Raman Spectra Vibrational Raman Spectra, Raman spectra of polyatomic molecules, Raman Spectrometer, experimental techniques.	10
Total		**40**

Texts:

1. *Principles of Lasers,* O. Svelto., Polytechnic Institute of Milan and National Research Council. Milan, , 5th Ed., 2014, Italy
2. *Physics of Atoms and Molecules*, B.H. Bransden and C. J. Jochain, Pearson Education, 2nd Ed., 2009, New Delhi.
3. *Laser and nonlinear optics*, B.B. Laud**,** New Age International (P) limited, 3rd Ed., 2010, New Delhi

References:

1. Arthur Beiser, *Concepts of Modern Physics*, 6th Ed., Tata McGraw-Hill, 2003, New Delhi.
2. M. C Gupta, *Atomic and molecular spectroscopy,* New Age International (P) limited,2nd Ed., 2005, New Delhi
3. B.P. Straughan and S. Walker, *Spectroscopy Volume I*, John Wiley & Sons, Inc., 2nd Ed., 1976, New York.
4. K. Thyagarajan and A. K. Ghatak, *Lasers: Theory and Application*, Plenum Press, 2nd Ed., 2010, London

SYLLABUS (4th SEMESTER)

Paper II/Subject Name: Semiconductor Devices		**Subject Code: PHY014C402**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. The objective of the course is to familiarize the students with basic semiconductor devices and related theorems and to make the student understand the working and application of different digital devices.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Semiconductor devices, Homo and Heterojunction devices 2. De Morgan's laws, Multiplexer, Demultiplexer. 3. Operational amplifier, Oscillators 4. Amplitude and Frequency modulation, Microprocessors and Microcontrollers.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Semiconductor devices: p-n junction diodes, metal-semiconductor junction diodes, BJT/JFET devices and their characteristics, Homo and Heterojunction devices. Transducers(temperature, pressure/vacuum, magnetic fields vibration, optical and particle detector), photo-detector, LED and Solar cell	10
II	Number systems, Boolean Algebra: De Morgan's laws, Karnaugh map, Basic logic gates, universal gates, Logic families, Arithmetic circuits, Flip-Flops, Registers, Counters, comparators, A/D and D/A converters, Multiplexer, Demultiplexer.	10
III	Operational amplifier, Op-amp as adder, subtractor, differentiators, integrators, logarithmic amplifier, Applications of op-amp, Solution of differential equations, Filters and noise reduction, Impedance matching, amplification, Differential amplifier, Feedback theory, Oscillators.	10
IV	Amplitude and Frequency modulation, Demodulation techniques, Bandwidth requirements, Pulse communication, Measurement and control, Signal conditioning and recovery. Basic concepts of Integrated Circuits, Basics of Microprocessors and Microcontrollers.	10
Total		**40**

Text:

1. *Semiconductor Devices: Physics and Technology*; S. M. Sze and M. K. Lee, John Wiley, 3rd Ed., 2012, New York.
2. *Digital Principles and Applications*; D. P. Leach, A. P. Malvino and G. Saha, Tata McGraw Hill Education, 7th Ed., 2011, New Delhi.

References:

1. Ryder J. D.; *Electronic Fundamentals & Applications: Integrated & Discrete Systems*, Prentice Hall, 5th Ed., 2007, New Delhi.
2. Boylestad R.L. &Nashelsky L.; *Electronic Device and Circuit Theory*, Pearson India, 7th Ed., 2009, New Delhi.
3. Talukdar P. H.; *Digital Logic and System Design*, Mani Manik Prakash, 1st Ed., 2016, Guwahati.
4. Chattopadhyay D.; Electronics*: Fundamentals & Applications*; New Age International, 1st Ed., 2010, New Delhi.

