Five Year Integrated Master of Science
(Physics)
Programme

Scheme and Syllabus (OBE based)

for Advanced level courses in Semester VII to X

Institute For Integrated Programmes & Research In Basic Sciences (IIRBS)

Mahatma Gandhi University

P. D. Hills P.O., Kottayam-686560

PREAMBLE

I am happy to present the detailed curricula and syllabi of the final four semesters (7-10) of the five year Integrated M.Sc. programmes of Institute for Integrated Programmes and Research in Basic Sciences (IIRBS) in the following five branches of Science.

1. Chemistry (CH)
2. Physics (PH)
3. Life Sciences (LS)
4. Computer Science(CS)
5. Environmental Science(ES)

It may be noted that, an expert committee was constituted *(vide UO 4460/ACA5/2019/MGU, dated 23.09.2019)* for framing the scheme, curriculum and syllabi for the five year Integrated Master of Science (Integrated M.Sc) programmes of Mahatma Gandhi University. Subsequently, the committee drafted the regulations, scheme, curriculum and syllabi of the five year integrated Master of science programmes of IIRBS and were approved *vide UO No. 4467/AC A 5/2020/MGU, dated 05.10.2020* w.e.f 2020 admission batch. However, this approval was involved the detailed scheme and syllabus for foundation level (first six semesters) courses and only scheme for the advanced level courses (in semesters 7-10). Now the expert committee has finalized the **detailed syllabi for advanced level courses in semesters 7-10** in accordance with the OBE format approved by the Mahatma Gandhi University and is presented hereafter. ***This syllabus shall be applicable w.e.f the 2023-24 academic year (for 2020 admisn batch) onwards.***

The expert committee has framed the curriculum as per the Outcome Based Education (OBE) system. OBE is an educational approach that bases each part of the educational system with respect to the goals set for the students. OBE aims to equip the students (learners) with knowledge, competency orientations required for achieving their goals when they depart the institution. Further OBE empowers students to choose what they would like to study and how they would like to study it. The teaching methodologies and the evaluation system are also modified in par with the outcome based approach. The programme Specific Outcomes (PSOs) and the Course Outcomes (COs) are presented in the syllabus. The PSOs and the COs are well correlated in the syllabus of each course.

-Sd-

P.D. Hills — Dr. S. Anas

July, 2023 — (Convener, Expert committee)

Members of the Expert committee

1.	Dr. S. Anas, Honorary Director, IIRBS	Convener
2.	Dr. P. R. Biju, Professor, SPAP	Member
3.	Dr. K. B. Subila, Assistant Professor, SCS	Member
4.	Dr. Mahesh Mohan, Assistant Professor, SES	Member
5.	Dr. E.K. Radhakrishnan, Associate Professor, SBS	Member
6.	Dr. V. R. Bindu, Professor and Director, SoCS	Member
7.	Dr. Cyriac Joseph, Director, SPAP	Member
8.	Dr. Anitha C. Kumar, Director, SCS	Member
9.	Dr. K. R. Baiju, Director, SES	Member
10.	Dr. M. S. Jisha, Director, SoBS	Member

Institute for Integrated Programmes and Research in Basic Sciences (IIRBS)

Institute for Integrated Programmes and Research in Basic Sciences (IIRBS**)**, was instituted directly under Mahatma Gandhi University in 2008 and was the first of this kind among the universities in Kerala. Subsequently, the Institute launched Five year Integrated Interdisciplinary Master of Science (Chemistry) programme in the year 2009. Over the years the institute has earned recognition as one of the best interdisciplinary institutions in terms of providing top-notch teaching learning environment and cutting edge instrumentation facilities. In 2020, IIRBS started innovative Five Year integrated interdisciplinary Master of Science programmes in five major disciplines of science (Physics, Chemistry, Life Sciences, Computer Science and Environmental Science). The major objective of the programmes is to integrate the conventional bachelors and masters' programmes under a specified research oriented leaning environment by bringing together various science disciplines and thereby empower basic science education. These programmes are designed with an interdisciplinary approach to provide strong foundations for students to prepare for high quality research and expected to contribute to the talent pool of researchers and specialized technicians.

The regulations, scheme, curriculum and syllabi of the five year integrated Master of science programmes of IIRBS were approved *vide UO No. 4467/AC A 5/2020/MGU, dated 05.10.2020.* However, this approval was involved the detailed scheme and syllabus for foundation level (first six semesters) courses and only scheme for the advanced level courses (in semesters 7-10). Now the **detailed syllabi for advanced level courses in semesters 7-10** are prepared in accordance with the OBE format approved by the M.G. University.

Outcome based Education (OBE)

A high priority task in the context of education in India is improvement of quality of higher education for equipping young people with skills relevant for global and national standards and enhancing the opportunities for social mobility. Mahatma Gandhi University has initiated an Outcome Based Education (OBE) for enhancing employability of graduates through curriculum reforms based on a learning outcomes-based curriculum framework, upgrading academic resources and learning environment. Learning outcomes specify what graduates completing a particular programme of study are expected to know, understand and be able to do at the end of their programme of study. The fundamental premise underlying the learning outcomes-based approach to curriculum development is that higher education qualifications are awarded on the basis of demonstrated achievement of outcomes, expressed in terms of knowledge, understanding, skills, attitudes and values. Outcomes provide the basis for an effective interaction among the various stakeholders. It is the results-oriented thinking and is the opposite of input-based education where the emphasis is on the educational process.

The OBE Framework is a paradigm shift from traditional education system into OBE system where there is greater focus on programme and course outcomes. It guarantees that curriculum, teaching and learning strategies and assessment tools are continuously enhanced through a continuous improvement process. All decisions including those related to curriculum, delivery of instruction and assessment are based on the best way to achieve the predetermined outcomes. Traditionally, educators have measured learning in terms of standardized tests. In contrast, outcome-based education defines learning as what students can demonstrate that they know.

OBE is a comprehensive approach to organise and operate a curriculum that is focused onand defined by the successful demonstrations of learning sought from each learner. The term clearly means focusing and organising everything in an education system around "what is essential for all learners to be able to do successfully at the end of their learning experiences". OBE is an approach to education in which decisions about the curriculum and instruction are driven by the exit learning outcomes that the students should display at the end of a programme or a course. By the end of educational experience, each student should have achieved the outcomes.

Vision and Mission of Mahatma Gandhi University

Vision

"Mahatma Gandhi University envisions to excel in the field of higher education and cater to the scholastic and developmental needs of the individual, through continuous creation of critical knowledge base for the society's sustained and inclusive growth."

Mission

- To conduct and support undergraduate, postgraduate and research-level programmes of quality in different disciplines
- To foster teaching, research and extension activities for the creation of new knowledge for the development of society
- To help in the creation and development of manpower that would provide intellectual leadership to the community
- To provide skilled manpower to the professional, industrial and service sectors in the country so as to meet global demands
- To help promote the cultural heritage of the nation and preserve the environmental sustainability and quality of life
- To cater to the holistic development of the region through academic leadership

Vision and Mission of IIRBS

Our Vision:

Quality education in basic sciences by providing intellectual, instrumental as well as experimental support for pursuing excellence and thereby contribute to the talent pool of scholars.

Our Mission:

- To promote and disseminate high level knowledge in frontier areas of science
- To develop students as multidimensional personalities to create innovators for the service of human welfare
- To equip students to build up a scientific career and contribute towards the national development
- To inculcate among students human values with global competence

Programme Outcomes (PO) of Mahatma Gandhi University

PO 1: Critical Thinking and Analytical Reasoning

Capability to analyse, evaluate and interpret evidence, arguments, claims, beliefs on the basis of empirical evidence; reflect relevant implications to the reality; formulate logical arguments; critically evaluate practices, policies and theories to develop knowledge and understanding; able to envisage the reflective thought to the implication on the society.

PO 2: Scientific Reasoning and Problem Solving

Ability to analyse, discuss, interpret and draw conclusions from quantitative/qualitative data and experimental evidences; and critically evaluate ideas, evidence and experiences from an unprejudiced and reasoned perspective; capacity to extrapolate from what one has learned and apply their competencies to solve problems and contextualise into research and apply one's learning to real life situations.

PO 3: Multidisciplinary/Interdisciplinary/Transdisciplinary Approach

Acquire interdisciplinary /multidisciplinary/transdisciplinary knowledge base as a consequence of the learning they engage with their programme of study; develop a collaborative-multidisciplinary/interdisciplinary/transdisciplinary- approach for formulate constructive arguments and rational analysis for achieving common goals and objectives.

PO 4: Communication Skills

Ability to reflect and express thoughts and ideas effectively in verbal and nonverbal way; Communicate with others using appropriate channel; confidently share one's views and express herself/himself; demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner and articulate in a specific context of communication.

PO 5: Leadership Skills

Ability to work effectively and lead respectfully with diverse teams; setting direction, formulating a goal, building a team who can help achieve the goal, motivating and inspiring team members to engage with that goal, and using management skills to guide people to the right destination, in a smooth and efficient way.

PO 6: Social Consciousness and Responsibility

Ability to contemplate of the impact of research findings on conventional practices, and a clear understanding of responsibility towards societal needs and reaching the targets for attaining inclusive and sustainable development.

PO 7: Equity, Inclusiveness and Sustainability

Appreciate equity, inclusiveness and sustainability and diversity; acquire ethical and moral reasoning and values of unity, secularism and national integration to enable to act as dignified citizens; able to understand and appreciate diversity, managing diversity and use of an inclusive approach to the extent possible.

PO 8: Moral and Ethical Reasoning

Ability to embrace moral/ethical values in conducting one's life, formulate a position/argument about an ethical issue from multiple perspectives, and use ethical practices in all work. Capable of demonstrating the ability to identify ethical issues related to one's work and living as a dignified person in the society.

PO 9: Networking and Collaboration

Acquire skills to be able to collaborate and network with scholars in an educational institution, professional organisations, research organisations and individuals in India and abroad.

PO 10: Lifelong Learning

Ability to acquire knowledge and skills, including "learning how to learn", that are necessary for participating in learning activities throughout life, through self-paced and self-directed learning aimed at personal development, meeting economic, social and cultural objectives, and adapting to changing trades and demands of workplace through knowledge/skill development/reskilling.

Programme Specific Outcomes (PSO) for
Integrated M.Sc. (Physics)

Upon completion of the Integrated M.Sc. Physics programme, the students should be able to accomplish the following outcomes

PSO	Expected Outcomes
1	Acquire adequate knowledge in physics which make students able to understand, remember, analyze, evaluate and interpret the world around in a scientific way.
2	Develop problem-solving ability
3	Attain skills to implement innovative and advanced ideas/techniques via collaborative, multidisciplinary means.
4	Have an outlook rooted in human and ethical values.
5	Impart skills and abilities to communicate effectively and hence network with scholars/educational institutions, collaborate and work in teams/lead teams.
6	Acquire a positive attitude towards learning which engenders lifelong personal and professional development.
7	Realize and analyse the world they live in, in a scientific and creative way and thereby make attempts for improving the quality of life of all.
8	Promote Research interest and aptitude in students and thereby enable them towards planning and execution of research in frontier areas of physical sciences.

SEMESTER VII to X
(List of Courses Under Physics Major)

Code	Course	L	T	P	C
SEMESTER VII					
IMSC701PH	Basic Electronics	4	1	0	4
IMSC702PH	Mathematical Methods in Physics	4	1	0	4
IMSC703PH	Electrodynamics	4	1	0	4
IMSC704PH	Classical Mechanics	4	1	0	4
IMSC705PH	Electronics Lab	0	0	6	4
	Total	**20**	**4**	**6**	**20**
SEMESTER VIII					
IMSC801PH	Quantum Mechanics-I	3	1	0	3
IMSC802PH	Mathematical Physics	3	1	0	3
IMSC803PH	Solid State Physics	3	1	0	3
IMSC804PH	Statistical Mechanics	3	1	0	3
IMSC805PH	Nuclear Physics	3	1	0	3
IMSC806PH	General Physics Lab	0	0	6	3
IMSE807PH-n (n=1,2,3...)	1. Basic Astronomy 2. X-Ray Crystallography 3. Laser Plasma 4. Plasma Physics 5. General Theory of Relativity 6. Thin Film Science 7. Semiconductor materials and devices 8. Nanophotonics	2	1	0	2
	Total	**17**	**5**	**6**	**20**
SEMESTER IX					
IMSC901PH	Quantum Mechanics-II	4	1	0	4
IMSC902PH	Spectroscopy	4	1	0	4
IMSC903PH	Advanced Practical	0	0	4	2
IMSC904PH	Minor Project	0	0	2	2
IMSE905PH-n (n=1,2,3...)	1. X-Ray Characterization Methods 2. Physics of Nanomaterials 3. Nanoscience and Nanostructured Materials 4. Applied Photonics 5. Star Galaxies and Cosmology 6. Multiferroic Materials and Applications 7. Advanced Solid State Physics 8. Physics of Mesoscopic Systems	2 2	1 1	0 0	2 2
IMSO906OC-n (n=1,2,3...)	Open Course	4	0	0	4
	Total	**16**	**4**	**6**	**20**
SEMESTER X					
IMSC100PR	Major Research Project	0	0	0	16
IMSC100VV	Comprehensive Viva-voce	0	0	0	4
	Total	**0**	**0**	**0**	**20**

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Basic Electronics**					
Type of course	**Core**		**Credit Value**		**4**	
Course code	**IMSC701PH**					
Name of Faculty						
Course Summary& Justification	The course comprises the theory and applications of analog and digital electronics. Students are introduced to circuit designing and analysis approaches in detail. Electronic devices are so much a part of our daily lives. The field of electronics is very diverse with lot many applications and a lot many career opportunities. This course of 'Basic Electronics' equips students with the necessary knowledge and skills to design, develop and operate different kinds of electronics systems.					
Semester	**VII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	72	18	-	10	100
Pre-requisite	Basic knowledge about electricity, passive and active electric components and electric circuits.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Make a better understanding of the basics of electronic components and circuits	R, U	1
2	Distinguish/analyse the types of electronic circuits	An	1,2
3	Design various analog and digital circuits for an expected output	C	2
4	Construct simple devices using the designed circuits for a specific application	C	2
5	Develop, at least conceptually, a new electronic product	C	2,3,7

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Analog Integrated Circuits** Introduction to analog integrated circuits, Introduction to operational amplifiers, Characteristics of Op-Amp, Characteristics of an ideal Op-Amp, Open-Loop Op-Amp configurations: differential, inverting and non-inverting amplifiers, Closed-Loop Op-Amp configurations: positive and negative feedback amplifiers, Negative feedback Op-Amp configurations: voltage-series/noninverting, voltage-shunt/inverting and differential amplifiers, Characteristics of a practical Op-Amp: total output offset voltage, frequency response, Compensating networks, Parameter evaluation for DC and AC applications of operational amplifiers.	22	1-4
2	**Analog Integrated Circuit Applications** DC and AC amplifier, Summing, scaling and averaging amplifiers, Instrumentation amplifier, Differential input and differential output amplifier, Voltage-to-current converter: with floating and grounded loads, Current-to-voltage converter, Integration amplifier, Differentiation amplifier, Filters: first, second and higher-order filters, low-pass, high-pass, band-pass, band- reject and all-pass filters, Oscillators: phase-shift, Wien bridge and quadrature oscillators, Wave generators: square, triangular and saw tooth wave generators, Voltage-controlled oscillator, Comparators: Schmitt trigger, Voltage limiters, Clippers and clampers, Absolute value output circuit, Peak detector, Sample-and-hold circuit, The 555 timer: monostable and astable multivibrators, Phase-locked loops.	22	1-5
3	**Digital Integrated Circuits and Applications** Introductory concepts of digital systems, Binary logic, Logic gates, Logic circuits, Binary number system, Boolean algebra, Standard forms of Boolean expressions, Introduction to digital integrated circuits, Analysis and simplification of logic circuits using Boolean algebra and Karnaugh maps, Combinational logic circuits: binary adders, decoders, encoders, multiplexers, demultiplexers, parity generators and checkers, comparators, Sequential logic circuits: Flip-flops: RS, D, JK Shift registers: serial and parallel transfer, Counters: asynchronous and synchronous, up and down counters, Microprocessor architecture and Microcomputer system design.	23	1-5
4	**Communication Electronics** Amplitude modulation, Single side band techniques- balanced modulator, phase shift method, Radio receivers-superheterodyne receiver, AM receiver, detection and AGC, Frequency modulation-theory and generation, FM receiver, Pulse communication, Types of modulation-PAM, PWM, PPM, PCM, Digital communication- error detection and correction, Frequency and time division multiplexing.	23	1-5

