Systems Thinking

Systems Analysis & Design

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2025-I

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Outline

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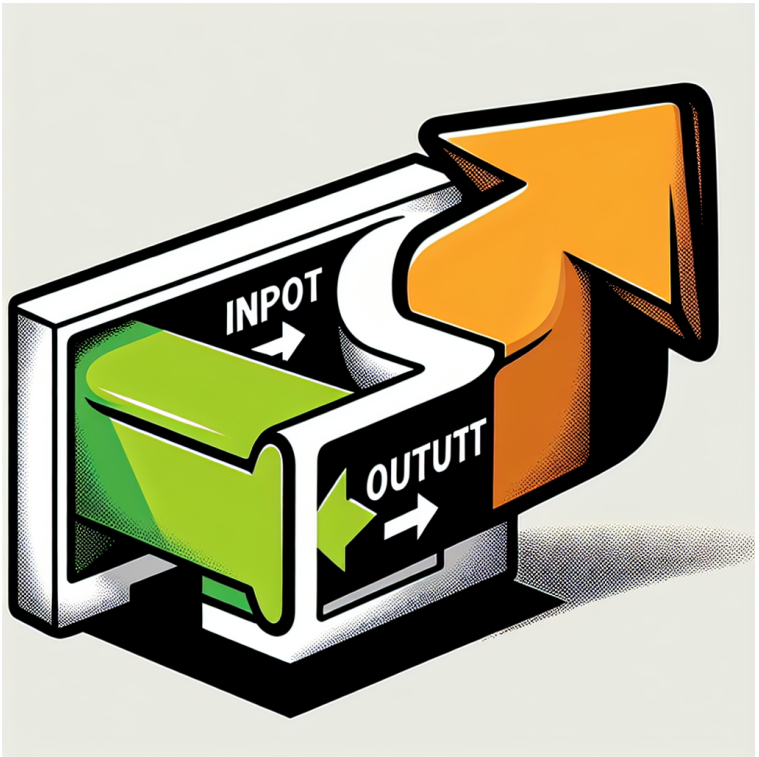
Introduction to Systems Thinking I

- A **system** is a set of interconnected elements with a common purpose.
- Not all elements need to be connected to each other, but every **connection** should be meaningful.
- The more **connections** 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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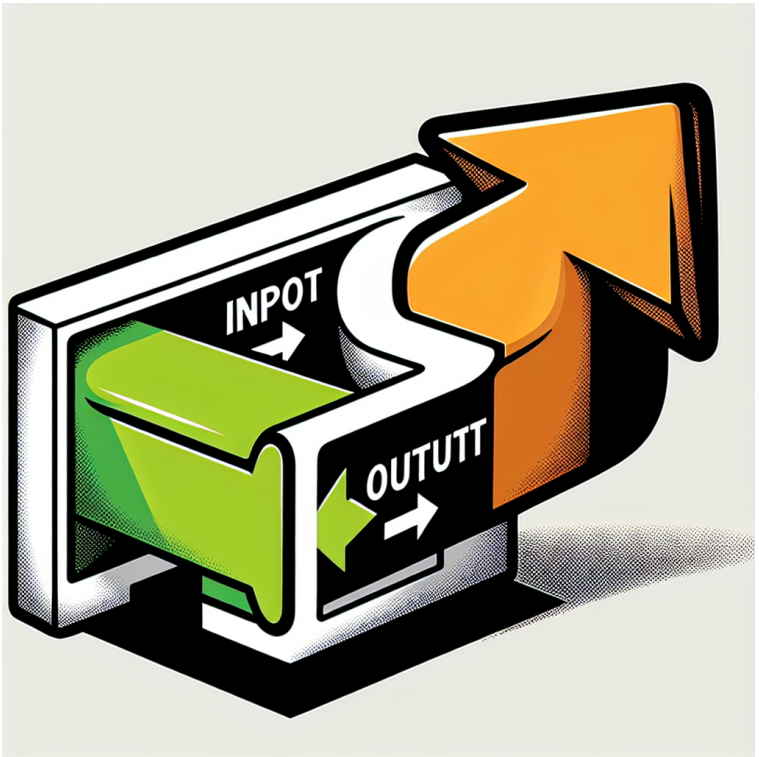

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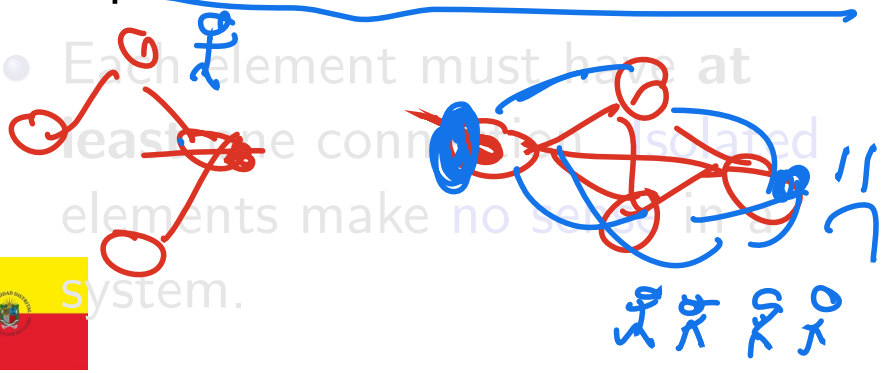

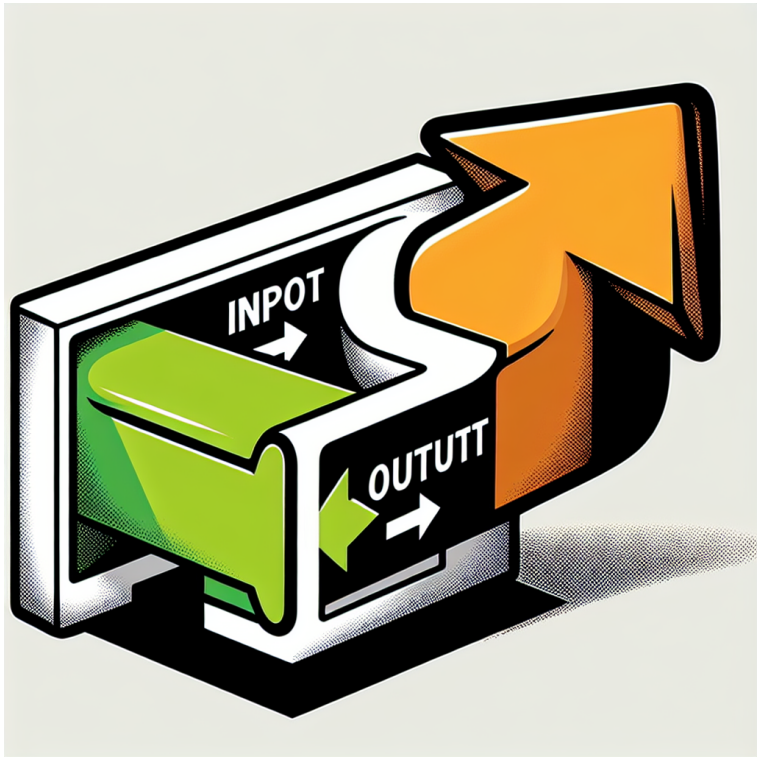

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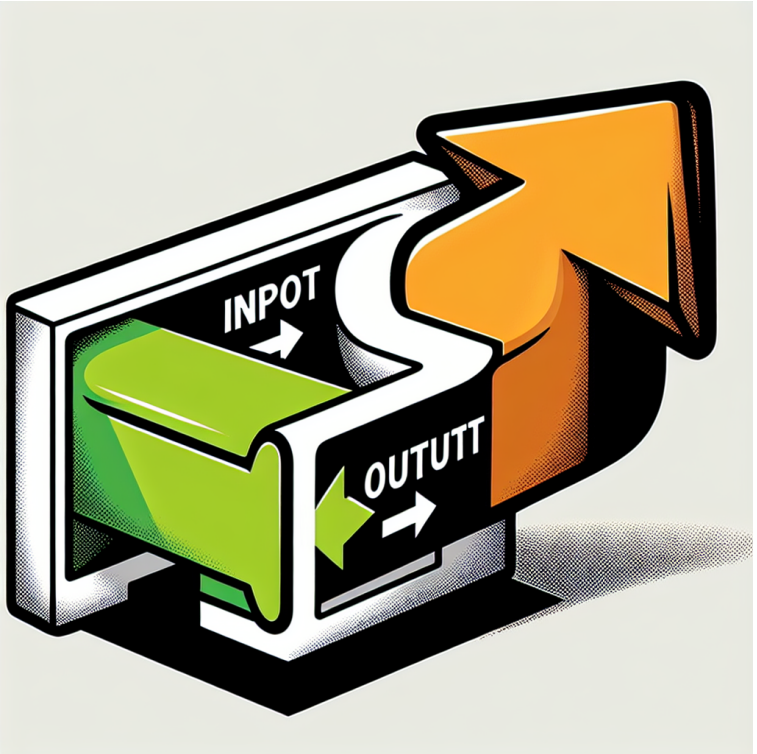

