SYLLABUS

JOINT MASTERS PROGRAMME IN PHYSICS (NANOSCIENCE AND NANOTECHNOLOGY)

Between

School of Nanoscience and Nanotechnology, Mahatma Gandhi University, Kottayam, Kerala

and

Department of Physics, Kannur University, Swami Ananthatheertha Campus, Payyanur, Kannur

PREFACE

We are happy to present the curricula and syllabi of the following Joint M.Sc. Physics (Nanoscience and Nanotechnology) Programme according to the OBE concept for favour of approval by the Faculty and Academic Council of the University. The Board of Studies has developed 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) for joint M.Sc. are presented in the syllabus. The PSOs and the COs are well correlated in the syllabus of each course.

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EXPERT COMMITTEE

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Convenor Dr. Sreekala M.S, Associate Professor, SCS Joint Director, School of Nanoscience and Nanotechnology	Convenor Dr. Sudheesh S., Professor & Head School of Chemical Sciences
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Dr. Kuruvila Joseph, Professor, IIST, Thiruvananthapuram.	
Dr. Hareesh, Principal Scientist, NIIST, Thiruvananthapuram.	

Programme Outcomes (PO) of Joint M.Sc. Programme

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/transdisc*i*plinary 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 12 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 organizations, research organizations 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 work place through knowledge/skill development/reskilling.

PROGRAMME : M. Sc. Physics (Nanoscience and Nanotechnology)
DURATION : 2 years
Credits : Core :71 Elective:12 Open course:4

Program Specific Outcomes (PSOs): Nanoscience and Nanotechnology being an interdisciplinary subject offers knowledge, understanding and output that is integrated and cross-disciplinary in nature. The programme specific outcome (PSO) envisaged in this post graduate programme would be;

PSO No:	**PSOs**	MGU & KU PO No.
1	Train students in the field of physical sciences with specific emphasis on Nanoscience and Nanotechnology to cater to the present demands of miniaturization and energy economy.	1,6
2	Help empower students to acquire objective as well as analytical skills to carry out scientific enquiries, which help unveil the natural phenomena.	1,2
3	Foster innovative cross-disciplinary research by posing newer questions transcending traditional scientific fields and enable students to get interactive skills.	3,8,4,8
4	Facilitate the students to be able to familiarise and to work with advanced experimental and computational techniques at various scales.	2,6
5	Exposure of students to research taking place worldwide at the frontiers of physics especially at the nanometre scale.	3,8,10
6	Equip the students to understand the Nature at various scales spanning from quantum mechanical through continuum, which covers the subatomic to cosmological space.	1, 6,7
7	Apply principles of theoretical and applied physics, to comprehend the scientific phenomenon in nano domain.	1
8	Nurture the quality of rationality and inquisitiveness, so that the students are capable of free and critical thinking to steer clear judgemental and social biases.	2,4,5,9
9	Inspire the students to be committed to deliver good to the society by judicious application of scientific skill sets they acquire doing physics at the nanoscale.	3,7,8,9

SEMESTER	COURSE CODE	NAME OF THE COURSE	CREDIT	TOTAL CREDIT
I (M.G. University + Kannur University)	**CORE**			24
	MGKUMPNSC01	Classical Mechanics	4	
	MGKUMPNSC02	Mathematical Physics I	3	
	MGKUMPNSC03	Basic Electronics	3	
	MGKUMPNSC04	Atomic and Molecular Physics	3	
	MGKUMPNSC05	Introduction to Nanomaterials	3	
	MGKUMPNSC06	Practical I - General Physics	2	
	MGKUMPNSC07	Practical II - Electronics - Practical	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE01	Statistical Physics	4	
	MGKUMPNSE02	Nanocomposites	4	
II (Kannur University)	**CORE**			24
	MGKUMPNSC08	Mathematical Physics II	4	
	MGKUMPNSC09	Quantum Mechanics I	4	
	MGKUMPNSC10	Condensed Matter Physics I	3	
	MGKUMPNSC11	Nanomaterials and Characterization	3	
	MGKUMPNSC12	Practical III - Electronics	2	
	MGKUMPNSC13	Practical IV - Advanced Physics	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE03	Electromagnetic Theory	4	
	MGKUMPNSE04	Nanophotonics	4	
	MGKUMPNSC14	**INDUSTRIAL INTERNSHIP**	2	
III (M.G. University)	**CORE**			23
	MGKUMPNSC15	Quantum Mechanics II	4	
	MGKUMPNSC16	Condensed Matter Physics II	4	
	MGKUMPNSC17	Applications of Nanomaterials	3	
	MGKUMPNSC18	Practical V - Synthesis of Nanomaterials	2	
	MGKUMPNSC19	Practical VI - Characterization of Nanomaterials	2	
	ELECTIVE (Choose any one)			
	MGKUMPNSE05	Nuclear and Particle Physics	4	
	MGKUMPNSE06	Nanomagnetic Materials	4	
		OPEN COURSE	4	
IV	MGKUMPNSC20	Dissertation	12	16
	MGKUMPNSC21	Comprehensive Course Viva	4	
			TOTAL PROGRAMME CREDITS	**87**

SEMESTER I

Programme	**Joint M.Sc.**					
Course Name	**Classical Mechanics**					
Type of Course	Core					
Course Code	MGKUMPNSC01					
Semester	First Credit: 4					
Course Summary & Justification	This course provides the student with accurate description of motion of macroscopic objects based on Newtonian, Lagrangian and Hamiltonian mechanics. This will include the mechanics arising out of the special theory of relativity. Moreover, this course will enable them to learn classical mechanics as a precursor to newer physical theories, such as quantum mechanics.					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	60	40	-	40	140
Pre-requisite	Introductory mathematical knowledge of algebra, trigonometry, vector and tensor analysis, calculus; basic knowledge of Newtonian mechanics.					
Others- Library, field work, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Get exposure to the Newtonian mechanics and variational formulation	U, R	4,6,7
2	Comprehend and learn more abstract Lagrangian and Hamiltonian mechanics	E	2, 6, 7
3	Identify generalized coordinates and coordinate transformations of a rigid body. Comprehend various aspects of rigid body dynamics.	An	2,6
4	Be able to solve some real-world problems using canonical transformations	A/An	2,6
5	Identify coordinates and spaces which will hold the invariance of light velocity.	U/An	5, 8, 7
6	Equip with the techniques of reconciling with speeds of objects comparable to the light velocity.	A/E	5, 8, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Module 1** **Newtonian, Lagrangian and Hamiltonian mechanics** Mechanics of a system of particles in vector form, Conservation of linear momentum, energy and angular momentum, Degrees of freedom, generalised coordinates and velocities, Lagrangian, action principle, external action, Euler-Lagrange equations, Constraints, Applications of the Lagrangian formalism, Generalised momenta, Hamiltonian, Hamilton's equations of motion, Legendre transform, relation to Lagrangian formalism, Phase space, Phase trajectories, Applications to systems with one and two degrees of freedom, Central force problem, Kepler problem, bound and scattering motions, Scattering in a central potential, Rutherford formula, scattering cross section	**1,2**
2	**Module 2** **Non-inertial frames of reference and pseudoforces** Elements of rigid-body dynamics, Orthogonal transformations, Euler angles, Rigid body equations of motion, The symmetric top, Small oscillations, Normal mode analysis, Normal modes of a harmonic chain, centrifugal and Coriolis forces.	**3**
3	**Module 3** **Elementary ideas on general dynamical systems** Conservative versus dissipative systems, Hamiltonian systems and Liouville's theorem, Canonical transformations, Poisson brackets, Action-angle variables, non-integrable systems and elements of chaotic motion	**4**
4	**Module 4** **Special relativity** Internal frames, Principle and postulate of relativity, Lorentz transformations, Length contraction, time dilation and the Doppler effect, Velocity addition formula, Four- vector notation, Energy-momentum four-vector for a particle, Relativistic invariance of physical laws	**5,6**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Direct Instruction, Explicit Teaching, E-learning, interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) *Internal Test* -20 marks *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature – 10 marks *Seminar Presentation* – A topic needs to be presented and discussed with the class- 10 marks 2. Semester End Examination – 60 marks

REFERENCES

1. H. Goldstein, Classical Mechanics, 2nd Edition, Narosa Pub. House, 1989
2. I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1987 [Chapters 4,5,6, 7 in particular and parts of Chapter 1-3,9, 10]
3. D. Rindler, Special Theory of Relativity, Oxford University Press, 1982
4. Stephen T. Thornton, Jerry B. Marion, Classical Dynamics of particles and system, 5th edition, Cengage; 2012
5. Douglas Gregory, Classical Mechanics; an undergraduate text, Cambridge University Press, 2006
6. Rana and Joag, Classical Mechanics, McGraw Hill Education, 2017
7. Landau and Lifshitz, Mechanics. Vol. 1 (3rd ed.). Butterworth-Heinemann, 1976.
8. Grant R. Fowles, George L. Cassiday, Analytical Mechanics, Thomson Brooks/ Cole, 2005
9. John R. Taylor, Classical Mechanics, University Science Books, California, 2005

Programme	**Joint M.Sc.**					
Course Name	**Mathematical Physics I**					
Type of Course	Core					
Course Code	MGKUMPNSC02					
Semester	First			Credit: 4		
Course Summary & Justification	This course allows the students to assimilate mathematical foundations of physics. A considerable body of background knowledge of mathematical techniques is essential for understanding and learning the theory behind every physical phenomenon. This course would equip the students with standard techniques of solving physical problems as well.					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	60	40	-	40	140
Pre-requisite	Introductory mathematical knowledge of algebra, trigonometry, calculus; basic knowledge of problem solving.					
Others- Library, field work, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Categorize physical properties according to the medium of their occurrence	U, R	2, 3
2	Comprehend the linear algebra underlying many of the numerical simulation algorithms	E	1, 8
3	Customize differential equations to depict various real-world problems	A	1, 8
4	Identify the applicability of special functions and polynomials	A/An	6, 2
5	Develop skills for describing uncertainty in terms of probabilistic models and for probabilistic reasoning	E,S	9, 4
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

Module No.		CO No.
1	**Vector and Tensor analysis:** Vectors and Tensors, Vector calculus and tensors in index notation	**1**
2	**Linear Algebra:** Linear vector spaces, Dirac notation, Basis sets, Inner Products, Orthonormality and completeness, Gram-Schmidt orthonormalization process, Linear operators, Matrix algebra, Determinants, similarity transforms, diagonalization, orthogonal, Hermitian and unitary matrices, Spaces of square summable sequences and square integrable functions, generalized functions, Dirac delta function and its representations, Differential operators, Fourier series.	**2**
3	**Ordinary Differential Equations:** Ordinary Differential Equations, Superposition principle, Power series solutions for second-order ordinary differential equations, singular points of ODEs, Sturm-Liouville problems, Hermite, Legendre, Laugerre and Bessel functions, Recurrence relations and generating functions, Spherical harmonics, Addition theorem, Gamma, beta and error functions.	**3**
4	**Probabilistic Systems Analysis** Probability theory and Random variables Probability distributions and probability densities, Standard discrete and continuous probability distributions, Moments and generating functions, Central Limit Theorem (Statement and applications).	**4,5**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Direct Instruction, Explicit Teaching, E-learning, interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) *Internal Test* *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature 2. Seminar Presentation – A topic needs to be presented and discussed with the class 3. Semester End Examination

REFERENCES

1. Schaum's outline series, Mcgraw Hill, 1964: (i) Vector and tensor analysis (ii) Linear Algebra (iii) Differential Equations, (iv) Probability, (v) Statistics
2. M. Boas, Mathematical Methods in Physics Sciences, 2nd Edition, Wiley International Edition, 1983
3. E. Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, 5th Edition, 1991
4. E. Kreyszig, Introductory Functional Analysis and Applications, John Wiley, 1978
5. P. R. Halmos, Finite Dimensional Vector Spaces, Prentice-Hall India, 1988
6. George B. Arfken, Hans J. Weber, Frank E. Harris, Mathematical Methods for Physicists, 7th Edition, Academic Press, 2012.
7. Gilbert Strang, Introduction to Linear Algebra, 5 th Edition, Wellesley-Cambridge Press, 2016

