Faculty: Faculty of Science	
Department: Physics	**Program: Master Program**
Semester: Second semester	**Academic year: 2023/2024**

Course Plan

First: Course Information

Course Name:	***Advanced Statistical Mechanics***			***Course No. 0302741***	
Credit Hours:	***3 hrs***	***Theoretical***	***3***	***Practical***	***0***
Prerequisite:	***-------***	***Class Number: 1***		***Lecture Time: --------***	
Level in JNQF	***9***				
Course Nature:	☐ ***Mandatory Faculty Requirement*** ☐ ***Mandatory University Requirement*** ☑ ***Optional Specialty Requirement*** ☐***Optional University Requirement*** ☐***Ancillary Course*** ☐***Mandatory Specialization requirement***				
Type Of Educatin:	☐ ***Face-to-Face Learning*** ☐ ***Blended Learning(2 Face-to-Face + 1Asynchronous)*** ☑ ***Online Learning (2 Synchronous+1Asynchronous)***				

Second: Instructor's Information

***Name*: Dr. Riad S. Masharfe**	***Academic Rank :Assistant professor***	
***Office Number*: 334D**	***Phone Number***:+962-5-3821100 ***ext.: 1151***	***Email:rmasharfe@zu.ed.jo***
Office Hours:	***11:00-12:30 Mon, Wed***	

Third: Short Description of the Course

The Statistical Basis of Thermodynamics, The classical ideal gas, Phase space of a classical system, Liouville's theorem and its consequences, The micro canonical ensemble, Physical significance of the various statistical quantities in the canonical ensemble, Alternative expressions for the partition function, The classical systems, Formulation of Quantum Statistics, Ideal Bose Systems, Ideal Fermions systems, The statistics of Para magnetism (Pauli), The statistics of diamagnetism(Landau), The statistical mechanics of reaction systems.

Fourth: Learning Source

Designated Book:	**Statistical Mechanics, ISBN 978-0-12- 382188-1**	**Elsevier**
Author: R. K. Pathria and Paul D. Beale,	**edition: 3nd ed.**	**Year: 2011**
Additional Sources: Website:	**Mandl, Franz (1971). *Statistical physics*. Chichester: Wiley. *ISBN 0-471-56658-6. 2e (1988) Chichester: Wiley ISBN 0-471-91532-7, ISBN 0-471-91533-5.*** **Reif, Frederick (1965). *Fundamentals of Statistical and Thermal Physics*. McGraw-Hill. *ISBN 0-07-051800-9*.** ***Sears, Francis W.* (1975). Thermodynamics, Kinetic Theory, and Statistical Thermodynamics. Addison Wesley. *ISBN 020106894X*.** ***Kittel, Charles* (1969). Thermal Physics. Chichester: Wiley. *ISBN 0-471-49030-X. 2e Kittel, Charles; and Kroemer, Herbert (1980) New York: W.H. Freeman ISBN 0-7167-1088-9*** **W. Griener, L. Niese, and H. Stocker, Thermodynamics and Statistical Mechanics, 1995**	
Teaching Type:	☐ ***Classroom*** ☐ ***Laboratory*** ☐ ***Workshop*** ▬ **MS Teams** ☐ **Moodle**	

Fifth: course objectives

1. Provide students with a comprehensive introduction to the principles and concepts of statistical mechanics, including ensembles, probability distributions, and partition functions.
2. Enable students to understand how statistical mechanics principles relate to thermodynamic systems, including the derivation and interpretation of thermodynamic quantities from statistical ensembles.
3. Introduce students to advanced topics in statistical mechanics such as phase transitions, critical phenomena, and the behavior of interacting systems.
4. Familiarize students with the mathematical techniques commonly used in statistical mechanics, including probability theory, calculus, and linear algebra.
5. Teach students how to apply statistical methods to analyze physical systems with large numbers of particles, including gases, liquids, and solids.
6. Introduce students to quantum statistical mechanics and its applications to systems of quantum particles, including Fermi-Dirac and Bose-Einstein statistics.
7. Cover classical statistical mechanics, including the Boltzmann distribution, the canonical ensemble, and the microcanonical ensemble.
8. Develop students' problem-solving skills by providing them with opportunities to apply statistical mechanics concepts to solve theoretical and practical problems in physics.
9. Foster critical thinking skills by encouraging students to critically analyze and evaluate scientific data, models, and theories within the context of statistical mechanics.
10. Develop students' research and communication skills by requiring them to conduct independent research projects and present their findings through oral presentations and written reports.