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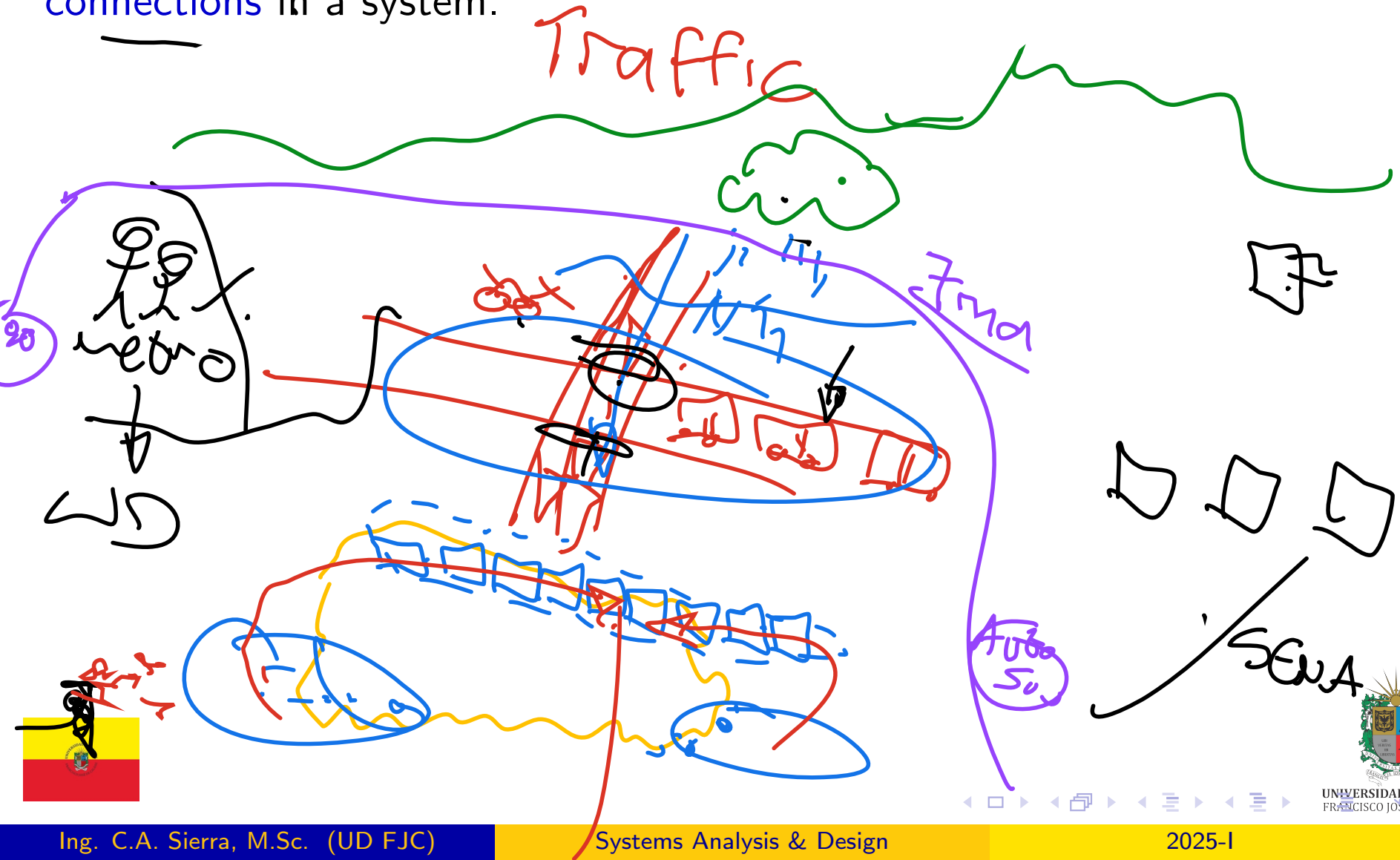
Complexity in Systems

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



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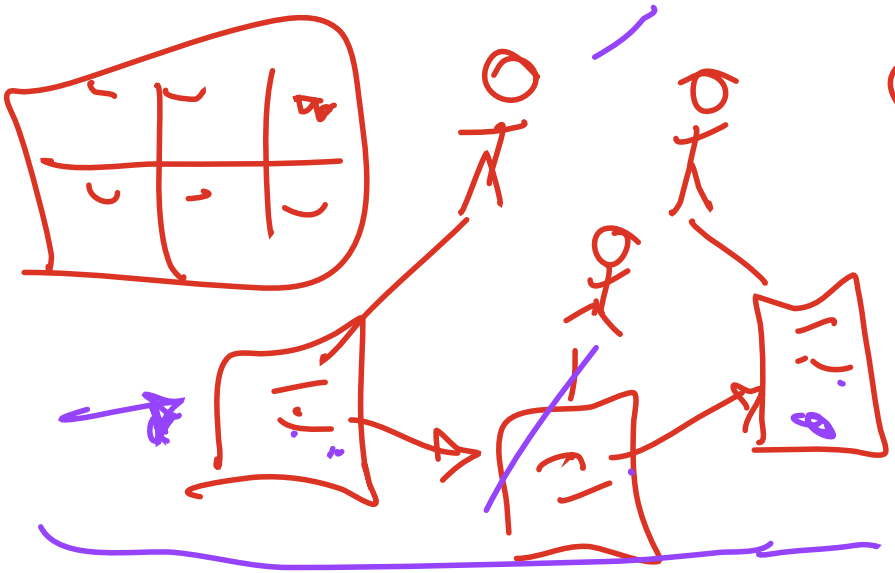

- In **systems thinking**, if you just split parts and forget relationships, you will lost the full picture.
- It is called **holistic** approach, try to see all the picture with all the meaning details.
- Define the **box boundaries** is sometimes tricky, as we said, not too complex, not too simple.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

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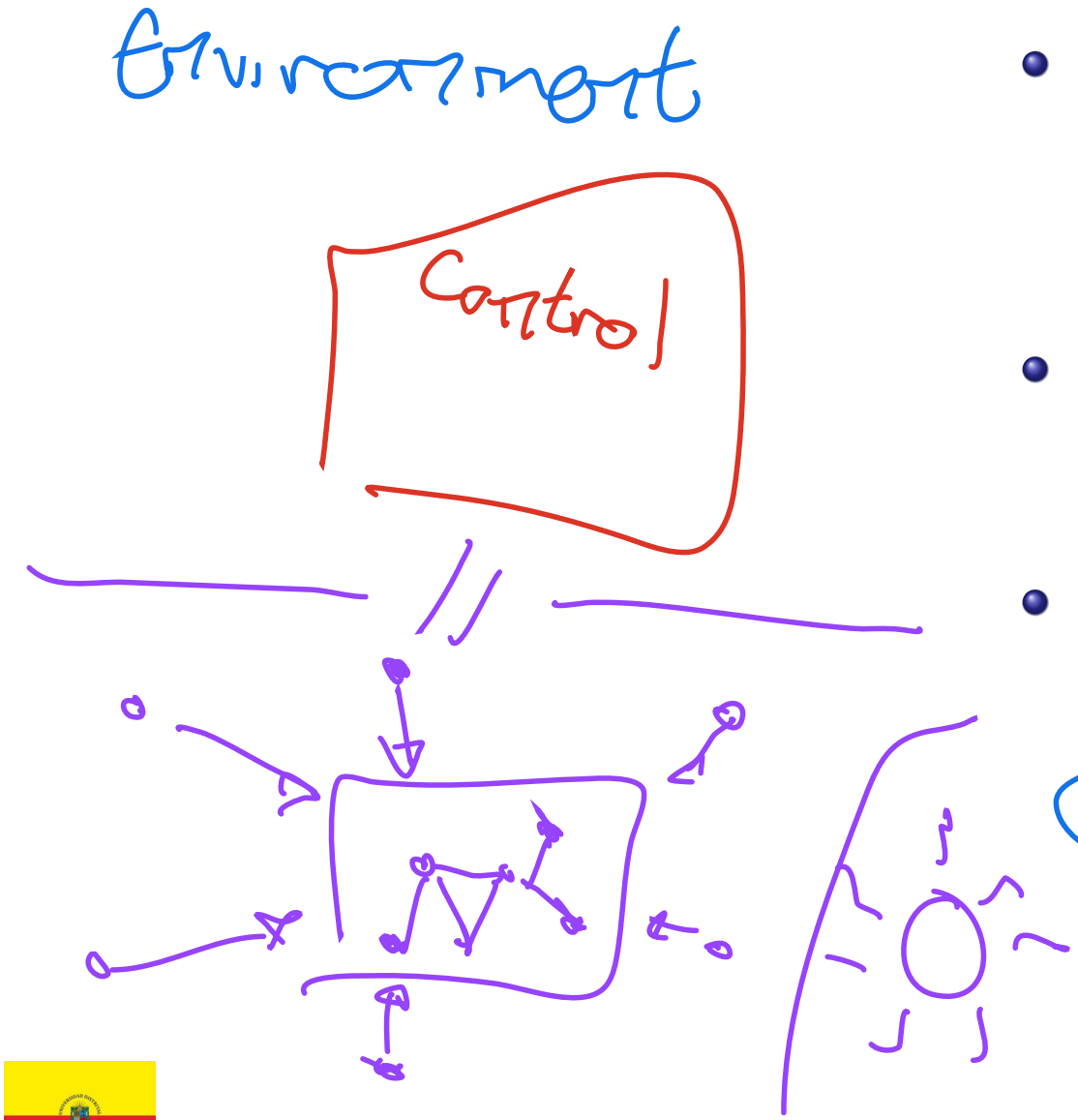

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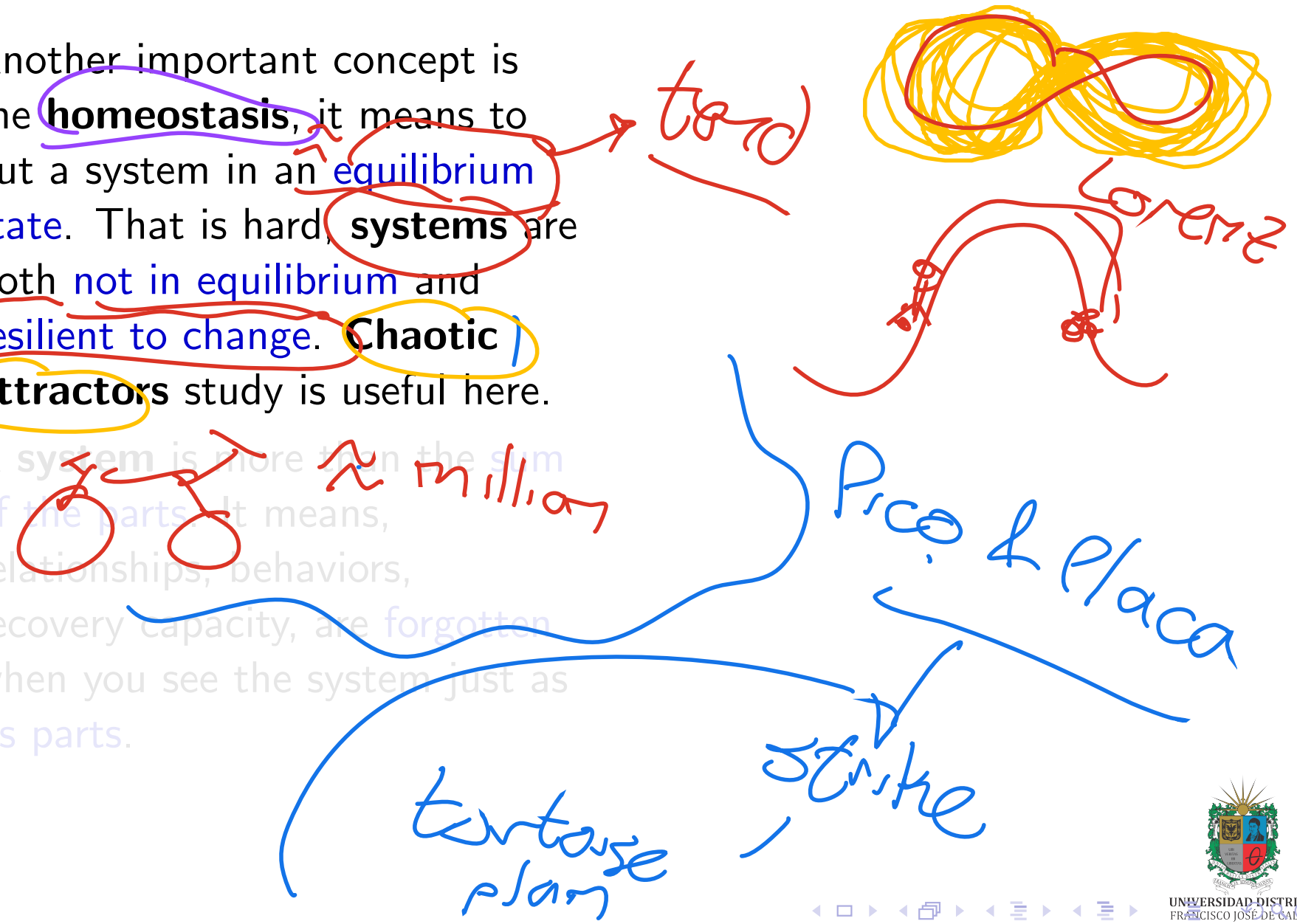
Introduction to Systems Thinking III