School Name	**Joint M.Sc.**					
Programme	**M.Sc. Nanoscience and Nanotechnology (Physics)**					
Course Name	**Basic Electronics**					
Type of Course	Core					
Course Code	MGKUMPNSC03					
Course Summary & Justification	This course aims to impart the basic knowledge of logic circuits and enable students to apply it to design a digital system. Students are expected to develop the skill to design circuits using operational amplifiers and other linear ICs for various applications. It also enables the learners capable of understanding the fundamental architecture of micro controllers. This course also enables the students to understand the basic concepts of analog and digital communication.					
Semester	1		**Credit**	3		
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Solid state devices, Semiconducting nanostructures, VLSI					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Explain the working of different combinational and sequential logic circuits. Students will be able to design the combinational and sequential circuits.	U, A	1, 4
2	Understand the primary applications of the operational amplifier as an adder, subtractor, differentiator, integrator, comparator, and waveform generator etc.	U	1, 4
3	Explain the working principle and instrumentation of analog and digital communications.	U	4, 7, 9
4	Explain the architecture of 8051 microcontroller, instructions, and it’s working.	U	4, 5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Logic gates and Combinational systems** Boolean postulates and laws – Logic Functions and Gates De-Morgan's Theorems, Principle of Duality, Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS), Karnaugh map Minimization. Combinatorial Logic Systems - Comparators, Multiplexers, Demultiplexers, Encoder, Decoder. Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder.	**1**
2	**Sequential systems** Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Conversion of Flipflops, Excitation table and characteristic equation. Ripple and Synchronous counters, Shift registers-SIPO, SISO, PISO, PIPO. Shift Registers with parallel Load/Shift, Ring counter and Johnson's counter. Asynchronous and Synchronous counter design, Mod N counter	**2**
3	**8051 microcontrollers** 8051 Architecture- Register Organization- Memory and I/O addressing- Interrupts and Stack- 8051 Addressing Modes- Instruction Set- data transfer instructions, arithmetic instructions, logical instructions, Boolean instructions, control transfer instructions, Simple programs	**3**
4	**Analog modulation and digital modulation** Amplitude Modulation – Double and Single sideband techniques – Frequency modulation and Demodulation techniques – Bandwidth requirements – Pulse communication – Pulse width, Pulse position and Pulse amplitude modulation, Digital modulation- Pulse Code Modulation (PCM): Pulse Modulation, Sampling process, Performance comparison of various sampling techniques, Aliasing, Reconstruction, PAM, Quantization, Noise in PCM system, Modifications of PCM: Delta modulation, DPCM, ADPCM, ADM	**4**
5	**Operational amplifiers** Operational amplifiers (Op Amps): The 741 Op Amp, Block diagram, Ideal op-amp parameters, typical parameter values for 741, Equivalent circuit, Open loop configurations, Voltage transfer curve, Frequency response curve. Op-amp with negative feedback: General concept of Voltage Series, Voltage Shunt, current series and current shunt negative feedback, Virtual ground Concept; Op-amp applications: Summer, Voltage Follower- Differential and Instrumentation Amplifiers, Voltage to current and Current to voltage converters, Integrator, Differentiator, Precision rectifiers, Comparators, Schmitt Triggers, Log and antilog amplifiers. Op-amp Oscillators and Multivibrators: Phase Shift and Wien-bridge Oscillators, Triangular and Sawtooth waveform generators, A stable and monostable multivibrators	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1 Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. Mano M.M., Ciletti M.D., "Digital Design", Pearson India, 4th Edition. 2006
2. D.V. Hall, "Digital Circuits and Systems", Tata McGraw Hill, 1989
3. Roddy and Coolen, Electronic Communications, Prentice Hall 4th Ed (1995).
4. B. P. Lathi, Modern Digital and Analog Communication Systems 3rd Ed, Oxford University press (1998).
5. Gayakwad R. A., Op-Amps and Linear Integrated Circuits, Prentice Hall, 4/e, 2010 6.Roy D. C. and S. B. Jain, Linear Integrated Circuits, New Age International, 3/e, 2010
6. Raj Kamal, Microcontrollers: Architecture, Programming, Interfacing and System Design, Pearson Education.
7. A. NagoorKani, Microprocessors and Microcontrollers, Second Edition, Tata McGraw Hill,
8. Thomas L. Floyd, Digital Fundamentals, Pearson Education; Eleventh edition, 2015
9. Kenneth J. Ayala, The 8051 Microcontroller, , Thomson Delmar Learning, 2005

Programme	**Joint M.Sc.**					
Course Name	**Atomic and Molecular Physics**					
Type of Course	Core					
Course Code	MGKUMPNSC04					
Course Summary & Justification	This course provides an introduction to the field of atomic and molecular physics. This will include a description of classic historical experiments and results and theoretical concepts from quantum mechanics. The first half of this course deals principally with atomic structure and the interaction between atoms and fields. It covers electronic transitions, atomic spectra, excited states, hydrogenic and multi-electron atoms. The second half of the course deals with the binding of atoms into molecules, molecular degrees of freedom (electronic, vibrational, and rotational), elementary group theory considerations and molecular spectroscopy.					
Semester	I		**Credit**		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Basics of Atomic stucture and Quantujm mechanics (Undergraduate)					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome**	**Learning Domains**	**PSO No.**
	Upon completion of this course, students will be able to;		
1	The module encompasses a detailed exposure to Hydrogen atom and time independent perturbation	U, A	2, 3, 6

	theory. Also discuss the relativistic corrections for the energy levels of the hydrogen atom and their effect on optical spectra and derivation of the energy shifts due to these corrections using first order perturbation theory. (Module 1)		
2	This module discusses different interactions associated with Hydrogen atom and review of time dependent perturbation theory. (Module 2)	U, A	2, 3, 6
3	The student will get knowledge about Quantization of the electromagnetic field and Raman effect. (Module 3).	An, E	2, 3, 5
4	The student will get theoretical understandings of Hartree Fock SCF method, proof of Koopmans theorem, Slater's approximation to exchange, Total Hamiltonian of a molecule, Born -Oppenheimer approximation, Rotational and Vibrational Spectra of molecules etc. (Module 4)	E	2, 3, 5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Hydrogen atom:** Review of the Bohr atom model, solution of the Schrodinger equation, spectra of hydrogen and hydrogen-like atoms, Review of time-independent perturbation theory, Fine structure of the hydrogen atom: spin-orbit coupling and relativistic correction to the kinetic energy, Review of the Dirac equation, Dirac equation in the non-relativistic limit	**1**
2	**Time Dependent Perturbation Theory** Zeeman and Stark Spectroscopy Hyperfine interaction in atomic Hydrogen, Spectroscopy with the 21 cm emission line, Review of time-dependent perturbation theory, Interaction of electromagnetic radiation with a two-level atom, Rabi flopping, The dipole approximation, electric dipole, magnetic dipole and electric quadrupole transitions, Selection rules, Transition probabilities and intensity of spectral lines	**2**

3	**Electromagnetic Field and Raman Effect** Line broadening mechanisms, Spontaneous and stimulated emissions and Einstein coefficients, masers and lasers, Lamb shift, Quantization of the electromagnetic field, The Raman effect, Introduction to NMR and ESR, Review of Pauli's exclusion principle, The spin-statistics theorem, The Helium spectrum, Many electron systems: Electron configurations and spectroscopic notation, equivalent and non-equivalent electrons and Hund's rules	**3**
4	**Approximation Methods** Hartree Fock SCF method, proof of Koopmans theorem, Slater's approximation to exchange, Total Hamiltonian of a molecule, Born - Oppenheimer approximation, Rotational and Vibrational Spectra of molecules, Anharmonicity, Franck-Condon principle, Electronic, Infrared and Raman Spectra analysis, Symmetry of atomic and molecular systems, Group theoretical treatment, proof of the Great Orthogonality Theorem. Optional Advanced Topics: Saturation absorption spectroscopy, atomic clocks, Laser-cooling and Bose-Einstein Condensation, Synchrotron radiation spectroscopy, Photofragmentation of molecules.	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. *Internal Test* -20 marks 2- *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature – 10 marks 3. *Seminar Presentation* – A topic needs to be presented and discussed with the class- 10 marks A. Semester End Examination – 60 marks

REFERENCES

1. B. H. Bransden and C. J. Joachain, Physics of Atoms and Molecules Longman Inc. New York, 1983
2. E. U. Condon and G. H. Shortley, The Theory of Atomic spectra, Cambridge University Press, 1989
3. G. Herzberb, Molecular Spectra and Molecular Structure -I Spectra of Diatomic Molecules, D. Von Nostrand Inc., 1956
4. G. Herzberg, Molecular Spectra and Molecular Structure -II Infrared and Raman Spectra of Polyatomic Molecules, D. Von Nostrand Inc., 1956
5. G. Herzberg, Atomic Structure and Atomic Spectra, Dover Pub. Go. 2nd Edition, 1944
6. H. E. White, Introduction to Atomic Spectra, McGraw-Hill, 1954
7. P. S. Sindhu, Molecular Spectroscopy, Tata McGraw-Hill, 1985
8. E. U. Condon and H. Odabasi, Atomic Structure, Cambridge Universtiy Press, 1980
9. H. A. Bethe and E. E. Salpeter, Quantum Mechanics of One- and Two- Electron Atoms, Plenum Press, 1977
10. M. Tinkham, Group Theory and Quantum Mechanics, Courier Dover Publications, 2004
11. D. J. Griffiths, Introduction to Quantum Mechanics (2nd Edition), Pearson Education 2005
12. Peter F. Bernath, Spectra of Atoms and Molecules, Oxford University Press, 1995
13. J. J. Sakurai, Modern Quantum Mechanics, Pearson Education, 2009
14. J. J. Sakurai, Advanced Quantum Mechanics, Pearson Education,2009

Programme	**Joint M.Sc.**					
Course Name	**Introduction to Nanomaterials**					
Type of Course	Core					
Course Code	MGKUMPNSC05					
Course Summary & Justification	The emphasis of the course is to understand the physics of nanomaterials in detail and to explore its wide application. This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain profound understanding of the principles governing nano and functional materials' properties, behaviour and interactions as well as their characterisation.					
Semester	1		**Credit**		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Strong mathematical background in graduation level is desirable.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Understand and use the properties of Nano-materials in diverse fields.	U	1,5
2	Gain knowledge about the Nanomaterials, their properties, behaviour, interaction and use of them over many disciplines of science.	U, A	1,5

3	Understand the chemistry of Nanomaterials in detail and to explore the wide application.	U, R	1,5
4	Understand the constituents of matter, nanomaterials, properties and usefulness.	U	1,5
5	Able to learn how to understand the basic behaviour of Nanomaterials.	U	1,5
6	Understand size and shape dependent properties of Nanomaterials.	U, A	1,5
7	Gain knowledge about classification of Nanomaterials	U, An	1,5
8	Deep understanding on surface characteristics of Nanomaterials	U, A, An	1,5
9	Able to understand different surface energy minimization techniques.	U, A	1,5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Fundamentals of Nanomaterials** History of Nanotechnology, Feynman's vision on Nano Science & technology, bulk vs nanomaterials. Central importance of nanoscale morphology - small things making big differences, nanotechnology as natures technology, clusters and magic numbers, nanoscale architecture. Recent developments, challenges and future prospects of nanomaterials.	**1,2,3,4,5**
2	**Size and shape dependent properties of nanomaterials** Size and shape dependent properties, Melting points and lattice constants, Surface Tension, density of states, Wettability - Specific Surface Area and Pore – Composite Structure - Mechanical properties, Optical properties: Basic principles of nanomaterials- Increase in surface area to volume ratio and quantum confinement effect. Surface plasmon resonance in metal nanoparticles and quantum size effect in in Semiconductors, Electrical conductivity: Surface scattering, change of electronic structure, quantum transport, effect of microstructure.	**6**

3	**Classification of nanomaterials** Classification based on the dimensionality, Zero-dimensional nanostructures: metal, semiconductor and oxide nanoparticles. One-dimensional nanostructures: nanowires and nanorods, Two-dimensional nanostructures: thin films, Three-dimensional nanomaterials, Special Nanomaterials: Carbon fullerenes and carbon nanotubes, micro and mesoporous materials, core-shell structures, organic-inorganic hybrids.	**7**
4	**Surface characteristics of Nanomaterials** Surface science for nanomaterials, surface energy, Surface Energy minimization: Sintering Ostwald ripening and agglomeration, Energy minimization by Isotropic and anisotropic surfaces, Wulff plot, Surface energy, surface curvature and chemical potential, Surface energy stabilization mechanisms, Electrostatic stabilization – Point zero charge (p.z.c), Nernst Equation, Electric double layer. Electric potential at the proximity of a solid surface - Debye-Huckel Screening strength. Interaction between nanoparticles – Van der Waals attraction potential, DLVO Theory, steric stabilization and electro steric stabilization. Nucleation and growth of nuclei, critical radius, homogenous and heterogeneous nucleation.	**8,9**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. A.W. Adamson and A.P.Gast, Physical Chemistry of surfaces, Wiley Interscience, NY 2004.

2. G. Cao and Y. Wang, Nanostructures and Nanomaterials, 2nd Ed., Imperial College Press, 2004.

3. R. Kelsall, I. Hamley and M. Geoghegan, Nanoscale Science and Technology, Wiley, 2005.

4. K. J. Klabunde, R. M. Richards, Nanoscale Materials in Chemistry, 2nd Ed., Wiley, 2009.

5. T. Pradeep, A text book of Nano Science and Technology, Tata McGraw-Hill Education, 2012.

6. G. Schmidt, Nanoparticles: from Theory to applications, Wiley-VCH, 2004

7. Malkiat S. Johal, Lewis E. Johnson, Textbook Series in Physical Sciences, CRC Press, Year: 2018

8. G. Cao , Nanostructures & Nanomaterials: Synthesis, Properties &Application, Imperial College Press, 2004.

9. Micheal F. Ashby, P.J. Ferreria, D.L. Schodek, Nanomaterials, Nanotechnologies and Design: An introduction for engineers and Architects.2012.

