Course Specification

(Postgraduate Programs)

Course Title:	Advanced Nuclear Physics
Course Code:	PHY 6171
Program:	Master of Science in Physics
Department:	Physics
College:	Science
Institution:	Imam Mohammad Ibn Saud Islamic University
Version:	3
Last Revision Date:	*26/09/2024*

Table of Contents

A. General information about the course:

1. Course Identification:

1. Credit hours: 4				
2. Course type				
A.	☐ University	☐ College	☒ Department	☐ Track
B.	☒ Required		☐ Elective	
3. Level/year at which this course is offered: Level 2/Year 1				
4. Course General Description:				
This course introduces basics of nuclear physics, including nuclear decays and reactions and nuclear structure. It also covers the essential areas of basic research and practical applications with emphasis on phenomenology and the results of real experiments. Discussions of theory are reinforced with examples, which illustrate and apply the theoretical formulism. As an advanced course in Nuclear Physics, it allows for an extended and more in-depth presentation of the major scientific and technological advances in modern day research both in nuclear physics and astrophysics.				
5. Pre-requirements for this course (if any): None				
6. Pre-requirements for this course (if any): None				
7. Course Main Objective(s):				

At the end of this course, students will be able to:

- **Understand the theoretical properties of the nucleus, nuclear force, structure and models.**
- **Evaluate nuclear conserved quantities, symmetries, spin and magnetic moment.**
- **Understanding the nuclear transformations, radioactive decay and Fermi theory of beta decay.**
- **Learn the basic principles of neutron cross sections, Kinematics of elastic scattering.**
  Gain a thorough understanding of angular and energy distributions, nuclear reaction energetic, compound nucleus models.

2. Teaching Mode: (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	75	100%
2	E-learning		
3	Hybrid • 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**	**0**
3.	**Field**	**0**
4.	**Tutorial**	**30**
5.	**Others (specify)……**	**0**
	Total	**75**

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

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Interpret the concepts of nuclear physics and their governing laws.**	**K1**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Participation. ▪ Discussions.
1.2	**Describe the background and main features of physical properties of the nucleus, nuclear force, structure and models, conserved quantities, symmetries, spin and magnetic**	**K1, K3**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
	moment, electric quadruple moment, nuclear.			
1.3	**Explain the historical importance of scattering, ground state of the deuteron, s-wave n-p scattering, nuclear transformations, bound states.**	**K1, K2**	• Lectures. • Class discussions. • Tutorials.	▪ Participation. ▪ Exams. ▪ Discussions. ▪ Homework.
1.4.	**Discuss physical phenomena kinematics of elastic scattering, angular and energy distributions, nuclear reaction energetic, compound nucleus model.**	**K1**	• Lectures. • Tutorials. • Class discussions.	▪ Exams. ▪ Homework. ▪ Quizzes.
2.0	**Skills**			
2.1	**Explain and summarize the basic knowledge gained from studying nuclear physics course.**	**S1, S2**	• Lectures. • Class discussions. • Tutorials.	▪ Exams. ▪ Discussions. ▪ Participation.
2.2	**Develop the students ability to solve and analyze problems in physics related the topics covered by the course.**	**S2, S3**	• Problem classes and group tutorial. • Homework assignments as well as problems solutions.	▪ Exams. ▪ Discussions. ▪ Homework.
2.3	**Communicate in a clear and concise manner orally, and using IT for acquiring and analyzing information.**	**S4**	• Lectures. • Class discussions. • Tutorials. • Encourage students to use electronic mail and internal network for submitting homework and assignments. • Use digital library.	▪ Exams. ▪ Participation and activities of students in the course community and blackboard. ▪ Homework.
3.0	**Values, autonomy, and responsibility**			
3.1	**Show the collaboration and inter-professionalism in class discussions or team works, as**	**V1, V2, V3**	• Small team tasks • Open discussion at classroom.	▪ Participation ▪ Homework. ▪ Mini-project(s).