References

1. *Op-amps and Linear Integrated Circuits, Ramakant A. Gayakwad. Pearson Education; Fourth edition (2015).*
2. *Microprocessor Architecture, Programming, and Applications with the 8085/8080A, Ramesh S. Gaonkar. Penram International Publishing; Sixth edition (2013).*
3. *The 8051 Microcontroller Architecture, Programming & Applications, Kenneth J. Ayala. Delmar Cengage Learning; Second edition (1996).*
4. *Electronic Communication Systems, Kennedy and Davis. McGraw Hill Education; Sixth edition (2017).*
5. *Digital Logic and Computer Design, M Morris Mano. Pearson Education India; First Edition (2016).*
6. *Integrated Electronics, Jacob Millman and C.C. Halkias. McGraw Hill Education; Second edition (2017).*
7. *Digital Principles and Applications, Donald P Leach, Albert Paul Malvino and Goutam Saha. McGraw Hill Education; Eighth edition (2014).*
8. *Electronic Communications, Roody & Coolen. Pearson India; Fourth edition (2008).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**				
Programme	**Five Year Integrated M.Sc. (Physics)**				
Course Name	**Mathematical Methods in Physics**				
Type of course	**Core**		**Credit Value**	**4**	
Course code	**IMSC702PH**				
Name of Faculty					
Course Summary& Justification	The course comprises the theory and formulate techniques of defining real systems and solving advanced level problems Mathematics is not only to solve the scientific problem but it is a need for day-to-day life. But the course we offer is Advanced Course on Mathematics which specifically for the need of understanding the natural dynamics.				
Semester	**VII**				
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	72	18	-	10	100
Pre-requisite	Basic knowledge about numbers, addition & division, subtraction & multiplication				

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understands the concepts of physical quantities, Concept of differentiation and how it describes the real systems	U	1
2	Solve problem using Matrix Algebra and formulate new methodology for formulating new physical systems	An	1,2
3	Can solve problems in Quantum Mechanics	C	2
4	Analyse the problems and classify the functions and formulate new solution and explore it for understanding complex systems of design new systems	An, C	2
5	Can develop analytical skill and confidence for approaching higher level scientific problems	S, C	2,3

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Vector Analysis** Basics of Vector Algebra and its physical concepts, Gradient, Divergence and Curl, vector integration, Gauss's theorem, Green's theorem and Stokes theorem, Potential theory, Gauss's Law and Poisson's Equation,	18	1,3,4,5

	Dirac Delta function and its properties, Orthogonal curvilinear coordinates-Gradient, Divergence, Curl and Laplacian. Evaluation of line, surface and volume integrals.		
2	**Matrices and Linear Vector Spaces** Matrix algebra, Matrix multiplication, Transportation and Hermitian conjugate, Trace and determinants, Inverse of matrix, orthogonal and unitary matrices, Linear vector spaces, Metric space, Schmidt orthogonalisation, Linear operators, dual space, ket and bra notation, Hilbert space, Function spaces, Basis, orthogonal expansion of separable Hilbert spaces, Bessel's inequality, Parseval's formula.	18	1-5
3	**Complex analysis** Functions of a complex variable, The derivative and Cauchy Reimann conditions, Line integrals of complex functions, Cauchy's integral theorem, Cauchy's integral formula, Taylor's series, Laurent's series, Residues, Cauchy's residue theorem, Singular points of an analytic function, The point at infinity, Evaluation of residues, Evaluation of definite integrals by contour integration, Method of steepest descent (Stirlings formula).	18	1,3,4,5
4	**Special functions and their differential equations** Gamma and Beta functions and its properties. Frobenius method for solving second order ordinary differential equations with variable coefficients. Bessel, Legendre, Hermite equations. Recurrence relations, Generating functions and Rodrigues formulae for the Bessel, Legendre and Hermite functions. Linear differential operators, adjoint operators, Greens identity, Eigen values and Eigen functions, Sturm-Liouville operators.	18	1,3,5

References

1. *Mathematical Methods in Classical and Quantum Physics, T Dass & S K Sharma, Univ. Press (1998)*
2. *Mathematical Methods for Physicists, G B Arfken & H J Weber, Elsevier; Seventh edition (2012)*
3. *Classical Theory of Fields, L D Landau & E M Lifshitz, 4th Edition (1980)*
4. *Mathematics for physicists, Susan M Lea, Brooks/Cole (2003)*
5. *Mathematical Methods for Physics and Engineering, K P Riley, M P Hobson S J Bence, Cambridge University Press; 3rd edition (2006)*
6. *Applied Mathematics for Engineers and Physicists, Pipes and Harvill,*
7. *Mathematical physics, Eugine Butkov Dover Publications Inc.; 3rd edition (2014)*
   http://nptel.ac.in/courses/111105035/
   #Mathematics through ICT –(Students may experiment with) Geogebra Wolfram Alpha

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)
School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**

Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Electrodynamics**					
Type of course	**Core**		**Credit Value**		**4**	
Course code	**IMSC703PH**					
Name of Faculty						
Course Summary& Justification	Electrodynamics course extends the fundamental understanding of static electric and magnetic fields and associated potential to time-varying fields. This master level course offers the familiarization of the concept of propagation of electromagnetic radiation and wave guiding, dynamics of charged particles under electromagnetic fields and its extension to relativistic conditions, which could be applied to physical situations. Electromagnetic fields and dynamics is an integral part of Physics to understand the phenomena associated with charged bodies in motion and varying electric and magnetic fields based on Maxwell's equations.					
Semester	**VII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: GD, Problems solving sessions, Seminars, Independant Learning etc.	72	18	-	10	100
Pre-requisite	Graduate level Mathematics (Calculus, Vector Analysis)					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Use calculus and vector in Physical situations containing charges	R, U	1,2
2	Analyse the electromagnetic field due to time varying charge and current distribution using Maxwell's equations	U, An	1,2
3	Explain charged particle dynamics and radiation from localized time varying electromagnetic sources	S	2,3
4	Explain the nature of electromagnetic wave and its propagation through different media and interfaces	C	2, 6
5	Use the theorems and laws to predict the electric filed around various surfaces containing charges and its extension to quantum electrodynamics	A	1, 5, 6

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Electrostatics & Magnetostatics** Gauss's law and its applications, Poisson and Laplace equations, the electrostatics potential, electrostatic field due to point charges and continuous charge distribution, Electric field energy, Boundary value problems and their solutions, Multipole expansion, Biot-Savart's law, Ampere's theorem, Magnetics field of a steady current, the divergence	22	1, 2, 5

	and curl of B, Applications of Ampere's law, the vector and scalar potentials.		
2	**Time varying fields** Electromagnetic induction and Faraday's law, Maxwell's displacement current, Maxwell's equations in free space and linear isotropic media, boundary conditions on the fields at interfaces, time dependent scalar and vector potentials, Gauge invariance, Coulomb and Lorentz Gauge, magnetic field energy, conservation laws, continuity equation, Poynting theorem, Maxwell's stress tensor and conservation of momentum.	23	1, 2, 3, 5
3	**Electromagnetic radiation & Guided waves** Electromagnetic waves in free space, Dielectrics and conductors, reflection and refraction at interfaces, Polarization, Fresnel's law, interference, coherence and diffraction, waveguides and transmission lines, Transmission line equations and wave characteristics, skin effect, Modes in rectangular wave guide, Retarded potentials, The Lienard-Wiechert potentials, radiation from moving point charges and oscillating electric and magnetic dipoles, dispersion relations in plasma.	25	1, 3, 4, 5
4	**Relativistic Electrodynamics** Lorentz transformation equations, Lorentz invariance of Maxwell's equations, Transformations of electromagnetic fields under Lorentz transformation, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics, Four potential of a field, Dynamics of charged particles in static and uniform electromagnetic fields.	20	1, 2, 3, 5

References

1. *Introduction to Electrodynamics, D J Griffiths, Prentice Hall of India, 4th Edition (2015)*
2. *Classical Electrodynamics, J D Jackson, Willey, 3rd Edition (2007)*
3. *The Classical Theory of Fields, L D Landau and E M L fshitz, Volume 2, Pergamon Press (1975)*
4. *Classical Fields, L D Landau and E M Lifshitz, Butterworth-Heinemann; 4th edition (1987)*
5. *Electrodynamics and Radiative systems, Jordan and Balmian, Pearson Education;2nd edition (2015)*
6. *Introduction to Special Relativity, R Resnick, Wiley; 1st edition (2007)*
7. *Classical Electrodynamics, J B Marion, Academic Press; 2nd edition (2012)*
8. *Electrodynamics of continuous media, by L D Landau, L. P. Pitaevskii, E.M. Lifshitz, Butterworth-Heinemann; 2nd edition (1984)*
9. *Introduction to Modern Optics, G R Fowles, Dover Publications Inc.; New edition (1990)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Classical Mechanics II**					
Type of course	**Core**		**Credit Value**		**4**	
Course code	**IMSC704PH**					
Name of Faculty						
Course Summary& Justification	The course is designed to introduce students to Classical Mechanics. This course deals with the fundamental understanding of Classical mechanics developed by Newton, Lagrangian, Hamilton and others. The study of classical mechanics gives the students an opportunity of basic understanding of vast field of physics through various mathematical techniques.					
Semester	**VII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	72	18	-	10	100
Pre-requisite	Basic understanding of Mechanics with mathematical knowledge including vectors and calculus (Undergraduate level).					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Students will understand the disciple-specific knowledge in classical mechanics. Basic understanding of Mechanics with mathematical knowledge including vectors and calculus.	U, R	1, 7, 8
2	Analyze various problems associated with mechanics and interpret the result with real time observations. Relate symmetries to conservation laws in physical systems, and apply these concepts to practical situations.	A, An	1, 2, 7
3	Students will know the concepts of classical mechanics and demonstrate a proficiency in the fundamental concepts in this area of science. Suggest solutions of unsolved problems using various concepts and mathematical tools.	An, S	1, 2, 5, 7
4	Explain the Lagrangian and Hamiltonian formulations and demonstrate its effectiveness in solving variety of problems. Describe the physical principle behind the derivation of Lagrange and Hamilton's equations, and the advantages of these formulations.	U, R	1, 2, 7
5	Explain the motion of rigid bodies and basic understanding of fluid dynamics.	U, E	1, 2, 7
6	Use of perturbation theory for the application of complex chaotic dynamical systems.	U	1, 2, 7
7	They will use critical thinking skills using their knowledge to formulate and solve quantitative problems in applied physics.	S	1, 7, 8

8	Employ conceptual understanding to make predictions, and then approach the problem mathematically and understand the important connections between theory and experiment. Develop concepts and mathematical rigor in order to enhance understanding.	An, E, S	1, 2, 3, 6, 7, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Lagrangian and Hamiltonian formulation:** A review of Newtonian Mechanics of a particle and system of particles. Conservation laws. Lagrangian formalism, constraints and their classifications. Lagrange's equations and its applications. Dissipative force, conservation laws and symmetry properties. Homogeneity of space and time. Variational Principle, Hamilton's principle, Lagrange's equation from Hamilton's principle, the Principle of least action.	20	1,2,3, 4,7
2	**Hamiltonian mechanics and Hamilton-Jacobi theory:** Hamiltonian formalism, Hamiltonian of a system, Hamilton's equations of motion, integrals associated with cyclic co-ordinate, Canonical transformations, Poisson Brackets and their properties, equations of motion- Hamilton-Jacobi Theory-Hamilton's Characteristic function- Harmonic Oscillator problem in Hamilton's-Jacoby method- Action Angle variable- Harmonic Oscillator and Kepler Problem in Action-angle variable.	24	1,3,4, 7,8
3	**Motion of rigid bodies and Fluid Mechanics:** Kinematics of rigid body motion. Infinitesimal rotations, Coriolis force, rigid body equation of motion. Central force motion, Scattering & centre of mass. Theory of small oscillations, normal modes of the system- Fluid Mechanics- equation of state and equation of continuity- Bernoulli's theorem- interpretation of Lagragian formalism of continuous system- sound vibration in gases.	22	1,3,5, 7
4	**Perturbation Theory and Chaotic Dynamical Systems:** Classical Perturbation theory- Time dependent perturbation- Simple pendulum with finite amplitude- Kepler problem- Chaotic Dynamical system- conservative system- integrable systems- KAM theorem (qualitative Idea)– nonlinear perturbation- Hamiltonian-chaos. Dissipative systems- continuous systems- Duffing oscillator- discrete systems -Logistic maps-fixed points- period doubling- limit cycle- chaotic Attractors- Lyoponov exponent- fractals and their dimension- Koch curve.	24	1,3,4, 6,7,8

References

1. *Classical Mechanics, H. Goldstein, C. Poole and J. Safko, Third Edition, Pearson (2011).*
2. *Classical Mechanics, N. C. Rana and P.S. Joag, McGraw Hill Education (2017).*
3. *Chaos and Integrability in Nonlinear Dynamics, Michael Tabor, Wiley (1989).*
4. *Classical Mechanics, V. B. Bhatia , Narosa Publishing House (2001).*
5. *Classical Mechanics, G. Aruldhas, 6th edition, PHI (2013).*
6. *Classical Mechanics, J. C. Upadhyaya, Himalaya Publishing House (2016).*
7. *Mechanics Vol. I, Landau and Lifshitz, 3rd Edition, Butterworth-Heinemann (1976).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Quantum Mechanics –I**					
Type of course	**Core**		**Credit Value**		**3**	
Course code	**IMSC801PH**					
Name of Faculty						
Course Summary& Justification	This course is aimed at teaching the student some of the mathematical machinery used in performing quantum mechanical calculations and the setting up and solving of some basic problems from a variety of situations. The case of the free particle, bound particle, particle under a time independent perturbation and tunnelling of a particle through a potential barrier are considered. In addition, how angular momentum is envisioned in quantum mechanics is set out as a fourth unit. The teaching is to be aimed at bringing out the link between the physical system and the mathematical machinery that is used to analyse the system. A few online courses/sites that would supplement the curriculum as well as enhance the ability of the student to navigate on-line and pick up useful information are also included to enhance and enrich the learning experience. This course is intended to be followed by the course 'Quantum Mechanics - II', the two together giving the students a comprehensive introduction to the basics and methods of Quantum Mechanics with respect to single particle systems (bound and unbound, non-relativistic and relativistic), many particle systems and an introduction to quantum field theory. The various units of the syllabus take the student through – (A) the basic mathematical set up (B) various representations and stationary states of some systems (C) approximation methods for more complicated potentials and (D) angular momentum.					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	54	18	-	10	82
Pre-requisite	Good understanding of basic level quantum mechanics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understanding and navigating the mathematical setup of the quantum prescription for physical systems	R, U, An, E	1,3,7
2	Understanding the mathematical setups for tracking the time evolution of a physical system	R, U, Ap	1,2,6,7
3	Solving for the stationary states of some standard three-dimensional systems	R, U, A, S	3,7