10. Hornyak, G. Louis, Tibbals, H. F., Dutta, Joydeep, Fundamentals of Nanotechnology, CRC Press, 2009.

11. Dieter Vollath, Nanomaterials: An introduction to synthesis, properties and application, WILE-VCH, 2008.

12. C. N. R. Rao, H. C. Mult. Achim Müller, A. K. Cheetham The Chemistry of Nanomaterials: Synthesis, Properties and Applications, 2004.

13. A.W. Adamson and A.P.Gast, Physical Chemistry of surfaces, Wiley Interscience, NY 2004.

14. G. Cao and Y. Wang, Nanostructures and Nanomaterials, 2nd Ed., Imperial College Press, 2004.

15. R. Kelsall, I. Hamley and M. Geoghegan, Nanoscale Science and Technology, Wiley, 2005.

16. K. J. Klabunde, R. M. Richards, Nanoscale Materials in Chemistry, 2nd Ed., Wiley, 2009.

Programme	**Joint M.Sc.**					
Course Name	**Practical I – General Physics**					
Type of Course	**Practical -Core**					
Course Code	MGKUMPNSC06					
Course Summary & Justification	At the end of this course students should acquire skills in doing experiments in physics as well as advanced physics.					
Semester	I		**Credit**		2	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	0	40	40		80
Pre-requisite	Strong theoretical knowledge in					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	To determine the carrier concentration, carrier mobility etc of semiconductors	A, An, S	1, 4
2	To determine the magnetic susceptibility, curie temperature, retentivity, coercivity etc	A, An, S	1, 4
3	To determine the Planks constant	A, An, S	1, 4
4	To determine the diffraction pattern and wavelengths by various methods	A, An, S	1, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

	CO No.
1. Hall Effect in Semiconductor. Determine the Hall coefficient, carrier concentration and carrier mobility.	
2. Ultrasonic- acoustic optic technique-elastic property of a liquid.	
3. Magnetic susceptibility of a paramagnetic solution using Quinck's tube method.	
4. Curie temperature of a magnetic material.	
5. Dielectric Constant and Curie temperature of ferroelectric Ceramics.	
6. Draw the hysteresis curve (B – H Curve) of a ferromagnetic material and determination of retentivity and coercivity.	
7. Cornu's method- Determination of elastic constant of a transparent material	
8. Determination of e/m by Thomson 's method.	
9. Determination of e/k of Silicon.	
10. Determination of Planck 's constant (Photoelectric effect).	
11. Measurement of resistivity of a semiconductor by four-probe method at different temperature and determination of band gap.	
12. Determination of magnetic susceptibility of a solid by Guoy's method.	
13. Measurement of wavelength of laser using reflection grating.	
14. Fraunhoffer diffraction pattern of a single slit, determination of wavelength/slit width.	
15. Fraunhoffer diffraction pattern of wire mesh, determination of wavelength/slit width.	
16. Fraunhoffer diffraction pattern of double slit, determination of wavelength/slit width.	
17. Diffraction pattern of light with circular aperture using Diode/He-Ne laser.	
18. Fresnel diffraction pattern of a single slit.	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 2. Assignments A. Semester End examination

REFERENCES

1. Advanced practical physics for students, B.L Worsnop and H.T Flint, University of California.
2. A course on experiment with He-Ne Laser, R.SSirohi, John Wiley & Sons (Asia) Pvt.ltd
3. Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan ,K.R Priolkar, Indian Academy of Sciences.
4. Advanced Practical Physics, S.P singh, Pragati Prakasan,
5. Practical Physics, Gupta, Kumar, Pragati Prakasan.
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd:

Programme	**Joint M.Sc.**					
Course Name	**Practical II - Basic Electronics**					
Type of Course	**Practical -Core**					
Course Code	MGKUMPNSC07					
Course Summary & Justification	At the end of this course students should acquire skills in designing and testing analog and digital integrated circuits.					
Semester	1		**Credit**		2	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	0	40	40		80
Pre-requisite	Strong mathematical background in graduation level is desirable.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	To recognize various digital gates and ICs	A, An, S	1, 4
2	To design and implement combinational circuits using basic gates and ICs	A, An, S	1, 4
3	To design and implement sequential circuits using basic gates and ICs.	A, An, S	1, 4
4	Design and demonstrate functioning of various analog circuits	A, An, S	1, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

	CO No.
1. Op-Amp parameters (i) Open loop gain (ii) input offset voltage (iii) input bias current (iv)) CMRR (v) slew rate (vi) Band width	
2. Design and construct an integrator using Op-Amp (μA741), draw the input output curve and study the frequency response.	
3. Design and construct a differentiator using Op-Amp (μA741) for sin wave and square wave input and study the output wave for different frequencies.	
4. Design and construct a logarithmic amplifier using Op-Amp (μA741) and study the output wave form.	
5. Design and construct a square wave generator using Op-Amp (μA741) for a frequency f0.	
6. Design and construct a triangular wave generator using (μA741) for a frequency f0.	
7. Design and construct a saw tooth wave generator using Op-Amp (μA741) generator.	
8. Design and construct an Op-Amp Wien bridge oscillator with amplitude stabilization and study the output wave form.	
9. Design and construct a Schmidt trigger using Op-Amp μA741, plot of the hysteresis curve.	
10. Design and construct an astable multivibrator using μA741 with duty cycle other than 50%	
11. Design and construct a RC phase shift oscillator using μA741for a frequency f0.	
12. Design and construct a first and second order low pass Butterworth filter using μA741 and plot the frequency response curve.	
13. Design and construct a first and second order high pass Butterworth filter using μA741 and study the frequency response.	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES:

1. Op-Amp and linear integrated circuit Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7
2. Electronic Laboratory Primer a design approach S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi
3. Electronic lab manual Vol I, K ANavas, Rajath Publishing
4. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central

<table>
<tr><td>Programme</td><td colspan="6">Joint M.Sc.</td></tr>
<tr><td>Course Name</td><td colspan="6">Statistical Physics</td></tr>
<tr><td>Type of Course</td><td colspan="6">Elective</td></tr>
<tr><td>Course Code</td><td colspan="6">MGKUMPNSE01</td></tr>
<tr><td>Course Summary & Justification</td><td colspan="6">Statistical mechanics provides a theoretical bridge that takes you from the micro world to the macro world. This makes an attempt to derive the macroscopic properties of an object from the properties of its microscopic constituents and the interactions amongst them. It tries to provide a theoretical basis for the empirical thermodynamics.
This course is designed at providing students with basic concepts of calculating properties of an energetically isolated system in equilibrium by imposing probability distribution over the set of microscopic states compatible with the external constraints imposed on the system. Using this probability distribution, average values of specified functions of the microscopic conditions of the gas can be calculated. Students will be able to understand what probability distribution really means, why average values for macroscopic conditions, and how do phase averages related to measured features of the macroscopic system etc. And helps the students to analyses how changing quantum mechanical basis leads to wholesale changes within statistical mechanics. Bose-Einstein statistics, Fermi Dirac statistics and Maxwell Boltzmann statistics will be discussed.</td></tr>
<tr><td>Semester</td><td colspan="2">I</td><td colspan="2">Credit</td><td colspan="2">4</td></tr>
<tr><td>Total Student Learning Time (SLT)</td><td>Learning Approach</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Others</td><td>Total Learning Hours</td></tr>
<tr><td></td><td>Authentic learning
Collaborative learning
Case based learning</td><td>60</td><td>40</td><td>-</td><td>40</td><td>140</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Basics of Thermodynamics, Quantum dynamics and Probability theory. This is based on statistical methods, probability theory and the microscopic physical laws. It can be used to explain the thermodynamic behaviour of large systems</td></tr>
<tr><td colspan="7">Others- Library, seminar and assignment preparations, test, journal, discussion etc.</td></tr>
</table>

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Knowledge of Thermodynamics and probability theory (Module 1)	U, A	2, 9
2	Understand the inadequacy of Quantum dynamics and Probability theory (Module 2)	U, A	2, 6
3	Identify the statistical methods and microscopic physical laws. (Module 3).	An, E	2, 6
4	Apply the principles of statistical thermodynamics that can explain the thermodynamic behaviour of large systems (Module 4)	E	2, 5
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Thermodynamics and probability theory** Systems with a very large number of degrees of freedom: the need for statistical mechanics, Macrostates, microstates and accessible microstates, Fundamental postulate of equilibrium statistical mechanics, Probability distributions, Microcanonical ensemble, Boltzmann's formula for entropy	**1**
2	**Quantum dynamics and Probability theory** Canonical ensemble, partition function, free energy, calculation of thermodynamic quantities, Classical ideal gas, Maxwell-Boltzmann distribution, equipartition theorem, Paramagnetism, Langevin and Brillouin functions, Curie's law.	**2**

3	**Statistical methods and microscopic physical laws** Quantum statistics: systems of identical, indistinguishable particles, spin, symmetry of wavefunctions, bosons, Pauli's exclusion principle, fermions, Grand canonical ensemble, Bose-Einstein and Fermi-Dirac distributions, Degeneracy, Free electron gas, Pauli paramagnetism, Blackbody radiation, Bose-Einstein condensation, Einstein model of lattice vibrations, phonons, Debye's theory of the specific heat of crystals.	**3**
4	**Principles of statistical thermodynamics** Phase diagrams, phase equilibria and phase transitions, Mean-field theory of liquid-gas transition (Van der Waals model) and ferromagnet-paramagnet transition (Weiss' molecular field theory), Heisenberg exchange interaction and the origin of ferromagnetism, Elementary ideas on Ising and Heisenberg models of ferromagnetism	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. D. Chandler, Introduction to Modern Statistical Mechanics, Oxford University press, 1987
2. C. J. Thompson, Equilibrium Statistical Mechanics, Clarendon Press, 1988
3. R. K. Pathria, Statistical Mechanics, Elsevier, 1972
4. F. Reif, Fundamentals of Statistical and Thermal Physics, International Student Edition, McGraw-Hill, 1988
5. K. Huang, Statistical Mechanics, Wiley Eastern, 1988
6. L. D. Landau and E. M. Lifshitz, Statistical Physics (Par1I), 3rd Edition, Pergamon Press, 1989
7. F. Reif, Statistical Physics (Berkeley Physics Course, Vol. 5), McGraw Hill, 1967
8. F. Mandl, Statistical Physics, 2nd edition, ELBS & Wiley, 1988
9. E. S. R. Gopal, Statistical Mechanics and Properties of Matter MacMillan India, 1988
10. R. Kubo. Statistical Physics -Problems and Solutions, North Holland, 1965
11. Y. K. Lim, Problems and Solutions in Thermodynamics and Statistical Mechanics, World Scientific, 1990
12. Sanchez and Bowley, Introductory Statistical Mechanics, Clarendon Press- Oxford, 1999
13. Callen, H. B., Callen, H. B., Thermodynamics and an introduction to thermostatistics. Egypt: Wiley, 1985

Programme	**Joint M.Sc.**					
Course Name	**Nanocomposites**					
Type of Course	Elective					
Course Code	MGKUMPNSE02					
Course Summary & Justification	Students will gain knowledge of the main types of nanocomposite materials and their specific physical and chemical properties required in applications. Graduates will become familiar with the methods of preparation and characterization of specific physical properties of nanocomposite materials. The current state of theory and modelling of nanocomposites will be presented. At the end of the course, students will have enough understanding of the main concepts in nanocomposites physics to allow them read and understand the most important research papers in this field.					
Semester	I		**Credit**		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Basics of solid-state physics (Undergraduate)					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Understand Metal based nanocomposite: preparation techniques and their final properties and functionality (Module 1)	U, A	1
2	Study of Ceramic based nanocomposites: some preparation techniques, properties and applications. (Module 2)	U, A	1,7

