Systems Thinking

Systems Analysis & Design

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Outline

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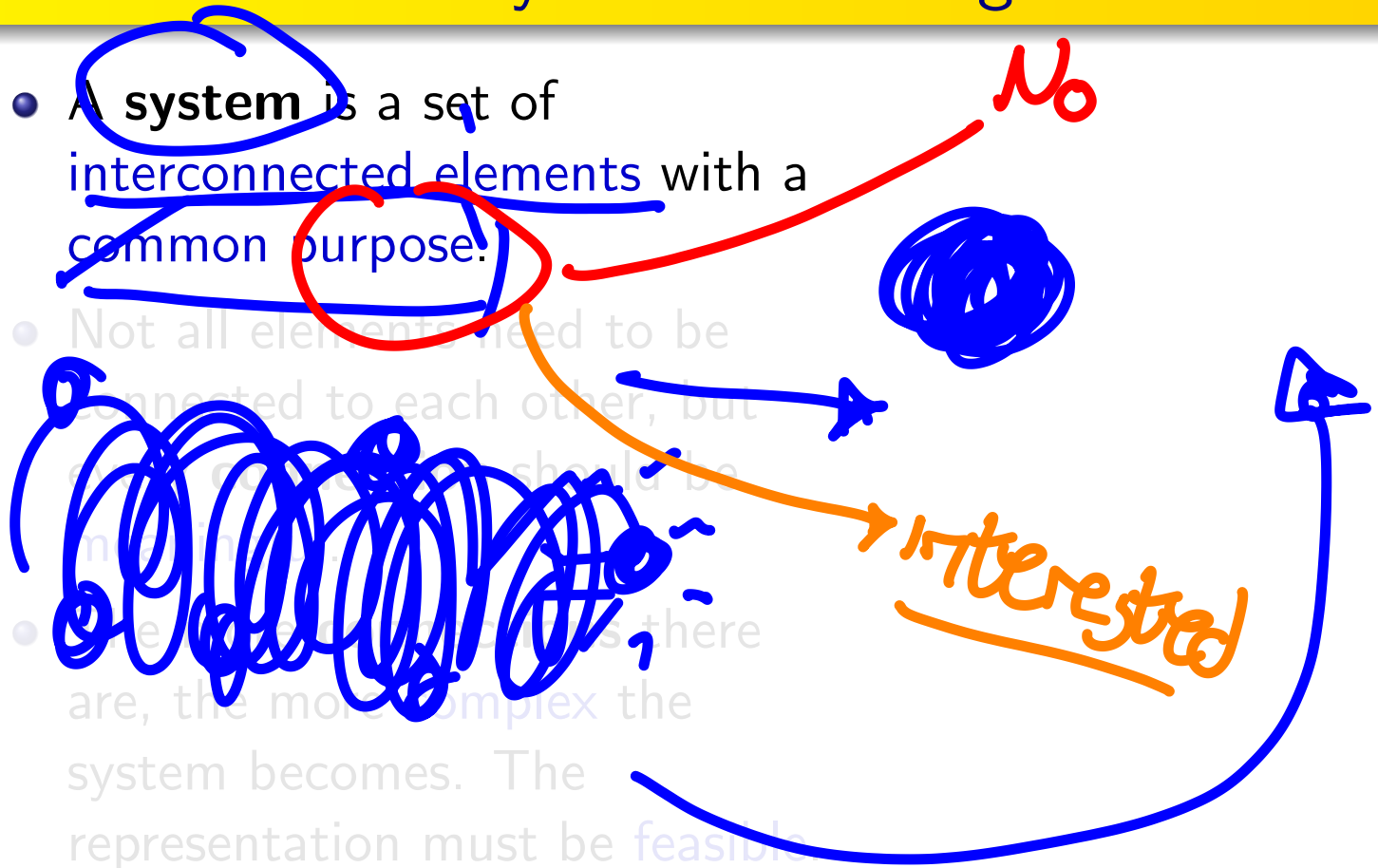
Introduction to Systems Thinking I

- A **system** is a set of interconnected elements with a common purpose.
- Not all elements need to be connected to each other, but each element should be connected to at least one other element.
- The more elements there are, the more complex the system becomes. The representation must be feasible.
- Each element must have **at least** one connection. Isolated elements make no sense in a system.



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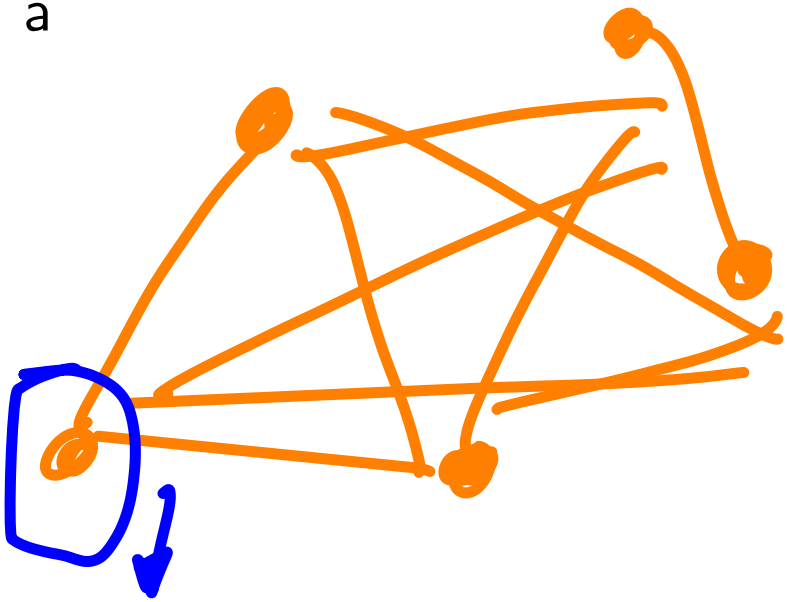

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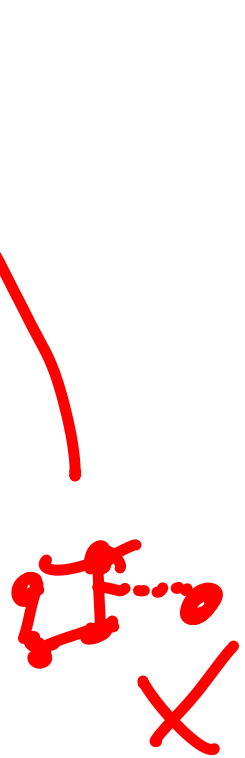
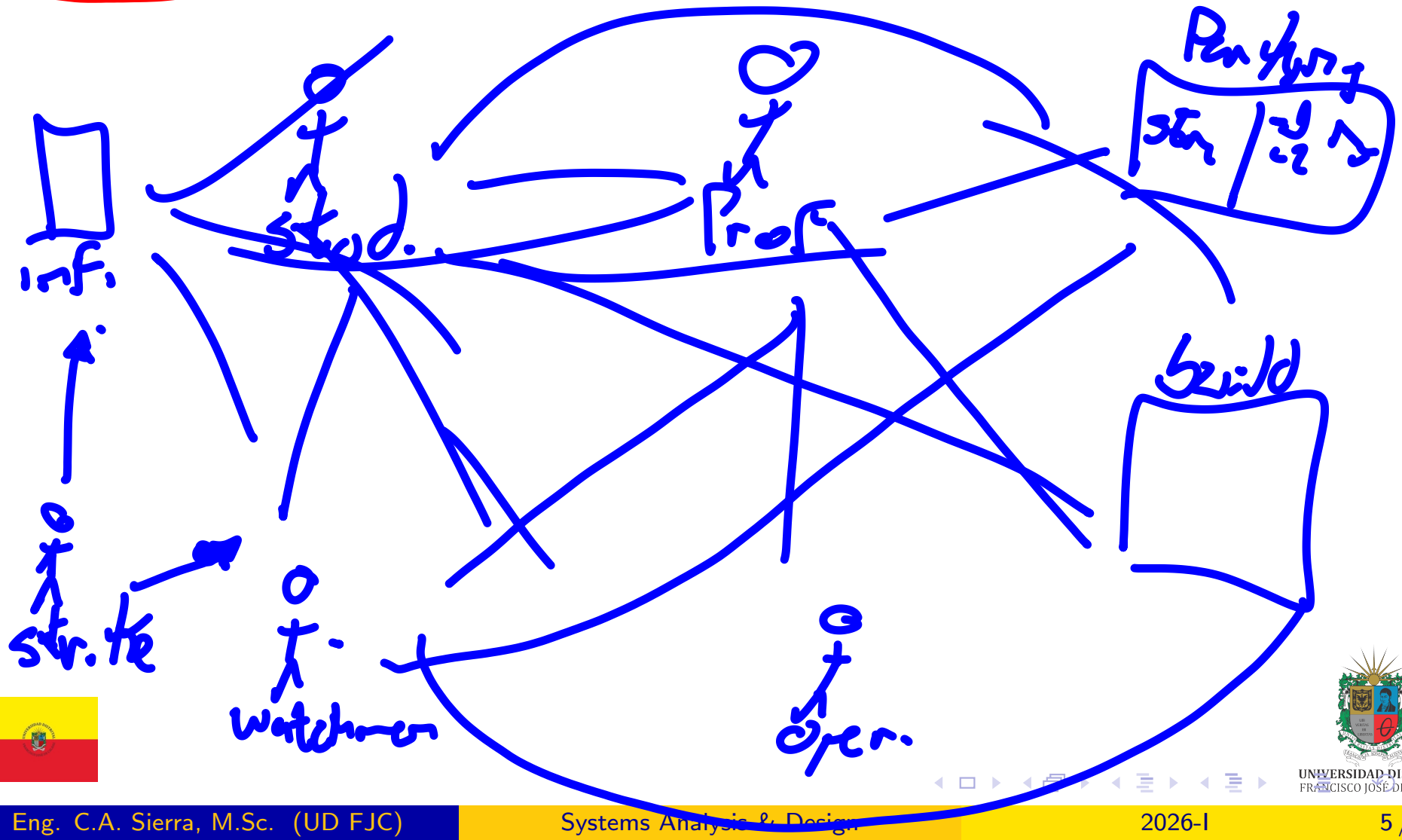
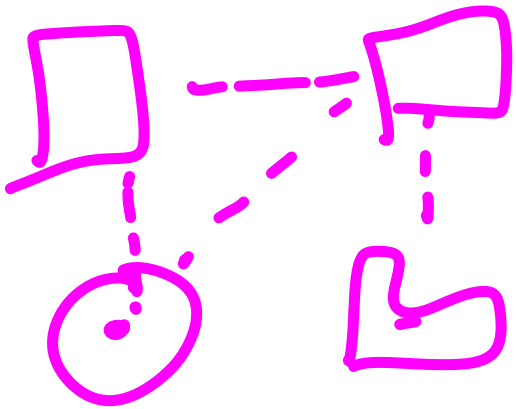


Complexity in Systems

System complexity can be defined as the number of elements and connections in a system.



