COURSES OF STUDIES

FOR

MASTER DEGREE COURSE

IN

PHYSICS

Part – I Examination – 2016-17

Part – II Examination – 2017-18

GOVERNMENT AUTONOMOUS COLLEGE,
PHULBANI, KANDHAMAL

There shall be 10 papers each carrying 100 marks as per the distribution given below. Theory and practical examination in each paper shall be of 4 hours and 6 hours duration respectively. One can opt to perform practical is special paper or to submit a dissertation in special paper in Part-II.

PART - I

	Subject	Full Marks
Paper-I	Quantum Mechanics	100
Paper-II	A) Mathematical Physics	50
	B) Classical Mechanics	50
Paper-III	A) Electro dynamics	50
	B) Solid State Physics	50
Paper-IV	Experiment (Practical) (Electricity, Magnetism & Modern Physics)	100
Paper-V	Experiment (Practical) (Computational Physics)	100

PART - II

Paper-VI	A) Advanced Quantum Mechanics and field Theory	50
	B) Basic Nuclear and Particle Physics	50
Paper-VII	A) Electronics	50
	B) Statistical Mechanics	50
Paper-VIII	Special paper- Nuclear Physics	100
Paper-IX	Expt. (Practical) (Electronics)	100
Paper-X	Experiment (Special paper Practical) Or Dissertation in Nuclear Physics	100

PART - I

PAPER – I : QUANTUM MECHANICS

Full Marks-100

Unit-I **17 Marks**

A) Linear Vector space, ket and Bra vectors, Scalar product of vectors and their properties, Linear operators, Adjoint operators, Unitary operators, Expectation values of dynamical variables and physical interpretation, Hermitian operators, eigen values and eigen vectors, Orthonormality of eigen vectors, Probability interpretation, Degeneracy, Schmidt method of Orthogonalisation, Expansion theorem, completeness and closure property of basis set, coordinate, momentum and energy representations.

Representation of ket and Bra vectors and operators in the matrix form, unitary transformation of basis vectors and operators.

B) **Quantum Dynamics:**

Time evolution of quantum states, Time evolution operator and its properties, Schrodinger picture, Heisenberg picture and Interaction picture, equation of motion, Operator method solution of Harmonic Oscillator, Matrix representation and time evolution of creation and annihilation operators Density matrix.

Unit-II **17 Marks**

Rotation and Orbital Angular momentum

Rotation matrix, Angular momentum operators as the generators of rotation, L_x, L_y, L_z and L^2 and their commutator 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 (OP method), spherical harmonics, Matrix representation of L_+, $L\_$, L_z and L^2

Spin Angular Momentum:

Spin ½ particles, Pauli-spin matrices and their properties, eigen values and eigen functions, spinor transformation under rotation.

Addition of Angular Momentum:

Total angular momentum J, eigen value problem of J_z and J^2, Angular momentum matrices, Addition of angular momenta and C.G. Coefficients and their values for J_1= ½ J_2= ½ and J_1=1 and J_2= ½ .

Unit-III **16 Marks**

Motion in a Spherically Symmetric field:

Hydrogen atom, Reduction to equivalent one body problem, Radial equation, Energy eigen values and eigen functions, Degeneracy, redial probability distribution, The free particle problem, Incoming and outgoing spherical waves, Expansion of plane waves in terms of spherical waves, Bound states of 3-D square well, particle in a sphere.

Unit-IV **17 Marks**

Approximation Methods:

Stationary perturbation theory, Rayleigh- Schrodinger method for non-degenerate care, First and Second order perturbation, An harmonic oscillator, General theory for the degenerate case, Removal of degeneracy, Linear and quadratic stark effect, Normal and anomalous Zeeman effect, Effect of electric field on the n-2 state of Hydrogen, spin orbit interaction.

Variational Method

Ground state of He-atom.

Unit-V **16 Marks**

WKB Method

Connection formulas, Bohr- Sommerfeld quantization rule, Harmonic Oscillator and cold emission, Hydrogen molecule-ion, Hydrogen molecule

Time dependent perturbation theory:

Transition probability, constant and harmonic perturbation, Fermi's golden rule, Electric dipole radiation and selection rules, spontaneous emission, Einstein's A,B Coefficients, Basis principles of LASER and MASER.

Unit-VI **17 Marks**

Scattering:

Scattering amplitude and cross section, Born approximation, Application to coulomb and screened coulomb potential, validity of Born approximation.

Partial wave analysis for elastic and inelastic scattering, effective range and scattering length, optical theorem, Black disc scattering from a hard sphere, Resonance scattering from a square well potential, Breit – Wigner formula.

