P.G. Department of Physics
BERHAMPUR UNIVERSITY
Bhanja Bihar
Ganjam, Odisha

Courses of Studies
For
M. Sc Physics Examinations (CBCS-Semester Pattern)
For 2015-2017

1st and 2nd Semester Examinations for the session 2015-16
3rd and 4th Semester Examinations for the session 2016-17

M.Sc. PHYSICS SYLLABI
BERHAMPUR UNIVERSITY,
BHANJA BIHAR, BERHAMPUR-760007
(Choice based credit system-2015-17)

Semester	Course	Course Title	Hrs per week L-----P	Credit L-----P	Exam Hrs L----P	Marks		Total
						Mid Sem	End Sem	
I	C C-PHY-101	Mathematical Methods in Physics	4	4	3	20	80	100
	C C-PHY-102	Classical Mechanics	4	4	3	20	80	100
	C C-PHY-103	Computer programming and numerical analysis	4	4	3	20	80	100
	C C-PHY-104	Quantum Mechanics-I	4	4	3	20	80	100
	C C-PHY-105	Computer programming in Physics, (Laboratory)	10	5	4	20	80	100
			26	**21**				**500**
II	C C-PHY-201	Classical Electrodynamics	4	4	3	20	80	100
	C C-PHY-202	Basic Nuclear physics	4	4	3	20	80	100
	C C-PHY-203	Basic Solid State Physics	4	4	3	20	80	100
	C C-PHY-204	Quantum Mechanics-II	4	4	3	20	80	100
	C C-PHY-205	Optics, (Laboratory)	10	5	4	20	80	100
			26	**21**				**500**
III	CC-PHY-301	Relativistic Quantum Mechanics & Field theory	4	4	3	20	80	100
	CEC-PHY-302	Electronics	4	4	3	20	80	100
	CEC-PHY- 303	General Theory of Relativity	4	4	3	20	80	100
	CEC-PHY- 304	Condensed Matter & Materials Physics-1	4	4	3	20	80	100
	CEC-PHY- 305	Nuclear Science-1(NP)	4	4	3	20	80	100
	CBCT-PHY-306	**Environmental Physics**	4	4	3	20	80	100
	CC-PHY-307	Modern Physics, (laboratory)	10	5	4	20	80	100
			26	**21**				**500**
IV	C C-PHY-401	Statistical Mechanics	4	4	3	20	80	100
	CC-PHY-402	Elementary Particle Physics	4	4	3	20	80	100
	CC PHY-403	Project and seminar	3 3	3 3	-- ---	-- ---	50 + 50	100
	CEC- PHY-404	Condensed Matter & Materials Physics-2	4	4	3	20	80	100
	CEC- PHY-405	Nuclear Science-2(FT &PP)	4	4	3	20	80	100
	CEC-PHY-406	Condensed Matter & Materials Physics, (Laboratory)	10	5	4	20	80	100
	CEC-PHY-407	Nuclear science, (laboratory)	10	5	4	20	80	100
			28	**23**				**500**
Grand Total			**106**	**86**				**2000**

CC---Core Courses, CEC---Core Elective Courses, CBCT---Choice Based Credit Transfer
L----Lectures, P----Practical

Summary

1. Total No. of semesters: 04
2. Total No. of courses offered in all semesters: 20
3. Total No. of credits for all the semesters: 86
4. Total marks: 2000
5. classification of courses
   - i.Core Courses:15
   - ii.Core Elective Courses: 04
   - iii. CBCT courses: 01

6. Courses in tabular form:

Core courses:			
Semester	No. of courses	Marks	**Credit**
1st	05	500	21
2nd	05	500	21
3rd	02	200	09
4th	03	300	14
Total	**15**	**1500**	**65**
Core Elective courses			
3rd	02	200	08
4th	02	200	09
Total	**04**	**400**	**17**
Choice Based Credit transfer			
3rd	01	100	04
Total	**01**	**100**	**04**
Grand Total	**20**	**2000**	**86**

CC---Core Courses
CEC---Core Elective Courses
CBCT---Choice Based Credit Transfer

NB: The students are required to choose one elective paper from CEC-PHY-302 & 303 and another elective paper from CEC-PHY-304 & 305 in 3rd semester. Those who will opt CEC-PHY-304 in 3rd semester, they have to opt CEC-PHY-404 & 406 in 4th semester and who will opt CEC-PHY-305 in 3rd semester, have to opt CEC-PHY-405 & 407 in respective semester.

Instructions to the Paper setter: (Theory)

Full marks: 80, Time: 3 hours

Each paper should contain two sections, A and B. Section A is compulsory which covers the whole syllabus containing 08(eight) objective type questions, carrying 2 marks each. Two long questions should be set from each unit in section B. Students should answer one question from each unit. All questions carry equal marks.

Instructions to students: (Theory)

Full marks: 80, Time: 3 hours

Answer all questions. All questions carry equal marks. Question No.1 consisting of 08(eight) objective type questions carrying 2 marks each, is compulsory. Right hand margin indicates the marks.

