SACRED HEART COLLEGE (AUTONOMOUS), THEVARA
KOCHI, KERALA, 682013

CURRICULUM AND SYLLABI

CHOICE BASED CREDIT AND SEMESTER SYSTEM (CBCSS)

M.Phil. Physics PROGRAMME

INTRODUCED FROM 2015 ADMISSION ONWARDS

BOARD OF STUDIES IN PHYSICS

Sacred Heart College, Thevara, Kochi, Kerala

Report of the Board of Studies

Board of Studies meeting was held on November 01, 2014. A total of 14 members were present including all the nominated members from outside.

Prof. George Philip – *HoD*

Dr. Georgekutty Joseph (*Chairman*, BOS)

Prof. (Dr.) N.V. Unnikrishnan (M.G.University, VC Nominee)

Dr. Joechan Joseph (S.A.College, Edathua)

Dr. Pramod Gopinath (IIST, Trivandrum)

Dr. Ison V Vanchipurackal (St.Thomas College, Pala)

Mr. Kuruvilla George (Industrialist, Ernakulam)

Dr. Siby Mathew

Prof. George V.M

Prof. Alex Shinu Scaria

Dr. Roby Cherian

Dr. Jimmy Sebastian

Dr. Sumod.S.G. (*Secretary*, BOS)

- ✓ Approved the panel for the Examiners for both UG and PG programmes.
- ✓ Modified the components in the distribution of marks in Internal Continuous evaluation scheme. The two conventional assignments in the present scenario will be modified with one assignment as Open book/Open library Tests. The other one will still remain as such, but will be focused only on solving physics problems, which will be different for different students.
- ✓ Modified and approved the question paper pattern for PG in such a way as to help the students to win many competitive examinations such as GATE/NET/JEST etc.

- ✓ Proposal for a new Mphil course was discussed and approved. The syllabus, scheme and other activities such as making MoUs with the other research labs/universities etc. were discussed in detail. A committee was selected from the Board of Studies (BOS) with Dr. Georgekutty Joseph as the Chairman.
- ✓ Separate committees were formed for both UG and PG programmes for making necessary modifications in the existing scheme/syllabus, if any with Prof. George Philip and Prof. (Dr.) N.V.Unnikrishnan as the respective chairpersons.
- ✓ 'Skill-development' was introduced in the curriculum as a separate component for both UG and PG programmes. This will promote the students to come out with originality of thoughts/creativity and ability of making independent decisions. As an initial step, forthe UG students, the revival of 'Home Tech' programme along with introducing hobbies like amateur radio was suggested.
- ✓ Decided to promote the students to use tools in the advanced technology in the field of science, such as introducing new software packages such as Origin, Matlab etc during lab activities.
- ✓ Identified conveners to conduct the International Seminar, Refresher course (Academy of Science) and Space Science Exhibition (ISRO) at our institution.
- ✓ Decided to promote UG level students to design new instruments, use Virtual labs, Phenix etc.
- ✓ After making the necessary decisions, a common mail will be circulated among the members of BOS.
- ✓ The meeting came to an end at 01:15 pm.

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PROGRAMME OVERVIEW

1. Scope

The Master of Philosophy (M.Phil), in Physics is a semester based one year programme designed for academicians and researchers to provide theoretical and practical research exposure in Physics. The programme empowers the researchers with domain specific capabilities and methodological competencies.

Applicable to all regular (self-financing) M.Phil Programmes conducted by the Sacred Heart College (Autonomous) with effect from 2015-16 admissions.

2. Course Duration

The duration of the course is one year spread across two semesters.

3. Eligibility criteria

A pass in M.Sc Physics (Pure, Applied, Materials Science, Theoretical Physics, New & Renewable energy, Non-conventional Energy Physics) with not less than 55% mark. The degree shall be from this University or shall have been recognized by this University.

4. Admission procedure

Admission will be on the basis of the marks in the qualifying examination, written test and interview in a ratio of 50 : 40 : 10.