Introduction to Systems Thinking II



- In **systems thinking**, if you just split the parts and forget the relationships, you will lose the full picture.
- It is called a **holistic** approach; try to see the whole picture with all the meaningful details.
- Defining the **box boundaries** is sometimes tricky; as we said, not too complex, not too simple. It is like the desired universe balance of Thanos.

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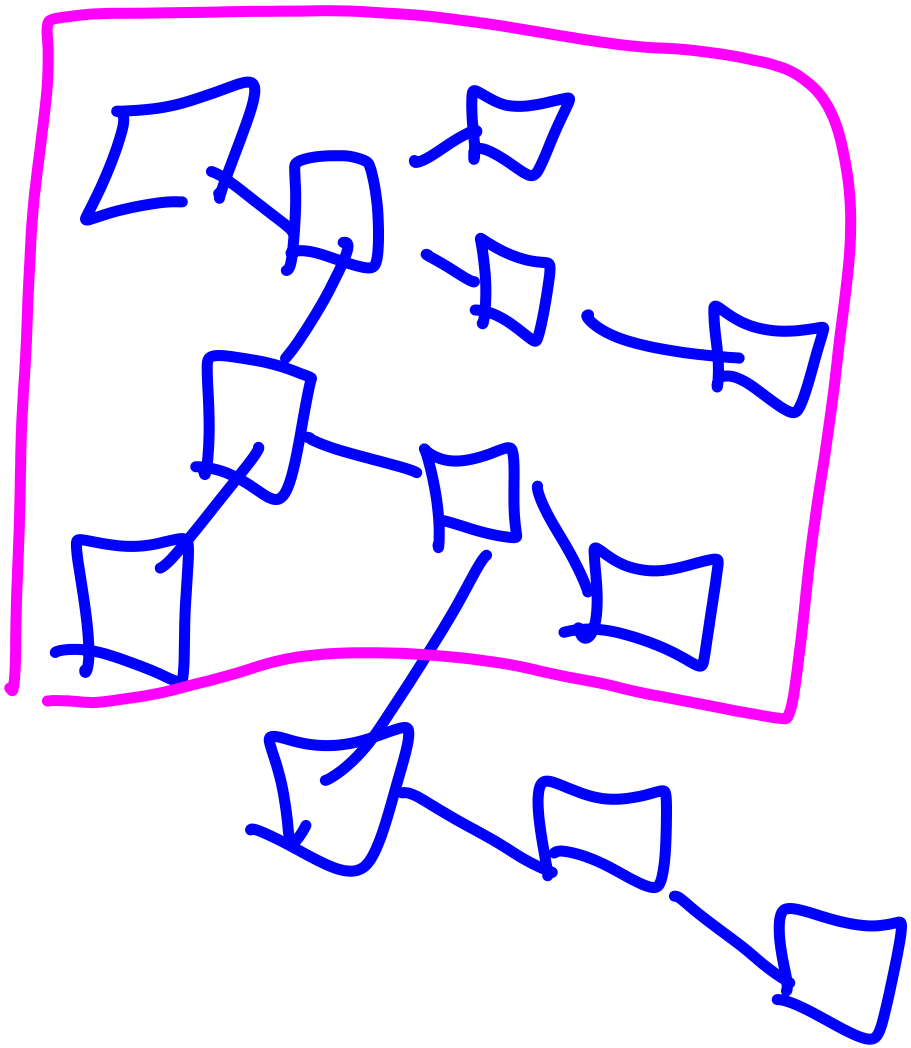

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Introduction to Systems Thinking III

- Another important concept is **homeostasis**; it means putting a system in an equilibrium state. That is hard because **systems** are both not in equilibrium and resilient to change.
- A **system** is more than the sum of its parts. This means relationships, behaviors, and recovery capacity are forgotten when you see the system just as its parts.

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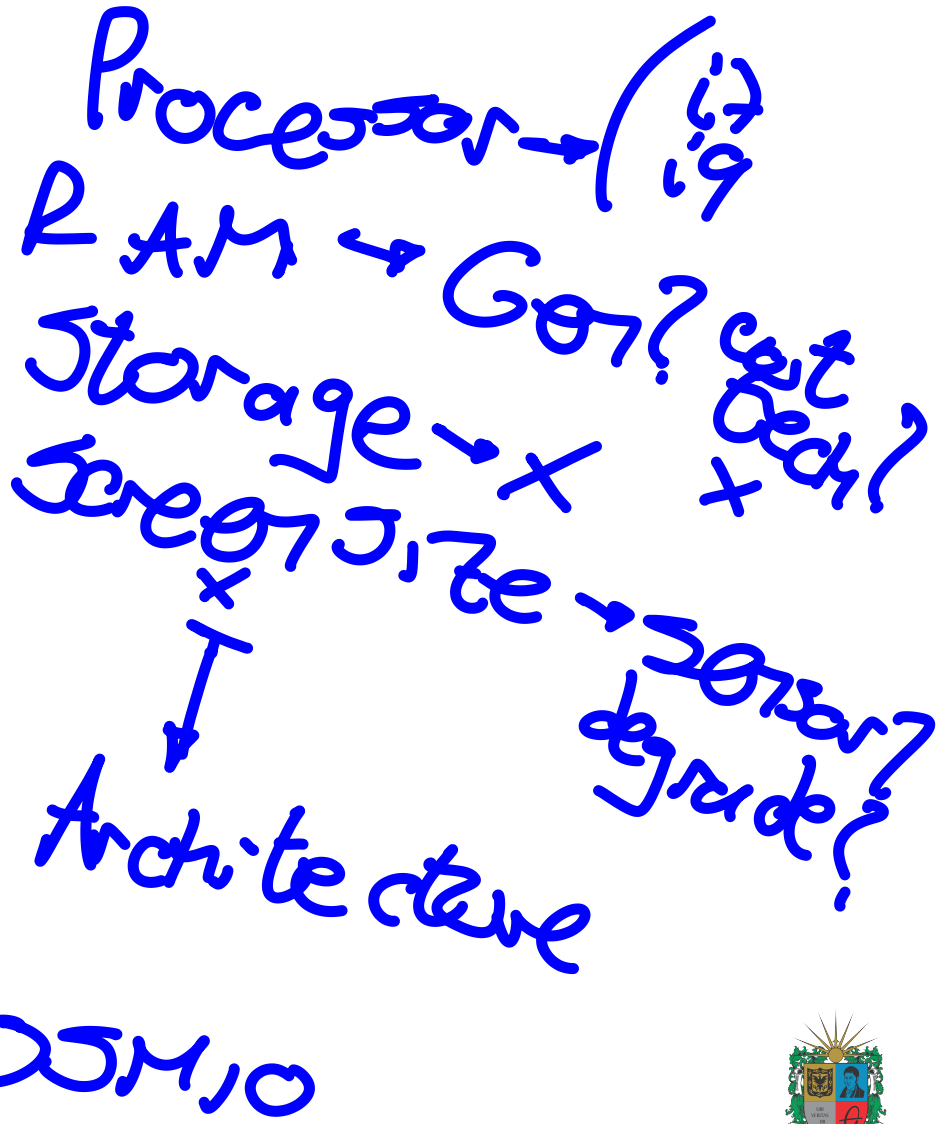
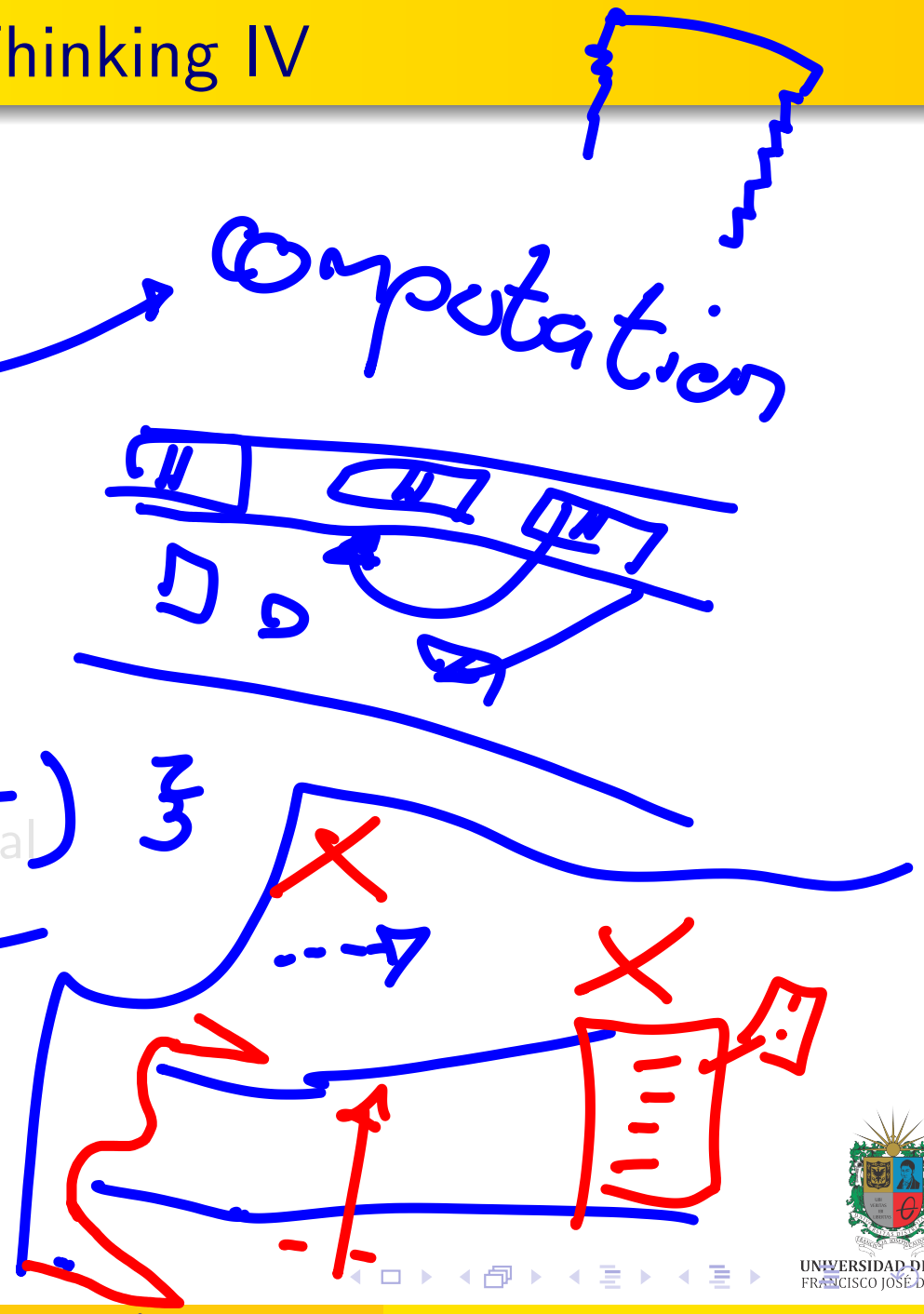