4	Understanding and applying perturbation methods to systems with Hamiltonians that are not exactly solvable	R, U, A, E, S	1,2,7
5	Developing of approximation methods for quasi-classical systems and application of these	U, E, C, S	1,2,7
6	Developing and generalizing operators for angular momentum	U, C, An, S	1,2,3,7
7	Developing the mathematical setup for combining angular momenta	U, An, C, Ap	1,2,3
** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Postulates of Quantum Mechanics** The Hilbert space and wave functions – Linear vector space and Hilbert space - Dirac Bracket notation- Operators - Commutator algebra - generalized Heisenberg uncertainty relations – eigen values and eigen functions of an operator – Representation in Discrete bases – change of bases and Unitary Transformations – Representation in continuous bases, Connecting Position and Momentum bases- Matrix and Wave Mechanics - Postulates of quantum mechanics- principle of superposition – state of a system –Observables and Operators – Measurements in Quantum Mechanics – Poisson brackets and commutators – Ehrenfest's theorems.	18	1,2,3,4
2	**Representations and stationary states** Schrodinger, Heisenberg and Interaction representation - time dependent Schrodinger equation and continuity equation - time independent Schrodinger equations – 1 D Harmonic Oscillator – eigen values and eigen states – creation and annihilation operators – 3 D problems in spherical coordinates – Free particle in spherical coordinates - spherically symmetric potentials - particle in a three dimensional box, three dimensional isotropic harmonic oscillator and Hydrogen atom-energy eigen values and eigen functions.	18	1,2,5
3	**Approximation methods** Time independent perturbation theory (degenerate and nondegenerate cases) - wave function and correction to energy to second order - anharmonic oscillator. Degenerate case: secular equation- corrections to eigen values and eigen functions in the first approximations for a double degenerate level - first order Stark and Zeeman effect in hydrogen. WKB approximation (Quasi classical case): Boundary conditions in quasi classical case- Connection formula- quasi classical motion in a centrally symmetric field- Quantization condition - Penetration through a potential barrier.	18	1,2,4
4	**Angular momentum** Rotations in Classical and Quantum Mechanics - operators for infinitesimal and finite rotations- Commutation relations of angular momentum operator- Generalised angular momentum operators - eigen values and eigen functions of the angular momentum operator - matrix representation – Pauli spin matrices - addition of angular momenta - Clebsch – Gordon coefficients for $j_1 = ½$, $j_2 = ½$.	18	1,2,3,6, 7

References

1. *Quantum Mechanics – Concepts and Applications – Zettili, Wiley; 2nd edition (2009)*
2. *Quantum Mechanics – Greiner, Springer Berlin, Heidelberg (2013)*
3. *Quantum Mechanics - Landau &Lifshitz, Pergamon press, 3rd Edition (1981)*
4. *Quantum Mechanics - G Aruldas, Prentice Hall India Learning Private Limited; 2nd edition (2008)*
5. *Quantum Mechanics – Merzbacher, 3rd Edition (2005)*
6. *Quantum Mechanics - V K Thankappan, New Academic Science Ltd; 4th edition (2014)*

Online resources

YouTube: Lectures by Prof V Balakrishnan
Keyword Quantum Mechanics at
https://ocw.mit.edu
https://www.ias.ac.in/search/index/reso

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**				
Programme	**Five Year Integrated M.Sc. (Physics)**				
Course Name	**Mathematical Physics**				
Type of course	**Core**		**Credit Value**	**3**	
Course code	**IMSC802PH**				
Name of Faculty					
Course Summary& Justification	The course comprises the theory and techniques fundamental problems in Nature From business transactions to basic execution program of computer, Mathematics become an inevitable part of life. This is an advanced Course on Mathematics which specifically for the need of understanding the complex scientific problems in physics.				
Semester	**VIII**				

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	54	18	-	10	82

Pre-requisite: Basic knowledge about integration, differentiation

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Students can understand the nature of problems and its periodicity. They would develop a skill to use the transform method for solving research problems	U	1
2	Students understands the concept of space and its role over the Astrodynamics	An	1,2
3	Develop a skill to formulate groups and to find the missing elements in the advanced level problems in particle physics and solid-state physics	C	2
4	Students understand to classify the differential equation and solve it with different approach and hence develop an analytical skill to formulate and find new methods to adapt.	C	2
5	Can develop analytical skill and confidence for approaching higher research problems	C	2,3

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Fourier Series, Fourier Transforms, Laplace Transforms** Fourier series – Dirichlet's conditions – Fourier series of even and odd functions – complex form of Fourier series – Fourier integral and its complex form – Fourier transforms – Fourier sine and cosine transforms –	18	1,2,3,5

	Convolution theorem and Parseval's identity – Laplace transform of elementary functions – Inverse Laplace transforms – methods of finding inverse Laplace transforms – Heaviside expansion formula – solutions of simple differential equations.		
2	**Differential Geometry, Elements of Probability Theory** Definition of tensors – metric tensor – covariant, contravariant and mixed tensors – differentiable manifolds and tensors – parallel transport – equation of geodesics –Christoffel symbols and curvature– Riemann curvature tensor – Ricci tensor and Ricci scalar. Elementary probability theory – random variables – Binomial, Poisson and Normal distributions – Central Limit Theorem.	18	1,2,3,5
3	**Group Theory** Definition of groups - examples – matrix groups – transformation groups – cosets – conjugacy classes – Lagrange's theorem – invariant subgroups – factor groups – homomorphism – homomorphism theorem – isomorphism – direct product of groups – representation of groups – matrix, faithful, unitary, reducible and irreducible representations – Schur's lemma – orthogonality theorem – Lie groups and Lie algebras – definition of Lie group – representation of SU(2) SO(3).	18	1,3,5
4	**Green's Functions** Definition and physical significance of Green's functions – translational invariance-eigen function expansion of Green's function-Green's functions for ordinary differential operators – first order linear differential operators and second order linear differential operators (eg forced harmonic oscillator)-Green's functions for partial differential operators – Laplace equation-solution of boundary value problems using Green's functions.	18	1-5

References

1. *Mathematical Methods in Classical &Quantum Physics, T Dass & S K Sharma, Uni. Press (1998)*
2. *Mathematical Methods for Physicists, G B Arfken & H J Weber, Elsevier; Seventh edition (2012)*
3. *Classical Theory of Fields, L D Landau & E M Lifshitz, 4th Edition (1980)*
4. *Mathematics for physicists, Susan M Lea, Brooks/Cole (2003)*
5. *Mathematical Methods for Physics and Engineering, K P Riley, M P Hobson S J Bence, Cambridge University Press; 3rd edition (2006)*
6. *Mathematical physics, Eugine Butkov Dover Publications Inc.; 3rd edition (2014)* *http://nptel.ac.in/courses/111105035/*
#Mathematics through ICT –(Students may experiment with) Geogebra Wolfram Alpha

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences**				
Programme	**Five Year Integrated M.Sc. (Physics)**				
Course Name	**Solid State Physics-II**				
Type of course	**Core**		**Credit Value**	**3**	
Course code	**IMSC803PH**				
Name of Faculty					
Course Summary& Justification	This course gives an introduction to solid state physics, and will enable the student to employ classical and quantum mechanical approaches to analyse physical properties of solids. The first part of the course is on "crystal lattice" focusing on crystal structure, lattice defects, lattice vibrations and lattice specific heat. This follows with the theory of semiconductor crystals. The last two units are devoted to study the magnetic, dielectric and superconducting properties of solids. The course explains the concepts that are used to describe the structure and physical properties of crystalline substances. Solid State Physics forms the theoretical basis of Materials Science, hence by studying Solid State Physics students will understand how the macroscopic properties of materials result from their microscopic, atomic scale properties.				
Semester	**VIII**				

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Learning Hours
	Others include: GD, Problems solving sessions, Seminars, Independent Learning etc.	54	18	-	10	82
Pre-requisite	Basic knowledge about atoms, molecules and properties of matter					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understand the basics of crystal structures	U	1
2	Formulate the theory of lattice vibrations (phonons) and use that to determine thermal properties of solids	An	1, 2
3	Understand the idea about semiconductor crystals	U	1
4	Evaluate the electrical and magnetic parameters of the solid	E	2
5	Think how to alter the properties of solids to make them suitable for particular applications	C	2, 3, 8
6	Apply the knowledge obtained to make a judicious choice of a solid in terms of its desired property	C	2, 3

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Crystal Lattice** Basics of crystal structures, Lattice defects: Point defects, Schottky and	18	1,5,6

	Frenkel defects – Equilibrium concentration of defects, Color centres. Line defects – Edge and screw dislocations, Dislocation energy, Plane defects. Lattice vibrations: Vibrations in one dimensional monatomic and diatomic lattices, Quantization of lattice vibrations, Phonon momentum. Inelastic scattering by phonons. Lattice heat capacity: Classical theory of specific heat, Einstein model, Debye model, Anharmonic crystal interactions.		
2	**Semiconductor Crystals** Band Gap, Equations of motion, Physical derivation of $\hbar k$=F, Holes, Effective mass, Physical interpretation of effective mass, Effective mass in semiconductors, Silicon and Germanium, Intrinsic carrier concentration, Intrinsic mobility, Impurity conductivity, Donor states, Acceptor states, Thermal ionization of Donors and Acceptors, Thermoelectric effects, semimetals, super lattices, Bloch Oscillator, Zener tunnelling.	16	2,5,6
3	**Magnetic properties** Diamagnetism and paramagnetism: Langevin's theory of diamagnetism and paramagnetism, Quantum theory of paramagnetism, Comparison with theory and experiment - Rare earth group and iron group ions, Paramagnetic susceptibility of conduction electrons. Ferromagnetism: Weiss molecular field theory, Heisenberg's exchange interaction, Ferromagnetic domains, Bloch wall, Spin waves, Dispersion relation for spin waves, Magnons, Magnon specific heat. Antiferromagnetism and ferrimagnetism. Two sub-lattice model of Anti ferromagnetism, Neel's model of ferrimagnetism.	20	4,5,6
4	**Dielectrics and Superconductivity** Fundamentals of Dielectrics, Dielectric polarizability, Clausius-Mossoti Relation, Types of polarizability, Frequency dependence of polarizability, Effects of Dielectrics, Ferroelectricity: Ferroelectric crystals and their properties, Classification of ferroelectric materials, Dipole theory of ferroelectricity, Basics of Superconductivity, BCS theory, Quantum Tunneling, Josephson's Tunneling, Theory of D.C. Josephson effect, Flux quantization, High Tc superconductors, Applications of Superconductors.	18	4,5,6

References

1. *Introduction to Solid State Physics, C Kittel, Wiley; Eighth edition (2012)*
2. *Solid State Physics, A J Dekker, Macmillan (1969)*
3. *Solid State Physics: Structure and Properties of Materials, M A Wahab, Narosa Publishing House Pvt. Ltd. - New Delhi, third edition (2015)*
4. *Elementary Solid State Physics, M Ali Omar, Pearson India; 1st edition (2002)*
5. *Principles of Solid State Physics, R A Levy, New York, Academic Press (1968)*
6. *Solid State Physics, N W Ashcroft and N D Mermin, Harcourt College Publishers (1968)*
7. *Solid State Physics, S.O. Pillai, New Age International Private Limited; Tenth edition (2022)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work

Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Statistical Mechanics**					
Type of course	**Core**		**Credit Value**		**3**	
Course code	**IMSC804PH**					
Name of Faculty						
Course Summary& Justification	Statistical Physics deals principally with equilibrium systems whose particles are either independent or effectively independent. It also treats equilibrium systems whose particles are strongly interacting as well as nonequilibrium systems. Statistical physics gives a rational understanding of Thermodynamics in terms of microscopic particles and their interactions. Statistical physics allows not only the calculation of the temperature dependence of thermodynamics quantities, such as the specific heats of solids for instance, but also of transport properties, the conduction of heat and electricity for example. Moreover, statistical physics in its modern form has given us a complete understanding of second-order phase transitions, and with Wilson's Renormalization Group theory we may calculate the scaling exponents observed in experiments on phase transitions. However, the field of statistical physics is in a phase of rapid change. New ideas and concepts permit a fresh approach to old problems. With new concepts we look for features ignored in previous experiments and find exciting results. Statistical physics, in fact, provides an intellectual framework and a systematic approach to the study of real-world systems with complicated interactions and feedback mechanisms. It is expected that the new concepts in statistical physics will eventually have a significant impact not only on other sciences, but also on the public sector to an extent that we may speak of as a paradigm shift.					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	54	18	-	10	82
Pre-requisite	Basic Quantum Mechanics, Thermodynamics and Basic Mathematical Physics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Conceptual ideas of ensemble formalism, particularly partition function and it's relation to thermodynamics properties	U, C	1,2
2	Different ensembles with examples	An	1,2
3	Thermodynamics of systems through ensemble formalism	U, C	1,2,3

4	Basics of probability theory and correlation to a statistical system	U, C	1,2,3
5	Concepts of phase transitions and theory	U, C	2,3
** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Thermodynamics and Statistical theory** Laws of thermodynamics and their consequences. Thermodynamic potentials and Maxwell's relations. Chemical potential. Phase equilibrium. The macroscopic and microscopic states, Contact between statistics and thermodynamics, The classical ideal gas, Entropy of mixing and the Gibb's paradox, Phase space of a classical system, Liouville's theorem and its consequences, The micro canonical ensemble, Quantum states and phase space, The equipartition theorem, The Virial theorem.	18	1,2
2	**The Canonical and Grand Canonical Ensembles** Equilibrium between a system and heat reservoir – a system in the canonical ensemble, Thermodynamical relations in a canonical ensemble, the classical systems, Energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble, Equilibrium between a system and a particle energy reservoir, A system in the grand canonical ensemble, Physical significance of statistical quantities, Density and energy fluctuations in the grand canonical ensemble: Correspondence with other ensembles.	18	1,3
3	**Quantum Statistics** Quantum mechanical basis, Statistical distribution, An ideal gas in quantum mechanical micro canonical ensemble and other quantum mechanical ensembles, Detailed balance, Partition functions and other thermodynamic quantities of mono-atomic and diatomic molecules. Thermodynamic behavior of a Bose gas, Thermodynamics of Black body radiation, The Planck distribution law, Bose Einstein condensation, Thermodynamic behavior of an ideal Fermi gas, Pauli paramagnetism, Electron gas in metals and thermionic emission.	18	1,2,3
4	**Theory of Phase Transitions and Fluctuations** Problem of condensation, Theory of Yang and Lee, Bragg – Williams approximation, comparison with experiment near transition temperature, Ising model and it's solution for a linear chain, Equivalence of the Ising model to other models, Lattice gas and binary alloy, Brownian motion, Langevin equation, Random walk problem, Diffusion equation, Introduction to non-equilibrium processes, Boltzmann transport equation.	18	1,2,4,5

References

1. *Statistical Mechanics, R K Pathria, Elsevier; 4th edition (2021)*
2. *Statistical Mechanics, K Huang, Wiley; Second edition (2008)*
3. *Statistical Mechanics, Donal A McQuarrie, Viva Books (2018)*
4. *Introductory Statistical Mechanics, Roger Bowley, OUP Oxford; 2nd edition (1999)*
5. *Statistical Mechanics and Properties of Matter, E S R Gopal, E. Horwood Ltd., Halsted Press, (1975)*
6. *Fundamentals of Statistical and Thermal Physics, Federick Reif, Sarat Book Distributors (2010)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Nuclear Physics II**					
Type of course	**Core**		**Credit Value**		**4**	
Course code	**IMSC805PH**					
Name of Faculty						
Course Summary& Justification	The forces that bind nuclei together, nuclear structures and dynamics, as well as nuclear reactions and their probabilities are studied in detail in this course. This is important to learn various nuclear reactions and associated energy release. The ideas on nuclear fusion and fission processes are explained and will be useful to conduct research on joint nuclear fusion programmes. Also, the smallest building blocks of the universe such as quarks will be discussed in detail here.					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	72	18	-	10	100
Pre-requisite	Graduate level Mathematics (Calculus, Vectors), Quantum Mechanics, Classical Mechanics, Electrodynamics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Use the knowledge of atomic physics and extend it to perceive the basic properties of the nucleus.	R, U	1, 2
2	Modeling a physical system from first principles of physics and compare it with the experimental outcome.	An	1, 2
3	Explain nuclear interactions based on scattering processes.	S	1, 2
4	Express different radioactive decays and hence calculate the half-times using various theories.	A	2, 6
5	Explain about the smallest building blocks of the universe and how modern science define it.	E	1, 5, 6

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Nuclear Structure and Models** Basic properties of nucleus - nuclear radius, Distribution of nuclear charge,	22	1, 2, 5