SYLLABUS (4th SEMESTER)

Paper III/Subject Name: Non-Linear Optics and Laser Spectroscopy-II		**Subject Code: PHY014D401**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To develop knowledge in the basics of nonlinearity in optical phenomenon and enhance comprehension in the knowledge of lasers spectroscopy. 2. To understand higher order phenomena.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Stimulated Brillouin Scattering, Raman Spectroscopy. SRS and CARS 2. Nonlinear absorption, Two photon Doppler free absorption spectroscopy 3. Rate equations and lasing criteria, single and multimode oscillation 5. Ultrashort pulse propagation, optical levitation, optical cooling and ion trapping	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Stimulated scattering processes: Spontaneous and stimulated scattering, Stimulated Brillouin Scattering, Stimulated Raman scattering, Quantum theory, coupled wave description of SRS. Stokes-anti stokes coupling, Inverse Raman effect. Four wave mixing and Coherent Anti-stokes Raman scattering (CARS). Basic principle of non-linear Raman Spectroscopy. SRS and CARS as techniques of non- linear Raman Spectroscopy.	10
II	Nonlinear absorption, saturation of inhomogeneous line profiles, saturation spectroscopy - lamb dip, hole burning, quantum beats. Two photon and multi photon absorption – theory; multiphoton ionization, optical damage. Two photon Doppler free absorption spectroscopy.	10
III	Rate equations and lasing criteria, laser gain, line width, threshold for lasing, calculation of threshold gain, Resonating cavity, gain and loss in cavity, longitudinal modes, Characterization of resonator, properties of Gaussian beam, single and multimode oscillation, resonator stability, common cavity configuration	10
IV	Ultrashort pulse propagation equations, interpretations, intense field non-linear optics-generation of 3rd and high harmonics. Motion of free electron in a laser field, Laser radiation force, applications – optical levitation, scattering of atomic beams, optical cooling and ion trapping.	10
Total		**40**

Texts:

1. *Non-Linear Optics*; **.**R.W. Boyd; Elsevier, 3rd Ed., 2008, New Delhi
2. *Laser and nonlinear optics*, B.B.Laud**,** New Age International (P) limited, 3rd Ed., 2010, New Delhi
3. *The principles of nonlinear optics*, Y.R Shen, Wiley-Interscience, 1st Ed., 2002, New Jersey
4. *Physics of Atoms and Molecules*, B.H. Bransden and C. J. Jochain, Pearson Education, 2nd Ed., 2003, Noida

References:

1. Arthur Beiser,*Concepts of Modern Physics*, Tata McGraw-Hill, , 6th Ed., 2003, New Delhi
2. G.D. Baruah, *Essentials of Non-linear Optics and Lasers*, Pragati Prakashan, 4th Ed., 2016, Meerut
3. M. C Gupta, *Atomic and molecular spectroscopy*, New Age International (P) limited, 2nd Ed., 2005, New Delhi
4. N. Bloembergen, *Non-linear Optics*, World Scientific, 4th Ed., 2002, Singapore

SYLLABUS (4th SEMESTER)

Paper IV/Subject Name: Physics of Nanomaterials-II		**Subject Code: PHY014D402**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To make the students understand the basic concepts of nanomaterials and enable them to explore the field of nanomaterials	2. Lecture 3. Assignment 4. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Quantum Confinement, Introduction of Quantum wells 2. Characterization of Nanomaterials 3. Electron transport in semiconductors and nanostructures 4. Applications of nanomaterials	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Quantum Confinement: Introduction of Quantum wells, wires and dots, size and dimensionality effects, Bohr excitons, Confinement-strong confinements and weak confinements.	**8**
II	Characterization of Nanomaterials: Introduction, Structural Characterization - X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM), Chemical Characterization- Optical spectroscopy- Absorption and transmission spectroscopy, Photoluminescence (PL), Electron spectroscopy.	**12**
III	Electron transport in semiconductors and nanostructures: Time and length scales of the electrons in solids- Electron fundamental lengths in solids, Size of a device and electron spectrum quantization, Electron transport in nanostructures.	**10**
IV	Applications of nanomaterials: Light emitting and detecting device, photo voltaic cell, gas sensor, Nanoparticle-based drug delivery system, Spintronic devices and spin field effect transistors (SPINFET).	**10**
Total		**40**