COURSE STRUCTURE

I. Course Structure

Sl. No.	Course code	Semester	Course title	Contact hours per week	Credits
1.	SHMP 1S C1	I	Research Methodology (Common course)	6	6
2.	SHMP 1S C2	I	General Physics I (Common course)	6	6
3.	SHMP 1S C3	I	General Physics II (Common course)	6	6
4.	SHMP 1S EL	I	Elective course	7	7
5.	SHMP 2S PR	II	Project	25	20
6.	SHMP 2S VP	II	Viva on Project	-	5
				Total Credit	50

Elective courses: options (to be framed/decided by the project guide)

Sl. No.	Course code	Semester	Course title	Contact hours per week	Credits
1.	SHMP 1S E1	I	Quantum Field Theory	7	7
2.	SHMP 1S E2	I	Plasma Physics	7	7
3.	SHMP 1S E3	I	Quantum heterostructures	7	7
4.	SHMP 1S E4	I	Atmospheric and Space Science	7	7

II. Course Code

The first two alphabets represent the college i.e., Sacred Heart College, third alphabet, the program M.Phil and the fourth one for Physics. The following digit and the alphabet represent the semester. The subsequent alphabet and the last digit represent the course.

Thus SHMP 1S C1 represents Sacred Heart College-M Phil-Physics 1st semester Core course 1 and SHMP 1S E2 represents Sacred Heart College-M Phil-Physics 1st semester Elective course 2.

GRADING AND EVALUATION

Examinations

The evaluation of each course shall contain two parts such as Internal or In-Semester Assessment. (IA) and External or End-Semester Assessment (EA). The ratio between internal and external examinations shall be 1:3. The Internal and External examinations shall be evaluated using Direct Grading system based on 5-point scale.

Internal or In-Semester Assessment (IA)

Internal evaluation is to be done by continuous assessments of the following components. The components of the internal evaluation for theory and practicals and their weights are as in the Table. The internal assessment should be fair and transparent. The evaluation of the components should be published and acknowledged by students. All documents of internal assessments are to be kept in the institution for 2 years and shall be made available for verification by the university. The responsibility of evaluating the internal assessment is vested on the teacher(s) who teach the course. The two test papers should be in the same model as the end semester examination question paper, the model of which is discussed below. The duration and the number of questions in the paper may be adjusted judiciously by the college for the sake of convenience.

THEORY (Semester I)	
Component	Weights
Attendance	2
Assignments.	2
Seminar	2
Test-1	2
Test-II	2
Total Weight of Theory =	10

Project	
Relevance /Quality of project under study	1
Literature survey	2
Experimental/Theoretical / Data validation/ Modeling	2
Result and Dissertation layout	2
Presentation of the project	3
Total Weight	10

Distribution of weights and components of theory and project

Attendance		Assignments		Seminar	
% of Attendance	Grade	Components	Weights	Components	Weights
≥90%	A	Punctuality	1	Innovation of Topic	1
≥85% and <90%	B	Review	2	Review/ Reference	1
≥ 80% and <85%	C	Content	4	Content	3
≥75% and <80%	D	Conclusion	2	Presentation	3
<75%	E	References	1	Conclusion	2

Both project evaluation and viva voce examination are to be conducted in batches of students formed for the practical examinations.

Question Paper Pattern for Theory Courses.

All the theory question papers are of three hour duration. All question papers will have three parts.

Part A: (very short answer questions) Questions from this part are very short answer type. Six questions have to be answered from among ten questions. Each question will have weight one and the Part A will have a total weight of six. A minimum of two questions must be asked from each unit of the course.

Part B: (Short answer questions) Part B is fully dedicated to solving problems from the course concerned. Four problems out of six given have to be answered. Each question has a weight two making the Part B to have total weight eight. A minimum of one problem from each unit is required. The problems need not always be of numerical in nature.

Part C: Part C will have four questions (essay questions). Two questions of equal standard must be asked from each unit with internal option. Each question will have a weight four making the total weight sixteen in Part C

Reappearance/Improvement: For reappearance / improvement as per university rules, students can appear along with the next regular batch of students of their particular semester. A maximum of two chances will be given for each failed paper. Only those Papers in which candidate have failed need be repeated. Chances of reappearance will be available only during the starting semester in which admission/ readmission is given to the candidate.

DETAILED SYLLABUS

<u>Common Course 1:</u>

SHMP 1S C1: RESEARCH METHODOLOGY

(Credits: 6) **108 Hrs**

Module I (General aspects) **30 hrs**

Research literature survey- Primary, secondary and tertiary sources- Information search using digital library and internet - Ideas of theoretical, experimental and computational research methods.

