Form: **Course Syllabus**	**Form Number**	EXC-01-02-02A
	Issue Number and Date	2/3/24/2022/2963 05/12/2022
	Number and Date of Revision or Modification	
	Deans Council Approval Decision Number	2/3/24/2023
	The Date of the Deans Council Approval Decision	23/01/2023
	Number of Pages	06

1.	**Course Title**	Nuclear Physics - 2
2.	**Course Number**	0302963
3.	**Credit Hours (Theory, Practical)**	(3,0)
	Contact Hours (Theory, Practical)	(3,0)
4.	**Prerequisites/ Corequisites**	Department of Physics Agreement
5.	**Program Title**	PhD in Physics
6.	**Program Code**	9
7.	**School/ Center**	3
8.	**Department**	2
9.	**Course Level**	10
10.	**Year of Study and Semester (s)**	5, 10
11.	**Other Department(s) Involved in Teaching the Course**	None
12.	**Main Learning Language**	English
13.	**Learning Types**	☒Face to face learning ☐Blended ☐Fully online
14.	**Online Platforms(s)**	☐Moodle ☒Microsoft Teams
15.	**Issuing Date**	
16.	**Revision Date**	2019

17. Course Coordinator:

Name: Prof. Mahmoud Jaghoub	Contact hours: 9:30 – 10:30 Mondays, Tuesdays, Thursdays
Office number: 312	Phone number: 0799955469
Email: mjaghoub@ju.edu.jo	

18. Other Instructors:

Name: **None**

Office number: --

Phone number: --

Email: --

Contact hours: --

Name: --

Office number: --

Phone number: --

Email: --

Contact hours: --

19. Course Description:

Theories of Beta and Gamma Decays. Nuclear Models: Vibrational Model, Nuclear Deformation, Deformation Parameters, Rotational Model. Nuclear Reactions: Conservation Laws, Kinematics, Resonances; Compound Nucleus: Formation and Decay, Optical Potential. Theory of Direct Reactions, Heavy Ion Reactions, Fission, Mass Distribution of Fission Fragments, Neutrons Emitted in Fission, Cross Section for Fission.

20. Program Intended Learning Outcomes: (To be used in designing the matrix linking the intended learning outcomes of the course with the intended learning outcomes of the program)

SO1: to be able to demonstrate an advanced and comprehensive understanding of core physics concepts and specialized knowledge in a chosen field of research, contributing to the frontier of physics.

SO2: to be able to develop and execute independent, original research projects that address complex scientific problems, advancing theoretical and experimental physics.

SO3: to be able to apply advanced mathematical and computational techniques to analyze complex physical phenomena and critically evaluate scientific literature and experimental results.

SO4: to be able to effectively communicate complex physics concepts, research findings, and their significance through academic writing, presentations, and public outreach.

SO5: to be able to adhere to high ethical standards and professional responsibility in conducting research, including data integrity, ethical treatment of subjects, and the responsible use of resources.

SO6: to be able to demonstrate leadership and collaborative skills within multidisciplinary teams, contributing to the development of new scientific knowledge and promoting knowledge-sharing across disciplines.

SO7: to be able to cultivate the ability to adapt to new scientific advancements and continuously engage in professional development to contribute to innovation in the field of physics.

SO8: to be able to master experimental and computational techniques relevant to the research field, demonstrating competency in operating and developing specialized physics instrumentation and software.

21. Course Intended Learning Outcomes: (Upon completion of the course, the student will be able to achieve the following intended learning outcomes)

1. Apply the Fermi theory of beta decay to interpret decay rates and the role of weak interactions.
2. Analyze gamma decay processes, know the characteristics of gamma rays, and explain their relation to nuclear energy levels and transitions.
3. Compare and contrast the vibrational and rotational models of the nucleus and assess their validity in describing nuclear structure.
4. Describe the concept of nuclear deformation and explain how deformation parameters are used to characterize nuclear shapes and energy states.
5. Apply the rotational model of the nucleus to explain nuclear spin and parity, and to predict the energy levels of deformed nuclei.
6. Apply the conservation laws in nuclear reactions.
7. Derive and interpret the kinematics of nuclear reactions.
8. Analyze the experimental evidence supporting direct reaction models and apply the principles to interpret data from nuclear reactions.
9. Use the optical potential to describe the interaction between an incident particle and the target nucleus.
10. Analyze the outcomes of heavy ion reactions, including fusion, fission.
11. Explain the process of nuclear fission, including the mechanisms that lead to the fission of heavy nuclei.
12. Understand the neutron emission in fission and its significance for chain reactions and nuclear reactors.

