M.Sc. Physics Syllabus

(Choice Based Credit system)

2015

Department of Physics

Rajiv Gandhi University

Rono Hills, Doimukh –791112,

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Content

PREFACE

The department of physics offers presently M.Sc. courses of two years' semester system comprising of mainly three types of papers-Core (Compulsory) theory papers, Elective theory papers and interdisciplinary papers at the advent of Choice Based Credit System (CBCS). As per CBCS, students will get a choice to select any four elective theory papers out of the set of the elective theory papers and any one interdisciplinary paper (s) offered by other departments of the university campus subject to the approval of the concerned departments. In each semester, there are four theory papers and one practical/project based course. End semester examination for each theory paper carrying 80 marks will be of 3 hours duration and each 100 marks carrying practical examination at every semester end will be of 5 hours duration. For each theory paper in a semester there will be internal assessment examination in forms of unit test/Quiz etc carrying 20 marks upon the decision of the concerned faculty member. Project works in the third and fourth semester can be assigned to students (if in demand) under one supervisor upon the consent of faculty members.

With the excellent results both in theory and practical examinations the department of physics has already started in opening specialisation paper -condensed matter physics, under well qualified and dedicated concerned faculty members at the end semesters so as to instigate the "researcher" in the students to be innovators or inventor of tomorrow. The department has committed to introduce other specialisation papers in near future to ensure good academic performance of the students and to realise the hidden potentials in the field of physical science. In addition to teaching, the department is at the point of introducing Ph.D. course in Nano Science and condensed matter physics firstly. In due course the department is destined to introduce Ph.D. course in high energy physics and astronomy and astrophysics shortly.

Board of Post Graduate studies
Department of Physics, RGU

M. Sc. Physics (Choice base Credit System)

1. Objectives of the Course:

The recent developments in Physics, had been included in the enriched M.Sc.,(Physics) Syllabus to meet the present day needs of Academic and Research Institutions and Industries. An important objective of the course is to develop an understanding of 'core physics' at deeper levels , each stage revealing new phenonmena and greater insight into the behavior of matter and radiation. The various courses in the first two semesters, are designed to bridge the gap between college and university level physics and to bring all students to a common point. These courses also aim to consolidate the college level knowledge of physics by providing much more logical and analytical framework which will be essential for the specialization courses in the third and fourth semester. In various advanced courses in the third and fourth semester, a number of recent topics broaden the perspective of the student to appreciate the great flexibility and generality of laws physics and their applications. However the different kinds of experimental works designed to develop practical skills and prepare the student for advanced laboratory work.

2. Duration of the Course:

The M.Sc. Physics Programme is for a period of two years. Each academic year shall comprise of two semesters viz. Odd and Even semesters. Odd semesters shall be from July to Decembar and Even Semesters shall be from January to May. A candidate can avail a maximum of 6 Semesters (3 Years), in a continuous stretch of 3 years from the date of admission to complete Masters's Degree.

3. CBCS System based syllabus:

The Course in M.Sc. PHYSICS PROGRAMME is based on Choice Based Credit System (CBCS) which is in force from June-2015. It is an instructional package developed to suit the needs of students to keep pace with the developments in higher education and the quality assurance expected of it in the light of liberalization and globalization in higher education.

3.1 Course Pattern: The Post Graduate degree course consists of three major components. They are Core Course, Elective Course and Open elective course . Also two compulsory components namely Laboratory based and Project based course and the extension components are mandatory.

Core Course: A core course is the course offered by the parent department, totally related to the major subject, components like Theory , Practical and Projects.

Elective Course: The course is also offered by the parent department. It provides choice and flexibility within the department to choose a particular area of Physics. The student can choose his/her elective paper subject to certain criteria. The department will offer various elective papers subject to availability of sufficient infrastructure.

Open elective Course: This course is offered by a department for the students belonging to other departments. The objective is to provide mobility and flexibility outside the parent department. This is introduced to make every course multi- disciplinary in nature. It is to be chosen from a list of courses offered by various departments.

3.2 Credit: Weightage to a course is given in relation to the hours assigned for the course. The credit refers to the weightage given to a course. Each course/paper for the academic programme will be measured in terms of credit where one credit is in general equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week for one semester.

3.3 Grade Point: It is a numerical weight allotted to each letter grade on a 10-point scale Once the marks of the Internal Assessment and end- semester examinations for each of the courses are available, they will be added and will then be graded as per details provided in Table 1

Table 1: Marks to grade conversion table

% of Marks	Grade Point	Letter Grade
90-100	10	O (Outstanding)
80-89	9	A+ (Excellent)
70-79	8	A (Very Good)
60-69	7	B+ (Good)
50-59	6	B (Average)
45-49	5	P (Pass)
44 and less	0	F (Fail)
Absent	0	Ab (Absent)

3.4 Credit point: It indicates that it is the product of grade point and number of credits for a course. or example for a particular paper of four credit a student has secured 78 marks out of 100 then his grade is A and grade point 8 , then

Credit point= grad point x credit =4x8=32

3.5 SGPA and CGPA: The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student, i.e

$$SGPA\ (S_i) = \Sigma(C_i \times G_i) / \Sigma C_i$$

where C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course.

The CGPA is also calculated in the same manner taking into account all the courses undergone by a student over all the semesters of a programme, i.e.

$$CGPA = \Sigma(C_i \times S_i) / \Sigma\ C_i$$

where S_i is the SGPA of the i^{th} semester and C_i is the total number of credits in that semester.

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts. (An example of details calculation of SGPA and CGPA is in Annexure A)

3.6 Transcript or Grade Card or Certificate Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details *(code, title, number of credits, grade secured*) along with SGPA of that semester and CGPA earned till that semester. The details of grading system will be mentioned in the overleaf of the transcript.

3.7 Ranks : Ranks of student will be of CGPA. If two or more students secure the same CGPA, the student with the highest total marks obtained will be considered.

4. **Specialization in M.Sc. Physics :** In the course students are allowed to in depth study in a particular area of physics of his/her interest. The main aim of the specialization is to provide comprehensive knowledge about that area and to prepare the student to carry out further study or research in that field. For that they have to choose a specialization offered by the department subject to availability of infrastructure. Based on the specialization students have to select various elective courses in third and fourth semester. The proposed specialization are -(a) Advanced Condensed Matter Physics (b) Advanced Electronics (c) Astrophysics

Course structure of M. Sc. Physics

This **M.Sc. PHYSICS PROGRAMME** is divided into f**our Semesters** (Two Years) and the duration of an academic year consists of two semesters. In the program, when the student admitted into the third semester he/she has to choose one specialization course and it will be decided by the department upon the fulfillment of certain criteria. In the programme, there will be **five** categories of courses/papers -

(a) Ten Compulsory Core theory courses of 4 credits each. In the first and second semester all the theory papers are Compulsory core course. One compulsory paper is there in the third and fourth semester.

(b) Three Compulsory core practical courses are there in the program. In the practical based courses the first and second semester comprises of various Physics experiments related to their theory courses while in the fourth semester the practical course is based on computational Physics.

(c) Four departmental elective courses (Theory or Practical course) are there in the third and fourth semester program in which students have to register on the basis of the specialization.

(d) One Choice Based open Elective Course (interdisciplinary) with 4 credits in the third semester. Immediately after joining a programme, student has to select one course from the Open Elective courses offered by other departments of the university. To register in that course the student has to fill up an Open Elective Course Application Form (Annexure B) to be issued by the parent department and to be submitted to the parent and offering department imultaneously . As par guideline of CBCS system of university, late registration/ permission for Elective courses and withdrawal from the from the course shall be allowed up to two weeks after the commencement of semester.

(f) Two Project based core compulsory course in the third and fourth semester. In this type of Course students are engaged with one supervisor to perform project work in two semesters which can be experimental or theoretical. The students can also take-up in-depth and detailed study of a specific topic in Physics as project work.

The details of course structure mentioning the credits are listed in the next page.

M. Sc. Physics (CBCS)
Course structure and Credit distribution

1st semester

Paper		Credits			
		Lecture	Tutorial	Practical	Total
PHYC- 401	Mathematical Physics	3	1	0	4
PHYC -402	Classical Mechanics	3	1	0	4
PHYC -403	Quantum Mechanics	3	1	0	4
PHYC -404	Electronics	3	1	0	4
PHYC -405	General Practical 1	0	0	6	6

Total Credits: 22

2nd semester

Paper		Credits			
		Lecture	Tutorial	Practical	Total
PHYC -411	Electrodynamics	3	1	0	4
PHYC -412	Condensed Matter Physics	3	1	0	4
PHYC -413	Atomic and Molecular Physics	3	1	0	4
PHYC -414	Statistical Mechanics and Theory of errors	3	1	0	4
PHYC -415	General Practical 2	0	0	6	6

Total Credits: 22

3rd semester

Paper		Credits			
		Lecture	Tutorial	Practical	Total
PHYC- 501	Nuclear and particle Physics	3	1	0	4
PHYE- 5X1	**Departmental Elective Paper-I**	3	1	0	4
PHYE- 5X2	**Departmental Elective Paper-2**	3	1	0	4
PHYC- 505	Project / Practical	0	0	6	6
	Open Elective Course 1 (CBCT)	0	0	4	4

Total Credits: 22

4th semester

Paper		Credits			
		Lecture	Tutorial	Practical	Total
PHYE- 511	Computational Physics	3	1	0	4
PHYE- 5X3	**Departmental Elective Paper-3**	3	1	0	4
PHYE- 5X4	**Departmental Elective Paper-4**	3	1	0	4
PHYC- 510	Computational Physics Laboratory	0	0	2	2
PHYC- 515	Project	0	0	10	10

Total Credits: 24

Departmental Elective Papers

Paper Code	Paper Title
PHYE-521	Experimental Techniques in Physics.
PHYE-522	Advanced Condensed Matter Physics 1
PHYE-523	Nanoscience and nanotechnology
PHYE-524	Advanced Condensed Matter Physics 2
PHYE-531	Optoelectronics and Photonics
PHYE-532	Semiconductor devices, Network analysis and Microprocessors
PHYE-533	Signal processing, Information theory and control systems
PHYE-534	Electronic Communications
PHYE-541	Quantum Field Theory
PHYE-542	Basics Astronomy and Astrophysics
PHYE-543	General Theory of Relativity
PHYE-544	Black Hole and Cosmology

Open Elective Papers form the Department of Physics

Paper Code	Paper Title
PHYO-591	Physics in Everyday life
PHYO-592	Industrial Nanotechnology
PHYO-593	Physics of living body

Pattern/Scheme of Examination of M. Sc Physics (CBCS)

There will be examinations at the end of each semester ordinarily during November / December for odd semesters and during April/May for even semesters. Out of the total marks for each course/paper maximum 20% marks shall be earmarked for Internal assessment (Through continuous internal evaluation process) and remaining 80% for semester-end examinations. The passing marks in each paper shall be 40%. A candidate has to secure a minimum of 40% of marks in the semester-end examination excluding internal examination pass mark for a particular paper.