3	Introduction of Polymer based nanocomposites, Diblock Copolymer based nanocomposites: preparation, properties and applications. Carbon nanotubes-based nanocomposites: functionalization of CNTs will also be discussed. (Module 3).	An, E	7
4	Introduction of new kind of nanocomposites, Design of super hard materials, Super hard nanocomposites, its designing and improvements of mechanical properties will also be discussed. (Module 4)	E	7, 9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Metal based nanocomposites:** Metal- oxide or metal-ceramic composites: different aspects of their preparation techniques and their final properties and functionality. Metal - metal nanocomposites: some simple preparation techniques and their new electrical and magnetic properties	**1**
2	**Ceramic based nanocomposites:** some preparation techniques, properties and applications	**2**
3	**Polymer based nanocomposites:** Diblock Copolymer based nanocomposites: preparation, properties and applications. Polymer- carbon nanotubes-based nanocomposites: functionalization of CNTs, preparation, properties and applications.	**3**
4	**New kind of nanocomposites** Fractal based glass- metal nanocomposites, its designing and fractal dimension analysis, Electrical property of fractal-based nanocomposites, Core-shell structured nanocomposites, Design of super hard materials, Super hard nanocomposite: s, its designing and improvements of mechanical properties	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. Nanocomposites Science and Technology – P. M. Ajayan, L. S. Schadler, P. V. Braum, Wiley, 2003
2. Physical properties of Carbon nanotube- R. Satio, Imperial College Press, 1998
3. Polymer nanocomposites, Edited by Yiu-Wing Mai and Zhong -Zeng Yu, Woodhead Publishing, 2006
4. Processing and properties of Nanocomposites, Suresh Advani, World Scientific Publishing, 2007
5. Polymer- Layered Silicate and Silicate and Silica Nanocomposites, Y. C. Ke and P. Stroeve, Elsevier Science, 2005
6. Novel synthesis and characterization of Nanostructured materials, Annelise Kopp Alves, Carlos P. Bergmann, Felipe Amorim Berutti, Springer, 2013
7. Hybrid Nanocomposites for Nanotechnology; Electronic, Optical, Magnetic and Biomedical Applications, Lhadi Merhari (Ed), Springer, 2009
8. Functional Polymer Nanocomposites for Wastewater Treatment, M J Hato, S S Ray (Eds), Springer Cham, 2022

SEMESTER II

Programme	**Joint M.Sc.**					
Course Name	**Mathematical Physics II**					
Type of Course	Core					
Course Code	MGKUMPNSC08					
Semester	II Credit: 4					
Course ISummary & Justification	The use of mathematical techniques in physics contexts is inevitable though the physical understanding is inexact and imprecise. This course provides some advanced topics in applied mathematics relevant to express physical reality and the governing laws. Partial differential equations and complex analysis encompass estimation, approximation and limiting process.					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Independent learning	60	40	-	40	140
Pre-requisite	Basic mathematical knowledge of complex variables, group theory and differential equations					
Others- Library, field work, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Grasp the Cauchy-Riemann equations, which give the conditions a function must satisfy in order for a complex generalization of the derivative.	U	1, 4
2	Identify the general qualitative features of solutions such as existence and smoothness of solutions of various partial differential equations appearing in physics	E	1, 8, 9

3	Use calculus of variations which seeks to find the path, curve, surface, etc., for which a given function has a stationary value (usually a minimum or maximum).	U, A	7, 9
4	Apply approximation methods such as Rayleigh-Ritz to reduce the number of degrees of freedom (DOF)	A	7, 9
5	Emphasize the role of group theory as the mathematical framework for labelling symmetry properties of classical and quantum mechanical systems.	U, An	7, 9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Complex Variables**: Analytic functions of a complex variable, Cauchy-Riemann conditions, Power series, Cauchy's integral theorem, Conformal mapping, Singularities: poles, essential singularities, Residue theorem, Contour integration and examples, Analytic continuation, Multiple-valued functions, branch points and branch cut integration.	**1**
2	**Partial Differential Equations:** Partial differential equations in Physics: Laplace, Poisson and Helmholtz equations; diffusion and wave equations, Applications	**2,3**
3	**Integral transforms:** Laplace transforms and Fourier transforms, Parseval's theorem, Convolution theorem, Applications, Calculus of Variations Functionals, Natural boundary conditions, Lagrange multipliers, Rayleigh-Ritz method	**4**
4	**Group theory:** Elements of group theory, Discrete groups with examples, Continuous groups (Lie groups) [rotation group in 2 and 3 dimensions, U (1) and SU (2)], Generators, Representations, Character tables for some point groups and the orthogonality theorem.	**5**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Direct Instruction, Explicit Teaching, E-learning, interactive Instruction: Active co-operative learning, Seminar, Group Assignments, Authentic learning, Library work and Group discussion, Presentation by individual student/ Group representative
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. *Internal Test* -20 marks 2- *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature – 10 marks 3. *Seminar Presentation* – A topic needs to be presented and discussed with the class- 10 marks Semester End Examination – 60 marks

REFERENCES

1. Schaum's outline series, McGraw Hill, 1964: (i) Complex Variables, (ii) Laplace Transforms, (iii) Group Theory
2. M. Boas, Mathematical Methods in Physical Sciences, 2nd Edition, Wiley International Edition, 1983
3. E. Kreyszig, Advanced Engineering Mathematics, Wiley Eastern, 5th Edition, 1991
4. L. A. Pipes and L. R. Harwell, Applied Mathematics for Engineers and Physicists, McGraw-Hill, 1995
5. M. Artin, Algebra, Prentice-Hall India, 2002
6. I. N. Sneddon, The Use of Integral Transforms, Tata McGraw Hill, 1985
7. D. H. Sattinger and O. L. Weaver, Lie Groups and Algebras with Applications to Physics, Geometry and Mechanics, Springer, 1986
8. M. Tinkham, Group Theory and Quantum Mechanics, Dover, 2003
9. George B. Arfken, Hans J. Weber, Frank E. Harris, Mathematical Methods for Physicists, 7th Edition, Academic Press, 2012.
10. P. Dennerey and A. Kryzwicki, Mathematics for Physicists, Dover (Indian Edition), 2005
11. K. F. Riley, M. P. Hobson and S. J. Bence, Mathematical Methods for Physics and Engineering, Cambridge University Press (Cambridge Low-priced Edition), 1999

Programme	**Joint M.Sc.**					
Course Name	**Quantum mechanics I**					
Type of Course	Core					
Course Code	MGKUMPNSC09					
Course Summary & Justification	This course provides a substantive introduction to the mathematical setting to the formulation of quantum mechanics and explains the basic concepts and elementary theory. It discusses the most important 1D and 3D quantum mechanical problems which helps to analyse the concept of quantum mechanics in potential practical applications. It also discusses Schrodinger and Heisenberg formulations of quantum mechanics.					
Semester	II		**Credit**		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Strong mathematical background in graduation level is desirable.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Students will get an understanding of linear vector spaces that are fundamental to quantum mechanics. They will also learn concepts and properties of inner-product, basis, linear operators and Hermitian operators etc. (Module 1)	U, A	6,8
2	Students will be able to understand the postulates of quantum mechanics	U, A	2
3	Students will solve various 1-dimensional time independent problems in quantum physics. This will help them to formulate such problems and understand	U, A	2,7

	the general properties of solutions. (Module 3)		
4	The student will learn to solve various 3-dimensional time independent problems like Hydrogen atom in Quantum Mechanics. Study of angular momentum and atomic structure will be crucial to understand other subjects like spectroscopy (Module 4).	An, E	2,7
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

Module No.		**CO No.**
1	**Module 1** **Linear Vector Spaces** de Broglie's hypothesis: matter waves and experimental confirmation, wave packets; Linear vector spaces: inner product, Hilbert space, Wave Functions; Linear operators: Hermitian operators, Projection operators, Commutator algebra, Unitary operators, Eigenvalues and Eigen vectors of a Hermitian operator; Basis: Representation in discrete bases, Matrix representation of kets, bras, and operators, Change of bases and unitary transformations, Matrix representation of the eigenvalue problem, Representation in position bases.	**1**
2	**Module 2** **Postulates of Quantum Mechanics** Postulates of Quantum Mechanics: State of a System, Probability Density, Superposition Principle, Observables as Operators, Position and Momentum operators, Position and Momentum representation of state vector, Connecting the position and momentum representations, Measurement in quantum mechanics, Expectation values, Commuting operators and Uncertainty relations; Time evolution of the state: Time-independent potentials and Stationary States, Time evolution operator, infinitesimal and finite Unitary Transformations; Conservation of probability; Time evolution of expectation values: Ehrenfest theorem; Poisson's brackets and commutators; Matrix and Wave mechanics	**2**
3	**Module 3** **Time independent 1D problems** Discrete, continuous and mixed spectrum; symmetric potentials and parity; Infinite square well potential; Symmetric potential well; Finite square well potential: Scattering and bound state solutions; Free particle; Delta function potential; Harmonic oscillator.	**3**

4	**Module 4** **Time independent 3D problems** Free particle in 3-dimensions: spherically symmetric solution; Particle in a 3D box; Schrodinger equation in presence of central Potential; Orbital angular momentum: eigen values and eigen functions of L^2 and L_z; Hydrogen Atom; Scattering: Cross Section, Amplitude and Differential Cross Section, Scattering of Spin-less Particles, The Born Approximation, Validity of the Born Approximation	**4**

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Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. E. Merzbacher, Quantum Mechanics, 2nd Edition, Wiley International Edition, 1970
2. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, Wiley India, 2016
3. V. K. Thankappan, Quantum Mechanics, Wiley Eastern, 1985
4. 1J. J. Sakurai, Modern Quantum Mechanics, Benjamin Cummings, 1985
5. R. P. Feynman, R. B. Leighton and M. Sands, The Feynman Lectures on Physics, Vol. 3, Narosa Pub. House, 1992
6. P. M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata Mc Graw-Hill, 1977
7. David J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press, 2017
8. Linus Pauling, E. Bright Wilson, Introduction to Quantum Mechanics with Applications to Chemistry, Dover Publications, 2012.

Programme	**Joint M.Sc.**					
Course Name	**Condensed Matter Physics I**					
Type of Course	Core					
Course Code	MGKUMPNSC10					
Course Summary & Justification	The course aims to make the learner understand the physics of solids, which forms the foundation for the study of other fields inside and outside the condensed matter physics. The course provides a clear picture about the solids and their properties used to change our society.					
Semester	II		**Credit**	3		
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Basic understanding of graduate level quantum mechanics and solid-state physics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome *Upon completion of this course, students will be able to;*	Learning Domains	PSO No.
1	Students will understand the underlying physics of solid-state materials. (Modules 1-4)	U, A	1, 6
2	Students will get an opportunity to revisit the fundamentals of solid state physics- crystal structure and space groups (Module 1)	R, U	1, 5
3	Students will learn the crystal symmetry and the macroscopic physical properties and diffraction of waves by crystals. (Module 2)	U, A	1, 5
4	The student will learn about different bindings in crystals, lattice dynamics and the thermal properties of crystals. (Module 3).	A, E	1,5, 9

5	Students will learn the details of band theory and the developments of semiconductor physics and bandgap engineering. (Module 4)	A, E	1, 5, 8
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Module 1** **Classification of condensed matter:** crystalline, non-crystalline, nanophase solids, liquids, Crystalline solids: Bravais lattices, crystal systems, point groups, space groups and typical structures	**1,2**
2	**Module 2** **Crystal symmetry and macroscopic physical properties** tensors of various ranks: pyroelectricity, ferroelectricity, electrical conductivity, piezoelectricity and elasticity tensors, Propagation of elastic waves in crystals and measurement of elastic constants, Diffraction of waves by crystals: X-rays, neutrons, electrons, Bragg's law in direct and reciprocal lattice, Structure factor, Principles of diffraction techniques, Brillouin zones.	**3**
3	**Module 3** **Types of binding, Ionic crystals** Born Mayer potential, Thermochemical Bom-Haber cycle, Van der Waals binding: rare gas crystals and binding energies, Covalent and metallic binding: characteristic features and examples, Lattice dynamics: monoatomic and diatomic lattices, Born-von Karman method, Phonon frequencies and density of states, Dispersion curves, inelastic neutron scattering, Reststrahlen Specific heat, Thermal expansion, Thermal conductivity, Normal and Umklapp processes.	**4**
4	**Module 4** **Band Theory and Semiconductor Physics** Free electron theory of metals, Thermal and transport properties, Hall effect Electronic specific heat, Bloch functions, Nearly free electron approximation, Formation of energy bands, Gaps at Brillouin zone boundaries, Electron states and classification into insulators, conductors and semimetals, Effective mass and concept of holes, Fermi surface, Cyclotron resonance, Semiconductors: carrier statistics in intrinsic and extrinsic crystals, electrical conductivity, Liquid crystal: thermotropic and lyotropic, Nematics and sematics: applications, Amorphous/glassy states.	**5**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 3. Continuous Internal Assessment (CIA) 4. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 5. Assignments B. Semester End examination

REFERENCES

1. Charles Kittel, Introduction to Solid State Physics, Wiley, 5th Edition, 1976
2. A. J. Dekker, Solid State Physics, Prentice Hall, 1957
3. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Saunders College Publishing, 1976
4. J. S. Blakemore, Solid State Physics, 2nd Edition, Cambridge University Press, 1974
5. Mendel Sachs, Solid State Theory, McGraw-Hill, 1963
6. Harald Bach and Hans Luth, Solid-State Physics, Springer International Student Edition, Narosa Pub. House, 1991
7. Gerald Burns, Solid State Physics, Academic Press, 1987
8. Marder, M. P. (2010). Condensed Matter Physics. Germany: Wiley.
9. Ali Omer, Elementary solid state physics, Pearson Education (1999)
10. Simon, S. H. (2013). The Oxford Solid State Basics. United Kingdom: OUP Oxford.
11. Sander, L. M. (2009). Advanced Condensed Matter Physics. United Kingdom: Cambridge University Press.
12. Azároff, L. V. (1986). Introduction to Solids. India: Tata McGraw-Hill.

