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**	Many Body Theory
2.	**Course Number**	0302957
3.	**Credit Hours (Theory, Practical)**	3
	Contact Hours (Theory, Practical)	0
4.	**Prerequisites/ Corequisites**	-
5.	**Program Title**	PhD
6.	**Program Code**	021
7.	**School/ Center**	Faculty of Science
8.	**Department**	Physics
9.	**Course Level**	Graduate
10.	**Year of Study and Semester (s)**	
11.	**Other Department(s) Involved in Teaching the Course**	
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**	

17. Course Coordinator:

Name:	Contact hours:
Office number:	Phone number:
Email:	

18. Other Instructors:

Name:

Office number:

Phone number:

Email:

Contact hours:

Name:

Office number:

Phone number:

Email:

Contact hours:

19. Course Description:

As stated in the approved study plan.

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)

1. **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.
2. **SO2:** to be able to develop and execute independent, original research projects that address complex scientific problems, advancing theoretical and experimental physics.
3. **SO3:** to be able to apply advanced mathematical and computational techniques to analyze complex physical phenomena and critically evaluate scientific literature and experimental results.
4. **SO4:** to be able to effectively communicate complex physics concepts, research findings, and their significance through academic writing, presentations, and public outreach.
5. **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.
6. **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.
7. **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.

8. 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. Explain the foundational principles of many-body quantum mechanics, including second quantization and operator formalism.
2. Demonstrate the use of Green's functions to analyze interacting quantum systems.
3. Apply diagrammatic perturbation theory to calculate physical properties of many-body systems.
4. Analyze the behavior of fermionic and bosonic systems using advanced quantum mechanical techniques.
5. Explain the concept of collective excitations and quasiparticles in interacting systems.
6. Solve problems related to superconductivity using the BCS theory and its extensions.
7. Apply many-body theory to analyze physical systems such as electron gases and condensed matter systems.
8. Use advanced mathematical techniques, such as Fourier transforms and contour integration, to solve problems in quantum many-body theory.
9. Explain the role of symmetries and conservation laws in simplifying many-body quantum systems.

Course ILOs	The learning levels to be achieved					
	Remembering	Understanding	Applying	Analysing	evaluating	Creating
1	x	x				
2		x				
3	x	x	x			
4				x		
5				x		
6			x	x		
7			x	x		
8			x	x		
9		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							
2	x		x					
3	x		x					
4	x		x					
5	x		x					
6	x		x					
7	x	x	x					
8			x					
9	x		x					
10		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 Lecturing	Evaluation Methods	Learning Resources
1	1.	Introduction to Many-Body Theory: Overview	CILO 1, CILO 1	Face-to-Face	Class room	Synchronous		Fetter & Walecka (Ch. 1)

	2	Review QM mechanics	CILO 1	Face-to-Face	Classroom	Synchronous		Supplementary
2	1	Pictures and representations	CILO 1	Face-to-Face	Classroom	Synchronous		Supplementary
	2	Second Quantization	CILO 1	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 1)
3	1	Field Operators and Creation/Annihilation Operators	CILO 1	Blended	LMS (e.g., Moodle)	Synchronous		Fetter & Walecka (Ch. 1)
	2	Field Operators and Creation/Annihilation Operators	CILO 1	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 1)
4	1	Non-Interacting Many-Particle Systems: Fermions	CILO 4	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 2)
	2	Non-Interacting Many-Particle Systems: Bosons	CILO 4	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 2)
5	1	Density Operators and Ensemble Averages	CILO 1	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 2)
	2	Green's Functions: Time-Ordered, Retarded, and Advanced	CILO 2	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 3)
6	1	Green's Functions: Time-Ordered, Retarded, and Advanced	CILO 2	Blended	LMS	Synchronous		Fetter & Walecka (Ch. 3)
	2	Equations of Motion for Green's Functions	CILO 2	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 3)
7	1	Diagrammatic Perturbation Theory: Feynman Diagrams	CILO 3	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 4)
	2	Diagrammatic Perturbation Theory: Feynman Diagrams	CIL	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 4)

			O 3					
8	1	Self-Energy and Dyson's Equation	CILO 3	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 4)
	2	Midterm						
9	1	Electron Gas	CILO 7	Blended	LMS	Asynchronous		Fetter & Walecka (Ch. 5)
	2	Quasiparticles	CILO 5	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 5)
10	1	Linear Response Theory	CILO 5,	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 5)
	2	Bose-Einstein Condensation and Superfluidity	CILO 9	Blended	LMS	Synchronous		Fetter & Walecka (Ch. 6)
11	1	Fermion Pairing and BCS Theory	CILO 6	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 7)
	2	Collective Excitations: Phonons	CILO 5	Blended	LMS	Asynchronous		Fetter & Walecka (Ch. 7)
12	1	Collective Excitations: Plasmons	CILO 5	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 7)
	2	Symmetries and Conservation Laws in Many-Body Systems	CILO 9	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 8)
13	1	Applications in Condensed Matter Physics: Band Structures	CILO 7	Blended	LMS	Synchronous		Fetter & Walecka (Ch. 8)
	2	Advanced Techniques: Fourier Transform Methods in Many-Body Theory, contour integration	CILO 8	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 9)
14	1	Advanced Techniques: Fourier Transform Methods in Many-Body Theory, contour integration	CILO 8	Face-to-Face	Classroom	Synchronous		Fetter & Walecka (Ch. 9)

	2	Final Exam							

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
Midterm	30	CH1-CH4	1-4	8th week	Face
HW	30	All	All	3rd, 6th, 9th weeks	Face
Final	40	All	All	Final week	Face

2٥. Course Requirements:

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

2٦. Course Policies:

A- Attendance policies:

B- Absences from exams and submitting assignments on time:

C- Health and safety procedures:

D- Honesty policy regarding cheating, plagiarism, misbehavior:

E- Grading policy:

F- Available university services that support achievement in the course:

2٧. References:

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

"Quantum Theory of Many-Particle Systems" by Alexander L. Fetter and John D. Walecka

Recommended books, materials, and media:

"Many-Particle Physics" by Gerald D. Mahan

2٨. Additional information:

Name of the Instructor or the Course Coordinator:	Signature:	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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