هيئة تقويم التعليم والتدريب
Education & Training Evaluation Commission

T-104
2022

Course Specification

Course Title:	**Nuclear Physics II**
Course Code:	**462PHYS**
Program:	**Physics**
Department:	**Physics**
College:	**Science**
Institution:	**Jazan University**
Version:	**2022**
Last Revision Date:	**20 December 2022**

Table of Contents:

A. General information about the course:

Course Identification					
1. Credit hours:	4				
2. Course type					
a.	University ☐	College ☐	Department☒	Track☐	Others☐
b.	Required ☒	Elective☐			
3. Level/year at which this course is offered: 12/4					

4. Course General Description

This is an advanced course offered to the 8th-level senior undergraduate students at Jazan University to complete their basic training in nuclear and particle physics (in continuation with the 461PHYS course). This comprehensive and quite involved course covers the interaction of particles and radiation with matter (via energy loss in media), particle detectors, particle accelerators, particle families and the standard model as the main chapters in this course. The learning outcome of this course is to get students acquainted with the particle types and their interactions (based on their identifications, charge, and mass, such as the electron, proton, alpha, photon etc.) with the matter. These interactions are measured by an electronic device named a detector. Students learn the theoretical aspects of detector physics, their development, and their work. To produce the particles in the laboratory, we need high-energy particle accelerators. Students are taught the basic design of these accelerators and their working principles and mechanisms. Students also learn elementary particles based on their spin, charge, mass, and lifetime. Finally, they will learn the Standard Model briefly that describes the elementary particles and their fundamental interactions (under the framework of QED, EW and QCD theories) that shape our known universe. Students must also perform the practical classes (labs) concerning the course contents.

5. Pre-requirements for this course (if any):461Phys

6. Co- requirements for this course (if any): None

7. Course Main Objective(s)

This course is designed to provide students with the following:

- The fundamentals of particle and radiation interaction with matter, particle detection, acceleration, particle zoo and the standard model of elementary particles.
- Knowledge of how the particle detectors and accelerators are designed and familiarity with the modern cutting-edge technologies and advanced research in nuclear and particle physics fields.
- Explanation of particle classifications and the corresponding theoretical model.

Demonstration of concepts concerning the course employing practical classes.

1. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1.	Traditional classroom	**60**	**91%**
2.	E-learning		
3.	Hybrid • Traditional classroom • E-learning	**6**	**9%**
4.	Distance learning		

2. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	Lectures	30
2.	Laboratory/Studio	33
3.	Field	0
4.	Tutorial	3
5.	Others (specify)	0
	Total	66

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

Code	Course Learning Outcomes	Code of CLOs aligned with the program	Teaching Strategies	Assessment Methods
1.0	Knowledge and understanding			
1.1	**Define** the Bethe-Bloch formula, the Standard Model (SM), CPT Theorem, Gell-Mann-Nishijima Formula, Bremsstrahlung, cross-section, stopping power/energy loss.	**PLO1.1**	Lectures, blackboard and visualization, group and interactive guided discussion, Interactive discussion	**Direct:** (formative and summative): In-class interactive questioning, quizzes, written exams

Code	Course Learning Outcomes	Code of CLOs aligned with the program	Teaching Strategies	Assessment Methods
				Indirect: Student Survey
1.2	<u>**Describe**</u> charged particle interaction pathways, photon interaction with matter, neutron interaction with matter; various ionization/ scintillation/ semiconductor/ calorimeter detectors, Photomultiplier tube and Geiger-Muller counter; weak & electromagnetic interactions, quark content of mesons and baryons, principles of electrostatic and resonance accelerators; charge, spin, strangeness in particle decay, and violation of quantum number in the radioactive decays, symmetries, and color quantum number.	**PLO1.1**	Lectures, blackboard and visualization, group and interactive guided discussion, Interactive discussion	**Direct:** (formative and summative): In-class interactive questioning, quizzes, written exams **Indirect:** Student Survey
1.3	<u>**Discuss**</u> the Quark model for mesons and baryons, ionization, scintillation, time of flight, parity, QCD (Quantum Chromodynamics) and confinement, charge, spin, strangeness in particle decay, and violation of quantum number in the radioactive decays, symmetries, and color quantum number.	**PLO1.2**	Lectures, blackboard and visualization, group and interactive guided discussion, Interactive discussion, Colored ball and stick model for quark model visualization	**Direct:** (formative and summative): In class interactive questioning, quizzes, written exams **Indirect:** Student Survey
2.0	Skills			
2.1	<u>**Solve**</u> problems in particle's energy and range in the collision with the matter, photoelectric effect, Compton effect, pair production, flight time and the corresponding velocities for	**PLO2.1**	Lectures, blackboard, and visualization, brainstorming, group and interactive discussion, Interactive	**Direct:** (formative and summative): In class interactive questioning,

