

***POST GRADUATE DEPARTMENT OF PHYSICS
UNIVERSITY OF KASHMIR, SRINAGAR - 6***



M. Sc. Physics (III Semester)

Course Curriculum (Syllabus for examination)

for the academic years

2014

Semester-III

S. No.	Subject Code	Subject Name	Total Max. Marks	Total Min. Marks	Internal Max.	Internal Min.	External Max.	External Min.
01	PHYC13301	Nuclear and Particle Physics	100	40	20	08	80	32
02	PHYC13302	Condensed Matter Physics	100	40	20	08	80	32
03	PHYC13303	Electrodynamics-II	100	40	20	08	80	32
04	PHYL13304	Computational Methods	100	40	50	20	50	20
05	PHYL13305	Lab. Course: Practicals	100	40	50	20	50	20
06	PHYS13306	Astrophysics-I	100	40	20	08	80	32
07	PHYS13307	Microwave Devices and Circuits	100	40	20	08	80	32
08	PHYS13308	Density Functional Methods	100	40	20	08	80	32

SEMESTER: III

(Course of Study for the year 2014, 2015, 2016)

Course No's PHY-C301, PHY-C302, PHY-C303, PHY-L304 & PHY-L305 are core (Compulsory) courses. However, students have to choose any one special papers out of course No's PHY-S306, PHY-S307 & PHY-S308.

<u>Course No.</u>	<u>Title of the Course</u>
PHYC13301	Nuclear and Particle Physics
PHYC13302	Condensed Matter Physics
PHYC13303	Electrodynamics-II
PHYL13304	Computational Methods
PHYL13305	Lab. Course: Practicals
PHYS13306	Astrophysics-I
PHYS13307	Microwave Devices and Circuits
PHYS13308	Density Functional Methods

Semester - III
Nuclear and Particle Physics

Course No: PHYC13301

Max. Marks: 100

Duration of Examination: 2.30 hrs.

(a) External Examination: 80

No. of Lectures: 45-60

(b) Internal Assessment: 20

(Valid for session 2014)

UNIT I

Nuclear Forces and Two Nucleon Systems: The deuteron, Deuteron magnetic moment, Deuteron electric quadrupole moment, Tensor forces and deuteron D-state, Symmetry and nuclear force, Yukawa theory of nuclear interaction, Nucleon-nucleon scattering phase shifts, Low energy scattering parameters, The nuclear Potential

Bulk Properties of Nuclei: Nuclear size, Electron scattering form factor, charge radius and charge density, Nucleon form factor, High energy lepton scattering, Nuclear shape and electromagnetic moments

UNIT II

Bulk Properties of Nuclei (contd.): Magnetic dipole moment of odd nuclei, Ground state spin and isospin, Nuclear binding energy, Semi-empirical mass formulae, Density of excited states, Low lying excited states, Infinite nuclear matter

Nuclear Excitation and Decay: Nuclear transition matrix and elements, Electromagnetic transition, Single particle value, Weak interaction and beta decay, Nuclear beta decay, Alpha particle decay, Nuclear fission

UNIT III

Models of Nuclear Structure: Vibrational Model, Giant resonance, Rotational model, Interacting boson approximation, Magic number and single-particle energy, Many body basic states, Hartree-Fock single-particle Hamiltonian, Spherical shell model, Deformed shell model, Fermi gas model

Nuclear Reactions: Coulomb Excitation, Compound nucleus formation, Direct reactions, The optical model, Intermediate energy nucleon scattering, Meson-nucleus reactions, Heavy ion reactions

UNIT IV

Introduction to Elementary Particles: The classical era, The photon, Mesons, Antiparticles, Neutrino, Strange particles, The eight-fold way, The quark model, Intermediate vector bosons, The standard model

Elementary Particle Dynamics: The four forces, Weak interactions, Decays and conservation laws, Unification schemes

Text Book:

Samuel S. M. Wong, Introductory Nuclear Physics, Pentice-Hall f India Pvt. Ltd., New Delhi (2002)