Introduction to Systems Thinking IV

- **Systems thinking** is a way to understand and represent problems in order to find the best possible solution.
- Thinking of a **problem as a system** lets you understand details, involved elements, and relevant information.
- **Systems** should be viable, self-sustainable, provide internal feedback loops, and also look like a whole living entity.



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Introduction to Systems Thinking V

- **Computation** helps to represent behaviors mathematically. Also, it helps to find patterns and information, and simplify processes; an example of all this is Artificial Intelligence.
- **Top-Down** approach is useful when you want to see the full picture, and then split it into parts.
- The **Bottom-Up** approach is useful when you want to see the parts and then connect them to get the full picture.

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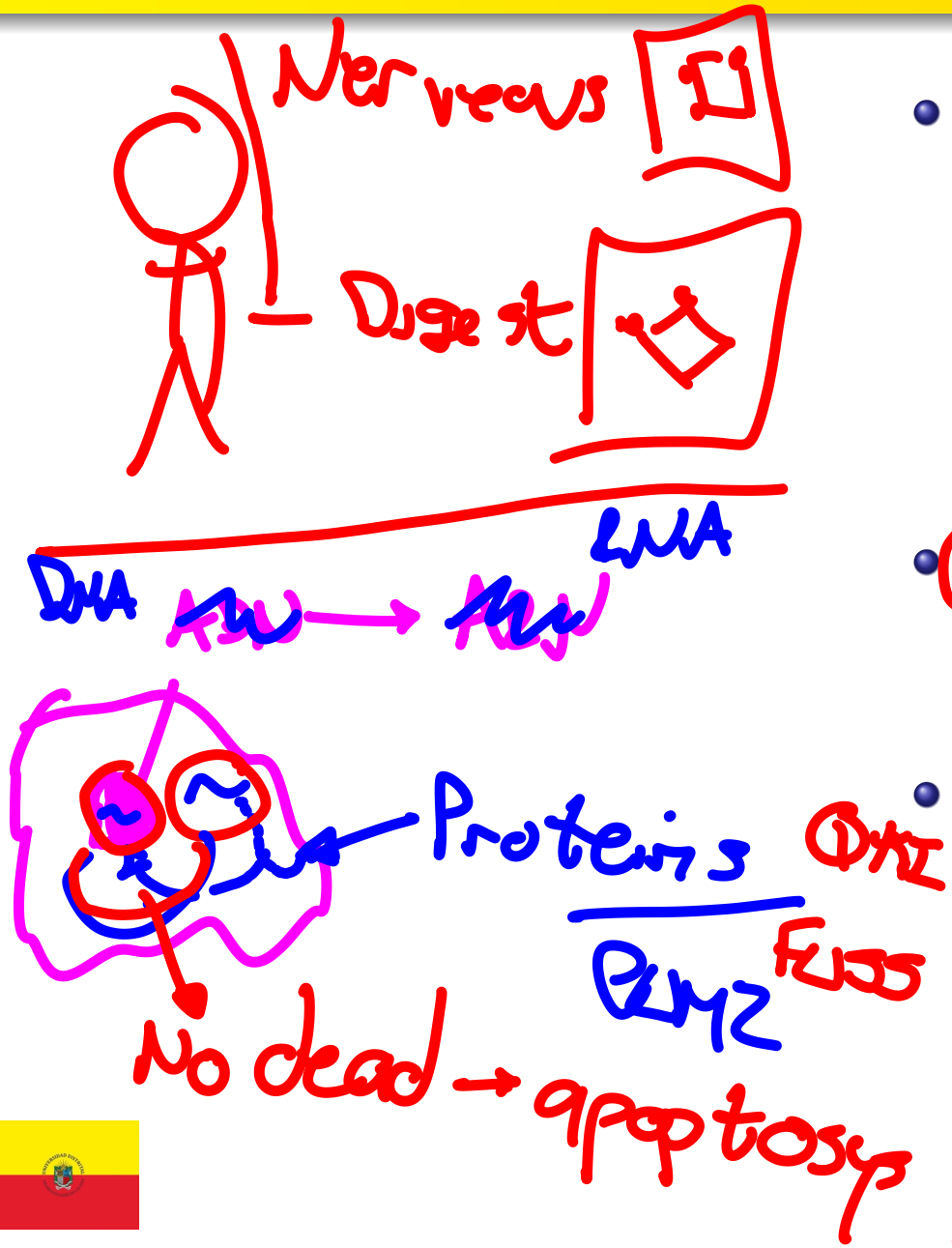

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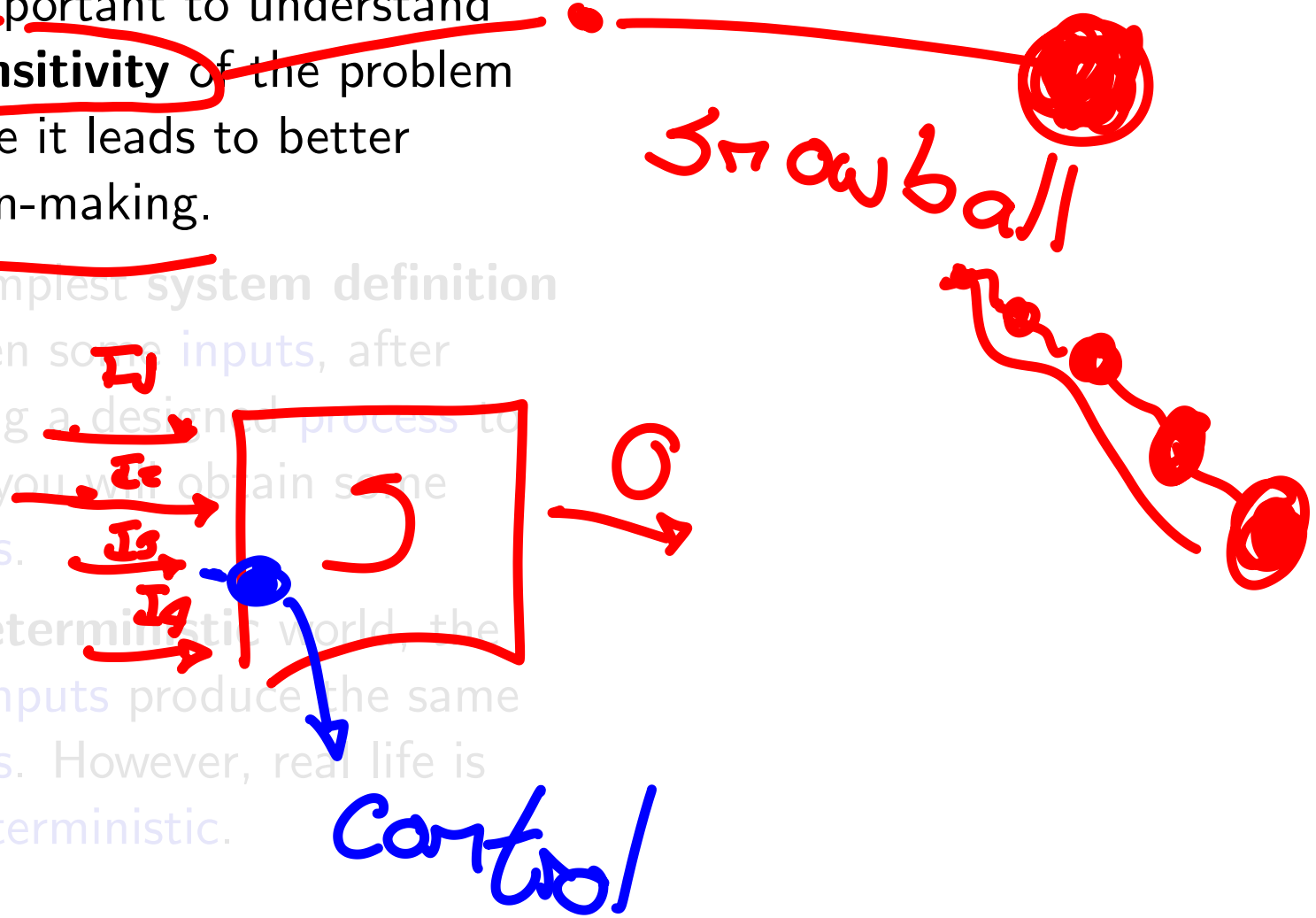
Introduction to Systems Thinking VI

- It is important to understand the **sensitivity** of the problem because it leads to better decision-making.
- The simplest **system definition** is: given some inputs, after applying a designed process to them, you will obtain some outputs.
- In a **deterministic** world, the same inputs produce the same outputs. However, real life is not deterministic.