Course ILOs	The learning levels to be achieved					
	Remembering	Understanding	Applying	Analysing	evaluating	Creating
1		X	X			
2		X		X	X	
3				X	X	
4				X		X
5			X		X	X
6		X	X		X	
7				X		X
8			X	X	X	X
9			X	X	X	
10				X	X	
11		X	X	X	X	
12		X		X		
13		X	X			

2٢. The matrix linking the intended learning outcomes of the course with the intended learning outcomes of the program:

Program ILOs / Course ILOs	ILO (1)	ILO (2)	ILO (3)	ILO (4)	ILO (5)	ILO (6)	ILO (7)	ILO (8)
1	X		X	X				
2	X			X				
3				X	X		X	
4	X	X	X					

5	X		X		X	X		X
6	X			X		X		
7	X					X		X
8			X	X			X	
9		X	X		X			
10			X	X	X	X		
11	X			X		X		X
12		X				X	X	X

2٣. Topic Outline and Schedule:

Week	Lecture	Topic	ILO/s Linked to the Topic	Learning Types (Face to Face/ Blended/ Fully Online)	Platform Used	Synchronous / Asynchronous	Evaluation Methods	Learning Resources
1	1.1	Vibrational model	3	Face to Face (For All)	Microsoft Teams and E-learning (For All)		Assignments, Presentations, Written Exams (For All)	
	1.2	Modes of nuclear vibrations	3					
	1.3	Phonons	3					
2	2.1	Possible states of two phonons	3					
	2.2	Deformation parameters	4					
	2.3	Use of deformation parameters to describe nuclear structure	3, 4					
3	3.1	Rotational model	5					
	3.2	Describing nuclear structure and identify	3. 4, 5					

		energy levels depending on deformation parameters and vibrational and/or rotational models							
	3.3	Assigning nuclear spin and parity for nuclear energy levels	1						
4	4.1	Fermi theory	1						
	4.2	Fermi transitions	1						
	4.3	Gamow-Teller transitions	1						
5	5.1	Applying the Selection rules	1						
	5.2	Quantization of electromagnetic fields	2						
	5.3	Interaction of radiation with matter	2						
6	6.1	Quantum and classical transition rates.	2						
	6.2	Selection rules	2						
	6.3	Factors affecting transition rates	2						
7	7.1	Discussing solutions to assignments	1,2						
	7.2	Nuclear reactions: Conservation laws	6						
	7.3	Understanding the concept of Resonances and its importance in nuclear reactions.	7,8						
8	8.1	Compound nucleus formation and modes of decay of the compound nucleus	8,9						
	8.2	Hypothesis of independence related to the decay mode of the compound nucleus	8,9						
	8.3	Optical potential	8						
9	9.1	Average properties of the nucleus described using the optical potential	8						

	9.2	Main terms of the optical potential	8					
	9.3	Importance of the real and imaginary terms of the optical potential	8, 9					
10	10.1	Optical potential: Direct reactions	8, 9					
	10.2	Optical potential: Compound nucleus	8,9					
	10.3	Heavy-ion reactions	9					
11	11.1	Discussing solutions to assignments	8,9					
	11.2	Nuclear reactions: Fission	10					
	11.3	Mechanisms leading to nuclear fission	10					
12	12.1	Mass distribution of fission fragments	10, 11					
	12.2	Factors affecting fission cross sections	11					
	12.3	Neutrons emitted in fission: Prompt neutrons, Delayed neutrons	11					
13	13.1	Discussing solutions to assignments						
	13.2	Group reflection on all the topics of the course						
	13.3	Group discussion of possible applications/implementation of the material to real life applications						
14	14.1	Presentation week: Students present their projects in front of the class						
	14.2							
	14.3							
15	15.1	Final written Exam						
	15.2							
	15.3							

2٤. Evaluation Methods:

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment methods and requirements:

Evaluation Activity	Mark	Topic(s)	ILO/s Linked to the Evaluation activity	Period (Week)	Platform
Assignments	20	All	All	At the end of each chapter	E-learning, MS Teams, Paper
Presentations	20	Chosen by the student and approved by the instructor	Depends on the chosen topic	Week 14	Face to Face
Mid-term written Exam	20	Material covered in the first 6 weeks	1, 2, 3, 4 and 5	Week 8	Face to Face
Final written Exam	40	All the material	1 to 12	Week 15	Face to Face

2٥. Course Requirements:

(e.g.: students should have a computer, internet connection, webcam, account on a specific software/platform…etc.):

Computer with internet connection and installed MS teams.

2٦. Course Policies:

A- Attendance policies: As per University regulations

B- Absences from exams and submitting assignments on time: As per University regulations

C- Health and safety procedures: As per University regulations

D- Honesty policy regarding cheating, plagiarism, misbehavior: As per University regulations

E- Grading policy: Assignments 20, Presentations 20, Mide-term exam 20, Final exam 40.

F- Available university services that support achievement in the course: Library, Computer labs, internet connction.

2٧. References:

A- Required book(s), assigned reading and audio-visuals:

Nuclear Physics in a Nutshell, C. A. Bertulani, Princeton University Press, 2007

B- Recommended books, materials, and media:

- Nuclear Structure volume I: single-particle motion, A. Bohr, B. Mottelson, World Scientific Publishing Co. Pte. Ltd.
- Nuclear Structure volume I: nuclear deformations, A. Bohr, B. Mottelson, World Scientific Publishing Co. Pte. Ltd.
- Introductory Nuclear Physics, S. M. Wong, Second Edition, Wiley-VCH, Verlag GmbH & Co. KGaA, 2004.

2٨. Additional information:

Name of the Instructor or the Course Coordinator:	Signature: M. Jaghoub	Date:
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Name of the Head of Quality Assurance Committee/ Department	Signature:	Date:
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Name of the Head of Department	Signature:	Date:
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Name of the Head of Quality Assurance Committee/ School or Center	Signature:	Date:
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Name of the Dean or the Director	Signature:	Date:
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