Reference Books:

1. D. Griffiths, Introduction to Elementary Particles, Harper and Row, New York, 1987
2. Nuclear and Particle Physics-An introduction by B.R. Martin (Wiley Publication)
3. Physics of Nuclei and Particles-Marmier and Sheldon (Vol-I & II) Academic Press New York and London.
4. A. Bohr and B. R. Mottelson, Nuclear Structure, Vol. 1 (1969) and Vol. 2, Benjamin, Reading, A, 1975
5. Kenneth S. Kiane, Introductory Nuclear Physics, Wiley, New York, 1988
6. Ghoshal, Atomic and Nuclear Physics Vol. 2
7. P. H. Perkins, Introduction to High energy Physics, Addison-Wesley, London, 1982
8. Shirokov Yudin, Nuclear Physics Vol. 1&2, Mir Publishers, Moscow, 1982
9. H. A. Enge, Introduction to Nuclear Physics, Addison-Wesley, 1975
10. G. E. Brown and A.D. Jackson, Nucleon-Nucleon Interaction, North – Holland, Amsterdam, 1976

Semester- III
CONDENSED MATTER PHYSICS

Course N.: PHYC13302

Max. Marks:100

Duration of Examination: 2.30 hrs.

(a) External Examination: 80

No. of Lectures: 45-60

(b) Internal Assessment: 20

(Valid for sessions 2014)

UNIT I

Two and three dimensional lattices, crystal planes. Diffraction of waves by crystals, Scattered wave amplitude, Fourier Analysis of a crystal structure. Reciprocal lattice and its applications to diffraction techniques. Diffraction Conditions, Brillouin Zones. Crystal structure factor and intensity of diffraction maxima, Extinctions due to lattice centering.

UNIT II

Electrons in a periodic lattice, origin of energy gaps. Bloch functions, wave equation in a periodic potential; Bloch theorem. Tight binding method of energy bands. Experimental methods in Fermi surface determination, Quantization of electron orbits in a magnetic field, De Hass-van Alphen effect, Cyclotron resonance, Quantum Hall Effect.

UNIT III

Superconductivity: Critical temperature, heat capacity, energy gap, isotope effect, Meissner effect, Types of superconductors, London equations, BCS theory (Qualitative), Josephson effect.

Point defects and line defects; the role of dislocations in plastic deformation and in crystal growth.

UNIT IV

Ferromagnetism: Weiss theory of ferromagnetism, Curie-Weiss law for susceptibility, Heisenberg model and Molecular Field Theory. Spin wave and magnons, Bloch $T^{3/2}$ law. Formation of Domains, Bloch-wall energy.

Ferroelectricity: Ferroelectric Crystals, Classification of ferroelectric Crystals, applications. Landau Theory of the Phase Transition; First and Second-Order Transition.

Text and reference books:

1. Introduction to Solid State Physics by Charles Kittel, John Wiley & Sons
2. Solid State Physics by Neil W Ashcroft, N. David Mermin, BlackWell
3. Solid State Physics by J. S. Blakemore, Cambridge University Press.

Semester- III
Electrodynamics-II

Course N.: PHYC13303

Max. Marks:100

Duration of Examination: 2.30 hrs.

(a) External Examination: 80

No. of Lectures: 45-60

(b) Internal Assessment: 20

(Valid for session 2014)

UNIT I

Fields and radiation of localized source, Oscillating electric dipole, Magnetic dipole and quadruple fields, centre-fed linear antenna, Kirchoff's integral for diffraction, Vector equivalents of Kirchoff's integral, Babinet's principle, Diffraction by circular aperture, Diffraction by small apertures, Scattering by a conducting sphere at short wavelengths

Magnetohydrodynamic equations, Magnetic diffusion, Viscosity, and pressure, Magnetohydrodynamic flow, Pinch effect, Dynamic model of the pinch effect, Instabilities, Magnetohydrodynamic waves, High-frequency plasma oscillations, Short-wavelength limit, Debye screening distance