Texts:

1. *Nanostructures and Nanomaterials: Synthesis, Properties, and Applications*; G. Cao, Y. Wang, World Scientific, 2nd Ed.,2011, Singapore
2. *Introduction to Nanotechnology;* C. P. Poole, J. F. J. Owens, Wiley India ,1st Ed.,2003, New Delhi

References:

1. Edelstein A.S., and Cammarata, R.C., *Nanomaterials: Synthesis, Properties and Applications,* Institute of Physics, 1st Ed., 2001, Bristol
2. L. H. Gaber, F. Harry Tibbals, J. Dutta, J.J. Moore, *Introduction to Nanoscience and Nanotechnology,* CRC Press, 1st Ed., 2009, London

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SYLLABUS (4th

Paper V/Subject Name: Advanced Quantum Mechanics -II		**Subject Code: PHY014D403**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To prepare a student for highly sophisticated studies in theoretical Physics	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Identical particles, many particle states, Ground state energy and elementary theory of the electron gas 2. Field Quantization , angular momentum and charge 3. Quantization of non-relativistic and relativistic fields, Klein-Gordon field 4. Quantization of the radiation filed, the free electromagnetic field and its quantization	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Non-Relativistic many particle Systems: Method of second Quantization; identical particles, many particle states; permutation symmetry; completely symmetric and antisymmetric states. A system of bosons, states, Fock space; creation and annihilation operators; particle number operator; single and many particle operators. A system of fermions; states, Fock Space; creation and annihilation operators; single and many particle operators. Field operators; field equations. Ground state energy and elementary theory of the electron gas; Hamiltonian; ground state energy in Hartree-Fock approximation; modification due to Coulomb interaction.	10
II	Field Quantization: Linear coupled oscillators; continuum limit, generalization to three dimensions; classical filed theory; Lagrangian and the Euler-Lagrangian equations of motion; Canonical quantization; Symmetries and conservation laws; Noether's theorem; the energy-momentum tensor; continuity equation and the conservation laws; conservation laws for four momentum, angular momentum and charge	10
III	Quantization of non-relativistic and relativistic fields: Quantization of the Schrodinger field; the Lagrangian density and commutation relations, the Hamiltonian; nature of the field quanta. Quantization of real Klein-Gordon field, the Lagrangian density, commutation relations, the Hamiltonian; the complex Klein-Gordon field; nature of field quanta	10
IV	Quantization of the radiation filed: Classical electrodynamics; Maxwell's equations; Gauge transformations; the coulomb gauge; the Lagrangian density for the electromagnetic field; the free electromagnetic field and its quantization; the field quanta	10
Total		**40**

Texts:

1. *Advanced Quantum Mechanics;* F. Schwabl, Springer, 4th Ed., 2008, Berlin
2. *Quantum Mechanics;*A. S. Davydov, Pergamon, 2n Ed., 1991, United Kingdom
3. ;*Advanced Quantum Mechanics*, J. J. Sakurai, Pearson, 5th Ed., 2009, New Delhi

References:

1. J. D. Bjorken and S.D. Drell, *Relativistic Quantum Mechanics*, Tata Mc Graw Hill education,1st Ed.,2013, New York

SYLLABUS (4th SEMESTER)