(Dr. Chapala Das)
The Chairman, BOS, Physics,
Berhampur University.

Courses in Detail

1st Semester

1

Course No. PHY-101: **Mathematical Methods in Physics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Complex Variables:
   Analytic functions, Contour integrals, Laurent's series, the residue Theorem, evaluation of single and multivalued functions, branch points and branch cuts ,Contour integratio involving branch point.

Unit-2

2. Tensors:
   Introduction, Types of tensor, Invariant tensor, epsilon tensor, Pseudo tensor, The Algebra of tensor, Quotient law , Covariant derivative of tensor, Fundamental Tensor, Cartesian tensor, Christoffel symbol.

Unit-3

3. Group theory:
   Definitions of groups, subgroups and classes, Cayley's theorem, Group representations, characters, irreducible representations of SU(2) and O(3) groups.

Unit-4

4. Special Function:
   Legendere Polynomials, generating functions, Recurrence formulae, orthogonality properties of legendre's polynomial of 1^{st} kind, Bessel generating function, Recurrence formulae, orthogonality properties of Bessel's polynomials, Fourier and Laplace transform.

Text books:

1. Mathematical Methods of Physics by Mathews and Walker (W. A. Benjamin Inc.)
2. Elements of Group Theory by A. W. Joshi (New Age International Publisher)
3. Matrices and Tensors in physics by A. W. Joshi (New Age International Publisher)
4. Mathematical Methods for Physicist by G. Arfken and H. Weber, Academic Press (Elsevier)

Reference Books:

1. Mathematical Physics by B. D. Gupta (Vikas Publishing House)
2. Mathematical Physics by P. K. Chattopadhyaya (New Age International)

2.

Course No. PHY-102 **Classical mechanics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Kinematics of rigid body motion:
   Independent co-ordinates of a rigid body, Orthogonal transformations, Eulerian angles, infinitesimal rotations, rate of change of vector, Coriolis force, angular momentum and kinetic energy of motion about a point, inertial tensor and the moment of inertia, Eigen values of Inertial tensor and the principal axis transformation, methods of solving rigid body problems and Euler's equations of motion, torque free motion of a rigid body. Heavy symmetrical top with one point fixed.

Unit-2

2. Hamiltonian formulation:
   Calculus of Variations and Euler-Lagrange's Equation, Brachistochrone Problem, Hamilton's Principle, Extension of Hamilton's Principle to Nonholonomic Systems, Legendre Transformation and the Hamilton Equations of Motion, Physical Significance of Hamiltonian, Derivation of Hamilton's Equations of Motion from a Variational Principle, Routh's Procedure, Principle of Least Action

Unit-3

3. Canonical Transformations**:**
   Canonical Transformation, Types of Generating Function, conditions for canonical transformation, Integral Invariance of Poincare, Poisson Bracket, Poisson's Theorem, Lagrange Bracket, Poisson and Lagrange Brackets as Canonical Invariant, Infinitesimal Canonical transformation and Conservation Theorems, Liouville's Theorem
   Hamilton Jacobi Theory**:**
   Hamilton-Jacobi Equation for Hamilton's Principal Function, Harmonic Oscillator and Kepler problem by Hamilton-Jacobi Method, Action-Angle Variables for completely Separable System, Kepler Problem in Action-Angle Variables

Unit-4

4. Small Oscillation**:**
   Problem of Small Oscillations, Example of Two coupled Oscillator, General Theory of Small Oscillations, Normal Coordinates and Normal Modes of Vibration,

Text book:

1. Classical Mechanics- by H. Goldstein (Addison-Wesley)

Reference books:

1. Classical Mechanics by S. N. Biswas, Books and allied Publisher Ltd.
2. Classical Mechanics by J.C. Upadhya, Himalaya Publishing House.
3. Classical Mechanics by Landau and Liftshitz (Butter Worth)

3

Course No. PHY-103 Computer Programming and Numerical Analysis Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. FORTRAN 77: Data types, expressions, statements, input and output commands, conditional and interactive constructs, character and data managements, array manipulations, subprogram, subroutine.

Unit-2

2. Fortran programs for problems like numerical integrations by trapezoidal and simpson method, finding the root of an equation by Newton-Raphson method, finding prime numbers, Runga-Kutta method, interpolation sorting and similar other problems .

Unit-3

3. Numerical Analysis-1:
Solution of simultaneous linear equations, Gaussian elimination, Pivoting, Iterative Method, Matrix Inversion, Root of a transcendental equation by Newton- Rapson Method, Least square fitting.

Unit-4

4. Numerical Analysis-2: Eigen values and eigenvectors of matrices, power and Jacobi method, Finite Differences, Interpolation with equally Spaced and unevenly spaced points (Newton's and Lagrange's method), Forward and Backward Interpolation, Extrapolation, Numerical Integration by trapezoid and Simpson's rule, Solution of first and second order differential equation using Runge- Kutta method.

Text books:

1. Fundamentals of Computers by V. Rajaraman, Prentice Hall of India Ltd Publishers
2. Numerical Mathematical Analyses by J. B. Scarborough, Oxford and IBH Publishing Company.