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



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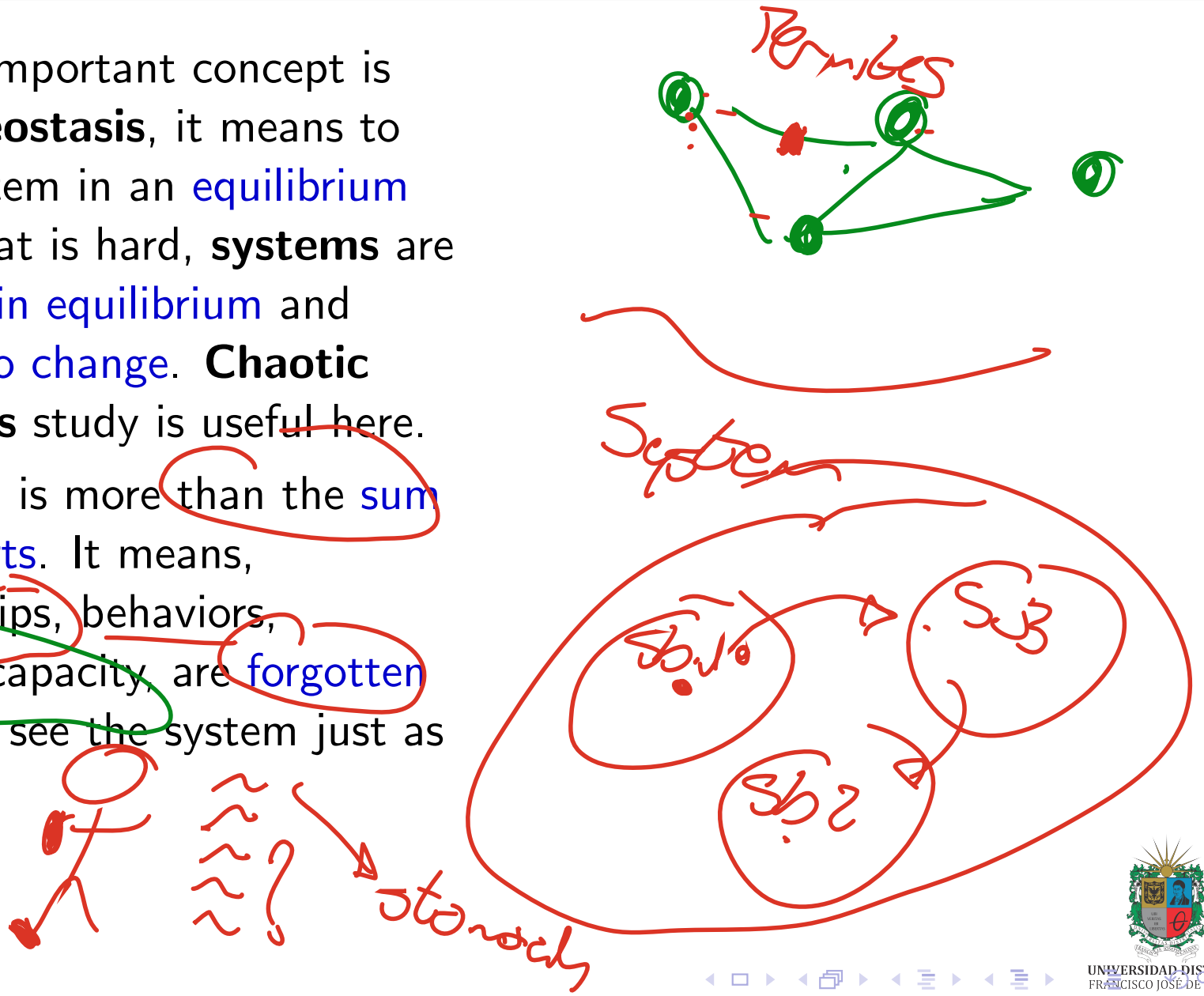
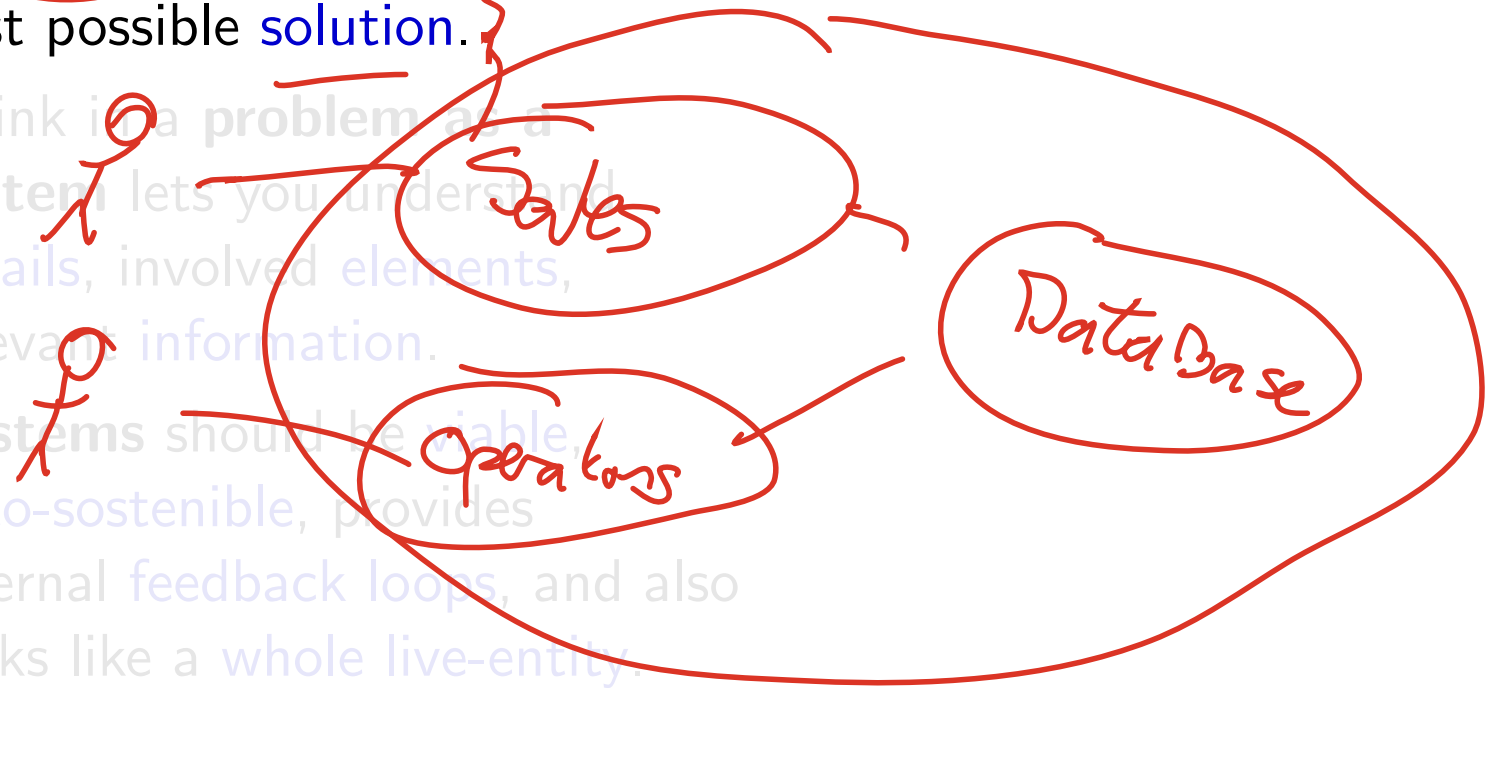


Introduction to Systems Thinking IV

- **Systems thinking** is a way to understand and represent problems in order to find the best possible solution.
- Think in a **problem** as a **system** lets you understand details, involved elements, relevant information.
- **Systems** should be viable, auto-sostenible, provides internal feedback loops, and also looks like a whole live-entity.



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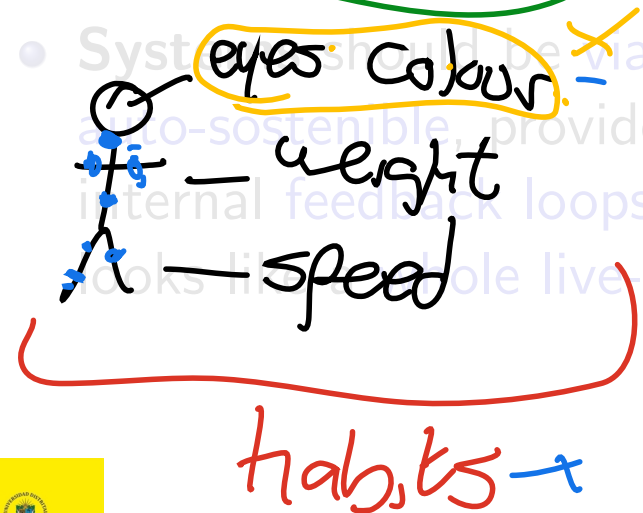