Programme	**Joint M.Sc.**					
Course Name	**Nanomaterials and characterizations**					
Type of Course	Core					
Course Code	MGKUMPNSC11					
Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the various nanofabrication techniques, synthesis strategies, and different characterization techniques.					
Semester	II		**Credit**		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Strong mathematical background in graduation level is desirable.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Students will get an understanding of different Synthesis strategies; Bottom up and Top-down approaches. (Module 1)	U, A	1, 3, 7
2	Students will learn physical, chemical and biological characterization methods (Module 2)	U, A	1, 2, 7
3	Students will learn AFM, SEM, Deep UV and X-ray based lithography techniques (Module 3).	An, E	1, 2, 4
4	Students will learn in detail about X-ray diffractometry, Scanning probe microscopy and scanning tunnelling microscopy , Optical microscopy– SEM, TEM, AFM, UV-Vis-NIR spectrometry and FTIR (Module 4)	E	1, 9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Synthesis strategies** bottom-up approaches- sol- gel technique-co-precipitation hydrolysis: sonochemical method- combustion technique- colloidal precipitation- template process Top-down approach: solid state sintering- grain growth-electric arc method-ion beam induced nanostructures- grinding-ball milling-control of grain size	**1**
2	**Physical, chemical and biological methods** Types of Nanomaterials: Carbon Nanotubes, Fullerene, Quantum dots, nanowire, nanocones, graphene and metal nanoparticles Inert gas condensation -RF plasma-Ion sputtering- laser ablation- laser pyrolysis- molecular beam epitaxy -chemical vapour deposition – electrode deposition-solvothermal synthesis -metal nanocrystals by reduction-arrested precipitation -photochemical synthesis-liquid -liqid interface-cluster compounds. Biological methods: use of bacterial fungi actinomycetes for nanoparticle synthesis, magneto tactic bacteria for natural synthesis of magnetic nanoparticles-mechanism of formation – role of plants in nanoparticle synthesis	**2**
3	**Lithographic techniques** AFM based nanolithography and nano manipulation, E beam lithography and SEM based nanolithography and nano manipulation, ion beam lithography, oxidation and metallization. Mask and its application. Deep UV lithography, X-ray based lithography	**3**
4	**Characterization Techniques** X-ray diffractometry- fundamental of X-ray diffraction, powder diffraction method, small angle x-ray scattering and wide-angle x-ray scattering, quantitative determination of phase, strain and particle size, Scanning probe microscopy and scanning tunnelling microscopy- basic principle and instrumentation and application, Optical microscopy– SEM, TEM, AFM: operation principle, instrumentation and application, UV-Vis-NIR spectrometry and FTIR – basic principle	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. Chemistry of nano materials: synthesis, properties and applications by C. N. R. Rao et, al, Wiley-VCH, 2004
2. Introduction to Nanoscience and Nanotechnology by K. K. Chattopadhyay and A. N. Banerjee, PHI Learning View All, 2009
3. Nanoparticle technology handbook by Masuo Hosokawa et. al, Elsevier Science, 2007
4. Handbook of nanoscience, engineering- Goddard et. al, CRC Press, 2012
5. Nanomaterials handbook -Yory Gogotsi, Taylor & Francis, 2006
6. Springer handbook of nanotechnology- Bharat Bhushan, 2004
7. Scanning probe microscopy: Analytical methods (nanoscience and technology)- Roland Wiesendanger, Springer, 1994
8. Advanced x-ray techniques in research and industries-A. K. Singh, New IOS Press Publication, 2005
9. X- ray diffraction procedures: for polycrystalline and amorphous materials, 2nd edition – Harold P. Klug, Leroy E Alexander, Wiley- Interscience, 1974
10. Transmission electron microscopy: A textbook for materials science (4- vol set)- David B. Williams and C. Barry carter, Springer, 2009
11. Introduction of X-ray crystallography-M. M. Woolfson, Cambridge University Press, 1970
12. Physical principles of electron microscopy: an introduction to TEM, SEM and AEM – Ray F. Egerton, Springer, 2005

Programme	**Joint M.Sc.**					
Course Name	**Practical III - Electronics**					
Type of Course	**Practical -Core**					
Course Code	MGKUMPNSC12					
Course Summary & Justification	At the end of this course students should acquire skills in designing and testing analog and digital integrated circuits.					
Semester	II		**Credit**		2	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	0	40	40		80
Pre-requisite	Strong mathematical background in graduation level is desirable.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	To recognize various digital gates and ICs	A, An, S	1, 4
2	To design and implement combinational circuits using basic gates and ICs	A, An, S	1, 4
3	To design and implement sequential circuits using basic gates and ICs.	A, An, S	1, 4
4	Design and demonstrate functioning of various analog circuits	A, An, S	1, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

	CO No.
1. Design and construct a first order narrow band pass Butterworth filter using μA741.	
2. Solving differential equation using μA741	
3. Design and construct ccurrent to voltage and voltage to current converter (μA741)	
4. Astable multivibrator using 555 timer, study the positive and negative pulse width and free running frequency.	
5. Monostable multivibrator using 555 timers and study the input output waveform.	
6. Voltage controlled Oscillator using 555 timer	
7. Design and construct a Schmitt Trigger circuit using IC 555.	
8. Design and test a two stage RC coupled common emitter transistor amplifier and find the bandwidth, mid-frequency gain, input and output impedance.	
9. Design and test a RC phase shift oscillator using transistor for a given operating frequency.	
10. Voltage controlled Oscillator using transistor	
11. Study the function of (i) analog to digital converter using IC 0800 (ii) digital to analog converter DAC 0808	
12. Study the application of op-Amp (μA741) as a differential amplifier.	
13. Solving simultaneous equation using op-Amp (μA741).	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 4. Continuous Internal Assessment (CIA) 5. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 6. Assignments B. Semester End examination

REFERENCES:

1. Op-Amp and linear integrated circuit Ramakanth A Gaykwad, Eastern Economy Edition, ISBN-81-203-0807-7
2. Electronic Laboratory Primer a design approach S. Poornachandra, B.Sasikala, Wheeler Publishing, New Delhi
3. Electronic lab manual Vol I, K ANavas, Rajath Publishing
4. Electronic lab manual Vol II, K ANavas, PHI eastern Economy Edition
5. Electronic lab manual Vol II, Kuriachan T.D, Syam Mohan, Ayodhya Publishing
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central

<table>
<tr><td>Programme</td><td colspan="6">Joint M.Sc.</td></tr>
<tr><td>Course Name</td><td colspan="6">Physics IV – Advanced Physics</td></tr>
<tr><td>Type of Course</td><td colspan="6">Practical -Core</td></tr>
<tr><td>Course Code</td><td colspan="6">MGKUMPNSC13</td></tr>
<tr><td>Course Summary & Justification</td><td colspan="6">At the end of this course students should acquire skills in doing experiments in physics as well as advanced physics.</td></tr>
<tr><td>Semester</td><td colspan="2">II</td><td colspan="2">Credit</td><td colspan="2">2</td></tr>
<tr><td>Total Student Learning Time (SLT)</td><td>Learning Approach</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Others</td><td>Total Learning Hours</td></tr>
<tr><td></td><td>Authentic learning
Collaborative learning
Case based learning</td><td>0</td><td>40</td><td>40</td><td></td><td>80</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Strong theoretical knowledge in general physics</td></tr>
<tr><td colspan="7">Others- Library, seminar and assignment preparations, test, journal, discussion etc.</td></tr>
</table>

<table>
<tr><td rowspan="2">CO No.</td><td>Expected Course Outcome</td><td rowspan="2">Learning Domains</td><td rowspan="2">PSO No.</td></tr>
<tr><td>Upon completion of this course, students will be able to;</td></tr>
<tr><td>1</td><td>To determine the intensity profile, beam divergence etc of Diodes/Lasers</td><td>A, An, S</td><td>1, 4</td></tr>
<tr><td>2</td><td>To determine the refractive index of various materials</td><td>A, An, S</td><td>1, 4</td></tr>
<tr><td>3</td><td>To determine the coefficient of viscosity of given liquids</td><td>A, An, S</td><td>1, 4</td></tr>
<tr><td>4</td><td>To determine the young’s modulus of materials</td><td>A, An, S</td><td>1, 4</td></tr>
<tr><td>5</td><td>To determine the dielectric constants as well as the dipole moment of various molecules</td><td>A, An, S</td><td>1, 4</td></tr>
<tr><td colspan="4">*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)</td></tr>
</table>

	CO No.
1. Study the beam divergence, spot size and intensity profile of Diode/He-Ne laser.	
2. Determine the numerical aperture of optical fibre and propagation of light through it.	
3. Determine the refractive index of the material using Brewster angle setup.	
4. Absorption bands of KMnO4 using incandescent lamp. Determine the wave lengths of the absorption bands. Determine the wave lengths of the absorption bands by evaluating Hartman‘s constants.	
5. Determine the co-efficient of viscosity of the given liquid by oscillating disc method.	
6. Measure the thermos emf of a thermocouple as function of temperature. Also prove that Seebeck effect is reversible.	
7. Determine the Young‘s modulus of the material of a bar by flexural vibrations.	
8. Using Michelson interferometer determine the wavelength of light.	
9. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law	
10. Study the dipole moment of an organic molecule (acetone).	
11. Determine the dielectric constant of a non-polar liquid.	
12. Photograph/Record the absorption spectrum of iodine vapour and a standard spectrum. Analyze the given absorption spectrum of iodine vapour and determine the convergence limit. Also estimate the dissociation energy of iodine (wave number corresponding to the electronic energy gap = 759800 m-1)	
13. Determine the dielectric constant of a non-polar liquid.	
14. Determine the charge of an electron using Millikan oil drop experiment.	
15. Linear electro optic effect (Pockel effect), Frank Hertz experiment.	
16. Frank Hertz experiment determination of ionization potential.	
17. Koening‘s method, Poisson‘s ratio of the given material of bar.	
18. Determination of Stefan’s constant of radiation from hot body	

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 2. Assignments A. Semester End examination

REFERENCES

1. Advanced practical physics for students, B.L Worsnop and H.T Flint, University of California.
2. A course on experiment with He-Ne Laser, R.SSirohi, John Wiley & Sons (Asia) Pvt.ltd
3. Kit Developed for doing experiments in Physics- Instruction manual, R.Srenivasan ,K.R Priolkar, Indian Academy of Sciences.
4. Advanced Practical Physics, S.P singh, PragatiPrakasan,
5. Practical Physics, Gupta, Kumar, PragatiPrakasan.
6. An advanced course in Practical Physics, D.Chattopadhayay, C.R Rakshit, New Central Book Agency Pvt. Ltd:

Programme	**Joint M.Sc.**					
Course Name	**Electromagnetic Theory**					
Type of Course	Elective					
Course Code	MGKUMPNSC03					
Course Summary & Justification	The course aims to develop the fundamental concepts in classical electrodynamics for students who are already familiar with the basics of electromagnetism. Maxwell's equations, the grand theory that unifies electricity, magnetism and light will be introduced and they will be equipped with advanced mathematical methods to tackle various boundary value problems in electrodynamics.					
Semester	II		**Credit**		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Basic knowledge in classical electrodynamics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	To understand the concepts of boundary value problems to be able to use various techniques for solving the boundary value problems	U, A	2, 6
2	Apply Maxwell’s Equations in Various situations (Module 2).	U, A	2, 8

3	The introduction of conservation laws and investigation of the propagation of electromagnetic waves in various media leads to a clear understanding and applications of Maxwell's equations (Module 3)	An, E	2, 9
4	Analyze the electromagnetic radiation phenomena (Module 4).	E	8
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Electrostatics:** Laplace and Poisson equations, Boundary value problems, Dirichlet and Neumann boundary conditions, Method of images, Concept of the Green function and its use in boundary value problems	**1**
2	**Module 2** **Magnetostatics:** Ampere's law and Biot-Savart's law, Concept of a vector potential, Maxwell equations and electromagnetic waves, Maxwell equations (both differential and integral formulations), Boundary conditions on field vectors D, E, B and H, Vector and scalar potentials	**2**
3	**Module 3** **Gauge transformations:** Lorentz and Coulomb gauge, Green function for the wave equation, Poynting's theorem, Conservation laws for macroscopic media, Propagation of plane waves and spherical waves in free space, dielectrics and conducting media, Reflection and refraction of electromagnetic waves, Superposition of waves, Radiation from an oscillating dipole and radiation from an accelerating charge.	**3**
4	**Module 4** **Electromagnetic stress tensor, Wave Guides:** Modes in rectangular and cylindrical wave guides (conducting and dielectric), Resonant cavities, Evanescent waves, Energy dissipation, Q of a cavity	**4**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	**Mode of Assessment** 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. J. D. Jackson, Classical Electrodynamics, Wiley Eastern, 2nd Edition, 1975
2. David J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India, 2nd Edition, 1989
3. J. R. Reitz, F. J. Milford and R. W. Christy, Foundations of Electromagnetic Theory, 3rd Edition, Narosa Pub. House, 1979
4. P. Lorrain and D. Corson, Electromagnetic Fields and Waves, CBS Publishers and Distributors, 1986
5. B. H. Chirgwin, C. Plumpton and C. W. Kilmister, Elementary Electromagnetic Theory, Vols. 1, 2 and 3" Pergamon Press, 1972
6. William Hart Hayt, John A. Buck, Engineering Electromagnetics, McGraw-Hill, 2012