Reference Books:

1. Numerical methods for engineering and scientific computation by M K Jain (Wiley Eastern)
2. Computer programming in Fortran-77 by V. Rajaraman, Prentice Hall of India Ltd Publishers.

4

Course No. PHY-104 **Quantum Mechanics-I** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. **General principles of Quantum Mechanics:**

Linear vector space, Ket and Bra vectors, Scalar product of vectors and their properties, Dirac delta function, linear operators, Adjoint operators, Unitary Operators, Expectation values of dynamical variables and physical interpretation of Hermitian operators, Eigen values and eigen vectors, orthonormality of eigen vectors, probability interpretation, Degeneracy, Schmidt method of orthogonalisation,

Expansion theorem, Completeness and closure properties of the basis set, Coordinate and momentum representations, compatible an Incompatible observables, Commutator algebra, uncertainty relation as a consequence of non- commutability, minimum uncertainty wave packet, Representations of Ket and Bra vectors and operators in matrix form, Unitary transformation of basis vectors and operators.

Unit-2

2**. Quantum Dynamics**:

Time evolution of quantum states, Time evolution operator and its properties, Schrödinger, Heisenberg and Interaction picture, Equations of motion, Operator method solution of Harmonic oscillator problem, Matrix representation and time evolution of creation and annihilation operators

Unit-3

3. Rotation and Orbital Angular Momentum:

Orbital angular momentum operators as generators of rotation, L_x, L_y, L_z and L^2 and their Commutation relations, Raising and Lowering operators (L_+ and L_-), L_x, L_y, L_z and L^2 in spherical Polar coordinates, Eigen values and Eigen functions of L_z and L^2 (operator method), Matrix representation of L_x, L_y, L_z and L^2

Unit-4

4. Spin angular momentum:

Spin ½ particles, Pauli spin matrices and their properties, Eigen values and Eigen functions, Spin and rotations.

Total angular momentum: Total angular momentum J, Eigen value problem of J_z and J^2, Angular momentum matrices, Addition of angular momentum and C. G. coefficients for the states with (i) $j_1 = ½$ and $j_2 = ½$ (ii) $j_1 = 1$ and $j_2 = ½$.

Text book:

1. Quantum Mechanics concepts and Applications by Nouredine Zettili, John Wiley and sons, Publications

Reference books:

1. Quantum Mechanics by L. I. Schiff, International Student edition.
2. Quantum Mechanics by D. Griffith, Pearson Publishers.
3. Quantum Mechanics by S. Gasiorowicz, John Wiley edition.
4. Quantum Mechanics by Eugene Merzbacher, Wiley International Edition

5

Course No. PHY-105 **Computer Programming in Physics** Total Marks: 100

(Laboratory work)

End Sem: Practical– 80 marks Mid-Sem: Practical- 20 marks

1. Numerical integration by trapezoidal method
2. Numerical integration by Simpson method
3. Solution of first and second order differential equation by Runga Kutta Method
4. Matrix addition, subtraction, multiplication and manipulation
5. Matrix inversion
6. Finding the roots of an equation by Newton-Rapson method
7. Least square fitting of linear parameters
8. Determination of prime numbers.
9. To arrange a set of numbers in increasing or decreasing order
10. Sum of A.P and G.P series, Sine and Cosine series
11. Factorial of a number
12. Evaluation of log and exponentials by summing of series
13. Any other suitable experiments.

Any other experiments that may be set up from time to time

2nd Semester

6

Course No. PHY-201 **Classical Electrodynamics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Wave equations for potentials, solution by Fourier analysis, Radiation field, Radiation energy, Hertz potential, Computation of radiation fields by Hertz method, electric dipole radiation, multi pole radiation

Unit-2

2. Field of a uniformly moving electron, Lienard-Wiechart potential, Fields of a charge in uniform motion, Direct solution of the wave equation, Convection potential, Virtual photon concept, Wave guides, Propagation of electromagnetic waves in rectangular wave guides

Unit-3

3. Radiation from an accelerated charge, Fields of an accelerated charge radiation at low velocity, Case of velocity parallel to acceleration, radiation from circular orbits, Radiation with no restrictions on the acceleration or velocity, Classical cross section for bremsstrahlung in a Coulomb field, Cherenkov radiation.

Unit-4

4. Radiation, scattering and dispersion, radiative damping of a charged harmonic oscillator, forced vibrations, scattering by an individual free electron, scattering by a bound electron, absorption of radiation by an oscillator, equilibrium between an oscillator and a radiation field, effect of a volume distribution of scatters, scattering from a volume distribution, Rayleigh scattering, the dispersion relation.

Text book:

1. Classical Electricity and Magnetism by W. K. H. Panofsky and M. Phillips (Addition-Wesley)

Reference books:

1. Classical Electrodynamics- J.D. Jackson, John Wiley and Sons.
2. Introduction to electrodynamics- D.J. Griffiths, Pearsons Publishers.