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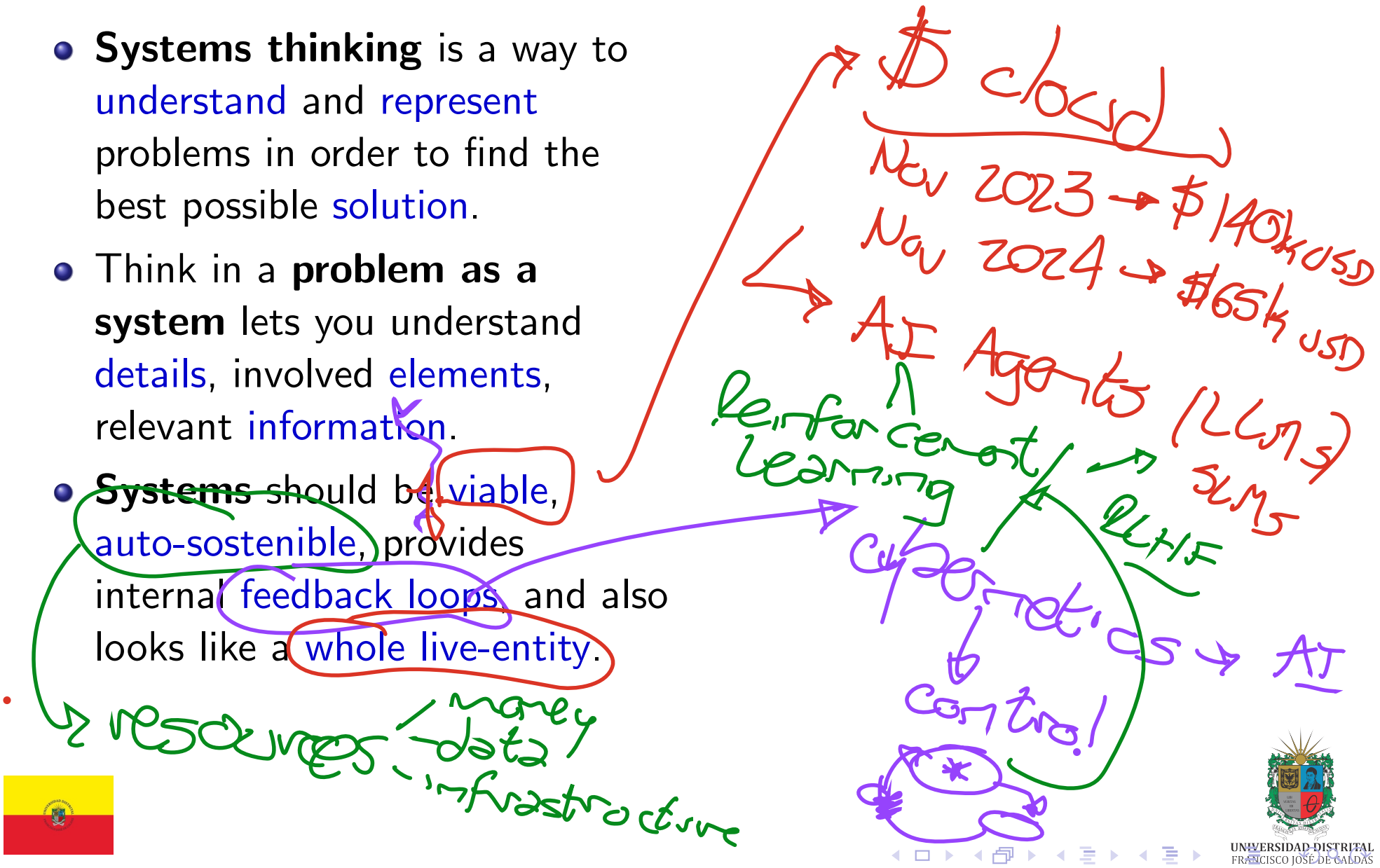
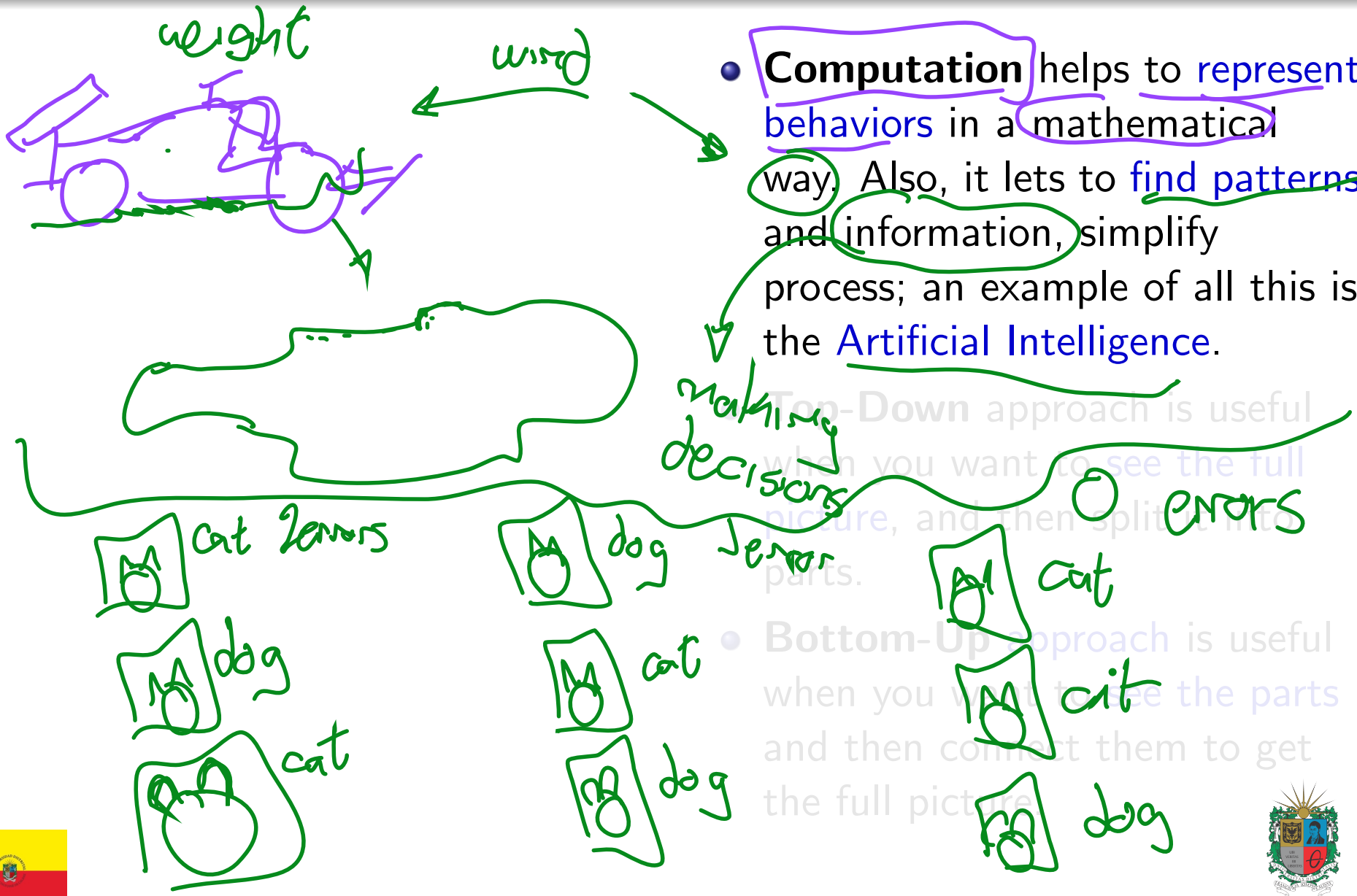


Introduction to Systems Thinking V



- **Computation** helps to represent behaviors in a mathematical way. Also, it lets to find patterns and information, simplify process; an example of all this is the Artificial Intelligence.

- **Top-Down** approach is useful when you want to see the full picture, and then split it into parts.
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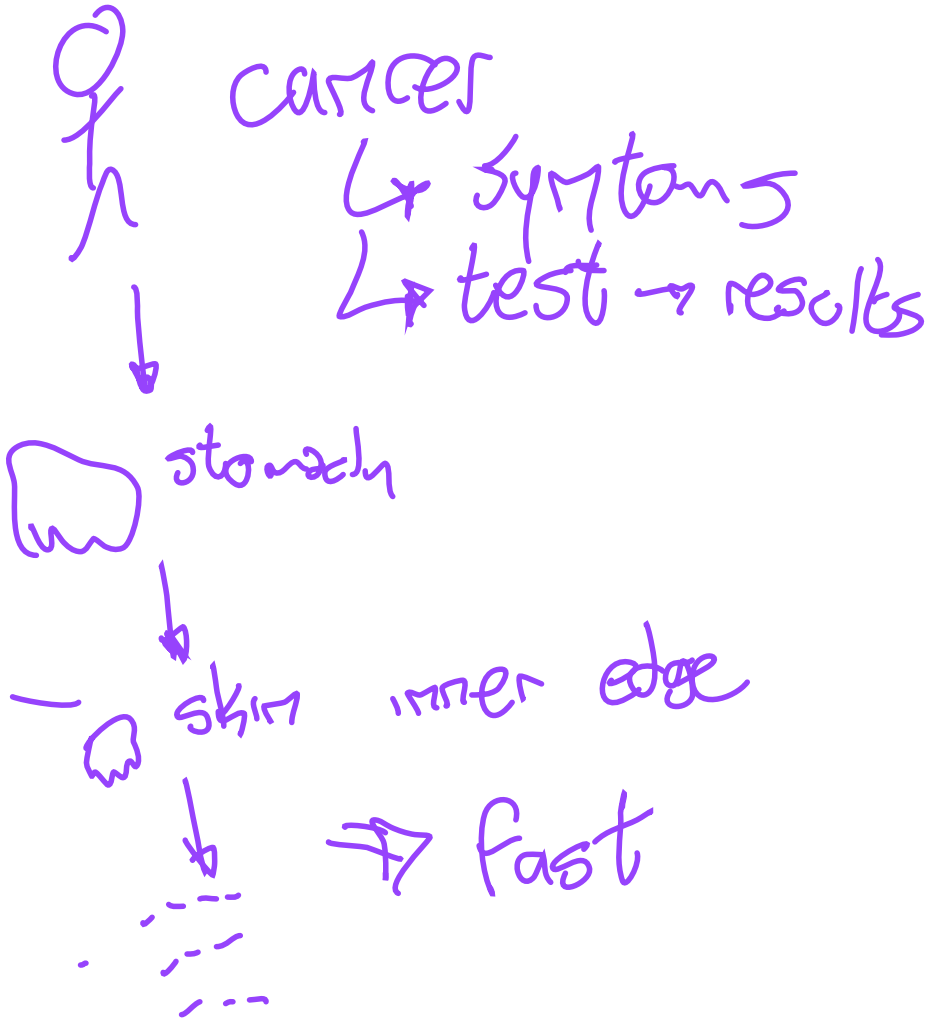

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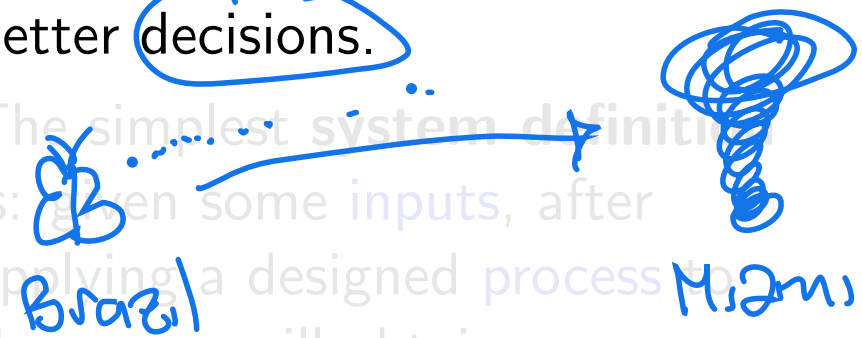
- It is important to understand the **sensitivity** of the problem because it leads to making better decisions.
- The simplest **system definition** is: given some inputs, after applying a designed process to them, you will obtain some outputs.
- In a **deterministic** world, the same inputs produce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