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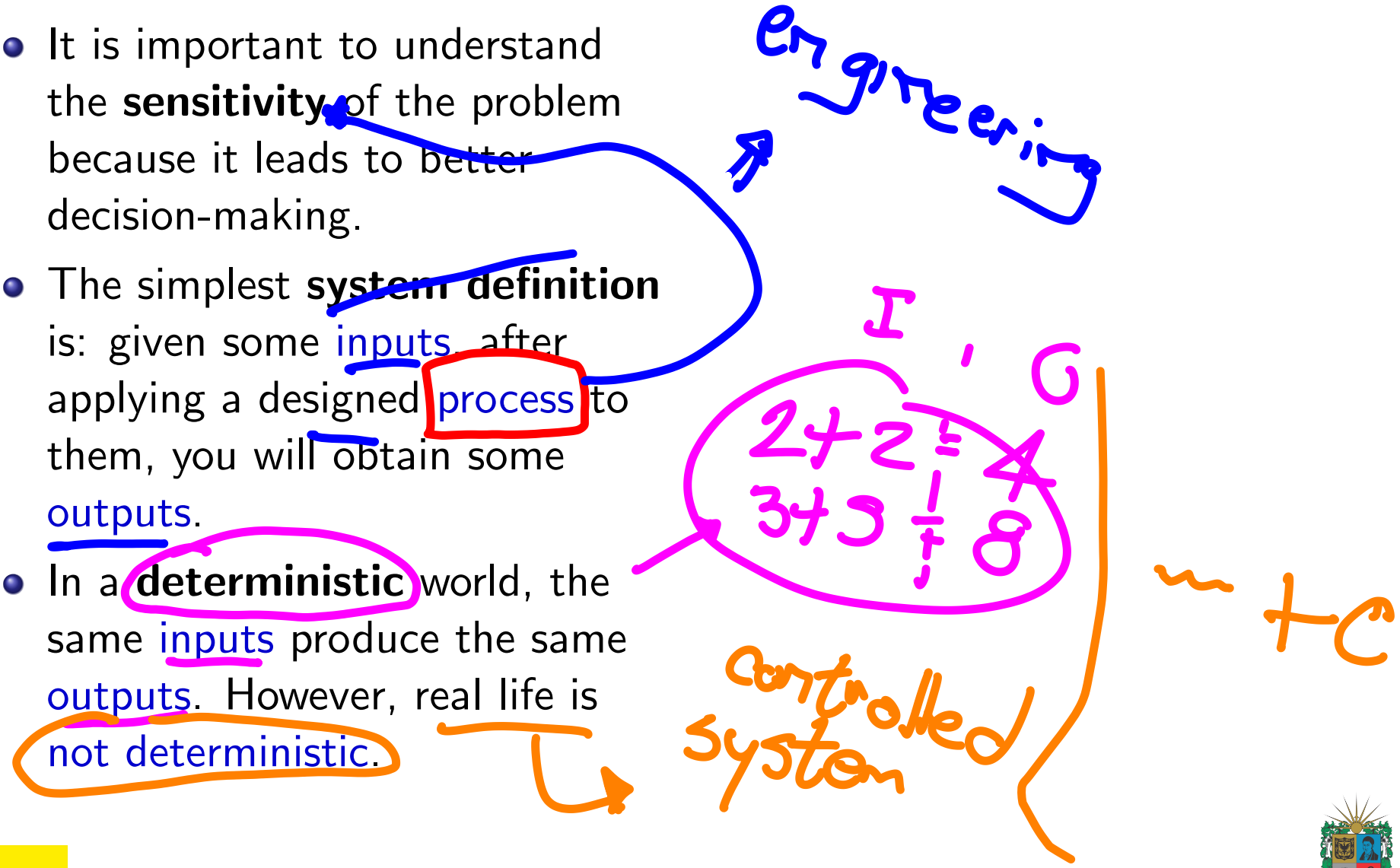
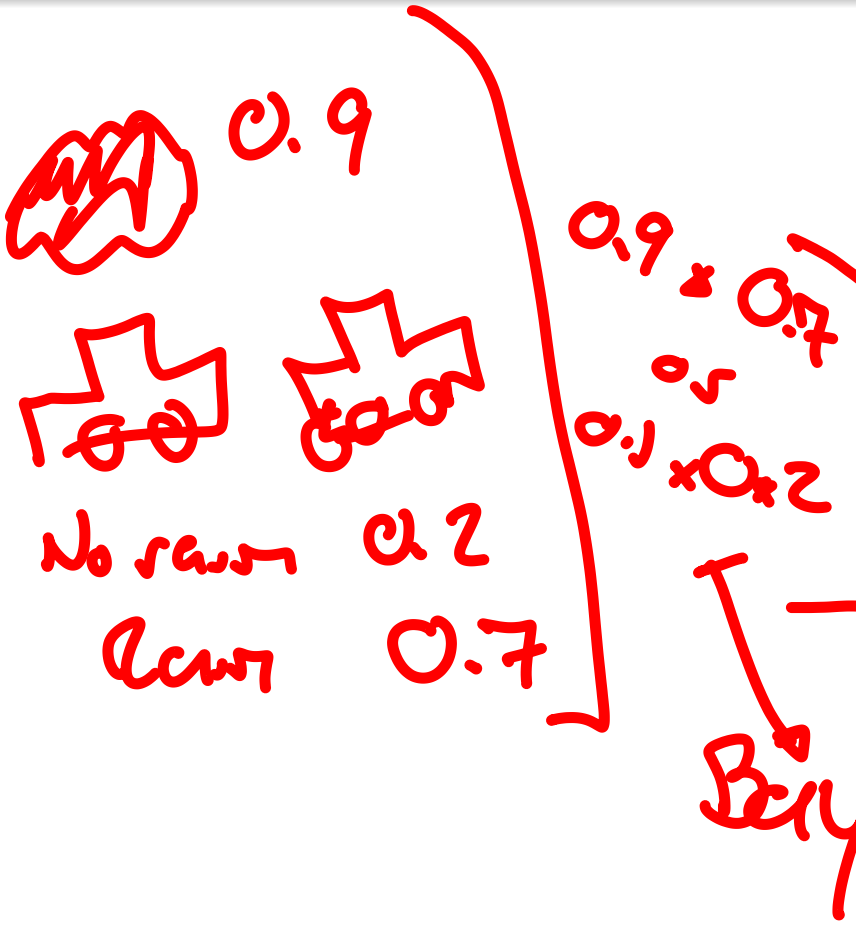


Introduction to Systems Thinking VII



- Since **randomness** is normal in the real world, relying solely on deterministic processes is dangerous. Using **stochastic processes** is a better approach.
- **Stochastic processes** make use of probability, which leads to a better representation of real-world behavior.
- Here, **Chaos Theory** becomes a useful tool. To put it simply, chaos can be defined as a harmonious balance between rules and randomness.

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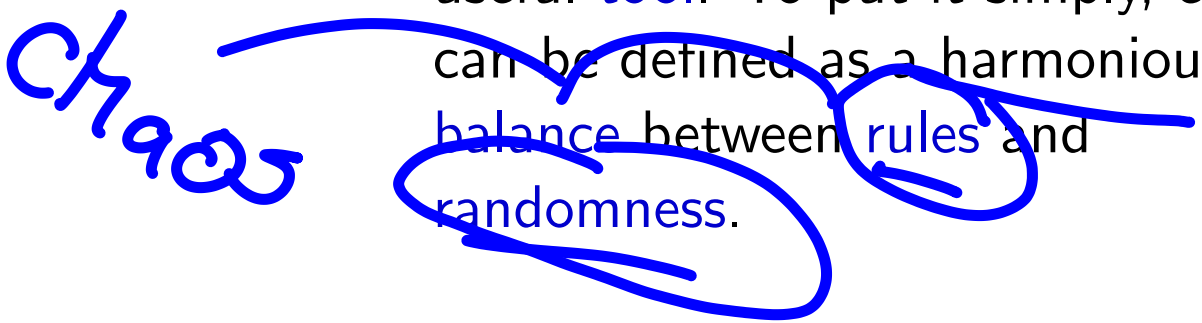