End term theory Examinations: There will be a examination at the semester end for each theory based paper. The examination comprises of 80 marks for three hours duration.

End term Practical Examinations: There will be Practical examination for each practical based papers. The end term practical examinations shall be conducted with one internal and one external examiner. In the examination students have to perform various laboratory works. The evaluation of practical examination will be done by their performance in the laboratory work and voice-viva.

End term Examination on Projects: For the end term evaluation process of Project based papers, students have to submit a project report followed by a presentation on his/her work in presence of an external and internal examiner. In the presentation, students have to go through a voice-viva on his/her work.

Internal Assessment: For each paper/course in a semester there will be continuous internal evaluation process which includes Unit Test / Internal Test, MCQ Test / quiz test, Seminar/ Poster, Presentation/ Assignment work, Attendance -Regularity , Library work etc . For the practical/ project papers the internal assessment process is done based on their activity, performance in their work or Seminar/poster presentation.

Grade Based evaluation: For the grade based evaluation, the numerical mark of each paper is converted into grade using the table 1 along with the credit earned from that particular paper . On the basis of the credit earned for each paper , the SGPA is calculated for a particular semester [Annexure A] . Finally the CGPA is evaluated [Annexure A] to categorize the student in various classes.

M.Sc. PHYSICS
(CHOICE BASED CREDIT SYSTEM)
SCHEME OF EXAMINATION

Semester	Course code	Title of the Course	No. of credits	Internal Assess-ment	Semester End Exams	Total Marks
1st	PHYC-401	Mathematical Physics	4	20	80	100
	PHYC-402	Classical Mechanics	4	20	80	100
	PHYC-403	Quantum Mechanics	4	20	80	100
	PHYC-404	Electronics	4	20	80	100
	PHYC-405	General Practical 1	6	20	80	100
2nd	PHYC -411	Electrodynamics	4	20	80	100
	PHYC -412	Condensed Matter Physics	4	20	80	100
	PHYC -413	Atomic and Molecular Physics	4	20	80	100
	PHYC -414	Statistical Mechanics and Theory of errors	4	20	80	100
	PHYC -415	General Practical 2	6	20	80	100
3rd	PHYC -501	Nuclear and particle Physics	4	20	80	100
	PHYE -5X1*	***Departmental Elective Paper-I***	4	20	80	100
	PHYE -5X2*	***Departmental Elective Paper-2***	4	20	80	100
	PHYC -505	Project / Practical	6	20	80	100
		Open Elective course 1 (CBCT)	4	20	80	100
4th	PHYE- 511	Computational Physics	4	20	80	100
	PHYE- 5X3*	***Departmental Elective Paper-3***	4	20	80	100
	PHYE- 5X4*	***Departmental Elective Paper-4***	4	20	80	100
	PHYC- 510	Computational Physics Laboratory	2	20	80	100
	PHYC- 515	Project	10	20	80	100
		Total credits 90		**Total Marks 2000**		

** X=1,2,3,4 (for various elective papers)*

PHYC-401: Mathematical Physics

1. Matrices and Tensors: Different kind of matrices, orthogonal matrices, Hermitian matrices, unitary matrices, diagonalisation of matrices, eigenvectors and eigenvalues. Tensor in three and four dimensions, rank of tensors, covariant and contra variant tensors, Addition, subtraction, inner and outer products, contraction, symmetric and anti-symmetric tensors, quotient law, metric tensor, covariant and contra variant derivatives, tensor differential Operators, Christoffel symbols, equation of Geodesic, Riemann tensors.

2. Complex Analysis: Complex algebra, graphical representation, Functions, derivatives, analytic and harmonic functions, Cauchy-Riemann condition, complex integration, contour integrals, Cauchy's theorem, Cauchy's integral formula, Cauchy-Goursat Theorem; Series: convergence, Taylor series for an analytic functions of complex variables, Laurent series and classifications of singularities, Cauchy's residue theorem, applications of residue theorem, conformal mapping and applications

3(a)Group Theory: Groups, symmetric & anti-symmetric group, discrete group, continuous groups, generators, group representations, reducible and irreducible representations, subgroups, conjugacy classes, invariant subgroups, factor group, homomorphism, kernels, lie group, continuous group, unitary groups, special unitary groups, SO(2) & SU(2), Homogeneous Lorentz group.

(b) Fourier series and integral transformation: General properties of Fourier series, Fourier integrals and applications. Laplace transform, Fourier transform and their applications.

4(a). Ordinary differential equations and Special functions: Gamma and Beta Functions: functions, Continuity and convergence of gamma and beta functions , Asymptotic Representation of Gamma and beta functions for Large /n/ , integral forms of beta and gamma functions, Properties of Gamma and Beta functions and their relationship; Series solution-Fuchs' theorem and Frobenius' method, Legendre, Bessel, Hermite, and Laguerre functions, their generating functions, recurrence relations, Rodrigue's formula, orthogonality of the special functions; Hyper geometric and confluent hypergeometric equations (Sturm-Liouville's theorem).

4(b). Partial differential equations: Solutions for Laplace, wave and Helmholtz equations by method of separation of variables and Green's function method(Dirac-Delta functions) in Cartesian, Spherical and Cylindrical coordinates, other PDE in physics .

Recommended Books:

1) Mathematical Physics, Mathews and Walker
2) Mathematical methods for Physics, George Arfken
3) Mathematical methods for Physics, A.W.Joshi
4) Mathematics for Engineers and Physicist, L. A. Pepes

PHYC-402: Classical Mechanics

1. Lagrangian Dynamics and Hamiltonian formulation: Constraints , Principal of Virtual Work, D'Alembert's principale and its applications, Lagrange's equation and its applications. Jacobi integral and energy conservation, Concept of symmetry, velocity dependent potential. Variational calculus and Least Action principle, Hamilton's principle, Lagrange's equation from Hamilton's principle, Legendre transformations, Hamilton's function and Hamilton's equation of motion, configuration space, phase space and state space, Hamilton's equations from Variational principle.

2.Canonical transformations and Hamilton Jacobi theory: Generating function, canonical transformation and its examples, group property, Lagrange and Poisson brackets and other canonical invariants, equation of motions, Infinitesimal canonical theorem in Poisson bracket formalism, Jacobi identity, Angular momentum-Poisson bracket relations. The Hamilton-Jacobi equation for Hamilton's principal and characteristic functions with example; the harmonic oscillator, Separation of variable in Hamilton-Jacobi equation; Action-angle variables and its examples – the Kepler problem in action-angle variables.

3. Central Force Motion and Rigid Body: Reduction to one-body problem, General Properties of central force, Effective potential, Motion in a central force field – general solution, Inverse Square Law force. Kaplers Laws – laws of gravitation form Keplers laws, orbits of artificial satellites, Satellite parameters, Virial theorem. Scattering in a central force field and in Laboratory Co-ordinates. ***The rigid bodies,*** Kinematics of rigid body motion, Orthogonal transformations, Euler's theorem and its applications. Finite and infinitesimal rotations, rate of change of a vector, the rigid body equation of motion, Coriolis effect, angular momentum and kinetic energy of motion about a point, tensors and dyadic, the inertia tensor and the moment of inertia, the principal axis transformation, the Euler equations of motion.

4(a)Small Oscillation: Formulation of the problem, the eigenvalue equation and the principal axis transformation, frequencies of free vibrations and normal coordinates, forced vibrations and the effect of dissipative forces. Resonance and beats. Linear and nonlinear waves, Solitary Waves, KdV equation, Numerical experiments of Kruskal and Zabusky , Solitons

4(b). Relativity: Review of special theory of relativity - Lorentz transformations; 4-vectors, 4-dimensional velocity and acceleration; 4-momentum and 4-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle. General theory of relativity: Curved space-time; Eotvos experiment and the equivalence principle.[8]

Recommended Books:

1) Classical Mechanics by Herbeert Goldstein (Narosa)
2) Classical Mechanics by Rana&Joag (TMH Publication)
3) Classical Mechanics by S.N. Biswas
4) Classical Mechanics by Landau &Liffshitz
5) Classical Mechanics by S.N. Gupta

PHYC-403: Quantum mechanics

1 Introduction to Quantum Theory :Matter waves, , uncertainty principle, wave packets, wave equations. Basic postulates of quantum mechanics, probability current density, ***Schrodinger equation and its applications:*** particle in a box, steps, barriers, well, bound states, delta function potential, and liner harmonic oscillator. ***Matrix formulation in quantum mechanics*** : linear and matrix algebra, Dirac bra and ket notation, matrix representations of vectors and operators, expectation values, Matrix representation of angular momentum, different representation in quantum mechanics , parity operation, Matrix theory of harmonic oscillator.

2(a). Theory of angular momentum: spherical harmonics, angular momentum operator, Eigen values of L^2, L_z, and commutation relations, addition of angular momentum, Clebsh Gordon coefficient, spin orbit interaction.

2(b) Perturbation Theory: Non-degenerate and Degenerate Cases and Applications:. Zeeman and Stark effects Induced electric dipole moment of Hydrogen Real Hydrogen Atom, Schrodinger equation for a slowly varying potential, Variational Principle, WKB approximation, turning points, connection formulae, derivation of Bohr-Somerfield quantization condition, applications of WKB. Time Dependent Perturbation Theory: Sinusoidal perturbation, Fermi's Golden Rule.

3(a) Scattering Theory: Scattering Cross-section, Scattering amplitude, Partial waves, Scattering by a central potential, partial wave analysis, the Born Approximation and its validity, Scattering for various kinds of potentials, applications. Laboratory and center of mass coordinate systems.

(b)Symmetries and Conservation laws: Symmetry and conservation laws, Translation in space-conservation of linear momentum, Translation in time- Conservation of energy, Rotation in space-Conservation of angular momentum, Space Inversion- parity conservation, Time reversal. Selection rules and conservation laws.

4(a) Identical particle- symmetric and antisymmetric wave functions, spin and space wave function.

(b) Relativistic Quantum Mechanics: Klein-Gordon equation, Interpretation of Klein-Gordon equation, Particle in a Coulomb field, Dirac equation for a free particle, Dirac matrices, covariant form of Dirac equation, Probability density, Plane wave solution, Negative energy states, spin of Dirac particles

Recommended Books:

1) Quantum Mechanics : Concepts and Application by Nouredine Zettili
2) Quantum Mechanics by L.I. Schiff
3) Quantum Mechanics: Theory And Applications by A. K. Ghatak, S.Lokanathan,
4) The Principles of Quantum Mechanics by P. A. M. Dirac, Oxford University Press.