UNIT II

Postulates of special relativity, Lorentz transformation, FitzGerald-Lorentz contraction and time dilation, Addition of velocities, Doppler shift, Thomas precession, Proper time and light cone, Lorentz transformation as orthogonal transformations, 4-vectors and tensors, Covariance of electrodynamics, Transformation of electromagnetic fields, Covariance of the force equation and conservation laws

Momentum and energy of a particle, Kinematics of decay of an unstable particle, center of momentum transformation, Transformation of momenta from center of momentum frame to the laboratory, Covariant Lorentz force equation, Lagrangian and Hamiltonian, Relativistic corrections to the Lagrangian for interacting charged particles, Motion in uniform, static, magnetic field, Motion in combined uniform, static, electric and magnetic fields, Particle drifts in nonuniform magnetic fields, Adiabatic invariance of flux through an orbit

UNIT III

Energy transfer in coulomb collision, Energy transfer to a harmonically bound charges, Classical and quantum-mechanical energy loss, Density effects in collision energy loss, Energy loss in an electronic plasma, elastic scattering of fast particles by atoms, Mean square angle of scattering, multiple scattering, Electrical conductivity of plasma

Lienard-Wiechert potentials and fields, Larmor's radiated power formula and its relativistic generation, Angular distribution of radiation, Radiation by an extremely relativistic charged particle, General angular and frequency distributions of radiation from accelerated charges,

Frequency spectrum from relativistic charged particle in an instantaneously circular orbit, synchrotron radiation, Thomson scattering, Scattering by quasi-free charges, Cherenkov radiation

UNIT IV

Radiation emitted during collisions, Bremsstrahlung in non-relativistic coulomb collision, Relativistic bremsstrahlung, Screening, relativistic radiative energy loss, Weizsacker-Williams method of virtual quanta, Radiation emitted during beta decay, Radiation emitted in orbital-electron capture

Scalar spherical waves, Multipole expansion of electromagnetic field, Properties of multipole fields, energy and angular momentum of radiation, Angular distributions, sources of multipole radiations, multipole moments, Multipole radiation in atoms and nuclei, Radiation from a linear center-fed antenna, Spherical expansion of a vector plane wave, scattering by conducting sphere, Boundary-value problems with multipole fields

Text Book:

Classical Electrodynamics, by John David Jackson, John Wiley & Sons Inc

Reference Books:

1. The Classical Theory of Fields, L. D. Landau and E. M. Lifshitz, Butterworth Heinmann
2. Introduction to Electrodynamics, David J. Griffiths, Pearson Education

Semester - III
Computational Methods

Course No: PHYL13304

Max. Marks: 100

Duration of Examination: 2.30 hrs.

(a) External Examination: 50

No. of Lectures: 45-60

(b) Internal Assessment: 50

(Valid for session 2014)

UNIT I

Computers, Interpreters and Operating system, Types of programming languages, C programming, Programme Characteristics, C character set, identifiers and key words, Data types, Constants, Variables and Arrays Declaration, Expressions, Statements, Symbolic constants, Operators and Expressions, Library functions, Data input and output, Error Diagnostics, Debugging Techniques, Control statements, Case studies, Programming exercises

UNIT II

Arrays, Character Arrays and Strings, User defined functions, Function properties, Recursion, Programme Structure, Structure and Unions, Pointers, Pointer Declaration, Operation on pointers, Pointers and one dimensional arrays, Arrays of pointers, User defined data types, File management in C, Preprocessor, Guidelines for developing a C programme, Case studies, Programming exercises

UNIT III

Developing algorithms and Computer programs in C-Language to solve following problems:

- (1) Linear Equations
- (2) Non-Linear Equations
- (3) Matrix Inversion
- (4) Eigen-Values and Eigen-Vectors

UNIT IV

Developing algorithms and Computers programs in C-Language to solve following problems:

- (1) Interpolation with equally spaced and unequally spaced points
- (2) Cubic Spline fitting
- (3) Numerical Differentiation and Integration
- (4) Second order differential equation by Runge-Kutta method and other methods

Text and Reference Books:

1. Sastry: Introductory Methods of Numerical Analysis
2. Rajaraman: Numerical Analysis
3. Press, Teukolsky Vetterling and Flannery: Numerical Recipes
4. Balagurusamy: Programming in ANSI C

Semester –III
Laboratory/Practical Course

Course No. PHYL13305

Max. Marks: 100

Duration of Examination: 6 hrs.