Research communications-different categories and formats-paper preparation for scientific journals -word processing and publication of software- LATEX documents - preparation of these and dissertations - conference presentations in oral and poster forms

Matlab programming: Matrices and vectors, Scripts and functions, Linear Algebra, Curve fitting and interpolation, data analysis, Ordinary differential equations, Graphics, Math toolbox

Module II (Basics of Spectral Analysis) **30 hrs**

1. Line Shapes in Spectroscopy- Lorenzian and Gaussian, Fitting of the spectras. (curve fitting) Deconvolution of spectrum, Derivative peak shapes. Some examples of generating spectra and analysis of spectra by taking examples of X-ray photo-electron spectra. Software/analysis using Origin and Easy plot

2.Noise and Signal handling- Signal to noise ratio, Johnson Noise and Nyquist theorem, Shot noise, Means of reducing noise. Grounding - shielding, pre amplifier, Considerations sampling theorem, filters - ADCs/DACs Fourier Transform, Laplace and Fast Fourier Transforms.

3.Resolution of spectrometer/ instrument (general), Resolving power and influence of different experimental parameters on it. Sensitivity of Measurement. Accuracy of measurements. Instrumental errors and measurement errors.(static & dynamic) Examples of UV-vis-NIR, IR, XRD, XPS, Mass Spectrometer spectra, vis-avis Instrumental parameter like slit width, relaxation time, scan speed etc. Ligand Fields, Crystal fields, their effects

Module III (Compositional analysis) **30 hrs**

Review of Atomic Spectroscopy. EDAX, Electronic transition in solids, Transmission reflection and absorption coefficient Infrared spectroscopy, Molecular vibration spectroscopy, Rotational spectroscopy, Bond analysis. Raman spectroscopy. Special analysis: Tutorials on each of the above spectroscopies.

Crystal structural and microstructure analysis

X-ray diffraction principles, Type of the cameras. Intensity dependence. Rietveld analysis For powder diffraction. Particle size determination using Scherrer formula Analysis Microstructure analysis. Scanning electron and Transmission electron Microscopy, Field emission microscopy, scanning Tunneling microscopy, Atomic force microscopy. Analysis of experimental results.

Module IV (Data analysis) **18 hrs**

Error analysis, statistical data analysis on data in physics contest, descriptive statistics-Mean, Standard deviation, Median, Interquatile ranges - comparison, Chi-Square test-association between variables, Pearson correlation, Spearman correlation, prediction of values, simple linear regression, non parametric regression.

Reference Books

1. Characterization of Materials John B. watchman (Butlerworth - Heinemann Manning Greenwich)
2. Quantitative Analysis - Day Underwood.
3. Fundamentals of Analytical Chemistry Skoog, West Holler.
4. Modern Methods for trace element determination C. Vandecasteele, (C. B. block -John Wiley and sons (NY).)
5. Numerical analysis - Francis Scheid, Schum's Outlines, Tata McGraw-Hill Publishing Company Limited.
6. Computer oriented numerical methods-V. Rajaraman, Prentice Hall of India Private limited.
7. Getting Started with MATLAB 7: A Quick Introduction for Scientists and Engineers, Rudra Pratap, Oxford University Press.
8. Numerical heat transfer, Suhas V patankar, Hemisphere Publication Corporation

9. Taylor, John R. An introduction to error analysis, - the study of uncertainties of physical measurements. University Science Books, 1982.

Common Course 2:

SHMP 1S C2: GENERAL PHYSICS I

(Credits: 6) **108 Hrs**

Module I (Mathematical Physics) **27 Hrs**

Dimensional analysis-Vector algebra and vector calculus- Review of vector calculus—Gauss's and Stokes theorem (no proof), orthogonal curvilinear coordinates--gradient, divergence, curl and Laplacian in Cartesian, spherical polar and cylindrical co- ordinate systems. Linear algebra, matrices-Cayley- Hamilton Theorem-Eigenvalues and eigenvectors- Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions)-Fourier series, Fourier and Laplace Transforms- Green's function-Partial differential equations (Laplace, wave and heat equations in two and three dimensions) integration by trapezoid and Simpson's rule, Solution of first order differential equation using RungeKuttamethod. Tensors. Introductory group theory: SU(2), O(3). Elements of complex analysis- analytic functions; Taylor & Laurent series; poles, residues. Complex algebra, De Moivres formula, Cauchy-Riemann conditions, Cauchy's integral theorem, Cauchy's integral formula. Calculus of residues—singularities, residue theorem, evaluation of definite integrals, Jordan's lemma. Singular points—Frobenius method and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem one dimensional Dirac delta function, properties and representations, three dimensional Dirac delta function-