PHYC-404: Electronics

1. Foundation of Electronics: Review of electronic circuits, Filter circuits, Voltage source and current source, voltage dividers and current dividers, KCL, KVL, DC and AC circuit with resistor, Inductor, capacitors – LR, CR, LCR circuits, Network theorems, Thevenin's and Norton's equivalent circuits, Maximum power transfer theorem – impedance matching, Methods of Circuit analysis- mach, loop and nodal analysis techniques – analysis of different circuits, equivalent networks.

2(a). Basic semiconductor electronic devices and its applications: semiconductor diode and its characteristics and its dependence on temperature, diode resistance and capacitance, applications of diode, Zener diode and its applications, various types of semiconductor diodes and its applications- varactor diode, Tunnel diode, photodiode, light emitting diode, gun diode etc. Bipolar junction transistor – various configurations, h parameters, biasing schemes, applications, construction of transistor, Field effect transistors – JFET and MOSFET, characteristics ,parameters and applications.

2(b)Amplifier and oscillators: Classification of amplifiers, distortion in amplifiers, frequency response of an amplifier – Bode plots, Multistage amplifier, Direct coupled amplifier, RC coupled amplifier, Differential amplifiers, Darlington amplifier, power amplifier -push-pull amplifier, complementary symmetry amplifier, Feedback in amplifiers, oscillators, Phase shift oscillators, Wein Bridge oscillators, Colpitts and Hartley oscillators, RC oscillator. Wave form generators, Multivibrators.

3 Operational amplifier: Differential Amplifiers - DC analysis, Introduction to Op-amps: Block diagram, equivalent circuit, parameters of op-amp -input-offset Voltage , input bias current, input offset current, total output offset voltage, CMRR, frequency response., open loop configurations of Op-amps (the differential amplifier, inverting and non-inverting amplifiers), Op-amp with negative feedback: Voltage series feedback – effect of feedback, bandwidth and output offset voltage, voltage follower. Practical Op-amp: Mathematical operations and analog computation- summing, scaling and averaging amplifiers, integrator and differentior, instrumentation amplifier, Oscillators: Principle, types, frequency stability, response. The phase shift oscillator and LC tunable oscillator. Op-amp in nonlinear applications-comparators, function generators, Multivibrators

4. (a) Digital electronics : Number systems; decimal, binary, octal and hexadecimal system, arithmetic; Logic families; Logic gates; Boolean algebra; De Morgan's laws; simplifying Boolean expressions; arithmetic circuits (adders, subtractor); flip-flops; registers; counters –design of counters, memories. A/D and D/A conversion: resolution and speed; various circuits. Digital integrated circuits –RTL, DTL, TTL, ECL, MOS, CMOS logic – characteristics, Microprocessors .

(b) Electronic communications: Modulation, Amplitude modulation, Frequency modulation Angle modulation, Transmitter and receiver (AM and FM), Digital communication, Continuous wave modulation and Pulse modulation, modem, multiplexing, Satellite communication.

Recommended Books:

1) Electronic Principles, Tata Mgraw Hill.
2) Integrated Electronics by Jacob Millman, Christos C. Halkias
3) An Introduction To Analog And Digital Communications by Simon Haykin,
4) OP-AMPS and Linear Integrated Circuits by R G Gayakwad

PHYC-411: Electrodynamics

1. Review of Electrostatics and Magnetostatics: Review of electrostatics, multipole expansion of charge distribution, Poisson and Laplace's equations, Uniqueness theorems, boundary value problems: with conducting & dielectric sphere, shell, cylinder; Review of Magnetostatics: scalar and vector potentials, multipole expansion of a current distribution.

2. Field equations and conservation laws: Equation of continuity, displacement current, Maxwell's equations, energy in electromagnetic fields, Poynting theorem and vector, momentum in electromagnetic fields, electromagnetic potentials, Maxwell equations in terms of electromagnetic potentials, Non-uniqueness of EM potentials and concept of gauge, Lorentz gauge, coulomb's gauge.

3(a).Electromagnetic waves and its Interaction with matter on macroscopic scale: Electromagnetic waves (EMW) in free space, propagation of E.M.W-in isotropic, anisotropic dielectrics, in conducting media; Boundary conditions, reflection and refraction of E.M.W, Fresnel formulae, Brewster's law and degree of polarization, total internal reflection and critical angle, reflection from a metallic surface, Propagation of E.M.W between conducting planes, Wave guides: TE and TM mode, Transmission lines, Rectangular and cylindrical wave guides, cavity resonator

3(b) Fields of moving charges and Radiating System: Retarded Potentials, Lienard Wiechert potentials, field of a point charge in uniform rectilinear motion, in arbitrary motion, Radiation from an accelerated charged particle at low and high velocity. *Radiating System:* Oscillating electric dipole, radiation from an oscillating dipole, from a small current element, from a linear antenna, Antenna arrays

4. Relativistic Electrodynamics and plasma physics: Transformation equation for current density and charge density, vector potential and scalar potentials, the electromagnetic field tensor, transformation equation for electric and magnetic field, Covariance of Maxwell equation in four tensor form, covariance of Maxwell and transformation law of Lorentz force, Basic plasma concepts, Debye shielding, Plasma parameters, waves in plasma, electrons and ions in plasma waves, their dispersion relations, fundamental equations of MHD.

Recommended Books:

1. Introduction to Electrodynamics- D. J. Griffiths, Prentice Hall.
2. Classical Electrodynamics – J. D. Jackson, Willey India.
3. Feynman Lecture, Vol II
4. Foundation of Electromagnetic Theory, J.R. Reitz and F.J. Millford,
5. W. Greiner, Classical Electrodynamics, Springer(1998).
6. Electrodynamics of Continuous Media, L.D. Landau and E.M. Lifshitz,
7. Fundamental of Plasma Physics – P.M. Bellan,

PHYC-412: Condensed Matter Physics

1. Crystal Physics: Crystal solids, unit cells,, two- and three-dimensional Bravais lattices, crystal systems, crystal planes and Miller indices, close packed structures, symmetry elements in crystals, point groups and space groups, crystal structure determination : X-ray, electron and neutron diffraction, Ewald construction, Reciprocal lattices and its applications to diffraction techniques. Boding in crystal - cohesive energy, Defects in crystals: Point defects (Frenkel & Schottky), line defects (slip, plastic deformation, edge dislocation, screw dislocation, Burger's vector, concentration of line defects, estimation of dislocation density), dislocation multiplication (dislocation reaction), surface (Planar) defects, grain boundaries and stacking faults.

2 (a) Lattice vibration and thermal properties: Einstein and Debye models; continuous solid; linear lattice; acoustic and optical modes; dispersion relation; attenuation; density of states; quantization of lattice vibrations, the concept of phonons and quantization; phonon momentum, Inelastic scattering of neutrons by phonons, Surface vibrations. Brillouin zones; thermal conductivity of solids. Thermal expansion.

2(b) Electronic Properties of Solids: Boltamann's transport equation, electrical and thermal conductivities of solid, Wiedemann-Franz law, Free elctron theory of metals; Electrons in periodic lattice: Bloch theorem, the Kronnig Penny model, band theory, classification of solids on the basis of band theory, effective mass of electron and hole, Fermi surface and Fermi gas, Semiconductors – carrier concentration and fermi level and extrinsic and intrinsic, Transport phenomenon in semiconductor - Hall Effect.

3(a)*Dielectric and ferroelectric properties* : Polarization, dielectric constants, Clausius-Mossotti equation, sources of polarization, frequency dependent of dielectric constants, ferroelectrics and piezo-electrics.

3(b)Magnetic properties: dia , para and ferromagnetic materials, Origin of magnetism – various theories, temperature dependence, domain structure ferromagnetic domains, antiferromagnetism, magnetic hysteresis and coercive force.

3(c)**Optical Properties**: Scattering, transmission and absorption in solid. optical properties of semiconductors, optical transitions, excitons, activators, Franck-Condon principle, colour centres, photoluminescence and thermoluminescence.

4. Superconductivity: Superconductivity and its historical perspective, critical temperature, type-I and type II superconductors, persistent current, effect of magnetic fields, Meissner effect, Thermodynamics of superconductors London and Pippard equation, Ginzburg Landau (G-L) Equation, Josephson junction, Giever tunneling, superconducting quantum interference devices, Cooper pairs, BCS theory; Energy gap; high T_c superconductors, applications of superconductors,

Recommended Books:

1) Introduction to Solid State Physics by C. Kittel.
2) Solid State Physics – A.J. Dekker.
3) Introduction to Solid State Physics – H.P. Myers.
4) Solid state Physics – N.N. Ashcroft and N.D. Mermin.
5) Solid state theory – F. Seitz.
7) Solid State Theory – W. Harrison.

PHYC-413: Atomic and Molecular Physics

1. Atomic Physics: Vector atom model and quantum numbers, Larmar precession, spectroscopic terms, Lande's g factor, fine structure of hydrogen atom- relativistic correction, spin-orbit interaction, intensity of fine structure lines, Lamb shift, hyperfine structure of spectral lines, determination of nuclear spin, ground state of one-electron and two-electron atoms and their spectra– perturbation theory and variational method, para and ortho states, pauli exclusion principle, Excited states, doubly excite states, Auger effect, resonance. Many electron atoms: Central field approximation, Thomas-Fermi model, Hartee-Fock method and self-consistent field, Hund's rule, L-S and j-j coupling schemes, fine structure of sodium d line, Lande interval rule, the idea of Hartee-Fock equations. The spectra of alkalis using quantum defect theory, selection rules for electronic and magnetic multiple radiations, Oscillator strengths and Thomas Reich-Kuhn sum rule.

2. Interaction of atoms with Electromagnetic fields: Spectra of alkali and alkaline earths elements - complex spectra - multiplet structure, Zeeman effect, Paschen-Back Effect, Stark effect, hyperfine structure of spectral line, broadening of spectral lines, X-ray spectra.

3. Molecular Physics: Born-Oppenheimer approximation, rotation and vibration of diatomic molecules, electronic spin and Hund's cases and nuclear spin, electronic structure of diatomic molecules, structure of polyatomic molecules. Rotational spectra: Intensity of rotational spectra, Isotopic effect of rotational spectra, non-rigid rotator, and vibrational spectra: anharmonic effect, Diatomic Vibrating rotator, Breakdown of Born-Openhemer approximation – interaction of rotational vibration, Electronic spectra, Fortrant diagram. Atomic collisions: Types of collisions, channels, thresholds, cross-sections, potential scattering, general features, Born approximation.

