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)**
IV	32221402	DSE-1A-Elements of Modern Physics	4	0	2	6
Teacher/Instructor(s)		Dr Anjani kumar Singh				
Session		2021-22				

Course Objective:

- The objective of this course is to teach the physical and mathematical foundations necessary for learning various topics in modern physics.
- Students also understanding atoms, molecules, photons, nuclei and elementary particles. These concepts are also important to understand phenomena in laser physics, condensed matter physics and astrophysics.

Course Learning Outcomes:

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

- This course will prepare the students to appreciate and comprehend the following aspects:
- Understand historical basis of quantum mechanics.
- Explain how quantum mechanical concepts answer some of unanswered questions of Classical mechanics such as photoelectric effect, Compton scattering etc.
- Explain inadequacy of Rutherford model, discrete atomic spectra from hydrogen like atoms and its explanation on quantum mechanical basis.
- Demonstrate ability to apply wave-particle duality and uncertainty principle to solve physics problems.
- Explain two slit interference experiment with photons, atoms and particles establishing non-deterministic nature of QM.
- Set up Schrodinger equation for behavior of a particle in a field of force for simple potential and find wave solutions establishing wave-like nature of particles.
- Demonstrate ability to solve 1-D quantum problems including the quantum particle in a box, a well and the transmission and reflection of waves.
- 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.

Lesson Plan:

Unit No.	Learning Objective	Lecture No.	Topics to be covered
1.	Birth of Quantum Mechanics and Matter waves	1-3	Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light;
		4-5	Blackbody Radiation: Quantum theory of Light;
		6-7	Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.
		8-10	Wave description of particles by wave packets. Group and Phase velocities and relation between them.
		11	Double slit experiment with electrons.
		12	Probability. Wave amplitude and wave functions.
2.	Position measurement	13	gamma ray microscope thought experiment;
		14-15	Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair 58 of variables:
		16-17	Derivation from Wave Packets; Impossibility of a particle following a trajectory;
		18	Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle:
		19	origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force
3.	Wave function	20-21	Two-slit interference experiment with photons, atoms and particles;
		22-23	linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles
		24-25	Momentum and Energy operators; stationary states; physical interpretation of a wave function,
		26-27	probabilities and normalization;
		28-29	Probability and probability current densities in one dimension.
4.	One dimensional infinitely rigid box LASER	30-31	energy eigenvalues, eigenfunctions and their;
		32-33	normalization
		34-35	Quantum dot as an example; Quantum mechanical scattering
		36-37	tunneling in one dimension : across a step potential
		38-39	rectangular potential barrier
		40-41	Metastable states. Spontaneous and Stimulated

			emissions.
		42-43	Optical Pumping and Population Inversion.
5.	Nuclear Physics	44	Size and structure of atomic nucleus
		45	relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle
		46	Nature of nuclear force, N-Z graph,
		47	Liquid Drop model:
		48	semi-empirical mass formula
		49	binding energy.
6.	Understand radioactivity	50	Radioactivity: stability of the nucleus
		51	Law of radioactive decay; Mean life and half-life
		52	Alpha decay; Beta decay: energy released
		53	Pauli's prediction of neutrino; Gamma ray emission,
		54	energy-momentum conservation
		55	electron-positron pair creation by gamma photons in the vicinity of a nucleus.
		56	Fission and fusion:
		57	mass deficit
		58	relativity and generation of energy
		59	Fission: nature of fragments
		60	emission of neutrons

Evaluation Scheme:

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

Details of the Course		
Unit	**Contents**	**Contact Hours**
1	Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. Wave description of particles by wave packets. Group and Phase velocities and relation between them. Doubleslit experiment with electrons. Probability. Wave amplitude and wave functions.	12
2	Position measurement : gamma ray microscope thought experiment; Wave-particle duality leading to Heisenberg uncertainty principle;	7

