ARSD College, University of Delhi

Model Course Handout/Lesson Plan

Course Name : B.Sc. (Physics Sc. Electronics)						
Semester	**Course Code**	**Course Title**	**Lecture (L)**	**Tutorial (T)**	**Practical (P)**	**Credit (C)**
VI	**42227639**	**Nuclear and Particle Physics**	**75**	**15**	**-**	**6**
Teacher/Instructor(s)		**Mr Mohd Sadiq**				
Session		2021-22				

Course Objective:

The objective of the course is to impart the understanding of the subatomic particles and their properties. It will emphasize to gain knowledge about the different nuclear techniques and their applications in different branches Physics and societal application. The course will focus on the developments of problem-based skills.

Course Learning Outcomes:

At the end of this course, students will be able to develop following learning outcomes:

- To be able to understand the basic properties of nuclei as well as knowledge of experimental determination of the same, the concept of binding energy, its various dependent parameters, N-Z curves and their significance
- To appreciate the formulations and contrasts between different nuclear models such as Liquid drop model, Fermi gas model and Shell Model and evidences in support.
- Explain nuclear structure, binding energy, nuclear models and impossibility of an electron being in the nucleus as a consequence of the uncertainty principle.
- Understand radioactivity, radioactive decays, apply radioactive laws to solve related physics problems and Pauli's prediction of neutrino, and the subsequent discovery.
- Familiarization with different types of nuclear reactions, Q- values, compound and direct reactions.
- To know about energy losses due to ionizing radiations, energy losses of electrons, gamma ray interactions through matter and neutron interaction with matter. Through the section on accelerators students will acquire knowledge about Accelerator facilities in India along with a comparative study of a range of detectors and accelerators which are building blocks of modern-day science.

- It will acquaint students with the nature and magnitude of different forces, particle interactions, families of sub- atomic particles with the different conservation laws, concept of quark model.

Lesson Plan:

Unit No.	Learning Objective	Lecture No.	Topics to be covered
1.	General Properties of Nuclei	**1-3**	General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density
		4-5	matter density (experimental determination of each),
		5-6	binding energy, average binding energy and its variation with mass number,
		7-8	main features of binding energy versus mass number curve, N/Z plot
		9-10	angular momentum, parity, magnetic moment, electric moments
		Tutorial (1-2)	Discuss the problem of basic properties of nucleus, binding energy, momentum, parity, and different models of nucleus
2.	Nuclear Models	**11-12**	Nuclear Models: Liquid drop model approach
		13-15	semi empirical mass formula and significance of its various terms,

		16-17	condition of nuclear stability, nucleon separation energies (up to two nucleons),
		18-19	Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas),
		20-21	evidence for nuclear shell structure and the basic assumptions of shell model
		Tutorial 2-3	Discuss about nuclear shell structure and the basic assumptions of shell model
3.	Radioactivity decay	**22-23**	Radioactivity decay: Decay rate and equilibrium (Secular and Transient)
		24-25	(a) Alpha decay: basics of α-decay processes, theory of α-emission,
		26-27	Gamow factor, Geiger Nuttall law, αdecay spectroscopy, decay Chains.
		28-31	(b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis
			. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.
		Tutorial 4-5	Related Problem of Radioactivity decay

4.	Nuclear Reactions	**32-33**	Nuclear Reactions: Types of Reactions, units of related physical quantities
		34-36	Conservation Laws, kinematics of reactions,
		37-38	Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction,
		39	resonance reaction, Coulomb scattering (Rutherford scattering).
		Tutorial 6	Problem related to Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction
5.	Interaction of Nuclear Radiation with matter	**40-41**	Interaction of Nuclear Radiation with matter:
		42-43	Energy loss due to ionization (Bethe-Block

			formula),
		44-45	energy loss of electrons, Cerenkov radiation.
		46-48	Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.
		Tutorial 7-8	Discuss related to the interaction of Nuclear Radiation with matter
	Understand detector for Nuclear Radiations	**49-52**	Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter.
		53-54	Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT).
		55-57	Semiconductor Detectors (Si and Ge) for charge particle and photon detection (concept of charge carrier and mobility), neutron detector.
		Tutorial 9-10	Discuss of the brief of detector for Nuclear Radiations
	Understanding of particle Accelerators	**58-60**	Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator)

