Syllabus

OF

Course Work

for

MASTER OF SCIENCE (M.Sc.)

PHYSICS

Choice Based Credit System (CBCS)

DEPARTMENT OF PHYSICS,
VEER NARMAD SOUTH GUJARAT UNIVERSITY,
UDHANA MAGDALLA ROAD,
SURAT -395007. (GUJARAT)

Structure for M.Sc. Syllabus

Effective from June 2018

SEMESTER- III

M.Sc. (PHYSICS)

Sr. No.	Course Code	Course Title	L	T	Cr.
1	PH-531	Quantum Mechanics -II	4	1	4
2	PH-532	Nuclear and Particle Physics	4	1	4
3	PH-(E)-533	Physics of Semiconductor Devices	4	1	4
4	PH-(E)-534	Microcontroller and Applications	4	1	4
5	PH-(M)-533	Crystal Growth and Characterization	4	1	4
6	PH-(M)-534	Advanced Materials Science	4	1	4
7	PH-(T)-533	Non-linear Systems and High Performance-Computing	4	1	4
8	PH-(T)-534	Computational and Simulation methods in Physics	4	1	4
9	PH-(N)-533	Nuclear Radiation Detection and Accelerators	4	1	4
10	PH-(N)-534	Nuclear Reactions, Nuclear Energy and Nuclear Reactor Theory	4	1	4
11	PH-(C)-534	Practicals (Common)	3	0	8
12	PH-(E)-535	Practicals (Electronics)	6	1	8
13	PH-(M)-535	Practicals (Materials Science)	6	1	8
14	PH-(T)-535	Practicals (Theoretical Physics)	6	1	8
15	PH-(N)-535	Practicals (Nuclear Physics)	6	1	8
TOTAL			25	05	24

Faculty Code: **Science** Subject Code: **PH** Level Code: **05**

Name of Program**: M.Sc.** Subject: **PHYSICS**

External Examination Time Duration: **03 Hours**

Name of Exam	Semester	PAPER No.	Course Group	Credit	Internal Marks	External Marks	Total Marks
M.Sc.	3	PH-531	Core	04	30	70	100
		PH-532	Core	04	30	70	100
		PH-533	Elective	04	30	70	100
		PH-534	Elective	04	30	70	100
		PH-535	Practical	08	60	140	200
			TOTAL	24	180	420	600

DEPARTMENT OF PHYSICS, VEER NARMAD SOUTH GUJARAT UNIVERSITY, SURAT -395007

M.Sc. Syllabus 2017
M. Sc. (Physics): Semester-III

PH-531: QUANTUM MECHANICS-II

Unit 1 **Scattering Theory**

Kinematics of the scattering process: Differential and total cross-sections, Wave mechanical picture of scattering: The scattering amplitude, Green's function; Formal expression for scattering amplitude, The Born approximation, Validity the Born approximation

Unit 2 **Scattering Theory-Phase shifts**

Partial Waves Analysis: Asymptotic behavior of partial waves - phase shifts Optical theorem, Phase shifts- relation to the potential, potentials of finite range, Low energy scattering, scattering by a square well potential, Scattering by a hard sphere, Yukawa and Coulomb potential

Unit 3 **Approximation Methods for Stationary States**

Time independent perturbation theory, non-degenerate and degenerate case, applications to fine structure splitting,, Zeeman (normal and anomalous) effect, Stark effect.

The Variational method, upper bound on ground state, application to helium atoms and simple cases

The WKB method, Bohr-Sommerfield quantization condition, applications of WKB to simple cases

Unit 4 **Time dependent Perturbation Theory**

The Schrodinger Picture, Heisenberg picture, interaction picture, Time dependent perturbation theory, transition probability, first and second order transitions, constant perturbation, Harmonic perturbation, Fermi's golden rule, adiabatic and sudden approximations

Unit 5 &6 **Relativistic wave equations:**

Generalization of the Schrödinger equation, The Klein-Gordon equation: Plane wave solutions; Charge and current densities, The Dirac's Equation: Properties of Dirac matrices, Dirac equation in covariant form, Plane wave solutions of the Dirac equation; Energy spectrum, The spin of the Dirac particles, Significance of the negative energy states.