Paper VI/Subject Name: Astrophysics-II		**Subject Code: PHY014D404**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To apply physical and mathematical concepts to the study of astronomy and astrophysics.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Degenerate stars, white dwarf, black holes, and gamma ray bursts 2. The Milky way Galaxy, Quasi-stellar objects 3. Principle of Equivalence, Particle trajectories in Gravitational field 4. Hubble's law, Elementary ideas on structure formations, age of Universe	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Degenerate stars, white dwarf, mass–radius relation and Chandrasekhar mass limit. Maximum mass of neutron star, Tolman-Oppenheimer-Volkoff equation. Basics of X-ray astronomy, black holes, and gamma ray bursts.	**10**
II	The Milky way Galaxy, Kinematics, Hubble classification scheme for external galaxies: spirals, elliptical, irregulars. Normal galaxies and AGNs. Quasi-stellar objects. Unified model.	**10**
III	Principle of Equivalence. Gravity and Geometry. Metric Tensor and its properties. Curved space time. Tensor calculus: co-variant differentiation, parallel transport, Bianchi Identities. Particle trajectories in Gravitational field. Einstein's Field equations and Stress-energy tensor, Schwarzschild metric.	**10**
IV	Hubble's law, Friedman-Robertson-Walker Model, Cosmological constant. Theories of origin and evolution of Universe. Standard Cosmological model, thermodynamics of early universe, nucleo-synthesis, Microwave Background radiation, Elementary ideas on structure formations, age of Universe.	**10**
Total		**40**

Texts:

1. *Astrophysics: A Modern Prospective;* K.S Krishnaswamy, New Age International Publication, 2nd Ed., 2006 , New Delhi
2. *An Introduction to Astrophysics;* Baidyanath Basu, Prentice Hall Publication, 2nd Ed.,2013, New Delhi

References:

1. V.B.Bhatia; *Text Book on Astronomy and Astrophysics with elements of cosmology,* Narosa Publishing House, 2nd Ed., 2001, New Delhi
2. K. D. Abhayankar; *Astrophysics: Stars and Galaxies,* Abe Books,1st Ed., 2002, Hyderabad

SYLLABUS (4th SEMESTER)

Paper VII/Subject Name: Physics of Semi-conductor-II		**Subject Code: PHY014D405**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To introduce the students with the operational principle and the analysis of different semiconductor devices.	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Special topics in semiconductor physics, Nano tube and their optical properties. 2. Bipolar semiconductor devices, Shockley diode 3. Unipolar semiconductor devices, MOSFET 4. Photonic semiconductor devices	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Special topics in semiconductor physics: Heterostructures: heteroepitaxy- growth methods, substrates; energy levels in heterostructures; Nanostructures: basic concept of quantum dots, electrical, transport and optical properties; Organic semiconductors: different materials and their electronic structure, optical properties; Carbon Nano tube: Introduction to carbon Nano tube and their optical properties.	10
II	Bipolar semiconductor devices: p-n junction diode: basic device technology, depletion region and depletion capacitance, current voltage characteristics, junction breakdown, transient behaviour and noise, terminal functions; Bipolar transistor: carrier density and current, current voltage characteristics, frequency response and switching of bipolar transistor; Thyristors: basic characteristics, Shockley diode and three terminal thyristor, diac and triac.	10
III	Unipolar semiconductor devices: Metal-semiconductor contacts: energy band relation, Schottky effect, current transport processes; JFET and MESFET: basic device characteristics, general characteristics, related field-effect device; MOSFET: fundamentals of MOSFET types, MOSFET memory structure.	10
IV	Photonic semiconductor devices: Basic information on radiative transition and optical absorption; light emitting diodes: spectral range, quantum efficiency; semiconductor laser: optical mode, loss mechanism, threshold, spontaneous emission factor, output power; Photodiode: principle of p-n and pin photodiodes, concept of photodiode array; Physics of solar cells: principle of solar cells, light absorption, charge separation; loss mechanisms in solar cells: optical losses, recombination losses, resistive losses; design of solar cell; conversion efficiency; type of solar cells.	10
Total		**40**

Texts:

1. *The Physics of Semiconductors: An Introduction Including Nanophysics and Applications*; M. Grundmann Springer-Verlag, 2nd Ed., 2010, Berlin.
2. *Physics of Semiconductors Devices;* S. M. Sze Jhon Wiley & Sons, 3rdEd. 2013, Singapore.
3. *Physics of semiconductors;* A. F. Loffe, Springer, 1st Ed., Reprint 2012 , New Delhi

References:

1. Sapoval B. & Hermann C., Physics *of Semiconductors*, Springer-Verlag; 1st Ed., Reprint 2003, New York.
2. Donald A N., *Semiconductor Physics and Devices: Basic Principle;* McGraw-Hill, 3rd Ed., 2007, New Delhi
3. Colinge J.P. & Colinge C.A., *Physics of Semiconductor Devices;*, Springer,1st Ed., 2005, New York
4. Solanki C. S, *Solar Photovoltaics - Fundamentals, Technologies and Applications;* Prentice-Hall of India, 3rd Ed., 2015, New Delhi

SYLLABUS (4th SEMESTER)

Paper VIII/Subject Name: Condensed Matter Physics-II		**Subject Code: PHY014D406**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To give foundation for research and higher studies in condensed matter physics	1. Lecture 2. Assignment 1. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 1. Dielectrics: theory and applications, plasmons, polaritons and polarons 2. Ferroelectric crystals, first order transitions; antiferroelectricity 3. Quantum theory of magnetic susceptibility & magnetic resonance 4. Superconductivity, Superconducting quantum interference device (SQUID)	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	Topics / Course content	Periods
I	Dielectrics: theory and applications: Polarization; dielectric constant; dielectric polarizability; sources of polarizability; electronic polarizability and optical absorption; ionic polarization; dielectric losses; optical phenomena; application to plasma; plasma oscillations; applications to plasmons, polaritons and polarons.	**10**
II	Ferroelectric crystals: Types of crystalline ferroelectrics; Theory of the displacive transitions in ferroelectrics; polarization catastrophe; transverse optical phonons; thermodynamic theory of ferroelectric transition; second-order transitions; first order transitions; antiferroelectricity; piezoelectricity; Electrostriction.	**10**
III	Quantum theory of magnetic susceptibility & magnetic resonance: The quantum mechanical formulation; Van Vleck Para magnetism; Pauli par magnetism; nuclear Para magnetism; magnetic resonance; electron spin resonance; nuclear magnetic resonance; Spin-relaxation; spin-lattice relaxation; spin-spin relaxation; Bloch equations.	**10**
IV	Superconductivity: Isotope effect and electron-phonon interaction; formation of Cooper pairs; derivation of binding energy of a Cooper pair; the BCS theory; the ground state energy of a superconductor; prediction of the BCS theory; Ginzburg- Landau theory; magnetic flux quantization; theoretical aspects of type II superconductivity; Josephson tunnelling; theory of Josephson effect; The dc Josephson effect and the ac Josephson effect; Supercurrent quantum interference; Superconducting quantum interference device (SQUID)	**10**
Total		**40**

Texts

1. *Introduction to Solid State Physics;* C. Kittle, John Wiley & Sons, 8th Ed. 2015, New Delhi
2. *Solid State Physics:* N.W Ashcroft and N.D. Mermin, Cengage Learning, 1st Ed., 2017, New Delhi.
3. *Principles of the theory of Solids;* J.M. Ziman, Cambridge University Press, 2nd Ed., 2013, Kolkata

References

1. J.P Srivastva, *Elements of Solid State Physics;* Prentice-Hall of India,4th Ed.,2006, New Delhi

SYLLABUS (4th SEMESTER)

Paper IX/Subject Name: High Energy Physics-II		**Subject Code: PHY014D407**
L-T-P-C: 4-0-0-4	**Credit Units: 4**	**Scheme of Evaluation: T**