4. Raman spectra and resonance spectroscopy: Raman Effect and Raman spectroscopy: Classical and Quantum theory of Raman Effect, Rotational and vibrational structure of Raman spectrum - pure rotational Raman spectra of diatomic molecules, vibration rotation Raman spectrum of diatomic molecule, intensity alterations, Application of IR & Raman spectroscopy. Resonance Technique: NMR – nuclear spin magnetic moment, interaction of nuclear magnet with external field. Quantum description of N.M.R., NMR spectrometer, Chemical shift, Spin–spin interaction, Applications of NMR spectroscopy. Quantum mechanical treatment of Electronic spin resonance (ESR) - Nuclear interaction and hyperfine structure - Relaxation effects - Basic principles of spectrographs - Applications of ESR method. Mossbauer spectra and its applications.

Recommended Books:

1) Introduction to Atomic Spectra – White.
2) Introduction to Atomic Spectra –Herberg.
3) Physics of Atoms and Molecules by B H Bransden and C J Jocachin
4) Laser: Theory and Application, K.Thyagarajan and A.K. Ghatak.
5) Lasers and Non-linear Optics, B.B. Laud.

PHYC– 414 Statistical Mechanics and Theory of errors

1. Statistical Thermodynamics : Review of Thermodynamics, laws of thermodynamics and their significance, specific heats, thermodynamic potentials, Maxwell relations, significance of entropy. Phase space, trajectories and density of states, macroscopic and microscopic states, postulates of equal a priori probability, Liouville's theorem, Ensembles, microcannonical, canonical and grandcanonical ensembles, Concept of ensemble average, Equation of state, specific heat and entropy of a classical ideal gas using microcanonical ensemble. Entropy of mixing, Gibb's paradox, Sakura Tetrode Equation. Energy and Density fluctuations; Equivalence of various ensembles, Virial and equipartition theorems.

2. Statistical Thermodynamics: Partition function- derivation of partition function, derivation of thermodynamic quantities from each ensembles, classical ideal gas, free energy, chemical potential, Boltzmann partition function and classical partition function, Application to an ideal diatomic gas. Classical harmonic oscillator, magnetic dipoles in a magnetic field. Inadequacy of classical theory, Quantum mechanical ensemble theory, density matrix, Ensembles in quantum statistical mechanics. Partition functions with examples ,

3. Statistical Distributions: Connection between entropy and probability, Boltzmann's equation, elementary ideas about three different statistics, Maxwell & Boltzmann statistics ,classical ideal gas , equipartition theorem. quantum statistics, Fermi & Dirac statistics, Bose & Einstein statistics, –Ideal Fermi and Bose Gas, Equation of state, Landau Diamagnetism, De Hass Van Alphen Effect, Pauli paramagnetism, photons, phonons, Bose-Einstein condensation, liquid Helium, thermionic and photoelectric emissions, Phase transitions, Critical indices and dimensionality, Ising model, Onsager Relations and applications

4. Probability and Theory of errors: Fundamental of Probability, Random variables, special distributions - Gaussian and Poisson distributions; Theory of errors: Precision and accuracy, error analysis, propagation of errors, least squares fitting, linear and nonlinear curve fitting, chi-square test; Statistical theory of errors – Histogram, the distribution function, Normal distribution, Binomial and Poisson distributions,.

Recommended Books:

1) Statistical Mechanics – K. Huang.
2) Statistical Mechanics – R.K. Pathria.
3) statistical Mechanics – B.K. Agarwal and M. Eisner.
4) Statistical Mechanics – S.K. Singh.
5) Statistical Physics – J.K. Bhattacharya.

PHYC– 501 Nuclear and Particle Physics

1. Properties of Nucleus & Nuclear Forces: Shape and Size, mass, spin and parity, masses and relative abundances, binding energy & nuclear stability, nuclear compositions, quantum properties of nucleon states, Radioactivity; Laws of radioactivity, radioactive dating, radioactive series, theory of alpha, beta & gamma decays and their properties. Nuclear forces: Properties of nuclear forces, two nucleon systems-deuteron with potentials, n-p and p-p/n-n interactions at different energies, Yukawa's hypothesis, Meson theory of nuclear force.

2. **Nuclear models**: Fermi gas model, liquid drop model and Bethe-Weizsacker formula, their applications; shell model and shell structure , extreme single particle shell model with potentials – square well, harmonic oscillator, spin orbit interaction, Magic numbers, Predictions of the shell model; collective nuclear model; superconductivity model (ideas only).

3. Nuclear reactions: Types of nuclear reactions, conservation laws, Nuclear reaction kinematics, nuclear scattering cross section determinations, compound nucleus disintegration, Breit Wigner dispersion formula (one level), direct reactions, nuclear transmutation reactions, nuclear fission and fusion,

4. Particle Physics & Cosmic rays: Broad classification of elementary particles and particle interactions in nature, conservation laws, symmetry classifications of elementary particles- Gell-Mann-Nishijima scheme, CPT conservation, Quark hypothesis & Quantum chromodynamics (ideas only); Cosmic rays: origin of cosmic rays, nature of primary cosmic rays and its energy distribution, its geomagnetic ,latitude effect, east-west asymmetry, origin of secondary rays, collision with electrons,. Particle accelerators and detectors: linear accelerators, cyclotron, synchrotron, colliding beam accelerators (LHC), gas-filled counters, scintillation detectors, semiconductor detectors.

Recommended Books:

1. Atomic and Nuclear Physics: Gopalakrishnan (MacMillan)
2. Concepts of Modern Physics: A.Beiser.
3. Concepts of Nuclear Physics: Bernard L Cohen.
4. Nuclear Physics: D C Tayal.
5. Subatomic Physics, Frauenfelder and Henley. (Prentice-Hall)
6. Nuclei and Particles, E. Segre.
7. Atomic Nucleus, R.D. Evans

PHYC-511: Computational Physics

1.Computer programming: Introduction to personal computers and operating systems (DOS/Windows and Linux), idea about different programming languages and packages. Introduction to C Programming : Algorithms, flow charts, constants, variables, expressions, conditional statements, loops, arrays, logical expressions, control statements, functions, structures, pointers, bit operation, files in C. Solving simple problems using C programming Language. Data analysis through different Mathematical packages.

2 *Numerical computations:* Errors in Numerical computations, Error considerations and error estimation, General error formula, Linear convergence and quadratic convergence – Aiken's acceleration formula. Roots of Nonlinear Equations and interpolation: Bisection, Newton-Raphson, secant method. System of Nonlinear equations, Newton's method for Nonlinear systems. Applications in Physics problems. Solution of linear systems: Gauss, Gauss-Jordan elimination, matrix inversion and LU decomposition. Eigenvalues and Eigenvectors. Applications. Interpolation and Curve fitting: Introduction to interpolation, Lagrange approximation, Newton and Chebyshev polynomials. Least square fitting, linear and nonlinear. Application in Physics problems.

3. Numerical Differentiation and Integration and solution of differential equations: Approximating the derivative, numerical differentiation formulas, introduction to quadrature, trapezoidal and Simpson's rule, Gauss- Legendre integration. Applications. Solution of ODE**:** Initial value and boundary value problems, Euler's and Runge- Kutta methods, Finite difference method. Schrodinger equations. Solution of PDE: Hyperbolic, Parabolic, and Elliptic Equations by finite difference. Application to 2-dimensional Electrostatic Field problems. Solution of eigen value problems.

4. Simulations: A system and its model; The basic nature of simulation; The simulation of continuous and discrete systems - suitable examples; Stochastic simulation - generation of random numbers with different probability distributions; Monte Carlo methods, Examples of simulation in physics, Molecular Dynamics, Monte Carlo simulation, Density functional theory, Electromagnetic Wave Analysis, High-performance computing :Parallel computing (MPI), Quantum computing.

Tutorial : *Basic Mathematical Operations in Matlab -accuracy considerations, Interpolations, differentiation and integration, Random numbers generators, Numerical methods of matrices in Matlab-Linear Algebra (systems of linear equations, Gaussian elimination), Eigenvalues and Eigenvectors, Spectral Methods and Fast Fourier Transform, Variational Principle and Minimization- Extremes of a multivariable function (Newton method, steepest descents, conjugate gradients),The Ritz variational method and Eigenvalue problems, Inverse problem (Maximun entropy method), Stochastic Methods-Metropolis algorithm, Variational Quantum Monte Carlo, The Stochastic Gradient Approximation (Robbins and Monro Theorem),Electronic structure of molecules, Partial Differential Equations (PDE)- Maxwell's Equations in Matter and Ising ferromagnet, Diffusion Quantum Monte Carlo.*

Recommended Books:

1) An Introduction to Numerical Analysis by Kendall E. Atkinson.
2) Computer Oriented Numerical Methods by V. Rajaraman,
3) Programming in C by Balguruswamy,

PHYE -521: Experimental technique in Physics

1. Electronic instrumentations*:* Measurement system- mechanical and electrical, Transducers and its types, sensors, differential output transducer, LVDT, Hygrometers, Measurement of thermal Conductivity (gas analyzer), Physiological transducers Bio-potential electrodes. Digital and analog measuring instruments – voltmeter, ammeter, oscilloscope, power meter, LCR meter, instrumentation amplifier, filtering and noise reduction in instruments, shielding and grounding, lock-in detector, box-car integrator, interfacing sensors and data acquisition, Integrated circuits technology – fabrications, Power supplies- primary and secondary cell, regulated power supply, SMPS, UPS, Step down switching regulator, Inverters- voltage driven inversion, current driven inversion.

2. Lasers and Optoelectronic instrumentation : Lasers: - Temporal and special coherence, Einstein coefficients, The threshold condition, two, three and four level laser systems, Modes of a rectangular cavity and open planar resonator, Quality factor, mode selection, The Ruby laser, The Helium-Neon laser, the carbon dioxide (CO_2)laser. Optoelectronic devices : Photoconductivity, LDR, photodiode, phototransistor, solar cell, metal semiconductor detector, LCD, CCD , LED, Laser diode, PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes,. Optical fiber- ray propagation Step –index and graded-index fibers, dispersion and attenuation in fiber optics, Dispersion compensation mechanism, Erbium-doped fiber amplifiers, Optoelectronic modulators.

3(a). X-ray analysis: Origin of X-rays, X-ray generators. Scattering of X-ray, atomic scattering factor, Diffraction of X-ray, various X-ray diffraction methods, X-ray powder diffraction method -indexing of powder lines, Laue's method, rotational/oscillation method, X-ray diffractormeter, determination of crystal structure and lattice parameter, small angle x-ray diffraction and its applications. XPS, XRF and its applications.