Text Books

1. Jon Mathews and R.L. Walker, Mathematical Methods of Physics.

2. George Arfken, Mathematical Methods for Physicists, Fourth (Prism Indian) Edition

Module II (Classical Mechanics) **27 Hrs**

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames Central force problem – equivalent one dimensional problem – classification of orbits – the differential equation for orbits. Rigid body dynamics- moment of inertia tensor -Poisson brackets and canonical transformations. Infinitesimal canonical transformation – generators. Symmetry, invariance and Noether's theorem. Hamilton-Jacobi theory. Non-inertial frames and pseudo forces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes Small oscillations – formulation of the problem – eigenvalue equation – normal coordinates – linear triatomic molecules. Special theory of relativity-Lorentz transformations, relativistic kinematics-four vectors- and mass–energy equivalence.

Text Books

1. H. Goldstein, C. Poole and J. Safko , Classical Mechanics

2. N. C. Rana and P. S. Joag, Classical Mechanics

3. Y.K.LIM, LIM SERIES: Problems and solutions on classical mechanics (For Problems)

Module III (Electrodynamics) **27 Hrs**

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. – Plane electromagnetic wave in a non-conducting medium, linear and circular polarization, reflection and refraction at a dielectric interface, polarization by reflection and total internal reflection Electromagnetic waves in free space-Dielectrics and conductors-Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction- Dynamics of charged particles in static and uniform electromagnetic fields-image problems- Dispersion relations in plasma Lorentz invariance of Maxwell's equation-Transmission lines and wave guides- Radiation from moving charges and dipoles - retarded potentials. Vector and scalar potentials – gauge transformations – Lorentz gauge, Coulomb Gauge- Poynting's theorem and conservation of energy and momentum, complex Poynting vector.

Text Books:

1. J. D. Jackson, Electrodynamics
2. David J Griffiths, Introduction to Electrodynamics

Module IV (Quantum Mechanics) **27 Hrs**

Wave-particle duality- Schrödinger equation (time-dependent and time-independent)- Eigenvalue problems -particle in a box(one dimensional, two dimensional, three dimensional)- harmonic oscillator- Tunneling through a barrier. Wave-function in coordinate and momentum representations- Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Timeindependent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection. Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

Text Books

1. P.M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics
2. V.K. Thankappan, Quantum Mechanics
3. G. Aruldhas, Quantum Mechanics
4. D.J.Griffith, Introduction to Quantum Mechanics
5. Nouredine Zettili, Quantum mechanics concepts and applications
6. Y.K.LIM, LIM SERIES: Problems and solutions on quantum mechanics (For Problems)

<u>Common Course 3:</u>

SHMP 1S C3: GENERAL PHYSICS II

(Credits: 6) **108 Hrs**

Module I (Thermodynamic and Statistical Physics) **27 Hrs**

Laws of thermodynamics and their consequences- Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibrium. Phase space, micro- and macro-states. Micro-canonical, canonical and grand-canonical ensembles and partition functions. First- and second-order phase transitions.Diamagnetism- paramagnetism- and ferromagnetism- Ising model- Bose-Einstein condensation. Diffusion Equation- Random walk and Brownian motion- Introduction to non-equilibrium processes-Free energy and its connection with thermodynamic quantities-Classical and quantum statistics- Ideal Bose and Fermi gases- Principle of detailed balance-Blackbody radiation and Planck's distribution law. monatomic molecules – diatomic molecules – ortho and para hydrogen.

Text Books

1.R. K. Pathria, Statistical Mechanics

2. K. Huang, Statistical Mechanics

3. Y.K.LIM, LIM SERIES Problems and solutions on statistical mechanics

Module II (Atomic & Molecular Physics) **27 Hrs**

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman- Paschen-Bach & Stark effects- Electron spin resonance. Nuclear magnetic resonance, chemical shift- Frank-Condon principle- Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

Text Books

1.H. E. White, Introduction to Atomic Spectra

2. C. N. Banwell and Elaine M. McCash, Fundamentals of Molecular Spectroscopy

3. Rajkumar, Atomic and molecular spectra:laser

4. Y.K.LIM, LIM SERIES Problems and solutions on atomic, nuclear and particle physics

Module III (Condensed Matter Physics) 27 Hrs

Bravais lattices, packing fraction, Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