Programme	**Joint M.Sc.**					
Course Name	**Nanophotonics**					
Type of Course	Elective					
Course Code	MGKUMPNSE04					
Course Summary & Justification	This course aims to impart knowledge about the physics of photonics. This course also aims to provide knowledge about photonic crystals and applications of photonic crystal devices.					
Semester	II		**Credit**	4		
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Solid state devices, Semiconducting nanostructures, VLSI					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome**	**Learning Domains**	**PSO No.**
	Upon completion of this course, students will be able to;		
1	understand the basic and advance concepts of nanophotonics.	U,R	1
2	Understand the concepts of near- field optics and near- field scanning optical microscopy,	U	3, 4
3	understand the basic concepts of plasmonics	U	4
4	understand the concepts of photonic crystals	U	3, 4
5	understand the applications of photonic crystals	U	3, 4
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

Module No.		CO No.
1	**Fundamentals of photonics and photonic devices:** lasers, LEDs, optical modulators (acoustic -optic and electro- optic), optical fibers and fiber optic components, frequency conversion, propagation and confinement of photons and electrons, tunneling, band gap, Quantum confinement effects, interaction dynamics, electronic energy transfer and emission	**1**
2	**Near- field optics and Near- field scanning optical microscopy**: Quantum Dots, Single molecular spectroscopy, and Nonlinear Optical processes, Time resolved studies, Heterostructures, Metallic Nanoparticles and Nanorods, Metallic Nanoshells, Local Field Enhancement, Subwavelength Aperture Plasmonics, Plasmonic Wave Guiding, Applications of Metallic Nanostructure, Radiative Decay Engineering	**2**
3	**Introduction to plasmonics**: Metallic nanoparticles and nanorods, metallic nanoshells, local field enhancement, sub-wavelength aperture plasmonics, plasmonic waveguiding, applications of metallic nanostructures, Evanescent wave excitation, dielectric sensitivity, radioactive decay engineering, metal dipole interaction	**3**
4	**Photonic crystals**: Introduction to photonic crystals, Modelling of photonic crystals, Photonic crystal optical circuitry, Non-linear photonic crystals, Photonic crystal fibres, photonic band gap materials	**4**
5	**Applications of Photonic crystals:** Applications in communication and sensing, Near field imaging of biological systems, Nanoparticles for optical diagnosis, upconverting nanopores for bioimaging	**5**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. Nanophotonics: Paras N. Prasad, Wiley, 2004
2. Nanophotonics with Surface Plasmons: Valdimir M. Shalaev, Stoshi Kawata, Elsevier Science, 2006
3. Principles of Nanophotonics, Motoichi Ohtsu, Kiyoshi Kobayashi, Makato Naruse, Taylor & Francis, 2008
4. Photonic devices, Jia Ming Liu, Cambridge University Press; Reissue edition, 2009
5. Integrated Photonics: Fundamentals, Gines Lifante, Wiley, 2003
6. Photonic crystals, Kurt Busch, Stefan Lolkes, Wiley, 2006
7. Nanophotonics, Arthur McGurn, Springer Cham, 2018
8. Fundamentals and Applications of Nanophotonics, Joseph W. Haus (Editor), Woodhead Publishing Series in Electronic and Optical Materials, Elsevier, 2016

Programme	Joint MSc					
Course Name	**Industrial Internship**					
Course Credit	**2**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC14					
Course Summary & Justification	The candidate shall do an industrial visit in any of the research institute.					
Semester	**4**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Team work, independent learning	-	-	-	-	-
Pre-requisite						

CO No.	**Expected Course Outcome**	**Learning Domains**	**PSO No.**
	At the end of the course the students are expected to		
	To clearly present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	7
8	Gain a consciousness of the ethical aspects of research.	E	6

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, , Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners.

SEMESTER III

Programme	**Joint M.Sc.**					
Course Name	**Quantum mechanics II**					
Type of Course	Core					
Course Code	MGKUMPNSC15					
Course Summary & Justification	The course aims to provide an introduction to advanced level topics in quantum mechanics. These include quantum theory of angular momentum, quantum concept of identical particles and an introduction to relativistic and multi-particle quantum mechanics. This includes the formulation of quantum theorem of spin and orbital angular momentum. This course also formulates the non-relativistic scattering theory and relativistic quantum mechanics.					
Semester	III		**Credit**		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite						
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Get a complete understanding of total angular momenta and spin angular momenta of particles. They will be able to understand the quantum mechanical techniques	U, A	4, 6

	to find the total angular momenta of combined system. This is very important to understand further studies of spectroscopic methods and techniques (Module I)		
2	Understand the quantum mechanical problems by approximation techniques. They will be able to study the time independent perturbation theory for understanding the quantum mechanical problems. (Module 2)	U, A	4,6
3	The student will be able to understand the quantum mechanical theories of time dependent perturbation theory. They can solve the quantum mechanical problems more accurately using this perturbation method (Module 3).	An, E	6, 9
4	Students will be able to understand the concept of identical particles. They will study the symmetric and antisymmetric wavefunctions and can understand the profound physics of bosons and fermions. Students will be able to understand the elements of relativistic quantum mechanics (Module 4).	E	6, 8, 9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Module 1** **Quantum Theory of Angular Momentum** Review of Orbital angular momentum; Total angular momentum: Commutation relations, eigenvalues, Matrix representation of angular momentum; Spin angular momentum: Pauli spin matrices and their properties, Two component wave function, Pauli's equation; Addition of Angular momentum and Clebsch-Gordan coefficients.	**1**

2	**Module 2** **Time Independent Perturbation theory** Time-independent perturbation theory: Non degenerate perturbation theory, The Stark effect, Degenerate perturbation theory: Spin Orbit Coupling, Fine structure; Variational method; WKB method, Bound states for potential wells with no rigid walls, Tunnelling through a potential barrier	**2**
3	**Module 3** **Time Dependent Perturbation theory** Schrodinger and Heisenberg Pictures of Quantum Mechanics; The interaction Picture and Time- dependent perturbation theory: Transition probability; Constant perturbation; Harmonic perturbation; Adiabatic and sudden approximations; Interaction of atoms with radiation: Transition rates for absorption and stimulated emission of radiation, Dipole approximation, Electric dipole selection rules	**3**
4	**Module 4** **Relativistic and Multi Particle Quantum Mechanics** Klein-Gordon equation: Free particle solutions, Probability density; Dirac equation: Dirac matrices, Probability density, Solution of free Dirac equation and positrons; Many-particle systems: Interchange symmetry; Systems of distinguishable non-interacting particle; Systems of identical particles: Exchange degeneracy, Symmetrization postulate; Constructing symmetric and anti-symmetric wave functions, Pauli's exclusion principle	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 1. Continuous Internal Assessment (CIA) 2. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 3. Assignments A. Semester End examination

REFERENCES

1. E. Merzbacher, Quantum Mechanics, 2nd Edition, Wiley International Edition, 1970
2. J. J. Sakurai Modern Quantum Mechanics, Benjamin / Cummings, 1985
3. Nouredine Zettili, Quantum Mechanics: Concepts and Applications, Wiley India, 2016
4. P. A. M. Dirac, The Principles of Quantum Mechanics, Oxford University Press, 1991
5. L. D. Landau and E. M. Lifshitz, Quantum Mechanics -Nonrelativistic Theory, 3rd Edition, Pergamon, 1981
6. P. M. Mathews and K. Venkatesan, A Textbook of Quantum Mechanics, Tata McGraw Hill, 1977
7. J. Bjorken and S. Drell, Relativistic Quantum Mechanics, McGraw-Hill, 1965
8. A. Messiah, Quantum Mechanics, Vols. 1 and 2, North Holland, 1961
9. John S. Townsend, A Modern Approach to Quantum Mechanics, University Science Books, 2000

<table>
<tr><td>Programme</td><td colspan="6">Joint M.Sc.</td></tr>
<tr><td>Course Name</td><td colspan="6">Condensed Matter Physics II</td></tr>
<tr><td>Type of Course</td><td colspan="6">Core</td></tr>
<tr><td>Course Code</td><td colspan="6">MGKUMPNSC16</td></tr>
<tr><td>Course Summary & Justification</td><td colspan="6">This course aims to make the learner understand the physics of solids, mostly concerned with their properties that are of great utility, and result from the distribution of electrons in metals, semiconductors and insulators. The course discusses important advances in condensed matter physics which would facilitate better understanding of the material behaviour at the nanometre scale.</td></tr>
<tr><td>Semester</td><td colspan="2">III</td><td colspan="2">Credit</td><td colspan="2">4</td></tr>
<tr><td>Total Student Learning Time (SLT)</td><td>Learning Approach</td><td>Lecture</td><td>Tutorial</td><td>Practical</td><td>Others</td><td>Total Learning Hours</td></tr>
<tr><td></td><td>Authentic learning
Collaborative learning
Case based learning</td><td>60</td><td>40</td><td>-</td><td>40</td><td>140</td></tr>
<tr><td>Pre-requisite</td><td colspan="6">Strong background in basic quantum mechanics and condensed matter physics.</td></tr>
<tr><td colspan="7">Others- Library, seminar and assignment preparations, test, journal, discussion etc.</td></tr>
</table>

<table>
<tr><td rowspan="2">CO No.</td><td>Expected Course Outcome</td><td rowspan="2">Learning Domains</td><td rowspan="2">PSO No.</td></tr>
<tr><td>Upon completion of this course, students will be able to;</td></tr>
<tr><td>1</td><td>Students will learn about dielectrics and ferroelectrics (Module 1)</td><td>U, A</td><td>2, 5</td></tr>
<tr><td>2</td><td>Students will learn about the magnetic properties of materials and perform mathematical derivations of different quantities. (Module 2)</td><td>U, A</td><td>2, 5</td></tr>
<tr><td>3</td><td>The student will learn about optical properties of solids and also superconductivity found in solids. This will help in understanding the different facets of solids. (Module 3).</td><td>A, E</td><td>5, 7</td></tr>
</table>

4	Students will learn to identify the types of point and extended defects in solids. (Module 4)	A, E	5, 7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		**CO No.**
1	**Module 1** **Dielectrics and Ferroelectrics** Internal electric field in a dielectric, Clausius-Mossotti and Lorentz-Lorenz equations, Point dipole, deformation dipole and shell models, Dielectric dispersion and loss, Ferroelectrics: types and models of ferroelectric transition.	**1**
2	**Module 2** **Magnetic Properties of Materials** Diamagnetic susceptibility, Quantum theory of paramagnetism, Transition metal ions and rare earth ions in solids, Crystal field effect and orbital quenching, Ferromagnetic and antiferromagnetic ordering, Curie-Weiss theory, Heisenberg theory, Curie and Neel temperatures, Domain walls, Spin waves and magnon dispersion.	**2**
3	**Module 3** **Optical properties of solids**: Band to band absorption, excitons, polarons, Colour centres, Luminescence, Photoconductivity. Superconductivity, experimental and theoretical aspects, new materials and models	**3**
4	**Module 4** **Defects in Solids** Point defects: Thermodynamics of point defects, Frenkel and Schottky defects, Formation enthalpies, Diffusion and ionic conductivity, Superionic materials. Extended defects: dislocations, models of screw and edge dislocations, Burgers vector, Stress field around dislocations, interaction between dislocations with point defects, Work hardening.	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 4. Continuous Internal Assessment (CIA) 5. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 6. Assignments B. Semester End examination

REFERENCES

1. Charles Kittel, Introduction to Solid State Physics, Wiley, 5th Edition, 1976
2. A. J. Dekker, Solid State Physics, Prentice Hall, 1957
3. N. W. Ashcroft and N. D. Mermin, Solid State Physics, Saunders College Publishing, 1976
4. J. S. Blakemore, Solid State Physics, 2nd Edition, Cambridge University Press, 1974
5. Mendel Sachs, Solid State Theory, McGraw-Hill, 1963
6. A. O. E. Animalu, Intermediate Quantum Theory of Solids, Prentice Hall, 1977.
7. Fröhlich, H. (1950). Theory of Dielectrics: Dielectric Constant and Dielectric Loss. United Kingdom: At the Clarendon Press.
8. Lines, M. E., Glass, A. M. (2001). Principles and Applications of Ferroelectrics and Related Materials. United Kingdom: OUP Oxford
9. Coey, J. M. D. (2010). Magnetism and Magnetic Materials. United Kingdom: Cambridge University Press.
10. Azároff, L. V. (1986). Introduction to Solids. India: Tata McGraw-Hill.
11. Sander, L. M. (2009). Advanced Condensed Matter Physics. United Kingdom: Cambridge University Press.