11. Emphasize the integration of statistical mechanics with other core areas of physics, such as quantum mechanics, classical mechanics, and thermodynamics, to demonstrate its broad applicability and importance.
12. Prepare students for advanced study and research in physics or related fields by providing them with a solid foundation in statistical mechanics and its applications.

Sixth : Learning Outcomes

Level descriptor according to (JNQF)	***CILOs Code***	***CILOs*** If any CILO will not be assessed in the course, mark NA.	***Associated PILOs Code*** *Choose one PILO for each CILO**	***Assessment method**** *Choose at least two methods*	***Scores out of 100*** State the total score identified for each CILO	***Minimum acceptable Score/percentage (%)*** *The percentage should not be less than 50% ******
Knowledge	K1	The systematic exploration of foundational physics principles that govern the behavior of systems at the microscopic level. This includes concepts such as the Boltzmann distribution, ideal gas law, entropy, and phase transitions, all of which arise from the statistical behavior of particles.	P. K1	**HOMEWORK/QUIZZ/FINAL EXAM**	26	13 (50%)
	K2	Highlighting the relationships between statistical mechanics and fundamental physics, students gain deeper understanding of the natural world and its underlying principles.	P. K2	**HOMEWORK/QUIZZ/FINAL EXAM**	14	7 (50%)
	K3	To execute substantial independent research, showcasing specialized physics knowledge in statistical mechanics through theoretical analysis, numerical simulations, and experimental investigations.	P.K3	**HOMEWORK/QUIZZ/FINAL EXAM**	12	6(50%)
Skills	S1	Proficiency in computational methods for modeling and simulating statistical systems.	P. S1	**HOMEWORK/QUIZZ/FINAL EXAM**	4	2 (50%)

	S2	Applying quantum mechanics principles extends to many-particle systems. Additionally, discussing statistical models in nuclear physics and solid-state phenomena illustrates real-world applications,	P. S2	**HOMEWORK/QUIZZ/FINAL EXAM**	8	4 (50%)
	S3	Apply statistical mechanics principles to diverse physical systems, including classical, quantum, and solid-state phenomena.	P.S2	**HOMEWORK/QUIZZ/FINAL EXAM**	10	5(50%)
	S4	Investigate the integration of research tools and results within subfields of statistical mechanics	P.S3	**HOMEWORK/QUIZZ/FINAL EXAM**	10	5(50%)
	S5	Proficiently design, create, and develop solutions to complex physics problems within the framework of statistical mechanics	P.S5	**HOMEWORK/QUIZZ/FINAL EXAM**	12	6(50%)
Competencies	C1	Work effectively within work teams	P. C1	**FINAL EXAM**	2	1(50%)
	C2	Logical problem-solving and reasoning (Identifying, strategizing, applying, evaluating, adapting, inferring, communicating	P. C3	**FINAL EXAM**	2	1(50%)

Sixth: Course Structure

Lecture Date	Teaching Outcome	Topics	Teaching Procedures*	Teaching Methods***	References***
	K1/K2/S5/ C1	**The Statistical Basis of Thermodynamics** (The macroscopic and the microscopic states / Contact between statistics and thermodynamics: physical significance of the number Ω(N, V , E).	ELCTRONIC	LECTURE+PRESENTATION	**1-10**
	K1/K3/S1	Further contact between statistics and thermodynamics /The classical ideal gas 9 The entropy of mixing and the Gibbs paradox	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	**12-22**
	K1/K2/S1/ S3	**Elements of Ensemble Theory** (Phase space of a	ELCTRONIC	LECTURE+PRESENTATION	**25-37**