Text Books

1 .A. J. Dekker, Solid State Physics

2. C. Kittel, Introduction to Solid State Physics

3. A. R. A. Levy, Introduction to solids

4. L. V. Azaroff, Introduction to X ray Crystallography

5. Y.K.LIM, LIM SERIES Problems and solutions on solid state physics

Module IV (Nuclear and Particle Physics) 27 hrs

Basic nuclear properties: size, shape and charge distribution, spin and parity. Binding energy, semi empirical mass formula, liquid drop model, Nature of the nuclear force, form of nucleon-nucleon potential, charge-independence and charge-symmetry of nuclear forces. Deuteron problem. Evidence of shell structure, single-particle shell model, its validity and limitations. Rotational spectra. Elementary ideas of alpha, beta and gamma decays and their selection rules. Fission and fusion. Nuclear reactions, reaction mechanism, compound nuclei and direct reactions. Classification of fundamental forces. Elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.). Gellmann-Nishijima formula. Quark model, baryons and mesons. C, P, and T invariance. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction. Relativistic kinematics.

Text Books:

1. Harald A Enge, Introduction to Nuclear Physics

2. Kenneth S Krane, Introductory Nuclear Physics

3. David Griffiths, Introduction to Elementary Particles

4. Y.K.LIM, LIM SERIES Problems and solutions on atomic, nuclear and particle physics

Elective Course 1.

SHMP 1S E1: QUANTUM FIELD THEORY

(Credits: 7) **126 Hrs**

Module I **40 Hrs**

Elements of Classical Field theory: Lagrangian and Hamiltonian densities, quantization of KG and Dirac and electromagnetic fields, propagators for KG, Dirac and vector (photons). Perturbation theory: Wick's theorem and Wick expansion, Feynman diagrams, cross sections and S matrix. Feynman rules for scalars, spinors and gauge fields (Abelian).

Module II **20 Hrs**

Elementary processes in QED: electron positron annihilation, Compton scattering, Bhabha scattering, crossing symmetry etc.

Module III **38 Hrs**

Radiative corrections for scalar theory: loop corrections, regularization and renormalization, dimensional regularization. Elementary ideas of the systematics of renormalization. Functional method techniques: Scalar field theory quantization (with, if time permits, some discussion of critical phenomena in this approach).

Module IV **28 Hrs**

Non-interacting electrons: Tight binding models, the many body ground state, quasi-particle and quasi-hole excitations. Partially filled bands and Fermi surface kinematics.

References:

1. M. E. Peskin and D. V. Schroyder, Quantum Field Theory, Sarat Book House, 2005.

<u>Elective Course 2.</u>

SHMP 1S E2: PLASMA PHYSICS

(Credits: 7) **126 Hrs**

Module I **32 Hrs**

Plasma state, characterisation, occurrence of plasma in nature, definition, concept of temperature, debye shielding, plasma parameters, criteria for plasma, applications of plasma physics (basis ideas) single particle motions: uniform E and B fields - Non uniform B and E fields -Summary of guiding centre drifts - magnetic mirrors, time - varying B and E fields, adiabatic invariants.

Module II **28 Hrs**

Plasma as fluids, the equation of motion, fluid drifts perpendicular to B, fluid drifts parallel to B, the plasma approximation, equilibrium and stability, hydromagnetic equilibrium, concept of diffusion of magnetic field into plasma, classification of instabilities, two stream instability, the gravitational instability, resistive drift waves, the weibel instability.

Module III **28 Hrs**

Representation of waves, group velocity, plasma oscillations, electron plasma waves, sound waves, ion waves, validity of plasma approximation, comparison of ion and electron waves, electromagnetic waves with B_0=0, experimental applications, electromagnetic waves perpendicular and parallel to B_0, experimental consequences, hydromagnetic waves, Alfven waves, magnetosonic waves, summary of elementary plasma waves, CMA diagram.

Module IV **38 Hrs**

Kinetic theory, meaning of f(v) equations by kinetic theory, derivations of the fluid equation, plasma Oscillations and Landau damping, meaning of Landau damping, physical derivation of Landau Damping, plasma diagnostics, eelectrical methods, Langmuir profits spectroscopic methods, line spectrum of a plasma, low density plasma, high density plasma ionization state of a plasma, particle methods, beam of charged particle to measure electric field in a plasma – measurement of the density of natural particles and charged particles.