Programme	**Joint M.Sc.**					
Course Name	**Application of Nanomaterials**					
Type of Course	Core					
Course Code	MGKUMPNSC17					
Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of the various application of nanomaterials in the field of medicine, agriculture, food, textile, defence, aerospace etc.					
Semester	III		**Credit**		3	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	40	40	-	40	120
Pre-requisite	Strong background in basic quantum mechanics and condensed matter physics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	**Expected Course Outcome** *Upon completion of this course, students will be able to;*	**Learning Domains**	**PSO No.**
1	Understand the applications of nanotechnology in medical field	U, A	2, 5
2	Student will learn about the applications of nanotechnology in the field of agriculture and food sector	U, A	2, 5
3	Understand the importance of nanotechnology in textile and cosmetics sector	A, E	5, 7
4	Understand the applications of nanotechnology in defence and aerospace field.	A, E	5, 7
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)**			

Module No.		CO No.
1	**Biomedical Applications** Nanoparticles and Micro–organism- Biosensors- Bioreceptors and their properties - Biochips- Integrated nanosensor networks for detection and response- DNA based biosensors and diagnostics- Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Implants and Prosthesis –Tissue Engineering – Neuroscience -Neuro-electronic Interfaces -Nanorobotics– Photodynamic Therapy - Protein Engineering – Nanosensors in Diagnosis–Drug delivery – Cancer therapy and other therapeutic applications.	**1**
2	**Agricultural and Food Sector Applications** Nanotechnology in Agriculture -Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges- Product innovation and Process improvement- Consumer benefits- Food processing - Packaging- - Packing materials; physical properties- Improvements of mechanical and barrier properties- Antimicrobial functionality- Active packaging materials- -Information and communication technology- Sensors- RF identification- Food safety- Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging- Nanoengineered Food ingredients- Potential risks to Nanofood to consumers	**2**

3	**Applications in Textile and Cosmetics Sector** Nanofibre production – Electrospinning and charge injectionmethod – morphological control- yarns and polymide nanofibers- Carbon Nanotube and Nanofibre Reinforced Polymer Fibres- multifunctional polymer nanocomposites- Improvement of polymer functionality- Nylon-6 nanocomposites from polymerization- Dyeable Polypropylene - nanocoatings and surface modifications - Nano-filled polypropylene fibers - UV resistant, antibacterial, self-cleaning, flame retardant textiles – Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear textiles- Cosmetics; Formulation of Gels, Shampoos, Hair-conditioners– Nanomaterials in Sun-screen UV protection – Color cosmetics	**3**
4	**Defence and Aerospace Applications** Pathways to Physical protection- Detection and diagnostics of chemical and biological agents, methods- Chemical and Biological counter measures- Decontamination- Post exposure and pre exposure protection and decontamination- Nanotechnology enabled bio chemical weapons- Influence operations- Evasion of medical countermeasures- Nanotechnology based satellite communication system- Guidance, Navigation and control- Spacecraft thermal control- mini, micro, nanosatellite concepts- Fiber optic and Chemical microsensors for space craft and launch support- Micro/Nano pressure and temperature sensors for space missions.	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment 7. Continuous Internal Assessment (CIA)

	8. Seminar Presentation – a theme is to be discussed and identified to prepare a paper and present in the seminar 9. Assignments C. Semester End examination

REFERENCES /COMPULSORY READINGS

1. Mark. A, Ratner and Daniel Ratner, "Nanotechnology: A Gentle Introduction to the Next Big Idea", Pearson, 2003.
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Barnes & Noble 2004.
3. Neelina. H, Malsch (Ed.), "Biomedical Nanotechnology", CRC Press 2005.
4. Udo. H, Brinker, Jean-Luc Mieusset (Eds.), "Molecular Encapsulation: Organic Reactions in Constrained Systems", Wiley Publishers 2010.
5. Jennifer Kuzma and Peter Ver Hage, "Nanotechnology in agriculture and food production", Woodrow Wilson International Center, 2006.
6. Lynn. J, Frewer, Willehm Norde. R. H, Fischer and Kampers. W. H "Nanotechnology in the Agri- food sector", Wiley-VCH Verlag, 2011.
7. Brown. P. J and Stevens. K "Nanofibers and Nanotechnology in Textiles", Woodhead Publishing Limited, Cambridge, 2007.
8. Mai. Y-W "Polymer Nano composites", Woodhead publishing, 2006.
9. Chang. W.N "Nanofibres fabrication, performance and applications", Nova Science Publishers Inc, 2009.
10. Helvajian. H and. Robinson. E.Y "micro and nanotechnology for space systems" the aerospace corporation, Micrograph , 1997.
11. Margaret. E, Kosal, "Nanotechnology for Chemical and Biological defence, Springer 2009.
12. A. K. Alves (Ed) Technological Applications of Nanomaterials, Springer Cham, 2022

Programme	**Joint M.Sc.**
Course Name	**Synthesis of Nanomaterials**
Type of Course	**Practical**
Credit Value	2
Course Code	MGKUMPNSC18

Course Name	Synthesis of different Nanomaterials.					
Semester	**III**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		0	40	40		80
Pre-requisite	Basic knowledge in practical chemistry (Undergraduate level).					

CO No.	**Expected Course Outcome**	**Learning Domains**	**PSO No.**
1	To Acquire sound knowledge about the fundamentals and importance of Nanomaterials.	R, U, An	3,4,5
2	To compare and correlate various Nanomaterials synthesis techniques.	U, A, An	1,3,4,5,6,7
3	To learn the handling of different chemicals (for nanomaterial synthesis), glassware, and precautions to be taken for safety in a chemistry lab	R, U, A	3,4,5
4	To learn the synthesis of different nanomaterials (bio-based nanomaterials, green synthesis of nanomaterials, etc.)	U, A, An, S	4,5
5	To perform experiments individually and to gain knowledge about principles and techniques involved in various experiments (nanomaterial synthesis)	An, A, S, I	5,6,7
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	Extraction of Nanocellulose, Extraction of Nanochitin, Synthesis of different sized Ag nanoparticles by aqueous method, Synthesis of different sized Au nanoparticles by aqueous method, Chemical synthesis of CdSe Quantum dots with different sizes.	**1,2,3,4,5**
2	Sol-gel synthesis of ZnO nanoparticles, green synthesis of ZnO nanoparticles, Coprecipitation synthesis of magnetic (iron oxide) nanoparticles, Synthesis of metal oxide nanotubes, Hydro/Solvothermal synthesis of metal oxide nanostructures of different morphology by varying parameters, Synthesis of SnO_2 nanostructures, Hydrothermal synthesis of TiO2 nanoparticles, Synthesis of Graphene and Graphene Oxide, Synthesis of nanosilica.	**1,2,3,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** **A.** Lab/Experiment skills **B.** Lab record/Report **C.** Viva-voce **D.** Lab Discipline (participation, punctuality, accuracy) **E.** **Semester End examination**

REFERENCES

1. Nanostructures and Nanomaterials- Synthesis, Properties & applications by Guozhong Cao, Imperial College Press, (2006). Publisher: World Scientific Publishing Company; 2 edition (4 January 2011) ISBN-13: 978-9814324557
2. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435
3. Nanomaterials and Nanochemistry by C. Brechignac.P. Houdy M. Lahmani, Springer-Verlag (2007). (For Unit III-Part I Chapter I)
4. PADINJAKKARA A, Scarinzi G, Santagata G, Malinconico M, Razal JM, Thomas S, Salim NV. Enhancement of Adhesive Strength of Epoxy/Carboxyl-Terminated Poly(butadiene-co-acrylonitrile) Nanocomposites Using Waste Hemp Fiber-Derived Cellulose Nanofibers. ACS Industrial & Engineering Chemistry Research. 2020, 59, 23, 10904-10913. https://pubs.acs.org/doi/abs/10.1021/acs.iecr.0c01053

Programme	**Joint M.Sc.**
Course Name	**Characterization of Nanomaterials**
Type of Course	Practical
Credit Value	2
Course Code	MGKUMPNSC19

Course Summary & Justification	Characterization of different nanomaterials					
Semester	III					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
		0	40	40		80
Pre-requisite	Basic knowledge in practical chemistry (Undergraduate level).					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	To acquire sound knowledge about the fundamentals and importance of different characterization techniques (chemical, morphological, thermal, electrical etc.) for nanomaterials.	R, U, An	
2	To compare and correlate various characterization techniques for nanomaterials.	U, A, An	
3	To learn the handling of different characterization techniques for nanomaterials and precautions to be taken for safety.	R, U, A	
4	To learn the basic/ working principle of different characterization techniques for nanomaterials.	U, A, An, S	
5	To perform experiments (characterizations) individually and to gain knowledge about instrument operation and analysing of data.	An, A, S, I, Ap	
**Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)*			

Module No.		CO No.
1	Studies of (synthesized) different nanomaterials using: Optical microscope, Scanning electron microscope, transmission electron microscope, confocal laser scanning microscopy, and atomic force microscope. Studies of different nanomaterials using X-ray diffraction, UV-visible spectroscopy, FT-IR spectroscopy, Nuclear Magnetic Resonance Spectroscopy, Raman spectroscopy, Absorption and emission Spectroscopy.	**1,2,3,4,5**
2	Characterization of different nanomaterials using: Thermogravimetric analyser (TGA), Differential Scanning Calorimetry (DSC), and Vibrating sample magnetometer.	**1,2,3,4,5**

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** Contact classes, Library work, Tutorials, Demonstrations, Workshops, Virtual laboratory videos
Assessment Types	**Mode of Assessment** A. Lab/Experiment skills B. Lab record/Report C. Viva-voce D. Lab Discipline (participation, punctuality, accuracy) E. Semester End examination

REFERENCES

1. Introduction to Nanoscience and Nanotechnology, by K K Chattopadhyay, PHI Learning Pvt. Ltd. New Delhi 2019, ISBN-13: 978-81-203-3608-7.

2. Characterization of Materials Vol 1 &2, by Elton N. Kaufmann, John Wiley and Sons Publication, 2003. New Jersey.

3. Principles of instrumental analysis, Douglas A Skoog, Donald M West, Saunders College, Philadelphia. Publisher: Cengage; 6 edition (1 November 2014) ISBN-13: 978-81-315-25579.

4. NANO: The Essentials- Understanding Nanoscience and Nanotechnology, by T Pradeep, Tata McGraw Hill Education Pvt. Ltd. New Delhi) ISBN-13: 978-0-07-061788-9

5. X-Ray Diffraction Procedures: For Polycrystalline and Amorphous Materials, 2nd Edition - Harold P. Klug, Leroy E. Alexander, Publisher: Wiley-Blackwell; 2nd Revised edition edition (1 January 1974) ISBN-13: 978-0471493693

6. Transmission Electron Microscopy: A Textbook for Materials Science (4-Vol Set)- David B. Williams and C. Barry Carter, Publisher: Springer; 1st ed. 1996. Corr. 6th printing edition (15 April 2005) ISBN-13: 978-0306453243

7. Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM - Ray F. Egerton, Publisher: Springer; Softcover reprint of hardcover 1st ed. 2005 edition (12 October 2010) ISBN-13: 978-1441938374

8. Springer handbook of Nanotechnology ed. Bharat Bhushan (Springer), Publisher: Springer-Verlag (15 May 2006) ISBN-13: 978-3540343660

9. Nanoparticles and Nanostructured Films- Preparation Characterization and Applications by Janos H. Fendler, WILEY-VCH Verlag GmbH. D-69469 Weinheim (Federal Republic of Germany), 1998. Publisher: Wiley VCH (28 May 1998) ISBN-13: 978-3527294435

