Course Title (in English)	Statistical Physics
Course Title (in Russian)	Статистическая физика
Lead Instructor(s)	Shlosman, Semen

Status of this Syllabus	The syllabus is a final draft waiting for form approval
Contact Person	Senya Shlosman
Contact Person's E-mail	shlosman@gmail.com

1. Annotation

Course Description	This is a course on rigorous results in statistical physics and random fields. Most of it will be dedicated to the theory of phase transitions, uniqueness or non-uniqueness of the lattice Gibbs fields. The topics will include: grand canonical, canonical and microcanonical ensembles, DLR equation, Thermodynamic limit, Gibbs distributions and phase transitions, one-dimensional models, correlation inequalities (GKS, GHS, FKG), spontaneous symmetry breaking at low temperatures, uniqueness at high temperatures and in non-zero magnetic field, Non-translation-invariant Gibbs states and interfaces, Dobrushin Uniqueness Theorem Pirogov–Sinai Theory O(N)-symmetric models the Mermin–Wagner Theorem Reflection Positivity and the chessboard estimate infrared bounds
Course Prerequisites	It is desirable that the students are somewhat familiar with the probability theory, measure theory and functional analysis. Of course, the calculus knowledge is assumed.

2. Structure and Content

Course Academic Level	Master-level

Number of ECTS credits	6

Topic	Summary of Topic	Lectures (# of hours)	Seminars (# of hours)	Labs (# of hours)
Grand canonical, canonical and microcanonical ensembles, DLR equation.	Interactions, Hamiltonians, boundary conditions, partition functions, finite volume Gibbs states.	1	3	
Thermodynamic limit, Gibbs distributions,	Free energy, Van Hove theorem, (in)dependence of free energy on the shape of the box and boundary conditions. Infinite volume Gibbs state.	1	3	
One-dimensional models.	Markov chains and 1D Gibbs fields. Phase transitions in 1D systems.	1	3	
Correlation inequalities	Applications of various correlation inequalities: GKS, GHS, FKG. Signs of the cumulants of the Ising model.	1	3	
Spontaneous symmetry breaking at low temperatures,	Peierls estimate. Contours. Positivity of magnetisation at low temperatures.	1	3	
Uniqueness at high temperatures and in non-zero magnetic field,	Dobrushin Uniqueness Theorem. Constructive uniqueness.	1	3	
Non-translation-invariant Gibbs states and interfaces,	Interfaces in the Ising and Potts models. Rigid interfaces. Pinning and entropic repulsion of the interfaces.	1	3	
Pirogov–Sinai Theory	Phase transitions in systems with no symmetry. Phase diagrams and the Gibbs phase rule.	1	3	
O(N)-symmetric models the Mermin–Wagner Theorem	Continuous symmetry breaking. No Goldstone bosons in 2D.	1	3	
Reflection Positivity, the chessboard estimate and infrared bounds	Phase transitions in 3D O(n) models and non-linear sigma-model.	1	3	

3. Assignments

Assignment Type	Assignment Summary
Test/Quiz	Will be decided later.

4. Grading

Type of Assessment	Pass/Fail

Grade Structure

Activity Type	Activity weight, %
Final Exam	50
Midterm Exam	30
Class Participation	20

Grading Scale

5. Basic Information

Attendance Requirements	Mandatory with Exceptions

Maximum Number of Students

	Maximum Number of Students
Overall:	20
Per Group (for seminars and labs):	20

Course Stream	Science, Technology and Engineering (STE)
Course Term (in context of Academic Year)	Term 3
Course Delivery Frequency	Upon request

Students of Which Programs do You Recommend to Consider this Course as an Elective?

Masters Programs	PhD Programs
Computational Science and Engeneering Mathematical and Theoretical Physics	Mathematics and Mechanics

Please List the Teaching Assistants (TAs) You Propose for Your Course

First Name	Last Name
Alexander	Povolotsky

Course Tags	Math

6. Textbooks and Internet Resources

Required Textbooks	ISBN-13 (or ISBN-10)
Theory of Phase Transitions: Rigorous Results by Ya. G. Sinai	9780080264691

Recommended Textbooks	ISBN-13 (or ISBN-10)
Statistical Physics L D Landau E.M. Lifshitz	9780080570464

Web-resources (links)	Description
http://www.unige.ch/math/folks/velenik/smbook/index.html	Statistical Mechanics of Lattice Systems: a Concrete Mathematical Introduction

7. Facilities

Software
Mathematica

Equipment
laptop

Labs for Education	None

8. Learning Outcomes

Knowledge
Theory of random fields, in particular, Markov fields and Gibbs fields. Mathematical theory of phase transitions. Random surfaces. Gaussian free field.

Skill
Ability to read and understand the literature on rigorous statistical physics, e.g. Journal of Statistical Physics and (some) papers in Communications in Mathematical Physics.
Ability to formulate and sometime also solve problems in the theory of phase transitions and related areas.

Experience
Experience of working in the area of {mathematical physics}cap{probability theory}=ProbaΦ

Do you want to specify outcomes in another framework?	Knowledge-Skill-Experience is good enough

9. Assessment Criteria

Select Assignment 1 Type	Test/Quiz
Input Example(s) of Assignment 1 (preferable)	Prove the existence of phase transition for the Ising model on uniform (infinite) Cayley tree.
Assessment Criteria for Assignment 1	A - for the correct proof. For a wrong or incomplete proof - depending on the sketch.
Select Assignment 2 Type	Test/Quiz
Input Example(s) of Assignment 2 (preferable)	Are there phase transitions of the first order in 2D models with finite range interaction possessing continuous symmetry?
Assessment Criteria for Assignment 2	A - for either a complete proof or for an example. For a wrong or incomplete proof - depending on the sketch.

10. Additional Notes