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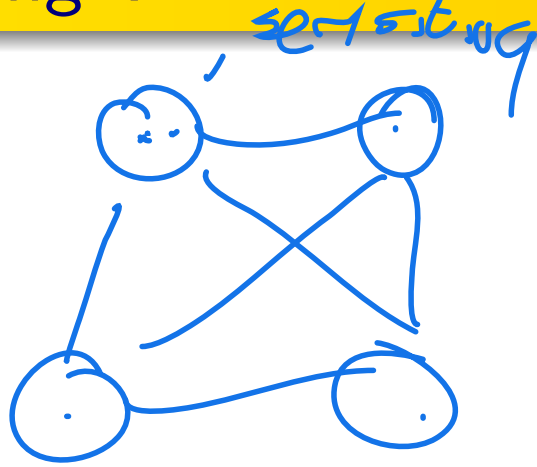

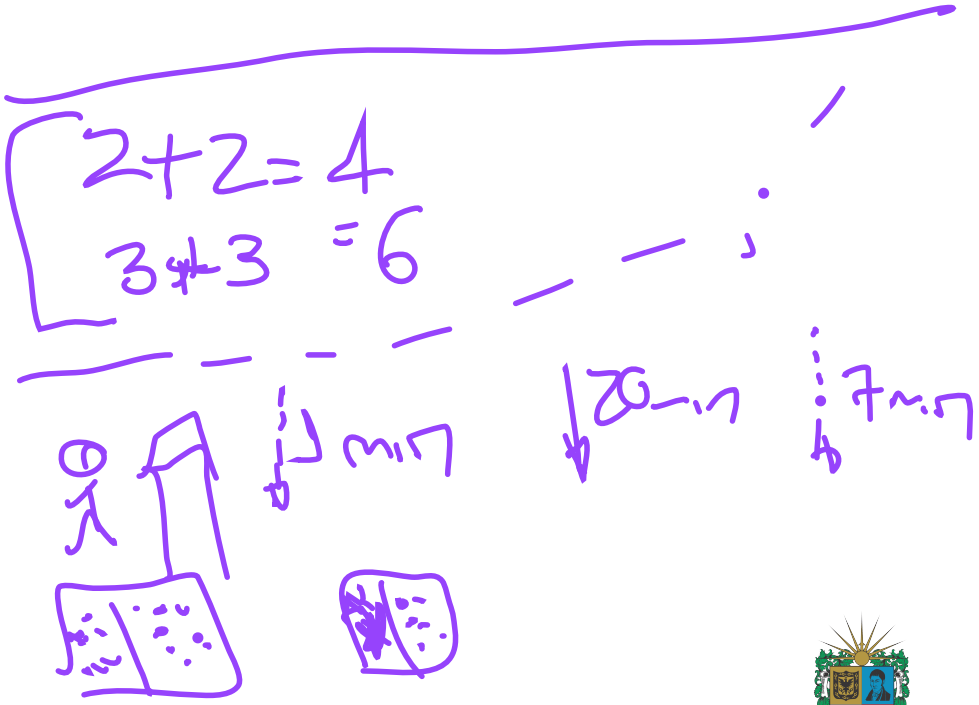

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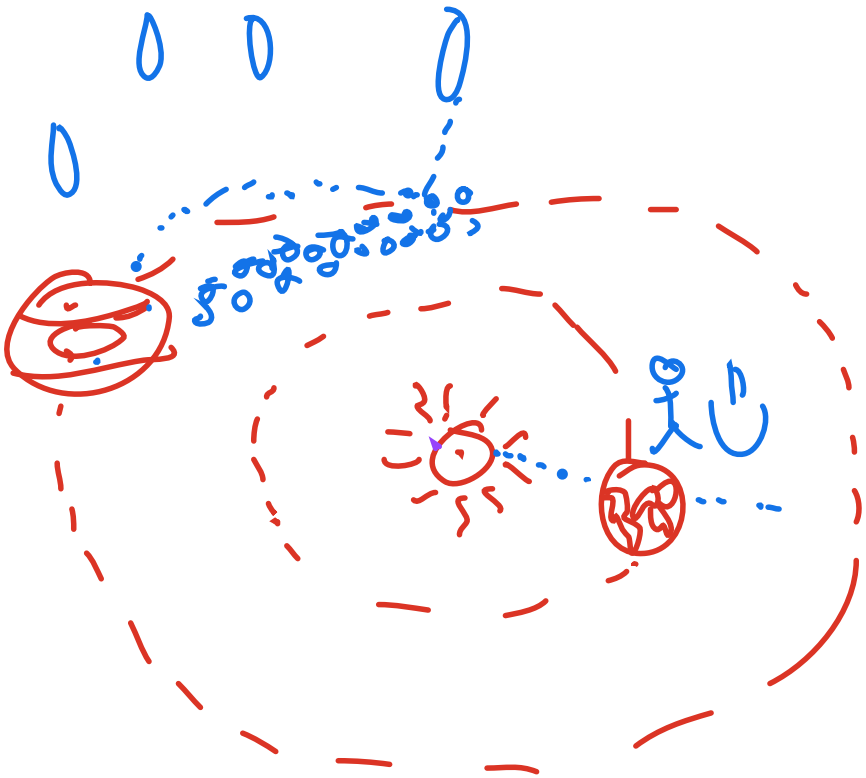

- Since **randomness** is normal in the real world, relying solely on deterministic processes is dangerous. Using **stochastic processes** is a better approach.
- **Stochastic processes** make use of probability, which leads to a better representation of real-world behavior.
- Here, **Chaos Theory**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

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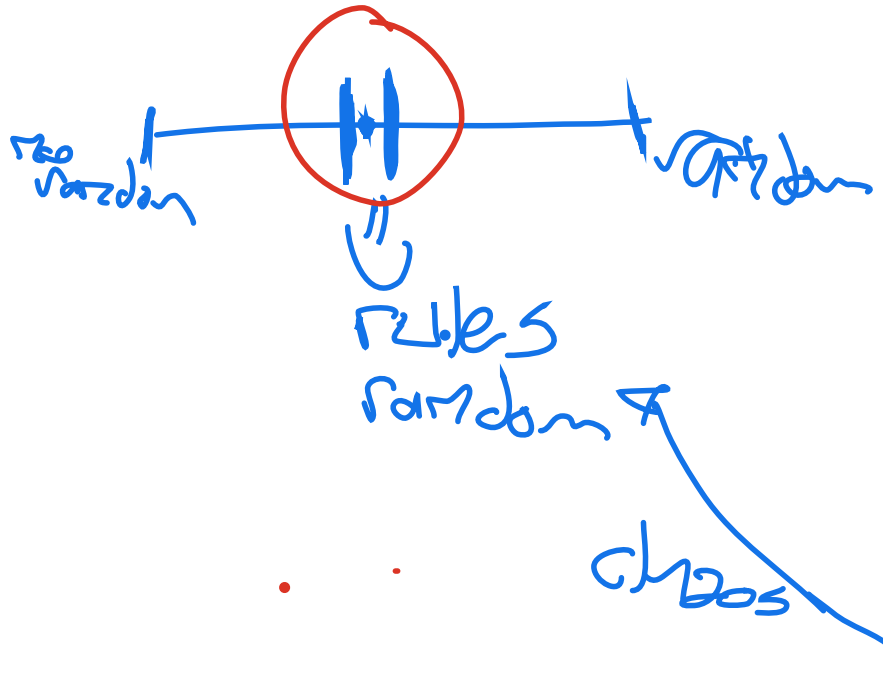