(a) External Examination:50

No. of Lectures: 45-60

(b) Internal Assessment: 50

(Valid for session 2014)

Condensed Matter Physics

1. Measurement of lattice parameters and indexing of powder photographs
2. Interpretation of transmission Laue photographs
3. Determination of Orientation of a crystal by back reflection Laue method
4. Rotation/Oscillation photographs and their interpretation
5. To study the modulus of rigidity and internal friction in metals as a function of temperature
6. To measure the cleavage step height of a crystal by Multiple Fizeau fringes
7. To obtain multiple beam Fringes of equal Chromatic order. To determine crystal step height and study birefringence
8. To determine magnetoresistance of a Bismuth crystal as a function of magnetic field
9. To study hysteresis in the electrical polarization of a TGS crystal and measure the Curie temperature
10. To measure the dislocation density of a crystal by etching

Tutorial

1. Study of X-ray diffraction from liquid, amorphous materials
2. Determination of dislocation density by Reflection X-ray topography
3. To take Buerger Precession photograph of a crystal and index the reflections
4. To measure the superconductivity transition temperature and transition width of high temperature superconductors
5. To determine the optical constants of a metal by reflection of light
6. Model evaluation of dispersion curves of one dimensional lattice

Nuclear and Particle Physics

1. To determine the operating voltage, slope of the plateau and dead time of a G.M. Counter
2. Feathers analysis using G.M.Counter
3. To determine the operating voltage of a photomultiplier tube and to find the photopeak efficiency of a NaI(Tl) crystal of given dimensions for gamma rays of different energies
4. To determine the energy resolution of a NaI(Tl) detector and to show that it is independent of the gain of the amplifier.
5. To calibrate a gamma ray spectrometer and to determine the energy of a given gamma ray source

6. To determine the mass attenuation coefficient of gamma rays in a given medium
7. To study the Compton Scattering using gamma rays of suitable energy
8. To study the various modes in a multichannel analyzer and to calculate the energy resolution, energy of gamma ray
9. To determine the beta ray spectrum of Cs-137 source and to calculate the binding energy of K-shell electron of Cs-137
10. To study the Rutherford scattering using aluminium as scatterer and Am-241 as a source
11. To measure the efficiency and energy resolution of a HPGe detector
12. Alpha spectroscopy with surface barrier detector-Energy analysis of an unknown gamma source
13. Determination of the range and energy of alpha particles using spark counter
14. The proportional and low energy X-ray measurements
15. X-ray fluorescence with a proportional counter
16. Neutron activation analysis
17. Gamma-gamma coincidence studies
18. Identification of particles by visual range in nuclear emulsion
19. Construction and testing of a single channel analyzer circuit
20. Decoding and display of the outputs from the IC-7490

Electronics

1. Pulse Amplitude Modulation/Demodulation
2. Pulse position/Pulse width Modulation/Demodulation
3. FSK Modulation Demodulation using Timer/PLL
4. Microwave characterization and Measurement
5. PLL circuits and applications
6. Fibre optics communication
7. Design of Active filters
8. BCD to Seven segment display
9. A/D and D/A conversion
10. Experiments using various types of memory elements
11. Addition, subtraction, multiplication & division using 8085/8086
12. Wave form generation and storage oscilloscope
13. Frequency, Voltage, Temperature measurements
14. Motor Speed Control, Temperature control using 8086
15. Trouble shooting using signature analyzer
16. Assembler language programming on PC
17. Experiments based on Computer Aided Design

Setting of new experiments will form tutorial for this laboratory course

Nuclear and Particle Physics (Special Paper – I)