Books Recommended :

1. Quantum Mechanics ---- L.I. Schiff
2. Quantum Mechanics ---- S. Gashorowicz
3. Quantum Mechanics ---- Ashok Das
4. Quantum Mechanics ---- Dickie & Whotekey
5. Quantum Mechanics ----Merzasecker
6. Advanced Quantum Mechanics ----Rajput

PAPER – II : MATHEMATICAL PHYSICS & CLASSICAL MECHANICS

Full Marks-100

(A) Mathematical Physics

50 Marks

Unit-I **16 Marks**

Complex Variables:

Cauchy's Residue Theorem, evaluation of definite integrals, Multi valued functions, Branch point and Branch cut, simple conformal mapping and applications, Schwartz-Christoffel transformations.

Unit-II **17 Marks**

Special Functions:

Solution of spherical Bessel function and Laguerre, Hyper geometric and confluent Hyper geometric equation by generating functions method and their properties.

Solution of inhomogeneous partial differential equation by Green's function method.

Unit- III **17 Marks**

Tenors and Group Theory:

Tenors: Cartesian tenors in three space, metric tensor, covariant derivative, Christoffel symbols, Frenet formula.

Groups: Definition, subgroup and classes, cayle's theorem group representation, characters, infinite groups and lie groups, Reducible and irreducible representations of SU(2), SU(3) and O(3) group.

Books Recommended :

1. Mathematical methods of Physics, J.Mathews and Walker
2. Mathematical Methods of Physics, G. Arfken.

(B) Classical Mechanics

50 Marks

Unit-I **17 Marks**

Lagrangian, Homogenity and isotropy of space and conservation of linear and Angular momentum, Homogenity of time and conservation of energy.

Rigid body motion:

The independent coordinates of a rigid body, orthogonal transformations, the Euler angles, The cayley- Klein parameters, Euler's theorems on the motion of a rigid body, infinitesimal rotations, Rate of change of vector, coriolis force.

Angular momentum and K.E. of motion about a point, the inertia tensor and moment of inertia, the principal axis transformation, The Euler equation of motion, Torque-free motion of a rigid body, the heavy symmetrical top with one point fixed.

Unit-II **17 Marks**

Hamiltonian Formulation:

Legendre transformation and Hamilton's equations of motion Physical significance of the Hamiltonian, Derivation of Hamilton's equation from variational principle.

Canonical transformations:

The equation of canonical transformations, Integral invariant of poincare, Lagrange and poission brackets as canonical invariants, The equations of motion in the Poisson bracket formulation, Infinitesimal contact transformations and conservation theorems.

Unit-III **16 Marks**

Hamilton Jacobi Theory:

Hamilton- Jacobi equations and application to harmonic oscillator, action angle variables, The kepler problem, H-J theory, Geometrical optics and wave mechanics.

Small Oscillations:

Problem of small oscillations, Normal- cordinates and free vibration of a linear triatomic molecule, Elementary idea about non linearity and chaos.

Books Recommended :

1. Classical Mechanisa----- H.Goldstein
2. Classical Mechanisa----- Taluk and Pranik
3. Classical Mechanisa----- Satya Prakash

PAPER – III : ELECTRODYNAMICS & SOLID STATE PHYSICS

Full Marks-100

(A) Electrodynamics

50 Marks

Unit-I **17 Marks**

Maxwell's Equations:

Green function solution of Maxwell's equation, Lorentz and coulomb gauge, Gauge invariance, plane waves in a non- conducting medium, linear and circular polarizations, stoke's parameters, Frequency dispersion characteristics of dielectric conductors and plasma, waves in a dispersive medium, Kramer, kroning relations.

Wave guides and Resonant cavities:

Cylindrical cavities and wave guides, mode in a rectangular wave guide, resonant cavities.

Unit-II **17 Marks**

Radiation by moving charges:

Leinard- Wiechart potential, and field for a point charge. Fields of an accelerated charge, Radiation at low velocity, Total power radiated by an accelerated charge, Larmor's formula, Angular distribution of radiation power from an accelerated charge, Thomas scattering and Rayleigh scattering.

Unit-III **16 Marks**

Covariant formulation:

Four vector notation, Relativistic particle kinematics and dynamics, covariant form of Maxwell's equations, Maxwell field tensor, covariant definition of electromagnetic energy and momentum, transformation of electro magnetic field components. Lagrangian of a charged particle in an external em field.

Books Recommended :

1. Classical Electro Dynamics-- J.D. Jackson
2. Classical Electro Dynamics--- S.P.Puri

3. Electromagnetic Theory & Electrodynamics--- Satya Prakash
4. Foundation of Electromagnetic theory—Reitz, Millford & Christry.