Course Objectives	**Teaching Learning Process**	**Learning Outcomes**	**Course Evaluation**
1. To understand the standard model of physics and to be able to work in high energy physics phenomenology	1. Lecture 2. Assignment 3. Individual and Group Presentation	On completion of this course students will be able to gain interest on the following: 2. Fundamental interactions , weak decays of quarks. 3. Electroweak interaction, Strong: matter fields 4. Unification schemes, neutrino mass 5. Introduction to field theory, quantization of Dirac field and non-relativistic Schrodinger equation.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks (Assignment, class test, Seminar, viva, quiz (any three): 15, Mid-term exam:10, Attendance : 05)

Detailed Syllabus:

Modules	**Topics / Course content**	**Periods**
I	Fundamental interactions: Four fundamental interactions and their characteristics in terms of decay life times, strengths, decay of muon, neutron and charged Pions. Weak interaction: Classification lepton universality, nuclear p-decay, fermi theory, inverse p-decay, neutrino interactions, parity non conservation in p-decay, helicity of the neutrino, weak boson and fermion couplings, pion and muon decay, neutral weak currents, observation of w± , weak decays of quarks.	**10**
II	Electroweak interactions and the standard model: Weinberg-Salam model, intimidate boson masses, electroweak couplings of leptons and quarks, standard model, spontaneous symmetry breaking, Higgs mechanism, basic information about LHC, Parton model, fermi theory, Gamow-teller transitions, electroweak unification. Strong: matter fields, gauge fields, non-abelian gauge field (Yang-Mills theory)	**10**
III	Unification schemes: SU(5) grand unified theory, generators of SU(5), proton decay, neutrino mass, Dirac and Majorana neutrinos, neutrino oscillations, superstrings, spontaneous breaking of SU(5) symmetry, fermion masses, mixing angles, SU(10) grand unified theory, fermion masses in SU(10), neutrino mass in SU(10).	**10**
IV	Introduction to field theory (classical and quantum): Concept of fields, coordinates of fields, classical fields as generalized coordinates, Lagrangian of a field, Euler Lagrange equation, canonical quantization of a one dimensional classical system, Fock space, Hamiltonian equations, creation and destruction operators, number operators, anticommutation relations. Quantization of fields: methods of quantization, canonical quantization of free fields, Hermitian and non-Hermitian scalar fields, quantization of Dirac field and non-relativistic Schrodinger equation.	**10**
Total		**40**

Texts:

1. *Introduction to High Energy Physics*, Perkins D.H.; Cambridge University Press, 4th Ed., 2014, Cambridge.
2. *Introduction to Elementary Particles*, Griffiths D.; Wiley-VCH, 2nd Ed., 2014, Weinheim, Germany
3. *Introduction to Particle Physics*, Khanna M.P.; Prentice-Hall of India, 3rd Ed., 2004, New Delhi

References:

1. Bettini A., *Introduction to Elementary Particle Physics*; Cambridge University Press, 2nd Ed., 2014, Cambridge.
2. Cottingham W.N., Greenwood D. A., *An Introduction to the Standard Model of Particle Physics*; Cambridge University Press, 2nd Ed., 2007, Cambridge.
3. Hughes I.S., *Elementary Particles;* Cambridge University Press, 3rd Ed., 1996, Cambridge.
4. Quigg C., *Gauge Theories of Weak, Strong and Electromagnetic Interactions;* Gorden & Breach, 2nd Ed., 2013, New York.

SYLLABUS (4^{th} SEMESTER)

Paper X/Subject Name: Project / Seminar **Subject Code: PHY014D431**

L-T-P-C: 0-0-0-12 **Credit Units: 12** **Scheme of**

Course Objectives	Teaching Learning Process	Learning Outcomes	Course Evaluation
1. To improve the presentation skill and subject knowledge of the students	1. One to one guidance and supervision 2. Individual and Group Presentation	On completion of this course students will be expected to acquire confidence to present their research work in the future.	A. Semester end examination : 70 marks B. Internal Assessment:30 marks Presenation:20, Viva:10

Project / Seminar