The University of Jordan

Accreditation & Quality Assurance Center

COURSE Syllabus

Course Name:

Statistical Mechanics – 1

(0342756)

1	Course title	**Statistical Mechanics - 1**
2	Course number	0342756
3	Credit hours (theory, practical)	3 (theory only)
	Contact hours (theory, practical)	3 (theory)/week
4	Prerequisites/corequisites	BSc in Physics
5	Program title	MSc in Physics
6	Program code	0342
7	Awarding institution	The University of Jordan
8	Faculty	Science
9	Department	Physics
10	Level of course	MSc
11	Year of study and semester (s)	2016-2017; second semester
12	Final Qualification	MSc in Physics
13	Other department (s) involved in teaching the course	None
14	Language of Instruction	English/Arabic
15	Date of production/revision	May 14, 2017

16. Course Coordinator: (Prof. Dr.) **Humam B. Ghassib**

Office numbers, office hours, phone numbers, and email addresses should be listed.

Office number: 310 (Physics Building); Office hours: Sun, Tue: 10:00-13:00; Mobile: 0777-872122; Extension: 22023: Email: humamg@ju.edu.jo, hghassib@orange.jo.

17. Other instructors: None

Office numbers, office hours, phone numbers, and email addresses should be listed.

18. Course Description:

As stated in the approved study plan.
Connection between Statistics and Thermodynamics; Entropy of Mixing and the Gibbs Paradox; Phase Space and Liouville's Theorem; Microcanonical, Canonical and Macrocanonical (Grand Canonical or Gibbs) Ensembles; Partition Function; Quantum States; Derivation of the Distribution Functions for an Ideal Classical Gas, an Ideal Fermi Gas and an Ideal Bose Gas; Thermodynamics of Ideal Gases; Energy Fluctuations; Statistics of a System of Harmonic Oscillators; Paramagnetism; Magnetic Cooling; A System of Molecules with Internal Motion.

19. Course aims and outcomes:

A- Aims:

1. **To study thoroughly the theoretical principles involved in Statistical Mechanics (including the derivation of Statistical Thermodynamics).**
2. **To look into some applications.**

B- Intended Learning Outcomes (ILOs): Upon successful completion of this course students will be able to …

1. Define the concept of entropy, in all its variants.
2. Use this concept to write down definitions for the (absolute) temperature and pressure.
3. Discuss thoroughly the implications of extensive thermodynamics.
4. Distinguish between microstates and macrostates.
5. Identify a macrostate of a system with the constraints imposed on it.
6. Describe a microstate of a system classically, quantum-mechanically and semiclassically.
7. Define the concept of phase space.
8. State Liouville's theorem and deduce its implications.
9. State the two fundamental postulates of Statistical Mechanics and discuss their significance.
10. Combine these two postulates into the entropy principle for a (totally) isolated system.
11. Define the concept of an ensemble.
12. Identify the isolated system with the microcanonical ensemble.
13. Write down the probability distribution for the microcanonical ensemble.
14. Identify the system in a heat bath with the canonical ensemble.
15. Write down the probability (Boltzmann) distribution for the canonical ensemble.
16. Define the partition function of a system and use it to derive the thermodynamic properties of the system.
17. Define the (Gibbs) entropy in terms of the probability distribution.
18. Derive an expression for the relative fluctuations in the total (internal) energy of a system and deduce from this why Statistical Mechanics works for a macroscopic system.
19. Investigate the paramagnetic solid within both the microcanonical and canonical ensembles.
20. Distinguish between reversible and irreversible processes.
21. Identify temperature as an integrating factor for reversible heat.
22. Derive Thermodynamics from basic statistical concepts.
23. Write down Maxwell''s relations in the context of thermodynamic potentials and thermodynamic variables.
24. Define (thermal) equilibrium in terms of thermodynamic potentials.
25. State the four laws of Thermodynamics (in both their positive and negative versions).
26. Emphasize the significance of the third law in low and ultralow temperature physics.
27. Outline the fundamentals of cryogenics, with emphasis on magnetic cooling.
28. Identify the system in a heat/particle reservoir with the grand canonical (Gibbs or macrocanonical) ensemble and derive the corresponding probability distribution.
29. Define the concept of chemical potential and explore its physical content.
30. Use the Gibbs ensemble to derive the distribution functions of ideal gases, both classical and quantum (Fermi-Dirac and Bose-Einstein).
31. Derive the properties of the classical ideal gas from 'first principles'.
32. Distinguish between distinguishable and indistinguishable systems.

