



Course Specification

(Postgraduate Programs)

Course Title: **Advanced Nuclear Physics**

Course Code: **PHYS 621**

Program: **Master of Science in Physics**

Department: **Physics**

College: **College of Sciences**

Institution: **Majmaah University**

Version: **1**

Last Revision Date: **30/12/2024**



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A. General information about the course:

1. Course Identification

1. Credit hours: (3)

2. Course type

A. University College Department Track-1 Others
B. Required Elective

3. Level/year at which this course is offered: (2nd/1)

4. Course general Description:

This course provides an in-depth exploration of nuclear structure, reactions, and models, with emphasis on modern theoretical and experimental approaches. It prepares students for research in atomic physics and related fields.

5. Pre-requirements for this course (if any):

Advanced Quantum Mechanics, PHYS 612
Electrodynamics, PHYS 613

6. Co-requisites for this course (if any):

NA

7. Course Main Objective(s):

- Understand advanced models of nuclear structure.
- Analyze nuclear reactions and decay mechanisms.
- Apply quantum mechanics to nuclear systems.
- Interpret experimental data and theoretical predictions.
- Explore applications of energy.

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	45	100%
2	E-learning		
3	Hybrid <ul style="list-style-type: none"> • Traditional classroom • E-learning 		
4	Distance learning		



3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	45
2.	Laboratory/Studio	
3.	Field	
4.	Tutorial	
Total		45

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	Explain the theoretical foundations of nuclear models, including shell, liquid drop, and collective models.	K1	Lectures, Teamwork, Discussions, Exercises, Quizzes, Problem-solving	Exams, Quizzes, Homework, Assignments
1.2	Analyze complex nuclear phenomena, such as decay chains and reaction mechanisms, using advanced principles of physics.			
1.3	Formulate nuclear physics problems by identifying relevant forces, symmetries, and conservation laws.	K4		
1.4	Evaluate nuclear reaction scenarios by applying appropriate approximations and boundary conditions.			
2.0	Skills			
2.1	Design and execute nuclear physics	S1	Lectures, Teamwork,	Exams, Quizzes,



	experiments using appropriate instrumentation and techniques.		Discussions, Exercises, Quizzes, Problem-solving	Homework, Assignments
2.2	Analyze experimental data to validate nuclear models and interpret physical outcomes.			
2.3	Solve nuclear physics problems using analytical methods such as perturbation theory and scattering theory.	S3		
2.4	Apply computational tools (e.g., MATLAB or Python) to simulate nuclear interactions and visualize the results.			
3.0	Values, autonomy, and responsibility			
3.1	Collaborate in teams to conduct nuclear physics research and present findings.	V1	<ul style="list-style-type: none"> • Discuss with students to make them aware of time management so they can complete their assignments. • Encourage students to help each other. • Group presentation/ assignments 	Exams, Quizzes, Homework, Assignments, Evaluation of group reports and individual contributions within the group
3.2	Demonstrate initiative and responsibility in individual research tasks and assignments.			
3.3	Plan and manage time effectively to meet deadlines for experiments, reports, and presentations.	V3		
3.4	Prioritize tasks and balance workload across multiple course components and research activities.			



C. Course Content

No	List of Topics	Contact Hours
1.	Reaction mechanisms: Types of nuclear reactions, Conserved Quantities in Nuclear Reactions, Reaction Kinematics, Nuclear Reactions Under Parity Conservation, Isospin in Nuclear Reactions, Exchange Symmetry in Nuclear Reactions of Identical Particles ,Time-Reversal Invariance.	6
2.	Cross Sections: Rutherford Scattering, Rutherford Scattering Cross Section, Consequences of the Rutherford Experiments, Quantum-Mechanical Derivation of Rutherford's Formula, Deviations from the Rutherford Formula ,Nuclear Radii from Deviations from Rutherford Scattering, Coulomb Scattering from an Extended Charge Distribution, Electron Scattering, Neutron Skins and Halo Nuclei.	6
3.	Qualitative features of nuclear reactions: Compound nucleus formation and direct reactions, Compound resonances, Reaction times, Energy spectra, Branching ratios, Coulomb effects, Giant resonances, and strength functions, Cross-section fluctuations, Some characteristics of heavy-ion reactions.	6
4.	Elementary Scattering Theory: Form of the wave function, laboratory and center-of-mass systems, the scattered waves, Differential cross-sections, coupled equations form of the Schrodinger equation, the Born and the distorted-wave Born approximations.	6
5.	Partial waves: Significance of partial waves, Partial wave expansions, Scattering matrix and phase shifts, Phase shifts for potential scattering, Partial wave expression for scattering amplitudes, Partial wave expressions for cross-sections.	6
6.	Classical and semi-classical descriptions of scattering: Classical elastic scattering of particles, Semi-classical treatments: The WKB approximation, The eikonal approximation.	6
7.	Models of Nuclear Reactions: (Direct reactions): Plane-wave Born approximation, Distorted-wave Born approximation, Inelastic scattering, Stripping and pick-up reactions, Knock-out reactions, (Compound-Nucleus (CN-Reactions) :(Simple theory of a resonant cross-section , Resonances with charged particles.	9
Total		45

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	First Mid exam	7	15%
2.	Second Mid Exam	12	15%
3.	Quizzes	5, 11	10%





4.	Assignments	Weekly	10%
5.	Presentation/Project	13	10%
6.	Final exam	End of the semester	40%

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	1. Nuclear and Particle Physics, 3rd, Brian R. Martin, Graham Shaw, Wiley 2019
Supportive References	2. Introduction to Nuclear Reactions, 2nd edition, G.R. Satchler, Palgrave, 1990 3. Nuclear Reactions: An Introduction, Hans Paetz gen. Schieck, Springer-Verlag Berlin Heidelberg, 2014
Electronic Materials	4. Saudi Digital Library (SDL) 5. https://www.wikipedia.org/ 6. Web of Knowledge 7. Physics Today (web version) 8. MIT Courseware 9. www.eagle.co.uk/news/ppnews.html 10. http://faculty.mu.edu.sa/mskhan 11. http://vlib.org/physics.html 12. http://dir.yahoo.com/science/physics 13. http://demonstrations.wolfram.com 14. http://askthephysicist.com 15. http://cyberphysics.co.uk
Other Learning Materials	16. J. Radiation Measurements 17. J. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment. (NIM A) 18. J. Radiation Physics and Chemistry 19. Excel software for drawing graphs. 20. MS Office for writing reports and presentations.

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Lecture room with at least 25 seats.
Technology equipment (projector, smart board, software)	A smart board





Other equipment
(depending on the nature of the specialty)

Library, Seminar Room, Wi-Fi internet connections, whiteboard

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Internal Reviewer Committee	Direct
Effectiveness of Students assessment	Students	Indirect
Quality of learning resources	Peer Reviewer	Direct
The extent to which CLOs have been achieved	Internal Reviewer Committee	Direct

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify))

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16
DATE	30/12/2024