3(b).Low pressure and Low temperature: Production of low pressure -Rotary, oil diffusion, turbo molecular, getter and cryo pumps; gauges – Macleod thermoelectric (thermocouple, thermistor and pirani), penning, hot cathode partial pressure measurement; leak detection; gas flow through pipes and apertures; effective pump speed; vacuum components. Production of Low temperature**:** Gas liquifiers; Cryo -fluid baths; liquid He cryostat design; closed cycle He refrigerator; low temperature measurement.

4. Analytical Instrument:- Electron Microscopy (SEM,TEM, HRTEM), Scanning probe microscopy (AFM, MFM, STM), UV-Vis, spectroscopy and its applications. FT-IR spectroscopy, Luminescence spectroscopy techniques- Fluorescence spectroscopy, Raman spectroscopy, Thermal analysis using DTA, TGA, DSC; Electronic transport analysis using Current vs Voltage characteristics – two probe and four probe techniques - various types of contacts, Dielectric and impedance spectroscopy, spectrum analyzer, fluorescence and Raman spectrometer, Interferometers for different analytical study.

Recommended Books:

1) Electronic Instrumentation - Kalsi H S
2) X-Ray Crystallography – B.E. Warren.
3) Materials Characterization: Introduction to Microscopic and Spectroscopic Methods,
4) Materials Characterization Techniques Sam Zhang, Lin Li, Ashok Kumar

PHYE-522: Advanced Condensed Matter Physics 1

1. Conduction electron in a crystal lattice: Thermal conductivity and thermal resistance of solids – phonon phonon interaction -normal and umklapp processes, Electron-phonon interaction, polaron as a prototype quasiparticle, Electron-electron interaction, The Boltzmann transport equation and electrical conductivity, electrical conductivity of metals, impurity scattering and resistance, thermal conductivity, Wiedeman Franz law, thermo electric effects, Transport properties in presence of magnetic field – magneto resistance, Hall effect and magnetoresistance in two band model, K-space analysis of electron motion in a uniform magnetic field, magnetoresistance for open orbits, cyclotron resonance, Azbel-Kaner resonance, Energy level and density of state in a magnetic field, Landau diamagnetism, de Haas van Alphen effect, quantum Hall effect. Kubo formula for electrical conductivity. Various transport coefficients.

2. Energy bands in solids: Kroing-Penney model, The nearly free electron approximation, The tight binding approximation, energy bands semiconductors and concentration of charge carriers in the bands, The fermi surface – its characteristics, experimental determination of fermi surface, Other methods for calculating band structure – independent electron approximation, valence band wave functions, cellular method, muffin-tin potentials, augmented plane wave (APW) method, Green function (KKR) Method, Orthogonolized Plane wave (OPW) method, Pseudopotential model

3(a) Physics of semiconductor devices: Carrier transport phenomena in semiconductor solids: drift and diffusion process, transport in crystalline and amorphous semiconductors, Carrier Diffusion, Diffusion Current Density, total Current Density, Graded Impurity Distribution, Induced Electric Field, The Einstein Relation, The Hall Effect, cyclotron resonance in semiconductors, Temperature dependence of semiconductor conductivity, Carrier life, Shockley-Read-Hall theory, Gun effect. p-n junction devices: Minority and majority carrier injection, Depletion layer, I-V characteristics, hetrojunctions and superlattices, Metal-semiconductor junctions, Schottky and Ohmic contacts. Three terminal devices: BJT, FET, MOSFET

3(b) Diffusion and Mechanical properties of Solids:

Diffusion in solids—various types of diffusion, Fick's laws of diffusion, Kirdendall effect, surface diffusion. Mechanical properties of solids -Origin of Hook`s law elastic properties of solids, Dynamic Mechanical Properties. Excitation of the optical branch. Verifying the dispersion relation in crystal lattices. Boundary conditions, Dispersion Relations and Modes.

4.Surface and interface Physics: Structure of surfaces, Energies of surfaces: simple surface relaxation, Electronic surface structure: surface charge density, Surface events: surface plasmon, surface phonons, Surface cleaving and interaction of gases with surfaces, Adsorption on surface: physisorption, chemisorption, Langmuir Blodgett films, Crystal face dependence, charge density effects from chemisorption, Surface related techniques: Low LEED, PES, AES, SIMS, EXAFS.

Recommended Books:

1) Introduction to Solid State Physics by C. Kittel.
2) Solid State Physics – A.J. Dekker.
3) Introduction to Solid State Physics – H.P. Myers.
4) Solid state Physics – N.N. Ashcroft and N.D. Mermin.
5) Solid state theory – F. Seitz.
6) Solid State Theory – W. Harrison.
7) Semiconductor Devices – S.M. Sze, Wiley-India,2009.

PHYC-523: Nanoscience and Technology

1. Nanoscience and semiconductor nanostructures: Conceptual development of nanoscience, Nanoscience in nature, Clusters, artificial atomic clusters,– clusters to solids, effect on structures, ionization potential, melting etc. Electronic states in semiconductor, Concepts of 2D nanostructures (quantum wells), 1D nanostructures (quantum wires) 0D nanostructures (quantum dots), Quantum mechanical treatment of quantum wells, wires and dots, Variation of electronic structure with size of semiconductor nanostructures, Widening of band gap, Effective mass approximation theory and other models for determination of electronic structures in semiconductor nanostructures, Strong and weak confinement in semiconductor nanostructures. Various classes of semiconductor nanostructures, optical properties of semiconductor nanostructures, Phonons in nanostructures. **Energy at nanoscale:** surface energy, surface tension, particle curvature and the Young-Laplace equation, chemical potential, DLVO theory, nucleation, ostwald ripening, sintering

2.Malterials at nanoscale: Metallic nanostructures- Surface Plasmons , permittivity and permeability based on Lorentz oscillator model, Properties of metallic nanoparticles, surface plasmon resonance, idea of mie theory, stability of metal nanoparticles, **carbon nanostructures-**Carbon nanomaterial, Fullerene, Carbon cluster, Carbon nanotubes, SWCNT, MWCNT, graphine, application of carbon nanotube. **Magnetic nanostructures-**magnetism in small and nanoparticles, superparamagnetism, introduction to spintronics, spin valve, magnetic tunnel junction, memory elements.

3. Synthesis and Analysis of nanomaterials : Various synthesis process, lithography, Ball milling, Atom manipulation by SPM, Microcontact printing, Ion beam deposition, chemical bath deposition , self-assembled mono layers, Molecular beam epitaxy, chemical vapor deposition (CVD) based techniques, pulsed laser deposition, ion beam assisted techniques including embedded nanoparticles, RF sputtering, Characterization of nanomaterial - X-ray diffraction, Transmission electron microscopy, Scanning electron microscopy, Energy dispersive analysis, electron energy loss microscopy, Atomic force microscopy, Magnetic Force Microscopy, Scanning tunneling microscopy, optical and vibrational spectroscopy, Scanning near-field optical microscopy, Raman Spectroscopy.

4(a) Quantum Transport in nanostructures: Ballistic transport, Phase coherence, Aharonv-Bohm effect, quantized conductance, Landauer formula, conductance behavior of quantum point contact, Landauer Buttiker formula for multileads, edge state – quantum Hall effect, single electron transport – coulomb blockage, coulomb diamond, SET, molecular electronics, Kondo effect in nanostructures

(b) Applications of nanomaterials and challenges: Application nanostructured material in electronics, photonics, biotechnology, nano-electromechanical systems, Nanocatalysis, nanocompsties and fibers, challenges of nanotechnology.

Recommended Books:

1) Introduction to Low Dimensional Semiconductors- J.H.Davis, Cambridge Press, 1998.
2) Optical Properties of Semiconductors- U.Woggon, Springer-Verlag, 2000.
3) Hand Book of Nanostructured Materials and Technology- Canham.

PHYE-524: Advanced condensed Matter Physics 2

1. Energy bands in solids: The basic Hamiltonian in solid, Reduction to one electron problem for determining bands in solids (single particle approximation) - variational principle, Hartree approximation, Hartee-Fock approximation, Density functional approximation- Comparison with conventional wave function approach, Hohenberg-Kohn Theorem; Kohn-Sham Equation; Thomas-Fermi approximation and beyond; Practical DFT in a many body calculation and its reliability.

2. Magnetism: Origin of magnetism, quantum theory of diamagnetism, Landau diamagnetism, Paramagnetism: Classical and quantum theory, magnetism in rare-earth and iron group atoms, quenching of orbital angular momentum, Van-Vleck Paramagnetism and Pauli Paramagnetism, Ferromagnetism: Cuire-weiss Law, temperature dependence of magnetization, Heisenberg exchange interaction, Ferromagnetic domains, Magnetic domains – exchange energy, magnetostatic energy, wall energy, magnetostrictive energy, Neel and Bloch wall, the Bloch $T^{3/2}$ law, Neel model of antiferromagnetism and ferrimagnetism. Magnetic anisotropy and magnetostatic interactions- Direct, exchange, indirect exchange and itinerant exchange, (double exchange and RKKY interactions). spin waves in ferromagnets - magnons, Spin waves in lattices – ferri and antiferromagnetism, Measurement of magnon spectrum. Magnetic resonance and crystal field theory, Jahn-Teller effect; Hund's rule and rare earth ions in solids. Pinning effects, The Kondo effect, spin glass, solitons, Magneto resistance – spin valves and spin switchs, giant magneto resistance (GMR), spintronics.

3. Dielectrics and Ionics: Dialectic properties in solid **–** polarization, electrical conduction, dielectric loss, breakdown of dialectics, nonlinear dielectrics – ferroelectrics, junction capacitor, piezoelectric, electrets , impedance spectroscopy, complex dielectrics, eclectic modulus. Ionic conduction in solid: defect in solid, conduction mechanism, Nernst Einstein equation, cataonic, protonic and anionic conductor, temperature and frequency dependent of conductivity, hopping mechanism, universal power law (Jonscher's Power Law) oxygen ion conductor, solid electrolyte, fuel cell, SOFC.

4. Polymers, Composites and Soft matters: Polymer and their classification, Molecular weight, degree of polymerization, techniques of polymerization, crystallinity of polymers, applications of polymers. Polymer electrolyte, Conducting polymers- concept of solitons, polarons, biolarons, Doping in conducting polymers, Common conducting polymers, Properties and applications of conducting polymers: PLED, sensors actuators. Composite Materials- various types of composites, microcomposites and mactrocomposites, fiber composites, and matrix materials, Different kinds of soft matters, Symmetry and order parameters, Dispersion colloids, liquid crystal, biological membranes, macromolecules- DNA condensation, bilayer, Marcelja's molecular field theory mesosphere.