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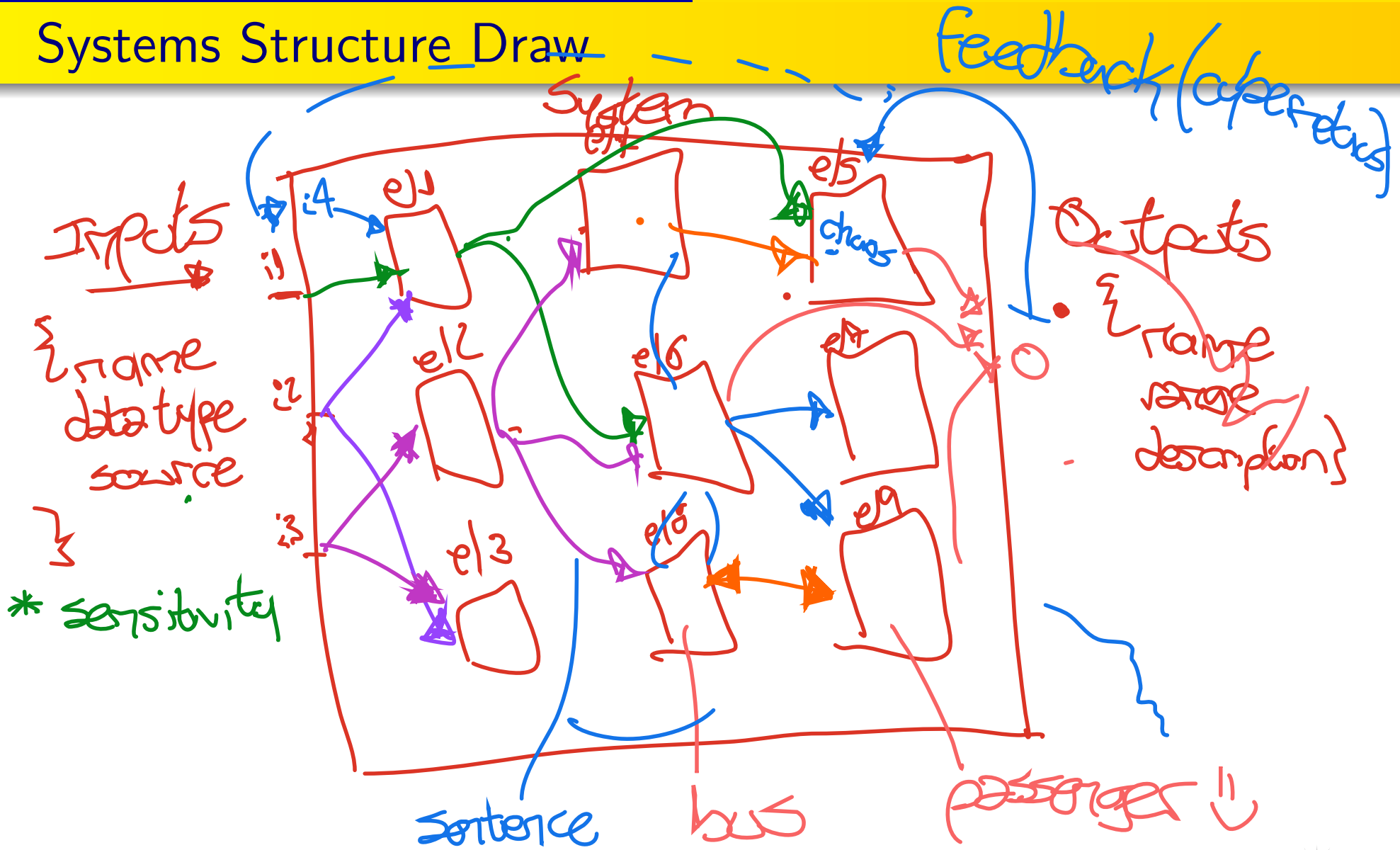
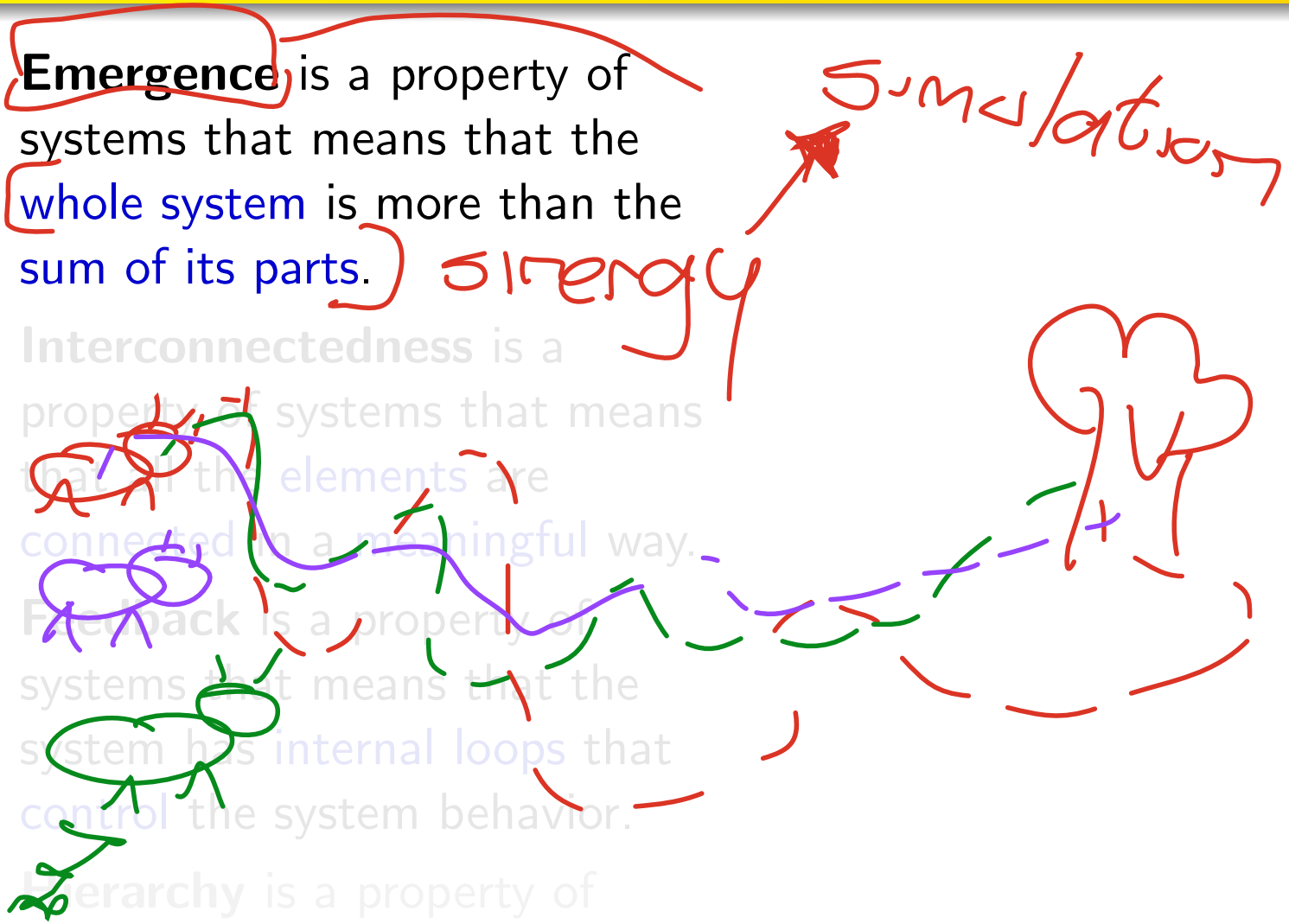


Case of Study: Transportation System

Outline

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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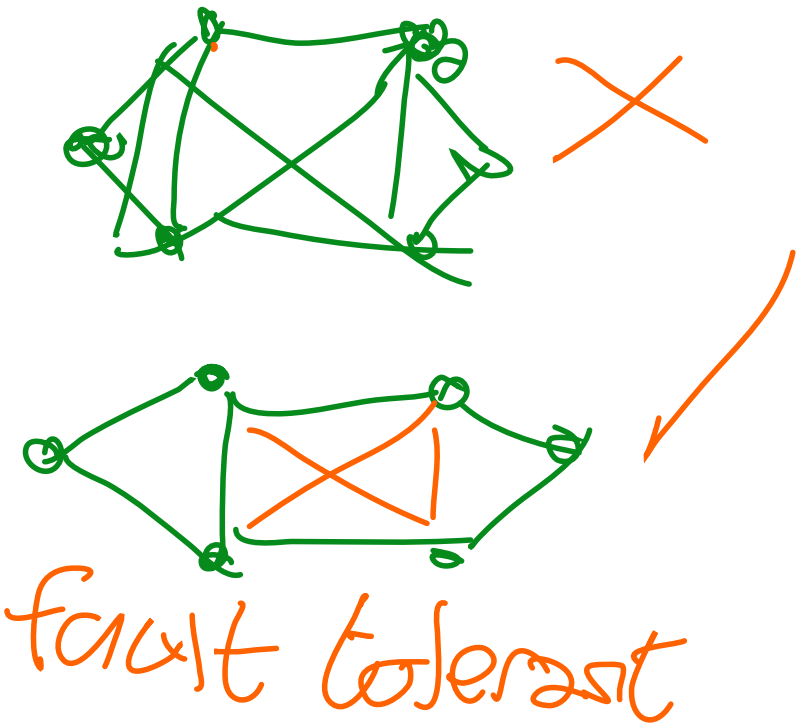

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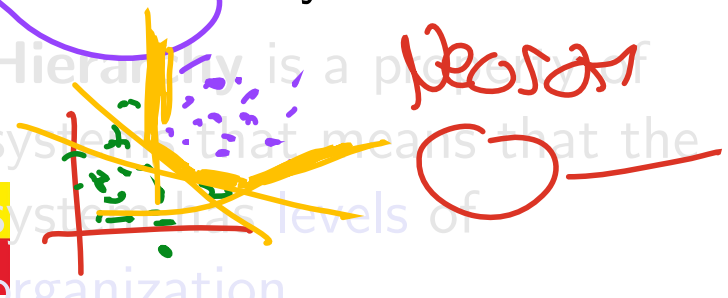

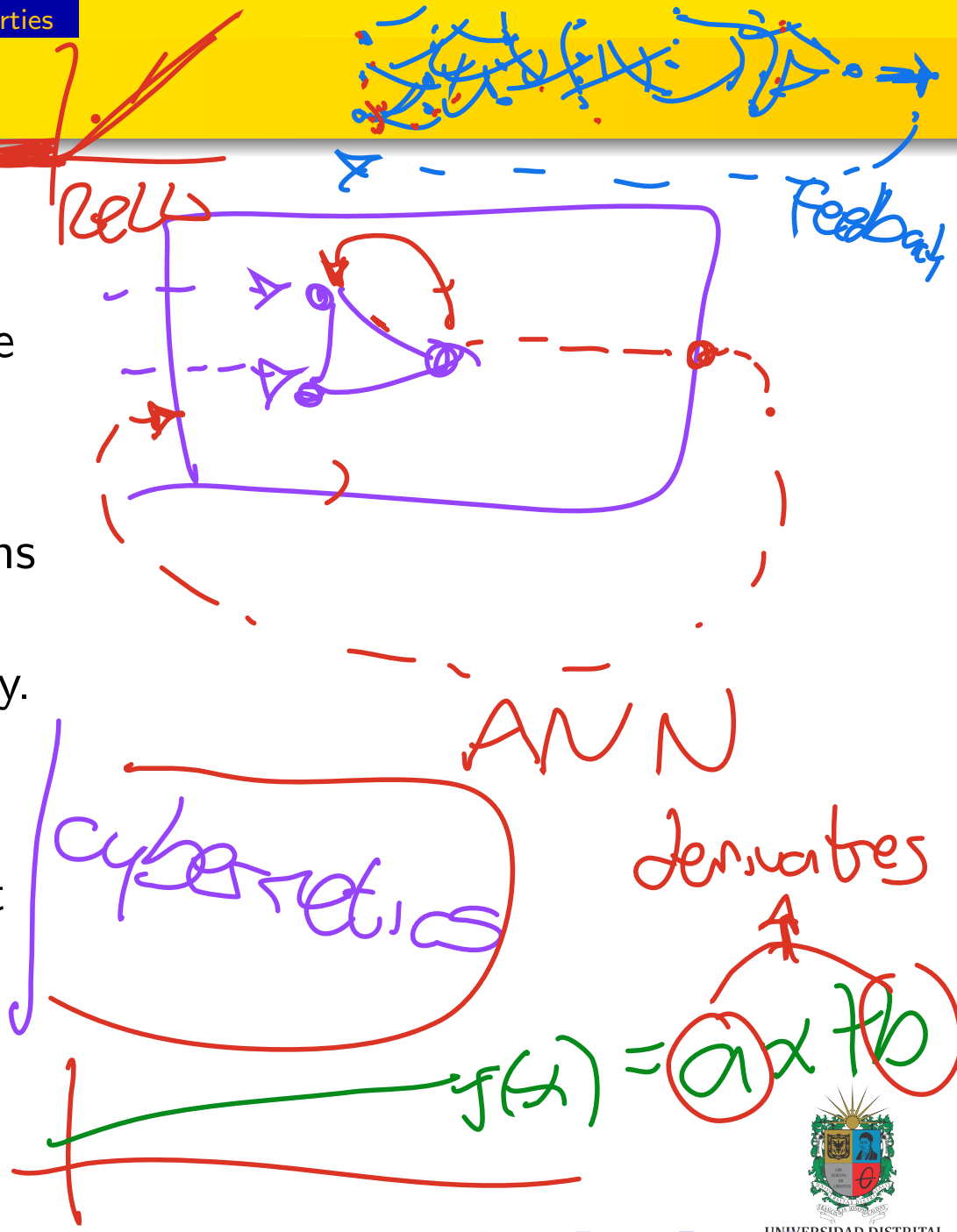

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Systems Properties II

- **Equifinality** is a property of systems that means that the system can reach the same goal from different paths.
- **Permeability** is a property of systems that means that the system can interact with the environment.
- **Dissipative** is a property of systems that means that the system can lose energy and information to the environment.
- **Homeostasis** is a property of systems that means that the system can maintain a stable state.

