Lecture #2

Problem Formulation

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Examples of Problems

- **Nutrition Problem**

- Each fruit contains different nutrients.
- Each fruit has different cost.

An apple a day keeps the doctor away – but apples are costly!

A customer's goal is to fulfill daily nutrition requirement at lowest cost.

Examples of Problems

- **Assignment Problem**

  - Each operation has its own importance.
  - Each military personnel member may handle operations differently.
  - Each military personnel member is skilled in different types of operations.

The goal is to find the best assignment for each personnel to operation.

Examples of Problems

- **Portfolio Management Problem**

- Each investment carries certain rewards and risks.
- Each investment also offers a different level of reward.

The goal is to maximize expected rewards while keeping lowest possible risks within an acceptable range.

The Nature of Problems in Complex Systems

- Systems usually consist of:
  - Multiple parts
  - Interconnections
  - Functions
- Complex systems pose greater technical and management challenges than simple systems.
- Building and managing complex systems involves addressing a large number of problems.
- **Finding the best solution from the set of all available alternatives** is a common requirement.

Optimization Problem!

System Engineering

Systems Approach

- There are three ways to address complex problems and issues:

  - Problems could be **resolved**. To resolve a problem is to find an answer that is '***good enough***,' one which satisfies.

  - Problem could be **dissolved**. To dissolve a problem is to change the situation in some way such that the problem disapprears, to '***move the goalposts***.'

  - Problem could be **solved**. To solve a problem is to ***find the correct answer***, as in solving an equation.

Source: D. K. Hitchins. "System Engineering: A 21st Century Systems Methodology." John Wiley & Sons, 2007.

The Structure of Complex Systems

By their nature, complex systems have a hierarchical structure.

Systems					
Communications systems		Information systems	Material processing systems		Aerospace systems
Subsystems					
Signal networks		Databases	Material preparation		Engines
Components					
Signal receivers	Data displays	Database programs	Power transfer	Material reactors	Thrust generators
Subcomponents					
Signal amplifiers	Cathode ray tubes	Library utilities	Gear trains	Reactive valves	Rocket nozzles
Parts					
Transformer	LED	Algorithms	Gears	Couplings	Seals

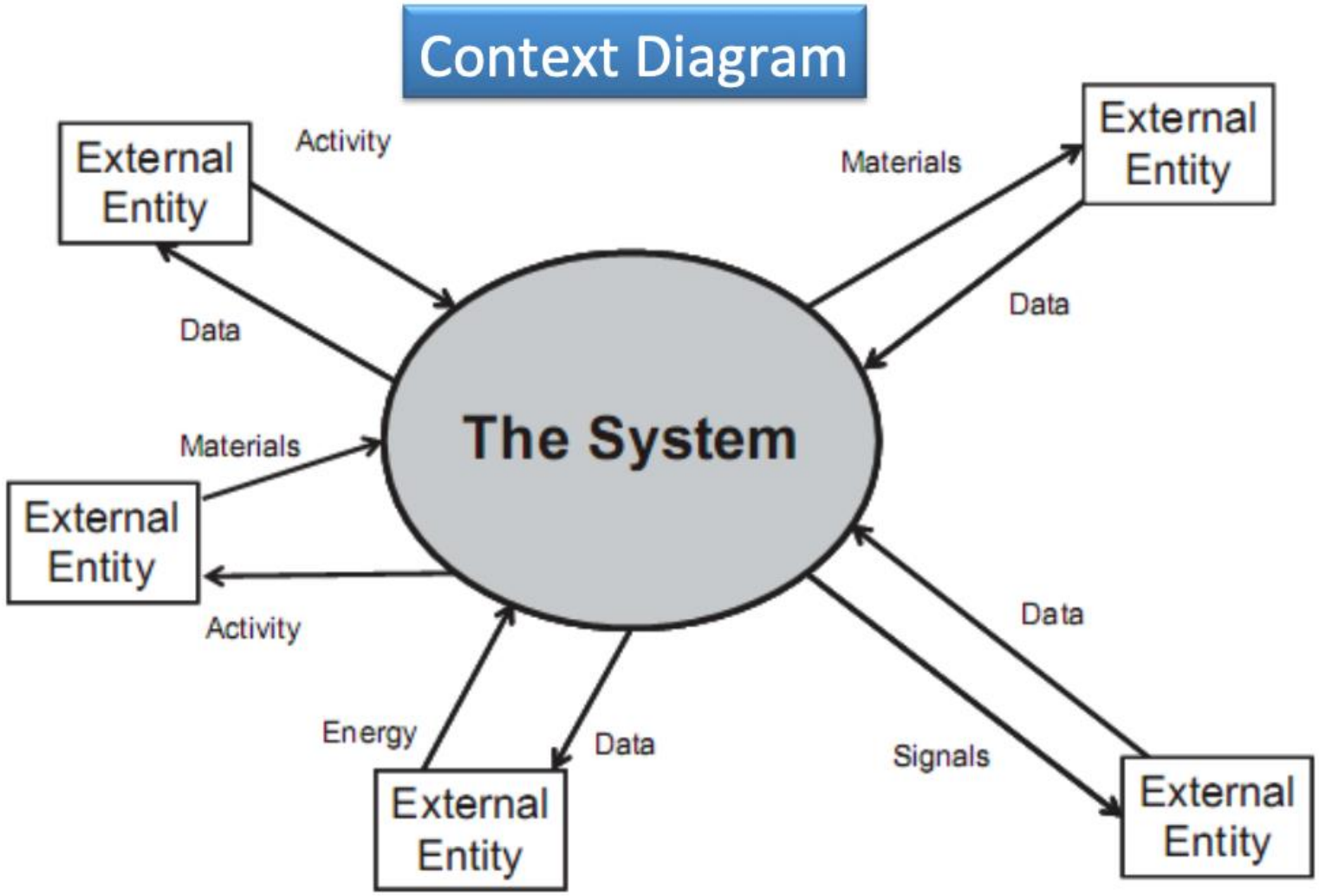
Source: A, Jossiakoff, W.N. Sweet, S.J. Seymour, and S.M. Biemer, "System Engineering Principles and Practice," 2nd Edition, John Wiley & Sons, 2011