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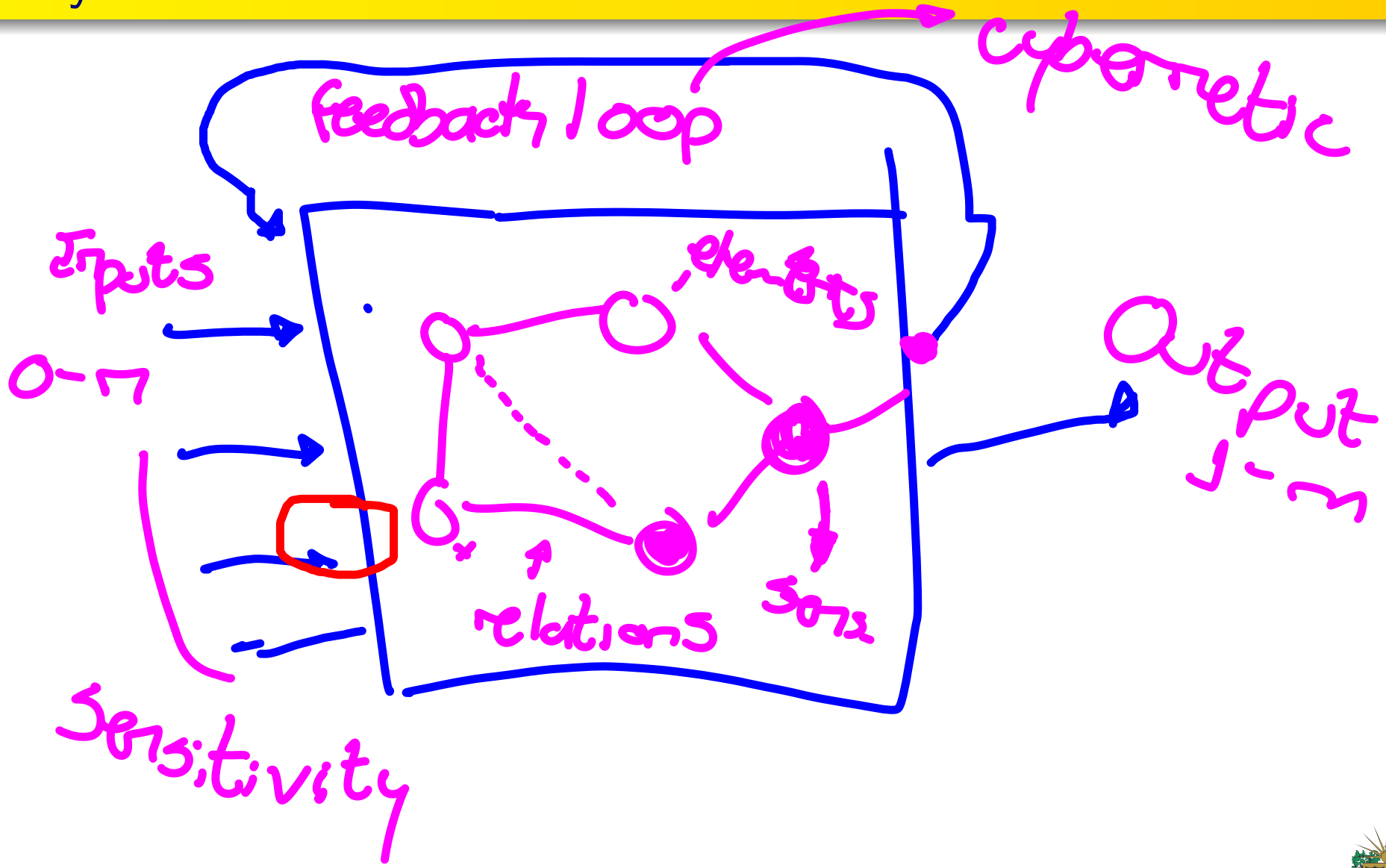
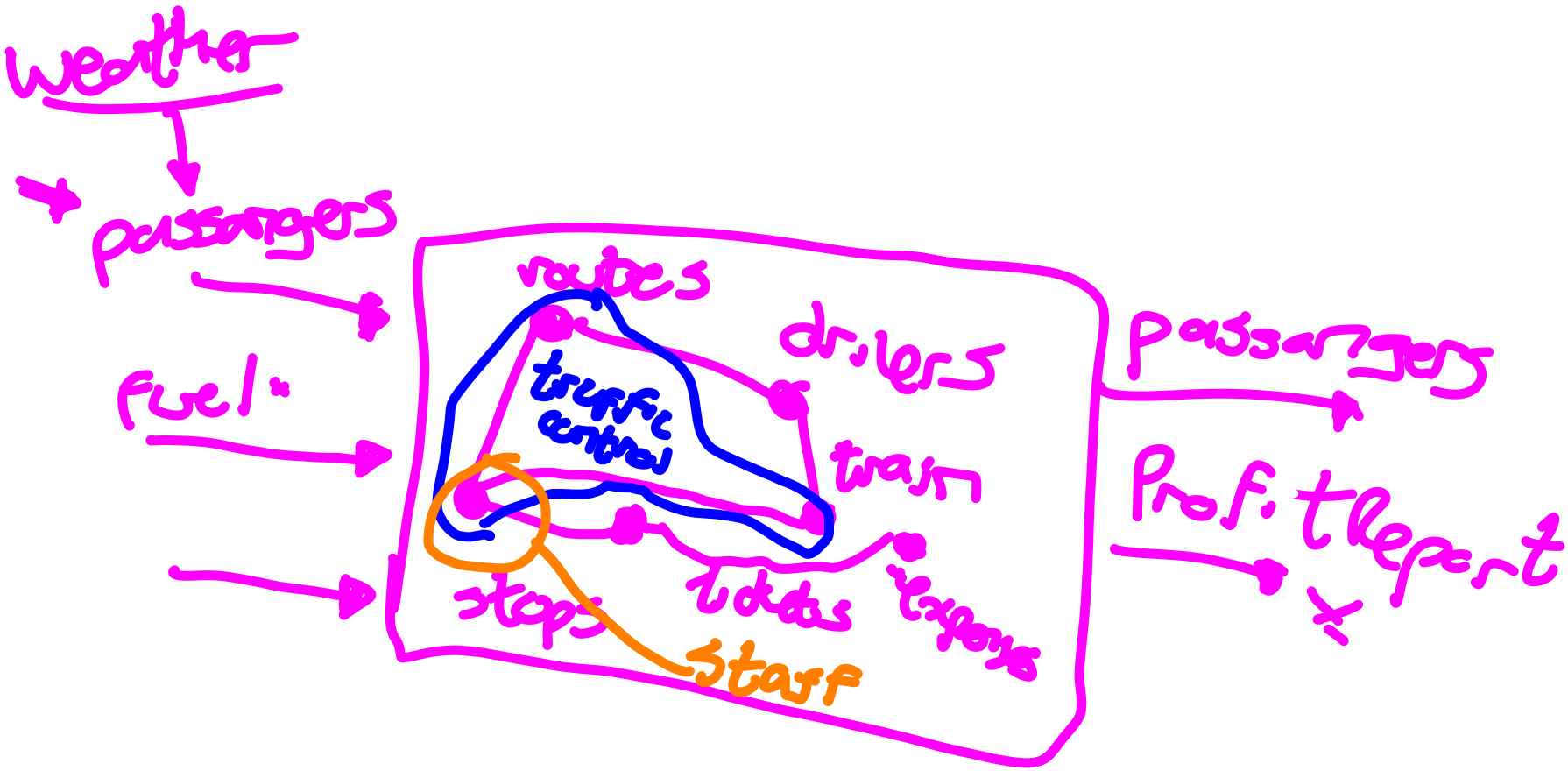
Systems Structure Draw



Case of Study: Transportation System



Outline

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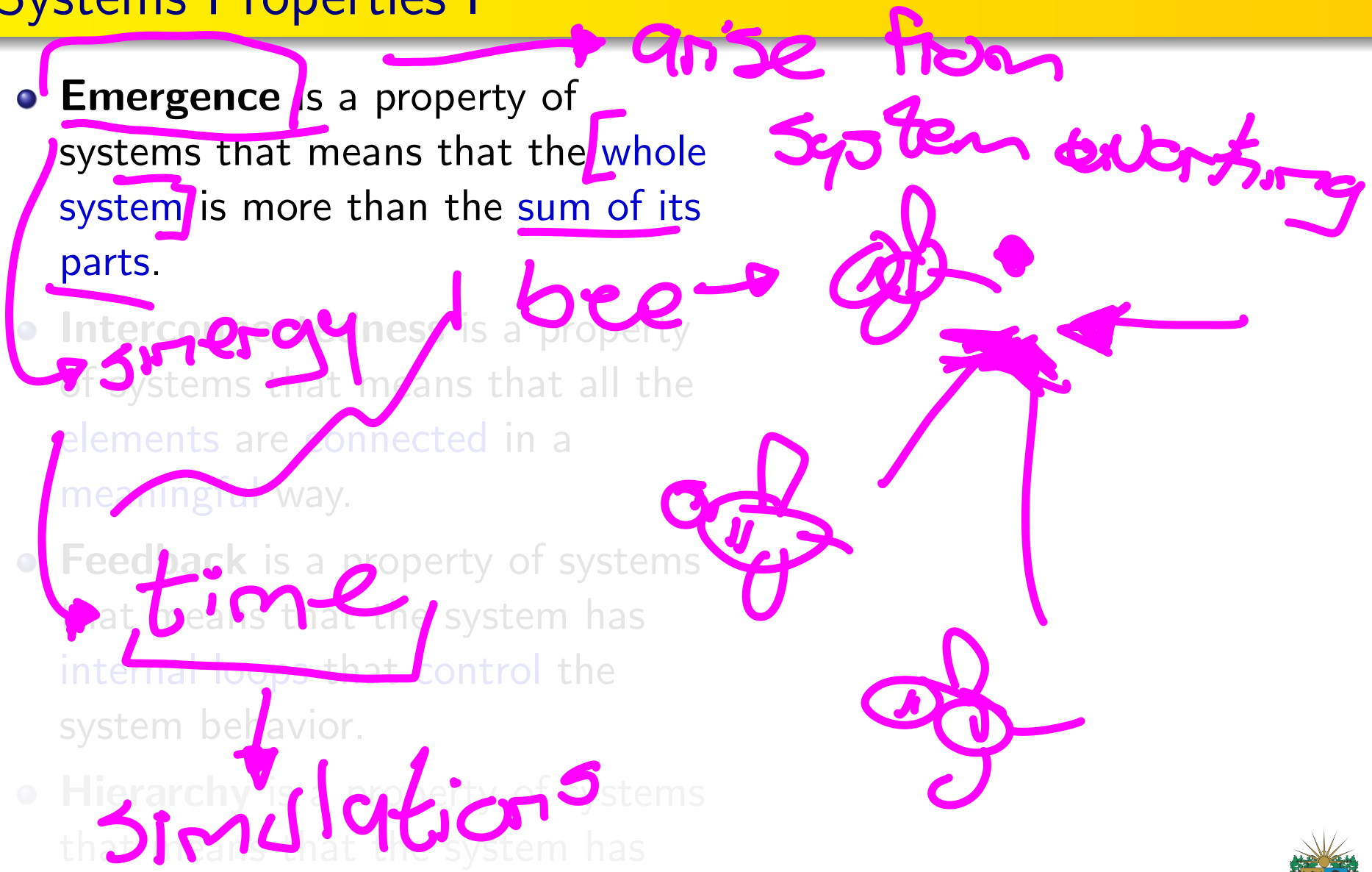
Systems Properties I

- **Emergence** is a property of systems that means that the whole system is more than the sum of its parts.
- **Interconnectedness** is a property of systems that means that all the elements are connected in a meaningful way.
- **Feedback** is a property of systems that means that the system has internal loops that control the system behavior.
- **Hierarchy** is a property of systems that means that the system has levels of organization.