		61-62	Linear accelerator, Cyclotron, Synchrotrons
		63-64	Principal, construction, working, advantages, and disadvantages).
		Tutorial 11-12	Discuss on the Accelerator facility available in India and their related issues
6	Particle physics:	**65-67**	Particle physics: Particle interactions (concept of different types of forces) basic features,
		68-71	Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number,

		72-75	Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons
		Tutorial 13-15	Classification of Particle physics and related question

Evaluation Scheme:

No.	Component	Duration	Marks
1.	Internal Assessment • Quiz • Class Test • Attendance • Assignment		25
2.	End Semester Examination	3 hr	75

Details of the Course		
Unit	**Contents**	**Contact Hours**
1	General Properties of Nuclei: Constituents of nucleus and their Intrinsic properties, quantitative facts about mass, radii, charge density, matter density (experimental determination of each), binding energy, average binding energy and its variation with mass number, main features of binding energy versus mass number curve, N/Z plot, angular momentum, parity, magnetic moment, electric moments.	10

2	Nuclear Models: Liquid drop model approach, semi empirical mass formula and significance of its various terms, condition of nuclear stability, nucleon separation energies (up to two nucleons), Fermi gas model (degenerate fermion gas, nuclear symmetry potential in Fermi gas), evidence for nuclear shell structure and the basic assumptions of shell model.	11
3	Radioactivity decay: Decay rate and equilibrium (Secular and Transient) (a) Alpha decay: basics of α-decay processes, theory of α-emission, Gamow factor, Geiger Nuttall law, αdecay spectroscopy, decay Chains. (b) β- decay: energy kinematics for β-decay, β-spectrum, positron emission, electron capture, neutrino hypothesis. (c) Gamma decay: Gamma rays emission from the excited state of the nucleus & kinematics, internal conversion.	10
4	Nuclear Reactions: Types of Reactions, units of related physical quantities, Conservation Laws, kinematics of reactions, Q-value, reaction rate, reaction cross section, Concept of compound and direct reaction, resonance reaction, Coulomb scattering (Rutherford scattering).	8
5	Interaction of Nuclear Radiation with matter: Energy loss due to ionization (Bethe-Block formula), energy loss of electrons, Cerenkov radiation. Gamma ray interaction through matter (photoelectric effect, Compton scattering, pair production), neutron interaction with matter.	9
	Detector for Nuclear Radiations: Gas detectors: estimation of electric field, mobility of particle for ionization chamber and GM Counter. Basic principle of Scintillation Detectors and construction of photo-multiplier tube (PMT). Semiconductor Detectors (Si and Ge) for	9

	charge particle and photon detection (concept of charge carrier and mobility), neutron detector.	
	Particle Accelerators: Accelerator facility available in India: Van-de Graaff generator (Tandem accelerator), Linear accelerator, Cyclotron, Synchrotrons (Principal, construction, working, advantages and disadvantages)	7
6	Particle physics: Particle interactions (concept of different types of forces), basic features, Cosmic Rays, types of particles and its families, Conservation Laws (energy and momentum, angular momentum, parity, baryon number, Lepton number, Isospin, Strangeness) concept of quark model, color quantum number and gluons.	11
6	**Total**	**75**

Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1	Nuclear Physics by S N Ghoshal, First edition, S. Chand Publication, 2010.	2010
2	Introductory Nuclear Physics by K S Krane, Wiley-India Publication,	2008
3	Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication,	1999
4	Radiation detection and measurement, G F Knoll, John Wiley & Sons,	2010
5	Introduction to elementary particles by D J Griffiths, Wiley,	2008
6	Concepts of Modern Physics by Arthur Beiser, McGraw Hill Education,	2009

Mode of Evaluation:	Internal Assessment / End Semester Exam