1. Mounting a Scintillation Crystal to a Photomultiplier Tube
2. Pulse Cable Making
3. Pulse shaping with an RC Circuit and to Display with an Oscilloscope

4. Training in the Usage of Oscilloscope and Electronic Meters – Sensitivity and Resolution Study
5. Usage of Radiation Monitors
6. Setting up the Gamma Ray Spectrometer
7. Photoelectric Effect, Compton Effect, Pair production and Back Scattering
8. Discriminators
9. Pulse Height as a Function of Applied Voltage for Gas Counters
10. Proportional Counter Characteristics
11. Scintillation Process in Intrinsic and Extrinsic Inorganic Crystals and Organic Crystals
12. Signal Formation in Solid State Devices
13. Neutron Activation Analysis

In addition to above, the tutorial will also consist of solving problems given in the Text and Reference books.

Astrophysics

1. Polar aligning a telescope and measuring declination of Polaris
2. Measuring distance to Moon by parallax method
3. Measuring limb-darkening of Sun
4. Finding rotation period of Sun by measuring motion of sun-spots
5. Measuring relative sensitivity of B, V, and R bands of a photometer with Sun and using this to find temperature of filament of a lamp
6. Measuring colour of a star by differential photometry
7. Measuring extinction of the atmosphere in B, V, and R bands
8. Characterizing a CCD camera for gain, read-noise, linearity, and field
9. Estimating atmospheric seeing by measuring differential motion
10. Measuring stellar scintillations for different zenith angles and comparing it with Scintillations for planets

Semester - III
Astrophysics - I

Course No: PHYS13306

Duration of Examination: 2.30 hrs.

No. of Lectures: 45-60

Max. Marks: 100

(a) External Examination: 80

(b) Internal Assessment: 20

(Valid for session 2014)

UNIT I

The Milky way Galaxy, size and shape, Rotation curves of the Galaxy, Implication of dark matter, Radio-observation and spiral structure, star counts, interstellar extinction, Implications of Dark matter, Hubble's classification of galaxies

External galaxies: Methods of extra galactic distance, determination spectra and red-shift, radio galaxies, quasars

UNIT II

Systems of coordinates in astronomy, Stellar parallaxes, Stellar magnitudes, stellar classification, H-R diagram, Saha-Boltzman equation, colour temperature, temperatures of stars; Observational tools: Optical Telescope, Photoelectric Photometry, CCD observations, Optical Spectroscopy

UNIT III

Equation of stellar structure, equation of conservation of mass, hydrostatic equilibrium, thermal equilibrium and energy transport, polytropic model, Lane-Emden's equation, central temperature, pressure and application to Sun, Application of virial theorem to isothermal spheres, Jean's criteria for stability

UNIT IV

Evolution of stars, interstellar dust and gas, formation of stars, Evolution of stars on the basis of HR-diagram, Binary stars, masses of binary stars, Fate of massive stars, Supernovae, White dwarfs, Chandrasekhar limit, neutron stars, Pulsars, black holes

Text books and Reference books:

1. Astronomy by R. H. Baker
2. Structure of Universe by J. V. Narlikar
3. Cosmology by J. V. Narlikar
4. Modern Astrophysics by B. W. Carroll and D. A. Ostlie Addison-Wesley Publishing
5. Introductory Astronomy & Astrophysics by M. Zelik & S. A. Gregory, 4th Edition
6. Saunders College Publishing
7. Theoretical astrophysics, Vol. II: Stars and Stellar Systems, T. Padmanabhan,
8. Cambridge University Press.
9. Stellar dynamics by Chandrasekhar

Semester- III
Microwave Devices and Circuits

Course No.: PHYS13307

Max. Marks: 100

Duration of Examination: 2.30 hrs.