Programme	**Joint M.Sc.**					
Course Name	**Nuclear and Particle Physics**					
Type of Course	Elective Credit: 4					
Course Code	MGKUMPNSE05					
Course Summary & Justification	This course looks at physics within the nucleus, exploring the consequences of quantum physics at the high energies, and short distances, explored by nuclear and particle physics. It begins with a review of relativistic and quantum mechanics, the symmetries of fermions and bosons, and the forces of nature. Further, it goes on to explore the nature of these forces in the nuclear and particle physics domain, and see how they are related to decays and scattering processes. This course will introduce the fundamental particles and composite states, including nuclei, which appear on subatomic scales and investigate the quantum numbers and symmetries associated with the interactions of these particles. We will discuss the models used to describe the phenomena observed on the subatomic scale, and explore both their many successes and their shortcomings. Also discuss the experimental methods used to explore the subatomic world.					
Semester	III		**Credit**		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Basics of Atomic stucture, Nuclear physics, Quantum mechanics (Undergraduate)					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	The module encompasses a detailed exposure to nuclear structure and models. A qualitative study on estimation of transition rates also be discussed (Module 1)	U, A	1, 6
2	This module discusses different nuclear interaction problems (Module 2)	U, A	1, 6
3	The student will get knowledge about nuclear reactions and decay (Module 3).	An, E	1, 6
4	The student will get theoretical understandings of elementary particles and its interactions (Module 4)	E	1, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Module 1** **Nuclear Structure and Models** Basic properties of nuclei: Masses and relative abundances, mass defect, size and shape, binding energy, magnetic dipole moments and electric quadrupole moments, Liquid drop model - Semi-empirical mass formula of Weizsacker - Nuclear stability Mass parabolas - Bohr-Wheeler theory of fission – Fermi gas model Shell model - Spin-orbit coupling - Magic numbers - Angular momenta and parities of nuclear ground state - qualitative discussion and estimates of transition rates - Magnetic moments and Schmidt lines - Collective model of Bohr and Mottelson - Nilsson Model - oblate and Prolate.	**1**

2	**Module 2** **Nuclear Interactions** Nuclear forces - Two body problem - Ground state of deuteron - Magnetic moment - Quadruple moment - Tensor forces - Meson theory of nuclear forces - Yukawa potential - Nucleon-nucleon scattering, scattering cross section - Low energy n-p scattering-phase shift - proton-proton scattering - Effective range theory - Characteristics of nuclear force - Spin dependence, charge independence and charge symmetry - Isospin formalism.	**2**
3	**Module 3** **Nuclear Reactions and Nuclear Decay** Reaction dynamics, the Q value of Nuclear reaction, Scattering and reaction cross sections Compound nucleus formation and breakup, nuclear fission and heavy ion induced reactions, fusion reactions, types of nuclear reactors, Beta decay - Fermi's theory - Fermi-Curie Plot - Fermi and Gamow - Teller selection rules - Allowed and forbidden decays - Decay rates - Theory of Neutrino - Helicity of neutrino - Helicity measurement - Theory of electron capture - Non-conservation of parity - Gamma decay - Internal conversion - Multipole transitions in nuclei - Nuclear isomerism - Angular correlation in successive gamma emissions.	**3**
4	**Module 4** **Particle Physics** Types of interactions between elementary particles - Hadrons and leptons, their masses, spin parity decay structure, the quark model, the confined quarks, colored quarks, Experimental evidence for quark model, The quark-gluon interaction, Gellmann- Nishijima formula, Symmetries and conservation laws, C, P and CPT invariance and applications of symmetry arguments to particle reactions, parity non conservation in weak interactions, Exchange Bosons of the weak interaction, electroweak unification.	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. *Internal Test* -20 marks 2- *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature – 10 marks 3. *Seminar Presentation* – A topic needs to be presented and discussed with the class- 10 marks A. Semester End Examination – 60 marks

REFERENCES

1. Introductory Nuclear Physics, Kenneth S. Krane, Wiley, New York, 1987
2. Introduction to Elementary Particles, D. Griffiths, Wiley, 1987
3. Nuclear Physics, R. R. Roy and B. P. Nigam,New Age International, New Delhi, 1983
4. The Particle Hunters, Yuval Ne'eman& Yoram Kirsh, Cambridge University Press, 1996
5. Concepts of Nuclear Physics, B. L. Cohen, TMH, New Delhi, 1971
6. Theory of Nuclear Structure, M. K. Pal, Scientific and Academic Edn., 1983
7. Atomic Nucleus, R. D. Evans, McGraw-Hill, New York, 1955
8. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi, 1989
9. Introduction to Nuclear Physics, H. A. Enge, Addison Wesle, London, 1975
10. Introductory Nuclear Physics, Y. R. Waghmare, Oxford-IBH, New Delhi, 1981
11. Elementary Particles, J. M. Longo, McGraw-Hill, New York (1971)
12. Particles and Nuclei, B. Povh, K. Rith, C. Scholz & F. Zetche, Springer, 2002

Programme	**Joint M.Sc.**					
Course Name	**Nanomagnetic Materials**					
Type of Course	Elective					
Course Code	MGKUMPNSE06					
Course Summary & Justification	This course provides research-focused teaching and training for post-graduates wishing to develop a career in nano and functional materials. Students will gain an in-depth understanding of nanomagnetic materials including the size dependence, fabrication, characterization and application of nanomagnetic materials					
Semester	III		**Credit**		4	
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Authentic learning Collaborative learning Case based learning	60	40	-	40	140
Pre-requisite	Strong background in basic quantum mechanics and condensed matter physics.					
Others- Library, seminar and assignment preparations, test, journal, discussion etc.						

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	Upon completion of this course, students will be able to;		
1	Student will learn about the basics of nanomagnetic materials including ferromagnetism, magnetic susceptibilities, magneto resistance etc	U, A	1, 6
2	Understand the size dependence of magnetic materials and magneto electronics	U, A	1, 6
3	Understand the different methods of fabrication and characterization of nanomagnetic materials	An, E	1, 6
4	Understand the applications of nanomagnetic materials	E	1, 4
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Module No.		CO No.
1	**Module 1** **Ferromagnetism and Magneto Resistance** Basics of ferromagnetism, Effect of bulk structuring of Magnetic properties, Dynamics of Nanomagnets, Nanopore containment of magnetic properties, Nanocarbon ferromagnets Giant Magneto resistance, GMR, Applications in data storage, Ferro fluids, Band structure in magnetic fields, Parallel and perpendicular field Magnetic susceptibilities, Disorder–order transformations. Spintronics	1
2	**Module 2** **Size dependence of Magnetic Materials and Magneto-electronics** Super paramagnetism, Effect of grain-size, Magneto-transport, Fermi's golden rule and mean free path, Ballistic vs. diffusive regimes, Persistent currents, Magnetization, Ferroelectrics. Electronic Properties and Quantum Effects, Magneto-electronics: Magnetism and Magnetotransport in Layered Structures, Magneto optics, magnetoelectrics.	2
3	**Module 3** **Fabrication and Characterization of Nanomagnetic materials** Particulate Nanomagnets – Geometrical Nanomagnets – Fabrication Techniques Scaling – Characterization using Various Techniques – Imaging Magnetic Micro spectroscopy – Study of Ferromagnetic & and Antiferromagnetic Interfaces – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy	3

4	**Module 4** **Applications and Devices** Magnetic Data Storage – Introduction – Magnetic Media – Properties – Materials Used – Write Heads – Read Heads – Magnetoresistance – General – in Normal Metals and in Ferromagnetic Materials – Future of Magnetic Data Storage - Magneto-Optics and Magnetooptic recording – Kerr Effect – Faraday Effect, Magnetic Semiconductors, Spintronics devices, noise reduction.	**4**

Teaching and Learning Approach	Classroom Procedure (Mode of transaction) Authentic learning, case-based learning, collaborative learning, seminar, group activities.
Assessment Types	Mode of Assessment Continuous Internal Assessment (CIA) 1. *Internal Test* -20 marks 2- *Assignment* – Every student needs to write an assignment on a given topic based on the available published literature – 10 marks 3. *Seminar Presentation* – A topic needs to be presented and discussed with the class- 10 marks A. Semester End Examination – 60 marks

REFERENCES

1. Principles of Nanomagnetism: Alberto P. Guimarães, Springer Berlin, Heidelberg, 2009
2. Nanomagnetism and Spintronics: Fabrication, Materials, Characterization and Applications, Farzad Nasirpouri and Alain Nogaret, World Scientific, 2011
3. Fine Particle Magnetism, Bandyopadhyay Bibek, Atlantic Publishers and Distributors, 2002
4. Magneto-optics: S. Sugano, N. Kojima (Editors), Springer Berlin, Heidelberg, 2000

5. Magnetic Materials: Fundamentals and Applications (2nd ed.), Spaldin, N., Cambridge University Press, Cambridge, 2010.
6. Introduction to Magnetic Materials, 2nd Edition, L. C. Cullity and C. D. Graham, IEEE Press, Willey.
7. Claude Fermon, Marcel Van de Voorde (Editors) Nanomagnetism: Applications and Perspectives, Germany: Wiley, 2017.
8. Chris Binns (Editor), Nanomagnetism: Fundamentals and Applications, Netherlands: Elsevier Science, 2014.
9. Akinobu Yamaguchi, Atsufumi Hirohata, Bethanie Stadler (Eds.) Nanomagnetic Materials: Fabrication, Characterization and application. (2021). Netherlands: Elsevier Science.

SEMESTER 4

Programme	**Joint M.Sc.**					
Course Name	**Dissertation**					
Course Credit	**12**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC20					
Course Summary & Justification	The candidate shall do a research project in any of the research institute. This follows discussion with the Examination Board consisting of the Chairman, the Internal Examiner and the External Examiner.					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Library work, lab work, Team work, independent learning	-	-	-	-	-
Pre-requisite	Should complete semester I, II and III. Aptitude for research work in one of the interdisciplinary areas in the realm of interface between physical science and nanotechnology. Literature survey.					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to		
	To clearly present and discuss the research objectives, methodology, analysis, results and conclusions effectively.	A	2, 3, 4, 5
2	Acquire a comprehensive knowledge of the area subject of study	Ap	1, 7
3	Gain deeper knowledge of methods in the topic of study.	A	6
4	Able to contribute to research and development work.	U	3
5	Undertake independent, original and critical research on a relevant topic.	U	5
6	Able to plan and use adequate methods to conduct specific tasks in given frameworks and to evaluate this work.	U	6
7	Create, analyse and critically evaluate different problems and their solutions.	C	7
8	Gain a consciousness of the ethical aspects of research.	E	6, 9

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction: Seminar, Authentic learning, , Library work, laboratory work, Team work, independent learning and Group discussion, Presentation of research work.
Assessment Types	**Mode of Assessment** Evaluation of the presentation by both internal and external examiners.

Programme	**Joint M.Sc.**					
Course Name	**Viva-Voce**					
Course Credit	**4**					
Type of Course	**CORE**					
Course Code	MGKUMPNSC21					
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. Thorough understanding of all the M.Sc. level course contents and of the recent trends in the broad area of physical sciences and nanotechnology are evaluated					
Semester	**IV**					
Total Student Learning Time (SLT)	Learning Approach	Lecture	Tutorial	Practical	Others	Total Learning Hours
	Classroom studies, lab work, library Library work, independent learning etc.	-	-	-	-	-
Pre-requisite	Basic as well as in-depth knowledge in the coureses he/she studied					

CO No.	Expected Course Outcome	Learning Domains	PSO No.
	At the end of the course the students are expected to;		
1	Achieve fundamental and in-depth knowledge of the subject	A	3
2	Acquire more in-depth knowledge of the major subject of study	Ap	1,2,3,4,5,6,7
3	Deeper knowledge of methods in the major subject of study.	A	1, 4
4	Be able to contribute to research and development work.	U	3, 8, 9
Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C), Skill (S), Interest (I) and Appreciation (Ap)			

Teaching and Learning Approach	**Classroom Procedure (Mode of transaction)** E-learning, interactive Instruction:, Seminar, Authentic learning, , Library work , laboratory work, Team work, independent learning and Group discussion, Presentation of research work
Assessment Types	**Mode of Assessment** Thorough understanding of all the M.Sc. level course contents and recent trends in the broad area of chemical sciences are evaluated. The candidate will be asked questions based on the whole syllabus he/she studied in the entire programme. How he/she answered or responded the questions asked will be considered for evaluation.

ADD-ON COURSES

In addition to Core, elective and practical courses, School of Nanoscience and Nanotechnology, Mahatma Gandhi University will offer add-on courses such as;

- Nano catalysis
- Social, ethical and legal issues of Nanoscience and Nanotechnology
- Nano sensors
- Advanced nanobiology
- Waste management, and Water purification through Nanoscience and Nanotechnology.

The course structure and syllabus will be announced before commencement of each semesters. The lectures will be delivered by reputed Professors/ Scientists from other Universities/ Institutions in India or Abroad.

MODEL QUESTION PAPER

QP Code

Reg.No:
Name:

JOINT M. Sc. PROGRAMME

MAHATMA GANDHI UNIVERSITY & KANNUR UNIVERSITY

SEMESTER

END SEMESTER EXAMINATION (YEAR/ MONTH)

COURSE CODE: COURSE NAME

Time: 3 Hours **Max. Marks: 60**

Part A. Answer any 10 Questions (Each question carries 2 marks)

1. ……………………………………………………………………………………
2. ……………………………………………………………………………………
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Part B. Answer any 4 Questions (Each question carries 5 marks)

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2. ……………………………………………………………………………………
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7. ……………………………………………………………………………………

Part C. Answer any 2 Question (Each question carries 10 marks)

1. ……………………………………………………………………………………
2. ……………………………………………………………………………………
3. ……………………………………………………………………………………
4. ……………………………………………………………………………………