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Course No. PHY-202 **Basic Nuclear Physics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. (A) Brief Discussion of Nuclear Properties: Nuclear Radius, Nuclear Mass and Binding Energy, Angular Momentum, Parity and Symmetry, Magnetic Dipole Moment and Electric Quadruple Moment.
(B) Two Nucleons Bound State Problem: Central and non central force, the deuteron, tensor forces, magnetic moment and quadruple moment of deuteron.

Unit-2

2. Nucleon Scattering Problem: n-p scattering at low energy, scattering cross section and scattering length, effective range theory.
Nuclear force: Meson theory of nuclear force, Yukawa interaction

Unit-3

3. Nuclear Reactions and nuclear energy: Nuclear reaction and resonances, Breit-Wigner formula for s-waves, compound nucleus. Liquid drop model, Bohr-Wheeler theory of fission, nuclear fusion

Unit-4

4. Nuclear Models: Single particle model of nucleus, magic numbers, spin-orbit coupling, angular moment and parities of nuclear ground states, magnetic moments and Schmidt lines, Collective model of Bohr and Mottelson.

Text Book:

1. Nuclear Physics by R.R. Roy and B.P. Nigam (John Wiley)

Reference Books:

1. Physics of the nucleus by M.A. Preston (Addison Wesley)
2. Nuclear Physics by S.S.M. Wong (Prentice Hall)
3. Introduction to Nuclear Physics by H. A. Enge (Addison Wesley)

8

Course No. PHY-203 **Basic Solid state physics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Crystal Binding:
   Crystals of inert gases, Ionic crystals, covalent crystals, Metals Lattice Dynamics-Vibrations of a mono atomic linear chain, Vibration of a diatomic linear chain, Dispersion relations, Acoustic and Optic modes, Long-wavelength limits

Unit-2

2. Specific heat of insulators:
   Phonon heat Capacity, Debye model for density of states, Debye T^3 law, Einstein's theory of the specific heat Free Electron Fermi gas-Energy levels in one-dimension, Effect of temperature on the Fermi-Dirac distribution function, Free electron gas in three dimension, Heat Capacity of the electron gas, Electrical conductivity and Ohm's law, Motion in magnetic fields, Static magneto-conductivity tensor, Hall effect, Thermal conductivity of metals, Wiedemann- Franz law

Unit-3

3. Energy bands:
   Nearly free electron model, origin of the energy gap, Bloch functions, Kronig-Penney model, Wave equation of electron in a periodic potential, restatement of Bloch theorem, solution of the central equation, approximate solution near a zone boundary, number of orbitals in a band, metals and insulators

Unit-4

4. Semiconductor crystals:
   Band gap, Holes, effective mass, intrinsic carrier concentration, intrinsic mobility, impurity conductivity, donor states, acceptor states, thermal ionization of donors and acceptors. Defects -Classification of defects, Point defects- Schottky and Frenkel defects, Diffusion and ionic conductivity. Dielectrics-local electric field at an atom, Lorentz field, field of dipoles inside cavity, dielectric constant and polarisability-Claussius-Mossotti relation, Mechanisms of electronic ionic and orientational polarisability.

Text book:

1. Introduction to Solid State Physics by C. Kittel, 7^{th} edition, (John-Wiley, 1996)

Reference books:

1. Introduction to the theory of Solid State Physics by J. D. Patterson (Addison- Wesley,1971)
2. Solid State Physics by N. W. Ashcroft and N. D. Mermin , (Harcourt Asia PTE Ltd.)
3. Physics of Condensed Matter by Prasanta K.Misra (Academic Press, 2010)

9

Course No. PHY-204 **Quantum Mechanics-II** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Motion in a spherically symmetric field: Hydrogen atom, Reduction to equivalent one body problem, radial equation, Energy eigen values and eigen functions, Degeneracy, Radial probability distribution, free-particle problem, Expression of plane waves in terms of spherical waves

Unit-2

2. Approximate methods: stationary perturbation theory, Rayleigh Schrodinger method for non-degenerate case, first and second order perturbation, anharmonic oscillator, general theory for the degenerate case, removal of degeneracy, linear Stark effect, normal Zeeman effect.

Unit-3

3. Time-dependent perturbation theory: Transition probability, constant and harmonic perturbation, Fermi Golden rule.
Variational method: Ground state of He atom.
W. K. B. method: connection formulas, Bohr-Sommerfeld quantization rule, Harmonic oscillator and cold emission.