	Skin thickness, Isotope shift, Nuclear matter distribution, Nuclear binding energy, Magnetic dipole moment - quadrupole moment, Liquid drop model – Semi empirical mass formula of Weizsacker, Nuclear stability, Mass parabolas, Bohr- Wheeler theory of fission, Shell model - Spin-orbit coupling, Magic numbers, Elementary ideas of collective model.		
2	**Nuclear Interactions** Nuclear forces-Two body problem, Meson theory of nuclear forces – Yukawa potential, Nucleon-nucleon scattering, Effective range theory, Spin dependence, Charge independence and charge symmetry of nuclear forces, Isospin formalism.	20	1, 3, 5
3	**Nuclear reactions** Radioactivity, Types of reactions and conservation laws - Reaction dynamics-Q-value equation, Basics of alpha decay and Gamow's theory of Alpha decay, Beta decay and energetic of beta decay, Fermi's theory of Beta decay, Kurie plots, Mass of the neutrino, lifetime, Allowed and Forbidden transitions, selection rules and parity violation in beta decay, Neutrino physics, non-conservation of parity, Gamma decay - Internal conversion, Multipole moments, lifetimes, Energetics of fission process, controlled fission reactions, Fusion process and solar fusion, Nuclear radiation detectors.	24	1, 3, 5
4	**Particle Physics** Elementary particles, Types of interactions between - Hadrons and Leptons, Symmetry and conservation laws, Elementary ideas of CP and CPT invariance, Classification of Hadrons -SU (2) - SU (3) multiplets, Quark model, Gell-Mann-Okubo mass formula for octet and decuplet Hadrons, Quantum chromodynamics (QCD), Elementary ideas of standard model of weak interaction and QCD.	24	1, 4, 5

References

1. *Introductory Nuclear Physics, K S Krane, 3rd edition, Wiley (2022).*
2. *Nuclear Physics, D. C. Thayal, 5th edition, Himalaya Publishing House (2021).*
3. *Concepts of Elementary Particle Physics, M. E. Peskin, OUP Oxford (2019).*
4. *Nuclear Physics, I Kaplan, Narosa (2002).*
5. *Nuclear Physics:Theory and experiments, R.R. Roy and B.P. Nigam, 2nd edition, New Age International (2014).*
6. *Introductory Nuclear Physics, Samuel S M Wong, 2nd edition, Wiley (2013).*
7. *Nuclear Physics, S N Ghoshal, S Chand Publishing (2019).*
8. *Theory of Nuclear Structure, M K Pal, Affl. East-West (2008).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments,Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Surprise Tests Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Basic Astronomy**					
Type of course	**Elective**		**Credit Value**		**2**	
Course code	**IMSE807PH-1**					
Name of Faculty						
Course Summary& Justification	This course is aimed at teaching the student the basics of astronomy in addition to introducing the Sun, the nearest star, as an astronomical object. The teaching is to be aimed at bringing out the link between the physics/mathematics /statistics that has been/is being taught and the use it has been put to/found in the astronomical topics included in this course. A few online courses/sites that would supplement the curriculum as well as enhance the ability of the student to navigate online and pick up necessary information are also included to enhance and enrich the learning experience. This course is intended to be followed by the course 'Stars Galaxies &Cosmology', the two together giving the students a comprehensive introduction to the basics and methods of Astronomy & Astrophysics. The various units of the syllabus take the student through – (A) Measurements in astronomy and the units used, (B) The Sun as a star, (C) The basics of various types of telescopes, and (D) Generation and Transmission of Radiation.					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Good understanding of basic physics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understand basic direct measurements in astronomy.	R, U, An, E	1, 2, 7
2	Exploring and understanding the closest star.	R, U, An, Ap	1, 2, 3, 7
3	Understanding observing instruments and the process of data acquisition.	R, U, A, C, S	1, 3, 5
4	Understanding the imprint of physical conditions in the generation and transmission of radiation/particles/gravitational waves.	R, U, A, E, Ap	1, 2, 5, 7
5	Getting skilled in making inferences from observations through application of physical laws and modeling.	U, E, C, S	1, 4, 6, 8
6	Develop analytical abilities wrt the observational processes involved in astronomical data acquisition and their interpretation.	U, C, I, Ap	1, 3, 5, 7, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Basic Units and measurements** Co-ordinate systems - sidereal, solar, universal, standard and ephemeris times. Parallax, precession, nutation, aberration. Proper motion -radial and transverse velocities, space velocity. Units of distance - AU, light year and parsec. Magnitude scale -magnitudes and luminosities (apparent and absolute), color indices, surface temperature. Distance modulus - distances and radii of stars and the masses of stars.	14	
2	**The Sun as a star** Solar structure -photosphere, chromosphere and corona. Activity in the sun -sunspots, flares, solar oscillations, helio-seismology, CME's. The solar system –general characteristics, origin of the solar system, orbits of planets, satellites and comets.	12	
3	**The basics of various types of telescopes** Concepts of sensitivity, resolving power and signal to noise ratio. Optical telescopes-parts, different focii and mountings. Radio telescopes-Interferometers, synthesis telescopes, VLBI. X-ray astronomy - detection and collimation. Infra-red, gamma ray, neutrino and gravitational-wave detectors (basics only). CCD's as detectors.	12	
4	**Generation and Transmission of Radiation** Radiation mechanisms -Lienard-Wiechert potentials and fields for a point charge, total power radiated by a point charge, Larmor formula and relativistic generalization (all without detailed derivations). Black body, bremsstrahlung, cyclotron, synchrotron, curvature, plasma and inverse Compton radiation. Interstellar extinction - the 21cm line of Hydrogen. Transmission through an ionized medium -Faraday rotation. Doppler, cosmological and gravitational redshifts	16	

References

1. *Textbook of astronomy and astrophysics with elements of cosmology, V.B.Bhatia, Narosa publishing house (2001).*
2. *Astrophysics - Stars and Galaxies, K. D. Abhyankar, University Press (2001).*
3. *Astrophysics, Baidyanath Basu, 2nd edition, Prentice Hall India Learning Private Limited (1905).*
4. *The Physical Universe F. H. Shu, University Science Books (1981).*

http://study.com/articles/5_Sources_for_Free_Astronomy_Education_Online.html
https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/

***Astronomy & Astrophysics through ICT** –(Students may experiment with)*
Stellarium, SciPOP -IUCAA, https://arxiv.org/abs/1402.3674

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar, Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**X-Ray Crystallography**		
Type of course	**Core**	**Credit Value**	**2**
Course code	**IMSE807PH-2**		
Name of Faculty			
Course Summary& Justification	Invention of X-ray and the development of crystallography have opened up various disciplines in science including solid state physics. Crystallography is an unambiguous technique for the structure determination of molecules and identifying intermolecular interactions. The main objective of this course is to understand the basic concepts of x-ray diffraction from matter and its applications in molecular structure determination and identification of molecular assemblies. The properties of molecules are closely related to their structure. Topics dealing in this course have numerous applications in industry, material science, molecular biology and medicine.		
Semester	**VIII**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Basic knowledge about concept of atoms, molecules, energy levels, electron distribution, quantum mechanics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Knowledge of crystal growth of various types of molecules.	U	1
2	Basic theory of diffraction from crystals, powder and glassy materials	An	1,2
3	Explain the data collection strategies, data analysis and structure determination	C	2
4	Accuracy of structure determination and calculation of molecular geometry and intermolecular interactions.	C	2
5	Develop skills for the structural characterisation and molecular assembly in crystals, powder and amorphous samples.	C	2,3

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Crystallization methods and processes**	14	1

	Crystal nucleation and growth, Types of crystallization: Slow Cooling from solution and the melt, Slow Evaporation, Vapour diffusion methods, Liquid-liquid diffusion, Gel growth method. Macromolecular crystallization methods: Factors affecting crystal nucleation and growth. Solvents used in crystallization and its solubility factors.		
2	**X-ray Diffraction theory** Concept of lattice and reciprocal lattice, Bragg's law in reciprocal space, point groups and space groups. Diffraction of X-rays from an electron, an atom, 1D lattice and a crystal. Atomic scattering factor and structure factor, Intensity of scattering from an hkl plane and various factors affecting the intensity. Elementary ideas about neutron and electron diffraction.	14	2
3	**Structure Determination methods** X-ray data collection strategies, Determination of symmetry and space group from diffraction data. Fourier transform and calculation of electron density. Phase Problem in crystallography, Structure determination from X-ray data: Direct method, Intrinsic phasing method, Heavy atom method, Equal atom method, Molecular replacement methods, anomalous scattering and absolute structure determination.	13	3,5
4	**Accuracy and structure refinement** The determination of unit cell parameters, Structure refinement strategies, Least-squares refinement based on F and F2, isotropic and anisotropic refinement strategies. Disorder: substitutional and positional disorder, refinement of disorder. Twinning: merohedral, pseudo- merohedral and non- merohedral twinning, twin law and component identification and refinements. Calculation of Geometrical parameters and estimated standard deviation. Error estimation in the data and the final structure validation.	13	4,5

References

1. *An introduction to X-ray crystallography, M. M. Woolfson, Cambridge University Press; 2nd edition (1997)*
2. *Elements of X-ray crystallography, L. A. Azaroff, International Union of Crystallography (IUCr) (November 1970)*
3. *X-ray Structure Determination, Stout & Jensen, Wiley, 2nd edition (1989)*
4. *Protein Crystallography, Blundel & Johnson, Elsevier Science, (1976)*
5. *Crystal Structure Refinement A Crystallographer's guide to SHELXL, P. Muller, R. Herbst- Irmer, A. L Spek, T. R. Schneider, M. R. Sawaya, Oxford University Press (2006)*
6. *SHELX Manual, G. M. Sheldrick*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Test, Assignments, Seminar Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Laser Plasma**		
Type of course	**Elective**	**Credit Value**	**2**
Course code	**IMSE807PH-3**		
Name of Faculty			
Course Summary& Justification	Laser-Matter interactions are being used for physical evaporation/deposition and spectroscopic applications in Science, in addition to many industrial applications. The course extends the fundamental understanding of production of laser plasma, its diagnostics and interactions. It deals with the concept of temperature, Debye shielding and different plasma parameters. Further, it covers the resonance absorption, basic equations in laser heating of plasma, impact of strong radiation in plasma. Creation of plasma by means of laser ablation, characterization and its spectroscopic applications are being trained.		
Semester	**VIII**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	15	69
Pre-requisite	Fundamentals of Laser and Solid State Physics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Introduction to laser plasma, its diagnostics and applications	R, U	1, 3
2	Discuss the laser-plasma interactions and new processes due to high intense light interactions	U, An	1, 5
3	Explain the laser ablation process on solid targets, under vacuum and liquid environment	U, S	1
4	Spectroscopic applications of laser produced plasma	U, An	1, 3
5	Use the theorems and laws to predict the macroscopic measurements of laser produced plasma	A	1, 3, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Basic Plasma Properties** Introduction to plasma, Tunnel and over- the- barrier ionization, Electrons in the intense laser field, Definition of Plasma, Concept of temperature, Debye shielding and different plasma parameters, Criteria	12	1, 5

	for Plasma, space field of charge, Relation of plasma physics to ordinary electromagnetics, The dielectric constant of plasma, Mixture of fluids of positive and negative charges, Some aspects of waves in plasmas.		
2	**Laser Plasma Interactions** Light matter interaction, Multi-photon ionization, The stimulated Raman Scattering (SRS) and Stimulated Brillouin Scattering (SBS) in Laser Plasma Interaction, Parametric interaction of three waves, Laser produced Plasma, Different processes in plasma: Free-free process, Bound-free process, Auto ionization and dielectric recombination, Bound-bound transitions, Resonance absorption, Basic equations in laser heating of plasmas, Impact of strong radiation in plasma.	14	2, 5
3	**Laser Ablation** Laser ablation of the target material and creation of plasma, Dynamic processes during laser plasma generation on solid planar targets, Processes governing formation and acceleration of charged particles in laser plasma namely multiply charged heavy ions, Characterization of Laser ablation plasmas. Concepts of Nucleation and cavitation, Spherical bubble dynamics, Cavitation bubble collapse, Dynamics of oscillating bubbles. Applications: Laser generation of plasma jets for applications in laboratory astrophysics, Plasma TV, Inertial Confinement Fusion, Pulsed laser deposition.	12	3, 2, 5
4	**Plasma Spectroscopy & Diagnostic Techniques** Fundamentals, Basic requirements for laser induced break down spectroscopy, Spectroscopic density measurement, Spectroscopic temperature measurements, Diagnostic applications of plasma spectroscopy, High resolution imaging of nanostructures. Basic macroscopic measurements: Electrical measurements, Pressure and momentum measurements, Langmuir probe, Other macroscopic Techniques, Magnetic diagnostics: Magnetic field measurement, Components and component parameters, Typical magnetic probe experiments, Electrical Probes: Sheath formation, The Line broadening mechanism in plasma, Application of Doppler Broadening to the measurement of atom and ion temperature, Diagnostic of dense plasma. Experimental probing of cavitation and bubbling.	16	1, 2, 4, 5

References

1. *Introduction to Plasma Physics and Controlled Fusion, Francis F Chen, Second Edition (1929)*
2. *Principles of Plasma Mechanics, Bishwanath Chakraborty, Wiley Eastern Limited (1990)*
3. *Plasma Diagnostic Techniques, Richard H Huddlestone and Stanley L Leonard (1965)*
4. *Principles of Plasma Spectroscopy, Hans R Griem, Cambridge University press (1997)*
5. *Principles of Plasma diagnostics, I H Hutchinson, Cambridge University Press (1987)*
6. *Cavitation and BUBBLE Dynamics, Christopher Earls Brennen, Oxford University Press(1995)*
7. *Introduction to Laser-Plasma Interactions, Pierre Michel, Graduate Texts in Physics (GTP) (2023)*
8. *Laser-Plasma Interactions and Applications, Paul McKenna, David Neely, Robert Bingham, Dino Jaroszynski, Scottish Graduate Series (2015)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work

Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Plasma Physics**					
Type of course	**Elective**			**Credit Value**	**2**	
Course code	**IMSE807PH-4**					
Name of Faculty						
Course Summary& Justification	Plasmas are so much a part of our daily lives. The field of Plasma physics is very diverse with lot many applications and a lot many career opportunities. This course of 'Plasma Physics' equips students with the necessary knowledge understand various processes in nature and design the fusion-based devices. The course comprises the theory and applications of plasma physics. Students are introduced to the systems of plasma and understand the natural and laboratory plasma and its application to both the Astrophysical and industrial devices					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	15	69
Pre-requisite	Basic knowledge in Electrodynamics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Make a better understanding of the basics of plasma physics	U	2
2	Understanding plasma as describing as Fluid will enhance the knowledge of fluid systems both in the Astrophysical and Laboratory plasmas	An	3
3	Studying the plasma with Kinetic theory would enhance the theoretical aspects of particle dynamics and its effects on various systems	C	3
4	Understanding various types waves in nature and the energy transfer mechanism in the various plasmas	C	6
5	The subject's completion would enhance the analytical power of the students to understand plasma systems and give the ability to formulate and solve the problems in both Astrophysical and Laboratory plasmas	C, An	4, 5, 8

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Introduction and Single Particle Motions** Occurrence of Plasmas in Nature, Definition of Plasma, Concept of Temperature, Debye Shielding, The Plasma Parameter, Criteria for Plasmas, Applications of Plasma Physics, Motion in uniform ***E** and* ***B*** Fields, ***E x B*** and Gravitational drifts, Motion in non-uniform ***B*** Field, Gradient and Curvature drifts, Magnetic Mirrors, Motion in time varying ***E*** Field, Motion in time varying ***B*** Field, Summary of Guiding Center Drifts.	14	1, 5
2	**Waves in Plasmas** Relation of Plasma to Ordinary Electromagnetics, The Fluid Equation of Motion, Representation of Waves, Group Velocity, Plasma Oscillations, Electron Plasma Waves, Ion Waves, Validity of Plasma Approximation, Comparison of Ion and Electron Waves, Electrostatic Electron Oscillations Perpendicular to ***B***, Electrostatic ion Waves Perpendicular to *B* - The Lower Hybrid Frequency. Electromagnetic Waves with $\mathbf{B_0} = 0$, Electromagnetic Waves Perpendicular to $\mathbf{B_0}$ - Cutoffs and Resonances.	14	2, 5
3	**Plasma Waves, Equilibrium and Stability** Electromagnetic Waves Parallel to $\mathbf{B_0}$, Hydro magnetic Waves, Alfven waves, Magneto sonic Waves, Hydro-magnetic Equilibrium, Concept of plasma β, Classification of Instabilities, The Two Stream Instability and the Gravitational Instability.	12	3, 5
4	**Nonlinear Plasma Physics** Parametric Instabilities – Coupled Oscillators, Frequency Matching, Instability Threshold and Growth Rate – Equations of Nonlinear Plasma Physics– Nonlinear Ion Acoustic waves – the Korteweg – deVries equation. The Ponderomotive Force - Nonlinear Electron Plasma waves – the Nonlinear Schrodinger equation.	14	4, 5