Code	Course Learning Outcomes	Code of PLOs aligned with the program	Teaching Strategies	Assessment Methods
	well as solve problems independently.		• Office hours.	

C. Course Content:

No	List of Topics	Contact Hours
1.	**Basic Concepts:** History and overview, Some introductory Terminology, Nuclear properties, Units and dimensions.	5
2.	**Elements of Quantum Mechanics:** Quantum behavior, Principles of quantum mechanics, Problems in one dimension, Problems in three dimensions, Quantum theory of angular momentum, Parity, Quantum statistics, Transitions between states.	8
3.	**Nuclear Properties:** Nuclear radius, Mass & abundance of nuclides, Nuclear binding energy, Nuclear angular momentum, Parity, Nuclear electromagnetic moments.	8
4.	**Nuclear Models:** The shell model, Even-Z, Even-N nuclei and collective structure, More realistic nuclear models.	8
5.	**Radioactive Decay:** The radioactive decay law, Production and decay of radioactivity, Growth of daughter activities, Types of decays, Natural radioactivity, Radioactive dating, Units for measuring radiation.	8
6.	**Alpha Decay:** Why alpha decay occurs, Basic alpha decay processes, Alpha decay systematic, Angular momentum and parity in alpha decay.	8
7.	**Beta Decay:** Energy release in β decay, The "classical" experimental tests of the Fermi theory, Angular momentum & parity selection rules, Comparative half-lives & forbidden decays.	6
8.	**Gamma Decay:** Energetic of gamma decay, Classical electromagnetic radiation, Angular momentum and parity selection rules, Angular distribution and polarization measurements, Internal conversion, Lifetimes for gamma emission.	6
9.	**Nuclear Reactions:** Types of reactions and conservation laws, Energetic of nuclear reactions, Isospin, Reactions cross sections, Experimental techniques, Coulomb scattering, Nuclear scattering, Compound-nucleus reactions, Direct reactions.	6
10.	**Nuclear Fission:** Why nuclei fission, Characteristics of fission, Energy in fission, Controlled fission reactions, Fission reactors, Fission explosives.	6
11.	**Nuclear Fusion:** Basic fusion processes, Characteristics of fusion, controlled fusion reactions, Thermonuclear weapons.	6
	Total	**75**

D. Students Assessment Activities:

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Class Activities (class quizzes, homework, solving problems, etc.....)	weekly	20 %
2.	Midterm Exam 1	6th week	20 %
3.	Midterm Exam 2	12th week	20 %
4.	Final Exam	16 thweek	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	*-K.S. Krane, Introductory Nuclear Physics, Wiley, 1988.*
Supportive References	*-W.E. Burcham, M. Jobes, Nuclear and Particle Physics, 2nd Edition, John Wiley & Sons Inc, 1995.* *-R.D. Evans, The Atomic Nucleus, McGraw-Hill Publishing Company Ltd, 1955.* *-A. Guran, M. Cloud, W.B. Zimmerman, The Quantum World of Nuclear Physics, World Scientific, 2005.*
Electronic Materials	https://units.imamu.edu.sa/colleges/en/science/Pages/default.aspx
Other Learning Materials	Multimedia associated with the textbook and the relevant websites.

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	- Classrooms.
Technology equipment (Projector, smart board, software)	- Classroom equipped with a whiteboard and a projector.
Other equipment (Depending on the nature of the specialty)	

F. Assessment of Course Quality:

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	- Students. - Second examiner	Indirect (The student will complete evaluation forms at the end of semester. Final exam is evaluated by the second examiner)
Effectiveness of students' assessment	- Instructors	Direct (exams, HW, project, ...)
Quality of learning resources	- Faculty - Students	Indirect (surveys)
The extent to which CLOs have been achieved	- Instructors - Program Leaders	Direct (excel sheet)
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval Data:

COUNCIL /COMMITTEE	Quality Unit-Physics Department
REFERENCE NO.	Department council No. 6
DATE	26/09/2024