Unit-4

4. Scattering amplitude and scattering cross section, Born approximation, application to Coulomb and screened Coulomb potentials,
Partial wave analysis for scattering, optical theorem, scattering from a hard sphere, resonant scattering from a square well potential,
Identical particles, Symmetric and antisymmetric wave function, Coulomb and exchange interactions

Text book:

1. Quantum Mechanics concepts and Applications by Nouredine Zettili, John Wiley and sons, Publications

Reference books:

1. Quantum Mechanics by L. I. Schiff, International Student edition
2. Quantum Mechanics by D. Griffith, Pearson Publishers
3. Quantum Mechanics by S. Gasiorowicz, John Wiley edition
4. Quantum Mechanics by Eugene Merzbacher, Wiley International Edition

10

Course No. PHY-205 **Optics (Laboratory work)** Total Marks: 100

End Sem: Practical– 80 marks Mid-Sem: Practical- 20 marks

1. Experiments with optical bench :
   Biprism
   Straight edge and narrow wire
2. Experiments with spectrometer:
   Single and Double split
3. Experiments with Michelson interferometer :
   Determination of A and α
   Thickness of mica sheet
4. Fabry Perot interferometer
5. Polarization Experiments
   Babinet compensator
   Edsar-Butlerbands
   Quarter wave plate
   Mallus Law
   Study of elliptical polarized light
6. Constant Deviation Spectrography
   Calibration
   Zeeman effect
7. Babinet Quartz Spectrography
8. Any other suitable experiments

Any other experiments that may be set up from time to time

3rd Semester

11

Course No. PHY-**301**: **Relativistic Quantum Mechanics and Field theory** Total Marks: 100

End-Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Relativistic quantum mechanics:

Unit-1

1. Brief introduction to Relativistic quantum mechanics, Notations, Klein-Gordon equation and its drawbacks, Charge and current densities, Positive and negative energy states, Dirac's Hole theory, Free particle Dirac equation, Properties of the Dirac matrices, Continuity Equation, Spin of the electron,

Unit-2

2. Plain wave solutions of Dirac Equation, Normalization of the wave functions, Dirac equation in an electromagnetic field, its non-relativistic correspondence, magnetic moment, Dirac equation for a central potential, spin-orbit coupling, Covariant form of the Dirac equation, Proof of its Lorentz covariance, Properties of the gamma-matrices.

Field Theory:

Unit-3

3. Concept of fields, , Classical field equation, Noether's theorem and conservation laws, Gauge invariance and charge conservation , Creation, Annihilation and number operators.

Unit-4

4. Field Quantization: (a) neutral scalar meson field (b) charged scalar meson field (c) Dirac field,

Text Book:

1. Relativistic quantum field theory by J.D. Bjorken and S.D. Drell , Mc Graw-Hill Book Company

Reference Books:

1. Lectures on Quantum Field Theory, Ashok Das, (World Scientific Publishing Co. Pvt. Ltd).
2. Introduction to quantum field theory by P. Roman
3. Quantum Mechanics and Field Theory by B.K. Agarwal, Asia Publishing House.

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Course No. PHY-302 **Electronics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. AMPLIFIERS:

Transisters, Two-port network analysis, transconductance model, Frequency response of linear amplifiers, RC and Transformer coupled amplifiers, gain bandwidth product, feedback amplifiers, effects of negative feedback, FET, MOSFET, Boot-strapping the FET

Unit-2

2. OSCILLATOR CIRCITS:

Feedback criteria for oscillation, Nyquist criterion, Phase shift, Wien-Bridge oscillator, Crystal controlled oscillator.

Unit-3

3. OPERATIONALAMPLIFIERS:

The differential amplifier, DC and AC signal analysis, integral amplifier, rejection of common mode signals, CMMR, The operational amplifier, input and output impedances, Application of operational Amplifiers, unit gain buffer, summing, integrating amplifier, Comparator, Operational amplifier as a differentiator

Unit-4

4. DIGITAL CIRCUITS:

Logic fundamentals, Booleantheorem, logicgates: AND, OR, NOT, NOR, NAND XOR, and EXNOR. - RTL, DTL and TTL logic, Flip-flop, RS-and JK-Flip flop, thevenins theorem, A/D and D/A Convertors.

Text Book:

1. Electronic fundamental and application by J.D. Ryder, PHI, Learning Pvt Ltd.

References:

1. Foundation of electronics – Chattopadhyay, Rakshit, Saha and Purkait , New age International publisher
2. Electronics principles-Albert Malvino, Tata Mc Graw-Hill Edition
3. Modern Digital Electronics-R.P Jain, Tata Mc Graw-Hill Edition

13

Course No. PHY-303 **General Theory of Relativity** Total Marks: 100

End-Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Unit-I

1. Special theory of relativity: Lorentz transformations; 4-vectors, Tensors and it's transformation properties, Contraction, Symmetric and antisymmetric tensors; 4-dimensional velocity and acceleration; four-momentum and four-force; Covariant equations of motion; Relativistic kinematics (decay and elastic scattering); Lagrangian and Hamiltonian of a relativistic particle.

Unit-2

2. The Equivalence Principle, The Weak and Strong Principle of Equivalence, The Equation of Motion in presence of Gravitational Forces, The affine connection, The Metric Tensor $g_{\mu\nu}$,Relation between Metric Tensor and Affine Connection, The transformation of Affine Connection, Covariant derivatives.

Unit-3

3. The Newtonian Limit: Relation between g_{00} and the Newtonian potential, Time Dilation in a Gravitational Field, Red shift of spectral lines, The Solar Red Shift.

Unit-4

4. Definition of Curvature tensor, Algebraic Properties of the curvature Tensor, Ricci Tensor and Curvature Scalar, Bianchi identities.
Einstein's field Equations, Energy, Momentum and Angular momentum of gravitation.