(B) Solid State Physics

50 Marks

Unit-I **16 Marks**

Phonons and Lattice vibration:

Vibrations of monoatomic and diatomic lattices, dispersion relation,optic and acoustic modes, quantum of lattice vibration and phonon, phonon momentum, inelastic scattering of neutrons and photons by phonons, 3-dimensional lattice vibration.

Thermal properties of Insulators:

Lattice heat capacity, Debye and Einstein model, Anharmonic crystal interactions, Thermal conductivity and thermal expansion.

Free electron Fermi gas:

Density of states in one dimension effect of temperature on Fermi-Dirac distribution, Free electron gas in three dimensions. Heat capacity of electron gas, Electrical and thermal conductivity of metals.

Unit-II **17 Marks**

Band Theory:

Nearly free electron model, Brillouin zones for square and cubic lattices, zone schemes, classification of solids (conductors, semi conductors and insulators).

Energy Bands:

General properties of energy bands, Tight binding methods, Orthogonalised plane waves, pseudo potential methods of energy band calculations, de-Hass-Vaan Alphen effect.

Representation Theory

Wannier functions, equation of motion in wannier representation, equivalent Hamiltonian and impurity levels.

Unit-III **17 Marks**

Semi Conductors:

Intrinsic and extrinsic semiconductors, band gap. Law of mass action, Intrinsic carrier concentration, mobility in the intrinsic region, Hall effect, P-n Junction and rectification.

Super conductivity:

Experimental survey, Meissner effect, type-I and type-II superconductors, Thermodynamics of super conductors, London's theory, Josephson Effect, cooper pair and BCS theory of superconductivity.

Books Recommended :

1. Introduction of solid state physics-C.Kittel
2. Quantum theory of solids- J. Callaway
3. Solid state Physics- O.E. Animallu
4. Solid state Physics- A. Dekker

PAPER – IV : OPTICS & MODERN PHYSICS & ELECTRICITY & MAGNETISM (PRACTICAL)

Full Marks-100

1. Anderson's Bridge
2. Maxwell's Bridge
3. Carey Fosters Bridge
4. Characteristics of Vacuum tubes & transistors
   I) Diode II) Triode & Pentode III) PNP & NPN
5. L.C.R. Bridge
6. Micheson's Interferometer
7. Fabry parrot interferometer
8. Bimirror

9. Biprism
10. Narrow wire
11. e by Millikan's oil drop method
12. em by Braun Tube
13. Measurement of Dielectic constant by lecher wire
14. Determination of h by photoelectric effect method.

PAPER – V : COMPUTATIONAL PHYSICS

Full Marks-100

1) Preliminaries of running computers taking out print out
2) Exercises to study various features of C-Language
3) Programming with FORTAN-77 & C Programming Language
4) i) To find the largest or smallest of a given set of numbers
   ii) To generate and print first hundred prime numbers
   iii) Sum of an 'AP'
   iv) Sum of a 'GP'
   v) Transpose of a square matrix using only one array
   vi) Matrix multiplication
   vii) Evaluation of Log and exponentials
   viii) Solution of a Quadratic equation
   ix) Evaluation of root by Newton-Raphson Method
   x) Solution of differential equations by Runge-Kutte Method.

PART - II

PAPER – VI : ADVANCED QUANTUM MECHANICS AND FIELD THEORY & BASIC NUCLEAR AND PARTICLE PHYSICS

Full Marks-100

(A) Advanced Quantum Mechanics and Field Theory

50 Marks

Unit-I **17 Marks**

Klein-Gordon equation and its drawback, Dirac equation, Properties of Dirac matrices, Non-relativistic reduction of Dirac equation, Free particle solution of Dirac equation, projection operators for energy and spin, Zitterbewegung, Hole theory, magnetic moment, Darwin's term, spin-orbit coupling, Dirac particle in a central coulomb field.

Unit-II **16 Marks**

Covariant form of Dirac equation, Algebra of Dirac gamma matrices, orthogonal transformations and invariance of Dirac equation under proper Lorentz transformations, charge conjugation, space reflection and Time reversal symmetries of Dirac equation, Bilinear covariants.

Transition from discrete to continuous systems, Lagrangian and Hamiltonian formulations, Noether's theorem, Second quantization, Quantization of fields: a) neutral scalar meson field
b) charged scalar meson field and c) Dirac field.

Unit-III **17 Marks**

Unequal space time commutators and anticommutators propagator functions and their integral representations Fock space, vacuum and Normal ordering Vacuum expectation values, Feyn-man propagator, chronological product (Dyson &Wick).

