ANDHRA UNIVERSITY
DEPARTMENT OF NUCLEAR PHYSICS

CURRICULUM FOR ***PRE – PH.D.*** AND ***M.PHIL***.COURSES IN NUCLEAR PHYSICS
PROGRAMME EFFECTIVE FROM 2010- 11 ADMITTED BATCH

The course work for Pre – Ph.D/M.Phil. candidates admitted in full- time, part-time and extra –mural categories from the academic year 2010-11 is as follows:

PAPER – I : Advances in Nuclear Physics and Data Analysis

PAPER – II : Special topic concerned with thesis including Research Methodology
(One of the following papers basing on Research Topic)

(i) Nuclear Reactions and Spectroscopy

(ii) Nuclear Techniques in Scientific Research

PAPER – III : Seminar on the topic of Research concerned.

PAPER – I : Advances in Nuclear Physics and Data analysis.

Module - I

Heavy ion physics:
Special factors - Coulomb excitation – Heavy ion scattering, grazing interactions, Compound nucleus and quasi molecule formation, Nuclei far from stability – New phenomenon exhibited by exotic nuclei.

Electromagnetic Transitions:
The nuclear electromagnetic current - exchange current and the effects of finite nucleon size – quantized electromagnetic field – emission of electromagnetic radiation – isotopic selection rules – internal conversion and pair formation – experimental determination – EM transitions, E1 transitions and M1 transitions.

References:

1. Physics of nuclei and particles by Marmier and Sheldon Vol.II
2. Nuclear Structure Vol. I by De Shalit and Feshback

Module – II

Gamma –ray Spectroscopy with Germanium Detectors:
Response function, Methods of Continuum Reduction, Energy Calibration, Detection Efficiency, Radiation Damage, Neutron – induced contamination in pulse height spectrum.

References:

1. Radiation Detection and Measurement (3^{rd} Edition) By G.F.Knoll Chapter 4 Section-IV(Pages 426-454)

Composite Germanium Detectors:
Clover detectors, Cluster detectors and Gamma-ray tracking Detectors.

References: (Following Papers and citations there)

1. G. Duchene et al, "The Clover : a new generation of composite Ge detectors, Nuclear Instrumentation Methods in Physics Research A 432 (1999)p90-110
2. J. Eberth et al, "Encapsulated Ge Detectors: Development", Nuclear Instrumentation Methods in Physics Research A 369(1999)135-140
3. I.Y.Lee, Gamma – Ray Tracking Detectors, Nuclear Instrumentation Methods in Physics Research A422(1999)195-200

Accelerator Physics:
High voltage Electrodynamic Accelerators, Industrial applications of electrostatic accelerators, Livingston chart, two bean accelerators and Wakefield accelerators

References:

Hand book of accelerator physics and engineering by Alex Chao, Maury Tigner, World Scientific Publishing Company. Pvt Ltd.2002.

Numerical methods in C Programming Language: Bisection method, Newton – Raphson method. Linear, Quadratic and Lagrange's Interpolations, Difference tables, numerical integration, Simpson's rule, Gaussian quadrature formula, Least square approximation of function, Liner regression, polynomial regression, fitting exponential and trigonometric functions.

References:

1. Computer programming in C by E.Balagurusamy.
2. C Language and Numerical Methods by C.Xavier.
3. Numerical Recipes in C by W.H.Press, S.A. Feekolsky,W.T. Vetterling and B.P. Fiannery

PAPER – II: Experimental Nuclear Physics: Nuclear Reactions and Nuclear Spectroscopy.