Code	Course Learning Outcomes	Code of CLOs aligned with the program	Teaching Strategies	Assessment Methods
	collisions, FWHM, range of alpha and beta in media, and Lorentz force calculation.		illustration, Problem-based Learning	quizzes, written exams **Indirect:** Student Survey
2.2	**Demonstrate** centre of mass-energy in the colliding beams, the Baryon Octet and Decuplet symmetries with examples, plotting a GM plateau, plotting a γ spectrum, Inverse Square Law. Show competencies in communication, critical thinking and reporting during lab work, interactive discussion and group assignments.	**PLO2.2**	Lab work and demonstrations, Blackboard lectures and visualization, group and interactive guided discussion, Interactive discussion. Movies, Group Assignments	**Direct:** (formative and summative): In-class interactive questioning, quizzes, written exams **Indirect:** Student survey
2.3	**Perform** laboratory experiments included in this course.	**PLO2.3**	Lab Lectures, Blackboard lectures and visualization, brainstorming, group and interactive discussion, Interactive illustration, Problem-based Learning	**Direct:** (formative and summative): In class interactive questioning, quizzes, written exams **Indirect:** Student Survey
2.4	**Develop** competency in understanding detector, accelerator and particle classifications based on their generation and properties.	**PLO2.4**	Lectures, blackboard, and visualization, brainstorming, group and interactive discussion, Interactive illustration, Problem-based Learning	**Direct:** (formative and summative): In class interactive questioning, quizzes, written exams **Indirect:** student Survey
3.0	Values, autonomy, and responsibility			

Code	Course Learning Outcomes	Code of CLOs aligned with the program	Teaching Strategies	Assessment Methods
3.1	**Show** the paradigm of collaboration with effective collaboration, demonstrating the important skills of working in groups while taking responsibility for individual tasks during group assignments and lab work and practising safety awareness in the lab.	**PLO3.1**	Interactive and Group discussion, expository and discovery teaching	**Direct:** (formative and summative): In-class interactive questioning, quizzes, written exams **Indirect:** Student Survey

C. Course Content

No	List of Topics	Contact Hours
1.	**Energy Deposition in Media:** - Introduction - Charged particle's interaction with matter - Bethe Bloch formula - Energy loss through bremsstrahlung - Photon interaction with matter - Photoelectric, Compton and pair production mechanism - Interaction of neutrons with matter Interaction of hadrons with matter (briefly)	6
2.	**Particle Detection:** - Introduction - Ionization detectors - Ionization counters, proportional counters and Geiger Muller counters - Scintillation detectors - Time of Flight - Cherenkov detectors - Semiconductor detectors6 - Calorimeters - Layer detectors (e.g., ATLAS, CMS at CERN)	6

3.	**Accelerators:** - Introduction - Electrostatic accelerators - Resonance accelerators - Synchronous accelerators - Phase stability, strong focusing and colliding beam - Large Hadron Collider at CERN (basic information from the web)	6
4.	**Properties and Interactions of Elementary Particle:** - Introduction - Four basic forces - Elementary particles (their history) - Quantum number (Baryon, lepton, strangeness, isospin etc.) - Gell-Mann-Nisjijima relation - Production and decay of resonances - Violation of quantum numbers - Weak interaction (Hadronic weak decays, semi-leptonic processes etc.) - Electromagnetic interaction - Symmetries - Parity - Time Reversal - CPT theorem	9
5.	**Formulation of the Standard Model:** - Introduction - Quarks and leptons - Quark content of mesons - Quark content of baryons - Color quantum number - Quark model for mesons and baryons - Valance and sea quarks in hadrons Chromodynamics and confinement	6
Total		33

Experimental Part:

No	List of Topics	Contact Hours
1	Plotting a GM Plateau	**3**
2	Geiger Tube Efficiency	**3**
3	Inverse Square Law	**3**
4	Absorption of Gamma Rays	3
5	Backscattering of Gamma Rays	**3**
6	Determining the half-life of Ba-137	**3**
7	Recording and calibrating a γ spectrum	**3**
8	Detection Efficiency of a NaI(Ti) Detector	**3**
9	Calculation of β/ϒ ratio	**3**
Total		27

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Homework assignment- Contribution to interactive discussion	2	2 % (2)
2.	1 Quiz	4	2 % (2)
3.	Homework assignment- Contribution to the interactive discussion	5	2 % (2)
4.	Midterm-Exam	6	15 % (15)
5.	Quiz 2	7	2 % (2)
6.	Homework assignment- Contribution to the interactive discussion- Group work essay or Project discussion	7	2 % (2)
7.	Laboratory Work	11	25 % (25)
8.	Final Examination	12	50 % (50)

*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	**Introduction to Nuclear and Particle Physics; A. Das and T. Ferbel (World Scientific Publishing, 2005).**
Supportive References	Radiation Detection and Measurement; G. Knoll (John Wiley & Sons, 2000). Nuclear Physics; Irving Kaplan (Addison-Wesley Publishing Company, Cambridge, Mass, 1962).
Electronic Materials	Particle Data Book (Online): http://pdg.lbl.gov
Other Learning Materials	CERN http://cern.ch JLab http://jlab.org

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom
Technology equipment (projector, smart board, software)	Multimedia Projector
Other equipment (depending on the nature of the specialty)	Nuclear Physics Laboratory

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students, Peers, and Program Leader	Indirect (CES)- Indirect peer evaluation
Effectiveness of students assessment	Students, Program assessment committee	Direct/Indirect
Quality of learning resources	Instructor	Direct/Indirect
The extent to which CLOs have been achieved	Students, Faculty members	Indirect (CES)- Indirect peer evaluation
Other		

Assessor (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)
Assessment Methods (Direct, Indirect)

G. Specification Approval Data

COUNCIL /COMMITTEE	DEPARTMENT BOARD
REFERENCE NO.	PHYS2304
DATE	28/2/2023