Recommended Books:

1) The Modern Theory of Solids- F.Sitz
2) Solid State Theory-W. Harrison, TMH,

PHYE-531: Optoelectronics and photonics

1. Optoelectronic devices : Photoconductivity, Light dependent resistor, photodiode, phototransistor, solar cell, metal semiconductor detector, Liquid crystal display, charged coupled devices, light emitting diode Laser diode: Spontaneous and stimulated emission, laser structures, time response of lasers, advanced semiconductor laser structures, temperature dependence of laser output. PIN photodiode, Avalanche photodiode, Heterojunction photodiode, Organic light emitting diodes (OLED) , way to perceive colors, conventional, transparent, inverted and flexible OLEDs, Organic thin films transistors (OTFT), OTFT based display technology; Organic laser-Lasing process, optically pumped lasing structures, applications; Organic multilayer, photodetectors; organic photovoltaic cells;

2 Optoelectronic modulators: Polarization of Light, Elliptical polarization, Optics of anisotropic media: The index ellipsoid, Birefringence, Optical activity, Electro-optic effect, Electro-optic modulators, Acousto-optic modulators, use of optoelectronic modulator, Kerr modulator- Kerr effect, Magneto-optic modulator – Faraday effect, Acousto-optic effect, Electro-optic Devices: Wave retarders, rotators and optical isolators, Intensity Modulators, Phase Modulators, Traveling Wave Modulator, Acousto-optic Devices: Raman-Nath acousto-optic modulator, Acousto-optic deflector, parametric oscillation.

3. Fiber optics: Basic characteristics and ray propagation in an optical fibers, Step –index and graded-index fibers, Multipath dispersion, pulse dispersion, material dispersion, combined effect of multipath and maerial dispersion, rms pulse width. Modes In planar waveguides – TE modes of a symmetric step-index planar waveguide, power distribution and confinement factor, wave propagation in a cylindrical wave guide, single mode fiber and its characteristic parameters, dispersion and attenuation in SMF, Optical fiber cable and connections, Dispersion compensation mechanism, Dispersion-tailored and dispersion compensating fibers, Birefringent fibers and polarization mode dispersion, Fiber bandwidth. fiber material and its fabrication, Erbium-doped fiber amplifiers, Fiber Bragg gratings. Photonic Crystal and Holey fibers. **Fiber optic communications:** Analog and digital fiber optic communication system, System architectures, Nonlinear effects in fiber optic: Stimulated Raman Scattering, Stimulated Brillouin Scattering, Self Phase Modulation, Cross Phase Modulation, Four wave mixing, Optical Solitons **optical amplifiers :** semiconductor optical amplifier, Fiber raman amplifier.

3. (a) Non-linear Optics: Non-linear optical media, second order non-linear optics- SHG, Three wave mixing. Third order non-linear optics, THG and self-phase modulation, Coupled wave theory of three-wave mixing. Four wave mixing and Optical Phase conju- gation. Frequency conversion, Parametric Ampli_cation and Oscillation. Self focusing of light. Optical Bistability [8] **(b)Concept Optical digital computer** - Optical components for binary digital computer, Optical Switches- SEED , Photonic logic gates [2]

Recommended Books:

1) Optoelectronics: An Introduction - J. Wilson & J. F. B. Hawkes,
2) Optical Electronics - Ajoy Ghatak & K.Thyagarajan,
3) Introduction to Fiber Optics - Ajoy Ghatak & K.Thyagarajan,
4) Optical Properties of Solids – Frederick Wooten
5) Quantum Electronics - Amnon Yariv, John Wiley & Sons,

PHYE -532: Semiconductor devices, Network analysis and Microprocessors

1. Physics of semiconductor devices: Carrier transport phenomena in semiconductor solids: drift and diffusion process, transport in crystalline and amorphous semiconductors, Carrier Diffusion, Diffusion Current Density, total Current Density, Graded Impurity Distribution, Induced Electric Field, The Einstein Relation, The Hall Effect, cyclotron resonance in semiconductors, Temperature dependence of semiconductor conductivity, Carrier life, Shockley-Read-Hall theory, Gun effect. p-n junction devices: Minority and majority carrier injection, Depletion layer, I-V characteristics, hetrojunctions and superlattices, Metal-semiconductor junctions, Schottky and Ohmic contacts. Three terminal devices: BJT, FET, MOSFET- *Modern semiconductor devices:* various kinds of diode and its applications – schottky barrier diode, tunnel or esaki diode, varactor diode, gun diode, GaAs MSFET, Thyristors: semiconductor power devices- Shockley diode, silicon controlled rectifier, DIAC, TRIAC, PUT.

2. Network analysis Network analysis techniques; Network theorems, transient response, steady state sinusoidal response; Network graphs and their applications in network analysis; Tellegen's theorem. Two port networks; Z, Y, h and transmission parameters. Combination of two ports, analysis of common two ports. Network junctions: parts of network functions, obtaining a network function from a given part. Application of Laplace transforms in network analysis, network synthesis.

3. Advanced digital electronics and microprocessor Registers and counters – design of counter, memory unit -RAM, Error correcting code, Algorithmic state machines- ASM chart, PLA control,
Microprocessor **-** Memory, I/O interface devices. 8085 CPU-Architecture, Bus Timing, Instruction Set, Addressing Mode, counters and time delays, stack and subroutine, Programmable Peripheral Interface. CPLD and FPGA basics, Concept of Hardware description Language. Microprocessor V/s Micro-controller,

4. Microcontrollers: 8051 Microcontroller: General architecture; Memory organization; I/O pins, ports & circuits; Counters and Timers; Serial data; Interrupts. Instructions: Addressing Modes, Instruction set: Data Move Operations, Logical Operations, Arithmetic Operations, Jump and Call Subroutine, Advanced Instructions. 8051 Interfacing and Applications: Interfacing External Memory, Keyboard and Display Devices: LED, PIC microcontroller features, PIC Architecture, Program memory, Addressing Modes, Instruction set, Instruction Format, Byte-Oriented Instructions, Bit-Oriented Instructions, Literal Instructions, Control Instructions (CALL and GOTO),Destination Designator, MPLAB overview: Using MPLAB, Toolbars, Select Development Mode and Device Type, Project, Text Editor, Assembler, MPLAB Operations. Other high performance RISC architecture: AVR, ARM microcontrollers and their applications

Recommended Books:

1)Digital Principles and Applications, Malvino, A. P. and Leach D. J.,

2) Fundamentals of Digital Electronics, A. Kumar,

3) , Microprocessor Architecture, Programming, and Applications with the 8085, R. S., Gaonkar

4) Hall, D., Microprocessors and Interfacing, 2nd edition

PHYE-533: Signal processing, Information theory and control systems

1. Linear systems and signal processing: signal and system, linear time invariant systems, fourier analysis for continuous time signals and systems, Noise: signal to noise ratio (SNR) and enhancement of SNR. Analog filters : Phasor diagrams. High pass filters, low pass filters, "Poles" and decibels per octave. Resonant circuits and active filters

2. Digital systems and signal processing: Discrete time signal and systems, sampling of signals in time and frequency domain, z-transform, discrete cosine transform, Hilbert transform, Fourier transform, DFT, FFTs, convolution, structures of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters,Linear phase filter, windowing method, standard and multi band, constrained least square filtering, arbitrary response filter design, IIR filter design, in frequency domain, Butterworth, Chebyshev type I and type II, elliptical, Spectral analysis: Welch's method, multilayer method, Yule-Walker method, covariance methods, MUSIC and eigenvector analysis method, Applications in real time problems like extraction of voice from noisy environment, filtering the signal using digital filters etc.

3. Information theory: Information, channel and fundamental limits on performance, Random signal, noise in communication systems, uncertainty, Information and entropy, Average information content (Entropy) of symbols in long independent and dependent sequences, Source encoding theorem, Shanon's encoding theorem, Shanon Hartley theorem and Channel Capacity

4. Control Systems: Basic control system components; Open loop and closed loop (feedback) systems, Transfer functions, Block diagram, signal flow graph, first and second order system with derivative and integral control, LTI controls, PID controls, control system analysis various control circuit – servomotor

Recommended Books:

1)Digital Signal Processing: Principles, Algorithms, and Applications, DG Manolakis , J.G. Proakis

2) Digital Signal Processing , S. Salivahanan

PHYE -534: Electronic Communications

1. Communication electronics: Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, super-heterodyne receivers; elements of hardware, realizations of analog communication systems; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes. Basics of TDMA, FDMA and CDMA and GSM.

2. Transmission line and antenna: characteristic impedance; Quarter and half wave transformation, Smith chart; impedance matching; S parameters, pulse excitation. Waveguides: modes in rectangular & circular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of Antennas: Dipole antennas; radiation pattern; antenna gain, Horn Antenna, its directivity and phase error reflector: Cylindrical and doubly curved; lens antenna : single surface dielectric, stepped lenses and metal plate lens antenna, aperture and field, Microstrip antenna : cavity model, impedance, radiation pattern.

3.Microwave communication: Merits and Demerits of Microwave transmission, loss in free space, propagation in fibre space, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources, detectors, components, and antennas used in MW communication systems.

4. Advanced Communication Techniques: RADAR Systems- Principle of operation, radar frequencies, pulse considerations, Radar range equation, minimum detectable signal, signal to noise ratio, integration of RADAR pulses, radar cross section, pulse repetition frequency, system losses and propagation losses, RADAR transmitters, receivers, Antennas, Displays. Satellite Communication:, look angles, orbital spacing, satellite systems, link modules. Computer Communication Systems: Types of networks, Design Features of a communication network, examples, TYMNET, ARPANET, ISDN, LAN. Mobile Radios and Satellites: TDMA, FDMA, ALOHA, slotted ALOHA, CSMA.

Recommended Books:

1) Electronic Communication Systems- Roy Blake; DELMAR, Cenage Learning.
2) Communication Systems- S.Haykin.
3) Antennas and Radio wave propagation-Robert E Collin.
4) Antennas for all Applications- J.D.Kraus, R.J.Marhefks.

PHYE-541: Quantum Field Theory

1. Relativistic wave equations in Quantum Mechanics: The real and complex Klein-Gordon equation , Dirac equations and their solutions, Lorentz invariance and the non-relativistic limit, Feyman-Hellman theorem; the virial theorem and related theorems; Relativistic wave equation for particles with arbitrary spin-Deduction of spin-0 and ½ particles, Arbitrary spin particles in the Feshbach-Villars Representation, Interaction of a spin-0 & 1/2 particles with an electromagnetic field.

2. Free fields and Quantization: Quantization of the Dirac Field and the Radiation Field; Interacting Fields, The Path-Integral Representation of Quantum Mechanics; Quantization and the Feynman Propagator; Simple Scattering Processes, Feynman Diagrams; Path integral and quantum field theory.