Properties of scattering matrix (S- matrix), Lipmann-Schwinger Theorem, Wick's theorem, Feynman diagrams, Feynman diagram rules in coordinate and momentum space, electron-photon interactions, Compton scattering and coulomb scattering, Elementary idea of electron self energy and Boson self energy.

Books Recommended :

1. Relativistic Quantum Mechanics- J.G. Sackurai
2. Relativistic Quantum Mechanics-Jorken and Drell.
3. Quantum field Theory- Schweber
4. Quantum field Theory- Mandel and Shaw
5. Quantum field Theory- L.H. Ryder
6. Quantum field Theory- B.K. Agarwaal

(B) Basic Nuclear and Particle Physics

50 Marks

Unit-I **16 Marks**

Central and noncentral forces, deuteron and its magnetic moment and quadrupole moment, force dependant isospin, exchange force, charge independent and charge symmetry of nuclear force.

Neutron-proton scattering at low energy, scattering cross section, scattering length, spin dependence of neutron-proton scattering, Effective range theory.

Nuclear Model:

Liquid drop model (Bohr-wheeler theory) and shell model

Unit-II **17 Marks**

Nuclear disintegration: Gamow's theory α-decay, Geiger Nuttal law, β-decay, Fermi' theory of β-decay, Parity Violation, selection rules for allowed transitions.

Nuclear Reaction:- Energetics of nuclear reaction, compound nucleus theory, resonance scattering, Breit-wigner formula.

Nuclear Structure: Form factor and charge distribution of the nucleus Hofstader form factor.

Unit-III **17 Marks**

Particle Physics:

Classification of elementary particles, basic forces , Conservation laws, Baryan number, Lapton number, Gellmann-Nishijima scheme, isospin and isospin quantum number, Hypercharge , Strangeness, invariance principles and symmetries, conservation of parity, charge conjugation symmetry, Time reversal, CPT theorem, elementary idea of quark model, SU(3) Symmetry, Meson and Baryon octets.

Books Recommended :

1. Introductory Nuclear Theory- L.R.S. Elton
2. Nuclear Physics- R.R. Roy & B.P. Nigam
3. Introduction to Nuclear Physics- H. Enge.
4. Elementary Particle Physics- S. Gasiorwicz
5. Concepts of Particle Physics- Gortifried & Weisskoff.

PAPER – VII : ELECTRONICS & STATISTICAL MECHANICS

Full Marks-100

(A) Electronics

50 Marks

Unit-I **17 Marks**

Amplifiers:

Frequency response of linear amplifiers, amplifier pass band, R.C., L.C. and transformer coupled amplifiers, Frequency response, gain band width product, Feedback amplifiers, effects of negative feedback, Boot- strapping the FET, Multi-stage feedback, stability in amplifiers, noise in amplifier.

Operational Amplifiers:

The differential amplifier, Integral amplifier, rejection of common mode signal, The operational amplifier, Input and output impedances, Application of operational amplifiers, Unit gain buffer, summing, integrating and differentiating amplifiers, comparators and logarithmic amplifiers.

Unit-II **17 Marks**

Oscillator Circuits:

Feedback criteria for oscillation, Hartley and colpitts oscillator phase shift, Wien-bridge oscillator, Crystal control oscillator, klystron oscillator, Principle of multivibrator.

Digital Circuits:

Logical fundamentals, Boolen theorem, Logic gates- RTL, DTL and TTL gates, CMS switches, RS flip-flop, JK flip-flop.

Unit-III **16 Marks**

Radio Communication: Modulation & Demodulation Ionospheric propagation, Antenna theory, Antennas of different types, superheterodyne, receiver (Block-diagram) Principle of T.V.

Books Recommended :

1. Electronic Fundamental and application- J.D. Ryder
2. Integrated Digital Electronics- Heap and Martin
3. Integrated Electronics- Millman and Halkitas
4. Foundation of Electronics- Chattopadhya, Rakshit , Saha and Purkait.

(B) Statistical Mechanics

50 Marks

Unit-I **17 Marks**

Postulate of classical statistical mechanics, Liouville's theorem, Micro canonical ensemble, Derivation of thermodynamics, equipartition, theorem, classical ideal gas, Gibb's paradox.

Canonical ensemble and energy fluctuation, grand canonical ensemble and density fluctuation, equivalence of canonical and grand canonical ensemble.

Unit-II **17 Marks**

The density matrix, ensembles in quantum statistical mechanics, Ideal gas in micro canonical and grand canonical ensemble, equation of state for ideal Fermi gas, theory of white dwarf star, pauli paramagnetism, Ising model, Definition of ising model, ID-Ising model.