(a) External Examination: 80

No. of Lectures: 45-60

(b) Internal Assessment: 20

(Valid for session 2014)

UNIT I

Introduction to microwaves and applications, advantages of microwaves, EM spectrum domain, electric and magnetic fields static electric and magnetic fields, time varying electric and magnetic fields, electromagnetic field equations, Maxwell's equations for time-varying fields, meaning of Maxwell's equations, characteristics of free space, Co-axial Components, Attenuators, Magic Tee, Directional couplers

UNIT II

Microwave Tubes: Limitation of conventional tubes, microwave tubes, velocity modulation, method of producing the velocity modulation, principle of operation of two cavity klystron, reflex klystron principle of operation, velocity modulation in reflex klystron, Applegate diagram with gap voltage for a reflex klystron. Principle of operation of magnetron, Semiconductor Devices, Microwave BJT's

UNIT III

Microwave Semiconductor Devices: Microwave bipolar transistor, FET, Principle of Operation and application of tunnel diode, Principle of operation of gunn diode, application of gunn diode advantages of gunn diode, principle of operation of PIN diode and applications, Tunnel diode, IMPATT, TRAPATT Diodes

UNIT IV

Microwave Passive components: Rectangular waveguides resonator isolator, types of attenuators, fixed attenuators, step attenuators, variable attenuators, salient features of directional coupler, parameters of directional coupler, coupling factor, directivity, applications of directional coupler, VSWR, Coupling and Directivity measurements

Text & Reference Books:

1. Microwave Engineering by Prof. G. S. N. Raju, IK International Publishers, 2007
2. Microwave Engineering, by P. A. Rizzi, PHI, 1999.
3. Microwave Engineering, Non-reciprocal active and passive circuits" by Joseph Helszajin, McGraw Hill, 1992.
4. Microwave Devices and Circuits, S. Y. Liao PHI

Semester- III
Density-Functional Methods

Course No.: PHYS13308

Max. Marks:100

Duration of Examination: 2.30 hrs.

(a) External Examination: 80

No. of Lectures: 45-60

(b) Internal Assessment: 20

(Valid for session 2014)

UNIT I

Elementary ideas of wave mechanics, Variational principle for the ground state, The Hartree-Fock approximation, Correlation energy, Electron density, Hellmann-Feynman theorem and Virial theorems

Density matrices, Description of quantum states and the Dirac notation, Density Operators, Reduced density matrices for fermion Systems, Spinless density matrices, Hartree-Fock theory in density-matrix form, N-representability of reduced density matrices, statistical mechanics

Unit-II

Density-Functional theory, Thomas-Fermi model, Hohenberg-Kohn theorems, v and N-representability of an electron density, Levy constrained-search formulation, Finite temperature canonical-ensemble theory, Finite temperature grand-canonical-ensemble theory, finite temperature ensemble theory of classical systems

Thomas Fermi and related models, Traditional TF and TFD models, Theorems in Thomas Fermi Theory, Assessment and modification, Alternative derivation and a Gaussian model, Local model, Conventional gradient correction, Thomas-Fermi-Dirac-Weizsacker model, Various related considerations

Unit-III

The Kohn-Sham method: Basic principles, Introduction of orbitals and the Kohn-Sham equations, Derivation of Kohn-Sham equations, More on the kinetic-energy functional, Local density and $X\alpha$ approximations, Integral formulation, Extension to nonintegral occupation numbers and transition-state concept

Spin-density functional theory, Spin-density functionals and the local spin-density approximations, Self-interaction correction, The Hartree-Fock-Kohn-energy functional via the exchange-correlation, Exchange-correlation-energy functional via wave-vector analysis, Other studies of the exchange-correlation-energy functional

Unit IV

Finite-temperature Kohn-Sham theory, Excited states, Time-dependent systems, Dynamic linear response, Density-matrix-functional theory, Nonelectronic and multicomponent systems

Remarks on problems of chemical binding, Interatomic forces, Atoms in molecules, More on HSAB principle, Modelling the chemical bond, Bond-charge model, Semiempirical density-functional theory

Text Book:

Density-Functional Theory of Atoms And Molecules, Robert G. Parr and Weitao Yang, University of North Carolina, Oxford University Press, New York, Clarendon Press, Oxford 1989