		classical system / Liouville's theorem and its consequences The microcanonical ensemble/ Examples /Quantum states and the phase space)			
	K1/K2/S1/ S5	**The Canonical Ensemble** (Equilibrium between a system and a heat reservoir / A system in the canonical ensemble / Physical significance of the various statistical quantities in the canonical ensemble / / Alternative expressions for the partition function	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	**39-58**
	K/K2/S1/S 2/S3/C1	/ The classical systems / Energy fluctuations in the canonical ensemble: correspondence with the microcanonical ensemble / /Two theorems — the "equipartition" and the "virial" / A system of harmonic oscillators. The statistics of paramagnetism / Thermodynamics of magnetic systems: negative temperatures)	ELCTRONIC	LECTURE+PRESENTATION	**59-77**
	K/K2/S1/S 2/S3/C1	**The Grand Canonical Ensemble** (.Equilibrium between a system and a particle-energy reservoir / .A system in the grand canonical ensemble/ . Physical significance of the various statistical quantities /	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	91-103
	K1/K3/S1/ S2/S3/S4/ C1	Density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles / . Thermodynamic phase diagrams / Phase equilibrium and the Clausius–Clapeyron equation	ELCTRONIC	LECTURE+PRESENTATION	**103-111**
	K1/K2/K3 /S1/S2/S3/ S4/C1	**Formulation of Quantum Statistics** (Quantum-mechanical ensemble theory: the density matrix / Statistics of the various ensembles / Contents / Examples /	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	115-127
	K1/K3/S1/ S2/S3/S5/ C1	Systems composed of indistinguishable particles /	ELCTRONIC	LECTURE+PRESENTATION	127-139

		The density matrix and the partition function of a system of free particles)			
	K1/K2/S1/ S2/S3/S4/ C2	**The Theory of Simple Gases** (An ideal gas in a quantum-mechanical microcanonical ensemble / An ideal gas in other quantum-mechanical ensembles / Statistics of the occupation numbers	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	141-152
	K2/K3/S1/ S2/S3/S5/ C1	/ Kinetic considerations / Gaseous systems composed of molecules with internal motion /Chemical equilibrium	ELCTRONIC	LECTURE+PRESENTATION	**152-178**
	K2/K3/S1/ S2/S3/S5/ C1	**Ideal Bose Systems** Thermodynamic behavior of an ideal Bose gas/ Bose–Einstein condensation in ultracold atomic gases /	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	179-191
	K1/K2/K3 /S1/S2/S3/ S4/C1	Thermodynamics of the blackbody radiation/The field of sound waves/ Inertial density of the sound field / Elementary excitations in liquid helium II	ELCTRONIC	LECTURE+PRESENTATION	191-215
	K1/K2/K3 /S1/S2/S3/ S4/C1	**Ideal Bose Systems (** Thermodynamic behavior of an ideal Bose gas/ Bose–Einstein condensation in ultracold atomic gases /Thermodynamics of the blackbody radiation/	ASYNCHRONOUS	HOMEWORK/QUIZZ/MINI LECT.	231-247
	K1/K2/K3 /S1/S2/S3/ S4/C1	The field of sound waves/ Inertial density of the sound field/. Elementary excitations in liquid helium II	ELCTRONIC	LECTURE	247-264

Education procedures: (Direct, synchronous, asynchronous). * * Teaching methods: Lecture, video…..). * * Reference: Pages of the book, recorded lecture, video….).(

Seventh: Assessment methods

Methods	Fully Electronic Education	Integrated Teaching	Face to face	Specific Course Output to be measured *State the score identified for each CILO for each method of assessment out of 100 **If any CILO will not be assessed in the course, mark NA.										
				K1	K2	K3	S1	S2	S3	S4	S5	C1	C2	
First exam														

Second exam													
Final Exam	40			**6**	**4**	**2**	**4**	**4**	**4**	**4**	**8**	**2**	**2**
Quizzes	30			**10**	**5**	**5**	**N.A**	**2**	**3**	**3**	**2**	**N.A**	**N.A**
Assignment	30			**10**	**5**	**5**	**N.A**	**2**	**3**	**3**	**2**	**N.A**	**N.A**
Total out of 100	**100**			**26**	**14**	**12**	**4**	**8**	**10**	**10**	**12**	**2**	**2**

* Refer to document (CC-2023-03)

Eighth: Course Polices

- Meeting the deadline for the lecture.
- Commitment to interaction and participation.
- Interactive lectures will be given through a platform (MS Teams).
- Duties and tests will be given through a platform (Moodle).
- Commitment to the right appearance in front of the camera with the proper background.
- University regulations for attendance and absence from lectures and examinations are in force.
- Academic Integrity: Fraud or moral impersonation are unacceptable and are punishable according to university regulations and instructions.

Approval	Name	Date	Signature
Head of Department	Dr. Riad Masharfe		
Faculty Dean	Dr. Aliaa Burqan		