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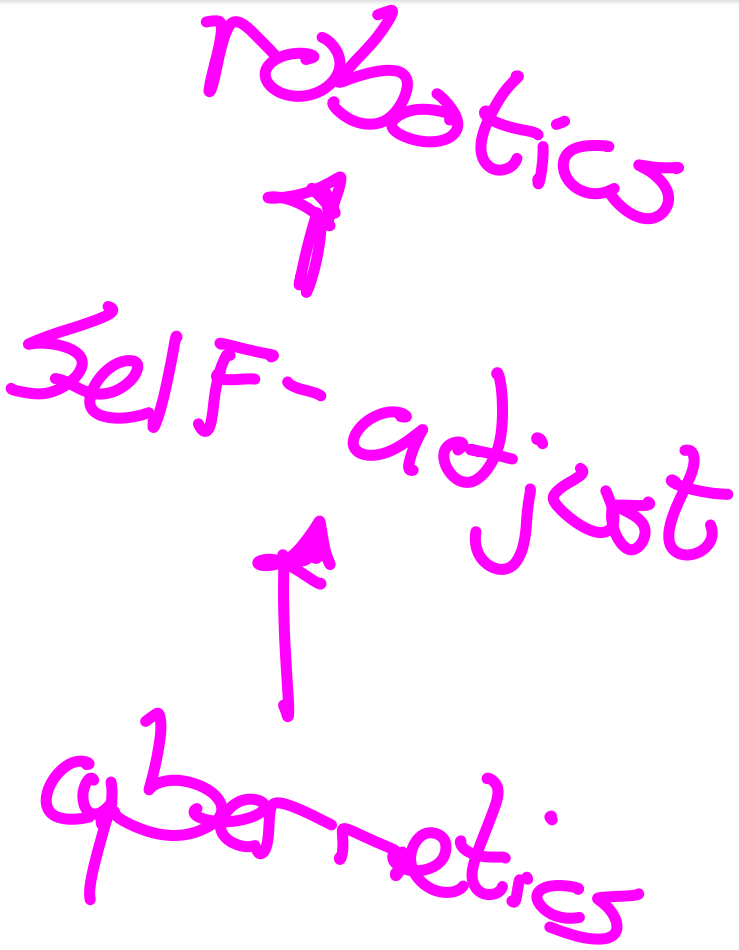

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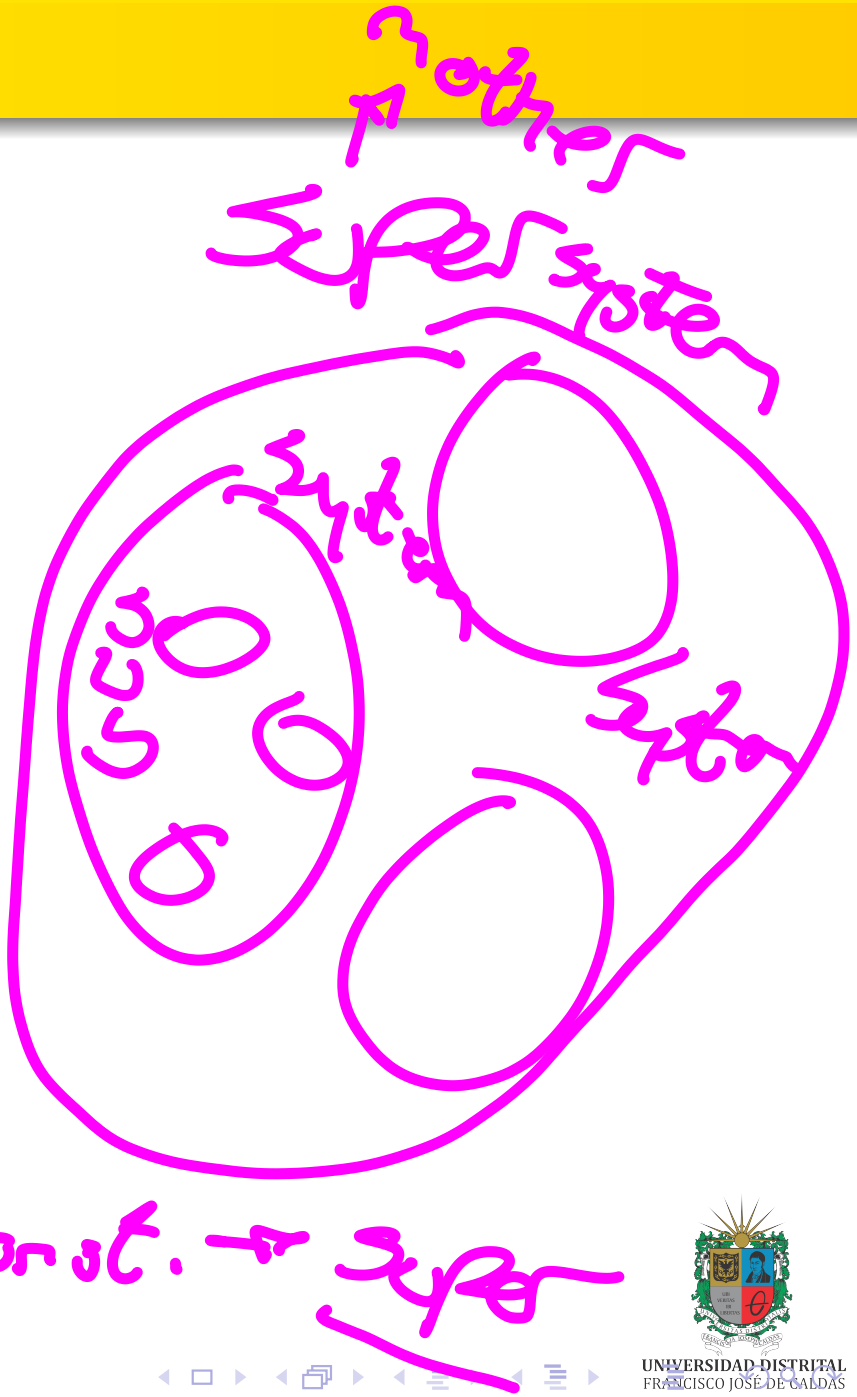

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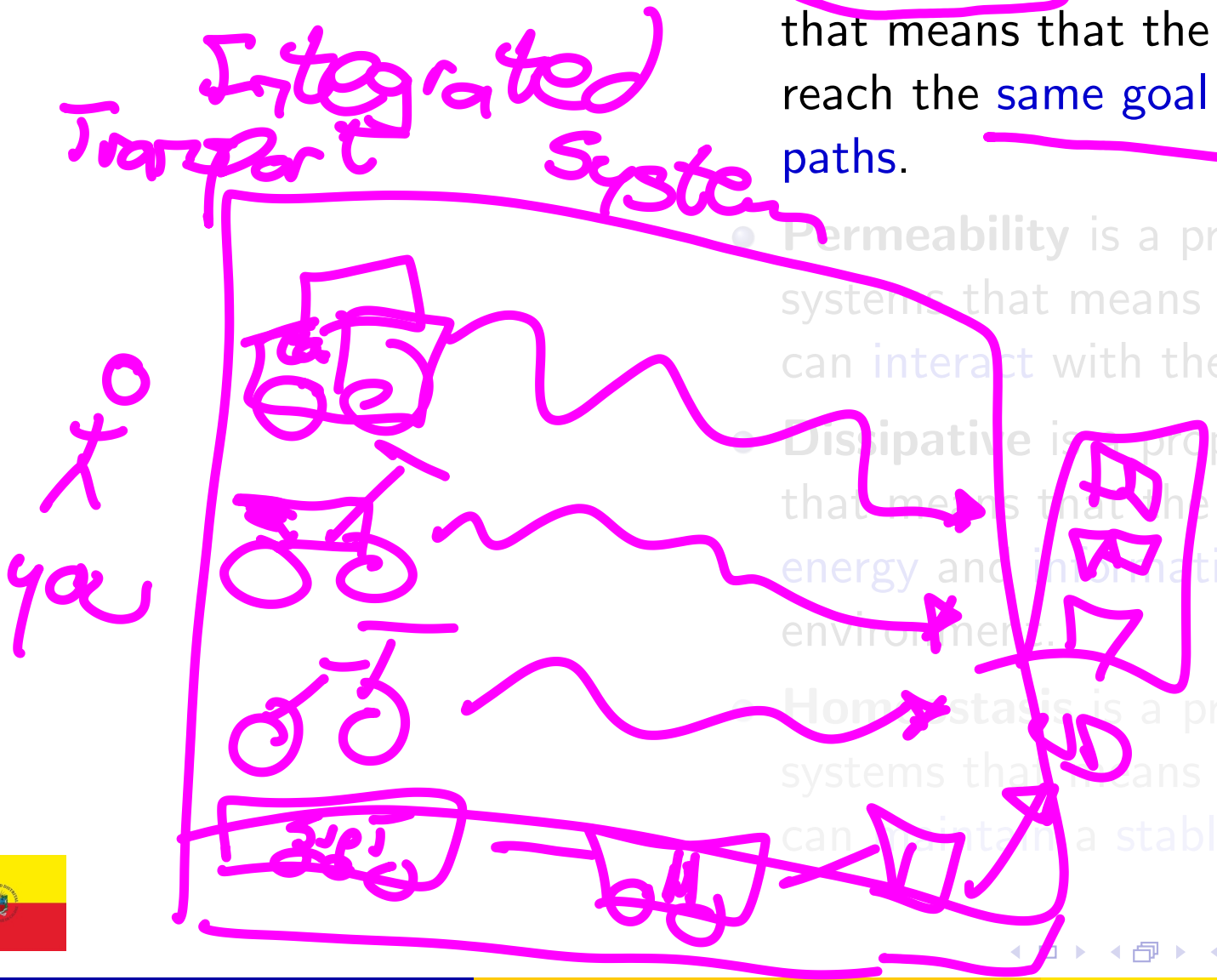