Recommended Books

1. Quantum Mechanics by Nouredine Zettili (Wiley) 2nd Ed. (2004)
2. Quantum Mechanics by Franz Schawbl Springer 4th Ed. (2007)
3. Introductory Quantum Mechanics by Liboff, Pearson Education India, 4th Ed. (2003)
4. Quantum Mechanics by Claude Cohen-Tannoudji, Bernard Diu, Franck Laloe Vol. I & II, Wiley-CH, (1997)
5. Quantum Mechanics, by L. I. Schiff, McGraw-Hill Inc.,US, 3rd Revised Ed.
6. Introduction to Quantum Mechanics by David Griffiths, Pearson Education; 2nd Ed. (2015)
7. Quantum Mechanics, by A. K. Ghatak and S. Lokanathan (Macmillan -India), 5th Ed.
8. Quantum Mechanics by Mathews and Venkatesan, 2nd Ed. (2010)

Theory Tutorials
PH – 531: QUANTUM MECHANICS - II
(Discussion and problem solving/exercise sessions)

1. Propagator for a free particle
2. Comparison of Schrödinger, Heisenberg and interaction pictures
3. Problems on various time independent perturbations
4 Problems on time dependent perturbations
5. Problems on WKB method
6. Problems on scattering theory
7. Problems on Born approximation
8. Scattering by different potentials
9. Problems on Phase shift
10. Partial wave analysis of scattering from simple potentials

In addition to above the tutorial will also consist of solving problems given in the text and reference books.

PH-532: Nuclear and Particle Physics

Unit 1 *Brief history*: developments in nuclear and particle physics. Fundamental interactions, classification of particles: fermions, bosons, leptons, hadrons (mesons and baryons), excited states, resonances.
Nuclear properties: nomenclature, symbols, charge, mass, charge and potential radii, spin, statistics, isospin, magnetic dipole moment, electric quadrapole moment, binding energy.
Nuclear force: saturation property, charge independence, exchange forces, tensor force, symmetry and nuclear force, low energy n-p and p-p scattering, low energy scattering parameters, nuclear potential, Intermediate bosons.

Unit 2 ***Nuclear Models***
Liquid-drop model: semiempricial mass formula, nuclear stability
Single Particle Shell Model: evidence of shell structure, magic numbers, Spin-orbit coupling, parity, spin and moments of nuclear ground states, Schmidt lines,
Collective Models: evidence for collective motion, brief introduction to vibrational and rotational states, single particle motion in deformed potential.

Unit 3 *Gamma Transitions*: Measurement of life-times of excited states, theoretical predictions of decay constants, selection rules, angular correlation, internal conversion.
Beta Decay: Fermi theory of beta decay, Kurie plots, comparative half-lives, selection rules, electron capture decay, parity violation in beta decay, double beta decay.
Alpha Decay: Barrier penetration, reduced widths of alpha unstable states, energy levels

Unit 4 *Nuclear Reactions*: Theories of nuclear reactions, partial wave analysis of reaction cross-section, Compound-nucleus (CN) formation and breakup, resonance scattering and reaction, optical model of particle induced nuclear reactions, direct reactions- theory of stripping reactions, Spontaneous fission, induced fission, fission theories, heavy-ion reactions.

Unit 5 *Symmetries*: Discrete and Continuous symmetry transformations, symmetry and degeneracy, conservation laws, parity, charge conjugation and time reversal, CPT theorem (statement), Permutation symmetry, Isospin, G-parity, strangeness, charm, beauty quantum numbers; need for color, Gell-Mann Nishijima Scheme; Multiplets of $SU(2) \otimes U(1)_Y$

Unit 6 *Standard Model*: quarks and leptons, isospin of antiparticles, isospin of quarks, static quark model of hadrons: mesons; pseudoscalar mesons; vector mesons, Baryon singlet; Baryon octet; magnetic dipole moment of baryon octet, hadrons mass and quark–quark interaction.

Recommended Books

M.Sc. Physics Semester-III
NUCLEAR PHYSICS – I (BASIC NUCLEAR STRUCTURE)

UNIT – I: Nuclear Properties:
Units and Dimensions, Nuclear Radius, Mass and Abundance of Nuclides, Binding Energy of Nucleus, Semi Empirical Mass Formula, Q- value Equation, Nuclear Spin, Nuclear magnetic Moments, Gyromagnetic ration, Larmor Precession, Measuring Nuclear Moments, Nuclear Excited States, Hyperfine structure.

UNIT II : Alpha And Beta Decays
Alpha Decay: Why alpha decay occurs, basic alpha decay processes, alpha decay systematic, theory of alpha emission, conservation law and spectroscopy.
Beta Decay: Energy Release in Beta Decay, Fermi Theory of Beta Decay, Classical Experimental tests of Beta Decay, Conservation laws, selection rules and spectroscopy.

UNIT III : Gamma Decay
Energetics of Gamma Decay, Classical Electromagnetic radiation, Transition to Quantum Mechanics, Angular momentum, pariy, selection rules, Angular distribution and polarization measurements, Internal Conversion, Lifetimes of Gamma Emission, Gamma Ray spectroscopy.