flexible
fault tolerant

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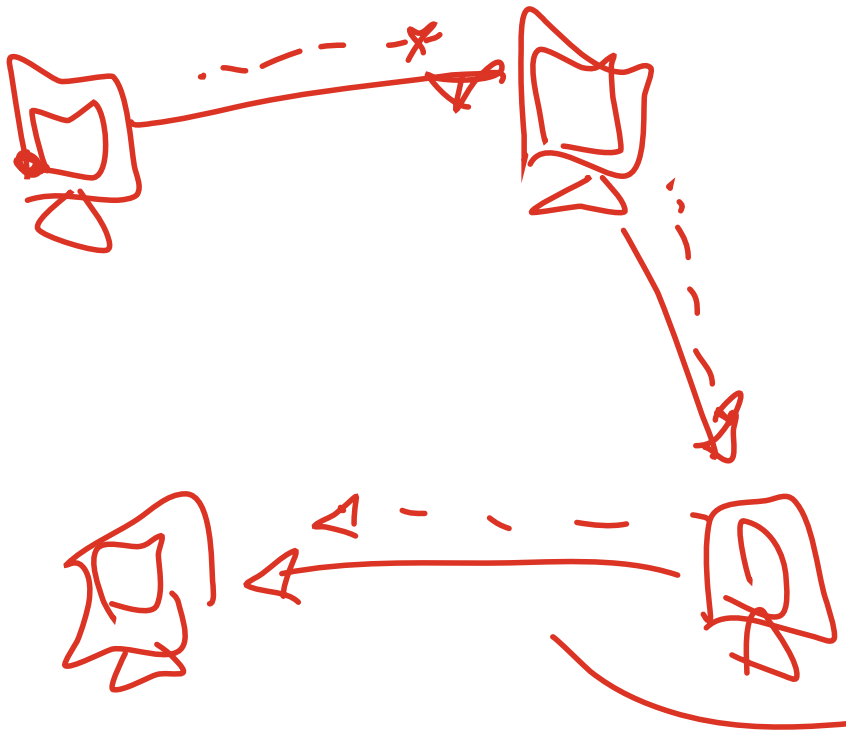

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Systems Properties III

- **Equilibrium** is a property of systems that means that the system can reach a stable state.
- **Adaptability** is a property of systems that means that the system can change to adapt to the environment.
- **Self-organization** is a property of systems that means that the system can organize itself.
- **Self-regulation** is a property of systems that means that the system can regulate itself.

≠ homeostasis

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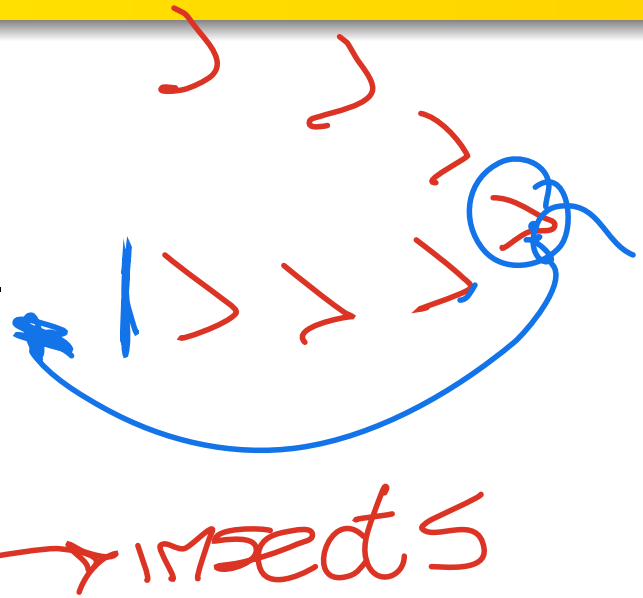

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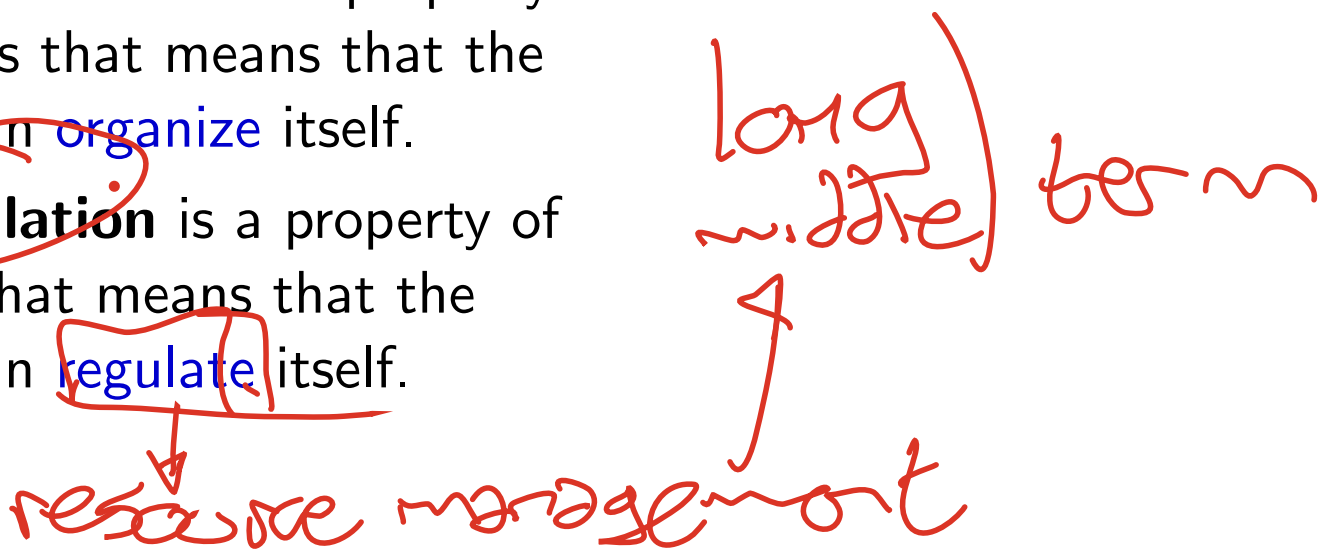

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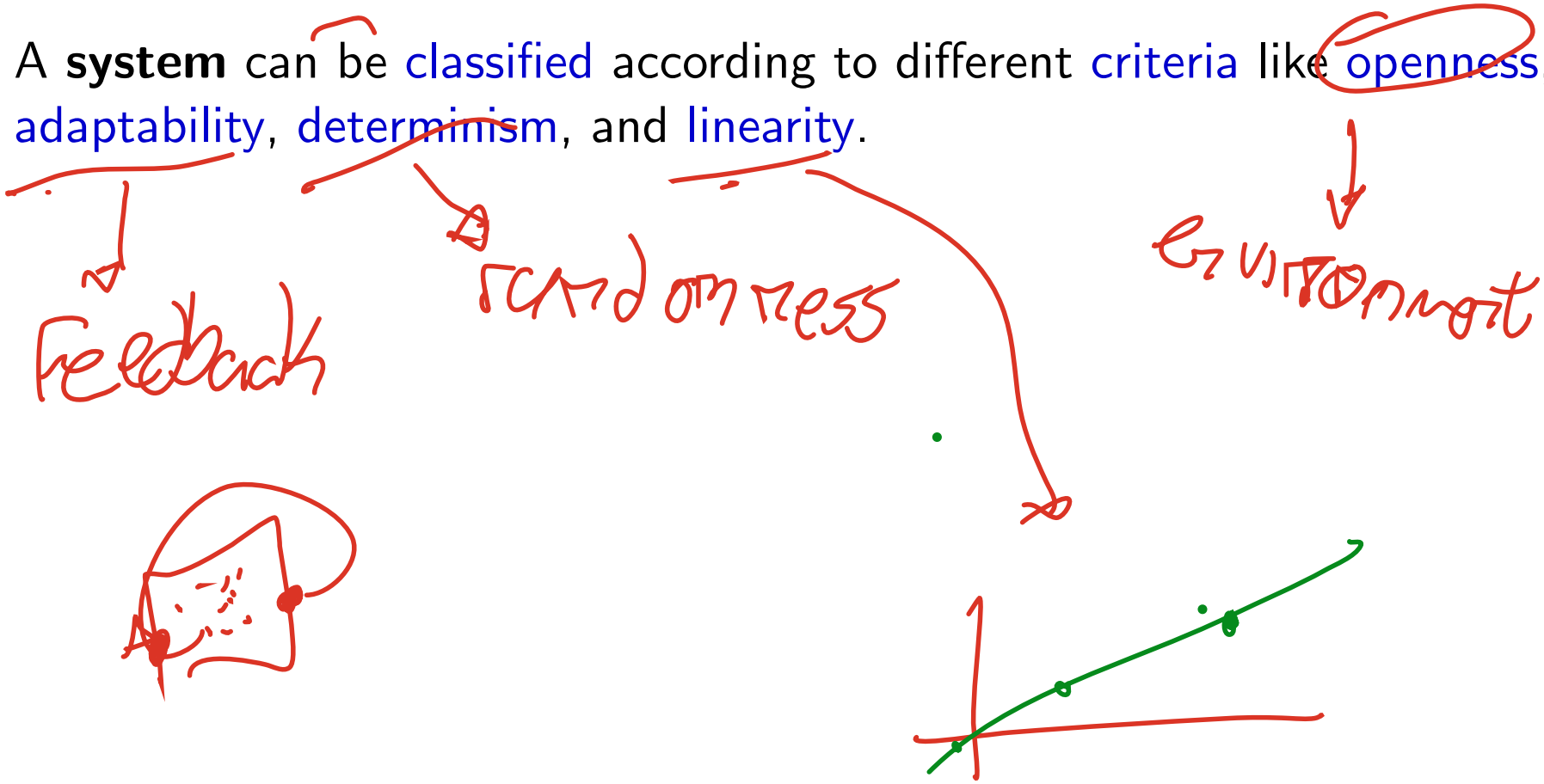
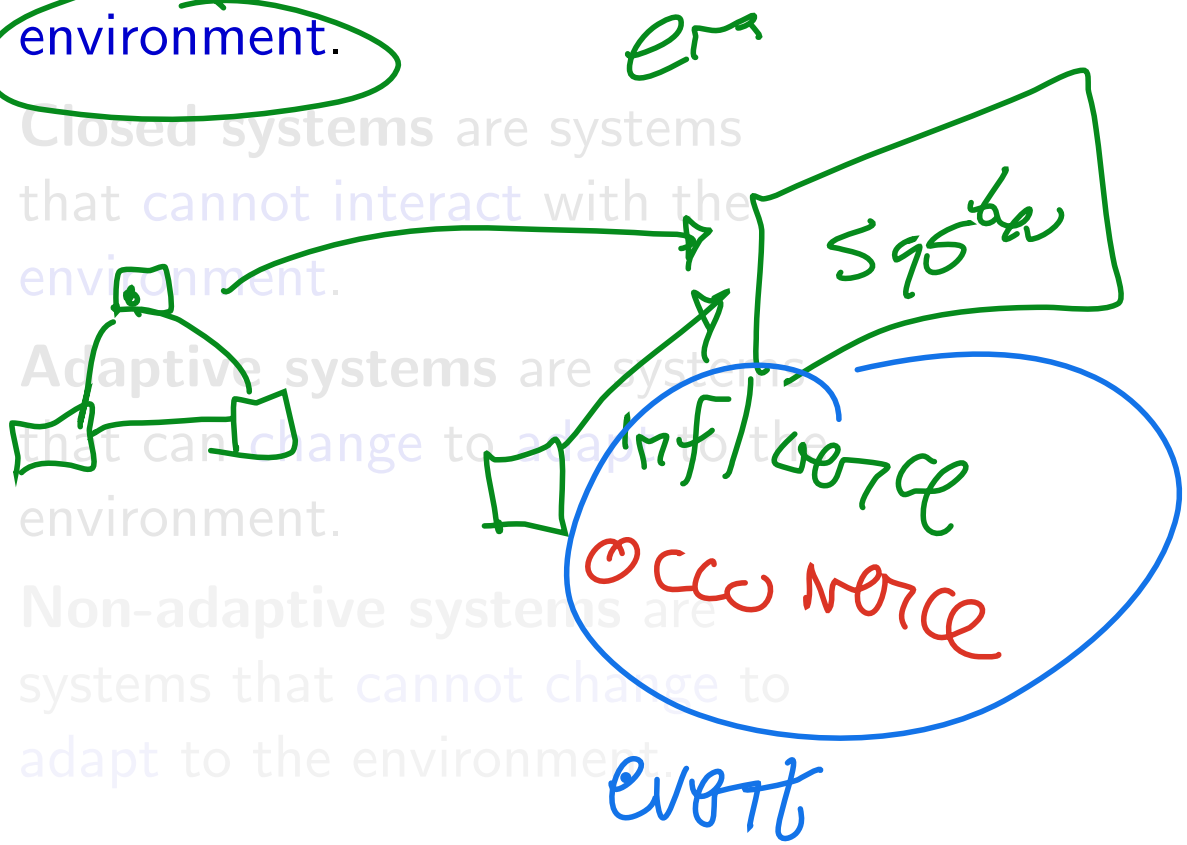
Basic Concepts

