JOINT INSTITUTE
交大密西根学院

Course Syllabus

MSE6204J Statistical Physics

Summer 2023

Course Description:

Statistical physics describes systems consisting of many particles. These systems include not only gases, liquids and solids, but also insect swarms, animal herds and robot collectives. Historically, the development of statistical physics is intertwined with the development of classical thermodynamics, so the two subjects are closely related. This course is intended for students who have some background in classical thermodynamics and would like to gain a deeper understanding from the statistical perspective. It first introduces the statistical physics of equilibrium systems and elucidates the statistical origins of macroscopic concepts, such as entropy and temperature. Next, the course covers non-equilibrium statistical physics, describes foundational concepts such as Markov processes, and introduces methods dealing with stochastic equations. Finally, the course briefly introduces significant recent development in the 21st century, such as fluctuation theorems, information thermodynamics, and active matter.

Instructor:

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Office hour: TBA

Reference Book (Author, Book Title, Publisher, Publication Year, ISBN):

We will use multiple books as references.

Reif, F. *Fundamentals of statistical and thermal physics*. (Waveland Press, 2009). 978-1-57766-612-7. Or equivalently, Reif, F. *Fundamentals of statistical and thermal physics*. (McGraw-Hill, Inc., 1965). 07-051800-9

Gardiner, C. W. *Handbook of stochastic methods for physics, chemistry, and the natural sciences*. (Springer-Verlag, 2004). 978-3-540-20882-2

Toda, M., Kubo, R., Saitō, N. & Hashitsume, N. *Statistical physics II - Nonequilibrium Statistical Mechanics*. (Springer-Verlag, 1991). 978-3-540-53662-8

Lecture:

Students are expected to attend every lecture.

Time:

Monday and Wednesday 10:00 – 11:40 am

Course prerequisites:

MSE3300J or PHYS2400/2401/2500/2600J

Classroom:

DZY-4-406 (东中院)

Grading Policy (Assignments %, Exams, etc.):

Homework (40%)
Literature paper presentation (20%)
Classroom participation (20%)
Final exam (20%)

Honor Code Policy:

We follow the guidelines set out by the JI honor code:

https://www.ji.sjtu.edu.cn/academics/academic-integrity/honor-code/

Some more specific requirements:

You are encouraged to discuss with your classmates about the problems in the homework and the proposals, but you must complete these assignments on your own. Presentations will be judged by both contents and clarity of delivery.

Tentative schedule:

Week	No.	Date	Lectures	Notes
1	1	8 May	Overview and introduction to statistical methods	Reif, ch1
	2	10 May	Statistical description of systems of particles	Reif, ch2
2	3	15 May	Statistical thermodynamics	Reif, ch3
	4	17 May	Macroscopic parameters and their measurements	Reif, ch4
3	5	22 May	Simple applications of macroscopic thermodynamics	Reif, ch5
	6	24 May	Basic methods and results of stat. mech.	Reif, ch6
4	7	29 May	Basic methods and results of stat. mech. II	Reif, ch6
	8	31 May	Applications of statistical mechanics: partition functions, ideal monatomic gas	Reif, ch7
5	9	5 Jun	Applications of statistical mechanics: equipartition theorem, paramagnetism, kinetic theory of dilute gases in equilibrium	Reif, ch7
	10	7 Jun	Equilibrium between phases and chemical species	Reif, ch8
6	11	12 Jun	Quantum statistics of ideal gases	Reif, ch9
	12	14 Jun	Quantum statistics of ideal gases	Reif, ch9
7	13	19 Jun	Systems of interacting particles: solids, non-ideal gas, magnetism	Reif. ch10
	14	21 Jun	Review	
8	15	26 Jun	Brownian motion and historical context of stochastic methods	Gardiner, ch1
	16	28 Jun	Probability concepts	Gardiner, ch2
9	17	3 Jul	Markov processes	Gardiner, ch3
	18	5 Jul	Ito Calculus and Stochastic differential equations	Gardiner, ch4
10	19	10 Jul	Ito Calculus and Stochastic differential equations	Gardiner, ch4
	20	12 Jul	The Fokker-Planck Equation	Gardiner, ch5

11	21	17 Jul	Fluctuation theorems, information thermodynamics	
	22	19 Jul	Active matter	
12	23	24 Jul	Active liquid and solids with odd properties	
	24	26 Jul	Review	
13	25	31 Jul		
	26	2 Aug		

Note：