System Functional Elements

- Four classes of system functional elements:
  - ***Signal Elements***, which sense and communicate information;
  - ***Data Elements***, which interpret, organize, and manipulate information;
  - ***Material Elements***, which provide structure and transformation of materials;
  - ***Energy Elements***, which provide energy and motive power.

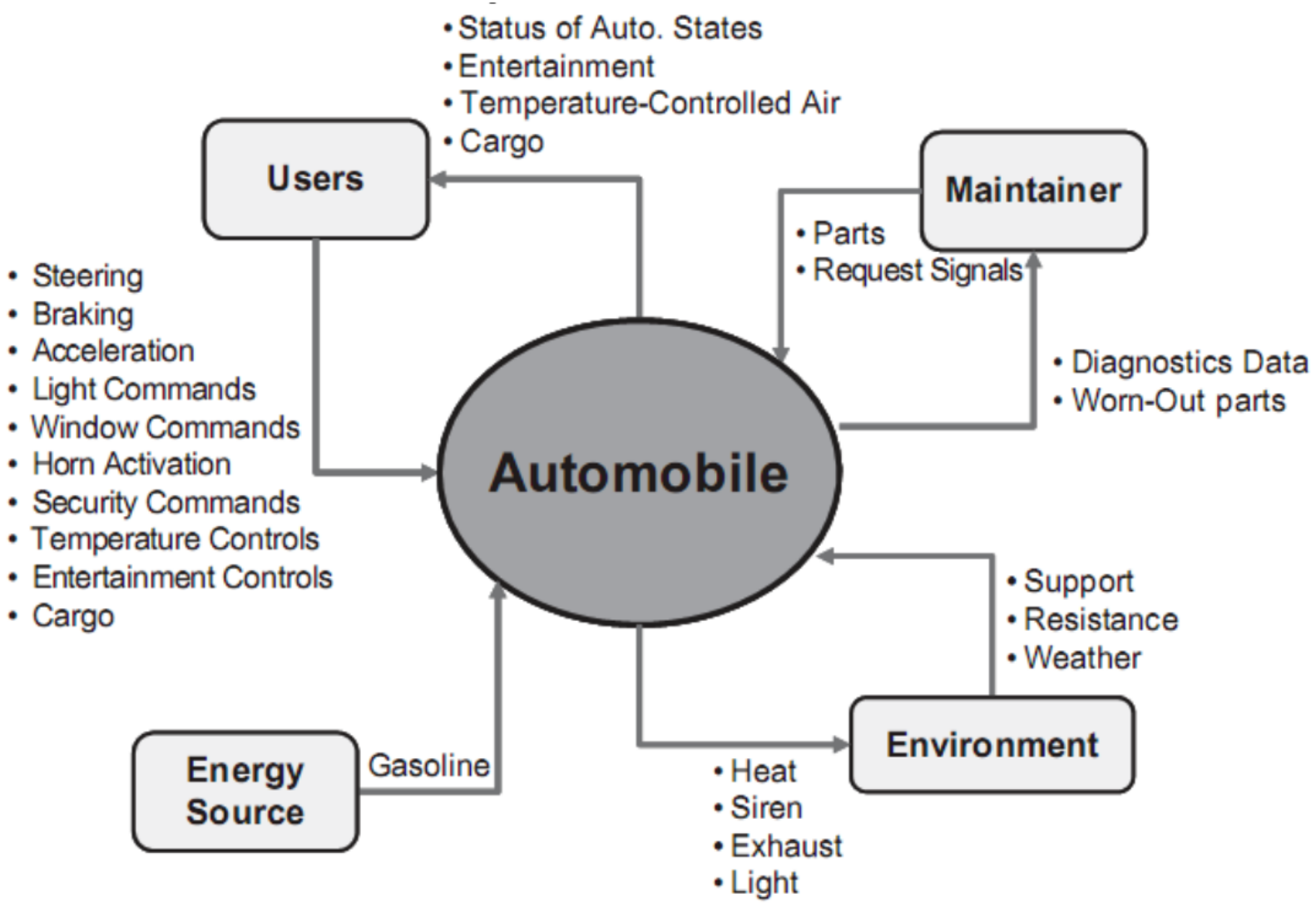
Source: A, Jossiakoff, W.N. Sweet, S.J. Seymour, and S.M. Biemer, "System Engineering Principles and Practice," 2nd Edition, John Wiley & Sons, 2011