Text Books:

1. Special theory of relativity, Robert Resnick, Oxford University
2. Gravitation and Cosmology by Steven Weinberg, Jon Wiley and Sons

Reference Books:

1. Introducing Einstein's Relativity by Ray D Inverno, Clarendon Press
2. An Introduction to General Relativity and Cosmology by Tail. Chow, Springer
3. Principles of Cosmology and Gravitation by M. Berry, Cambridge University
4. Special theory of relativity, Robert Katz D. Van, Nostrond Company, INC

14

Course No. PHY-304 Condensed Matter and Materials Physics-1 Total Marks: 100

(Elective, CMMP-1)

End Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Quantisation of lattice vibration:
   Phonons, normal coordinate transformation, creation and annihilation operators methods of band calculation-tight binding method, OPW and pseudo-potential methods. Fermi surface-de Haas-van Alphen effect Transport theory-Boltzman equation, relaxation time approximation, electrical conductivity and thermal conductivity.

Unit-2

2. Electron-electron interaction:
   Hartree approximation, Hartree-Fock approximation, Hartree-Fock theory for jellium Density functional theory-general formulation, Local Density approximation

Unit-3

3. Superconductivity:
   Occurrence of superconductivity, Meissner effects, Type- I and II superconductors, energy gap, Isotope effect, Theoretical survey: Thermodynamics of superconducting transition, London Equations, coherence length, Qualitative ideas about the BCS theory, Single particle tunneling, Josephson Effect

Unit-4

4. Advanced Superconductivity:
   Electron-phonon interaction, Microscopic theory of superconductivity, Quasi lectrons, Cooper pairs, BCS theory, Ground State of superconducting electron gas, elementary ideas of high T_c superconductors.

Text book:

1. Physics of Condensed Matter By Prasanta K.Misra (Academic Press, 2010)
2. Quantum Theory of Solid State by J.Callaway, Academic Press

Reference books:

1. Principles of the theory of solids, J.M.Ziman, Cambridge, University press
2. Solid State Physics By C. Kittel, John Wiley and sons, Ins Singapore.

OR

15

Course No. PHY-305 **Nuclear Science-1** Total Marks: 100

(Elective: Nuclear Physics)

End Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Rotational invariance in three dimensions, eigen values and eigen functions of angular momentum operators, explicit representation of the rotation matrices, addition of angular momenta, Clebsch-Gordon coefficients, irreducible spherical tensor, matrix element of tensor operators, Wigner-Eckart theorem

Unit-2

2. Optical model, deuteron stripping and pick-up reaction, Elementary ideas of Brueckner theory

Unit-3

3. Collective Vibrational modes of a spherical nucleus, collective oscillations, quadruple deformation, Expression for moment of inertia.

Unit-4

4. Rotational spectra of even-even nuclei, coupling of a particle and collective motion, electric quadruple moments, magnetic dipole moments

Text Book:

1. Nuclear Physics by R.R. Roy and B.P. Nigam, John Wiley

Reference Books:

1. Physics of the nucleus by M.A. Preston, Addison Wesley.
2. Nuclear Physics by S.S.M. Wong, Prentice Hall.
3. Introduction to Nuclear Physics by H. A. Enge, Addison Wesley
4. Structure of the Nucleus by M. A. Preston and R K Bhaduri, Addison Wesley

16

Course No. PHY-306 **Environmental physics** Total Marks: 100

(CBCT)

End Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

UNIT-1

1. The human environment:

Laws of thermodynamics: First law, Second law and third law of thermodynamics, Laws of thermodynamics and the human body, Energy and metabolism: First law of thermodynamics and the human body, Second law of thermodynamics and the human body, Energy transfers: Conduction, Convection, Radiation, Evaporation, survival in cold climates, Survival in hot climates

UNIT-2

2. Atmosphere and radiation:

Structure and composition of the atmosphere: Residence time Photo chemical pollution, Atmospheric aerosol, Atmospheric pressure, Escape velocity,
Ozone : Ozone hole ,Ozone in polar region, Terrestrial radiation, Earth as a black body: Greenhouse effect, Greenhouse gases, Global warming.

UNIT-3

3. Wind:

Measuring the wind, Physics of wind creation: Principal forces acting on air masses Gravitational force, Pressure gradient, Coriolis inertial Force, Frictional force, Cyclones and anticyclones : Global convection, Global wind patterns.

UNIT-4

4. Energy for living:

Fossil fuels, Nuclear power, Renewable resources: Hydroelectric power, Tidal power, Wind power, Wave power, Biomass, Solar power, Solar collector, Solar photovoltaic.