Module - I

Nuclear Reactions:

1. Kinematics and Conservation Laws; Coulomb barrier, Q-value; Centre-of –mass co-ordinate and Laboratory systems; Particle Identification; Cross section, Isospin, Optical Potential.
2. Rutherford scattering, Elastic Scattering, Inelastic Scattering and Coulomb Excitation.
3. Direct Reactions: Types of direct reactions, Transfer Reactions, Breakup reactions and Deep- Inelastic Reactions. Direct reactions as a tool for nuclear Spectroscopy.
4. Fusion Reactions: Compound Nuclear Reactions, Slow neutron resonances, limiting Cross section, phase – shift, neutron width, gamma decay width, Isobaric Analog States, Compound nucleus reaction cross section, Heavy Ion Fusion.
5. Fission: Spontaneous fission, Hill-wheeler Model, fusion – Fission.

References:

(1)Fundamentals of Nuclear Physics, By N.A.Jelley,1990
Chapter 5&Chapter 6

(2)Nuclear Physics, by H.S.Hans, New Age International (P) Ltd., 2001
Chapters 9, 14 &17.

Module - II

Nuclear Spectroscopy:

1. Recent interests in Spectroscopy of Nuclei: Mass regions of Deformation, Types of deformation, Normal deformation, Highly deformed structures, super-deformation and Hyper-deformation. Regions of small deformations: Chiral Rotation, Magnetic rotation and Anti-magnetic rotation. Octupole and tetrahedral deformations.
2. Gamma-ray and electron spectroscopy: Measurement of life-time using Doppler shift attenuation and Recoil Distance Methods – Perturbed Angular Correlations – higher order effects in the measurement of internal conversion coefficients.
3. Physics of high spin states – discrete gamma –ray spectra, rotational alignment, back - bending and related phenomenon, continuum spectra –angular momenta, moment of inertia and other properties.
   Multiplicity selection and determination – total energy spectra and selection of channels – higher performance systems.
4. Nuclear reactions used to produce nuclei at high angular momentum: fusion evaporation, induced fission transfer reactions and deep – inelastic collisions. Estimation of cross sections and production of angular momenta.

References:

1. The electromagnetic interaction in nuclear Spectroscopy
   Edited by D.D.Hamilton(1975)North –Holland
2. F. Stephen – Reviews of Modern Physics (1975)43

Paper – II : NUCLEAR TECHNIQUES IN SCIENTIFIC RESEARCH

Module – I

1. Experimental Techniques: Theory and Concept, Experimental arrangement and applications of the XRF,XRD,PIXE,ICPMS and INAA Techniques. Study of their sensitivity and limitations.

References: Atomic and Nuclear Analytical methods by H.R.Verma.

2. Mossbauer spectroscopy:
   Resonance fluorescence, Recoil energy, Natural broadening, Doppler's broadening, the experiment of Mossbauer Effect, Classical and Quantum theories of Mossbauer Effect. Importance of Mossbauer Effect and its applications. (Ref: Solid state Physics by S.L.Gupta and V.Kumar ; Solid state Physics by R.L.Singahal)

3. Magnetic Resonance:

   Nuclear magnetic Resonance, Line width, Hyperfine Splitting, Nuclear Quadrupole Resonance, Ferromagnetic Resonance, Antiferromagnetic Resonance, Electron paramagnetic resonance. (Ref: Introduction to Solid state Physics by C.Kittel; Solid state Physics by R.L.Singhal)

Module – II

1. Protection of personnel against nuclear radiation –radiation monitoring and film badge technique. Application of radioisotopes in medicine – study of the function of thyroid gland using I-131 isotope – Use of radioisotopes in medical field to trace out restricted blood flow regions in the body, to trace out of the distribution of Fe and Vitamin B-12 in different body organs.

2. Radiation therapy: Tele therapy – Use of Cobalt -60 isotope in the treatment of cancerous tumors – dose depth relations –Therapeutic ratio – Fractionation – Oxygen effect – survival of patients. Brauchy therapy – Treatment of leukemia Use of high energy C – ions in the treatment of cancer.

3. Positron Emission Tomography (PET), Image analysis in brain SPECT and PET.

   Ref: Nuclear Medicine By J.H.Thrall and Harvvey V.Ziessman
   Text Book of Nuclear Medicine by John. Harbert and A.F.G.Rocha.