System Building Boxes



Source: A, Jossiakoff, W.N. Sweet, S.J. Seymour, and S.M. Biemer, "System Engineering Principles and Practice," 2nd Edition, John Wiley & Sons, 2011

Example: Automobile



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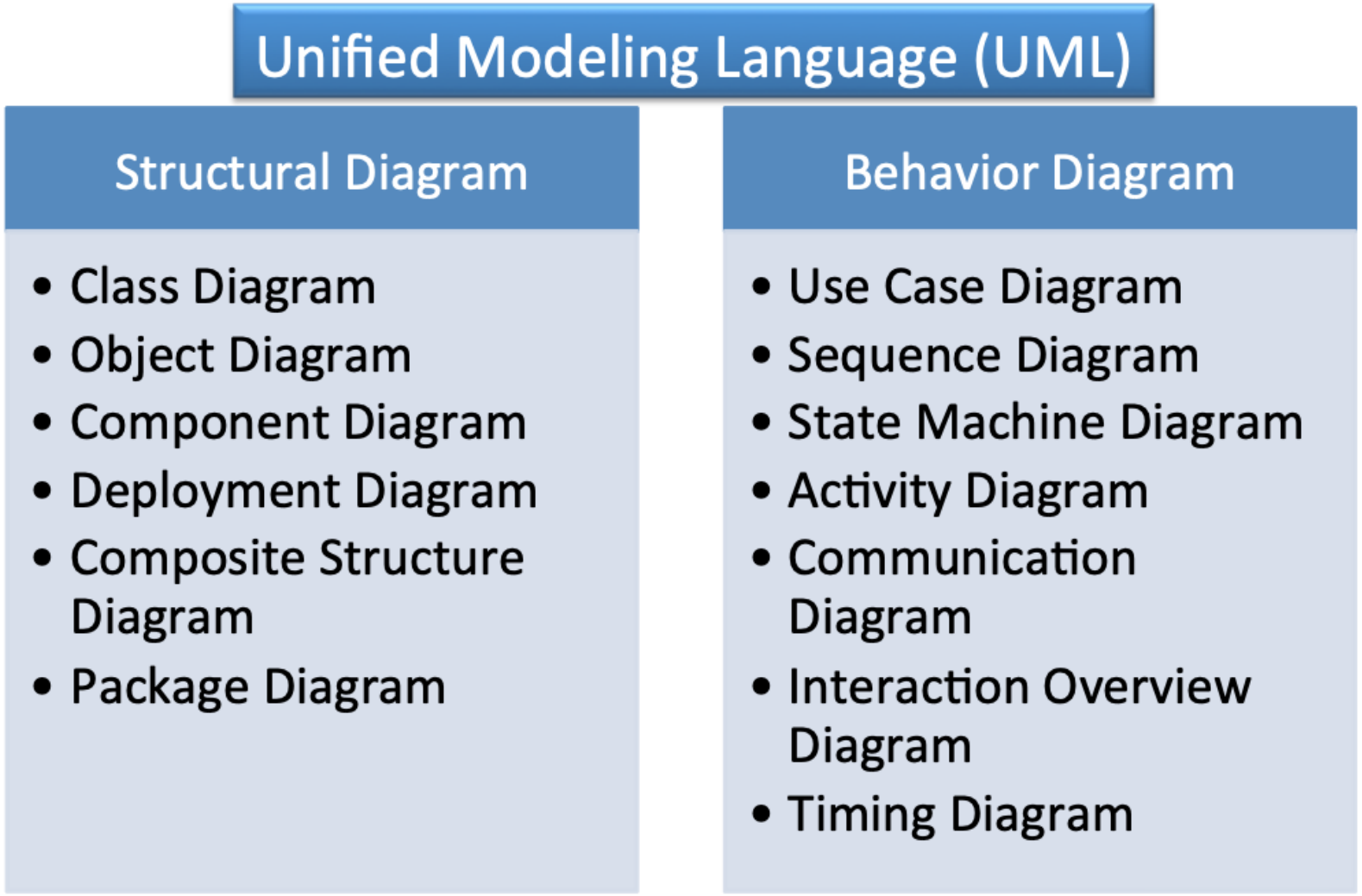
System Modeling Language