References

1. *Introduction to Plasma Physics and Controlled Fusion F. F. Chen, Springer Nature; 3rd ed. edition (2016)*
2. *Introduction to Plasma Theory – D. R. Nicholson 1 st edition, John Wiley & Sons (1983)*
3. *Chaos and Structures in Nonlinear Plasmas W. Horton & Y. H. Ichikawa, World Scientific Pub Co Inc. (1996)*
4. *Fundamentals of Plasma Physics – J. A. Bittencourt, Springer; 3rd ed. (2004)*
5. *Fundamentals of Plasma Physics – Paul M. Bellan, Cambridge University Press (2006)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**General Theory of Relativity**					
Type of course	**Elective**			**Credit Value**	**2**	
Course code	**IMSE807PH-5**					
Name of Faculty						
Course Summary& Justification	The course provides a comprehensive introduction to the general theory of relativity, including the principle of equivalence, the Schwartzschild metric, black holes, and the stellar structures and cosmology. General theory of relativity formalizes Einstein's revelation that gravity is not a force in the Newtonian sense but is instead a manifestation of the 4-dimensional geometry of space-time being curved by massive bodies. This course will explore topics that are frequently used in current research in gravitation theory. Einstein's general relativity is increasingly important in contemporary physics on the frontiers of both the very largest distance scales (astrophysics and cosmology) and the very smallest (elementary particle physics).					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Good understanding of basic physics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understand basic concepts of the General Relativity Theory and its applications.	U, R	1
2	Master the equivalence principle and have a good knowledge of how this leads to a geometric description of gravity, in the form of the general theory of gravity.	U, An	1, 2
3	Acquire detailed knowledge about how space and time are curved for spherically symmetric mass distributions, and can solve practical problems in such geometries.	U, An, Ap	1, 2
4	The fourth module of the course will help the student to understand the stellar structures, expansion and thermal nature of the universe.	U, R	1
5	Gain knowledge of Einstein's general relativity and some modern research areas and expertise in solving problems with appropriate methods.	E, S	1, 2, 3, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Special theory of Relativity and General Tensors** Introduction to Special theory of Relativity, Length contraction and Time dilation, Relativistic velocity and Energy momentum Equation; Tensor Notation and General tensors- Metric tensor-Riemann tensor - Ricci tensor.	12	1, 5
2	**Influence of gravitation on Physical systems** Principle of equivalence – Principle of general covariance- Maxwell's equation with gravitation - Representation of Energy Momentum Equation; Derivation of Energy and Momentum tensor; Action integral - Einstein equations from the action integral - Newtonianlimit of Einstein's equations.	14	1, 2, 5
3	**Schwarzschild Line Element and its consequences** Einstein Equation for a Centrally Symmetric gravitational fields; Schwarzschild Solution for centrally Symmetric gravitational Fields – Singularities – Motion in a centrally symmetric gravitational field with application to the Planetary motion; Perihelion shift of mercury and Saturn and Earth - Deflection of light- gravitational slowing down of light and Schwarzschild radius; gravitational waves – propagation of gravitational waves.	16	2, 3, 5
4	**Stellar structures and Cosmology** Relativistic equation of stellar structures-Newtonian stars-white dwarfs Neutron stars; General Relativistic instability; Spherical Collapse; Black holes and the Kerr Metric; Cosmological Principles- the Robertson – Walker metric and Exp	12	4, 5

References

1. *Gravity: An Introduction to Einstein's General Relativity, J. Hartle, Cambridge University Press (2021).*
2. *Spacetime and Geometry, S. Carroll, Addison Wesley, (2004).*
3. *General Relativity: An Introduction for Physicists, M. P. Hobson, G. P. Efstathiou and A. N. Lasenby, Cambridge University Press (2006).*
4. *Gravitational Waves, Maggiore, Oxford Press (2008).*
5. *A First Course in General Relativity (2nd Edition), B. Schutz, Cambridge University Press (2009).*
6. *Gravitation: Foundation and Frontiers, T. Padmanabhan, Cambridge University Press (2010).*
7. *Einstein Gravity in a Nutshell, A. Zee, Princeton University Press, (2013).*
8. *Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, Steven Weinberg, Wiley, (2008)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar, Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Thin Film Science**		
Type of course	**Elective**	**Credit Value**	**2**
Course code	**IMSE807PH-6**		
Name of Faculty			
Course Summary& Justification	Thin film is a deposited layer of material with size ranges from fractions of a nanometer to several micrometers in thickness. The controlled synthesis of materials as thin films to create layers (monolayer or multilayers) is a fundamental step in 20^{th} century and has enabled a wide range of technological breakthroughs in many areas in industry. Nucleation is an important step in growth; that helps to determine the final structure/layer/thickness of a thin film. Many growth methods rely on nucleation control such as atomic layer deposition. Nucleation and growth of deposited films can be characterized either by in situ/ex situ measurements. Modelling of the nucleation process can be evaluated by characterizing surface process of adsorption, desorption and surface diffusion.		
Semester	**VIII**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	10	64
Pre-requisite	Basic undestanding of Materials Science					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Discuss the concept of nucleation and thin film growth	R,U	1, 2
2	Draw the attention types of Physical and Chemical ways of deposition/growth of thin films	U, An	2, 3, 5
3	Explain the characterization techniques to understand the thickness, structural morphology and composition of thin films	A, An, S	4, 5, 6
4	Discuss the applications of thin films including Electronics industry, Bio-Medical industry and Photovoltaic cell etc.	An, E	4, 5, 6, 7, 8
5	To understand the effect of deposition parameters; it explains atomistic theory and rate equation approach of nucleation	A, E	1, 2, 3, 5

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Introduction to thin films** Concept of nucleation and film growth, Types, and properties of films - Amorphous, poly crystalline, Epitaxial, Inorganic, Organic, Metallic, Semiconducting, Insulating, Magnetic, Superconducting, Transparent, Transparent conducting, Piezoelectric, Multiferroic, etc.	14	1, 5
2	**Deposition Methods I** Introduction to physical vapor deposition (PVD) methods, Introduction to vacuum systems, Rotary and turbomolecular pumps, Penning and Pirani gauges, Thermal Evaporation deposition, DC/RF Sputtering deposition, Magnetron Sputtering, Pulsed Laser Deposition.	12	2, 5
3	**Deposition Methods II** Introduction to chemical methods of deposition, Dip coating, Chemical bath deposition, Sol-gel Spin coating, drop casting, Chemical Vapor deposition (CVD), Thermal activated CVD, Plasma enhanced CVD, Metal organic CVD.	12	1, 5
4	**Characterization techniques** Introduction to the types of characterizations, X-ray diffraction, UV-Vis-NIR spectroscopy, Photoluminescence, X-ray photoelectron spectroscopy, Scanning Electron Microscopy, Transmission Electron Microscopy, Electrometer measurements	14	3, 4, 5
5	**Technological Applications and challenges of thin films** In and as, Optical coatings, Anti-corrosion and anti-oxidant layers, Resistors, Diodes, Transistors, Capacitors, MOSFET, CMOS, Data storage devices, Photovoltaic cells, Heat Reflector, Piezoelectric devices, Biomedical devices, etc.	12	1, 2, 3, 5

References

1. *The Materials Science of Thin Films, Milton Ohring, Academic Press Sanden (1992)*
2. *Handbook of Thin Film Technology, L. I. Maissel and Glang,McGraw Hill Higher Education (1970)*
3. *Thin Film Phenomena, Kasturi L. Chopra, Mc Graw Hill (NewYork)(1969)*
4. *Thin Film Deposition properties; Principles and practices, Denald L. Smith, Mc. Grow Hill, Inc. (1995)*
5. *Vacuum deposition of thin films, L. Holland, Chapman and Hall (1956)*
6. *Physical Vapor Deposition of Thin Film, John E. Mohan, John Wiley & Sons (2000)*
7. *Handbook of Vacuum Science and Technology, Dorothy Hoffman, Academic Press (1997)*
8. *Materials Science and Engineering: An Introduction- 6th Ed. William D. Callister, Jr., J Wiley & Sons, Inc (2003)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Semiconductor Materials and Devices**		
Type of course	**Electives**	**Credit Value**	**2**
Course code	**IMSE807PH-7**		
Name of Faculty			
Course Summary& Justification	The course mainly comprises the physics behind the behavior/properties of semiconductor materials under equilibrium and nonequilibrium conditions. Methods for growing semiconductor crystals have also been discussed. Semiconductors have the unique ability to act either as insulators or as conductors, at different ambiences. This unique feature makes semiconductors pivotal in modern industries/ technologies. Without semiconductors, transistors, integrated circuits, solar cells, and many other electronic/optoelectronic devices would not have existed. To understand the changing nature of semiconductor materials and industry and to manufacture them for various applications, it's necessary to understand the physics of existing semiconductor materials. This course of semiconductor materials equips students with the necessary knowledge of semiconductors and helps them to design and develop new materials and then devices.		
Semester	**IX**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	10	64

Pre-requisite	Basic knowledge about energy bands in crystals, types of solids, concept of electrons, holes and photons

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Make a better understanding of the basics of semiconductor materials	R, U	1
2	Analyse the different carrier transport mechanisms and effects in semiconductors	U, An	1, 2
3	Understand the various methods of semiconductor material growth	An	1, 2
4	Develop, at least conceptually, new semiconductor devices with various electrical and optical properties	C	2, 3, 4, 6, 7, 8

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Introduction to Semiconductors** Energy bands in solids, Elemental and compound semiconductors, Intrinsic and extrinsic semiconductors, Energy bands of n-type and p-type semiconductors, Amphoteric dopants, Variation of energy bands with alloy composition, Effective mass of charge carriers, Carrier concentration at thermal equilibrium, Direct and indirect semiconductors, Density of states, Fermi level, Carrier mobility, Current density, Conductivity and Resistivity of semiconductors, Invariance of Fermi level in a heterogeneous system at equilibrium. Excess carrier generation via optical absorption, Excess carrier recombination via luminescence, Photoconductivity.	22	1, 2, 5
2	**p-n junctions** Properties of an equilibrium p-n junction, Space charge and electric field distribution within the transition region, Doping concentration and width of deletion region, P-N junction under forward bias, Diode equation, P-N junction under reverse bias, Capacitance of p-n junctions, Junction capacitance, Heterojunctions, Band diagram of heterojunctions.	23	1, 2, 3, 5
3	**Optoelectronic device applications** P-N junction photodiodes, Optical generation of carriers in a p-n junction, Current and voltage in an illuminated junction, Photovoltaic effect, I-V characteristics, Solar cells, Short circuit current, Open circuit voltage, Fill factor, Photodetectors, Depletion layer photodiode, p-i-n photodetector, Avalanche photodiodes, Intrinsic and extrinsic detectors, Gain, bandwidth and signal to noise ratio of photodetectors, Light emitting diodes, Injection electroluminescence, Internal radiative efficiency, Extraction efficiency, External quantum efficiency, Fiber optic communication, Step index and graded index fibers, Single mode and multimode fibers, Losses in fibers, Semiconductor Lasers, Population inversion at a junction, Emission spectra for p-n junction lasers, Homojunction and heterojunction lasers, Semiconductor materials used for optoelectronic device fabrication.	25	1, 3, 4, 5

References

1. *Introduction to Semiconductor Materials and Devices, Tyagi, Wiley Publications (2002)*
2. *Semiconductor Devices, Basic Principles Jasprit Singh, Wiley Publications (2001)*
3. *Physics of Semiconductor Devices 3/e S. M. Sze, Wiley Publications (2007)*
4. *Semiconductor Physics and devices by Donald A Neamen&Dhrubes Biswas, McGraw Hill Education; 4th edition (2017)*
5. *Semiconductor materials & devices by D.N. Bose, New Age Int.Private Limited (2012)*
6. *Optoelectronics: An intro. to materials&devices, Jasprit Singh, McGraw-Hill Inc., US (1996)*
7. *Introduction to solid state physics by Charles Kittel, Wiley; 8th edition (2012)*
8. *Solid state physics by S.O. Pillai, New Age International; 8th edition (2018)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work

Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Nanophotonics**					
Type of course	**Elective**		**Credit Value**		**2**	
Course code	**IMSE807PH-8**					
Name of Faculty						
Course Summary& Justification	Nanophotonics investigates the behavior of light on nanometer scale as well as the interactions of nanometer-sized objects with light. The field is considered as a branch of nanotechnology, photonics, electrical engineering, optics and optical engineering. Nanophotonics is a very active field of research. The understanding of fundamental phenomena and the progress in technologies have already been made possible numerous applications but a large number of new applications will certainly come in the near future. The 21st century will be the century of nanophotonics. A significant multidisciplinary challenge lies ahead for the broader nanophotonics visions to become reality. These challenges require a significant increase in the number of knowledgeable researchers and trained personnel in this field. This need can be met by providing training for the future generation of researchers at graduate level.					
Semester	**VIII**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	15	69
Pre-requisite	Basic knowledge about Electromagnetic waves, Ray and Wave Optics, Photonics and Nanotechnology					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Make a better understanding of the basics of electrodynamics and photonics	R, U	1
2	Distinguish/analyse the types of nanomaterials	U, An	1, 2
3	Understand light – matter interaction at nanoscale	U	1, 2
4	Understand the working of optoelectronic devices	U	1, 2
5	Develop, at least conceptually, a new Nanophotonic device	C	2, 3, 7, 8

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Fundamentals of photonics and photonic devices** Fundamentals of photonics and photonic devices – lasers (population inversion, pumping, nanolasers), LEDs (inorganic, organic and polymer LEDs), Optical modulators (acousto-opticand electro-optic), optical fibres and fibre optic components, Frequency conversion, Introduction to Nanophotonics, scope, Propagation and confinement of photons and electrons, tunneling, band gap, Quantum confinement effects, interaction dynamics, electronic energy transfer and emission.	16	1, 2, 5
2	**Near field optics** Near field optics and Near field scanning optical microscopy, Fundamentals of Near field microscopy, aperture and aperture-less techniques, near-field probes, Quantum dots, Single molecule spectroscopy, Non-linear optical processes, Aperture-less NSOM, nanoscale enhancement, Time-resolved studies, Heterostructures.	13	1, 3, 5
3	**Introduction to plasmonics** Introduction to plasmonics, metallic nanoparticles and nanorods, metallic nanoshells, local field enhancement, sub-wavelength aperture plasmonics, plasmonic wave guiding, applications of metallic nanostructures, Evanescent wave excitation, dielectric sensitivity, and radioactive decay engineering, metal dipole interaction.	13	1, 4, 5
4	**Introduction to photonic crystals** Introduction to photonic crystals, Modelling of photonic crystals, Photonic crystal optical circuitry, Non-linear photonic crystals, Photonic crystal fibres, Applications in communication and sensing, Near field imaging of biological systems, Nanoparticles for optical diagnosis, up converting nanophores for bioimaging.	12	1, 4, 5