References:

1. F. F. Chen, Introduction to plasma physics and controlled fusion, vol 1, Plenum press, 1983.

<u>Elective Course 3.</u>

SHMP 1S E3: QUANTUM HETEROSTRUCTURES

(Credits: 7) **126 Hrs**

Module I **36 Hrs**

Electrons in quantum structures, quantum wells, quantum wires, quantum dots, coupling between quantum wells, superlattices, excitons quantum structures, properties of quantum structures, energy spectra of semiconductor materials, lattice matched and pseudomorphic heterostructures, single heterojunction devices, modulation-doped quantum structures.

Module II **36 Hrs**

Electron scattering in quantum structures, electron scattering in two-dimensional electron systems, screening of a two-dimensional electron gas, scattering by remote ionized impurities, scattering by interface roughness, electron-phonon interaction, interaction with acoustic and optic phonons, interaction in wells and wires.

Module III **36 Hrs**

Parallel transport in quantum structures, linear electron transport, high field electron transport, hot electrons in quantum structures, perpendicular transport in quantum structures, perpendicular transport in quantum structures, double-barrier resonant-tunneling structures, super lattices and ballistic injection devices, single electron transfer and Coulomb blockade.

Module IV **18 Hrs**

Electronic devices based on quantum heterostructures, FET, velocity modulation and quantum interference transistors, bipolar heterostructure transistors, hot electron transistors.

References:

1. V.V. Mitin, V.A. Kochelap, M.A. Stroscio, Quantum heterostrucures, Cambride University press (1999).

2. G.W. Hanson, Fundamentals of nanoelectronics, Pearson (2010).

<u>Elective Course 4.</u>

SHMP 1S E4: ATMOSPHERIC AND SPACE SCIENCES

(Credits: 7) **126 Hrs**

Module I **18 Hrs**

Basic structure of Atmosphere-Hydrostatic Equilibrium-Scale Height-Geo potential Height-Thermodynamic considerations-Elementary Chemical Kinetics-Composition and Chemistry of Lower, Middle and Upper Atmosphere-Thermal Balance in Thermosphere

Module II **36 Hrs**

Solar Radiation at the Top of the Atmosphere-Attenuation of Solar radiation in the Atmosphere-Radiative Transfer-Thermal Effects of Radiation- Photochemical Effects of Radiation.

Equation of Motion of Neutral Atmosphere-Thermal Wind Equation-Elements of Planetary waves-Internal Gravity waves and Atmospheric Tides-Fundamental Description of Atmospheric dynamics and Effects of Dynamics on Chemical Species

Module III **36 Hrs**

Introduction of Earth's Ionosphere-Chapmann's Theory of Photoionization-Continuity equation and photochemical equilibrium-Loss processes-α and β Chapman layers-Chemistry of E and F1 regions-D region chemistry-F region splitting-Vertical Transport-Ambipolar diffusion and F2 peak-Topside ionosphere

Module IV **36 Hrs**

Properties of magnetoplasma-Gyrofrequency-Plasma frequency-Debye length and Frozen in field-Basic fluid dquation-Steady state plasma motions due to applied forces-Electrical conductivity of the ionosphere-Generation of electric field and electric field mapping-Ionosphere dynamo-Ionospheric irregularities-Equatorial Spread F and Equatorial Electrojet-Equatorial Ionization Anomaly, Sporadic E.

Space weather, Geomagnetic storms, solar flares, coronal mass ejections, Effect of Magnetic disturbance on Ionosphere and Thermosphere.

References:

1. Wallance, John and Hobbs, Peter, Atmospheric Sciences- An Introductory Survery, Academic Press, 2006

2. Rees M.H, Physics and Chemistry of the Upper Atmosphere-Cambridge University Press, 1989
3. Andrews, D.G., Middle Atmosphere Dynamics (Int.Geophysics Series V40, Holton Jr, USA, Academic Press, 1987
4. Hargreaves, J.K., The Solar-Terrestrial Environment: An Introduction to Geospace-The Science of the Terrestrial Upper Atmosphere, Ionosphere, and Magnetosphere, Cambridge University Press, 1992
5. Rishbeth, H and OK Garriott, Introduction to Ionospheric Physics, Academic Press, New York, 1969
6. Kelley M.C, Earths Ionosphere, ,Academic Press, 1989.

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