Course Specification
(Postgraduate Programs)

Course Title: Statistical Physics
Course Code: PHYS 623
Program: Master of Science in Physics
Department: Physics
College: College of Sciences
Institution: Majmaah University
Version: 1
Last Revision Date: 30/12/2024

Table of Contents

A. General information about the course:

1. Course Identification

1. Credit hours: (2)					
2. Course type					
A.	☐University	☐College	☒Department	☐Track	☐Others
B.	☒Required		☐Elective		
3. Level/year at which this course is offered: (2^{nd}/1)					
4. Course general Description:					
Statistical physics is witnessing a revolution: understanding the dynamics of a very large number of interactive degrees of freedom, which has been from the beginning the main aim of statistical physics, has now become a central problem in many fields, such as physics, biology, and computer science, just to cite a few. Now more than ever, statistical physics, for its methods and its applications, is a powerful discipline with a broad range of theoretical approaches and ramifications across many branches of science. This course aims to introduce the students to this very rich state of the art: on one hand by teaching fundamental notions and methods of statistical physics, and at the same time by presenting its modern applications in physics and beyond					
5. Pre-requirements for this course (if any):					
Advanced Quantum Mechanics, PHYS 612 Electrodynamics, PHYS 613					
6. Co-requisites for this course (if any):					
None					
7. Course Main Objective(s):					
1. Explain statistical physics and thermodynamics as logical consequences of the postulates of statistical mechanics. 2. Apply the principles of statistical mechanics to selected problems. 3. Apply techniques from statistical mechanics to a range of situations. 4. Use tools, methodologies, language, and conventions of physics to test and communicate ideas and explanations 5. Use the tools, methodologies, language, and conventions of physics to test and communicate ideas and explanations					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	2	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**	30
2.	**Laboratory/Studio**	
3.	**Field**	
4.	**Tutorial**	
Total		**30**

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

Code	Course Learning Outcomes	Code of PLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	Explain the fundamental laws of thermodynamics and their implications for equilibrium systems.	**K2**	Lectures-Class discussions	Exams-Writing reports
1.2	Describe the principles and mathematical formulations of statistical ensembles.	**K2**	Lectures-Class discussions	Exams-Writing reports
1.3	Analyze phase transition phenomena using Ising models and mean-field approximations.	**K4**	Lectures-Class discussions	Exams-Writing reports

1.4	Interpret theoretical frameworks for non-equilibrium systems, including fluctuation-dissipation relations.	**K4**	Lectures-Class discussions	Exams-Writing reports
2.0	**Skills**			
2.1	Apply ensemble theory to compute thermodynamic quantities for different physical systems.	**S2**	Solving Problems-Class Discussions-Presentations	EXAMS Assignment Quizzes-Observation
2.2	Use mathematical tools to derive critical exponents and scaling relations in phase transitions.	**S2**	Solving Problems-Class Discussions-Presentations	EXAMS Assignment Quizzes-Observation
2.3	Solve problems involving stochastic processes using Langevin and Fokker-Planck equations.	**S4**	Solving Problems-Class Discussions-Presentations	EXAMS Assignment Quizzes-Observation
2.4	Evaluate non-equilibrium behaviors through simulation or analytical techniques.	**S4**	Solving Problems-Class Discussions-Presentations	EXAMS Assignment Quizzes-Observation
3.0	**Values, autonomy, and responsibility**			
3.1	Demonstrate scientific integrity in modeling and interpreting physical systems.	**V2**	Presentations-Small group supervisions	Small projects Presentations Survey
3.2	Appreciate the role of statistical physics in advancing interdisciplinary research.	**V2**	Presentations-Small group supervisions	Small projects Presentations Survey
3.3	Exhibit persistence and critical thinking when tackling complex theoretical problems.	**V3**	Presentations-Small group supervisions	Small projects Presentations Survey
3.4	Promote collaborative learning and ethical use of computational resources in research.	**V3**	Presentations-Small group supervisions	Small projects Presentations Survey

C. Course Content

No	List of Topics	Contact Hours
1.	Review of equilibrium thermodynamics: First law and equilibrium, Second law, Thermal equilibrium and temperature, Phase transitions	6
2.	Principles of statistical mechanics: Microcanonical ensemble, Canonical ensemble, Grand canonical ensemble, Maximum entropy principle	6
3.	Phase transitions: Ising model, Lattice gas, Broken symmetry and range of correlations, Ising model in one dimension, Mean field theory, Landau theory of phase transitions, Critical exponents, Scaling, Renormalization group theory, Ising model in two dimensions	8
4.	Statistical mechanics of non-equilibrium systems: Systems close to equilibrium, Onsager's regression hypothesis and time correlation functions, Fluctuation-dissipation theorem, Response function, Brownian motion, Langevin Equation, Fokker-Planck equation, Master equation and detailed balance, Systems far from equilibrium, Concepts of work and heat revisited, Fluctuation theorems15	10
Total		**30**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	Quizzes	4,10	10%
2.	Assignment	Entire semester	10%
3.	Midterm 1 Examination	6,7	15%
4.	Midterm 2 Examination	12,13	15%
5.	Project	14	10%
6.	Final Examination	15	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	Statistical physics, by Raman, Amit, 2018 Mandl, F. (1998): Statistical Physics, 2nd edition, Wiley
Supportive References	- Reif, F. (1965): Fundamentals of Statistical and thermal Physics, McGraw-Hill Kerson Huang's book on "Statistical Mechanics" Chaps 1,2,6,7,8
Electronic Materials	Saudi Digital Library (SDL
Other Learning Materials	None

2. Required Facilities and equipment

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	Classroom (must be the same for the same subject) • Seminar room • Computer lab for (e-Quiz)
Technology equipment (projector, smart board, software)	•BlackBoard software/login •MS software suite •Origin Graphic software •Smart board that maintains feedback • Whiteboard
Other equipment (depending on the nature of the specialty)	Library, Seminar Room, and Wi-Fi /internet connections

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	Indirect
Effectiveness of Students assessment	Students	Indirect
Quality of learning resources	Students	Indirect
The extent to which CLOs have been achieved	Students	Indirect

Assessors (Students, Faculty, Program Leaders, Peer Reviewers, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	Physics Department
REFERENCE NO.	16
DATE	30/12/2024