References

1. *Nanophotonics, Paras. N. Prasad, Wiley (2004)*
2. *Nanophotonics with surface plasmons, Vladimir.M.Shalaev, Stoshi Kawata, Elsevier (2006)*
3. *Principles of Nanophotonics, Motoichi Ohtsu, Kiyoshi Kobayashi, Makato Naruse,Taylor & Francis; 1 edition (2008)*
4. *Photonic devices, Jia Ming Liu, Cambridge University Press; Reissue edition (2009)*
5. *Integrated Photonics: Fundamantals, Gines Lifante, Wiley; 1 edition (2003)*
6. *Photonic crystals, Kurt Busch, Stefan Lolkes, Wiley (2006)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Surprise Test Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Quantum Mechanics II**					
Type of course	**Core**		**Credit Value**	**4**		
Course code	**IMSC901PH**					
Name of Faculty						
Course Summary& Justification	The course covers advanced topics in quantum mechanics that find application in almost all other branches of modern physics. It includes the application of quantum mechanics to scattering experiments, which help probing the nature of fundamental interactions between microparticles at the subatomic level. It also extends the student's knowledge in single particle quantum systems to many particle systems consisting of bosons and fermions. The mathematical skills of the student are enhanced by way of solving the Schrodinger equation for physical systems that experience time-dependent potentials. The application of the theory of relativity to quantum mechanics is covered and the new insights provided by the theory are discussed. An introductory review of quantum field theory helps to realise how theoretical physics explains several properties of fundamental particles, which are the building blocks of the physical world.					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	72	18	-	10	100
Pre-requisite	Basic understanding of the fundamental postulates of quantum mechanics and workingknowledge in its general formalism, including that of representations, stationary states, approximation methods and angular momentum theory.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	The student should be able to remember both the definitions of basic measurable quantities in scattering experiments and how these quantities are predicted with the help of quantum theory. Various techniques of time-dependent perturbation theory are to be memorized. The quantum nature of many particle systems consisting of identical particles, the statistics obeyed by them, the relativistic formulation of quantum theory, and introductory quantum field theory are also studied and remembered.	R	1
2	The first Unit of the course will help the student to understand under what conditions the Born approximation and the partial wave approach are useful in scattering experiments. The Unit on identical particles will help to understand the origin of Bose-Einstein and Fermi-Dirac statistics obeyed by fundamental particles. The relativistic formulation of quantum mechanics explains particle-antiparticle pair production and annihilation	U	1

	and the origin of intrinsic spin of electrons. The student will find Quantum field theory helpful in understanding several properties of fundamental particles of nature.		
3	The student becomes capable of applying the quantum scattering theory in probing the nature of interaction potentials between target and incident particles. They will also be able to apply time-dependent perturbation theory to obtain transition rates, when atomic electrons interact with radiation.	A	1, 2
4	The analysis of wavefunctions of a system of particles leads to the understanding of the statistics obeyed by them. Similarly, analysing the solutions of relativistic wave equations and the quantisation of the resulting fields help to obtain deep insights into the properties of fundamental particles.	An	1, 2
5	The relative merits of Born approximation and partial wave analysis, while applying them to concrete problems, are subject to evaluation. Similarly, the advantage of time-dependent perturbation theory in evaluating transition probabilities for electrons in atoms are studied.	E	1, 2
6	Various kinds of many particle wave functions, for distinguishable and indistinguishable particles, are created by the students. Their creative ability to solve the fundamental problem of solving the Schrodinger equation is extended to time-dependent problems also.	C	1, 2
7	Skills are developed for solving the Schrodinger equation of many particle systems. Skills for making approximations in the quantum theoretical evaluation of scattering amplitudes and transition probabilities are also imparted.	S	1, 2
8	The course is expected to arouse the interest of the student in understanding the properties of fundamental particles, the quantum behavior of systems of identical particles, the new insights obtained by applying relativity to quantum mechanics and by quantizing the resulting relativistic fields. The Units on Scattering theory and Approximation methods is to help the students in appreciating the role of experiments in physics. In general, they will appreciate the satisfactory explanation of several properties of subatomic and fundamental particles that make up the microworld.	I, Ap	1, 2
** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Scattering Theory** Scattering Cross Sections; Laboratory and CM reference frames – connecting angles and cross-sections; Scattering amplitude of spin-less particles; Scattering Amplitude and Differential cross section - Total scattering cross section; Born Approximation – First Born Approximation – Validity of Born Approximation; Scattering by Coulomb potential; Partial wave analysis for elastic and inelastic scattering; Optical theorem; Scattering by a square wellpotential.	18	1, 2, 3
2	**Identical Particles** The Indistinguishability Principle; Symmetry of wave functions; Spin and Statistics; The Pauli's Exclusion principle; Scattering of identical	18	2, 4, 6, 8

	particles; Spin function for many electron systems; Slater determinants; Sate vector space for a system of Identical particles – Creation and Annihilation Operators – Fermions and Bosons.		
3	**Approximation Methods** Variational method. Time Dependent Perturbation theory - Transition probabilities for constant and harmonic perturbations; Adiabatic and Sudden approximations – Interaction of atoms with radiation – Classical treatment of the incident radiation; Transition rates for Absorption and Emission of radiation – Transition rates within the dipole approximation – Spontaneous emission.	20	1, 5, 8
4	**Relativistic Quantum Mechanics** Klein-Gordon equation; Difficulties with the Klein-Gordon equation; First order wave equations Dirac equation – Free Dirac Particle ; Equation of continuity - Non-relativistic limit of Dirac equation; Spin and orbital angular momentum of the electron from Dirac equation – Hole theory	16	1, 5, 8
5	**Quantum Field Theory** Lagrangian Field theory – Classical field equations - Hamiltonian formulation; Quantization of the field – Bosons and Fermions – Relativistic fields – Quantization of the Klein – Gordon, Dirac and electromagnetic fields - Gupta-Bleular formalism.	18	7, 8

References

1. *Quantum Mechanics - Concepts and Applications, N Zettilli, 2nd edition, Wiley (2009).*
2. *Modern Quantum Mechanics, J. J. Sakurai, 3rd edition, Cambridge University Press (2020).*
3. *Quantum Mechanics, V M Thankappan, 5th edition, New Age International (2019).*
4. *Quantum Mechanics, E Merzbacher , 3rd edition, Wiley (2011).*
5. *Quantum Field Theory, L.Ryder, Cambridge University Press (1986).*
6. *Quantum Field Theory, C.Itzykson and J.Zuber, Dover Publications Inc., (2006).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Surprise Tests Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Spectroscopy**					
Type of course	**Core**			**Credit Value**	**4**	
Course code	**IMSC902PH**					
Name of Faculty						
Course Summary& Justification	The topics, Lasers and Spectroscopy have played an integral role in developing quantum mechanics leading to identify the constituents of matter. The main objective of this course is to understand the origin of the quantum nature of atomic and molecular energy levels. More over this course explores the interaction of Matter with EM radiation leading its application in molecular structure determination. This course also aims to give the basics of lasing action and a detailed working principle of different laser systems					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	72	18	-	10	100
Pre-requisite	Basic knowledge about concept of atoms, molecules, energy levels, electron distribution, quantum mechanics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Capable of writing rate equations of three-level and four-level laser systems, describe the working principle of specific laser systems and their applications	R, U	1
2	Knowledge of the electronic energy states in atoms in terms of quantum numbers, origin of spectra and the consequence of spin orbit coupling, effect of magnetic and electric fields, and the interpretation of term symbols	U, An	1, 2
3	Explain the transitions between rotational, vibrational and electronic states of molecules, spectra of molecules and their use in molecular structure determination	C	2
4	Distinguish different spectroscopic techniques (absorption, fluorescence, Raman, NMR, and EPR)	C	2
5	Develop skills to characterize and identify the structure of molecules	C	2, 3

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Atomic Spectroscopy** Quantum numbers and spectroscopic terms, spin orbit interaction, Lande g factor, Equivalent and nonequivalent electrons, Zeemen effect and Paschen Back effect, LS and JJ coupling schemes, Hunds rule, Examples of LS and JJ coupling, Lande intervel rule, Stark effect-hyperfine structure.	22	1, 2, 3
2	**Microwave, IR and Raman spectroscopy** Different types of molecules, rotational spectra of diatomic molecules, intensity of spectral lines, Isotopic substitution, non-rigid rotator. Diatomic molecules as harmonic and an- harmonic oscillators, diatomic vibrating rotator, spectrum of CO and CO_2 molecules,Rotational Raman spectra, vibrational Raman spectra, Mutual exclusion principle, structure determination from Raman and IR spectroscopy, Elementary ideas of Nonlinear Ramaneffect.	23	1, 3, 5
3	**Electronic and Spin Resonance Spectroscopy** Electronic spectra of diatomic molecules, Intensity of spectral lines, Frank-Condon principle, dissociation energy, rotational fine structure of electronic vibrational transitions, Fortrat diagram, pre-dissociation. NMR–Bloch equations, relaxation processes, chemical shift, ESR-hyperfine structure, Mossbauer effect- hyperfine interaction- chemical isomer shift.	25	1, 4, 5
4	**Lasers** Spontaneous and stimulated emission; Einstein A and B coefficients, The laser idea - amplification of light – threshold condition, Coherence time coherence length- three- and four-level rate equation analysis. Laser systems; solid-state lasers-Ruby laser and Nd-YAG laser, gas lasers-He-Ne and CO_2 laser, dye lasers, semiconductor lasers. Modes of resonators.	20	1, 2, 5

References

1. *Introduction to atomic spectra, H E White, Mcgrawhill Exclusive (CBS) (2019)*
2. *Spectra of diatomic molecules, G Herzberg, Krieger Publishing Company; Second edition (1989)*
3. *Molecular structure & Spectroscopy, G Aruldas, Prentice Hall India Learning Private Limited; 2nd edition (2007)*
4. *Fundamentals of molecular spectroscopy, C Banwell, McGraw Hill Education; Fourth edition(2017)*
5. *Lasers fundamentals and applications, Ghatak & Thyagarajan, Laxmi Publications; Second edition (2019)*
6. *Spectroscopy (I & II), Stroaughan and Volker, Wiley ; distributed in the U.S.A. by Halsted Press (2016)*
7. *Raman spectroscopy, D A Long, McGraw Hill Higher Education (1980)*
8. *Principles of lasers, O Svelto, Springer New York, NY (2010)*
9. *Quantum Electronics, A Yariv, John Wiley & Sons Inc; 3rd edition (1988)*
10. *Laser Fundamentals, W T Silfvast, Cambridge University Press; 2nd edition (2008)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work

Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**X-ray Characterization Methods**		
Type of course	**Elective**	**Credit Value**	**2**
Course code	**IMSE905PH-1**		
Name of Faculty			
Course Summary& Justification	Invention of X-ray and the development of theoretical and experimental methods over a period of more than a century have opened up various characterization methods which nowadays are extensively used for characterization of materials in science and technology. The main objective of this course is to understand the basic concepts of x-ray diffraction from matter and its applications in characterization of crystalline, powder and amorphous materials. Topics dealing in this course have numerous applications in industry, material science, molecular biology and medicine.		
Semester	**IX**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Basic knowledge about concept of atoms, molecules, solids energy levels, basic mathematics, quantum mechanics.					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Knowledge of crystal structure, symmetry and arrangement of molecules in crystals (Module 1).	U	1
2	Basic theory of x-ray diffraction from crystals, powder and glassy materials (Module 2).	An	1, 4
3	Explain the data collection strategies, data analysis, structure determination and validation (Module 3).	C	2
4	Structural studies on powder, amorphous and glassy materials (Module 4).	An	2
5	Develop skills for the structural characterisation and molecular assembly in crystals, powder and amorphous samples.	C	2, 3

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Structure and Symmetry in solids** Introduction to bonding in solids, Basic ideas about crystalline and amorphous materials, crystal packing: HCP and CCP, Interstitial sites, coordination number and Packing fraction, NaCl, CsCl, ZnS, Fluorite,	14	1, 5

	Wurtzite structure, Diamond structure, Cristobalite, Perovskite structure, Corundum Structure, Rutile structure, Spinel Structure, Graphite, Silicate structures, Pyrosilicates, Fullerenes, symmetry in crystals, super symmetry and super lattices.		
2	**Diffraction theory** Symmetry in crystals. Real lattice and the concept of reciprocal lattice. Point groups and space groups, Geometry of diffraction, Diffraction of X-rays from an electron, an atom, 1D lattice and a crystal. Atomic scattering factor and structure factor. Intensity of scattering from an hkl plane and various factors affecting the intensity. Elementary ideas about neutron and electron diffraction.	14	2, 5
3	**Structure Determination methods** Determination of symmetry and space group from diffraction data. Fourier transform and calculation of electron density. Phase Problem in crystallography, Elementary ideas about Structure determination from X-ray data: Heavy atom method, Equal atom method and Molecular replacement methods of structure solution.	12	3, 5
4	**Powder and Amorphous materials** Powder diffraction, Data collection strategies, Rietveld refinement, Direct methods in powder diffraction. Ceramics and Glasses, Preparation of glasses and ceramic materials, Melt spinning, Sputtering. Structural studies of glasses: RDF analysis. EXAFS analysis, Properties of ceramics andglasses. Small angle scattering, wide angle scattering.	14	4, 5

References

1. *Crystal Structure Refinement A Crystallographer's guide to SHELXL, P. Muller, R. Herbst- Irmer, A. L Spek, T. R. Schneider, M. R. Sawaya, Oxford University Press (2006).*
2. *Structure Determination from Powder Diffraction Data, W.I.F. David ,K.Shankland, L.B. McCusker and Ch. Baerlocher, Oxford University Press (2006).*
3. *The Science and Engineering of materials, Askeland, 6th edition, Wadsworth Publishing Co Inc (2010).*
4. *An introduction to X-ray crystallography, M. M. Woolfson, 2nd edition, Cambridge University Press (1997).*
5. *Elements of X-ray crystallography, L. A. Azaroff, McGraw Hill (1968).*
6. *X-ray Structure Determination, Stout & Jensen, 2nd edition, Wiley (1989).*
7. *Characterization of Nano-phase materials, Zhong Lin Wang, Wiley VCH (1999).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Physics of Nanomaterials**					
Type of course	**Elective**		**Credit Value**		**2**	
Course code	**IMSE905PH-2**					
Name of Faculty						
Course Summary& Justification	The emerging fields of nanoscale science, engineering and technology are fundamentally based on the ability to develop new materials at the atomic and molecular level and to employ them to achieve novel properties for next generation devices and systems. On December 29th 1959, the famous Nobel Laureate Richard P Feynman said in his famous speech "There is plenty of room at the bottom". In the year 2000, when they look back at this age, they will wonder why it was not until the year 1960 that anybody began seriously to move in this (nanometer) direction". The word 'nano' has attracted enormous attention, interest and investigation in recent years. What it presents in terms of Science & technology, which are also called Nanoscience & Nanotechnology, is much, much more than just a word describing a specific length scale. Nanometer is a special point in overall length scale because nanometer scale is the junction where the smallest manufacturable objects 'meet' the largest molecules in nature. At this size scale, everything, regardless of what it is, has new exotic properties and these make "Nano" so fascinating! The breadth and vastness of the exploding field of nanotechnology makes it essential to limit the content covered in a one semester course offering. This course is designed to introduce students to the fundamental changes in various physical properties which occur when particle sizes approach atomic and molecular dimensions. A major goal is to provide students with a design tool based on nanotechnology that will allow them to engineer next generation materials and devices and appreciate the different properties offered by nanostructured materials. This course focuses on Nanomaterials synthesis, characterization and various applications. The basic physics and fundamental mechanisms responsible for nanoscale-induced changes in properties will be stressed. Representative advances in each of the targeted topical areas will be discussed and examined to provide students with some insight with regard to the potential future impact of nanotechnology on materials science and engineering.					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Solid Sate Physics, Basic Quantum Mechanics					