3. Symmetry & Gauge theories in quantum mechanics : Orthogonal transformations in four dimensions; Inhomogeneous Lorentz group, conformal group, Representation of SL & SO. Abelian and Non Abelian gauge invariance; Yang-Mills theories; chiral symmetry; linear sigma model; Spontaneous symmetry breaking; Non Linear sigma model; chiral symmetry breaking and PCAC.

4. Loop- renormalisation & Gauge transformations: Wick's theorem; QED to second order; Electron self-energy; Vacuum bubbles; Loop integrals and dimensional regularisation; Disperse relations; Vertex correction; Charge renormalisation; Bremsstrahlung and irradiative corrections. Gravitational Gauge Transform; Electromagnetic Gauge Transforms; Alternate Approach to Gauge Transforms, Tensors in Quantum Mechanics: Reducible and Irreducible Tensors.

Recommended Books:

1) Advanced Quantum Mechanics, Freeman Dyson
2) Introduction to Quantum Mechanics with Applications to Chemistry, L. Pauling, E. B.Wilson
3) Modern Quantum Mechanics (2nd Edition), J.J Sakurai
4) Quantum Mechanics: Concepts and Applications, Nouredine Zettili
5) Relativistic Quantum Mechanics, Greiner

PHYE-542: Basics Astronomy and Astrophysics

1. Time and Celestial Co-ordinate systems: Spherical Trigonometry: Spherical triangle, terrestrial latitude and longitude, the cardinal points and circles on the celestial sphere. Equatorial, ecliptic and galactic system of co-ordinates, Constellations and nomenclature of stars. Aspects of sky from different places on the earth. Twilight, Seasons, Sidereal, Apparent and Mean solar time and their relations, Equation of time, Ephemeris and Atomic Times. Calendar. Julian date and heliocentric correction. precession, nutation and proper motion on the coordinates of stars.[12]

2. Astronomical Measurement and Stars: Magnitude systems: apparent and absolute magnitudes, distance modulus, colour index; Atmospheric extinction, *seeing* and scintillation; Distances of stars from the trigonometric and moving cluster, parallaxes; Stellar motions; Stellar interiors: Hydrostatic equilibrium, Pressure equation of state, Energy transport and convection, Main sequence; Spectral stars- Interstellar dust and gas, formation of proto stars, Pre and post main sequence evolution; mass determination using Visual Binaries; Eclipsing and Spectroscopic Binaries. H R diagrams, evolution of main sequence-late stages-supernovae degenerate remnants: white dwarf, Chandrasekhar limit-Neutron star- pulsars, black holes.[12]

3. High Energy Radiative Process in Star : Synchrotron emission for a single particle and an ensemble of particles – Energy loss and electron scattering-Compton scattering-Bremsstrahlung radiation, Binary stars-types of binaries and variable stars-period luminosity relations and distance determination, Interstellar medium(ISM)-various nebula-Jeans condition for collapse-Protostars –star formation.[10]

4. Galaxies and the Universe: The Galaxy- kinematics- Hubbles classification scheme for external galaxies-spirals and elliptical –irregulars-Normal galaxies and AGNs-Quasi-stellar objects-Unified Model-Gamma Ray burst; Normal Galaxies, Classification scheme for external galaxies, Hubble's law, Distances, Big Bang and steady state theory of the origin of universe, The present epoch and evolution of universe.[6]

Recommended Books:

1. Physical Universe, Frank Shu
2. Text book of Spherical Astronomy, W.M.Smart.
3. Astronomy: From the Earth to the Universe (Sixth Edition), Jay M. Pasachoff.
4. Orbital Motion, A.E.Roy.
5. Introduction to Celestial Mechanics, McCusky.
6. Astrophysics:Stars and Galaxies, K.D.Abhyankar, Tata McGraw Hill Publication.
7. Astrophysics, K.S Krishnaswamy , CUP.
8. Astrophysics, Baidyanath Basu, Prentical Hall.
9. Astrophysics, KD Abhankar, Orient Longman.
10. Electronic Imaging in Astronomy, Mclean, Willey.
11. Text Book on Astronomy and Astrophysics with elements of cosmology, V.B.Bhatia, Narosa.

PHYE-543: General Theory of Relativity

1. Review of Special Relativity: Principles of special relativity; Transformation of coordinates and velocities; Volume and surface integral in four dimensions; Concept of particle dynamics-scalar and electromagnetic fields; Energy momentum tensor-the distribution function and its moments; uniformly accelerated observer; Lorentz boost in an arbitrary direction.

2. Geodesics and covariant derivatives: Geodesic curves and its properties; affine parameter and null geodesics; covariant derivatives; geometrical interpretation of covariant derivatives; manipulation of covariant derivatives and its consequences; Ideas of parallel transport; Lie transport and killing vectors and Fermi-Walker transport; Curvature tensor and its algebraic properties.

3. Einstein's Field equations and Gravitational Dynamics: Properties of the gravitational and matter action and their variations; Gravitational field equations and its general properties and consequences; metric of a stationary source and a light beam in linear zed theory.

4. Gravity in Higher and lower dimension and as an emergent phenomenon: Gravity and black hole solutions in (1 + 2) dimensions; Gravity in two dimensions; Black holes in higher dimensions; Brane world models; Actions with holography; Surface term and the entropy of the horizon.
Notion of an emergent phenomenon; Einstein's equations as a thermodynamic identity; Gravitational entropy and the boundary term in the action and horizon thermodynamics.

Recommended Books:

1. The classical theory of Fields Vol-2, Landau and Lifshitz, Butterworth Heinemann
2. Introduction to cosmology, J V Narlikar, CUP.
3. General relativity and cosmology, J V Narlikar, Mcmmillan.
4. Text Book on Astronomy and Astrophysics with Elements of cosmology, V B Bhatia, Narosa.
5. Cosmology by Steven Weinberg (Oxford University, 2008)

PHYE -544: Black Hole and Cosmology

1. Einstein field equation and Schwarzschild space times: Historical development of black hole ;Einstein field equation and metric ; the time like and null like geodesics in the Schwarzschild and Reissner-Nordstrom space times space times; the radial solution; the bound and unbound orbits of the first and the second kind; their description in the Newman –Penrose formalism.

2. Kerr-Newman black hole and Entropy: Metrics; Horizons and Singularities; their geodesics in the space times; particle orbits in the metrics; conditions for bound stable and periodic orbits in and around the black hole; other types of black holes as the special of Kerr-Newman black hole, Entropy and super-radiance in the geometry.

3. Cosmology Cosmological principle, Robert Walker metric, Red shift and Hubble's law, Magnitude & red shift relation, Hubble's constant and deceleration parameter, Einstein equation and standard models-closed, flat, open universe, Age of the universe, critical density and problems of missing mass or light.

4. Relativistic Cosmology: The Friedman space time; Kinematics of the Friedman model-measures of distance and distribution functions for particles and photons; dynamics of the Friedman model; Brief thermal history of the universe; helium formation, decoupling of matter and radiation, microwave background radiation.

Recommended Books:

1. Introduction to cosmology, J V Narlikar, CUP.
2. General relativity and cosmology, J V Narlikar, Mcmmillan.
3. Cosmology by Steven Weinberg (Oxford University, 2008)
4. General Relativity -An Introduction for Physicists; M. P . Hobson, G . P . E and A . N . Lasenby.
5. Introduction to General Relativity; Lewis Ryder, University of Kent, UK

List of experiments for Practical papers

Electronics Practical.

1. Characteristics of PN junction diode at different temperature
2. Characteristics of Zener diode at different temperature.
3. Characteristics of transistor with CB and CE configuration
4. Characteristics of FET
5. Use of Zener diode as a voltage regulator
6. Study of logic gates
7. Use of oscilloscope.
8. applications of a Solid State diode
9. Study of regulated power supply
10. Transistor Amplifier : gain, phase shift, band width etc.
11. Phase shift oscillator using transistors.
12. To Study a ripple counter.
13. To study encoder and decoder ciecuits.
14. To study half adder and full adder using logic gates.
15. To study half substractor and full substractor using logic gates.
16. Study of OP-AMP as inverting amplifier, non-inverting amplifier, difference amplifier, adder etc.
17. To measure input offset voltage, input offset current, band width and slew rate of an OP-AMP.
18. To study OP-AMP as function generator.
19. Study of monostable multivrator using IC 555.
20. Use of IC 555 (timer) as astable multivibrator.
21. Study of lock – in – Amplifier.
22. Study of modulating and demodulating circuits.
23. To design and implement a 4:1 Multiplexer using Logic gates.
24. To design and implement a 1:4 Demux using Logic gates.
25. To study the operation of the different types of following Flip Flops and verification their truth tables.
26. Use of DA and AD Converters.
27. Use of OPAM as active filters- as 1st order low pass.
28. Use of OPAM as active filters As 1st order high pass.
29. Use of OPAM as active filters As 2nd order low pass.

List of experiments for Practical papers

1. Experiments with Michelson Interferometer: Determination of wavelength, small difference in wavelength, etc.

2. Experiments with Fabry-Perrot Interferometer: Determination of wavelength, small difference in wavelength, etc.

3. Study of Zeeman Effect and determination of e/m of electron.

4. Determination of wavelengths of spectral lines using Constant Deviation Spectrometer.

5. Analysis of elliptically polarized light using Babinet Compensator.

6. Determination of refractive index or thickness of a thin film using Jamin's Inetrferometer.

7. Study of Hall Effect.

8. Study the variation of resistivity of a semiconductor with temperature and hence to determine the Band Gap.using Four Probe set up.