Text Book:

1. Enviormental Physics by M. Dželalija,
University of Molise, University of Split, Valahia University of Targoviste

17

Course No. PHY-307 **Modern Physics (Laboratory Work)** Total Marks: 100

End-Sem: Practical– 80 marks Mid-Sem: Practical- 20 marks

1. Determination of e/m by
   I) Braun tube method
   II) Magnetron Valve method
3. Determination of Planck's constant (h) by
   Photo-electric effect methods
4. Measurement of velocity of light by Lecher wire
5. GM counter experiments:
   I) Characteristics of the Geiger tube
   II) Inverse Square Law.
   III) Absorption coefficient of the Aluminium foil.
6. Characteristics of Diode and Zener diode.
7. Study of logic gates AND, OR, NOT, NAND, NOR, EXOR .
8. Making AND, OR, NOT Gates using NAND Gates.
9. Verification of Boolean Algebra.
10. Verification of Dual nature.
11. Characteristics of FET (Field Effect Transistor).

Any other experiments that may be set up from time to time

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4th Semester

Course No. PHY-401 **Statistical Mechanics** Total Marks: 100

End Sem: Theory – 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Classical Statistical Mechanics:
Postulates of classical statistical mechanics, Liouville's theorem micro-canonical ensemble, derivation of thermodynamics, Equipartition theorem, Classical ideal gas, Gibb's paradox, canonical ensemble, energy fluctuation in canonical ensemble, Grand canonical ensemble, density fluctuation in grand canonical ensemble, equivalence of canonical and grand canonical ensemble.

Unit-2

2. Quantum Statistical Mechanics:
Postulates of quantum statistical mechanics, density matrix, Liouville's theorem, ensembles in quantum statistical mechanics, third law of thermodynamics, Ideal gases in micro-canonical and grand canonical ensembles. Particle in a box, Maxwell-Boltzman, Boltzman-Einstein and Fermi-Dirac distributions.

Unit-3

3. Fermi gas:
Equation of state of ideal Fermi gas, Theory of white dwarf stars, Pauli paramagnetism

Unit-4

4. Bose gas:
Ideal Bose gas, Photon, Planck's law, Bose-Einstein condensation.
Phase transition:
1st order and 2nd order phase transitions, Ising model (one dimensional)

Text Book:
1. Statistical Mechanics – K. Huang, Wiley India
Reference books:
1. Statistical Mechanics – Landau and Lifshitz, ButterWorth
2. Statistical Mechanics- R. K. Patheria, P.D. Beale 3rd Ed, ButterWorth
3. Fundamental statistical and thermal Physics- F. Reif, Tata Mc Graw-Hill Edition
4. Elementary statistical mechanics, C. Kittel, Dover Publications.

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Course No. PHY-402 **Elementary particle physics** Total Marks: 100

End Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Historical introduction to the Elementary Particles, Classification of elementary particles and their interactions: Photons, Leptons, Quarks, Mesons, Baryons. Lepton number, Baryon number, color quantum number, Strangeness quantum number

Unit-2

2. Charge independence of nuclear forces, Isospin, Test for isospin conservation , Associated Production of Strange particles, Gell-Mann Nishijima scheme, conservation laws in relation to particle reactions and decays.

Unit-3

3. Discrete Symmetry:
Parity (P) : Parity in quantum mechanics and Field theories, Test of Parity. Time reversal (T) : Time reversal in quantum mechanics and Field theories , Test of Time reversal Charge conjugation (C) : Additive quantum number, Charge conjugation in field theories, Test of Charge conjugation .
CPT theorem and its consequences.

Unit-4

4. Unitary Symmetry: SU(2), SU(3), Concept of I-Spin, U-Spin, V-Spin, SU(3) Quark model, The Eight-fold way, Mesons and Baryons in the Octet representation. The Baryon Decouplets, Evidence of color, Baryon-meson coupling.

Text Book:
1. Introduction to Elementary Particles by D.Griffiths. Prentice Hall
Reference books:
2. Elementary particle physics by Gasiorwicz
3. Modern Elementary Particle Physics by G.Kane, Addison-Wesley Publishing Company
4. Quarks and Leptons by F.Halzen and A.D.Martin, World Scientific Singapore

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Course No. PHY-403 **Project and Seminar** Total Marks: 100

Project: 50 Marks Seminar: 50 Marks

Students will be assigned topics for project and seminar under the supervision of teachers of the department.

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Course No. PHY-404 Condensed Matter and Materials Physics-2 Total Marks: 100

(Elective-CMMP-2)

End-Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Unit-1

1. Optical properties:

Absorption, intraband and inter band transition, Absorption spectra of materials, Luminiscence, Fluorescence, phosphorescence, Colour centres, Optical fibres (elementary ideas). Basic principles of Electron Spin Resonance, NMR and Lasers-principles, Induced absorption, Spontaneous Emission and stimulated Emission, Einstein A and B Coefficients, the Ruby laser, Helium-Neon Laser and Semiconducting Laser

Unit-2

2. Magnetism:

Langevin Diamagnetism and Van Vleck Paramagnetism, Paramagnet: Derivations of Curie law, Pauli paramagnetic susceptibility, Ferromagnetism: Curie point and the exchange interaction, Curie-Weiss law, Ferrimagnetic order, Curie temperature and susceptibility of ferrimagnets, Antiferromagnetic order, susceptibility below the Neel temperature

