ISING MODEL: PRELIMINARY PLAN

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The plan of this design is to cover a 75-minute class on the Ising model, and we plan to cover fundamental concepts, examples, and encouraging interactive discussions. The following is an skeleton of the class, we're still working on the actual notes for the class nd also the "problem set".

Goals (Primary Ideas).

(1) Get the Basics of the Ising Model: By the end of the class, you should understand what the Ising model is all about—how it represents spins on a grid, the interactions between them, and why it's a big deal in statistical mechanics. You'll see how it helps us study phase transitions and critical behavior in materials.
(2) Learn to Solve Ising Model Problems: We want to provide our classmates with the skills to tackle simple problems related to the Ising model. This means using formulas like Hamiltonians and partition functions to figure out stuff like magnetization and critical temperatures.
(3) Think Critically about the Model and Possible Generalizations: Finally, we want to provide our classmates with an overview or the things that we can study with the Ising Model or Spin Systems, i.e., some generalizations and cool stuff that people are doing in the research community.

Outline of the topics and class Structure:

(1) Introduction to Statistical Mechanics (10 minutes)** - Briefly review the principles of statistical mechanics relevant to the Ising model. - We want to discuss the importance of models in understanding physical systems, with an special emphasis on the fact that the model is designed to capture some specific phenomena, and sometimes a full description of the system under study is not possible, at least not with just one framework. - Introduce the Ising model as a key model in statistical mechanics.
(2) Ising Model Basics (15 minutes)** - Define the Ising model and its historical significance: in a "pictorial" way - Define the Hamiltonian of the Ising model. - Discuss the basic elements: lattice, spins, nearest-neighbor interactions.
(3) One-Dimensional Ising Model (15 minutes)** - Explore the one-dimensional Ising model as a starting example. - Show how to write the Hamiltonian and calculate partition function/Z. - Discuss analytical and numerical solutions for simple cases.
(4) Two-Dimensional Ising Model (15 minutes)** - Extend to the two-dimensional Ising model. - Introduce concepts like phase transitions and critical phenomena. - Discuss the role of Monte

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Carlo simulations and mean-field theory: the objective of this point is to show several kinds of approximations that one can make in order to find a "solution".

(5) Discussion and Q&A (10 minutes)** - Open the floor for questions and discussion. - Try to engage the discussion in such a way that we can incorporate concepts of other areas of physics. - Address any confusion or delve deeper into specific topics based on interest.

(6) Assignment (10 minutes)** - Provide an assignment related to the Ising model. - Emphasize applying concepts learned in class to solve a specific problem. - Specify the deadline and any resources or guidance available.

Teaching Methodology:

- We want to use diagrams and graphs through the class. - In the derivations we want to ask question as: "ok, what could be the next step?". - We plan to theoretical concepts to real-world applications (e.g., magnetism, phase transitions). - Emphasize problem-solving techniques and computational methods.

Assignment:

- For this part we're still deciding on a good problem that captures a good amount the theory presented, but we have some ideas, such as: - Analyzing a specific Ising model configuration. - Calculating critical temperatures or magnetization.