- **Equifinality** is a property of systems that means that the system can reach the same goal from different paths.
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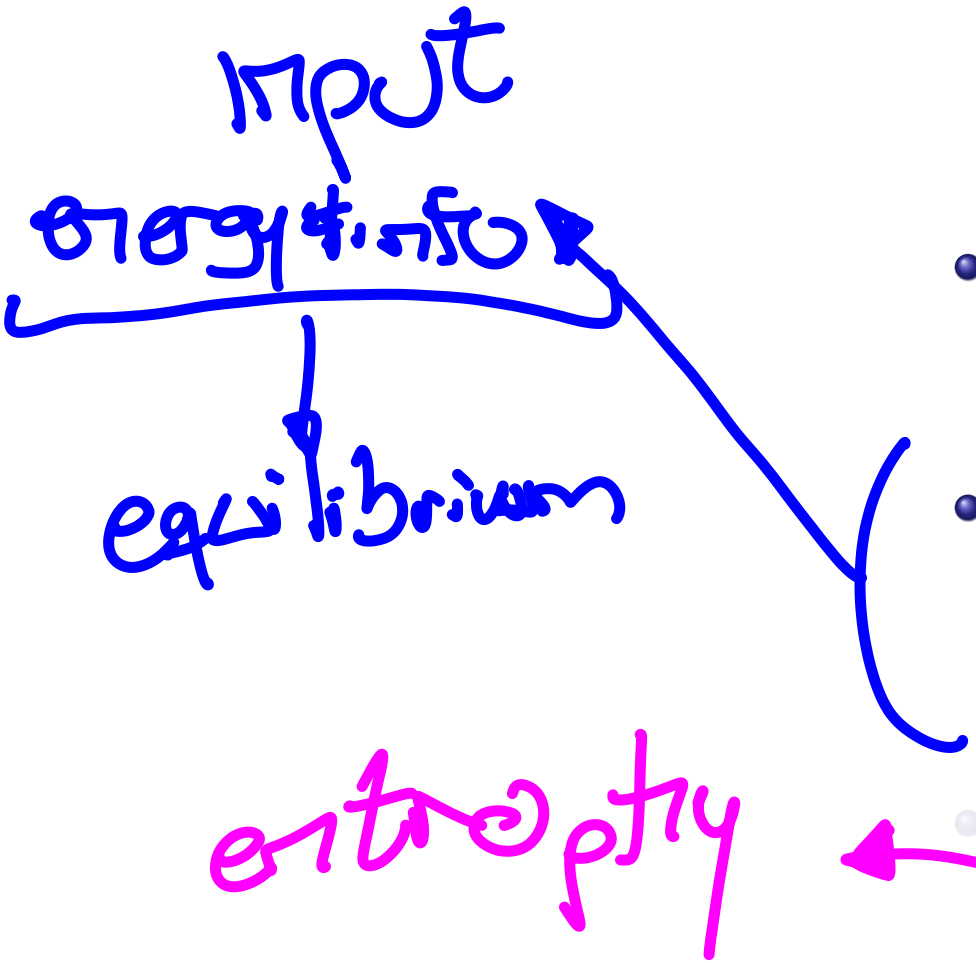

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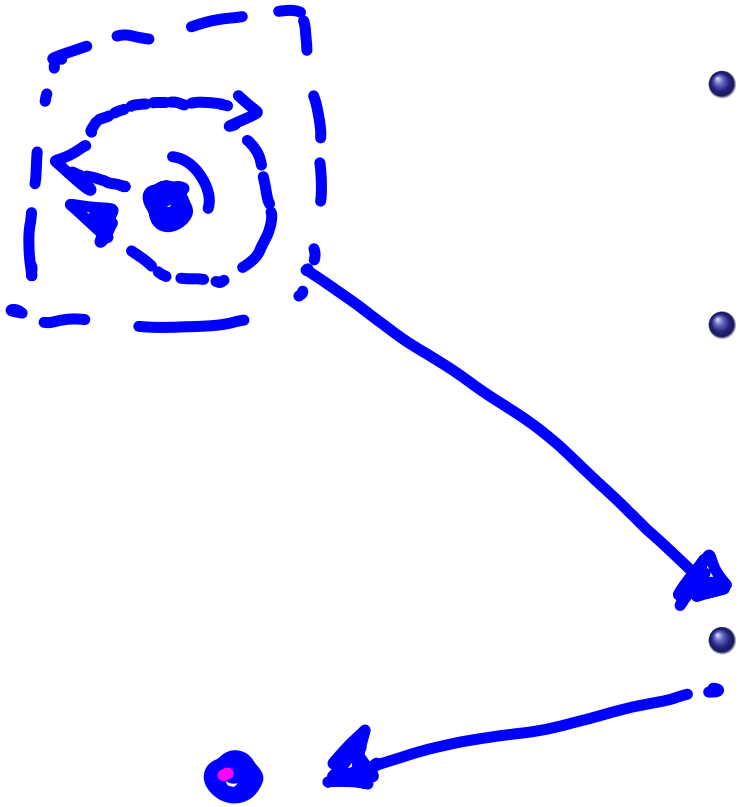

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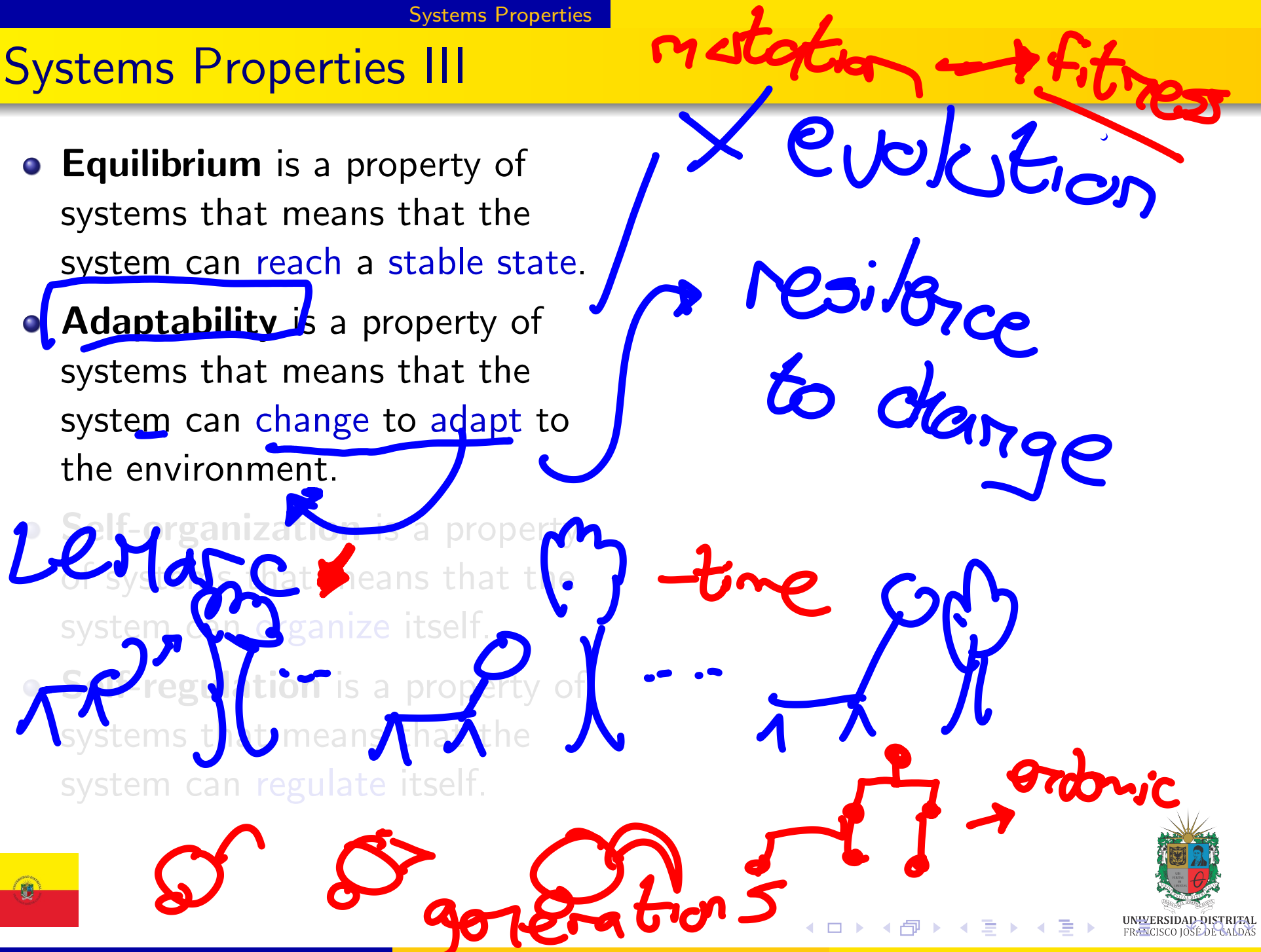

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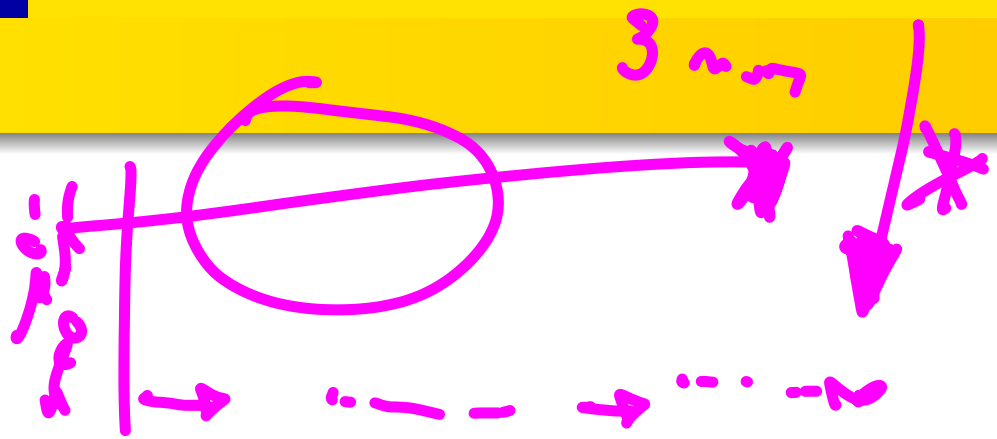

