

## NetLogo Assignment 1: Exploring Emergence in the Ising Model

### Assignment Level Student Learning Objectives:

In this assignment, students will:

- **Develop Observation Skills:** Analyze phase transitions and emergent behaviors in the Ising model under varied parameters like temperature and initial spin configurations.
- **Practice Scientific Inquiry:** Formulate and test hypotheses about how parameter changes, such as temperature or external magnetic fields, influence system dynamics.
- **Draw Connections to Real-World Systems:** Relate the Ising model's behaviors to phenomena like magnetism, neural networks, or economic systems.
- **Explore Emergence:** Understand how macroscopic patterns (e.g., magnetization) arise from microscopic interactions.
- **Critically Reflect on Philosophical Implications:** Evaluate the Ising model's ability to simulate complex systems and its limitations in capturing real-world processes.

### Assignment Purpose:

This assignment introduces students to the Ising model as a computational tool to study emergence and phase transitions. Through experimentation, students will explore how the interaction of simple spins leads to macroscopic phenomena like magnetization. The activity bridges computational modeling with critical thinking by challenging students to:

- **Connect Theory and Application:** Demonstrate how the Ising model can represent real-world processes such as ferromagnetism, social behavior, or phase transitions.
- **Critically Engage with Simulations:** Reflect on the strengths and weaknesses of simplified models in understanding complex systems.
- **Lay Foundations for Further Inquiry:** Provide skills and concepts relevant to philosophical discussions on simulations and the nature of reality.

### Objective:

Students will explore the Ising model using NetLogo (or another tool), modifying parameters like temperature, external magnetic fields, and initial configurations. Through experimentation, they will analyze emergent patterns, connect these findings to real-world phenomena, and reflect on philosophical implications.

## Assignment Overview:

Before exploring advanced computational models, you will experiment with the Ising model in NetLogo or a similar platform. This assignment will focus on how local interactions between spins lead to system-wide behaviors. Key areas of exploration include:

1. **Phase Transitions:** How does the system behave near the critical temperature? What patterns emerge?
2. **Emergent Magnetization:** When and why does the system exhibit strong magnetization versus disordered spins?
3. **Effect of External Magnetic Fields:** How does the system respond to an added magnetic field?
4. **Initial Conditions:** How does the starting configuration of spins (e.g., random or ordered) affect the outcomes?

This assignment demonstrates how complex, emergent phenomena arise from simple, rule-based interactions

## Assignment Instructions:

There are two components to this assignment:

1. A 3-5 min video and 2 peer responses (Described Below)
2. A 500–1000-word report.

### Video Component

For your assignment you will record a video covering the following components:

1. **Introduction (30-45 seconds):**
  - Briefly introduce the Ising model, its purpose, and its rules (e.g., spin interactions and energy minimization).
  - State the parameters you will vary (e.g., temperature, magnetic field, initial spin configuration).
2. **Experiment Setup (45 seconds):**
  - Demonstrate your initial configurations and parameter settings.
  - Explain how the simulation evolves based on these settings.
3. **Observations (1-2 minutes):**
  - Run the simulation and document how spin patterns evolve.
  - Identify key behaviors, such as magnetized regions or phase transitions, and what they reveal about the system.

#### 4. Hypotheses and Analysis (45 seconds):

- Propose hypotheses about the effects of changing temperature or magnetic fields on the system.
- Analyze whether the simulation results support your hypotheses.

#### 5. Conclusion (30 seconds):

- Summarize your findings, focusing on the role of temperature, magnetic fields, and initial conditions in shaping emergent behaviors.

### Reflection Paper

Write a 500–1000-word report addressing the following:

#### 1. Simulation Overview:

- Describe the Ising model, its rules, and purpose.
- Explain the parameters and configurations you tested and why.

#### 2. Observations and Patterns:

- Discuss how patterns evolved under different conditions.
- Highlight key phenomena, such as phase transitions or magnetization, and their implications.

#### 3. Hypotheses and Analysis:

- Present your hypotheses and compare them to your results.
- Reflect on unexpected outcomes and possible causes.

#### 4. Real-World Implications:

- Connect Ising model behaviors to real-world systems (e.g., magnetism, social interactions, or neural networks).
- Discuss the model's strengths and limitations in representing these systems.

#### 5. Philosophical Implications:

- Reflect on what the Ising model reveals about the emergence of order from simple rules.
- Consider its relevance to broader philosophical questions about the nature of reality.

#### 6. Conclusion:

- Summarize key insights about the Ising model and its ability to simulate emergent phenomena.

**Rubric:**

Can be found on Canas Assignment.