UNIT – IV: The Deuteron Problem:
Experimental data for the deuteron, The spin-orbit coupling, Magnetic and electric moment of the deuteron, the deuteron wave function, two nucleon system in the continuum.

UNIT – V: Nuclear Forces
Nature of the nuclear force, Nucleon-Nucleon Scattering, Proton-Proton and Neutron-Neutron Interactions, Properties of Nuclear Force, The exchange force model.

UNIT VI :Nuclear Structure Models
Liquid drop model, Fermi gas Model of the nucleus, Evidence of shell structure, single-particle shell model, its validity and limitations, The collective model: Vibrational levels, Rotational levels.

Books:
Nuclear Physics by S. N. Ghosal
Introductory Nuclear Physics – K. S. Krane (Wiley India, 1988)
Nuclear Physics by D.C. Tayal (Himalaya Publishing House 2017)
Nuclear Physics – Roy & Nigam (Wiley Eastern Ltd. 1979)
Atomic and Nuclear Physics – S. N. Ghoshal (S. Chand & Company)
Nuclear Models, by W. Greiner and J.A. Maruhn (Springer 1996)

M.Sc. Physics Semester-III
NUCLEAR PHYSICS- II (NUCLEAR DETECTORS AND DETECTION)

UNIT – I: Nuclear radiation Detectors-I
Interaction of particles with matter, Types and Principle of different detectors, G. M. Counter, Scintillation detectors, Semiconductor detectors, Si(Li), Ge(Li) detectors, Intrinsic germanium detectors,

UNIT – II: Nuclear radiation Detectors-II
Gamma-ray spectrometer, pulse height selection, analysis of gamma-ray-spectra, Alpha and beta spectrometers, Solid state nuclear track detectors.

UNIT – III: General Characteristics of Detectors
Detector response, sensitivity, Energy Resolution, Timing characteristics, Dead time, Detection efficiency, Modes of Detector operation

UNIT – IV: Analysis and Errors in Detection
Characteristics of Probability Distributions, The binomial Distributions, The Poisson Distribution, The Gaussian Distribution,.
Measurement of errors: Systematic errors, Random errors, Error Propagation.

UNIT – V: Nuclear Electronics
Nuclear Electronics for Pulse signal processing - Pre-amplifiers, amplifiers, pulse shaping, discriminators, single channel analyzer (SCA), analog-to-digital converters (ADC) and multi-channel analyzer (MCA), time to amplitude converters (TAC)

UNIT – VI: Experimental Techniques
Basic coincidence technique, Resolving time characteristics of a coincidence set up, charge particle identification, few applications of coincidence technique in nuclear experiments.

Books:
Nuclear Physics by S. N. Ghosal
Introductory Nuclear Physics – K. S. Krane (Wiley India, 1988)
Nuclear Physics by D.C. Tayal (Himalaya Publishing House 2017)
Fundamentals of Nuclear Physics by Jahan Singh (A Pragati Publication 2012)
Radiation Detection and Measurement by G. F. Knoll
Nuclear Radiation Detectors by S. S. Kapoor and V. S. Ramamurthy.

Semester III

List of experiments for students of Nuclear Physics Specialization:

1. Study the random nature of radioactive decay by G. M. counter.
2. Study of characteristics of G. M. Tube and determination of its Operating voltage, Plateau, Length/Slope, Dead time (single and double source method) and to study its variation with paralysis time.
3. To determine the efficiency of a GM counter using gamma source and also verify the Inverse Square Law using gamma & β - sources.
4. Analysis of efficiency spectrum of Ge detector using 152Eu standard source.
5. Linear and Mass absorption co-efficient of gamma rays using G.M. counter - (for aluminium, lead etc.).
6. To study the pulse height spectra and the resolution of a NaI Scintillator Detector (Cs137, Co60, Mn54, Co57, Ba133).
7. Study of the energy calibration of NaI Scintillator Detector and to determine the energy of unknown source.
8. To study the Compton scattering using NaI (TI) detector.
9. To determine the Linear Absorption co-efficient of gamma rays using NaI Scintillator Detector and establish the relation between energy and linear absorption coefficient.
10. Study of Back Scattering of β-particle using G. M. counter with different materials.
11. Study of Feather analysis by G. M. counter.
12. To find the activity of an unknown gamma source.
13. Determination of absolute efficiency of NaI (Tl) Scintillation detector using standard sources.
14. Determination of the activity of a gamma source using NaI (Tl) detector.
15. To study the working of an active low and high pass filter circuits
16. To study the transistor co-incidence circuit