	Uncertainty relations involving canonical pair 58 of variables: Derivation from Wave Packets; Impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle: origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force	
3	Two-slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of a wave function, probabilities and normalization; Probability and probability current densities in one dimension.	10
4	One dimensional infinitely rigid box : energy eigenvalues, eigenfunctions and their normalization; Quantum dot as an example; Quantum mechanical scattering and tunneling in one dimension : across a step potential & across a rectangular potential barrier. Lasers: Metastable states. Spontaneous and Stimulated emissions. Optical Pumping and Population Inversion.	14
5	Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, N-Z graph, Liquid Drop model: semi-empirical mass formula and binding energy.	6
6	Radioactivity: stability of the nucleus; Law of radioactive decay; Mean life and half-life; Alpha decay; Beta decay: energy released, spectrum and Pauli's prediction of neutrino; Gamma ray emission, energy-momentum conservation: electron-positron pair creation by gamma photons in the vicinity of a nucleus. Fission and fusion: mass deficit, relativity and generation of energy; Fission : nature of fragments and emission of neutrons. Fusion and thermonuclear reactions driving stellar evolution (brief qualitative discussions).	11
6	**Total**	**60**

Suggested Books:

Sl. No.	Name of Authors/Books/Publishers	Year of Publication/Reprint
1	Concepts of Modern Physics, Arthur Beiser, McGraw-Hill	2002
2	Modern Physics by R A Serway, C J Moses and C A Moyer, 3rd edition, Thomson Brooks Cole,	2012.
3	Basic ideas and concepts in Nuclear Physics: An introductory approach by K Heyde, third edition, IOP Publication,	1999

4	Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn, Wiley	2002,
5	QUANTUM MECHANICS: Theory and Applications, (Extensively revised 6th Edition), Ajoy Ghatak and S. Lokanathan, Laxmi Publications, New Delhi	2019

Mode of Evaluation:	Internal Assessment / End Semester Exam

Progress Report:
Lesson Plan:

Unit No.	Learning Objective	Lecture No.	Topics to be covered
1.	Birth of Quantum Mechanics and Matter waves		Planck's quantum, Planck's constant and light as a collection of photons; Blackbody Radiation: Quantum theory of Light;
			Blackbody Radiation: Quantum theory of Light;
			Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment.
			Wave description of particles by wave packets. Group and Phase velocities and relation between them.
			Double slit experiment with electrons.
			Probability. Wave amplitude and wave functions.
2.	Position measurement		gamma ray microscope thought experiment;
			Wave-particle duality leading to Heisenberg uncertainty principle; Uncertainty relations involving canonical pair 58 of variables:
			Derivation from Wave Packets; Impossibility of a particle following a trajectory;
			Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle:
			origin of natural width of emission lines as well as estimation of the mass of the virtual particle that mediates a force from the observed range of the force
3.	Wave function		Two-slit interference experiment with photons, atoms and particles;
			linear superposition principle as a consequence; Schrodinger equation for non-relativistic particles
			Momentum and Energy operators; stationary states; physical interpretation of a wave function,
			probabilities and normalization;
			Probability and probability current densities in one dimension.
4.	One dimensional infinitely rigid box LASER		energy eigenvalues, eigenfunctions and their;
			normalization
			Quantum dot as an example; Quantum mechanical scattering
			tunneling in one dimension : across a step potential
			rectangular potential barrier
			Metastable states. Spontaneous and Stimulated

			emissions.
			Optical Pumping and Population Inversion.
5.	Nuclear Physics		Size and structure of atomic nucleus
			relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle
			Nature of nuclear force, N-Z graph,
			Liquid Drop model:
			semi-empirical mass formula
			binding energy.
6.	Understand radioactivity		Radioactivity: stability of the nucleus
			Law of radioactive decay; Mean life and half-life
			Alpha decay; Beta decay: energy released
			Pauli's prediction of neutrino; Gamma ray emission,
			energy-momentum conservation
			electron-positron pair creation by gamma photons in the vicinity of a nucleus.
			Fission and fusion:
			mass deficit
			relativity and generation of energy
			Fission: nature of fragments
			emission of neutrons