Unit-III **16 Marks**

Ideal Bose gas, Photon and planck's law, Phonons, Bose- Einstein condensation.

Thermodynamics description of phase transitions, 1^{st} order and 2^{nd} order phase transitions, Discontinuity of specific heat, change in symmetry in a phase transition of second kind.

Books Recommended :

1. Statistical Mechanics- K. Huang
2. Statistical Mechanics-H. Patheria
3. Fundamentals of statistical and thermal Physics- F.Reif
4. Statistical Mechanics—landau K Lifshitz.

PAPER – VIII : NUCLEAR PHYSICS (SPECIAL PAPER)

Full Marks-100

Unit-I **16 Marks**

Rotational invariance in three dimensions, eigen values and eigen functions of angular momentum operators, explicity representations of the rotation matrices, addition of angular momenta, C.G. Coefficients, irreducible spherical tensor, matrix element of tensor operators, Wigner- Eckrat theorem

Unit-II **17 Marks**

Two nucleon system: Ground and excited states of the deuteron, Tensor forces and Quadrupole moment of deuteron, photo disintegration of the deuteron.

Nuclear Model: Shell model, Analysis of shell predictions, extreme single particle model, configuration mixing, individual particle model, L.S. and J, J coupling scheme.

Unit-III **17 Marks**

The vibrational modes of a speherical nucleus, collective modes of a deformed even-even nucleus, symmetries of the collective wave function for well deformed even-even nuclei, collective spectra of even –even nuclear strong coupling of a particle and collective motion, electric quadrupole moments, magnetic dipole moments.

Unit-IV **16 Marks**

Nuclear Reactions: Energy considerations in Nuclear reactions, cross section for nuclear reaction (statistical consideration), inverse reaction cross section, nuclear reaction (geometric consideration) Nuclear reaction mechanism, Neutron scattering cross section, resonance scattering reaction.

Unit- V **17 Marks**

Theory of Nuclear Optical Model:

Concept of elastic, shape elastic, compound elastic, reaction and absorption cross section, Optical model calculation method for nuclear scattering including spin-orbit and coulomb potential, phenomenological optical potential, theory of optical calculation of optical potential using folding models (single folding and double folding)

Heavy Ion Collision:

Characteristics of heavy ion collision, Diffraction and reaction model: rainbow, glory and orbiting, semi classical methods, fusion cross section, sub-barrier fusion.

Unit-VI **17 Marks**

Nuclear Detectors:

Ionization chambers, Semi conductor counters, proportional counters, G.M. Counter, Scintillation counter, Wilson expansion chamber, Bubble chamber, The nuclear emulsion, neutron detection: time of flight technique, measurements based on recoil protons, Beta and electron spectrometers, Acceleration of charged particles.

Linear Accelerator, Cyclotron, Synchrocyclotron.

Books Recommended :

1. Nuclear Physics—R.R. Ray & B.P. Nigam
2. Elementary Theory of Angular Momentum- M.E. Rose
3. Introduction to Nuclear Physics—H. Enge
4. Nuclear- Nucleus Collision—D.M. Brink
5. Theory of Nuclear structure—M.K. Pal
6. Structure of the Nucleus—M.A. Presten & R.K. Bhaduri
7. Fundamental of Nuclear Physics - J. Verma, R.K. Bhadum and D.R.S. Somaya Julu.

PAPER – IX : ELECTRONICS (PRACTICAL)

Full Marks-100

(Each examinee has to pick up one expt. by lot)

1. Zener Diode
2. Study of logic gates
3. Characteristic of Hartley Oscillator
4. Determination of different parameters of transistor.
5. Study of multivibrator- A stable

6. Study of multivibrator- bi stable
7. Study of multivibrator- Mono stable
8. Colpitt's Oscillator
9. Design of operational amplifier circuit
10. Study of two stage RC amplifier with frequency compensator.

PAPER – X : NUCLEAR PHYSICS (SPECIAL PAPER) (PRACTICAL)

Full Marks-100

1. G.M. Counter Experiments
   (a) Determination of characteristics of Geiger tube
   (b) Determination of absorption Coefficient
   (c) Determination of operating voltage, plateau length/ slope etc.
2. To analyze the energy of an unknown gamma source.
3. To calibrate the energy of the gamma sources.
4. Estimation of efficiency of the GM-detector for (a) Gamma Source (b) Beta Source
5. Verification of inverse square law for gamma rays.

OR

A student has to submit three copies of dissertation in special paper (Nuclear Physics) which comprises (100 Marks) and to be evaluated by external examiner (75 Marks) and internal examiner, followed by viva-voice (25 Marks).

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