33. Explain the Gibbs paradox.
34. Derive the validity criterion for the classical regime and apply this to several physical systems.
35. Explore the thermodynamic properties of the classical ideal gas.
36. Explain the behavior of the heat capacity of this gas and derive the difference between the heat capacity at constant pressure and that at constant volume.
37. Discuss the Maxwell-Boltzmann distribution in all its variants.
38. Derive the Theorem of Equipartition of Energy and apply it to classical systems.

20. Topic Outline and Schedule:

Topic	Week	Instructor	Achieved ILOs	Evaluation Methods	Reference
Preliminaries + the microcanonical ensemble	1-3	Humam Ghassib	100%	As in Sections 21 & 22	As in Section 25
The canonical ensemble + Statistical Thermo-dynamics	4-8	Humam Ghassib	100%	As in Sections 21 & 22	As in Section 25
The Gibbs (grand canonical) ensemble + derivation of distribution functions of classical & quantum ideal gases	9 & 10	Humam Ghassib	100%	As in Sections 21 & 22	As in Section 25
The classical ideal gas in depth	11 & 12	Humam Ghassib	100%	As in Sections 21 & 22	As in Section 25
Maxwell-Boltzmann distribution; theorem of equipartition of energy	13	Humam Ghassib	100%	As in Sections 21 22	As in Section 25
Cryogenics; magnetic cooling	14	Humam Ghassib	100%	As in Sections 21 & 22	As in Section 25

21. Teaching Methods and Assignments:

Development of ILOs is promoted through the following teaching and learning methods:

1. Weekly assignments (problem sheets + ‘search assignments’ + qualitative problems).
2. Two short projects (to be undertaken by each student over a period of 3 weeks).
3. A major project (involving an extended abstract + a presentation to be given at the end of the semester).
4. An oral ‘assessment’ session.

22. Evaluation Methods and Course Requirements:

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

Written and oral exams; seminars presented by students; problem sheets; 'qualititive' assiagnments and projects.

23. Course Policies:

A- Attendance policies:

As stated in the University by-laws.

B- Absences from exams and handing in assignments on time:

As stated in the University by-laws; any delay in handing in assignments is penalized.

C- Health and safety procedures:

As provided by the Department; nothing specific is needed.

D- Honesty policy regarding cheating, plagiarism, misbehavior:

As stated in the University by-laws.

E- Grading policy:

60% of the total grade is devoted to the works submitted throughout the semester (cf. Section 21 above + a mid-semester exam) and 40% to the final exam at the end of the semester.

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

None needed.

24. Required equipment:

25. References:

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

Pathria, R. K. and Beale, P. D. (2011), ***Statistical Mechanics*** (3rd ed.), Amsterdam: Elsevier.

B- Recommended books, materials, and media:

1. Huang, K. (1987), ***Statistical Mechanics*** (2nd ed.), New York: Wiley.
2. Reif, F. (1965), ***Fundamentals of Statistical and Thermal Physics***, New York: McGraw-Hill.
3. Sethna, J. P. (2005), ***Statistical Mechanics: Entropy, Order Parameters and Complexity***, *http://www. Physics.cornell.edu/sethna/StatMech/book.pdf.*

[Plus many materials and 'handouts', both electronic and paper.]

26. Additional information:

Name of Course Coordinator: --(Prof. Dr.) **Humam B. Ghassib**-----------------Signature: ------------------------

- Date: -May 14, 2017----------------------- Head of curriculum committee/Department: -------------------------

Signature: ---------------------------------

Head of Department: ------------------------- Signature: ---------------------------------

Head of curriculum committee/Faculty: ------------------------- Signature: ---------------------------------

Dean: -- -Signature: ---------------------------------

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Head of Department
Assistant Dean for Quality Assurance
Course File