COURSE OUTCOMES (CO)			
CO No.	**Expected Course Outcome**	**Learning domain**	**PSO No**
1	Understanding the concepts of Nanoscience and Nanotechnology	U, C	1, 2
2	Different approaches of nanomaterials syntheses such as chemical, physical, engineering, biological and hybrid methods	An	1, 2
3	Quantum concepts of nanomaterials and envisaged applications	U, C	1, 2, 3
4	Detailed understanding of different characterization methods	U, C	1, 2, 3
5	Potential applications of nanomaterials in diversified fields	U, C	2, 3, 8
6	Social, ethical, legal and environmental (SELE) issues of Nanoscience and nanotechnology	U, A, An, Ap	4, 5, 6, 7, 8
** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Introduction** Overview: When does size matter? Trend of miniaturization and Moore's law, Scales of various systems, Characterization methods-Direct and Indirect methods.	10	1
2	**Synthesis, preparation and fabrication** Preparation of Nanomaterials: Bottom-up approach, Top-down approach. Chemical approaches: Self assembly, Sol-gel synthesis. Physical approaches: Molecular beam epitaxy, Atomic layer deposition, Laser Plasma Ablation. Engineering approaches: Lithography-Photolithography, Electron beam lithography, X-ray lithography, Focused ion beam (FIB) lithography, Soft lithography-Micro contact printing, Molding, Nanoimprint, Dip-pen nanolithography. Biological approaches.	14	2
3	**Properties and characterization of nanomaterials** Physical properties of nanomaterials: Melting points and lattice constants, Mechanical properties, Optical properties-Surface Plasmon Resonance, Quantum size effects. Electrical conductivity-Surface scattering, Charge of electronic structure, Quantum transport, Effect of microstructure, Structural characterizations: X-ray diffraction, Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Probe Microscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy, Chemical characterizations: FTIR Spectroscopy, Electron Spectroscopy, Ionic Spectroscopy, Functional characterization:-Optical properties, Magnetic properties, Electrical properties.	14	3, 4
4	**Applications of nanomaterials** Molecular Electronics and Nanoelectronics, Biological applications of nanomaterials, Band gap engineered quantum devices, Nanomechanics, Photonic crystals and Plasmon waveguides, Carbon nanostructures-Carbon nanotubes-Graphene.	10	5
5	Social and ethical issues of nanoscience and nanotechnology and research article presentation	6	6

References

1. *Nanoparticle Technology Handbook, Masuo Hosokawa et al, 3rd edition, Elsevier Publications (2018).*
2. *Nano: The Essentials by T. Pradeep, Tata MacGraw-Hill Publishing Company Limited (2017).*
3. *Nanophotonics by Paras N Prasad, Wiley Interscience (2004).*
4. *Nanostructures & Nanomaterials-Synthesis, Properties and Applications- Guozhong Cao, 2nd edition, Imperial college Press (2011).*
5. *Characterization of Nanophase Materials- Zong Lin Wang, Wiley VCH (2001).*
6. *Hand Book of Nanotechnology, Bhushan, 3rd edition, Springer (2010).*
7. *Introduction to Solid State Physics, Charles Kittel, 8th edition, Wiley (2012).*
8. *Solid State Physics by Gerald Burns, Academic Press Inc (1998).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Nanoscience and Nanostructured Materials**					
Type of course	**Elective**		**Credit Value**		**2**	
Course code	**IMSE905PH-3**					
Name of Faculty						
Course Summary& Justification	The course designed to introduce students to NANOSCIENCE AND NANOSTRUCTURED MATERIALS, which include the understanding Nanoscience and nano structured materials and its novel properties application in the modern technological world. This course deals with the fundamental understanding of Nano structured materials, and its various methods of synthesis, characterisation and properties. The study of Nano Materials gives the students an opportunity of better understanding of vast field of nanoscience and nano materials based technologies.					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Basic understanding of Quantum Mechanics, Solid state Physics and Spectroscopy with fair mathematical knowledge (Graduate level)					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Students will understand the disciple-specific knowledge in Material sciences especially nanomaterials. Basic understanding of Quantum Mechanics, Solid state physics and spectroscopy.	U	1, 7, 8
2	Analyse various novel properties of materials in the nano regime. Students will understand the basic skill to be achieved for making the nano structured materials and its importance in the fabrication of sophisticated devices for technological applications.	A	1, 2, 7
3	Students will know the concepts of various synthesis methods, chemical and physical methods. Also able to understand technology needed materials and their synthesis.	Ap	1, 2, 5, 7
4	The theoretical understanding of various sophisticated characterisation techniques and their use in designing material-based devices.	E	1, 2, 7
5	Explain the use of nano devices for various societal needs.	U	1, 2, 7
6	Application in various field of activity in science engineering and agriculture etc.	U	1, 2, 7
7	They will use critical thinking skills using their knowledge to design new devices.	S	1, 7, 8

8	Employ conceptual understanding to make new materials of technological importance, and then approach different methods and understand the important skills needed for this synthesis and characterization.	E	1, 2, 3, 6, 7

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Introduction to Materials in the Nanoscale** Materials in the Nanoscale, Size effect of nano system, Dependence of properties on size, Moore's law, Scale of various systems, Quantum structure: 2D(Quantum well), 1D(quantum wire), 0D(Quantum dot), Quantum behavior of nanomaterials, Molecular physics :Molecular bond, covalent bond, Molecular Spectra:- Rotational, Vibrational, & Electronic, Raman spectra.	14	1
2	**Synthesis, Preparation,& Fabrication of Nanomaterials** Top down and Bottom up approach of synthesis with examples, Chemical approaches: Self Assembly, Sol-Gel method ,Hydrothermal method, Chemical reduction, electro and electroless deposition, Chemical bath deposition, Examples, Physical Approaches: Molecular beam epitaxy, Pulse laser deposition, Engineering Approaches and other methods, Lithography, photolithography, Electron beam lithography, X-ray lithography, Ball milling, sputtering , examples.	14	2, 3
3	**Properties and characterization of Nanomaterials.** Mechanical Properties: Theoretical aspects, strength of nanomaterials and measurements, Optical properties:-Refractive index and dispersion, Non linear refractive index, Absorption coefficient and other special optical properties, Surface plasmon resonance, Magnetic properties, Magnetic anisotropy, Spin glass, Spintronics, Electrical properties, Characterization of nanomaterials: X-ray diffraction, Scanning electron microscopy, Transmission electron microscopy, Scanning tunnelling microscopy, Atomic forced microscopy, FTIR spectroscopy.	16	4, 6
4	**Nano structured materials and applications** Carbon Nanotubes, Semiconductor quantum dots, Core-shell nanoparticles, Nanoshells, Nano ceramics, Nano polymers, Photonic crystals, Nano electronics, Nano medicines, Nano sensors, Molecular Nanomachines, Biological applications	10	5, 7, 8

References

1. *Nano: The Essentials, T. Pradeep, Tata MacGraw-Hill Publishing Company Limited (2017).*
2. *Nano Materials, A K Bandhopadhyaya, New Age (2008).*
3. *Introductory Nanoscience: Physical and Chemical Concepts, Masaru Kuno, Garland Science Publication (2011).*
4. *Introduction to Nanoscience and Nanotechnology, K K Chattopadhyay and A N Banerjee, PHI Learning Pvt. Ltd (2009).*
5. *Encyclopaedia of Nanoscience and Nanotechnology :- Nalwa H S (2004).*
6. *Nanostructures & Nanomaterials-Synthesis, Properties and Applications, Guozhong Cao, 2nd edition, Imperial college Press (2011).*
7. *Nanoscale materials, Liz Marzan and P V Kamat, Springer (2003).*
8. *Carbon Nanotubes:Properties and Applications, Michael J O Connell, CRC Press (2006).*
9. *Principle of Lithography, Harry J. Levinson, 4th edition, SPIE Press (2019).*
10. *Nanotubes and Nanowires, CNR Rao and A Govindraj, 2nd edition, Royal Society of Chemistry (2015).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Applied Photonics**		
Type of course	**Core**	**Credit Value**	**2**
Course code	**IMSE905PH-4**		
Name of Faculty			
Course Summary& Justification	The course covers the basic principles of important photonic components of Optoelectronics which find its application in visible, near-infrared, and mid-infrared wavelength ranges. Several of these devices, such as semiconductor lasers, detectors, sensing and display technologies, are the foundation for our modern information society. Also discuss the white-light LEDs and solar cells, have also drastic impact on our modern lives in terms of energy saving. Other topics covered, including photonic materials including semiconductors and photonic crystals and Nano photonics. Specifically, the course covers the following topics • Electronic properties of semiconductors • Electronic properties of semiconductors • p-n junction band diagram • Light-emitting diodes • Semiconductor lasers • Optical amplifiers • Optical detectors • Solar cells • Optical Modulators • Optoelectronic integration • Display technologies • Photonic crystals • Photonics in lighting • Infrared sources • Nanophotonics • Quantum confined structure Intended leaning outcomes After completing the course, the student should be able to # Explain the structure and working principles of basic photonic devices. # Make calculations and measurements to quantify performances of various photonic devices. # Design appropriate photonic devices for achieving certain system requirements, including the aspects of energy consumption and sustainable development. # The technological limits of various photonic devices and describe potential solutions to those problems. We describe the content of the course on photonics sometimes referred as optoelectronics. The main goal of the course is to equip students with sound theoretical and practical knowledge for photonic related research and also for industry. The content of the course are constantly updated to keep the latest technological development in the field of optoelectronics, owing to the dynamic nature of photonic research and application. This paper presents various aspects related to this course such as its acting role in the program curriculum system,		

	teaching methods and assessment					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Good understanding of BSc level Spectroscopy, Mathematics and Advanced learning in Quantum Mechanics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Knowledge of optoelectronic development and understanding information on various photonic devices, optoelectronic information system and the corresponding functional components. Knowledge of major photonic materials and its applications of optoelectronic technology	U	1,7,8
2	Mastering fundamental theories, basic knowledge and professional skills in the fields of optoelectronic information and electronic information	A	1,2,7,8
3	Students will know the concepts of optoelectronics and demonstrate a proficiency in the fundamental concepts in this area of science.	Ap	1,2,5,7,8
4	Develop device-level knowledge & concept, such as light sources, optical modulators, optical waveguides, optical detectors, and optical displays etc.	E	1,2,7,8
5	Explain the basic concept of semiconductors and detectors.	U	1,2,7,8
6	Advance knowledge in photonic crystals and optical communications.	U	1,2,7
7	They will use critical thinking skills using their knowledge for applied photonics	S	1,7,8
8	Employ conceptual understanding to make predictions, and understand the important concepts in optoelectronics and Nano photonics.	E	1,2,3,6,7,8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Basics of optoelectronics** Electronic properties of semiconductors, Energy level and density of carriers in intrinsic nd extrinsic semiconductors, consequence of heavy doping , Direct and indirect bandgap semiconductors, electron-hole pair formation and recombination, recombination life time, p-n junction band	14	1,2,7,8

	diagram Conduction process in semiconductors, open circuit - forward and reverse bias, light emitting diodes – principles - device structures, LED materials, heterojunction high intensity LEDs, double heterostructure, LED characteristics and LEDs for optical fiber communications - surface and edge emitting LEDs.		
2	**Optoelectronic devices and detectors** Principle of p-n junction photodiode, absorption coefficient and photodiode materials, quantum efficiency and responsivity, PIN-photodiode, avalanche photodiode, phototransistor, photoconductive detectors and photoconductive gain, noise in photo- detectors, noise in avalanche photodiode, solar energy spectrum, photovoltaic device principles, I-V characteristics, temperature effects, solar cell materials, device and Efficiencies.	13	1,3,7,8
3	**Photonic crystals** Basic concept, Theoretical modeling of photonic crystals. Features of photonic crystas, One dimensional photonic material- Bloch modes, dispersion relation, photonic band gap- Methods of fabrication, photonic crystal optical circuitary, Non linear photonic crystals, photonic crystal fibres (PCF), photonic crystals and optical communications. Photonic crystal sensors.	14	1,4,7,8
4	**Nano Photonics** Photons and electrons similarities and differences- Confinement of photons and electrons- Propagation through classically forbidden zone: tunneling, Nano scale optical interactions, Nano scale confinement of electronic interactions -quantum confinement effect. Nano crystals and quantum confined materials. Quantum confined structures as lasing media and super lattice; Optical properties, Metaliic nanoparticles and Nanorods Applications of Metallic nano structures.	13	1,5,7,8

References

1. *Laser fundamentals, William T. Silfvast, Cambridge University Press, second edition (2004)*
2. *Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson (2009)*
3. *Nano Photonics, P N Prasad, John Wiley & Sons, (2004)*
4. *Semiconductor optoelectronic devices, Pallab Bhattacharya, Pearson (2008)*
5. *Optoelectronics: An introduction to materials and devices, Jasprit Singh, Mc Graw Hill International Edn., (1996)*
6. *Quantum Electronics, A. Yariv, John Wiley & Sons Inc; 3rd edition (1988)*
7. *Nonlinear Optics, Y.R. Shen, John Wiley (2002)*
8. *Principles of Lasers, O.Svelto, Springer New York, NY (2010)*
9. *Laser Spectroscopy, W. Demtroder, Springer Berlin, Heidelberg (2014)*
10. *Hand Book of Nonlinear Optics, R. L Sutherland, CRC Press, second edition (2003)*
11. *Fundamentals of photonics, Teich and Saleich, Wiley; 3rd edition (2020)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**				
Programme	**Five Year Integrated M.Sc. (Physics)**				
Course Name	**Stars, Galaxies and Cosmology**				
Type of course	**Elective**		**Credit Value**	**2**	
Course code	**IMSE905PH-5**				
Name of Faculty					
Course Summary& Justification	This course is aimed at teaching the student the basics of astrophysics. The teaching is to be aimed at bringing out the link between the physics / mathematics / statistics that has been / is being taught and the use it has been put to in understanding the physical nature of stars, our own galaxy, galaxies and the universe. A few online courses / sites that would supplement the curriculum as well as enhance the ability of the student to navigate on-line and pick up necessary information are also included to enhance and enrich the learning experience. This course is intended as a sequel to the course 'Basic Astronomy', but may be taught independently also if the student is prepared to pick up a few basic concepts in astronomy on their own. The two courses 'Basic Astronomy'and 'Stars Galaxies and Cosmology' together, is intended to give the students a comprehensive introduction to the basics and methods of Astronomy &Astrophysics. The various units of the syllabus take the student through – (A) Stellar structure – a star as a ball of gas (B) Stellar evolution – end stages (C) Our Galaxy -its structure, components, properties and general inferences – Galaxies -their morphologhy and classification – onto hierarchical structure in the Universe (D) Brief introduction to the General Theory of Relativity and Cosmology.				
Semester	**IX**				

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Good understanding of basic physics at Masters level and basic astronomy					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Understanding the steps in the setting up of a physical model of a star.	A, An, C	1, 7
2	Understanding the formation, evolution and end stages of stars of various masses.	An, I, Ap	1, 3, 6
3	Understanding the structure, contents and formation scenario of the Milky Way galaxy, star formation theory, dark matter and, classification and hierarchical clustering of galaxies.	U, A, Ap	2, 3, 4, 6

4	Understanding the current observational status wrt our knowledge of the universe and setting up a model for the physical universe.	U, An, C, Ap	1, 2, 3, 4, 7
5	Getting skilled in developing physical models, comparing with observations and drawing inferences about astronomical systems and the whole universe.	R, U, An, S	1, 2, 6, 8
6	Develop analytical abilities wrt astrophysical modeling and the use of models in making inferences about the physical conditions in astronomical sources.	An, I, Ap	3, 5, 6
** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Stellar structure** Correlations between stellar properties - M-L relation, HR diagram, Physical state of the stellar interior, Hydrostatic equilibrium, distribution of mass, estimation of central temperature and pressure, Energy generation equations, Energy transport by radiation and convection, Equations of stellar structure, Equation of state for stellar interiors - perfect gas - degenerate gas, Sources of opacity.	14	1, 6
2	**Stellar evolution – its end stages** Nuclear reactions, H burning, CNO cycle, Helium burning, Neutrinos, solar neutrino experiments, Structure of main sequence stars, Qualitative account of pre-main sequence evolution, Early post main sequence evolution, Turn off and the ages of stellar clusters, Advanced evolutionary stages, degenerate stars.	14	2, 6
3	**Our Galaxy, galaxies, hierarchical structure in the Universe** The Galaxy, structure of the Galaxy, Stellar populations and the formation of the Galaxy, The ISM – its components, Giant Molecular Clouds and star formation, Determination of the rotation curve of the Galaxy - its implications regarding dark matter, Classification of galaxies, Hierarchy of structures (groups, clusters, super-clusters), Active Galactic Nucleii and quasars.	16	3, 6
4	**General Theory of Relativity and Cosmology** The equivalence principle, Action for the gravitational field, Einstein's equation (without derivation), Olber's paradox, Hubble's law, Fundamental assumptions -homogeneity and isotropy, the FRW metric, Contents of the Universe - dust and radiation, density evolution, critical density, Cosmological constant, the uniformity of the CMB, the origin of the anisotropies in the CMB, Conditions in the early universe, big bang nucleo-synthesis, accelerated expansion, dark energy.	10	4, 5, 6