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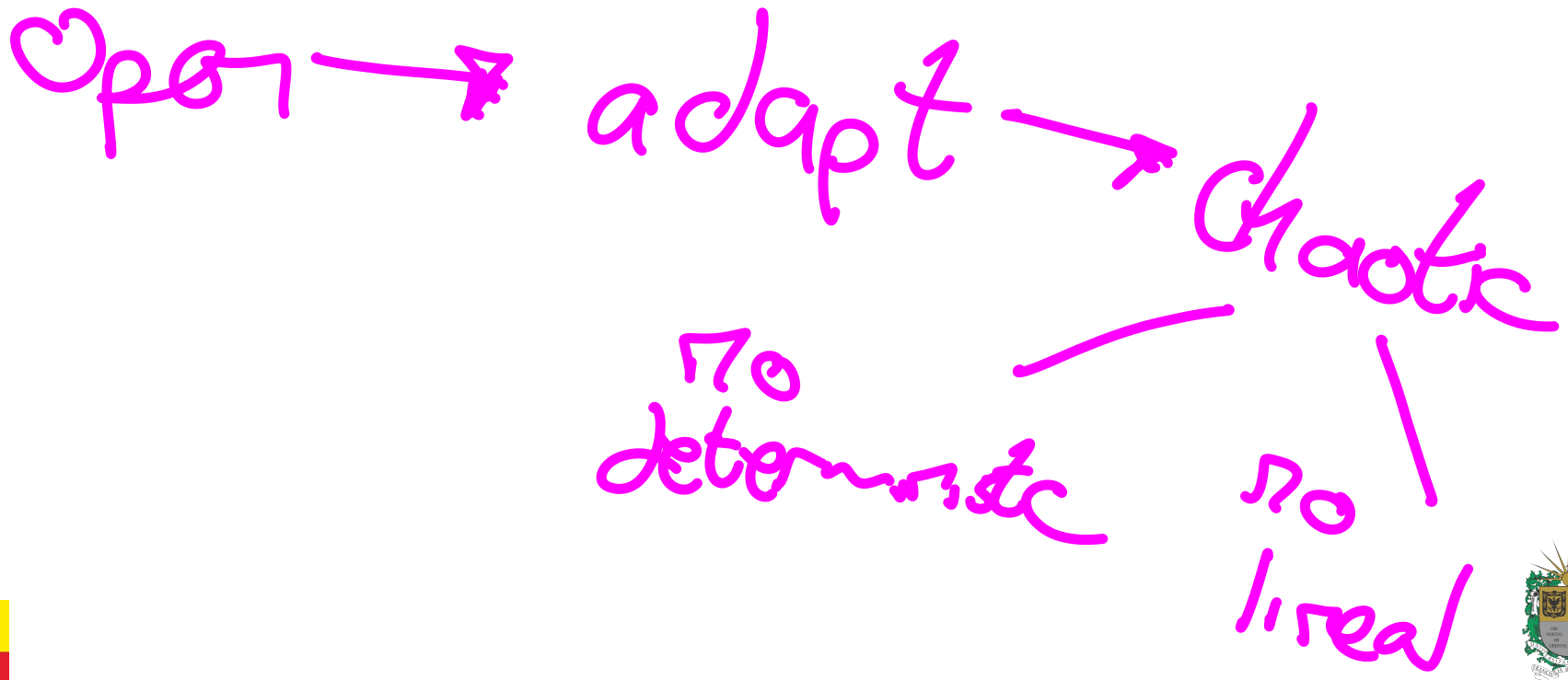
Basic Concepts

A **system** can be classified according to different criteria like openness, adaptability, determinism and linearity.



Systems Classification I

- **Open systems** are systems that can interact with their environment.
- **Closed systems** are systems that cannot interact with their environment.
- **Adaptive systems** are systems that can change and adapt to their environment.
- **Non-adaptive systems** are systems that cannot change or adapt to their environment.

almost all

laboratory experiments

highly controlled

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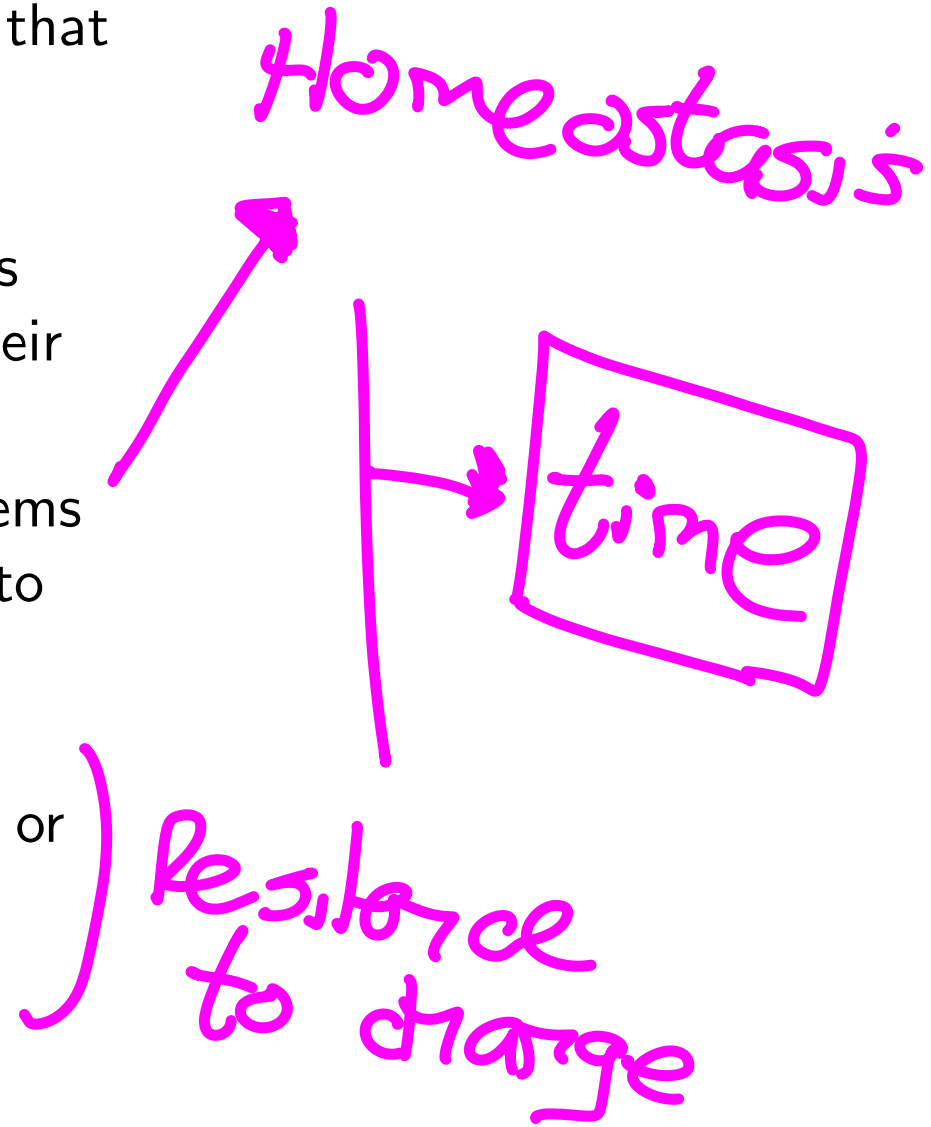

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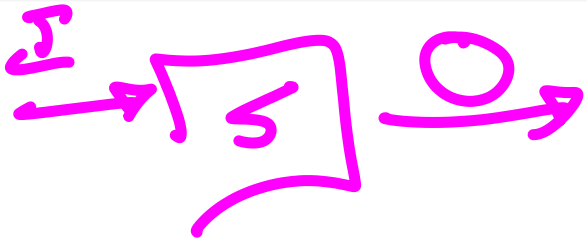
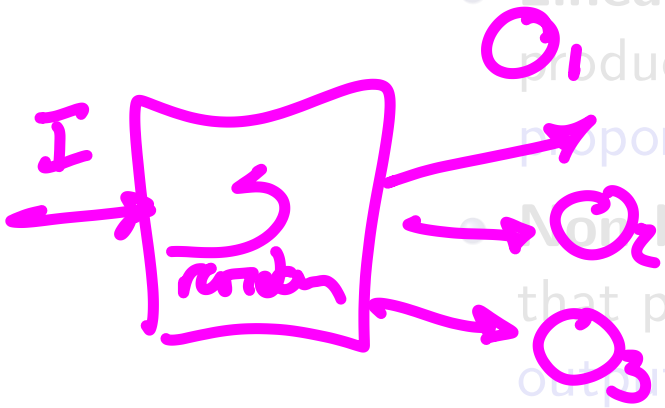


- **Deterministic systems** are systems that produce the same output for the same input.
- **Stochastic systems** are systems that produce different outputs for the same input.
- **Linear systems** are systems that produce proportional outputs for proportional inputs.
- **Nonlinear systems** are systems that produce non-proportional outputs for any given inputs.



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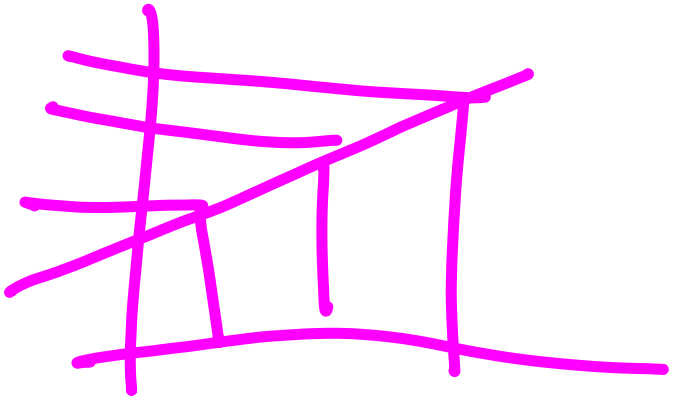

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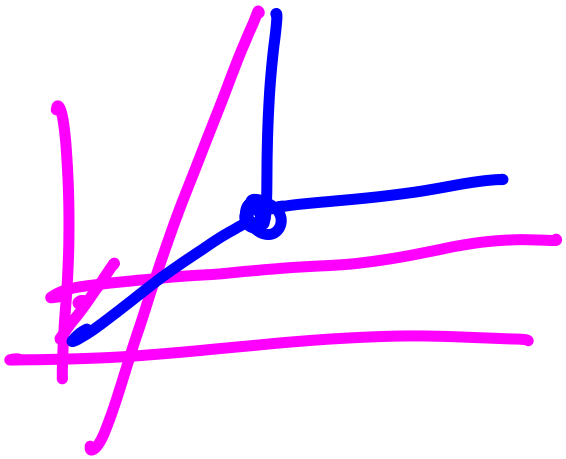

chaotic + stochastic

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Thanks!

Questions?

Repo: *https://github.com/EngAndres/ud-public/tree/main/courses/systems-analysis*

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