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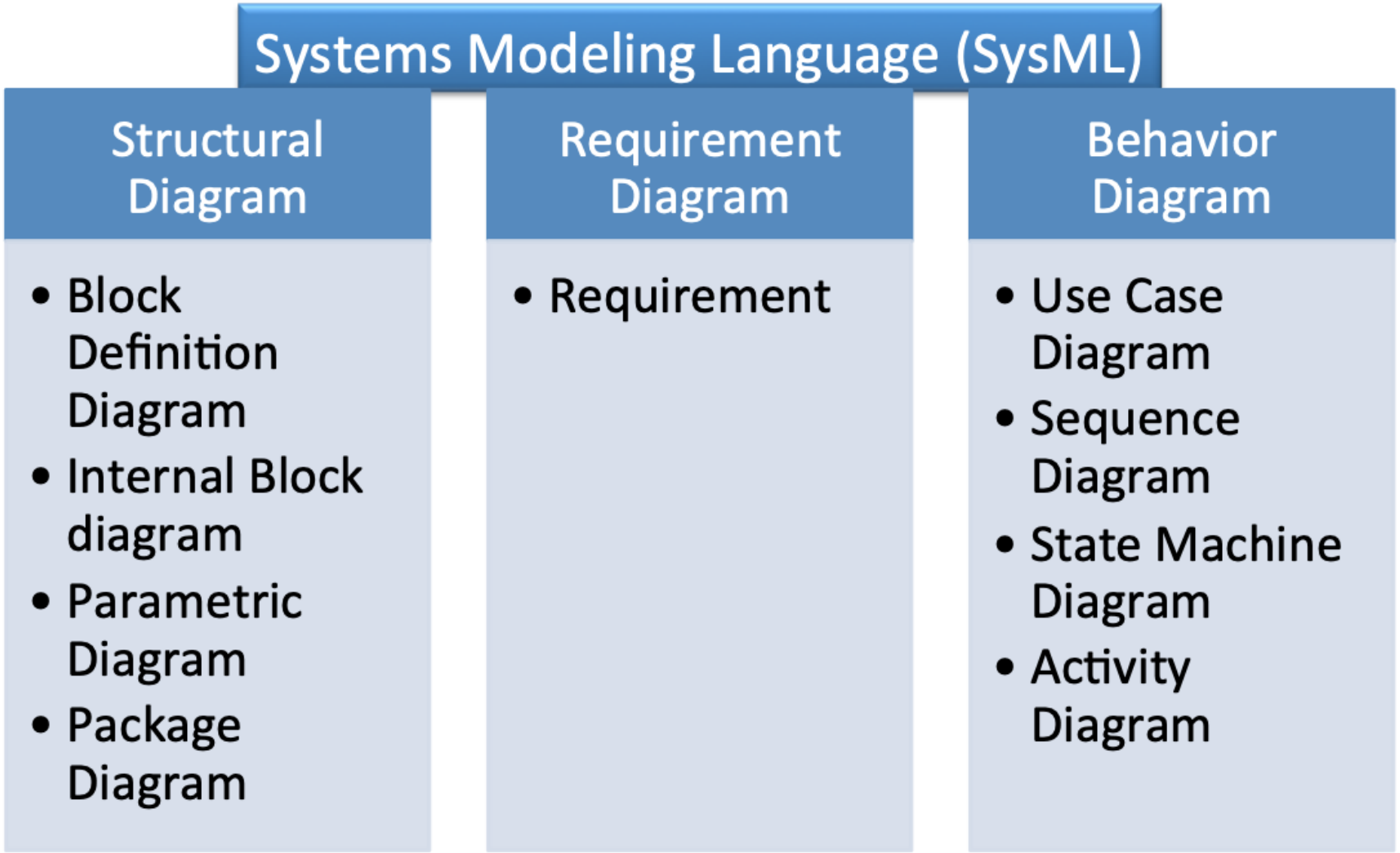

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The Role of Problem Formulation in Research

- Why do we need to specify the problem?
- When do we formulate the problem?
- Who should do the problem formulation?
- Where do we do the problem formulation?
- What do we need to formulate the problem?
- How do we do the problem formulation?

5W + 1H Questions to ask for every problem

End of the Lecture

Please don’t hesitate to raise your hand and ask questions if you're curious about anything!