References

1. *Textbook of astronomy and astrophysics with elements of cosmology, V.B.Bhatia, Narosa publishing house (2001).*
2. *Astrophysics - Stars and Galaxies, K. D. Abhyankar, University Press (2001).*
3. *Introduction to Cosmology, J V Narlikar, 3rd edition, Cambridge University Press (2002).*
4. *Astrophysics, Baidyanath Basu, 2nd edition, Prentice Hall India Learning Private Limited (1905).*
5. *The Physical Universe F. H. Shu, University Science Books (1981).*
6. *Theoretical Astrophysics, T. Padmanabhan, Volume 3, Galaxies and Cosmology, 1st Edition, Cambridge University Press (2002).*
7. https://www.springboard.com/blog/astronomy-for-beginners-free-online-courses/
8. https://ocw.mit.edu/courses/physics/8-282j-introduction-to-astronomy-spring-2006/

Astronomy & Astrophysics through ICT – (Students may experiment with)
VO India
NED – NASA Extragalactic Database
https://www.galaxyzoo.org/
https://einsteinathome.org/

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**					
Programme	**Five Year Integrated M.Sc. (Physics)**					
Course Name	**Multiferroic Materials and Applications**					
Type of course	**Elective**		**Credit Value**		**2**	
Course code	**IMSE905PH-6**					
Name of Faculty						
Course Summary& Justification	This course provides basic understanding of multiferroics materials and its applications. It covers the basic symmetry elements in crystal, quantum confinement and its effect to the properties of nanomagnetism and giant magnetoresistance (GMR) to control magnetism in multiferroics. Ferroic systems Multiferroics, Basic properties of multiferroic materials, its synthesis and applications.					
Semester	**IX**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	10	64
Pre-requisite	Graduate level Mathematics, Electric and Magnetic properties					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Apply the concepts of free electron theory and band theory of solids.	A	1, 2, 3
2	Evaluate the electrical and magnetic parameters of the solid	U, An	1, 2
3	Capable of analyzing the electric properties on the basis of electronic band structure, charge carrier statistics	E	2, 3
4	Develop the competence to apply physics for the description of electric, magnetic and optical properties	A	5, 6, 7, 8
5	Think how to alter the properties of solids to make them suitable for particular applications	C	7, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No
1	**Structures and properties of advance materials** The symmetry Elements in Crystals, Crystallographic point groups, Effect of crystal symmetry on crystal properties: Neumann's principle,	22	1, 2, 5

	Quantum confinement and its effect to the properties of nanoparticles, Nanomagnetism and giant magneto resistance (GMR), Super paramagnetism, Spin glass, Electric field versus current control of magnetism in multiferroics.		
2	**Ferroic systems** Ferroelectric materials, Pyroelectric effect, Induced polarization, Orientational polarization, Clausius-Mosotti Equation, Ferrobielectrics and Ferrobimagnetics, Magnetic moments and exchange interaction, coupling between magnetic moments: RKKY coupling, double exchange, Super exchange, Ferromagnetism, Paramagnetism, Antiferromagnetism, Diamagnetism, Ferrimagentism, Giant moment ferromagnetism, Characteristic of spin glass, Common types of magnetism: Modern magnetic oxides: Ferrites, Manganites, Ferroelectric devices and integration. Nanoenergy generators-piezoelectric and pyroelectric nanogenerators, Fabrication, working, applications etc.	23	1, 2, 3, 5
3	**Multiferroics** Multiferroics, Basic properties of multiferroic materials, Linear magnetoelectrics, Magnetodielectrics, Magnetoelectric effect, Single phase multiferroics, Multiferroic composites, Lone pair mulltiferroic structure, Multiferroics due to charge ordering, limitations of multiferroic materials, Multiferroic nanoparticles, Applications of multiferroic materials, Dimensionality and size dependent phenomena of multiferroics.	25	1, 3, 4, 5
4	**Nanostructure synthesis & Characterization techniques** Sol-gel processing, Ball Milling, Flash evaporation method, Electron beam method, R. F Sputtering, Pulsed laser deposition, Chemical Vapour deposition, Chemical deposition, Magnetic measurements using VSM/PPMS/SQUID, Dielectric spectroscopy, Magneto electric coupling, Mossbauer spectroscopy, Fundamentals of X-ray diffraction, Quantitative determination of phases, strain and particle size, Scanning electron microscopy, Transmission electron microscopy, Atomic force microscopy, Scanning tunneling microscopy.	20	1, 2, 3, 5

References

1. *Introduction to Ferroic materials, Vinod K Wadhawan, Gorden and Breachscience publisher (2000)*
2. *Chemistry of nanomaterials : Synthesis, properties and applications, C. N. R.Rao, Achim Muller , Anthony K. Cheetham, Willy (2004)*
3. *Synthesis of Nanostructured Materials, Cao, Imperial College Press (2004)*
4. *Introduction to Nanoscience and Nanotechnology , K K Chattopadhyay and A. N. Banerjee, PHI Learning Private Limited (2013)*
5. *Classical Electrodynamics, J B Marion, Academic Press; 2nd edition (2012)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment**

	A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Advanced Solid State Physics**		
Type of course	**Core**	**Credit Value**	**2**
Course code	**IMSE905PH-7**		
Name of Faculty			
Course Summary& Justification	This course is an extension of the topics included in the basic course on solid state physics. The first part of the course is on band theory of solids followed by detailed aspects of semiconductor physics. The remaining parts of the course focus on low dimensional quantum structures and quasi particles in condensed state. The purpose of this course is to provide a framework for post-graduate students to understand some of the important aspects of the physics of condensed matter at an advanced level employing quantum mechanical approaches.		
Semester	**IX**		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independent Learning etc.	36	18	-	10	64
Pre-requisite	Basic knowledge on solid state physics					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Familiarize with the description of energy bands in solids through various approaches	U	1
2	Formulate the theory of band structure	An	1, 2
3	Analyze the transport characteristics of semiconductor materials	U	1
4	Understand the quantum mechanical considerations of nanostructures	E	2
5	Familiarize the origin of quasi particles as excitations in interacting systems	C	2,3
6	Altering the properties of solids to make them suitable for particular applications	C	2,3

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hrs.	CO No.
1	**Band Structure of Solids** Bloch function, Kroning Penny model for an electron in a periodic potential, E-k relationship in various representations, Energy band calculations, Nearly free electron approximation, Tight binding	14	1,2,6

	approximation, Wigner-Seitz cellular method, Augmented plane wave method, Orthogonalised plane wave method. Pseudopotential method.		
2	**Semiconductor Physics** Density of states, Effective density of states mass action law, Doping: intrinsic vs. extrinsic semiconductors, Charge neutrality, Fermi energy as a function of temperature, Carrier concentration in a intrinsic semiconductor. Electrical conductivity, Hall effect charge carrier diffusion- Diffusion currents, Einstein Relations, Diffusion lengths, Quasi- Fermi energy, Carrier generation and recombination mechanism-direct band to band recombination.	14	1,3,6
3	**Low Dimensional Quantum Structures** Two dimensional Quantum structures; Quantum Wells- Energy spectrum, density of states, Influence of effective mass, One dimensional structures-Quantum wires, density of states, Infinitely deep rectangular wire, Zero dimensional structures- quantum dotes, density of states, Infinite spherical quantum dot, Optical properties of two dimensional and three dimensional structures, Examples of low dimensional structures.	13	4,6
4	**Quasi Particles in Materials Science** Phonons, Oscillations within a one dimensional diatomic chain of atoms, Vibrations of a three dimensional crystal, Polarons- dielectric polarons, Molecular polarons Holstein's model, Bipolarons, Excitons, Wannier and charge transfer excitons, Frenkel excitons, Plasmons, Dielectric response of an electronic gas, Spin waves, Magnons.	13	5,6

References

1. *Introduction to Solid State Theory, Otfried Madelung, Springer; 1978th edition (1995)*
2. *Quantum Theory Of Solids, Eoin O'Reilly, CRC Press (2002)*
3. *Solid State Physics, James D Patterson and Bernard C Bailey, Springer; 3rd edition (2019)*
4. *Fundamentals of Solid State Engineering, Manijeh Razeghi, Springer; 4th edition (2018)*
5. *Solid State Physics for Electronics, André Moliton, ISTE Ltd and John Wiley & Sons Inc; 1st edition (2009).*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests Assignments Seminar Presentation Review Report B. End Semester Examination (60%)

School Name	Institute for Integrated programmes and Research in Basic Sciences (IIRBS)		
Programme	Five Year Integrated M.Sc. (Physics)		
Course Name	Physics of Mesoscopic Systems		
Type of course	Elective	Credit Value	2
Course code	IMSE905PH-8		
Name of Faculty			
Course Summary& Justification	Physics of Mesoscopic systems is subdiscipline of condensed matter physics deals with materials and devices from the size of atoms (such as a molecule) to the micrometer range, where the devices start revealing quantum mechanical properties. The lower limit can also be defined as being the size of individual atoms. Mesoscopic objects contain many atoms like macro systems and average properties derived from constituent materials. Macro properties like thermal fluctuations around the Mesoscopic systems are described by the laws of classical mechanics, and its electronic behavior may require modeling at the level of quantum mechanics		
Semester	IX		

Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Others include: Group discussions, Problems solving sessions, Seminars, Independant Learning etc.	36	18	-	10	64
Pre-requisite	Understanding of classical and quantum effects					

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Study the Mesoscopic regime and its effects	R, U	1
2	Analyse the electronic transport in Mesoscopic systems and effects of electron-electron interactions	U, An	1, 3
3	Understand the Macro and quantum effects in Mesoscopic systems	An, S	1, 2
4	Study the coherent backscattering, diffusing wave spectroscopy and spectral properties	C	1
5	Use the theorems and laws to predict various effects in Mesoscopic systems	U, A, S	3, 8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Module	Course Description	Hours	CO No

1	**Introduction to the Physics of Mesoscopic Systems** The Mesoscopic Regime, Prominent Mesoscopic Effects, Aharonov-Bohm Oscillations, The Integer Quantum Hall Effect, The Fractional Quantum Hall Effect, Universal Conductance Fluctuations, Conductance Quantization in Quantum Point Contacts, Persistent Currents in Mesoscopic Rings.	14	1, 3
2	**Theory of Electronic Transport in Mesoscopic Structures** Breakdown of Classical Transport, Linear Response Theory, Definition of the conductance, The Landauer Approach, One-Channel Two-Point Conductance, Multi-Channel Two-Point Conductance, Edge States and Quantum Hall Effect, Resonant versus Sequential Tunneling, Resonant Tunneling, Sequential Tunneling.	12	1, 2, 3, 5
3	**Effects of the Electron-Electron Interaction** The Coulomb Blockade, Transport through Quantum Dots, The Single Electron Transistor, Transport Spectroscopy, Mesoscopic Superconductivity: Josephson effect, RCSJ model, Bloch oscillations, approach to flux and charge Q-bits.	10	1, 2, 3, 5
4	**Coherent backscattering of light** Introduction, The geometry of the albedo, Definition- Albedo of a diffusive medium, The average albedo, Incoherent albedo: contribution of the Diffusion, The coherent albedo: contribution of the Cooperon, Time dependence of the albedo and study of the triangular cusp, Effect of absorption, Coherent albedo and anisotropic collisions, The effect of polarization, Depolarization coefficients, Coherent albedo of a polarized wave, Experimental results, The triangular cusp, Decrease of the height of the cone, The role of absorption, Coherent backscattering at large, Coherent backscattering and the "glory" effect, Coherent backscattering and Opposition effect in astrophysics, Coherent backscattering by cold atomic gases, Coherent backscattering effect in acoustics, Diffusing wave spectroscopy**,** Spectral properties of disordered metals.	18	1, 2, 4, 5

References

1. *Mesoscopic Physics: An introduction, by Harmans, version 3, TU Delft (2003)*
2. *Introduction to mesoscopic physics, by Y. Imry, OUP USA (1997)*
3. *Electronic Transport in Mesoscopic Systems, by Supriyo Datta, Cambridge University Press (1997)*
4. *Quantum Transport, Lecture Notes by Yuri M. Galperin (available at http://folk.uio.no/yurig/quTpdf.pdf)(2013)*
5. *Quantum Transport in semiconductor nanostructures, C. W. J. Beenakker and H. vanHouton in "Solid State Physics", vol.44, ed. by Frederick Seitz and David Turnbull, Academic Press (1991)*
6. *Mesoscopic Physics of Electrons and Photons by Eric Akkermans, Cambridge University Press; Reissue edition (2011)*

Teaching and Learning Approach	**Class room Procedure (mode of transaction)** • Direct Instruction: Lecture, Explicit Teaching, E-learning • Interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Peer teaching and learning, Technology-enabled learning, Library work
Assessment Types	**Mode of Assessment** A. Continuous Internal Assessment (40%) Internal Tests, Assignments, Seminar Presentation, Review Report B. End Semester Examination (60%)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Major Research Project**		
Type of course	**Core**	**Credit Value**	**16**
Course code	**IMSC100PR**		
Name of Faculty			
Course Summary& Justification	As part of this course student is expected to carry out an Internship/ project work under the guidance of a research supervisor, in a reputed research/academic Institutions. This course will provide extensive training on methods and methodology of research in the area of study. Accordingly, the student shall acquire updated knowledge, skill and training on the area of research. At the end of this course student has to submit a detailed project report and present a seminar. It will be evaluated by the Examination Board consisting of both Internal and External Examiners.		
Semester	**X**		
Total Student Learning Time (SLT)	Total Learning Time		
	5 months		
Pre-requisite	Theoretical knowledge in Physics and Basic laboratory skills		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Acquire sufficient Knowledge, training and skills to undertake independent, original and critical research on a relevant topic.	U, A, S, E, C	1, 2, 7,8
2	Gain expertise in Scientific literature survey and academic writing and develop interest for further research	S, I, AP	1,3
3	Skills to effectively present the objectives, methodology, analysis, and results of the research study.	S	1,3,7
4	Familiarize with advanced and modern research topics/trends	U, Ap	3,7,8
5	Capability to plan and use adequate methods to conduct specific tasks in given frameworks	A, An	1,3,7
6	Gain a consciousness of the ethical aspects of research	U, An	4,7
7	Create, analyze and critically evaluate different problems and their solutions	An, E, C	1,2,7

* *Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

COURSE CONTENT

Course Description	Months	CO No.
Student shall carry out a 5 to 6 months of Research Project in a relevant area related to Physics and submit the project report/dissertation at the end of the course.	5-6	1-7

Teaching and Learning Approach	**Laboratory Procedure (mode of transaction)** • Direct Instruction: Explicit Teaching, Demonstration, Hands on experimental sections, Skill acquisition by laboratory training, Journal Club
Assessment Types	**Mode of Assessment** • Evaluation of the Project by the Examination Board consisting of the Chairman, both Internal and External Examiners based on the quality and quantity of the project work done, Report, and 30 minutes presentation at the End of the Semester (100 %)

School Name	**Institute for Integrated programmes and Research in Basic Sciences (IIRBS)**		
Programme	**Five Year Integrated M.Sc. (Physics)**		
Course Name	**Comprehensive Viva Voce**		
Type of course	**Core**	**Credit Value**	**4**
Course code	**IMSC100VV**		
Name of Faculty			
Course Summary& Justification	The comprehensive viva-voce shall be conducted by the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner. A thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of Physics are evaluated.		
Semester	**X**		
Total Student Learning Time (SLT)	Total Learning Time		
	-		
Pre-requisite	Thorough knowledge on all the M.Sc. level course contents he/she have studied		

COURSE OUTCOMES (CO)

CO No.	Expected Course Outcome	Learning domain	PSO No
1	Reproduce acquired knowledge/ understanding about the subject of study	R, U, A	1,2,7
2	Acquire more in-depth knowledge of the major subject of study and apply this knowledge in diverse contexts.	U, A, I	1,3,7
3	Develop problem solving ability by promptly analyzing /evaluating a problem	An, E, S	1,2,3
4	Increase communication skill and confidence of students by question answering and discussion.	S, I, Ap	5
5	Able to contribute to research and development work	I	1,7,8

** Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*

Assessment Types	**Mode of Assessment** • A thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of physics are evaluated through questions and discussions by the board of examiners at the End of the Semester (100%)