9. Determination of velocity of ultrasonic wave liquid using Ultrasonic Interferometer.

10. Determination of velocity of ultrasonic wave in liquid by study of diffraction of light by the wave.

11. Determination of Stefan's Constant.

12. Study of plateau of a Geiger –Muller counter and carry out statistical analysis of the data

14. Study of Characteristics of LED.

15. Determination of Dielectric Constant.

16. To measure the dielectric constant and loss using microwave bench.

17. To measure the diameter of a thin wire using (a) interference, and (b) diffraction and compare the results.

18. Study using Electron spin resonance spectrometer

19. GM counter based analysis

20. To determine the coercivity, saturation magnetization using hysteresis loop tracer set-up.

21. To measure the impedance of a coaxial cable and a rectangular waveguide using microwave bench.

22. Determine the dielectric constant of the ferroelectric ceramic sample using the given experimental set-up.

23. Determine the electrical charge of an electron by Millikan oil drop experiment

24. To study response of a non-linear crystal as a function of intensity of Nd:YAG laser (532nm)

25. Plot and study of intensity of Luminescence vs. Temperature glow curve using thermo-luminescence set-up.

26. Determination of thermal conductivity of a substance by Lee's method.

27. Study on Zeeman lines using Zeeman effect set-up. (SES instruments Pvt. Ltd).

28. To study Talbot imaging and to obtain Talbot distances with moiré interferometry

List of experiments for Practical papers

1. Preparation of particles of different sizes by chemical method. (e.g.CdS, ZnS, Au,Ag etc.)
2. Study of the particles (e.g. CdS, ZnS, Au,Ag etc.) using UV/VIS spectroscopy for the particle size ,colour, (Luminiscence/Fluroscence)& and gap energy.
3. Preparation of particles of a given material (e.g. CdS, ZnS, Au, Ag , Fe2O3 etc.).
4. Separation of different sizes using differential centrifugation and their characterization for the band gap by UV/VIS spectroscopic techniques.
5. Nanoparticles conjugation studies using FTIR.
6. Synthesis of magnetic oxides by using solid state reaction route (weighing, mixing & reaction).
7. Calcination & sintering of magnetic oxides.
8. Determination of crystal structure of given material by X-ray Diffractometer.
9. Determination of size of given samples from broadening of X-ray.
10. Determination of Band gap of given material by UV-Visible-IR spectroscopy.
11. Determination of interatomic bond length by studying Rotational vibrational IR spectra.
12. Study of Beer and Lamberts law in absorption spectroscopy by using IR spectroscopy.
13. Study of Hystersis of hard and soft ferrites
14. Determination of resonance frequency of piezoelectric element.
15. Study of Thermogravimatric analysis of a given material.
16. Differential Thermo-Analysis of a given material.
17. Study of phase transformation in ferroelectric crystal.
18. Measurement of Magnetoresistance.

PHYO-591 : Physics in Everyday life

1. Physics and Life: Brief history of development of physics &its roles and importance to society and life, Life: Information, Matter, Energy and Temperature; Form and Forces; Fluids in the Body; Animals in Motion; Locomotion; Waves-the Carriers of Information; Sound; Body Electronics and Magnetic Senses; Continuity equation and its applications; Energy and metabolism of human body , Survival in cold and hot climates.

2. Language of Physics and its applications to other fields: Functions; differentiation; integration; Expansion of a function; differential equations and solutions applicable to physics and other fields; vector analysis; Measures of Central Tendency; Probability distribution functions and its applications; Matrix and their properties (only ideas); Beta and Gamma functions and their properties (Definitions and formulae & their applications only); Ideas of polarisation and magnetisation, Essential physical principles related to life process.

3. Non-conventional energy and Atmospheric physics: Wind Energy, Solar Energy, photovoltaic- solar cells & its applications, Ocean energy; Energy from Bio-mass; biochemical, thermo- chemical conversion of biomass; Geothermal Energy; Small hydropower: Assessment of hydropower, working principle of different types of turbines.

Physics of atmosphere, Composition and structure of the earth's atmosphere: physical and dynamic processes on layers, vertical variation of temperature; Residence time, Photochemical pollution, Atmospheric aerosol, Atmospheric pressure, Escape velocity, Ozone, Ozone hole, Ozone in polar region; Greenhouse effect and gases, Global warming, Principal forces acting on air masses (Gravitational force, Pressure gradient, Coriolis inertial force, Frictional force, Cyclones , anticyclones, Global convection, Global wind patterns).

4. Electronics in everyday life: Electrical charge, Ohm's law, electrical energy, power, watt, consumption of electrical power-kWh, resistance, capacitance, inductance, multimeter. AC and DC currents - RMS and peak values, House wiring , overloading, Earthing – construction of proper earthing, short circuiting - Fuses - color code for insulation wires, Inverter, UPS – online UPS and offline UPS, generators and Electrical switches. Transformers. Semiconductor electronic devices – diode, transistor – applications. Electrical appliances**:** Electrical bulbs, Fluorescent lamps, LED lamps, electrical fans, water heater, electrical iron, mixer-grinder, Air conditioner and refrizarators, microwave oven, Voltage Stabilizer, induction cooker. Communication systems: Basic concepts of radio transmitter and receiver - Basic concepts of TV Transmitter and receiver, TV antennas - Dipole antenna - Folded dipole - Yagi antenna, Yagi antenna design, Dish antenna, DTH system, Mobile communication system, MODEM. Other modern way of communications**.**

PHYO-592 : Industrial Nanotechnology

1. Nanodimensional Materials: 0D, 1D, 2D structures – Size Effects – Fraction of Surface Atoms – specific Surface Energy and Surface Stress – Effect on the Lattice Parameter – Phonon Density of States – the General Methods available for the Synthesis of Nanostructures – precipitative – reactive – hydrothermal/ solvothermal methods – suitability of such methods for scaling

2.(a) Nanotechnology in electronic and electrical industry: Advantages of nano electrical and electronic devices –Electronic circuit chips – Lasers - Micro and Nano-Electromechanical systems – Sensors, Actuators, Optical switches, Bio-MEMS –Diodes and Nano-wire Transistors - Data memory – Lighting and Displays – Filters (IR blocking) – Quantum optical devices – Batteries - Fuel cells and Photo-voltaic cells – Electric double layer capacitors – Lead-free solder – Nanoparticle coatings for electrical products

2(b) Nanotechnology in Pharmaceutical and Chemical Industry: Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy - Nanosensors in Diagnosis– Neuro-electronic Interfaces – Protein Engineering – Drug delivery – Therapeutic applications. Nanocatalyts – Smart materials – Heterogenous nanostructures and composites – Nanostructures for Molecular recognition (Quantum dots, Nanorods, Nanotubes) – Molecular Encapsulation and its applications – Nanoporous zeolites – Self-assembled Nanoreactors - Organic electroluminescent displays

3(a) Nanotechnology in agriculture and Food Technology Nanotechnology in Agriculture -Precision farming, Smart delivery system – Insecticides using nanotechnology – Potential of nano-fertilizers - Nanotechnology in Food industry - Packaging, Food processing - Food safety and bio-security – Contaminant detection – Smart packaging

(b) Nanotechnology in textiles and Cosmetics: Nanofibre production - Electrospinning – Controlling morphologies of nanofibers – Tissue engineering application – **Polymer nanofibers** - Nylon-6 nanocomposites from polymerization – Nano-filled polypropylene fibers - **Bionics**– Swim-suits with shark -skin-effect,Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, antibacterial, hydrophilic, self-cleaning, flame retardant finishes) – **Modern textiles** (Lightweight bulletproof vests and shirts, Colour changing property, Waterproof and Germ proof, Cleaner kids clothes, Wired and Ready to Wear) **Cosmetics –** Formulation of Gels, Shampoos, Hair-conditioners (Micellar self-assembly and its manipulation) – Sun-screen dispersions for UV protection using Titanium oxide – Color cosmetics

4. Economic impact of Nanotechnology:

Socio-Economic Impact of Nanoscale Science - Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria - The Emerging Nano Economy: Key Drivers, Challenges, and Opportunities - Transcending Moore's Law with Molecular Electronics and Nanotechnology - Semiconductor Scaling as a Model for Nanotechnology Commercialization - Sustaining the Impact of Nanotechnology on Productivity, Sustainability, and Equity.

References:

1. Mark A. Ratner and Daniel Ratner,*Nanotechnology: A Gentle Introduction to the Next Big Idea,*
2. Bharat Bhushan,*Springer Handbook of Nanotechnology,*
3. Neelina H. Malsch (Ed.),*Biomedical Nanotechnology,*
4. Jennifer Kuzma and Peter VerHage, *Nanotechnology in agriculture and food production, ,*
5. P. J. Brown and K. Stevens, *Nanofibers and Nanotechnology in Textiles,*

Annexure A

Illustration of Computation of SGPA and CGPA and Format for Transcripts

Semester	Course code	Title of the Course Core/ Elective	Credit	Grade letter	Grade point	Credit Points (Credit x Grade)
1st	PHYC 401	Mathematical Physics	4	A	8	32
	PHYC 402	Classical Mechanics	4	B^+	7	28
	PHYC 403	Quantum Mechanics	4	O	10	40
	PHYC 404	Electronics	4	B	6	24
	PHYC 405	General Practical 1	6	B	6	36
SGPA= (32+28+40+24+26)/22=150/22=6.82						
2nd	PHYC -411	Electrodynamics	4	O	10	40
	PHYC -412	Condensed Matter Physics	4	B	6	24
	PHYC -413	Atomic, Molecular and Theory of errors	4	B	6	24
	PHYC -414	Statistical Mechanics and Theory of errors	4	A^+	8	32
	PHYC -415	General Practical 2	6	B^+	7	42
SGPA=(40+24+24+32+42)/22=162/22=7.36						
3rd	PHYC -501	Nuclear and particle Physics	4	O	10	40
	PHYE -5X1	***Departmental Elective Paper-I***	4	B	6	24
	PHYE -5X2	***Departmental Elective Paper-2***	4	A	8	32
	PHYC -505	Project / Practical	6	A^+	9	54
		Open Elective course 1 (CBCT)	4	B^+	7	28
SGPA=(40+24+32+54+28)/22=178/22=8.09						
4th	PHYE- 511	Computational Physics	4	O	10	40
	PHYE- 5X3	***Departmental Elective Paper-3***	4	B^+	7	28
	PHYE- 5X4	***Departmental Elective Paper-4***	4	B	6	24
	PHYC- 510	Computational Physics Laboratory	2	A	8	16
	PHYC- 515	Project	10	B	6	60
SGPA=(40+28+24+16+60)/24=168/24=7.00						

Illustration for **CGPA**

Semester 1	**Semester 2**	**Semester 3**	**Semester 4**
Credit : 22 SGPA:6.82	Credit : 22 SGPA:7.36	Credit : 22 SGPA: 8.09	Credit : 24 SGPA:7.00

$$\text{CGPA}= \frac{(22*6.82)+(22x7.36)+(22x8.09)+(24x7.00)}{22 + 22 + 22 + 24} = 658/90 \approx 7.31$$

Annexure B

RAJIV GANDHI UNIVERSITY

Application form for Registration for Open Elective Courses under CBCS III / IV Semesters

(To be submitted in Duplicate for each Open Elective Course applied for)

1. Name of Student :……………………………………………………………………………….
2. Name of Department /Institute: ………………………………………………………………….
3. Dept. Roll Number ………………………… Semester: ..……………………………...………
4. RGU Registration Number ………………………………………………………………………
5. Department /Institute offering Open Elective Course :…………………………………………….
6. Open Elective Course with Code …………………………………………………………………

Signature of Student

Signature of Student Advisor	Signature of Head of the Department with seal

Accepted / Not Accepted

Signature of Head of Department / Institute (with Seal)
offering the Open Elective Course

Copy 1: to be submitted to Head, Parent Department

Copy 2: to Department where student is applying for Open Elective Course