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 the environment.



- **Closed systems** are systems that cannot interact with the environment.
- **Adaptive systems** are systems that can change to adapt to the environment.
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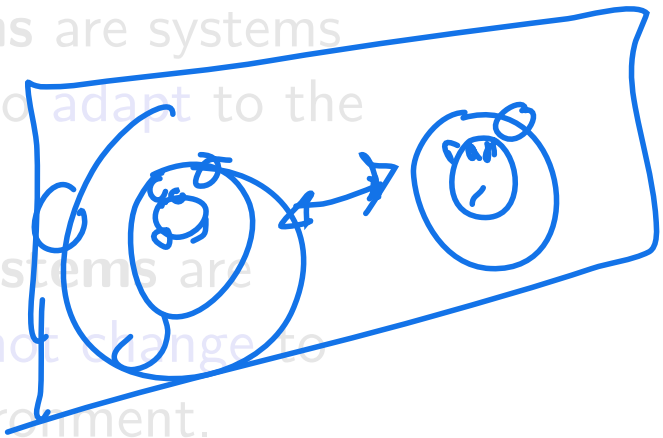

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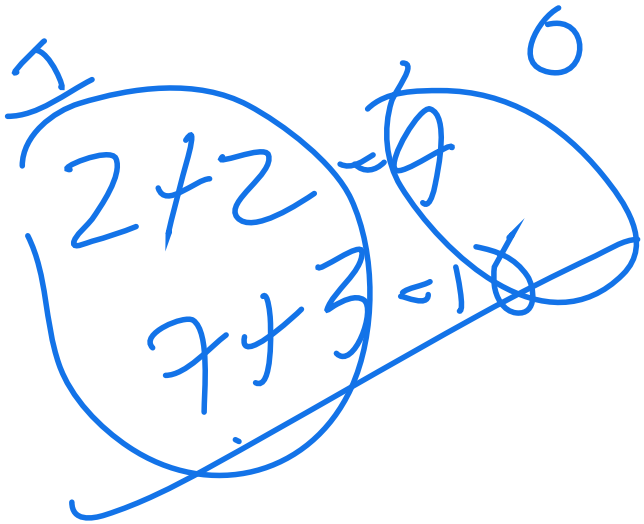

- **Deterministic systems** are systems that produce the same output for the same input.
- **Stochastic systems** are systems that produce different outputs for the same input.
- **Linear systems** are systems that produce proportional outputs for the same input.
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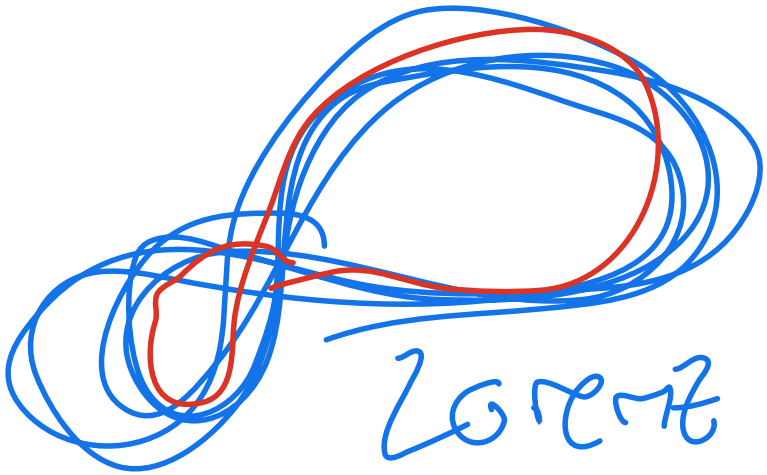

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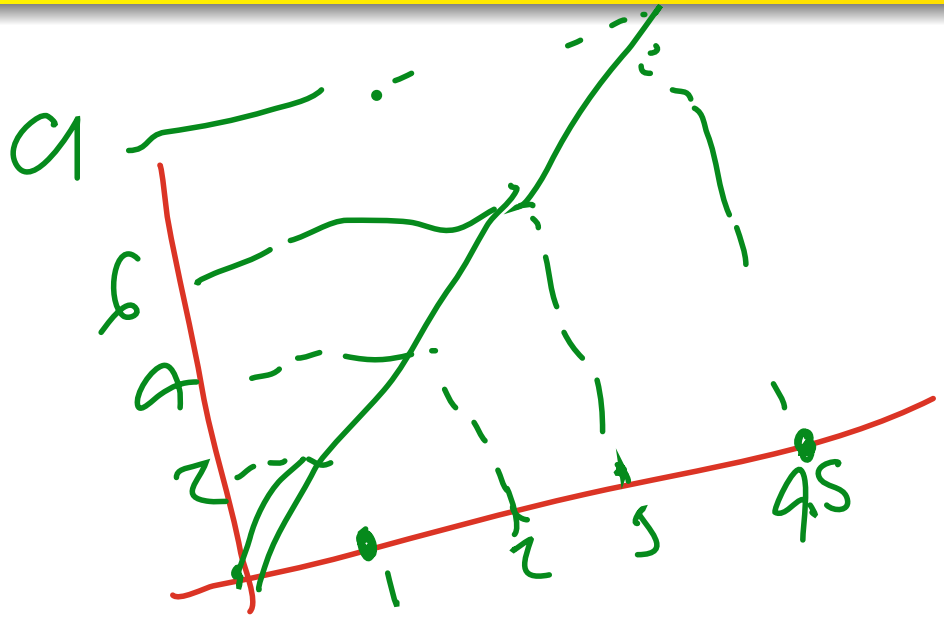

- **Deterministic systems** are systems that produce the same output for the same input.
- **Stochastic systems** are systems that produce different outputs for the same input.
- **Linear systems** are systems that produce proportional outputs for the same input.
- **Non-linear systems** are systems that produce non-proportional outputs for the same input.

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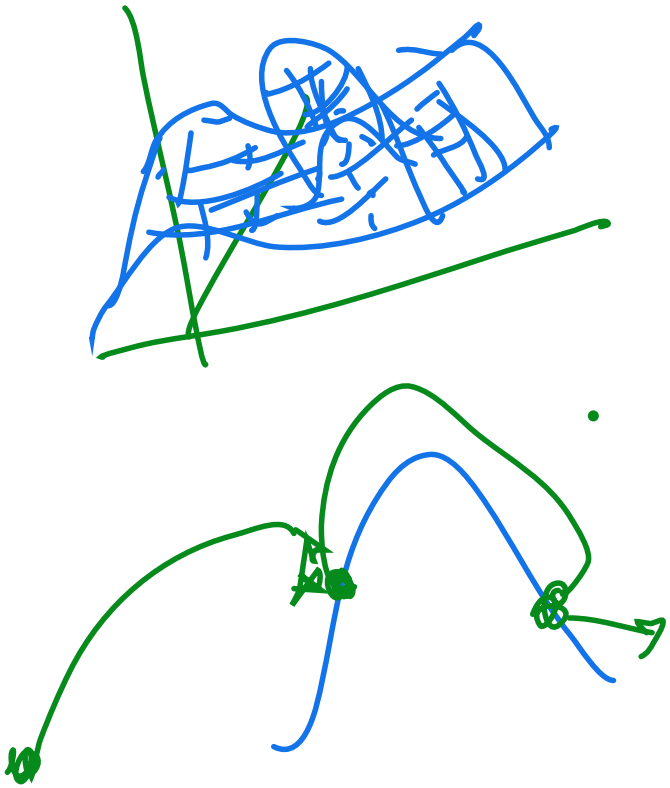

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Outline

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Thanks!

Questions?

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

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