Unit-3

3. Advanced magnetism and materials:

Landau's theory of diamagnetic susceptibility, Spin waves and magnon specific heat, NMR Knight shift, Diluted magnetic and ferromagnetic semiconductors Spintronics-giant magneto Resistance (GMR), Mott's theory of spin-dependent scattering of electrons

Unit-4

4. Novel Materials:

Metallic nano clusters: Nano science and nano clusters, liquid drop model, size and surface volume ratio. Graphene: Graphene lattice, tight binding approximation, Dirac Fermions Elementary ideas about polymers, Charecterisation of materials: Experimental diffraction methods, Bragg law, Laue conditions, Geometrical Structure factor and Atomic form factor, Non-crystalline materials-diffraction pattern, amorphous semiconductors, low energy excitations, heat capacity, thermal conductivity. Basic principles of Raman Effect in crystals and Mossbauer techniques

Text Book:

1. Physics of Condensed Matter-By Prasanta K.Misra (Academic Press, 2010)

References

2. C.Kittel-Introduction to Solid State Physics by C. Kittel, John Wiley and Sons, Inc. Singapore.
3. Solid state Physics by Aschcroft and Mermin, Harcourt Asia PTE. Ltd. (A Harcourt publishers International company)

OR
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Course No. PHY-405 **Nuclear Science-2** Total Marks: 100

(Field Theory and Particle Physics)

End Sem: Theory: 80 marks Mid-Sem: Theory- 20 marks

Field Theory:

Unit-1

1. Unequal space time commutation and anti-commutation rules for field operators. Propagator functions and their integral representations, Vacuum expectation values, Feynmann propagators, Feynman diagram rules in co-ordinate and momentum space, Concept of T-Product and Normal Product, Wick's Theorem, Properties of scattering matrix, Brief idea of electron-photon scattering.

Particle Physics:

Unit-2

2. Brief review of elementary particles and their interactions, SU(3) Quark Model, The Baryon and Meson State, Baryon-Meson coupling: The F and D terms, Gell-Mann-OKubo mass formula. The Magnetic Moment, The Heavy Quarks: Charm and Beyond, SU(6) and The Quark Model, SU(6) wave-function for Mesons and Baryons, Magnetic moments of Baryons.

Unit-3

3. Weak interaction : V-A form of weak interaction, Helicity of neutrino, Muon and Pion decay calculation, elementary notion of leptonic decays of strange particles, the cabibbo angle, intermediate vector bosons, Elements of Neutral K-meson theory : Decay of Neutral K-mesons, regeneration of K-mesons, CP violation in neutral K decay

Unit-4

4. Spontaneous symmetry breaking, Higgs Mechanism, Brief idea of Salam-Weinberg Theory of Standard Model. Neutrino Physics: Neutrino Mass and Experimental limits, Neutrinoless Double- Beta decay, Neutrino oscillation, Solar neutrinos, Magnetic moment of neutrino.

Text Book:

1. Introduction to Elementary Particles by D.Griffiths, Prentice Hall
2. Relativistic quantum field theory by J.D. Bjorken and S.D. Drell, Mc Graw-Hill Book Company

Reference Books:

1. Elementary particle physics by Gasiorwicz, Addison-Wesley publishing Company
2. Elementary Particle Physics by G.Kallen, Addison-Wesley publishing Company
3. Quarks and Leptons by F.Halzen and A.D.Martin, World Scientific, Singapore
4. A modern introduction to particle physics by Fayyazuddin and Riazuddin, World Scientific, Singapore
5. Introduction to High Energy Physics by D. H. Perkins .

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Course No. PHY-406 Condensed Matter and Materials Physics **Total** Marks: 100

(Elective-CMMP) (Laboratory work)

End Sem: Practical– 80 marks Mid-Sem: Practical- 20 marks

1. Determination of energy gap of a given semiconductor by four probe method
2. Determination of Hall constant of a sample and its identification
3. Determination of energy gap by p-n junction method
4. Study of dispersion relation of an electric analog of mono atomic linear chain
5. Study of dispersion relation of an electric analog of diatomic linear chain
6. Determination of specific heat of a given sample using a thermocouple
7. Determination of dielectric constant of a given sample by lecher wire method
8. Determination of B-H curve of a given ferromagnet

Any other experiments that may be set up from time to time

OR

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Course No. PHY-407 Nuclear Science (Laboratory work) Total Marks: 100

(Elective, Nuclear & Particle Physics)

End Sem: Practical– 80 marks Mid-Sem: Practical- 20 marks

1. Determination of half-life of unknown source
2. Determination of linear absorption coefficient
3. Verification of inverse square law
4. Experiment with gamma ray spectrometer
   i.Energy analysis of unknown gamma source
   ii.Spectrum analysis of 60 Co and 137 Co
   iii.Activity of Gamma emitter
5. High resolution of gamma ray spectroscopy
   Energy resolution with Ge (Li) detector
   Photo pick efficiency for Ge(Li) detector

Any other experiments that may be set up from time to time

(Dr. Chapala Das)
The Chairman, BOS, Physics
